Symposium on

Antarctic Logistics

NATIONAL ACADEMY OF SCIENCES—
NATIONAL RESEARCH COUNCIL

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SYMPOSIUM
ON
ANTARCTIC LOGISTICS

Held at Boulder, Colorado—August 13-17, 1962

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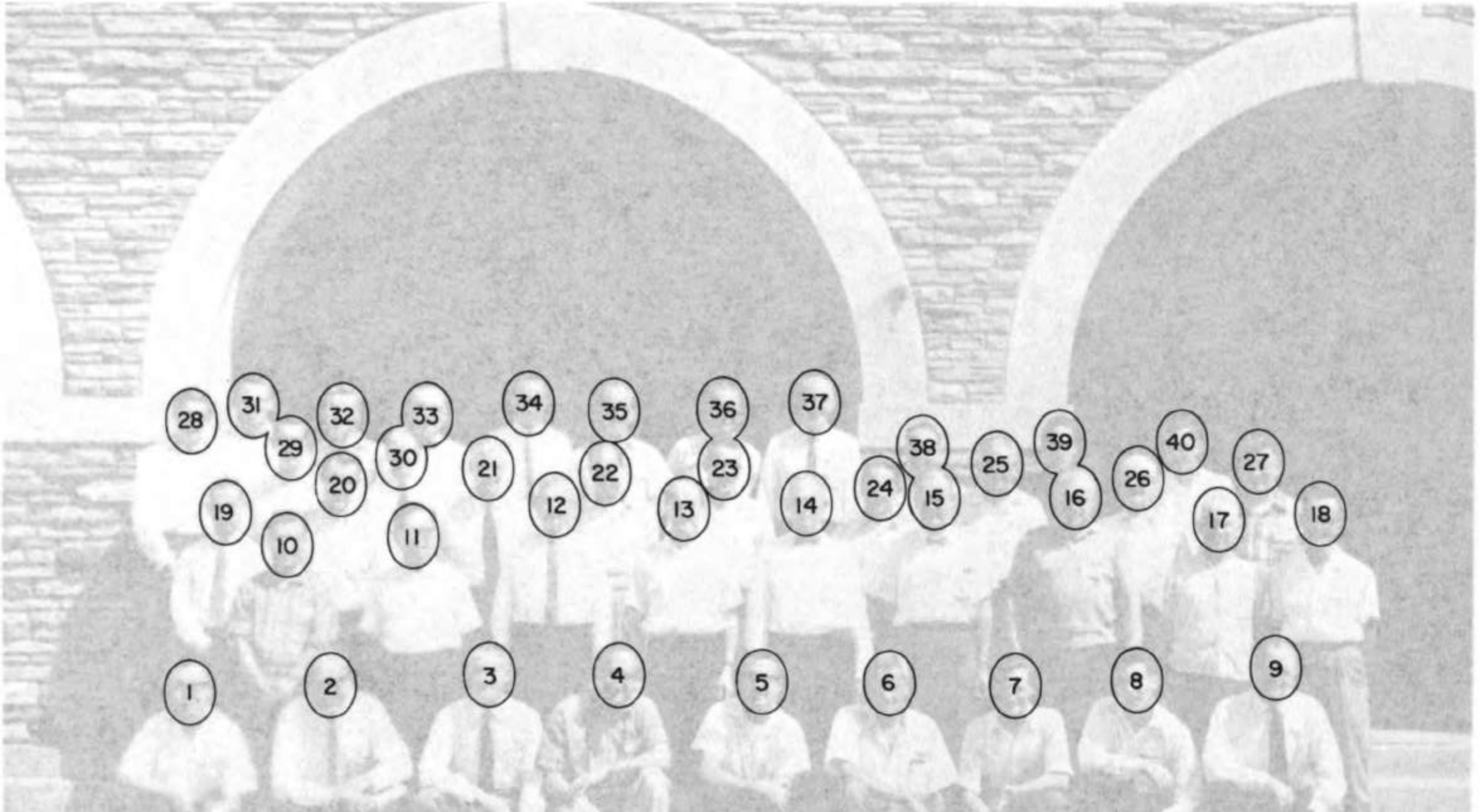

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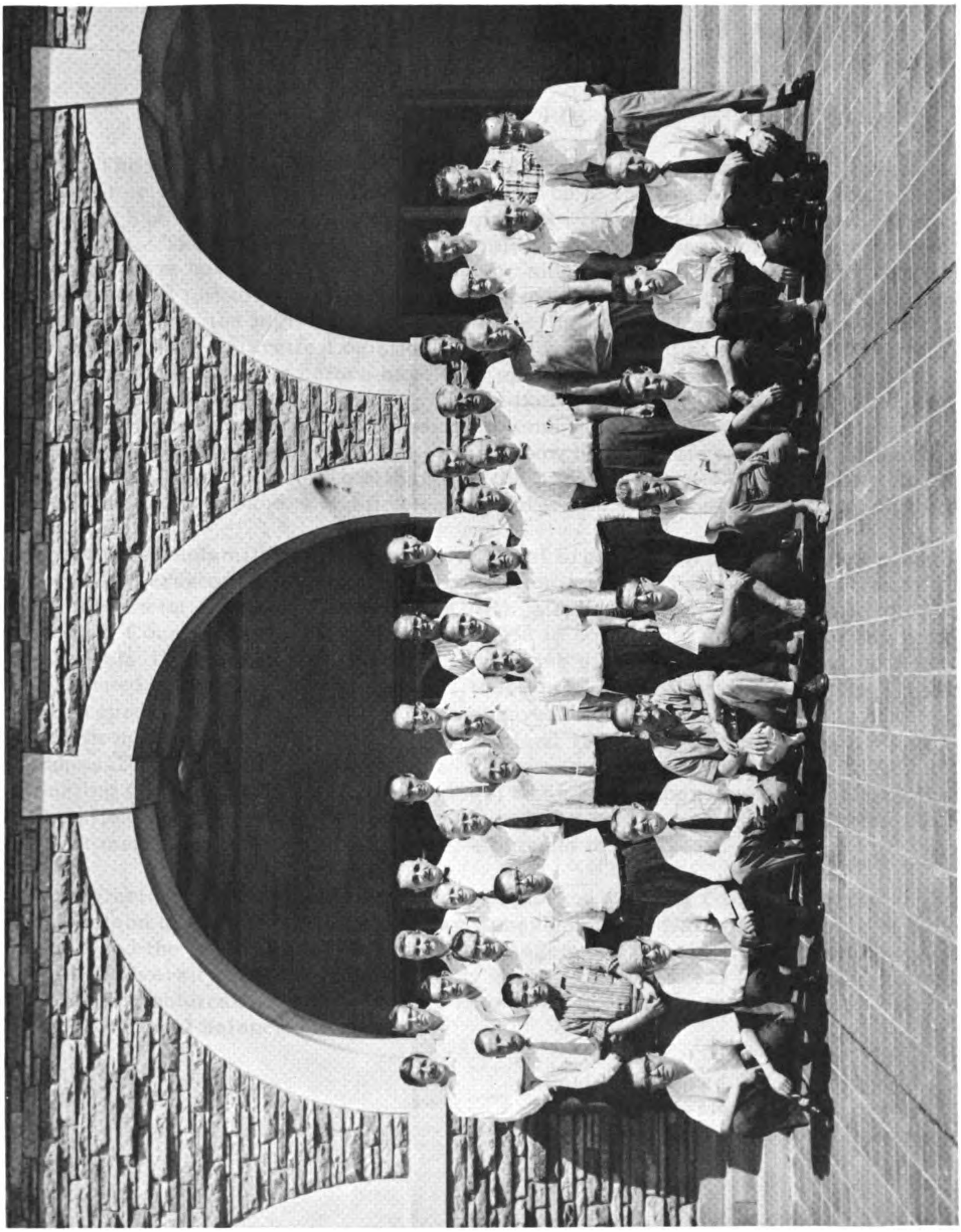

FOREWORD

The driving force of antarctic exploration from earliest days, through the heroic period of Scott, Amundsen and Byrd, up to the present era of antarctic endeavor, has seen the acquisition of human knowledge, scientific research and exploration. The co-partners in the gigantic task of uncovering the scientific secrets of Antarctica have been the men with their ships, aircraft and vehicles, and those who plan and toil to provide shelter, food and clothing for polar conditions. It was for these men, the logisticians who provide the material support for antarctic research that the Antarctic Logistics Symposium was held at the University of Colorado, Boulder. Never before have the "operators" of the nations carrying out antarctic research met together to exchange their experiences and knowledge of operations in Antarctica, to discuss problems of providing buildings, food and clothing for polar conditions, and to study how best to carry out difficult and hazardous field operations. This then was the purpose of the "Antarctic Logistics Symposium," the papers and proceedings of which are recorded in this volume.

Those unfamiliar with the international organization of antarctic research may be interested to learn how the Symposium came to be held. The Scientific Committee on Antarctic Research (SCAR), a special committee set up by the International Council of Scientific Unions in 1958 to coordinate and promote antarctic research, includes several permanent working groups. Although most of these are concerned with scientific disciplines, there is also the Working Group on Logistics with representatives of the 12 nations engaged in antarctic operations. At the Fourth meeting of SCAR (Cambridge, England 1960) this group first considered a proposal for a logistics symposium. Plans were formalized at the Fifth SCAR meeting (Wellington, New Zealand, 1961) when SCAR approved proposals by the Logistics Working Group for a Symposium to be held in connection with the Sixth SCAR meeting scheduled for Boulder, Colorado in 1962.

During the early part of 1962 the Logistics Working Group, with the support and liaison of the Committee on Polar Research of the National Academy of Sciences, organized the program and completed arrangements for the meeting which was held at the University of Colorado, Boulder, August 13-17, 1962. The local arrangements and publication of this volume have been made possible by a grant from the U. S. National Science Foundation.

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1. Papers in this volume have been published as received, without official editing. This procedure was recommended by the Symposium to expedite publication and circulation.

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SECTION I

SCIENCE AND LOGISTICS

THE CHANGING CONCEPT OF ANTARCTIC SCIENCE

A. P. Crary

Before assessing the new logistic tools available for work in Antarctica, it might be appropriate to look into the future, as much as may be possible at present, and estimate the major trends that may be expected in the scientific development of the continent.

In the five years since the beginning of the IGY period, immense gains have been made in our knowledge of the southernmost continent. The size, shape, elevations, ice thickness, ice volume and annual snow accumulation are now much better known, and the numerous oversnow traverses furnishing most of this information are perhaps two-thirds completed in the detail that is now considered appropriate. The annual patterns of surface and upper atmosphere, temperatures and wind systems, have been well established. The locations of all major ice-free areas are now known and mapping is proceeding at a rapid rate. The geological parties will soon have visited most of the new ranges. All but a few of the birds have been banded, and the biology of the land and the waters; the microbiology and bacteria are under close scrutiny. Truly, Antarctica is moving out of the darkness into the light. The IGY conception was a very successful one for Antarctica, and yielded enormous amounts of information. Much of this data is still to be analyzed and digested, but this is being done as rapidly as can be expected and scientists are busy in the preparation of scientific atlases and monographs. With the completion of the individual areas of study, there will be more synoptic studies of the overall continent. At the end of this first five-year period then the descriptive phases of the work is continuing in all aspects, with some parts nearing completion; and meanwhile the analysis period is now in full swing. What, then, can be predicted for the next five years?

The future of science is built on new knowledge. As more is known of a specific subject, methods are altered, sometimes even objectives. No true science is static but is continually following new and promising leads, and abandoning others. No attempt will be made to detail here the many changing and dynamical objectives of science in Antarctica, but a few of the main goals may be mentioned, mainly to portray the direction that Antarctic science appears to be headed.

What has been learned about the continent itself? Though little progress has been made in the main goals of the history of the continent and the paleoclimates in the past, at least science has in a sense stripped off the ice and revealed the geography of the continent itself, and this is the logical beginning. More and more is being known of the rocks, their types and most important their ages and the orogenies of the past. The ever penetrating search for fossils will continue at all fronts. Though scientists have progressed far in their details of the ice thickness, only a beginning has been made in the study of the ice movement in the interior areas, and on this movement will depend many of the answers to the questions of present growth, and past history of the ice. The inland ice must be drilled and aged, like the rocks, and the paleotemperatures determined. Many of the clues and past history of Antarctica lies in the deep sediments off shore and these must be gathered and studied.

The concept of the IGY was developed, as of the previous polar years, by studies of the upper atmosphere. The Antarctic continent with the geomagnetic poles and southern aurora zone is most important in this field and the knowledge gained has already led to new concepts and new recording instrumentation. The concept of the IQSY, the year of the quiet sun, was conceived to give a reference plane from which solar effects can be better evaluated. It is expected that great advances will be made here in the full exploitation of rockets and satellites, and particularly as viewed by synoptic studies at conjugate points, the ends of magnetic lines of force, north and south.

Much of the analysis of the meteorological data was required in the operational use, the weather maps being more urgently required than such maps as would portray the aurora or ionosphere. The unknowns for the aerology scientist now are outward and upward, outward into the vast ocean belt surrounding the continent and upward beyond the reach of the balloons. In the future there will be new tools needed to exploit these deficiencies, such as rockets and transosondes balloons. The oceans of the southern hemisphere are vast and many areas untapped or little exploited for their knowledge. The magnitude of the oceanographic problem is not alone for Antarctic science but these waters outward of Antarctica form the bottom waters over much of the globe, and if it were not for the vast problems of distance from the populated areas of the world, these seas would perhaps be logically the first to study. Both the studies of the oceans and the atmosphere above the oceans will be greatly enhanced by the satellites, and indeed the polar satellites is the greatest single potential logistics tool for the exploration of the weather of the vast area of seas north of the continent and the delineation of the Antarctic ice pack. No future foreseeable tool will have a greater direct application to the needs of meteorology and oceanography in the Antarctic.

For the biological sciences, much remains to be accomplished in purely descriptive work through taxonomy and centers of collections. Though the ecology of Antarctic species and the peculiar adaptation processes that distinguish Antarctic forms, require increased study, the need both in land and marine forms is for continued sampling. The biologist must by necessity be mobile but also he must have well equipped laboratories at hand to study his subjects in the field. In this aspect his requirements are more stringent than the geologist who is assured that his specimens can be brought back to the home laboratories much as he has collected them.

This bird's-eye view of scientific pursuits of the next five years is by no means thorough but it may help in its vague assessment to point the way for the logistic tools of the future. Obviously the great need is for mobility. While the upper atmosphere physicists and the meteorologists will be content for the most part at a permanent camp, the majority of scientists; the biologists, geologists, glaciologists and oceanographers need mobility, some with little equipment, others with elaborate equipment. Their stays at specific locations will never be permanent but will vary from a few hours to a few years. They will not be concerned with the dark winter months but will want to take full advantage of the daylight periods. Full concern should be given to the potentials of the satellite so that Antarctic science will be ready to accumulate, digest and utilize the enormous amounts of data that will be made available by this medium.

SYMBIOSIS OF ANTARCTIC SCIENTIFIC AND LOGISTIC OPERATIONS

Paul A. Siple

I. Introduction

Among broad technological advances of the past two or three decades those which provided improved sea, land and air transportation, communications, and power and laborsaving devices have been most responsible for the freeing of scientific investigators from the former arduous labors involved in exploring Antarctica. Living and travel conditions are only slightly substandard to average facilities available in other areas of the world. Except for occasions of misadventure men have been isolated from the lethal potential of the climate and freed from the time-consuming and strenuous essentials of survival. An Antarctic scientific observer can anticipate about 90 percent more time to devote to his investigations than was possible a quarter century ago even though he may still suffer by a 50 percent loss of the time he anticipates.

The technology of polar logistics, * formerly a highly specialized art has now become virtually a minor engineering adjustment to standard operating procedures. This does not imply that logistics operations themselves do not require a high degree of specialization with the ever increasing complexity of devices; rather, it means that the failure to make sound environmental adjustments are less apt to result in serious human hazards. Therefore, adequate logisticians without previous polar experience can meet requirements peculiar to Antarctica with low risk of endangering human life, albeit the depreciation of facilities and equipment as a result of poor adjustment to environment may reduce the available transportation, supply and economic backing. Wherever these latter factors are seriously limited, the need for greater polar experience in assuring the increased effectiveness of logistics support becomes more important so that economic supporters of the total effort do not discontinue the effort prior to meeting the over-all objectives of continuing missions. In the long run, for missions with no anticipated terminal dates, the increasing of logistics effectiveness and efficiency is desirable, if not mandatory. To achieve this requires an equal effectiveness and cooperation among the participants of the missions being logistically supported. Achievement of the latter in cases of scientific programs appears to be largely a matter of qualitative and quantitative selection of projects and personnel, and above all to adopt scheduled planning compatible with logical and reasonable logistics support requirements. That is, scientific support requirement should not, as is its normal nature, increase radially on all fronts simultaneously; but rather, adopt linear and segmental steps in a systematic manner to achieve equivalent goals in a similar period of time.

*Logistics as used in this paper connotes all material aspects of Antarctic living and operating requirements necessary for an individual or a group of individuals to carry on its specific mission. Thus, logistics support for a mission of "logistics support" may dwarf the logistics support of a mission such as a "scientific program."

By the linear and segmental approach the logistics support system can be oriented about a main axis of communications and transportation rather than disperse its efforts in many different directions. The point often overlooked by the users of the logistics support is that effective radial logistics support decreases in service potential by the typical fourth power of other radiation laws, as compared to deflecting, focusing and concentrating the energy along a narrower path.

I have participated in expeditions with wide variations in the approach to logistics support of scientific programs. These have included: planning for both science and logistics by a common authority; divided authority; science added on to existing logistics; logistics tailored to specific science missions; priority missions transcending over lesser projects; radial and linear support. Contrary to opinions I've often heard expressed relative to which factor should take prime leadership between logistics and science operations, I believe either system will work equally effectively, if the personnel involved cooperate in planning and operations with a spirit of mutual respect and oneness of purpose.

II. Essential Partners of a Union

For Antarctic activity, as with all other types of scientific field work, success depends upon the combined effectiveness of the scientific program and its supporting logistics. The purpose of this paper is to outline the inter-responsibilities and respect for one another when research and logistics are handled, as is frequently the case, by separate specialists. Only in exceptional cases can we assume that the scientist is a capable logistician or vice versa. A logistic technician is not necessarily a polar technologist simply by assignment. He needs experience to become master of his trade; and although he need not be a scientist, if his task is to support scientific missions, he at least must be sympathetic to the aims and methodology of science. Despite the extensive formal training scientists receive they may prove clumsy or downright helpless as logisticians, if they have not studied this art as diligently as they pursued their own scientific discipline.

For the purposes of this discussion we will assume that we are dealing with both capable scientists and capable polar logistic technologists, and that together they form a team with a common purpose. This attitude alone is the most important assurance for success. We will assume also that neither group nor individual is more important than the other; but rather that each is vital to the other, if the mission is to be successful. Expert logistics tailored to polar requirements will not alone assure the success of a scientific mission; if the scientist fails to perform good research, the effort is a waste of time for all. Similarly, if a superior scientist or team of scientists are furnished poor or inadequate logistic support for their mission they may never have a chance to achieve their goals. Simple as this logic sounds, the degree of success and esprit de corps hinges on the wholehearted, mutual understanding and cooperation which historically has made certain polar operations differ from others.

To begin with, let us examine the general nature of the problem and the responsibilities of the two elements. In extreme cases the scientific element may be expected to receive such full support that they are at liberty to spend full time on their scientific mission. Often this is not practical, for the size of the party may not permit five or ten men necessary to look after the personal needs of a single individual. In small parties the scientist may be expected to share in some housekeeping duties. It is not unreasonable that he may be at least expected to make his bed, keep his quarters and working space clean, wash his own clothing, and even help to some extent on community chores such as K. P., snow melter details, or cooperate with all hands in emergencies, etc. From the human standpoint it is not best for morale that any man be served "hand and foot," unless the mission creates unreasonable working hours for an individual. That is, if everyone works basically on an 8-hour day, each can reasonably put up with his own lot; but when one's assignment or devotion to duty continually consumes the entire waking hours, whether he is a scientist or a logistic technologist, he merits special consideration.

Unbalanced work loads whether assigned or self-imposed can engender a basis for criticism and hurt feelings. Some men can't remain idle if they feel responsible for a never ending load of work ahead. It is natural that they should feel resentment for extra assignments to share in community chores so that the rank and file of men can end up with a 6 or 8 hour work day. Scientific or logistics personnel who continually cut into their leisure hours to continue their work are sufficiently dedicated to merit relief from community tasks whereas others may have duties which require only occasional attention during the work day except during emergencies or breakdowns. These "idle men" can rightly irk the "overworked man" when the latter is taking his turn on K. P. or snow shoveling extra duty. Such problems as these are basically the task of balancing time among a team; and, fundamentally is the joint problem of the station scientific and support leaders unless, of course, they themselves have become victims of the disease of idleness.

III. Cleavage Tendencies

Smooth, effective cooperation between scientific and logistic technicians forming an Antarctic team depends upon minimizing avoidable causes of physical and psychological friction. In this paper physical friction is intended to connote physical activities and situations which destroy, hinder or disturb the operations of either the scientific or logistic activities. A few simple symbolic examples serve to recall typical examples.

A science team member in an enthusiastic urge to try a new experiment laboriously strings out a long surface wire antenna oriented carefully. A few hours later a cold, tired tractor operator drives along an accustomed path, and may or may not see the new antenna. His tractor treads not only cut the wire, but the wire tangles in the tracks and he spends an hour cutting it free. The science experiment is terminated at a critical moment. Both men involved grow angry and their colleagues join sides.

Another example: An irate cook gets downright fed up with two meteorologists who always arrive late for meal time which adds to his galley duty hours. One day he decides to teach these gentlemen a lesson in punctuality, when they are even later than usual. He throws out the food and closes the galley. The two men arrive already frustrated because of instrument difficulties during observation periods which conflict with the scheduled meal hour. Tempers flare with righteous indignation and bystanders join sides to create a real station-wide emotional upset.

Still another example: The station logistics leader orders a team of his men to clean out the passageways that have become unsightly and hazardous. The men with these limited instructions clear the passages including a few unidentifiable objects and personal effects. An hour later troubles begin. A scientist is fuming when he discovers his box of spare parts he'd pulled into the passage earlier that day is gone—yes, gone for good—"We thought it was just an empty box of excelsior and burned it." Angry also are two pi-ball observers who lost their balloon run because of local smoke. A light breeze was not only drifting pall of smoke from the trash fire, but soot in large chunks are falling promiscuously into the snow area for the camp's water supply. The anger and beefing doesn't die down quickly, for a radio operator coming off watch discovered his spare clothing duffel bag he set outside the barracks while cleaning his room was buried under a pile of heavy boxes and barrels by the diligent work team. —Just when the radio operator needed an item in the bag before bathing and turning in.

There is no point of continuing examples of these familiar expedition "rough spots." Obviously in retrospect one could easily recognize the solutions: pre-planning, thoughtfulness and consideration could solve most of such problems. — The antenna should have been placed in a zone inviolate to tractor movement. Meal hours should more flexibly adjust to observation hours and emergencies. And, if a leader has authority to command, he must assume responsibility for clarity of instructions and think of ramifying problems, if his subordinate who may take minimal instructions too literally does not bother to think.

We will discuss the physical pre-planning in greater detail a little later on. However, let us return to the subject of psychological friction for a further look at the problem.

IV. Differing Opinions

Psychological friction between the logistic and scientific elements of a team may for our purposes be divided into four classes.

1. Personality idiosyncrasies.
2. Higher command influences.
3. Uncoordinated regulations.
4. Uncoordinated planning.

1. Personality idiosyncrasies is a random element present in varying amounts in each member of any social community. It is not restricted to either logistics or scientific personnel. "Odd balls" will crop up, especially where neophytes are selected for a task by nominators who are inexperienced in spotting personality weaknesses. The types of traits most commonly irritating to others on an expedition include: technical incompetence of assigned duty; habitual carelessness, discourtesy or clumsiness; "goof-offs" and job shirkers; slovenly and unsanitary habits; inconsiderate noise makers; uncouth and loud talk; excessive practical jokers; moody or quick tempered grouches; stingy lenders; unauthorized

borrowers; losers of tools; extravagent users of limited supplies; and finally, those who develop real or imagined physical disabilities or unmanly traits, including disloyalty and tale carrying.

In only a slight way does one dare to generalize the differences common among the two classes of expedition citizens-scientists and logisticians. Where the latter are selected from a military source, their prior enforced training or vestige of discipline tends to maintain better cleanliness habits but worse language habits than the civilian group as a whole. The usually higher degree of formal education of the scientists is generally respected by the less well educated, unless the former flaunts his knowledge with an air of superiority which quickly engenders disgust toward his apparent asset.

2. Higher commands who issue orders from afar to affect the endemic social order of a station can have excessive effects in morale and esprit de corps, both good or bad. Unfortunately, there seems to be a principle at stake which governs such matters. In a field operation, distrust, misinterpretation, and accredited stupidity square with the distance between forward and rear echelons, both of whom are well meaning and rational. Clearly, this is mostly due to faulty communications; each minimizes words or holds back as unnecessary, the rationale behind its respective demands. Patience, restraint and sympathetic understanding are required at both ends. Rear echelons should far exceed their share of give and take with a distant field group, the latter of whom feels penalized, whether actually or not, by isolation and minimal comforts. They resent being left out of planning, news, or decisions affecting them. Because logistics controls the major lines of communications, they may more easily abuse it. Higher commands, exercising unnecessary precautions or simply yielding to expansiveness of their feeling of authority, can unwittingly tantalize the morale of a field party or advanced station already overtaxed by local problems. It is well to bear in mind that this same sort of misunderstanding, bred by distance between loved ones, has broken up many a marriage or engagement of expedition men. Broken morale can destroy a man's ability to fulfill an assignment.

3. Discussion of uncoordinated regulations will here be confined to a station or field party, even though it be founded upon command of higher absentee officials. The nature of this source of friction arises commonly by the logistics controllers of a station establishing rules and regulations affecting the scientists or scientific operations without consultation. Meal or recreation hours, communications regulations, use of facilities and equipment, off-limits, safety precautions, etc. These are clearly prerogatives of the station logistics officer-in-charge; however, if the times or the restrictions hinder the science programs directly or indirectly, the station logistics OIC is abusing his authority, for he is hindering the very program he is placed there to support. It has been my own experience among responsible adults of a close knit expedition community, that the fewer the administrative regulations the better. Furthermore, the reason for those that are necessary should be amply made clear by prior open discussions.

4. Uncoordinated planning is a sin which can be induced by either the logistic or scientific elements of the station. Furthermore, it can be aggravated by vagaries in the weather that suddenly makes the time ripe for action of several events requiring the use of the same equipment, facilities or manpower simultaneously.

Conflicts in priorities for use of transport, communications and physical assistance are most common. Well coordinated plans and generous compromises become essential. Health and safety in emergencies take precedence over scientific accomplishments; however, in times of opportunity, low priority logistics activity should not cause postponement of scientific efforts well planned in advance.

Scientific planners seldom anticipate their needs, changes and delays to the extent of the desires of their logistics supporters. If the logistician knows the exact requirements of his support mission well enough in advance, weather and providence be willing, he can reasonably meet his goal. Science as carried on in the Antarctic is of two types: (a) routine observations which can usually be planned well in advance, and (b) scientific problems germinated on the spot. A geologist, for example, may not know which of several peaks he wishes to visit until he sees the strike of the formation; an oceanographer needs to linger for a longer look when he discovers a new rise or a deep; an ionospheric physicist wishes to shut off all local interfering electronic equipment when a solar flare suddenly occurs; or a biologist insists on reaching a treacherous pinnacle for his senses suggest that it's the nesting place of a rare bird.

In short, science in the field needs to change its plans according to the opportunities that arise. It is here that the logistics personnel must exercise patience with the scientists' apparent changeableness of plans.

As mentioned earlier, the natural trend of science is to spread out radially like an expanding amoeba. If, however, the over-all planning is more linearly channeled, the random spread of science will be held in more reasonable bounds for providing logistic support.

Let us finally turn to the more concrete physical problems which arise between scientific and logistic elements especially at a station site.

V. Site Selection and Installation Development

We will start at this point with the assumption that teamwork is balanced so there is proper morale and respect among the scientific and logistic personnel. Normally the scientific mission can be well defined. However, its peculiar characteristics may be highly demanding on the physical arrangements in order not to destroy or introduce hindering interference. We will examine some of these cases a bit later. The responsibilities of the logistic staff are more embracing. They include not only physical assistance to erect or arrange scientific setups; but, they incorporate the entire element one could loosely refer to as housekeeping, including communication, transportation, food, water, heat and power service, safety and health. With such broad responsibilities it is easy to see why the logistic staff may at times feel that the very existence of the facility and its operation exceeds the piecemeal scientific missions of individuals; although the mere existence of an Antarctic station implies a purpose. Some stations exist for logistic reasons alone to support field parties or satellite stations, others for political or even economic reasons. However, we are concerned here only with those whose primary mission is dedicated to scientific research of one sort or another.

Interference most common to scientific programs include those which introduce vibrations, visual obscuration (smoke and vapors), power failures or variable electric voltage, electronic disturbances, drifting snow, inadequate working spaces, improper heating or shelter, noise, etc. Logistics operations by their very nature can produce these interferences unwittingly. The layout and operations of a camp can do much toward self-eliminating many of these problems, if the design is well planned ahead of time. This, however, is not always easy to do, for the scientific requirements introduced one or two years later may demand new considerations not laid down at the time the station was first planned. Therefore, we should seek principles of design which will minimize interference in general.

In laying out a camp or polar scientific station it is desirable to first determine the prevailing wind direction. In some areas the variability may make it difficult to establish this within the limits of one right angle quadrangle. This quadrant should be layed off at the start running indefinitely away from the camp as an inviolate sanctum for the exclusive use of the scientific program. The wind blowing from the prevailing direction will make this area least contaminated. If it is not walked over or driven over, it will remain essentially virgin snow suitable for glacial studies close at hand. Barricades should be set up along the borders of this quadrant to prevent tractors or logistic operations even accidentally entering this zone. During construction of facilities bordering the apex of this windward quadrant, minimum working paths close to the buildings may be necessary for a temporary period only. No storage of supplies or wide swings by vehicles should be permitted.

The down-wind quadrant opposite the science up-wind sanctum should, in turn, be given over entirely to logistics operations and the scientist should not expect to utilize space in this zone without receiving or causing logistic interference. Outdoor storage, transportation movement, etc., should be confined to this quadrant as much as possible. The two intermediate "cross-wind" quadrants should be layed out in compromise form to accommodate the requirements of both science and logistics, as necessary. In general, one of these quadrants may be assigned mostly to science and the other to logistics; however, various logistic operations may interfere with one another as do various scientific operations, especially if there is not ample planned space. One conflict which must be resolved next within these two intermediate cross-wind zones is camp water supply, under the province of logistics command. The station must have a continuously clean supply of snow for melting unless the specific locale is such that a lake or artificial water well is available. The snow collecting area for water supply should be in the logistics "cross-wind" quadrant bordering on the edge of the up-wind (exclusive science) quadrant. Snow coming from this direction will be least contaminated by the station itself, and the snow collecting area can form a barrier to help protect the science up-wind quadrant. The water supply system should never be on the down-wind side of camp for sooner or later it will be seriously contaminated unless subterranean snow is mined.

Serious interference often arises between logistics and science use of electronic equipment. Each requires its own antenna systems. The antenna systems can in due time create a gross hazard to the logistics transportation service. Logistics support communications should be located in the logistics "cross-wind" quadrant with the antennas as far removed as practical and still permit proper orientation and servicing. The farther the antenna can be removed from the station site the less interference will be induced into the electronic recording devices used by the scientists. Ionospheric antennas and other electronic recording devices should, if possible, be located in the science "cross-wind" quadrant opposite from the logistics communications quadrant; and, in turn, signal emitting antenna should be placed as far away from the camp as practical and efficient. If a magnetic tunnel is to be established, this may have to be oriented along a magnetic meridian. It should be placed parallel to the appropriate border of the science up-wind exclusive reserve quadrant; and, if necessary, oriented to enter the adjacent science "cross-wind" quadrant. Tunnels or paths leading to seismic stations and other observatories should, where possible, be placed on the bordering edges of the up-wind science quadrant. Meteorological equipment should be placed in the up-wind exclusive science quadrant; however, it should not be so scattered or create damage by snow drift or compaction to any more of the science quadrant than necessary. In general, they might well border along the logistic snow collection zone in order to provide part of the barrier to further inhibit unauthorized entry into the science up-wind quadrant.

The building layout itself should, in general follow these same principles and orientation; i.e., the science and logistic buildings, in accordance with their functions, should occupy the apexes of their respective quadrants as outlined above. Of course, in small stations there may be but one or two buildings, whereas in larger stations there may be many. The most favorable windward facing corner of the science buildings where the least station-originated interference by vapor, smoke or thermal refractions will be encountered should be reserved for scientific work dependent upon good atmospheric visibility. This would include the aurora, meteorological and astronomic observatories, etc. Heating plants, electrical generators and any devices which could create vapors or vibrations should be located in the down-wind building section facing toward the logistic quadrant. Obviously, the vehicle maintenance shop will belong in this area as well. This is not necessarily a desirable location for a garage entrance for it is also the snow accumulation zone on the lee side of the buildings. If a compromise is to be made, the garage entrance might be placed facing more toward the communications quadrant where cross winds will keep the entrance free of drift. Outdoor storage (temporary or for longer periods) should be placed along the borders of the logistic quadrant, which will tend to restrict vehicle traffic close to the camp into this one zone. Occasionally, vehicles will be required to enter the other quadrants for work purposes; but, this should be done under close supervision to prevent damage to lead-in wires, tunnels and other facilities. It will help to lay out a narrow vehicle path encircling but close to the buildings where all lead-in wires can be specially protected from traffic injury.

For stations that are intended to remain in existence over a period of years, each annual group of inhabitants should learn to respect the problems that they create in regard to the future. The worst offense of all is the broad scattering of debris, discarded vehicles, barrels, and shipping crates which induce drifting around them, and finally burial. The life of many stations has been shortened by the unwitting "jacking-up" of the surface. This is commonly due to poor management of outdoor storage caches. For example, full drums of fuel may be cached in an orderly fashion during the summer months; however, before they are to be used they may be drifted to their tops. In order to get at them or to prevent loss of the entire cache, it is standard procedure to dig the barrels out and set them on the surface again. In some cases this is done two or three times in a year. As a result, the entire surface will build up by drift snow to the height of these barrels each time they are elevated; and, in the course of two or three years the overburden dome will be "jacked-up" 20 or 30 feet. The weight of this snow encroaching over the buildings and tunnels can cause them to collapse. Carelessly discarding debris or leaving piles of shoveled snow on the surface does the same thing and each generation of needless surface discontinuities builds the surface higher and higher. If no science quadrant has been layed out into the prevailing up-wind quadrant, and this becomes a dumping ground as well, the piled-up section will proceed at a more disastrous rate for the station lies in the drift path. It should be the responsibility of the logistics officer to continually police the area for the removal of all unnecessary objects standing above the level of the snow. In the future expansion of a facility empty barrels and crates, trash and debris will make excavation most difficult and at times virtually impossible. One station recently replaced had to be moved five miles from its original site in order to get clear of debris which had been permitted to accumulate in all quadrants. If the station is supported by aerial drop or aircraft, the air strip should be placed at a convenient distance away from the buildings in the logistics down-wind quadrant.

An inevitable problem arises in the disposal of unwanted or discarded material of both the scientists and the logisticians. Burnable material could be periodically disposed of by having it burned at some suitable point in the logistic quadrant down-wind. Smoke can interfere with visual observations; and, even the flames could interfere during the night time period with visual observations such as those of the aurora observers. Trash that cannot be burned should be disposed of in an orderly manner such as a cache or a trench bulldozed out and marked on the station map for future reference. They should be also placed in the logistic quadrant or closely adjacent thereto. The modern cut and cover subsurface construction provides a hopeful solution to accessible storage caches as well as waste disposal.

A new station is like an infant that is bound to grow in size. Each new generation of occupants provides the requirements and nourishment. If the potential of growth is not reckoned with in the initial site planning and layout, growth will proceed randomly into any nearby unoccupied space. Unplanned growth can become cancerous in nature and can "sicken" a station in time, and even hasten a period of abandonment for an entirely new site. If scientific and communication antennas and lead-in wires are not restricted to a specific quadrant, the station becomes so strangled with wires that the transport traffic cannot move effectively about the station. If new buildings are scattered about the periphery without well-defined access paths, resupply of the original center buildings becomes increasingly difficult. Random new piles of excavated snow, higher new buildings and more caches and debris jack-up the snow level at an ever-increasing rate with new drift patterns to complicate operations. Perhaps the best solution to this growth dilemma is to plan the growth along the cross-wind axis of the station. If this is prepared for from the start, then it would appear necessary to develop a high overhead or undersurface conduit system for lead-in wires and a generous removal of antenna "farms" well away from the buildings which in turn favors the reduction of interference between scientific and logistics electronic equipment.

Scientific programs tend to develop their own more intimate logistics self-support; i.e., related to the science operations, instruments, and specialized gear. Each discipline may have a little of its own and because these personnel may be unschooled in the arts and engineering of logistics may create their own interference patterns. The interferences may develop concurrently between disciplines or linearly between succeeding generations. Furthermore, the carelessness with placement of new facilities, excavation or abandonment of materials and equipment may contribute to the lessened suitability of the station site for future generations of research workers inheriting their chaos. The rudiments of Antarctic logistics is a worthy prerequisite course for all visitors to the continent so that they learn to respect the interferences their unwitting carelessness may cause to fellow workers and to following generations.

Because logistics must serve itself as well as the science community, it may tend to become so self-centered in improving its own comforts, working conditions and facilities, that it loses sight of equal improvements for working and living conditions of the scientists. It is obvious that everyone, scientists and logisticians alike, benefit from improved facilities such as a galley, workshops, sick bays, communications facilities, etc; however, there is a tendency to place lower on the priority list an increase in the quality and quantity of working and living space for the scientists' partners of the wintering and summer seasons.

The change-over season for stations coincides with the busy field season and resupply period. It is also a period of psychological nonconformities; i.e., the past wintering group is anxious to go home, the new wintering groups are bewildered by the strange new world they find themselves in, and the "summer visitors" are in everyone's way or impatient and demanding for assistance to get the most out of their brief stay. It is during this period of disconformity that there is the greatest need for stable, experienced intermediaries with authority to set things right. It is only human nature that a departing crew leaves unaccomplished maintenance for the next year's crew. However, due to lack of experience and understanding they let the needed maintenance go until winter makes the work nearly impossible. They let the work go until spring; but, by then, they have learned to live with the problem as one can in due time get used to a hole in one's trousers. It's easy again to avoid the responsibility even though they recognize the necessity by now. Thus can develop the spiraling deterioration of a station. To cope with such a problem affecting both the logistics and scientific potential of a station, it appears desirable to introduce a third partner to the station. This partner could be in the form of a summer maintenance and turnover team representing the highest joint authority of both the logistics and scientific operations. If the work party were to be composed of industrious and skilled workmen under an experienced leader, the required maintenance and mistake of the departing wintering crew could be rectified and the new wintering crew could receive on-the-job training. The weakness in this suggestion lies in compounding the personnel requirements and the task of finding the broad experienced leadership willing to accept so much responsibility for so mundane a task. The strength of the concept lies in the provision of a "paternal" strong leadership of the station when it is at its weakest ebb (at the height of the work season), and that it would undoubtedly pay for its costs by the improved longevity of the station.

In this paper I recognize that I have drawn instinctively upon the problems and solutions of stations built on deep snow surfaces. I've neglected those fortunate enough to be built on solid land. The neglect is for two reasons: first, that they are in my opinion less unique than those built entirely on snow (though they do have specific problems); and second, that my own experience of wintering over four times has never been at a land-based station.

VI. Summary

The harmonic symbiosis of scientific and logistic elements of an Antarctic mission can be strengthened by adhering to certain principles. A few of the more salient ones are repeated here in summary:

1. Establish a proper and respectful attitude toward the important responsibilities each has to the success of the joint mission.

2. To receive maximum quality and quantity of logistics support scientific field missions should, as much as possible, be oriented along linear segments directed annually toward a new area or goal.

3. Establish the camp in such a manner that the interfering operations are most widely separated and inviolate from one another.

4. Orient the camp to give the prevailing up-wind quadrant and adjacent segment to the scientific operation, whereas the down-wind quadrant and adjacent segment should be devoted entirely to logistics. Do not attempt to intermix them.

5. In rough layout the station buildings should be allocated to the services facing the appropriate quadrants. All sources of vapor and smoke, as well as vibrating machinery, should be concentrated as much as possible into the down-wind or adjacent logistic quadrant.

6. Storage caches and disposal areas should be located in down-wind zones and never permitted to unnecessarily jack up the surface level of the snow above its normal accumulation rate.

Of all the principles mentioned, by far the most important is the one which establishes proper attitudes and cements both the scientific and logistic teams into a single mission unit. There will always be problems and conflicts; however, if a spirit of cooperation and common sense are employed, the mission will be successful and the station will engender high morale.

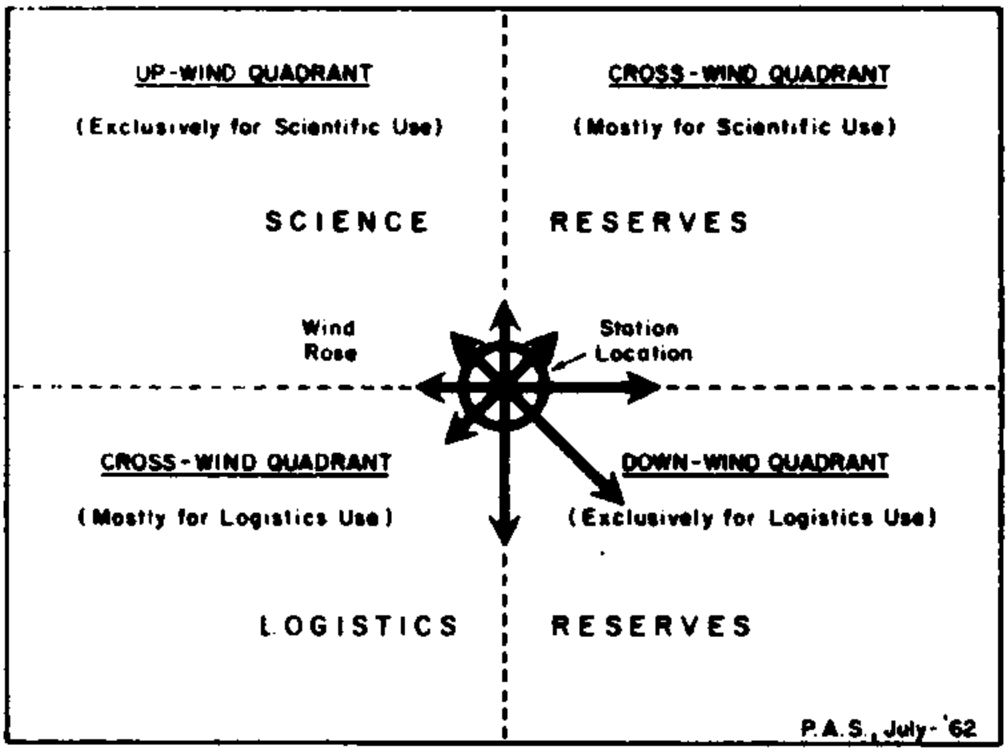

Figure 1. Idealized Antarctic Station layout with respect to primary prevailing winds.

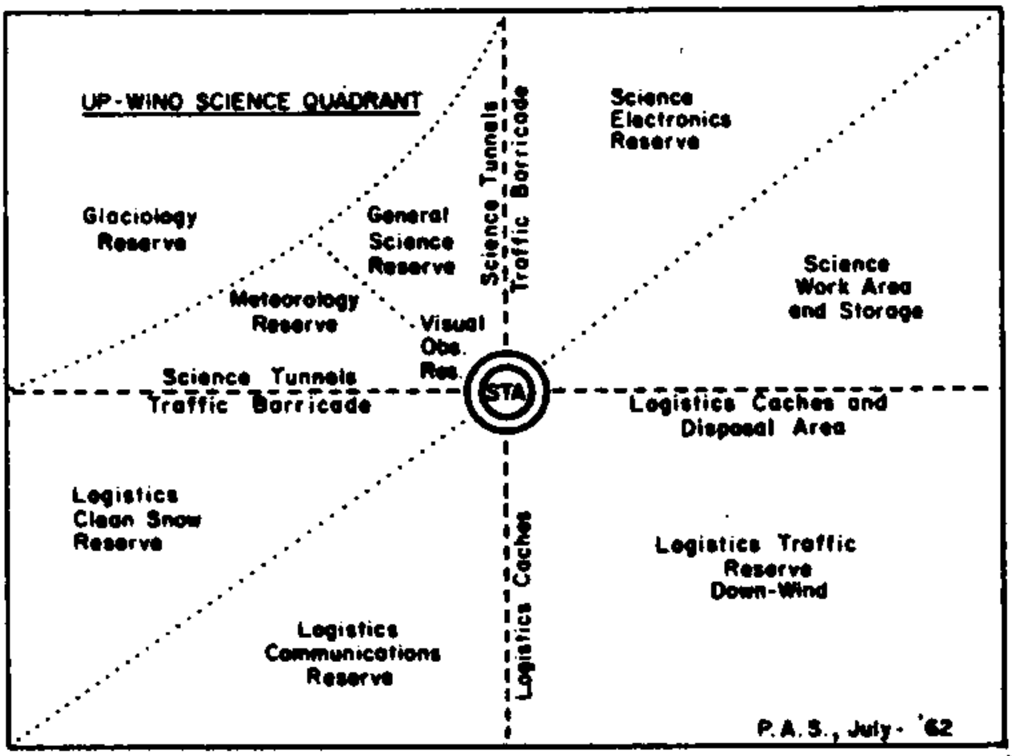

Figure 2. Functional distribution of reserved areas around an Antarctic Station.

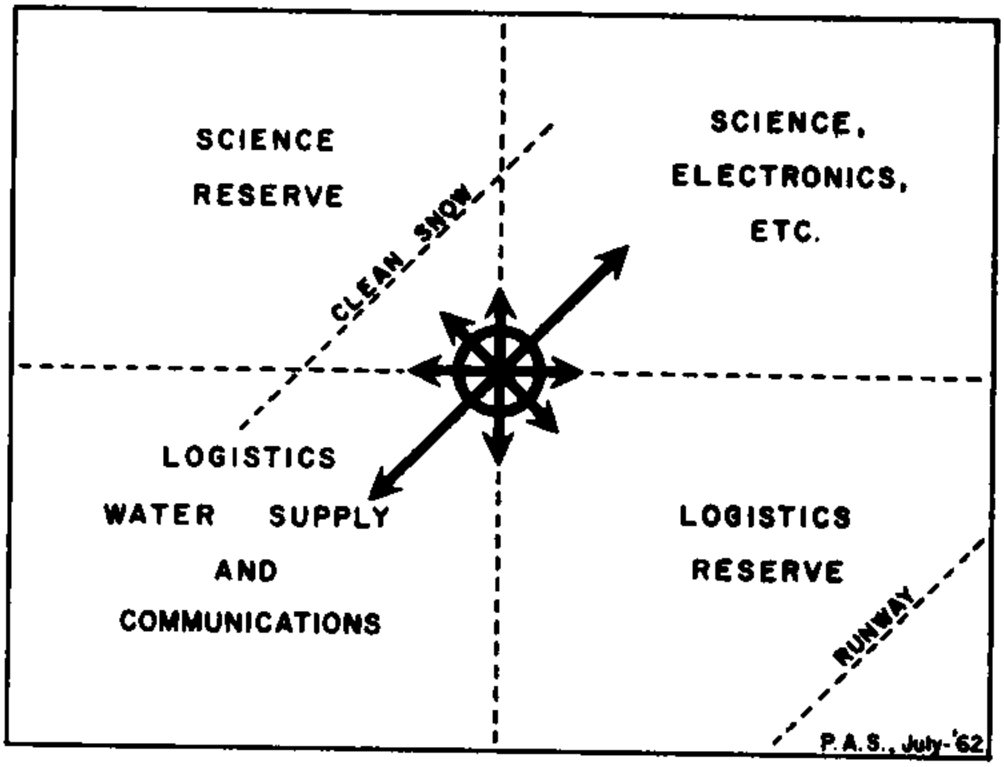

Figure 3. Alternating wind solution to Antarctic Station layout.

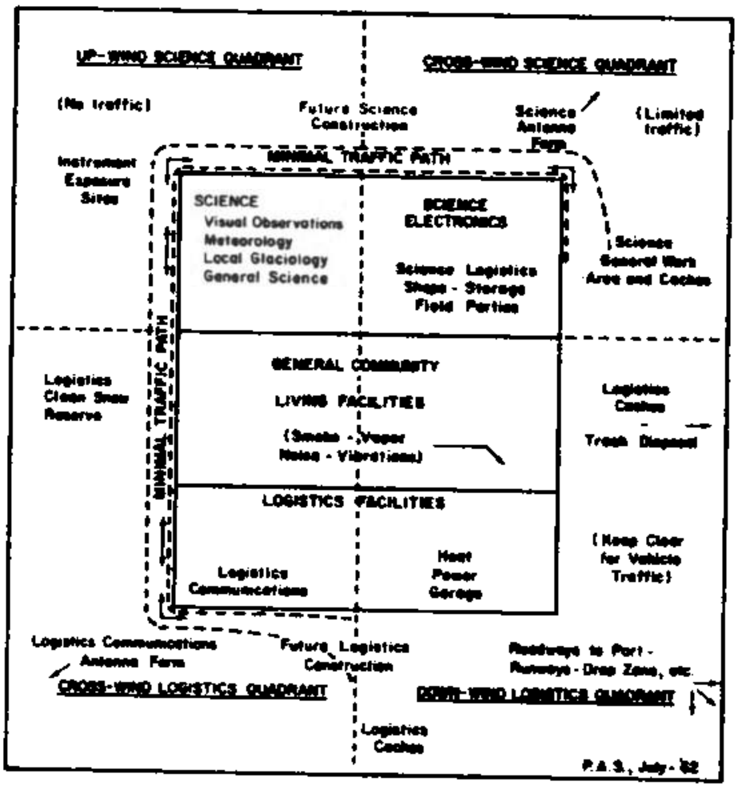

Figure 4. Idealized facilities layout for an Antarctic Science Station.

CHANGING ASPECTS OF ANTARCTIC LOGISTICS

Paul-Emile Victor

Up to now scientific research has been the main, if not the only, export product of Antarctica.

Applied scientific research as well as technical and industrial research are coming of age and are going to take more and more importance in Antarctic Research. Consequently future logistics will have to take in consideration this new aspect of research in Antarctica.

Basic scientific research will evidently continue as in the past. It will more and more become routine work. But it will more and more have to become coordinated and "concerted." By "concerted" is meant a program of research dealing with several scientific disciplines working together to give the elements of solution for one problem (example: geodesy, micro-meteorology, physicochemistry, etc, ... studying certain specific aspects in order to solve one specific glaciological problem).

Applied scientific research. Basic and applied scientific researches cannot, of course, be separated. But, as the general knowledge of Antarctica increases, and as more and more is known on problems of basic science, the importance of applied scientific research in Antarctica increases (example: the study of biomasses on the shores of Antarctica as a source of food for the overpopulated and undernourished populations of the tropical and subtropical belt).

Technical and industrial research. Technical problems under Polar climates have had to find solutions in function of Polar bases and Polar traverses. But a number of technical and industrial problems in completely different fields necessitate experimentation in severe cold and wind for which laboratory conditions are not sufficient. For these problems, Antarctica is the ideal laboratory in "true dimensions" (example: the production and accumulation of energy based on wind and water; a solution which, when found can be applied anywhere where there is wind and water).

Several important themes of research have developed in the past ten years on a global scale; in particular space research, and ocean research. To these two themes will soon be added a few others: in particular biology and human sciences. Every one of these themes will have to be developed in Polar regions and in particular in Antarctica. Consequently future logistics will have to take in consideration this second new aspect of research in Antarctica.

Space research. The 300 first miles are the most important in the near future, because of their immediate influence on our earth. Certain specific problems of this specific sector of space research can be most easily solved in the

Polar regions and more particularly in Antarctica. Others cannot be solved in any other region. Coordinated research between the Arctic and the Antarctic will become more and more imperative (example: simultaneous high altitude observations at both magnetic poles).

Ocean research and biology. It seems that the density of animal population on the shores of Antarctica is one of the highest, if not the highest of all the waters on the earth (except for the Arctic where the study is well on its way).

Its future exploitation as food source is certain.

But a study of the biomasses (the capital) and period and intensity of reproduction (the reserve) is imperative (example: year round coordinated observations of animal life on and under the winter sea-ice all along the shores of Antarctica).

Human Sciences and biology. Artificial cities in Antarctica, stations on and under the oceans, space stations, etc., ... are no more of the realm of science fiction. Consequently, the problem of human groups living artificially in special environments will have to be solved in the near future. The study of human adaptation becomes imperative, i.e.; the study of how human groups can live artificially, technically and psychologically in special bio-climatological environments (example: specific study of the Antarctic environment under its aggressive and usable aspects as seen from its medical, psychological and technical angles).

The aspect of research in Antarctica will consequently change rapidly from one of

-basic scientific, more or less isolated observations, (generally) without direct applications, concerning general geophysical problems

to one of

-basic and applied concerted scientific observations on specific problems for immediate and general use; as well as technical and industrial research of growing importance.

Consequently near (very near) future logistics will have to take in consideration these new aspects of research in Antarctica.

Future logistics will therefore have to face the following lines:

(a) permanent bases giving support to regular (permanent) and routine observations following programs of basic scientific research (as in the past).

(b) permanent bases (same) giving support to regular (permanent) observations and experimentations following programs of applied scientific research (example: human and animal biology including for instance group psychology, wild life and fisheries, etc., ...

(c) permanent bases (same) giving support to specific, temporary and important requirements (example: rocket firings and/or very high balloon launchings).

(d) permanent bases (same) giving support to technical and industrial experimentations.

(e) permanent bases (same) able to give logistics support to:

1. traverses:

-medium weight vehicles such as weasels, without air support

-medium weight vehicles with light air support

-medium weight vehicles with heavy air support.

2. establishment of light stations:

-for periodic occupation (example: the Central Greenland Ice Cap Station; Charcot Station on the Antarctic plateau)

-for temporary occupation and possibly transportable (example: Charcot Station if established on surface instead of under the surface or elaborate wanigans which can be towed by tracked vehicles).

(f) very light stations for short periods, transportable by helicopters or by very light vehicles towing light sleds (as, for instance, light wannigans or tents).

(g) Launchings areas for light and maneuverable aircraft (STOL airplanes and/or helicopters) (for instance for stations on sea-ice or in crevassed regions).

Conclusion

In view of the eventuality of increased logistics and wider research necessities (including a scope of research wider than basic scientific research), it is suggested that the SCAR working group on logistics become a SCAR Commission for Technical Research and Logistics (C. A. T. R. A. L.).

THE REQUIREMENTS AND NATURE OF THE LOGISTIC SUPPORT FOR A SMALL NATIONAL ANTARCTIC EXPEDITION
(A. Science and Logistics)

J. J. la Grange

Introduction

There is usually quite a controversy over the word "expedition" and what it actually means. For the purpose of this article an expedition will be regarded as any group of men acknowledged as an expedition by authoritative organizations in their respective countries. The word "National" refers to an expedition totally or mainly financed by a Government direct or indirectly. It is furthermore assumed that it will be a scientific expedition with the purpose of doing scientific observations or research in the various scientific fields as suggested by SCAR. As the accent in this paper falls on the word small in the title, it is obvious that the expedition under discussion will be smaller than the ideal one and thus will not be able to cover all these scientific subjects or programmes as suggested by SCAR.

The "small" expedition will usually be small because of limited funds. Thus some of the scientific programmes will have to be sacrificed and many of the commodities found on the bigger expeditions will be absent. On the small expedition it is usually a case of trying to do as much as possible with as little as possible.

The author envisages under the "small" expedition one of 10 to 12 persons. They could carry out a reasonable programme if they are divided in something of this nature: 4 meteorologists, 2 radio operators/technicians, 1 geologist, 1 medical officer/physiologist, 1 diesel mechanic, 1 geophysicist. Probably beyond the scope of this paper is the author's firm belief that if possible, the leader of an expedition should not be responsible for a specific programme but that he should have a reasonable sound knowledge of all the scientific programmes, he should be able to decide which or what should have preference, if need for such a decision arises; he should also be able to assist where necessary.

It will be noticed that Section 2: Aircraft operations, is omitted in this paper. The author is strongly in favour of the use of aircraft whether winged or helicopter as may be most suitable for the occasion, but he also feels that as soon as aircraft are included in the operations of an expedition on land (aircraft on board ship not included) then immediately the number of people have to be increased by at least three, other expedition members have to provide assistance from time to time, transport of supplies from the ship to the Base will be much more, and last but not least the total cost of such an expedition will be greatly increased. For these reasons it is felt that as soon as aircraft are included then it is no longer a small expedition.

It will also be noticed that nowhere under the headings mention is made of radio and power installations. Possibly it is assumed that such equipment is fairly standard and readily available and thus do not warrant being included in the discussion certainly both radio and power installations are major divisions of logistic support.

Another item of logistic support, clinical medicine (not to be confused with medical research), of which the sole purpose is to keep scientists and non-scientists in a healthy condition to do their work and thus is purely of logistic nature, is usually classified with the sciences as the medical officer with some scientific background will usually also do some medical research work. Thus clinical medicine is also left out of the discussion.

A. (Section 1) Science and Logistics

On a big expedition it is probably possible if not essential to draw a clear cut division between "Science" and "Logistics"—from there this separate symposium of Logistics. On the small expedition there is of course also a logistic side. Since an expedition exists firstly out of people and secondly out of things (scientific apparatus and logistic equipment) the author feels that the small expedition should be divided into these two categories rather than into "Science" and "Logistics"; in other words the first grouping together is of all personnel and secondly the activities and all equipment and apparatus necessary for these activities. The author feels that for several reasons the small expedition exists as a whole out of expedition-members and not out of scientists and non-scientists.

Surely the primary purpose of the small expedition under discussion, is to do some or other sort of scientific observation or research, and not to go and have a nice time in which mountaineering, skiing, aimless travelling and other suchlike activities will be predominant at the cost of the scientific work.

The era in which any simple observation, even that done by an amateur added to the scientific knowledge of Antarctica, is now something of the past. Scientists going to Antarctica must be fully qualified persons in their specific fields, the same applies to all technicians and mechanics. On the small expedition there is no place for the person who cannot fill a responsible post whatever it may be.

As the number of persons on the small expedition is very limited for all the programmes to be carried out as proposed by SCAR it is essential that several of the scientists must be able to do the work in more than one programme. So for example the glaciological work and also auroral observations and other geomagnetic work can be done by a geologist or a meteorologist, etc. There is however one condition—the persons required to do such work for which they have a reasonable background must have the opportunity to be fully trained before they set out for Antarctica.

Often it is possible to make use of the logistic personnel to help with these programmes. The author has had experience of diesel mechanics, radio technicians, radio operators and others who did excellent service in assisting with meteorological, geomagnetic and glaciological work. Of course there is and should be some professional jealousy among scientists, but on the small Antarctic expedition where the main aim is to do as much work as possible, the scientist will help himself if he sets this professional jealousy aside and draws in the non-scientist to assist him where possible. Here it is necessary to apply psychology of a high standard as the non-scientist, having to do something outside his own field, will want to feel that he is not doing only the scientist's dirty work but that he is indeed doing something very constructive and of great scientific importance! The atmosphere between scientist and non-scientist will be further cleared if the scientist on his part, now and again will be prepared to assist the non-scientist with some of his work—whether it be erecting a new aerial or cleaning the piston rings of a diesel engine.

If such co-operation exists between scientists and those responsible for the logistic support, it will be a happy expedition and a comprehensive programme can be attempted and achieved. If however there is constant animosity of a lesser or major degree between the "two groups" it will be extremely difficult to work together as a team and achieve the maximum, a small Antarctic expedition of necessity exists of a team and not of loose individuals each going his own way—for the simple reason that it is virtually impossible for any single person to achieve the utmost in his specific field if he does not from time to time, when necessary, get the help of others.

Tasks such as cleaning the station, working in snow for melting purposes, washing dishes and also the outside major tasks of digging, etc., should be communal tasks and not only for the logistic support. If everything works out correctly a diesel or radioman who is really worth his salt will, if he has little to do, often stand in for a scientist who is hard pressed for time and assist him in some of these communal chores.

The author thus feels that although scientists should be responsible for the scientific work, and logistic personnel for the logistic support without which the scientists cannot do their work, there should be as much integration between the two groups as possible—that they will form one expedition in which everybody should have a share, however small it may be, when one day in the future the expedition's scientific work is published which of course is the crown upon the expedition's work.

Photography

Although the heading of "Photography" as such is not included under any of the sections it is such an important aspect of an expedition that it will possibly serve a purpose if it is brought in here as photography will probably be a combined effort by scientists and the logistic support of the small expedition—a fulltime professional photographer cannot be included on the small expedition.

Coverage of the activities of an expedition on colour slides, black and white photography and cine film is very important especially for usage after the expedition's return from Antarctica. Not only are photographs of immense value for research value, or as refreshers of the memory, but also for the publicity of any expedition (not that the expedition is keen on publicity but because the public wants to see it and the public is entitled to see it!)

The fact that this article is not illustrated as fully as it could have been is proof of the fact that some of the important items were not covered photographically!

If one or two persons are responsible for the photography, then all other expedition members can co-operate by assisting and encouraging the photography of interesting matters of which the "photographers" might be unaware or even hesitant to do. Again a case of team work.

It is important to have the correct equipment, i.e. cameras, etc., that will work even under winter conditions. It is not necessary to have very expensive cameras, as long as they are either de-oiled or lubricated with low temperature oil. As far as the cine camera is concerned it is almost important to have a heating element built in so that the camera can be warmed to some extent while it is used outside. A hotbox in which it can be kept, will also be useful.

The following is an indication of the photographic requirements (expendable) for the small expedition: (not including the requirements of the scientific programmes)

Colour film—16 m.m.	36 rolls
Black and white film—16 m.m.	6 rolls
Colour film, 35 m.m.	36 exp. each 20 rolls
Black and white film, 35 m.m.	36 exp. each 5 rolls
Black and white film 2-1/4" x 2-1/4" negs.,	12 exp. each 36 rolls

If no automatic flashlight is taken, then also:

Flash-bulbs (for black and white)	24 doz.
Flash-bulbs (for colour film)	24 doz.

Developer, fixing salts, printing paper, etc., according to how much the expedition plans to use in Antarctica.

Non-expendable equipment should include cameras, ultraviolet and other filters, exposure meters, developing tanks, photographic enlarger, printing trays, thermometers and other utensils.

Recreation

Every expedition needs recreation, the amount and type depends upon the individual expedition. It is likely that the logistic support will to a large extent be responsible for the maintenance and in some cases operating of e.g., the cine-projector for films, radiogram and general purpose radios. Here also scientists and non-scientists can work together and foster good relations.

Figure 1. Radio technician left, assisting scientist in doing ramsonde.

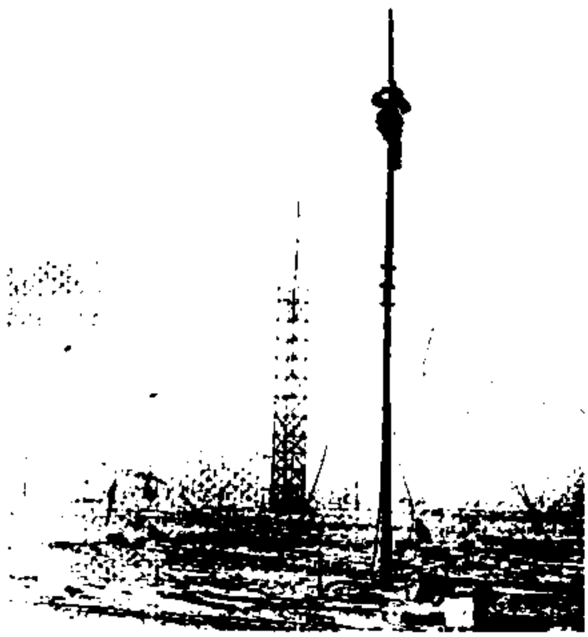

Figure 2. Radio technician erecting new rhombic mast. Meteorological tower in background.

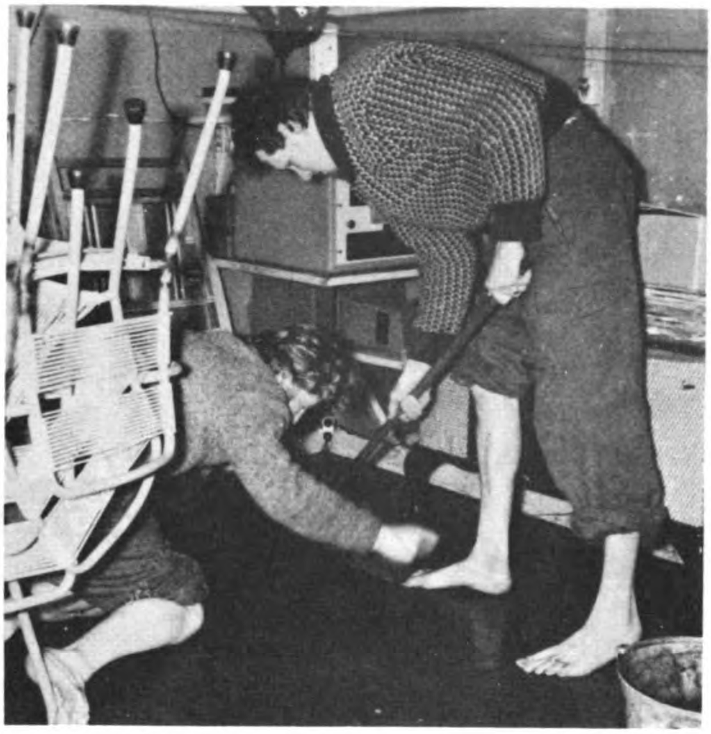

Figure 3. General station chores: scrubbing the living hut's floor once a week.

Figure 4. General station chores: hauling small sledge with garbage away to the rubbish dump 400 yards away.

Figure 5. Tractor vehicles at SANAE 1960. Left to Right, Muskeg, Oliver. OC-6 and Oliver OC-3.

Figure 6. Removing dug-out snow from the station.

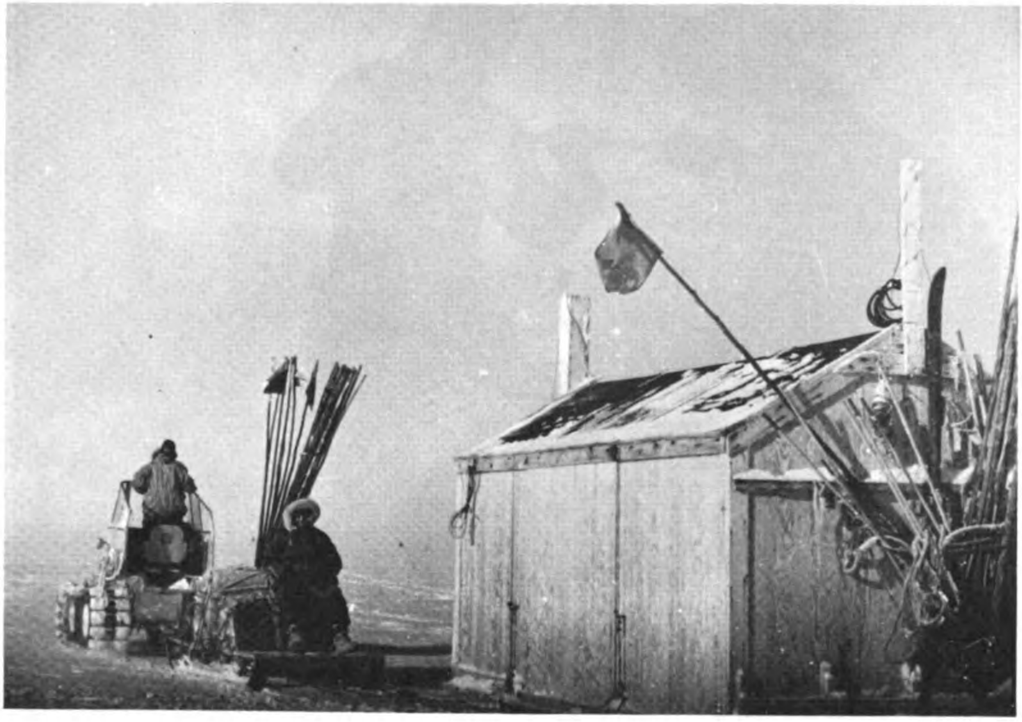

Figure 7. Oliver OC-6 tractor with supply sledge and caboose setting out to lay depot for field work.

Figure 8. A dog sledge team camp near the nunatak.

Figure 9. Digging snow for kitchen usage in the snow tunnel next to the kitchen.

Figure 10. Bringing in snow for kitchen usage through the kitchen window from the snow tunnel outside.

Figure 11. Cutting fresh meat in the snow tunnel.

Figure 12. Preparing a meal at SANAE.

Figure 13. Afternoon tea at SANAE Base.

SECTION II

AIR OPERATIONS

THE ARGENTINE FLIGHT TO THE SOUTH POLE 1961-1962

Pedro F. Margalot

The Commandant of Naval Operations ordered in September, 1961, a "visual and aerophotographic reconnaissance flight of the Western Route (by sea in case it did exist) of the Weddell Sea and of the area south of Ellsworth and Belgrano stations so as to (eventually) establish a new alternative route to those bases and to increase the knowledge of the Argentine Antarctic sector."

The Command of Naval Air Transport organized the Unit of Exploration and Aerophotographic Reconnaisance under the Naval Antarctic Group for the 1961-62 season, to be known as Task Unit 7.8 (U.T. 7.8), that had to carry out the above mentioned order with the limited means put at its disposal.

Within the short time available, and due to the lack of modern aircraft having ample radius of action and flying safety, two old C-47s, with almost twenty years service in the Navy were prepared for the operation at the Navy's aviation workshops of Ezeiza and Punta Indio.

The main work done on these aircraft was:

1. the installation of two R 1830-92 engines overhauled to zero hours;

2. the installation of two auxiliary gas tanks, one of 420 and one of 200 gallons capacity, so that each of the aircraft could carry 1420 gallons of gas;

3. the installation of an auxiliary oil tank of 18 gallon capacity;

4. the installation of an extra oxygen system so as to provide for an 8 hour capacity for 6 persons at 17, 000 feet altitude;

5. the installation of an auxiliary, electrical power system;

6. the installation of two racks for 1000 lbs jato (at Ellsworth it was necessary to add two other racks);

7. the installation of an auxiliary 140 liters alcohol tank;

8. the installation of skis (also on the tail)

9. the installation of a polar compass and a doppler radar on the CTA-15 and of a polar compass on the CTA-12 aircraft.

10. the painting of the nose, wing tips and tail with fluorescent orange paint; and

11. the installation of a "Janitrol" heating system for the cockpit and chart room.

A consumption of 90 gallons per hour of gas was estimated, corresponding to a capacity of about 14 hours, sufficient enough for the purpose. Two jatos were thought to be sufficient, but at the take-off at the South Pole it was shown that four were in fact not enough and that eight should be considered a satisfactory number to safely cover adequate take-offs at sealevel and on the plateau with the aircraft at their normal weight or at their maximum of 33,000 lbs. as accepted by our engineers.

The competence of our pilots from the Command of Naval Transports was excellent, and their flying experience in the south Patagonian area allowed us to assume that with a little practising in the Antarctic they would do well. The Argentine Navy had been flying in the Antarctic region since 1942; its first experience being with a small "Stearman" seaplane; a non-stop flight to beyond the Polar Circle was also made with a DC-4; the "Catalinas" crossed on several occasions Drake Passage as mail carriers; and the PBMs or the "Grumman Goose" carried out a number of photographic flights. All this experience and the specialized literature that was available, were considered for the preparation of the operations plan.

Our operations were to start from the Rio Gallegos airfield, the only one from which they could be carried out in any weather situation at the extreme south of Patagonia. From this point to Ellsworth and the South Pole 2525 nautical miles were to be flown over rough seas, ice shelves, mountains and a plateau that had been very little explored. In agreement with the means available, it was decided to plan for three quite ambitious legs:

1. First leg: From Rio Gallegos to Capitán Campbell (temporary) air strip to be installed near Robertson Island on the iceshelf.

The greater part of the distance of 857 nautical miles was to be flown over the sea. The point near Robertson Island was selected because of the proximity it had to Teniente Matienzo Base that the icebreaker "General San Martin" had to resupply, the availability of many places adequate for landing near the Seal Nunataks, and the feasibility for the icebreaker to get as far South as that position on the shelf ice front (the reality was, however, quite different as the ship was beset in the ice during 22 days and was damaged in the vicinity of Robertson Island).

2. Second leg: From Capitán Campbell to Ellsworth along the Larsen Ice Shelf, the southeastern part of the Antarctic Peninsula and the Filchner Ice Shelf to Austral Bay (Gould Bay), covering a distance of 927 nautical miles.

3. Third leg: From Ellsworth to Amundsen-Scott Station over 740 nautical miles of little explored country. All of the available information was used to prepare an operations chart to be used for the navigation of this leg. The sources of information used were:

(a) The discoveries made by the Argentine Polar Expedition that in November 1955, reached latitude 83° South and longitude 30°30' West and that correspond to the Forrestal Range, the Dufek Massif, the Spann and Ferrara Mounts, the Whichaway Nunataks, the Shackleton Range and the Theron Mountains. General Hernán Pujato, the leader of the expedition, called them the Diamante Range, the Santa Teresita Range, the Ejército Argentino Plateau, the Rios Mounts, the Los Menucos Range and the Rufino Mountains, on his flights from General Belgrano Base established in January 1955 (Ronne, 1961);

(b) Captain Ronne's flights in 1947 and 1957;

(c) the 18 hours flight of the US Navy aircraft in 1956 from the Ross Sea area.

(d) Sir Vivian Fuchs' sketch map of the Commonwealth Transantarctic Expedition of 1957-58 (Fuchs and Hillary, 1958); and

(e) Observations made by Argentine naval aircraft belonging to the Antarctic Naval Group on several occasions while resupplying the Belgrano and Ellsworth stations.

This chart is now being completed for publication with the recently acquired data.

The original plan considered the establishment of an advance base in the vicinity of the Buenos Aires Peak (lat. 83° South, long 38° West), but due to the "General San Martín" having been stopped in ice during 22 days near Robertson Island, this was not possible.

A land support group of 12 men under a man with Antarctic experience was to prepare the landing strip at Capitán Campbell, organize the support at Ellsworth and mark emergency landing strips at Dundee Island, Snow Hill Island and Hope Bay.

With only two support bases (Capitán Campbell and Ellsworth) along 2525 nautical miles, the aircraft had to carry a certain amount of spare parts and a couple of additional jatos in case of there being a need for an emergency landing.

Search and rescue at sea depended on a PBM ready to operate in the Cape Horn area, the DC-4 for weather support to fly over the aircraft in emergency until the arrival of rescue, the ships of the Naval Antarctic Group, one of which was stationed north of Smith Island, and a seagoing tug stationed south of Cape Horn.

On the Antarctic continent the means for rescue were two Beavers and two S-55 helicopters on the "General San Martín" and the Antarctic stations oversnow vehicles. Each of the two C-47s had survival equipment and supplies for 15 days at sea and for 90 days on the ice.

The meteorological support was given by the Buenos Aires Naval Weather Central, the Rio Gallegos Naval Weather Central, the Antarctic Naval Group Weather Central (on board the icebreaker), the Antarctic stations (including British and American stations to which we are very grateful for the help given), and a DC-4 aircraft.

The communications support was from Buenos Aires, Rio Gallegos, Rio Grande, Ushuaia, Decepción, Esperanza, Matienzo, Capitán Campbell, the DC-4 aircraft, the icebreaker "General San Martin", the surveying ship "Chiriguano", Ellsworth, General Belgrano, South Pole and McMurdo.

All the support worked as planned except for the radio beacon of Amundsen-Scott which failed at the last moment. Besides fuel, the supplies consisted of 6.5 tons with a volume of $12m^3$ in 100 boxes. The logistics distribution was as follows:

(a) At Capitán Campbell

120 drums of 100/130 octane aviation gas, 40 gallons of 100W oil, 1000 litres of Aeroshell Compound 6 alcohol (also for use at the camp), one drum of hydraulic fluid, one drum of 80 octane gasoline, 20 litres of regular oil, 6 jatos (2 of which were used on test take-offs), 40 boxes with aviation spare parts, material for a radio beacon and cold region survival equipment and food (350 kgr. in $2m^3$ for each aircraft to replace the sea survival equipment after landing at Capitán Campbell).

(b) At Ellsworth Station

180 drums of 100/130 octane aviation gasoline, 40 gallons of 100W oil, 1000 litres of Aeroshell Compound 6 alcohol, one drum of hydraulic fluid, one drum of regular gasoline, 30 litres of regular oil, 8 jatos and 60 cases with aviation spare parts.

As the icebreaker arrived at Ellsworth on the same day that the C-47s were leaving on their return flight, only a few drums of gasoline were unloaded to replenish them.

(c) At the South Pole

The U. S. Navy carried by air from McMurdo the engineers, the gasoline and the jatos that were needed. For the take-off each of the C-47s used 4 jatos.

This operation, carefully prepared with qualified and optimistic men, was successful in flying to and from 90° South with two very old but well-maintained aircraft.

The good conditions of the flying material and the zeal of the maintenance team, made it only necessary to add in the field two extra jato racks. This work was done in two days at Ellsworth in view of the delay of the icebreaker to bring in the gasoline, thus obliging to carry a full load plus 200 gallons of fuel in cans for the return flight from the South Pole to Capitán Campbell.

The hospitality given by the Amundsen-Scott Station personnel was as warm as it could have been and their help was extremely useful in contributing to the success of the flight.

Finally, it was demonstrated once more that with limited materials and means, carefully organized and prepared, the carrying out of seemingly over-ambitious plans can be effected.

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PERFORMANCE OF THE C-47 AIRCRAFT IN THE FLIGHT TO THE SOUTH POLE 1961-62

Jorge A. Pittaluga

To be carried out in the 1961-62 summer, the Argentine Naval Aviation planned a flight to the South Pole from the southern part of South America.

Only Douglas C-47's were available for this purpose, so that the two matriculated CTA-12 and CTA-15 that were having a major overhaul, were selected from among eleven.

This paper describes the experience gained during this flight carried out under conditions that are different to those that are normal for these aircraft.

Such conditions of Antarctic flying are very different indeed, so that a careful analysis and a correct estimate of the situation had to be made to arrive at a balance of objective and risk.

In view of the object: to fly from the southernmost part of South America to the South Pole making the necessary stops, the limitation that "no margin for any cargo can be contemplated so that these aircraft can only be used for observation, reconnaissance, and photographic flights" should be considered.

The results in take-offs, climbing, cruising, landing, taxiing and parking are given.

Take Off

Experiments at the Rio Gallegos Naval Air Station on a 1700 meters runway gave normal take-off runs within 2/3 of its length with total weights of 29, 000, 30, 000 and 31, 000 lbs. using no boosters.

The engineers of the Naval Aviation had installed a quick action fuel discharge system for this flight.

In the vicinity of Robertson Island with a soft snow 2000 meters runway on the ice shelf, the take-off run was of 1, 000 meters for a 29, 000 lbs. weight using no boosters and of 1, 200 meters for a 32, 000 lbs. weight using one 1, 000 lbs. thrust booster.

At an altitude of some 3, 000 meters above sea level—at the South Pole—the take-off was normal with four boosters not being necessary to use all of the 2, 400 meters runway and with the aircraft weight at 33, 500 lbs.

At Ellsworth Station on a 2, 000 meters air-strip, the take-off run was of 950 meters for 30, 000 lbs. using two boosters. During this test one of the boosters failed five seconds after ignition without there having been any noticeable effect.

It can therefore be concluded that the performance of the C-47 in the take-off from South America and snow covered Antarctic runways in the conditions required by this operation is satisfactory.

Climbing

From the tests carried out at Rio Gallegos and the Antarctic it should be said that though there were no dangerous situations in the ascent, but ascent is slow and difficult due to the increase in weight from necessary fuel and survival equipment.

The rates of ascent were 200 and 300 ft/min. for take off weights of 32, 000 and 29, 000 lbs., so that it was necessary to consider that there should be no nearby obstacles on the site to be selected for the runway in Antarctica.

It can thus be said that the performance of the C-47 during ascent is acceptable, taking into account the risk inherent in any Antarctic operation, as long as no high obstacles are present in the vicinity of the airfield.

Cruising

To fly south of Rio Gallegos the oxygen equipment was installed and the capacity of the alcohol system to propellers, carburetors and windshields was increased.

The sparseness of meteorological information makes it very probable to find bad weather while crossing Drake Passage. Actually the ceiling was 18, 000 feet and it was possible to fly over most of the cloud formations. There was practically no icing and the maneuverability was good with slight turbulence. Between Robertson Island and Ellsworth there is no meteorological information and bad weather with low clouds, poor visibility and some icing prevailed on the route especially from Cape Agassiz to Cape Adams. The performance of the C-47 was excellent on this part of the flight. The ceiling having been ample to fly over the cloud formations, it was possible to fight efficiently the small amount of icing that resulted with the means available.

The leg between Ellsworth and the South Pole was generally in fine weather and presented no restrictions to flying, but ice formation can be severe.

Landing

On the snow the landing run of this aircraft is very short and can be perfectly controlled.

The landing gear proved to be strong and quite adequate for an emergency landing.

Taxiing and Parking

The freezing of the skis to the snow was the only difficulty encountered, but good results were obtained using alternately two jacks on a wooden board two feet by two feet square.

For taxiing it becomes necessary to use more power, and the turns are of a considerable diameter.

Conclusion

The performance of the C-47 on this flight allows the conclusion that it is a very adequate aircraft for the Antarctic. It is restricted on long range flight by the increase of its take-off weight to an amount that is great for the type.

THE TEMPORARY AIRSTRIP FOR THE FLIGHT TO THE SOUTH POLE IN 1961-62

Enrique Luan Dionisi

To prepare airstrips in the Antarctic several geographical and climatic factors are to be considered that are also to be accounted for in non polar regions, but that in this case have an outstanding significance.

Following the discussion of each of those factors we could prepare more easily the temporary airstrip for the flight to the South Pole with its facilities for the operation of the aircraft, that is parking, storing of spare parts, fuel areas, navigation radio-aids, radio station and meteorological instruments.

Having been our first experience on the subject, there were some unavoidable mistakes that served to acquire useful knowledge. Moreover, we did not have adequate and modern equipment that should have been used in agreement with the requirements of this operation.

Obstacles in the Vicinity of the Selected Site

The site for the construction of the airstrip was selected in consideration of topographical obstacles, prevailing meteorological conditions and restrictions imposed by the capability of the aircraft.

The area selected was surveyed with helicopters and theodolite which verified heights, distances and the shape of obstacles. After comparing the new data with available charts a new sketch map was prepared for the use of the pilots.

The criterium used for the selection of the airstrip site was that there should be no obstacle in the vicinity of the skiway heading that exceeded 300 meters in height, and that on the take-off the plane should be capable of clearing the highest obstacle by 125 meters.

The site for the airstrip was finally selected at a point some 20 nautical miles westward of the ice shelf front where the nunataks and islands around it prevented the ice from movement.

Orientation and Marking of the Airstrip

At the selected site there were two possible orientations for the air-strips; East-West and Northeast-Southwest.

The East-West orientation is near Murdoch Nunatak which is about 600 feet high and in the vicinity of very active melting. This melting was considered to be a potential melt water stream across the airstrip with the advancing of the season.

The Northeast-Southwest orientation had none of these difficulties and turned out to coincide with the direction of the prevailing winds as experienced by the support party that built the skiway. Landing "into the wind" is considered to be an important requirement for snow and ice operations.

Two parallel lines of three men each were used to examine the area looking for crevasses or sastrugi, along 2,000 meters of the runway plus 500 meters from its "22" head, where the radio-beacon was to be erected, and 500 meters to both sides where the aircraft were to taxi in order to avoid using the runway unnecessarily.

The runway was marked with red flags on two meters high bamboo canes every 50 meters for the first 200 meters and every 100 meters onward.

Between the "22" head and the radio-beacon a double central line of black flags every 100 meters was used as a mark.

A caterpillar vehicle marked the edges of the runway with its track, a yellow marking of dye powder previously dissolved in water was used to spray the heads of the airstrip and at 100 meters from the "22" head and on the axis of the runway a T shaped bright green canvas 10 meters long and 5 meters wide was spread out.

The "09-27" runway maintained itself in good condition until the beginning of January, after which time rather wide melt water streams cut it at right angles from the Murdoch Nunatak.

It is therefore important to consider that runways should not be prepared near nunataks that encourage the melting of ice, and that there should always be a second runway prepared to replace the one in operation.

Fuel and Spare Parts

Fuel and spare parts were stored near the head of the runway to avoid the aircraft as much as possible the necessity to taxi since they needed full power to do so. Aircraft were moored in the vicinity of runway heads and were anchored with manila ropes to wooden crosses buried in the ice.

Those spare parts cases, the contents of which could become damaged by drifting snow, were housed in small aluminum huts. 20 gallons capacity "pillow-tanks" were used to carry extra gasoline on the planes.

Radio-Aids to Navigation

At 1,000 meters from the "22" head and on the axis of the runway, a radio beacon working on 380 kcs was installed on a 2 meters high by 80 centimeters thick cement base built into the ice, over which a 24 meters high triangular iron tower in three sections was erected and kept in place by three cables fixed to dead-men two meters below the surface of the snow.

The electronics part was housed in an aluminum hut lined inside with canvas because of condensation on the walls. For generating power a portable set was used.

In a similar nearby hut the radio station was housed having a BC-375 transmitting and receiving set that worked between 300 and 10, 000 kcs for ground to aircraft communications.

The power was supplied by a 32 volt FA Model D generator through batteries. The transmitter had a stylo aerial and the receiver a 15 meter long simple antenna. The range of the transmitter was increased by using a ground antenna.

THE OPERATION OF BEAVER AIRCRAFT FOR ANTARCTIC OPERATIONS

R. F. M. Dalton

Summary

Beaver aircraft on floats, skis and on wheels have been successfully used by ANARE for Antarctic work since 1956. This paper describes the performance of this type of aircraft as equipped by the ANARE in its various configurations and the work it has done in aerial photography, aerial reconnaissance and support for field parties. Some problems which have arisen are discussed, together with measures adopted to solve them.

1. The Beaver Aircraft

Standard Beaver aircraft were purchased from the de Havilland Aircraft Co. (Canada) Ltd., together with accessories to allow the alternative landing configurations of wheels, wheel-skis or floats.

The Antarctic Division's requirements necessitated some additional installations: trimetrogon cameras, more elaborate navigational aids and electronic search and rescue equipment, long-range fuel tanks, supply dropping apparatus and special survival packs. The modifications required are described in another paper by the author entitled "The Equipping of a Beaver Aircraft for Antarctic Operations".

2. Beaver Operations from an Antarctic Station

Operating Conditions. The Headquarters for ANARE air operations during the years 1956-1960 were at Mawson (67° 36'S, 62° 52'E). This Station is built on a horseshoe of dark brown rock jutting from the edge of the Continental ice. The two arms of the horseshoe enclose a small deep-water harbour which is further protected by a scattering of islands close off-shore. To the south, rises the icy Antarctic Plateau, broken by the nearby peaks of Mt. Henderson and the Masson, David and Casey Ranges.

The hangar on Mawson is built on rock at the water's edge on one arm of the harbour. In Summer the aircraft, mounted on floats, can operate from the open sea and then taxi back into the harbour to be hauled out with special wheel beaching gear into the hangar. During the Winter months the aircraft can be hauled straight out of the hangar onto the sea ice which provides a smooth and extensive airfield suitable for aircraft mounted on skis or wheels.

However, at the onset of summer, the sea ice breaks up and this type of airfield is not available for the months December until April. Towards the end of November, before the sea ice deteriorates too much, it therefore becomes necessary to fly the aircraft inland to a permanent ice airfield on the plateau at the northern end of the Masson Range.

Here a special facility called Rumdoodle Airfield has been set up at an altitude of about 1000' above sea level. It embraces a vast expanse of hard blue ice, tie down points, wind fences and several sledge-mounted caravans to provide living accommodation, power, radio facilities and a workshop. These latter lie on moraine rock at the foot of the Painted Hill. The hard ice of the ablation zone, dusted by snow in winter or pitted by ablation in summer, is suitable for operations involving either wheels or skis.

Air temperatures at Mawson in summer vary from +35°F to 10°F and in winter from +20°F to -30°F. At Rumdoodle the temperatures are roughly 10° lower. Strong winds are of course the major concern at both places. At Mawson, the problem has been largely solved by providing hangar protection, but at Rumdoodle where such an installation would have been difficult and expensive, use has been made of wind fences and tie-down points anchored to "dead-men" sunk in the ice (a separate paper describing the procedure of tying down has been presented by Phillip Law entitled "The Anchoring of Aircraft Against Strong Winds").

At Mawson and at Davis' Beaver aircraft, moored on rock or on sea ice, have withstood winds up to 87 m.p.h. and at Rumdoodle winds up to 82 m.p.h. However, Beaver aircraft at Rumdoodle finally succumbed to hurricane force winds estimated to have reached velocities in excess of 130 m.p.h. In this latter case, however, the aircraft were not tied down in accordance with the principles described.

3. Analysis of Flights

The primary role of the Beaver at Mawson was its contribution to the Cartographic programme. With trimetrogon aerial photography, radar heighting flights and reconnaissance. Its secondary roles comprised support flights for field parties and search and rescue.

The following table outlines the amount of aerial photography achieved by Beaver aircraft in the period 1956-1960:

Year	No. of Flights	Total Miles (mm)	No. of Photo Flights	Distance Flown on Photography	No. of Photos Taken
1956	232	55,000	46	4,800	15,000
1957	214	49,000	11	1,500	4,400
1958	200	47,000	6	1,100	1,600
1959	180	36,000	33	5,100	7,087
1960	146	29,200	25	1,400	4,316

The extent of the aerial photography carried out over the five year period is shown in Figure 1, (Page 56).

The above summary shows that, of the total 202, 000 nm flown by the Beaver over this five year period, 13, 900 nautical miles were flown on aerial photography. It is difficult to summarize the flying in other roles for this long period, but the following table will illustrate a typical year's flying from Mawson:

Year 1959

Total No. of Flights	180
Total Hours Flown	371 hrs. 25 mts.
Aerial Photography	53 " 10 "
Field Support	210 " 55 "
Reconnaissance	39 " 55 "
Radar Heighting	12 " 55 "
Travel Flights, Tests, etc.	65 " 00 "
Cargo Carried	2600 lbs.
Passengers carried	222

Perusal of this year's work reveals that on a number of occasions the Beaver remained in the field with a survey party to provide close support. On one of these occasions the aircraft stayed out for seven days.

The majority of the flying was carried out in the wheel-ski configuration. However, in the early years float operations were common. On one occasion a landing was made on Lake Stinnear in the vicinity of Davis. The highest recorded altitude for a landing on the plateau was at 7, 300 feet above sea level.

4. Fuel Consumption and Endurance

The effect of weight distribution, coupled with the high initial all up weight of ANARE Beavers and the high altitude demands for aerial photography result in power settings that are much higher than normal: consequently fuel consumptions when operating in these roles are also higher than normal. Experience has proven that, for planning purposes, a consumption of 24 imperial gallons per hour must be assumed.

For flight planning two separate fuel reserve allowances have been laid down:

For flights which have a radius of action of more than 215 nautical miles the fuel reserve plan is:

Reserve "A"	Weather reserve	1 hour	= 24 gallons
	General reserve	30 mins.	= 12 "

For flights with a radius of action of less than 215 nautical miles the fuel reserve plan is:

Reserve "B"	Weather reserve	30 mins.	= 12 gallons
	General reserve	30 "	= 12 "

After applying the selected reserve, the radius of action and "time-on" photography for the various fuel tank arrangements is as follows:

Main Tanks Only

= Endurance at 10,000' - 1 hr. .04 mins.
Radius of action - 79 n.m.
Reserve - "B"

Main Tanks and Tips or Belly

= Endurance at 10,000' - 2 hrs. 32 mins.
Radius of action - 146 n.m.
Reserve - "B"

Main, Tips and Belly

= Endurance at 10,000' - 4 hrs. 4 mins.
Radius of action - 216 n.m.
Reserve - "A"

It will be obvious that to attempt to set out predetermined power settings for the various phases of flight to cover the different possible types of Beaver flying in Antarctica is impracticable. "Bush" flying techniques must be employed, the success of which will depend upon the ability of the pilot to assess the results of each flight for his particular aeroplane and to create his own parameters. It will be seen later in this paper that not only fuel management but also the navigational techniques closely follow this well tried pattern for short range flying operations.

5. ANARE Beaver Weight Summary

During the preliminary weighing of our Beaver it became very evident that, when operating in its primary role of Aerial Photography, the maximum permissible gross weight of 5,100 lbs. would be exceeded on long range flights. Special permission was, therefore, given for the Beaver flying in Antarctica to operate at an overload take-off weight of 5,600 lbs. provided that none of the load was carried on the wing-mounted supply-dropping racks.

On field support flying, where loads would possibly be required to be carried on these wing-mounted racks, the ANARE Beaver is restricted to the normal 5,100 lbs. gross weight.

When loads are carried on the wings the weight at the wing positions is restricted to 500 lbs. (250 lbs. on each wing) on a floatplane and 600 lbs. (300 on each wing) on a land or ski plane.

The main problem associated with cargo air lifts is the weight and space penalty of the survival equipment which must be carried. Survival equipment for a two man crew imposes a penalty of 308 lbs. and takes up quite a lot of the cabin space. For very short flights in the vicinity of the station and where rescue by surface vehicles could easily be achieved in a matter of hours, departure from the standard survival equipment is permissible; therefore it is possible to handle loads up to 1,000 lbs. weight. However, on medium range flights of about 180 miles radius of action the cargo uplift falls to 700-800 pounds.

The cabin of the Beaver will hold two 44 gallon drums quite easily and loading and unloading is not a serious problem due to the easily removable wide doors on each side of the cabin. When possible wing loads are carried in "Storepedoes". These are suspended direct from the supply-drop racks and are either "free-dropped" or removed after landing. Dog sledges, railway sleepers and 25 gallon drums of fuel have been successfully carried in this way without difficulty.

6. Beaver Operations from an Antarctic Ship

The ANARE Beaver aircraft have assisted during the annual relief voyages with aerial reconnaissance and photography. This work calls for a small air group of four men, comprising two pilots and two mechanics. Such voyages last about three months.

The Beaver is carried fully rigged as a float plane on one of the forward hatches of the ship. It is located on the hatch on float cradles with the aircraft pointing towards the bow. Some protection is offered by the winch house immediately forward of the aircraft. Wheel-ski landing equipment is also carried and has been used in cases when low "bay ice" bergs or fast ice have provided suitable ice runways.

It is worthy of note that Beavers have been carried successfully in this fashion for more than 25,000 nautical miles over the Stormy Southern Ocean without loss or serious damage. On two occasions minor repairable damage has been caused through heavy seas. The biggest problem is the eradication of the corrosion set up from the constant dousing with sea water. The lack of surplus fresh water on board ship prohibits regular washing down during the voyage; consequently the after-voyage treatment is usually difficult and expensive.

The Beaver, when operated from an Antarctic ship, is equipped and instrumented as for operations from an Antarctic Station, but with more emphasis on sea survival.

7. Summary of Work Carried Out

The following summary outlines the work carried out during a typical annual relief voyage which covered the period January-March, 1962. The aims of the voyage were to relieve two ANARE Stations, and to carry out coastal exploration between Long 90°00E and Long 167°00E.

Total number of flights	= 24
Total hours flown	= 80 hrs.
Miles flown	= 7,500 n.m.
Number of photos taken	= 9,510
Photographic coverage	= 3,170 n.m.
Hours flown on other duties	= 38 hrs.

During this particular voyage the weather was, in general, unsuitable for aerial photography and the 24 sorties were flown in a total of 16 flying days.

The weather requirements for trimetrogon photography are more exacting than those for ordinary vertical photographic operations. Virtually blue sky from horizon to horizon is necessary to produce first quality results. This, however, is rarely possible; consequently some flights are conducted in less than ideal conditions in order to achieve maximum results in the relatively short time available at each location.

8. Aircraft Handling

The operation of unloading and loading the aircraft from the ship is one which must be conducted with the maximum speed consistent with the greatest of care. The very restricted space on the deck of a 2000 ton ship allows very little freedom of manoeuvre; consequently the handling of aircraft demands skill and concentration on the part of the handling crew.

The lift is taken by the ship's gear through a spring-loaded shock-absorbing device at a single point above the fuselage centre section. Consequently, once the aircraft rises clear of its float cradle, it tends to swing into wind unless checked. To control this swing, nylon ropes are secured to each wing tip and at the rear fuselage section and men of the handling crew are drilled in the correct use of these controls.

As the aircraft is lowered over the rail and down the side of the ship, long poles with soft-pad attachments are used by men on deck to fend the wings off from the ship's side should the aircraft begin to swing.

Normally the aircraft rests on the hatch cover, facing towards the bows. For unloading it is lifted clear of the cradles, turned side on and moved to the side of the ship with the airscrew pointing inward. From this position it is lowered down the side of the ship into the water. An inflated rubber buffer moored to the ship's side prevents the floats from making hard contact with the hull. As soon as the aircraft is safely in the water it is towed backwards clear of the ship by a motor launch.

The loading sequence is virtually the reverse of this procedure.

During all handling operations the ship's lifting gear is controlled and operated by the ship's crew and a party of six expedition men controls the steadying ropes and fending poles.

Before unloading the Beaver it is normal procedure to start and warm up the engine as well as to check the functioning of all systems. This procedure is important as it reduces the taxi time in the water and keeps to a minimum the icing up of the aircraft by sea spray.

9. Maintenance

Routine maintenance on board ship presents no serious problems other than perhaps the unusual environment under which work has to be carried out. The restricted space, the movement of the ship and the exposed conditions impose difficulties and hardships which usually have to be experienced by personnel completely unaccustomed to such conditions. In spite of this the serviceability record for ANARE shipboard operations stands at 95% throughout three long and arduous voyages.

A number of minor unserviceabilities have occurred but, apart from some slight damage caused through heavy seas breaking over the ship, all could easily have been experienced on operations anywhere.

10. Operating Techniques

The normal ANARE crew for the Beaver consists of a pilot and second pilot who performs the duties of navigator/camera operator. (This arrangement has proved more efficient than the earlier crewing arrangement of a pilot with one of the ground staff as camera operator.)

The division of duties is arranged as follows:

The pilot is responsible for all normal duties associated with the pure flying of the aircraft, for pre-flight planning, for the reading and recording of all instrument data, for map reading and for communications.

The navigator is responsible for the navigation of the aircraft and the operation of the camera installation as well as the recording of all navigation and photographic data.

Special attention is given to post-flight analysis. Every aspect of the flight data is carefully studied, summarized and recorded. For aerial photographic flights especially the summarizing of data is of vital importance.

In-flight position reports are required at half hour intervals; these are monitored at the ship, plotted and checked against the flight plan. Changes of course and height are reported immediately by radio, as are readings of drift and comments about the terrain crossed and the landmarks passed. At all times the flight plotter on the ship has a reasonably accurate idea of the position of the aircraft. All radio messages are recorded on tape at the ship.

11. Navigation

The difficulties experienced in determining aircraft position in polar regions are well known; Limited radio and visual aids, the general inaccuracy of maps, difficulties caused by overcast conditions and proximity to the magnetic pole, etc. Many of these problems can, of course, be offset by the installation of modern high performance flight and navigation systems.

Air operations carried out by ANARE are all of short range and mostly confined to coastal regions of Antarctica at least 20°N of the Pole. ANARE pilots use the Polar grid techniques, heading is maintained largely by gyro steering and determination of position by either visual or Astro fixing.

The normal procedure is to set the gyro against the orientation of a known set of land marks or, when operating from a ship, to make one or two runs over the ship in order to set the plane's gyro to the heading of the ship's master gyro.

During flight frequent heading checks are carried out against the Astro Compass and Sky Compass. After applying the correct allowance for latitude on the rate corrector of the Polar path compass it has been found that the drift is for practical purposes zero.

The only ground navigational aid available at an ANARE Station is a non directional beacon, which is limited in range over plateau ice to 30-40 nautical miles. Along the coast, however, such beacons have provided ranges from 100 to 150 nautical miles.

The corresponding airborne instrument is the ADF14 Radio Compass, modified to enable aural nul bearings to be taken. This installation has functioned very satisfactorily. Its major function is for homing only, during which the "overhead" indications have been reported as excellent.

The supplementation of the above data with the "Bush" Flying techniques of manually taken drift and ground speeds and the all important "knee-pad" sketch has provided a very reliable technique of navigation that is particularly suited to short range operations. Visual recognition of coastal and mountain features is an important part of this technique.

12. Communications

The radio equipment installed in the ANARE Beaver is the H. F. Transmitter/Receiver type AN/ARC-2 which provides Pre-set multi-channel two-way radio communications using C. W. M. C. W. or Voice.

Radio control is kept by the pilot over the range 2 mc to 9.05 mc using either a fixed or trailing aerial. Experience has shown that best results are achieved by using the trailing aerial with frequencies below about 6 mc.

The AN/ARC-2 equipment is rather heavy but its performance has been excellent and it has withstood years of service under the very exacting conditions involved in operating ski-equipped aircraft from rough plateau runways in Antarctica.

13. Search, Rescue and Homing

To assist in Air Search operations the ANARE Beavers are fitted with the S. A. R. A. H. model TR 8971 electronic search and homing equipment. The installation is removable and can be located in the aircraft for operation by the pilot or navigator.

Its performance in Antarctica is good; the pick-up ranges at 10, 000' altitude are of the order of 35 to 40 miles when the ground beacon is located directly ahead of the aircraft and of the order of 50 miles when the beacon is at 45^{o} to the plane's heading.

Overhead indications are very satisfactory and homing is accurate.

14. Survival

In view of the limited payload that can be carried, a great deal of effort has been devoted to the preparation of the survival equipment which is carried in the ANARE Beavers. (The detailed lists of survival equipment are given in another paper "The Equipping of a Beaver for Antarctic Operations").

The ANARE Air Survival packs are so designed that each aircraft always carries gear sufficient for the normal crew of two. With each additional passenger a standard pack is added. Consequently the survival equipments fall under three standard groups:

(a) Equipment permanently stowed in the aircraft
(b) Crew survival packs
(c) Passenger survival packs

The stowed equipment and the contents of the packs are reviewed after each year's operations and modified where it is possible to improve the quality or reduce the weight of this gear.

The current ANARE Beaver Survival packs carry with them the following weight penalties:

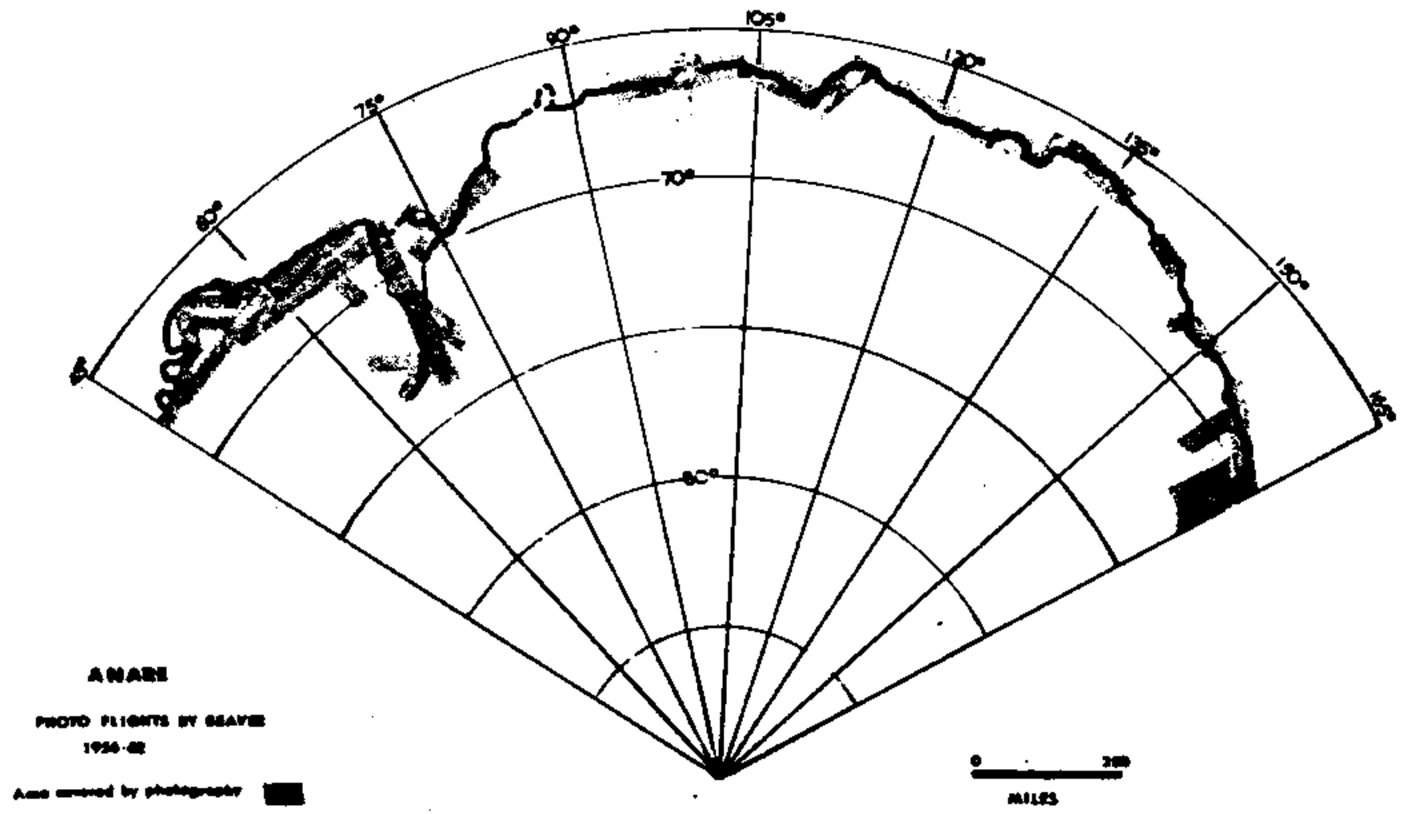
(a) Stowed survival equipment	196 1/2 lbs.
(b) Crew survival pack	112 "
(c) Passenger survival pack	19 "

Some variation is permissible with the stowed survival equipment to suit specific flights. For example, on inland flights the life jackets, dinghy, anchor and chain would be removed and a gain of 77 lbs. achieved.

No variation is permissible with the crew or passenger survival packs, no matter what the nature of the operation. The contents of these two packs are designed around the concept of a six day survival period on full rations.

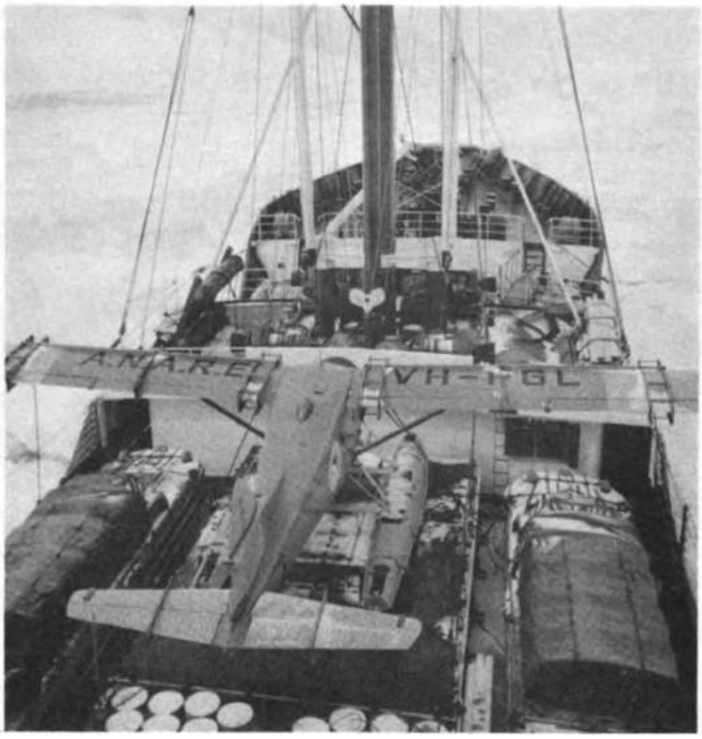
15. Conclusion

The Beaver has demonstrated its ability to contribute worthily and inexpensively towards aviation in Antarctica. With its true S.T.O.L. characteristics and rugged strength and in spite of the fact that it was in production in 1949, it is still worthy of very serious consideration when the need is for a light aircraft for short range Antarctic operations.



105°
90°
120°
75°
135°
60°
150°
165°
70°
80°
ANARE
PHOTO FLIGHTS BY BEAVER
MILES

Figure 1



Beaver positioned on deck of M. V. Thala Dan, February 1962, on each side are amphibious landing craft. (DUKW's).

Beaver moored against fast ice astern of M. V. Thala Dan off Wilkes Land.

Beavers refueling on sea-ice at Depot Island 200 miles west of Mawson.

Beaver aircraft which have just landed at Amundsen Bay, Enderby Land, after transporting dogs and sledges from Mawson for the start of a 400 mile surface journey.

Mobile air facilities at Rumdoodle Air Field, on plateau ice
10 miles from Mawson at northern extremity of Masson Range.

THE EQUIPPING OF A BEAVER AIRCRAFT FOR ANTARCTIC OPERATIONS

R. F. M. Dalton

Summary

DH-C2 "Beaver" aircraft used by the ANARE are required to operate in Antarctica from land, snow, ice or water for the purposes of aerial photography, support for field parties and reconnaissance. The object of this paper is to outline the preparation of the aircraft and describe the special installations which have been considered necessary.

1. Description

As the DH-C2 Beaver is well known, only a brief overall description of the aircraft is considered necessary:

Dimensions:	Landplane
Span	48'
Length	30'3"
Height	10'7"
Gross Wing Area	257.3 sq. ft.
Weight Tare	2, 775 lbs.

Performance at gross weight 5, 100 lbs.

Take off—zero wind	560 feet
Cruising speed—5, 000'	140 m.p.h.
Service ceiling	18, 000 feet

Fuel Consumption—20 to 24 imp. galls. per hr.

The ANARE Beaver is the Series I model, powered by a Pratt and Whitney Junior engine of 450 BHP driving a two-bladed Hamilton Standard constant speed airscrew.

Two types of landing gear are available for fitment:

(a) The normal cantilever type wheel undercarriage, with its single disc hydraulic braking system, to which are fitted special attachments carrying the hydraulically operated de Havilland Main Skis. This arrangement permits either wheel or ski landings to be carried out, the skis being lowered beyond the wheels for snow or ice landings.

(b) A float undercarriage using the Standard "EDO" type 4580 all-metal floats.

The work of equipping the Beaver for A. N. A. R. E. purposes has been to Australian Quality Control Standards. The all-up weight (A. U. W.) of the aircraft in all configurations must not be greater than 5, 100 lbs. and the centre of gravity limits of 1.25 inches forward and 8.8 inches aft of the datum point as a land or ski plane must not be exceeded. (A special dispensation for an A. U. W. of 5, 600 lbs. has now been approved for Antarctic operations only).

2. Airframe

To facilitate aircraft maintenance under Antarctic conditions the number of nut and bolt assemblies secured with split pins has been reduced to a minimum by substituting bolts secured with "Nyloc" insert self-locking nuts or plain nuts secured with shakeproof washers.

Bolts used in the flying control system which are subject to movement, as for the attachment of major components, have been left secured with the usual slotted nuts and split pins.

The round-headed screws on the float compartment cover have been changed to screws with hexagon heads.

The plumbing of the aircraft fuel system has been thoroughly checked for localities likely to act as water traps. (Fortunately the system was found to be clean in this respect and no re-working of pipelines was required).

The aircraft lifting attachments in the centre section have been strengthened to carry a total load of 5, 600 lbs. with a safety factor of 6 and the holes in the new lifting lugs have been sized to accommodate a 1/2 inch bolt.

An additional step has been provided to allow access to the top of the mainplane. It is located on the port side of the fuselage just forward of and level with the bottom of the perspex in the pilot's port entrance door. A hand grip has also been added on the port forward upper surface of the centre section. Cargo anchoring nuts have been fitted to the cabin floor at 9" module spacings.

3. The Engine

The Pratt and Whitney R985 Wasp Junior engine was initially treated by the manufacturers for the prevention of salt water corrosion of the magnesium alloy castings. Further applications of standard type protective compounds such as Protective Compound PX-107 are made when and where necessary around the engine. For shipboard operations it is normal ANARE practice to remove the engine after each annual voyage for thorough inhibiting and re-treatment.

Where possible, the number of nut and bolt assemblies secured by split pins has been reduced to a minimum by substituting "Nyloc" self locking nuts. Bolts used in the engine mountings and engine controls have been left secured with split pins.

To prevent oil fouling of the vertical camera hatch the accessory drain and overflow pipes from the oil drain collector box have been re-routed to a point aft of the camera hatch.

To cope with requirements of the camera installation the existing 4 cu. ft. capacity vacuum pump has been replaced by an 8 cu. ft. capacity pump—type "Pesco" B3X MK 1—and to cover the requirements of the additional electronic installations the existing 50 amp. generator has been replaced by a 100 amp. unit.

4. Instruments

The standard instrument panel has been enlarged by the addition of a U.S.A. type L20 panel and the following additional instruments have been fitted:

(a)	Artificial Horizon	Type AN 5736
(b)	Directional Gyro	Type AN 5735
(c)	Rate of Climb	Type 1610/1634
(d)	Vacuum gauge	Type C2F-807
(e)	Fuel Pressure warning light	Type C2-N-1641
(f)	Polar Path Compass	
(g)	Radio Compass	Type ADF-14

All instrument dials, including radio and electrical equipment requiring illumination, were treated with a fluorescent non-radio-active luminating compound.

The Airspeed pitot head, the static vent for the A.S.I., the Altimeter and the rate of climb indicator are electrically heated.

The A.S.I. has been recalibrated in "Knots" and the altimeter barometer scale in millibars instead of inches of mercury. The D.G. has been adjusted for continuous operation in Latitude 68°S.

It was considered that oxygen would only be required on occasional photographic flights, and that the permanent installation of oxygen equipment was not warranted. Portable oxygen apparatus is available if needed.

5. Electrical Equipment

The fitment of the 28V/3000 watt generator type 30-E-16-1C has necessitated the inclusion of an ammeter cut out and voltage regulator suitable for this capacity generator. Also suitable wiring outlets have been provided for the additional equipment such as the Polar Path Compass, Radio Altimeter, Trimetrogon Camera installation and the Kollsman Sky Compass.

Additional thermal circuit breakers for this extra equipment are mounted on the starboard side of the instrument panel.

The standard battery has been replaced by a 24V 34 amp/hour lead acid accumulator Type AN3150-2.

6. Radio Installations

(a) Radio Compass

The "Lear" radio compass Type ADF 14 modified to operate in the Aural Nul mode has been installed with the bearing indicator in the centre and the controls on the starboard side of the instrument panel. The radio compass loop aerial is corrected for quadrantal error for operation on 400 Kcs. (The frequency used at Mawson).

(b) Communications

A Transmitter-Receiver Type AN/ARC-2 is located immediately aft of the co-pilot's seat and is remotely controlled by the pilot using control unit Type C732A/ARC-2.

The transmitter-receiver is base mounted so that it can be easily moved forward, when required, to occupy the space normally taken up by the co-pilot's seat.

Radio control is kept by the pilot over the range 2 mc to 9.05 mc using either a fixed or trailing aerial type RL 42B.

The AN/ARC-2 is standard airborne communications equipment which provides pre-set multi channel two-way radio communications using CW, MCW or Voice.

(c) Radar Altimeter

The Radar Altimeter Type SCR 718 is completely mounted in a removable frame and is positioned in the second pilot's rudder control well with the indicator head so positioned as to be completely visible and easily read from the pilot's chair.

7. Navigation

(a) Directional Reference

To provide an accurate directional reference with a minimum of weight penalty the Bendix, Eclipse-Pioneer Polar Path System has been chosen. This system offers a precise directional gyro as well as a long term reference consisting of a miniature flux gate transmitter. However, owing to the unreliable magnetic information in Antarctica the flux gate is not used on Antarctic Operations.

Some difficulty was experienced in suitably locating the three components of the Polar-Path System in the Beaver and after considerable technical study of the problem the units have been located as follows:

The compass controller and Autosyn indicator are positioned on the pilot's instrument panel immediately to the left of the control pedestal. The directional gyro transmitter unit and the compass coupler are positioned aft in the fuselage at floor level on the starboard side between fuselage stations 90.0 and 104.0. The location of the units in this fashion, although not completely desirable from a weight distribution point of view, e.g. (weight 19.5 lbs. Arm 81.0" Moment (lbs-in) 1,580), appears to be the only possible method which offers accessibility for servicing.

(b) Heading Reference

The standard magnetic stand-by compass has been replaced by a fluorized compass Type E2A which is balanced for use in southern latitudes. The compass is bracket-mounted above the port upper windscreen. In addition, provision has been made for the installation of an Astro Compass MK 11 (modified to operate in the inverted mode). This instrument is bracket mounted centrally above the windscreen.

To reduce the work of the pilot on long range flights when a navigator is carried a "Kollsman" Sky Compass fitted with bracket type 1708-1 is positioned centrally in the top of the cabin at fuselage station 49.0.

(c) Drift and Ground Speed

This navigational facility is positioned at the window ledge of the starboard rear door and is operated by either the navigator or other crew members. The selected instrument is a Drift Recorder Sight MK2A with right and left hand rail slides.

8. Role Equipment

(a) Aerial Photography

The trimetrogon camera installation consists of three "Fairchild" Cameras Type K17B. These automatic cameras use roll film which produce a 9 x 9 inch negative; the lens cone has a F/6.3 lens of 6 inch focal length; all three cameras are controlled through a type 35/8 control unit.

The three cameras and control unit are mounted in a readily removable tubular frame which is positioned in the aft end of the cabin at fuselage station 63.3.

To compensate for the tail down altitude of the aircraft during flight the camera mounting frame is so designed that when the aircraft is in the rigging position the axis of each camera lens is inclined 4° forward of the vertical.

Two camera hatches with optical flats are positioned on the sides of the fuselage to accommodate the port and starboard oblique cameras and one beneath to accommodate the vertical camera.

The port and starboard camera hatches are vented with cold air to prevent moisture within the cabin forming frost on the inner surface of their glass optical flats.

To prevent fouling of the lower vertical optical flat from sea water thrown up during take off, the flat is covered with a disposable aluminium disc which can be released by the camera operator after the take off.

The positioning of this installation so far aft in the fuselage is dictated by the blanking effect of the floats. (It was found impossible to locate the cameras in a position that would avoid photographing portion of the floats). As it is, a portion of the float appears on the lower edge of the port and starboard photos, but this of course is not a problem when operating in the ski configuration.

To complete the aerial photographic installation a clinometer type DX/50163 is fitted to the camera mounting and aligned so that it is parallel to the axis of the camera. More recently this instrument has been duplicated at the pilot's position as a guide instrument to flight level. (See photos of camera installation).

(b) Field Support

Four type S2A supplying dropping racks, each capable of carrying a maximum load of 300 lbs., are fitted to the main plane, 2 racks on the port side and two on the starboard side. Each rack is fitted with adjustable scissor type load steadies and provision is made for individual or simultaneous electrical release of stores supplemented with a mechanical jettisoning system which can be operated in the event of electrical power failure. (For float plane operations the load at the supply racks is limited to 500 lbs. evenly distributed over the four racks).

The cabin floor is fitted with 42 anchor nuts at 9 inch pitch spacing and 12 truss head screws with cargo tie down rings attached are normally carried in the aircraft.

(c) Search and Rescue

The electronic search equipment is "Search and Rescue and Homing" (S. A. R. A. H.) Type TR8971. The Transmitter-Receiver is rack mounted and can be readily positioned in the aircraft cabin for operation by the crew members or navigator.

The aircraft search and homing aerials are of the wing tip mounted unipole type (aerial system Type 370A). This system consists of three light alloy elements mounted on the underside of each wing tip—a director, a driven unipole and a reflector.

In order to make possible the use of the normal carbon microphone a microphone alternator unit, Type 7157, has been fitted. (Normally S. A. R. A. H. is designed for magnetic microphones). This fitment obviates the necessity to change microphones during search operations.

9. Minor Modifications and Changes

(a) Two access steps to the mainplane are fitted on the port side of the fuselage, just forward and level with the bottom of the perspex in the pilot's entrance door.

(b) A handgrip is fitted on the upper surface of the centre section, positioned fore and aft along the centre line of the aircraft and approximately 10 inches aft of the upper edge of the windscreen.

(c) A soft leather gaiter is fitted around the tail wheel oleo strut and fuselage tail cone to prevent snow entering the tail cone.

(d) The control cable operating the winter nose cowl shutter has been reworked to incorporate push-pull control.

(e) The four bolts securing the float rear struts incorporate tie down fittings, and the tie down rings are fitted to the tying down and manoeuvring points on the mainplanes.

(f) The accumulator compartment door and opening has been slightly enlarged to accommodate the larger accumulator Type AN3150/2.

10. Colour Schemes

The aircraft is painted deep orange colour matching BSI Specification 381C Colour No. 591. The top section of the nose cowl is painted in flat black and the fuselage carries the normal registration identification symbols, as well as the ANARE insignia.

11. Fuel, Lubricants, Anti-Freeze Solution

The following is a list of the approved fuel and lubricants which have been successfully used throughout the ANARE Antarctic operations:

Fuel	Aviation Spirit 100/130 octane NATO Symbol F18. Specification MIL-G-5572B
Lubricant	Aviation Oil 80, MIL-L-6082
De-Icing Fluids	Ethyl Alcohol. De-Icing Fluid No. 1 MIL-F-5566
Protective Fluids	Protective Compound MIL-C-16173A " " MIL-T-5544A (For Aircraft Components, threads, shafts, etc.)
Grease	Aero Grease - MIL-G-3278A " " - MIL-L-7711 (Both for general use)
Hydraulic Fluids	MIL-H-5606A

12. Conclusion

Despite the difficult climatic and environmental conditions under which the ANARE Beavers are operated and maintained reports show that no great disparity from normal operations versus maintenance is experienced. The need to work in gloved hands reduces the mechanics' efficiency and increases the manhour requirement to about twice that of normal climates.

ANARE Beavers have flown approximately 225,000 nautical miles over the past six years of Antarctic operations, during which period the parts usage has been negligible and all of the additional systems described in this paper have functioned satisfactorily.

Appendix "A"

ANARE Survival Equipment

The ANARE Air Survival Packs are so developed that each aircraft permanently carries survival gear for its normal crew of two. The planned period for survival depends upon the operation but is never less than six days. A separate pack is added for each passenger carried.

The Aircraft Packs

Pack No. 1

	Quantity	
Ice pitons	10	
Carabiners	4	
Tent (3-4 man)	1	
Piton hammer	1	
Ice Saw	1	
Tie down pegs	8	
Tent (inner)	1	
Crampons	2 prs.	
Total Weight		38 lbs.

Pack No. 2

Signal panels	2	
Sun tan cream	2	
Torch (electric)	1 (spare batteries globes)	
Prickers, primus	3	
Mattress, onazote	4	
Medical Kits (personal)	2	
Ground Strips	8	
Knife Fork & Spoon set	2	
Dish (eating)	2	
Pots (cooking)	2	
Funnel (plastic)	1	
Toilet paper	1 roll	
Ground/Air code	1	
Flares, signal	6	
Stove, "Coleman"	1	
Matches	6 boxes	
Fuel, solid	6 tablets	
Stove (Solid fuel)	1	
Toothbrush	2	
Toothpaste	1 tube	
Candles	4	
Cigarettes	200	
Tablets (ascorbic acid)	2 bottles	
Total Weight		24 lbs.

Pack No. 3

Trousers, windproof	2
Jackets, windproof	2
Mukluks, assemblies	2
Socks, wool	4
Socks, cotton/wool	4
Mittens, ski	4
Wool cap	2

Pack No. 3 (cont'd) | **Quantity**

Goggles, snow	2	
Sweaters, wool	2	
Pyjamas, flannel	2	
Singlets, wool	2	
Gloves, heavy winter	2	
Underpants, wool	2	
Singlets, string	2	
Mukluk, inners (spares)	2	
Gloves, wool, inner	2	
Tissues, "Kleenex"	1 pkt.	
Total Weight		35 lbs.

Pack No. 4

Sleeping bags	2	
Sheets, sleeping bag	4	
Cover, sleeping bag	2	
Total Weight		25 lbs.

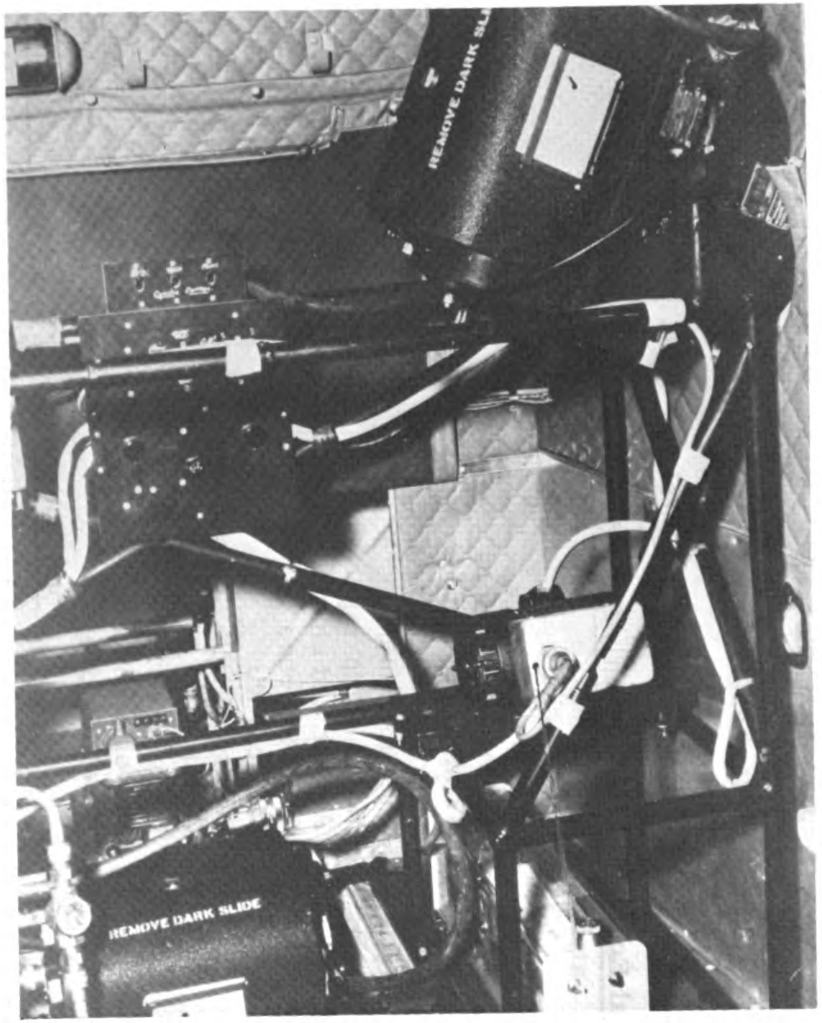
Pack No. 5 (The passenger pack)

Sleeping bag	1	
Sheets, sleeping bag	2	
Cover, sleeping bag	1	
Mattress, onazote	2	
Jacket, windproof	1	
Trousers, windproof	1	
Life jacket	1	
Crampons	1	
Total Weight		19 lbs.

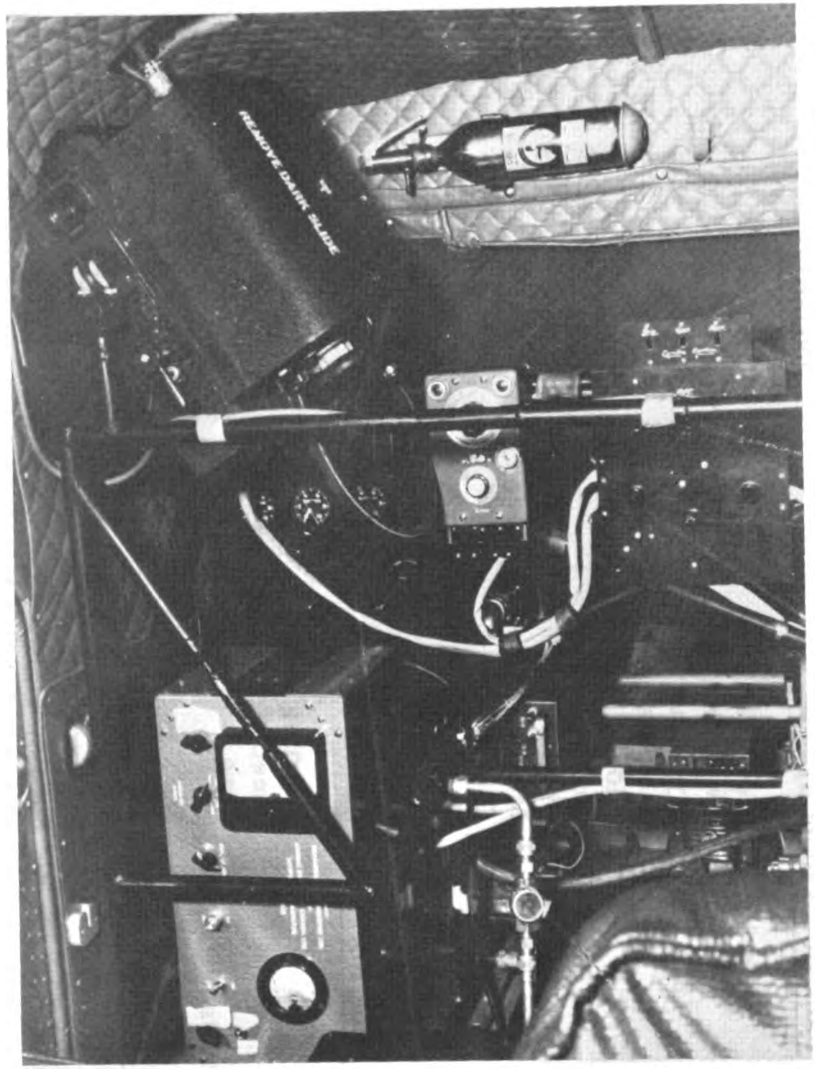
Survival Equipment Permanently Stowed in Aircraft

Life Jackets	2 = 5 lbs.	
3 man dinghy	1 = 58 lbs.	
Emergency rations	1 = 32 lbs.	
12 man/day rations	1 = 30 (inc. if passenger carried)	
Fuel for stoves	1 gln = 8 lbs.	
Water, drinking	1/2 gln = 5 1/2 lbs.	
Anchor and chain	1 = 14 lbs.	
Climbing rope	2 x 40' = 5 lbs.	
Medical Kit	1 = 1 lb.	
"Gibson Girl" Transceiver	1 = 26 lbs.	
Crash Axe	1 = 3 lb.	
Ice pick	1 = 1 1/2 lbs.	
Shovel, snow	1 = 1 1/2 lbs.	
Repelling line	120' = 6 lbs.	
Total Weight		196 1/2 lbs.

Note: On long coastal flights a small bore rifle and 50 rounds of ammunition are also carried.



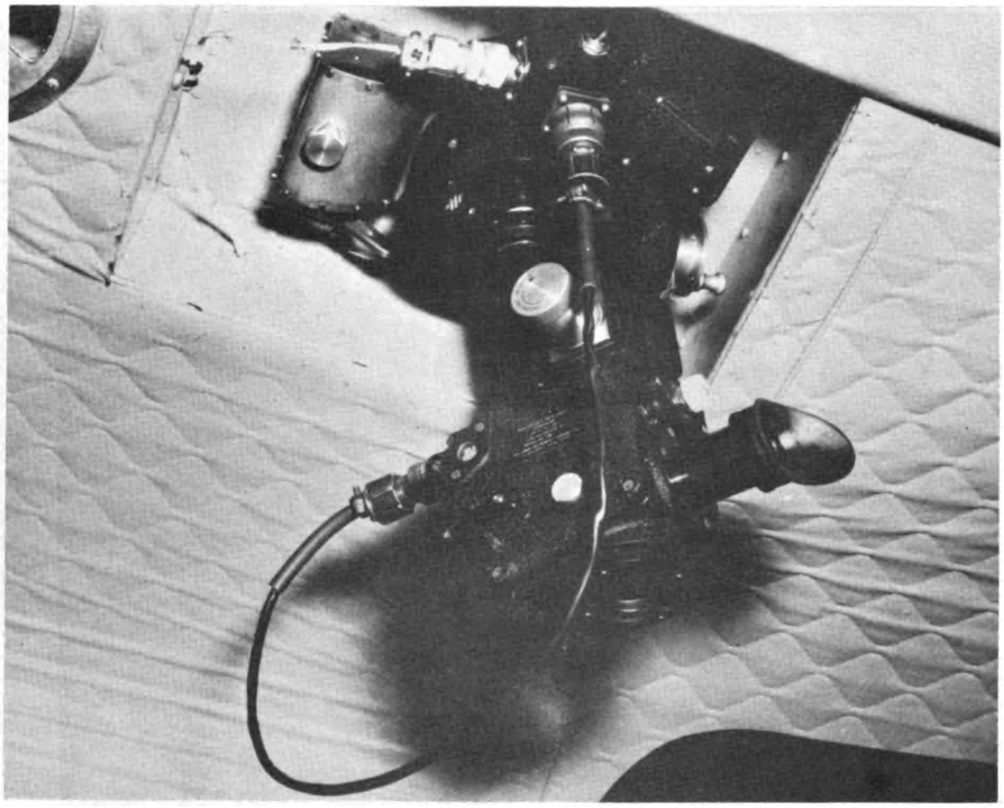
"Beaver" K17 trimetrogon camera installation, showing port oblique and vertical cameras.



"Beaver" K17 trimetrogon camera installation, showing starboard oblique cameras and type 35 control.

"Beaver" K17 trimetrogon camera installation, showing starboard optical flat.

"Beaver" K17 trimetrogon camera installation, showing vertical optical flat.



Beaver installation of the "Kollsman" type 2029B. Polarized sky light compass.

MOORING AIRCRAFT IN ANTARCTICA AGAINST STRONG WINDS

Philip Law

Introduction

Although aircraft of various types are widely used throughout Antarctica, hangars are seldom provided for their protection. In general they are tied down in the open and must be firmly anchored to withstand buffeting by high winds. Most aircraft, fitted with wind-spoilers, can be moored effectively by fairly simple methods to survive winds of up to 60 knots and, in many regions, wind velocities above this figure need not be expected. There are, however, places where winds up to 100 knots are fairly common and gusts beyond 130 knots have been recorded on a number of occasions. The problem of mooring aircraft safely on ice or névé in such places raises a number of difficult problems which normally are not encountered in usual aviation practice outside Antarctica. The object of this paper is to examine the problems involved and to suggest solutions.

General Principles

It is desirable that each of the following motions of the aircraft due to the action of the wind be controlled or prevented:

(i) overall lift, or bodily translation in a vertical direction;

(ii) overall horizontal displacement in the direction of the wind;

(iii) weather-cocking, or the rotation of the aircraft in a horizontal plane as the gusts of wind vary in direction;

(iv) wing-tipping, or the rotation of the aircraft in a vertical plane;

(v) wing-flapping.

The problem will vary according to whether the aircraft is tethered on rock or on ice or on névé, and will be somewhat different for an aircraft mounted on wheels from one on skis. The solutions, too, may depend upon whether the machine is to be temporarily moored pending further flights within a few hours or whether it is to be tied down for a fairly long period.

In most Antarctic regions strong winds come only from one sector, varying in direction through an angle of less than 120°. In some places the direction of hurricane winds can be restricted to within 60°. The solutions set out below do not apply to the case where strong winds can blow from any direction without warning.

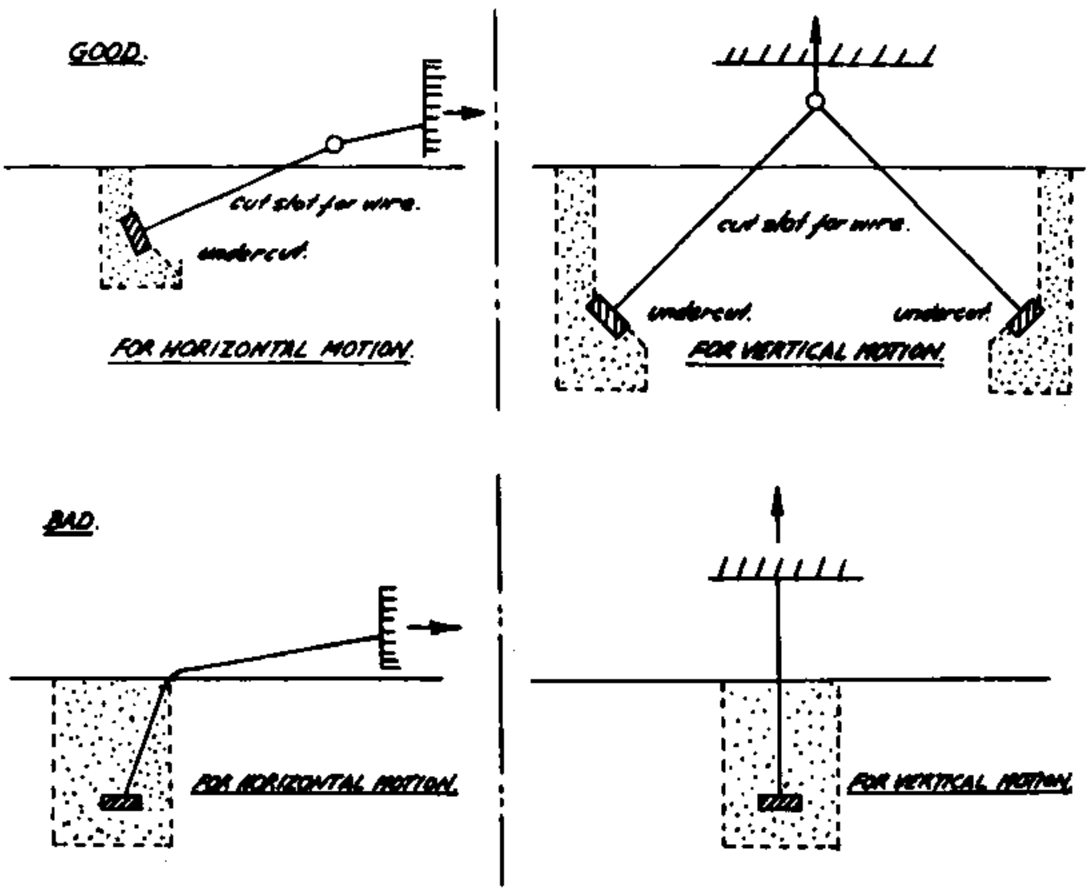
An anchorage is only as strong as the tie-down point on the aircraft. In exceptional winds a light aircraft could be buffeted to pieces or torn from its moorings with no failure of the anchorages or mooring cables if the structure of the machine itself were not strong enough to withstand the forces applied.

First class rigging is essential in all tying down. Strengths of cables and shackles should be properly assessed and allowances should be made for the decrease in strength that occurs at low temperatures. It should be remembered that thermal expansion will slacken steel cables as temperatures rise. Steel wires should be spliced if joins are required and kinks and sharp angles should be avoided. If a number of weak cables are to share the strain at an anchorage in place of one strong cable they must be adjusted to equal tension, otherwise the stress may come on each separately and they will then snap one by one.

Anchors must not be capable of being pulled out. It is easy to ensure this with eye-bolts fixed into rock, but much harder with "dead-men" sunk into ice or névé.

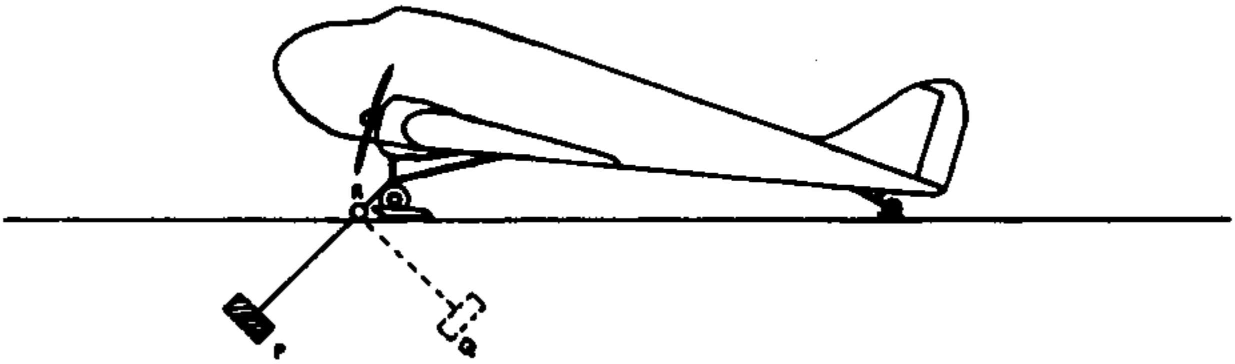
The mooring system should be arranged so that minor anchorages will never have to take stress intended for major anchorages, and every different type of motion to be controlled should preferably have a separate anchorage.

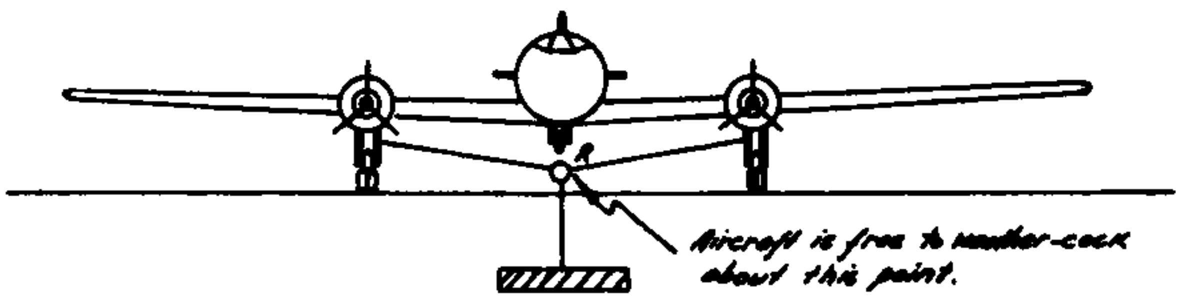
The following diagrams illustrate the desirable features of a good "dead-man" anchor in névé or ice:



An Anchorage for Moderate Winds or for Temporary Safety

In moderate winds (up to about 60 knots) it would seem that the best general-purpose tie-down is a single anchorage that will control movements (i) and (ii). If mounted on skis and resting on ice the aircraft will be able to swivel or weather-cock to a certain degree in order to follow small changes in the direction of the wind. The greatest danger would be from a side gust which might tip the plane over on its wing-tip. The method of anchoring would be:





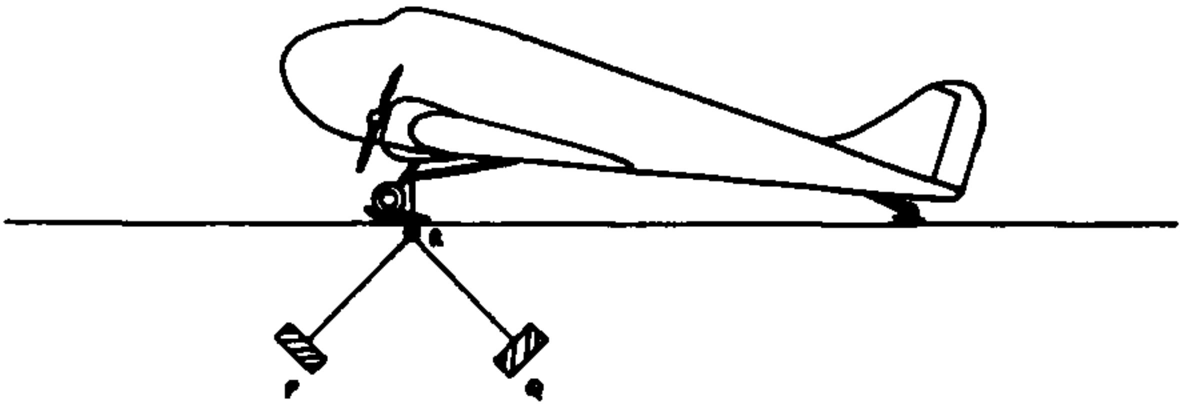
An anchor is sunk at P with an anchoring ring at R midway between the wheels. Extra strength can be achieved with a second anchor at Q if desired. The tie-downs are attached to R from the wheel brackets above the oleo cylinders. With a permanent anchorage, the plane taxis up to R and cables are shackled onto the anchor ring and onto the wheel brackets. For a temporary mooring in lighter winds it may be sufficient to place a heavy weight at R and to tie down to it instead of installing "dead men" as at P and Q. Wing-tipping could be controlled by portable heavy weights placed under the wings and attached to them by slack cables.

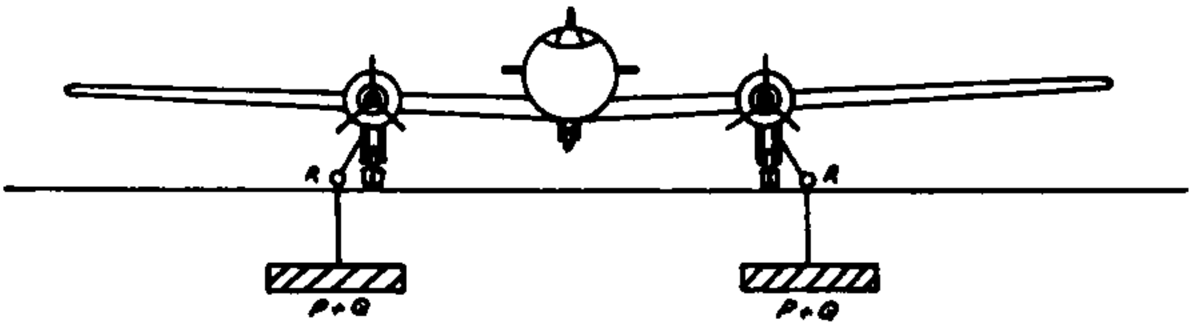
A Permanent Anchorage for Safety in High Winds

In hurricane type winds the gusts may vary in direction as much as 40° each side of the main wind direction. The rapidity of these fluctuations is such that the aircraft cannot swing fast enough to follow them, so there is no point in providing freedom for weather-cocking. Also, movements (iv) and (v) assume much more dangerous proportions and must be controlled.

For such conditions it would seem that a number of anchors, controlling every form of motion from (i) to (v), should be provided. The method of anchoring the aircraft would then be:

To Control Movement (i)

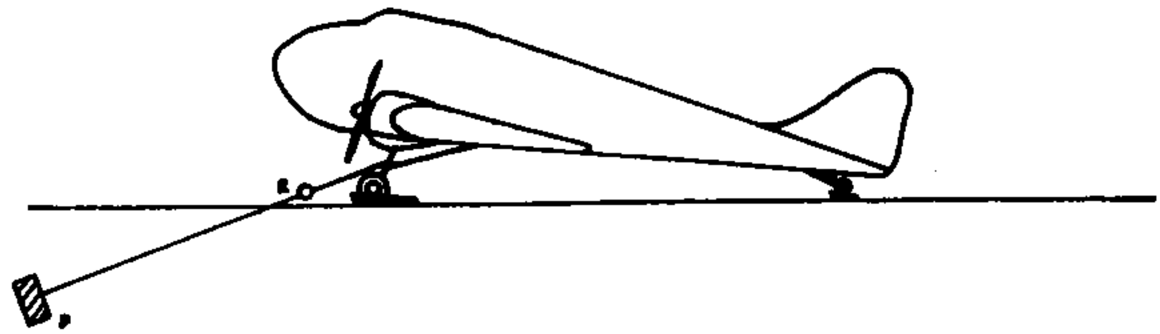


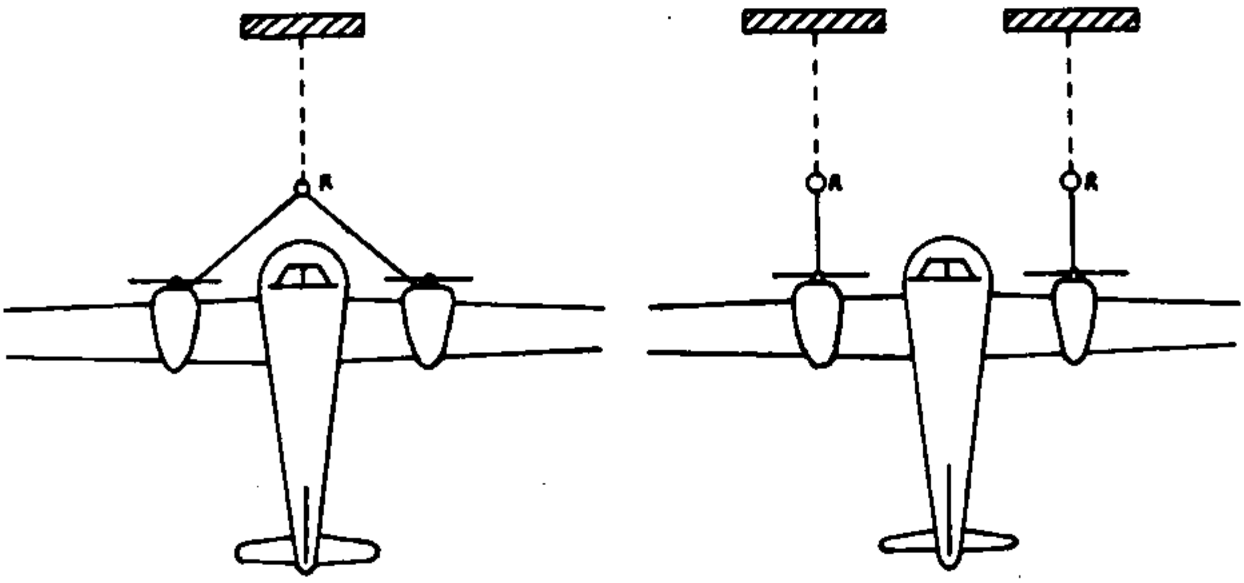


The permanent anchoring ring R is held by two dead-men P and Q. Cables from R are shackled to the wheel brackets on the outer sides above the oleo cylinders. This gives good control of movement (i) and (iv) and some control of (ii) and (iii). Movement (i) should be reduced also by fitting wind spoilers to all lift surfaces.

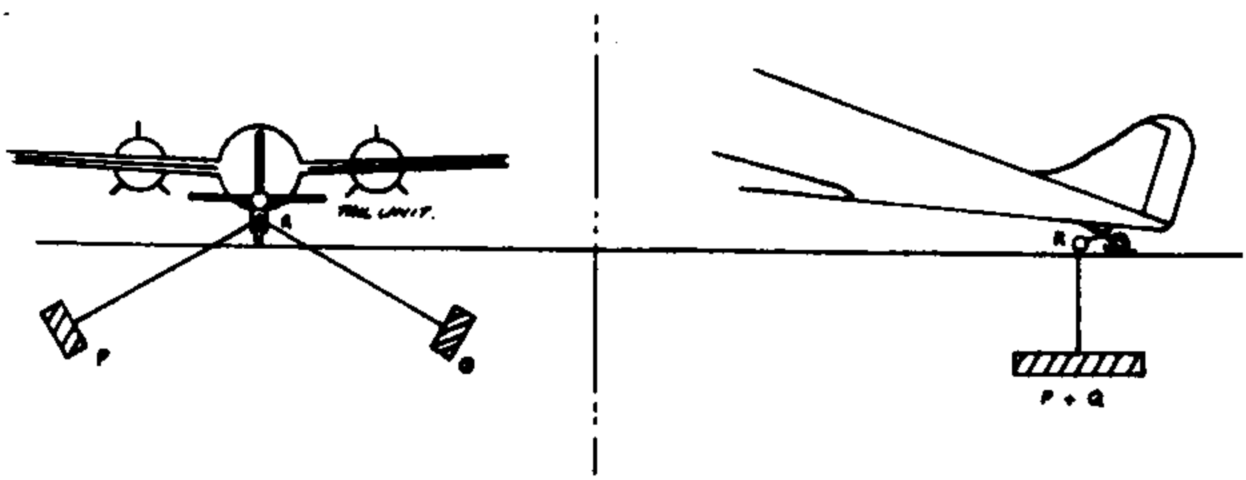
To Control Movement (ii)

This is the most important anchorage and must be designed to bear the greatest load, namely the full blast of the wind on the plane tending to blow it downwind. So long as this anchorage holds the plane cannot be lost, even though it may be damaged. The anchoring ring R should be well forward of the aircraft and cables should shackle it to the wheel brackets. Single or double anchoring rings and anchors can be used. The double method gives control of movement (iii) as well as (ii).





To Control Movement (iii)

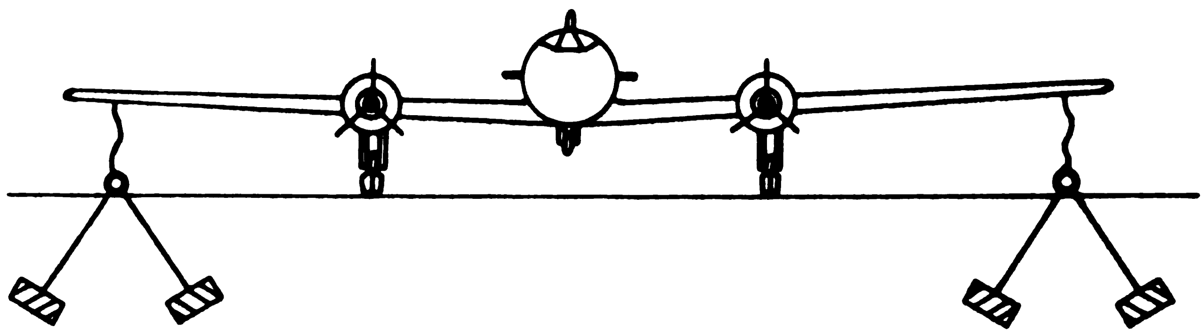


The tail is anchored. The anchoring ring R should be tied to the rear wheel bracket and perhaps to the tail ring as well. The tail ring alone is not strong enough.

To Control Movement (iv)

The method shown for controlling (i), in which each wheel is anchored on the outside, appears to be the only reliable way of controlling (iv). Control of (v) as shown below will help, but the wings are not strong enough to allow wing-tip anchorages to control completely the wing tipping motion.

To Control Movement (v)



Limited use may be made of wing-tip anchorages. The ties from R to the wings should be left slack to allow the wings to move six or twelve inches. Alternatively, fairly heavy concrete blocks resting on the ice surface beneath the wings may be attached by tight ties to the wings. They would no doubt be lifted by strong gusts but would exert considerable restoring force to a rising wing-tip.

Supplementary Methods of Protection

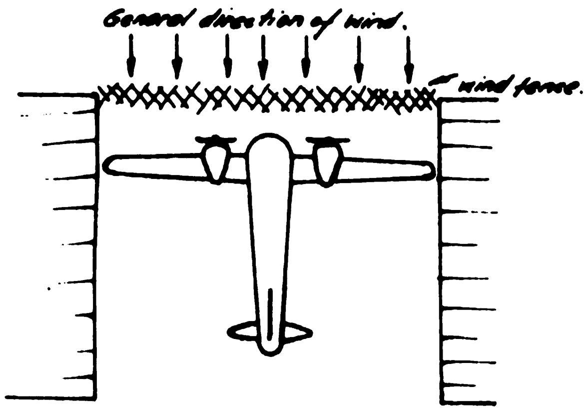
The Wind Fence

A wire net fence with a mesh from 1/2 to 1-1/2 inches will reduce the velocity of high winds by producing turbulence in the lee of the fence. The effort is negligible at low wind speeds but the reduction becomes progressively greater as the velocity increases. For winds in excess of 80 knots such a fence provides considerable protection for an aircraft moored behind it. The fence must, of course, be strongly constructed and adequately guyed, for a broken piece of fence hurled by the wind against the aircraft could cause major damage.

Because the wind velocity behind the fence is never reduced below 40-50 knots, drift snow will not accumulate in the lee of the fence.

The Wind Chute

One of the major problems with hurricanes is the variation in direction of the wind gusts and the danger to the aircraft of blasts from the sides. To reduce this danger it is suggested that banks of snow or ice might be built on each side of the tethered aircraft, in the general direction of the wind, to a height a little greater than that of the aircraft. The entrance to the corridor so provided should be protected by a wind fence.



General Precautions

Wind spoilers should be fitted to wings.

Control surfaces should be locked with external chocks.

The rudder should be removed. (It can be stored inside the aircraft.)

If there is a rear slinging point on top of the fuselage, a bridle from that point to anchorages in the ice on each side will give added protection against weather-cocking.

If the aircraft is parked on névé it should rest on skis which, becoming drifted over with snow, help to hold down the plane.

Wheels should be raised off the surface so that standing for long periods on the snow will not produce "flats" on the tyres.

If parked on ice, the aircraft should stand on its wheels which should be chocked with contour blocks, tied together and pinned to the ice.

REPORT ON AIRCRAFT OPERATIONS
JAPANESE ANTARCTIC RESEARCH EXPEDITIONS

Noboru Itoh and Seiki Watanabe

Introduction

This report provides information concerning aircraft operations carried out by Japanese Antarctic Research Expeditions during the period 1957-62 and has been prepared in accordance with the circular dated March 15, 1962 on Logistics Symposium at Boulder, Colorado, U.S.A., August 13-17, 1962.

1. General Description

The initial duties assigned to aircraft in the beginning days of Japanese Antarctic Research Expedition were to assist "Soya" in its navigation and to survey topographical features as well as ice conditions. However, because of the experience of the 1958 when caterpillar cars were found unworkable due to adverse ice condition, the furnishing of transportation to the Syowa Base was added to these duties. Consequently, beginning with the 1959 expedition, such transportation work became a most important duty of aircraft.

Despite the added problems caused by accommodating large-sized helicopters on the limited space aboard the "Soya" and transporting a sufficient quantity of materials to the Syowa Base under polar conditions, our aircraft performed their duties satisfactorily all through the 1959-62 Expeditions. It is now an accepted conclusion that no facilities other than aircraft can fulfil the requirements of the transportation service between "Soya" and the Syowa Base.

A topographical survey was made during 1957-62, covering the area from 37°E Long to 45°E Long. Conditions in the polar area were generally not good for air flight, but the duties were completed in safety.

2. Aircraft Used and the Work Performed

Year	Aircraft Carried	Work Done by Aircraft	Remarks
1957	2 Bell 47-G	Helicopters served mostly in such assistance work in the frozen sea navigation as the survey of water way and communication between "Soya" and the base.	
	1 Cessna 180	Airplane served mostly in the observation and photographing work of the continent coast.	
	1 Bell 47-G	Served in the survey of water way	Carried by m/s "Umitakamaru"
1958	2 Bell 47-G	Navigation and piloting for "Soya"	
	1 Beaver DHC-2	Picked up wintering personnel from the Base	
1959	2 Bell 47G-2	Bell 47G-2 served exclusively in navigation and piloting.	
	2 Sikorsky S-58	Sikorsky S-58 served mostly in the transportation of personnel and cargo between "Soya" and the Base.	
	1 Beaver DHC-2	Beaver served in aerial photo.	
1960	2 Bell 47G-2	Bell 47G-2 served piloting vehicles on sea ice.	
	2 Sikorsky S-58	Sikorsky S-58 served in the transportation between the Base and "Soya"	
1961	2 Bell 47G-2	Bell 47G-2 served in navigation and piloting.	
	2 Sikorsky S-58	Transportation and geographical survey along the coast.	
1962	2 Bell 47G-2	Bell 47G-2 served navigation and piloting.	
	2 Sikorsky S-58	Transportation and geographical survey along the coast.	
	1 Cessna 185	Aerial survey	Served as a skiing plane stationing at the Base.

3. Air Transportation

Beginning with 1959 Expedition, air transportation became the most important function of the air services. From that time on, 92% of the total amount which was carried into the Syowa Base during the period of 1959 to 1962 was done by Sikorsky's. The detail is shown below:

	1959	1960	1961	1962
Transportation flights made	58	103	98	28
Tonnage transported	60 tons	126	121	41
Total flight hours in transportation flight	141 hr 44 min	132 hr 10 min	131 hr 05 min	75 hr 50 min
Longest transportation distance	113 miles	87	67	114
Shortest transportation distance	78	40	48	70
Average transportation distance	86	46	54	98
Numbers of staff who wintered	14	15	16	The Syowa Base closed

The Sikorsky S-58 was assigned transportation. Most of the material transported was carried inside the plane. On occasion, however, when it was unavoidable, some material was hung outside the plane, such as in the case of some 24 items including the fuselage and main wings of the Cessna (in a container), the bodies of snowcars, and the sleigh. The heaviest such item weighed 2,490 lbs. When the structural materials and the Cessna's wings were carried by hanging them outside the plane, instability was encountered during flight. What was most worrisome was the hanging outside, of the Cessna fuselage but, hanging without main wings (i.e. weighing 1,373 lbs.) and with the speed of about 60kts., the flight was maintained in a very stable condition throughout the total 111 nautical miles which were covered in 2 hours and 10 minutes.

4. Principal Facilities for Aircraft

4.1. Facilities aboard "Soya":

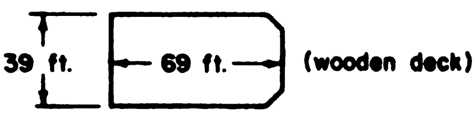
4.1.1. Aviation control room: Situated at the rear of the bridge and equipped with communication devices. All the instructions to and controls on aircraft were issued from this room.

4.1.2. Wireless communication devices for air service:

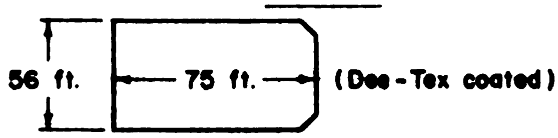
300 W HF transmitter	x 1
30 W VHF transmitter	x 1
500 W transmitter (for beacon)	x 1
All wave receiver	x 1
Medium and short wave receiver	x 1

4.1.3. Flight deck: Installed at the rear of the upper deck for the departure and arrival of helicopters. Reconstructed during 1958 for large-sized helicopters.

1957-8



1959-62



4.1.4. Hangar: Installed at the forepart of flight deck to accommodate 2 Bell type helicopters, measuring 19 ft wide, 49 ft long and 12.5 ft high. But only in the 1957/8.

4.1.5. Fuel tank: Installed for accommodating Sikorsky helicopters since the 1959 Expedition. 2 gasoline tanks (displaceable with sea water) with the capacity of 8,400 US Gal. and with powered supply pumps of the flow of 26.5 US Gal. per a minute. For aircraft other than S-58, fuel was supplied from drum containers.

4.1.6. Light beacon: A white arc (500W) light beacon was set on the top of front mast.

4.2. Facilities at the Syowa Base and on the sea-ice:

4.2.1. Heli-port on the sea-ice: Selected a big ice floe capable of supporting loading of aircraft and materials, and large enough to permit the departure and arrival of aircraft. After bringing "Soya" alongside thereof, laid a bedding, as shown by the drawing above, with lumber 7 inches square and wooden plates 2.5 inches thick so large-sized helicopters could depart and arrive there. The dimension of the ice floe ranged from 6,000 ft^2 to 60,000 ft^2 with a thickness of 8-30 ft.

4.2.2. Heli-port at the Syowa Base: A vacant space located about 150 ft west of the Syowa Base was selected to be the heli-port, at which 2 Sikorsky helicopters could depart and arrive. In stormy weather, however, helicopters were transferred into a cave about 800 ft from the Base and supported firmly by hooks into the ground, and with their blades folded in.

4.2.3. Strip at the Syowa Base: The strip was set on the sea-ice surface about 1,800 ft north-east of the Base, with a length of 950 ft and a width of 90 ft, and with a runway set at 53°. Here the surface was smoothed and signs were erected.

Aircraft were moored by "deadman" and ice-hook on the sea-ice about 300 ft northward from the base so that they could stand blizzards. Also, bamboo hurdles were laid between skii sleigh of the airplane and ice surface.

4.2.4. Radio communication facilities for air service at the base:

400 W RF transmitter x 1 (for general use)
All wave receiver x 1 (")
10 W VRF portable transmitter-receiver x 1

5. Meteorological Conditions Pertaining to Air Activities Around the Syowa Base

5.1. The Syowa Base is situated between the oceanic high pressure from middle latitudes and the cold high pressure from the Antarctic Continent, and is frequently attacked by low pressure. Sometimes, it is also covered by continental or mobil high pressures.

5.2. In summer, the continental high pressure are prevailing December above the Syowa Base and bring there fine weather for several days at a time. In January, the continental high pressure is replaced by the low pressure, which moves against the base with increasing frequency, spreading a stagnating front around the base. Toward middle February, the base is again surrounded by continental high pressures, usually providing continuous fine weather, but sometimes stormy snow moves in consequence of the low pressure growing up around it. In March, such stormy snow becomes less frequent but the temperature declines drastically.

5.3. The state of fog was as follows:

5.3.1. The radiant fog of a high pressure nature was seen mostly in the nights of middle January to February. This was, however, thin and mostly used to disappear in daytime.

5.3.2. When there was a developed front, an extensive fog was observed along the front covering 20-30 nautical miles in width. The peak of this fog was very high, there was a danger of icing.

5.3.3. Fog was also observed above open waters and elsewhere even when there was no developed front. In most cases, however, this was only partial and easy to avoid.

5.3.4. As mostly seen in the area of the 60°/65°S Lat., the fog caused between open sea and air mass continued for a long time and extensively above sea.

5.4. There was no difficulty experienced by wind alone. Continental descending winds sometimes blew from 0600 hr until 1200 hr in local time at the base with the speed of 20 to 30 knots, and this phenomenon was often seen when high atmospheric pressure was stagnant in the vicinity of Enderby Land. When the upper winds were within the continental high pressure, they were at the speed of less than 10 knots in south to southwest directions up to a height of 10, 000 ft.

5.5. "Soya" always approached from the north of the Syowa Base, but was always interrupted on her way by hard ice. She was compelled to use helicopters in making airborne transportation from 40 to 114 miles away from the base. The biggest problem that caused trouble in flight was, however, the front that was stagnant to the north of the base. Sufficient precaution was taken against the icing of aircraft, but still the rotor blades of Bell type helicopters were frozen twice.

During the flight, slight whiteout was encountered two or three times, but there was no trouble caused by such whiteout.

We conducted airborne transportation between "Soya" and the base by means of Sikorsky helicopters during the period January to February. During this period only about 40 per cent of the total number of days was available for flight, at least one flight. In terms of hours, the percentage was about 10 per cent. As for the weather, there was a tendency that the closer we approached the base, the more fine days we had.

6. Maintenance

6.1. Helicopters: During the 1956-58 expeditions the helicopters were carried on board "Soya" in the hangar without being given any anticorrosive treatment and so, they were operated now and then during the voyages in order to prevent rusting. From 1959 expedition through 1962's, however, S-58 type helicopters were carried on board and the hangar was removed. Anticorrosive measures were needed for all the aircraft. S-58's were placed on the weather deck in the fore part of the flight deck and the Bell's were put in the container on the flight deck. From the 1960's on, one of the Bell's was put in the ship hold.

6.2. Airplane: These were always carried on the fore deck after anticorrosive measures were taken. On the 1956 expedition, "Soya" encountered a typhoon en route to the Antarctica, causing damage to part of the airplane, there was no other trouble, however.

6.3. Pre-warmer: Herman-Nelson heated air blower (400, 000 BTU) or Gokotype heating machine (120, 000 BTU) was carried on board. S-58's were equipped with a 200, 000 BTU heater with winterization kit. The cold did not cause any significant hindrance as far as summer operations were concerned.

THE OPERATION IN ANTARCTICA OF LIGHT AIRCRAFT BY THE R.N.Z.A.F.

W. J. Cranfield

1. Introduction

The R.N.Z.A.F. Antarctic Flight was formed on 1 May 1956 to provide air support to the New Zealand Party of the Trans Antarctic Expedition and was reactivated on 1 April 1959, to support the Antarctic Division of D.S.I.R., with its field work in the Ross Sea Dependency. The Flight operated from Scott Base on Ross Island using an Auster and a Beaver Aircraft. The task briefly consisted of:

(a) Reconnaissance of the ice pack to locate suitable routes for the expedition ship.

(b) Reconnaissance of the Antarctic Continent to locate suitable bases and routes for land parties.

(c) Air supply of land parties and depots.

(d) Oblique photography of specified areas.

2. Aircraft

(a) Auster MK VII

Construction. The Auster has a welded steel tube fuselage. The wings have wooden spars and light alloy ribs. All surfaces are fabric covered.

Engine. DH Gypsy Major 7G unsupercharged developing 145 BHP at sea level.

Propellor. Two bladed metal Fairey Reed type fixed pitch.

Dimensions.	Wing Span	36 ft
	Height	8 ft 8 in
	Length	23 ft 2 1/2 in
	Cabin Length	8 ft 10 in
	Cabin Height	4 ft
	Cabin Doors	2 ft 6 in x 3 ft

Weight	Tare Weight as a Float Plane	1800 lbs
	Tare Weight as a Ski Plane	1565 lbs
	Maximum all up Weight	2450 lbs
	Maximum all up Weight used during operations	2581 lbs

Fuel Capacity.	Two wing tanks each of 16 gals	32 gals
	One external tank fitted below cabin	13 gals
	Total Capacity	45 gals

Performance: Ski Plane

Rate of Climb at Sea Level	520 FPM
Cruising Speed at 5000 ft	89 Kts TAB
Absolute Ceiling	11500 ft
Range Still Air	534 NMS

Skis. Laminated Wood Construction soled with bakelite.

Special Modifications

(i) Oil dilution system.

(ii) Engine driven generator 24 volt 500 watt

(iii) Plessey cartridge starter

(iv) Radio equipment consisting of 1 Marconi AD97/108 HF transmitter/receiver with an eight crystal tuning unit and a drogue type trailing aerial. This radio could transmit and receive RT, CW or MCW. 1 Marconi AD7092 Radio Compass.

(v) Full blind flying instrument panel.
(vi) Oil cooler removed.

(b) Beaver

Construction. The Beaver is of all metal construction.

Engine. Pratt and Whitney Wasp Jnr. 450 BHP. Supercharged.

Propellor. Hamilton standard, two blade constant speed counterweight propellor.

Dimensions.	Wing Span	48 ft
	Height	10 ft 7 in
	Length	30 ft 4 in
	Cabin Length	9 ft
	Cabin Height	4 ft 3 in
	Cabin Doors	3 ft 3 in x 3 ft 4 in
	Cargo Capacity	134 cubic ft
Weight.	Basic Weight	3877 lbs
	Maximum Landing Weight	5100 lbs
	Maximum all up Weight	5500 lbs
	Maximum all up Weight used during operations	5705 lbs

Fuel Capacity.		
	3 Main fuselage tanks	79 gals
	Wing tip and long range tanks	72 gals
	Total Capacity	151 gals

Performance as Ski Plane

(Straight Skis) Rate of climb at sea level	1020 FPM
Cruising speed at 5000 ft at maximum continuous weak mixture	108 Kts TAS
Service ceiling	18000 ft
Maximum range still air	860 NMS

Skis. Metal alloy soled with polyethylene. The main skis being fitted with three narrow nylon runners.

Modifications

(i) Two supply dropping racks could be fitted to each wing.

(ii) F24 Camera installation.

(iii) Similar radio equipment as in the Auster with the addition of a SARAH receiver. When the flight was reactivated an emergency VHF set was installed.

(iv) Winter engine nose shutters.

(v) Bendix Polar Path Gyro Compass.

(vi) Astro Compass.

(vii) Drift Sight.

3. Period of Operations

During the Trans Antarctic Expedition the two aircraft flew in the period from 15 January 1957 till 28 February 1958. The Auster was kept in a serviceable state for the whole of this period while the Beaver was placed in storage for the winter from 13 April 1957 till 7 October 1957.

When the Flight was rectivated both aircraft started operations on 18 December 1959 and finished with the Auster on 28 January 1960. The Beaver crashed and was written off in the area between the Asquith and Beardmore Glaciers on the 15 January 1960.

4. Aircraft Operations

(a) Flying Operations

(i) Planning. As the Beaver was the only aircraft which could carry a reasonable payload over the distances that the field parties were working from Base, the whole plan of air support was based on its performance. As the range of operations became more extended it was obvious that a method of relaying would have to be used. This was necessary for the following reasons.

(A) Small payload possible on a long flight due to the fuel load required by the aircraft.

(B) The rapid changes in weather conditions that happened over a long route and particularly the changing conditions at the destination. The weather fluctuations could cause abortive flights that would be both time consuming and wasteful of fuel.

(C) The shorter turn-round time with greater payloads from a relay depot would release the field party receiving the supplies earlier for further field work.

During the T. A. E. two relay depots were established. One was at the mouths of the Darwin and Barne Glaciers and the other at Cape William Henry May. The distances from base to these depots was 142 NMS and 250 NMS respectively. The direct distance from these relay depots to the positions at which the supplies were required was 135 NMS and 141 NMS respectively, as opposed to flying direct from Base 250 and 390 NMS. The risk of operating a single aircraft without a second aircraft of comparable performance, as a back up, was accepted as the USN at Hut Point accepted the Search and Rescue commitment.

The Auster's original task was to act as a spotter aircraft on floats to find a suitable route for the expedition ship through the pack ice. Unfortunately a wing was severly damaged when the ship was sailing from New Zealand and it was never used in this role. The Auster was used for reconnaissance work up to 100 NMS from Base.

(ii) Weather. The flying season started in September and finished at the beginning of April. However, weather conditions did not settle until mid October when the ground temperatures started to rise above -30°F at Base. November and December proved to be the best months with light winds and clear skies predominating. In January, the temperature reached its hottest and then began to decline with unsettled weather following—fogs, strong winds and overcast skies. February was marked by a sharp drop in temperature with unsettled weather and several blizzards, whilst in the mountains, strong local Katabatic winds were experienced. By April temperatures had fallen to where outside maintenance on the aircraft became most unpleasant and blizzards were more frequent. Strong Katabatic winds were experienced in the mountains separating

Victoria Land and the Ross Sea Dependency in September, October, February and April.

(iii) Navigation. Grid navigation was used. The standard meridian chosen for this grid was 160E as this meridian was approximately in the centre of the area of operations. The Chart Scale was 1:1, 500, 000. An Astro Compass was used in the Beaver to find the true heading from the sun's azimuth and from this the grid heading of the aircraft was calculated. In the Auster true headings were obtained from a specially constructed sun's azimuth table and it was necessary to steer the aircraft directly up sun to obtain a heading check. The Bendix Polar Path Compass was used in the gyro mode for maintaining the grid headings and at no time did this instrument precess more than 1° an hour. Heading checks were carried out every 30 minutes. The drift sight was rarely used as it was necessary for the pilot to lower his head to read this instrument while ground definition was often not clear enough to get an accurate reading. An airplot was maintained by the pilot at all times. Drift could be fairly accurately assessed by using the aircraft Ski as a datum line and wind velocities were found by the following method:

(A) At a suitable ground feature the airplot was discontinued.

(B) Fly aircraft for 3 minutes from this feature on a heading at right angles to the estimated wind direction.

(C) At the end of 3 minutes turn through 180° and fly that heading for 3 minutes.

(D) Turn towards the ground feature and time the run into overhead. The Gyro heading is the grid wind direction.

(E) Calculate wind speed from the following formula

$$\frac{TAS \times t}{T + t}$$

When T = Total time of outbound and reciprocal headings.
t = Time in minutes of the final run into the ground feature.

It was found that an airplot could be maintained for five hours without an accurate pinpoint being obtained, provided a new wind velocity was found each hour. The resultant estimated elapsed time for the flight would not vary by more than 5 minutes and the distances off track at destination would not be more than five miles. However, it was necessary to be flying over prominent land features to be able to find a wind each hour.

Precomputed sunlines were used with success, with the lines drawn through the depot positions. This method was used for the two depots which were 90 NMS out on the Polar Plateau. The method was:

(1) Find the local wind at the plateau edge.

(2) Navigate to a DR position eight miles up sun of the depots position.

(3) Intercept the sun line through the depot on the Astro Compass at the DR position and then turn the aircraft down sun. The aircraft would then pass very close to the depot.

This method required the sun to be either north or south of the depot.

(iv) Flight Planning. Normal flight planning action was carried out converting the forecast W/V to a Grid W/V and one hours reserve fuel was always carried for search or holding at destination. A duplicate flight plan was always lodged with the base radio operator. Whenever a landing was planned away from base there usually was a field party at that position, whom at least 1 hour before the projected flight passed an actual weather observation and thereafter maintained a listening watch on the aircraft frequency until it arrived. The aircraft always called base before landing and again once it was on the ground. As snow is a dielectric radio communication with base was always maintained once the aircraft had landed providing the trailing aerial was left out.

(v) Position Reports. Position reports were passed every 30 minutes and contained the following information:

Position
Time
Altitude
R.A.S.
Grid Heading
Flight Conditions
ETA Destination
Any other pertinent information

(vi) Ground Control. A full radio log of all transmissions to and from the aircraft was maintained by the base radio operator from which an airplot could be constructed if required for Search and Rescue operations.

(vii) Homing Aids

(A) SARAH. A light weight SARAH receiver was fitted to the Beaver which presented the transmission of a small beacon as a blip on a cathode ray tube relative to a centre line. The presentation gave direction to the beacon but not range. All field parties carried a beacon which transmitted on slightly different frequencies so that each beacon could be tuned in separately for homing purposes. Ranges of approximately 5 NMS were obtained on the Polar Plateau when the aircraft was 1000 ft above the surface. However, when the aircraft could be flown at 5000 ft above the surface, ranges of 30-40 NMS could be expected.

(B) MF Homing. The N.Z. Tractor Party in 1957 carried a modified SCR 274 transmitter as a radio compass beacon operating on 1580 Kcs. Using a ladder mast this beacon had a useful range of approximately 15 NMS. However, to obtain reasonable bearings the aircraft trailing aerial had to be wound in as it upset the radio compass sense aerial. This precluded any HF transmissions from the aircraft and as the tractor party could not transmit on HF when the beacon was in use this homer proved of very limited value.

(viii) Emergency Procedures

(A) Radio Failure. If radio communications were lost with base and not re-established within 30 minutes and the aircraft had not passed its point of no return, it returned by its outbound track to base. If radio communications were lost near its destination or after leaving its destination the aircraft continued to its original flight plan. In the event however, radio communications were always maintained and CW had to be reverted to only on ten occasions.

(b) Weather Closure

If the weather precluded landing at the destination and or the base, the aircraft was to be landed in the most suitable area available and a camp established until the weather conditions improved. Radio watches would be established with base and all necessary information would then be passed.

(c) Survival

Survival equipment was carried in each aircraft to enable the survivors to exist for fifteen days. These survival packs were based on a two man crew and if more passengers were carried extra survival equipment had to be taken. The following list of survival and picketting gear was carried in the Beaver:

Survival Pack	1
Tent Survival 2 man	1
Poles tent dural	6
Pegs 9" dural	12
Pins Wire No. 8	10
Bag tent	1
Bag pegs	1
Crampons instep	2 prs
Brush snow	1
Goggles snow	2 prs
House Wife	1
Socks knitted	2 prs
Mitts leather	1 pr
Mitts woollen	1 pr
Primus No. 41	1
Spares Primus No. 41	1 set

Burner Borde Petrol	1
Stand for Burner Borde	1
Fuel Tablets 'Profol'	2 sets
Funnel	1
Matches Nestor Waterproof	6
Candles	6
Canteen Trio	1
Mugs 1 pint	2
Knife fork spoon set	2
Rations Mk. 5 Universal Component and Land Mass Supplement (2 tins per set)	6 sets
Dye Marker (Calcocid Orange Y Ex. Conc.)	1 bottle
Heliograph	1
Emergency Ground/Air Code	1
Distress smoke Orange Hand held Mk. 1 mod 1.	6
Strips Signal red	1
Bags Sleeping Down	2
Suits Down	2 sets
2 Kit Bags	2
Knife Sheath with Steel	1
Shovel (lightweight)	1
Axe Ice	1
Ropes picketting Nylon (alpine)	2
Receiver Diplomatics Mk. 301	1
Container 1/2 Gal polythene filled with kerosene	2

Equipment Stowed in Aircraft

Mattress Plastic	2
Picketting Gear	1 set
Locks Control	1 set
Sextant Mk. 5	1
Reduction Tables	1
Air Almanac	1
Gibson Girl Modified 5400 KCS. SCR 578	1
Pistol Signal	1
Cartridges very red	3
Cartridges very green	3

Total weight of all this equipment was 180 lbs.

The following instructions were a guide to be followed in a survival situation.

(i) Vacate aircraft as quickly as possible with all survival equipment and move away to a safe distance.

(ii) Treat injured personnel.

(iii) When risk of fire had passed return to aircraft following in the original tracks and salvage all useful equipment and aircraft fuel.

(iv) Set up camp as close as possible to aircraft and rope up until the area has been proved safe from crevasses.

(v) Start taking sun shots with sextant to find ground position and operate the emergency radio.

(vi) Rope up and mark out best available landing strip.

(vii) Make your position as obvious as possible, using the dye marker and lay out the signalling panels.

(viii) Make the camp as comfortable as possible and do not move away from the proven safe area.

(ix) Make no attempt to walk out.

5. Ground Operations

(a) Picketting of Aircraft. Both aircraft were picketted tail into the strongest wind direction in a sheltered bay on fast sea ice below Scott Base. This bay had some 30 feet of compacted snow on top of the sea ice and in an emergency the aircraft could have been flown onto the Ross Ice Shelf or towed some 300 yards onto Ross Island below the base. The controls were locked with strong external control locks. The Beaver was moored at thirteen separate points in the following manner.

(i) Main Planes. Two mooring rings were screwed into the supply rack attachment points on each mainplane. The combined lift spoilers, aileron and flap clamps were fitted with mooring rings—two to each mainplane. In fine weather these lift spoilers were dispensed with.

(ii) Undercarriage. A rope was taken from each axle forward and slightly outboard to a deadman to prevent any rearward or sideways movement.

(iii) Tail. A rope was passed through the fuselage lifting tube and attached to deadmen either side of the fuselage. A further rope was attached from the tail ski to a deadman directly behind the aircraft preventing any forward movement.

The mainplane tie downs consisted of 60 cwt cables which were attached to the deadmen. The other end of these cables were clamped to a turnbuckle. Lengths of chain were shackled to the mainplane mooring rings and the open eye of the turnbuckle fitted into a link of this chain. In this manner the accurate positioning of the aircraft over the picketting points could be reduced. The deadmen consisted of half railway sleepers, which were dug in four feet and then frozen in with water. The Auster was moored in the same manner except ropes were used at all tiedown points. It was found that in compacted snow conditions heavy gauge angle iron driven in at an angle could be used in lieu of deadmen. The aircraft were always tied down tightly so that there was no play in the ropes or cables. This was found necessary under gusty conditions to prevent any snatching at the pickets. The cables proved superior from this point of view as the ropes would become slightly loose and would then stretch allowing the aircraft to snatch at its pickets.

(b) Protection from the Elements

(i) Aircraft. A nine foot high wire-netting windbreak was constructed on the windward side of the Auster. This served to break up the smooth airflow over the aircraft and so reduce the lift. A test was carried out with hand held anemometer in a 30 knot wind and it was found that six feet on the leeward side of the windbreak the wind speed was reduced to 25 knots. Engine covers were used for pre-heating purposes only as it was found that when they were left on overnight they became packed with wind blown snow. With the covers off the engines remained relatively clear of blown snow. Pitot heads, static vents and external fuel vents were always covered when the aircraft were picketted. An engine tent was constructed for each aircraft into which hot air was blown from a heater. This enabled engine servicing to be carried out with the engineer protected from the wind and in relatively warm conditions.

(c) Hot Air Blower. A type H-1 Herman Nelson Hot Air Blower Specification No. MIL-H-4607 Rating 400,000 BTU/Hour was used for the following purposes:

(i) Engine pre-heating.

(ii) Cabin and instruments pre-heating.

(iii) Warming items of equipment before working on same.

(iv) Directing warm air on hands when the task required the removal of gloves.

(v) Removing snow by melting especially from inaccessible places.

(vi) For heating plastic or rubber covered leads and hoses to prevent them cracking when they had to be moved.

(vii) Blowing hot air into the aircraft engine tent when work was in progress.

(d) Airfield Workshops. The Auster aircraft case was fitted on runners and towed to the airfield. The inside of the case was fitted out as a workshop and most of the tools and small spares were stored in it. The workshop was connected to the base power supply and had a telephone direct to the Base Radio Room. All other spares were stored in or beside the Beaver aircraft crate which was tied down in an exposed position below the base on solid land.

(e) Refuelling. All refuelling was done by hand or through a small engine driven pump, direct from 44 gallon drums. The fuel was always filtered through chamois leather. The drums were stored in a fuel dump 1/4 mile from the base on an exposed hillside and were sledged to the airfield as required. The drums were stored singly on the surface on their sides for two reasons.

(i) Blown snow will only drift up to the height of any foreign object, which is above the normal surface.

(ii) The rubber surrounding the bungs did not perish with resulting loss and possible contamination of the remaining fuel.

(f) Winter Storage of the Beaver. The wings of the Beaver were removed and after all apertures had been sealed with masking tape were stored in the Beaver aircraft crate which had been weather proofed. The motor was inhibited and all openings in and around the cowls were sealed. The winter shutters in front of the cylinders were completely sealed. The aircraft was then towed into a small exposed wind-swept valley close to the base and securely picketted facing into wind. The following items of equipment were removed for storage in a warm room.

(i) Aircraft Battery.
(ii) Blind flying panel containing all the gyroscopic instruments.
(iii) All removable radio equipment.

All apertures doors and windows in the fuselage were then sealed with masking tape. The aircraft never moved throughout the winter although winds of 70 Kts were experienced and the drift never built up around the aircraft or over its skis. When the aircraft was brought back into operation it was found that snow had accumulated in the rear part of the fuselage, tail plane, elevators and rudder and that the rest of the aircraft was clear of drift.

(g) Special Difficulties and Countermeasures

(i) Removal of Snow Accumulations from Aircraft. During blizzards drifting snow finds it's way into the smallest of openings. On the Beaver many openings were formed at the trailing edges of the control surfaces due to the corrugated form of construction. These plus gaps where panels joined, hinge brackets for control surfaces and many similar places allowed large amounts of snow to accumulate.

To remove this drift a cover was placed over or surrounding the affected area and the ducts from the hot air blower were directed into this cover. It was of paramount importance that once the snow started to melt the heat was not removed until it had all melted and drained away as water. When the melting starts, the water is absorbed by the surrounding snow like blotting paper and if the heating is stopped before all the snow has turned to water and drained away a solid block of ice will be formed. This ice will be very difficult to remove.

(ii) Control Cables. With the much lower temperatures it was found that the control cables contracted at a lesser rate than their surrounding structures, thus necessitating period retensioning.

(iii) Fire Extinguishers. CO_2 fire extinguishers became inoperative at temperatures below -30°F. This necessitated replacing all these extinguishers with Pyrene PDU 25 dry chemical extinguishers fitted with nitrogen gas cartridges.

(iv) Freeing Aircraft Skis. Under some conditions aircraft skis will stick to the snow surface and the application of full power as well as moving the rudder and elevators fails to free them. This sticking to the surface is caused in three ways.

(A) When the ski is sliding the friction between the ski surface and the snow crystals causes a rise in temperature sufficient to melt a small amount of snow. As soon as the Ski ceases to move, this freezes to the ski and to the snow.

(B) In summer the heat from the sun's rays is absorbed by the ski and causes melting underneath. If the source of heat is removed the ski will immediately freeze to the surface.

(C) With heavy laden aircraft standing in one place for some time the pressure causes the ski to sink. This pressure can also cause local melting which will then freeze to the ski. Several methods were used to free the ski once freezing had taken place:

(D) Tapping the side of the ski with a block of wood in most cases was sufficient to free it. The shock of the tap was sufficient to break the bond.

(E) Drawing a length of thin rope or cord from front to rear immediately below the sole of the ski.

(F) In the most difficult cases the use of a hydraulic jack to lift the ski would break the bond.

(G) If out in the field the snow could be dug away from each side of the ski leaving it sitting on a knife edge, so that a small tap would be sufficient to break the bond.

6. Summary of Work Achieved

(a) During the Trans Antarctic Expedition:

	Hours Flown	Landings	Inspections	Freight
Beaver	412	306	4-50 hr minor 4-100 hr minor	50 tons
Auster	143	173	2 minor 1 intermediate	3 tons

(b) During Operations with D. S. I. R.:

	Hours Flown	Landings	Inspections	Freight
Beaver	85	71	1-50 hr minor	10 ton
Auster	28	28	Nil	Nil

The greatest distance the Beaver flew to from Scott Base was 510 NMS.

7. Conclusions

(a) Beaver Aircraft

(i) This aircraft proved itself to be ideal for close support work with field parties. It is rugged, reliable and has very good short landing and short take-off characteristics.

(ii) Many unusual items of equipment could be attached to its supply racks such as dog sleds.

(iii) It proved an economical aircraft to operate to ranges of up to 200 NMS.

(b) Auster Aircraft

This aircraft may have carried out its float plane role satisfactorily but it has no place in Antarctic Operations.

(c) Ideally for the type of work carried out during these operations two aircraft were required. An aircraft was needed which could carry a large payload over ranges of 400-500 NMS and was capable of landing at the foot of the mountain ranges separating Victoria land from the Ross Sea Dependency. This aircraft would have built up depots from which a Beaver type aircraft could have operated carrying out all the close support work with the field parties.

In this manner far less time would be spent re-supplying the field parties and building up the depots. This would allow the field-parties to carry out a much greater amount of work in a season. As there would have been two aircraft for re-supply purposes, the Beaver-type aircraft then could have been used in a more ambitious close support role.

Field parties could have been air transported from point to point in their areas of operation. This aircraft proved that it had little difficulty lightly loaded in taking off at altitudes of 8500 ft and it could be landed on slopes of up to 25 degrees with safety.

AIR NAVIGATION IN THE ANTARCTIC

L. A. Arsenault

Basically, navigation in Polar regions does not differ from that of lower latitudes, but some differences in techniques and equipment have evolved because of the unique conditions encountered near the Poles.

Prior to World War II virtually all navigation took place in low or intermediate latitudes. During the war, operations gradually pushed to higher latitudes, and by the time hostilities ceased in 1946, long-range aircraft had been sufficiently developed to make this last great, virtually unknown area readily accessible.

In his thinking, conventional man has lived in a "rectangular" world. Usually he has thought of the North-South Meridians as being parallel to each other, and perpendicular to the East-West parallels of latitude, the two forming the familiar Mercator Graticule. Directions measured relative to the meridians and maintained by means of a magnetic compass have seemed adequate. However, as man travels toward the Polar regions, the meridians are no longer parallel and converge very rapidly approaching the Pole. This rapid convergence of meridians in the Polar regions makes it difficult to use True North as the directional reference. Steering a constant true course (rhumb line) will result in an extremely curved path which is far from the most direct route even for relatively short distances.

Another condition encountered, in the Polar regions, which causes difficulties in conventional navigational techniques is the rapid change in magnetic variation caused by the displacement of the magnetic poles from the geographic poles.

If an aircraft were steered on an average magnetic heading in short legs, to compensate for rapid changes in variation the result would again be an extremely curved path the extent of which would depend on the amount of change in magnetic variation for a specific distance.

In addition, as the vertical component of the earth's magnetic field becomes stronger the horizontal components become too weak to provide a satisfactory signal and the magnetic compass becomes too erratic for accurate navigation.

To avoid all these inconveniencies in the navigation process in the Polar regions, an alternate directional reference system was developed, and adopted by the United States Air Force. Polar charts are overprinted with a series of parallel straight lines called a grid. One direction along these lines is designated Grid North. All directions then are expressed as grid directions, measured clock-wise through 360 degrees from Grid North.

The gyro was adopted as a directional reference device in the Polar latitudes to replace the unreliable magnetic compass, however, a gyro is subject to precession.

The N-1 compass system, in use in most first line aircraft today, compensates for precession and has a rate of less than one degree per hour, which is ideal for accurate grid navigation.

Tactical Air Command in 1956 and the Military Air Transport Service since 1957 have been supporting the United States Navy in Operation "Deep Freeze" with C-124 (Globemaster) aircraft, first in support of the International Geophysical year 1957-58, and a continued United States Scientific endeavor since. The aircrews assigned to this mission are the most qualified available and have extensive experience in Polar operations and Grid Navigation techniques.

Air navigation in the Antarctic region is dependent almost entirely on the use of the USAF grid overlay and the N-1 gyro compass system to maintain accurate dead-reckoning. There are virtually no navigational aids available, with the exception of short range radio facilities at some of the remote sites. The navigator must rely on self contained equipment and celestial references while flying in that area.

On a flight from New Zealand to the Antarctic continent, the aircraft is in clouds 75 per cent of the time, and the navigator obtains very little aid from celestial references and has to resort to dead-reckoning updated by pressure pattern lines of position. Pressure pattern lines of position are course lines only and do not contain any head-wind or tail-wind components, and are not always completely dependable in that area of the world due to the prevalent, relatively small, intense low pressure areas which cause wind sheer and thereby errors in pressure information.

All of the flights in the Antarctic are conducted during the period of twenty-four hours daylight and for the most part the sun, the driftmeter, and the airborne weather radar are the only aids to dead reckoning available to the navigator. The navigator considers himself very fortunate when the moon has sufficient southern declination to utilize with the sun to obtain a fix. Actual fixing is accomplished primarily with the aircraft radar on the approach to and over the outer extremities of the Antarctic continent and as far inland as the top of the Beardmore Glacier. The route from McMurdo Sound to Byrd Station is largely over the Ross Ice Shelf. This ice shelf has many crevasses and submerged islands that have identifiable radar returns. These returns vary with the season, amounts of snowfall, and the angle from which they are approached. During past years navigators have indicated on their charts the more prominent returns as they appeared to be and in the position they had calculated. Although there are wide differences in the artistic ability of the various navigators the positions of the radar returns were uniform. These returns have been consolidated and with proper briefing this becomes a fairly reliable radar flight. These crevasses and many other erroneously plotted landmarks have been reported to Headquarters Aeronautical Charting and Information Center for inclusion in revised editions of the air navigation charts of the Antarctic region and will help make it a little easier for the next navigator that happens to pass that way.

With the advent of high speed, high altitude, jet aircraft, equipped with astrotrackers, inertial guidance systems, doppler automatic navigators, tied to digital computers, navigation in remote regions of the world, such as the Antarctic, should cease to be a problem. However, in spite of all the sophisticated navigation equipment anticipated in future aircraft, actual landings on the ice and compacted snow will be equally as hazardous as it was in 1929, when Admiral Byrd landed in a Ford Tri-motor airplane on the Antarctic continent.

OPERATION OF TURBINE ENGINE HELICOPTERS IN THE ANTARCTIC

John H. Greene

The rapid advances of science in the Antarctic has been closely allied to the advancement of newer and improved forms of transportation. Since November 26, 1928, the date of the first airplane flight in the Antarctic, aircraft have played an increasingly important and useful role toward the conquest of this vast continent. A relative newcomer, the helicopter, was first utilized extensively during Operation WINDMILL in 1947-1948 and has proved itself to be an invaluable tool of Antarctic exploration.

This discussion will be limited to helicopter operations and more specifically, the turbine powered helicopter. Proper and efficient utilization of the helicopter requires a knowledge of its advantages and limitations. Although much slower, with a shorter range than propeller-driven or jet aircraft, the helicopter can land or take-off from unimproved areas, move in any direction, and to hover motionless. They are primarily a short range vehicle and any attempt to extend its mission range invariably impairs its load carrying ability thereby reducing the effective payload. Helicopters should not be placed in competition with conventional aircraft. They are a special-mission type aircraft and full utilization requires full exploitation of their unusual flight characteristics.

Conventionally powered helicopters have operated satisfactorily in polar climates but special equipment has been required to support their operations. At a minimum this has included engine pre-heaters and auxiliary power units which are both heavy and bulky. Flight operations conducted beyond the aircrafts normal range impose an additional logistics burden in transporting the required support equipment to the field camp. Turbine powered helicopters, on the other hand, require no preheating or auxiliary power units and can be started quite satisfactorily in temperatures as low as -35^{o} centigrade. This is a conserative figure since cold chamber tests have proved the turbine engine capable of starting in temperatures down to -65^{o} centigrade.

Additionally, no lengthy warm-up period is required of the turbine powered aircraft. Lubricants utilized throughout the various aircraft systems perform properly through a wide temperature range of from -55^{o} centigrade to -65^{o} centigrade. Consequently, the aircraft can become airborne within two minutes even though it may have been exposed for lengthy periods to the extremes of temperature.

Another distinct advantage of the turbine engine is the horsepower to weight ratio. The turbine engine will develope two horsepower per pound of engine weight as compared to one horsepower per pound of the ordinary piston engine. These are average figures attempting to indicate the relationship of available horsepower.

Therefore the turbine powered rotocraft is capable of carrying a greater payload at higher average speeds and at higher altitudes. During the past season, two turbine powered helicopters operated in the Antarctic supporting a topographic survey in mountainous terrain between Cape Adare and the head of the Beardmore Glacier. Many of the landing sites exceeded 10,000 feet, the maximum being 13,500 feet pressure altitude. The altitudes mentioned are normally considered excessive for rotocraft operations. Yet, each aircraft carried a payload of 1,700 pounds! A similar utility-type, conventionally-powered rotocraft presently in service would have difficulty attaining these altitudes with a 100 pound payload.

The use of helicopters during the project, dubbed TOPO-SOUTH and TOPO-NORTH, provide a dramatic example of their usefulness. During a three (3) month period, November 1961 to January 1962, two turbine powered helicopters supported a topographic survey traversing some 1510 miles along the mountain range bordering the Ross Ice Shelf and Ross Sea to a point at the head of the Beardmore Glacier.

Survey teams established control points on the mountain peaks for an area of over 100,000 square miles of previously unmapped or partially charted terrain. It is estimated that utilization of helicopter reduced by ninety per cent the time which would have been required by normal surface means and at considerably less risk.

During the entire operation both aircraft and members of the team lived upon the Ross Ice Shelf and within the Beardmore Glacier. A minimum of tools and equipment was required. No insurmountable maintenance or repair problems were encountered although maintenance manhours were trebled. Performance of routine maintenance is materially affected by the low temperatures, blowing snow, high winds and the bulky clothing worn by the mechanics reducing their efficiency and dexterity. Manhours expended therefore unavoidably exceeded the average established for more temperate zones. This is to be expected of all endeavors in polar regions.

Due to the relative inaccessibility of the area's of operation and the problems of survival inherent in polar environments, rigid flight and communications procedure are mandatory. "Living off the land" is an impossibility, consequently, adequate survival equipment, supplies and training become essential elements of the mission. During the topographic mission, each aircraft carried a total of 228 pounds of survival equipment separated in two parcels, one of which remained in the aircraft with the flight crew, and the second, which remained with the surveying crew atop the mountains. Each contained rations which could be stretched for thirty (30) days.

Fuel for turbine powered helicopters operating independently impose a heavy logistics burden. All deliveries were accomplished generally by conventional aircraft. The high rate of fuel consumption and somewhat limited range of the helicopters required the establishment of numerous fuel caches along the planned route. Fuel caches must be established not only to meet the planned flight program but to meet emergency requirements should they arise. Based upon a flying hour program of 100 hours per aircraft, a total of 455 tons of fuel must be air-lifted to support two utility-type turbine powered helicopters. Logistical support of any

Antarctic project has always posed a tremendous problem and operations within the interior compound it further.

Flights of helicopters in the desolate Polar regions are conducted under what is termed, "visual rules." Although fully instrumented for weather flight they are not fully equipped for numerous reason, i.e., weight, limited range, etc. Also, lack of adequate navigational facilities and the attendant problems of navigating in high latitudes due to unreliable compass readings require flights solely by visual means. Development of light-weight, self-contained, inertial navigational systems will eliminate much of this problem.

A constant threat to the aviator is the "white-out." This can occur in varying degree's and can develope very rapidly. Constant observations of the weather is required and flight operations must cease upon loss of positive surface definition.

An associated problem arises when landing is attempted on a loosely packed snow surface caused by the high velocity rotor downwash. The billowing snow may cause a complete loss of visual reference and an immediate take-off is required. Also, landings at high altitudes on the mountain tops are complicated not only by the decreased aircraft performance but by lack of sufficient reference points and consequent loss of depth perception. Flying over vast reaches of snow and ice, there is virtually nothing for the eye to focus upon and it is difficult to determine distance and altitude. This condition is commonly termed, "empty field myopia." Practice and experience eliminates the problem once the pilot learns to utilize all visual clues.

The helicopter is not the perfect machine nor the final answer to all the problems of surface transportation. It does have limitations but these are far outweighted by the advantages. It affords the means to surmount obstacles which normally impeded or greatly delay surface progress. Large crevassed areas are easily over-flown and landings can be accomplished atop the mountains in a fraction of the time required to scale them and otherwise provides a degree of mobility never known before by the "Old Explorer."

The helicopter, particularly when turbine-powered, has a tremendous potential and its capabilities are limited only by the imagination of its user.

ICE AND SNOW RUNWAYS

Earl H. Moser

In 1947, the U. S. Navy conducted a training exercise in the Antarctic known as Operation Highjump.[1] Ships were deployed to the Ross Sea and a temporary shore facility was established by the Seabees on the ice shelf at Little America. This marked the beginning of a research program by the Bureau of Yards and Docks to develop the knowledge and materiel to construct and operate shore stations in the cold regions of the world.

Because of the wide distribution and great abundance of ice and snow in these regions, an integral part of this program was the development of methods and techniques for using these materials to construct roads, airfields, building foundations and even limited-use structures. Utilization of ice and snow as construction materials, especially for aircraft runways, was considered essential to the success of Polar operations. Operation Deep Freeze has shown this to be true.

In this presentation I can only highlight the results of our work in ice engineering and snow compaction. I will attempt to relate this effort to ice and snow runways in Antarctica and show the possible potential benefit of a continued research effort in this field.

Ice Runways

Methods to improve sea ice for heavy aircraft operations was first investigated by the U. S. Naval Civil Engineering Laboratory for the Bureau of Yards and Docks offshore at Point Barrow, Alaska in 1951. Since then, a technique has been developed to strengthen natural sea ice for increased bearing capacity by accelerated thickening of the natural ice. Equipment has been conceived for leveling, grading and finishing the surface of sea ice for improved utility and a prototype ice dozer has been developed for grading rough ice. Also, ablation of ice surfaces during the Polar summer has been studied and methods for retarding and controlling this deterioration are being investigated.

Strengthening Sea Ice

An early study of sea ice indicated that accelerated thickening of natural ice appeared to be the most promising method to increase its strength and bearing capacity. The natural formation of ice decreases with increased thickness, so any artificial process for rapidly thickening the ice had to short-circuit the normal heat flow path through the ice. The simplest way to accelerate thickening appeared to be the formation of new ice on the surface where the low ambient temperatures which normally prevail during winter would provide a heat sink favorable to the rapid freezing.

The first artificially thickened sea ice was built by casting sea water on a 150- by 400-foot area of relatively smooth, young sea ice. As dikes were used to retain the flood water, this technique was called confined flooding.[2] During a three-month winter period, the ice was built-up in layers of various thickness to a depth of ten feet. The flooded ice was produced almost three times as fast as natural ice, but the product left much to be desired. For example:

1. The built-up block of ice, which had a bearing pressure of nearly 600 pounds per square foot and total weight of over 17, 000 tons, (Figure 1), caused severe distortion and cracking in the underlying 6-foot sheet of natural ice.

2. Large unfrozen areas within the flooded ice resulted in internal structural weakness.

3. Construction of the dike system was extremely difficult and time-consuming.

4. The flooding equipment was cumbersome to operate and subject to frequent freeze-up.

5. The vertical edge produced by the dikes, together with the distortion and cracking in the natural ice, made access difficult.

Subsequent investigations have resulted in a technique which eliminates most of these problems. It also produces an ice mass which is integrated into the parent ice sheet rather than one which is superimposed upon it. This technique is called free flooding.

Dikes are not used in free flooding; instead, the flood is distributed from a central discharge point and allowed to spread freely over the surface. This results in a circular flood zone which is controlled by partial quick-freezing of the relatively thin flood front as it advances over the surface and by the total volume of water spread during a single increment of flooding.[3]

The profile of a free flooded area (Figure 2) is best described as a convexo-plane shape with the convex surface at the interface between the parent ice sheet and the flooded ice. The supporting ice under each new flood layer relaxes or plastically deforms until buoyant equilibrium is established. Thus, the surface of a free flooded area is always near the same elevation as the surrounding ice sheet.

A 1, 500 gallon per minute pump will produce a free flooded area about 600 feet in diameter; two such pumps spaced 500 feet apart will produce an elliptical area about 1, 200 feet wide and 600 feet long. This also has a lens shaped profile.

One free flooded area (Figure 3) built in 1960 with two pumps, was 4 feet thick at the center when completed. Its total weight was 57, 000 tons, or three times that of the 1951 effort and its maximum bearing pressure was nearly 250 pounds per square foot. Even so, it was so well integrated into the parent ice that

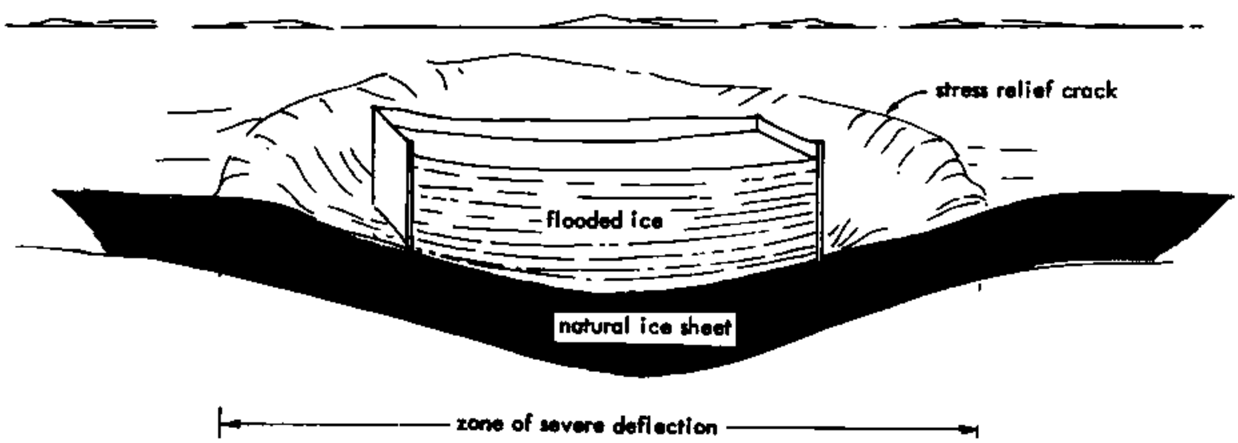


Figure 1. Typical section of a block of built-up ice superimposed on the natural ice by confined flooding.

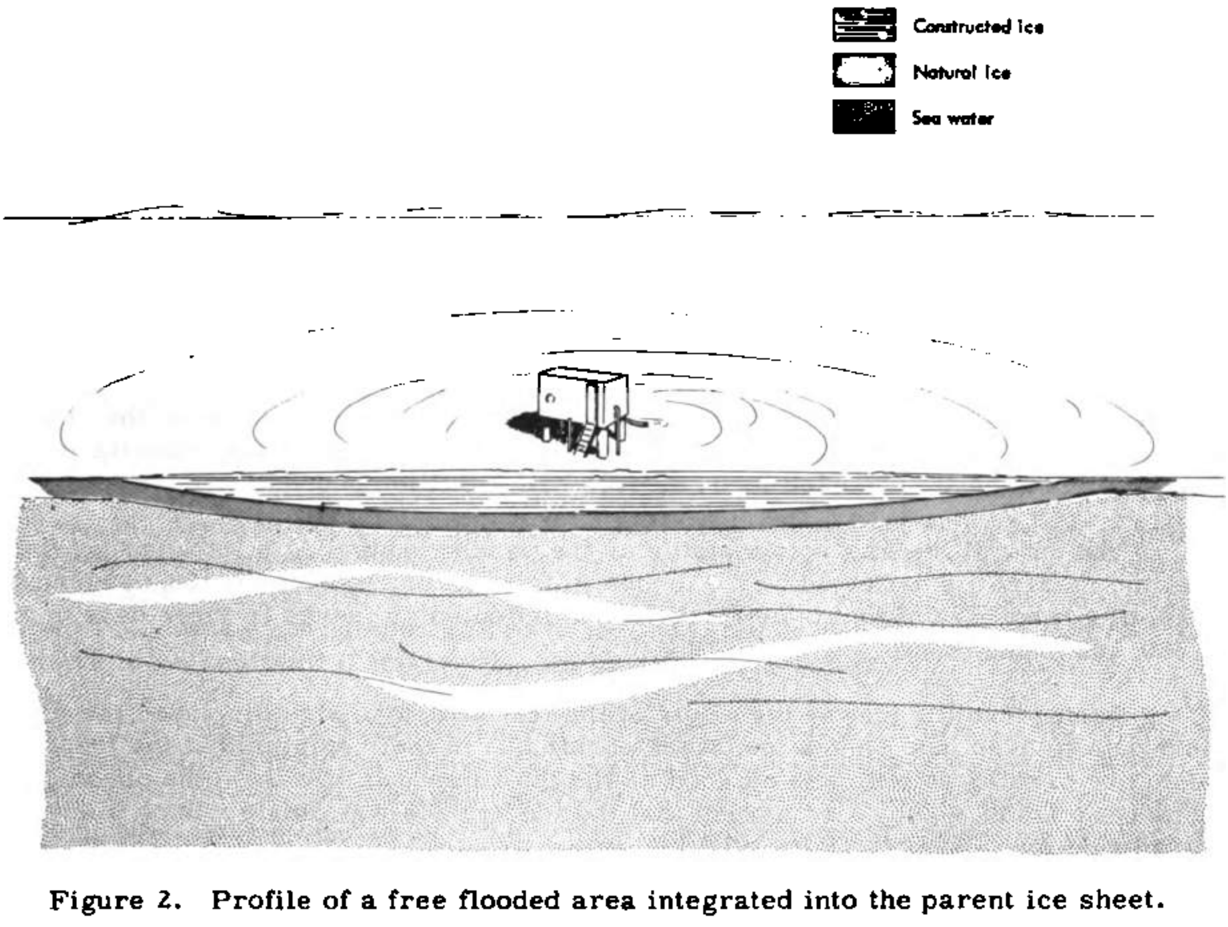


Figure 2. Profile of a free flooded area integrated into the parent ice sheet.

it was only 1/2-foot above the natural ice surface. There was no distortion and no structural cracks in the construction area. Once the pumps were in place, two men working only part time easily constructed this 15 acres of ice in just over one month.

In February 1961, a 600-foot diameter free flooded parking pad was built on North Star Bay, Thule, Greenland during Project Iceway.[5] This was a joint Navy-Air Force effort on the operational utility of natural and improved sea ice. It included the construction of three parking pads, the clearing of a 14, 000 foot runway on the 3-1/2 to 4-1/2 feet thick bay ice, and the testing of these areas with heavy aircraft including a C-130 and a KC-135, the military version of a Boeing 707. The parking pads included the free flooded one mentioned above, a similar one reinforced with fiberglas and one built of ice aggregate saturated with sea water. They were used to park the aircraft between landings and take-offs on the relatively thin natural ice runway.

Preparing the runway on North Star Bay was fairly simple as the ice was very smooth and the snow cover was only one to five inches deep. It was cleared and marked in less than a week by a team of Air Force Maintenance personnel using graders, V-plows and snow plows.

The parking pads, which were constructed by Navy personnel, took somewhat longer because of the freezing involved. They were built over a 30-day period by a six-man team. The free flooded pads were built-up in 4-inch increments. Each increment, which tapered to a thickness of less than 1-inch at the boundary, required about eight hours to cast and about 40 to 48 hours to cure, or freeze. The curing period, of course, is temperature dependent. In this case it was related to an average air temperature of -10F.

The free flooded pad was four feet thick when completed, and its total thickness at the center including the natural ice was about eight feet. When an aircraft with a gross weight of 200, 000 pounds was parked on this pad it caused an initial deflection of 3/4 of an inch; but, as no further deflection occurred during an extended parking period it was attributed to elastic deformation. Tests on the fiberglas reinforced parking pad showed similar results under load even though the flooded ice in this pad was only three feet thick and its total thickness at the center was just under seven feet. Preliminary analyses of the data indicate that the parking pads could have supported loads of over half a million pounds.

The natural ice was not as stable as the parking pads. At a thickness of four feet the natural ice deflected 3-3/4 inches in thirty minutes under a 200, 000 pound load; at a thickness of just over three feet it deflected 15 inches in three days under a 250, 000 pound load.

During Project Iceway the pilots of the test aircraft, which included the first pure jets to ever land on sea ice, were unanimous in their opinion that the traction, including braking action, was as good on the ice runway as it was on the paved runway at Thule. They also agreed that the ice surface was as smooth as many paved runways.

Increased strength is not necessary on the old sea ice in McMurdo Sound. Even so, it is interesting to note that continuous snow removal on the runways has probably caused a natural thickening of the ice in this area. Meager data indicates that the ice under Williams Field is about 30 feet thick as compared with a thickness of 20 feet for most of the old ice in McMurdo Sound.

This thickness is more than adequate for the runway camp and aircraft loads imposed each austral summer. However, the permanent loads imposed by the snow berms along the runways are another matter. In 1962 these berms, which are separated by the width of the runways, were about 300 feet wide and nearly ten feet high. Their total weight was well over a half million tons and the bearing pressure under the middle third of each berm was at least 300 pounds per square foot. Much of the surface buckling and most of the stress relief cracks in the runways can probably be contributed to these massive, superimposed loads and the method of loading.

The principles of surface flooding which I have just described, could be used to alleviate this problem by building the runway surfaces up above the snow cover. This would eliminate the berms, and probably most, if not all, of the stress relief cracks. It would also improve the runway surfaces and should improve their general operational characteristics. The present flooding techniques, of course, would have to be modified to consolidate the deep snow cover. Good ice can be produced in snow up to 12 inches deep by compressively compacting the snow before flooding; however, this simple method would not be successful on snow three to four feet deep. Instead, irrigation flooding, or some similar technique, would be required for complete consolidation of this snow. That is, the snow cover would have to be dissected with trenches which would be flooded in four-inch increments until ice was formed through the entire depth of snow. The success of such a technique would depend upon proper spacing of the trenches for complete lateral coverage with each flood increment and complete freezing, or curing, of each increment as flooding progressed.

These runways, which would be at, or above, the surface of the snow, would add about 150, 000 tons of additional weight would be evenly spread over the surface and its unit loading would be only 200 pounds per square foot.

Grading and Leveling Ice

In January 1955, the Bureau surveyed the 20-foot thick ice in Kainan Bay for its possible use as a runway to support Little America V. There was adequate area within the bay for a 10, 000 foot runway, but the surface of the ice was covered with numerous ice hummocks two to four feet high. It was obvious that they would have to be removed if the bay was to be used for a runway.

As this ice went to sea during the construction of Little America V, the runway was never built but surveys in other areas showed the ice surface in Kainan Bay to be fairly typical of sea ice. For, aside from infrequent areas of flat smooth ice, most usable sea ice is either rough and slightly undulating or it is crisscrossed with low pressure ridges. Hummocks often occur on both types of ice. This has resulted in the need for development of equipment to improve its general utility.

The first step toward development of this equipment was a high speed ice-cutting device. Since fracture is the most effective way to cut ice, a revolving drum fitted with a series of pointed teeth was developed for this purpose (Figure 4). The teeth are set in a helix to increase their efficiency. A model of this drum has been used to cut sea ice to a depth of 6 inches at travel speeds up to 400 feet a minute.

A prototype ice dozer has recently been developed for leveling hummocks and low pressure ridges. This was accomplished by replacing a tractor dozer blade with the ice cutting drum and modifying the support arms so that the drum can be elevated up to four feet above the surface when cutting. Thus, unlike the pulvimixer which normally cuts with its drum below the surface, the ice dozer can be used for high angle cuts as well as surface cuts.

It is also planned to adapt the drum to a standard construction grader for leveling rough ice. The drum will be located just ahead of the grader blade and it will be so mounted that it can be tilted for angle cuts. This will permit ice surfaces to be crowned for good drainage.

Deterioration During Melt

Ice with a slope of two per cent drains without channeling and its surface is normally free of melt pools and pot holes. Even so, the total deterioration, or ablation, of such a surface is the same as a surface with a greater or lesser slope.[7] It is believed that adequate drainage of the ice runways at McMurdo could be achieved by first building the runways up and then sloping the surfaces for proper drainage; but, it is doubtful that these improvements alone would provide adequate runways for the entire flying season. To achieve this goal it will probably be necessary to insulate the runways from the solar radiation which occurs when the sun is over 25 degrees above the horizon. At McMurdo this period starts in late October and ends in mid-February. Between mid-November and mid-January this radiation occurs over eight hours a day with a maximum of ten hours and forty minutes on 21 December.

The Bureau of Yards and Docks is presently investigating the use of a tough, high-wear, aqueous foam insulator for protecting ice surfaces from this type of deterioration. Foam was selected over other materials for this use because of its low shipping bulk, its simplicity of application and its potential ease of repair when damaged. The investigation is not sufficiently advanced to predict positive results with this material, but pilot tests at Point Barrow this past spring did demonstrate the need to protect an insulated surface from melt water occurring in adjacent areas.

Snow Runways

Methods to improve snow for aircraft operations were first investigated during Operation Highjump.[1] Since then, techniques and equipment have been developed for building roads, runways and foundations on both shallow and deep snow fields. These techniques have been applied with varying degrees of success in the northern hemisphere over the past few years.[8] Current investigations are directed

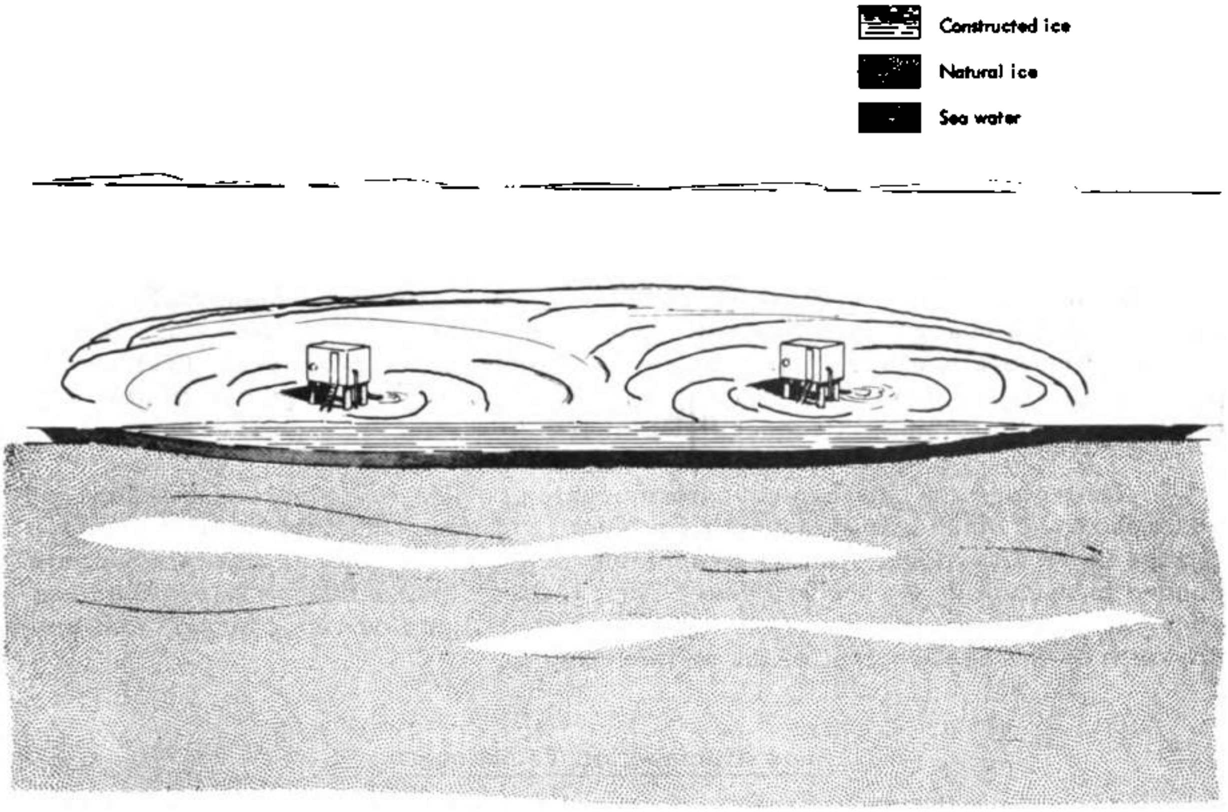


Figure 3. Profile of a free flooded area built with two pump stations.

Figure 4. Ice cutting drum on the ice dozer.

toward their utilization for building snow compacted runways for heavy cargo aircraft at the United States stations in Antarctica.

Snow as a Construction Material

Unlike sea ice which is formed in-place and whose density varies between 0.85 and 0.92 gm/cc, snow is deposited on the surface in particle form with a density ranging between 0.01 and 0.20 gm/cc. Being thermo-dynamically unstable, these particles change from flakes to granular crystals and, as the natural metamorphic process continues, the density of the snow mass increases. In time it produces a dense, coarse-grained snow with densities greater than 0.30 gm/cc. Continued metamorphism produces glacial ice.[9, 10]

Hardening is also a natural metamorphic process which causes marked changes in the mechanical properties of snow, independent of those produced by a change in density alone. In the hardening process the individual crystals become bonded to each other by ice bridges. The process of hardening required the presence, at least temporarily, of an excess of either liquid or vapor beyond that supportable by the heat content of the snow mass.

Snow-Compaction Techniques

The Navy snow compaction techniques are founded on the in-situ acceleration of the natural processes occurring in snow. The basic techniques include precompaction preparations, compressive compaction, depth processing, double depth processing and surface hardening. They are used alone or in combination to produce various types of load bearing snow. Special equipment has been developed to accomplish these techniques.

In the early snow compaction trials it was found that nearly all snow fields require preliminary leveling and packing to produce a compacted-snow mat of uniform strength. This is especially true of sastrugi, where, without preparation, compaction accentuates the natural undulations of the wind-driven snow and produces a finished snow mat whose surface has the appearance of a miniature roller coaster.[11] The special equipment developed to prepare this type of surface for compaction includes a ski-mounted snow plane (Figure 5) to grade and level the snow[12] and a snow-compacting roller (Figure 6) to compressively compact the level surface.[13] The effective depth of compressive compaction is about ten inches regardless of the weight of the compacting equipment.

In Russia during World War II, Kragelski[14] advanced a concept called depth processing for increasing the effective depth of compaction. Based on this concept, the Navy developed a technique that will compact snow to a depth of 32 inches. A power-driven snow mixer[15] (Figure 7) is used for in-place pulverizing and blending of the snow particles and the snow compacting roller is used to compressively compact the processed material. It was also found that double depth processing is more effective for compaction than single processing. For example, single depth-processing of sastrugi in Greenland or Antarctica in below freezing temperatures will increase its density about 50 per cent and its hardness about ten times within

Figure 5. The Navy snow tractor towing the Model 40 snow plane.

Figure 6. Snow compacting roller in deep, soft snow.

three days. Reprocessing the top 90 per cent of this material will further increase its density only 10 to 20 per cent, but it will more than double its hardness within eight days for a net increase about twenty-four times that of natural snow.

It should be pointed out that intense daily solar radiation coupled with prolonged air temperatures about 25°F delay hardening in compacted snow and that such conditions are not uncommon during summer in polar regions. Even so, when the air temperature drops below 20°F the hardness growth is resumed.

The hardness in depth-processed snow is not uniform with depth. Instead, the bulk of the hardness is in the middle two-thirds of the mat. As a result, a special technique using a standard 13-ton, pneumatic-tired roller[13] (Figure 8) and a snow finishing drag[16] (Figure 9) has been developed to improve the surface hardness of compacted snow. In below freezing temperatures this technique will increase the hardness in the top 6 inches of compacted snow up to twenty-four times within a single day (Figure 10).

Investigations using free water to increase the overall hardness of compacted snow[17] have been made at test sites in California. These tests have shown that free water infiltrates easily when added to the surface of compacted snow and its depth of penetration is dependent on the amount of water and rate of application. Also, it results in a rapid increase of hardness with the magnitude of increase dependent, within limits, upon the quantity of water applied and the air temperature after application.

Using a free-water additive on compacted snow for more uniform hardness is presently considered feasible only when the compacted area is located near the ocean or a fresh-water lake. Development of a ready source of water on deep perennial snow will make this method of increasing hardness feasible on both the Greenland Ice Cap and Antarctica.

Layered Compaction

Aircraft tests on compacted snow in Greenland[11, 18] with wheel loads up to 100 psi resulted in the development of a curve showing the minimum average hardness required in a given thickness of compacted snow for marginal support of aircraft with various main wheel inflation pressures. The curve showed that the average hardness required to support a specific load decreased rapidly as the compacted snow depth increased. Based on this knowledge, a snow compaction technique, called layered compaction, was developed for building runways on deep snow.

This technique, which is currently being investigated in Antarctica, offers several advantage over the single layer systems used to date. First, it results in a runway that is elevated above the natural surface. A single-layer runway is usually depressed about eight inches below the surface, thus forming a perfect trap for drift snow. However, a second layer will elevate the runway about eight inches above the surface, and a third layer will elevate it almost two feet. This is a decided advantage as drifting will not occur on an elevated snow surface until the natural surface has reached the same elevation.

Figure 7. Depth-processing with the Model 4-2 snow mixer.

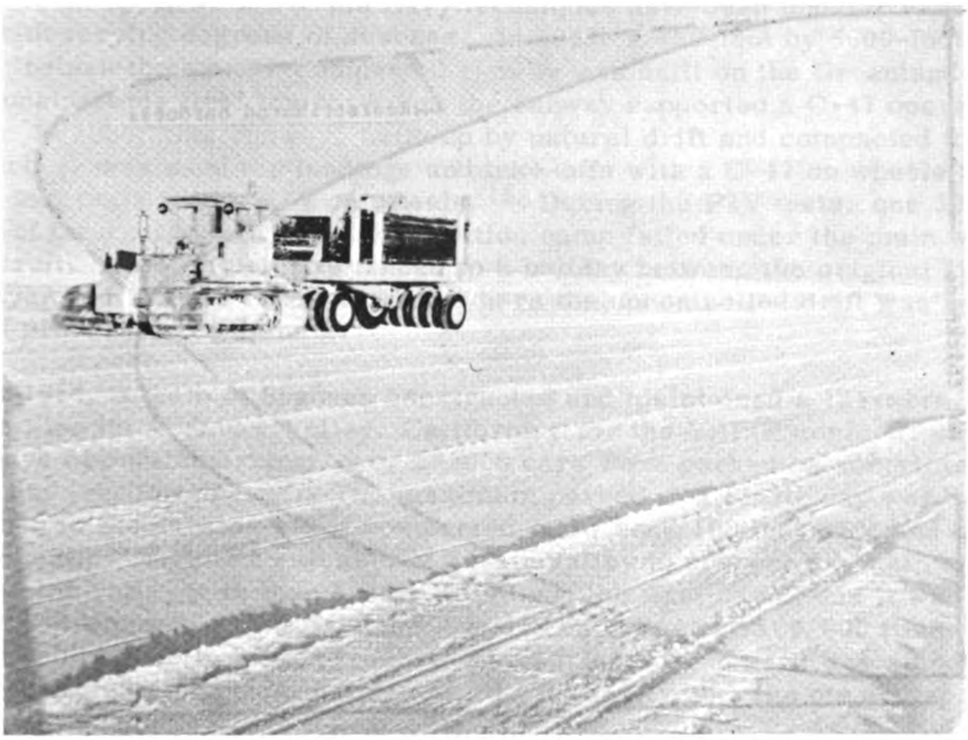


Figure 8. Thirteen-wheel 13-ton pneumatic-tired roller, surface-hardening roller.

Figure 9. Smoothing snow road with snow finishing drag.

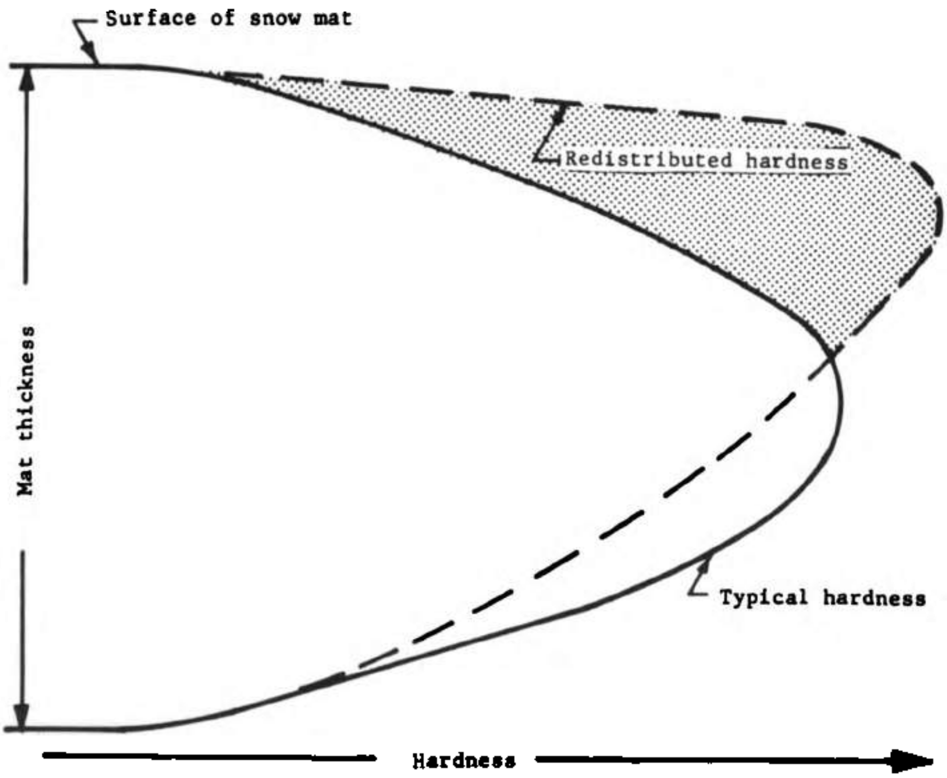


Figure 10. Typical vertical hardness in compacted snow compared with its redistribution after surface-hardening.

Another advantage of layered compaction is that of attaining a uniform load-bearing surface regardless of the random scatter of low-strength areas in the individual layers. The probability of coincidence of such areas is very small in a two layer system and very remote in three or more layers. While this does not eliminate the need for quality control during compaction, it does permit some relaxation in the degree of control needed to produce a single thickness of compacted snow with a high uniform hardness.

The major objection to layered compaction is the quantity of borrow material required for controlled construction. Bulldozers have been used to build up small elevated test areas and during this past season in Antarctica, snow planes were used to move snow laterally across the surface to build an experimental two-layered runway. It is now planned to use a track-mounted snow plow for moving this material.

Applications

Experience has shown that a basic understanding of the principles and techniques of snow compaction is required for their application and timing in relation to existing snow conditions. It has also been found that the basic plan for construction of a compacted-snow area must be supplemented with daily detailed planning in order to cope with the changes introduced by nature. Furthermore, as with any type of construction, routine inspection is essential for good quality control.

Several applications of the Navy techniques have been made over the past few years with varying degrees of success. In 1953, a 150-foot by 5000-foot experimental 16-inch thick snow-compacted runway was built on the Greenland Ice Cap.[12] After considerable field improvement the runway supported a C-47 operating on wheels. In 1954, this runway, built-up by natural drift and compacted to a depth of 33 inches, was used for landings and take-offs with a C-47 on wheels and serpentine taxi tests with a P2V on wheels.[18] During the P2V tests, one 300-foot section of the runway near the construction camp failed under the main wheels of the aircraft. This failure was traced to a holiday between the original 16-inch thick layer and the new layer above it where the uncontrolled drift was beyond the depth of processing equipment.

In 1960, a team of Seabees constructed and maintained a 125-acre compacted snow parking lot at Squaw Valley, California, for the VIII Olympic Winter Games.[19, 20] In ten days of public parking, over 60, 000 cars were parked on compacted snow without any traffic mishaps. The maximum parked in a single day was 11, 000. In addition to the parking lot, a compacted-snow road 100 feet wide and one mile long was built along the south side of Squaw Valley to connect the main entrance road into the valley with the parking area. On the first day of use it was trafficked over 20, 000 times and by the games it had been used over 100, 000 times with all types of vehicles up to 30-ton trucks. The surface of the road was smooth and level and speeds of 60 mph could be maintained with safety, but the normal speed of travel was about 35 mph.

A snow road was built between McMurdo Station and Williams Field in October and November of 1960. The first mile of the road was located on bare ice but the next three miles were located on four feet of snow. As this was a single layer road, it was depressed below the natural surface when completed. As a result, it was rapidly filled with drift and abandoned after only a few days of use.

Following the road construction a single layer runway 150 feet wide and 4, 000 feet long, and a separate elevated section 150 feet wide by 300 feet long, was built on the Ross Ice Shelf near McMurdo Sound during December 1960 and January 1961. The 16-inch thick runway was tested with a P2V in early February 1961. As predicted from previous experience, processing holidays resulted in several wheel break-throughs during this test.

During Deep Freeze 62 a two-layer runway was built on top of the 1960-61 runway. The field work was resumed in late October 1961, but due to unforeseen circumstances, construction was not completed until late January 1962. Because of a delayed growth in hardness due to solar radiation, the runway could not be tested with an aircraft on wheels; even so, it served a useful purpose following break-up of the ice on McMurdo Sound in late January 1962. At that time the runway was placed in daily use as a skiway for the aircraft operating in Antarctica. It served this function well because a C-130 on skis with a full 10-ton payload could take off in 3, 000 feet on the compacted runway as compared with a 7000-foot take-off and a partial seven-ton payload on an unprepared skiway adjacent to the runway.

In all, thirty-nine full-load ski take-offs were made on the compacted runway. The only surface changes observed during this period of repeated use were a slight indentation of the ski tracks down the center of the runway, and the development of a progressively harder surface. Spalling from propeller blast was insignificant and, except for small finger drifts along the storm-wind edge of the runway, the elevated surface was clear of drift and in excellent condition at the end of February.

During early February, the adjacent skiway was improved by leveling its surface with a snow plane and compacting it with a snow drag and the aircraft skis during use. By mid-February this work had resulted in a skiway suitable for a C-130 take-off on skis in 4000 feet with a 10-ton payload.

Summary

Successful application of any engineering technique for improving sea ice or compacting snow not only requires a basic understanding of the principles involved and the proper use of the techniques but also a knowledge of the variables that influence these techniques. Such variables include the geographic location, the season of the year, the type and condition of the base materials, and the temperatures involved. The effect of these variables on the end product, whether it be a snow compacted runway at Byrd Station or a built-up ice runway at McMurdo, can have a pronounced influence on its ability to perform its designated function. As only a limited knowledge of these variables and their influence on snow and ice products is available, experimentation is necessary to adapt or improve the techniques for specific locations. The Bureau of Yards and Docks plans to continue its current work in snow compaction at McMurdo during the coming season and expand this effort to Byrd Station next season.

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U. S. AIR OPERATIONS IN ANTARCTICA

Martin D. Greenwell

Chapter I
Introduction

The Antarctic Continent, covering an area of about 5-1/2 million square miles or about the size of the United States and Europe combined, remains relatively unexplored due to the forbidding nature of the climatology, the difficult terrain features and the great distance of the area from world population and materials generating centers.

There is no known local source of fuel, food or conventional building materials and there is no indigenous human population in Antarctica. If there is to be a continuing productive and comprehensive program for the scientific exploration of the continent, the requirement for a broad transportation system is obvious.

In order to meet the transportation requirement, the United States has included in her support program, a system that includes ships, surface vehicles and aircraft and has attempted to marry these means into an efficient transportation team.

This paper was prepared for distribution at the Logistics Symposium sponsored by the Scientific Committee on Antarctic Research, held 13-17 August 1962 at Boulder, Colorado, U. S. A.

In this paper, air operations, as a means of providing transportation, reconnaissance, mapping and rescue service, are discussed and air operating techniques, problem areas and successes are described.

Chapter II
The Requirement

The purpose of the United States in Antarctica is, through scientific research and study, to unveil the secrets of the land, sea, atmosphere and the broad expanse of deep ice and snow associated with that continent in order to contribute to the pool of basic world knowledge.

Since human beings, unassisted, cannot survive in the Antarctic environment and since the scope of the research program of the United States is not limited to any particular local geographic area, logistic support from without and distribution of logistic resources within the continent are essential in the penetration of the continent for scientific knowledge.

The scope of the United States Antarctic Research Program is such that permanent type stations and logistic facilities have been established at several locations. The permanent stations are McMurdo, Hallett, Byrd, and Amundsen-Scott South Pole Stations. In addition to permanent stations, the United States maintains additional temporary facilities and field camps. (Base facilities are described in Chapter VII of this paper.)

McMurdo is in a sense a seaport and air support station at which a large stockpile of fuel, equipment and supplies are positioned to meet the requirements of continuing programs. The station features an excellent airfield on thick old bay ice which can accommodate either wheel or ski aircraft.

Hallett Station, operated in cooperation with New Zealand, is a seaport and has an ice runway adequate for limited air operations. It is located about 350 miles north of McMurdo.

Byrd Station and Amundsen-Scott South Pole Station are inland. Both stations provide excellent skiway facilities and are located about 800 miles from McMurdo. Trail routes over the snow have been established to both stations but surface travel is slow and hazardous.

Hallett, Byrd and South Pole Stations maintain a sufficient stockpile of fuel, equipment, and supplies to provide for current local needs.

In order to take maximum advantage of environmental conditions, two working seasons have been designated. During the period from March through August, designated the Wintering Over Season, extremely low temperatures, frequent severe storms, and darkness confines movement to the immediate vicinity of established camp facilities. From early September through March, designated the Summer Support Season, the severity of the elements abates and movement beyond the immediate vicinity of established camp facilities can be undertaken. Science projects within the research program are scheduled in a manner to best fit the season.

During the Wintering Over Season, only those scientists and support personnel that can be effectively employed within the confines of established camps remain in Antarctica. Transportation requirements during this period are limited to that which is necessary for data and sample collection in the area proximate to base camps and that which is incident to camp maintenance and operation.

As the summer support season approaches, the scope of the operation expands rapidly. Scientists and supporting personnel for base camps, field camp and traverse maintenance and operation are assembled and required equipment and materials are prepared for transportation to predetermined locations or to ultimate destinations in Antarctica. During the progress of the Summer Support Season, personnel, equipment and supplies are repositioned and supported as necessary. Further, during this season, resupply of permanent camps and prepositioning of the required materials for a continuing science program must occur. As the Summer Support Season comes to a close, a large percentage of the personnel and certain recoverable equipment are withdrawn.

In program planning and during the conduct of their studies, the scientists need accurate maps, charts and knowledge gained from reconnaissance in order to select favorable traverse routes, camp sites and to provide an aid in recording the location of their findings. Mapping and reconnaissance projects have a high priority for accomplishment and a substantial part of the logistic effort is directed toward this field of endeavor.

In the United States there is great competition for the services of talented and highly qualified scientists. The demand on the time available to these learned and dedicated gentlemen is pressing. The U. S. Antarctic Research Program attracts scientists of highest status and caliber. Fast, convenient transportation, free from the hardships of the trail, is necessary in order to allow the scientist to devote his full effort in the area of interest and to reduce to a minimum the time that would be lost if a slower method of travel was used.

To support the U. S. Antarctic Research Program and the complex of permanent and temporary stations, thousands of tons of equipment, spare parts, provisions, supplies, building materials and fuel are required each year. In addition, many scientists and support personnel conduct the various scientific projects, maintain and operate the camps, airfields and other essential facilities.

The need for transportation to, from and within the Antarctic Continent stems from the logistic requirements of the scientists and must be responsive to the principle that the vast uninhabited wastes of Antarctica shall be used only for peaceful purposes. The Summer Support Season is a short period, limited by environmental factors, and must be used to maximum advantage.

From the above, it is apparent that if the logistics requirement for the Antarctic scientific and operational programs of the United States are to be met, the transportation system must include a means to:

a. Transport large quantities of bulk materials to Antarctica.

b. Deliver essential materials to inland stations.

c. Lift personnel and priority cargo to, from and within Antarctica during that period which is consistent with the working seasons.

d. Conduct essential mapping and reconnaissance.

e. Provide utility service in direct support of scientific projects and personnel in the field.

f. Assure safety in Antarctica and the capability to assist those who may be in distress.

Due to ice obstructions in the sea lane approaches to Antarctica, ships normally cannot reach Antarctic shores until about the first of December and these must be free from Antarctic waters in March.

Land vehicles are operated throughout the year but are limited to the immediate vicinity of established camps during most of the Wintering Over Season. During the Summer Support Season land vehicles traverse large areas of the continent but their progress is slow and their path is sometimes hampered by terrain features, disturbed ice or other obstacles.

Most assigned aircraft can operate during the entire Summer Support Season and some can operate during the opening and closing phases of the Wintering Over Season. Generally, all aircraft are grounded during periods of darkness, since night flying navigation aids and base facilities are not adequate.

Ship transportation provides delivery of bulk and heavy materials. Land vehicles are employed for utility service throughout the year in or near base camps facilities and when the nature of the scientific project requires a surface traverse. Air lift is used, as a means of intercontinental transportation during periods when ships otherwise engaged or cannot operate, to provide rapid transportation to field sites within the Antarctic in order to capture a larger productive Summer Support Season. Additionally, air lift is used to penetrate remote areas which may be otherwise inaccessible, and to provide mapping, reconnaissance, utility and rescue service.

There are many scientific and logistic applications connected with traverse operations. When the object of scientific interest is in several localized remote areas which are an appreciable distance apart, the airborne traverse is frequently the most economical form. (The extremely successful TOPO NORTH and TOPO SOUTH projects are examples of the economy, speed and adaptability of airborne traverse operations.)

Chapter III
Basic Principles

In the development of efficient air transportation systems throughout the world, basic principles common to all operators have been established. The key words of these operating principles are dependability, economy, frequent service and safety. It has been the experience of United States aviation personnel that these principles are equally applicable in Antarctica and their use is required.

As will be shown in other sections of this paper, environmental conditions, base support and en route navigational facilities for aircraft operations in Antarctica are marginal for safety and are unique to the area. Normal hazards common to the area can be minimized, however, by the employment of experienced airmen who are trained in cold weather flying techniques and aircraft maintenance and by the selection of adaptable equipment.

In Antarctica, the "total" transportation requirements is dictated by the direct and indirect needs of the science program. The sum of that portion of the total transportation requirement which cannot be conducted by other means, plus, that which can be more efficiently conducted by aircraft, composes the airlift load for any individual year.

The task of air operations management personnel then is to analyze the airlift load in terms of manpower and equipment, and, by the use of already established operating principles and cold weather flying techniques, provide the required service.

Chapter IV
Selection of Aircraft

The aircraft types selected by the United States to provide the required service in Antarctica are "off the shelf models" that have been cold weather equipped and configured for adaptability to the Antarctic environment.

The aircraft chosen are as follows:

a. Globemaster. A long-range, four engine, heavy transport, nonpressurized, wheeled aircraft with a large cube accommodation and an aerial delivery system.

This aircraft is used to provide intercontinental cargo service and makes regular flights to the inland stations. Without skis, landings are restricted to conventional airfields and the ice runways at McMurdo. Cargo is delivered to the inland stations by air drop methods. The restricted altitude capability of the Globemaster limits this aircraft for photographic mapping.

b. Super Constellation. A long-range, four engine, pressurized cabin, heavy transport, wheeled aircraft with passenger accommodations, a trimetrogon camera system and air sampling equipment.

This aircraft is used to provide intercontinental passenger service. Without skis, landings are restricted to conventional airfields and the ice runways at McMurdo. On all flights, the air sampling equipment is employed. This aircraft is capable of making flights over the continent, and is occasionally used for photographic mapping and air sampling in the interior of Antarctica.

c. Rescuemaster. A long-range, four engine, nonpressurized, wheeled aircraft specially equipped for search at low altitude and aerial delivery of the tools and provisions for survival on land, ice or sea.

While this aircraft has excellent search capabilities, it is without skis and landings are restricted to conventional airfields and the ice runways at McMurdo.

d. Hercules. A medium-range, four engine turbo-prop, pressurized cabin, ramp loaded, heavy transport, equipped with a bulk fuel carrying and transfer system, jato system and skis. The aircraft has a large cube accommodation and aerial delivery system.

This aircraft has most of the desired characteristics for Antarctic heavy transport requirements. It is capable of hauling 25,000 pounds at ranges of 1,500 miles. The aircraft has both wheels and skis and can land on conventional airfields, ice runways or on a smooth or semi-prepared snow surface. It is restricted in load when used to provide intercontinental cargo and passenger service and is most effective when used in support of the inland stations from McMurdo. The Hercules is most economical when flown at high altitudes and is capable of airlifting a single package of six tons anywhere on the Antarctic Continent where a reasonably level snow surface of 5,000 or more lineal feet exists or can be carved out. At extreme ranges the aircraft would require refueling for the return trip.

e. Neptune. A long-range, combination propeller and jet driven aircraft with a medium high altitude capability equipped with a tri-metrogon camera installation, jato system and skis.

This aircraft has both wheels and skis and can land on conventional airfields, ice runways or prepared snow surfaces. The Neptune is being used for photographic mapping, reconnaissance and rescue service.

f. Dakota. An intermediate range, twin engine, medium transport, equipped with a bulk fuel carrying and transfer system, jato system and skis.

This aircraft is the "Grand Old Lady" of Antarctic air operations. It has both wheels and skis and can land on conventional airfields, ice runways or on a snow surface. Open snow landings in sastrugi of up to 18 inches have been frequently made. The Dakota is capable of delivering a 5,000 pound load to a range of 500 miles and then returning to the point of departure without refueling. It is relatively easy to maintain but requires a substantial period of time for pre-heating the various engine and ski components prior to flight. Launching of the aircraft on skis with even a moderate load or from high elevations requires the use of jato which is both costly and logistically difficult to provide. The aircraft can be ferried from the United States to Antarctica via the Pacific Islands and New Zealand but there are attendant risks. However, even with her limitations, the Dakota is the best medium range field party support aircraft available.

g. Otter. A short-range, single engine, light transport aircraft. Some of these aircraft are equipped with a tri-metrogon camera system, others have a jato system. All have skis.

This aircraft has both wheels and skis and can land on ice runways or reasonable smooth surfaces. The Otter is capable of delivering a 3,000 pound load to a range of 150 miles and then returning to the point of departure without refueling. It is easy to maintain but with only one engine, the Otter is not dependable and is a search and rescue risk. The Otter is being phased out of the U. S. program.

h. Sea Horse. A medium-range, single engine, intermediate transport helicopter, equipped with a bulk fuel carrying and transfer system, and a cargo sling and hoist.

The Sea Horse is an extremely versatile and useful helicopter. It can deliver a cargo load of 3,000 pounds at a range of 150 miles and return to the point of origin without refueling and it can land and take off vertically. When used within range limitations it is extremely valuable for utility cargo and personnel transportation. It is employed for field camp support, airborne traverse operations, reconnaissance, photography, sample and data collection at remote locations, and for rescue service. The Sea Horse does not have a high altitude capability and has a very limited application at elevations above 4,000 feet. It is relatively easy to maintain, but requires a substantial period of pre-heating of engine and rotor-head components prior to flight. The Sea Horse lacks multi-engine dependability and presents a serious rescue risk especially when operating over rugged terrain. As a rescue aircraft, the Sea Horse when employed within her operating limitations, is invaluable.

i. Iroquois. A short-range, single turbine engine, intermediate transport helicopter capable of high altitude performance.

Like the Sea Horse, the Iroquois is an extremely versatile and useful helicopter. It can deliver a cargo and passenger load of 2,000 pounds at a range of 100 miles and return to the point of origin without refueling, and it can land and take off vertically. Introduced into Antarctica only last season, the full capability of the Iroquois has not been realized. Used in association with other aircraft, it was employed for field camp support and airborne traverse operations in connection with the completely successful TOPO NORTH and TOPO SOUTH projects. The high altitude capability of the Iroquois was the key element in locating data collection teams on mountain peaks from the vicinity of the Beardmore Glacier to Cape Adare. The aircraft is easy to maintain and requires no preheating. It lacks multi-engine dependability and presents a rescue risk. As a potential rescue aircraft, it shows great promise.

j. Various other types of short-range, light utility ship based helicopters are used for ship support.

Ship based helicopters are used to provide ship to shore light cargo and personnel transportation and to provide ice and shore line reconnaissance.

During the last DEEP FREEZE operation, the United States had the following aircraft assigned:

Globemaster	9
Constellation	2
Rescuemaster	2
Hercules	4
Neptune	3
Dakota	4
Otter	3
Sea Horse	4
Iroquois	2
Miscellaneous helicopters	4
Total	37

All assigned aircraft are equipped with a polar compass, low frequency automatic direction finding gear, UHF/VHF command radio, heavy duty cabin heaters, high capacity de-icers, polar survival equipment and an auxiliary power unit for electrical power. All aircraft except helicopters and Otters have high powered navigation and search radar, UHF/DF, and single sideband long-range radio. All aircraft except Otters are equipped with TACAN.

Chapter V
Personnel Assignment

Flying in Antarctica has frequently been referred to as one of the world's most hazardous occupations. From my personal experience, there is no question as to the high quality of airmanship required.

The pilot must be thoroughly trained and experienced. He must be able to resist boredom, to respond without hesitation when circumstances dictate and he must be an accomplished instrument pilot.

Maintenance and aircrew personnel must have a thorough knowledge of assigned equipment, the ability to determine the nature of a discrepancy and the ingenuity to effect repairs without sophisticated shops and tools. Maintenance and aircrew personnel must perform their tasks reliably, regardless of the physical hardship, in a forbidding environment.

The United States from the resources of the military services, selects only the most highly professionally trained, mentally adapted and physically qualified aviation personnel to participate in the DEEP FREEZE air support program.

In the United States, there is abundant competition among aviation personnel for assignment to the Antarctic program. Volunteers are given specialized equipment and cold weather operations training. After a period under the observation and testing of Antarctic experienced personnel, the volunteer is either accepted or rejected.

Chapter VI
Training

"Flying in Antarctica is not inherently dangerous, but, like the sea, is mercilessly unforgiving of human carelessness."

The foregoing statement by an unknown author has been the by-word of instructors engaged in training the airmen of DEEP FREEZE for the past few years.

The training program for Antarctic airmen includes both formal classroom instruction and practical training. The training syllabus includes geography, climatology, polar navigation, survival techniques, first aid and technical instruction in aircraft and special equipment maintenance.

Throughout the training period, the proficiency of pilots and crewmen is maintained by frequent actual flight in the type aircraft to be flown in Antarctica and "on the job" supervised practical training in aircraft and equipment maintenance is conducted.

During the period from April 1 to September 1, 300 hours are devoted to formal classroom instruction, 150 hours are spent flying, and the balance is allocated to "on the job" training and study.

Both professional instructors and selected airmen with previous Antarctic experience are employed as teachers. Professional instructors are obtained from American industrial firms that manufacture the equipment and aircraft.

In order to assure that techniques learned during the training period are not forgotten and that a high state of proficiency in airmanship is maintained, several of the key professional instructors that were used during the training period are taken to Antarctica to observe performance and conduct refresher courses.

Chapter VII
Base Facilities

In order to provide for the logistic support of aircraft, aviation equipment and personnel assigned to air operations in Antarctica, the United States, in cooperation with New Zealand, has provided aviation support facilities at certain Antarctic stations and in New Zealand.

Facilities normally used by the United States in direct support of the Antarctic Scientific Program and a brief description of each is as follows:

Christchurch International Airport, Christchurch, New Zealand, is among the world's finest airdromes and is the main staging and transit point for most flights to the continent. Runways are in all respects capable of supporting any propeller aircraft contemplated for DEEP FREEZE use by the United States. A range of spare parts sufficient to support aircraft maintenance are prepositioned at this airdrome and resupply normally occurs by ship transportation. Cargo and personnel are assembled by the Cargo and Passenger Coordinator, on the staff of Commander Naval Support Force, Antarctica and individual aircraft loads are prepared and delivered to the scheduled plane. Radio aids to navigation are maintained and operated by the New Zealand Civil Aeronautics Agency.

Invercargill Airport, Invercargill, New Zealand, is the closest airdrome in that country to McMurdo Station and is used as a primary staging point for Dakota aircraft to Antarctica. Limited commercial maintenance facilities and services are available. The turf runways are designed to support medium transport traffic. All radio aids to navigation are maintained and operated by the New Zealand Civil Aeronautics Agency.

McMurdo Station is the primary location in Antarctica for U. S. flight activity. Commencing about October 1, there are two ice runways suitable for the operation of wheeled aircraft. The ice runways become undependable after December 15 due to melt and formation of pot holes. Though the runways are located on old bay ice that has not gone out for several years, their use following bay ice break-out which usually occurs in February, is considered to be an unacceptable risk. Prepared skiways are constructed annually in adjacent areas and safe ski operations can be conducted at any time during the year when natural light and terminal weather conditions permit. Except in or near crevassed areas, the surface of the snow, covering the Ross Ice Shelf, is sufficiently smooth to accommodate a safe emergency ski landing in the open field. The United States maintains the capability to perform complete aircraft maintenance (short of annual overhaul) at McMurdo

Station. A range of spare parts to support the aircraft maintenance function is prepositioned. Radio aids including LF Homer, UHF/DF, TACAN, and GCA surveillance and precision radar are maintained and operated by the United States. The LF Homer facilities are usually reliable at ranges of 75 to 100 miles. UHF/DF and TACAN are dependent upon special equipment installed in the aircraft and are reliable at ranges of 30 to 150 miles depending on the altitude of the aircraft. McMurdo Station is the primary staging point in Antarctica for all cargo and passengers destined for the U. S. Inland Stations.

Byrd Station is a secondary location for U. S. flight activity. There is a prepared skiway, suitable for ski operations only, during the period from October 1 to late February. Due to the field elevation (5, 150 feet) and to the slow and sticky snow surface, heavily laden aircraft always use jato for take-off. Aircraft that are not heavily laden do not require the use of jato at Byrd Station. Surrounding the station there is a very large area of snow surface that is relatively smooth. In this large area a safe emergency ski-landing can be made in the open field. Maintenance facilities at Byrd Station are limited to en route servicing and repair of minor discrepancies. Spare parts are drawn from McMurdo Station on a need basis, and, in the event of a maintenance requirement beyond the capability of the flight crew, an augmenting maintenance crew is dispatched from McMurdo. Fuel facilities are limited. Navigation aids, maintained and operated by the United States, include a low frequency homer and UHF/DF. Technical difficulties limit the effective range of the low frequency homer to about 15 miles. UHF/DF is effective at maximum ranges of 30 to 100 miles depending on the altitude of the aircraft. During DEEP FREEZE 63, the U. S. plans to install TACAN and GCA. From Byrd Station, Dakotas and Neptunes provide airlift in direct support of field camps and surface traverse operations. Airborne traverse parties sometimes use Byrd as a staging base. Further, aircraft from Byrd Station provide aerial reconnaissance, photographic mapping, and rescue services.

Amundsen-Scott South Pole Station features a long prepared skiway, suitable for ski operations only, during the period from November 1 to late February. Due to the field elevation (9, 200 feet), all aircraft, except a lightly loaded Hercules must use jato for take-off. Navigation aids, maintained and operated by the United States, include a low frequency homer, UHF/DF and TACAN. Technical difficulties limit the effective range of the low frequency homer to about 10 miles and it is considered to be unreliable. UHF/DF and TACAN are effective at maximum ranges of 30 to 100 miles depending on the altitude of the aircraft.

Hallett Station has, during the period from October 1 to about November 15, an ice runway. The ice runway is located on annual ice and its capability to support will vary from year to year. Normally, aircraft no larger than a Dakota should be operated. The ice runway has accommodated heavy transports on occasion. Terrain features in the vicinity of Hallett Station are a serious hazard during periods of low ceilings or visibility and air operations at low altitude during such periods in the vicinity of Cape Hallett should be avoided. Repair facilities and en route services are not normally maintained at this station. A low frequency homer which has an effective range of more than 50 miles is maintained and operated by the United States. There is no skiway available and all except helicopter operations cease when ice deterioration is detected.

In addition to the base locations described above, the United States uses unprepared and semi-prepared areas for ski aircraft operations where necessary. Among the more frequently used locations are: Eights Station (formerly called Sky-Hi), Camp Beardmore, Little Rockford, Camp Minnesota, Roosevelt Island, Ohio State Camp, and many others. At these locations there are no maintenance or servicing facilities and no navigation aids are maintained.

Chapter VIII
Aircraft Maintenance

If safe, economical, dependable airlift service is to be provided, thorough aircraft maintenance is absolutely essential.

Aircraft maintenance in Antarctica is attended by the lack of hangar facilities, unstable footing for work stands and lifting equipment, the difficulty of moving heavy test equipment over snow and ice and a host of problems associated with cold weather effects on men and material.

The most time consuming and recurring maintenance task is that of preheating the various aircraft components, lubricants, spare parts and tools to a degree which will allow freedom of activation of the various moving systems of the aircraft and which will permit men to touch metal without freezing exposed parts of the body on contact. However, through the use of the Herman Nelson pre-heating device and the employment of ingenuity and perseverance, skilled and dedicated men can, with few modifications, follow routine maintenance procedures and practice.

To achieve the maximum rate of aircraft availability and to reduce down time, a thoroughly trained mechanic with broad experience in all phases of the maintenance program is assigned to each aircraft as the Plane Captain. The Plane Captain is the supervisor and coordinator for all maintenance work which is performed on his aircraft. The Plane Captain flies with his aircraft frequently to observe performance and to detect areas of possible trouble. The aircrew that is scheduled to fly the aircraft performs the preflight inspection under the supervision of the Plane Captain, and corrects minor discrepancies and servicing deficiencies. Under the supervision of the crew chief, the same aircrew: (1) loads the cargo; (2) flies with the aircraft; (3) off-loads the cargo and performs en route servicing and repair; (4) conducts the post-flight inspection; (5) services the aircraft for the next flight.

Intermediate inspections and periodic preventive maintenance checks are conducted on the ice and in New Zealand depending on the location of the aircraft at the required time. The capability to perform major inspections is maintained both at McMurdo and at Christchurch. When the condition of the aircraft permits, aircraft which have adequate range are flown to Christchurch for major inspection and maintenance. In order to achieve maximum utilization of aircraft, airlift capacity and ground maintenance crew manpower, careful coordination and judicious scheduling of operations and maintenance is necessary.

In order to achieve maximum mobility and footing for ground support equipment, external power units, work stands, pre-heaters, heavy test devices and accommodation ladders are sled mounted. Mechanics make excellent use of small personal sleds for moving tool boxes and spare parts over the snow.

For the comfort of men working on the interior of an aircraft, a pre-heater is frequently used as a space heater. For all work on the exterior of an aircraft, heat is applied to the vicinity of interest.

The key to maintenance success is supervision of work in progress and careful inspection of the work accomplished.

Chapter IX
Aircraft Operations

Thorough flight planning, meticulous flight plan execution, close adherence to the proposed route and regular reporting of progress and intentions are key elements of dependability and safety in Antarctic air operations.

Flight operations centers are operated at Christchurch, McMurdo and at Byrd Station. The centers are operated by professional air control men and are equipped with long-range medium-frequency liaison radio. The centers are the focal point of flight planning, weather briefing, flight following and en route traffic control.

Control towers are operated at McMurdo, Byrd and South Pole Stations handling aircraft traffic within 100 miles of the respective station. En route inbound traffic is released by the center to the tower after positive two-way radio contact has been established with the tower; conversely, outbound traffic is released by the tower to the center after positive two-way radio contact has been established with the center.

Inbound and outbound traffic operating within a New Zealand Air Control Zone is controlled by the New Zealand Civil Aeronautics Agency. McMurdo center is responsible for all aircraft south of 60° South except for traffic that is within 250 miles of Byrd Station which is the responsibility of Byrd center.

A standard track is designated for the use of aircraft traveling over frequently used air routes. This method facilitates flight planning, progress reporting and navigation. Along the standard track, reporting points have been selected and named. Standard tracks are selected in a manner to best conform to terrain and visual features. The distance between reporting points approximates 150 miles. The site of a reporting point is located over or near an object that will give a clearly identifiable radar target.

An instrument approach procedure is developed at each location where landings are frequently made. The procedures are designed to provide maximum obstacle clearance and, except for the final approach, provide vertical separation of at least 1,000 feet between the aircraft and the surface. The final approach is usually started at 1,000 feet above the surface at a distance from the end of the landing area which will permit the aircraft to descend at the rate of 300 feet per minute and arrive at a position which is one mile down wind of the landing area at an altitude of 100 feet above the surface. Each operation center maintains copies of approved instrument approach procedures for distribution prior to flight.

In Antarctica, there are extremely large areas both on the continent and in the surrounding sea that are not adequately covered by meteorological observation posts. As a result, forecasting marginal flight operating conditions with an acceptable degree of accuracy is practically impossible. In the interest of safety, weather minima at the point of departure, en route stops and terminal, has been established for all continental air operations. The weather minima applies to the point of departure, en route stops and the point of flight termination and must be in existence at the time of take-off and predicted to remain, at or above minima, for the duration of flight plus two hours. The prescribed weather minima is 2,000 feet ceiling and two miles visibility/ or 1,500 feet and three miles/ or 1,000 feet and five miles.

Aircraft that encounter weather at en route stops that is less than the prescribed minima are permitted to continue and are allowed to make an instrument approach to the station. If the airstrip can be visually sighted from an altitude of 100 feet and if approach line-up is acceptable to the pilot, a landing is allowed.

Approaches during conditions of low ceilings or restricted visibility at locations where GCA is not available are usually made using modified air surveillance radar methods. The airborne navigator/radar operator using the aircraft radar installation and employing the approach end of the runway as a target passes bearing and distance information to the pilot. The pilot maintains headings and adjusts altitude as necessary to intercept and maintain the desired approach bearing and to arrive at a position one mile from the target at an altitude of 100 feet.

It has been my experience in the Antarctic that due to surface and horizon definition difficulties, the entire final approach should be flown at five to eight knots above the published handbook touchdown speed for the type, configuration and weight of the aircraft flown and that the rate of descent from one mile out to touchdown should be 150 to 200 feet per minute. Using this technique, the aircraft will be in a landing attitude and damage to the aircraft will not be incurred if the skis touch down prior to the pilot sighting the surface. In order to safely employ this technique, aircraft and surface vertical separation must be accurately known. During DEEP FREEZE 62 the use of this approach method was so successful that only two aborted flights resulted from more than 30 attempts under adverse weather conditions by the various assigned pilots.

Some of the more important rules that are prescribed are as follows:

a. All flights are scheduled.

b. Fuel, sufficient for the planned duration of flight, plus 10 per cent en route reserve, plus two hours holding, is carried on all flights.

c. Sufficient survival rations and equipment to accommodate all embarked personnel for 20 days is carried on each flight.

d. No aircraft may take off until: (1) a flight plan is filed, (2) passengers, cargo and equipment are secured, (3) aircraft gross weight and balance are within limitations and a load plan is filed, (4) the pilot is cleared through the appropriate operations center, and (5) two-way radio communication is established.

e. The pilot will respond promptly to positive tower control when operating within a control zone and to positive center control while en route.

f. ICAO flight rules and air reporting procedures are observed.

g. If two-way communications are interrupted for a period of more than 30 minutes, the aircraft will proceed to destination or will return to the point of departure, whichever is closer.

h. No en route aircraft may proceed on instruments at an altitude of less than 2, 000 feet above all terrain within 25 miles.

i. The navigator will use all means available to him to determine and record a geographic fix and compass error at least every 30 minutes.

j. Intentional instrument flight is prohibited in single engine aircraft.

k. Single engine aircraft may not be flown over open water.

l. Whenever practical, regardless of the prevailing weather, approaches to landing will be made using a standard instrument approach procedure.

Aircraft are scheduled to fulfill the need for regular frequent service throughout the operating year, to provide for the movement of large quantities of building materials and fuel at prescribed times, and, under certain conditions, to respond to emergency or other unplanned needs. All scheduling is coordinated by the Logistics Staff.

For ease of discussion, air operations scheduling in support of the U. S. DEEP FREEZE program can be divided into flight categories as follows:

a. Flights between Christchurch and McMurdo.

b. Flights between McMurdo, the inland stations, and Hallett.

c. Utility service in support of field camp, trail party, and airborne traverse operations.

d. Photographic mapping and reconnaissance.

e. Search and rescue.

For the convenience of passengers, to insure an even flow of mail and to move the large quantities of high priority cargo, daily service from Christchurch and McMurdo is provided when possible during the period from October 1 to

December 1. From December 1 until ice runway conditions preclude further wheeled aircraft operations, or until February 15, approximately weekly service is provided. To reduce priority cargo and passenger backlogs, special flights are added to the basic schedule when required. Insofar as possible, the times of departure and arrival at Christchurch are controlled to avoid airport activity outside of normal working hours. Aircraft employed are the Globemaster, Super Constellation and Hercules.

Service between McMurdo and Hallett Station is provided weekly during the period from October 1 to about November 15. The aircraft employed is usually the Dakota.

Service between McMurdo and Byrd Station is provided daily, as weather permits, during the period from October 1 to February 15 by the Hercules. In addition, during the period from November 1 to December 1, large quantities of specially packaged fuel in drums, building materials and supplies that are compatible with aerial delivery techniques are delivered by Globemasters using the aerial delivery technique. To reduce the backlog of priority cargo, special Hercules flights are added to the daily schedule as necessary.

Service between McMurdo and South Pole Station is provided about twice weekly during the period from November 1 to February 15 by Hercules. During the period from November 1 to December 1, large quantities of specially packaged fuel and lubricants are delivered by Globemasters using the aerial delivery system.

The needs of field camp, trail party and airborne traverse operating parties are sporadic. Generally, a target date for commencing and concluding the operation is established and weekly or more frequent flights are planned. A pool of aircraft, however, is maintained to be able to respond to actual needs as they arise. Employing this technique, large stocks of spares and emergency materials do not have to be maintained at the field camp site or carried on the trail. Helicopters, Otters and Dakotas are the aircraft most frequently employed for utility service.

Most of the photographic and reconnaissance requirement is planned in advance. Some of the requirement develops as work progresses. If the desired results are to be achieved, photographic mapping and reconnaissance must be accomplished during periods of minimum sky cover. Photographic and reconnaissance operations are therefore scheduled by using the weather forecast as a guide. The primary photographic and reconnaissance aircraft is the Neptune.

Search and rescue service requires that a potential be maintained. At all times during the operating year while air operations are in progress, at least one aircraft and aircrew is maintained in an alert status at Christchurch, McMurdo and at Byrd Station. No aircraft is cleared for a flight until an adequate search and rescue aircraft is in all respects ready for duty if called.

Search and rescue facilities are alerted for a variety of emergencies which will not be enumerated here. When search and rescue procedures are alerted, the flight operations centers become SAR headquarters and following the launch of the alert aircraft, all aircraft become at the disposal of the SAR Coordinator. The primary aircraft used for SAR service are the Rescuemaster and the Neptune.

Chapter X
Navigation

Aerial navigators assigned to DEEP FREEZE operations are selected on a basis of broad training and experience. In addition to the ability to navigate accurately in both polar and subpolar regions, all assigned navigators are expert radar operators.

A professional navigator is assigned to each aircraft crew, except helicopter and Otter crews. In addition to the navigation talent possessed by the professionals, every aircraft commander assigned to a DEEP FREEZE air crew is required to be an accomplished navigator.

Air navigation charts employed are polar stereographic projections with a grid oriented parallel to the Greenwich Meridian. The Air Almanac and Sight Reduction Tables for Air Navigation published by the U. S. Navy are used in connection with celestial observations.

In navigating the Antarctic sky, error is intolerable and every means available must be employed to act as a method of mutual check.

En route radio aids to navigation do not exist in the continent; however, terminal radio aids can be used en route with varying degrees of effectiveness. (See Chapter on Base Facilities.)

Radar provides a means of accurately fixing position over routes previously flown and for avoiding obstacles in the flight path. Areas of disturbed ice, crevasses and many terrain features make good targets and can be readily identified on the radar scope. The position of many of the more prominent features have been determined and plotted on existing charts for use as reference points.

Radar is considered essential for flight in Antarctica under instrument conditions and is extremely helpful during visual flight conditions. All U. S. aircraft except the Otter and helicopter are radar equipped.

Summary and Conclusions

The United States is dedicated to the principle that the vast uninhabited wastes of Antarctica shall be used only for peaceful purposes. Through a comprehensive scientific research and mapping program, the United States, in cooperation with many nations, is studying and recording the secrets of the continent in order to do their share in benefiting the world from the knowledge gained.

Aircraft as supporting elements for scientific activities and the mapping program are employed in direct response to the needs of the scientists and their programs. Airlift is used as a means of transportation for cargo and personnel that cannot be carried by other means or for cargo and personnel that can be carried more economically by air. Aerial photography is an essential element of the mapping and reconnaissance program.

Through the use of air transportation, a larger percentage of the total time that is available to the scientists can be devoted to productive effort and the hardships of long unnecessary traverse operations can be avoided. Aircraft, through their speed and flexibility, have overcome the natural barriers to travel in Antarctica, have made the interior of the continent accessible and have permitted the horizons of scientific endeavor in Antarctica to be broadened.

While base facilities are rudimentary, the climate extreme and the environmental conditions difficult, skilled professional airmen operating and maintaining well equipped aircraft can, by the judicious application of the basic principles of aircraft operation and the adaptation of routine maintenance procedures, provide the required aviation services.

SECTION III

BUILDINGS

HOUSE FOR EXTREME COLD ZONE

Alberto P. Giovannini

Abstract

A type of house is described which has room for up to 20 men and includes the essential facilities: bedrooms, living room, dining room, radio room, bathroom, and kitchen.

The same building, with a different inner partitioning wholly independent of the structure, can be used to supplement the facilities of a base, it furnishing space for workshops, battery room, powerhouse, laboratories, etc.

Once the site has been levelled, its assembly time is approximately 60 hours, no technicians being required.

Upkeep is very easy: the building is simple to heat and completely windproof.

It will withstand indefinitely being covered with three or more meters of snow, with no difficulties of any sort.

Transportation of the house to the building site is facilitated to the maximum by the ease of handling of its components.

It is particularly well suited for places with the characteristics of Lassiter or Filchner shelf ice, with their ground of compact snow.

The house described in the present paper was designed with only twenty days available for shipping it to the Antarctic.

In these twenty days it was necessary to fit the complete operations including designing, construction, and transportation.

Its salient features are ease of construction at the factory, ease of transportation and handling of the component elements owing to the low weight of each of the latter, rapidity and simplicity of assembly at the destination, great heat insulation, ability to withstand enormous pressures from snow, complete interchangeability of the component elements, and ease of increase and decrease in capacity because the building is of modular construction. On the other hand, it is completely recoverable for subsequent assembly in another place and its initial cost is low, considering its strength, insulating capacity, and practically unlimited resistance to the harsh climatic conditions of the Antarctic zone for which it was destined. As has already been stated, construction of it is quite simple, this simplicity including the electric wiring, plumbing, and water supply system in general. It may thus be assembled without the need for specialists, by the very expedition personnel who will subsequently live in it.

Interior Arrangement

Two types, designated as type "A" and "A" special, were designed and built. The two are essentially equal, but type "A" special can accommodate 24 men and type "A" 17; their exterior measurements are 7.30 x 30 m in one case and 7.30 x 24 m in the other. In their front part both have a 6 x 2.50 m radio room, 2 x 2.50 m base commander's room, 6 x 2.50 kitchen-pantry, and 2 x 2.50 m bathroom and snow liquefaction room. All these facilities have sound insulation up to the ceiling. Between them is a 2 x 8 m passageway serving effectively as a repository of outer clothing (anorak, etc.). The remainder is a large room along the sides of which there are, in the case of the type "A" building, two rows of individual 2 x 2 m cubicles with partition walls 2.15 m high. In the case of the type "A" special, the number of cubicles of the same characteristics is 23. The central space, of 3.30 x 16 m in one case and 3.30 x 20 m in the other, is used as a dining room, living room, etc.

Ventilation

Ventilation is provided by six telescopic pipes situated in the center of the ceiling and having an interior cover to close them. They are used as follows:

To achieve entry of new fresh air, one telescopic pipe is lowered to approximately one meter from the floor. Owing to its greater specific weight, the fresh air descends naturally through this pipe into the building. To achieve expulsion of the foul air, the telescopic pipe nearest the one which has been lowered is raised as far as it will go; the lighter foul air leaves through it, the expulsion being aided additionally by the draft regulators situated on the outside. The correct adjustment for adequate ventilation varies with the outside and inside temperature and the wind blowing. The system in question has proved in practice that it functions perfectly well.

Lighting

Since this building was planned for a zone such as is the south of Weddell Sea, where buildings are covered with snow the first winter and afterward only ice crystals form, and on rare occasions at that, on the upper central part of the roof, natural light, and thus windows, which involve so many inconveniences of filtration and breakage, were almost entirely dispensed with. This is the case to the extent that natural light is provided only by three double sheets of fiber glass impregnated with resins and situated in the upper central part of the dwelling, one in the front passageway and two in the common living room.

Artificial lighting is represented by two independent installations.

The main installation, of 220 volts alternating current, meets the needs of the whole building during the hours in which the motor is in operation. At the times when the latter is not in operation, the secondary installation, of 32 volts direct current, meets the needs of the whole building. The current of this secondary line is provided by two 300-ampere nickel-cadmium batteries, both located in the radio room. These batteries are used alternately so that they may be kept at a correct charge level. The battery being charged receives its charge from a direct-current generator installed in the generator room. While the 220-volt generators are in operation, the battery in use receives a compensatory charge of 6/7 amperes through a static charger.

Heating

Heating is provided by the following elements: in the common living room, two gas oil stoves each of 10,000 calories, of the common gutter system, situated at both ends of this room; in the radio room, and electric stove of the resistance/fan system; in the Commander's room, a common electric stove. The kitchen-pantry and bathroom and snow liquefaction room have natural heating for their functions. As for the cubicles, they are heated naturally by the atmosphere of the common room. This is why the cubicles are preferred to rooms with complete walls.

Bathroom and Snow Liquefaction Room

As its name indicates, this room is intended for the production of water and for bathing, being provided with a snow liquefier consisting of a central chimney heated by a pressure kerosene system and having a stainless steel tank from which the water obtained is pumped into a 300-liter tank situated in the highest corner of the room, whence it is distributed to the shower or to the kitchen, which is the adjoining room. An absolute minimum of piping is achieved with this arrangement. The piping in question is of bronze and is not embedded, but rather on the outside of the inner wall of the building.

Kitchen and Pantry

The kitchen has a main liquefied gas (propane) range supplied from the outside and having four burners, griddle, and two ovens. The secondary, auxiliary range is a kerosene gas range having two burners and an oven. The remainder of the furnishings is made up of a six-meter kitchen cabinet with a stainless steel basin and shelving for a week of food supplies.

Drains

Advantage is taken of the unlimited capacity of the ground of compact snow to absorb water, the drains being run directly to the outside, vertically from the appliance, without extension of the pipe on the outside.

Latrine

Considering the difficulties it presents, it was elected to install the latrine in a separate hut located in one of the tunnels which make up the bases in these zones.

Composition of the Floor

The floor consists of the following layers, from bottom to top: pine planking 5 cm thick, a layer of asphaltic binder, a layer of No. 1 asphalt roofing, a 5-cm layer of telgopor (expanded polystyrene), a 3.8-cm layer of dovetailed planking, and a layer of linoleum or tile or plastic tile.

Supporting Structure

It is made up essentially of midpoint arches spaced at intervals of 2.00 meters, made of I.P.N. No. 12, and joined together lengthwise by double-layer mouldings. The lower ends of the arch are connected beneath the floor with I.P.N. No. 8 iron.

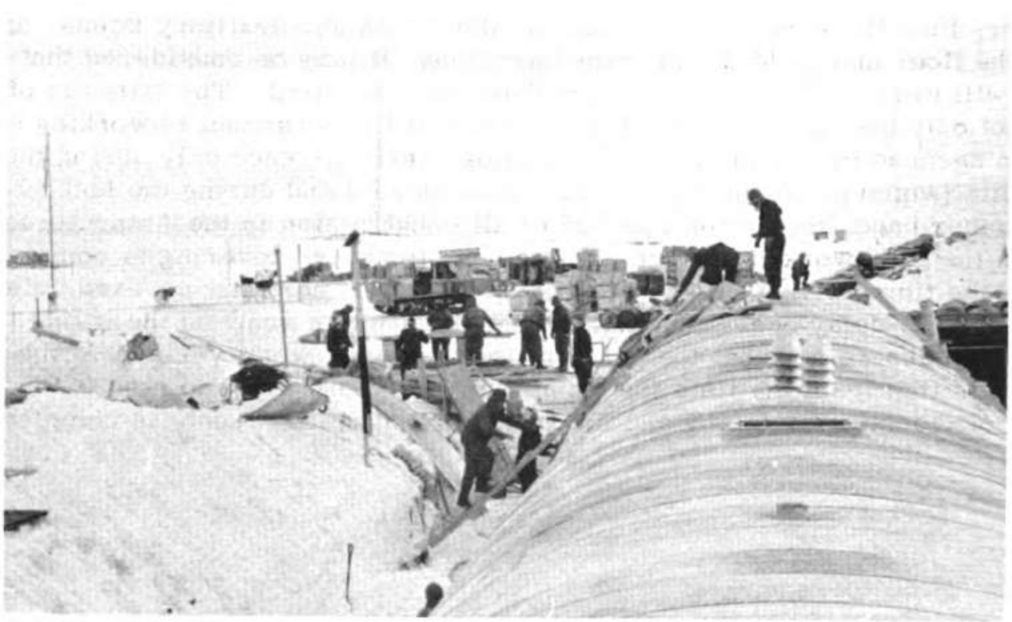
Roofing

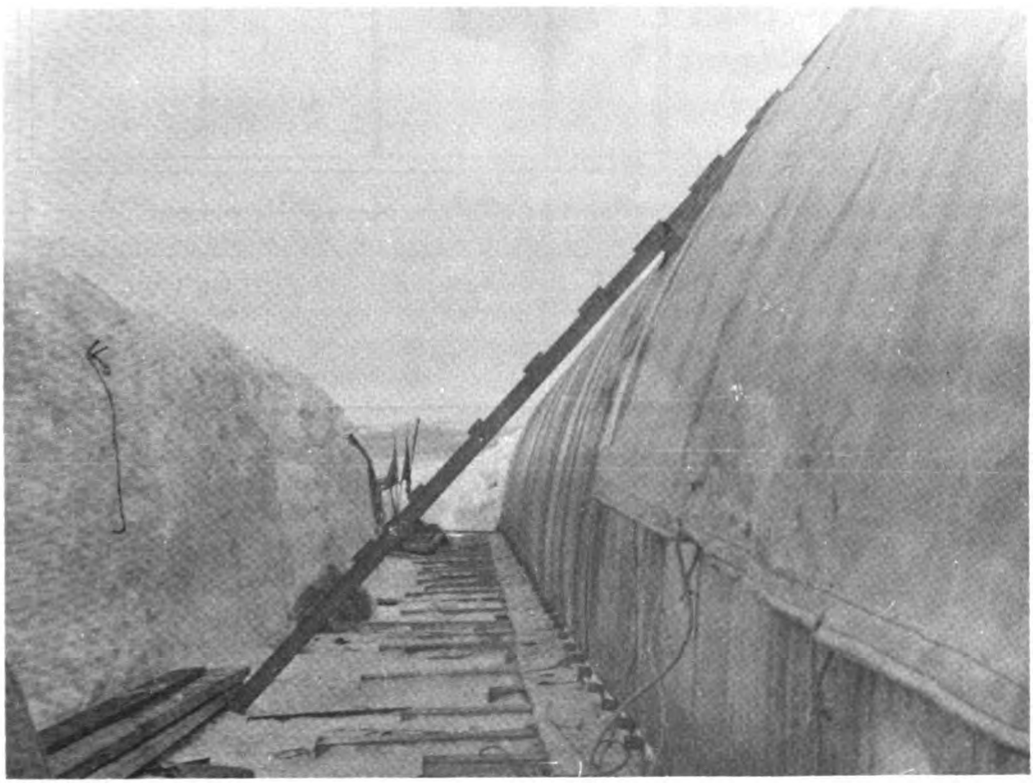
This structure is covered by several layers, the whole of the structure remaining inside the building. These layers are, from the inside outward: a layer of hard aluminum sheeting 0.55 mm thick, a layer of telgopor (polystyrene foam) 5 cm thick, a layer of waterproof cotton canvas, and then a layer of No. 24 corrugated galvanized sheet metal, precurved. These layers are tightened together by a cable which is fixed on one of the lower sides, runs completely around the building, and is tightened by a winch located on the opposite lower side, thereby compressing all the outer covering and securing it to the structure. The fronts and auxiliary fronts are made up of five prefabricated panels, which have a framework of Parana pine and insulation of 0.55 mm of telgopor and are covered with sheeting. The inner panels consist of a framework of Parana pine and a facing of 0.55 mm of aluminum. The outer panels are joined by means of double joined caps connected by pins which already have the corresponding foam-rubber weather strips on them.

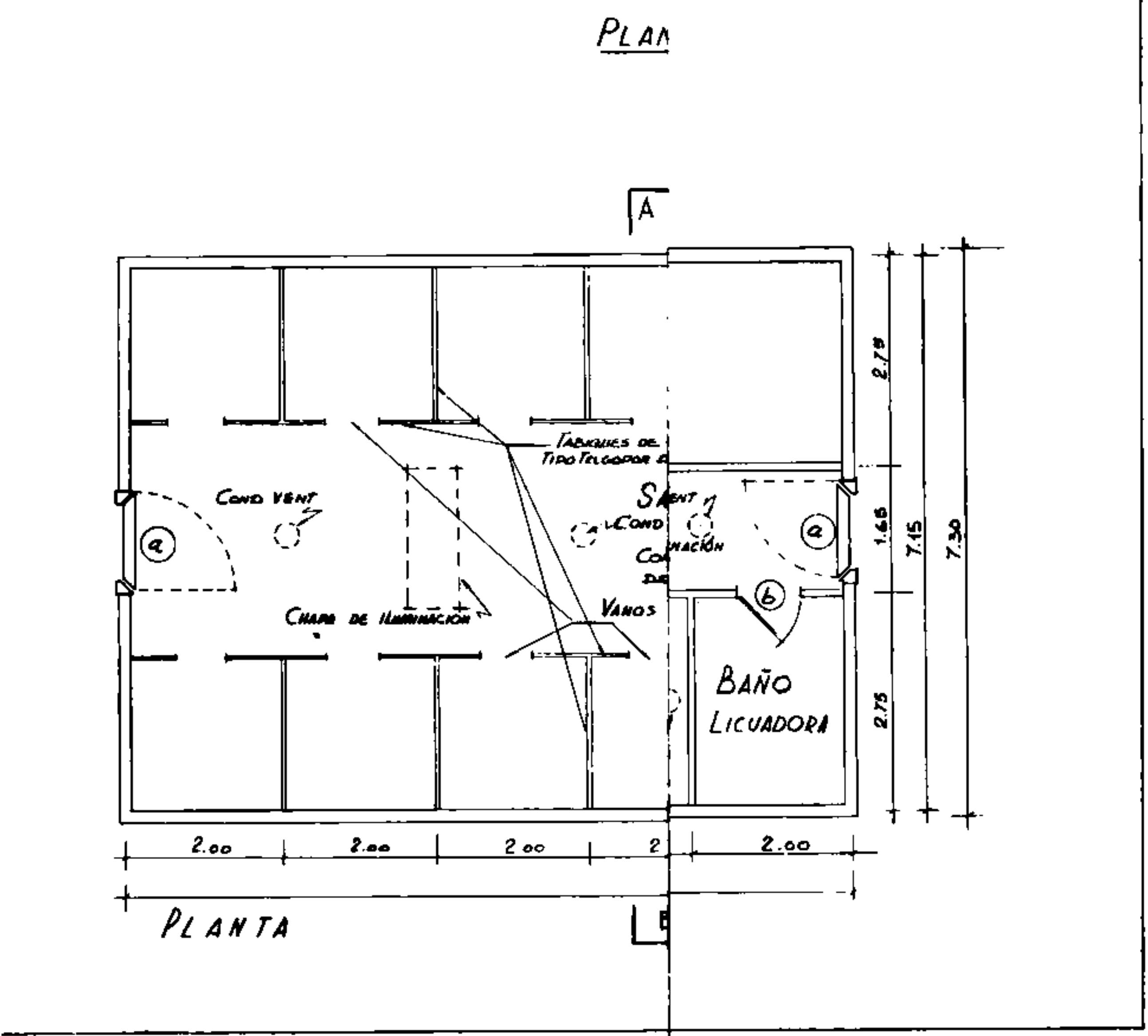
Both the aluminum and the canvas are carried in rolls which greatly facilitate placing them in position.

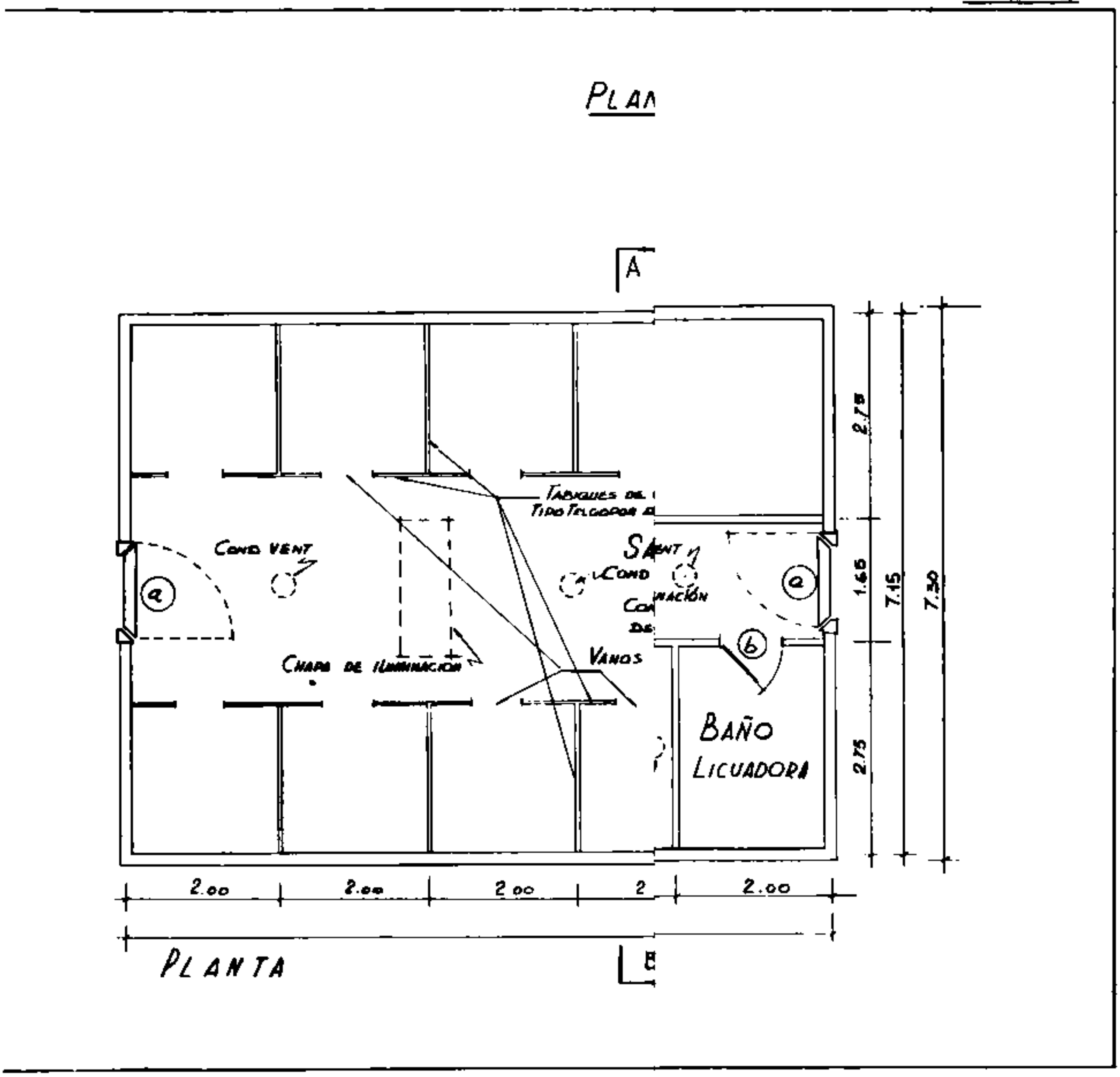
Assembly Time

Once the site on which the building is to be erected has been levelled, less than 60 hours of work with 12 men is necessary to complete the assembly of this house. If it is taken into account that it is entirely possible to build only part of the floor, then the structure, insulation, the fronts and auxiliary fronts, and then finish the floor and build the interior partitions, it may be considered that the personnel will work outdoors less than 50% of the time cited. The latter is of importance not only because of the fatigue suffered by the personnel in working outdoors, but also because the weather conditions thus exert influence only during the levelling of the site (which proceeds rapidly with a bulldozer) and during the last 30 hours. On the other hand, the critical period of all construction in the Antarctic is that between the time work is started and the time the outer covering is completed, that is, the time during which a storm can destroy a partially covered building or at best greatly delay operations due to accumulation of snow on the inside. In this particular case we see that the phase of the assembly work which is of the shortest duration is that from the time the supporting structure is completed to the time that placing of the exterior facing and the fronts and auxiliary fronts is completed.



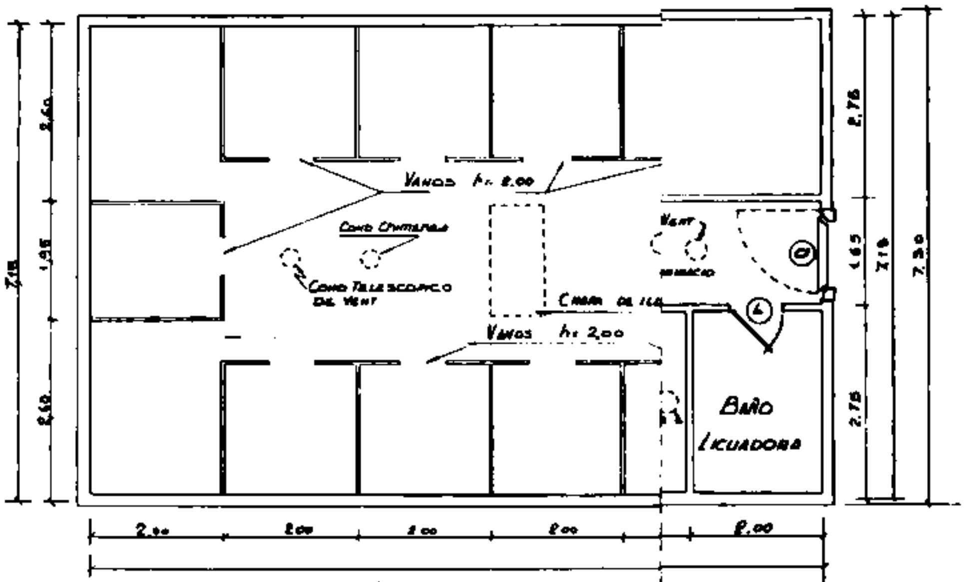



PLAN
A
TABIQUES DE
TIPO TELGOPOR
COND VENT
VENT
COND
NACIÓN
CHAPA DE ILUMINACIÓN
VANOS
a
a
b
BAÑO
LICUADORA
2.75
1.65
2.75
7.15
7.30
2.00
2.00
2 00
2
2.00
PLANTA
B


PLAN
A
TABIQUES DE
TIPO TELGOPOR
COND VENT
a
CHAPA DE ILUMINACIÓN
VANOS
SA
COND
NACIÓN
b
BAÑO
LICUADORA
2.75
1.65
7.15
7.30
2.75
2.00
2.00
2.00
2
2.00
PLANTA
B

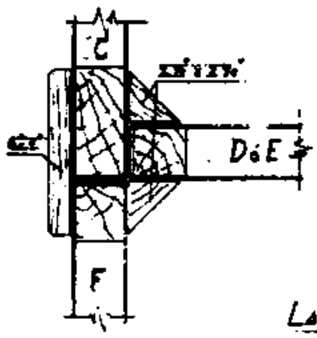
ANEXO 5

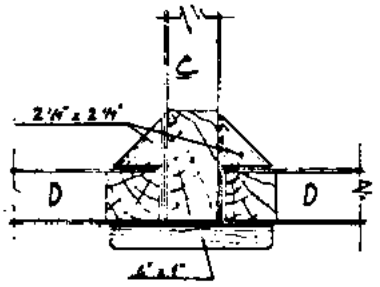
PLANO



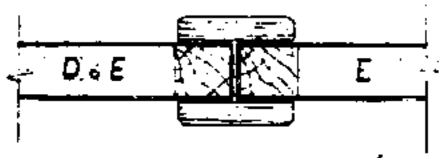
PLANTA

DETALLES DE UNION DE PANELES

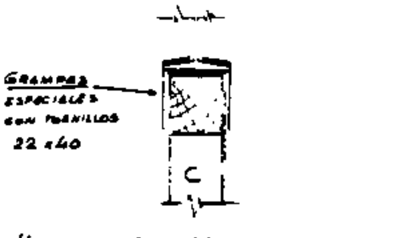




LA UNION DE LOS PANELES SE HARA MEDIANTE LAS MADERAS INDICADAS Y CLAVOS DE 2½"

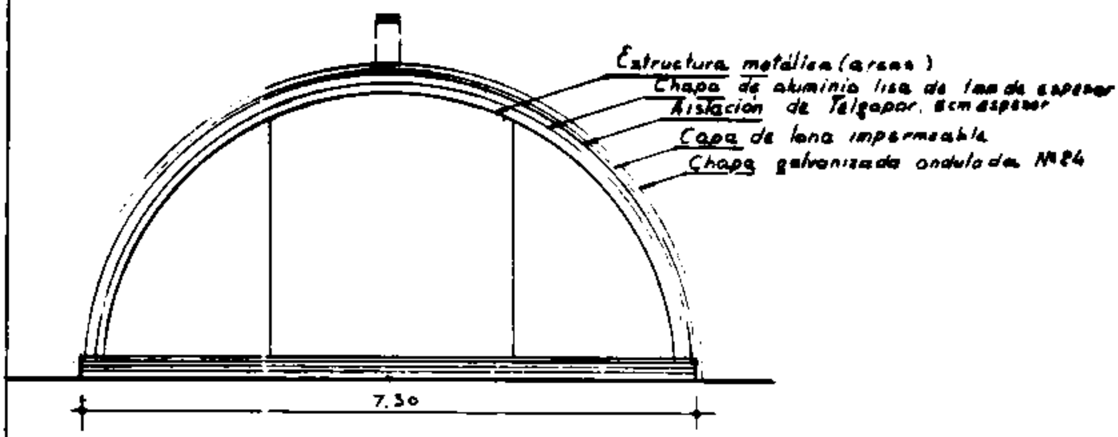


NOTA: LOS TABIQUES INTERIORES DE LA SALA COMÚN DE LOS ALOJAMIENTOS "A" Y "A" ESPECIAL, SON DE CARACTERISTICAS ANÁLOGAS, A LOS DE LOS PANELES TIPO C Y D, PERO DE 2.15 m DE ALTURA.—

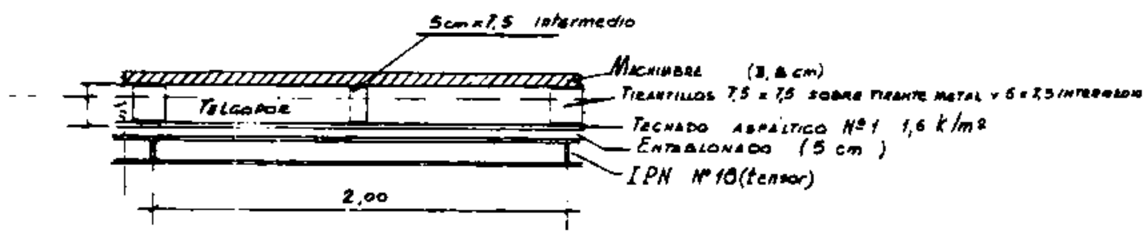


UNION DE PANELES INTER A ARCOS

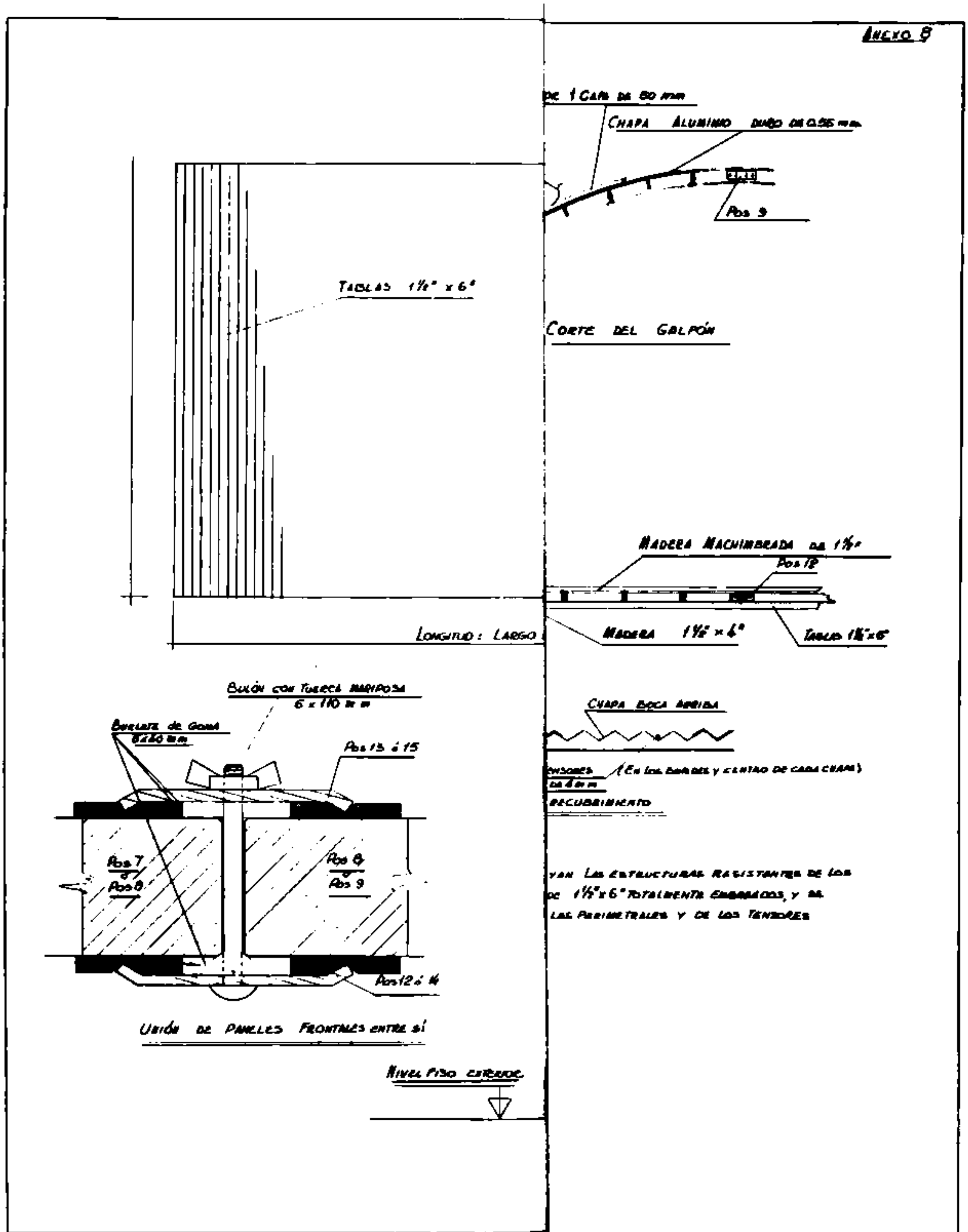
Detalle de Aislación Exterior y Construcción del Piso

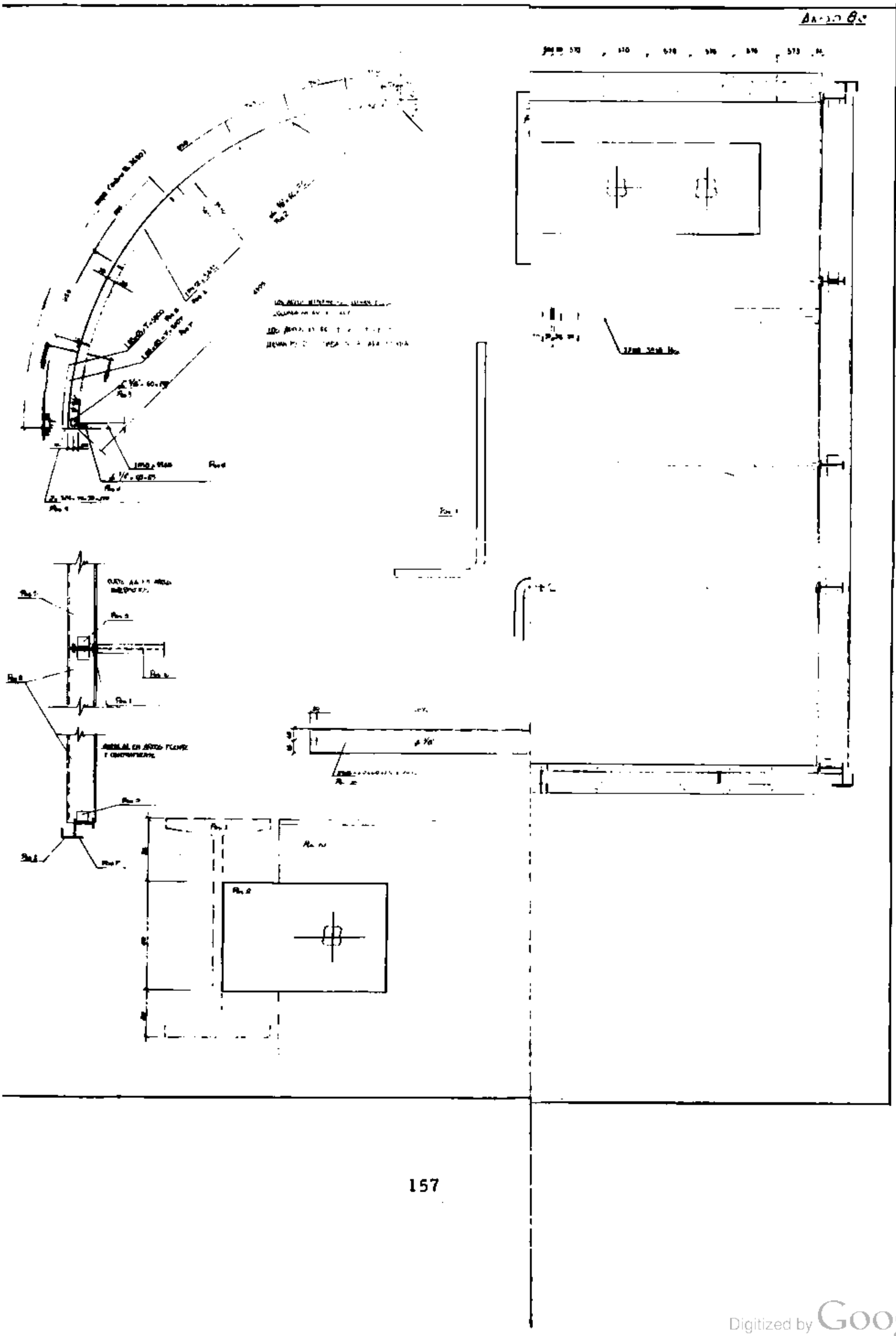


Corte A-B

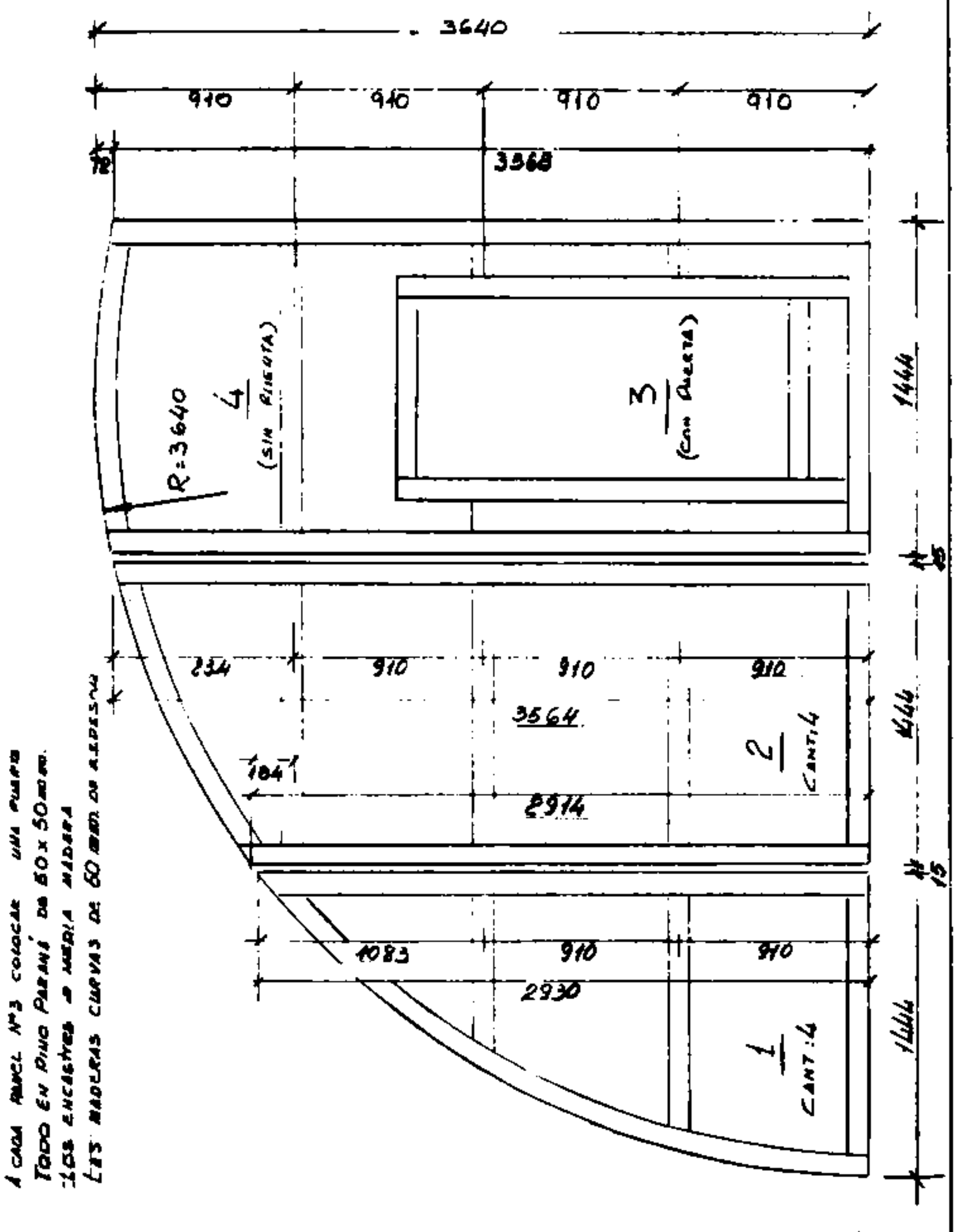


Detalle de Piso


Anexo 8
Chapa Aluminio duro de 0.56 mm
Pos 9
Tablas 1½" x 6"
Corte del Galpón
Madera Machimbrada de 1½"
Pos 12
Longitud : Largo
Madera 1½" x 4"
Tablas 1½"x6"
Bulón con Tuerca mariposa
6 x 110 mm
Burlete de Goma
Pos 13 á 15
Chapa boca arriba
Pos 7
Pos 8
Pos 8
Pos 9
Pos 12 á 14
Unión de Paneles Frontales entre sí
Nivel Piso exterior

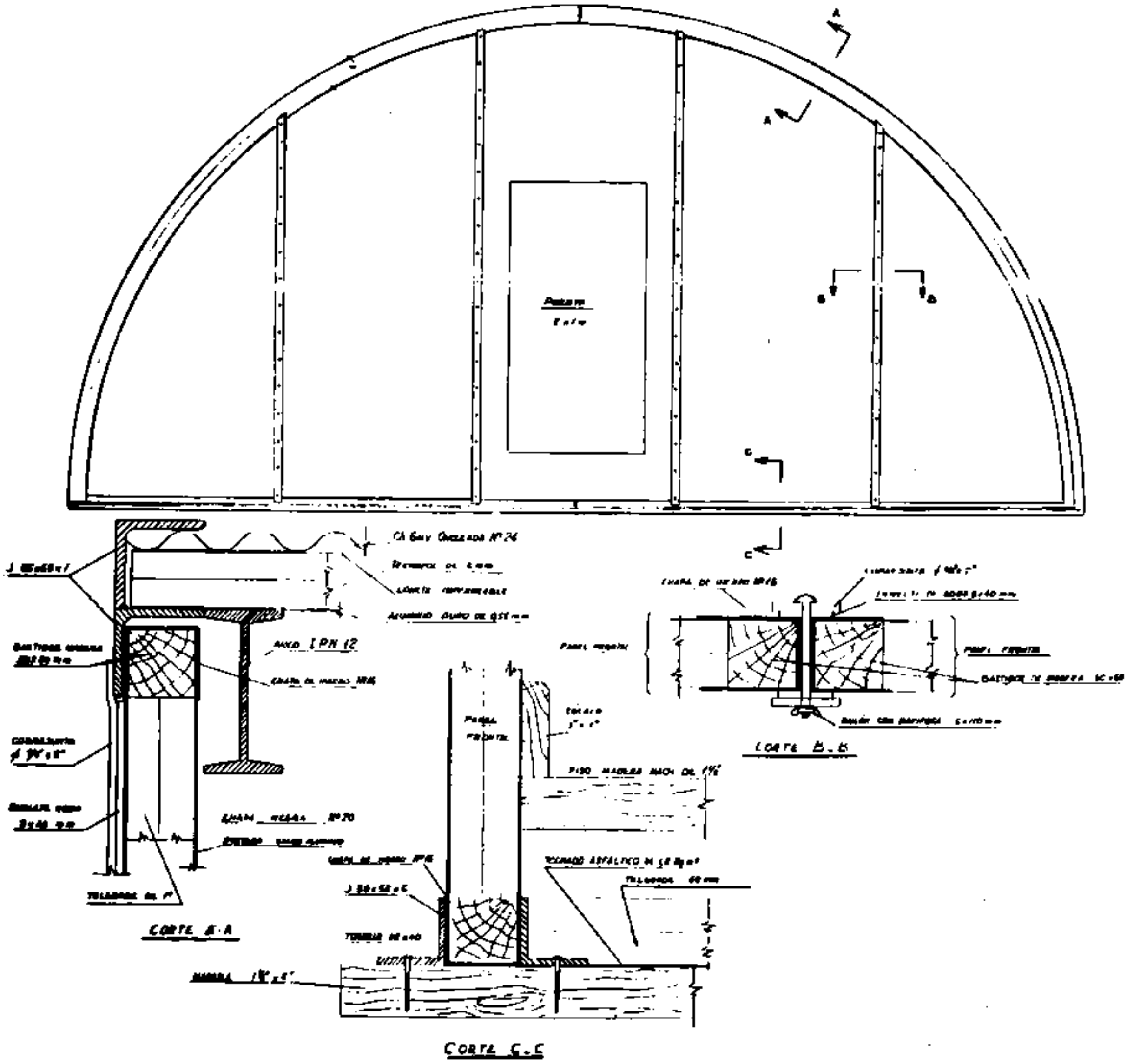


PANELES DE FRENTE Y CONTRAFRENTE — ANEXO 9



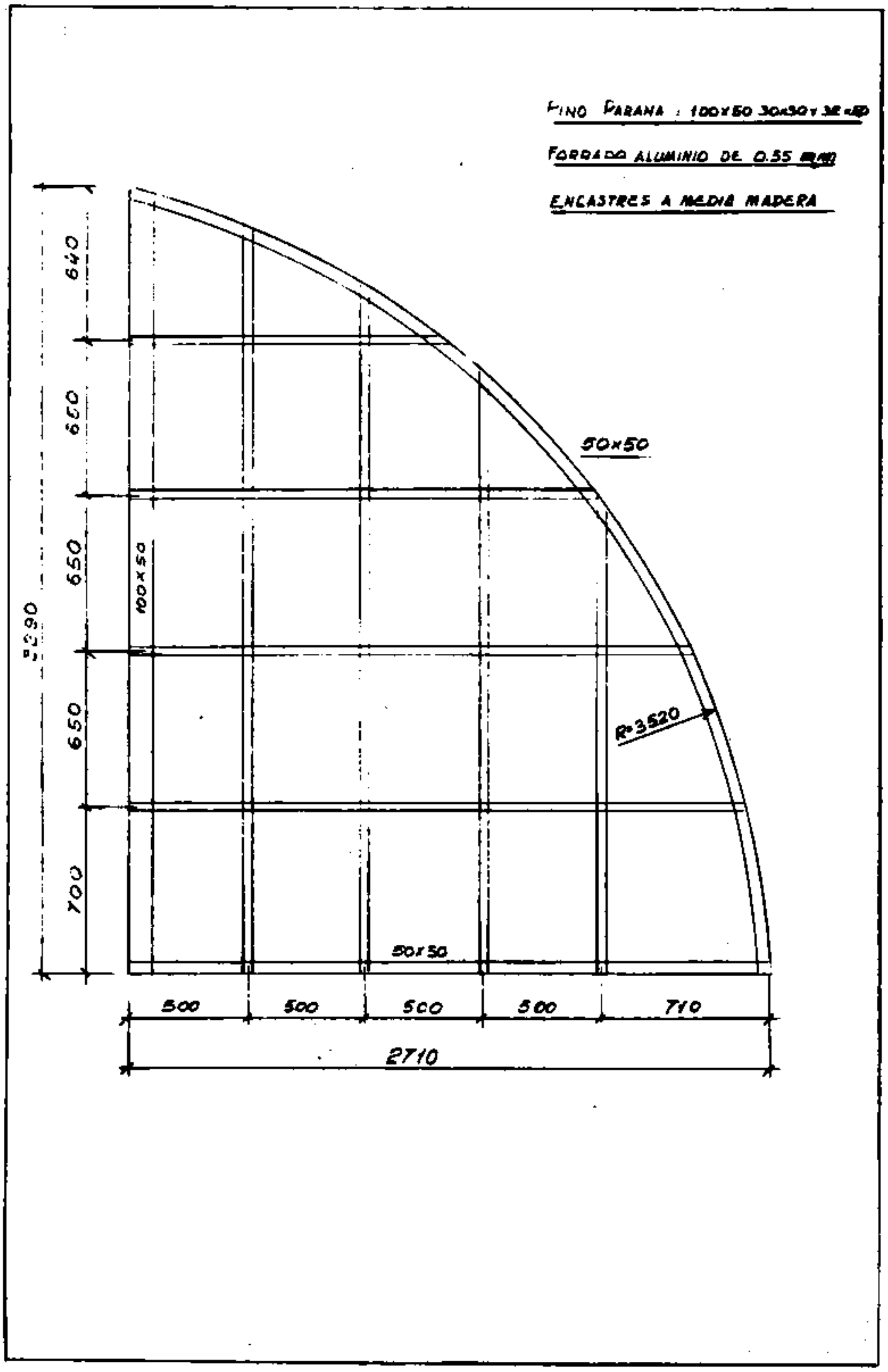
Paneles para frente y contrafrente constr. para Antártida

Detalle de Armado de Paneles de Frente



PANEL INTERIOR TIPO "C"

ANEXO 10

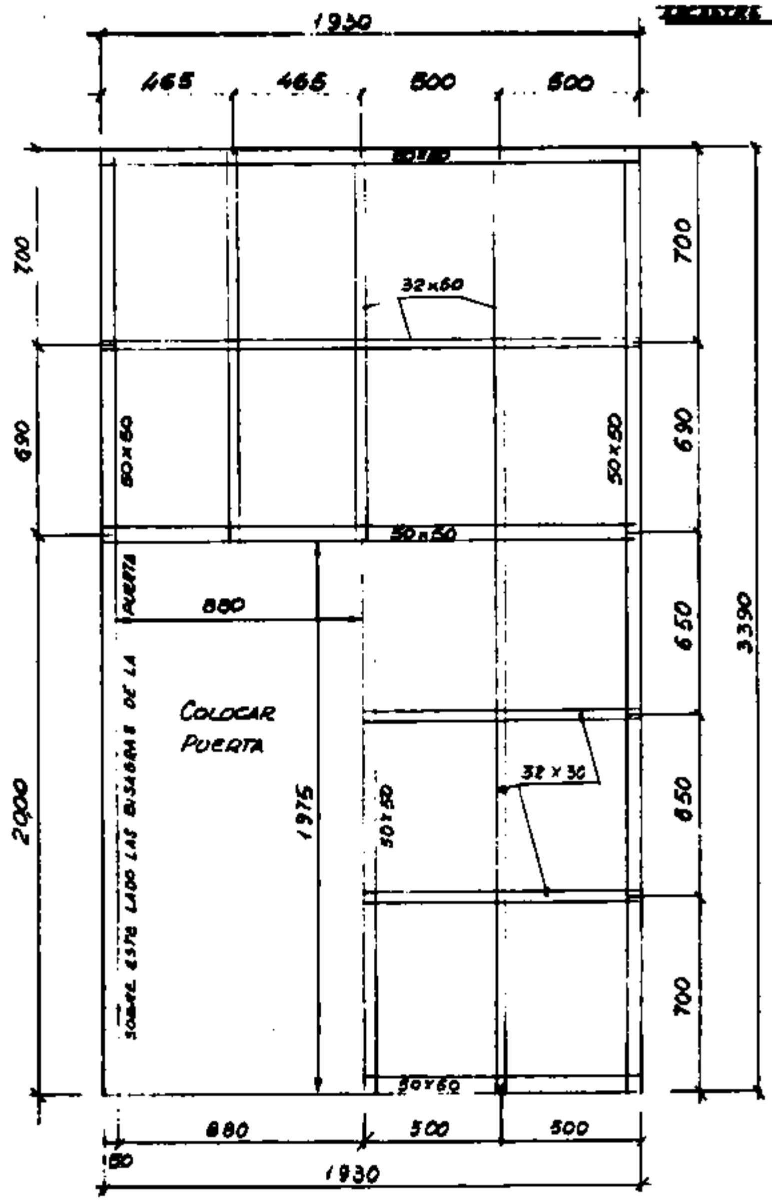


PANEL INTERIOR TIPO "D"

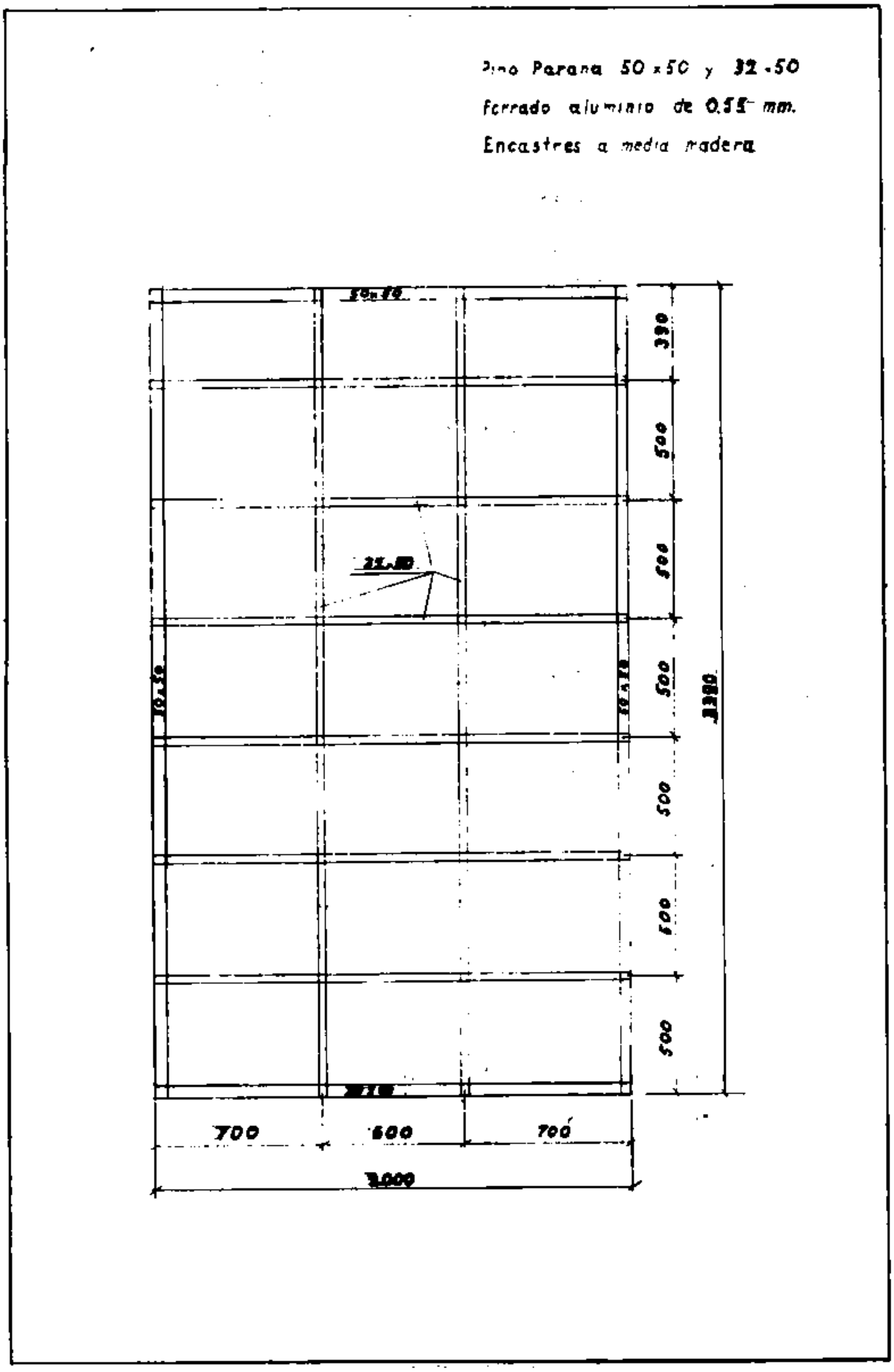
ANEXO 11

FINO PARANA 50x50 . 32x30

FORRADO ALUMINIO DE

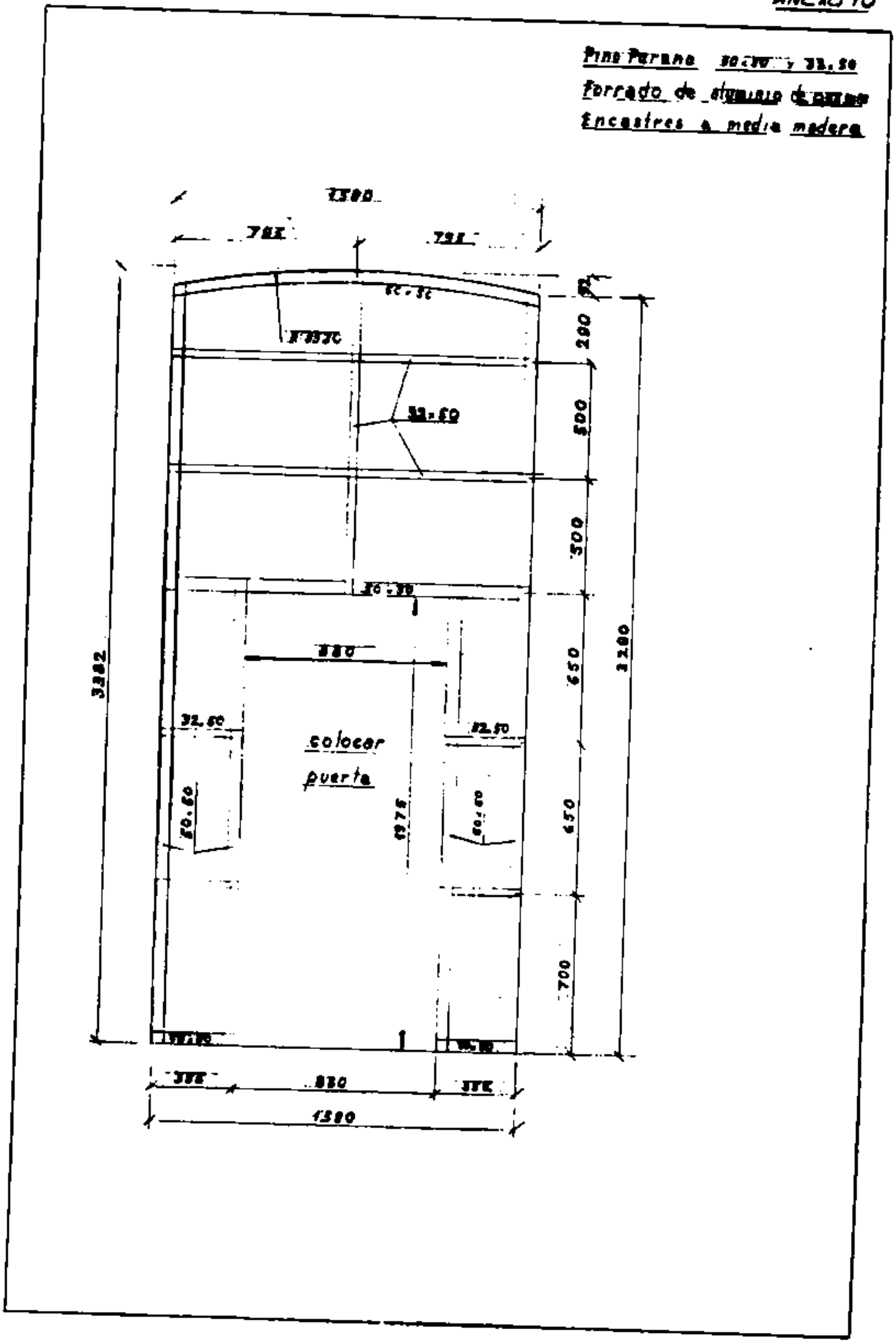


PANEL INTERIOR TIPO "E" - ANEXO 12



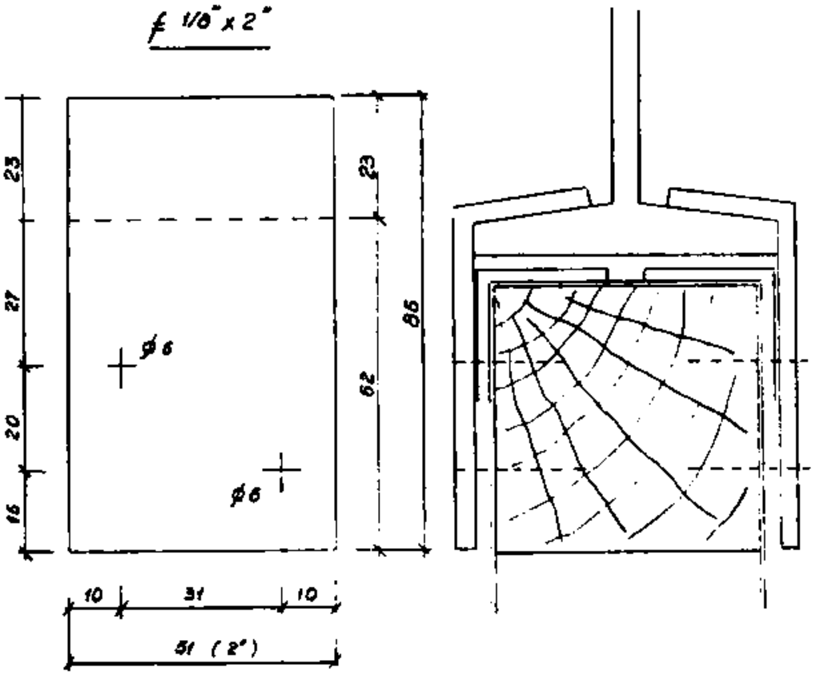
PANEL INTERIOR TIPO "F"

ANEXO 13



GRAMPAS PARA FIJACION DE PANELES INTERIORES A ARCO

ANEXO 14



INSTRUCCIONES PARA EL MONTAJE DE ALOJAMIENTOS "A" Y "A" ESPECIAL DE 7,30 m. X 24 m. y 7,30 X 30 m. RESPECTIVAMENTE EN ANTARTIDA ARGENTINA

1°) Disponer sobre el terreno perfectamente alisado, las tablas de 1½" X 6" formando un piso de 7,30 m. de ancho por 24,30 m. o 30,30 m. de longitud, según el caso, estando las tablas dispuestas en forma transversal al alojamiento.

2°) Sobre esta primer capa de madera se colocarán y abulonarán entre sí las Pos. 5 y 6. A continuación se levantarán los arcos (Pos. 1, 2 y 3) y se los unirán con los largueros Pos. 4. Se colocan en su lugar los paneles que componen el frente y contrafrente. Se fijarán ahora los ángulos 50 X 50 X 5 (Pos. 11) al piso mediante los tornillos de cabeza redonda de 22 X 40. La unión entre paneles se hará con unas planchuelas interiores y exteriores unidas por bulones de 6 mm. con tuerca mariposa. Esta unión irá sellada con dos burletes de goma.

3°) Sobre las maderas ya colocadas del piso se dispondrá en forma transversal al alojamiento el techado asfáltico. Sobre esto y en forma longitudinal se colocarán las tablas de 1½" X 4" distanciadas de 80 cm. a 1 m. entre sí. Se las fijará provisoriamente con algunos clavos para colocar encima el piso de madera machihembrada de 1½" que constituirá el piso, y que se fijará a las tablas de 1½" X 4" mediante clavos de 3". Previamente a la colocación del piso de madera machihembrada se colocará una capa de Termofol.

4°) El aluminio para el techo se provee en rollos cuyo extremo se elevará al borde del piso. Se colocará sobre los largueros y transversal al alojamiento. Entre una tira y la siguiente habrá un recubrimiento de 2 cm. aproximadamente y se unirán con tornillos Parker de ½" colocados cada 30 cm. Cuando sea necesario unir un sobrante de un rollo con otro se hará mediante dos filas de cuatro tornillos cada una. El aislante será Termofol que se colocará en una capa.

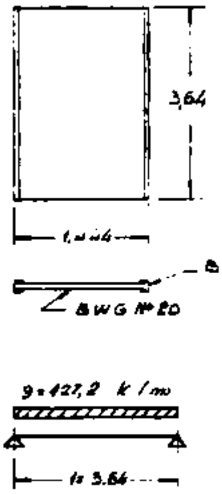
La lana se colocará sobre el aislante en sentido transversal y con un recubrimiento de 5 cm.. A continuación se colocarán las chapas galvanizadas que tendrán un recubrimiento de 5 cm.

A continuación se colocarán las chapas galvanizadas que tendrán un recubrimiento de 2½ ondas como indica el plano de montaje y se sujetarán con los tensores con sus torniquetes bien ajustados.

———oOo———

Calculo resistente panel frente y contrafrente

Caso muy desfavorable panel central: considerando solamente estructura metalica, despreciando el efecto de la madera.



Momento max. ocasionado por viento 150 Km/h. - presión 110 Kg/m2.

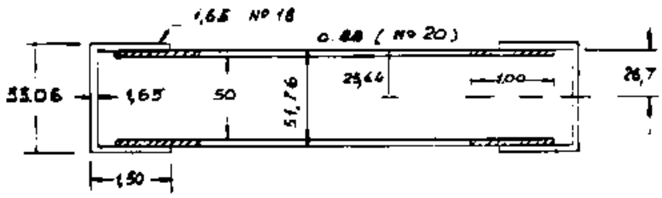
Según normas Din 1055 para viento frontal galpón cerrado debe tomarse el factor 0,8 para superficie de incidencia.

0,8 X 110 = 88 Kg/m2 resultando por metro lineal en la luz 3,64 m.

$$88 \times 1{,}444 = 127{,}2 \ \text{Kg/m}$$

$$M = \frac{ql^2}{8} = \frac{127{,}2 \times 1{,}64^2}{8} = 221 \ \text{Kgm.}$$

Calculo de Jx y Wx



Aún considerando como sección resistente los 2 u extremos y solamente 100 mm de c/chapa Nº 20 en cada extremo, se tendría:

1°) 2 perfiles U

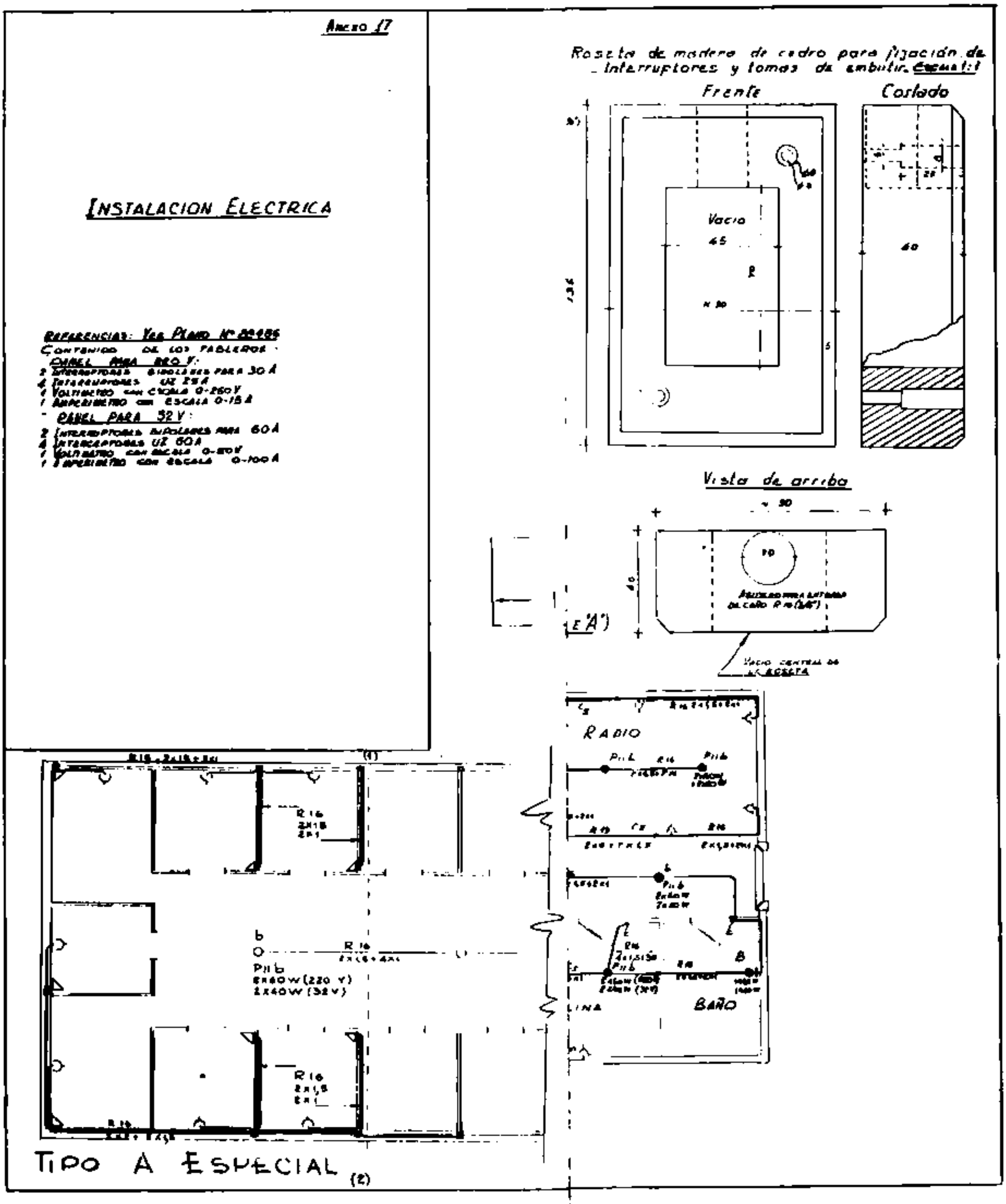
$$2\,Jx = 2 \times \left(\frac{0{,}165 \times 3{,}176^3}{12} + 2 \times 0{,}165 \times 5 \times 2{,}67^2 \right) = 27{,}6$$

2°) 4 Chapas 0,88 x 100. $2\,Jx2 = 2 \times (0{,}088 \times 10 \times 2 \times 2{,}554^2) = 22{,}8$ cm.4

$$Jt = 50{,}4 \ \text{cm.}^4$$

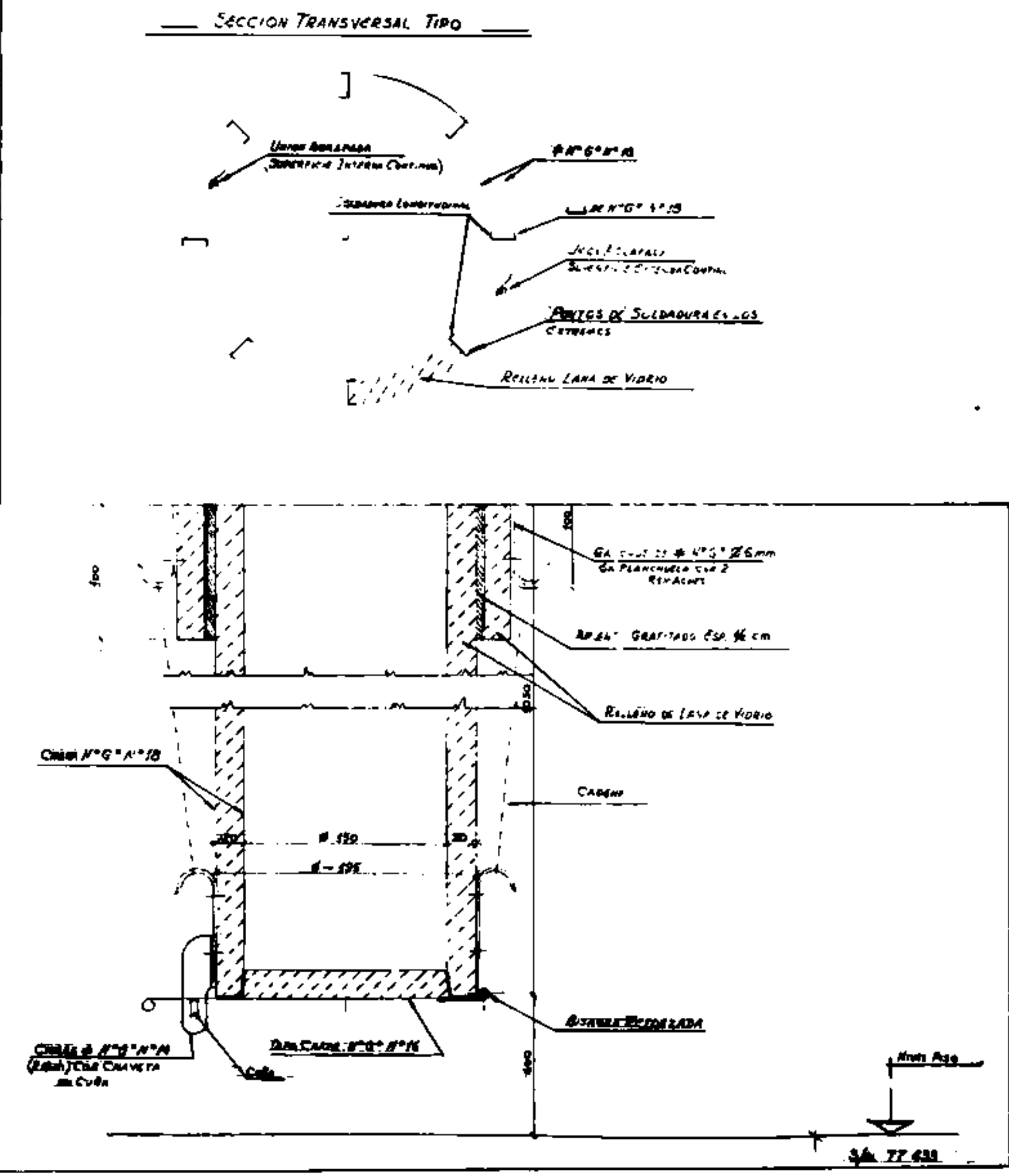
$$W = \frac{Jt}{2{,}753} = 18{,}3 \ \text{cm.}^3$$

$$\sigma = \frac{M}{W} = \frac{221}{18{,}3} = 1192 \ \text{Kg/cm}^2$$


Anexo 17
INSTALACION ELECTRICA
Referencias: Ver Plano Nº
Contenido de los tableros:
2 Interruptores bipolares para 30 A
1 Voltimetro con escala 0-250 V
1 Amperimetro con escala 0-15 A
Panel para 32 V:
2 Interruptores bipolares para 60 A
4 Intercaptores UZ 60 A
1 Amperimetro con escala 0-100 A
Roseta de madera de cedro para fijación de interruptores y tomas de embutir.
Frente
Costado
Vacio
45
Vista de arriba
Radio
Baño
Pii b
2x40W (220 V)
2x40W (32 V)
TIPO A ESPECIAL (2)

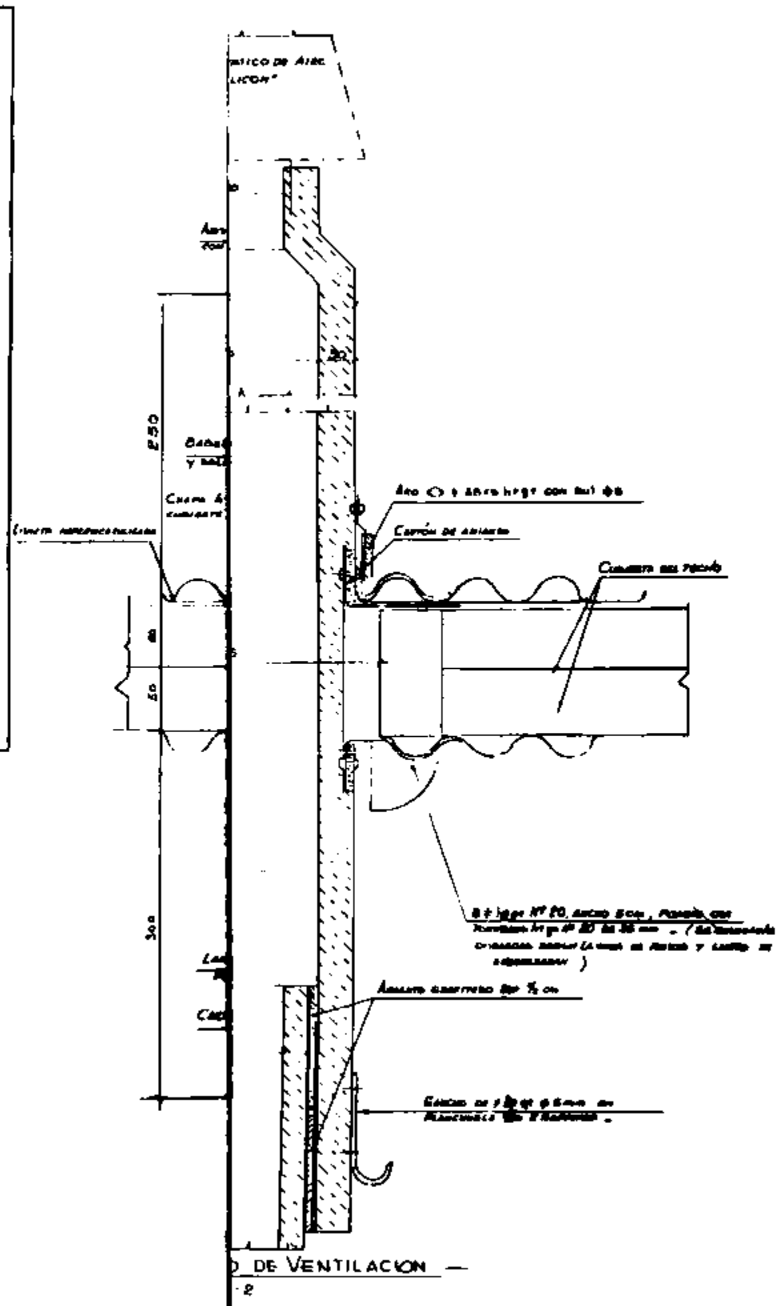
Anexo 18

TUBOS DE VENTILACION



ANEXO 19

DETALLE DE PASAJE DE CHIMENEA Y CONDUCTO DE VENTILACION



AUSTRALIAN DESIGN AND CONSTRUCTION OF ANTARCTIC BUILDINGS

D. F. Styles, A. M. Brown,
G. D. P. Smith and Z. Lukinovic

Summary

A.N.A.R.E. stations are based on rock, moraine, or sand and are kept fairly clear of snow by the wind. Building techniques have been developed which provide easy and quick erection on rough, unprepared ground of very rigid, insulated and well sealed buildings. These techniques are described under the main headings of foundations, floors, panel construction and assembly, functional design, anchorage, heating and ventilation, maintenance, and preparation and packing of components.

1. Foundations

When the A.N.A.R.E. first established Mawson on the Antarctic mainland in 1954 the site selected for the station was on a rock exposure on the edge of the continental ice. The snowdrift which covers the site for most of the year always melts in mid-summer when the sun has been above the horizon long enough to warm the rock. Although ice-free, the rock nevertheless posed certain problems in building, one of the principal difficulties being the provision of suitable foundations. Although concrete has been used for the bases of some technical and scientific buildings, the process is involved owing to the quick-freezing climatic conditions and is generally not used for living or sleeping huts.

a. Sleeper Block Foundations

For several years huts were built up on railway sleepers which were piled in stacks and packed with smaller pieces of timber until the tops were level. The bearers of the hut were then placed on these stacks. Small rocks and boulders were piled around to stabilize them. This method was also used at Australia's second station at Davis, which was based on moraine. The disadvantages of sleeper foundations are:

i. The necessity for frequent inspection and repacking of sections dislodged by vibration of the buildings in the wind

ii. The accumulation of drift under the buildings

iii. Unsuitability for steep sites.

b. Pipe Scaffolding Foundations

Steel pipe foundations were introduced in 1960 to avoid these disadvantages.

Boring of holes in the Mawson granite for anchorage points has been accomplished readily and conveniently by the Atlas Copco "Cobra" rock drill, a light petrol-driven hammer-type drill with drill rotating equipment. By using the "Cobra" with a 2 inch diameter tungsten carbide tipped star drill, holes are drilled six inches into the granite. Two inch steel pipes are cut to approximate height and driven into the holes. Fine adjustment of height is achieved using a screw and nut fitting designed to be set in the tops of these pipes. The fitting has a fork reveal attached, in which the wooden bearer is cradled. Scaffolding fittings are used to provide bracing where height requires it. An accompanying photograph shows these details.

A sub-floor frame consisting of six inch by two inch timber is laid over the bearers, then the floor panels are put down and the building is erected.

This type of foundation is more expensive but involves less cargo space, provides more accurate and more rigid building support, with some resistance to sideways movement, and allows the wind to scour under the building so that there is almost no build-up of drift snow.

c. Concrete Foundations and Floors

Where a concrete floor is required (e.g. powerhouse, garage, balloon filling shed, etc.) a method has been evolved which enables the building to be erected before large quantities of concrete are poured. The prevention of freezing of setting concrete is then simplified.

Concrete piers four inches square are poured round threaded rods set in holes drilled in the rock about four feet apart. This operation takes place in the open and it is necessary to add an accelerator to the concrete mixture. Slotted steel channel beams are bolted to the piers and the building is erected on them. Concrete form-work is then placed for dwarf walls—it serves to exclude most of the wind from the building. Reinforcing mesh is then tied to the channel and the concrete floor is poured in the shelter of the building, in such a way that the channel beam and the piers are encased in the concrete. Warm water for the concrete mixture is obtained from a snowmelter or from drums heated over a fire.

Where the building is to be erected on sand or gravel, precast concrete piers may be set in the sand or gravel for initial erection instead of pouring the piers on site.

2. Floors

Flooring materials vary according to the functional design of the building and in heavy utility areas insulation is sometimes sacrificed for strength.

In living, sleeping and scientific huts an insulated panelled floor is provided. The floor sections consist of 4 inch x 2 inch timber frame, zinc coated steel exterior sheeting, polystyrene foam or expanded bakelite insulation and 1/2 inch waterproof ply inside lining. The floors are covered with heavy duty cork-inlaid linoleum. Mild steel brackets anchor the floor to the sub-floor framing.

Garages, workshops, etc. usually have a concrete floor poured after the erection of the main building (Sub-section 1). In one power house, where the ground is a steep rock slope and a solid floor uneconomical, the floor is made up of box-sectioned steel decking.

3. Panel Construction and Assembly

The accompanying illustrations show that the buildings are cubicles. This simplifies the construction, panels and erection. Walls, roofs and floors (generally) are made of prefabricated panels, the size of which is limited.

Buildings may be any length desired, but widths over twelve feet require supporting beams or partitions to support the roofs. In any case no panel is made more than fifteen feet long because it is too difficult to handle.

As far as possible, standard sizes of panels are used. Wall panels are either six feet or four feet wide and three inches thick. Roof and floor panels are three feet wide and four inches thick. The panel widths are chosen to stagger the joints and provide additional strengthening of the structure.

The panels are the structural members of the building as well as the cladding, lining and insulation. They are built up from Douglas Fir timber with hardboard, plywood, aluminum, or galvanized steel on each side and all cavities are filled with foamed polystyrene or foamed ebonite insulation. A latex based compound called "Hornex" (A. C. Horn Co. Inc., New York) is used to bond all the timber mortice and tenon joints, insulation, and sheets, fill any cavities or irregularities, and seal the panel against moisture and water vapour. A paste and a powder are mixed together, then brushed, trowelled or spread with a serrated tool, then the surfaces are held together by press, clamp or nails till set. The "Hornex" sets to become a flexible material like rubber. Joints between panels are fitted with mating wooden tongues and grooves, with a strip of closed cell foamed rubber (1 inch by 1/4 inch) glued to one panel on each side of the tongue.

Tie-rods, passing through the full length of the roof, the floor and each wall of the building, are used to connect the panels. The tie rods pass through light steel tubes built into the panels during their manufacture. They are usually about three feet apart. The tightening of the nuts on the ends of the rods, which are readily accessible outside the building on the ends of the walls, compresses the rubber strips to seal the joints between the panel edges and provides a well distributed post-tensioning which makes the building exceedingly rigid and strong. The tie rods for long walls are jointed with screwed sockets. The rods are 1/2 inch in diameter and have a coarse thread (British Standard Whitworth).

Bolts are used to fasten roof and floor panels to wall panels. These bolts are inserted from outside the building through the roof or floor panel and the timber member of the wall panel, into an aluminum nut plate fixed in the panel during manufacture.

After assembly joints are further sealed both inside and outside the building by applying "Hornex" and nailing on cover strips of metal or timber.

By using such a design large buildings are erected very rapidly, with a minimum of fumbling with small items such as nuts, screws, nails, etc.

This construction system has been developed over the years by A. N. A. R. E., the Commonwealth Department of Works and the manufacturer, Explastics Insulations Pty. Ltd., Melbourne. The manufacturer uses the system in his normal business of constructing refrigerated cold rooms.

4. Functional Design

The buildings at A. N. A. R. E. stations are limited in size and the construction of connecting passages between them is not encouraged. This principle has effectively prevented the spread of fire and contained any destruction to the one building and the one function. Considerable thought is given in the design to fire proofing but in normal buildings the contents and the combustible timber and insulation make fire a hazard. Even when a building is entirely incombustible, (such as the Mawson Power House described in Section 9 of this paper), the fire hazard of the contents is usually considerable.

There are some disadvantages involved in separating buildings at a station. Men moving from one functional area to another must expose themselves to the weather, and the scattered nature of the station greatly increases the time taken to reach the seat of any fire which might occur and complicates the control of small fires before they take hold. Telephones, thermal fire detection system, public address system, etc. help to overcome difficulties in communication.

There are some compensating advantages: remaining indoors continuously for long periods has a depressing effect, whereas men are refreshed and their morale is boosted by the necessity to move about outdoors; further, sound proofing of sleeping huts is more effective and odour from kitchen and engines cannot pervade living quarters.

The drifts of snow formed in the station area are an obstacle to moving about in winter, and careful siting of buildings is required to avoid the obstruction of entrances to buildings and of main traffic routes by drifts. Fortunately, the prevailing winds blow predominantly from one direction only. The pipe scaffolding foundations described earlier in Section 1 help to prevent drift formation by allowing unrestricted passage of the wind beneath the buildings.

Doors are of the design used for refrigerated coldrooms, double-rebated and splayed and fitted with fabric-covered closed-cell foam rubber seals. Coldroom type heavy hinges and locks are used to overcome the obstruction by packed ice. The locks have wedge strikers which engage heavy throw-over handles to seal the door. A cam on the handle offers a mechanical advantage to pull the door open if ice is binding it. Most buildings have a large door for furniture, etc. with a smaller door set within it for general use. In some cases a building panel is made removable for very large equipment.

Windows are kept to a minimum in size and number consistent with the function of the building. Stores are usually without windows. Living and working spaces have small windows. Sleeping quarters have square one-foot windows, one above the bunk and one above the writing desk in each cubicle. Some windows are fixed and some are made openable for ventilation in summer or for fire escapes. Sealed double-glazing units (Polyglass) have been used with success. In such cases some hygroscopic material such as silicagel is often left in the space between the panes. Glazing is shipped separately from panels and inserted after erection is complete.

Sleeping quarters for A.N.A.R.E. are designed to provide each man with a separate cubicle which is his own 'home' or retreat. This has been found to be a most desirable feature. By careful functional design, each cubicle, although only seven feet long and five feet six inches wide, contains a bunk, a writing desk and a large amount of shelf and hanging space, yet leaves half the area free for movement, entertaining visitors, dressing, etc. This is achieved by placing the bunk at a high level, with the desk, shelves and hanging space beneath it. The cubicles are fitted with weighted curtains instead of doors which would make disturbing noise. The occupant of the cubicle is responsible for its up-keep and may decorate his cubicle to suit his own taste. The number of cubicles in a hut varies from four to nine. A passage divides them and a cold porch is provided at the entrance. A solid fuel heating stove is set at one end of the passage and a shower recess at the other. Hot air is drawn from over the stove by a fan and circulated down each side of the building in sheet metal ducts. Adjustable outlets are provided in the duct under each desk. A 12-gallon tank is fitted over each heating stove and connected to a copper tube coiled in the furnace. This provides for snow melting and hot water for ablutions. The shower is provided from a two gallon container fitted with a valve and rose; after being filled by the user, it is hoisted into position in the shower recess by a rope and pulley. The heating of water for ablutions and the shower provides water vapour to raise the humidity in the building to a satisfactory level. There are further comments on the solid fuel stove in Section 6 of this paper.

5. Anchoring of Buildings

In order to enjoy the advantages of being placed in exposed situations as ice free rock an efficient method of tying down the building is essential. The system now in use has proved quite effective, having adequately resisted winds of a velocity considerably in excess of 100 knots.

Steel corner and intermediate brackets are placed on the edges of each roof (without being fastened to it) and connected together by half-inch diameter mild steel rods and nuts as shown on the accompanying drawing. Stranded steel wire rope is connected to a lug on each bracket and anchored to a pin set in a hole drilled in the rock. The pin is wedged with rock bolts as used in mines, or held with sulphur. After inserting the anchoring pin and pouring molten sulphur into it—the rock temperature remains sufficiently low at all times for the sulphur to act as a cement of great strength. On moraine sites 'dead men' are used in place of rock pins. Splices, or "U" clips and "D" shackles, are used to fasten the wire ropes to the brackets and the rock pin eyes. Turn-buckles are provided to apply tension to the anchoring.

This assembly, being a large network not fastened at any one point to the building, distributes the wind load over the whole structure.

The base of the building is also anchored. A wire-rope guy passes through holes bored through the ends of the subfloor bearers which protrude two feet beyond the building and the ends are anchored to the rock and tightened by means of a turn-buckle.

Regular inspection and maintenance is carried out on the assembly. This includes the tightening of nuts on the roof network and of "D" shackles, wire-rope clips and turn-buckles. Turn-buckles would be gradually loosened by wind-vibration, so they are locked by tie-wires twisted through their eyes and centres.

6. Heating and Ventilation

As already mentioned, A. N. A. R. E. stations are divided into relatively small buildings isolated from each other to prevent the spread of fire. Each isolated building requires only a relatively small amount of heat and this is most simply supplied from a single stove.

A briquette burning slow combustion stove is often used. Briquettes are made from compressed dried brown coal from Victoria, Australia, having a calorific value of 9, 600 BTU/lb. The stove is cheap, the briquettes are cheap and the installation is simple. On the other hand, the fuel is dirty, heavy for its heat value, awkward to handle, and a chore to collect from the dump in winter; the ash is light and fine and finds its way on to all surfaces and equipment; stoking must be done several times in 24 hours, and no automatic temperature or combustion control is provided.

Kerosene (paraffin) heaters are also in use. These heaters are cheap, efficient, simple and portable. On the other hand, they are a fire hazard, require more ventilation (which lowers their efficiency) and produce fumes which are unpleasant and may become dangerous if ventilation is obstructed by the icing up of vents, etc.

The oil-burning space heater provides a simple, self-contained unit requiring only the installation of a fuel supply pipe and a flue. Such units are giving satisfactory service but their operation is impaired by the sensitivity of the vapourizing burners to variations in draft due to wind. They operate quite well on a mixture of kerosene and diesel distillate, although more frequent cleaning of the burner is required as the concentration of the distillate is increased.

Electrical heating is discouraged because of the inefficiency of fuel usage and the general shortage of such power at stations. Some situations are heated electrically, e.g. scientific equipment laboratories, surgeries (except when combustible gas is being used), warm food stores. Thermostatic controls are used to conserve power and provide constant conditions.

At one station, Davis, central heating by hot water from the waste heat of the diesel generators has been used in a small group of buildings adjacent to the powerhouse. The use of generator waste heat can raise the thermal efficiency to very high levels, but the complications and additional maintenance can be an added burden on the station personnel unless this aspect is carefully considered in the design.

At Macquarie Island a conventional central heating system, using hot water from an oil-fired boiler, provides efficient heating to mess and sleeping quarters as well as a domestic hot water supply. This installation is most satisfactory from the aspects of efficiency, maintenance, safety and reliability.

The ventilation of buildings in Antarctica is complicated by the need to conserve heat and to ensure that openings do not admit excessive drift or become blocked by ice or snow. An additional need when combustion heaters are used is to provide sufficient air for combustion, to ensure that stove flues do not become blocked, and to prevent the accumulation of carbon monoxide. There have been several dangerous instances of high carbon monoxide concentrations in sleeping buildings, invariably caused by the blocking of flues or ventilation apertures during blizzards.

a. Air intake openings are designed to eliminate the chance of drift snow entering the building. This is difficult to achieve and it is usual practice to provide openings on each side of a building and to close off the side from which the drift is blowing. This often results in air intake openings acting as exhaust vents while the fresh air finds its way in as best it can when the doors are opened. Air intake from beneath a hut floor has been found satisfactory except for a case in which the vent became blocked by accumulated snow and ice. The provision of fans to prevent the development of large vertical thermal gradients within huts is important.

b. Air exhaust openings of the "H" and "T" cowl design have been tried and found useful. They are usually insulated to avoid blockage by condensation. However, it has been found that a simple hole in the flat roof, with no outside protuberances and nothing but a damper inside, is a most satisfactory exhaust ventilator. It is necessary to provide proper intake ventilation so that the exhaust ventilator only discharges air from the building.

c. Flues to remove waste gases from combustion stoves are carefully designed to minimize downdraft and icing, especially on high efficiency and slow combustion equipment. A double flue for insulation and an adequate height to reach beyond wind turbulence are most desirable features. Once again, if these precautions are taken a plain opening at the top of the flue is very satisfactory.

7. Maintenance Problems

The main causes of maintenance problems are high winds, ice and snow from outside, ice from vapour within the building, the dry atmosphere, and of course, damage by the occupants.

Recently constructed A.N.A.R.E. buildings are metal covered and embody many refinements which largely overcome maintenance problems. The exterior of metal covered buildings requires no painting. Nevertheless many older buildings, particularly those with plywood covering, require frequent attention and painting.

The dessication of timber in the dry atmosphere results in loosening of nails and brittleness. Moisture penetrating the ends of plywood (even marine standard plywood) and later refreezing separates the layers. Moisture may come from drift snow or from pools lying on the sun-warmed flat roofs during calm periods in summer. The wind soon completes the destruction. To reduce the rate of deterioration of timber, existing exposed timber surfaces are painted annually with an oil paint which is prepared to a specification designed for naval ships' hulls. A red lead primer is applied first except where there is a good paint surface already. Exposed timbers on new buildings are now soaked in preservative oils before being shipped. Moisture damage is reduced by clearing the snow from against buildings and foundations before warmer weather comes.

In several cases, plywood buildings have been covered with sheetmetal on the site by the use of 'Hornex' as adhesive and sealer. The same adhesive is used to seal the ends of plywood sheets and to cover holes and cracks. It can be applied to wet or dry surfaces and at extremely low temperatures.

8. Packaging, Handling and Erection

Before leaving Melbourne all new buildings are trial erected at the factory. Expedition members take part in this operation under the direction of the manufacturers. This trial-erection is absolutely essential if rapid construction on the site is to be achieved.

Hut panels are numbered on edges and on the faces. Wall numbers are only placed at the top to indicate the correct way up. The edges of roof and floor panels are painted with a line, using a different colour for each side of the building to warn against reversing them. Removable parts of panels are marked with the panel number. Tie-rods, etc. are tagged with metal strips and marked with numbers identifying the panels they pass through. The panels are crated in pairs. After wrapping the panels in 'Sisalkraft' water-proof building paper, an open hardwood crate is constructed with all joints secured with metal straps. Panel numbers are stencilled on both ends of the crate.

The threaded ends of the tie rods are carefully greased and covered with adhesive tape. The rods are then bound into bundles, sewn into hessian wrapping and finally bound with metal strapping and numbered metal tags.

All other components are protected and cased. At least 50 per cent spare bolts, nuts, washers, screws, and glass are supplied and several sets of erection tools such as spanners, screwdrivers and adjustable wrenches, are enclosed.

A complete inventory of the items in each case or crate and a set of instructions and erection procedures is sent with the expedition. A cardboard model showing the numbered panels is provided to facilitate erection.

Hut components are brought ashore at the stations by amphibious vehicles and stacked at the building site. While some men prepare the foundations, subfloor and rock tie-downs, others unpack the panels and lay them out conveniently for erection. When the actual panel erection commences sufficient men are allocated to the work to ensure that the building is assembled and securely anchored in the one day. If bad weather threatens after the panels are unpacked they are securely tied down by ropes and weighted with rocks until it clears.

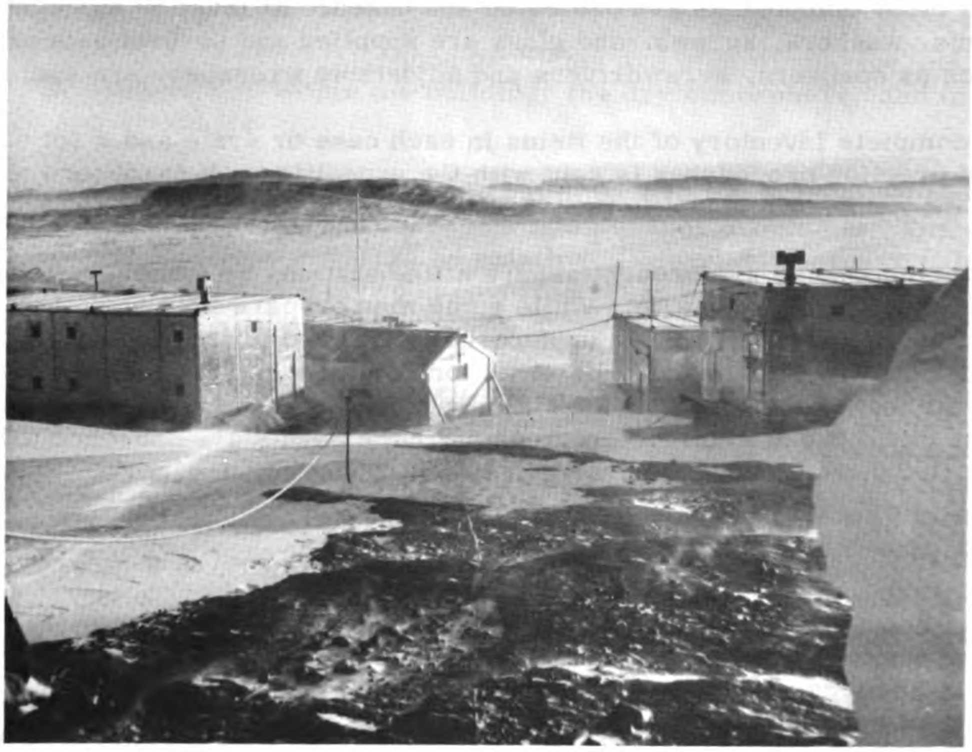
9. Some Specialized Buildings

a. Aircraft Hangar

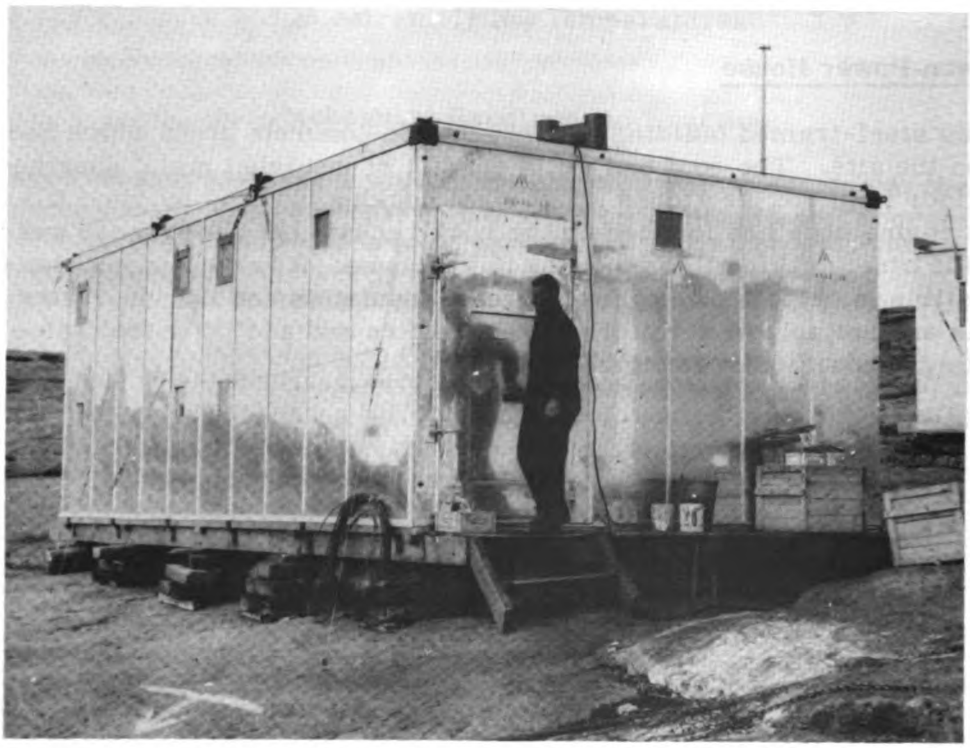
This building was erected at Mawson and has a span of 55 feet and a length of 60 feet. The columns of the structural steel frame are secured to the rock by bolts sulphur-sealed into drilled holes. Corrugated galvanized iron sheets cover the exterior and the whole building is anchored by steel guy-cables. The 50-foot wide entrance is fitted with a winch-operated overhead door which gives an opening 12 feet 9 inches high.

b. Mawson Power House

This steel-framed building was erected on concrete piers which had been poured on the site. The roof and walls consist of insulated metal sheathed panels and the floor is of box-sectioned sheet steel decking covered by vinyl tiles. The concrete engine beds are founded on the rock beneath the powerhouse and project through the steel decking floor into the powerhouse. The building is made from incombustible materials except for the foam insulation and the vinyl tiles. These materials are not able to aid in the spread of fire and add little fuel value so that the building is practically incombustible.



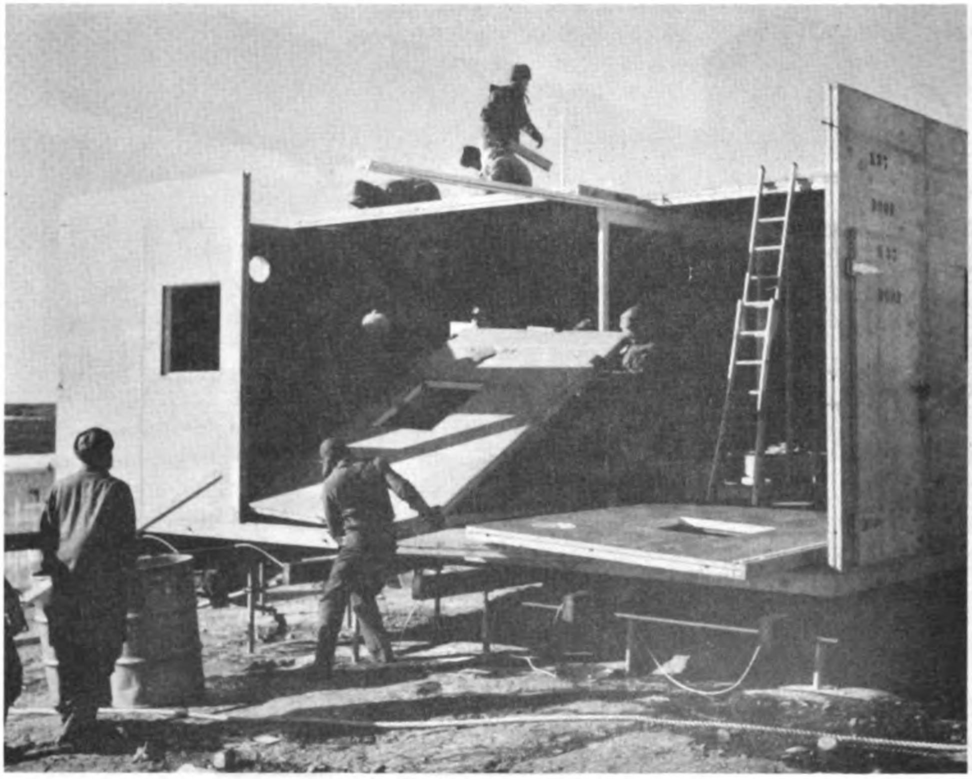
Living area of Mawson with sleeping huts in foreground.



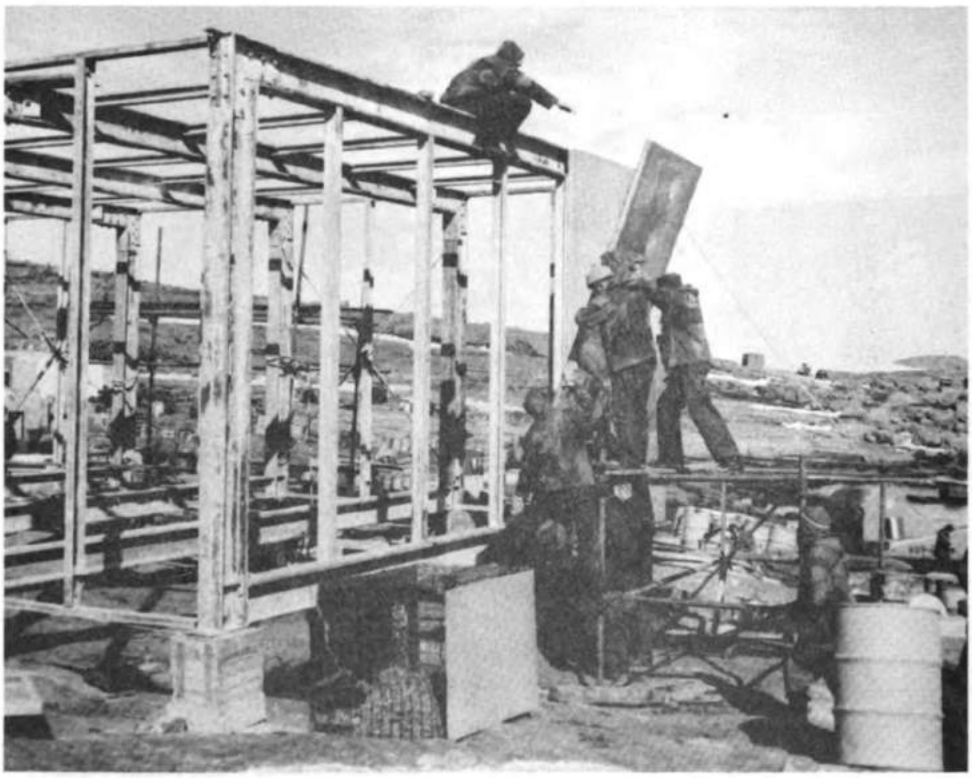
Standard sleeping hut showing tie-down system.

Pipe foundations and bearers showing fine adjustment of forked reveal pins.

Erection of walls. Note tie-rods laid out ready for insertion.

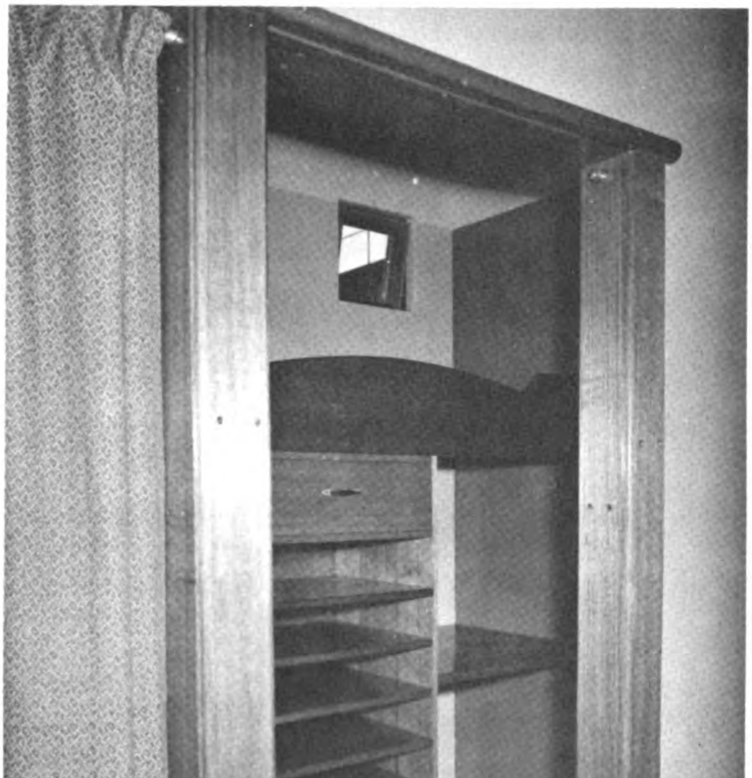


Erection of walls and roof panels in a wide building. Roof panels are joined over a central partition.



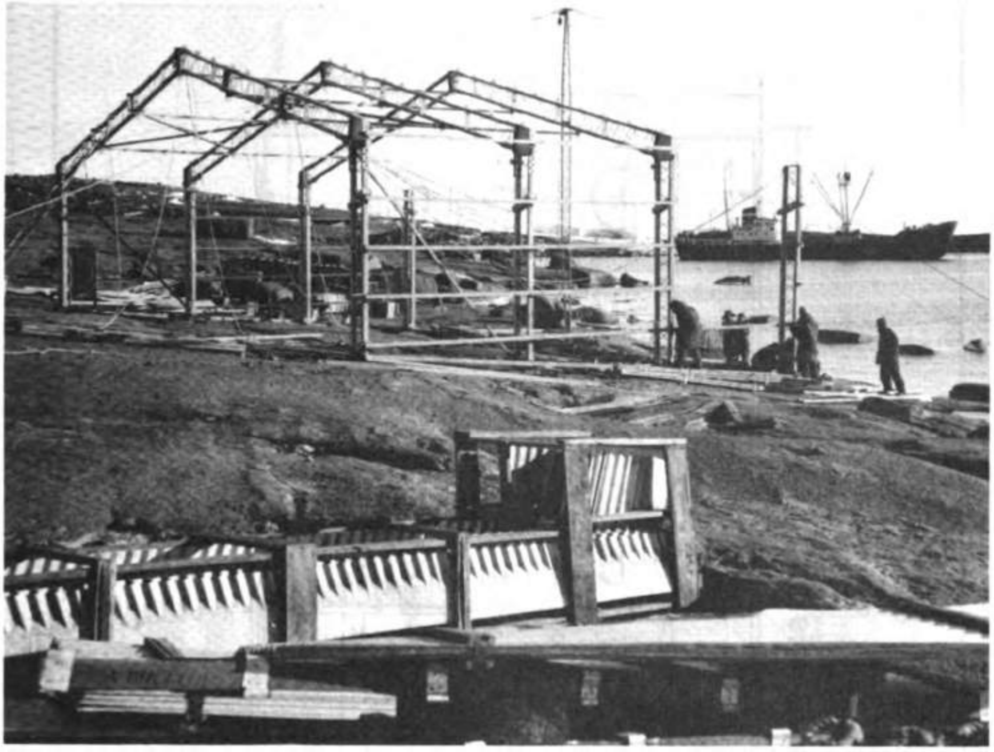
Fixing metal panels to the exterior of a steel framed power house.

Standard sleeping hut during erection showing the heating-stove recess and hot air ducting.



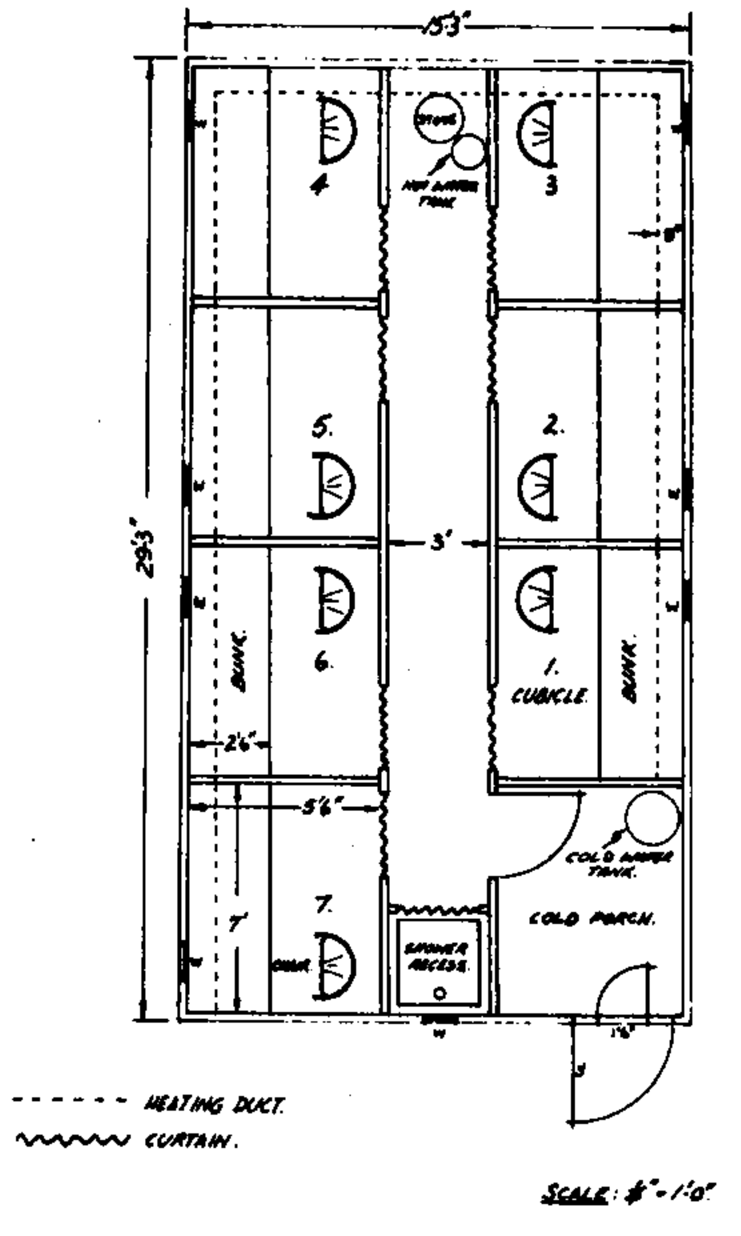
Interior of standard individual sleeping cubicle.

Interiors of sleeping cubicles.

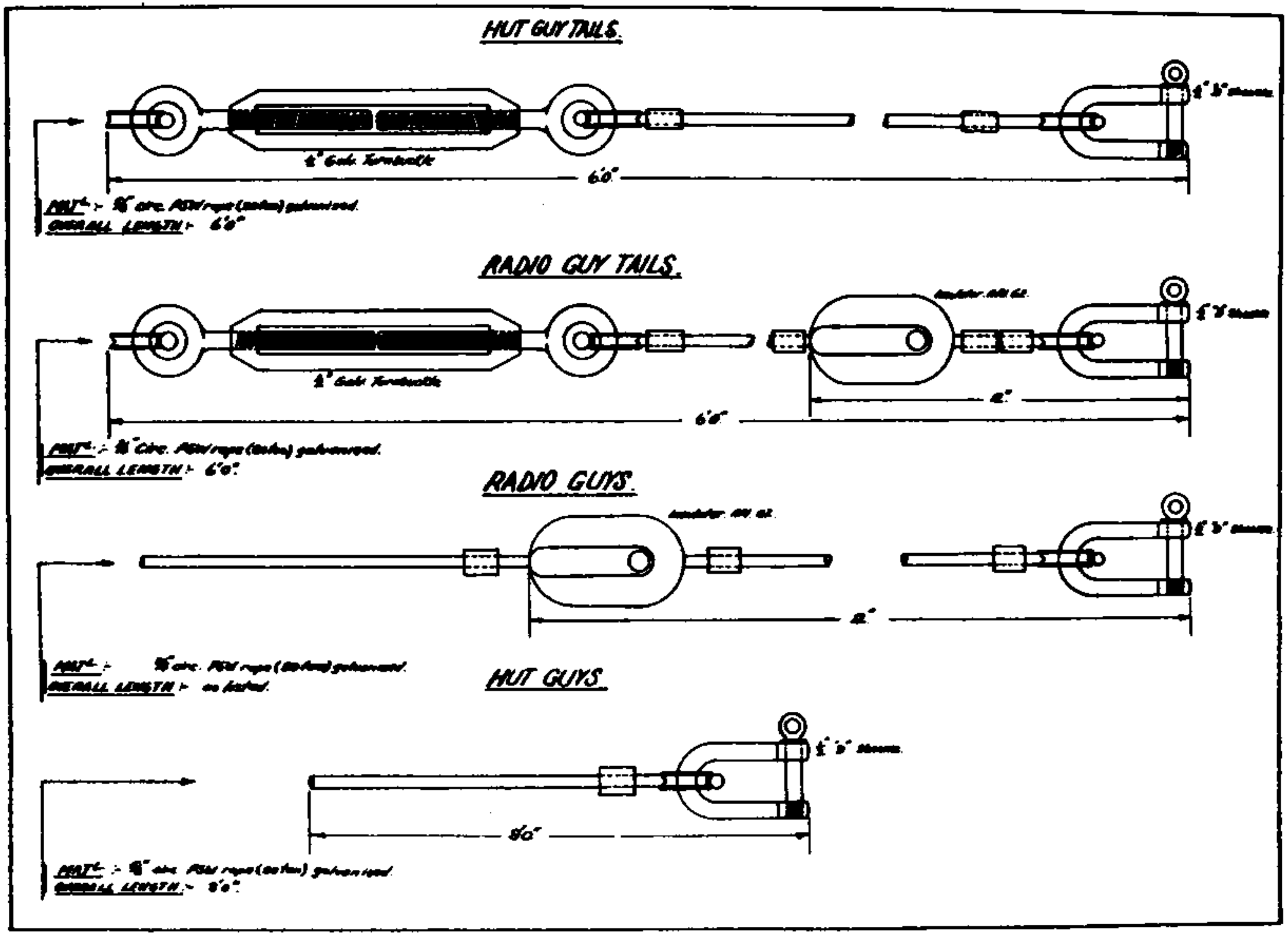


Erection of aircraft hangar at Mawson. This building was sheeted with galvanized corrugated iron.

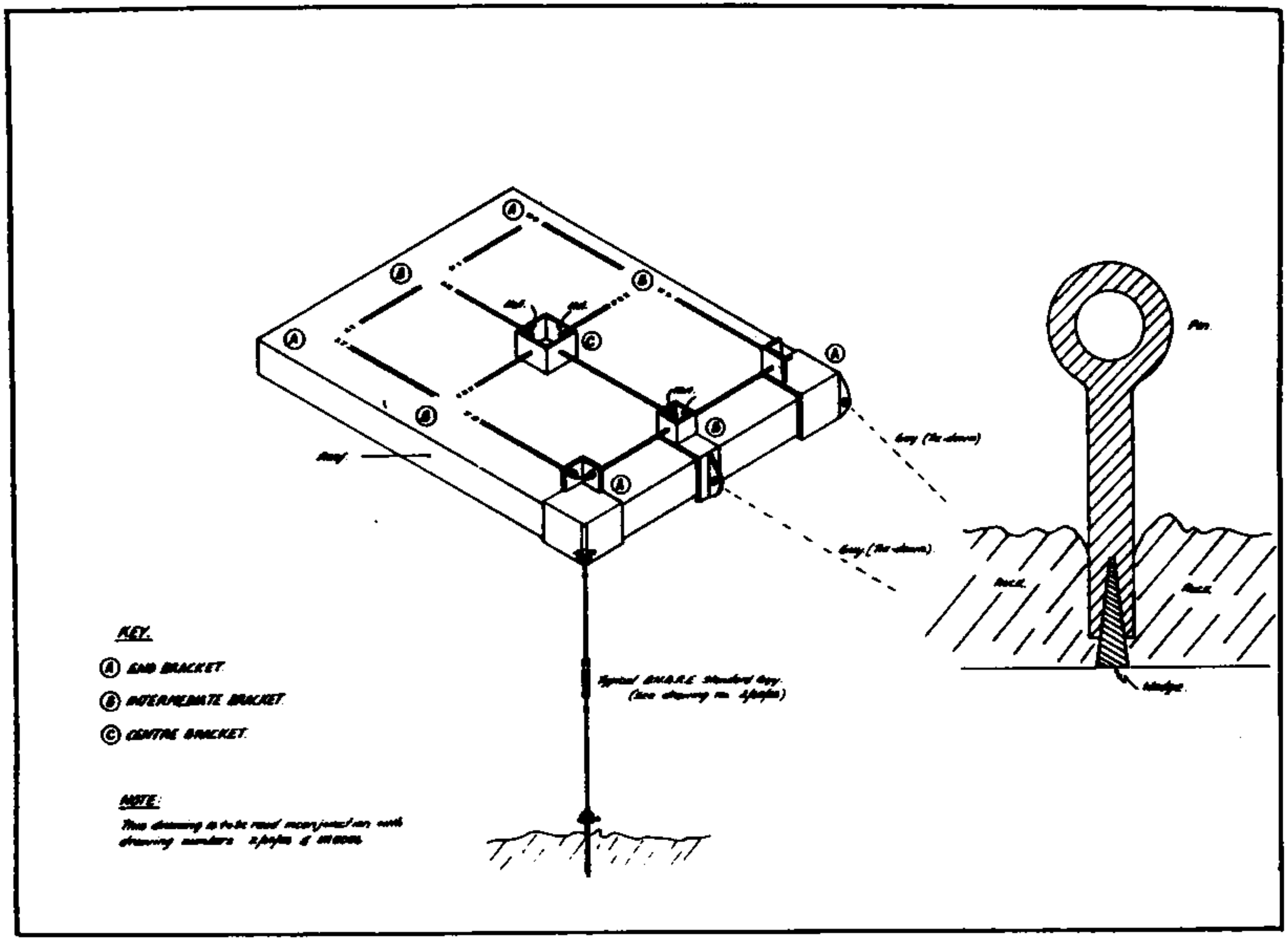
Completed cosmic-ray laboratory showing roof vents.



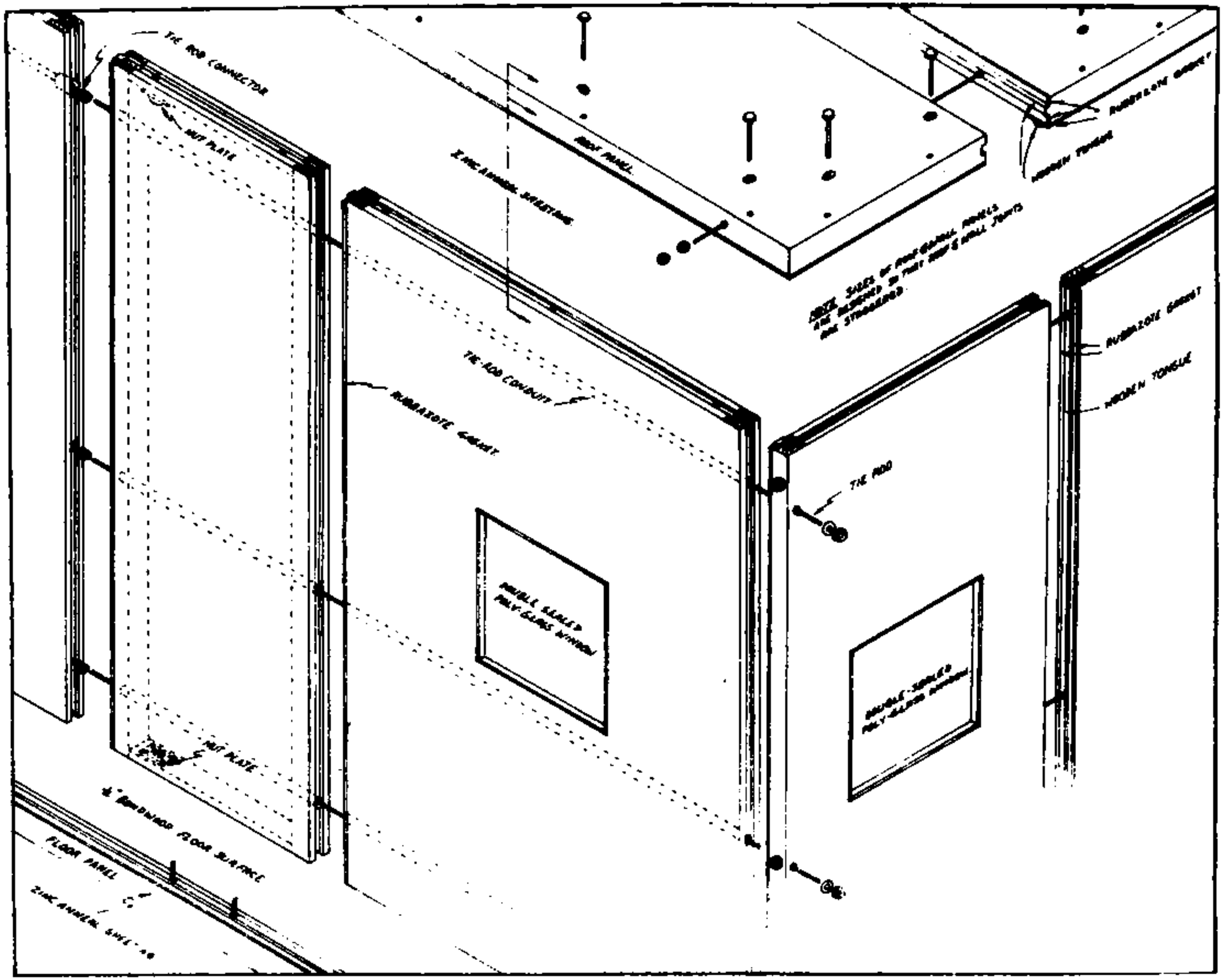
Lay-out of standard A. N. A. R. E. sleeping hut.



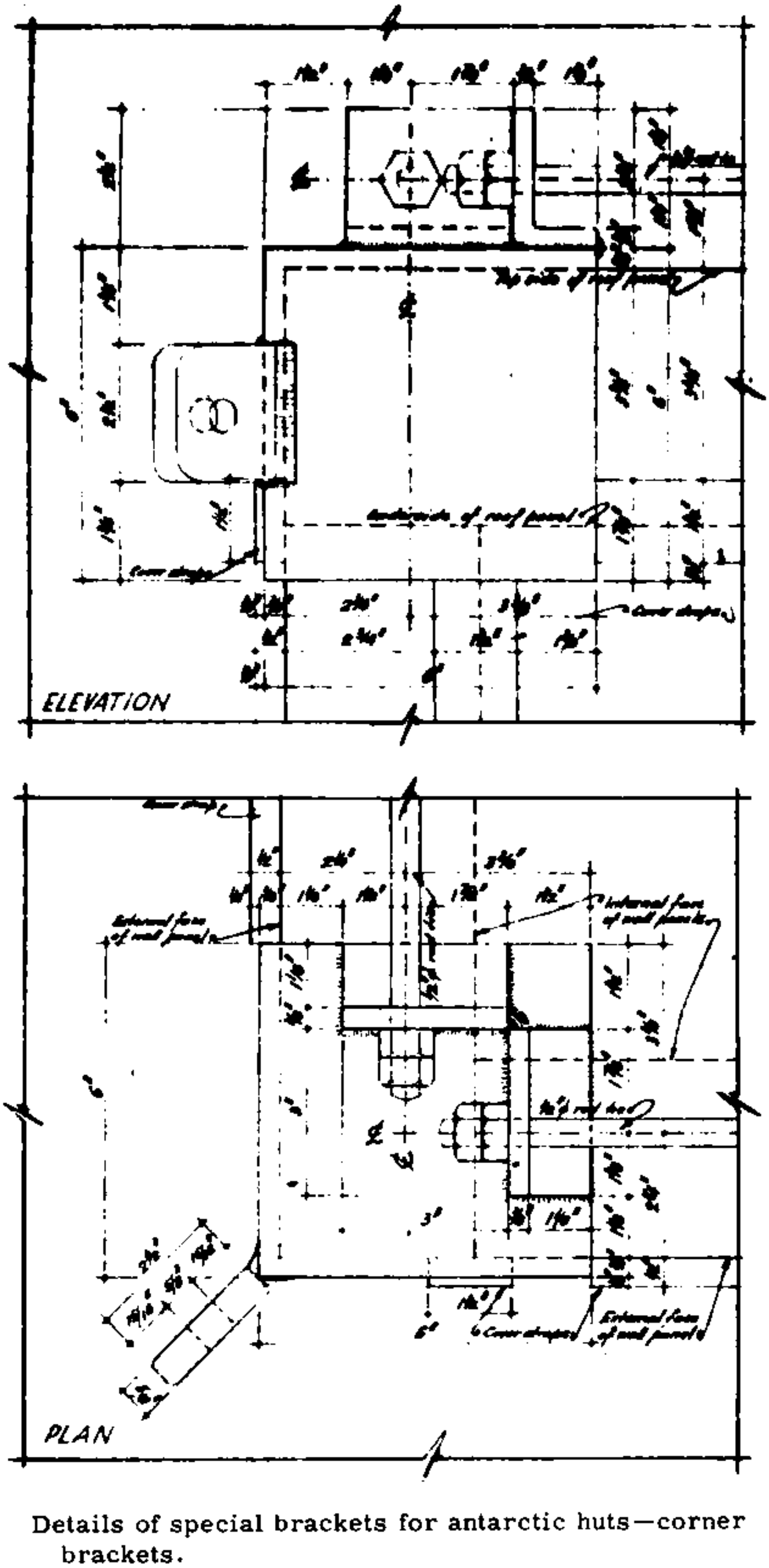
Standard A. N. A. R. E. guys.



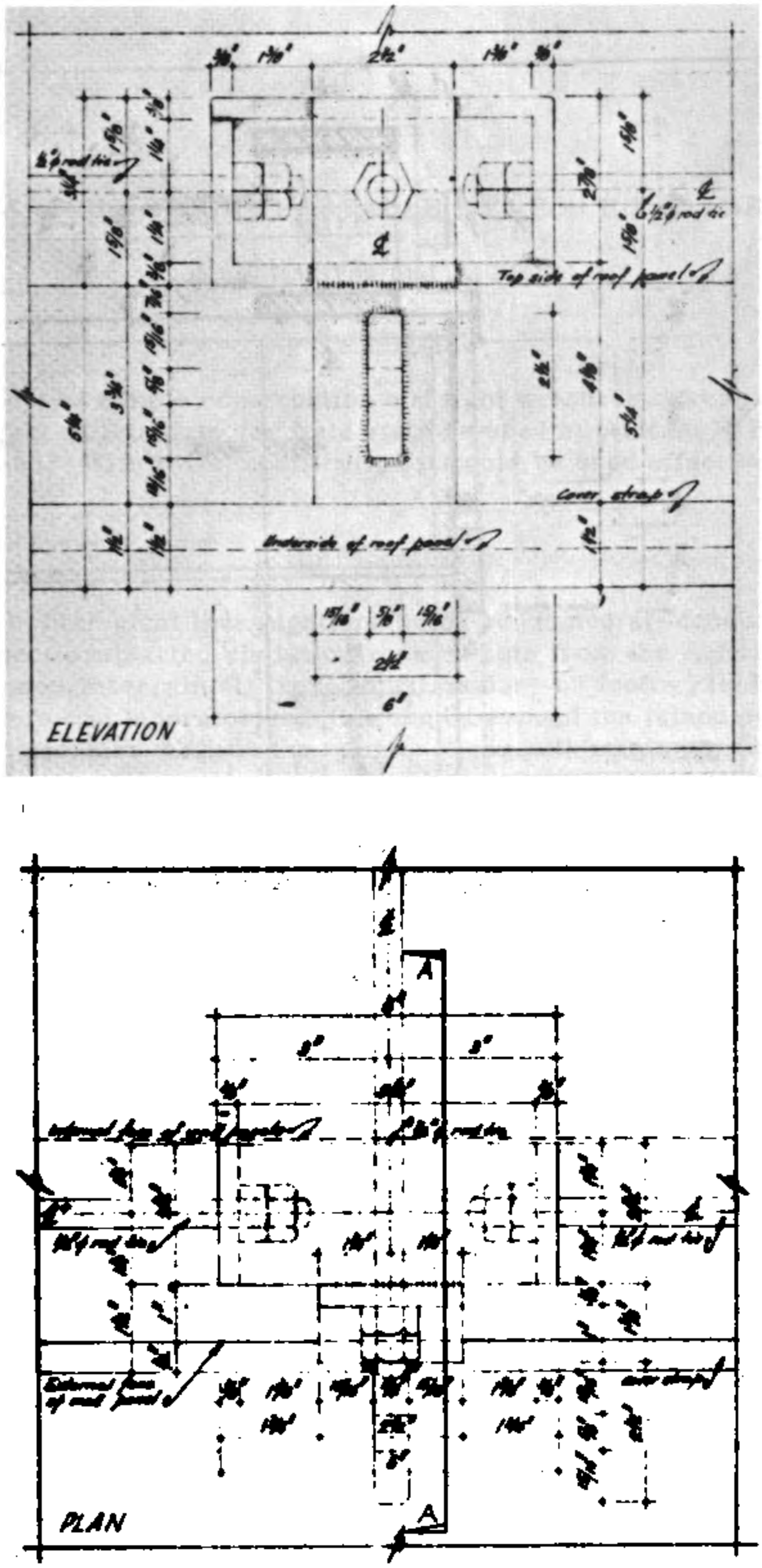
Typical A. N. A. R. E. tie-down assembly.



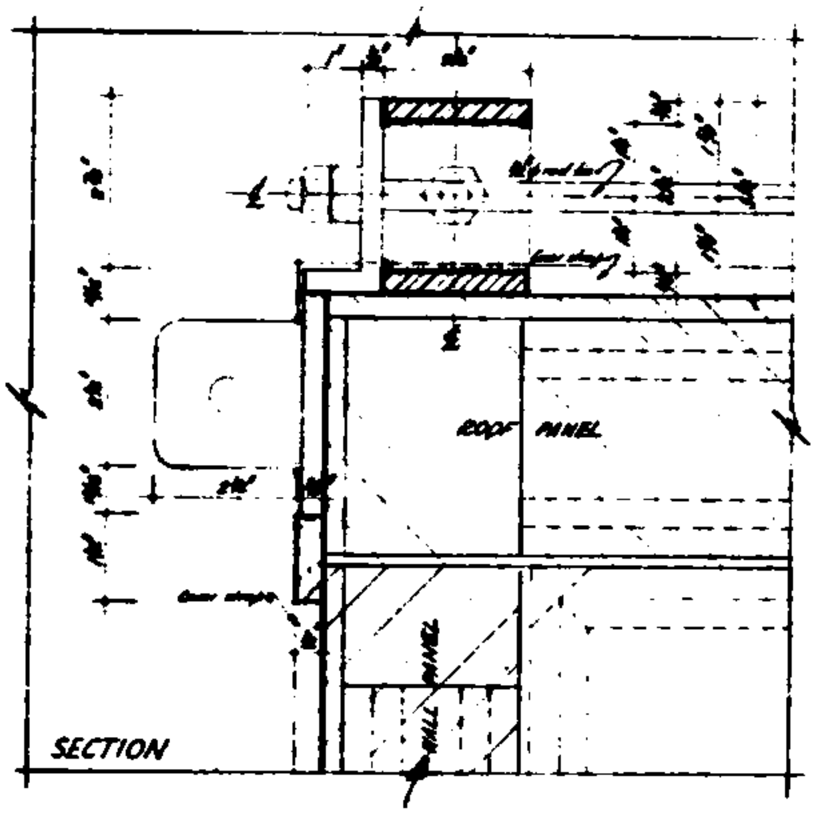
Exploded view of standard insulated hut-panel assembly.



Details of special brackets for antarctic huts—corner brackets.



Details of special brackets for antarctic huts—intermediate brackets.



Details of special brackets for antarctic huts—intermediate brackets.

A LIGHT-WEIGHT PORTABLE HUT FOR FIELD USE

J. Ballantyne and J. Nisbet

Summary

A small hut of simple construction and light weight is described. The design has proved highly satisfactory for field stations used by A.N.A.R.E. biologists at Macquarie Island. With little modification it could be used effectively in Antarctica.

Introduction

Long term biological investigations being conducted at Macquarie Island necessitate frequent protracted visits to areas remote from the A.N.A.R.E. station. Because of the rough terrain all travel must be done on foot. Field huts, fitted out as living quarters and laboratories, distributed around the island provide good opportunities for intensive work in the remote areas with minimum time spent in travelling.

Because of the difficulty of access to their sites these huts were designed to be transported by man power. One is located beside Prion Lake, about three miles from the coast and 600 feet elevation.

Description

The inside dimensions of the hut are approximately 8 ft x 6 ft x 6 ft high. Two bunks are built in at one end and a bench at the other; these add considerably to the rigidity of the structure.

The main features of the design are illustrated in Figure 1 and the arrangement of panels in Figures 2-5. A total of 54 panels is used—34 of size "A" and 20 of size "B" (see Figs.). A further 6 panels of size "A" are used for bunks and bench. Four perspex windows are provided with vents formed from two inch plastic tube elbows.

The basic framework consists of four uprights, four top plates and four bottom plates; the sub-floor frame of four bearers supported on 12 stumps on sole plates. These members are made from 3 inch x 3 inch x 1/8 inch angle aluminium. A framework of 1 inch x 1 inch x 1/8 inch angle aluminium provides additional support for the bunks and bench. Two members of similar dimensions fixed from top corners to bottom centre on the outside of each wall (not shown in Fig. 1) increase the rigidity of the whole structure.

The panel frames are formed from 3 inch wide x 3/8 inch marine bondwood. The size "A" panels are divided with a central member to increase their rigidity. These are covered with 26 g. aluminium folded over 1/2 inch and fixed with aluminium rivets driven into the wood.

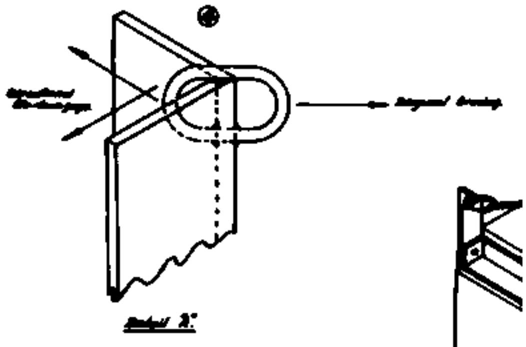
The whole assembly is held together with 1/4 inch bolts. All external joints are covered with aluminium faced adhesive tape and all external bolt heads covered with a rubber based adhesive.

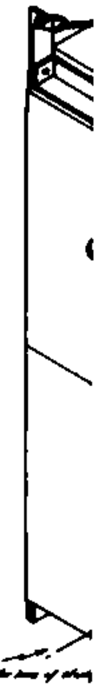
The interior of the hut is lined with PVC coated fabric stretched across the bondwood panel frames. Storage shelves formed from 16 g. aluminium are held by screws to the bondwood panel frames.

The floor panels (with aluminium facing down) are covered with 3/8 inch bondwood as also are the bunk and bench panels.

The total weight of the building (including bunks and bench) is approximately 500 lb. It is remarkably strong and rigid and if properly tied down with guys should stand securely against the wind even in Antarctica.

No insulation is used at Macquarie Island. Some water condensation occurs on the walls, especially while cooking, but not enough to be inconvenient. For use in Antarctica insulation would certainly be required. This could easily be provided in the form of, say, expanded polystyrene slabs fitted into the panels. This would increase the weight by approximately 130 lb.



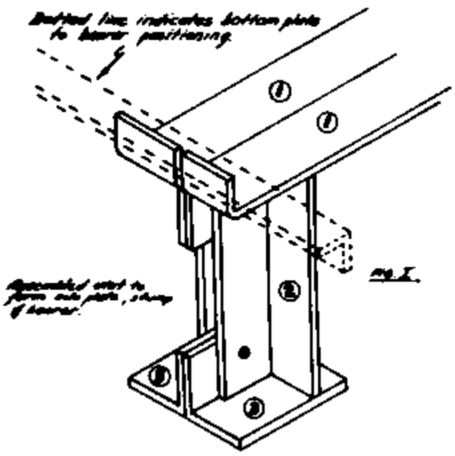


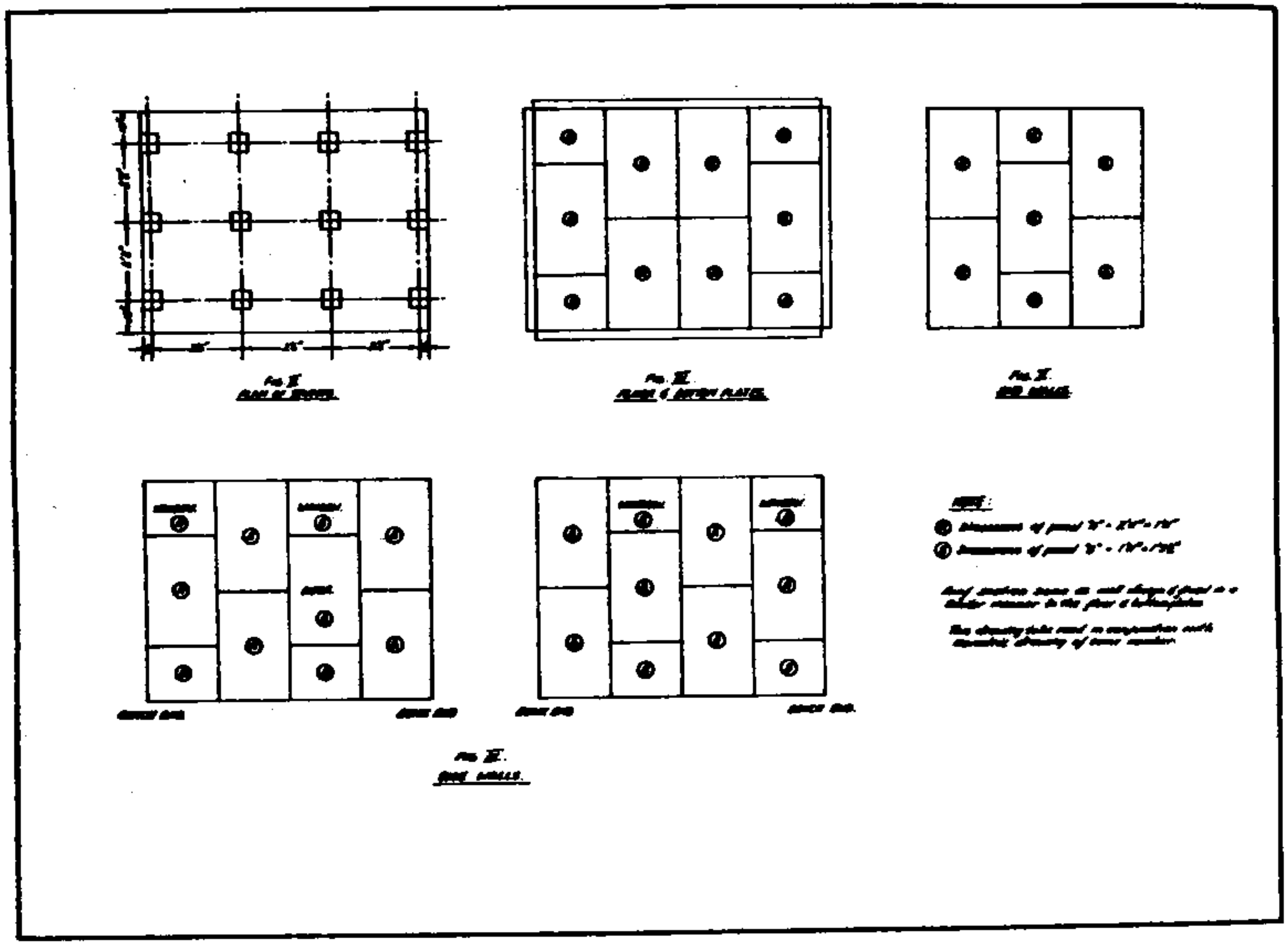
KEY.

(1) Bearers. 2 per line of stumps.
(2) Stumps. 2 per stump position.
(3) Sole plates. 2 per stump position.
(4) Tie down & bracing ring 4 off.
(5) Top & bottom plates. 4 long, 4 short.

(A) Panel 'A' 2'11" x 1'11".
(B) Panel 'B'. 1'11" x 1'3½".

Material: Bearers, sole plates, stumps, top & bottom plates, vertical members all formed from 3"x3" aluminium angle.





Macquarie Island Huts. Wall, roof and floor panels.

AN INCINERATOR LATRINE

G. D. P. Smith

Summary

The effective disposal of wastes is a special problem in Antarctica. Australian stations, being mainly rock-based, present additional difficulties. A.N.A.R.E. has adapted the incinerator-type latrine to suit Antarctic conditions. The incinerator unit, which includes a controlled draught system, efficiently disposes of all faecal matter and provides radiant heat which warms the latrine hut.

General

The climate and topographical conditions encountered in Antarctica create waste disposal problems which are not encountered elsewhere. The low temperatures and lack of permanent water prohibit the installation of normal sewerage systems. As the sea is frozen for most of the year, it cannot be used as a dumping area. Australian stations, being rock-based, cannot use a burial method and so are faced with a pressing problem. At Australia's Mawson Station the disposal of faecal matter has been successfully accomplished by means of an incinerator latrine which has been in operation for several years.

Description

The incinerator unit consists of a 44-gallon drum provided with an outlet flue and a lid fitted with a toilet seat. The drum, which rests on the ground, protrudes 18 inches above the floor of the building, which is slightly raised. When the unit is to be burnt-off, a burning-lid replaces the seat lid. The burning-lid, which fits closely over the drum, is provided with an inlet-flue and adjustable damper for controlling the draught. The outlet flue, which is attached to the drum, passes through the wall of the building and is provided with a sealing cap to block draught. During burning-off, a chimney replaces this cap.

Four units are housed in a prefabricated building which is insulated and metal-lined. To lessen the fire-risk, adequate clearance is provided in the floor-holes through which the drums protrude. The space around the drums is packed with stones to floor-height and the floor is sheeted with metal. The outlet flues are asbestos-lagged and air insulated where they pass through the wall. To ensure efficient operation it is essential that no liquid be placed in the drums, so a separate urinal is provided. The urine is collected in 5 gallon containers and removed daily.

Operation

Careful attention must be given to (a) preparation for burning and (b) burning-off.

a. Before restoring a newly-burned drum to use, a pyramid of kindling wood is laid in the bottom. A small quantity of diesel distillate oil is poured on and the seat-lid is fitted.

b. To burn off the seat-lid is replaced by the burning lid, the chimney is fitted to the outlet flue, one pint of diesel distillate oil is poured over the contents, and the drum is ignited through the inlet flue. The rate of burning is controlled by adjusting the inlet damper.

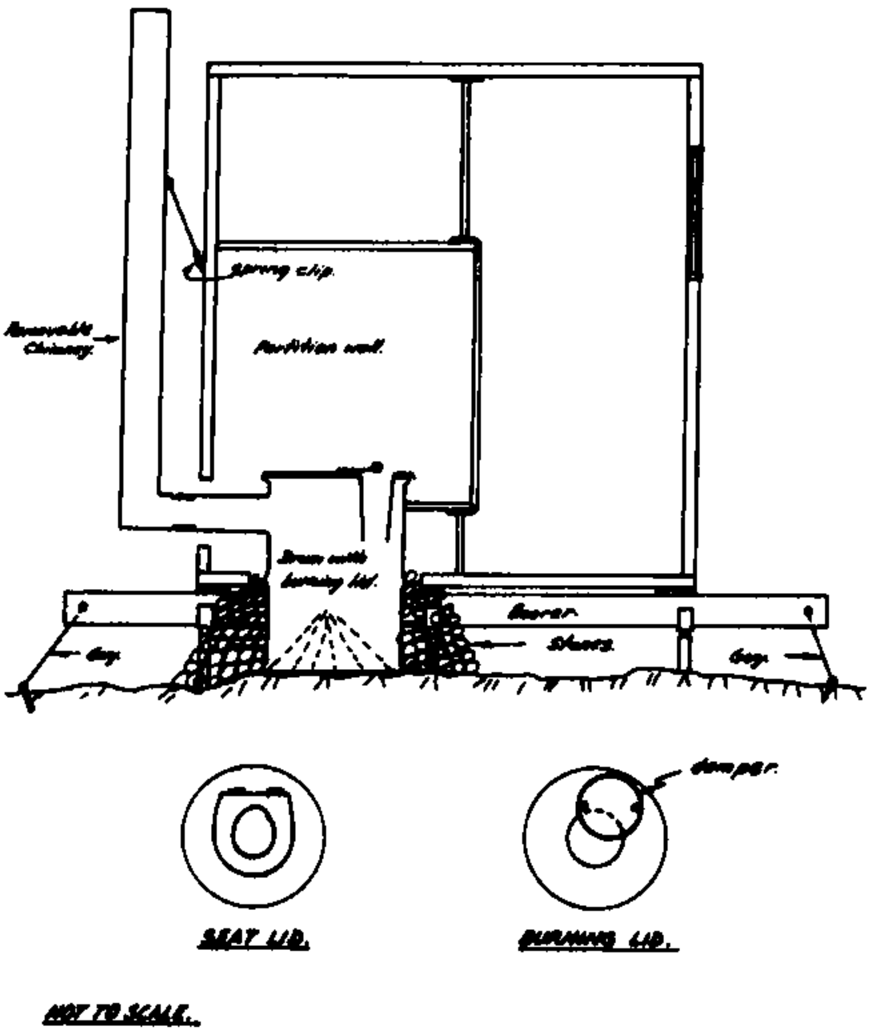
Mawson's four-unit latrine is operated by burning off one unit daily. Combustion is so complete that only a small residue of ash remains. This only needs removing after several months' operation.

All station personnel are instructed in the operation of the latrine and the special fire precautions necessary for safe operation. These are simple and few:

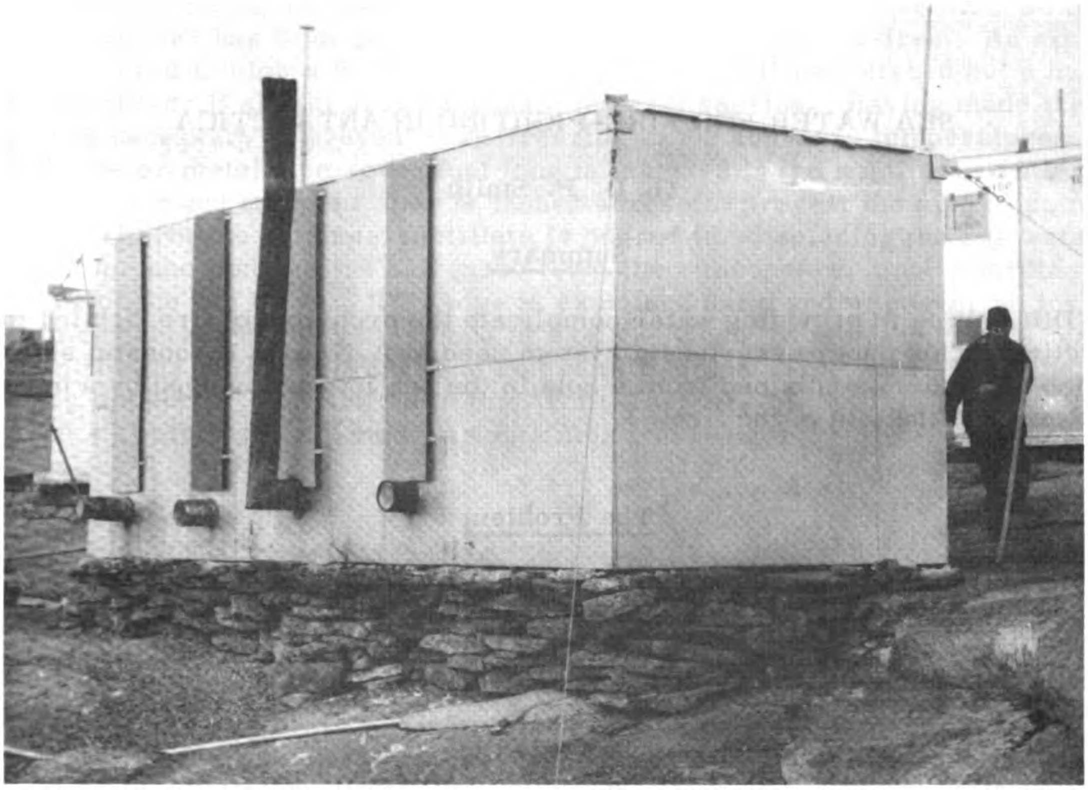
a. Do not apply excessive fuel oil.
b. Always make sure the chimney is fitted before burning.
c. Do not ignite before placing burning-lid in position.
d. Remove containers of fuel-oil from building before igniting.
e. Replace faulty flues when necessary.

The daily burning-off provides enough radiant heat to warm the building adequately. The odour from the incinerator cannot be described as offensive but the building should be placed down-wind of living areas.

This system has proved so successful at Mawson that it is being introduced at other stations.



Incinerator Latrine.



Exterior of Mawson Incinerator Latrine. Note protective heat shields.

SEA WATER FOR FIRE-FIGHTING IN ANTARCTICA

G. D. P. Smith

Summary

Difficulties in providing water complicate the problems of fire fighting in Antarctica. This paper describes a system used at A. N. A. R. E. coastal stations in which sea water is obtained from a hole in the sea ice and pumped by a portable motor pump to the site of the fire.

The Problem

The climate of Antarctica being extremely dry, fire is an ever-present threat to continental stations. This accentuated fire-risk, therefore, introduces the need for efficient fire-fighting methods. Although most station buildings contain chemical extinguishers as standard equipment, a plentiful supply of water is desirable.

Sufficient quantities of readily available water are hard to obtain owing to climatic and physical conditions. The supply of water in Antarctica is generally derived from one of three sources:

a. Snow and ice
b. Melt streams and pools
c. The sea

Method (a) is used extensively for domestic purposes, snow being melted in a boiler and the resultant water stored in insulated and heated tanks or in containers within an insulated or heated building. However, the economic and technical problems involved in the production and storage of the vast quantities needed for fighting major fires make this method of supply generally unacceptable. Melt streams and pools (b) provide plentiful water to stations fortunate enough to have them in their area but do not remain open throughout the year. As many Antarctic bases are sited on the coast, the supply of water from the sea is worthy of consideration.

Sea-water in liquid form is present throughout the year although often covered by many feet of sea-ice. The successful tapping of this great reservoir and the employment of sea water for fire-fighting has been carried out at the Australian station at Mawson. (67° 36'S, 62° 53'E).

Maintaining an Opening in Sea Ice

The sea-ice at Mawson attains a thickness in excess of five feet, so this formidable barrier has to be penetrated and the opening kept ice-free. An explosive charge is used to blow a hole in the sea-ice if it is well established but a hand-operated ice-drill should prove adequate in early sea-ice. Having made the opening, it is necessary to prevent it re-freezing in the sub-zero temperatures. A six-inch diameter metal pipe seven feet long is inserted in the hole, penetrating the water beneath and a timber spar is lashed across to prevent the pipe slipping through. Kerosene or diesel distillate is poured in, displacing the sea water to fill the pipe and insulate the sea water from the atmosphere, thus retarding re-freezing of the sea water. This pipe is examined daily and whenever an icy sludge is formed, it is broken up by means of a pole. When the pump unit is in use, the suction hose is lowered through the centre of the pipe to the water below before starting the pump. (An article in the Arctic Journal Vol. 4, No. 1, May 1951 describes a similar arrangement for obtaining fresh water).

Pumping Unit

The pumping unit is a "Godiva" 300 G.P.M. lightweight portable fire pump consisting of a "Coventry Climax" Single-Stage centrifugal pump driven by a Coventry Climax F.W. type water-cooled 4 cylinder engine which is rated at 30 B.H.P. at 3,500 R.P.M. The cooling system is indirect, a heat exchanger being employed in conjunction with the pump. Pump-priming is accomplished by exhaust-gas ejection. The opening of a valve allows exhaust-gases to create a vacuum in the pump thus drawing water through the inlet. Priming time is from 8 to 24 seconds, according to the height of lift. The engine is a high performance engine which has been quite successful in racing cars. It is equipped with magneto ignition. Starting is achieved by normal cranking and is remarkably reliable under Antarctica coastal conditions. Reliable starting at -15°F was obtained.

The unit is mounted in a tubular frame fitted with carrying handles. A small hand-sledge is used for moving the unit over the sea-ice. Elsewhere, it is carried by two men. It is normally housed in a heated workshop near the water's edge.

Hoses

Water intake is by means of 4-inch wire-bound suction hose supplied in 10 foot lengths and fitted with male and female couplings. This hose is also provided with a strainer. The delivery line consists of 2 1/2-inch 18-ply canvas hose in 100 foot lengths fitted with snap-on couplings. Branch pipes and nozzles complete the ancillary equipment.

The rate of flow through the hoses generally prevents freezing; however, should the pressure be reduced through leaks, exceptional lifts, etc., icing-up may take place due to evaporative and sensible cooling effects.

All station personnel are instructed in the care and maintenance of hoses: draining after use, care in laying and moving over sharp rocky terrain and repair of leaks. Hoses are stored by distribution in a number of warmed buildings at strategic points around the station. It is necessary to have a large drainage tray for storage. The provision of space in suitable buildings may be a problem. However, hoses should be sited in or near such danger points as kitchen, power house and garage.

Operation

The station Fire-officer or his deputy is generally responsible for all fire-fighting equipment and the training of personnel in handling it. In the case of the sea-water system at Mawson, all station personnel are trained to operate the equipment and frequent drills are carried out. This drill consists of:

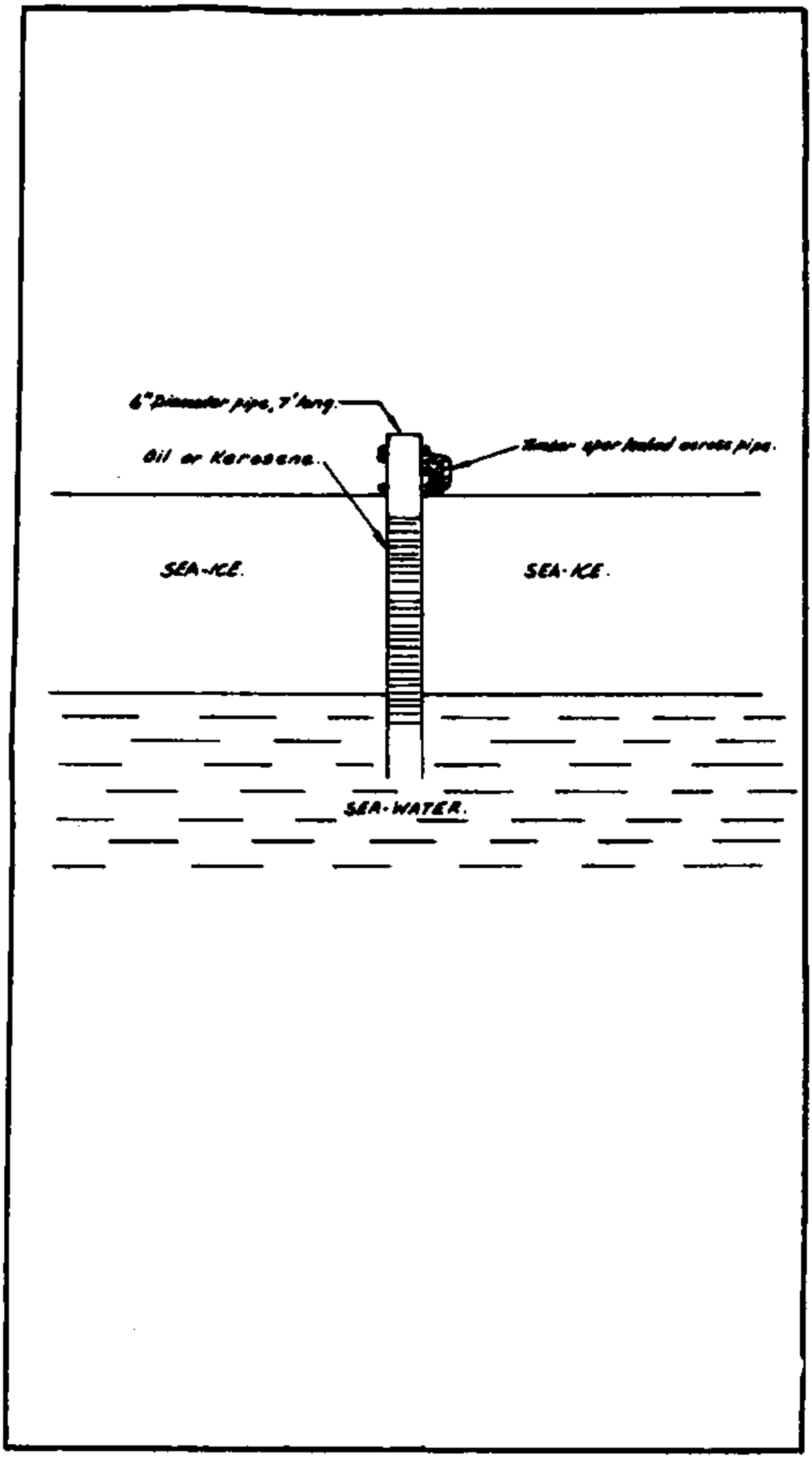
a. Two men place the unit on its sledge and move it to the ice-hole, where the suction hose is connected and pushed down, within the ice-pipe, into the water. The unit is then primed and started.

b. Two men run out hoses until the distance to the fire has been covered.

c. Two men join hoses by their snap-on couplings and fit branch and nozzle. When branch-men signal, the delivery valves are opened.

The employment of this unit is not restricted to fire-fighting. Frequent hosing in early summer accelerates the ablation of snow from the camp area, after which daily hosing keeps the rock clean. When the melt-pools are open, fresh water is pumped from them for domestic use.

The reduced fire-risk since the introduction of the sea-water system, plus the domestic convenience, has amply justified the installation of this versatile machine.



Method of maintaining an opening in the sea-ice.

AN ECONOMICAL SNOW-MELTING AND CENTRAL HEATING SYSTEM

F. A. Smith

Summary

The paper describes a snow melter which uses a closed circuit between a high efficiency oil-fired boiler and a jacketed storage tank. The circuit may be extended to provide a central heating system for Antarctic buildings.

Boiler

The construction of the boiler consists of a bank of three glazed, ceramic lined, cast-iron waterways which are bolted together to form a combustion chamber with closed base and water cooled sides. The lower section of the chamber is lined with preformed brickwork. The flue adaptor includes an integral draft stabilizer. The complete boiler is enclosed in a detachable sheet steel casing, the overall dimensions being 36 inches high, 18 inches wide and 24 inches deep.

The gun-type burner, ignited by an electric spark, is mounted externally for simplicity of maintenance and inspection and is suitable for diesel distillate, heating oil, or kerosene. The heating unit produces 60,000 Btu/hr. and fuel consumption is .46 imp. gallons per hour. During tests efficiencies as high as 83% were recorded. Electric power is required for fan, fuel pump, spark ignition and automatic controls. Electrical requirements are low; starting current is ten amperes and running current is 3.7 amperes for 240-volt 50-cycle single-phase supply.

Davis Station, for which the unit was intended, is occupied by nine men, so it was desired that the unit be as automatic as possible to avoid interruption of duties of the limited staff.

Storage Tank

The actual storage and snow-melting tank is of 112 imp. gallons capacity enclosed within an annular water jacket and the whole unit is insulated externally with three inches of mineral-wool. An insulated removable lid is provided to reduce heat losses. The tank is mounted on a stand three feet high and the annular jacket is connected to the boiler by flow and return pipes so that circulation by thermal convection is achieved. A small expansion tank is mounted above the storage tank and connected to this closed circulation system.

To prevent the circulating water short circuiting within the outer jacket, a helical scroll-type baffle is incorporated and this has the effect of circulating the water around the jacket to obtain good heat transfer to the contents of the tank. The tank, jacket and piping are copper. Capacity of the heating jacket is 36 gallons and total water in jacket and boiler circuit is 40 gallons.

Performance

Production is rapid. Approximately three hours is required to produce 100 gallons of water from snow. Generally fresh snow is added to the storage tank as water is drawn off, but this is not essential, and no damage can occur even if the storage tank runs dry. The heating jacket is thermostatically controlled at 150°F, and to prevent damage by freezing, glycol is added to the closed heating circuit.

Possible Use With Central Heating System

As the daily water requirement for the station is under 100 gallons, the boiler can also provide hot water for circulation in a central heating system. Valves have been provided in the circuit to provide this facility when required. Such a system will be introduced shortly. Hot water will be circulated by a small electric pump through small-bore pipes, which will be heavily lagged when out-of-doors, to various heat radiating devices. Engine jacket heat from the diesel generators will also be added to the system. Temperature control of the circulating water will be provided by the boiler thermostat and each radiator will be provided with manual or automatic control. Again, glycol in the central heating system will be used to prevent damage by freezing. This system will not be a danger and inconvenience like combustion stoves or heaters, and will be much more efficient thermally than electric heating.

Fuel

Heating oil only is used in the boiler, for diesel distillate fuel can become too viscous when cold, causing incorrect combustion and blocking filters and nozzles. Maintenance problems are reduced by using heating oil for cold conditions.

Maintenance

Very little trouble has been experienced. Several Davis personnel were thoroughly trained in trouble shooting and adjustment techniques while the unit was on test in Australia.

Flue Design

An insulated flue is desirable on efficient oil-fired boilers and the draft stabilizer must be clear and free to operate at all times. By maintaining a high flue temperature, corrosion carbon and soot deposits are reduced and efficient burning is maintained.

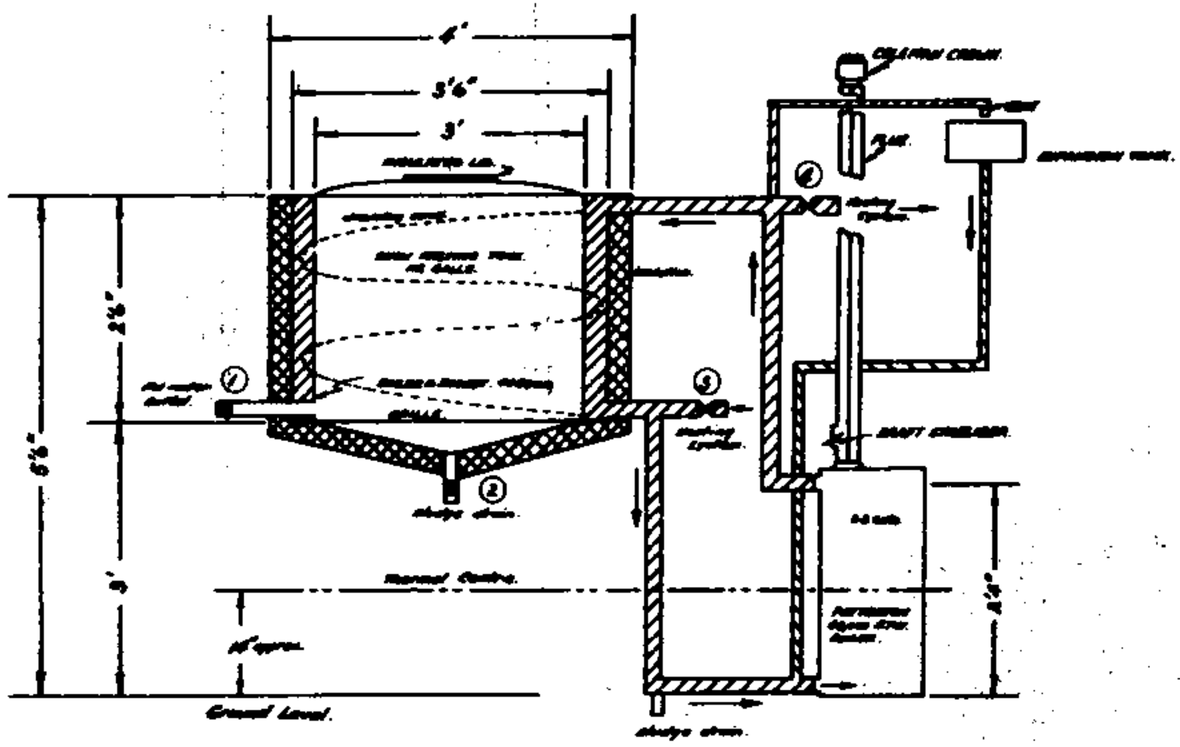
The patented Coleman Chimney Crown has been very successful with this type of installation, as it will maintain positive draft and prevent down draughts caused by varying wind conditions.

Safety

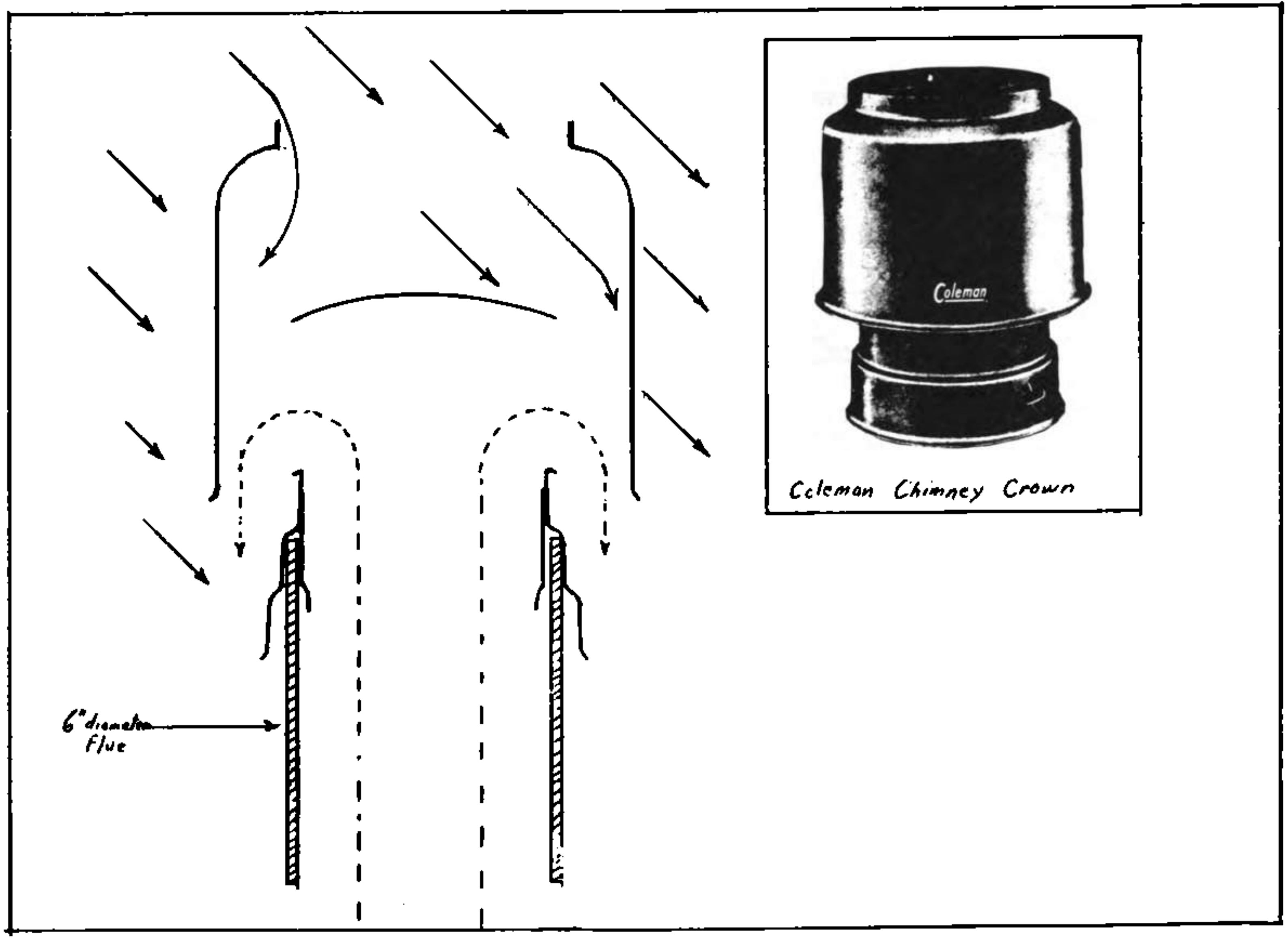
The boiler unit is fully protected against power failure, fuel blockage and flame failure. Continuous spark ignition is provided for immediate re-lighting in the event of a flame-out and a cycling device is incorporated which ensures that after shut-down the combustion chamber is cleared of fumes and fuel vapour by the fan for about one minute before ignition is switched on and fuel flows to the nozzle.

Conclusion

The unit has been operating successfully for several months, including the coldest, and indications are such that, while it is simple, inexpensive and efficient, it has filled a requirement for snow-melting which can function with the minimum of attention. The use of the closed hot water circulation in the boiler rather than icy meltwater and the copper construction of the jacketed tank should ensure long economic life for the system.



Snow-melting and heating system—Davis, 1962.



Coleman Chimney Crown showing positive draught maintained during downward wind current.

IGLOO

(Plastic polar building)

Expéditions Polaires Françaises
Bureau Technique

The scientific program of the International Glaciological Expedition to Greenland during 1957-60, (E.G.I.G.), allowed for a wintering on the Ice Cap in 1959-60.

To make all necessary arrangements for this wintering, the Expéditions Polaires Françaises (E.P.F.), responsible for the organization and achievement of the E.G.I.G., have surveyed and built a dwelling-place named "Igloo", entirely of plastic material, and which was installed at the winter station of E.G.I.G. in 1959.

1. Logistic Specifications

The principal specifications, arising from conditions of use, and which decided the solution adopted, were as follows:

1-1. Staff Strength

The scientific wintering program of the E.G.I.G. was limited to the measures necessary for completion of the principal summer season. The staff strength was therefore likewise limited, and "Igloo" was designed to provide shelter and facilities for this strength of 5 or 6 men.

1-2. Lay-Out Necessities

Like all winter stations on the ice-cap constructed by the E.P.F. since its foundation in 1947, the winter station of E.G.I.G. had to be constructed entirely in the snow, below the surface. "Igloo" had, therefore, to be installed in an excavation dug in the snow, and linked with the other station installations by underground corridors. Its structure had therefore to be designed to stand loads of accumulated snow. A spherical or semispherical shape could offer excellent resistance-power, at the same time allowing of the lightest structures; surveys were therefore generally made with a view to buildings of this shape.

1-3. Duration of Use

The scientific program of the E.G.I.G., foreseeing the renewal of operations 5 to 10 years later, "Igloo" had to be able to withstand loads and deformations during this period, so as to be able, at all costs, to be reoccupied in 1965.

1-4. Method of Transport

In conformity with the general operational concept of the E. P. F. the operations plan of the E. G. I. G. (see paper on this subject, page 671 "Field Operations"), allowed for the setting-up of the winter station exclusively by air.

"Igloo" had therefore to be designed in such a way as to be entirely transported by plane, and parachuted.

Knowing the type of plane which would be used, the parachuting methods were studied in conjunction with the French Air Force; it was decided that the parachutings should take place on a parachuting platform, the plane flying with open cockpit. The maximum characteristics to be observed for the parts of "Igloo" had to correspond to the loads admissible on the parachuting platforms used, i.e.

length:	4.20 metres
width:	1.90 metres
height:	1.25 metres
maximum weight:	3,000 kg per platform
minimum weight:	1,300 kg per platform

Moreover, air transport increases all the more the advantages of choosing the lightest material and methods of construction.

1-5. Assembly

Taking into account the total work to be accomplished, the limited staff strength, in particular with regard to technical staff, the work of assembly had to be effected in the minimum time and with the minimum of handling. It was worth while therefore to aim at the maximum of prefabrication and standardization of "Igloo" parts. Simple geometrical shapes allowed for a center or an axis of symmetry, therefore a sphere or a cylinder greatly facilitated this standardization.

The weight of the panels was limited to 50/60 kg, so as to be able to be handled and assembled by two men.

2. Conception of the Igloo

Allowing for the logistic specifications above, the engineering office chosen by the E. P. F. (Atbat, Engineer W. BODIANSKY) surveyed 2 projects: a spherical building project, comprising 2 floors, of 6.50 meters interior diameter; finally, a project for a building consisting of a lined cylinder, a semi-sphere 6.50 in diameter, and likewise 2 floors.

2-1. Evolution of the Project

In spite of certain advantages of the sphere (better proportions of weight to volume and volume to habitable surface, maximum standardization of parts) this project was not adopted because of practical and theorical considerations. Practically speaking, the digging of the excavation in the snow presented certain difficulties in constructing a perfect base for the lower hemisphere, which was in contradiction with the essentials of high-theorical considerations concerning the mechanics of snow.

2-2. Theorical Conception

In point of fact, two opposite methods and one compromise method may be noted for the construction of a building below snow-level:

2-2-1. Active Method

The building is constructed in direct contact with the snow, and is subject to the pressures, growing with the time, of these masses of snow. The spherical building project was an illustration of this method.

The method of calculating the strains withstood still seeming hazardous and not being agreed unanimously by the glaciologists, this project was abandoned because of uncertainties; the most unfavorable hypothesis, allowing for margins of security, would in fact have led to prohibitive structures.

2-2-2. Passive Method

The building is constructed in an excavation of decidedly greater volume; it is surrounded by an empty space which separates it from the snow. The covering of this excavation necessitates metallic frameworks permitting the formation, with a snow milling machine, of an arch in compacted snow. Since the building no longer had to support external pressures, it became in fact an insulating envelope and its structure could be very light, but air circulations might be formed in the empty space at low temperatures, and might complicate the problems of insulation.

This method of construction, interesting for a large station, was not adopted for the winter station of the E. G. I. G. The temporary occupation of the station for one year, then its abandonment for five years not allowing for control of the eventual deformations of the covering and the empty space.

2-2-3. Plastic Method

In this solution between the two preceding methods, the empty space used in the passive method is filled with compressible material which allows for a deformation of this empty space, without submitting the building to strong pressures.

This was the solution adopted, the compressible material being available in large quantities at the winter station: "fibrenap" (wooden fibers in strips of constant thickness, wrapped in kraft paper) used systematically for packing of all material and as a damper on the parachuting platforms. The trials carried out confirmed the fact that "fibrenap" affords an excellent compressibility very much superior to that of snow.

2-2-4. Scheme Adopted

The selected solution consists of a building whose shape suggests that of an igloo, composed of a cylinder 6.50 meters in diameter and 2.20 meters high, lined with a hemisphere of the same diameter.

This building is installed in an excavation dug in the snow. An empty space in the form of a circular corridor separates the lower cylinder from the snow. A rack placed on the upper hemisphere covers this circular corridor. The hemisphere and this rack were covered with "fibrenap", covered in turn by a compact layer of snow, ground so as to form an arch. This construction lightly touches the surface when installation is completed (see photos). The building itself consists of a shell, without framework, composed of 54 panels (three types of 18 identical panels) resting on a circular foundation-raft placed on the snow. All the internal structure is independent of the shell (planks at two levels and a central frame) and rests on a central plate mounted on mechanical screw-jacks.

This arrangement permits the accommodation to deformities which might appear in the case of difference of loads between the shell and the internal structure.

For the making of panels, the greatest strength and minimum weight and volume has been sought, which led to the adoption of a sandwich construction method (see below).

For insulation, the choice fell on expanded rigid polyvinyl chloride, usable in sandwich form, and giving a coefficient of K = 0.03.

For the construction of revetments for the sandwich panels, the metal was finally separated, because of numerous subjections imposed to avoid the formation of "thermal bridges", and the price of tool-sets for getting the panels into shape. The use of plastic materials simplified all these problems and the choice fell on polyester resins reinforced with glass tissue.

Panel tests, carried out in the laboratory gave the following results:

Pressure on slabs and charring on test-piece 25 cm wide
- on height 25 cm: 10 tons (breaking load)
- on height 2 m: 5.5 tons (breaking charge).

The entire construction survey was carried out by the Technical Commission of "Syndicat des Plastiques Renforcés" (Reinforced Plastics Union) and by the "Centre Scientifique et Technique du Bâtiment" (Scientific and Technical Center for the Study of Buildings).

3. Structure

The igloo is a dwelling consisting of a shell, without framework, cylindrical in shape, topped by a hemispherical dome which forms the first floor.

The exterior dimensions of the dwelling are:

height (overall):	5.793 m
diameter:	6.614 m
total weight:	8,300 kg

It consists of:

54 panels of plastic material which form the shell;
an interior metal skeleton supporting the flooring of the first floor;
a wooden foundation-raft carries the whole building.

3-1. The Foundation-Raft

(See the sketch: "Cross-section of Igloo", plan of frame "Foundation-raft", and photographs.)

Taking the whole weight of the building, the foundation-raft is designed to distribute the pressure on the neve. To provide for a uniform distribution and to correct possible deformations, it is made up of two distinct elements, a central plate and a circular ring, interconnected by the beams carrying the floor.

The foundation-raft is entirely made of wood.

3-1-1. The Circular Ring (peripheric beam)

This ring takes the weight of the shell-building panels and the weight of snow accumulating on this shell.

The ring is divided into 18 identical elements trapezoidal in shape consisting of a sole-piece 0.777 m wide and 40 mm thick, supporting a beam portion 1 m long and having a 200 x 80 cm section.

Two consecutive elements of this peripheric beam are connected through radial beams secured by bolted sheet metal gussets.

3-1-2. Central Plate

This plate takes the inner load of the building: the floors of the two stories and interior appointments.

If the loads were not evenly distributed between the central plate and the circular ring of the foundation-raft, level variations would occur resulting in deformations of the floor and of the whole interior structure. Therefore, the central plate is mounted on three mechanic jacks designed to correct these deformations. These jacks are carried by a tubular metal scaffolding resting on a plate of the same size placed on the neve.

The central plate, 1.50 m in diameter, consisting of a sole-piece 40 mm thick; it carries a circular crown 1.20 m in diameter and mm 200 x 50 in section. To this crown are bolted the gussets to which the radial beams are secured.

The central plate has a circular aperture of 0.15 m diameter through which fresh air enters the igloo. The plate carries the three bases of tubular posts supporting the interior skeleton.

3-1-3. Radial Beams

Eighteen identical radial beams, three meters long and 200 x 50 mm in section connect the central plate and the circular ring (peripheric beam). The joints are bolted gussets made of folded sheet metal.

The bottom face of each radial beam carries a cleat. Between two adjoining beams, isolating panels are placed on these brackets. The panels are made of expanded rigid polyvinyl chloride (50 mm thick) covered by polyester resin.

3-1-4. The Floor

The floor rests on the radial beams, on the peripheric beam (of the circular ring) and on the crown of the central plate.

Twenty-five mm thick, it consists of the following elements:

One circular central element, corresponding to the central plate of the foundation-raft, is pierced with two openings (one to let in combustion air for the heating stove, and the other to air the igloo); it has also three openings to accommodate the tubular poles which carry the inner skeleton.

Eighteen identical peripheric elements, nailed to the radial beams and to the peripheric beam. Thence, the panels of the igloo rest on these floor elements which have chocks to facilitate the assembly of the panels.

Eighteen identical intermediate elements, some of which are not secured and can be removed to provide inspection traps.

All floor elements are covered with a glued polyvinyl chloride mat.

Between two adjoining radial beams, the above-mentioned floor and isolating panels, form a sort of duct in which warm air is circulated underneath the floor.

3-2. The Shell Panels

The shell of the igloo is made up of 54 panels of three different types:

Eighteen panels in the shape of cylindrical segments for the lower floor which is 2.220 m high, (weight: 55 kg).

Thirty-six panels in the shape of spherical segments for the top-floor reaching a height of 3.307 m in the center. Eighteen panels for the lower part (weight: 60 kg), 18 for the upper portion of the demi-sphere (weight: 45 kg).

Of these 54 panels only two are of a special type: one door for the entrance, one for an emergency exit on the first floor.

3-2-1. Construction

(See sketch "Assembling of panels" and photographs.)

All the panels are of sandwich construction:

A web of "expanded rigid polyvinyl chloride" 50 mm thick, with a density of 75, hot-formed and glued between two coverings (or "skins").

Two linings in "reinforced plastic, fiber glass polyester resin", 3 mm thick to 5 mm thick throughout the periphery and the edges of the panels. As the two inner and outer skins fit one into the other, the thickness of the panel edges is increased to 10 mm. The edge of the inner skin forms an inner rib 45 mm wide, which permits the panels to be bolted together; small stiffening plates are glued on this rib around each bolt hole.

Tightness between panels is achieved by two coil-sections of low temperature resistent rubber permanently glued to the edge of two adjoining sides of each panel.

The outer and inner skins are molded and assembled on jigs by the "low pressure bag method" (méthode du sac à dépression). A 1 mm tolerance has been allowed for.

3-2-2. Assembly (see photographs)

The panels are directly put together by bolts which also tighten the outer ribs.

The shell thus built up is tightened on the outside of the building by two steel belts, 80 x 4, with hinged tighteners; one belt is at bottom floor level, the other at the junction of the cylinder and of the demi-sphere (top floor level). The latter belt is held in place by angle-pieces of "reinforced plastics" glued to the outer skin of the cylinder panels.

The whole shell rests on peripheric floor sections in the plane of the peripheric beam of the outer ring of the foundation-raft.

3-3. The Inner Metal Structure

This structure, secured to the center portion of the foundation-raft, is only supported by the plastic panels of the shell, to be independent of possible displacements of the shell under snow pressure.

This structure comprises:

Three tubular metal posts (diametre 40/49) resting on foundation plates provided for this purpose on the center plate of the foundation-raft. These posts carry a triangular piece of channel iron gauging 80, which receives the girders of the upper floor.

Eighteen omega-section radial metal girders 60 x 35 x 22, three metres long, with one shrunk end. These floor-supporting girders are secured at one end to the central triangular prop. Their shrunk end fits into a housing at the junction of the four plastic panels of the shell. All these girders are interchangeable except one which rests on the stairway post.

Eighteen metal floor sections of $15/10^{th}$ sheet metal, each stiffened transversally by six welded omegas, rest on the radial metal girders. The lower side is corrugated while the upper side is covered with a glued polyvinyl chloride mat. All these floor sections are interchangeable, except two at the top landing of the stairway.

One metal winding staircase placed against the shell connects the two floors. This stairway is made of 12 identical stairs fitted into a tubular post. These stairs are covered with a glued polyvinyl chloride mat.

4. Inside Accommodations

The inside accommodations have been designed for six men, covering a total available space of 60 m^2.

The lower level is reserved for community activities (cooking, meals, entertainment); the upper level for work and sleeping quarters.

4-1. The Lower Level Includes (see drawings and photographs)

4-1-1. In the middle the heating and water unit, composed of: the heating stove, a water tank, sink, shower and kitchen.

Water is produced in a galvanized sheet steel two hundred liters snow vat, located near the heating stove. The melting of snow is accomplished by electrical resistance heat-plungers and, in case of emergency, by an oil lamp. One faucet is located above the kitchen sink, the other above the wash basin.

The kitchen includes: a three-flame four-plate gas stove, working on propane; the propane bottle, containing 30 kg of gas, is installed in the corridor, in the neve, connected to the stove by copper tubing.

a plastic sink (acrylinic resin)
metallic floor and wall cabinets
a hood for steam evacuation.

4-1-2. Along the circular wall, successively

a dining hall with table and stools
a recreation room with arm-chairs, books, records and radio
a large closet
a photographic laboratory
the stairway leading to the upper level
the electrical layout board for the installation of the entire station.

Separators and dividing walls are always radial, constructed of plywood, and supported by the panel ribbing of the igloo shell.

4-2. On the Upper Level are (see drawings and photographs), along the Circular Wall and Situated Radially:

Six individual rooms, including:

a work table
shelves
a stool
a bed placed against the circular wall
a trunk under the bed
individual lighting.

One room for meteorological apparatus and recording devices
One sealed insulated room for the radio

All the furnishings are in metallic tubing, collapsible for shipment. Wide use has been made of laminated plastic coverings of various colors.

4-3. Heating, Ventilation

4-3-1. Heating of the building is assured by a warm air generator of 7,000 calories/hour, with calefaction, burning special odorless oil.

The circulation of warm air takes place:

In the lower level, in the double floor (either by convection or by means of a small ventilator), and by small apertures in the floor along the igloo shell.

In the upper level, by apertures in the floor along the igloo shell.

Fresh air needed for combustion is taken up in the corridors dug in the neve and transmitted to the stove fire-box by a sheath passing under the lower level floor and through the central beam plate (see photo).

Smoke is evacuated through a vertical duct, located in the center of the igloo, leading directly to the outside and equipped with an anti-backflow damper.

4-3-2. Ventilation

Fresh air is taken in through apertures in the central beam plate and the outside door. Stale air is evacuated through a pipe concentric to the smoke duct in the center of the igloo. This pipe being slightly heated, induces an air current by depression, avoiding in large part frosting at the outside opening.

The system is equipped with a suction opening at ceiling height on both levels. The stove hood also leads to this evacuation system.

5. Setting up the Igloo

5-1. Shipment

As planned the igloo parts were transported by plane from France to Greenland in April and May of 1959.

They were parachuted to the winter station in June, almost all the parachuting being done with parachute platforms, especially for the 54 shell panels. The stowing on platforms included a shock-absorbing mattress 40 cm thick in "fibrenap".

The parachute drops occurred without incident, and all the equipment landed in perfect condition.

5-2. Digging the Excavation

Digging was done on a diameter of 8 meters, 6 meters deep around the perimeter and 7.50 meters deep in the center, for the igloo excavation, by a "Peter Junior" track snow drill, operated by one man (which was used for all the station's excavations.

5-2-1. The Main Features of this Snow-Milling Machine are:

Porshe 1600 cc 4-cylinder air-cooled engine, 55 W at 4,500 RPM.
Horizontal drum mill.
Working area 1.20 meter, thrust height 80 cm.
Snow ejected through two adjustable pipes, ejection height: 10 meters.
Output: 100 m^3/hour.

5-2-2. Digging was Done in the Following Conditions:

Altitude:	2,870 meters
Temperature:	from -2°C to -15°C
Wind:	0 to 10 m/sec
Snow:	density 0.350 on the surface
	density 0.427 at -6 meters
	density 0.473 at -7.50 meters

The digging was done on 478 m^3 for the excavation of the igloo and the snow drill access tunnel.

This digging was completed in 114 manhours.

5-3. Assembly

The assembly of the igloo took place in the following conditions:

5-3-1. Means Used

A team of four men for the assembly itself
A team of four men for supply and transporting parts from the storage area to the igloo site with a weasel and a sled.

5-3-2. Assembly Time

The complete assembly of the igloo (building empty, but heating system installed) was done in nine hours time by these four men, in other words a total of 36 manhours.

The supply team worked the same number of hours.

The assembly and the installation of all the interior fixtures up to completion were done in 144 manhours.

5-4. Use

This building gave complete satisfaction during the entire winter period.

The ease and speed of assembly met all the established requirements.

The circular shape and the two levels create the illusion of an available space much greater at the actual surface and allowed for a comfortable stay for the six men.

The insulation, obtained through panelled construction and insulating materials, turned out to be excellent, and the heating stove only worked at half heat for most of the winter. As an example, the following figures were taken on August 13, 1959:

Outside: wind seven meters/second, humidity 84%, temperature -17°C
Circular corridor around the igloo: temperature -14°C
Inside (hood open, door open most of the time):
lower level floor, temperature + 8°C
lower level ceiling, temperature + 20°C
upper level floor, temperature + 17°C
upper level ceiling, temperature + 19°C

At the end of the winter season, after a year's use and before closing the station for five years, accurate measurements were taken in an attempt to find possible buckling or shifting, but none were ascertained and the central beam plate jacks did not have to be used.

6. Conclusion

To our knowledge this is the first building built entirely of plastics actually used and lived in; all preceding ones throughout the world having been just exhibition models. In any case it was the first building of this type used in these conditions in polar regions.

The results obtained were a complete success, contrary to the misgivings of many specialists in France. They prove that building in plastics has been perfected, on condition that the building be done by competent specialists. (The igloo was built in France by Sud-Aviation Co. —creators of the "Caravelle"—in other words with "aviation" manufacturing procedures, finishing and tolerances).

The igloo perfectly answered the necessary requirements, i.e., a lightweight building for an Ice-Cap station, transportable by plane, quickly and easily assembled by a few men, and assuring use over a period of many years.

It can be used in any place where a station can be constructed under the surface of the neve. If the E.P.F. were to install a new station on the Antarctic plateau, to replace the Charcot Station, this type of building would be adopted. The only modification would be the replacing of the wooden beam with a metallic one, wood not guaranteeing sufficient dimensional stability for a trip to the Antarctic.

KEY

Interior Arrangements of the Igloo

Lower Level

1. Partition 1.20 x 2.10 x 0.015 in plywood
2. Stairs leading to the superior level
3. Entrance door of the igloo
4. Photograph laboratory
5. Cupboard and table of electric distribution

Living Room

6. Bookcase
7. Benches
8. Radio-phono furniture
9. Armchairs
10. Bridge table

Meals—Kitchen

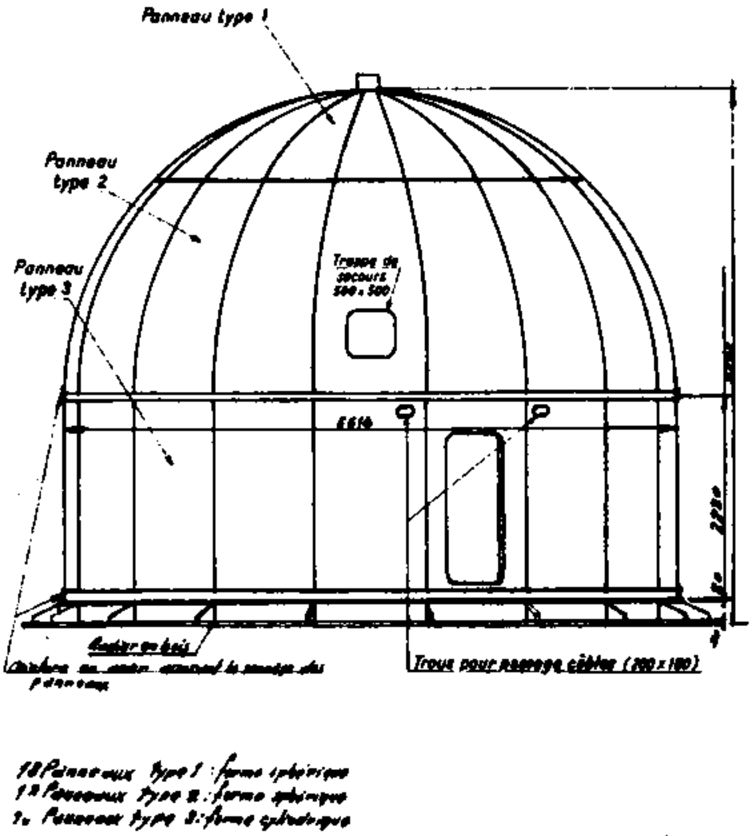
11. Table
12. Chairs
13. Shelves and furniture for kitchen ranging; 13 (a) - Bar

Central Block

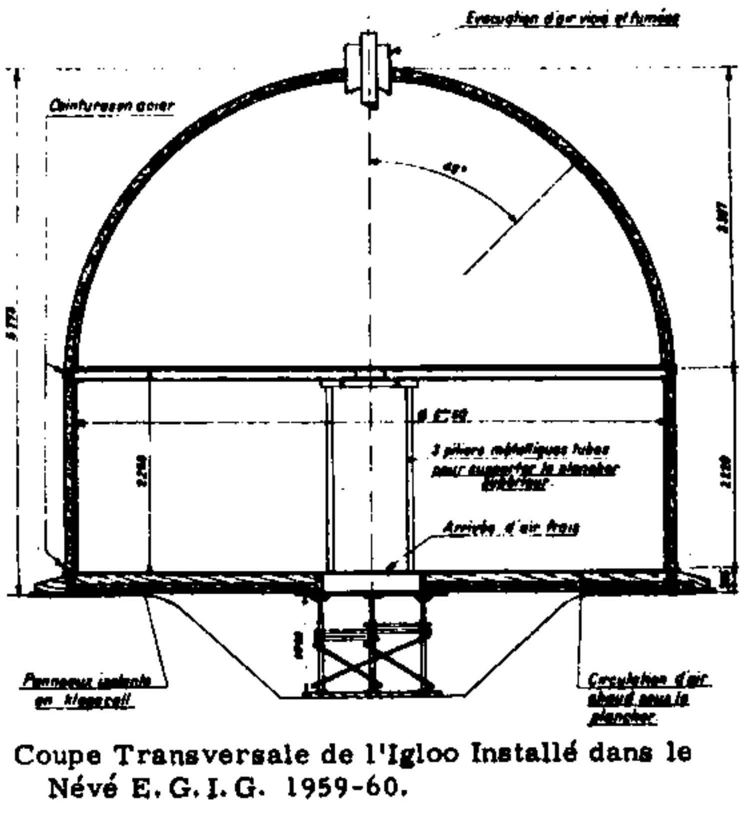
14. Kitchen partition, consisting from 2 panels 2 x 1 m in plywood 20 mm covered with 2 sheets of satined Duralumin 5/10
15. Kitchen sink
16. Gas stove
17. Furniture for ranging - buffet
18. Aeration hole
19. Large snow bucket
20. Aerotherm
21. Arrival of air for combustion
22. Arrival of fresh air
23. Clotheshangers
24. Passage for meteo cables
25. Passage for electric cables
26. Separation curtains
27. Metallic posts of the interior metallic skeleton

Upper Level

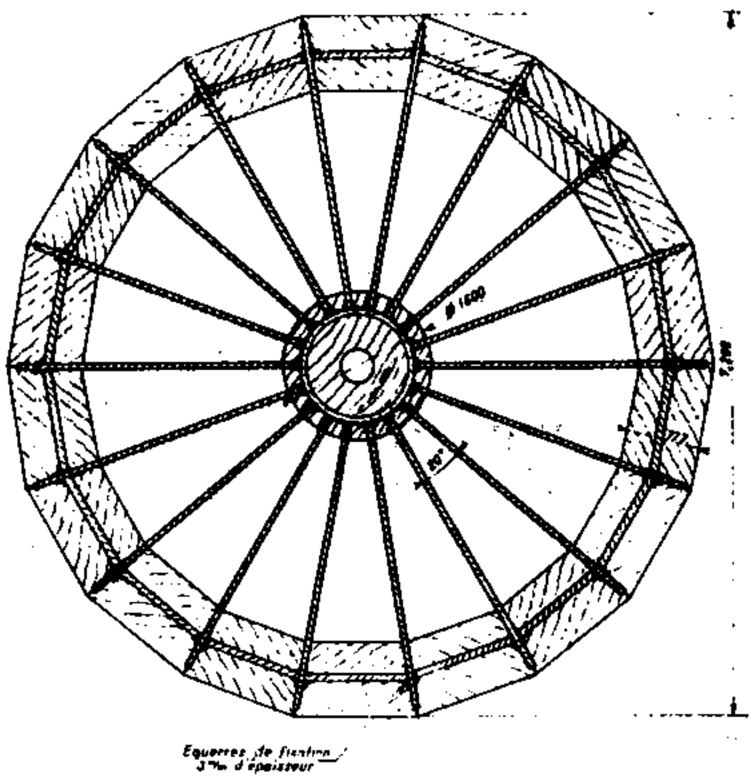
1. Partition 2 x 2 x 0.0015 m in plywood
2. Half partition 2 x 1.20 x 0.0015 m in plywood
3. Tube 22/25 forming a strut and supporting the curtains
4. Individual cell
5. Bed (legs in tubes and chest)
6. Double ladder in tube supporting a table with drawers and shelves
7. Radio room
8. Meteo room
9. Safety door trap
10. Hole for the passage of the antenna cable
11. Stairs



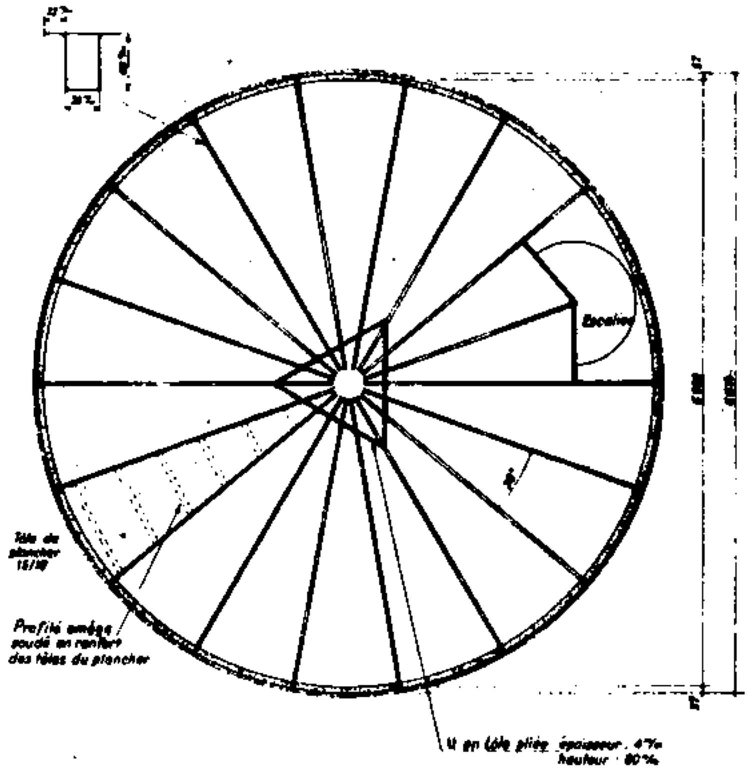
Vue Exterieure de l'Igloo E. G. I. G. 1959-60.



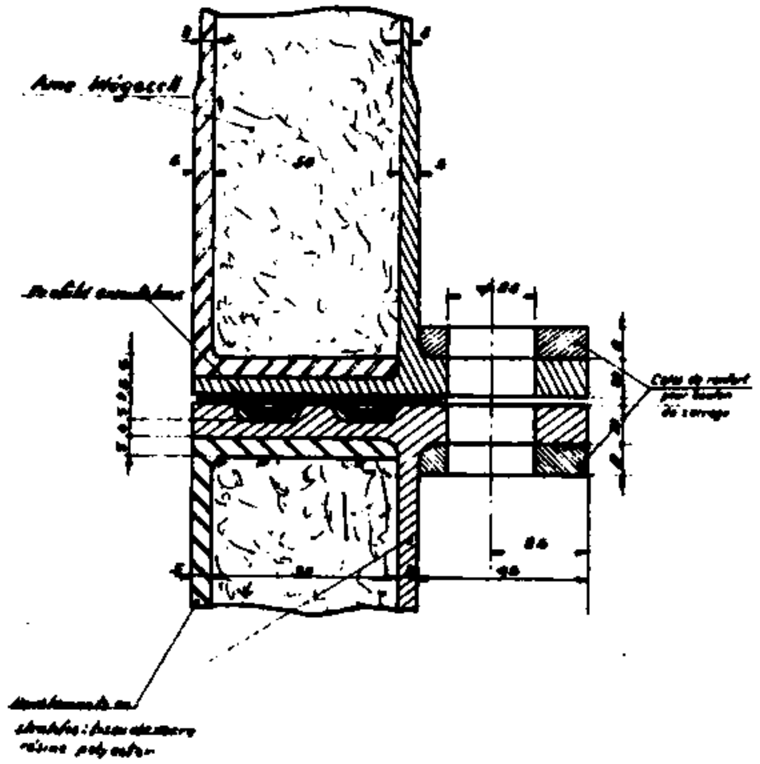
Coupe Transversale de l'Igloo Installé dans le Névé E. G. I. G. 1959-60.



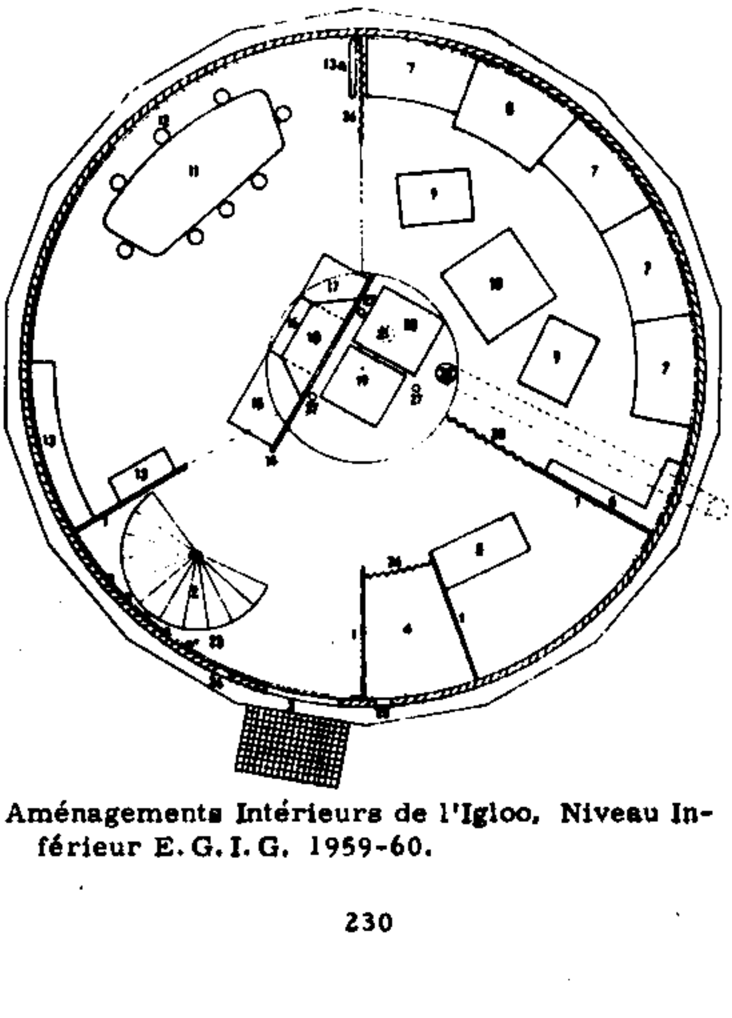
Vue en Plan du Radier de l'Igloo E. G. I. G. 1959-60.



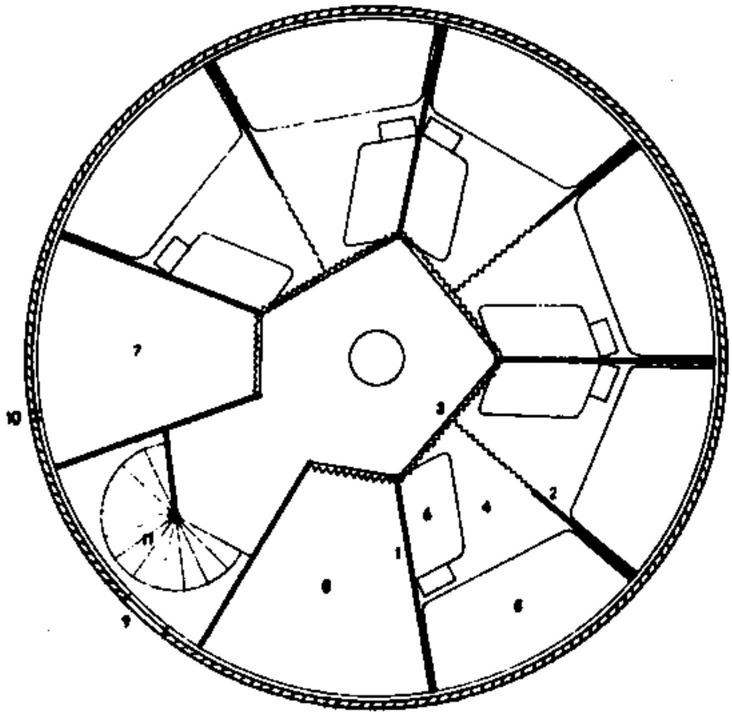
Plan Niveau Supérieur de l'Igloo Elements Métal (Poutraison) E. G. I. G. 1959-60.

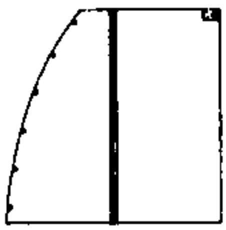


Assemblage des Panneaux de l'Igloo E.G.I.G. 1959-60.



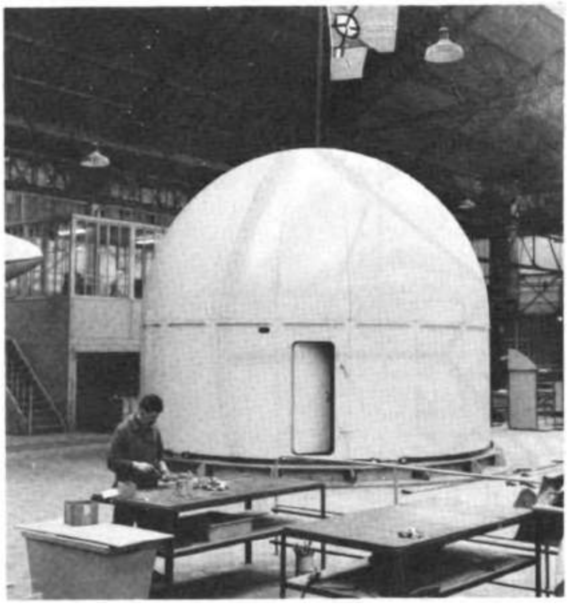
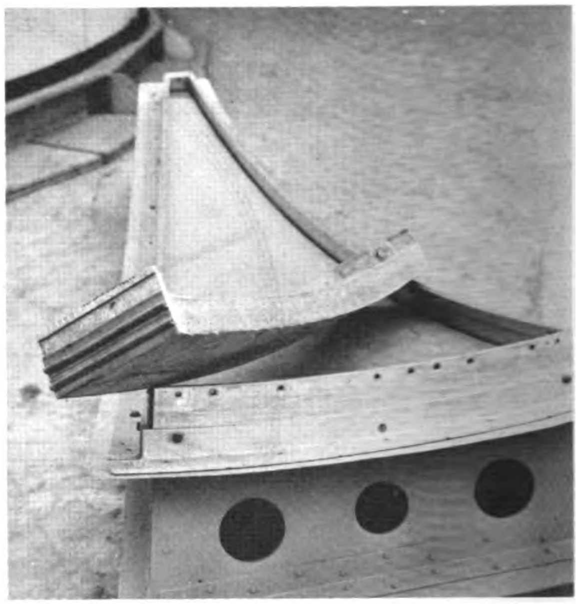
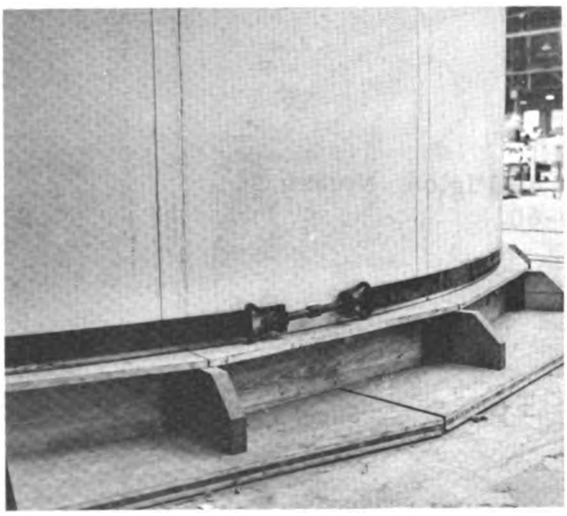
Aménagements Intérieurs de l'Igloo, Niveau Inférieur E.G.I.G. 1959-60.

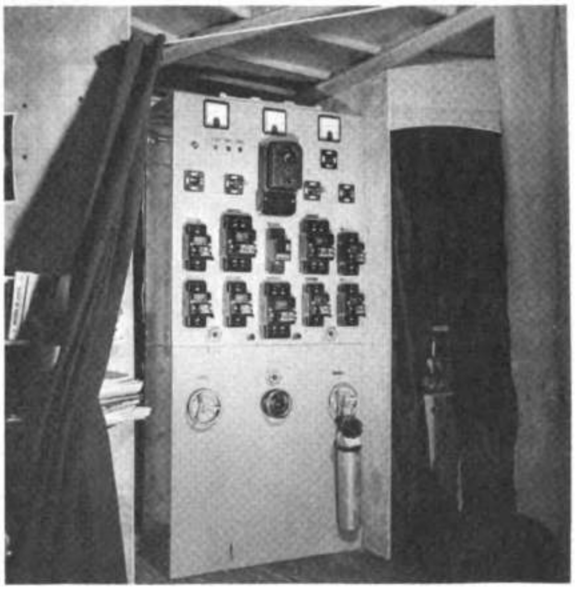


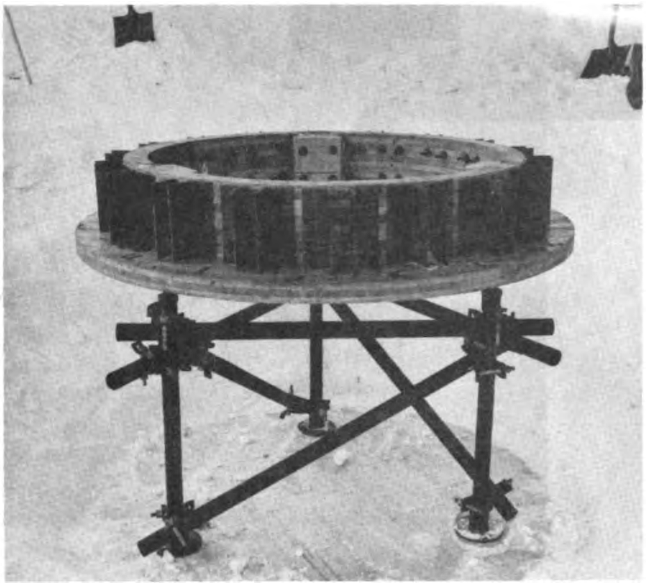


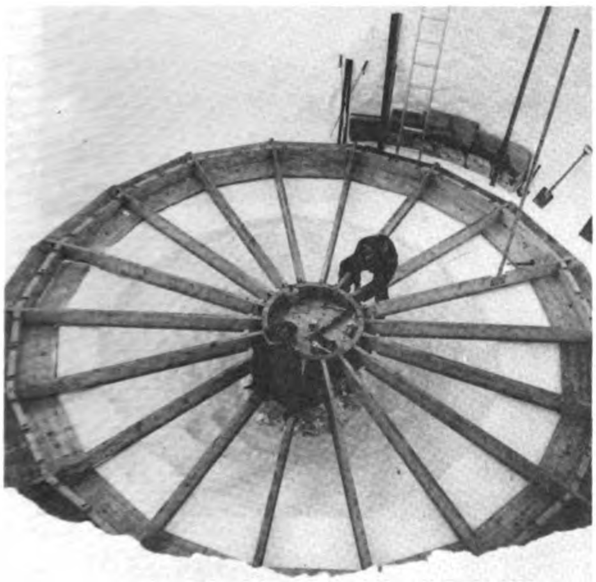
Détail d'une cloison

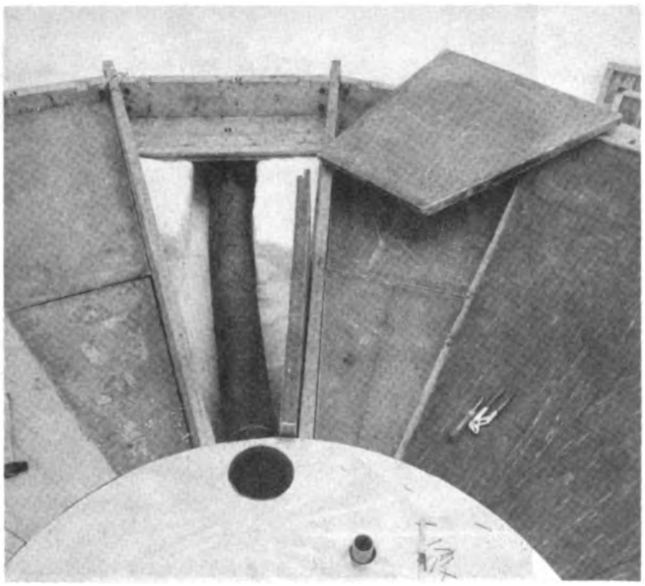
Aménagements Intérieurs de l'Igloo. Niveau Supérieur E.G.I.G. 1959-60.

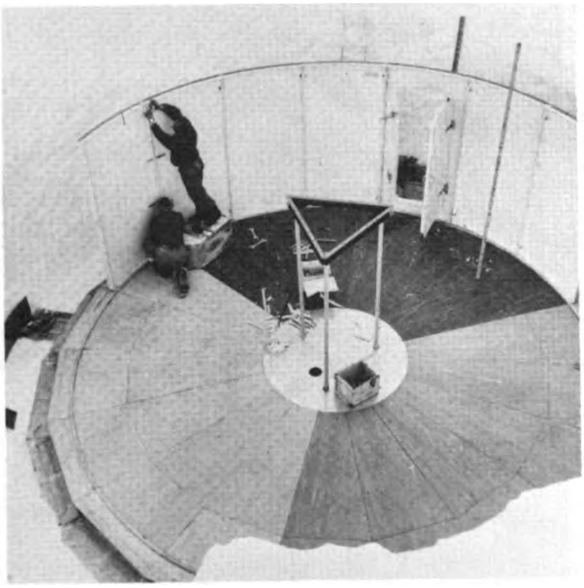




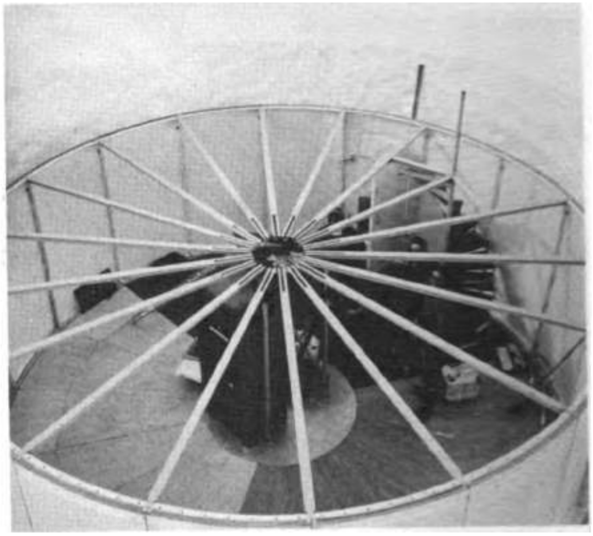













DESIGN AND CONSTRUCTION OF BUILDINGS IN SYOWA BASE

Hideo Futami, Arinobu Minow
and Naoto Hida

1. Introduction

Complying with a request of the National Antarctic Committee, Science Council of Japan, the Architectural Institute of Japan decided in 1956 to take charge of the design of buildings to be erected at a base for the Japanese Antarctic Research (J. A. R. E.), which was going to be established somewhere in Lützow-Holm Bay. The Institute appointed a committee for this, which was headed by Prof. H. Futami and was named the Committee for Antarctic Expedition Buildings (C. A. E. B.).

The base, now called Syowa Base, was established early in 1957, and the buildings were successfully erected. They have served five years, and are almost as good as they were when built. The design and construction of these buildings will be described below. The text presented here may be too brief to give full informations, but the attached illustrations will supplement it.

2. Fundamental Design of J. A. R. E. Buildings

No one had ever been to the bottom of Lützow-Holm Bay. The weather as well as the ground conditions were quite unknown. C. A. E. B. decided that the buildings were to be designed so that they should stand

1. a wind of 80 m/s (160 kt) velocity,
2. a low temperature of -70°C

and

3. a snow-cover on the roof as deep as 2 m.

Another requirement was that the erection should be possible on the snow as well as on the rocky or sandy ground.

As a result of a careful consideration, it was decided that the main buildings—main hut (with two beds), sleeping hut (with seven beds), wireless hut (with three beds) and laboratory—should be of the prefabricated panel-type. The outline of the design of these buildings is given below.

Every building is of 16 ft span. It is of the stressed skin construction, being composed of flooring, wall and roof panels joined together with special connectors.

The rectangular house constructed in this way is reinforced by floor- and roof-beams. No pillars are used.

A modular system was adopted throughout the design of all construction parts. Every part was designed taking 2 ft* as the fundamental unit. This system proved most fruitful in the design of the kitchen and the individual rooms (see Appendix 13010, 31100, 32100 et al.). It was a prerequisite presented by the J. A. R. E. 1956-57 that every member of the wintering team should have a private or individual room; and in the limited space this would not have been possible if the modular system had not been adopted.

It would be worthy of note, too, that the adoption of the modular system materially improved the efficiency of shipping. Packing, loading and unloading the construction parts could successfully be carried out with a minimum labor, and the space in the hold occupied by these goods was reduced to a minimum.

Being composed of the light-weight panels and beams, the details of which are to be described in the following section, the J. A. R. E. buildings are believed to be the lightest prefabricated buildings ever built in the Antarctic.

Any of the J. A. R. E. buildings can be erected in five hours by eight men.

3. Description of Some Construction Parts

3-1. Panels

The size of a panel is 4' x 8' x 4" (see Appendix 22210, 22310) in accordance with the modular system adopted.

The outer frame is made of Japanese cypress, an excellent building material, which has a density of 0.44 and a tensile strength of the order of 1,200 kg/cm^2. The longitudinal and transversal pieces are tenoned and glued together with a resorcinol type adhesive. No nails are used.

Crosspieces, 12 mm in thickness, of Japanese cypress are glued to the inside of the outer frame to form a grid structure. The crosspieces are fixed along the line of maximum stress. Thus, for instance, the direction of these pieces in a wall panel is different from that in a roof panel (see Appendix 22001).

Thin plywood boards are firmly glued on both sides of the framework to form a hollow chest. The panel completed in this way is akin in structure to the wing of an airplane. Thus the most important stress members in the panel are the plywood boards. These are six-ply, 6 mm thick boards, composed of thin sheets of Japanese birch (density 0.61) stacked and glued with a phenol type binding agent. Low temperature test has proved that such a plywood board stands -70°C.

*Actually the unit was two shakus. Shaku (1 ft = 1.006 shaku) is a Japanese unit of length, which has been used as a module in the Japanese style architecture.

The panel is filled with foamed polystyrene, an excellent insulator with a heat conductivity 0.029 kcal/m.h.°C. The average weight of a panel is 70 kg.

Some panels are equipped with a small window (Appendix 22001). The window pane, ca. 1 ft square in size, consists of four sheets of reinforced glass with spaces filled with dried nitrogen.

3-2. Connectors for Panels

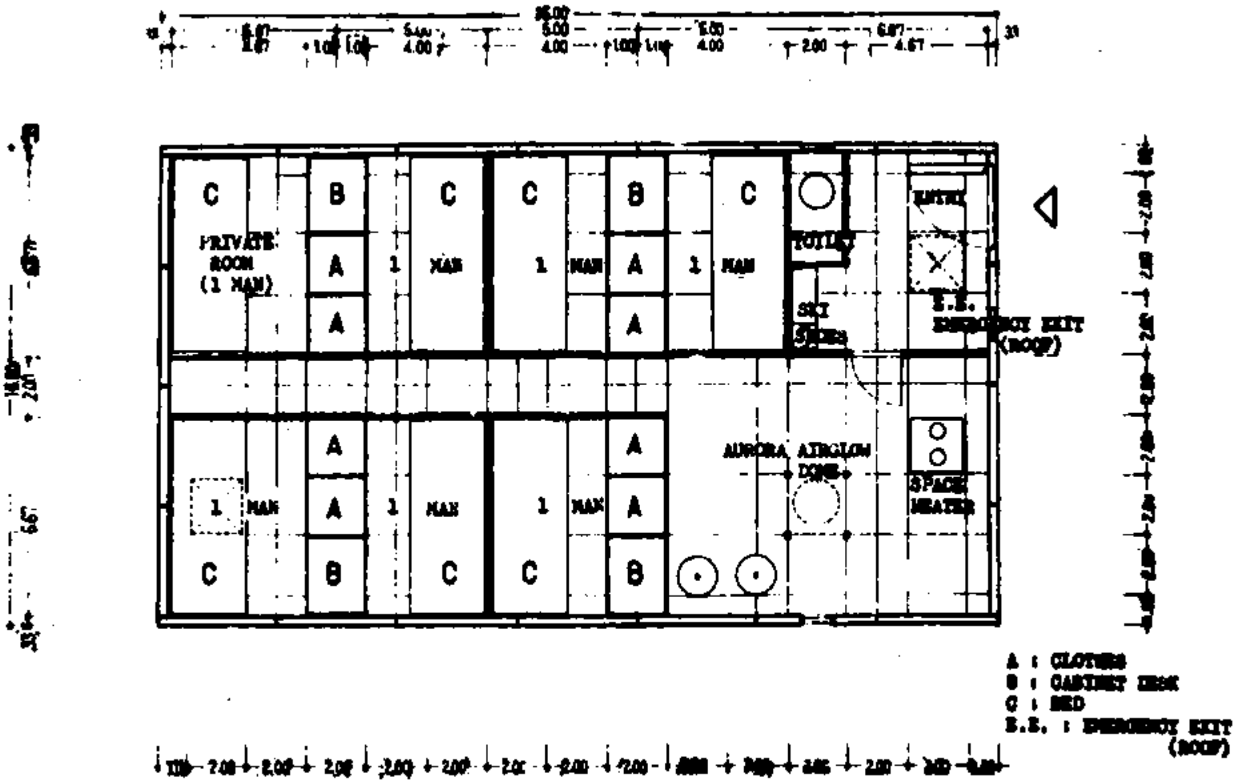
Two types of connectors illustrated in Appendix 70000 allow one to joint the panels firmly and erect the building with nothing but an iron hammer. Considering the convenience in transportation, the connectors were designed as thin as possible. The maximum height from the panel surface is 14.5 mm.

Low temperature fragility was the main concern in selecting the material for connectors. They were forged from a low-carbon steel, JIS SF-34.

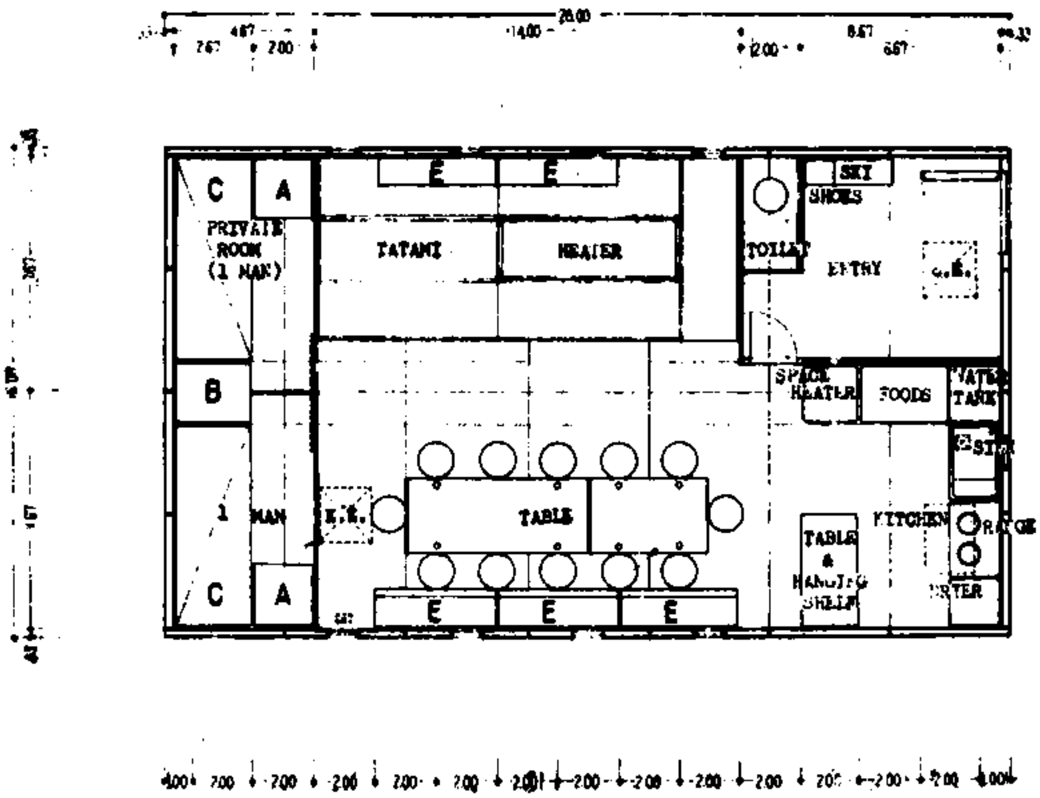
3-3. Beams

Two kinds of beams are used, the roof-beam and the floor-beam. The former is illustrated in Appendix 23101.

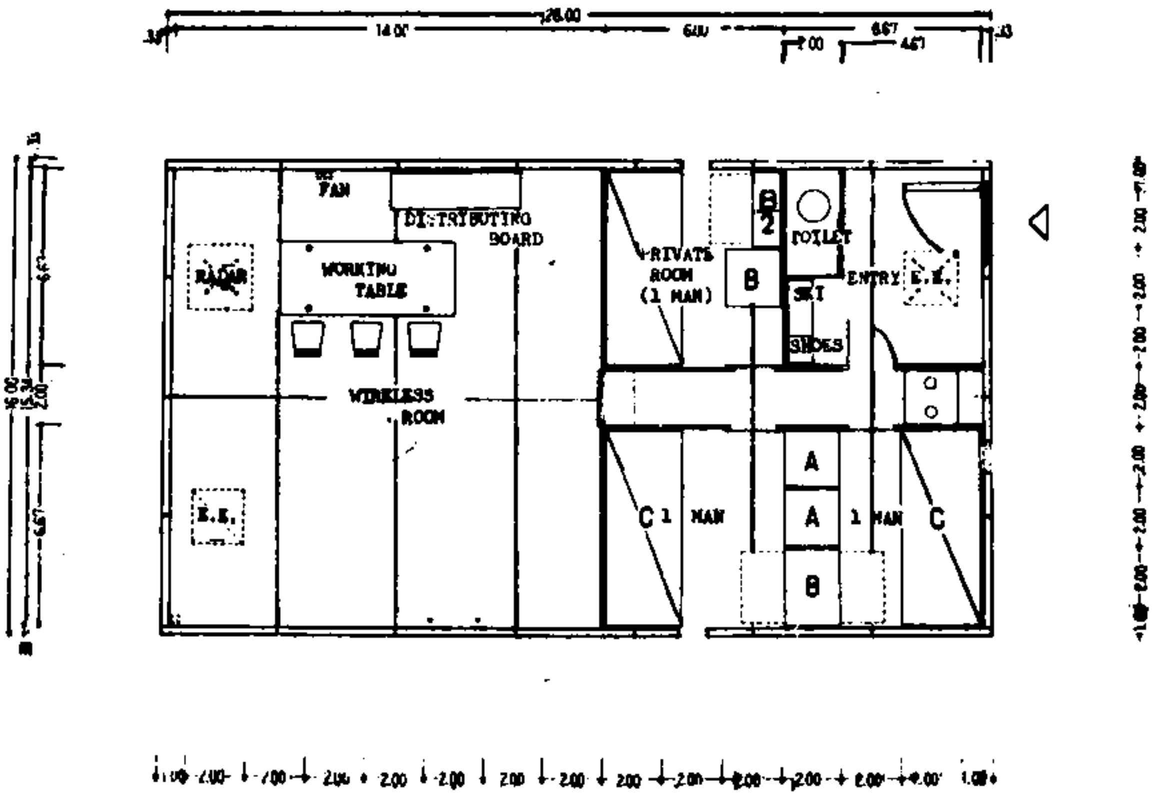
Every beam is made of a web plate, 2.3 mm in thickness, and two flange plates, 2.6 mm in thickness. Welding these thin plates was a pretty difficult work. A low hydrogen welding rod was used. After the welding, each beam was thoroughly examined by X-rays. The average weight of a beam is 55 kg.



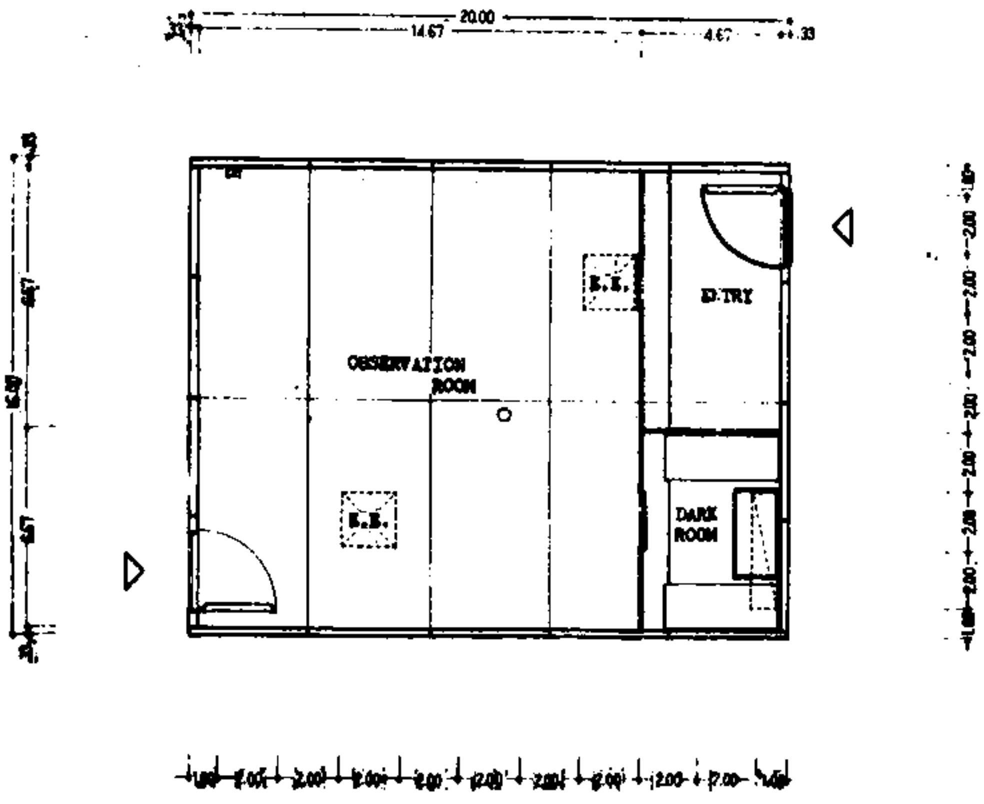
Appendix 10010 sleeping hut plan.



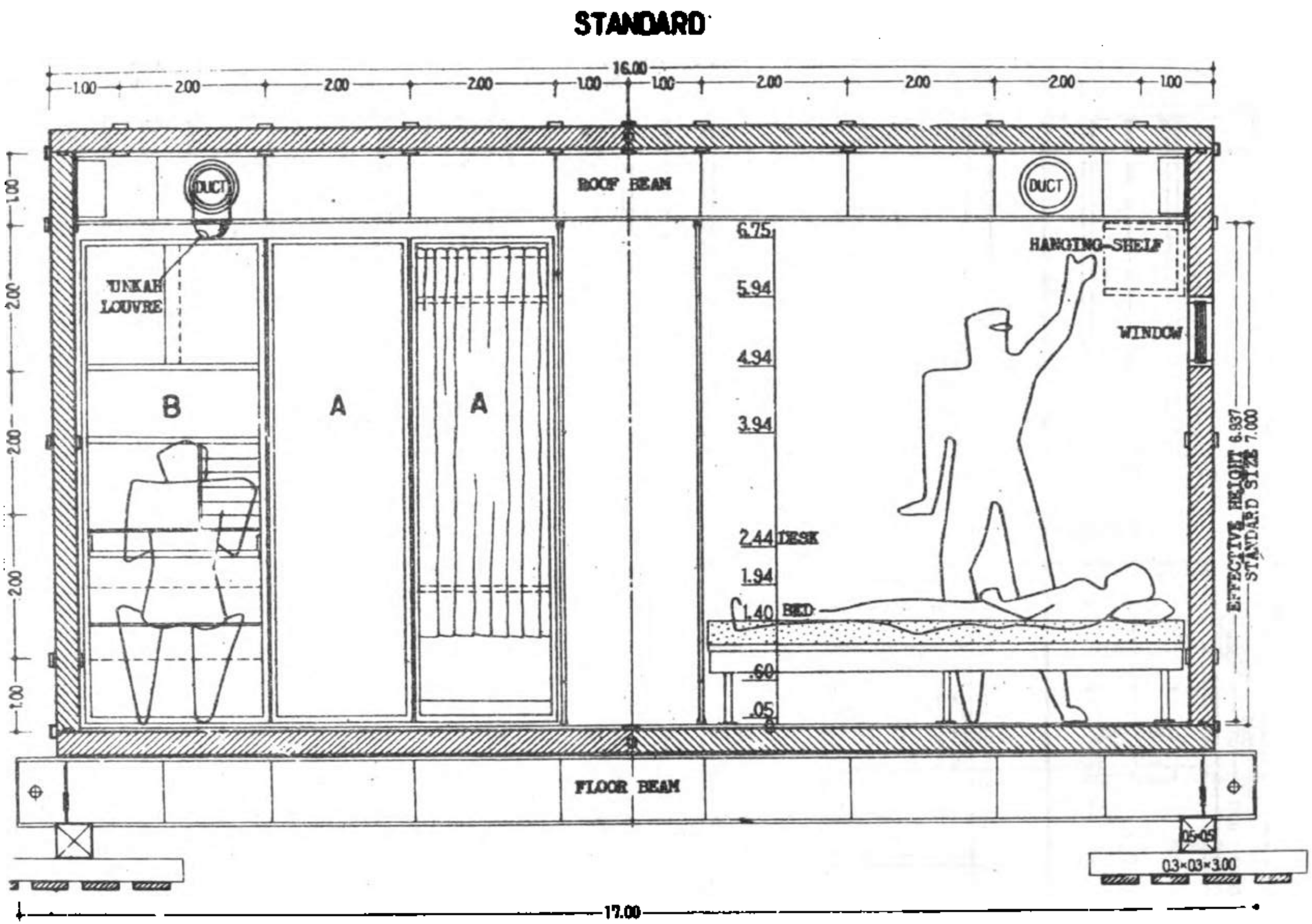
Appendix 10020 main hut plan.



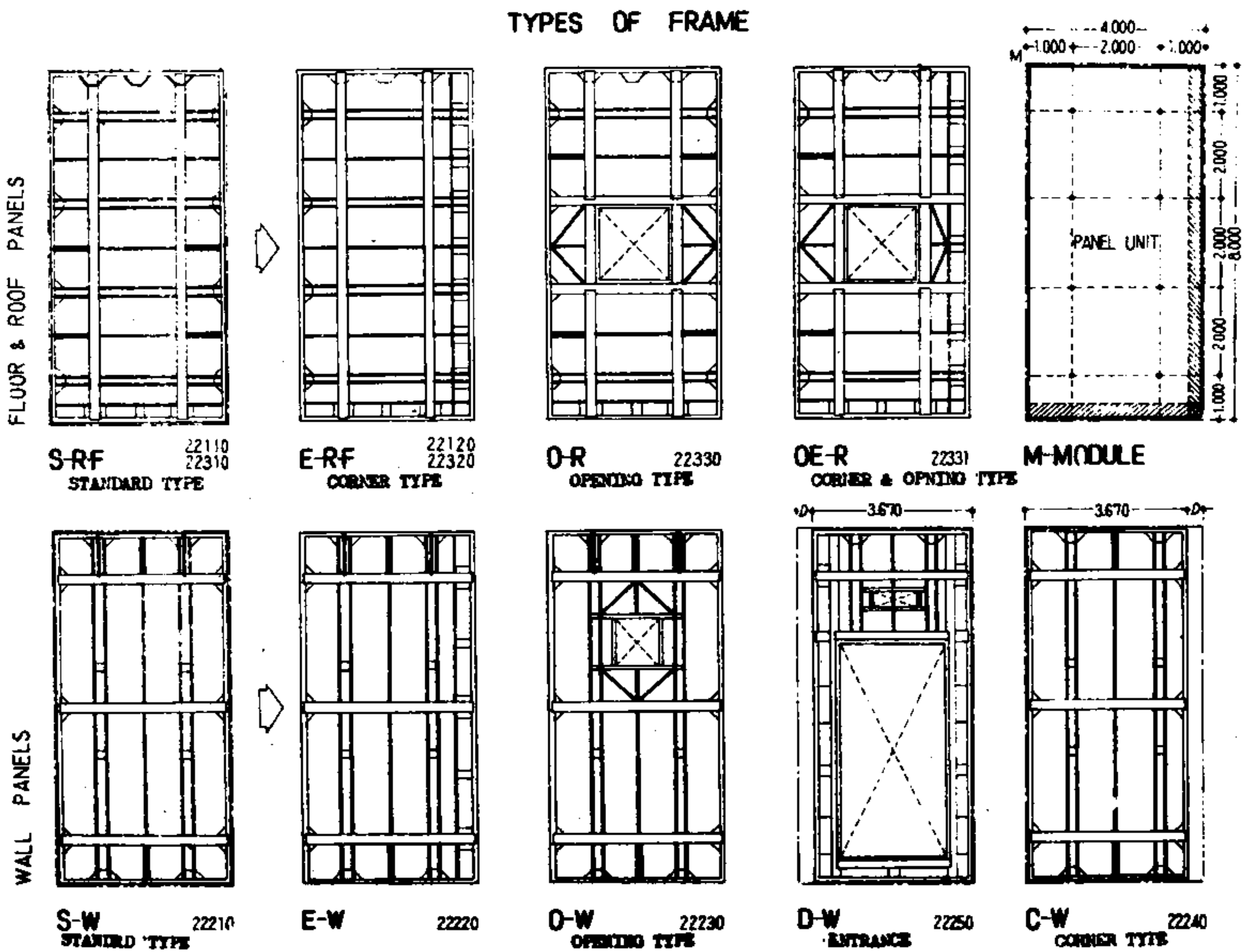
Appendix 10030 wireless hut plan.



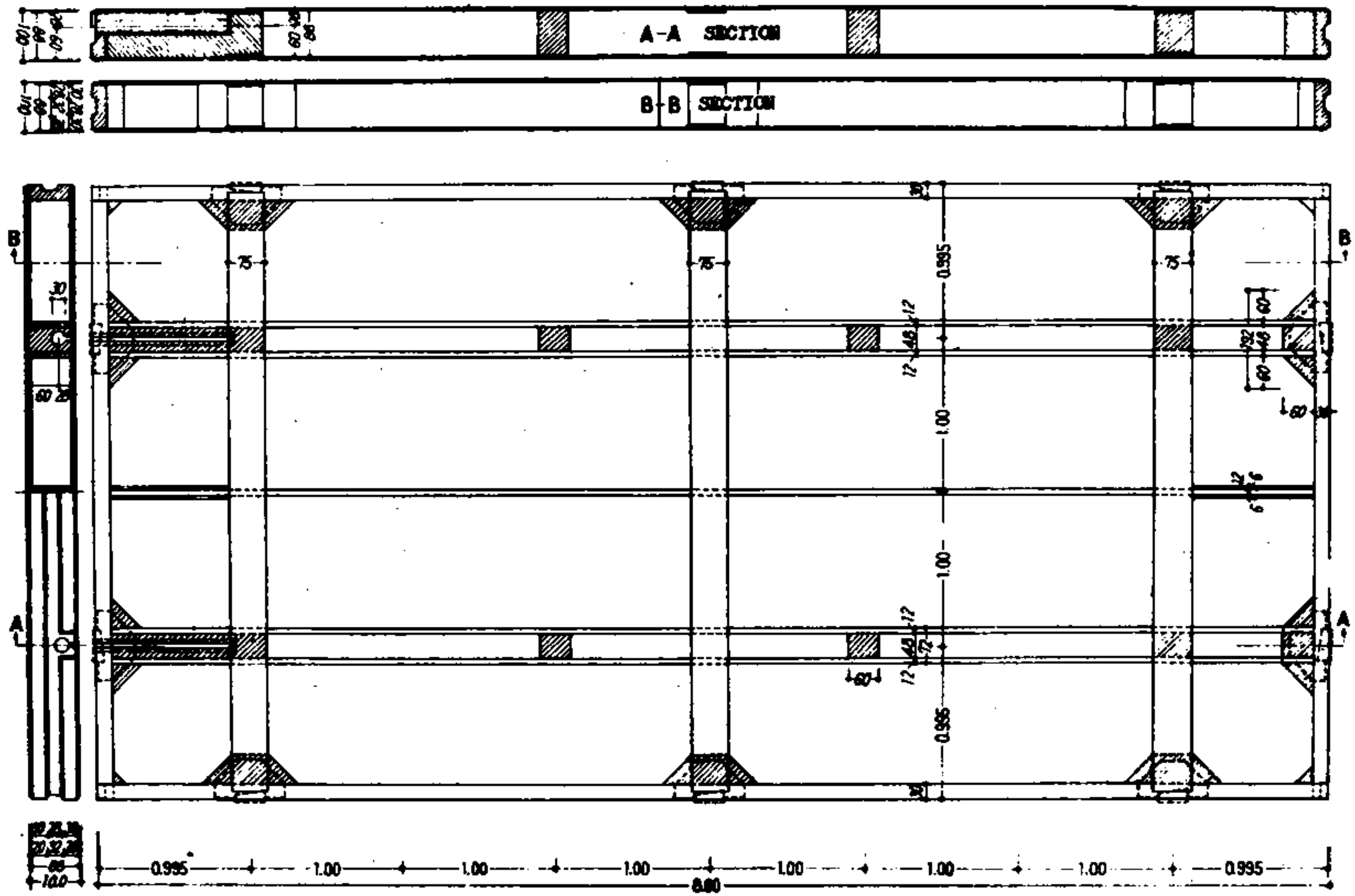
Appendix 10040 observation hut plan.



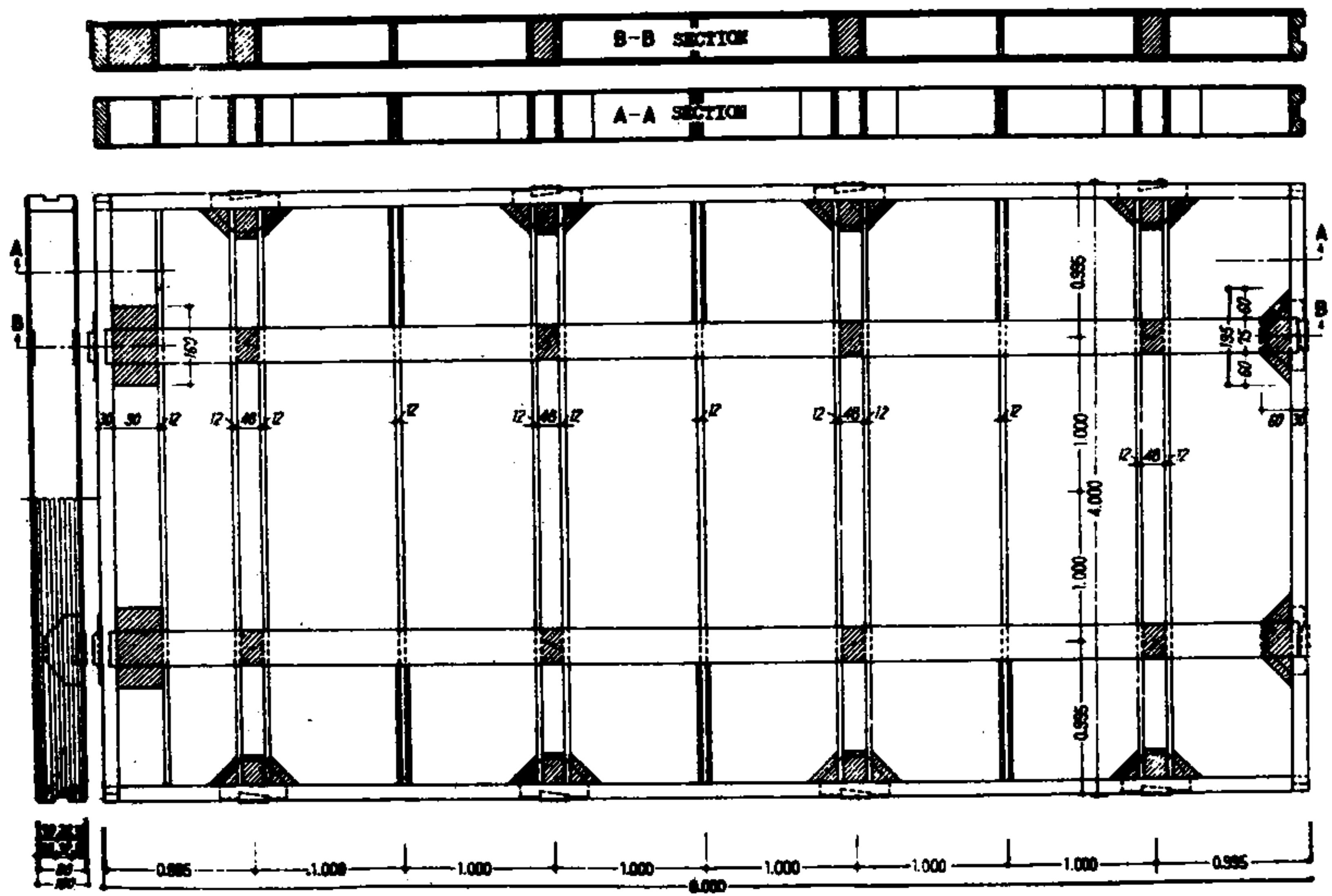
Appendix 13010 sectional detail.



Appendix 22001 panel index.

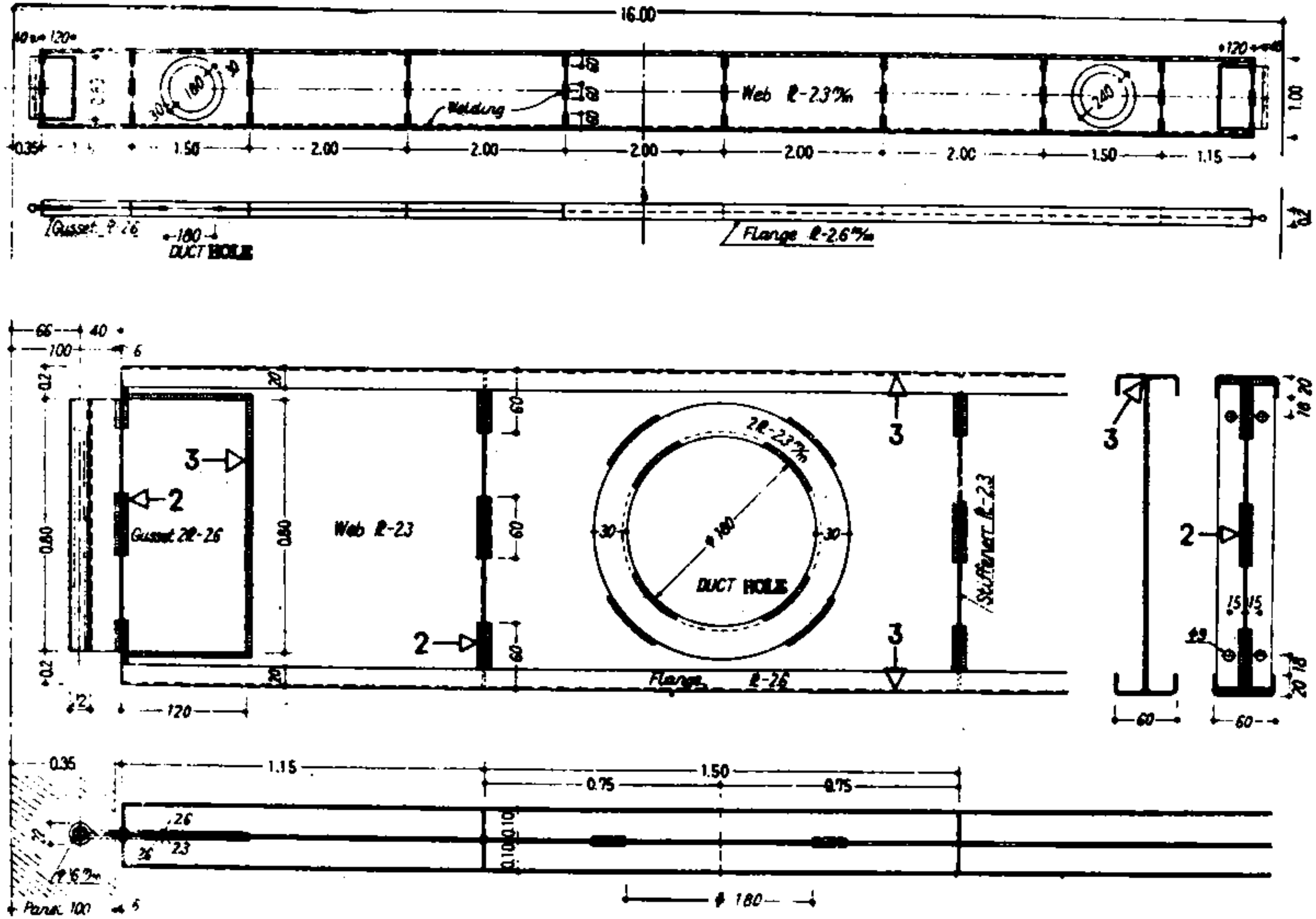


Appendix 22210 wall panel frame/standard type.

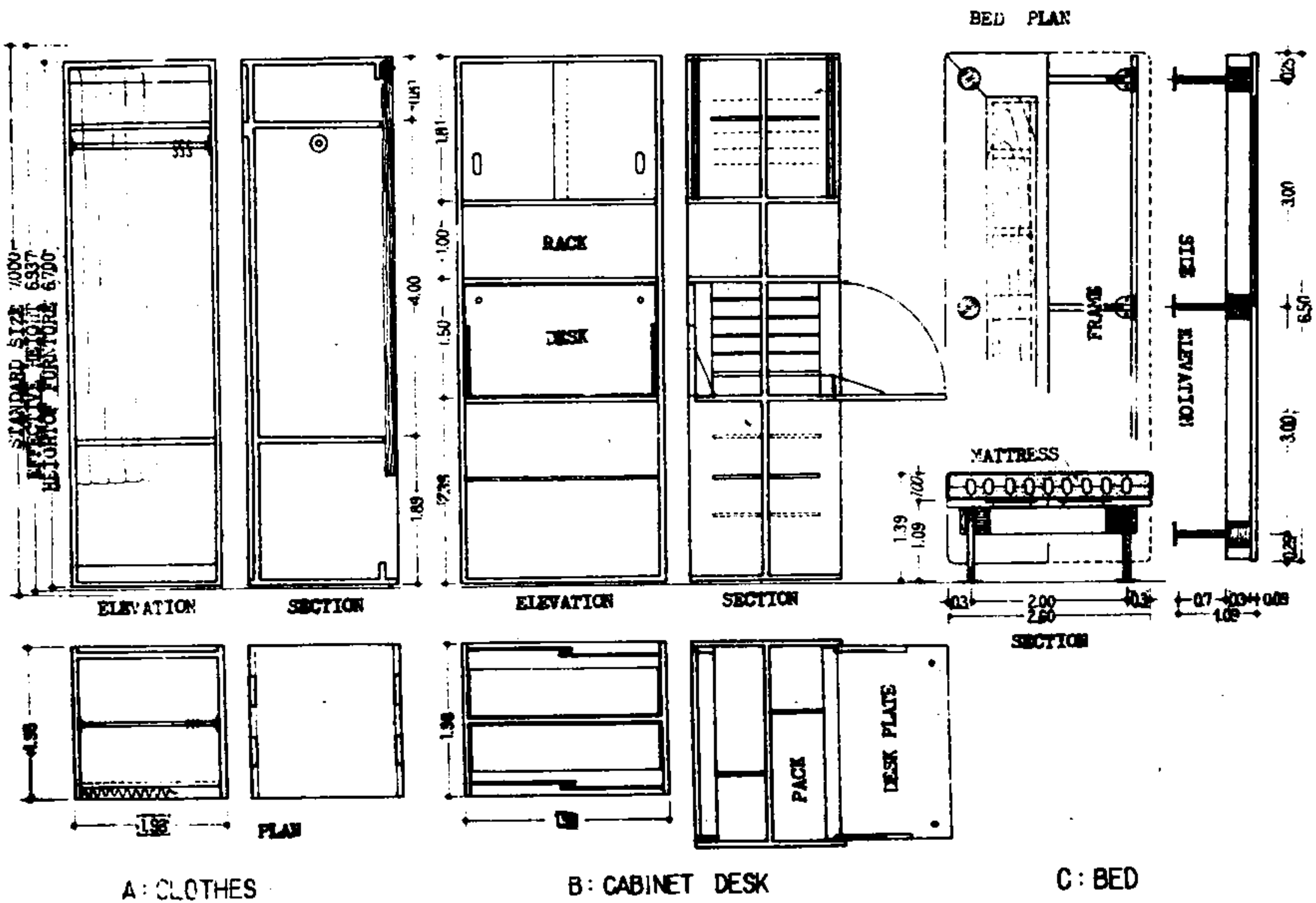


Appendix 22310 roof panel frame/standard type.

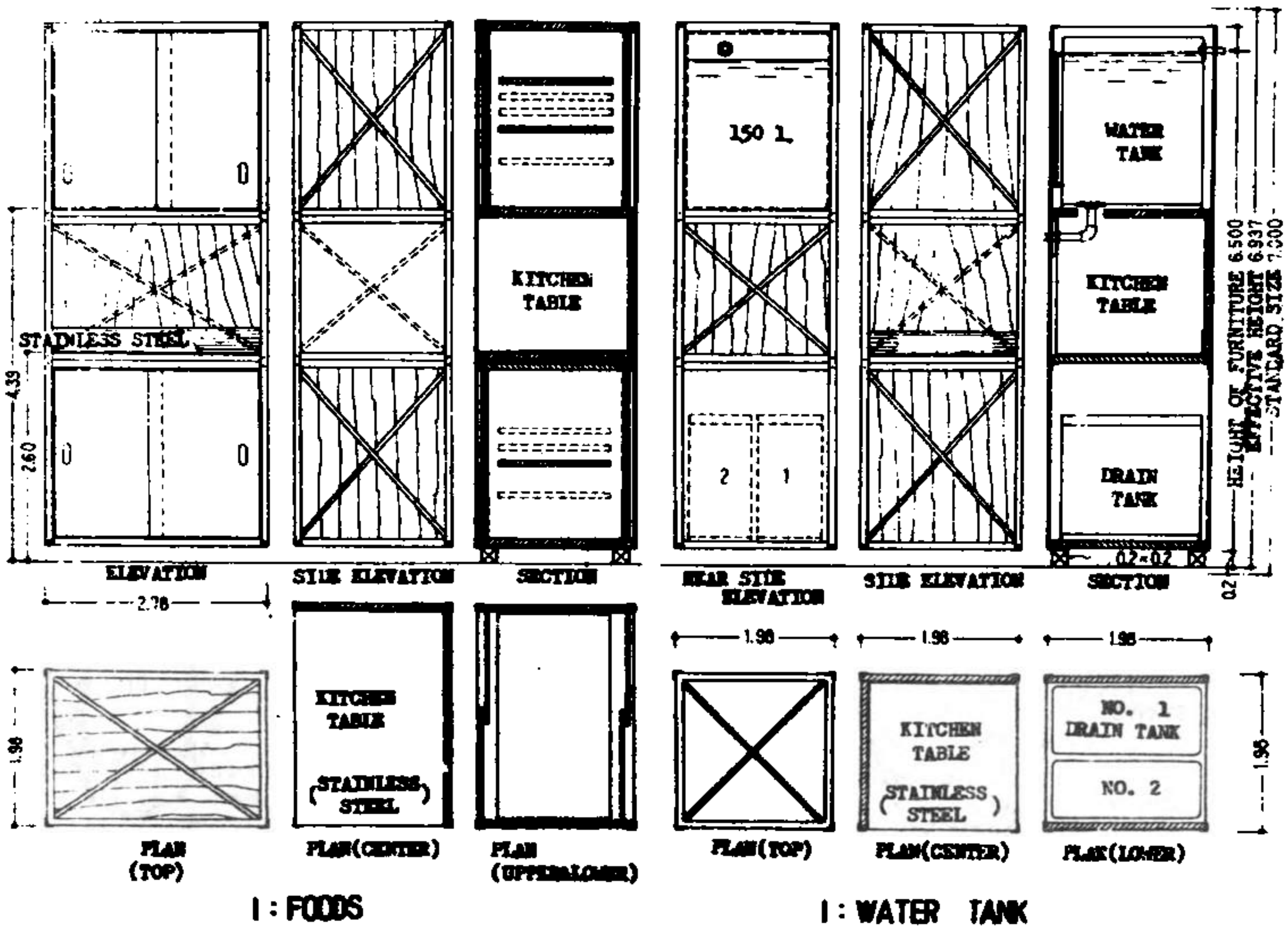
DETAIL-1



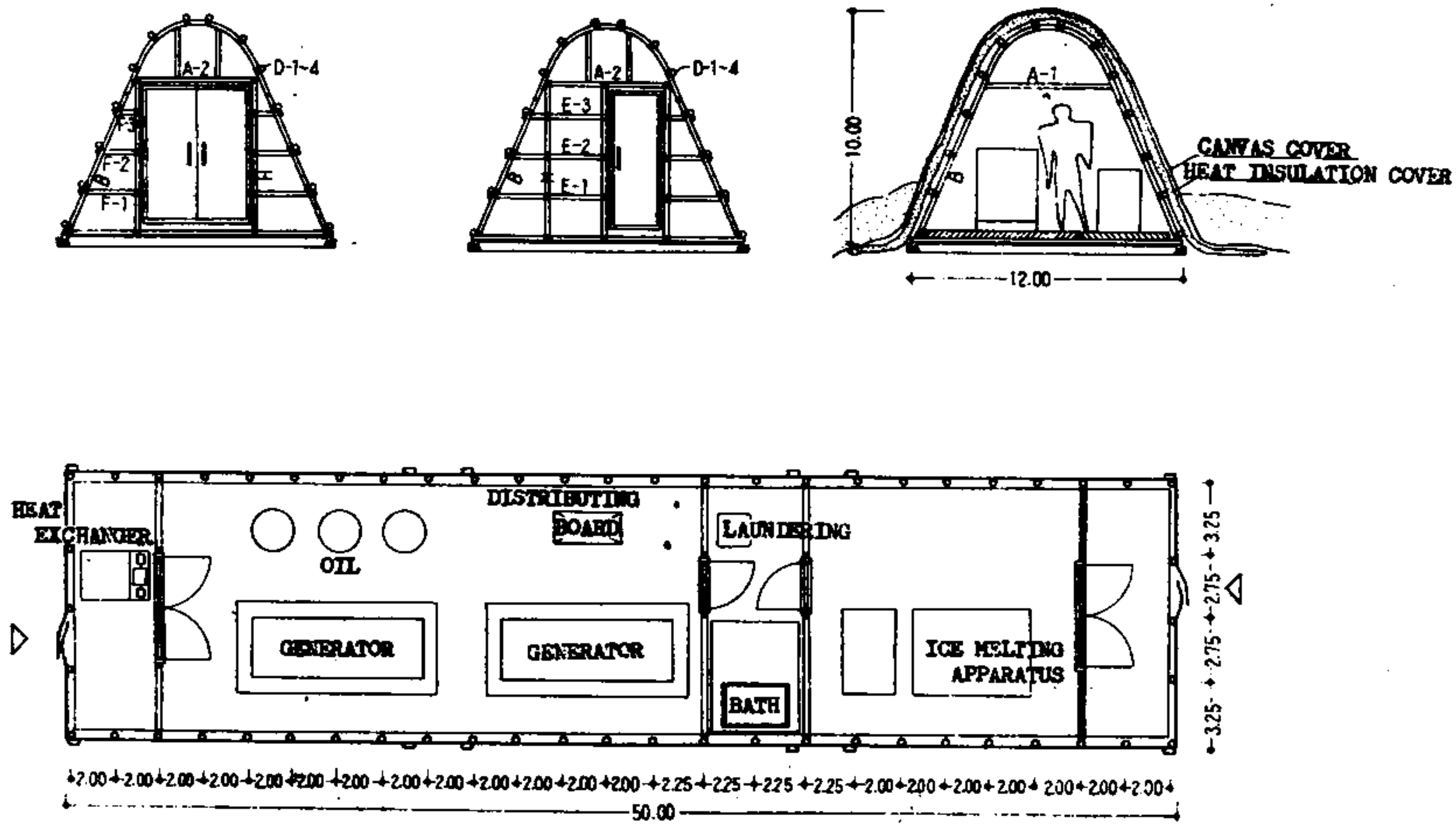
Appendix 23101 roof beam detail–1.



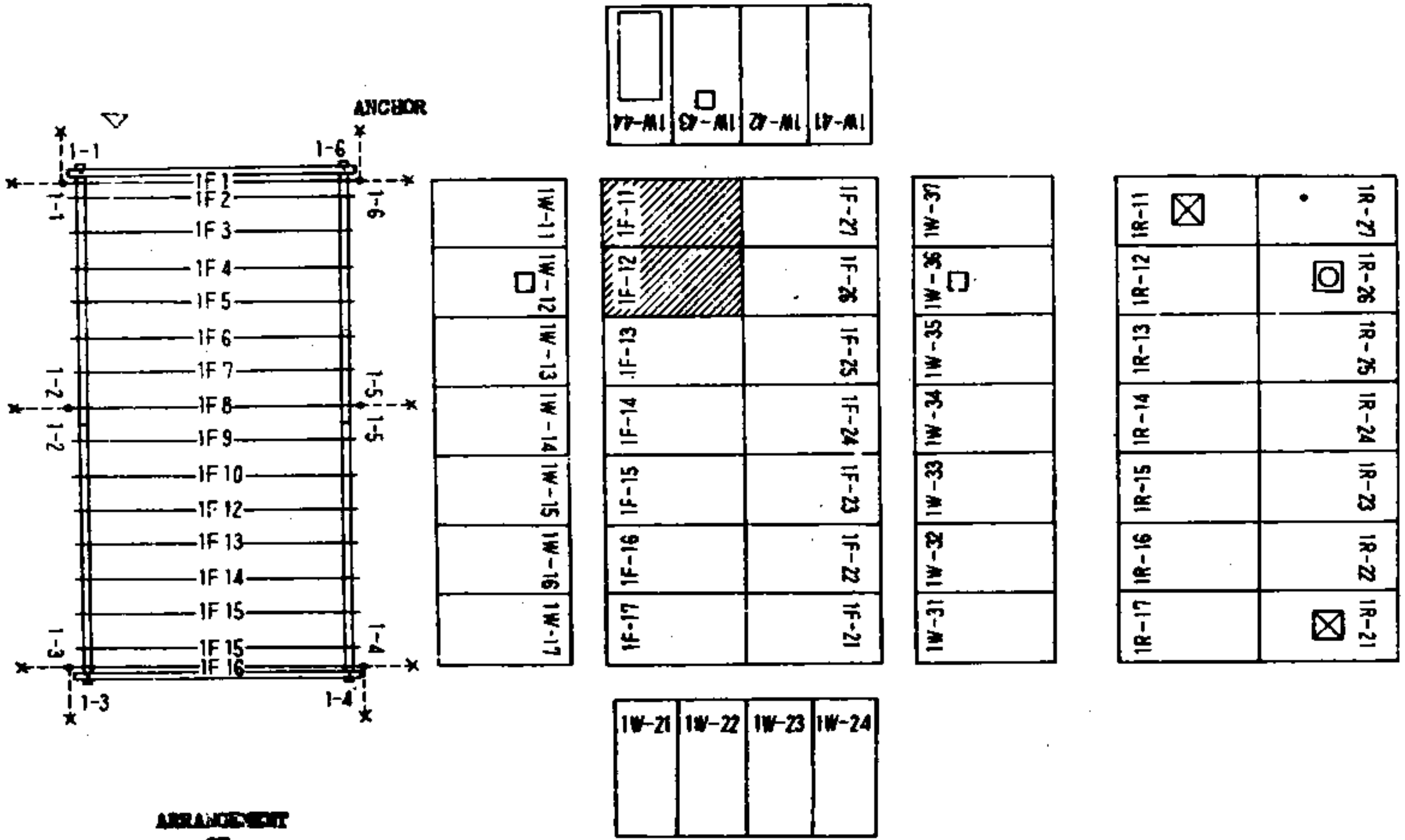
Appendix 31100 furniture set for cabinet.



Appendix 32100 kitchen unit. Stock and supply.



Appendix 10050 power hut.

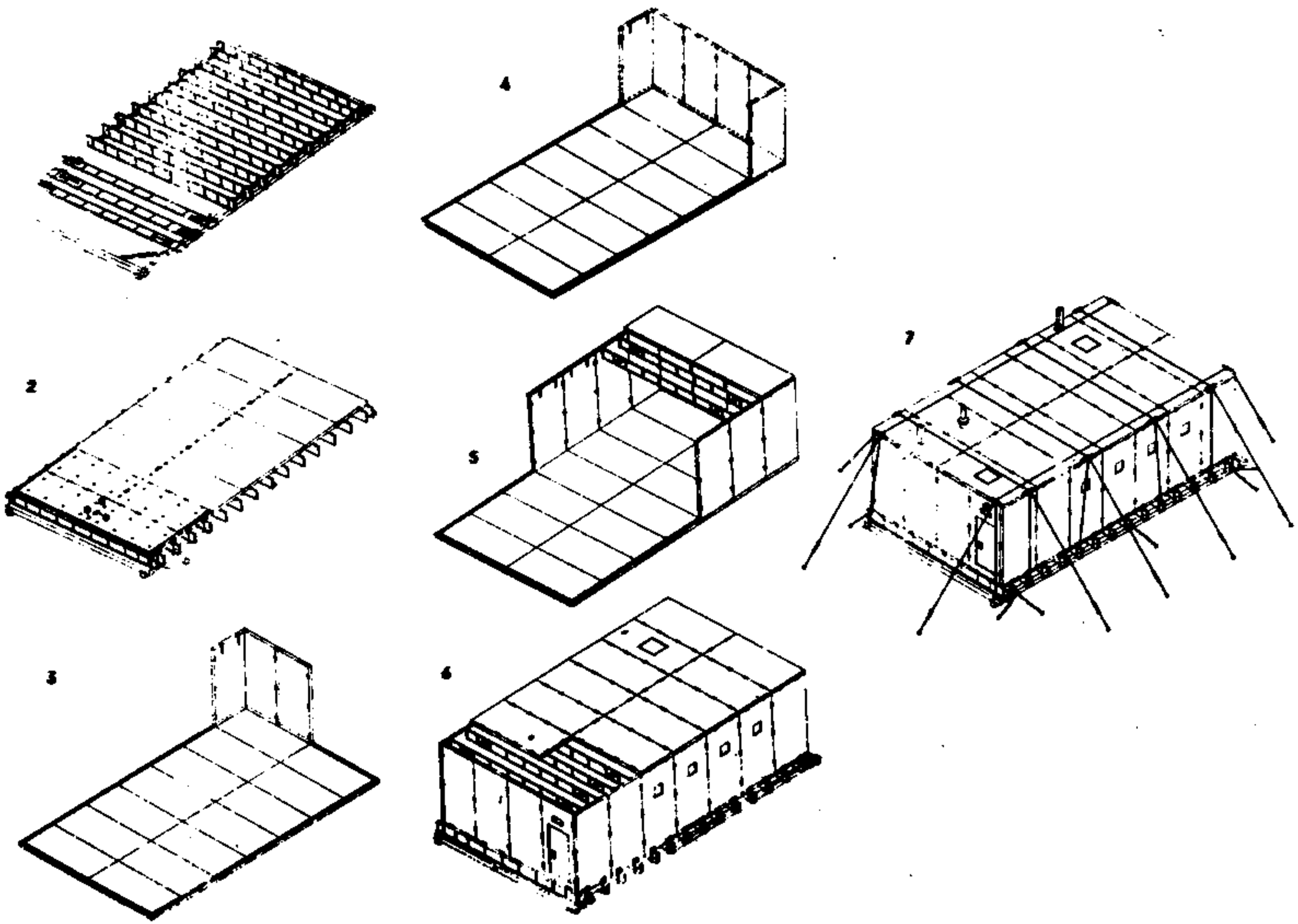


ARRANGEMENT OF SILL & ROOF BEAM

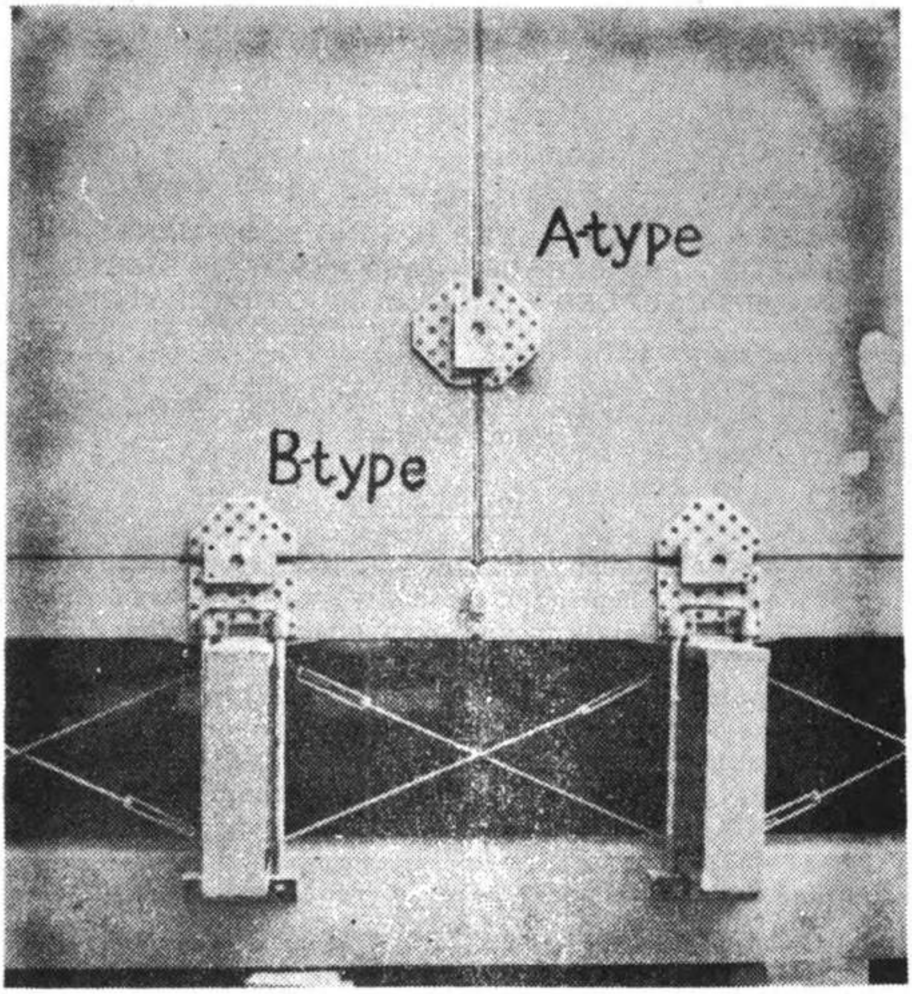
ASSEMBLAGE OF FLOOR & WALL

ASSEMBLAGE OF ROOF

Appendix 11010 sleeping hut/panel combination.



Appendix 60000 order of erection.



Appendix 70000 connector.

COLD AND HOT WATER MAKING EQUIPMENT UTILIZING THE EXHAUST-GAS ENERGY OF DIESEL ENGINES COUPLED WITH ELECTRIC GENERATORS

Seiiti Awano
and
Sumio Maita

1. Introduction

The cold and hot water supplies in the winter at Syowa Base were dependent on the melting of ice and the heating of the melted water because all of the water in puddles and ponds was completely frozen from June to November.

During the preparations for J. A. R. E. I (1956-58) in the early part of 1956, the Special Committee decided to build new systems for supplying water for drinking, general uses, hot bath and for washing, by utilizing the waste heat of diesel engines coupled with 20 KW electric generators, the main electric source of Syowa Base.

The minimum quantity of water necessary for the livelihood at the Base was assumed to be about 20 litres a day per person. The following three systems were designed and constructed for J. A. R. E. I:

a. A system for recovering the exhaust-gas heat energy of the diesel engines.
b. A system for recovering the cooling-loss of the same diesel engines.
c. Directly heating system for emergency uses.

These three systems were completed in October, 1956, and tested at Isuzu Motor Company, Ltd., and the expected results were obtained. The equipment was transported to Syowa Base, but only the exhaust-gas heat recovery system was set up by the first wintering team in an electric generator room. This system supplied sufficient cold and hot water for the wintering teams of J. A. R. E. —I, III, IV and V, and not even a drop of fuel was needed for these purposes, whereby it helped to decrease the quantity of fuel transported to the Base.

Though the system (b), the coolant-heat recovery system, was not re-built at the Base, the air of the generator room was warmed by the heat radiated from engine radiators, and a part of the ice in the ice-melting tanks was melted by the warmed air. The details of these systems will be described in the following articles.

2. Heat Balance for a Diesel Electric Generator System

Two sets of 20 KVA diesel electric generators were installed in an electric generator room at Syowa Base in Jan. 1957. The specification of the generator is shown in Table 1.

TABLE 1

Specification of Diesel Electric Generators

Model:	Isuzu ZX-111 20KVA diesel electric generator
Generator:	Meidensha Model E-AF 4-pole, 3-phase, 50-cycle 100 V, 20 KVA (continuous running at 1500 rpm) Power factor, 100%
Exciter:	Meidensha Model GHI 110 V, 1 KW (continuous running at 1500 rpm)
Voltage regulation:	Manual and automatic regulation systems.
Coupling:	direct coupling
Battery for starter:	12V, 150Ah x 2
Capacity of fuel tank:	50 l.
Capacity of coolant:	20 l.
Fuel consumption:	about 8 l./h at 20 KW
Oil consumption:	about 100 cc/h
Diesel engine:	Isuzu Model DA-220, four-cycle diesel engine Bore 100 mm, Stroke 130 mm No. of cylinders: 4 Total piston displacement: 4, 084 cc Compression ratio: 19.5 Cooling: liquid cooling Coolant: 30% Prestone coolant Output: about 33 Ps/1500 rpm Specific fuel consumption: about 200 gr/Ps h Fuel: Gas-oil, Specific density 0.858

The heat balance sheet for full and partial loads is shown in Figure 1 and Table 2. In Figure 1, the power expressed in KW is plotted against the reciprocal of excess-air factor n. The heat flow per unit hour, Q, can be calculated by

$$Q = 860 \text{ KW kcal/h} \qquad (1)$$

and 1/n is proportional to fuel consumption per hour, B, because

$$\frac{1}{n} = \frac{B\, L_{min}}{3600\, G_a} \qquad (2)$$

where B: fuel consumption, kg/h

G_a: weight flow of intake air to the engine, kg/s (constant at a constant engine speed.)

L_{min}: stoichiometric air quantity for fuel (= 14.2 kg/kg).

For the calculation of heat energy Q_f contained in the supplied fuel, the higher calorific value H_o must be used instead of the lower calorific value H_u. Because the latent heat of condensation of steam contained in the exhaust gas of the diesel engine as well as its sensible heat can be used for heating the melted water. In Figure 1 and Table 2, Q_r represents the total heat energy contained in the exhaust-gas and consists of sensible heat Q_{rs} and latent heat Q_{rl}. The friction-loss of an engine

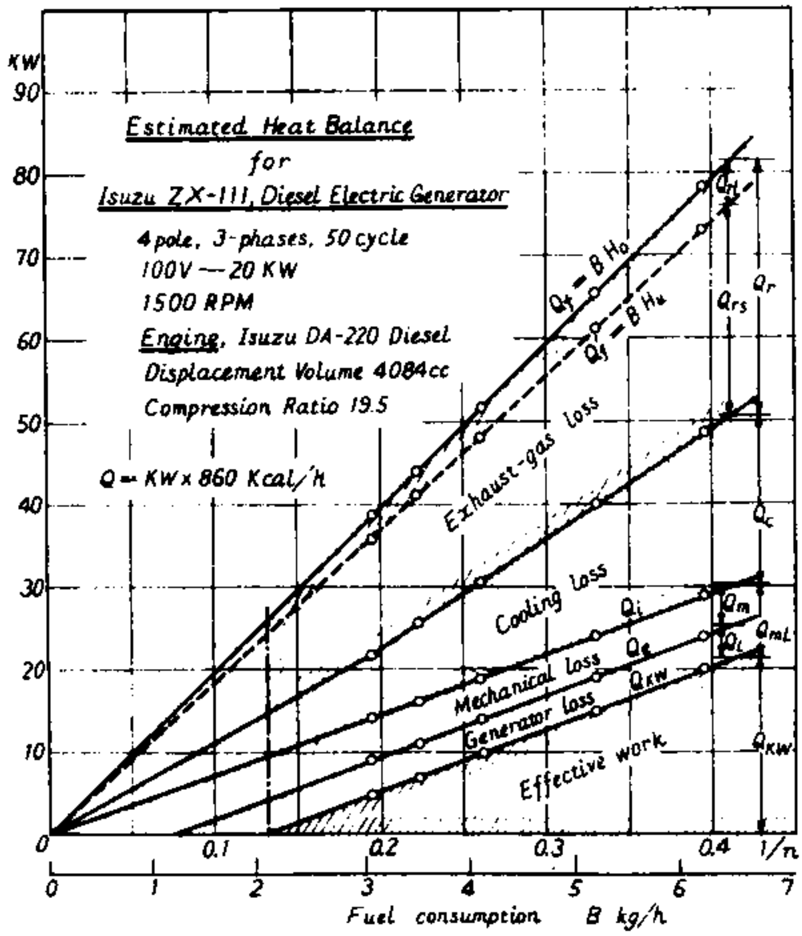


Figure 1. Estimated heat balance for Isuzu ZX-111 20 KVA diesel electric generator.

raises its oil temperature, and the heat is transferred to the air flowing through the oil radiators. The cooling-loss of the engine, absorbed by the coolant, Q_c, is also transferred to the room air, as is the generator-loss, Q_L. In Table 3, the heat balance of this plant is summarized. From Tables 2 and 3, it is apparent

TABLE 2

Heat Balance at Partial and Full Load of the Isuzu ZX-111 Diesel Electric Generator (20 KW, 100 V AC, 3 Phases, Coupled with Isuzu: DA-220 Diesel Engine)

Run No.	Generator Out-Put	Specific Fuel Consumption[1] b	Fuel Consumption[2] B		Heat Supplied[3] Q_f	Heat Supplied[3] Q_f'	Generator Out-Put Q_{KW}[4]	Engine Out-Put (Brake)[5] Q_e	Engine Out-Put (Indicated)[6] Q_i	Mechanical Loss of[5] Engine Q_m	Generator Loss[5] Q_L
	KW	gr/KWh	kg/h	l/h	Kcal/h	Kcal/h	Kcal/h	Kcal/h	Kcal/h	Kcal/h	Kcal/h
1	20	310	6.20	7.14	67,200	63,000	17,200	20,700	24,900	4,300	3,500
2	15	345	5.18	5.97	56,100	52,700	12,900	16,400	20,700	4,300	3,500
3	10	410	4.10	4.72	44,500	41,700	8,600	12,100	16,300	4,300	3,500
4	6.8	515	3.50	4.03	37,900	35,600	5,840	9,340	13,640	4,300	3,500
5	5	620	3.10	3.57	33,600	31,500	4,300	7,800	12,100	4,300	3,500

Notice:

1. These values were obtained by experiments.
2. $B = b \times KW/1000$ = Fuel consumption kg/h
3. $Q_f = H_o B$ — H_o: Higher calorific value of gas-oil — $H_o = 10,837$ Kcal/kg
   $Q_f' = H_u B$ — H_u: Lower calorific value of gas-oil — $H_u = 10,162$ Kcal/kg
4. $Q_{KW} = 860(KW)$ = Equivalent heat to generator output Kcal/h
5. $Q_e = Q_{KW} + Q_L$ = Equivalent heat to engine out-put (generator efficiency was assumed to be 83% at 20 KVA.)
6. $Q_i = Q_e + Q_m$ = Heat equivalent to the indicated output of the engine. Q_m was always constant and i for any load.

TABLE 2 (Cont'd)

Run No.	Exhaust-Gas Temp.[7] t_r	Exhaust-Gas Loss Sensible Q_{rs}[8]	Latent Q_{rl}[9]	Total Q_r[10]	Engine Cooling loss[11] $Q_C = Q_f - Q_r - Q_i$	Total Energy Transferred to Air[12] $Q_{CML} = Q_C + Q_M + Q_L$	Heat Balance Q_{KW}/Q_f	Q_{mL}/Q_f	Q_c/Q_f	Q_r/Q_f	1/n
	°C	Kcal/h	Kcal/h	Kcal/h	Kcal/h	Kcal/h	%	%	%	%	
1	380	21, 200	4, 180	25, 380	16, 920	24, 720	25.6	11.6	25.2	37.6	0.397
2	327	18, 250	3, 560	21, 810	13, 590	21, 390	23.0	13.9	24.2	38.9	0.330
3	274	15, 300	2, 770	18, 070	10, 030	17, 830	19.4	17.5	22.6	40.5	0.262
4	243	13, 550	2, 365	15, 915	8, 345	16, 145	15.4	20.6	22.0	42.0	0.223
5	221	12, 330	2, 090	14, 420	7, 080	14, 880	12.7	23.2	21.1	43.0	0.195

7. Exhaust-gas temperature at full load (20 KW) was measured, and other temperatures were estimated.

8. $Q_{rs} = 3600\, C_pG_at_r$ = Sensible heat of exhaust gas, Kcal/h
   G_a = weight flow of air in kg/s. (G_a = 0.062 kg/s)
   C_p = mean specific heat at constant pressure of gas. $C_p = 0.25$ Kcal/Kg°C

9. $Q_{rl} = (H_o - H_u)B = 675B$ = Latent heat of steam contained in the exhaust-gas.

10. $Q_r = Q_{rs} + Q_{rl}$ = Total exhaust loss

11. $Q_c = Q_f - Q_r - Q_i$ = Heat rejected to coolant.

12. $Q_{cmL} = Q_c + Q_m + Q_L$ = Heat rejected to room air, when radiators for oil and coolant are used.

13. n = Excess air-factor calculated by Equ. (2)

TABLE 3

The Maximum Available Heat Energy for this Plant

No.	Generator Output KW	Heat Supplied kcal/h Q_f	Generator Output kcal/h Q_{KW}	Gas Energy kcal/h Q_r	Coolant Energy kcal/h Q_c	Energy Absorbed Room Air kcal/h $Q_L + Q_m$
1	20	67, 300	17, 200	25, 380	16, 920	7, 800
2	15	56, 100	12, 900	21, 810	13, 590	7, 800
3	10	44, 500	8, 600	18, 070	10, 030	7, 800
4	6.8	37, 900	5, 840	15, 915	8, 345	7, 800
5	5	33, 600	4, 300	14, 420	7, 080	7, 800

that the exhaust-gas heat energy reaches 25, 380 kcal/h (37.6% of the heat supplied) at full load (20 KW) and 15, 915 kcal/h (42% of the heat supplied) at actually used partial load (6.8 KW). If the heat of 85% of Q_r can be recovered, the available heat will be 21, 600 kcal/h at full load and 13, 550 kcal/h at 6.8 KW output. This means that 270 l/h and 170 l/h of cold water can be easily made from ice by using this plant. When all of the coolant heat, Q_c, is radiated into the air, the total heat energy contained in the air becomes to

$$Q_{cmL} = Q_c + Q_m + Q_L \qquad (3)$$

The value of Q_{cmL} is nearly the same as Q_r at any load, but it is only partially available for melting ice under actual conditions.

3. System for Recovering the Exhaust-Gas Heat Energy of Diesel Engines Prepared for J. A. R. E. I (1956-58)

The electric generator room at Syowa Base had a floor area of 15, 160 x 3, 640 mm, a maximum height of 2, 660 mm, and an inverted "V" type sectional form. It was built up from steel pipes and special joints in a short time and covered by thick canvas awnings, and panels were laid on the floor.

In this room, the following apparatuses were installed in a line as shown in Figure 2.

a. 20 KW diesel electric generators — 2 sets
b. Exhaust-gas heat exchangers — 2 sets
c. Recirculating water-pump and motor set — 1 set
d. Bath — 1 set
e. Hot-water tank — 1 set
f. Ice-melting tank — 1 set
g. Pipings
h. Other machines (an electric washing machine, a sewing machine, a small air compressor, an engine-driven fire-extinguishing pump, etc.)

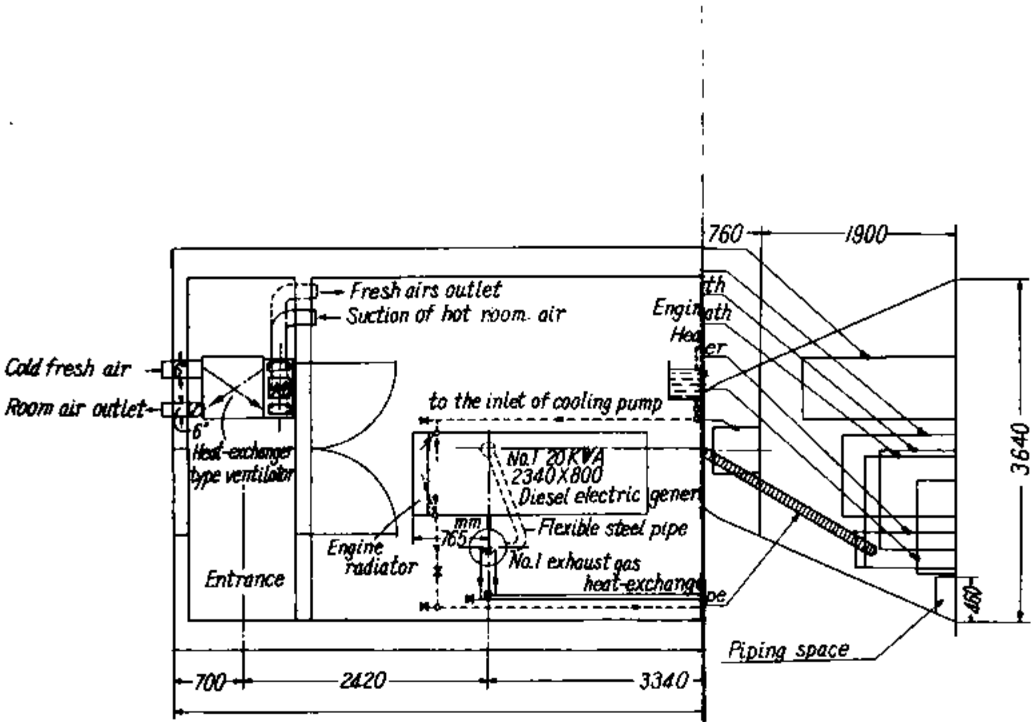


Figure 2. Arrangement

The exhaust-gas heat recovery system was composed of (a)-(g) and the piping diagram for this system is shown in Figure 3. The ice-melting tank was divided

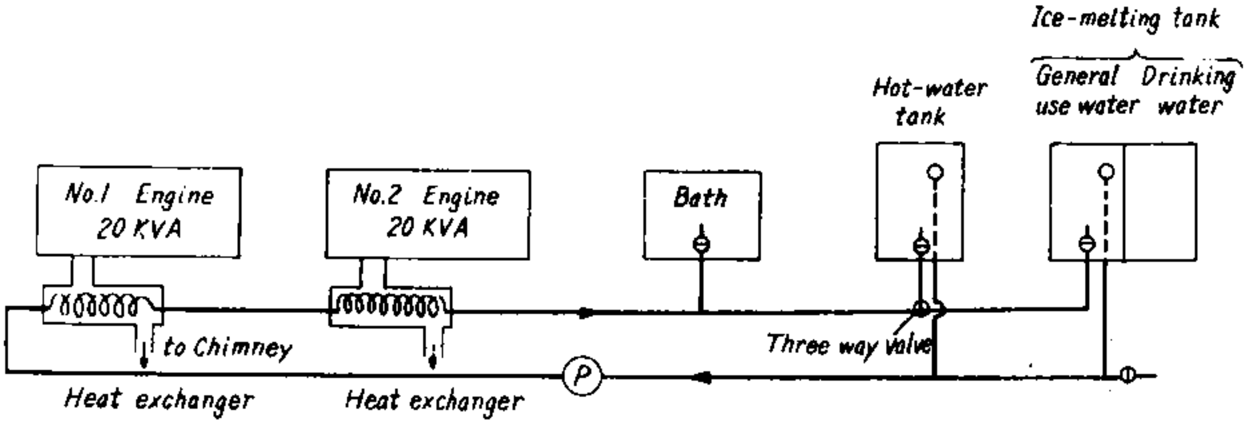


Figure 3. Exhaust-gas heat recovery system prepared for J. A. R. E. -I (1956-58).

into two sections by a steel partition. One of the sections was a vessel for making the water for general-uses, and the other was for drinking-water. The water pumped up from the former by a recirculating pump was fed to the heat-exchangers, which were heated by the exhaust-gas of the diesel engines, and the hot water flowing out of the heat-exchangers was recirculated to the melting tank. By this means, the ice in the melting tank (for general-uses water) could be easily melted. If hot water was desired, the melted cold water had to be transferred to a hot-water tank, and by recirculating it between the heat-exchangers and the tank, hot water of about 40-80°C. could be easily obtained. The hot water was transferred again to a wooden hot bath, if it was so desired. The water for drinking could be obtained by melting pure ice dug from an iceberg, by using the heat transferred through the steel partition and the steel walls of the melting-tank, and to the upper surface of the ice block. The room temperature varied between +3°C and 42°C throughout one day, and it was always kept above 0°C.

3-1. Exhaust-Gas Heat Exchanger

The construction of the heat-exchanger for absorbing the exhaust-gas heat energy is shown in Figures 4 and 5. It is composed of a steel shell and two helical coils. The shell has a diameter of 300 mm and a height of 705 mm, and it has a water jacket of 350 mm diameter and 555 mm height. The double helical coils attached to a steel cover are installed in the shell, and the shell is closed. The hot exhaust gas of a diesel engine flows into the shell tangentially through a gas-inlet at the upper side and flows down to the bottom by undergoing a circular motion through the helical coils, and then turns upward and discharges from an outlet, which is connected to a chimney by a flexible steel pipe. On one hand, cold water flows into the jacket through a water-inlet and flows out from the jacket outlet that is connected to the inlet of the helical coils. While the water is flowing through these two helical coils, the exhaust-gas energy is transferred to it. The shell and coils are made of steel and aluminized to protect them from rust. As material for

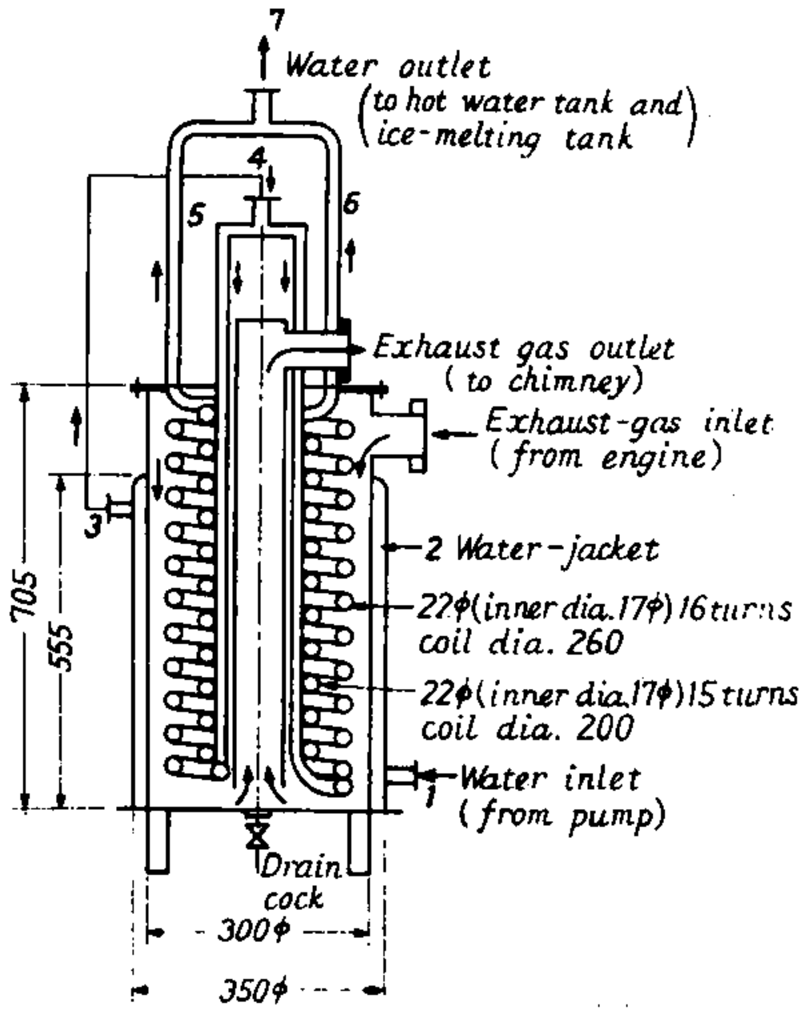


Figure 4. Construction of an exhaust-gas heat exchanger prepared for J. A. R. E. -I (1956-58) vertical type.

their construction, stainless steel is most desirable, but its cost is very high, and the welding of these parts is hardly possible for the wintering members. The inner diameter of the coil is 17 mm and the external diameter is 22 mm. The total length of an inner coil is 10.1 m, and that of an external coil is 13.7 m.

The effective heating surface area of the inner helical coil is 0.620 m^2, and that of the outer helical coil is 0.838 m^2 at the mean diameter of the tube. The heating area of the water jacket is 0.522 m^2. Hence, the total heating area A is 1.98 m^2.

The performance of the heat-exchanger was tested at Isuzu Motors, Ltd. Co. in Oct. 1956. The inlet gas temperature t_{gi} was 380°C and the outlet gas temperature t_{go} was 52°C at full-load operation (20 KW), and this means that the following heat was transferred from the hot gas to the recirculating water.

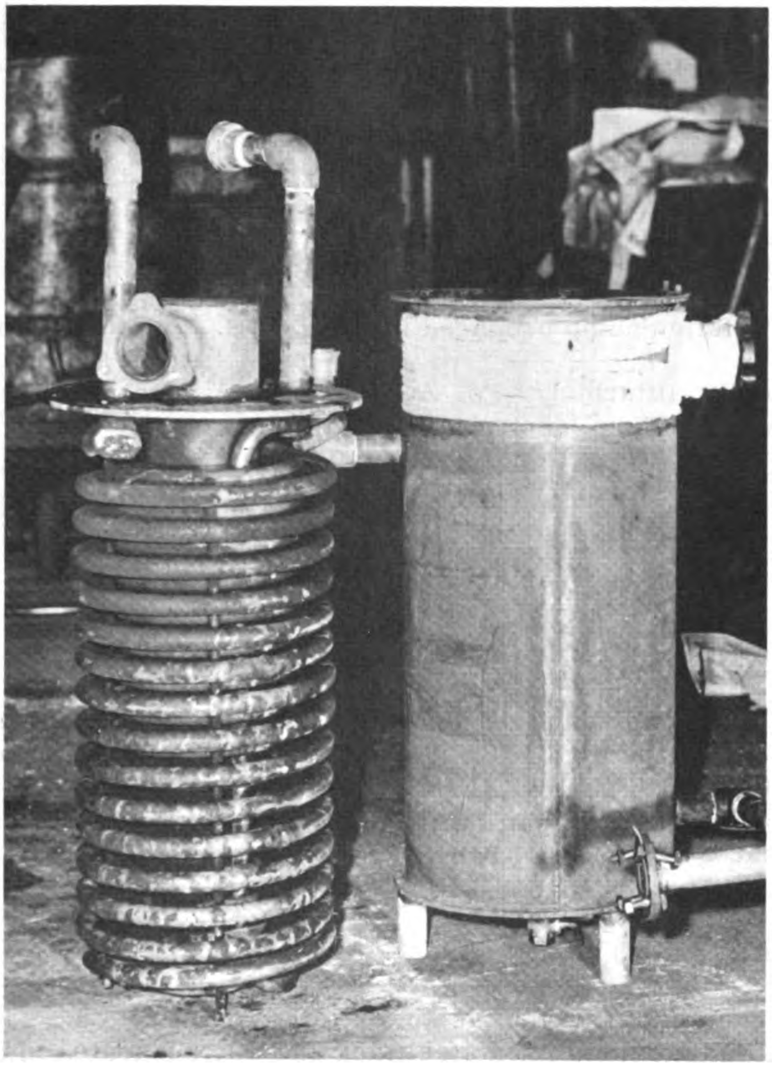


Figure 5. Helical coils and shell of an exhaust-gas heat-exchanger prepared for J. A. R. E. -I (1956-58).

Sensible heat, $Q_{rs} = 3600\ G_a(t_{gi} - t_{go})c_{pm} = 3600 \times 0.062 \times (380 - 52) \times 0.25$
$= 18,300$ kcal/h

Latent heat, $Q_{rl} = 4,180$ kcal/h (by referring to Table 1)

Hence, the total recovery heat from the exhaust gas was

$$Q_r = 22,480 \text{ kcal/h}.$$

The heat quantity absorbed from the exhaust gas was about 88.5% of the theoretical value of Q_r shown in Table 1.

The logarithmic mean temperature difference of the heat-exchanger was Q_m = 135°C for this experiment. The over-all heat transmission coefficient of the heat-exchanger was

$$K = Q_r/A\,\theta_m = 22,480/\,(1.98 \times 135) = \underline{84\ \text{kcal/m}^2\text{h}^\circ\text{C}}.$$

3-2. Recirculating Pump and Motor Set

The recirculation pump prepared for J. A. R. E. -I was as follows:

Motor: Hitachi 1/4 Ps, AC 100V, single-phase motor
Pump: Mikuni centrifugal pump (delivery pipe dia. 1")

capacity	1670 l/h at head	H = 0 m
	1400 l/h	H = 10 m
	1200 l/h	H = 18 m.

3-3. Hot-Water Tank

This was an aluminized steel tank (Fig. 6). It had an inner size of 539 x 910 x 800 (depth) mm. and capacity of 393 l, and it was insulated with glass wool, which was packed in the space between the tank walls and thin steel covers. Hot water of 40-80°C was made available from this tank by recirculating the water between this tank and the exhaust-gas heat-exchangers.

3-4. Ice-Melting Tank

The construction of this tank is shown in Figures 7 and 8. The tank prepared for J. A. R. E. -I was an aluminized steel tank and was separated into two sections by a steel partition. A detachable circular steel flue tube was placed through these two sections. This flue tube was a heating surface when the outlet of an oil burner was inserted in it as a heat source in an emergency. The small oil-burner had a capacity of 96, 000-120, 000 kcal/h by burning gas-oil at a rate of 12-15 l/h. In the field, however, the flue tube and oil-burner were not used at all.

The total capacity of the tank, including the two sections, was 930 l, and 800 l of water was obtained by melting a tank-full of ice, and this was sufficient to supply the necessary water for 40 persons.

3-5. Hot-Bath

A knockdown type wooden bath tub was prepared. The five boards of Japanese cypress were built up and tightened by steel tie-bolts. The inner size of the tank was about 2' x 3' x 3'. Several other pieces of cypress were also prepared for the cover. These wooden pieces were packed in a vinyl bag and enclosed to protect them from drying and deforming on the long trip to the Antarctic across the equator. This packing method was successful and the wintering team was able to assemble

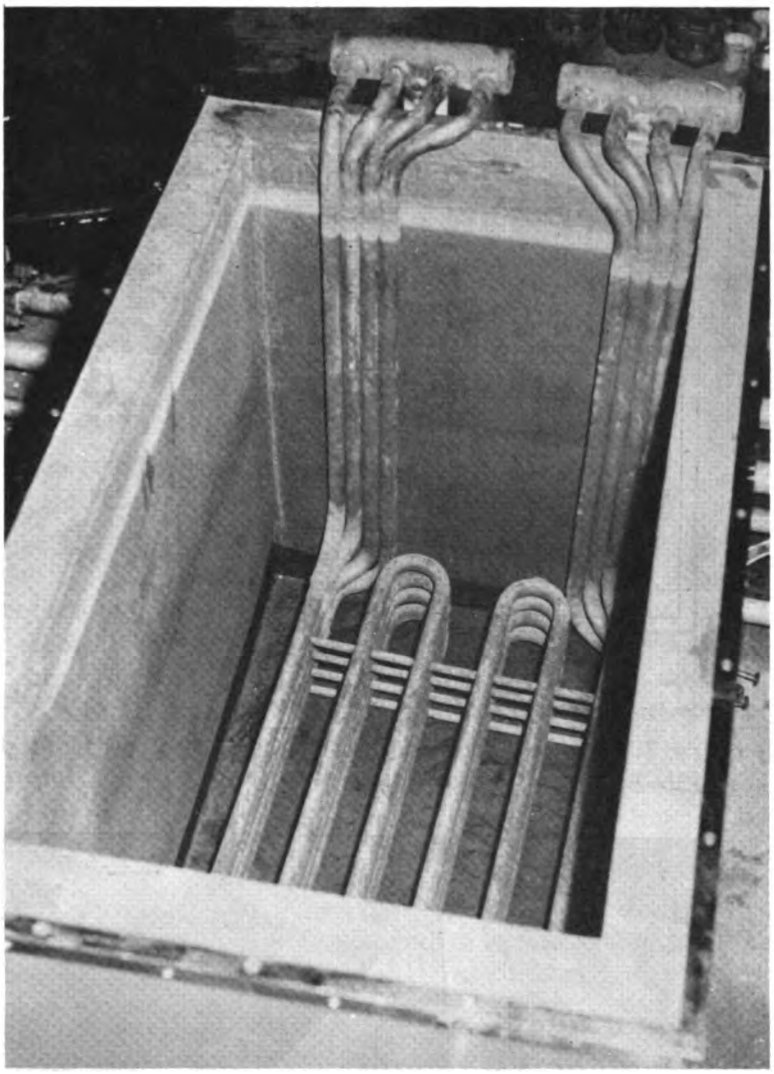


Figure 6. Hot-water tank prepared for J. A. R. E. -I (1956-58).

the bath tub easily. The wintering team enjoyed a bath once a week. The temperature adjustment of the hot-water was done with an electric heater and snow blocks.

3-6. Piping

Galvanized steel pipes of 1" diameter were prepared for J. A. R. E. -I after they were cut, threaded at both ends, and arranged for preliminary piping (Fig. 9). The pipes were insulated with glass wool tube of 1" thickness and covered with vinyl tape and thin steel plate covers. However, need for this heat insulation was not expected for the case when the engine was run throughout the day and Prestone was used as its coolant. For absorbing some of the heat energy of the hot room air, the temperature of which varied between +3°C and +40°C during the day, bare tubes would be better than insulated tubes.

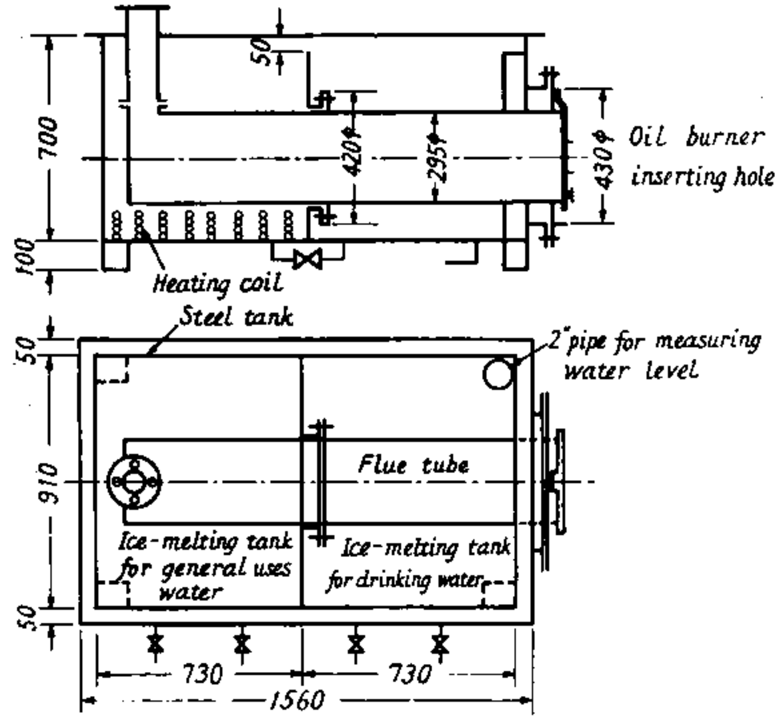


Figure 7. Ice melting tank prepared for J. A. R. E. I (1956-58).

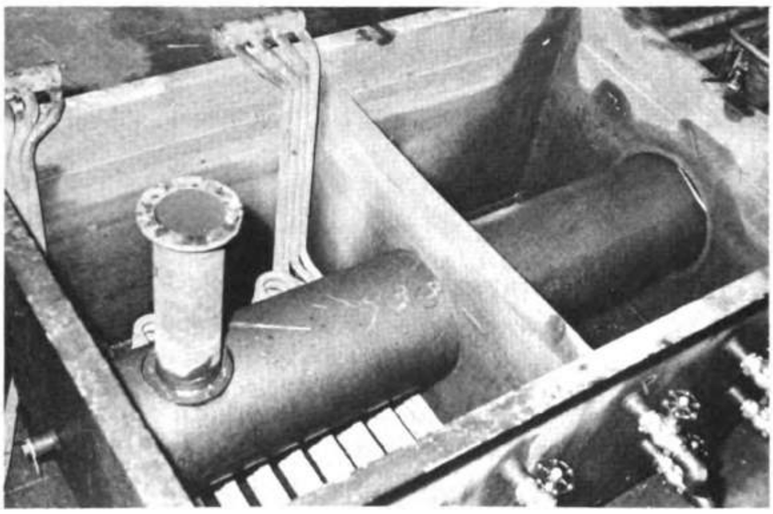


Figure 8. A feature of the ice melting tank for J. A. R. E. -I.

3-7. The Experience Obtained at the Base

As stated before, only this exhaust-gas energy recovery system was built in an electric generator room at Syowa Base in June 1957 by the 1st wintering team, and it supplied the sufficient water for eleven wintering members. The following experience with this plant was obtained:

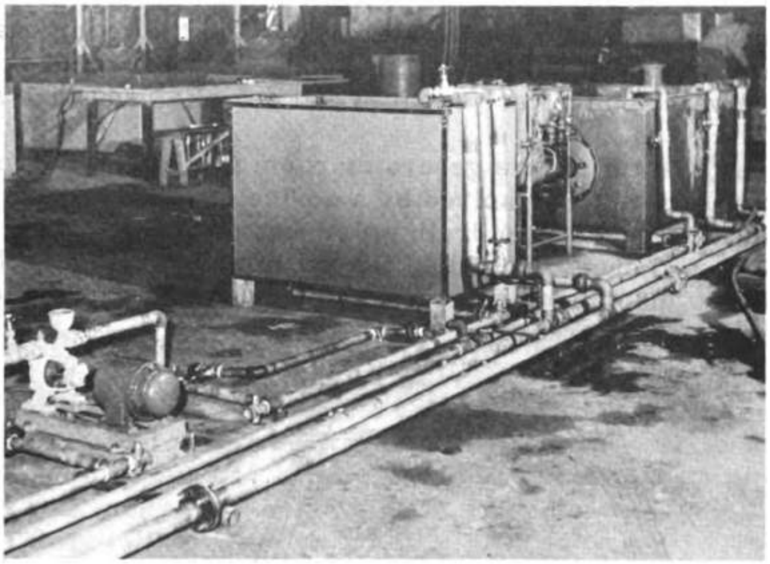


Figure 9. Preliminary piping at Isuzu Motor Company, Ltd. The small size piping (1") shows that for the exhaust-gas heat recovery system, and the large size piping (1 1/2") shows that for the coolant heat recovery system. In this figure, a pump-motor set, a hot water tank, and an ice melting tank are shown.

a. The steel piping in a narrow room caused difficulties in the assembly of this plant. Piping must be changed to rubber hose piping, and joints must be tightened by steel bands. This method was adopted in the preparation for J. A. R. E. II.

b. The circulation water was contaminated by rust, and the water for general-uses and bath was coloured.

c. The work of digging ice from icebergs was very hard. For the transportation of the ice, a snow-car and a sleigh were used. The work of carrying ice blocks from the sleigh to the ice-melting tank was very hard.

d. Some wool fibers and pebbles choked the flow of the recirculating water and caused wear in the pump. These fibers had fallen from the wool gloves used for ice digging, and the pebbles had been contained in the ice blocks. To prevent this trouble, wool gloves were not used for ice digging, and the position of the inlet hole of the recirculating water was elevated about 2" from the bottom of the ice-melting tank so as to prevent its sucking pebbles.

e. For obtaining the general-uses water, snow blocks found near the Base were transported and melted. The drinking-water, however, was made by melting ice blocks dug from ice-bergs. The ice blocks contained many air bubbles, and the water obtained by melting them was very pure and fresh.

f. The transportation of melted water by hand to the living quarters was very hard work. To eliminate this labour, a feed water service operated by a feed water pump was prepared and actually used in J. A. R. E. V.

g. The sewer system for the generator room was one of the most difficult problems, and this was solved by a device of the 1st wintering team as shown in Figure 10. The drain water was caused to flow into an empty fuel drum, and once in a while, the accumulated water in the drum was exhausted to the outside snow field by pressurizing the drum with the aid of a small air compressor.

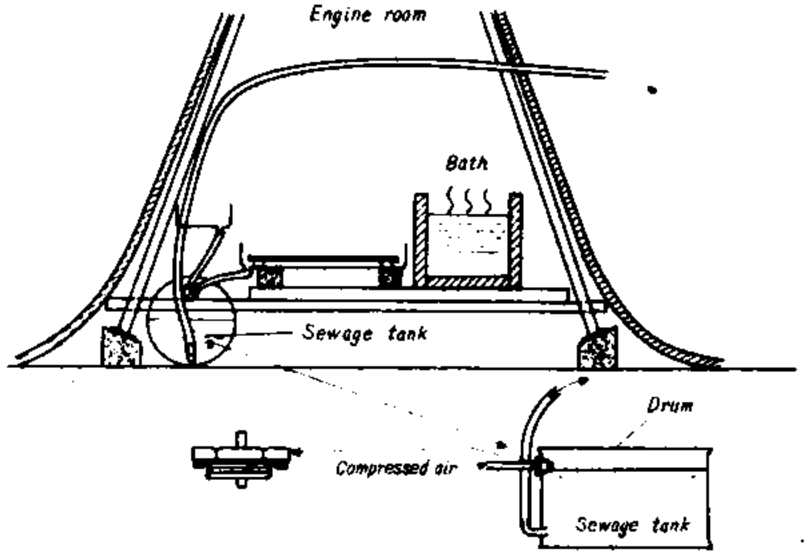


Figure 10. A sewer system used in the Base.

4. An Improved System for Recovering the Exhaust-Gas Heat Energy of Diesel Engines Prepared for J. A. R. E. II-V (1956-62)

From the experience gained in the 1st wintering in 1957-8, an improved system for this purpose was prepared for J. A. R. E. II in 1957 and shipped to the Antarctic. The following improved equipment was prepared:

a.	Improved exhaust-gas heat-exchanger	2 sets
b.	An ice-melting tank for drinking-water	1 set
	A heating coil for the same	1 set
	A stainless steel vessel for ice-melting	1 set
c.	A snow-melting tank for general-uses water	1 set
	A heating coil for the same	1 set
d.	A water pump set (the same one prepared for J. A. R. E. I)	1 set

e. Rubber hoses, resistant to high pressure and to Prestone, 1" diam.

f. Steel bands (clamps) and fittings

g. A water-cooled exhaust manifold for Isuzu diesel DA-220 — 2 sets

The most different point was that the recirculation water system was changed from an open system to a closed system for protecting the general-uses water from contamination by the rust created inside the heating coils. Furthermore, the ice or snow melting tanks were improved to be knock-down type wooden vessels and were divided into two independent vessels so as to be convenient for air transportation by helicopters. Moreover, each of them was equipped with a heating coil made of aluminized steel pipes of 17 mm internal diameter as shown in Figures 11 and 12. The snow block was melted in the tanks directly by the recirculating hot water flowing through the coil.

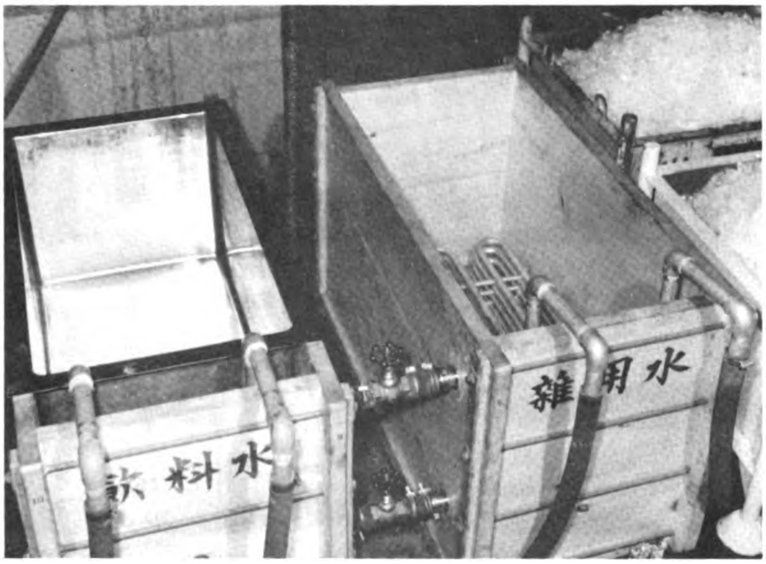


Figure 11. An improved ice-melting tank for drinking water (left) and an improved snow-melting tank for general uses water (right), prepared for J. A. R. E. II-V.

The ice blocks in the stainless tank was melted indirectly by the heat transferred from the outside hot water through the stainless tank walls and the outside hot water was heated by a coil, through which the recirculation hot water was fed from the exhaust-gas heat-exchangers. By using this indirectly heating closed system, the contamination of the water was fully prevented.

In Figure 12, a view of the heating coil is shown. The total length of the heating coil was 22.6 m, and the total heating surface area was 1.385 m^2 on the basis of the mean diameter.

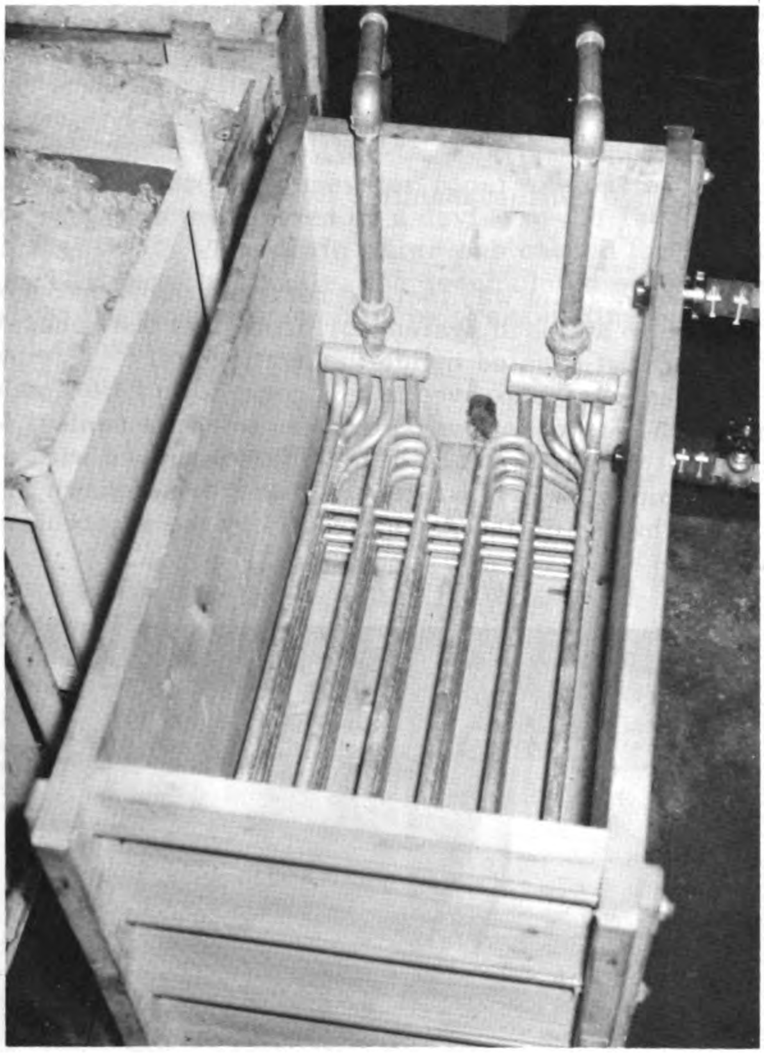


Figure 12. An improved snow-melting tank and a heating coil for general uses water, prepared for J. A. R. E. II-V (1956-62).

The new system was reassembled at Syowa Base as shown in Figure 13, and the water service to a cooking house was also completed in J. A. R. E. V.

The exhaust-gas heat exchanger was changed from a vertical type to a horizontal type as shown in Figure 14. The shell was nearly the same as the one stated before, but the helical heating coils were changed to three helical coils. The diameter of the tubes was 22 mm outside and 17 mm inside. The most inner coil had a coil diameter of 139 mm and 22 turns (the heating area was 0.588 m^2), the middle helical coil had a coil diameter of 198 mm and 22 turns (the heating area was 0.840 m^2), the external coil had a coil diameter of 257 mm and 24 turns (the heating area was 1.185 m^2), and the shell heating surface was shaped 296 mm in diameter and 500 mm in length (the heating area was 0.464 m^2). Hence, the total heating area A was increased to 3.08 m^2 from 1.98 m^2 of the old type. The position

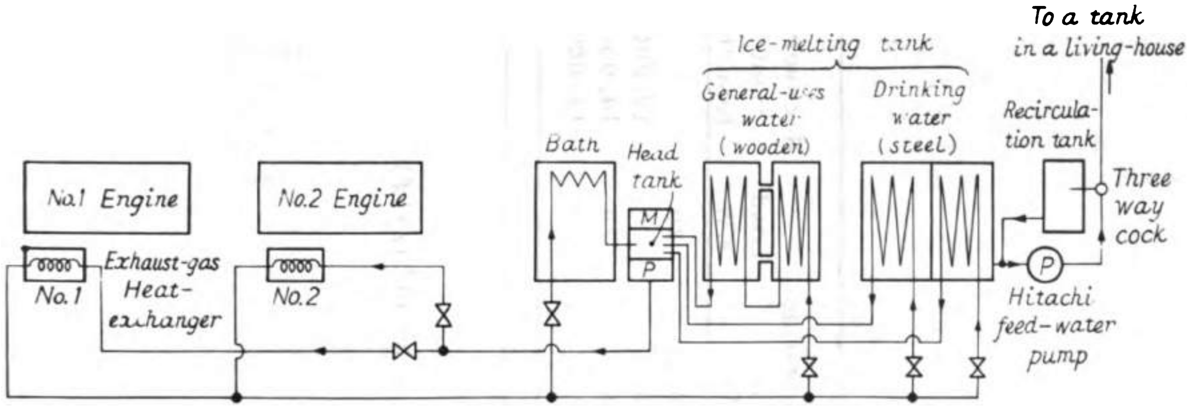


Figure 13. The final arrangement of the water-making equipment at the end of J.A.R.E. V (1962).

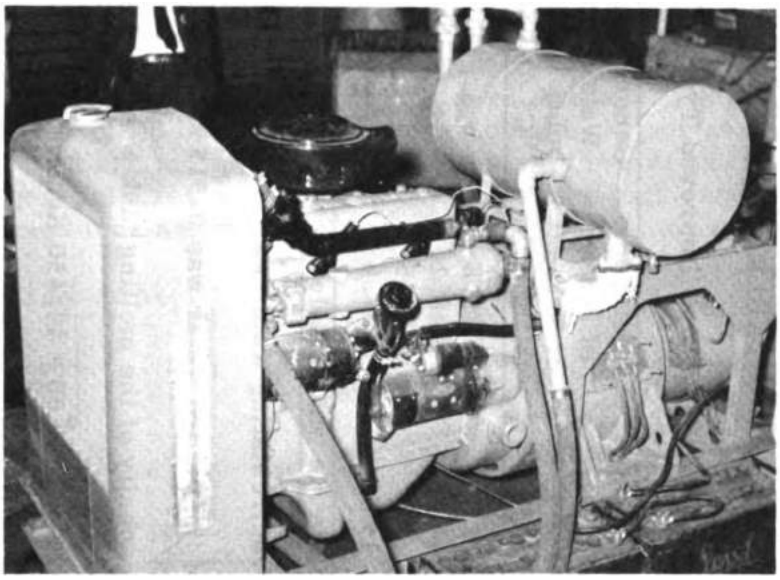


Figure 14. An improved horizontal type exhaust-gas heat exchanger installed on a generator.

of the drain cock was changed from bottom to shell side. An exhaust-gas heat-exchanger was mounted on a panel covering the electric generator to decrease its occupying space in the narrow room of the Base and to facilitate the piping. The new system was reassembled at the Base in a shorter time and was more effectively used than the old type. The ordinary exhaust manifold of the diesel engine was heated by the exhaust gas, and its temperature was very high. To utilize the cooling-loss from the exhaust manifold, a new exhaust manifold with a jacket was prepared, and the water outlet of an exhaust-gas heat-exchanger was connected to the inlet of the jacket.

In Table 4, the results of an ice-melting test at Isuzu Motors, Ltd. tested in 27th, September 1957 are shown. In this test, 231 kgs of ice in the ice-melting

TABLE 4

Ice-Melting Test (Improved Type)

Time	Temp. of Water in Head Tank °C	Inlet Temp. of Heat-Exchanger °C	Outlet Temp. of Heat-Exchanger °C	Outlet Temp. of Jacket of Exhaust Manifold	General-Uses Water Tank Inlet °C	General-Uses Water Tank Outlet °C	Exhaust-Gas Temp. °C	Load KW	Recovered Heat Kcal/h
20.38	64.0	65.4	72.3	73.8	-	-	78.0	20	-
20.50	35.0	35.0	44.4	46.2	45.6	32.2	68.5	20	19,800
21.00	28.8	28.8	38.0	39.5	40.5	30.4	58.5	20	14,950
21.17	20.5	22.0	35.2	37.0	36.6	27.8	39.0	20	13,000
21.35	Engine was stopped. All of the ice was completely melted.								

Notice:

1. Flow-rate of recirculating water was 1,480 ℓ/h
2. The volume of the melted water was $0.515 \times 1.047 \times 0.430^{m} = 0.231 m^3$ (231ℓ)
3. The average capacity of the melting tank was calculated by

$$231 \times \frac{60}{57} \times 80 = 19,450 \text{ Kcal/h.}$$

tank for general-uses water was melted by the heating coils. The following rate of the recirculating water was 1480 l/h, and all of the ice was melted after 57 minutes. The recovered heat was about 19,800 kcal/h (78,600 Btu/h at the start but it decreased to 13,000 kcal/h (51,600 Btu/h) when the temperature of the recirculating water was decreased after continuous running. By this test, it was confirmed that about 230 l/h of water was obtained and this was sufficient for livelihood at Syowa Base.

5. A System for Recovering the Cooling-Loss of Diesel Engines Prepared for J. A. R. E. I

Besides the system for recovering heat from the exhaust-gas of diesel engines, an independent system for recovering the cooling-loss contained in the coolant of the same diesel engines was prepared for J. A. R. E. I in 1956. This system was constructed and tested in Japan and transported to Syowa Base in 1957, but it was not assembled in the electric room because the exhaust-gas heat recovering system was sufficient for supplying the water necessary for wintering and for maintaining the room temperature of the engine room and was more desirable from the view point of the safe running of the engines. However, some details of this system will be described below. The engine coolant, 30 per cent solution of Prestone, was branched and fed to the coils installed on the bottoms of the ice-melting steel tank for general-uses water and of the hot-water tank, and the return was collected in a head tank and recirculated again to the engines as shown in Figure 15.

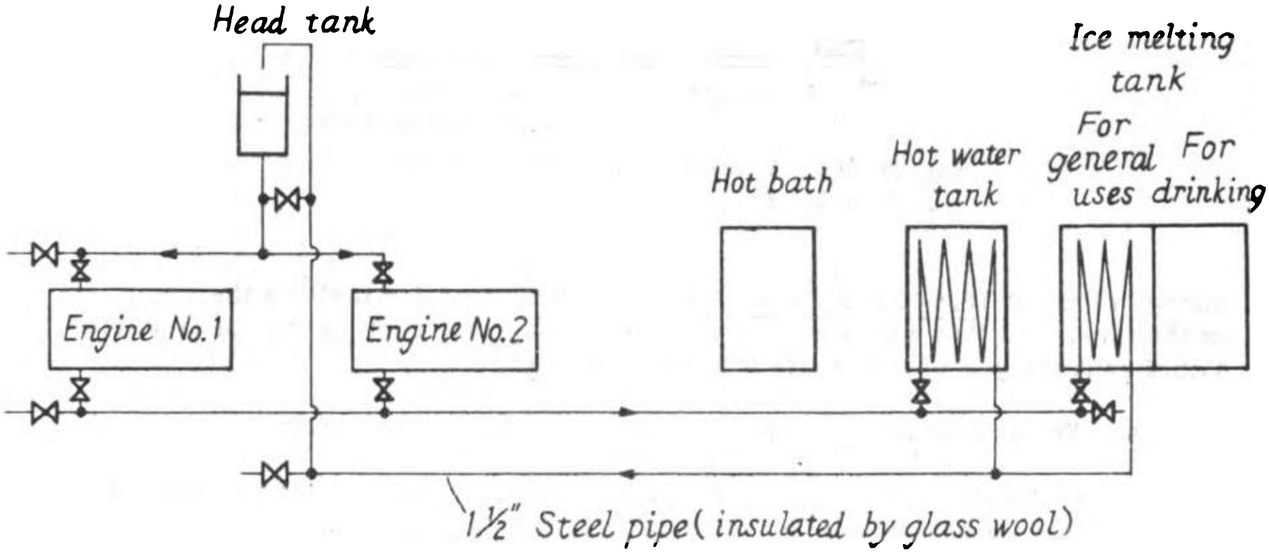


Figure 15. System for recovery of engine coolant heat for melting ice and for heating water.

The dimensions of the heating coils are shown in Figure 16, and their features are shown in Figure 8. The heating coils were made of steel tubes and aluminized externally. A special pump was not needed, the cooling water pumps of the engines being sufficient. By experiment in Japan, the inlet temperature to the engines decreased to 20-22°C, and the engine outlet temperature was kept at 70-72°C. Heat

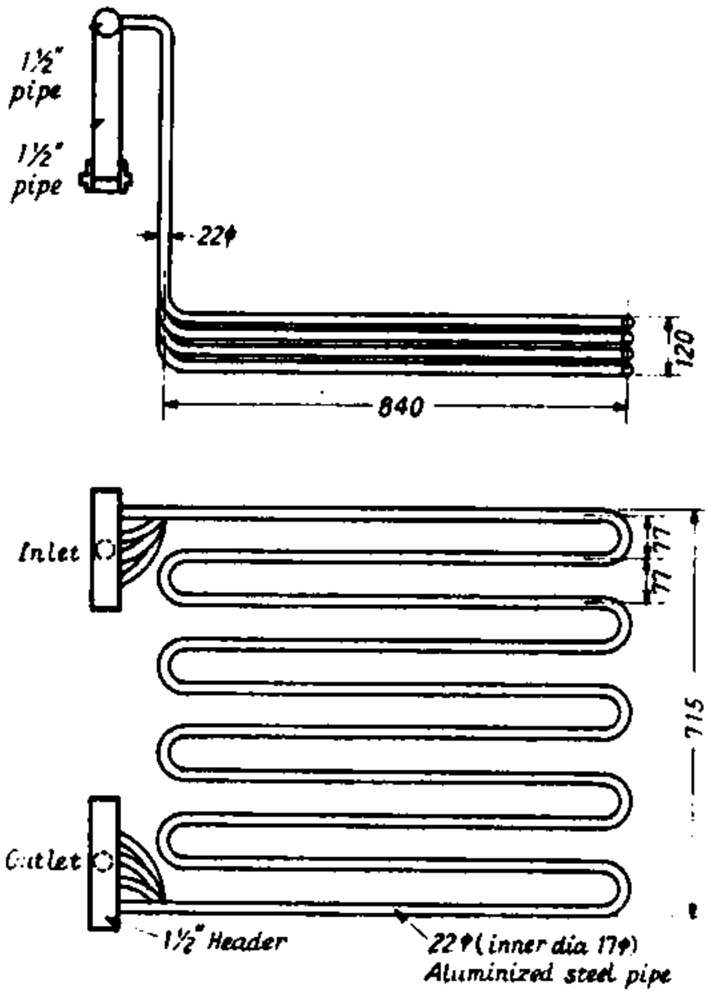


Figure 16. A heating coil prepared for J.A.R.E. I.

energy of about 10,000 kcal/h (40,000 Btu/h was used for melting the ice or snow in the tank, and this was about 56 per cent of the total cooling loss of an engine. The disadvantages of this system were as follows:

a. The engine room temperature is decreased excessively.

b. If Prestone is used as the coolant, contamination of the drinking-water by this poisonous coolant must be guarded against.

c. Thermal stresses are increased in the engine cylinders.

Two tests for determining the total capacity of these heat recovery systems were made in Isuzu Motors, Ltd. Co. in 1956. One test result showed that 699 kg of ice contained in the melting-tanks was melted completely in 100 minutes by using both the open-type exhaust-gas heat recovery system and the engine coolant heat recovery system. This means that the total capacity of these two systems is 32,000 kcal/h and that the water-making capacity is 400 l/h. The other test showed that the temperature of the water contained in a hot water tank (the volume was 364 l) was increased from 21°C to 62°C in 30 minutes by using the heating coil for recovering coolant heat and the hot water recirculating system for recovering exhaust-gas energy.

This means that the total capacity of the two systems prepared for J. A. R. E. I was 30, 000 kcal/h, and this shows good coincidence with the result of the former test. As a conclusion, it was confirmed that the capacity of the direct type heat recovery system for exhaust-gas was about 20, 000-22, 000 kcal/h (80, 000-88, 000 Btu/h) and that the heat recovered from coolant was about 10, 000 kcal/h (40, 000 Btu/h) under full load running condition. As stated before, the exhaust-gas energy was effectively recovered at Syowa Base, but the coolant energy was hardly used for melting ice. Consequently, the engine room temperature was too high, and occasionally reached 35-42°C. In the preparation for J. A. R. E. II, a new device was developed. It was for utilizing this coolant heat to heat the room air in one of the living quarters. The hot water in a hot water tank heated by these two systems was designated to be fed to the nearest living house through a special insulated rubber hose, and the intake air to a pot type warm air heater to be heated by the hot water flowing through a radiator provided on its inlet side. The cooled water is recirculated again to the hot water tank. By this arrangement, heat of about 7, 000 kcal/h can be utilized for warming the air of a living house and this nearly balanced with the heating load of a living house built at Syowa Base.

This equipment was tested at Isuzu Motors, Ltd. Co. in 1957. The hot water inlet temperature to a radiator was 71.9°C and the water was cooled to 67.2°C at the outlet, the measured rate of flow of water being 1, 480 l/h. This means that heat of 6, 960 kcal/h was utilized for warming the room air. The delivery air temperature was raised to 41.7°C from 18.7°C at the inlet. This proved that one of the three living houses can be warmed comfortably without any consumption of fuel. This equipment was transported to the Base but has not yet been actually used.

In Figure 17 a pot type warm air heating furnace, provided with the heat recovery radiator at its air inlet, is shown. This furnace is the main heater of the living houses. Its maximum heating capacity is 10, 000 kcal/h (40, 000 Btu/h), and it supplies heat by burning gas-oil. It contains also a 3 KW electric space heater for economical running of the generators and for saving fuel. Unfortunately, the coolant-heat-recovery system was not realized, but it is believed that this system will be used effectively in the near future and will be capable of to saving much fuel.

6. Fuel Economy at Syowa Base

In Table 5, the total fuel quantity consumed in a year from 18th, January 1960 to the end of January 1961 is shown.

As shown in Table 5, no fuel was burned for melting ice and for producing cold and hot water. The total quantity of gas-oil used at Syowa Base was about 200 drums a year and 75 per cent of this was used as fuel for the diesel engines of the 20 KW generators. The mean output of the generator was kept at about 6.8 KW for saving fuel, and the recovered exhaust-gas energy reached 35 per cent of the

TABLE 5

The Quantity of Gas-Oil Consumed at Syowa Base in 1960

Month	20 KW Litre	Snow-Car Trips	Snow-Car Around Base	Fur-nace	Hot-Air Heater	Cooking	Miscel-laneous	Sum
From 18, Jan.	1, 245	0	0	30	0	28	0	1, 303
Feb.	2, 710	0	20	175	0	52	0	2, 957
March	2, 383	0	403	367	35	0	8	3, 193
April	2, 185	370	113	540	12	0	400	3, 620
May	2, 420	60	26	497	12	0	0	3, 015
June	2, 370	0	0	428	0	0	6	2, 804
July	2, 483	0	0	397	0	0	44	2, 913
Aug.	2, 600	187	0	484	0	0	50	3, 321
Sept.	2, 500	1, 404	0	469	20	0	20	4, 413
Oct.	2, 588	0	163	214	20	0	5	2, 991
Nov.	2, 428	0	85	150	0	0	0	2, 663
Dec.	2, 543	2, 350	90	30	0	0	0	5, 013
Jan.	2, 355	0	0	0	0	0	0	2, 355
Total	30, 810	4, 371	900	3, 781	99	80	533	40, 574 liters

TABLE 6

The Quantity of Gasoline Consumed at Syowa Base in 1960

Month	Snow-Car Trips	Snow-Car Around Base	Hot-Air Heater	Miscellaneous	Sum
Jan.	0	80	0	0	80
Feb.	0	70	0	0	70
March	0	50	36	0	86
April	606	69	0	0	675
May	0	0	0	0	0
June	0	0	0	18	18
July	0	85	0	18	103
Aug.	130	13	0	18	161
Sept.	0	0	0	0	0
Oct.	0	46	0	1, 492	1, 538
Nov.	0	35	18	0	53
Dec.	0	50	43	0	93
Total	736	498	97	1, 546	2, 877 liters

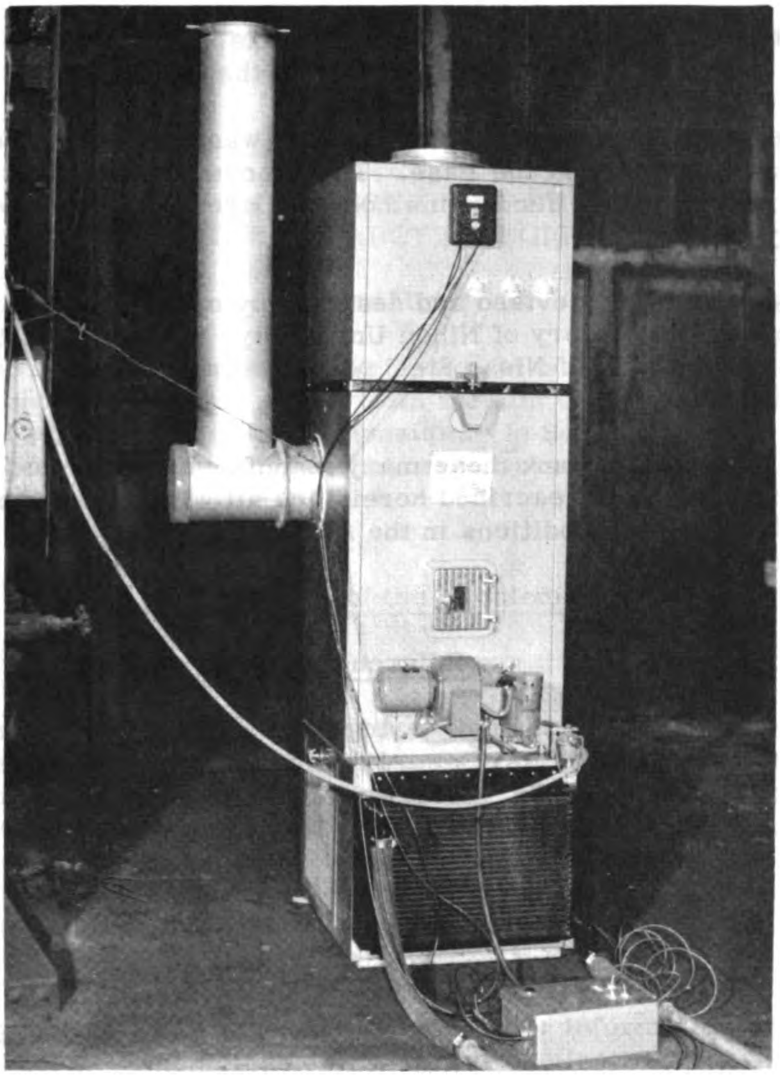


Figure 17. A warm air furnace manufactured by Minorigawa Manufacturing Co. (Pot type, maximum capacity 10, 000 kcal/h, air flow, 500 ft^3/min.) A coolant heat recovery radiator was placed at the air inlet of the furnace.

supplied total heat Q_f. This means that 50 drums of gas-oil was saved during one year by the newly developed water-making equipment.

7. Conclusion and Acknowledgement

As shown in this paper, for J. A. R. E. I-V (1956-62) a most economical ice-melting and hot-water making system was developed, in which the heat source was mainly dependent on the exhaust-gas heat energy of the water-cooled diesel engines coupled with 20 KW electric generators. This system supplied sufficient cold and hot water for the wintering members during the last several years and every one year saved 50 drums of fuel to be transported to the Base.

A recovery system for engine coolant heat was also devised and constructed, but it was not actually used at the Base. The recovering of exhaust-gas energy is a safer, easier, and more effective method compared with the recovering of coolant heat energy.

These systems were devised and designed by one of the authors and constructed in the working factory of Nihon University, with the assistance of many manufacturers, especially of Nisso Steel Manufacturing Ltd. Co. and Isuzu Motors, Ltd.

The authors wish to thank these many manufacturers for their kind assistance in producing the equipment described herein and all wintering members of J. A. R. E. who, despite the adverse conditions in the Antarctic, successfully put this equipment to practical use.

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Member of Special Committee for J. A. R. E. of J. S. M. E.

Masaaki Kawada	Prof. of Univ. of Tokyo, Engrg. Dept., Committee chairman.
Osamu Hirao	Prof. of Univ. of Tokyo, Engrg. Dept., Committee secretary.
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Riichi Maeda	Nissan Motor Ltd. Co., Committee member.
Masanosuke Yanagimachi	Yanagimachi Solar Energy Research Institute, Committee member.

Technical members of J. A. R. E. I, II, III, IV, V and VI.

PROBLEMS IN ERECTION OF BUILDINGS IN THE ANTARCTIC REGION

Naoto Hida

A brief review of the problems in erection of buildings in the Antarctic region will be given in Section 1 of this paper, with the aim of stimulating lively discussions among the participants of the Symposium. In Section 2, the measures taken in the design of the J. A. R. E. buildings in order to cope with some of these difficulties will be described.

1. Review of the Problems

1-1. Weather Conditions

The intense cold is naturally the first opponent we have to negotiate. With heavy gloves and mittens on, one cannot but be an awkward worker. An Antarctic building has to be designed so that its erection needs least of skill.

Building materials, especially those which are exposed to the open air, have to be selected so that they can stand very low temperatures, sometimes -70°C or lower. Low temperature fragility of metals is one of the points of question. Adhesives may cause a trouble in the cold. In most districts of the Antarctica, concrete work is practically impossible throughout the year. Application of cements of special compositions has been suggested, but no further information has been obtained. It has been recommended to use lead or sulphur, in place of concrete, as filler for use in anchor holes.

The wind is another nuisance. In some regions of the Antarctica the erection of buildings itself would have to be carried out in the teeth of a howling wind. In other regions where the situations are better, buildings have to be constructed all the same to stand strongest blizzards. They have to be strong enough against positive and negative pressures exerted by the wind. Figure 1 will give an idea of these pressures. In some cases it may be necessary to support buildings by stays and anchors.

Snowdrifts have also to be taken into consideration. Snowfall may crush a building. A snow-cover of 2 m depth on the roof will bring forth about 600 kg/m^2 vertical pressure. Many of the Antarctic stations are buried in the snow. If buried, buildings are proof against the wind, but other troubles, such as difficulties in ventilation, will appear.

In conclusion, it should be emphasized that a sudden change of weather is quite likely to occur during the erection. Any arrangement to reduce the period of erection is worth while.

1-2. Ground Conditions

Most Antarctic stations are built on snow-covered ice. The snow in the building site has to be pressed by some vehicles etc. before the building is erected. This work has something in common with the construction of a runway. A special consideration should be paid to drainage. One of the troubles with a building built on the snow is a gradual inclination of the floor which will take place gradually as the building sinks down. The rocky or sandy ground, if such could be found, is more negotiable.

1-3. Transportation

The erection will virtually be a success if the transportation is accomplished according to the schedule. Construction parts should be so designed as to elevate the efficiency of transportation by ship, by vehicles and sledges, and sometimes by airplanes or helicopters, to a maximum. For this purpose, modular coordination of construction parts is recommended (See Section 2).

Sometimes it may happen that cargos temporarily stored on a floe or on bay ice are lost. Providing against possible loss of some construction parts, the building should be designed so that it can be completed in a smaller scale with the remaining parts. For this, adoption of a modular co-ordination system in the design is again recommended.

1-4. Types of Building

The types of the permanent buildings hitherto constructed in the Antarctica could be classified into three categories:

1. Conventional wooden buildings such as those left at Hut Point and Cape Adare since the days of Captain Scott. Some present day expeditions, e.g. the Commonwealth Trans-Antarctic Expedition 1955-58, have established their bases according to this style.

2. Prefabricated panel-type buildings such as those of American and Japanese bases.

3. Steel-pipe and canvas (or corrugated sheet iron) structures such as those for workshops, garages, hangars and store huts. Ordinary concrete buildings are out of the question, as was discussed in 1-1.

In the present paper, our concern will be limited to living houses.* Hence the last of the three types mentioned above will be excluded from our consideration.

It is clear that prefabricated panel-type buildings are by far superior to conventional wooden buildings in the facility of erection. The construction of the latter takes much more time and needs more skill. It may be admitted that living in an ordinary wooden building would have a good effect in the psycho-hygiene of the wintering party. But more importance should be attached to the ease of erection.

2. Solutions for Some Problems

Effective measures for some problems discussed in Section 1 of this paper, were devised in the design and construction of the buildings erected at Syowa Base for J. A. R. E. Some measures were found successful, while some proved over-cautious because on the one hand the weather conditions were better than we had expected and on the other we were lucky to find a good base site on the solid ground of a rocky island.

The details of the buildings have been described in another paper presented at this Symposium (Futami, Minow and Hida: Design and Construction of Buildings in Syowa Base), which shall be referred to as Paper I in the following. Points of interest for those who are in charge of erection could be summarized as follows.

The buildings are of prefabricated panel-type. A single panel, 4 ft x 8 ft x 4 in. in size, weighed no more than 70 kg. The stressed skin structure composed of these panels and reinforced by roof- and floor-beams can stand a wind of 80 m/s speed. The beams, all of 16 ft span, ** are I-beams of J. I. S. SS-41*** steel, each consisting of a 2.3 mm thick web and 2.6 mm thick flanges. The average weight of a beam is 55 kg. These light-weight panels and beams elevated the efficiency of transportation and erection very much.

Connectors for joining panels together were forged from a low-carbon steel, J. I. S SF-34, **** which is not liable to become fragile at low temperatures. They are so designed that the panels can be joined together by a most awkward hand (see Appendix 70000, Paper I). The maximum height of the connectors from the panel surface is no more than 14.5 mm. This was very convenient in transportation, in which the panels had to be piled and packed.

*Wireless huts, laboratories, etc., in which men spend most of their time shall be included in living houses.

**In adding a new building for ionospheric observation in 1960, 8 ft beams, with joints for making 16 ft ones, were employed for the convenience of air-transportation. See Murayama's paper in Section 2.

***Chemical composition:	P, below 0.060 (%)
	S, below 0.060 (%)
Tensile strength:	41∼50 kg/mm^2
****Chemical composition:	P, below 0.045 (%)
	S, below 0.045 (%)
Tensile strength:	34∼42 kg/mm^2

The buildings were designed according to a modular system, taking 2 ft as the fundamental unit in length. This again contributed much to the efficiency of transportation.

Besides, the adoption of the modular system rendered it possible to alter the design of a building in erection. Such an alteration has often been required in establishing a station in the Antarctic region—and unfortunately this was the case with us.

In standard conditions, any one of the J. A. R. E. buildings—main hut, sleeping hut, wireless hut and laboratory—can be erected in five hours by eight men. This includes the time required for installing the prefabricated furnitures (see Appendices to Paper I).

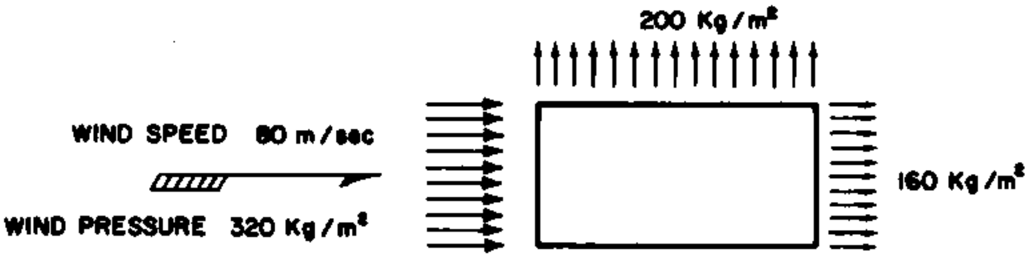


Figure 1

FIRE SECURITY IN DESIGN OF ANTARCTIC BUILDINGS

W. Frank Ponder

Part I

A Brief Summary of Fire Protection and Prevention and its Effect on Planning and Design

A. Introduction

Fire protection and prevention is possibly the most important of the many considerations that have a bearing on the planning and design of buildings in Antarctica. It is well known that a building fire in Antarctica could bring tragedy and no effort is too great to ensure that fire is prevented.

Without means of effective second stage fire fighting, a fire could destroy a base and, apart from the possibility of direct injury to the occupants, loss of shelter could be a disaster.

Every aspect of fire protection and prevention must be given detailed attention at the planning and design stage of the buildings.

In Antarctica this includes the siting of buildings, the selection of fire resistant materials, the introduction of devices to prevent fire spread and the proper provision of means of escape from buildings other than their normal entrances.

Every means must be employed to prevent fire outbreak and the planning of these measures is a responsibility that can only be undertaken by the Architect responsible for the basic design and it must be part of that design.

B. Fire protection considerations that must be fully understood by the Architect in his design include:

1. The importance of siting buildings.

2. Fuelling arrangements.

3. Duplication of amenities.

4. Possible spread of fire or smoke through ducts or connecting passages.

5. Fire treatment of materials and selection of fire resistant materials.

6. Close examination of all possible fire hazards—flues, exhausts, stores, heaters, etc.

7. Careful study of the function of the base, movement of personnel, etc., and the possible resultant fire risk.

8. Provision for escape from all spaces.

9. Provision of adequate warning devices.

To illustrate the problem, the following comments grouped under the above headings indicate the various fire protection and prevention arrangements made at Scott Base:

1. Siting of Buildings

   a. Rather than one large building, there are several buildings sited remote from one another to avoid fire enveloping the base.

   b. This siting is so arranged that buildings are not in line with the prevailing wind to avoid fire spread from one building to another.

2. Fuelling Arrangements

   a. Bulk fuelling is kept below the base or remote from it. Fuel storage is sited to ensure that spillage will not affect the base.

   b. When fuelling is in progress it is kept under control and inspection. While fuelling is as 'automatic' as possible, it is always the responsibility of the operator to ensure the supply line is empty on completion and that any spilt fuel is cleared away.

3. Duplication of Amenities

Amenities are distributed among buildings to ensure that if one building is lost in a fire the base can still be operated with the minimum inconvenience. For example, there are several snow-melting appliances, there are generators in several buildings, and storage of equipment and materials is separated as far as possible.

4. Precautions in "Covered Way" Connection and Ducts

   a. The "covered way", or connecting tunnel, is made from non-combustible materials, mostly corrugated steel. Fire curtains are provided, and these are dropped in the covered way in the event of a fire to ensure that the tunnel does not act as a flue.

   b. Every precaution is taken to ensure that air conditioning ducts and other passages connecting spaces are designed to prevent fire spread.

5. Materials

Great care and attention is necessary to ensure that the materials selected are as fire-resistant as possible. At Scott Base all timber is fire treated and all interior linings are non-combustible, being made of an asbestos material which will not ignite. Where there may be oil spilt from heating and cooking devices, walls and floor have been covered with aluminum sheets to ensure that oil will not soak into the various materials and become a fire hazard. Drip trays are supplied. The insulation material used (foamed ebonite) is selected, partly because it is self-extinguishing and will not become a fire hazard in itself.

6. Flues

Wherever flues are used, particular care is taken to ensure that by means of proper insulation and air movement the area surrounding the flue is not a fire hazard. Complete separation of the flue from surrounding material is essential, and any metal stay contacts must be carefully insulated.

7. Every operation likely to be undertaken in the base must be carefully considered by the Architect. As an example, at Scott Base in many areas where oil or fat is likely to be spilt, floors and walls have had an additional metal layer over the incombustible lining to prevent saturation that could render the linings ineffective. In some areas (e.g., in the vicinity of the cooking stove) an asbestos blanket is provided to enable a fat fire to be quickly smothered.

8. Provision of Escape

Every building is designed so that there is at least one escape hatch remote from the entrance door. This escape hatch is as high up the wall as possible and opens inwards. Several alternative exits are also provided in the "covered way".

9. Warning Devices

At Scott Base there are several alternative means of fire warning. The main device is an automatic fire alarm with thermostatic detectors which rings alarm bells and indicates on a master panel the seat of the fire. There are alarm bells between buildings with codes to indicate which building the fire may be in. There are also hooters which can raise the alarm for anyone outside the base. An intercom system can give warning of the fire situation.

C. The Architect should also make recommendations to ensure that in the operation of the base proper careful attention is given to:

1. Training all base personnel in fire fighting and seeing that all are aware of the special hazards involved.

2. Good Housekeeping—Everyone at the base should be kept constantly aware of the dangers of accumulating rubbish around buildings.

3. Provision of suitable and adequate fire fighting equipment and its regular maintenance.

4. The necessity for a night-watchman.

5. The selection of an enthusiastic fire officer—who will check all equipment regularly and be responsible for briefing newcomers to base as to their duties.

D. Some of the Rules Established at Scott Base

1. It is essential that everyone knows precisely what has to be done in the event of a fire. Everyone going to Scott Base is given a briefing on what happens in case of fire, and is assigned a particular job. This briefing is very important and includes training with the equipment in New Zealand.

2. There is always danger in the contents of a building. One of the Fire Officer's jobs must be to ensure that good housekeeping prevents an accumulation of material which could cause trouble in the event of a fire. Such rules as no smoking in bed and careful extinguishing of cigarette ends are obvious, but are also difficult to enforce, particularly as more and more people are visiting Antarctica. This difficulty makes it all the more important that fire, if it does start, is restricted to one space, and can be smothered very quickly.

3. Different types of fire extinguishers are used to suit different types of fire. Extinguishers are sited in convenient positions and are clearly marked. Testing and regular maintenance is the duty of the Fire Officer.

4. The night-watchman's responsibility includes a visit to all parts of the base once every hour.

5. The Fire Officer must ensure that his team are properly prepared and ready and aware of what is to be done on the spot. He is also responsible for ensuring that any visitors or newcomers are made aware of the fire precautions and what the alarm signals are for. He must regularly test the various fire warning devices that are distributed about the base.

Part II

Comments on Fire Fighting and Fire Equipment in Antarctica

A. Type of Fire Extinguishers in Use at Scott Base

1. The Bucket Pump

This is a simple 4-gallon container incorporating a double action pump and a short length of hose with a 3/16" nozzle.

It is intended for use only in heated buildings, and has proved most effective as it can be rapidly re-charged. It is easily maintained.

This equipment is effective on all but oil fires. (Anti-freeze chemicals can be used, but care must be taken that chemicals do not corrode containers.)

2. Dry Powder Extinguishers

Dry powder extinguishers were originally pressurized by 'Nitrogen' bulbs. A new type operated on air pressure is now in use. An external gauge indicates operating pressure.

B. Fire Fighting in Antarctica

At all costs fire must be prevented. If an outbreak does occur, it is essential that it be dealt with immediately as there is normally no provision for second stage fire fighting. (Until sufficient water supply can be made available second stage fire fighting is impossible.)

An efficient fire alarm system, a fast response, and absolute efficiency of the fire extinguishing equipment, are vital if a major fire is to be prevented.

The fire fighting team must at once get to the seat of the fire and smother it. No effort can be too great to achieve this, and every man in the base must be properly trained to know what he must do to combat smoke and heat to reach the seat of the fire.

Frequent training is necessary at base to ensure that everyone knows what to do, but on no account should a training alarm be sounded without a previous warning. All alarms are then treated as genuine.

After the fire has been extinguished a careful watch must be kept to ensure that places inside walls, etc., are not smouldering. If there is the slightest doubt, walls must be opened up and carefully inspected.

C. Suggested Duties of the Fire Officer

1. Inspect and record state of all extinguishers and alarm systems at least once weekly.

2. Arrange for regular training.

3. Ensure that a proper night watch is kept at all times.

4. Ensure that no "bad housekeeping" such as accumulation of rubbish is allowed.

5. Ensure that fuelling is carried out without spilling.

6. Make everyone aware of the fire danger and demand careful adherence to base regulations such as smoking restrictions.

7. Ensure that all visitors are properly briefed in what to do in the event of a fire.

8. Regularly check that all escape hatches are readily accessible and in working order, and that fire curtains are not obstructed in any way.

9. Make a regular check of all flue and exhaust outlets and take temperature readings to ensure that there is no fire hazard at these points.

Part III

Conclusion

Although an efficient fire fighting organization and carefully selected fire extinguishing equipment are essential at an Antarctic base, the more important consideration is the prevention of fire outbreak.

The Architect must be aware in every aspect of his design of the need to plan to prevent fires starting, and to ensure that there will be little to maintain combustion if a fire does start.

Finally, he must be sure that every building and space has an escape route should fire block a normal entrance and that fire hazards are clearly defined so that everyone at the base is aware of the problem.

HEATING, VENTILATION AND MECHANICAL SERVICES—SCOTT BASE, ANTARCTICA

J. G. Davies

Introduction

Scott Base (Fig. 1) was established as New Zealand's contribution to the International Geophysical Year (of 1957/58) and to provide a base for the New Zealand section of the Trans-Antarctic Expedition. The terms of reference of the designers being made clear that this was not to be a permanent establishment. This had an obvious bearing on the nature of the engineering services. It was intended that the base construction materials, equipment and scientific party would travel down on the R.N.Z.N. ship "Endeavour" and that the base would be erected by the members of that party.

To make this practicable, the designs for the various services were evolved on a basis of prefabrication whereby all components would be manufactured, assembled, erected and tested prior to despatch. The base party would receive instruction in the operation of the gear and on its assembly on site. All components would be marked with a system of identification and erection drawings with corresponding markings would be provided. Sheet metal ductwork for the heating and ventilation systems was designed with tapered sections so that lengths were telescoped and smaller components packed inside. Crates and cases were designed to suit both the "Endeavour's" hatches and the shore transport capacity (sledge and tractor).

This arrangement was adhered to with one exception; a working party of tradesmen was sent down for the erection. Nevertheless, the pre-erection program, etc., proved to be an almost essential precursor to the establishment of the base, and as a consequence the engineering services were assembled and put into operation without difficulty.

1. Services provided were:

   Heating and Ventilation
   Electric Power Generation and Distribution
   Cold and Hot Water Supplies
   Fire Detection
   Sanitation
   Fuel Handling
   Cooking Facilities

2. A principal was established that there must be at least two alternative services in each section and that one should not be dependent on electric power. The exception to this rule being that a common fuel should be used to avoid risks in handling and over-complication in equipment.

3. Fuel

After consideration of temperatures, storage handling and transport facilities, a grade of kerosene was decided on. The fuel would be transported in 44-gallon drums, sufficient for 12 months' operation, the drums would form dumps in the open, lying handy to the base. Temperatures down to -70°F would not be uncommon. The fuel specification was such that it would not wax, jell or become crystalline under average minimum temperatures and would be suitable for vapourizing and for pressure jet burners, for tractors, and diesel generators.

Fuel is brought on tractor-towed sledges up to the generator hut. Drums are taken into a tunnel formed on one side of the hut. Accommodation for 12 drums is provided in the tunnel on a roller conveyor. In the progress from 12th to first position along the conveyor, the fuel temperature is raised by the passage of exhaust ventilation air from the hut; at the final position a rotating device enables the drum to be vented and drained into a 100-gallon holding tank from which it is distributed by transfer pump and pipe line to fuel service tanks in each hut. The empty drums are discharged through a half door in the hut side.

In each hut porch a steel framed aluminium sheeted cabinet is provided incorporating: at the base an 80-gallon storage tank, on which a 40-gallon drum rests, a hand operated semi-rotary fuel pump, and a 10-gallon service or head tank. From the head tank valved and filtered outlets are connected to each burner in the hut. The drum is fed from the central pumping position.

In the first year, drums were handled directly to these fuel cabinets via the covered way of the base. As the base developed out of the IGY concept into a permanently manned scientific establishment this system was modified by the addition of the pumped fuel line. In an emergency the original system can still be used.

Heating and Ventilation (Fig. 2)

The base comprises a number of huts of uniform shape joined by a covered way of corrugated iron made up from rolled sheets, half round at the roof and flat-sided. This covered way forms a tunnel sometimes buried in snow. Vent shafts in the roof of this tunnel provide a reliable means of admitting air to the huts unaffected by weather conditions. (The tunnel is reminiscent of England's wartime "Anderson" shelters.)

The huts are raised on timber bearers to avoid interference with the stability of the permafrost by heat leakage downward from the hut. The hut construction provides a loss coefficient of 10 Btu/sq. ft./deg. difference per hour.

Externally, the huts are sheathed with aluminium and internally lined with an asbestos board. The floors are plywood faced. The insulation material is 3" thickness Onazote. Doors are cool-room type. Each hut design incorporates a "snow porch". The snow porch provides a buffer space between covered way and the hut, cool-room doors being fitted to both covered way and hut entrances. Heavy clothing, boots and the like being left in the porch.

Normal heating and ventilation is provided by a circulation of warm air from vertical mechanical warm air furnaces housed in the snow porches. Fresh air inlet is taken from the covered way via a dampered opening in the porch wall to the circulating fan chamber in the base of the furnace cabinet. At this position it mixes with re-circulated air entering via a duct led from the hut through the porch wall at low level. The plenum air leaves the furnace bonnet ducted above the hut door and is discharged at high level, horizontally, through jet outlet fittings. Jet outlet velocities are between 900 and 1000 p.m. Circulated air volumes average 900 cfm per hut, furnace loads about 50, 000 Btu/hour, net air change (or turnover rates about 10 per hour). Burner control is by room thermostat via high limit duct thermostat, a low limit duct thermostat controls the circulation fan. Flame failure control is by flue stat.

Hut ceiling heights are 8' 0" and, as could be expected, the floor area is limited so that most walls are filled with sundry furnishings. It was argued that the only free space for air circulation would be above head level. Consequently, jet outlets were designed to promote secondary circulation by entrainment of room air and so that the fluctuations in entering air temperature due to the essentially on/off furnace control would be acceptable. The approach velocity to the single low velocity recirculation inlet grille is unnoticeable but a smoke test showed a reasonable air movement in the hut.

Average temperature gradients measured show 65°F at head level to about 50°F at floor. Entering air temperature at the jets is 120°F under design conditions.

Chimneys

The warm air furnace flue is constructed out of 22 g. stainless steel, insulated with slag wool and sheathed with 24 g.m.s. The flue passes through the flat roof of the hut porch in a 5 sheet constructed housing, also insulated, an annular space between flue and housing leading to an external cravat provides ventilation to the snow porch while isolating the flue from roof structure. This arrangement being also intended to maintain flue gas temperatures above dew point to avoid icing at the terminal vent of the flue.

Alternative Heating

Alternative heating is provided by oil fired, vapourizing convection stoves, placed in the huts in as near central positions as room layouts would permit. When these convectors are used, the mechanical furnace is out of action for maintenance or repair and under these conditions, with power available, a propeller fan placed above and discharging downward promotes a reasonable circulation and reduces the temperature gradient. A metal disc placed beneath the fan prevents interference with the natural convection of the heater. The convector output is hand regulated by float level control.

The flue design is standardized as for the warm air furnace so that a measure of ventilation is built in.

Ventilation

Ventilation outlets follow a standard pattern whereby a S. M. box is fitted to the hut wall housing a propeller fan, a slide damper connecting with an opening through the wall, and an internal top hung access flap beneath the fan. Externally, a circular vertical duct shaft with top cowl and bottom access cover is bolted over the opening. This arrangement provides for a controllable positive extract, by regulation of the access flap (recirculating) and by regulation of the slide damper. Outlets are arranged on opposite walls and positioned to avoid snow drift areas.

Identical ventilation boxes but with fan rotation and blades reversed provide alternative means of fresh air inlet.

When the fans are stopped, the external shafts admit and exhaust air according to wind direction.

Cowls

Above roofs stay clear of snow because drifts follow a regular and predictable pattern and the flat roofs of the base are always clear of snow.

In a few instances troubles were experienced with down draughts in winds at a particular velocity and direction. These have been cured by altering the flue or vent height (flues and vents generally are no higher than 4 to 6 feet above roof. No great chimney heights were required under the temperature conditions obtaining).

Water Supply

The provision of a water supply in Antarctica involves continual sledging of snow to the huts on sledges specially adapted for the work. The sledges, tractor drawn, are brought up a ramp to the hut side where the snow is handled through hatches into snow melters.

Snow melters developed for Scott Base, in the absence of a proprietary article, are based on the use of waste heat from diesel generators and are constructed out of mild steel plate, welded. They were designed to produce 100 gallons/day.

Initially, exhaust gases from the engines were discharged through pipes placed in the main snow reception tank (6' x 3' x 3'). Each engine exhaust, 2" diameter, traversed the 6' 0" length of the tank once. This diameter and length representing the most favorable arrangement in terms of gas velocity, heat exchange and outlet temperature. The arrangement worked reasonably well and was augmented by a water pipe coil served by an oil fired (vapourizing pot type) small boiler, circulating by gravity. This same boiler provided the source for hot water supply.

Latterly, in the generator hut, with the installation of greater generating capacity, the arrangement has been modified whereby snow melting is by hot water pipe coil with accelerated water circulation from waste heat boilers in the engine exhaust system.

Snow entering the main tank rests on a coarse screen under which the coil is placed. As the water level builds up it is led by an overflow connection to two 3' x 3' x 3' tanks beneath.

Hot and Cold Water Services

Water has to be used frugally. The snow is awkward and tedious to handle, the amount of heat for melting is limited, storage capacity is limited, and when the water has been used its disposal is difficult.

The system in the first year was designed to place the onus for production and handling on the user, making the system self limiting; for example, each bather would draw off water in a bucket and fill his own bath, empty it and pump the water away. This arrangement was too tedious for continued use and the services now operating in the ablutions hut are rather more sophisticated.

A water transfer pump is arranged to take either cold or hot water from the storage tank or calorifier by way of a 3-way cock to the point of usage. The pump starter and the valves are manipulated by the user in the ablutions hut.

When the pump is stopped the pipe lines drain back to the storage system.

In the Mess Hut, water is pumped to a head tank feeding a calorifier and sinks by gravity.

Electric Power Generation

Two water cooled 40 KVA diesel generators supply power at 230V single phase AC. One set is on stand-by.

Exhaust Gas Waste Heat Recovery

Waste heat boilers are connected to the exhaust manifolds and water is circulated from the boilers by submerged rotor pump to a vertical thermal storage tank. This tank is constructed in copper and pressurized with an air cushion.

Secondary services from the thermal storage tank are circulated in copper pipework to:

a. Snow melter.

b. Hot water calorifier.

c. Air heater battery serving a warm air heating system in the ablutions hut adjoining.

Engine Jacket Waste Heat Recovery (Fig. 3)

Two axial flow fans in parallel induce air through the engine cooling radiators, these being standard radiators fitted to the sets. The air is then ducted to grille outlets providing warm air heating to the workshop and garage.

Engine jacket temperature is regulated by mixing valve and pumped water circulation.

Sanitary

A "night soil" system operates whereby solids are collected in discarded fuel drums cut into halves. The toilets are enclosed and extract fans are connected. The half drum is accessible through the hut wall and in the low temperatures obtaining the task of the "House Mouse" deputed to this duty is not quite so objectionable as it would be in more temporate climates. The drums and their contents are disposed of at the tide crack via sledge and tractor.

Liquids discharge through a heated waste pipe and the practice has been that the winter's accumulation, forming a glacier, is dealt with in summer. It is shattered by a charge of gelignite and bulldozed down to the tide crack.

A more difficult problem is met in waste disposal from the mess hut. Here the quantities of waste water are greater and from an interceptor and grease trap a rubber hose, 1 1/2" diameter, is run approximately 175 ft, conveying heated waste direct to the tide crack. The pipe is supported on spiders concentrically within a 4" rubber pipe insulated overall with 1 1/2" thickness of mineral wool wrapped in tar-paper faced with aluminium foil (Fig. 4).

Exhaust air from the hut taken from above the kitchen range is discharged through the annulus formed by the two pipes to emerge in a box constructed over the tide crack. The emerging air keeps the outlet clear and the final 40' 0" of hose contains an electric heating cable as a safeguard against freezing.

150 cfm of air is delivered at 5" WG.

Cooking

Two oil fired cookers are installed, one a double oven range with fan assisted vapourizing pot burner under the control of the Cook.

The standby range is a single oven with a natural draught, vapourizing burner.

Standarized insulated and ventilated flues are used.

In practice, the standby range is in continual use, providing tea and coffee, etc., on a self-service basis.

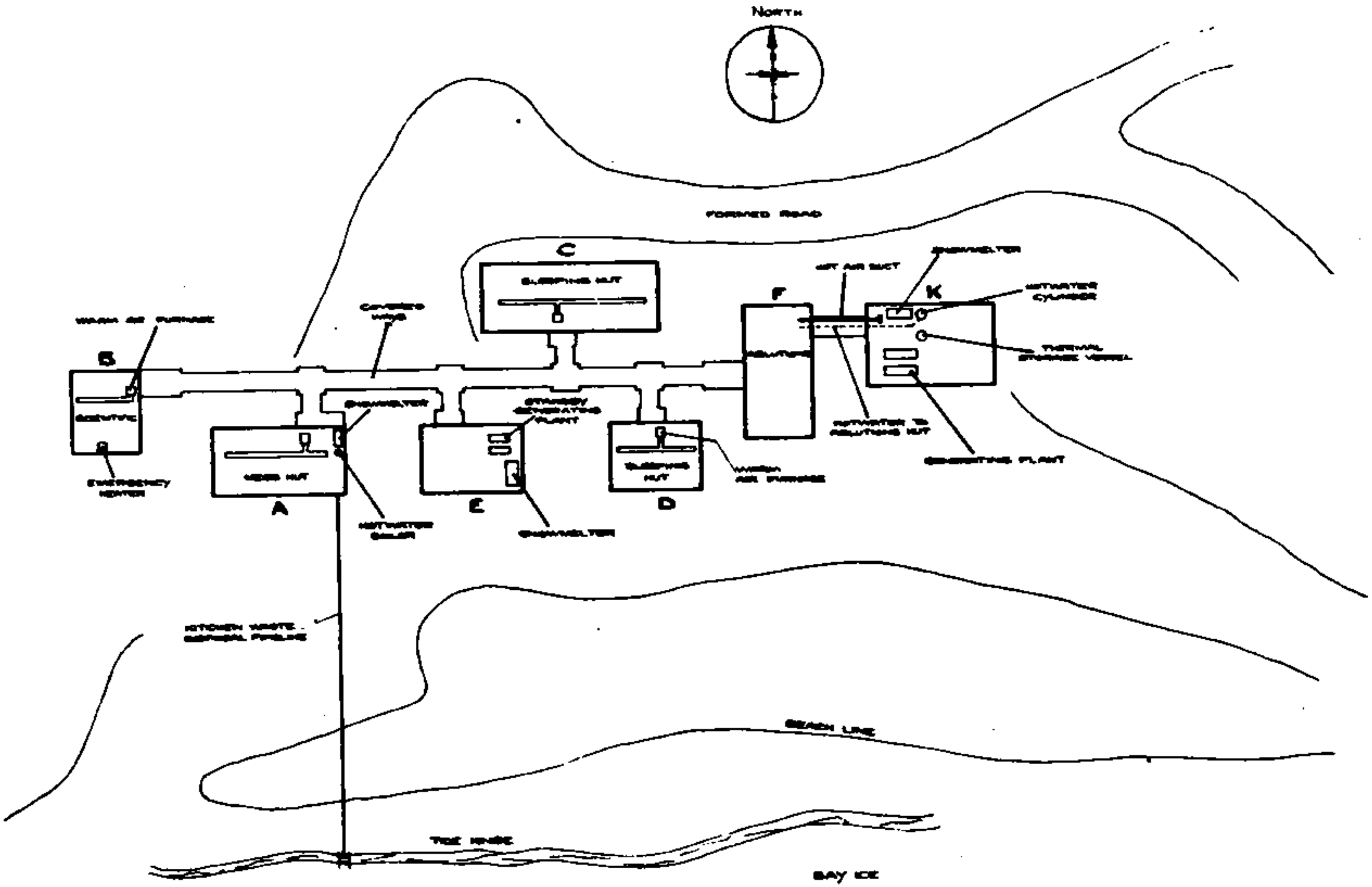


Figure 1. Scott Base.

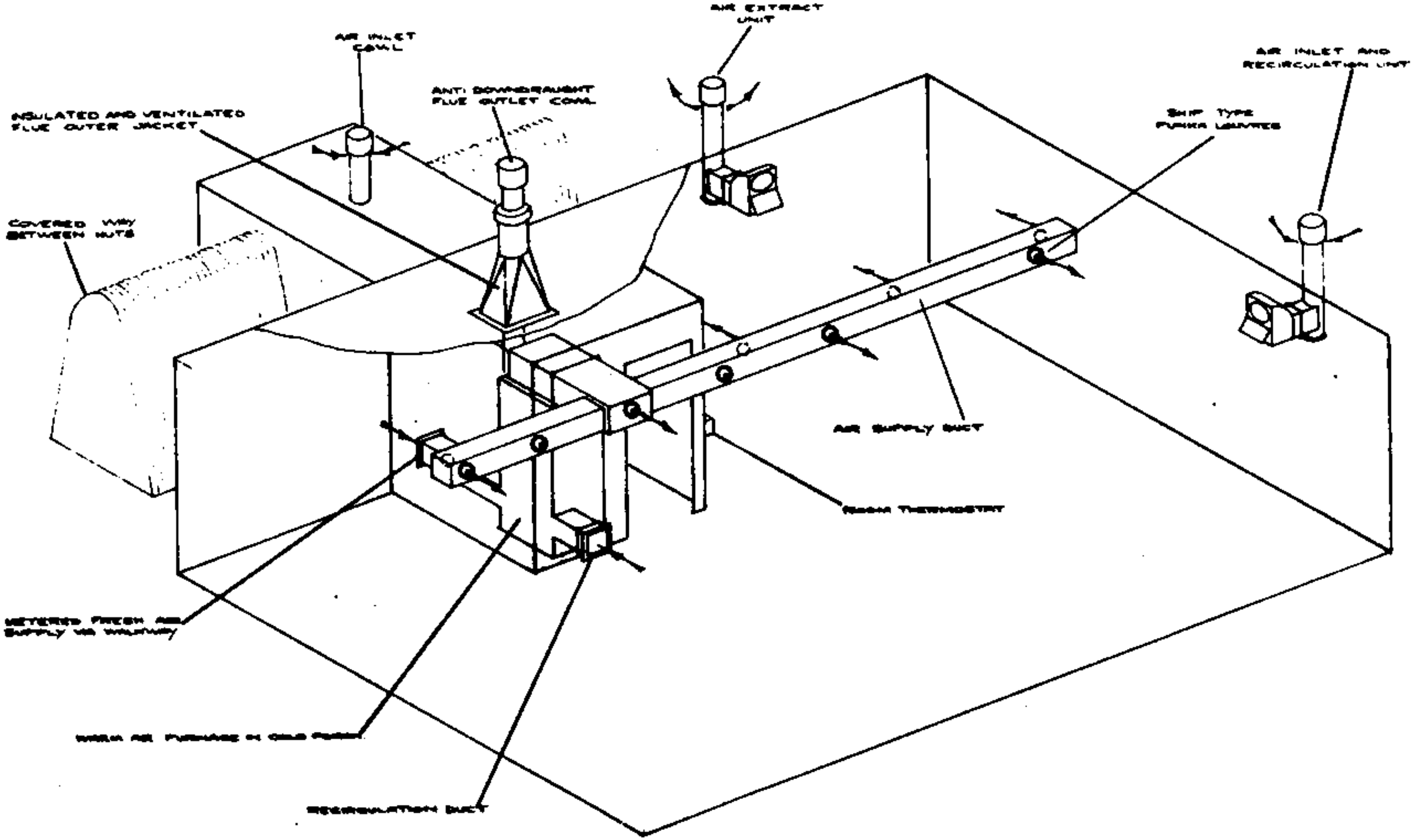


Figure 2. Heating and ventilation.

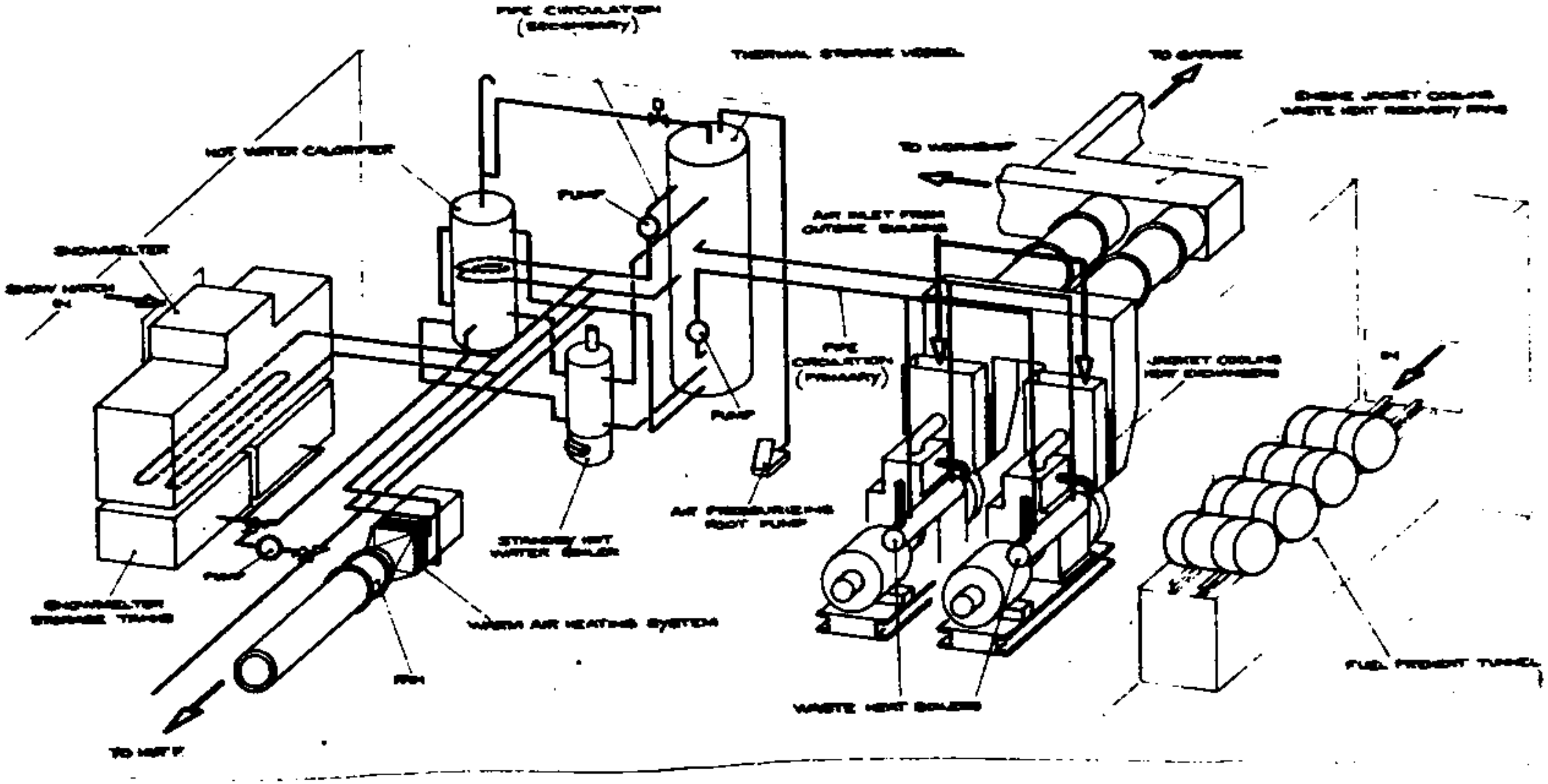


Figure 3. Engine jacket waste heat recovery.

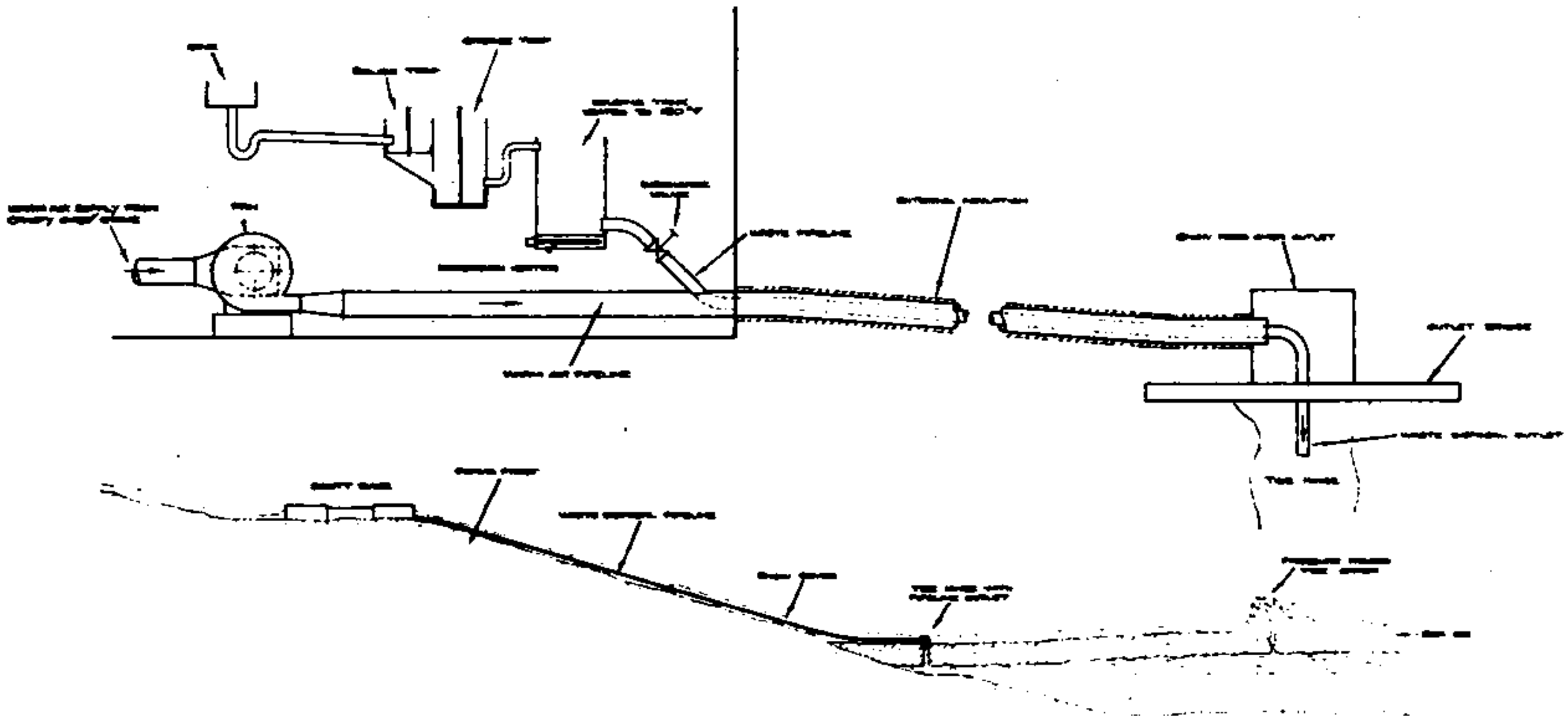


Figure 4. Waste disposal from mess hut.

THE REQUIREMENTS AND NATURE OF THE LOGISTIC SUPPORT FOR A SMALL NATIONAL ANTARCTIC EXPEDITION (B. Buildings)

J. J. la Grange

The technical data, photographs and sketches for this section have been provided by Mr. F. Mc All of the Public Works Department, Cape Town. Mr. Mc All came in right at the beginning when the Departments of Transport and Public Works started planning the new South African station on Antarctica in 1961, and he was in charge of assembling everything and erecting the station in Cape Town before sailing for Antarctica. Rightly he was in charge of the team of P. W. D. artisans who were responsible for the erection of the huts in Antarctica as well.

As different nations will be responsible for the various sub-sections, the author will not attempt to cover the whole section of Buildings. The contribution will be a short note here and there to point out a few aspects concerning the "small" expedition.

A. Permanent Establishments

a. The housing of personnel at S. A. N. A. E. is clearly indicated on the layout plan of the buildings. Separate buildings were decided upon to prevent fire, in case it should break out somewhere, from destroying the whole station. Every member has his own sleeping cubicle and as far as possible also a separate working place. Recreational facilities are in the living hut, laboratories are in the offices or for medical research next to the hospital. Part of the sleeping hut has been constructed in such a way that it can be used either as offices or if the number of expedition members should be increased, it can provide sleeping accommodation for 22 men.

b. A workshop for the radio technician is next to the radio operating room, the diesel mechanic's is in the power room. The erection of the outside garage has been left to be done after the winter. It is possible to do without such a garage if proper windbreaks made of canvas and eight feet high posts are used, however this makes maintenance on tractors in winter almost impossible. Storage space is provided for in the system of corridors between and alongside the huts.

1. Site Selection and Development

The "small" expedition's station can usually be erected on a fairly level site. Thus the amount of snow to be shifted is minimal and can be done by a small tractor with snow shovel (such as the Ferguson or Oliver OC-3 tractors) or to an extent even by hand. If the buildings have proper foundations in the form of several layers of beams lying across each other, then no holes for foundations are required. It is important that the site for the station should be carefully selected. If the station is on shelfice then being too close to the ice-edge is dangerous for break-off; there is usually a strong Katabatic wind near the ice-edge and to some extent meteorological observations will be influenced by frost-smoke, etc. About 20 miles inland meteorological observations will be more representative of Antarctic continental conditions but in this case the distance for transportation from the ship becomes too big. A happy medium seems to be about 10 to 12 miles away from the ice-edge.

2. Factors Affecting the Design and Siting of Buildings

The "small" expedition is fortunate in so far that it will have only a few buildings. Since the predominating winds on an open ice-shelf is usually from NE through SE to SW the drift will be mainly from a SE'ly direction. The big problem of one building's drift covering another, can thus be mainly prevented by having all the huts in a row in a NE-SW direction (or across the predominating direction if the winds are different to the above.) Outside constructions such as the garage and meteorological tower could with success be at the end of this line. Even afterwards when the huts have been covered by snow this arrangement will prevent drift which forms around the entrances, chimneys, etc., from spreading out over the rest of the buildings.

If the various huts are more than six feet apart, the snow in between will prevent fire from spreading. Communication between the buildings is easily obtained by covered corridors. Telephone communication between the huts, offices and laboratories will be easy.

If the huts and outside instruments are not spread out too far from each other, a guide rope can be erected which will safely lead expedition members to their outside instruments, huts or equipment in case of poor visibility or bad weather.

Erection problems in winter are almost insurmountable as driftsnow constantly covers everything and the intense cold makes it virtually impossible to handle screws, nails and small tools. When erecting new buildings, an all-out effort should be made to finish the outside work before the third week of March when winter usually suddenly sets in. Even in summer metal surfaces will be cold and should be avoided as much as possible if non-metal material of about equal durability can be used.

Heating and ventilation are very important factors and should be planned properly when buildings are planned. It is not enough if the air inside a room is heated to the required temperature by whatever heating device is used. Usually this results in a stable condition where the warm air will be near the ceiling and the cold air on the floor. In this way temperature differences of 10°C and even 20° between ceiling and floor is not uncommon. The air should be circulated inside the room, the most effective way to do this is by means of an electric fan inside a duct which will force the warm ceiling air down to the floor. It is also necessary to get fresh air into a room. Air let in through a window or door in winter is too cold, it should be heated. The air should be heated outside the building in a closed duct, in other words the gases from the heating element must be prevented from entering the air which will be forced into the rooms. Temperatures inside the buildings should not be too high, about 15°C at three feet height is a good working temperature. For sound sleep a temperature of 10°C has been found comfortable. Excessive heating becomes very expensive and has a psychological effect on men who, once used to high temperatures, will dread to go outside—the necessity of men getting out of the station regularly cannot be too strongly emphasized.

Living conditions should be comfortable; working conditions however should be given priority as far as comfort is concerned. The more luxurious living and recreation facilities are, the more difficult it is to get down to work as on an expedition there can be no such thing as "office hours" or "working hours" which force people to get on with their work. Decorations, especially bright coloured ones, provide a wonderful boost in morale. A certain amount of decorations should be supplied at the outset such as wall pictures but mainly, decorations should be of such a nature that they can be changed from time to time and thus help to prevent boredom setting in. A new layer of decorative paint now and again has a wonderful psychological effect. Decorations for Christmas and Mid-winter are essential.

The "small" expedition without aircraft will have to do all its transport by means of tractors and sledges even if they plan to set up a secondary station at some distance from the main Base.

On most of the small expeditions water is supplied by bringing in snow from outside and melting it in a container. The result is usually that water is very scarce. Bringing in snow from right outside can be a rather unpleasant experience in a blizzard. At Norway Station a covered snow tunnel next to the kitchen window supplied the snow which was used for the kitchen, another tunnel near the bathroom provided snow there. In the new S. A. N. A. E. Base snow is melted in the power station, as soon as the buildings are covered by snow, snow will be worked into a shute which leads into the power station; from here warm water is pumped to the other huts where it can be heated further if required.

Waste, which so often spoils the appearance of Antarctic stations, should with a little bit of trouble, not do so. If the station is on snow, garbage which is taken say 400 yards down wind, will drift over and rarely will a big rubbish heap be seen. A station on rock can dump its rubbish in the sea some distance away. The main point is that the station has to be kept clean, any dirt should be picked up and every day or second day all waste should be taken away. This can easily be done on a small manhauling sledge. A clean station and surroundings will certainly boost the morale and thus indirectly increase and improve the work that is being done.

3. Construction methods are well covered in the paper by Mr. McAll

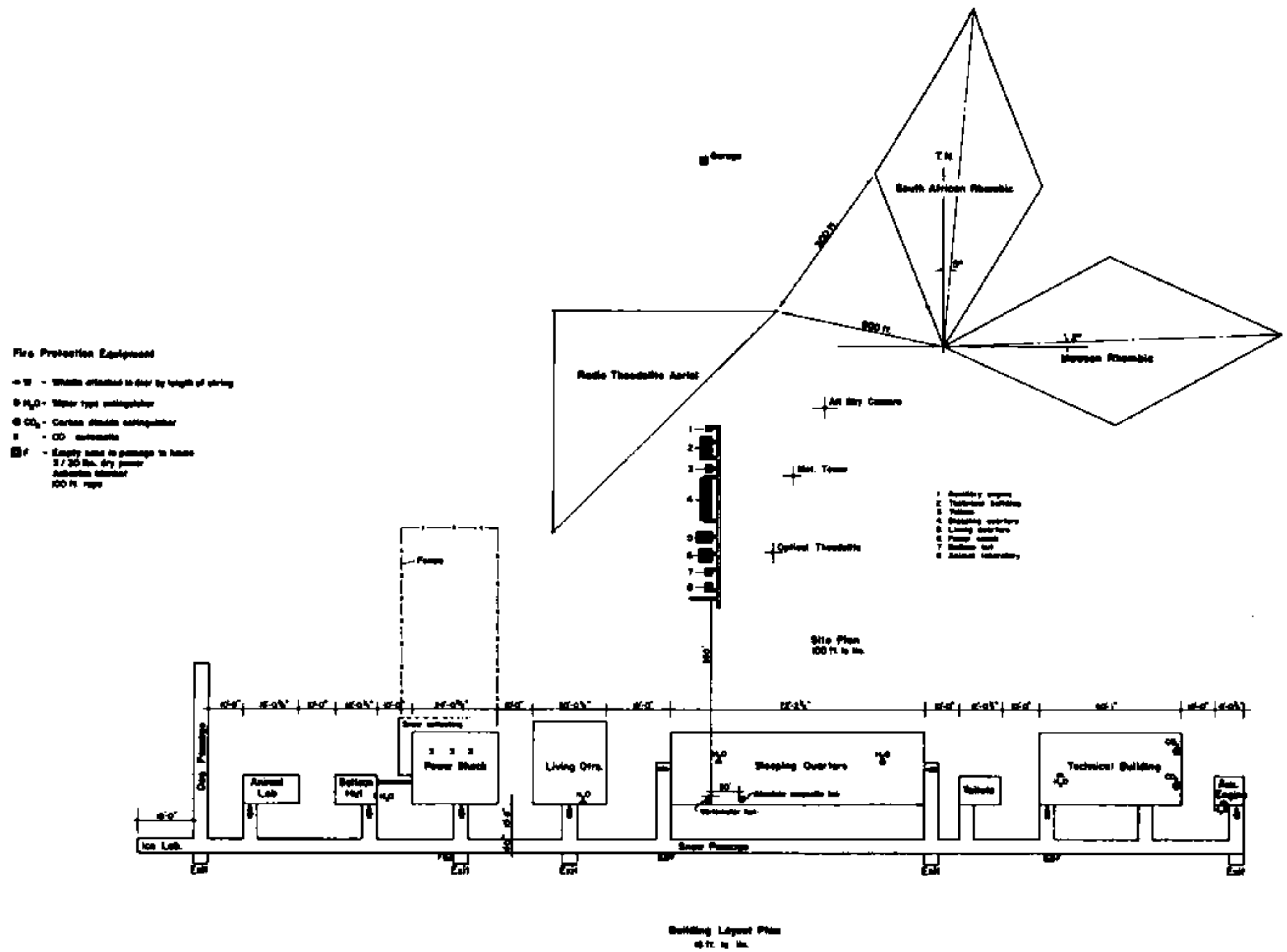
4. Fire Precautions

The author thinks that more lives have been lost due to fires than to any other reason at Antarctic stations. There is hardly a station at which a fire, big or small, has not occurred. Fire fighting but especially fire prevention should therefore almost have the highest priority at a station. A system can be worked out whereby every room and passage will have the necessary fire fighting equipment. Of course everybody must know how to handle the equipment and they must be able to find the equipment and use it even in the dark. Escape hatches apart from main entrances must be checked regularly to ensure that they can be used if necessary. In the new S. A. N. A. E. station the bigger huts all have two doors, at various places the corridors have escape hatches, it should therefore not be necessary for anybody to remain trapped in case of fire. The base should have discussions on fire fighting and prevention from time to time, everybody should have a clear cut picture of what to do in case of fire. More important than fire fighting though is fire prevention. Never throw a match away before breaking it in two halves, never knock out a pipe or throw a cigarette end into a wastepaper basket or some other rubbish heap, never leave a room unattended if an open flame is burning in it, do not strike matches or have open flames near the balloon hut, do not hang clothing articles to dry near chimneys or hot air vents—these are all golden rules. Most of the expeditions have a 24-hour duty roster, it is well worthwhile to have the "nightman" do an inspection round every hour in the power station, radio room and other unattended buildings.

5. Maintenance

As there will not be a professional carpenter on the small expedition, it is the duty of everyone to be on the watch the whole time for possible deterioration and to bring this to the expedition leader's attention—the best way of repairing can then be worked out. After a few years it will become necessary to put props in somewhere to keep the roof up or most commonly to prevent the floors from coming up.

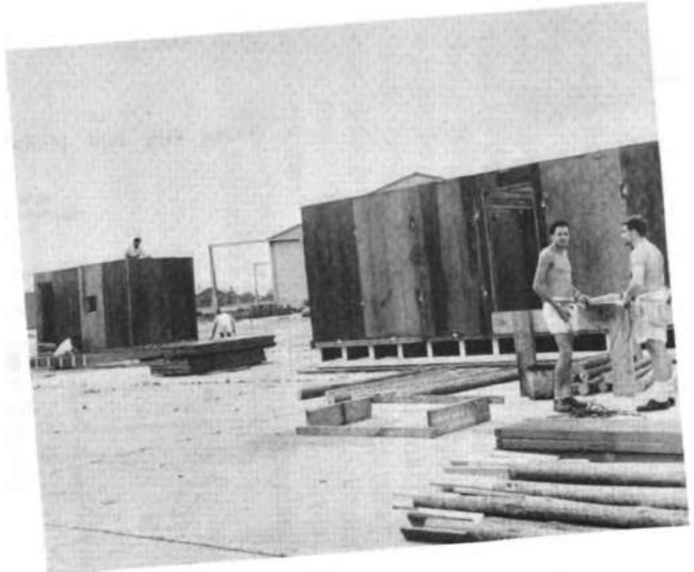
If everybody would endeavour to make the Base and his own as well as communal rooms his "home away from home" then most problems regarding cleanliness, fire prevention and other maintenance duties will never occur.



S. A. N. A. E. - New Meteorological Station - Layout and Site Plans

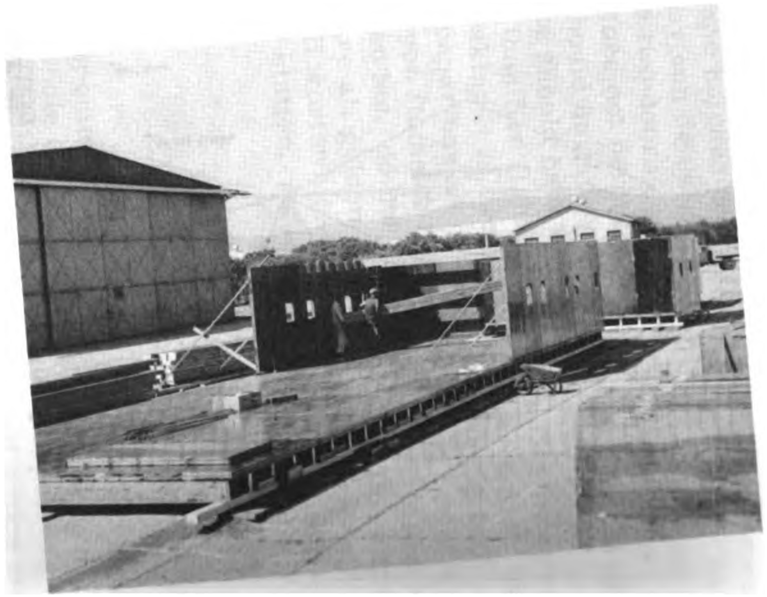
Drawing No. 10748/9

Dining

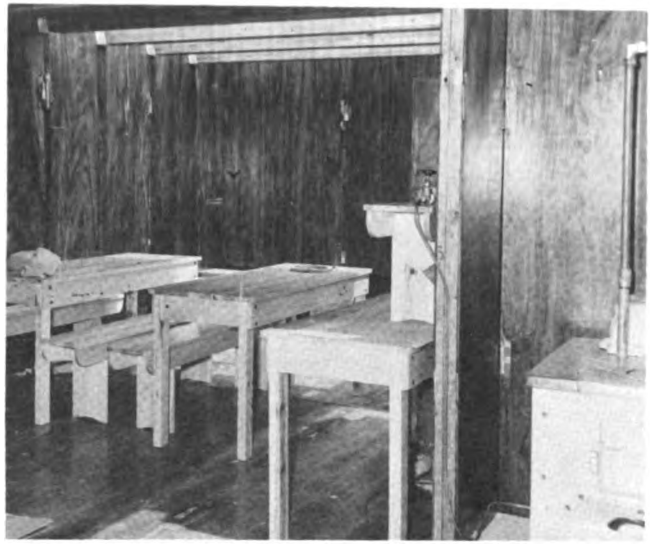


Animal Lab and Power-Shack

Power Shack and Dining

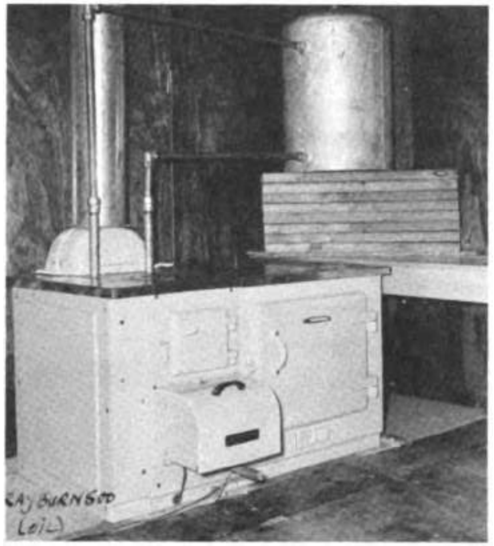


Sleeping Quarters

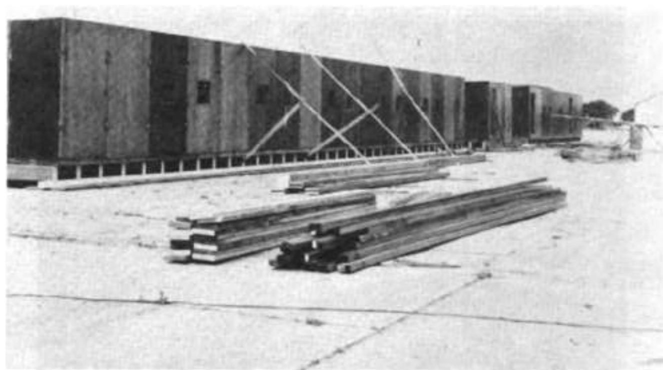


Kitchen

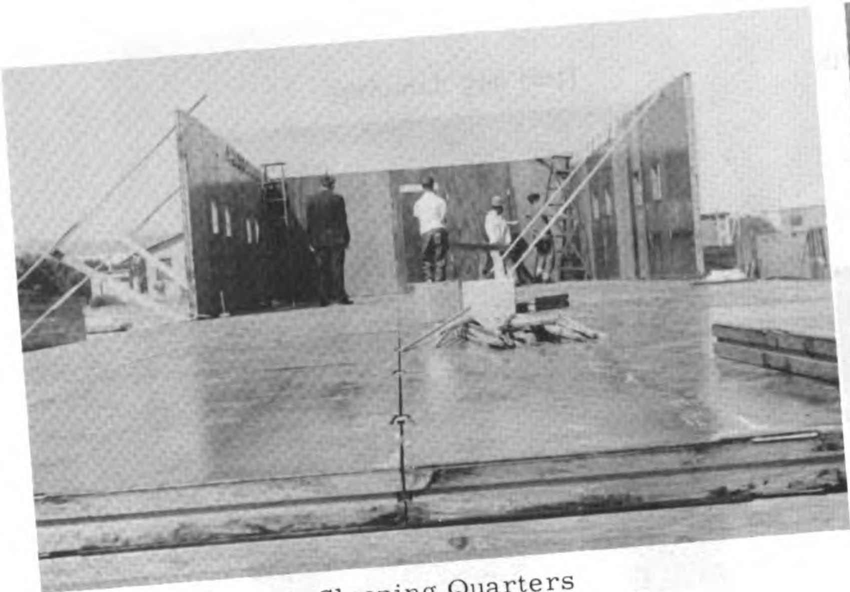
Kitchen



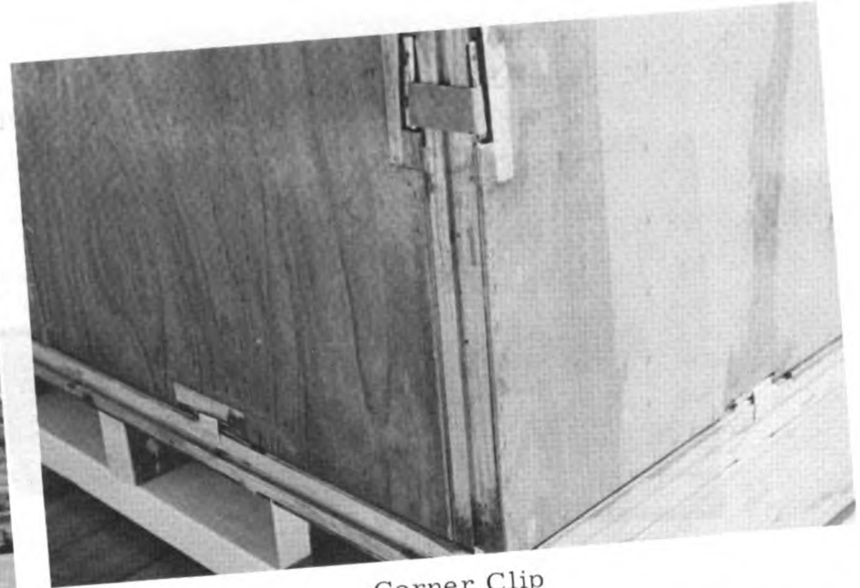
Rayburn 500 (oil)



Sleeping Quarters, Toilet and Technical Building

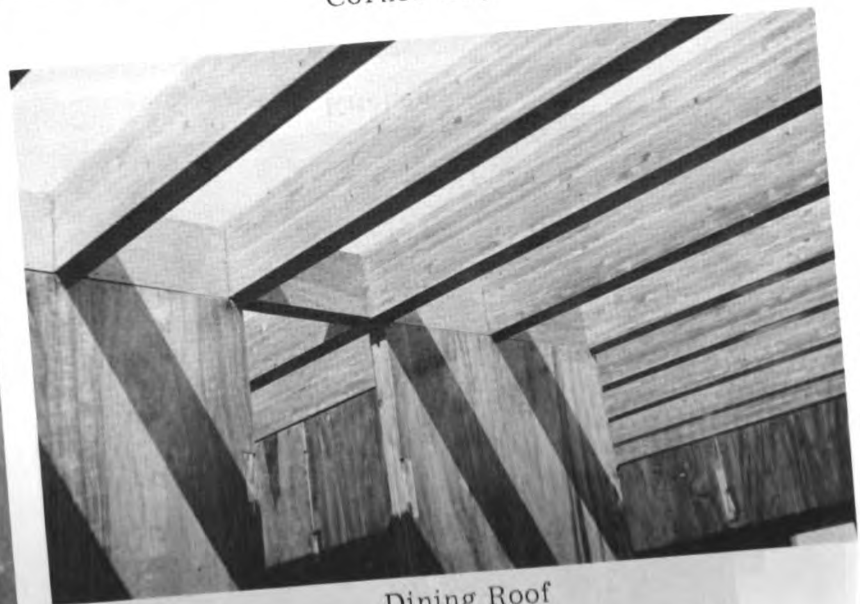


Sleeping Quarters



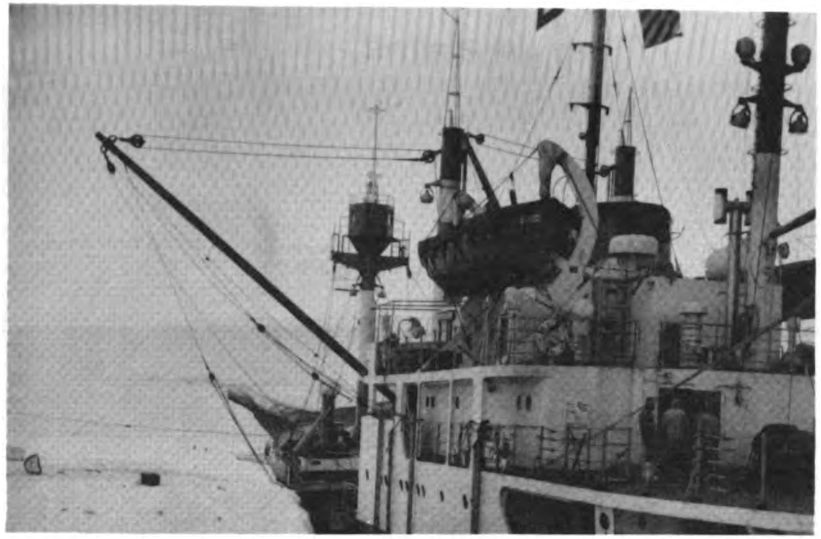
Corner Clip

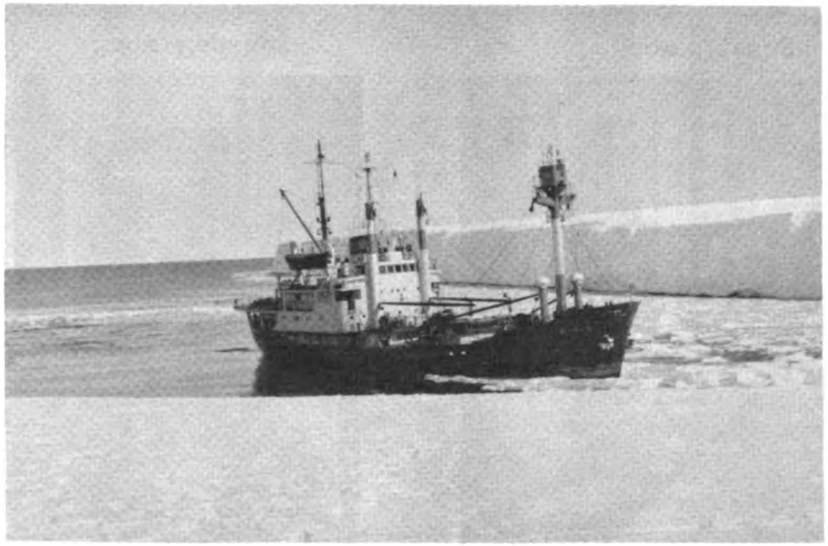
Common Wedge Clip



Dining Roof

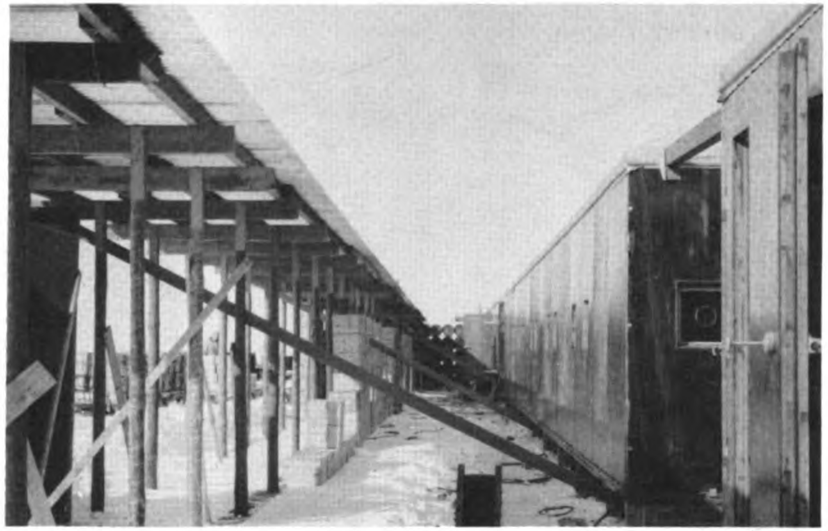

P. W. D. Team


RSA at Polarsirkel Bukta

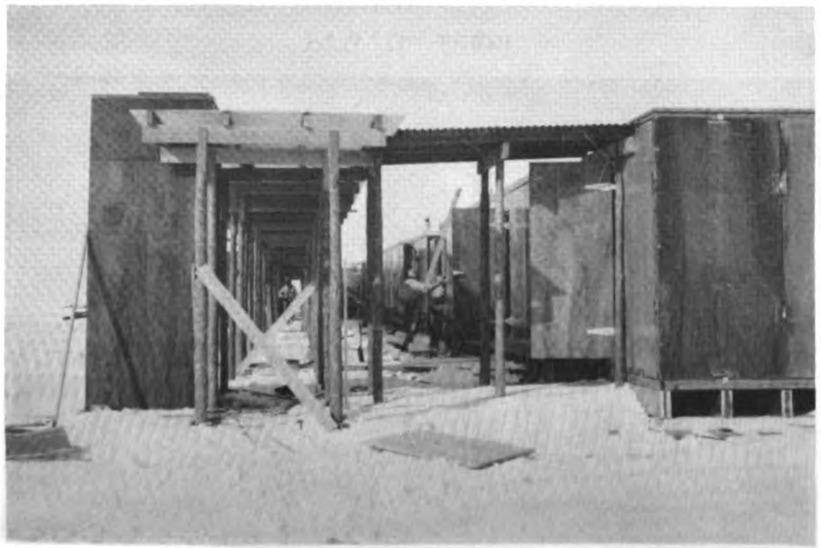

RSA


Snow Passage

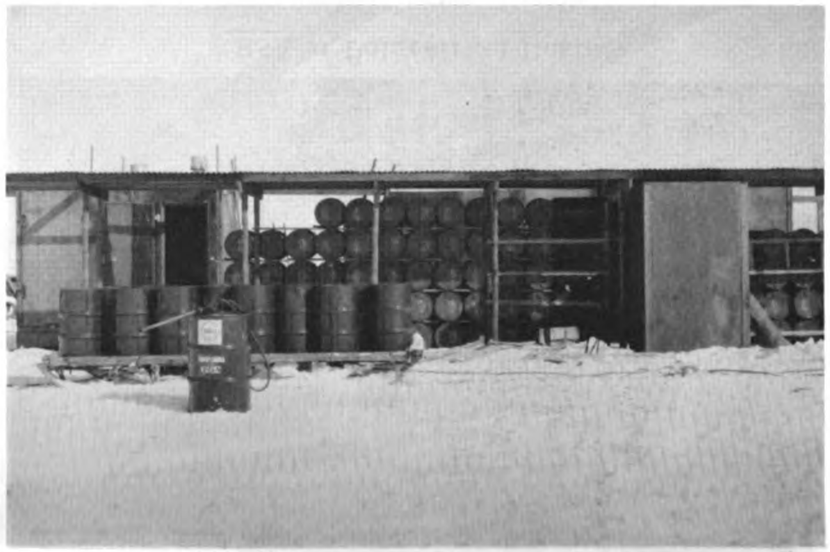
Snow Passage



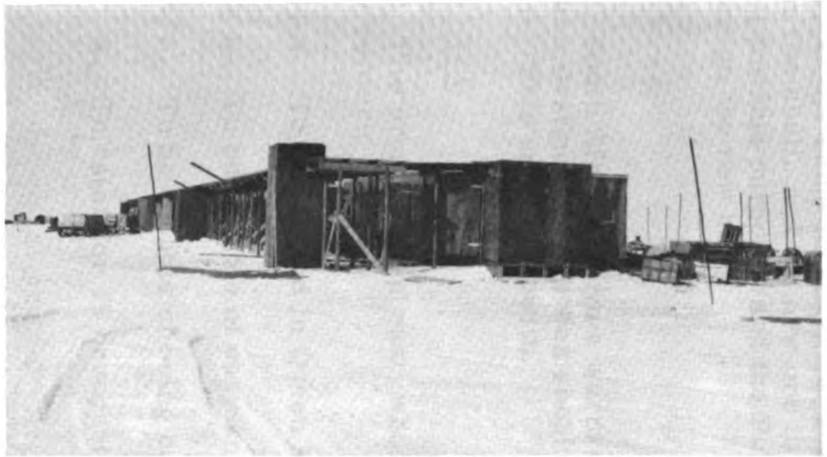
Snow Passage and Sleeping Quarters



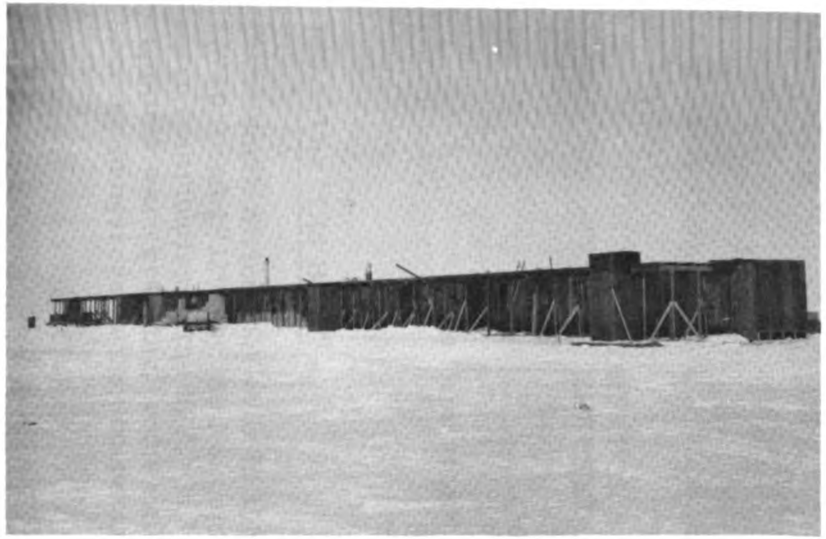
Exit, Snow Passage and Auxiliary Room



Hydrogen Building and Exit

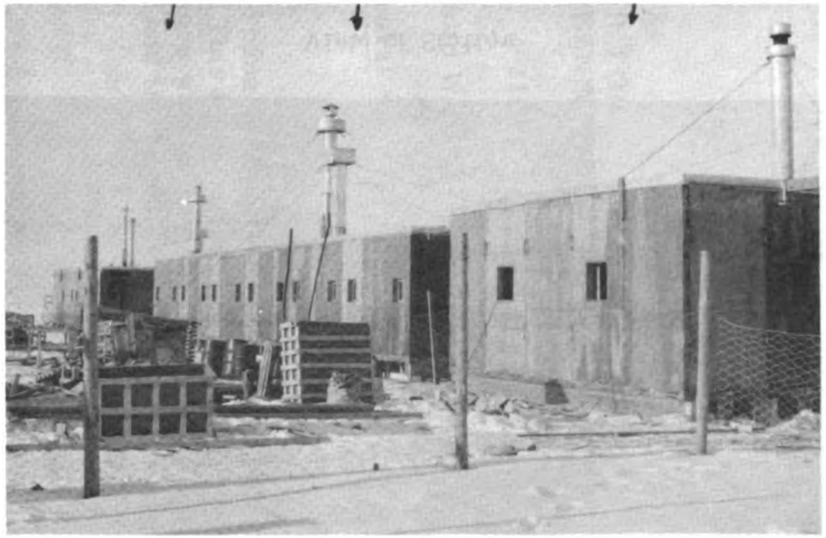


View from NNE

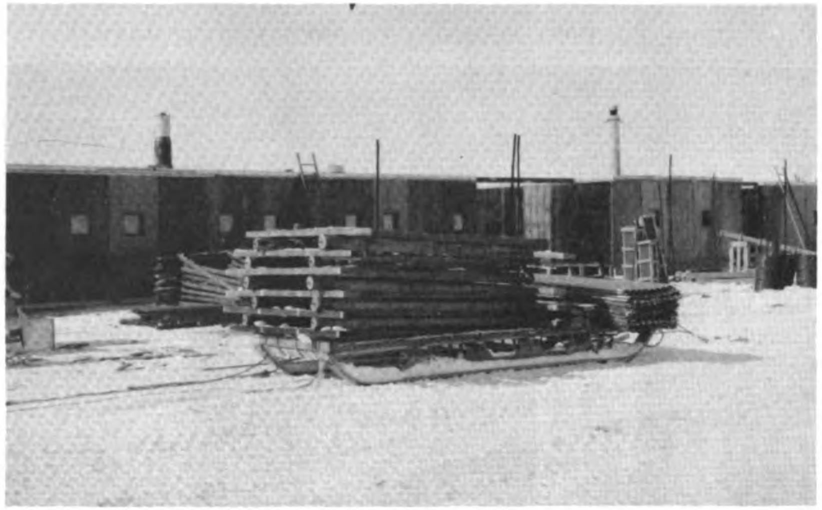


View from NE

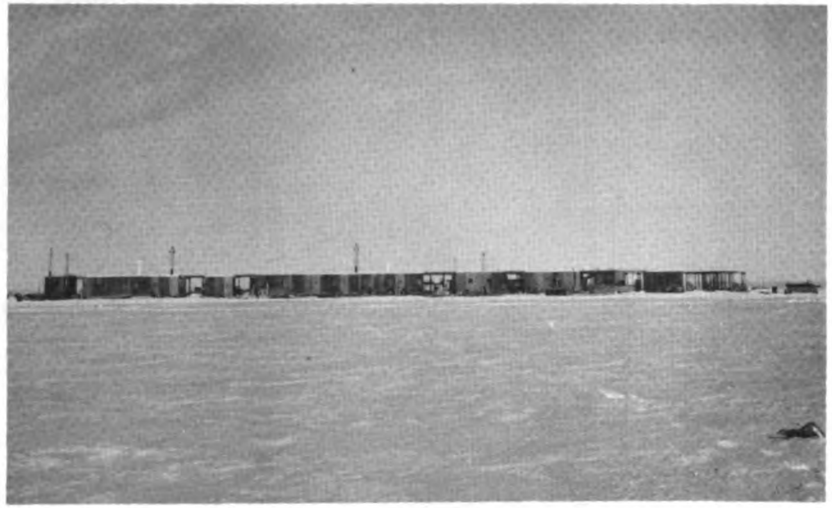
Taken from Technical Building Looking South



Technical Building Sleeping and Dining, Southwest of Dining



Sleeping Quarters and Dining with Maudheim Sledge 12' x 14' (app.) in foreground



View of Station

REPORT (FOR S.C.A.R.) ON THE NEW BASE
ERECTED IN QUEEN MAUD LAND

(70°16'S, 2°21'W)

The Department of Public Works, Cape Town

General

1.0. The "Old Base"

South Africa took over in 1960 the research base established in position 70°30'S and 2°32'W by the Norwegians. This base had been erected by Norway for their contribution to the IGY. In 1961 there was 18' of snow on the roofs, timber supports were cracking, roofs caving in and floors pushing up: the buildings had become dangerous to the occupants.

2.0.

The South African Government therefore decided on the erection of a new base, in the same locality, but nearer to the ice shelf. The old base was 24 miles from the shelf, and the new one to be 12 miles from it. A sum of £25,000 was voted for this purpose, and the Public Works Department was asked in May 1961 to design the new base.

3.0.

South Africa enjoys a warm climate and has therefore little or no experience in such design. Advice was sought from Britain, America, New Zealand and Belgium. This came forthwith.

3.1.

The problem then was: whose design would nearest suit the South African requirement:

a. To be erected in Queen Maud Land, which has a high rate of snow build-up.

b. To be capable of easy and speedy erection.

c. To be capable of being completely prefabricated in six months.

d. To cater for 15 occupants in 1962, possibly increasing to 22 in later years.

3.2.

It was decided that the safest course would be to adopt in principle the layout and construction employed by the Belgians (The Baron Gaston de Gerlache de Gomery) in their base at Breid Bay. This they erected in January 1958 for the IGY. The buildings were of the "Clements" type, with flat roofs. Breid Bay's conditions approximated those at Queen Maud Land. The Baron was most helpful in supplying information.

3.3.

It seems therefore most appropriate that South Africa is grouped with Belgium in Section 3, paragraph 3 of the S.C.A.R. agenda.

4.0.

Design, size of buildings and quality had to be tailored all the while to fall in line with the voted funds.

5.0.

The fabrication of the buildings was given out in several contracts for the different materials required: panels, hardware, roof covered, etc. and the general pre-assembly carried out in an open area by the P.W.D. artizan staff.

6.0.

The six months was all too short, but the ship sailed with all materials on board, essential imported installations arriving two days before sailing date.

7.0.

Erection took place between the 25th January and 12th February; 16 days. 10 artisans working shifts of 5 a shift erected the 3,500 square feet of buildings to over 90 per cent completion, and in a habitable state. The 1962/3 wintering staff have completed the remaining work.

8.0. List of Buildings Erected (dwg. No. 9)

Auxiliary Engine room	8' x 8' x 8'
Technical Building	40' x 20' x 8'
Toilets	12' x 8' x 8'
Sleeping quarters	72' x 20' x 8'
Living and dining	40' x 20' x 8'
Power shack	40' x 20' x 8'
Balloon hut	12' x 8' x 8'
Animal laboratory	16' x 8' x 8'
Garage	16' x 12' x 8' (erection on site delayed until summer).
Variometer hut	16' x 8' x 8' (erected by base staff).

NOTE: Further particulars are available through Transport Pretoria.

Some Lessons Learned

Light, open framed side supports for sledges were desirable.

Wedge clips could have been stronger.

Hydrogen cylinder residue burns deep holes in snow and could be used to make pits for outlets, toilets, etc.

A satisfactory fingered working glove for artizans has yet to be found.

Always take too many plumbing fittings.

Digging down a few inches into snow for foundations is far better than digging in some parts and filling up in others.

PORTABLE PREFABRICATED LABORATORY

L. G. C. E. Pugh

The Himalayan Scientific and Mountaineering Expedition 1960-61, leader Sir Edmund Hillary, took out to the Himalaya a prefabricated laboratory-hut incorporating design features that might fit it for use in the polar regions. The hut was a cylindrical structure 22 ft long and 10 ft in diameter, and weighed approximately 1 ton. It was composed of about 100 sections, the walls consisting of 4 1/2" thick plywood panels of stressed-skin construction. Each panel was filled with foamed plastic and lined with aluminum foil. There were eight bunks, and space for a laboratory at one end. Heating was provided by a kerosene stove specially designed to operate at 20, 000 ft over a wide range of wind velocities. It was completely sealed off from the interior hut, thus eliminating the danger of carbon monoxide poisoning. The hut was transported from Kathmandu to the Ming Bo glacier, a journey of 200 miles, by 60 porters, and erected on the glacier névé at 19, 000 ft. It was erected on jacks and held down by steel cables. Erection was completed in less than one day. The hut was occupied continuously for five and a half months, and a major scientific programme was completed. The hut was designed to give protection at temperatures down to -40°C. However, the lowest temperature encountered was -27°C. Winds of 40 knots gusting to 60 knots were common during the winter months. The kerosene requirement for all purposes was 1 1/2-2 gallons a day. Electrical power for light, radio communication and scientific instruments was provided by a wind generator, with a petrol generator held in reserve. Nickel iron storage batteries were used, giving 24 volts and having a capacity of 45 ampere hours at the five-hour rate of discharge. After the expedition the hut was dismantled and transported 170 miles to Darjeeling, where it was re-erected and is still in use.

Details of the specification and construction are as follows:

The 22-ft length of the hut was divided into eleven 2-ft wide rings consisting of curved wall-panels and straight floor-panels. The floor-panels were of the same stressed-skin construction as the curved-panels, but had a 6 mm. plywood skin on the upward-facing surface which formed the floor of the hut. This proved to be strong enough for the purpose. Each ring was erected separately upon a base frame previously erected and levelled by means of adjustable jacks. Spirit levels were built into certain beams as an aid to accurate levelling. The frame could be erected either on a rocky surface or on snow. In the latter case the jacks were located on 3-ft square wooden panels dug into the snow.

Stressed-Skin Panels

The majority of these were identical and the curved shape was designed not only to fit the circular section of the hut but also to make manhandling easier for the porters; they could either be used as carriers for other equipment, or four of them could be placed together to make one 60-lb. load. The main frame of the panels was of 9 mm. WBP plywood, additional stiffening being provided by balsa angle blocks; the outer skin was of 2 mm. birch plywood to A.I.D. specification. The whole assembly was fabricated in an accurately made jig and glued with a cold-setting resorcinol adhesive. Foamed polystyrene was packed in one-inch layers into the cavity between the panel skins. A layer of aluminium foil was placed immediately internal to the inner skin and served the dual role of radiant heat and moisture barrier. The panels were treated with aluminium paint to act first as a moisture-retardant treatment and secondly to help retard radiative heat exchange with the environment. In order to minimize the fire risk the inside panel face was treated with a fire-retardant paint. The estimated 'U' value of this form of panel construction was less than 0.05, or about six times better than the insulation afforded by the average brick 11-inch cavity wall.

Joints

The panels were located together by large hard-wood dowels engaging in pre-bored holes in the main frame. These dowels took the shear-stress during erection and were essential to the stability of the structure. The panel edges were compressed together by means of steel clips. The primary seal between adjacent panels when assembled was provided by 1/4-inch thick expanded polyurethane strip glued around the panel edges. After erection the outer seams were filled with mastic applied by the normal gun technique. Finally all joints were covered with a two-inch wide waterproof tape.

Guys and Stress Wires

Each ring was fitted with a 3/16-inch circumferential stressing wire, tightened by means of a turnbarrel. Upon completion of the ring structure, five longitudinal stressing wires were fitted and tightened in a similar manner to the circumferential wires. The employment of these high tensile stressing wires was a new development in the application of post-stressing techniques to timber construction, i.e., producing a rigid cylinder from a number of small component panels.

Attached to the circumferential stressing wires were steel guy-ropes which could be attached to bags of ice buried in the snow, to piles of rock, etc., in order to hold the hut down against the force of the wind.

Windows and Internal Fittings

Windows were placed at each end of the hut and the door at one end. The windows were quadruple glazed with 1/8-inch clear perspex. Behind the external door was a small storm-lobby with an inner door. Internal fittings consisted of eight bunks, a drop-leaf table for preparation of food, two laboratory benches and a second drop-leaf writing table.

Ventilation

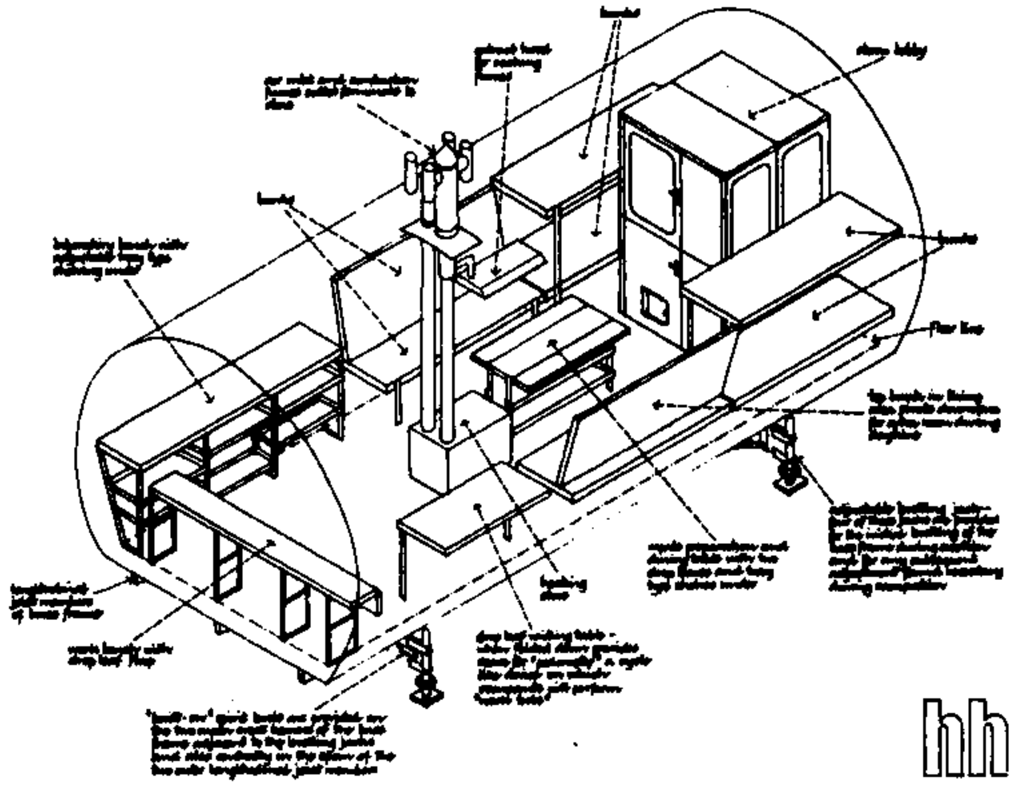
Adjustable louvred ventilators at high and low level at each end of the hut provided natural ventilation. There were also ventilating sleeves surrounding the stove flues where they passed through the roof. When conditions warranted, the large central window at one end of the hut and the top half of the stable doors at the other end could be opened. Ventilation proved adequate, but large temperature gradients often developed between floor and ceiling and were a cause of some discomfort.

Acknowledgement

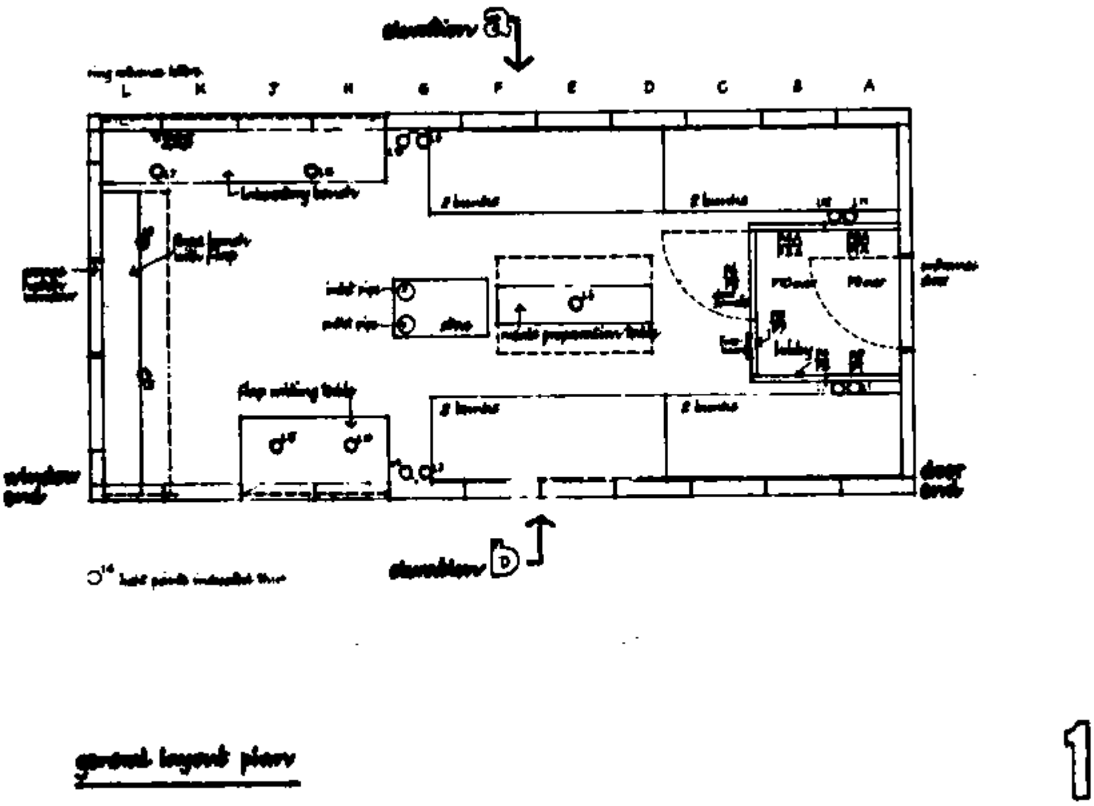
The expedition was sponsored by the publishers of World Book Encyclopedia, Chicago, Illinois, U.S.A.

The hut was designed by E. Levin, of the Timber Development Association, 21 College Hill, London, E.C.4., in collaboration with the author, and built by J. M. Jones & Sons Ltd., Highway Works, Maidenhead, Berkshire, England.

High Altitude Laboratory at 5800 m



High Altitude Laboratory at 5800 m



High Altitude Laboratory at 5800 m

DESIGNS FOR ANTARCTICA

Harold G. Lewis

Stations for IGY Program

The seven stations constructed under the IGY Program were located in areas having two basic environments i.e., either coastal or inland. The coastal stations, except for Little America V which was located on an ice shelf, were constructed on exposed soil or permafrost and the inland stations were constructed on the surface of the ice caps. The principal difference in the design concepts employed in development of these stations was that stations located on the ice cap or shelf were designed as buried stations, although initially placed on the snow surface, while the coastal stations were designed to remain exposed, or partially exposed, year round, since snow does not continue to accumulate in these areas.

Although the design concepts to be considered for a buried station vary widely from those of the coastal stations, a basic multi-purpose building for all stations was employed. The short time available for planning and design of the basic structure and the uncertainties of the site conditions to be encountered, dictated the advisability of utilizing a multi-purpose structure which would have maximum interchangeability of component parts and which would require minimum erection time. A simple prefabricated insulated panel structure was developed for use at all stations and for nearly all facilities. The 20 foot wide structure is made up entirely of 4' x 8' x 4" thick panels, that are fitted together with loose splined joints, providing maximum interchangeability and a minimum of dissimilar parts. High tensil steel roof trusses are fitted into wedge shaped pockets built into wall panel and when driven tight develop a rigid frame action providing latteral rigidity to the structure. The roof trusses also aid in the erection process by supporting wall panels and providing a platform for placement of roof panels. All panels are held together with surface applied wedge clips which when driven tight draw the panels together against special cold weather rubber gasket. The shell of a 20' x 48' building can be erected with a four man crew in two hours without special tools and without weight handling equipment. The building, which has no through-metal parts was provided in modular lengths of 8 feet and by variation of wall panels, with ceiling heights of 8' or 12'. The interior of the multi-purpose building was lined with a continuous aluminum sheet and joints were taped with pressure sensitive tapes to provide a positive vapor barrier. The building was designed to withstand a 125 lb/sq ft snow load, 100 mile per hour wind and had a panel "U" factor of .085.

Building constructed on permafrost at the coastal stations were placed on 8" x 8" wood sills laid directly on the permafrost without gravel pads, and the space beneath the floor was not insulated. Experience has shown that heat transmissions through the floor of buildings erected in this manner has been insufficient to cause foundation problems and floor settlement. Building constructed on snow or ice at the inland stations, however, were placed on high tensil steel "saddle-type" trusses which transmit the weight of the building to timber pads outside the projected floor perimeter. Past experience had shown that buildings supported directly on the snow with foundation sills beneath the building, become distorted and unstable due to heat loss through the floor, melting snow beneath the building. Foundation pads, placed on the snow surface without compaction, were sized so that the maximum pressure exerted on the snow did not exceed four pounds per square inch. Foundations of this type erected at the Byrd and Pole Stations have proven very successful, capable of supporting weights up to 15 psi, and after seven years of service show no signs of structural stress.

Although the buildings for inland stations were initially constructed on the snow surface, it was recognized that they soon would become buried and the stations must function as sub-surface facilities. Therefore connecting corridors, and storage caches were also constructed on the surface to provide access and storage space between the units when the stations became snowed in. Since the total cube of undersnow storage caches and tunnels, required for annual operations, considerably exceeded the total cube of the buildings, it was necessary to develop a structure of minimum cost. The resultant solution was a timber frame in 4, 8 and 20 foot widths covered with chicken wire and then burlap or canvas. This type of construction was very economical and has proved to be quite satisfactory for corridors and caches in areas of relatively light snow accumulation such as the South Pole Station. After seven years of service, they are still in near perfect condition at the Pole, however, at the Old Byrd Station heavy snow accumulation caused failures within three years.

Heating, Ventilation and Fire Protection

Most of the buildings erected in the early Deepfreeze Program were heated with diesel oil burning jet heaters. These high velocity hot air furnaces were equipped with two-inch diameter ducts which were run to each room and terminated into silencing diffusers. 55, 000 Btu radiant type space heaters, also were used as standby units in the event a power failure rendered the forced air system ineffective. Radiant type space heaters are less satisfactory as a primary heat source because of heat stratification and their lower efficiency.

One of the greatest fears of men when living in buried buildings is the fear of carbon monoxide poisoning. Therefore, particular care was taken to provide a positive means of fresh air in the buildings and to locate smoke and exhaust stacks so that discharge gases could not be drawn back into the buildings. In addition to carbon monoxide detectors, which were provided in each buried building, air intake fans sized to maintain a slight positive pressure in the buildings at all times, were provided. These were located at the ceiling to pull cold air through insulated flues and discharge it horizontally along the ceiling to minimize stratification of the warm air at the ceiling. Exhaust fans were located in the vestibules leading to tunnels, to serve a dual purpose of tempering the air in the connecting corridors, however, this feature proved a mistake as the warm air caused the corridors to glaze with ice which became rather hazardous. Positive fresh air intake and exhaust of all habitable spaces cannot be overstressed in design and operation of sub-surface facilities.

Another important concern to men living in combustible buildings below the surface is fire protection. Since water in the liquid state is a premium in interior Antarctica, adequate fire protection poses a difficult problem. The current policy is to provide buildings fabricated only of non-combustible materials; however, funds available for the IGY Program did not permit this feature. Therefore, fire protection features were limited to the provision of heat sensing devices located in each building and connected to visual and audible alarm panels, separation of buildings with snow barriers, smoke screens in connecting corridors, portable water and carbon dioxide extinguishers and isolated emergency living facilities. This level of fire protection is based on the assumption that an individual building would be lost once the fire is beyond control of hand extinguishers. We have been fortunate at our interior stations in that no serious fires have occurred.

Above Surface Structures

The scientific programs required that certain buildings be permanently elevated above the snow, such as the Aurora building and rawin towers. A simple light weight aluminum tower was developed, utilizing telescoping pipe columns for legs that offered minimum wind resistance and which could be jacked periodically to maintain the structure above the snow. The telescoping legs consisted of six inch aluminum pipes inside of seven inch aluminum pipes that were drilled on six-inch centers and fitted with dowels and jacking beams. These towers, which are guyed to "dead-men" in the snow to withstand 100 mph winds, are light enough to be erected without the use of weight handling equipment under weather conditions which prevail at an elevation of nearly 10, 000 feet at the South Pole. They are still in use and have proven quite satisfactory. An enlarged version of the same tower use provided for four structures at the new Byrd Station.

Water and Sewer Facilities

The stations constructed for the IGY Program were provided with only the simplest and most primitive type of water and sewer facilities. Since they were designed for only a three year life, we did not consider that costly and elaborate utility systems were warranted. Each building that required water such as washrooms, galleys and photo labs was provided with a separate snow melter. These snow melters were designed to utilize waste heat from the jacket water of diesel generator units, from the galley or space heaters. Auxiliary electric heaters were also provided in the melters for use when the power demand is low and to balance electrical loads in the various phases. In order to utilize waste heat from the diesel generator units, washrooms or buildings requiring water were located within or adjacent to the power building. This type snow melter has proven to be both adequate and satisfactory for small stations with populations not exceeding 25 persons. For the larger stations where the water demand is 1, 000 gals/day or more, standard commercial type asphalt kettles have been found to be quite effective snow melters. However, use of these oil burning kettles, which were developed to melt bituminous products for road work, results in a costly water supply system when burning Arctic diesel oil.

Sewage and waste disposals at stations located on the ice cap present considerably less problems than at the coastal stations located on permafrost. Simple pits dug beneath the buildings have been used quite successfully at the interior station. The original buildings were provided with interior waste tanks for collection of water from showers, lavatories and the galley. These waste tanks were equipped with immersion heaters and when the tanks were filled, the water was heated and released. This jet-type disposal of large quantities of hot water caused the sewage pit to continue to grow deeper without latteral enlargement and without jeopardizing building foundations. Privy type latrines were placed over the pits for disposal of wastes. Experience has shown that sewage and wastes may be disposed at stations on the ice cap without the necessity for the heated waste tank system, if the toilet facility is relocated periodically when the pits become filled.

Sewage collection at the coastal station has proven to be a difficult operating problem. The facilities provided were based on the "honey-bucket" system. Toilet buildings were elevated slightly by placing them on steel trusses similar to those used for foundation trusses at the inland stations. Human wastes are collected in half sections of 55 gallon fuel drums, allowed to freeze, and then delivered to the bay ice in hopes that the summer thaw will dispose of them. Water from showers and wash basins is merely drained through rubber hoses to an area a short distance from the building where it freezes and remains until the summer thaw. Since a system of this type is both unsanitary and odorous during the summer months, reconstruction plans are based on installation of above ground heated collection systems.

Fuel Facilities

Fuel oil for heating, equipment operation and power generation, the largest single logistic problem in Antarctica, is delivered in bulk form by ship to the coastal stations. At McMurdo, it is pumped from the ships across the ice, from five to ten miles, through rubber hoses into 250, 000 gallon steel tanks. These tanks, which are constructed directly on the permafrost, are prefabricated in the States and welded together in the field. In addition to these large permanent tanks, 10, 000 gallon neoprene tanks also are used at both inland and coastal stations. These flexible tanks, which weigh approximately 750 pounds and may be folded for storage into 125 cubic feet spaces, have been used successfully when layed directly on snow, ice or permafrost. They require only minimum effort for installation and provide convenient bulk storage for almost any use. Fuel oil for the interior stations is delivered by ship in 55 gallon drums to McMurdo and then flown to the interior generally by C-124 aircraft for air drop. Both the free drop and the chute drop methods have been used. Free drop of drummed fuel however, proved costly due to excessive drum breakage and loss in deep snow. Since many manhours are consumed during the summer months by construction personnel bucking sastrugi and corralling drummed fuel across multi-acred drop zones, the C-130 aircraft is being used as much as possible for delivery of fuel to the interior stations. However, the limited number of C-130 aircraft available for Antarctic operations necessitate continued use of C-124 aircraft and air drop delivery of fuel and supplies.

Current Construction Program

Sea Water Conversion Plant

Designs were recently completed for a multi-stage flash type seawater conversion plant. This plant will utilize process steam from the nuclear power plant to produce 14,400 gallons of potable water per day. Sea water will be pumped from beneath the ice of McMurdo Sound through an insulated and heated pipe over 300 feet up Observation Hill to an indoor salt water storage tank. A flexible suction line, designed to carry away when the ice goes out, will be connected to permanent pumps mounted in a heated pump house located on the shore, to provide the salt water supply system. The hot salt brine will be returned through a pipe encased in the same jacket with the intake line to prevent the intake water from freezing. Potable water will be delivered by gravity through an insulated and electric heated, above ground water main nearly 3/4 of a mile down the hill to service the camp. Flush type toilets and pressure water systems will be provided in all buildings where such facilities are required. The 50,000 gallon of potable water also will be utilized as a reservoir for indoor fire fighting with hose reels being provided in each building.

A standard prefabricated steel insulated panel building, of all noncombustible materials, has been developed for general use in reconstruction of the McMurdo Station. This type building, which utilizes steel sandwich panels having four-inch fiber glass insulation, with steel inner and outer surfaces supported on a steel frame, will be used for the sea water conversion plant building, maintenance and storage buildings, new barracks, etc. The building is designed for a 100 mph wind load, 35 psf snow load and a panel "U" factor of .085. Plank type wood decks four-inch thick, covered with linoleum or steel, are provided for the first floor and steel decks are used for the second floor. The foundation consists of a three foot deep gravel pad placed on the permafrost, wood timber sills, a rigid steel frame, four-inch insulation, and a treated timber deck. This type of foundation insulates the permafrost from the warm floor and permits air circulation beneath the building. Future use of this building at McMurdo will greatly alleviate the structure fire hazards and will provide facilities which are commensurate with facilities in this Country.

Marginal Wharf

Another facility now being designed for McMurdo, is a ship unloading facility. Preliminary studies indicate that a marginal wharf may be feasible on the west side of Hut Point adjacent to McMurdo Station, our port of entry and principal supply facility for the continent. Soundings completed last season confirmed opinions that deep water is available very close to the shore line and ice observations indicate that the downwind side of the Point is least affected by ice break-ups. Preliminary studies indicate that a cantilevered truss system supported on the shore would offer the least problems from the standpoint of annual ice movements. This type wharf would utilize trusses anchored on the shore and extended some 50 feet from the shore line to form a 70' x 200' wharf.

However, a marginal wharf consisting of a sheet pile enclosure (50' x 200') filled with rock blasted from the Point would be less costly and more serviceable.

Installation of this type wharf is dependent upon the possibility of driving piles in the bottom at the shore line. A geological survey has reported that the bottom off shore of Hut Point is covered with blue ice, and that it is extremely doubtful that piles can be driven near the shore line. Therefore, a site investigation will be made during the next season to determine the feasibility of the marginal wharf installation. Core borings will be taken and an effort made to drive test piles through holes in the ice.

A ship unloading facility at McMurdo would reduce the annual effort now required for multi-cargo handling, using sleds and tractors across the ice, by thousands of manhours. Such a facility would be self-liquidating in a matter of two years based on preliminary cost estimate.

Permanent Runway Facility

We are also making tests and conducting research to determine the feasibility of constructing a more permanent runway at McMurdo. Mixed implace asphalt and soil cement test pads constructed on the permafrost at Marble Point indicates the feasibility of such construction; however, land area that is relatively snow free and with adequate characteristics does not appear to be available in the McMurdo area. Therefore, current efforts are being directed toward compaction of snow on the permanent ice barrier off Scott Base. Tests completed last year indicate that compaction is possible with the pulvi-mixer, aided by water spray and rollers, to densities for wheel aircraft. Plans for the coming season include use of the Peter Snow Miller to build a strip approximately five feet above the surrounding snow surface prior to compaction with the pulvi-mixer. By this means, it is hoped to minimize snow accumulation and drifts across the runway. Details on this project are being presented by another delegate.

New Byrd Station

A new sixty-man sub-surface scientific station, designed in the Spring of 1960, was commissioned in March of this year, with construction about 65 per cent complete. This camp is based on the cut and cover concept, i.e., trenches approximately 25 feet deep and 300 feet long are cut by use of the Peter Snow Miller; these are then covered with steel Wonder Arches, the Arches are backcast with 2-3 feet of snow, and prefabricated insulated panel structure erected within. More than 3,000 feet of tunnels utilizing 30 foot and 40 foot diameter Wonder Arches and 16 foot wide Granco arches make up the main tunnel complex while an additional 3,500 feet of tunnels utilizing 9 foot wide Granco arches were provided for access to isolated under snow scientific facilities required for making geomagnetic, seismology and glaciology studies. In addition to more than 6,000 feet of undersnow trenches, the New Byrd Station includes four above surface structures utilizing 35 foot high aluminum telescoping leg towers. These towers which are designed to be jacked a total of 25 feet are required for supporting the aurora, rawin, balloon inflation and radio noise structures.

The new undersnow camp is the most modern of all the U. S. Antarctic Stations. Twenty foot wide T-5 buildings, erected on steel saddle trusses, were used throughout the station. This building is a prefabricated panel building which can be erected in modules of four feet, utilizing fire treated plywood skin interior and exterior and insulated with 2 1/2 inches of fiber glass. Private bedrooms, flush type toilets facilities in each quarters building, exterior water distribution and sanitary collection systems, more liberal recreational facilities and laboratory spaces, constitute luxuries not previously provided in the interior of the continent. The station which is presently heated with oil burning hot air furnaces, also is designed for conversion to all electric heating with installation of a 1000 KW nuclear power plant.

Utilities

The New Byrd Station is the first U. S. Antarctic Station provided with complete exterior distribution utility systems. Water which is presently supplied from melted snow utilizing waste heat from the diesel jacket water is pumped into a pneumatic pressure system and circulated through the main tunnel complex. Ric-well pipe made up of an inner pipe, insulated and strip electric heated, and jacketed with an outer pipe is used for the distribution main. The main is run through each building to pick up heat and is provided with flexible connectings as it enters and leaves each building. The water is kept circulating at all times to minimize freezing problems. With installation of the nuclear power plant a Rodriquez well utilizing steam from the plant will be constructed for supply of potable water. Sewage and waste water is collected in similar ric-well insulated pipes from each building and drained by gravity to a central pumping station. From here it is pumped approximately 500 feet from the camp where it is discharged into a dry Rodriquez well. To prevent activation in the well and possible contamination of the area by lateral movement of the sewage, two dry wells will be alternately used to assure freezing action in each well.

Bulk storage of fuel oil, using 10, 000 gallon neoprene bags, is provided within the tunnels. Drummed fuel is pumped into the bags from a drum unloading room and then distributed to local day tanks at each building, through a piped distribution system. Facilities have been provided for unloading bulk fuel directly from C-130 aircraft into the tunnels storage tanks. Modifications are planned to equip the C-130 aircraft for delivery of bulk fuel oil. Since approximately 400, 000 gallons of diesel oil will be required annually prior to installation of the nuclear power plant, bulk delivery of fuel will vastly decrease manpower requirements for handling drummed fuel.

Ventilation

Fresh air for the buildings is drawn from the tunnels by the warm air furnaces, thus creating a slight positive pressure in the buildings and releasing heat into the tunnels. Therefore, continuous tunnel cooling is required to prevent the air temperature within the tunnels from rising more than 10°F above the surrounding snow temperature. If heat is allowed to build-up within the tunnels it will decrease the bearing capacity of the snow walls and increase arch settlement. Studies indicate that each 10° rise in temperature increases the arch settlement by a factor of two, thus shortening the life of the camp.

Two tunnel cooling systems were provided, consisting of air wells for use during the summer months when the outside temperature exceeds -18°F and conventional exhaust fans for use during the winter months. The air wells consist of 15 inch diameter holes drilled 50 feet deep into the tunnel floors, with the upper 25 feet cased. Vertical fans mounted on top draw air through the permeable snow cooling it to the constant snow temperatures of -18°F. In this way refrigerated air is provided for tunnel cooling during the summer months.

Eights Station

The most significant construction project in our Deepfreeze 1963 program is the establishment of a new eleven man station in the Ellsworth Highland, to be known as the Eights Station. This Station will consist of fifteen air transportable, skid mounted van type units that are completely fabricated and equipped prior to shipment to Antarctica. These van units, now under construction by the Alberta Trailer Company of Canada, measure 8' x 8' by a maximum length of 27 feet. They will be delivered to McMurdo by ship and then flown approximately 1700 miles by C-130 aircraft to the site. At the site they will be offloaded and positioned with a tractor into a central complex making one structure approximately 24 feet by 116 feet. This structure will contain housing and kitchen units, electric-power units, science labs, and recreation area. Since the site is in a high snow accumulation area, the units are designed so that they may be disassembled each year and repositioned on the snow surface. The scientific function for which this station is required also may require relocation of the entire station to another area. By use of portable ramps, the skid mounted units may be reloaded on C-130 aircraft and flown to another area for re-erection. This type facility will require a minimum of field construction effort and will provide comfortable quarters for scientific research in the remote areas of Antarctica, little dreamed of a few short years ago.

Closing Remarks

Antarctica imposes the severest climatic conditions on construction personnel, materials and equipment that are encountered at any place in the world. The extreme environmental conditions prevailing at inland Antarctic stations required the establishment of new design criteria, new engineering and construction techniques and even the development of new materials. Construction work at the Pole Station must be conducted not only in temperatures well below 0°F but also in the rarified air at 10,000 feet elevation. Further, erection of structures and facilities must be accomplished with a minimum of power tools and weight handling equipment and with personnel hampered by cumbersome arctic clothing and gloves. It is essential that prefabrication be utilized to the fullest extent possible, that simple and tested materials and facilities be provided, and that field erection procedures be well planned and organized prior to arrival at the site. The number of construction personnel deployed to interior regions must be held to a minimum so that the effort required to build the temporary construction camp and to support the construction personnel, permits accomplishment of the basic mission. Low construction efficiency, short construction seasons, and the tremendous logistic efforts required in delivering construction materials to remote sites deep in the interior of Antarctica often reduce the effective construction effort up to 75 per cent. All new projects for Antarctica should be well planned and carefully designed; the facilities should be skillfully fabricated and crated well to prevent damage in shipment, and, the construction should be phased over a three year period. It is imperative that careful attention be given to every detail in each step of the long process from the statement of a requirement to the completion of an adequate facility, when providing designs for Antarctica.

GLACIER WATER SUPPLY AND SEWAGE DISPOSAL SYSTEMS

Richard P. Schmitt and Raul Rodriguez

One problem of living on a glacier is how to produce a reliable and acceptable drinking water supply with a minimum of manpower and equipment. Heretofore, with small groups of men at temporary glacier camps, this requirement has been met by melting surface snow when needed. Various heating devices into which snow is manually or mechanically loaded have been used. Such systems, when called upon to produce large quantities of water at semi-permanent type installations have been inefficient in use of fuel supplies and manpower. In addition, the surface snow becomes contaminated and the melt produced must be treated to make it acceptable for drinking purposes. Other problems occur when operating these systems in the extreme surface, sub-freezing climatic conditions.

A new concept, producing melt from glacial sub-surface sources, was investigated under temporary camp conditions at Greenland, and sufficient success was obtained to warrant the design of a full scale system for Camp Century, Greenland. Basically, the sub-surface water system entails melting a shaft vertically downward into the impermeable ice structure of the glacier. In this shaft, with the continuous introduction of heat, the surrounding ice is melted and the resultant melt collected or pooled. When sufficient water has been collected, it can be pumped to the surface as required. This system in many respects is similar to deep wells in non-glacial regions where water is pumped from underground aquifiers as a clear, uncontaminated drinking supply.

For two summer seasons at Greenland exploratory work was performed to determine the feasibility of this system for producing bulk water supplies. Figure 1 illustrates the principle components of equipment required; namely, a diesel fired steam generator for providing heat to melt the snow and ice, an engine driven electric generator to provide electric power for pumping and illumination, and a servicing drill rig with cable winch for raising and lowering the melting bit assemblies. That equipment which cannot be readily drained, such as the steam and electric generators, should be located in a shelter where temperatures above freezing can be maintained. The shelter and servicing rig should in turn be located in a snow trench. The trench, when roofed and covered with snow level with the glacier surface, provides a working environment protected from the winds and other severe surface weather conditions. Trench ambient temperatures of approximately 20°F were experienced in Greenland.

The first water well was started in July 1959 and a shaft 42 inches in diameter (Figure 2) was melted downward with a 36-inch diameter melting bit. It was essential to keep the shaft a few inches larger so that the melting bit could be raised or lowered at will. Saturated steam, 165 psig at 373°F, was delivered to the melting bit nozzles at a rate of 750, 000 Btu per hour. A vertical shaft, 139 feet deep, was melted into the glacier in approximately 30 hours. At this depth the melt which was produced no longer permeated into the surrounding snow, but accumulated in the bottom of the shaft. When the pooled melt was approximately 4.5 feet deep the melting bit was replaced with a combination melting-pumping bit assembly. This bit assembly permitted continuous injection of steam simultaneous with the pumping of water to the surface when required.

In this first venture into the sub-surface regions of the glacier, steam was introduced for a total of 295 hours over a 23 day period. Water was intermittently pumped to the surface by the electrically powered submersible pump at a rate of 25 gpm. A total of 138,600 gallons of water were produced and 30,150 gallons were used for production of steam. With this arrangement it was determined that at least 8,700 gallons of water could be produced each day. Upon conclusion of the melting-pumping period, a man was lowered into the cavity to physically examine the sub-surface cavity that had been made. What he found was a symmetrical bell shaped configuration represented in the bottom portion of Figure 3. The cavity was approximately 50 feet high with a maximum diameter of about 50 feet that gradually tapered into the smaller cylindrical shaped entrance shaft. The bottom of the cavity was 170 feet beneath the glacier surface and the sidewalls of the cavity and shaft were lined with an impermeable ice coating. It was fairly conclusive that once the melt cavity was formed, the melt would be contained and the shape of the cavity could be controlled by the quantity of melt stored in the sub-surface reservoir.

In the summer of 1960 similar operations of the original test well were resumed, only the melting and pumping was intensified. Water from the well was used to satisfy all requirements of the test and construction personnel at a temporary camp, and surplus water was pumped to waste in order to maintain a water production rate of at least 8000 gpd. This meant that melting equipment had to be operated 24 hours a day, six days per week, and one man had to be present at all times to operate the equipment. The unit was run for 102 days and a total drinking water supply of 947,000 gallons of water were produced.

Operations of the well were fairly constant and the objective of forming a cylindrical shaped cavity about 50 feet in diameter was possible. Through some surface on-site temperature and depth measurements, it was calculated that a diameter slightly greater than 50 feet could be maintained provided 12-17 feet of water was in the reservoir at all times. For the latter part of the study, with a constant heat input and a constant rate of pumpage to the surface, this criteria was maintained. It was later determined that this required storage of 300,000 gallons of water in the well.

Figure 4 illustrates the shape of the cavity after conclusion of the second summer season tests. When a man was lowered into the well he found a cylindrical shaped cavity immediately beneath the previous year's bell shaped cavity. The dimensions were approximately 65 feet in diameter, 65 feet in height, and 232 feet beneath the glacier surface. An interesting incident in the examination of this cavity occurred when we were able to physically inspect it. In the base of the cavity with an ice auger, a hole was cored through 5.5 feet of ice, and water under pressure was found to a total depth of nine feet. Introduction of steam had stopped on 5 October 1960, at which time there remained approximately 322,000 gallons of water in the base of the cavity. On 9 August 1961, ten months later, the core drilling revealed the presence of water. This is significant in empirically revealing the insulating properties of ice to the stored liquid products. In this sub-surface reservoir the heat losses are primarily by conduction, and ice with a poor heat transfer coefficient for conductance becomes somewhat an insulating material.

Figure 5 is a photograph of the ice cavity. This is possibly the first picture ever taken of the impermeable ice layers of the interior of a glacier by a man holding a camera in his hands. The interior of this cavity, because of its size, is somewhat breathtaking at first but very interesting. Our problem after the first entrance was one of restricting the sightseers. The serrations seen in the sidewalls of the cavity reflected the raising and lowering of the water as melting progressed. All of the interior surfaces were glazed with a hard impermeable ice layer. Core samples drilled into the side revealed this shallow skin of ice to be from 0.5 to 3.0 cm thick, after which the core ice had a density of 0.82 to 0.84 gm/cm^3 as far back as 2.8 meters.

In the final tabulations for the summer season's operation, an average of 9,200 gallons of drinking water were produced per day. The water pumped to the surface had an average temperature of $36^{\circ}F$. On the surface the water had to be stored in small containers located in living quarters, mess hall, or shelters where temperatures above freezing were maintained. The principle supply expended in production of the water was diesel fuel for operation of the steam and electrical generators. Steam was used for purposes other than producing water at the test site. Other uses included heating water for shower and laundry purposes and thawing of waste, garbage pits, and other equipment. It was difficult to separate these other uses, but some allowances were made and it was calculated that approximately 59 pounds of water were produced for each pound of fuel consumed.

The quality of the water produced was very good. The water as pumped from the sub-surface reservoir was bacteriologically safe for drinking. Chemical characteristics of the water were very similar or better than laboratory distilled water. For example, water from the well showed a specific resistivity of 708,000 ohms/cm, whereas triple distilled water in glass is occasionally reported at 1,000,000 ohms/cm. Water samples were periodically collected during the test and a typical chemical analysis of these samples are shown in Figure 6. It is noted that the water has a low acid pH value and its mineral content is reported in only fractions of mg/l. These characteristics are those of a very pure but also very aggressive water, corrosive to metal surface. For this reason, some stabilization with calcium carbonate might be required where the water is to be transmitted in pipe systems or stored in metal containers.

With the acceptability of glacial wells for production of water, an important question arises as to the quantity of water that can be obtained from a single well. The answer to this is dependent on several factors such as the method of operation, complexity and size of melting equipment, and the economic limits of equipment and operating costs. Taking these factors in order, the method of operations will determine the shape of melt cavity. The volume of melt increases with the square of the diameter of the cavity and thus greater amounts of water are obtainable from the larger diameters per unit of depth. In the first year operations when the melt was pumped to the surface almost as quickly as it was produced, the narrow part of the bell shaped cavity was formed. In the second year operations when it was determined that with the heat source available greater quantities of water could be pooled, a cavity diameter of at least 65 feet was possible. Water can be stored in the cavity as long as there is sufficient heat and the heat is adequately distributed to prevent freezing. The upper limits of the cavity diameter are not established, but because of the lateral undermining, some structural problems may be introduced which will be more important to the surface loading and traffic than the aforementioned thermal limitations.

The depth of the cavity is the other dimension effecting the quantity of water from a well. Deeper wells require longer pipelines, larger pumps to pump against greater static heads, bigger servicing rigs to carry heavier loads, more electrical power and greater steam capacity to deliver the required Btu output. With the bigger equipment, complexity increases to some degree because of increased steam and water pressures and electrical requirements, but more important, the costs of the equipment and operations increase.

An attempt has been made to examine the costs of three typical wells, 600 feet, 800 feet, and 1000 feet deep. These costs are based primarily on the type of equipment used in the exploratory work at Greenland. All three wells are capable of producing 10, 000 gallons of water per day. Basic equipment for a 600-foot well including steam generator, building for housing the generator and accessories, servicing rig, melting bit, submersible pump, insulation, pipelines, and all the accessories for electric, steam and water connections are estimated to cost approximately $34, 000. Equipment costs to extend the well to an 800-foot depth would mean a nine per cent increase, a 1000-foot well would increase costs 20 per cent. The initial equipment costs are significant, but to this must be added an increase in operating cost as a deeper well is developed. The operating costs in this comparison are the costs for additional fuel. It is estimated that daily fuel consumption would increase as much as 10 per cent as the well increased in depth from 600 to 1000 feet. The equipment that has been utilized is sectionalized and transportable. Because of this feature, it is believed shallower wells and more frequent relocation of well sites would be economically advantageous. In addition, the abandoned well cavity has utility for storage of other supplies, fuel, waste products, etc. All of these uses have not been fully exploited yet.

No water supply is complete with just the production of water; it must be distributed or made available so that it can be consumed. At glacial camps with the inherent freezing conditions this is not a simple procedure. Usually the water using points such as mess halls, latrines, and laundries are centralized so that water storage tanks can be located within the heated confines of a building. These systems are workable and have the advantage that the availability of water is limited and the water requirements per man decrease. Ten gallons of water per day per man appeared to be adequate in our studies at the temporary camp in Greenland. When fire protection and water borne sewage become a camp requirement, the water demand increases and as much as 50 gallons per day per man are required. Daily delivery of this quantity requires a more sophisticated system, such as a pressure distribution system to the majority of the camp buildings. At Greenland a pressure distribution system has been installed. Water is continuously recirculated through a 2-inch pipe loop servicing the key building outlets. The pipeline is insulated and equipped with electrical heating tape thermostatically controlled over a 37°F to 40°F temperature range. The factors of water velocity, insulation and electric heat have performed satisfactorily and prevented freezing problems in the distribution system even at ambient temperatures as low as -60°F.

A water borne sewage system has several advantages. Certainly from an aesthetic and health standpoint, it is preferred. Figure 7 illustrates one system that is now operational in Greenland. The camp with a water borne sewage system has a large volume of liquid waste to dispose of daily. All camp waste water from the latrines, laundries, mess halls, etc., flow by gravity to a central collecting tank. A high capacity pump mounted on the tank automatically pumps the waste water through a pipeline several hundred feet from the camp to a sub-surface waste disposal hole. The sewage, as it discharges from this pipeline, pours downward melting a vertical shaft through the porous layers of glacial snow into the more impermeable ice layer; hence, the flow is outward in a lateral direction until it freezes. The exact shape of the sub-surface waste zone is not known. Some core drillings were made from the surface at another glacial camp to determine extent of the contamination. The probable shape from the core samplings were reported by Major Ostrom, MSC,[1] and are shown in Figure 8. It is projected that the shape is conical with the apex only 38 feet beneath the pipe outfall. The radius of the base of the cone is between 80 and 120 feet. The estimated contaminated liquid volume at the time of the core sampling was 1, 700, 000 gallons.

The water supply and waste disposal systems that have been described were developed to satisfy a specific requirement on the Greenland glaciers. Variations to produce lesser quantities of water and disposal of less waste are entirely feasible. The differences, of course, could mean reduction in size and weight of equipment and more important, decreases in cost. The sub-surface water well concept has been proven at Camp Century, Greenland, and it is not difficult now to conceive its use for other permanent or temporary camps. At Camp Century over 3, 000, 000 gallons of water have been produced from one well. Already a smaller system is being studied for the Byrd station in the Antarctica.

Reference

1. Ostrom, T. R., West, C. R. and Shafer, J. J., "Investigation of a Sewage Sump on the Greenland Ice Cap," Journal Water Pollution Control Federation, January 1962, p. 56.

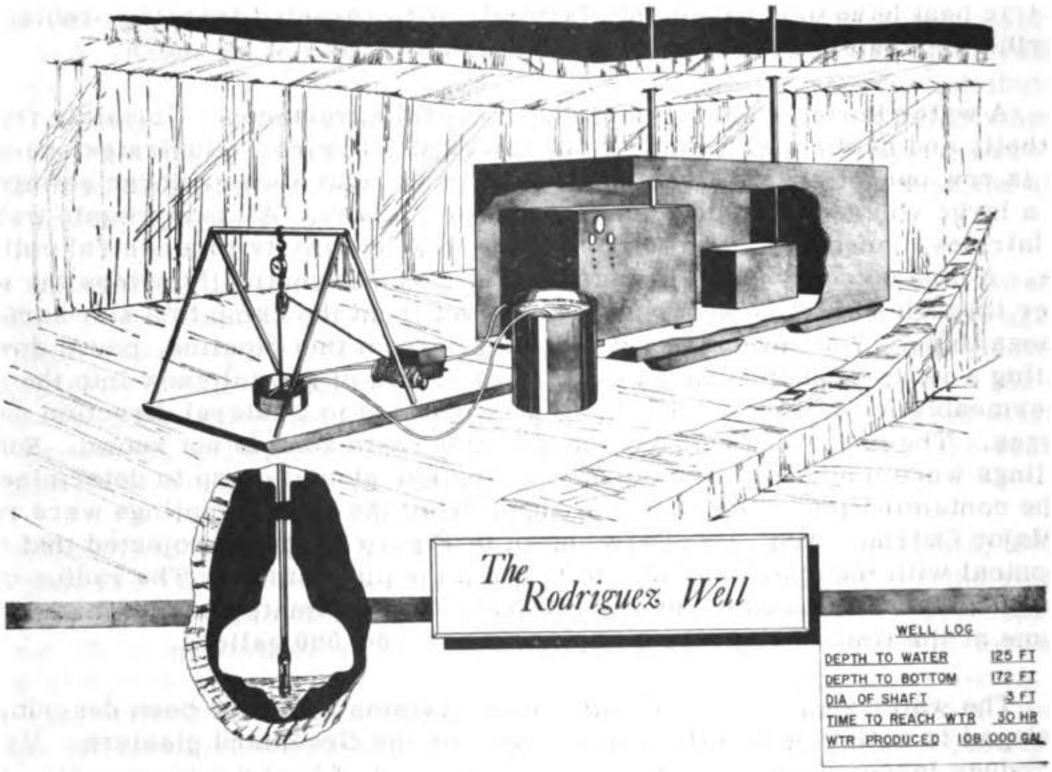


Figure 1

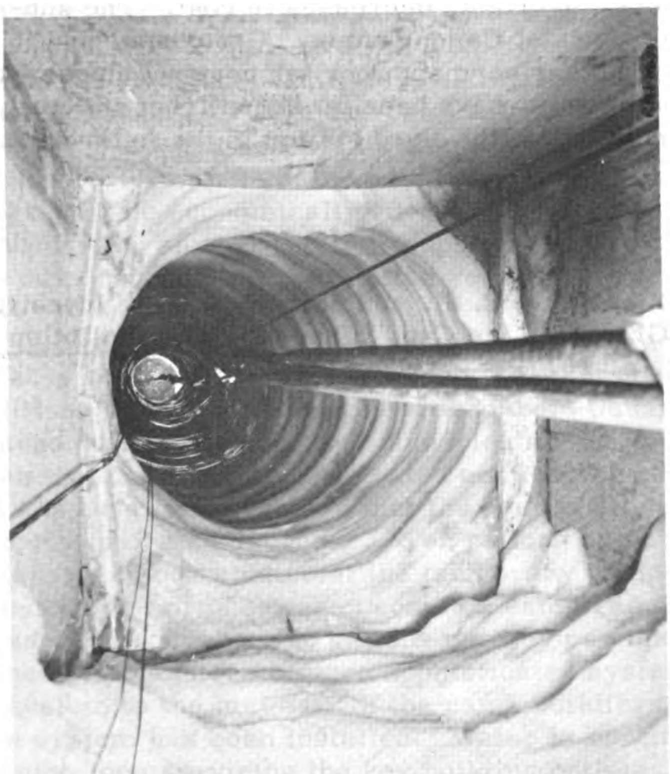
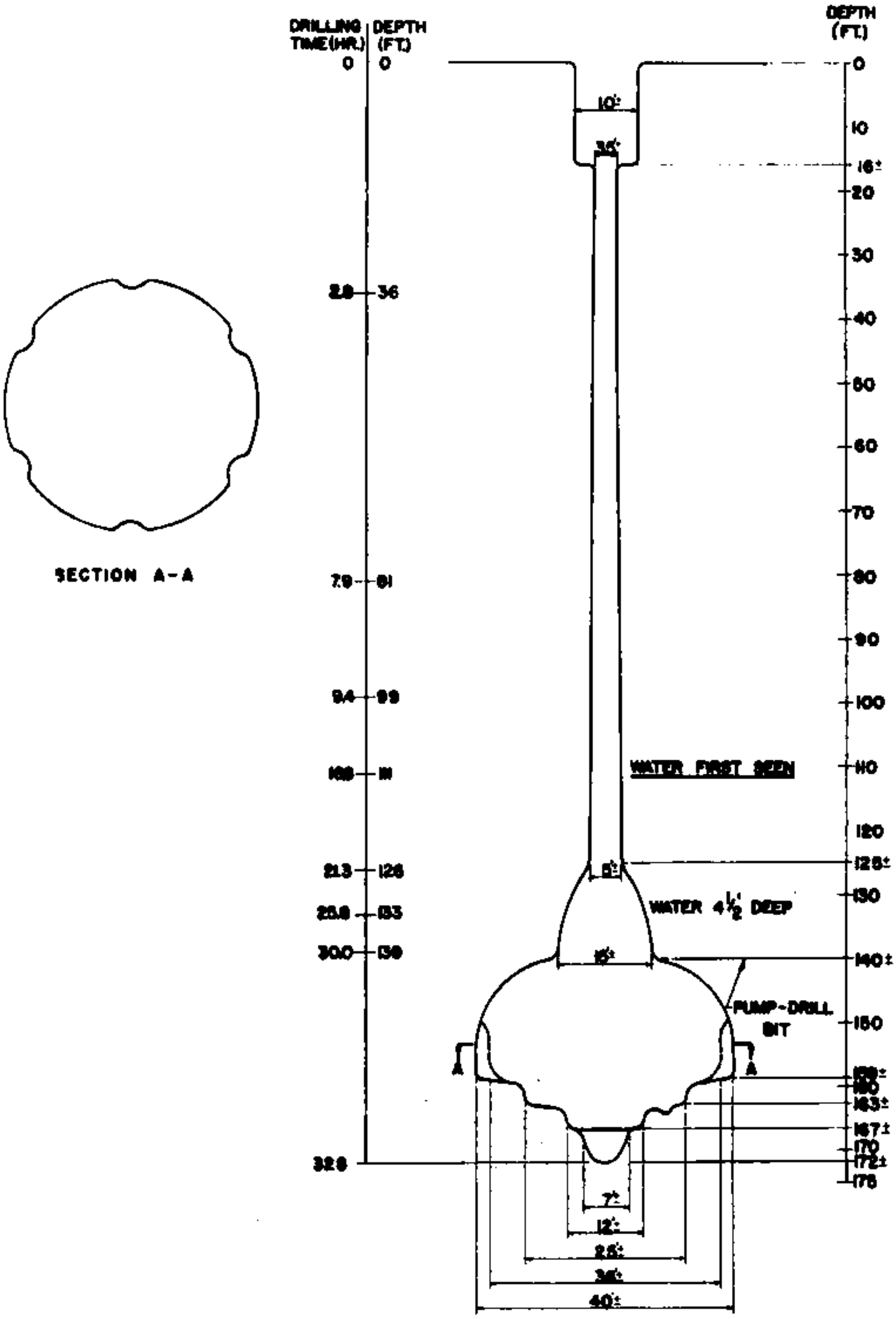
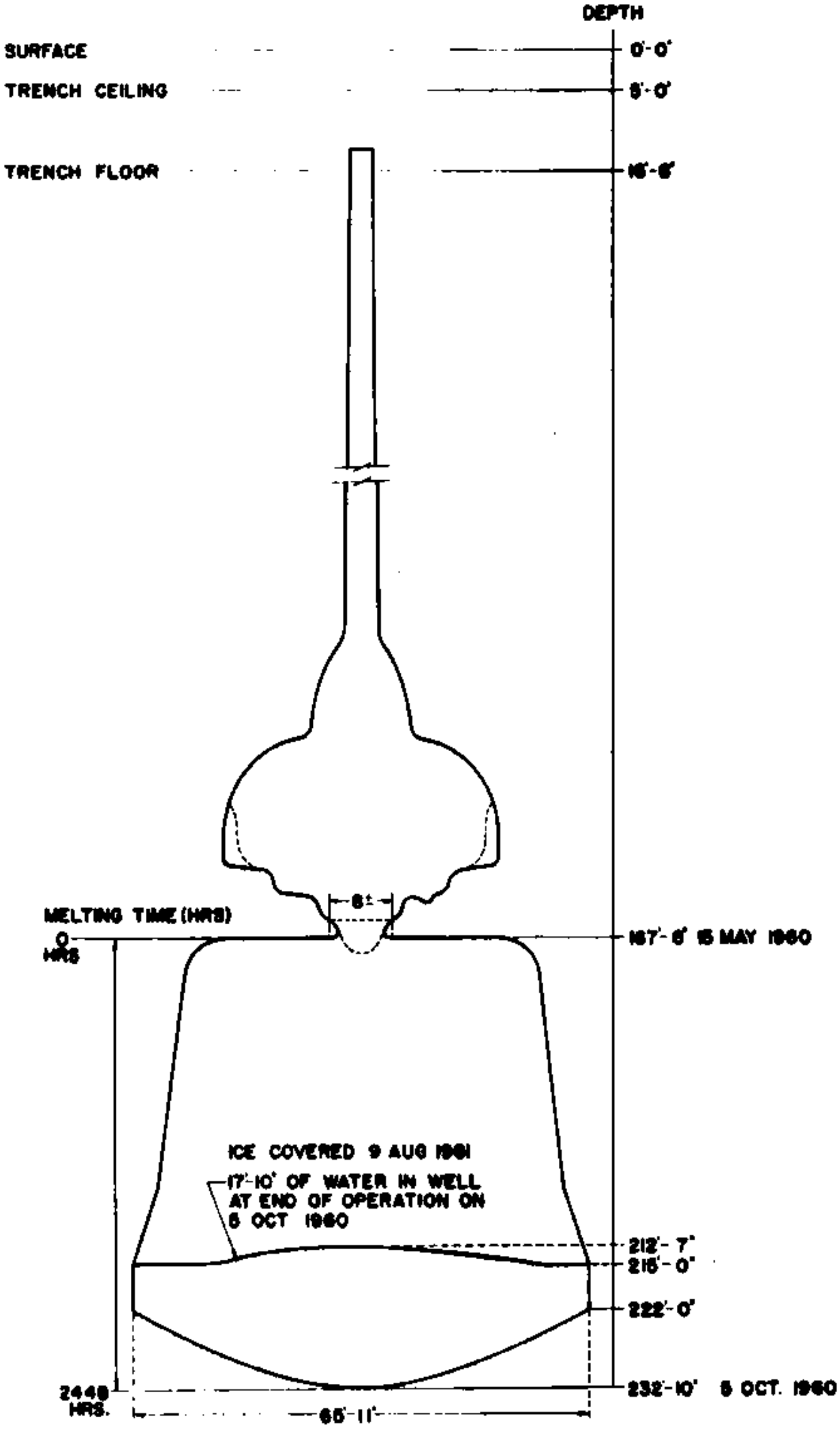


Figure 2



RODRIGUEZ WELL - 1959
TEMPORARY CAMP
CAMP CENTURY

Figure 3



RODRIGUEZ WELL - 1960
TEMPORARY CAMP
CAMP CENTURY

Figure 4

Figure 5

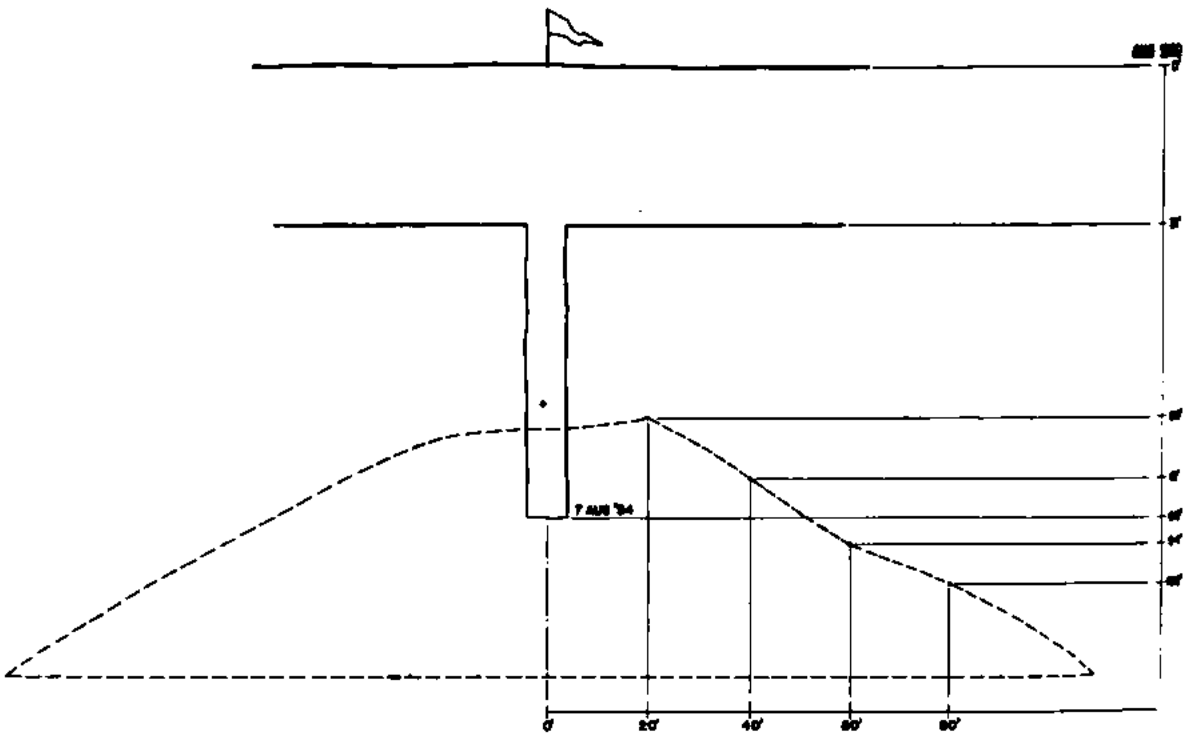
Table I

CHEMISTRY OF WATER

Resistivity, ohms/cm	708,000
pH	5.1
Carbon dioxide, mg/l	1.2
Dissolved Oxygen, mg/l	6.4
Sodium, mg/l	0.02
Potassium, mg/l	0.03
Calcium, mg/l	0.1
Chlorides, mg/l	0.04
Sulfates, mg/l	0.1
Nitrates, mg/l	0.2
Temp of Water, °F.	38

Figure 6

Figure 7



GLACIAL SEWAGE DISPOSAL SYSTEM

Figure 8

TRANSPORTATION OF PREFABRICATED UNITS FOR BUILDINGS FOR SOVIET ANTARCTIC STATIONS

Soviet Committee on Antarctic Research

All the buildings of the Soviet Antarctic Expedition, erected in Mirny Observatory and at inland stations, are made of special panels, prefabricated at the plants of conventional house construction.

The house units are sealifted to the Antarctic Continent and disembarked at Mirny and at the stations Novolazarevskaya and Molodezhnaya. Ready-made houses, assembled and fully equipped on sledges, were delivered to the inland stations Pionerskaya, Komsomolskaya, Vostok and Sovetskaya. This was made in order to avoid unnecessary work on assembling the buildings in conditions of extremely low temperatures, oxygen deficiency, and weather fluctuations in the areas of these stations.

Houses were assembled in Mirny from prefabricated panels, specially heated for Antarctic conditions and designed to maintain normal temperatures inside the buildings, with the outdoor air temperature being -80°C.

The houses were mounted on sledges, firmly fastened to them, and sustained difficult transportation behind heavy-duty tractors running over the rough terrain of the Antarctic Continent.

Apart from ready-made houses, tractor-sledge trains transported some building materials and among them prefabricated heated panels for prefabricated houses to the construction site of the station.

From these building materials and panels tambours were built and the total area of the station was enlarged.

The sledges, on which houses were assembled, were of a strong wooden construction, with a weight of about three tons. One heavy-duty tractor towed two sledges.

Later, houses were mounted on steel sledges. In this case the useful area of a house exceeded 20 m^2.

Such a method of construction, transportation and erection of houses on site requires a minimum of time and labour to put the station into operation. This is of extreme importance in the severe climatic conditions of Central Antarctica.

In several cases some building material was transported to inland stations with the help of aircraft (both with landing of airplanes and with air-drops). These were the materials necessary for construction of pavilions, tambours and non-heated store-houses. However, their number was small and therefore the main vehicle, transporting the buildings and their units to inland stations, is the tractor-sledge train.

During the construction of Novolazarevskaya Station, which is about 100 km from the coast, all the details of houses and building materials were transported to the construction site of the station by tractor-sledge trains. Units of four pre-fabricated houses, four scientific pavilions and three auxiliary buildings were transported there.

The total weight of building materials amounted to about 380 tons.

WATER SUPPLY OF SOVIET ANTARCTIC STATIONS

Soviet Committee on Antarctic Research

Mirny Observatory

To provide personnel of the observatory with drinking and washing water in the area of the ice massive at a distance of 500 m from the village there are three tubular electroheaters with the total capacity of 10, 5 kw operating around-the-clock and inserted into a special hole in the ice.

These were enough to obtain one ton of clear fresh water per day which accumulates in the hole as ice melts and does not freeze up with the outdoor temperature being -30°C.

For transportation of water from the site of ice melting to users a welded cistern with the capacity of about seven tons was made. It was mounted on a sledge and specially heated. On the same sledge an electric pump for the pumping of water from the cistern was also mounted. The sledge cistern was enclosed into the house where there was an electroheater for the heating of air inside the house and also for the heating of water in the cistern if it was necessary.

This prevents water from freezing up when keeping it in the cistern in the course of several days with low outdoor air temperatures.

In the other specially heated house, mounted on the sledge, an assembly for ice sawing is arranged. An electric pump with an electric drive for the pumping of water, obtained from ice melting, is mounted there too.

As ice melts and water spends, the house on the sledge is towed by the tractor to a new site where tubular electroheaters are mounted again.

The obtaining of water by ice melting in an ice massive does not take expenses of manpower and time, and this water is free of pollution, which is inevitable when snow is loaded into snowmelters.

With the purpose of uninterrupted water supply of the galley a cistern of 25 m^3 capacity with electroheaters was laid down a snow trench dug near auxiliary buildings. This cistern is regularly filled up with water. An electric pump pumps this water into the discharge tank of the galley.

Inland Stations

At inland stations and during tractor-sledge trips drinking and washing water is obtained by means of snow melting in special snowmelters equipped with tubular electroheaters or with a system using the heat of circulation water cooling engines.

As the number of people in a train and at stations is limited, such a method of water production is not difficult.

There are special quarters at Vostok and Sovetskaya stations where a bath-house is situated. The bath-house is regularly supplied with hot water (450 litres). At any time of day the station personnel can take a bath and wash their personal things.

Water for the bath-house is obtained from two snowmelters of 250 litres capacity each and equipped with thermal panels (one with the three section thermal panel, another with the four section one). These thermal panels are included in a cooling system of the power station's diesels. For the galley an individual electric snowmelter is installed.

Novolazarevskaya and Molodezhnaya Stations

At Novolazarevskaya and Molodezhnaya stations, situated on the coasts of fresh water lakes, water pipe for water supply is laid.

A hole is drilled in the ice of the lake and heated by electroheaters. Over this hole a heated building with a pump is erected.

Water enters the houses through the pipes, enclosed into special boxes with good thermal insulation. To prevent water pipe from freezing, tubes with circulating heated anti-freeze coming from the cooling system of the power station's diesels are laid between the pipes, through which water enters.

To supply the station with hot water, the latter is heated through a system of the electroboiler's heating (for washstands in houses) or through a special heater which uses heat from the exhaust gases of diesels (for the bath-house and laundry).

Such a system of water supply permitted to have enough quantity of cold and hot water in washstands, in the bath-house and laundry around-the-clock.

FUEL SUPPLY OF SOVIET ANTARCTIC STATIONS AND PRECAUTIONS

Soviet Committee on Antarctic Research

Uninterrupted fuel supply of scientific stations and observatories in severe conditions of the Antarctic Continent is not only of great significance but it is an undertaking of vital importance. The existence of scientific stations in Antarctica without fuel is impossible, the fuel availability means the survival of scientists at these stations. Therefore, a great deal of attention is paid to the problems of timely and complete fuel supply of all Antarctic stations.

All kinds of fuel and lubricants are drummed and sealifted to the Antarctic Continent by the Soviet Antarctic Expedition. The annual total quantity of these materials amounts to 1,400-1,500 tons.

Fuel drums are delivered to fuel depots where they are sorted and arranged in the way convenient for pumping.

From the fuel depot at Mirny Observatory a pipeline is laid and the fuel is pumped over into special tanks situated on an elevation in the area of the power station. After the filling up of all the tanks the store amounts to 220 tons of diesel fuel. This quantity is quite enough for the whole period of storms and low temperatures, when the pumping of fuel from the drums is usually difficult. Cisterns are situated on Sopka Komsomolskaya and fuel is delivered to the discharge tanks of the power station diesels by gravity. There are nine cisterns: seven cisterns with the capacity of 25 m^3 each, and two cisterns with the capacity of 50 m^3 each.

The heating of living quarters and auxiliary buildings both at Mirny Observatory and at all the inland stations is a hotwater one. The heating of water is made by two methods. At Mirny electric heaters (electroboilers) are used for this purpose, and at the inland stations the circulation water, cooling the power station diesels, is used. Such a system of heating eliminates the application of stoves. The fuel supply of inland stations was carried out with the help of tractor-sledge trains and aviation.

One heavy-duty Caterpillar tractor running in a train can transport about 25-26 tons of fuel in drums, 5-6 tons being in a body and 19-20 tons being on towing sledges.

When fuel is airlifted drums are unloaded whether after landings or by air drops, depending on local conditions, such as: weather, airstrips availability, air temperature, etc. The air drops are made by two methods: with parachutes and without them during flights at low levels.

Fuel is delivered to inland stations not only for the needs of the station, but also for refueling of heavy-duty tractors running in tractor-sledge trains. Therefore the total quantity of fuel that it is necessary to deliver to these stations, which are intermediate bases for tractor-sledge trips, sometimes amounts to 100 tons.

The Polar Aviation pilots, working in Antarctica, mastered the drops of fuel drums during flights at low levels without parachutes. Sometimes flights were made at the 5 m altitude. The technique of drops was mastered so well that almost all the drums dropped on the snow had no damages.

Coal, as an emergency fuel, was delivered to stations. However, there was no need of it.

At stations (for instance Vostok Station) the depot with fuel is situated in the open air in the immediate vicinity of the power station building. A pipeline is laid from the diesel cisterns to the fuel depot. The pumping is made by means of a special pump when it is necessary.

At low temperatures fuel in drums was heated by means of electroheaters up to about 5°C and in this case it was pumped easily.

In view of the fact that there was hotwater heating at all the Soviet Antarctic stations, there was no need of the heating of stoves and providing them with special fuel (such as coal, firewood, etc).

During transportation and storing of fuel all the necessary fire-prevention measures are taken.

The holds of the ship, transporting fuel in drums, are specially equipped according to the fire-prevention regulations. They have wooden planking inside and they are equipped with a special ventilation. All the wiring is removed from the holds.

Special precautionary measures are taken during embarkation and disembarkation of fuel and also during the storing of drums at the depot at Mirny.

Drums are arranged into regular rows with their plugs upwards at a safe distance from the village buildings.

Volumes with fuel (with capacities of 25 m^3 and 50 m^3), which are established in Mirny and Novolazarevskaya, are arranged in such a way as to keep strictly to the fire-prevention regulations.

Near the sites of fuel storages there are necessary means of fire extinguishing such as, sand and foam fire extinguishers.

CLEANLINESS OF THE BUILDINGS OF SOVIET ANTARCTIC STATIONS AND SOME PECULIARITIES OF CONSTRUCTION AND MATERIALS PROMOTING IT

Soviet Committee on Antarctic Research

In Soviet Antarctic Expedition a great attention is paid to mode of scientific personal life. All the houses and constructions in the Antarctic in Mirny observatory, as well as in intercontinental stations were built and equipped according to principles of convenience, cleanliness and comfort necessary for a man's life and work in severe conditions of ice continent.

Walls of dwelling and official buildings are made from special plywood shields, inner parts of which are trimmed with bakelite plywood. Walls in dwelling houses are papered for decorative purposes. Floor is covered with special incombustible linoleum, ceilings are painted in light colors.

Linoleum and paints are easy washable and that is why they are always in clean condition.

Walls of official houses are also papered or painted in dependence with building purpose.

In most official houses low halves of walls are made from panels covered with linoleum or decorative plywood. In the houses of intercontinental stations inner wall surface is also covered with bakelite plywood which is easily washed if it becomes dirty.

In all dwellings and in many official houses floor is covered with carpets, so that one can wear home shoes in the buildings.

Daily control of the cleanliness of dwelling and official houses is carried out. In each building there is a responsible man who takes care of cleanliness, order, timely doing up and fire safety.

Every day the doctor goes the rounds all the houses and keeps watch over cleanliness and order inside and outside the buildings as well as over neatness of the station territory, doing up of sweepings, food debris and over hygiene of lavatories, and toilets.

Water heating of dwelling and official buildings also promotes cleanliness maintenance and eliminates the dust and sweepings in buildings.

Scientific and subsidiary personal are housed in special buildings. In dwellings and official rooms people wear clean home costumes.

On Novolazarevskaya station there is a drainage system—from washstands, established in rooms, dirty water flows down in special pipeline far away from the houses. The buildings are trimmed with non-inflammable linoleum, decorative panels and painted with incombustible dyes. As Novolazarevskaya station is situated on rock, wood walkways are laid between the houses for convenience of travelling and to keep cleanliness in houses.

ANTI-FIRE MEASURES IN THE SOVIET ANTARCTIC EXPEDITION

Soviet Committee on Antarctic Research

The specific conditions of expedition members life and work in Antarctica lay particular claims to providing of general security of people and constructions and in particular of fire safety.

Severe winds almost constantly predominant in Mirny, higher snow drift, low temperatures, difficulties with water delivery and great amount of inflammable materials—everything gives constant fire danger. That is why preventative measures warning or at least decreasing at any degree fire danger are of a great importance in Antarctica conditions.

The tragic accident taking place on August 3, 1960 in Mirny when a building was burned down and people perished, made Soviet polar explorers extremely anxious to increase the requirements for anti-fire safety, to take strict preventative measures and add different anti-fire means.

The anti-fire maintenance of Soviet Antarctic Expedition is as follows:

I. Measures, Foreseen During Expedition Objects Projecting and Construction

These measures include the following:

a. Proper planning and arrangement of dwelling and official objects. Dwelling and official houses, heated store-houses and wardroom (14 houses) were built on morain, arranged in one line with 15 m distance, one from another. Side parts of houses were faced southeast, i.e., towards prevailing gravity winds.

   Receiving and transmitting radio-stations, electrostation and other objects were erected on rock with intervals of 530 to 50 m one from another.

b. Use in projecting dwelling and official objects incombustible and fireproof materials.

   Dwelling houses and other less dangerous objects in anti-fire relation were made from two layered shields of fireproof bakelite plywood.

   Arboreous-fibrous plates were used as a filler in the character of a heat insulating layer.

   Such objects as electrostations, garage and working shop were made from collapsible metallic shields.

c. Arrangement of necessary quantity of outlets and their rational placing. Each house presently has two outlets through doors in the tambours.

   At present most of the houses are snow covered outlets through doors being difficult and in some cases impossible. That is why for the evacuation of people during fire additional outlets through windows (as emergency outlets) were constructed.

d. Organization of technological processes of work, placing of equipment and instruments is carried out with fire safety taken into account. For example, the most dangerous process from the fire safety point of view is treatment of pilot-balloon shells and hydrogen supply. For safety purposes these processes are carried out in a specially equipped lodging considerable distance from other objects.

e. Proper choice of heat and illumination system and their correct arrangement.

   Heating establishments often became a hazard for fires. To decrease this danger all the houses were equipped with waterheating.

   Water is warmed in electrical boilers and then goes to the heating system. In houses these boilers are established in a separate apartment with higher fire resistance. This system of heating guarantees fire safety.

   Previously the electric wiring and illuminating armature in objects were made from ordinary materials used in city buildings. They quickly became worthless due to the extreme climate. At present all previous electro wiring and electroarmature has been replaced by materials designed according to rules of ship equipment, providing complete fire safety.

II. Measures Foreseeing Special Training of Expeditional Personal

The studying and analysis of the reasons for the origin and spread of fires in polar expeditions allow us to conclude, that fires mostly arise in consequence of violation of fixed rules and instructions of fire safety by individual expeditional members and as a result of laxity in the use of fire extinguishing means.

The detailed study of the rules of fire safety by expedition workers and their training in methods of fire extinguishing is a necessity for special instruction for expedition personnel.

Practical organization of anti-fire training of expedition members comes to the following.

Introductory instruction was conducted before expedition departure and repeated instruction at the working place; training is conducted concerning the character of fire danger in connection with technological processes of work carried out. The introductory anti-fire instructing is studied by all members of the expedition.

The instructing is conducted by personnel well acquainted with fire safety organization in polar conditions, to assure that all the expedition members are acquainted with the general rules of fire safety for polar expedition members and in particular with special objects. Leading workers of expeditions (leaders of expeditions, stations, parties, groups) attend lecture courses, then the examination on knowledge of the rules of fire safety techniques takes place.

All the expedition members complete the instructing at the working place, which serves to acquaint expedition members with peculiarities of fire danger and anti-fire regulations of the observatory, station and their working places and also to show means of fire extinguishing and nearby fire communication and to train expedition members to use them. This instructing is conducted by the leaders of stations, parties, groups, etc.

Expedition members connected with most dangerous fire hazards in relation processes of work and surveying anti-fire technique receive special instruction, and take examinations before qualified commission and get certificates, for example, cinema operators, managers of explosive material depots, electro and gas welders, persons responsible for charging of acidic and dioxide fire extinguishers, etc.

Instructions on fire safety were prepared for each profession and for fulfillment of individual dangerous work. All the members must become acquainted in detail with these instructions.

III. Expedition Maintenance with Anti-Fire Techniques and Equipment

Antarctic expeditions are provided with the following anti-fire techniques and equipment:

1. Portable emergency electrostation—in case of main electrostation having failed.

2. Fire motopump M-1200 (productivity of 1200 m^3/hour).

3. Fire motopump M-600 (productivity of 600 m^3/hour).

4. Portable fire e/pump with productivity of 25-30 t/hour.

5. Fire fighting equipment for each house (object)—an axe, crow, hook, spade, buckets.

6. Portable (field) charging station for charging of dioxide fire-extinguishers.

Means of Fire Extinguishing

1. Dioxide fire extinguishers (OU-2, OU-5, OU-8).
2. Portable dioxide fire extinguishers (VII-I M).

3. Foamy fire extinguishers (OP-3, OP-5).
4. Mats.

Means of fire extinguishing have the following distribution:

a. Non-heated compartments, depots, electrostation, radio-station and other laboratorial and industrial lodgings are equipped with dioxide fire extinguishers.

b. Heated dwelling houses as a rule are complete with foamy fire extinguishers.

Each dwelling house and other heated lodgings as a rule have one or two water barrels with 250-300 l capacity. Furthermore, a portable van is equipped with a water cistern on 6 t. Because of the absence of natural reservoirs, an ice melter has been installed (electroheater sinking in ice body). Such arrangement permits constantly 25-30 t of water available. At present most houses of Mirny are under snow layer with thickness of 2-3 m. With less fire hazards due to insufficient natural ventilation, a house is at once filled with smoke.

For the safety of people at work in smoked lodging, observatories and stations have the following equipment:

Oxygen—isolating gas masks (KIP-5)
Hose gas masks (PSCH-I, PSC-2)

To notify appearance of fire hazard the objects are equipped with automatic fire signalization. When the temperature in the apartment is higher than 40°C a signal acts and alerts to man on duty, who takes necessary measures.

All the objects are equipped with telephone and radio communication.

IV. Measures of Regulation Character

These measures include the following:

Daily supervision of observance of fire prevention rules. The supervision of observance of fire prevention rules is carried out in the process of duty watch service, execution of work and establishment of equipment by expeditional staff, by personnel responsible for the fire safety of dwelling, official, industrial and storing lodgings (responsible personnel are appointed by expedition order), by the members of voluntary fire-brigade (DPD) and by fire technical commission.

Limiting of Fire Spreading

Besides engineered technical measures carried out during the planning and construction, the following measures are fulfilled to limit the fire spreading:

a. Wood panels of walls in dwelling and official houses are covered by non-flammable linoleum.

b. Storage of inflammable matter and material on possible ways of fire spreading (in intervals between houses, depots, electrostations) is prohibited.

c. Special cameras, boxes, boards and safes are equipped for storage of inflammable matter and material (oiled rags, inflammable films, reagents, etc.).

Providing the Conditions for Quick and Safe Evacuation of People and Material Valuables

To avoid accidents during evacuation of people and material valuables the following measures are carried out:

a. Constant supervision of good conditions of doors and emergency outlets.

b. All passages, corridors and outlets are kept loose.

c. Storage of inflammable matter in dwelling and official houses is prohibited, storage being in special places.

d. Dwellings and official lodgings are equipped by emergency illumination.

e. Personal staff study its duties regarding fire appearance. Thus in summary one can conclude, that anti-fire safety of buildings and constructions in the Antarctic may be provided by the following complex of measures:

-proper construction of houses;

-maintenance of rules of exploitation of buildings and constructions;

-discipline of personal staff;

-modern means of fire extinguishing.

All this complex is an object of particular attention by Soviet polar explorers and now a great attention is paid to improvement of all anti-fire measures.

BEHAVIOR OF BASIC MATERIALS AT LOW TEMPERATURES

Soviet Committee on Antarctic Research

In 1958 at Soviet Antarctic Vostok station situated in the vicinity of the south magnetic pole some experiments and episodic observations of behavior of fuel lubricant materials, steel, rubber, etc., were made at low temperatures.

In 1958 at Vostok station the lowest temperature of -87, 4°C was recorded. An average annual temperature in the vicinity of this station was about -55°C and so observations of the behavior and state of various materials under such conditions are of great interest.

At -52°C it was revealed that B-70 gasoline did not catch fire from a burning match. In order for gasoline to catch fire it is necessary to keep a burning match over it for 30-40 sec., one end of the match being immersed into the gasoline.

At lower temperatures the burning duration of gasoline is longer.

The following experiment was made. At an air temperature of -80°C a bucket was filled with B-70 gasoline. Then a burning torch was brought to its surface. The gasoline did not catch fire, but it extinguished the torch fire being immersed into the bucket. This experiment was made several times and the result was the same.

Thus it is revealed that B-70 gasoline practically does not evaporate at such low temperatures.

To examine the intensity of gasoline evaporation at low temperatures a tin of 176 cm^2 area was filled with gasoline. Then it was left out for 48 hours, gasoline level dropped 1.5 mm.

This experiment was made three times and the same result was received.

Then at an air temperature of -48°C an iron barrel was filled with kerosene and soon it turned into a whitish mass of relative density, but it was still in a fluid state. At a temperature of -60°C kerosene turned into a dense snowy mass and at a temperature of -85°C into a solid mass.

At a temperature of -60° diesel oil became so solid that it might be broken only with an axe and at a temperature of -75°C -85°C the oil can be broken into pieces.

A state of anti-freezing lubricant was also observed at low temperatures.

It was revealed that anti-freezing lubricant did not freeze down at the lowest temperature of -87, 4°C recorded at Vostok station but it turned into dense mass of a gruel form.

At Sovetskaya station the following experiment was made. A tin was filled with three litres of anti-freezing lubricant and then it was kept during two days at temperatures of -59°C to -67°C. Some time later hexagonal form crystals of 3-5 mm in diameter appeared. They resembled ice crystals with rounded faces. Then these crystals served as nuclei for the formation of irregular forms small balls of 15 mm in diameter. By the middle of the second day compact ice balls began to unite one with another and at midday of the second day they formed a compact crust on the anti-freeze surface, at the bottom and walls of an iron tin. The crust became thicker up to 25 mm, with temperature lowered to -75°C. Inside the tin anti-freeze turned into soft mass like gruel.

In one of the heavy-tractors, which was under conservation anti-freeze was in the engine cooling system and was under influence of temperatures -87, 4°C.

During the process of anti-freeze freezing in the cooling system a number of solid blockings were formed, but still no unit of this system was damaged while the process of freezing, and after being heated the whole system worked as usual.

It was determined too, that best of all is to add some anti-freeze to the ink of the recorders working in the open air at -80°C; it saved ink from freezing and provides a good visible line on paper.

To determine the conditions of work for transport facilities in low temperatures some tests for diesel fuel "DA" and gasoline B-70 were made to determine their outflow at different air temperatures. For this purpose two tanks of 15 l capacity were used. A tube of 3 m long and of 10 mm in inner diameter was soldered at the bottom to each of these tanks. The free end of a tube was closed with a plug. The tubes position was strictly horizontal.

Then tanks were filled with ten litres of diesel fuel and gasoline. Ten hours later at a certain air temperature plugs were opened and a stop-watch was switched on.

A speed of the flowing out is given below:

AIR TEMPERATURE

Kind of Fuel	-87, 4°	-80, 0°	-72, 2°	-71, 0°	-64, 0°	-60, 0°	-58, 0°	-50, 0°	+15, 0°
Diesel "DA"	not flow	not flow	drops appeared	period between drops 45 sec	stream appeared	8 hrs 05 min	7 hrs 40 min	6 hrs 28 min	8 min 22 sec
Gasoline B-70	10 min 32 sec	9 min 05 sec	8 min 15 sec	7 min 55 sec	7 min 15 sec	6 min 25 sec	6 min 10 sec	5 min 44 sec	2 min 16 sec

Observations of metals behavior at low temperatures were also made. During disassembling of metal constructions at Vostok station when an air temperature was -80°C it was revealed that steel boring tubes of 100 mm in diameter and with a wall of 4 mm thickness broke into pieces at 5-8 blows of the back of an axe. In the place of the fracture pronounced grainy structure of metal was observed.

In the places of welding the construction broke at the first blow.

Steel set squares of 45 x 45 x 5 mm broke into pieces at 10-12 blows of the back of the axe.

At a temperature of -85°C the metal became more brittle and less efforts were spent on its destruction.

At a temperature of -87, 4° a bottom of a metal barrel with diesel fuel was broken into pieces at three blows of an axe. It was revealed that at this temperature the axe itself was also partly broken.

At Komsomol'skaya station it appeared that during station conservation, lasting seven winter months when the minimum temperature was -74, 5°C a battery of radio-station acid accumulators filled in autumn with electrolyte of 1, 25 density proved to be in a working state having poles voltage of 24 v that was quite enough for work. Without charging these accumulators after their being exposed to frost for seven months the work at the radio station was carried out during one hour.

The radio-station apparatus proved to be in a good state.

During the examination of the assemblies of the electric-power station no faults were found. The starting accumulators were in a good state, but the poles voltage was 15 v. The electric generators were also in order. The gas stoves, connected to cylinders filled with propane (C_3H_8), were easily set on fire. All the food supplies left there were good for use.

BUILDINGS AND INSTALLATIONS OF THE
SOVIET ANTARCTIC EXPEDITION

Arctic and Antarctic Research Institute

Mirny Observatory

The buildings at Mirny are situated as follows: living houses, a heated storeroom, a messroom (14 houses in total) situated on the moraine in a line at a distance of 15 m from each other. The houses are erected with their sides facing the southeast, to the prevailing gravity winds directions. The messroom is in the centre of the base. The total area of the main buildings in the Mirny observatory erected by the First Soviet Antarctic expedition in 1956 is presented in the following table:

		Total area sq. m.	Useful area sq. m.
1.	Heated food-store	141, 2	121, 0
2.	Living house N 2	141, 2	96, 0
3.	Living house N 3	141, 2	93, 0
4.	Messroom (house N 4)	141, 2	118, 0
5.	Living house N 5	141, 2	96, 0
6.	Living house N 6	141, 2	96, 0
7.	Living house N 7	141, 2	92, 7
8.	Meteo-station	70, 6	54, 0
9.	Ionospheric pavilion	70, 6	52, 0
10.	Transmitting radio-station	70, 6	55, 0
11.	Magnetic pavilion	70, 6	51, 0
12.	Seismic pavilion	26, 0	19, 5
13.	Living house	70, 6	51, 6
14.	Receiving radio-station	70, 6	49, 0
15.	Diesel-fuel store	47, 7	47, 7
16.	Power station	166, 6	166, 6
17.	Bath-house, laundry	24, 0	24, 0
18.	Non-heated storeroom	214, 2	214, 2
19.	Non-heated garage	255, 0	255, 0
20.	Heated garage	95, 2	95, 2
21.	Aerological pavilion	72, 2	72, 2
		2312, 3	1926, 5

Including:	Total area sq. m.	Useful area sq. m.
a. Prefabricated metal-frame panel constructions	874, 9	874, 9
b. Prefabricated wood-frame panel houses and pavilions	1437, 4	1051, 6
c. Floor space in wooden houses		449, 6
d. Space used for laboratories, libraries, etc., in wooden houses		602, 0

All houses in Mirny are of rectangular form 9, 22 x 7, 53 m in size with attached non-heated tambour. The houses are designed for regions with temperature -60°C and wind speed 70 m/sec, and for erection in the permafrost region or on the continental ice surface. The interior height of the buildings is 2, 65 m, they have rectangular windows of 0, 45 by 0, 45 m in size; doors are 1, 85 m high. Entrance is through a warm door.

The house is heated with an electrical boiler and there is another ordinary boiler in reserve heated by coal. The roof is flat with inclination of 0. 01 and a heated overhead cover. The floor has intensified thermal insulation.

The foundation of the houses is a bolted-frame construction of steel beams. Beams are put on the base of the house, and boards are put on the beams in the diagonal direction. The floor is of double-layer panels with insulation, consisting of 10-15 layers of arboraeous-fibrous plates with rubberoid padding.

The walls are made of plywood in the shape of a panel, warmed by seven layers of arboraeous-fibrous plates. The panels are made of 8 mm waterproof and fireproof bakelite plywood, and glued to the beams. To strengthen the house the panels outside are coated with boards in diagonal direction with insulation paddings. All joints are coated with planks. The walls outside are coated with plywood.

An overhead of the house consists of panels similar to wall-panels and are coated with boards in diagonal direction too. All joints are coated with planks as well. The roof is covered with galvanized iron 0, 51 mm thick.

The house is bolted to the base with beams. The ends of diagonal coating on the outside walls are nailed to the beams.

The entrance doors are warmed with two layers of insulation plate.

The windows are made of four safety glass sheets.

The houses for the expedition personnel are assembled in pairs. There is an extra door in the joint wall between the houses as an extra-exit for emergency cases.

The interior plan of all the living houses is the same. Each house has 4-5 rooms, a corridor, one or two tambour and a toilet. One room is occupied by a boiler unit to provide hotwater heating to all the rooms. The boiler is heated by pipe electrical heaters providing smooth regulation of water temperature and fire safety.

The walls of living and service compartments are papered, the floors and ceilings-painted. All sections have radio sets and telephones.

The thermo-insulating properties in Mirny houses fit the meteorological features of this place.

While the temperature was -43°C and wind speed 20 m/sec the temperature in the houses was normal. The walls and floors are resistible to winds.

Since six years had passed from the day of setting up Mirny, most of the houses and buildings were almost completely buried under the snow. As a result of this the frames of the houses appeared to be in new conditions. A considerable snow load and extensive moisture caused by thawing during summer time appeared to influence the roof. In spite of this condition, the walls were in a good state and there were neither slits nor deformation.

As a result of thawing between ice (snow) and walls a clearance appears up to 10 sm wide.

In the houses under snow the heating conditions of surroundings have greatly changed. The houses are isolated from low temperatures and strong winds and the result of it was that the requirement of electricity for heating was reduced by 1/3.

For instance: when the heating was switched off for 10-12 hours in the "undersnow" houses the temperature there was lowered by 2-3°C while in the houses not buried under snow the temperature lowered by 8-10°C.

This also proves a good quality of thermal insulation materials in panels. In spite of a great quantity of moisture in summer the insulation plate in panels was well preserved.

Waterproof plywood applied in this case provides good protection from water to thermal insulation materials.

The "undersnow" position of houses brings greater danger of fire for the station personnel; the evacuation of people becomes more complicated. To lessen the possibility of accidental fire the interior of the houses is covered with non inflammable layers. Wiring is made of shielded cable as that on ships.

For the quick evacuation of personnel every house has two independent exits to the surface: a main one and, in case of emergency, another one. The exits are in opposite sides of the houses. Besides, there are some more exits through the windows. For such a case, a window opens easily and has a slope pit attached to it from outside. The height of a pit depends on the thickness of snow cover above the window. The pit exit is covered with a light frame with a glass fitted in it. If necessary, the pit is made longer in case the snow cover becomes thicker. No precautions, nevertheless, can give full guarantee against accidents and wooden houses still remain a danger in case of fire.

To avoid such accidents a new design of houses made of fireproof materials is under construction and in 1962, one or two houses will be brought to the Antarctic to test their qualities in practice.

Inland Stations

The houses were delivered ready-made and assembled on sledges and fully equipped to the Pionerskaya, Komsomol'skaya, Vostok and Sovietskaya inland stations.

It was done to avoid extra work while assembling in low temperatures, oxygen insufficiency and in changeable weather conditions in the sites of stations.

The number of houses depended on the number of personnel working at these stations. For example: at Komsomol'skaya station—there were three houses; at Vostok I—five houses; at Vostok—six houses; etc. At Mirny the houses were assembled of prefabricated panels, specially warmed for Antarctic regions to keep normal temperature inside at an air temperature -80°C out of doors.

The interior size of a house measures 470 by 250 by 210 cm, the useful space—22 m^3. Each house contains one door and one or two windows of 46 by 46 cm, fitted with a frame of four thick glasses which underwent special treatment.

Being on site, the houses on sledges were put at an angle-turn to each other forming an unoccupied square inside, closed from all directions. Beams were put across this square, fastened by their ends to the sledges under the houses. Panels, covered with plywood, were put on the beams. A floor of 22 m^2, and a roof were made in such a way that this interior space was used as a storeroom for equipment and stock of the station.

The doors in all houses opened inside. In one of the corners, the houses which were on sledges were removed from each other and at this place a tambour of panels was erected. It has a window through which an outside entrance was made into the house.

All cracks and holes were coated with boards and plywood.

The stores were made for food, fuel and other things outside the houses in the corners formed by their walls.

The houses served as follows: power plant house, radio-locator house, radio-station house, combined galley and messroom house, and living house.

Radio-station and radio-locator houses were also used as service and living rooms.

The walls and the ceiling inside the houses were decorated with bakelite plywood; the floor and lower part of walls were coated with non-inflammable linoleum. These precautions guarantee the fire safety and help to maintain the cleanliness of the rooms as bakelite plywood and linoleum are washed easily with warm water.

Novolazarevskaya Station

This station is situated in Schirmacher Oazis at a distance of 100 km from the shore.

The main houses and installations of the station are set up on rocks on the site measuring 200 by 200 m.

The general line of erecting the houses is perpendicular to the prevailing wind direction, and the houses themselves are at an angle-turn facing the predominant winds. This position helps winds to blow round the walls and prevent them from being buried under the snow.

The following houses are built at the stations:

1. Service house—useful space 62, 8 m^2.

2. Living house—useful space 62, 2 m^2.

3. Messroom and galley—useful space 62, 2 m^2.

4. Diesel electro-plant with a bath-house attached—62, 2 m^2.

5. Aerological pavilion with a tower for radiosonde launching—useful space 42, 2 m^2.

6. Magnetic pavilions three pavilions—total space about 23 m^2.

7. Glaciological pavilion—space 18 m^2.

8. Storeroom for property—space 41 m^2.

9. Pig sty—space 12 m^2.

10. Hangar for control surfaces of aircraft (wing unit).

All houses are built on stone base put on wooden foundation (wooden beams) and fastened with pulls of steel rope 12 mm in diameter.

Wooden pavements are laid down between the service, living, messroom and diesel-room houses.

The designs for houses in Novolazarevskaya are the same as in Mirny.

There is a water-supply system with hot and cold water in all the houses. Dirty water is disposed away with special pipes far away from the site of the houses. The interior of the houses is decorated with panels painted with non-inflammable paints, the floors and the lower part of the walls are covered with non-inflammable linoleum.

SECTION IV

VEHICLES

ANTARCTIC LAND VEHICLES USED BY ARGENTINA

Pedro Osvaldo Baeza

Argentina's experience on the subject of land vehicles for use in the Antarctic dates back to 1951, when the Army outfitted its bases with Studebaker weasels.

The characteristics of these vehicles are well known by all, as is their efficiency.

In 1954, by way of experiment, three light motorized sleds called toboggan carriers were taken to the Esperanza base situated on the bay of the same name on Trinidad Peninsula. These sleds were equipped with 2.5-hp Brigg Straton motors mounted in the rear part, with a tractor system consisting of a single central band.

Considering the low capacity of these vehicles, the practical results were unexpectedly good, especially as regards the efficiency of the motors. It is pertinent to mention, as an illustration, that when the toboggan carriers were rejected, one of these small motors was assigned to function as a power plant in the base refrigeration chamber, and has continued in service up to the present without trouble.

In 1957 a wheeled vehicle was tested, the unimog, again at the Esperanza base. It is a light truck with diesel engine and rear and front traction, and produced by the Mercedes Benz firm.

The characteristics of the zone of Trinidad Peninsula in which the Esperanza base is situated—rocky soil finely fragmented and generally free of snow—make possible the use, within certain limits, of vehicles provided with wheels with pneumatic tires. The usual transportation requirements—carrying of a low number of fuel drums, rations boxes, personnel, etc.—are easily met by a vehicle such as the unimog.

The advantages are even greater during the operations of unloading annual supplies on the coast, especially when it is remembered that the sleds cannot move over the rocky soil.

The quality of production of the unimog is made clear by the fact that the vehicle placed in service in 1957 by the Army is still functioning today without trouble.

Another favorable characteristic of this vehicle is the additional power takeoff.

A noteworthy disadvantage is the difficulty of starting it in ambient temperatures lower than 10°C below zero, and the use of preheaters becomes unavoidable under such circumstances.

Heating of the crankcase by means of a kerosene or liquid propane burner may be resorted to as a provisional solution.

It should be noted, however, that during the Antarctic summer in the zone suitable for operation of the unimog, the temperature rarely reaches values below 5°C below zero.

A little more than two years later, in January 1960, Argentina began to use two types of motorized vehicles: the muskeg and the model 443 sno-cat. Both vehicles were also employed extensively by the ground support group under my command during operations connected with flights of the C-47 aircraft of the Naval Aviation of Argentina.

Comparison of the two vehicles shows the efficiency of the sno-cat to be clearly superior; its accessory characteristics are also outstanding: good average speed with medium loads; safety on the march in cracked zones; ease and simplicity of handling; roomy and comfortable cab; versatility in its possible uses.

I must make it clear that in mentioning safety of travel in crevassed areas I refer principally to its ability to pass over the snow bridges of the crevasses without breaking them or causing a slight cave-in in the top of them. The muskeg, on the other hand, owing to its two single caterpillars and reduced length in zones with crevasses, especially if the latter are parallel and close together, acquires during travel a violent "pitching" motion which causes caving in or breaking of the snow bridges, or at best the track formed presents a series of elevations and depressions which render subsequent travel over the track difficult.

The latter circumstance is aggravated with the passage of new muskegs, and subsequent snowstorms do not improve the track conditions in this case.

The disadvantage is an important one when logistic requirements impose the necessity of transporting a large cargo—in repeated trips—over a difficult zone in which there is limited space which is known to be without danger.

We encountered a situation with these characteristics on Robertson Island, over the Larsen ice barrier, during construction of the provisional Capitán Campbell airfield, which was one of the stopping places of the Argentine flight to the South Pole.

On this occasion the zone we reconnoitered and found to be suitable for landing aircraft of the C-47 type was approximately 20 miles distant from the edge of the ice barrier, and legs greatly dissected by crevasses appeared along the track, some covered by snow caps approximately a meter and a half thick. The cargo, of a weight near 50 tons, had to be transported on successive trips over a trail which coincided with the one used by the vehicles which carried the cargo destined for the Teniente Matienzo base. Under these circumstances use of the sno-cat presented no difficulties in travelling over the trail several times, but when several muskegs were placed in service the route deteriorated, and as the summer progressed, with the consequent softening of the surface snow, the conditions worsened almost to the point of preventing movement of these vehicles.

My own experience and that of others have convinced me that up to the present, and within the limits of what is available to us, the sno-cat is the vehicle which offers greater advantages for our Antarctic needs, with a single limitation, the rocky zones. These zones are unfortunately common during the summer in the area of our northernmost stations.

As regards the sleds, requirements are met in our country by domestic production effected at the Esteban de Luca Arsenal, with designs developed by the Antarctic Division of the Army.

The following types of sleds are currently in use:

a. Small Sled

Designed to be drawn by man: they are light (20 kg) and have a small load-carrying capacity and are usually used in the vicinity of bases or shelters to carry small loads over short distances.

They are also suitable for carrying aboard aircraft—the C-47 type or larger—constituting a part of the customary survival equipment. It is advisable to outfit aircraft operating in the Antarctic with these sleds, against the event that, in an emergency, the crews may be forced to cover a certain distance on foot, when they can load the indispensable items of individual equipment on the sleds. A man can easily pull 50 kg of cargo placed on a sled of this type. The structural details of the sled are to be seen in Figure 1; it should be mentioned that wood exclusively is employed in its structure. The various fastenings are made with cotton cord or raw leather.

b. Medium Sled

Designed to be drawn by dogs. Weighing 80 kg, it takes a payload of up to 500 kg, depending on the number of dogs making up the team. Seven, nine, or eleven dogs are usually harnessed at our bases, the approximate maximum loads being 300, 400, or 500 kilograms.

As may be seen from Figure 2, this sled is 3.60 meters long and has a maximum width of 55 cm. It has a brake operated by the driver with his foot, and as an interesting detail, in areas with pronounced slopes it is customary to add to the fore part a thick line carried loosely across the lateral spaces formed by the two skids and the straight ends of the arch of the sled, being joined together underneath the skids. This line is usually carried raised and fastened to the arch of the sled, but at the beginning of a very pronounced slope it is loosened and allowed to come between the skids and the ground; this greatly retards speed.

The design of this sled is based on the Nansen model, with the modifications introduced by the Antarctic Division of the Army. The materials employed in its manufacture are:

Wood of the Guayabí (Alburá) [Sacellium lanceolatum] or Guatambú [Balfouro-dendron Riedelianum]: for skids, openwork beams, reinforcing and side beams, openwork support crossbars and crossbars joining the side beams, supports, stops, and crossbars joining the jib, brake blocks, and harness trace arches.

SAE 1010 steel: for brake irons and their lugs, connection supports between the skids and beams, braces, and fastening plates.

"Micarta": for lining the slip plane of the skids.

Cotton rope: for harness traces, harness moorings, and hafts.

Tarred cotton rope: for protective wrappings and lashings to reinforce the arch.

Thongs of raw leather: for lashings of the skid supports, of the supports of the crossbars and beams, and of the ends of the skid arch.

c. Large Hauling Sled

It is coupled to motor vehicles and is of three types:

I. Sled with booth—complete housing unit.
II. Sled with booth—complete kitchen and space for cargo.
III. Sled for cargo.

These three types have a common bottom section structure: skids; stops; beams; and coupling hook system—this presents the advantage making possible the interchange of spare parts. The dimensions in all cases are:

Total length (from end to end of the skids)	4.35 m
Useful length (between the outer edges of the outer crossbars)	3.60 m
Width (between the side beams)	1.40 m
Maximum width (between the outer edges of the skids)	1.65 m
Width of the skids	25 cm
Height (between slip plane and upper face of side beams)	45 cm

Metal plated SAE 1020 iron is used in the construction of the skids, and the detailed drawings in Figure 3 are followed.

As is to be seen in the cross section, the slip plane of the skids is faced with Micarta 5 mm thick connected by means of a double row of aluminum rivets of 3.5 x 12 mm placed 15 mm from the outer edge of the skids and spaced at intervals of 10 cm.

Starting at 83.2 cm from each end, the skids are curved 134°. The radius of curvature of 57.5 cm locates the free ends 45 cm from the slip plane.

The hitching and coupling system, which is similar on all the sleds, is described in detail for the cargo sled.

It is appropriate to give a brief description of the sleds with booths.

Starting from the lower section (slip and hitching), type (I) carries a quadrangular structure of light pine wood faced with sheet aluminum and having a maximum height of 2 meters; it constitutes living quarters which can accommodate six men in bunks.

The interior is faced with heat insulating plastics, and the floor is lined with dovetailed lapacho [Foigneniaceae] planks.

Each booth has four windows of fixed double panes of plexiglas and a watertight door located in the front side.

On the type (II) sled the booth of wood and aluminum occupies half the total length, the remainder of the useful space of the sled being enclosed by a railing similar to the one to be described for the type (III) sled.

This space is designed for carrying food supplies or fuel for the kitchen during patrols with caravans of motor vehicles.

Of this series, the cargo sled is the one most used. Above its bottom or slip plane it carries on its sides and ends removable openwork of guatambu wood which constitutes the railing. As may be seen in Figure 4, the side members consist of a 12 x 2.2 cm panel of guatambu wood and five 5 x 2.2 cm laths of the same material. The length is 3.60 meters, and they are connected by five 5 x 4 x 80 cm cross laths, also of guatambu, which taper at the bottom so that they will fit into the metal catches fastened on the side beams. The vertical laths are spaced at intervals of 90 cm.

The front railing acts as a system for connecting and securing the side railings by means of a system of grooved guides (which permit them to slide vertically) and two catches with lugs.

As another accessory for securing the side railings, use is made of two pairs of galvanized iron chains of 2.5 x 0.6 cm connected in the center by a tightener hook. These chains are secured to the upper connecting pins of the second and fourth vertical stops of each of the side railings.

Figure 4 shows the details, the Figure 5 the arrangement, of the whole of the different component elements.

The latter figure shows the front and rear hitching systems, which are designated by numerals 7 and 8.

The hitching system illustrated in Figure 6 is made up of 1 1/2 inch galvanized iron pipe and has at its vertex a large ring (made of SAE 1040 steel) which is mounted in a shock absorber system based on a spiral spring 0.8 cm in diameter, of SAE 1020 steel. This spring is 16.5 cm long. The pole has two supports, which are secured to the side beams of the sled. By means of a linch-pin of SAE 1030 steel located in each support, the front hitching system is connected to the sled and acquires vertical free play.

These same supports permit attachment of the rear hitching system, which is shown in detail in Figure 7.

As may be seen, the system consists of a galvanized pipe 38 mm. in diameter, reinforced with an arch of galvanized pipe of 19 mm. diameter. In the center of the cross pipe there is a U-shaped piece 23 cm long connected by a galvanized pipe 19 mm in diameter to the reinforcing arch. The U-piece has round holes permitting passage of the hitching bolt of SAE 1040 steel, which in turn has a cross hole 8.5 mm in diameter designed to receive the safety bolt, which is made of SAE 1055 steel.

The rear hitching system is connected to the sled, by means of the same supports used for the front hitching system. This permits rapid interchange of the system, with the attendant advantages.

A description has been given of what has thus far been Argentina's experience in the matter of land vehicles for use in the Antarctic. The author has had personal experience in the use of the majority of these vehicles, gained during nearly two years of stay at Antarctic bases.

Acknowledgements

The drawings of Figures 3, 4, 5, 6 and 7 were kindly made available by the Antarctic Division of the Army.

Figure 1 and 2 were supplied by the Argentine Antarctic Institute.

Summary

An analysis is made of the various vehicles which Argentina has used, or is now using, at the various Antarctic bases. A detailed description is added of the various models of sleds, specifying the materials used to build them.

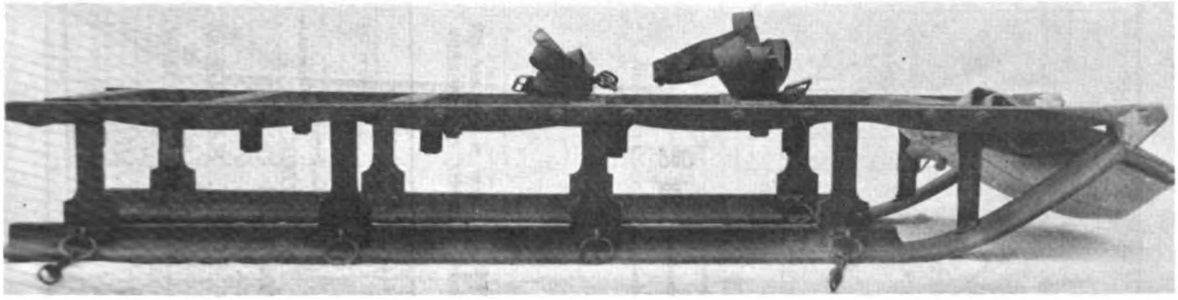


Figure 1. Small Sled.

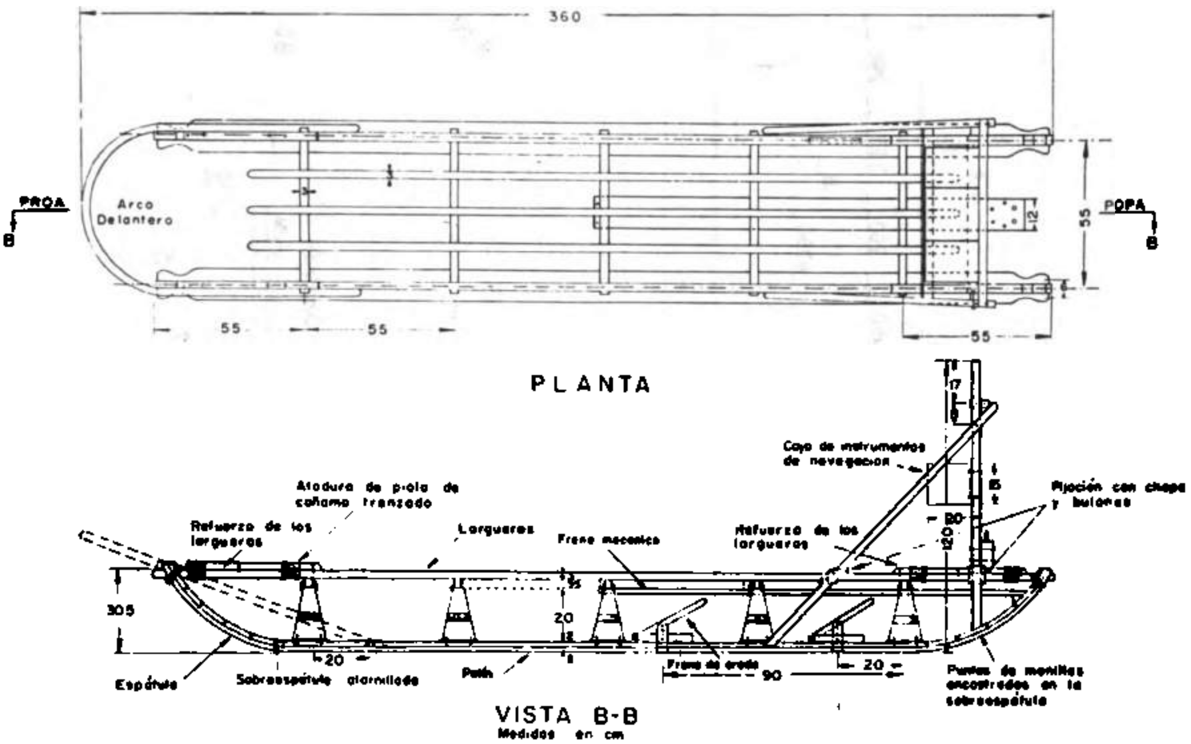


Figure 2. Nansen model sled modified by the Antarctic Division of the Army.

PROA = BOW; POPA = STERN; arco delantero = front arch; PLANTA = TOP VIEW; caja de instrumentos de navegacion = box of navigation instruments; atadura de piola de canamo trenzado = fastening of braided hemp rope; refuerzo de los largueros = reinforcement of beams; largueros = beams; freno mecánico = mechanical brake; fijación con chapa y bulones = fastening with plate and pins; espátula = tip; sobreespátula atornillada = screwed on tip cover; patín = skid; freno de arado = plow brake; puntas de manillas encastradas en la sobreespátula = bracket points embedded in tip cover; VISTA B-B = VIEW B-B; medidas en cm = measurements in cm.

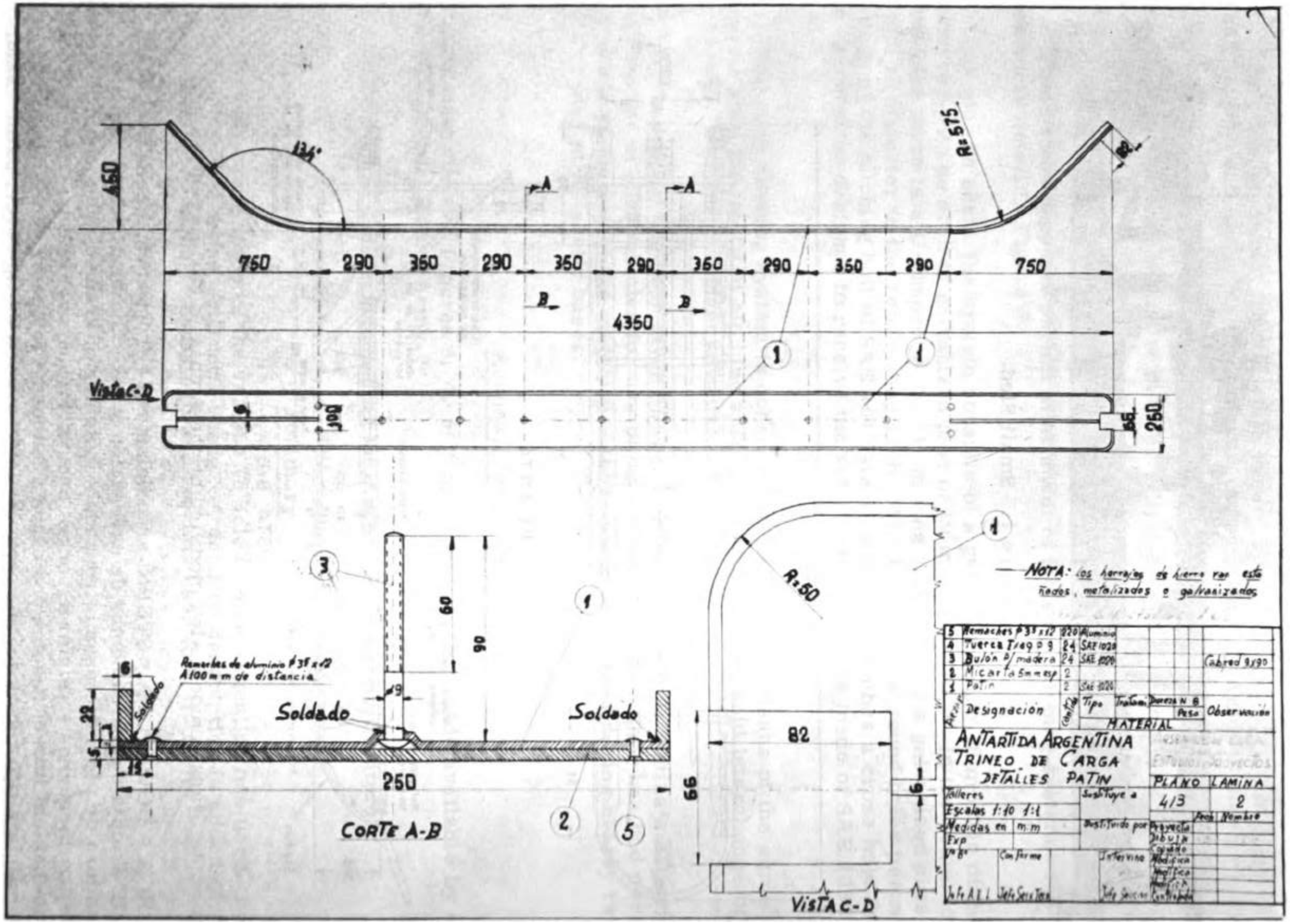


Figure 3. Cross section, large hauling sled.

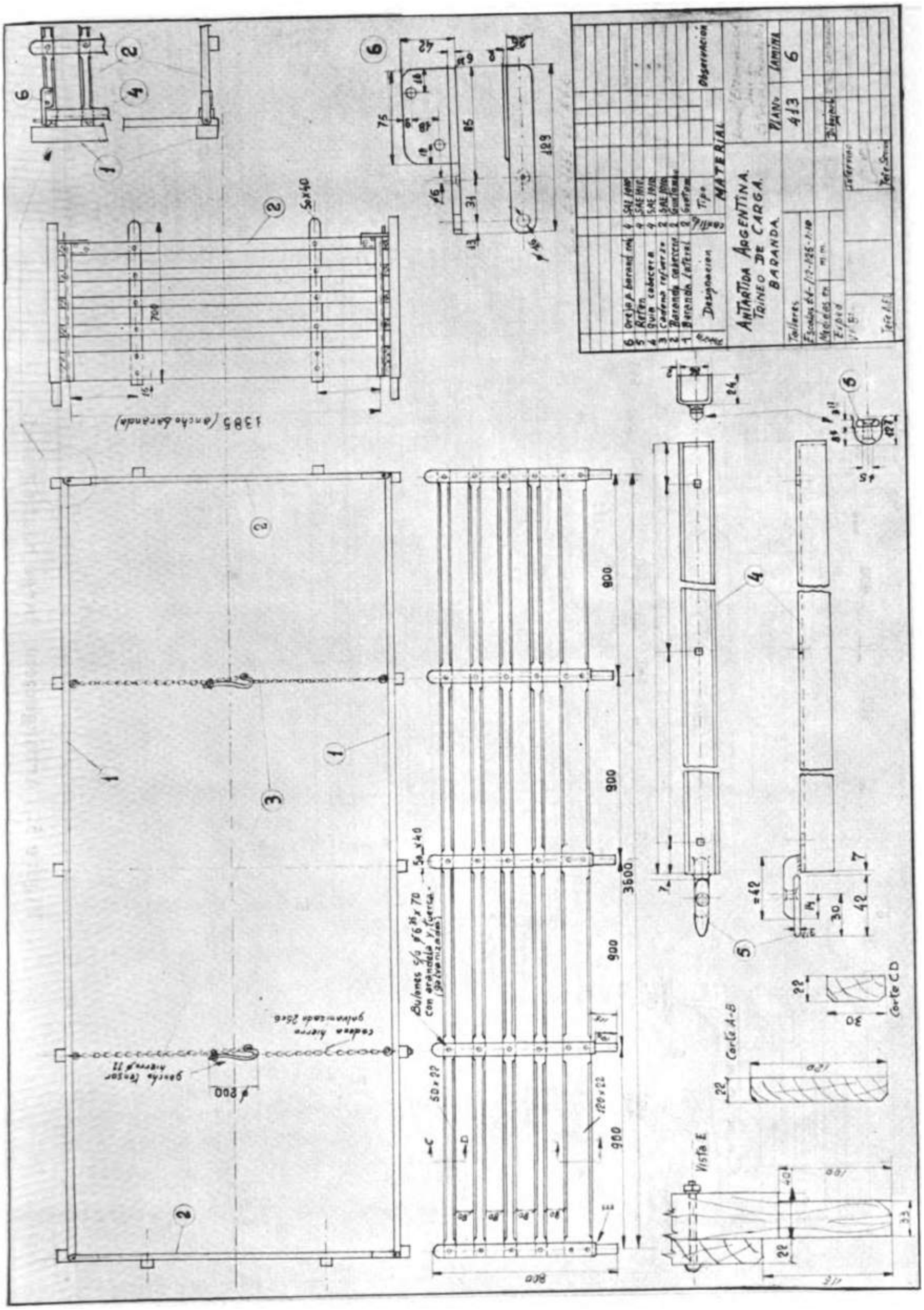


Figure 4. Detail, large hauling sled.

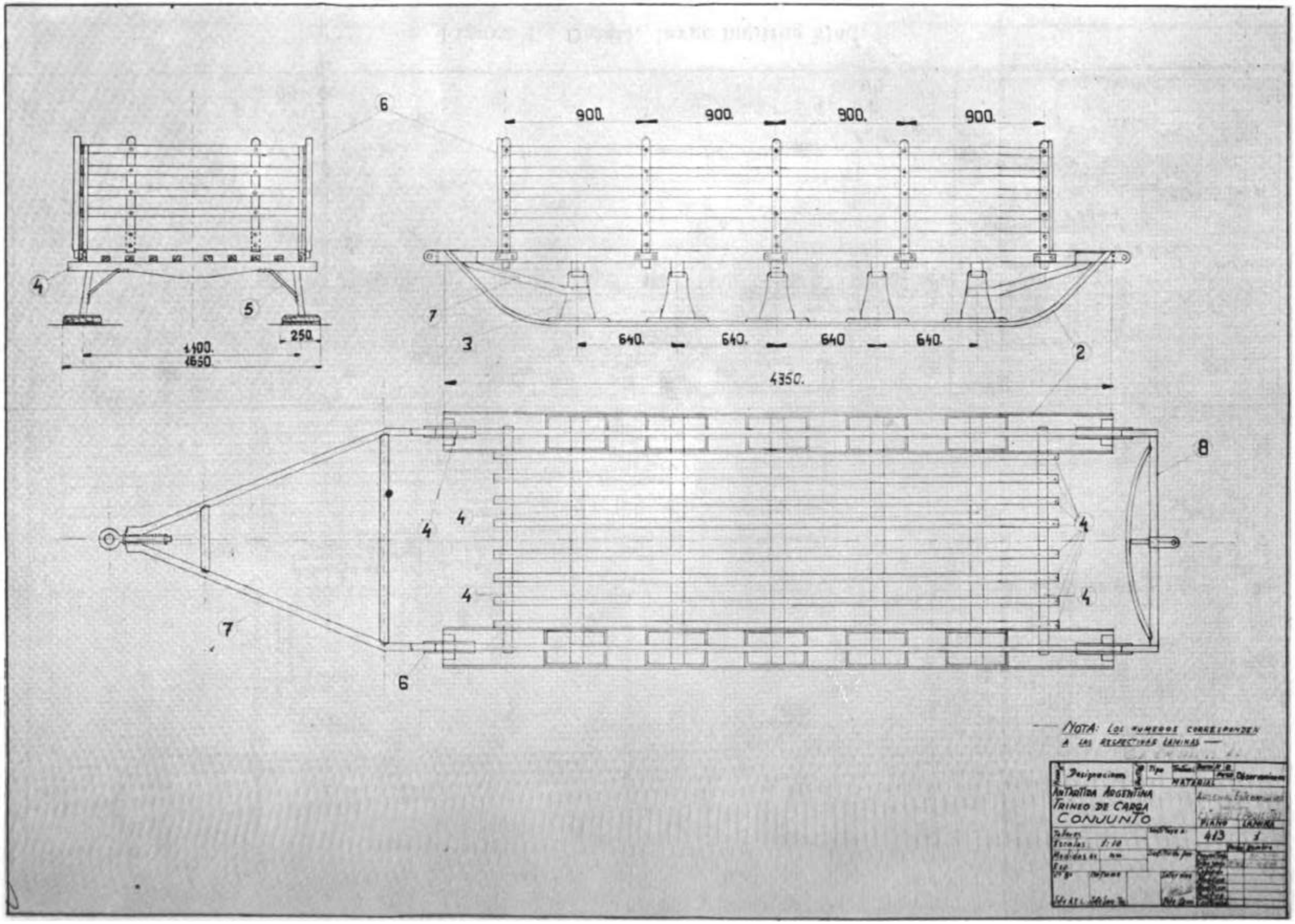


Figure 5. Arrangement, large hauling sled.

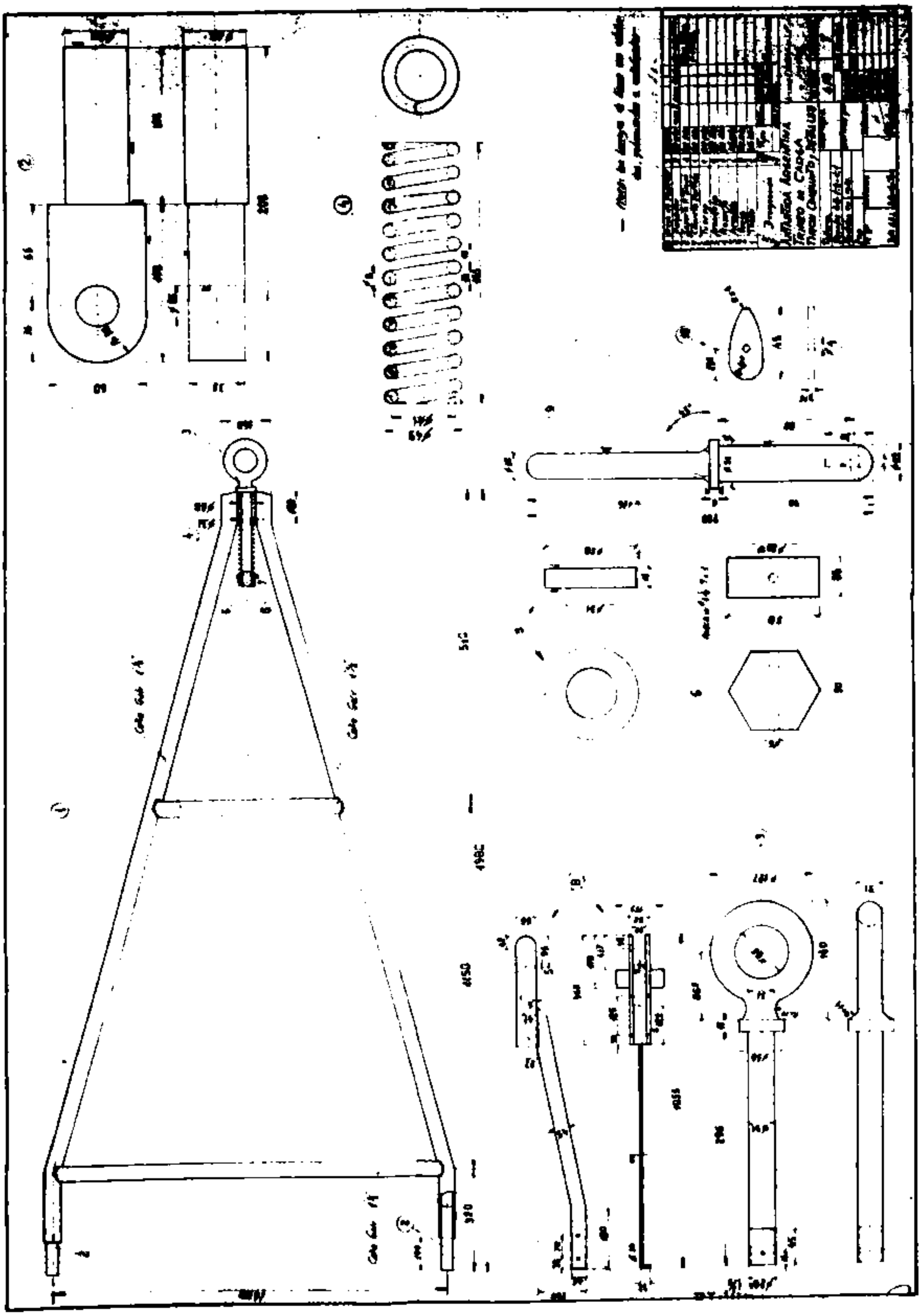


Figure 6. Hitching system, large hauling sled.

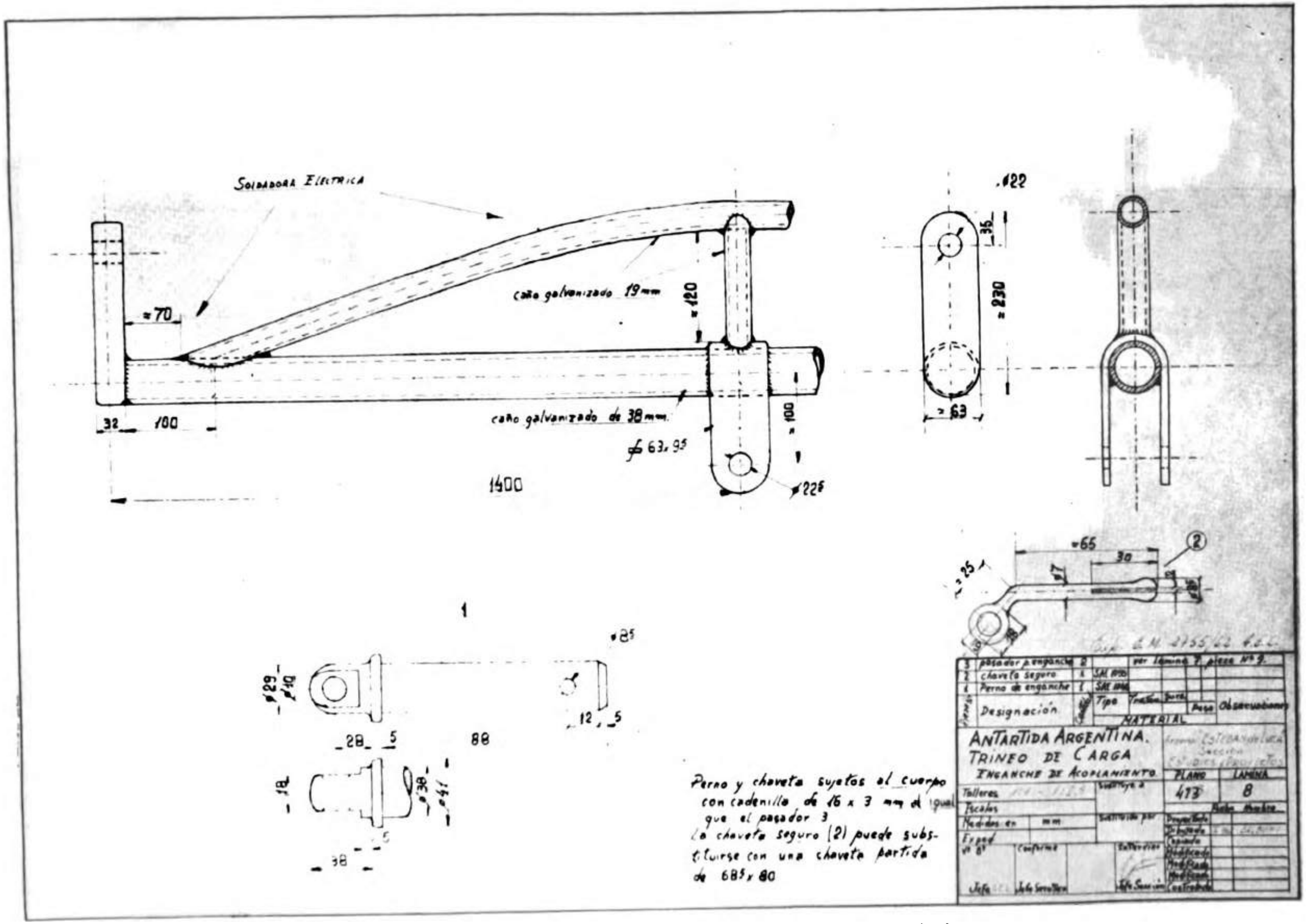


Figure 7. Rear hitching system, large hauling sled.

THE PERFORMANCE OF D4 TRACTORS ON PLATEAU TRAVERSES

F. A. Smith

Summary

A. N. A. R. E. has had considerable experience in operating tractor trains on plateau traverses using the Caterpillar D4 tractor as prime mover. The results of this experience are given under the headings:

1. General description of tractors used
2. Accessories and special equipment
3. Type of fuel used
4. Starting methods
5. Operation under various snow conditions
6. Maximum loads as related to terrain, sledges and altitude
7. Fuel consumption as related to terrain, load and altitude
8. Operation in crevassed areas
9. Maintenance problems

(This paper is complementary to the paper "Economics of a Tractor Train Traverse Near Wilkes" to be presented under Section 6.)

1. General Description of Tractors Used by A. N. A. R. E.

The tractors are manufactured by Caterpillar, U. S. A., and two models are in use, the 7U series and 30A series. These models are practically identical and allow for almost 100 per cent interchange of spares. Engines are standard products, rated at 32.4 hp and developing 50 hp at full governed speed of 1600 rpm. A six-volt electrical system is provided for lights and the electrical starting of the petrol starting engine.

Transmission is standard with five forward and one reverse gear, and power is transmitted through a dry flywheel clutch. All tractors are 60 inch between track centres and this gauge is suitable for 24 inch wide tracks. A fully equipped tractor gives a ground pressure of 5 lb/sq inch. Drive sprockets are specially designed for snow conditions, having a relieved tooth which does not induce snow accumulation between sprocket and track. Tracks incorporate a large hole in each plate which matches sprocket teeth so that at all times snow and ice is forced through the track and prevents build-up of ice. Six tractors are in use in Antarctica and are fully equipped for plateau travel. Several of them have been used continuously throughout the summer periods since early 1957. In spite of numerous minor crevasse incidents, damage has been negligible and repairable on site.

2. Accessories and Special Equipment

The engine is left exposed and no protection has been found necessary.

The radiator fan blades are removed, leaving only the blade arms rotating on the pulley. The pulley must still be driven because it also drives the cooling water circulating pump. Excessive cooling of the engine is thus avoided and problems with icing are reduced. A sheetmetal cover over the radiator front is also provided to control heat dissipation. Hot water from the engine is used in a small cabin heater (described later). The engine temperature rarely reaches the ideal operating temperature of 175°F, and this does contribute to incorrect combustion and loss of power.

All main engines are fitted with a standard ether starting aid which uses an ether capsule. The device punctures the capsule and injects the ether into the intake manifold. The petrol starting engine has an electric starter motor, but aids to starting in very cold conditions are not fitted, so that this forms a considerable difficulty which has not yet been overcome satisfactorily. Preheating and liquified petroleum gas (propane) seem most promising possibilities for development.

Ice grousers are fitted to the tracks, one on every fourth plate. This number has been found adequately to prevent sideslipping on ice yet not to interfere with the steering of the tractor. The ice grousers would be damaged by rock and must be removed before venturing on to such terrain.

Four tractors are equipped with rear-mounted "Hyster" logging winches of 19,000 lb capacity with 300 feet of steel rope. These winches are useful for pulling sledges through soft snow and in recovery from crevasses.

Two of the tractors are equipped with 5KVA 230-volt single-phase alternators and Lincoln 32-volt dc arcwelding generators, both driven from rear power take-off pulleys on the tractors.

Each tractor is fitted with a steel fully glazed cab. Two full length sliding doors for driver entry are provided and an escape hatch is located in the roof.

A safety belt is positioned centrally across the driver's seat. No provision is made for passengers, nor are they encouraged to ride with driver because of the restricted space and position of controls. The driver must have freedom of movement at all times.

A small cab heater is fitted for driver comfort, using hot water from the engine but the capacity is only sufficient to provide limited background heating. This type of heater has disadvantages and an electrically driven petrol or kerosene burning turbine type heater with an output of 15,000-20,000 Btu/hr which could be used for engine preheating as well is under consideration. Steel floors of tractors are insulated with removable insulated blocks to prevent cold feet and possible frostbite for the driver.

3. Type of Fuel Used

Arctic grade diesel distillate is not available in Australia. Aviation Turbine Kerosene (ATK) has been used with complete success. The specification for this fuel is similar to DRD2482 or DRD2494 (Nato Spec. F30 or F34) having cloud points -40°F and -60°F, respectively. Ordinary Diesel Distillate has been used but at very cold temperatures heavier fractions solidify and the resulting slush chokes lines, filters, etc. Lubricity of the ATK seems adequate as no undue fuel pump wear has been experienced. The ATK has been used successfully down to -63°F.

An important advantage for A. N. A. R. E. of using diesel engines is that the fuel used for them can be stowed below decks in the supply ships. Petrol (gasoline) must be carried as deck cargo because of its high inflammability and, in addition to problems of securing it in large quantities, the space available is limited.

4. Starting Methods

The great difficulty of arranging starting of diesel engines at low temperatures is largely avoided by the use of the petrol starting engine. Although premium quality winter grade gasoline is used in the starting engines, it has been our experience that at -5°F or below, gasoline does not readily vaporize. This condition causes wet spark plugs, dilution of oil, loss of compression, etc. Most operators first use a cord to rotate the starting engine to break oil drag and clean out cylinders. This method is preferred to conserve the batteries for the actual starting. The biggest handicap with the Caterpillar Electric Starter is that the Bendix Drive on the electric starting motor (i.e., a pinion mounted on a helically screwed shaft) is rejected on the first explosion in either cylinder even though the engine does not have sufficient inertia to go beyond the second compression stroke. This fault causes severe wear of the meshing teeth and severely tries the operator's patience. Starting by hand using the cord is often resorted to when patience ends.

A simple, but effective, method of obtaining vaporized fuel uses the bowl of the air filter on the starting engine. This bowl normally contains the oil which wets the filtering pads. For this work, air filtering is unnecessary, oil is not used, and the filter remains clean and dry. A small quantity of petrol is poured into the filter bowl, and heated with a blowtorch till boiling. The vapor is drawn into the engine when the engine is rotated. There is a risk of fire and the method should only be used in the open air.

Tractors tow-start very readily and much time may be saved if this method is adopted. The towed machine should be off compression until oil is circulating and the machine is reasonably free of oil drag. Either fourth or fifth gear must be used in the towed vehicle.

Removal of drift snow can be a major item in starting. The tractor is largely unaffected by drift snow and indeed the method used to solve the drift problem is to remove all unnecessary covers, panels, etc., seal the remaining panels, and leave the cab doors open on both sides to let the snow blow through the cab. A little brushing is all that is required before starting. V-belt pulleys on the engine driving the waterpump, and the various controls, must be checked to see that they are free of ice, and the tractor may be operated without further preparation.

Fuel tanks are topped up before leaving the tractor to prevent condensation of water vapor inside.

Engine lubricating oil is diluted with ATK at cold temperatures. Ten per cent is sufficient down to -30°F and is varied according to temperature at the discretion of the mechanic in the field party. A log is kept to control the amount of dilution carried out and dilution is always done with the engine running for 15 minutes to ensure adequate mixing before shutting down. The ATK is mixed with lubricating oil before pouring into the sump of the engine.

5. Operation Under Various Snow Conditions

A. Soft Snow

For the greater part of our inland travel, soft snow does not present a problem, but precautions should be taken to ensure that tractors are fully equipped to cope with such conditions. Although the overall ground pressure of a D4 tractor does not exceed about 5 lb/sq inch it will "dig-in" on soft snow unless it is balanced when towing by fitting a bulldozing blade, or suitable front-mounted counterweight such as fuel drums, or both. The effect of the weight is to keep the full length of each track flat on the snow, providing full traction and even ground pressure. On one traverse (in 1958) a tractor had to be driven in reverse for sixty miles over soft snow because no counter weight was fitted.

Often a long cable can be used between the tractor and the first sledge to provide maximum freedom of movement and to enable the tractor to become mobile before the load is taken up. If this cable is attached to the winch, the operator can release the winch at the onset of digging-in, then winch the sledge train through after reaching firmer conditions.

B. Sastrugi & Névé

Sastrugi does not present a problem to the tractors because they are so strongly constructed. Tractors towing sledges are quite maneuverable. Safety belts are essential to protect the driver from injury or from losing control when tossed around in the cab. (This applies particularly in whiteout conditions.) Névé is ideal for tractors, except when humidity causes snow to stick and form a solid block around the top track support roller. This will force tracks out of adjustment and, although many ideas have been tried in an effort to overcome this problem, it seems that the only safe way is to stop the tractor every few miles and chip away the ice with a crowbar or ice-axe.

C. Ice

For ice conditions all A. N. A. R. E. tractors are fitted (as mentioned in Section 2 above) with ice grousers, one on every fourth track plate. These provide maximum gripping qualities and do not interfere with steering ability. Grousers are removed from tracks before tractors are driven on rock, as this will quickly render them useless for future ice work.

Sledges can be controlled on ice slopes by wrapping several turns of chain around and towards the rear ends of runners. The method is quick and chains are easily removed when no longer required. Alternatively, tractors can be connected at each end of a train of sledges.

6. Maximum Loads Towed

For all conditions, a maximum load of 12 1/2 tons was considered practical. Under certain conditions slightly more could be towed, but only at the expense of much greater fuel consumption, due to the necessity for using the lower gears.

Several types of sledges have been tried but we have found the most successful is a Norwegian type, built of timber and reinforced with steel brackets. It is flexible and light.

Heavy wooden, steel-reinforced sledges have been used with some success, but these were inclined to push through soft snow rather than glide over it.

Two types of steel sledges are used. The first type, having four articulated runners similar to the Canadian "Otaco" type, is successful but inclined to be rather too much for the D4 tractor when laden to capacity.

A smaller flexible sledge having two rigid steel runners was designed in 1957 and later used on two traverses. This type of sledge carried a convenient load and was satisfactory mechanically but required a wider runner to lower the ground pressure.

Many towing arrangements have been tested and it is generally accepted that a rigid tow bar is required for connecting the tractor to the first sledge to prevent the sledge fouling the tracks of the tractor and to support the tractor on crevasses. For other sledges two crossed wire ropes are used and found quite suitable. This arrangement provides for sledges to close-up at overnight stopping points and assists easy starting as each sledge may be "broken-out" separately, creating much less strain on the tractor sledges.

Above an altitude of 5, 000 feet above sea level a decrease in power is apparent unless turbo chargers are fitted. The lower air density causes incorrect combustion, which is indicated by clouds of black smoke blown from the exhaust. However, a sufficient reserve of power is available, for loads are generally lighter by the time such altitudes are attained. In any case after the first year's experience turbo chargers have been fitted to all A. N. A. R. E. D4 tractors. Where it can be arranged, fuel should be depoted for use on the return journey.

7. Fuel Consumption

The fuel consumption for diesel engines is much less than that which would be required by petrol engines for the same purpose.

As most A.N.A.R.E. traverses cover surfaces of ice, snow and sastrugi it is interesting to note that fuel consumption per tractor mile has been almost constant. Fuel is provided at the rate of one imperial gallon per mile on an inland trip. While actual consumption is lower, i.e., 1.2 mpg., the figure of 1 mpg allows for wastage, idling and warm-up periods, discarding of the last gallon in each drum to prevent contamination by rust and ice, etc. To prevent wastage, reject fuel is used in Kindlerwick type of kerosene (paraffin) heaters in the living caravans.

It is generally the terrain which determines the speed and hence the gear used. Although fuel consumption is greater in lower gears, the engines operate better at fully governed rpm. Pulling a load of 12 1/2 tons the tractors would be very seldom in top gear.

Fuel consumption is increased by high altitudes for two reasons, firstly incorrect combustion due to the rarefied air and secondly the use of lower gears to offset loss of power. The above factors have been considered in nominating overall fuel consumption.

When the tractor's main engine is used to drive the 5KVA alternator the fuel consumption is most uneconomical because such a large engine is used for such a small alternator, and the engine must be run at 1600 rpm. The use of the alternator continuously while camping for caravan lighting, etc., is therefore not recommended.

8. Operations in Crevassed Areas

A. Precautions

At all times, terrain and horizon are closely studied for possible crevasses and, in known crevassed areas, tractor trains proceed with extreme caution. The route is usually surveyed by a light forward scout vehicle ("weasel" or "snowtrac"). This method is not 100 per cent safe for a lighter scout machine will cross dangerous areas unaware of crevasses and often the first indication is a heavier tractor breaking through a snow-bridge or falling into a crevasse.

A steel crowbar or probe is most useful for locating crevasses in suspect areas; the opportunity for drivers to get out and walk is usually appreciated as an opportunity to stretch their legs. Crevasses are not bridged with timbers carried for the purpose unless a more suitable crossing cannot be found. Tractors are never taken over known crevasses towing the full load, but a steel rope is used between tractor and first sledge; this allows the tractor to move freely and at a higher speed. Other sledges are then hauled across another section of the crevasse, away from the weakened section.

Crevasses up to 2'6" wide have been crossed numerous times in the above manner and it has been found much faster than arranging bridges. Always the angle of the approach is 90°, so that both tracks will touch the opposite side together and pull without swerving into the crevasse.

When crevasses are large and hazardous, the two tractors may be connected together with steel ropes for support in a break through. This may mean that the second tractor must cross a snow-bridge in the same place, more or less, which increases the likelihood of its breaking through.

B. Recovery

Many ingenious methods have been used in tractor recovery but, without preliminary planning preparations, the risk of losing the tractor down a crevasse is very real. The accent is on safety, and one person is generally appointed to supervise operations and keep an eye on inexperienced but over-keen members of the party.

The logging winches fitted to four of the tractors are most useful in recovery operations, either when the winch is on the disabled tractor or on a second tractor.

The use of a second tractor cannot be relied upon entirely, for it may be in difficulties at the same time, or its use may be limited by the presence of other crevasse hazards near the disabled tractor.

The first step in recovery is to secure the tractor from falling further using anchors and 'dead men', where necessary.

If the tractor has fallen too far for it to be winched straight from the crevasse, excavation may be necessary to prepare a platform at the level of the tractor onto which it may be hauled. From the platform the tractor may be hauled or driven up a suitable ramp. For such excavations, it is very useful to have available a second tractor equipped with a bulldozing blade.

C. Repairs

It could be claimed that A.N.A.R.E. expeditions have been fortunate for, in spite of numerous crevasses, no serious damage has been caused and not one tractor has been written off. All recovered tractors are given a thorough mechanical check before restarting.

9. Maintenance Problems

A. Engine

No serious faults have been experienced over several years of plateau traverses, but the usual troubles are loose bolts and fittings due to pounding and vibration. These problems can generally be avoided by preventative maintenance. Fuel tanks and filters are drained and cleaned at appropriate intervals, usually on the warmer days when oil is more fluid. A log is kept by the engineer to control the amount of oil dilution carried out. Fan belts are closely watched for ice build-up. On an occasion when a belt did break, it was not replaced immediately but a link-type belt was fitted as a substitute. This served quite well as a quick replacement, perhaps because the fan had been removed (see 2) and only the water pump had to be driven by the belt. Air breathing tubes of engine sumps will block in heavy drift, causing the sumps to build up pressure and forcing oil out of dipstick tubes. Frequent checks are made to keep the breathers free under these conditions. On the whole, the Caterpillar engine used has been found to be most suitable for Antarctic traverses because it is designed to be exposed to the elements, is appropriately sealed for that exposure, is well proven and requires very little maintenance.

B. Transmission and Tracks

Again, preventative maintenance is the key to successful traverses, for tracks in particular must be inspected regularly for loose bolts, incorrect track tension and signs of wear. The transmission is designed for rugged service and causes little trouble; clutch adjustments are essential but simple; gear cases need to be checked for lubrication at scheduled service periods only; gear oil changes are not usually necessary on traverses; track rollers and guides are lubricated every 100 miles or so and do not require further attention.

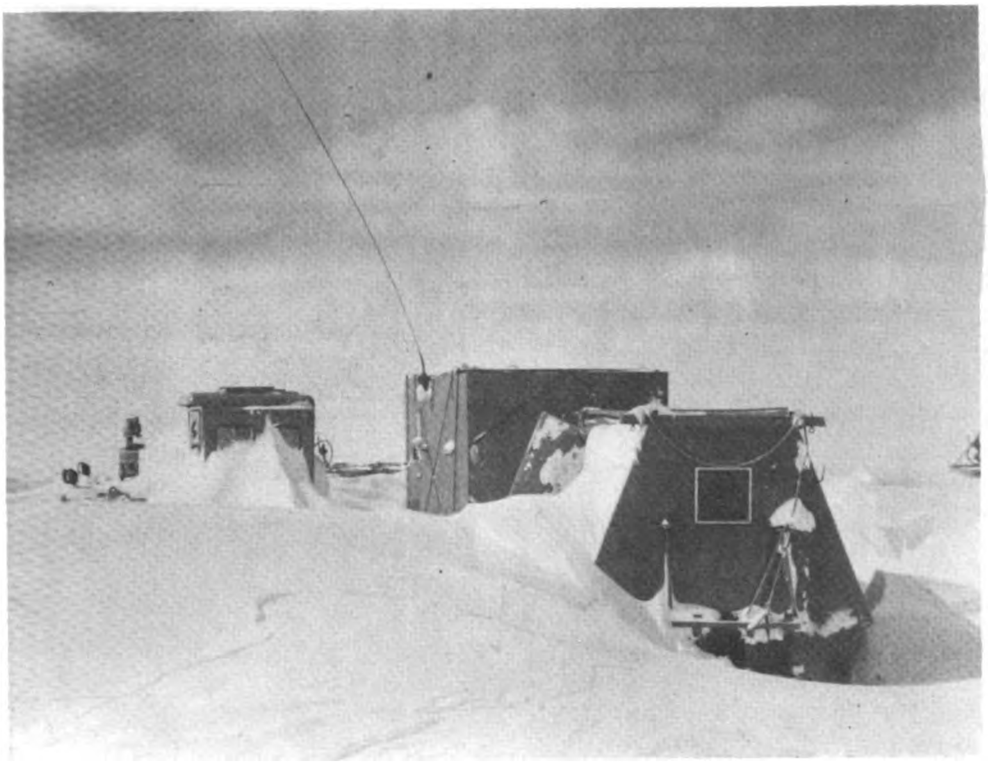
C. Lubricating Oils and Greases Used

For engine lubrication a wide range oil SAE 10-20-30 is used both winter and summer. In winter, aviation turbine kerosene is added but in proportion to the fall in temperature. ATK is never added direct to sumps, but premixed with oil. Engines are given at least a 15 minute run after dilution to ensure that the oil is carried to all bearings and cylinder walls.

Tracks are not lubricated, but rollers are lubricated with a light extreme pressure oil, using a gun thoroughly warmed before use and often applying heat to the grease points as well.

Summary

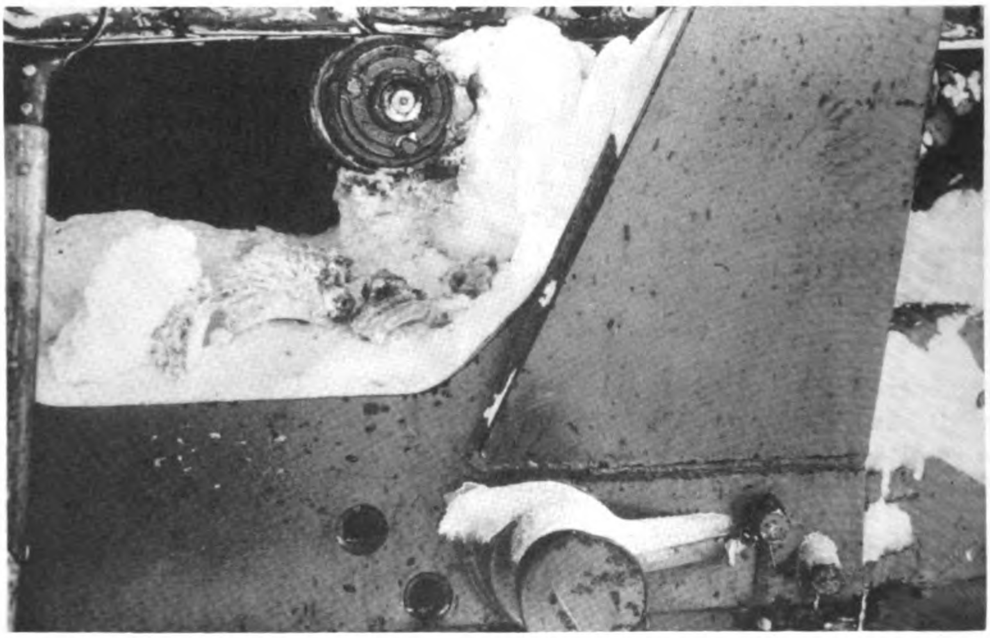
In conclusion, Caterpillar tractors have been magnificient "work-horses". They are essentially a prime mover and consequently carry no payload themselves. They are very robust, completely reliable, and simple to maintain. They are safe when safety rules are followed, and can be managed by drivers with very little experience.



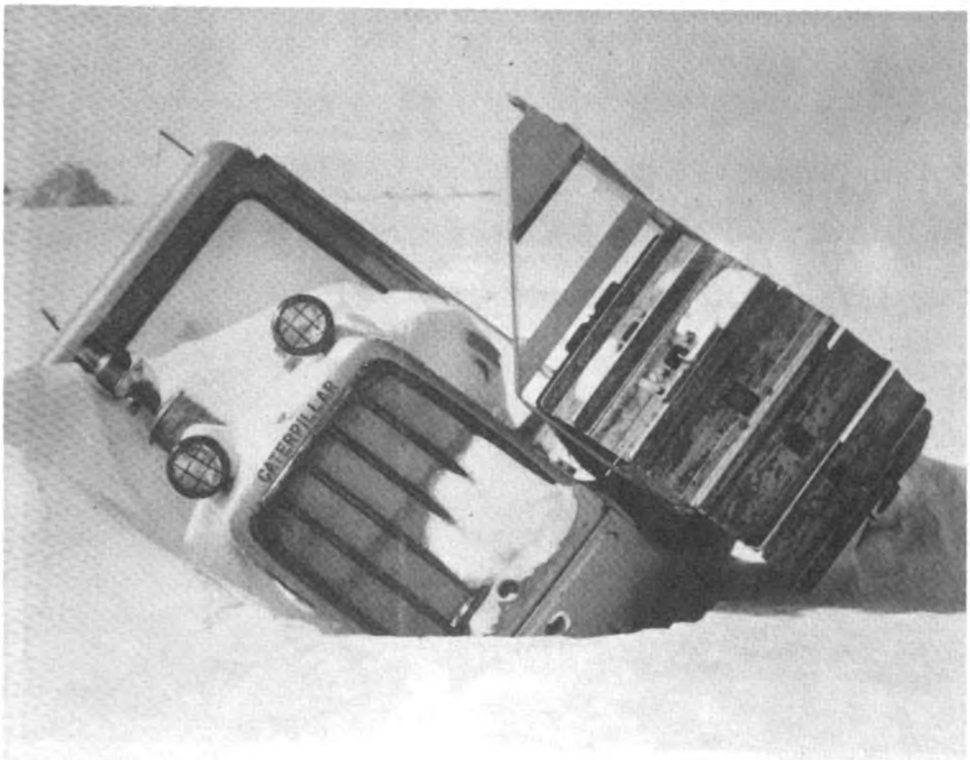
Drift deposited during four day blizzard 1958.

Close-up of drift around engine 1958.

Soft snow compacted on track plates 1960.

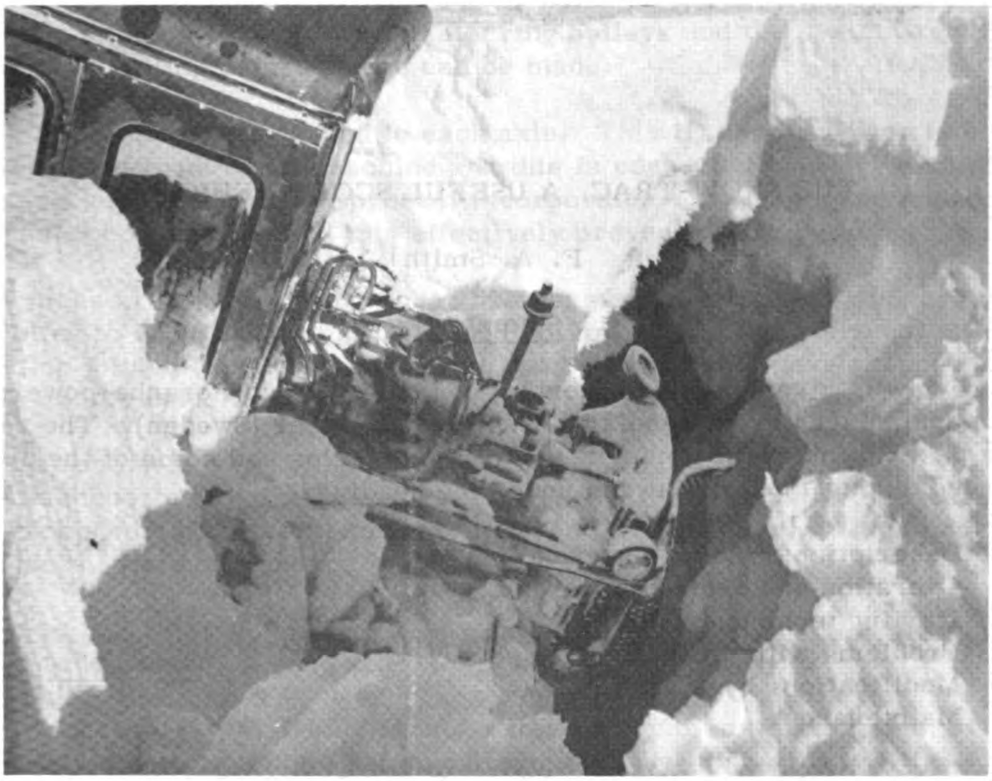


Hard ice build-up on track support roller 1958.



Difficult situation. Both tractors crevassed at same time 1958.

Both tractors in trouble. Preparing to salvage tractor 1960.



Tractor suspended in crevasse 1960.

Recovery operation showing ramp 1960.

THE SNOW-TRAC, A USEFUL SCOUT VEHICLE

F. A. Smith

Summary

A review is given of twelve months' operation of two Porsche-powered Snow-Tracs, manufactured by Aktiebolaget Westerasmaskiner (Sweden). The review covers a description of the performance of the vehicles and some of the problems experienced during 1961 at Mawson under the headings:

1. Description of Snow-Trac;
2. Operation and performance;
3. Starting technique;
4. Problems with altitude;
5. Modifications by A. N. A. R. E.;
6. Maintenance.

1. Description of Snow-Trac, Model ST-2

A. Engine

The Snow-Trac is powered by a horizontally opposed 4 cylinder O. H. V. air-cooled Porsche industrial engine and develops 55 hp (SAE rating) at 4000 rpm. The ignition system uses coil and distributor and the carburetor is a dual choke downdraft Zenith model 32 NDIX. The clutch is a standard heavy duty dry plate and the gear case is not synchronized on these models.

B. Transmission and Tracks

Power is transmitted to an extended differential which forms part of the steering mechanism. The steering is simple and unusual, for it consists of two variable pitch pulleys each mounted on vertical shafts above the axle housing on each side of the differential gear box and coupled together by a rubber V-belt. Both pulleys are mechanically in constant mesh with the half axles through bevel gears.

In normal straight running both pulleys are equal pitch and a turn is made by rotating an automotive steering wheel which moves a lever, which in turn opens one pulley and closes the other pulley to vary the pitch ratio and hence causes a difference in speed between the two pulleys. The lever is loaded by a screw adjustment of its fulcrum position to control belt tension. Two opposed springs tend to return the mechanism to a central position and these springs are adjusted to give straight running. In effect the arrangement monitors the difference in speed of the respective half axles and so the Snow-Trac is made to turn. Only the power required for steering is transmitted through the steering pulleys and the system requires the vehicle to be rolling before a turn can be made.

A chain sprocket is fitted to each axle. This transmits power to a larger sprocket at the front of the machine and this is connected by a drive shaft to the track sprocket. Each track sprocket incorporates a small bronze scroll fixed to the periphery of the face and this effectively prevents snow build up.

Tracks are made of two rubber belts for each track with grippers of spring steel bolted to each rubber belt. A good feature is that belts are not endless and may be lap jointed when the screw type track adjustments have reached their limit. Repairs can be made to tracks by bolting on short belt segments.

Suspension is very simple but inclined to be too light for rough work. The weight is supported by a pneumatic rear wheel and six pairs of independently sprung bogie wheels which use semi-pneumatic tires. All exterior fittings provide for easy access, and maintenance is very simple.

C. Body and Cabin

A rigid box girder frame forms a flat platform on which a steel body is bolted. The whole unit forms a rigid cabin. A single bucket type seat is fitted for the driver, and padded seats are attached to each side wall of the cabin to accommodate four passengers. Ample windows are provided and an escape hatch is fitted in the roof. A 7, 000 Btu turbine-type heater which burns petrol is fitted for passenger comfort.

2. Operation & Performance

The Snow-Trac is not designed as a "work-horse" and is limited to light loads, but has proved very useful as a scout vehicle. The best results have been achieved on sea-ice travel. It is light (2, 235 lbs) and will tow 1, 100 lbs. Fuel consumption at sea level is approximately seven mpg. As the wheel base is relatively short, it requires careful handling over sastrugi.

Total load recommended is 1, 100 lbs on the Snow-Trac and 1, 100 lbs on a light sled. This allows it to travel 400 miles at four mpg. The increase in consumption is due to gear work and the effect of altitude on the engine.

While the Snow-Tracs have not been tried on a major inland traverse, they have been over ice, neve, soft snow and sastrugi. Because of the extremely low ground pressure of 0. 75 lb/sq inch, they were not troubled by soft snow. The grippers were not designed for ice, but ice spikes have been fitted to each track, one every second gripper and alternated from side to side. This enables the vehicles to climb and traverse the most difficult ice slopes with complete safety.

Drivers require very little training to become competent operators, for the Snow-Trac has all the qualities and equipment of a small sedan car. The hand ratchet type throttle recently provided is an advantage as drivers are inclined to develop clumsy footwork while wearing insulated boots on rough terrain, and the foot throttle is very sensitive. The steering wheel must not be turned while the vehicle is stationary, as this may damage the steering mechanism.

3. Starting Technique

Starting a cold engine can be very difficult if settings and adjustments are not perfect. One disadvantage of the Porsche engine is that the intake manifolds are too long and do not permit the fuel to reach inlet valves and combustion chambers in a suspended form in cold weather. As a result plugs become wet with fuel and short out the spark. Twin carburettors would be a partial answer to this problem. A simple solution devised was to use a pressure pack containing a mixture of ether, upper cylinder lubricant, propane and freon. These have been used with success at temperatures as low as -25°F.

The personnel heater may also be ducted to the engine compartment to assist starting. From experience, it is considered that 7, 000 Btu is insufficient and at least 15, 000 Btu is required for good results.

4. Problems with Altitude

The standard Porsche engine is not fitted with altitude compensating equipment on the carburettor and starting in rarified air is even more difficult than at sea-level. Altitude compensation on the carburettor is essential for operation on the Antarctic plateau. A simple, sealed-capsule-operated unit is available to meter the fuel automatically according to height. If this is not fitted, carburettor metering jets should be changed to maintain the correct mixture.

Fuel consumption is directly affected by altitude and at 5, 000 feet drops to about 2 mpg unless the fuel-air mixture is corrected.

The loss of power at high altitudes above 8, 000 feet is sufficient to almost immobilize the machine. Correcting the fuel-air mixture would partly rectify this, but it would be desirable to restore full power output by the use of a supercharger and this is being investigated.

5. Modifications by A. N. A. R. E.

Two ST2 Snow-Tracs were tested during 1961 at Mawson and one ST4 is undergoing trials at Davis during this year. In all, twenty-nine modifications and improvements have been incorporated on the ST4. There are five more yet to be tested and approved. (See recommendations at end of paper.)

The body needs little modification. Insulation has been glued to the interior but is not really successful because the large window area, having low resistance to heat flow, renders the insulation of little value. Body design is good for a scout vehicle, but does not lend itself to sleeping arrangements. Finish is only mediocre. Rubber sealing is lacking in corners and what may be termed difficult areas. Body assembly is rough. To sum up, it seems that a great amount of thought has been given to the design of this vehicle, but assembly and manufacture have not been supervised to the extent that is warranted.

The tracks and grousers are obviously an example of simplicity of design which has proved to be exceptionally functional for after 1,500 miles, the tracks and sprockets appeared sufficiently serviceable to repeat the performance. It is interesting to note that more damage and wear was caused during a three day test on Australian snowfields than a complete year in Antarctica. A sketch of the A.N.A.R.E. ice-grouser is shown on an attached drawing.

6. Maintenance

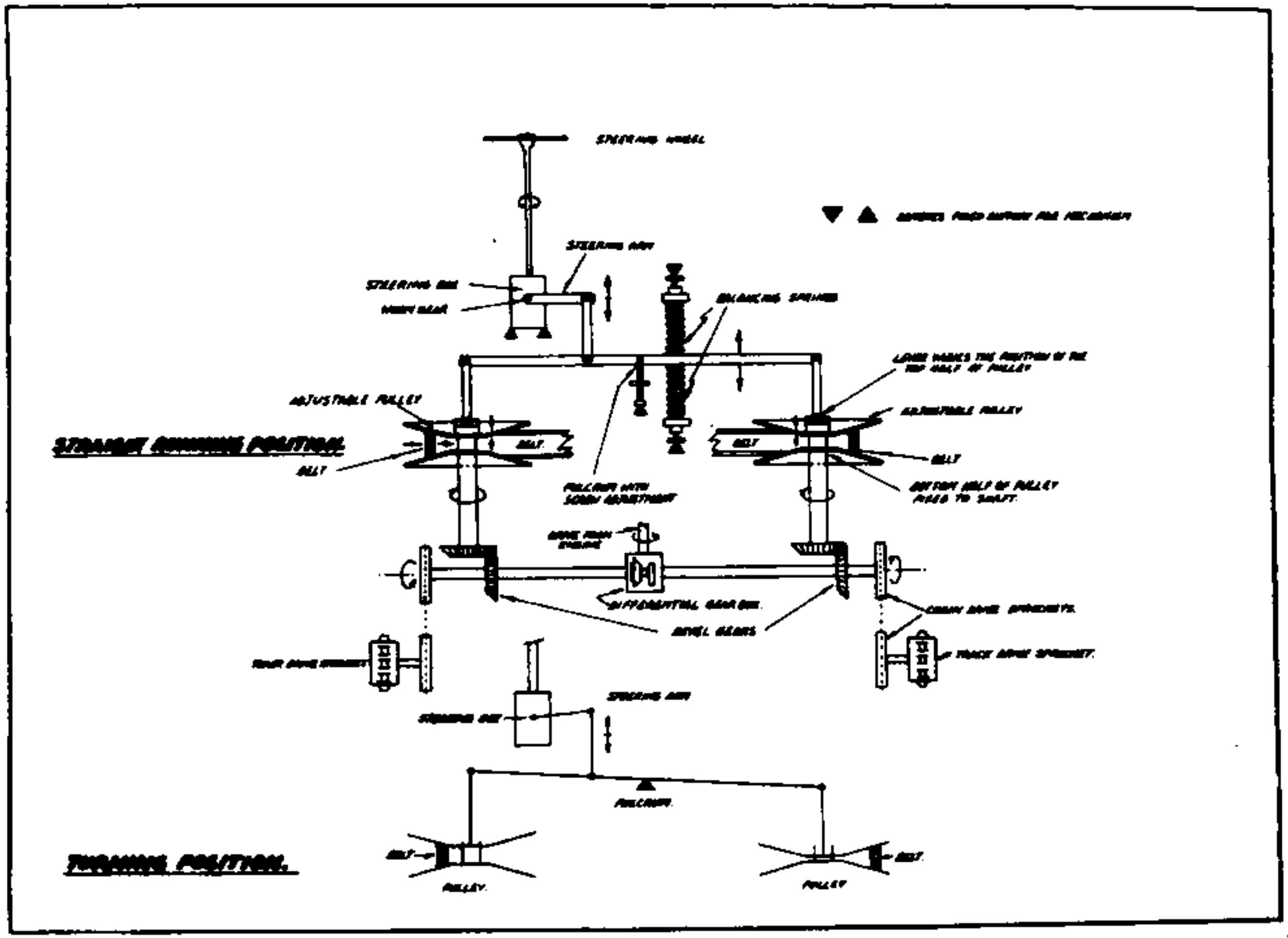
Replacements for the engine have been very light during the first year of operations, demonstrating that the engine can withstand rough treatment. The engine compartment is not designed for in-situ maintenance, but removable panels on each side have simplified adjustments. The body, being light, does not require much attention, although rivets and bolts become loose regularly which is more a nuisance than a serious maintenance problem.

Modifications and Recommendations for Snow-Tracs

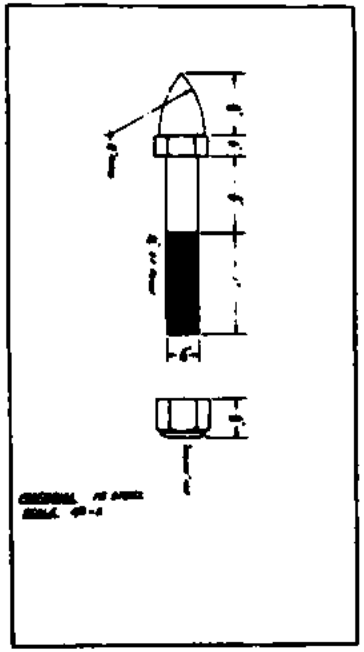
Some of the following improvements and modifications have been included in the ST4 model Snow-Trac, following our experience with the ST2 Models in use at Mawson. The manufacturers have also included other modifications, contributing to a vastly improved vehicle.

1. Heavier type Porsche industrial engine rated at 5 HP extra.
2. Fully synchronized gear box.
3. Improved and reinforced construction of the "Variator" (Steering Control) with stronger "V" belt. All difficult grease points brought to a central point for easier servicing.
4. Main frame reinforced against torsion.
5. Heavier and stronger leaf springs for bogie suspensions.
6. Six double shock absorbers instead of four.
7. Improved bogie wheels and higher quality tires for same.
8. Bogie wheel hubs reinforced by extra bolts.
9. Track plates rubber coated for better de-icing action.
10. Drive sprockets of more wear resistant material.
11. Engine compartment sealed at front axle housings.
12. Removable plate in engine compartment side-wall for easier access to valves and tappets, etc.
13. Guards fitted to lights and blinkers.
14. One extra windscreen wiper and both having longer blades.
15. Two tow hooks bolted to front bumper.
16. Light for cabin interior.
17. Chain guards fitted on drives to track sprockets.
18. Improved down draft carburettor, fitted with altitude compensator.
19. Exhaust modified and one connection eliminated.

20. Driver's window removed and replaced with full slide-open type.
21. Bodywork better finished and substantial screws and bolts to replace original lighter type.
22. Outlet from fuel tank re-located and fuel filter bowl securely mounted on side wall.
23. Solid Control rod for carburettor, throttle linkage instead of cable type.
24. Fuel lines mounted for easier access and improved type fuel pump fitted.
25. Distributor replaced by a more robust Bosch type.
26. Fuse carrier moved to position on instrument fascia.
27. Map case mounted on passenger side on instrument fascia.
28. Tool case, pump, crank handle, spot light and spare wheels to be securely mounted in suitably fixed carriers.
29. Six volt system to be replaced with a 12 volt system.
30. Steel turret top, fitted with escape hatch.
31. All bogie wheels to be pneumatic to reduce rim fractures.
32. A personnel heater capable of supplying 15,000 Btu and ducted to engine compartment.
33. Improvements to chassis to withstand rugged use.



Snow-Trac steering mechanism—schematic.



Grouser Bolt. Ice
Snow-Trac type.

Swedish Snow-Trac in crevasse 1961.

THE DESIGN OF FIELD CARAVANS

N. R. Smethurst and R. F. M. Dalton

Summary

In this paper the four berth sledge-mounted living caravan is described. This caravan has been used extensively in the field at the A.N.A.R.E. stations, Mawson and Wilkes. Alternative interior layouts have also been designed and similar caravans have been used for radio communication and workshops at the plateau airstrip at Mawson.

1. Dimensions

For detailed dimensions of the caravan and interior layout refer to the attached drawings. General inside measurements are length 14' 1 5/8" width 7' 1 5/8" height 6' 6". The overall weight of the caravan including fittings (but not including transporting sledge) is approximately two tons.

2. Construction

The frame is constructed from lightgauge, electrically welded, pressed steel sections. Stressed skin side panels made from corrugated 20 SWG aluminium alloy, are rivetted to this framework while roof panels of 20 SWG steel are lock-seamed over a standard two-inch cambered roof. Floor panels are made from 1/2-inch marine plywood and in each wall a double armour plate glass window is mounted. An escape hatch of similar construction to the windows is located in the roof and is hinged to open outwards. This hatch is fitted with a heavy duty locking device operable from both sides. The door, floor, ceiling and walls are insulated with three inches of onazote and the interior of the walls and ceiling are lined with 1/4-inch masonite. Ventilation is provided by two six-inch controlled ventilators in the roof and one at either end of the caravan.

A partition of kiln dried hardwood with 1/4-inch masonite panelling is fitted on the hinge side of the door and extends 2'6" into the cabin. An interior door closes against this partition to form a cold porch in which some shelving for food storage is provided.

At the opposite end to the door, hinge type wire mesh bed frames are mounted with two against each side wall. Drawers are fitted beneath each lower bunk and other drawers, shelves and coat hangers are placed as indicated in the Interior Layout drawing.

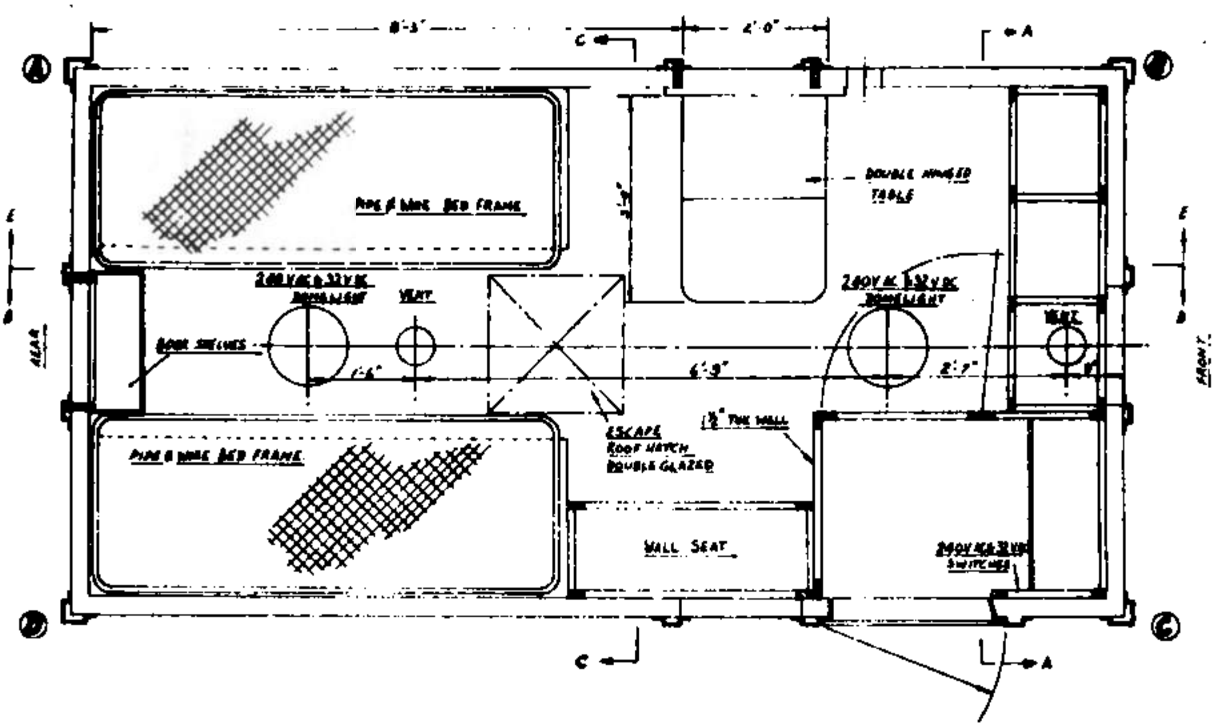
A galley is provided at the door end of the caravan and consists of a two burner heatane stove with griller, oven, table, stainless steel sink and cupboards for food storage and cooking utensils. Fuel for stove and a radiator, is supplied from gas bottles mounted in the cold porch. This galley comfortably catered for six men over a period of three months, two men sleeping in another smaller caravan.

The caravan is wired for electrical lighting and can operate from a 240 VAC or a 32 VDC power source. Usually power was supplied from a generator mounted on the tractor. A dual wiring system is incorporated, consisting of 10A power points for 240 volts and suitable connectors for 32 VDC with completely separate wiring. The dc wiring has a maximum voltage drop of 1.5V at a current of 30A. A four connection TRS junction box is provided near each light and both 240VAC and 32VDC wiring is brought to this point. The actual lamp connection is then made via rubber covered leads to the actual voltage supply in use.

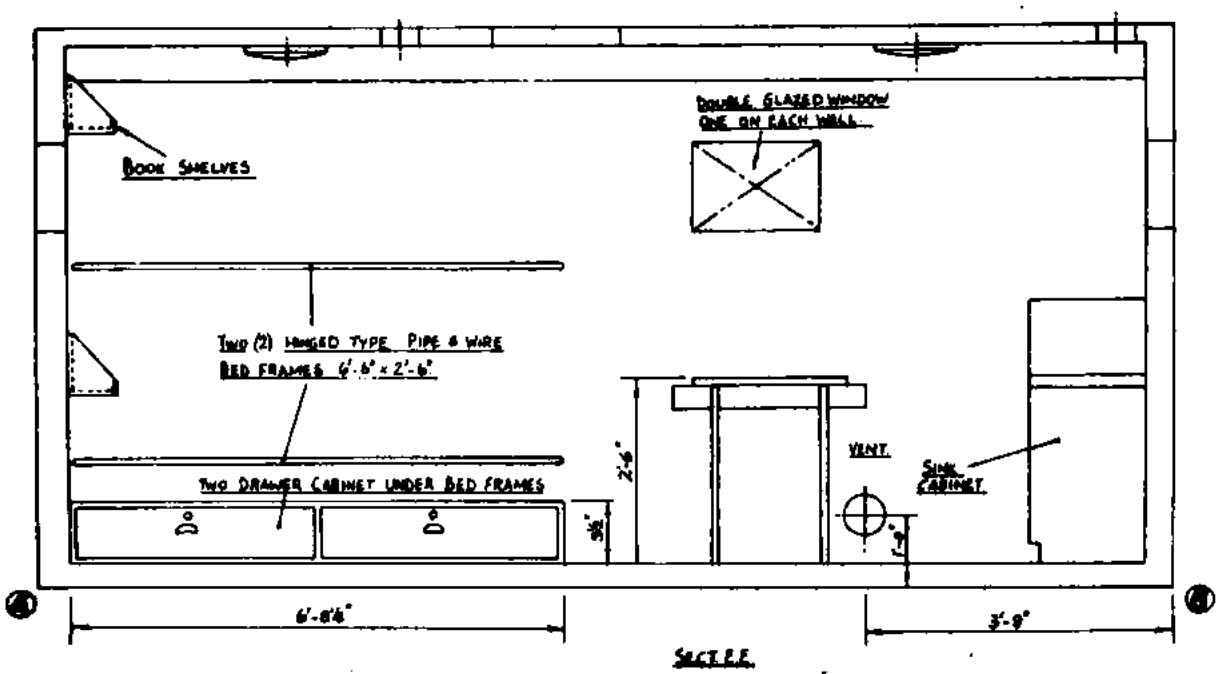
After undercoating, the exterior of the caravan was painted international orange and the interior in attractive colored enamel while cabinets and bench work were painted with light varnish.

3. Lashing and Lifting

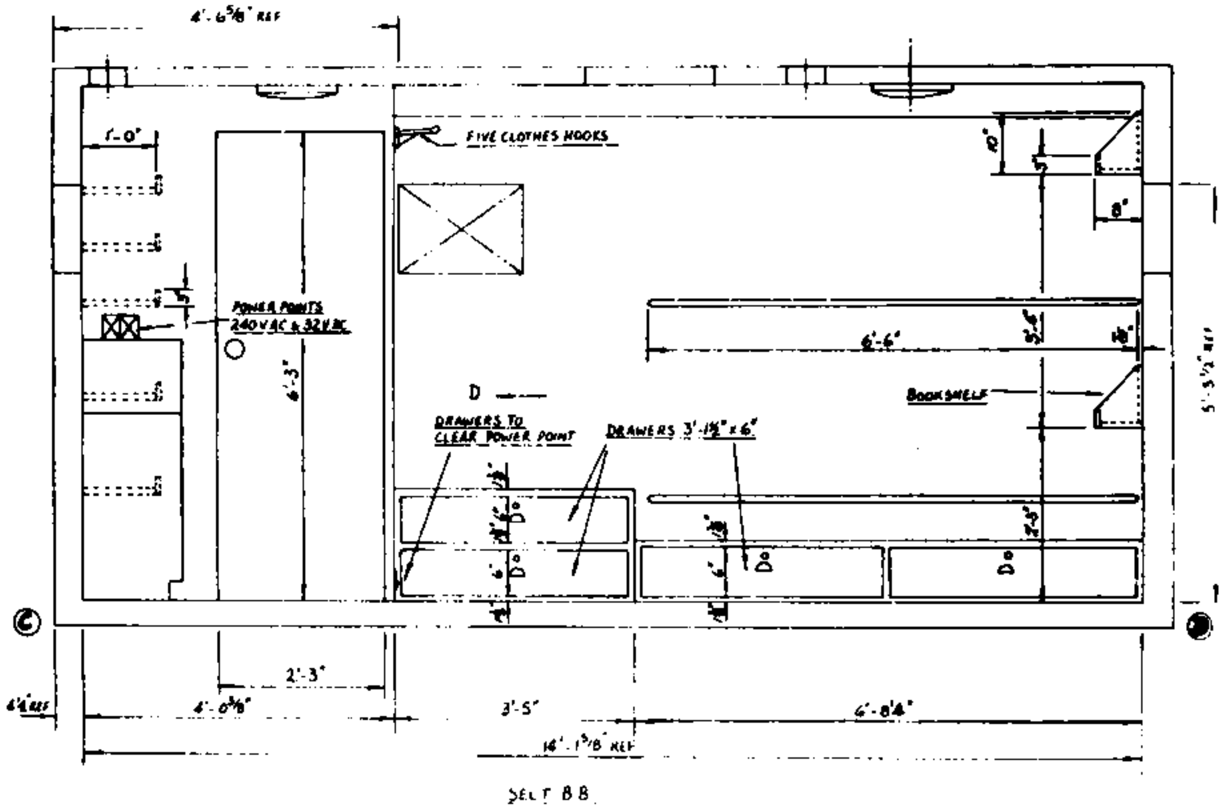
On each corner, approximately three feet up from the bottom of the unit, a lug is mounted to permit lashing up to the sledge. On each top corner rings are bolted to facilitate lifting for shipping and sledge mounting. These lifting rings are removable and after mounting may be removed and replaced with a roof rack to give additional storage room.



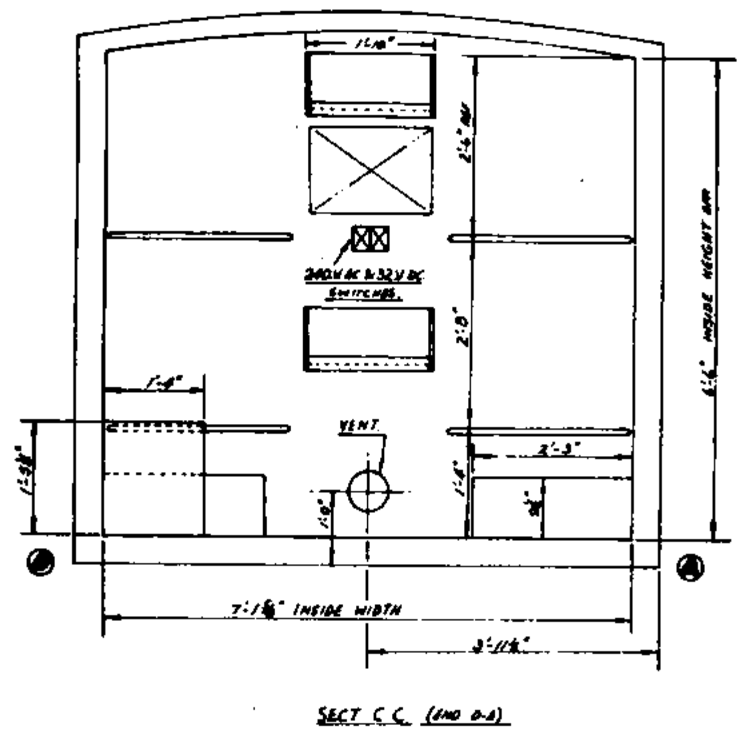
A. N. A. R. E. Living Caravan.



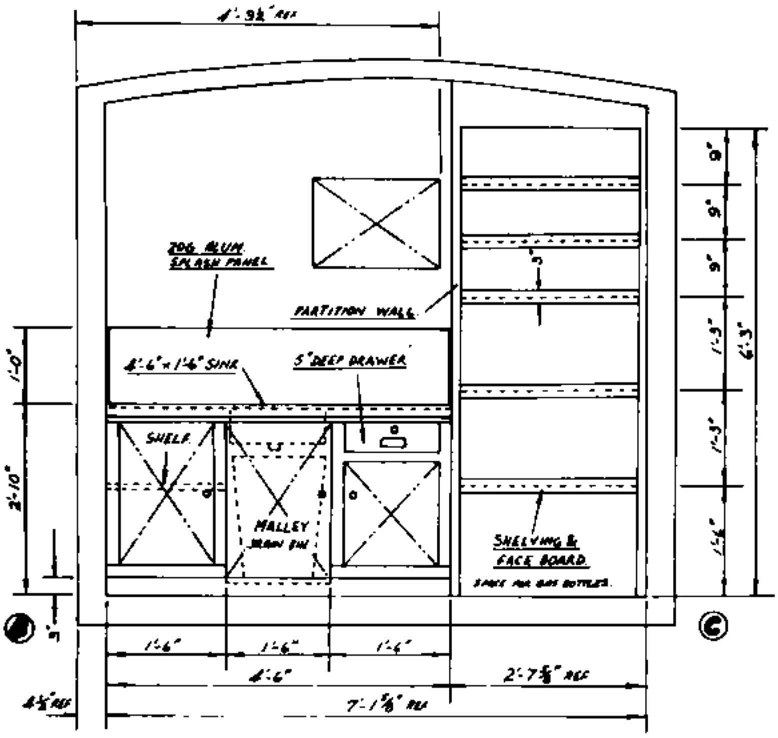
A. N. A. R. E. Living Caravan.



A. N. A. R. E. Living Caravan.



A. N. A. R. E. Living Caravan.



SECT AA

A. N. A. R. E. Living Caravan.

An A. N. A. R. E. Sledge-Mounted Caravan with Stores Rack Fitted to the Roof.

MEDIUM WEIGHT TRANSPORT FACILITIES
OF
EXPEDITIONS POLAIRES FRANCAISES (E. P. F.)

Expeditions Polaires Françaises
Bureau Technique

1. General Considerations

Since 1948, Expéditions Polaires Françaises (Missions Paul-Emile VICTOR) have organized expeditions in the Arctic (on the Greenland Ice-Cap) and in the Antarctic (in Adelie Land). For these expeditions, E. P. F. have been using, practically to the exclusion of all other types, amphibious vehicles: cargo carriers M. 29 C weasels.

This equipment was adopted in 1948 as, at that time, it was the only one available for use on the Greenland Ice-Cap or in Antarctica. Since then, it has been maintained for reasons of standardization (notwithstanding E. P. F. 's first experiments with the sno-cat in 1956), and also because no new vehicle could fully supersede the weasel in its class (amphibious, rough ground, operating on dirt, rock, snow, sea-ice, as well as sturdy, maneuverable and economical).

The widespread use of the weasel as a light tractor implies the following obligations:

Operational planning must make allowance for weight and range of ground transport; hence, for the necessity of aerial support when operations reach a certain scope. The operations-plan of "Expedition Glaciologique Internationale au Groenland" (E. G. I. G.) is quoted as an example.

Consequently transport equipment must be light. Expeditions Polaires Françaises have developed, since 1949, an aluminium sled and a wannigan adapted to the weasel. These have been used in Greenland and in Adelie Land. As to the weasels, they have had no major modification, but were provided with a body specially designed for polar regions.

2. Weasel Body

The original weasel has no actual body, but only a canvas top.

2-1.

To make the weasel available for all-weather and all-duty service in polar regions, a body complying with certain fundamental requirements had to be developed:

It had to be water, wind, snow and blizzard proof;

Reasonable heat conditioned;

Provide for adequate all-round visibility to ensure all-out maneuverability;

Be crush-proof to meet the hazards of accidents or overturning;

Have the right number of doors and exits to provide for rapid evacuation of the crew, whatever the position of the weasel;

Be of the lowest possible weight.

Following trials of various types of wood, plywood or aluminium bodies, the latest model, entirely of plastics, built in 1959 for the International Glaciological Expedition to Greenland, proved fully satisfactory for Greenland as well as for Adelie Land.

2-2. Construction

Moulded shell-type one-piece coachwork. Sandwich construction: expanded rigid polyvinyl chloride (thickness 30 mm) between 2 sheets of reinforced plastics (fiber glass/polyester; thickness: outside 3 mm, inside 1.5 mm).

2-3. Characteristics: (see sketch)

length	3.27 m
width	1.53 m
height	1.20 m
weight	235 kg

2 lateral doors with panes, 0.85 x 0.70 m

2 small windows, one lateral, one rear made of acrylic resin (plexiglas) 0.47 x 0.37 m.

1 exit in the roof 0.60 x 0.60 m

2 wind-shields 0.60 x 0.50 m in therglass (glass with incorporated electric heating resistance: 6 Amp/h per wind-shield).

2-4. Utilization

After serving throughout the International Glaciological Expedition in Greenland (some 3,000 km per weasel) several vehicles were shipped to Adelie Land. The bodies of these weasels had thus been in continuous service since 1959, requiring neither maintenance or repair.

3. Medium Weight Aluminium Sled, For Weasel

The first aluminium sled model was built in 1948 for overland runs by weasel in Greenland. Since then this model has been slightly modified.

Its light structure is of the semi-rigid type to absorb ground irregularities and answer rough-ground service requirements (deep snow in Greenland, ice and sastruggi in the Antarctic).

3-1. Construction

Two wide runners (30 cm) of 3 mm thick aluminium. The runners have the same spacing as the weasel tracks. They carry a chassis made of duralumin (AU4G) sections.

Floor, sides, front and rear ends are made of corrugated omega-section aluminium sheet.

To facilitate maintenance and repair bolts with lock-nuts have been substituted for rivet joints.

The tow-bar is rigid and triangular. Its traction loop is mounted on a coil spring.

3-2. Characteristics: (see sketch)

length (overall)		4.35 m
width (overall)		1.80 m
height at floor level		0.43 m
height with sides, front and rear ends		0.93 m
weight:	chassis	200 kg
	total	340 kg
pay load:	normal	1,500 kg
	maximum	2,000 kg
ground pressure		100 g/cm^2 with full load

3-3. Utilization

This sled has been widely used in Greenland and in Adelie Land; it has been standardized for the transport of all equipment; it can also be used for wannigans.

Fully satisfactory on snow and ice, but on border-zones, runners are easily damaged by rocks.

4. Wannigan

Weasels are generally used as tractors; they also often carry scientific instruments and therefore cannot be made available to accommodate crews during overland runs.

Living in tents generally is not comfortable and this lack of comfort affects the work of the men.

E. P. F. have therefore developed a light wannigan mounted on standard aluminium sleds, easily towed by a weasel. A normal train consists of:

1 weasel
1 caravan
1 sled carrying equipment

4-1. Construction

Light Structure:

Metal chassis supporting floor

Light wood structure, made of bulkheads, uprights and cross-members with an outer covering of reinforced plastics (fiber glass-polyester resin; thickness: 3 mm) and an inner plywood covering

An isolating filling of polystyrene foam (thickness 30 mm)

This wannigan secured in four points to the standard aluminium sled (without the sled-floor) through a Neidhart type suspension based on the compression of rubber coils, (see photograph).

4-2. Characteristics: (see sketch)

length (overall)	4.20 m
width (overall)	2.24 m
height (without sled)	2.04 m
height on sled	2.52 m

weight fully equipped but without sled	815 kg
with sled	1,015 kg
pay load	700 kg
1 door	1.65 x 0.55 m
2 opening plexiglas windows (acrylic resin)	0.78 x 0.52 m
1 exit on roof	0.60 x 0.60 m

4-3. Accommodations: (see sketch)

This wannigan is provided with standard accommodations for six men (bedding, cooking and meals):

Six berths, stacked two by two, along three of the walls. The three lower berths are fixed and may be used as seats. The three upper berths fold up against the wall. All berths have latex foam mattresses. There is storage space under the lower berths.

The kitchen corner comprises:

1 gas-stove with two burners

1 cupboard 0.80 x 0.40 x 0.80 m

1 cupboard for food and dishes 0.55 x 0.40 x 1.65 m

1 propane bottle, 17 kg of gas, mounted outside the wannigan on a special rack and connected with the burners (stove) by a stationary copper piping a pressure-reducer.

1 folding table 1.10 x 1.10 m (when folded: 1.10 x 0.20 m) and 2 stools.

Electric ceiling light, current being supplied by the weasel batteries.

Heating by hot air from the weasel heaters (3,200 calories per hour) connected to wannigan by hoses or scoops during stopovers.

4-4. Utilization

These wannigans have been fully satisfactory in Greenland where nine were used during the International Expedition, covering from 2,500 to 4,000 km in 1959 and 1960.

Two wannigans were shipped to Adelie Land. Their limited use there does not permit any conclusion concerning their usability in Antarctica. But there is no reason why they should not be satisfactory for crossings there, as well as on the Greenland Ice-Cap.

These wannigans must be handled with care, especially while being loaded on or unloaded from shipboard, lashed or conveyed by fork elevators on the ground.

5. General Conclusion

This medium weight transport equipment is entirely satisfactory. It has permitted expeditions to be organized, especially in Greenland since 1948, during which the general logistic concept of Expeditions Polaires Françaises has been substantiated: medium weight trains for overland travel (using medium or light equipment) with air support varying in scope according to requirements and work in progress.

This concept was applied in its integrality in Greenland where the necessary means can be set up because of the geographical proximity of France. On the contrary, in Adelie Land, E.P.F. were unable to implement the necessary means for the application of this concept, the reasons being:

The distance to France and the long-time tying down of equipment (especially aircraft)

The necessity of setting up, beforehand, is important ground organization now non-existent (base for departure, air fields, meteorological network, radio network, etc...)

Financial means and large-scale equipments, necessary but not available.

This same medium and light weight transport equipment has therefore also been used in Antarctica but following different logistic lines which imply the transposition to mechanized means of methods applicable to dogs and sleds: setting up of depots during preliminary runs and lengthening of ultimate distances by the setting up of new depots during ingoing final overland runs: the reasonable range when this concept and these means are applied to scientific traversing is approximately 500 km in the climatic and surface conditions of Adelie Land, which are particularly severe.

This medium and light weight transport equipment without air support also restricts the possibilities of setting up over-wintering stations on the continental shelf: only light stations not too distant from the coast are practicable (Station Charcot, three men, 300 km from the shore).

6. Future Prospects

E.P.F.'s future prospects are based on the following considerations:

E.P.F. refuse to go in for the technique of heavy ground transport; not only because they lack proper financial means, but because this would mean a radical change in general equipment which would have to be heavier and hence would have to be handled in a completely different way;

There is no possibility, in the near future, to anticipate, for Adelie Land, heavy air support similar to that used in Greenland.

Consequently, E.P.F. have been studying and have started the construction of a new medium-weight polar vehicle; furthermore they envisage the possibility of using cargo S.T.O.L. airplanes.

6-1. New Polar Vehicle

The new polar vehicle, the study and the construction of which have been taken up by E.P.F. to replace the weasel, is a vehicle of similar characteristics taking advantage of the experience gained during the past 15 years of overland runs in Greenland and in the Antarctic. This is a tracked amphibious vehicle to be used as rough-ground transport or tractor (dirt, rock, snow, ice, etc...). It will weigh approximately three tons. It has an air-cooled 100 HP gasoline engine. Designed as a tractor, it has a forward cabin with three seats, the rear being a carrying "platform" designed to receive any possible kind of installations. Its speed on snow should be three times that of the weasel, with a range of approximately 500 km. The new features of this vehicle are more particularly its tracks, entirely made of rubber, and its running gear using a rubber ring suspension.

Trial runs will start in October 1962 in France.

This vehicle is developed along the lines of E. P. F. 's medium, light-weight transports.

6-2. S. T. O. L. Cargo Plane

To make the best use of the light and medium weight ground transport equipment, E. P. F. is studying the possibility of air transport by S. T. O. L. cargo plane Breguet 945.

In fact, it would seem that only S. T. O. L. aircraft can be used in Adelie Land in view of the surface of the terrain and of the general land-formation.

Such aircraft would be used for:

The installation and maintenance of light stations on the Antarctic shelf (over wintering stations or summer-stations);

The setting up of depots for light overland trains during the summer-expeditions and the renewal of supplies.

6-3. Helicopters

E. P. F. have used helicopters in Greenland since 1957 ("Alouette") as well as in Adelie Land since 1956 ("Bell" to begin with, followed by "Djin" since 1958).

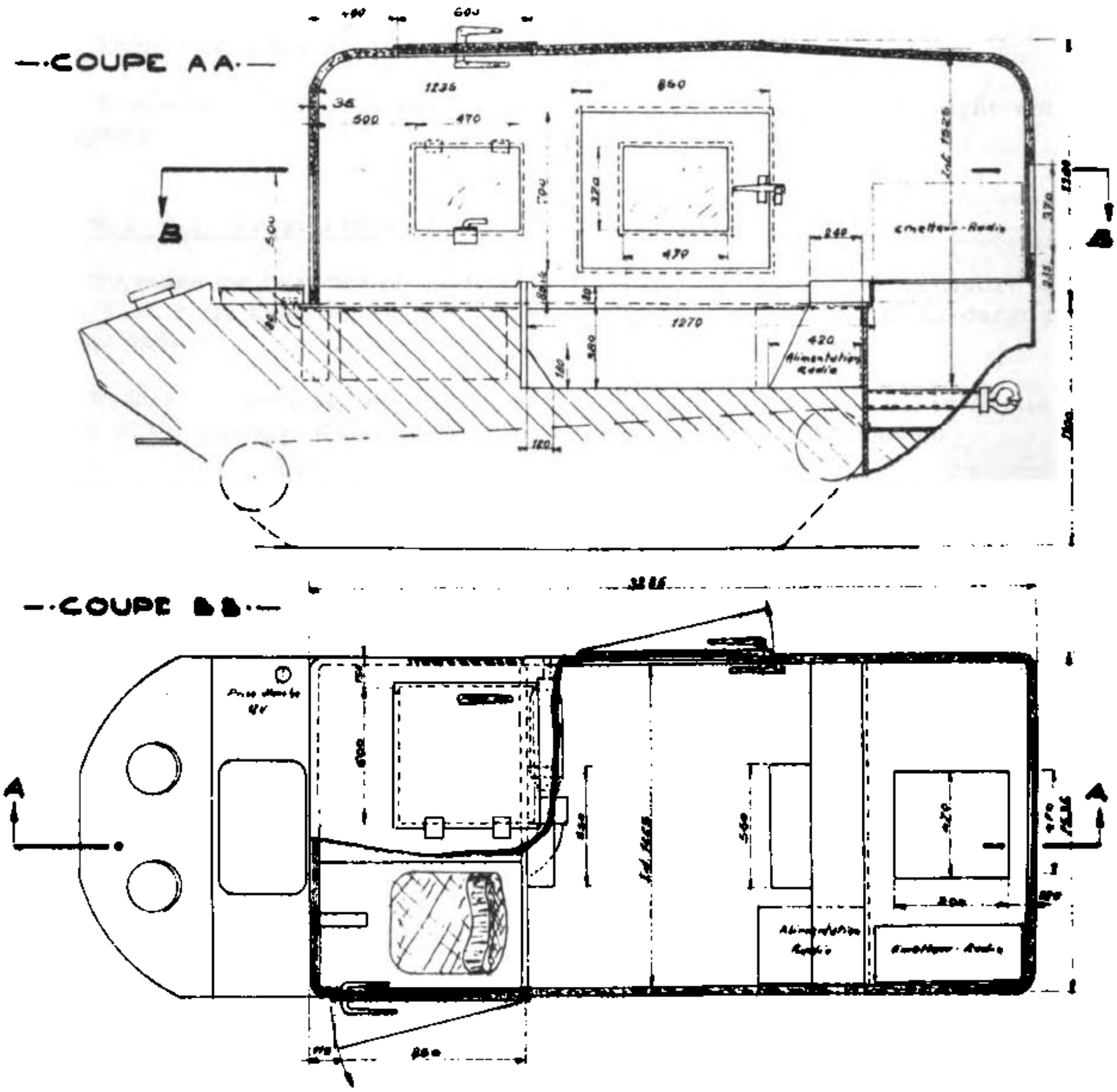
Turbine-powered helicopters ("Alouette" and "Djin") have proved fully satisfactory under most unfavorable conditions (e. g.: on the Greenland Ice Cap, altitude 2,800 m, temperature -28°C).

Their use is envisaged by E. P. F. to set up and renew the supplies of very light temporary stations where the S. T. O. L. aircraft is neither appropriate nor necessary (sea-ice, marginal zone of the Antarctic shelf, crevassed zones).

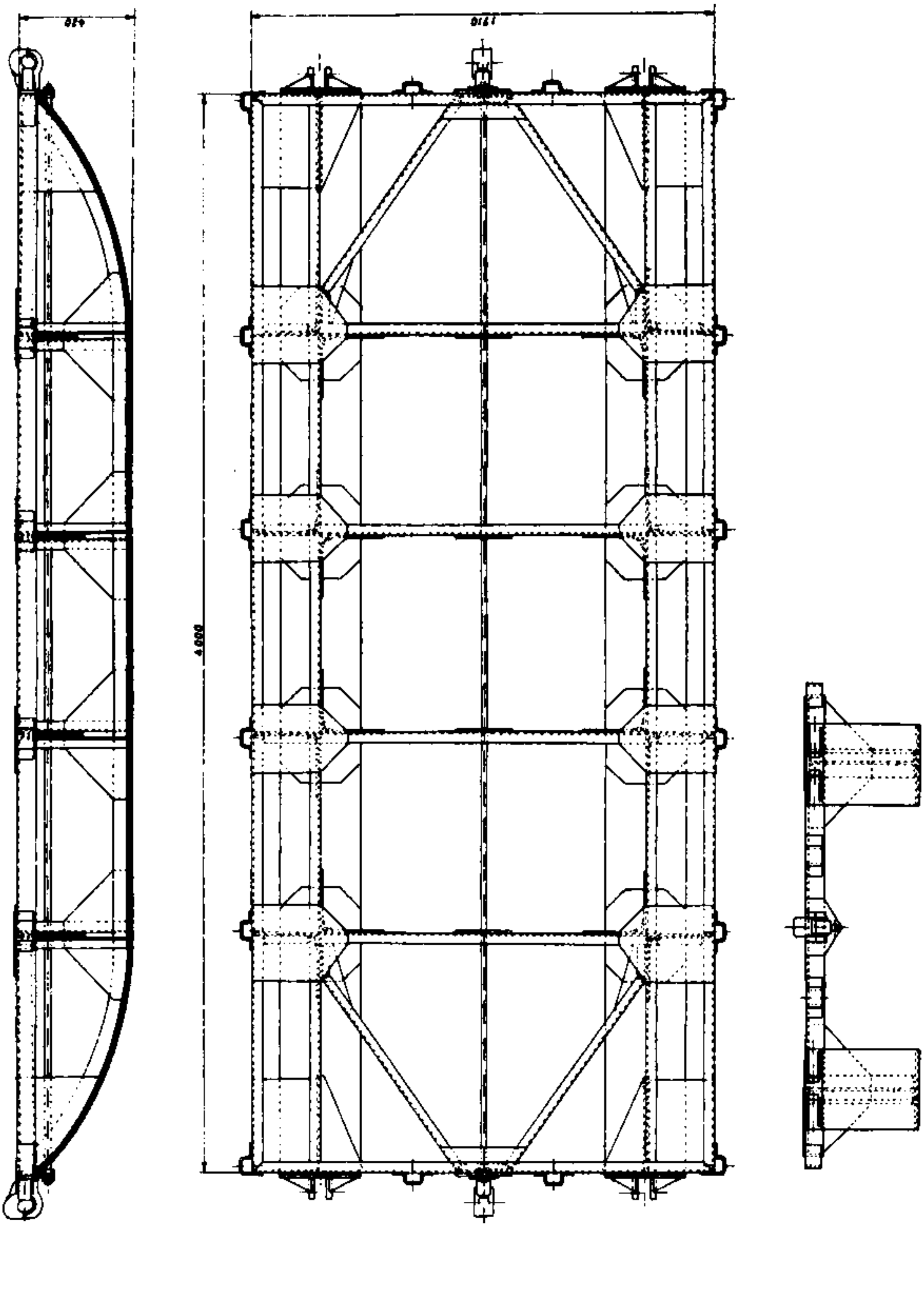
6-4. Conclusion

The combined operation of S. T. O. L. cargo plane, turbine-powered helicopters and medium-weight vehicles should permit the intensification and development of scientific and technological research in Adelie Land without requiring the heavy financial investments in ground organization and equipment which would be necessary for heavy air support and heavy overland transport material.

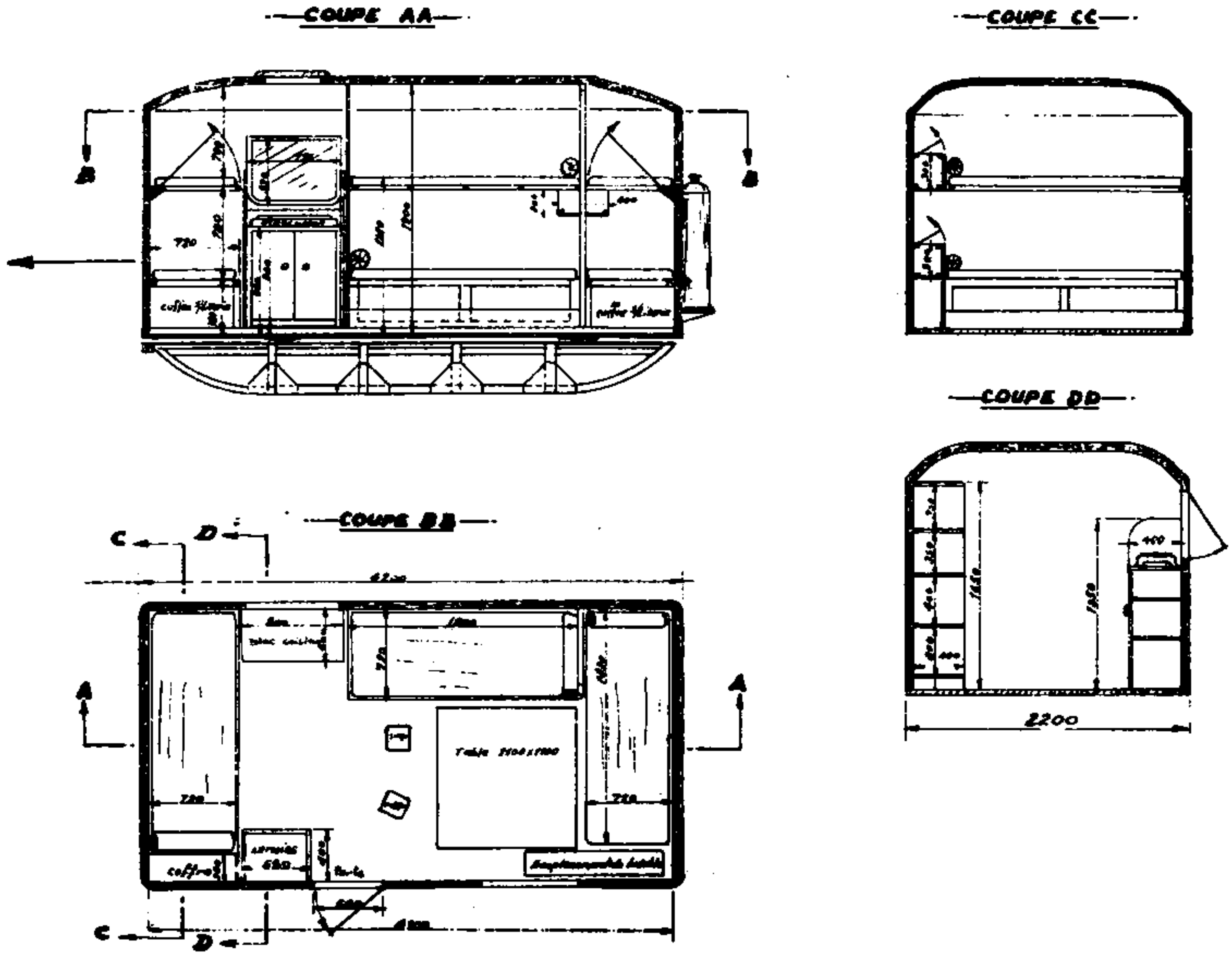
The same solution might also be of interest in other regions of the Antarctic where access is difficult.



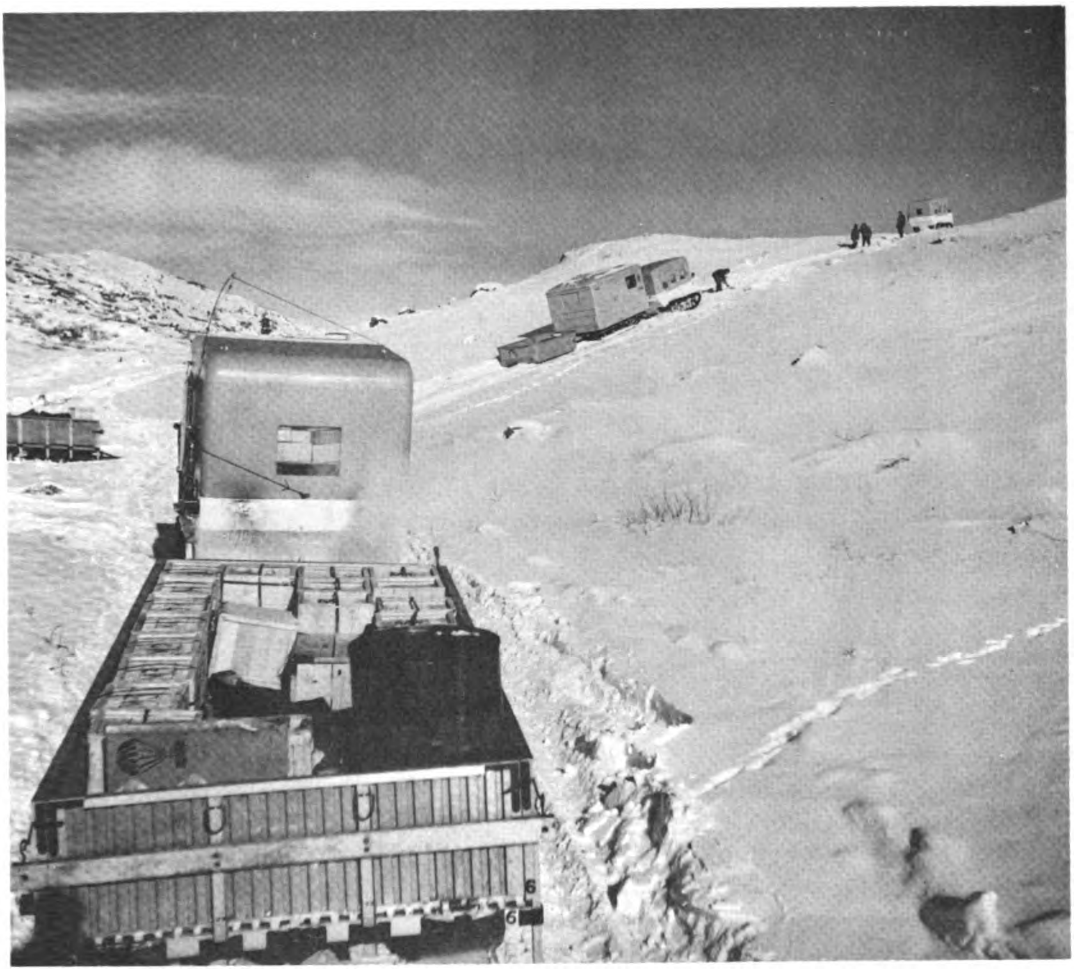
Weasel Model E. G. I. G. 59-60

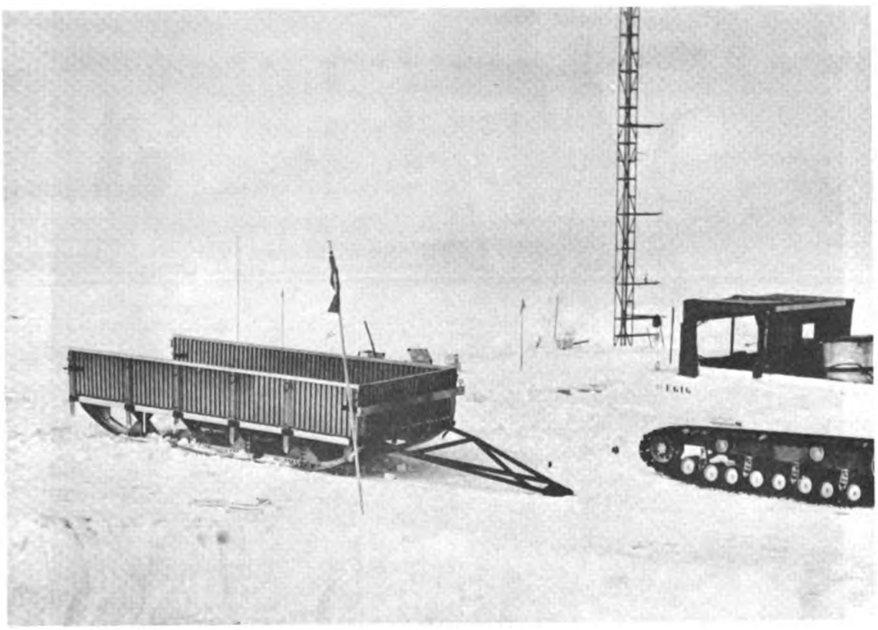


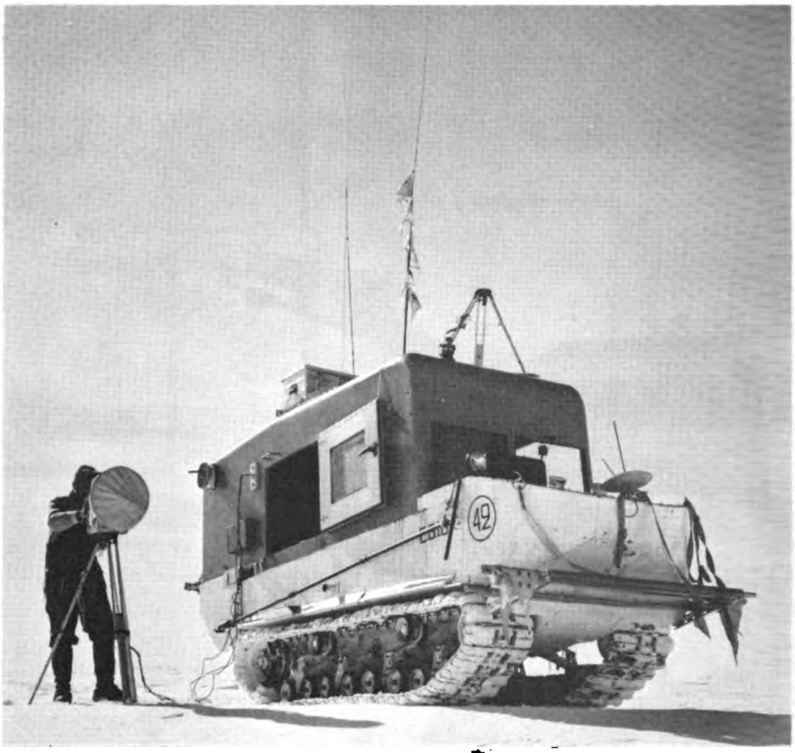
Traineau E. G. I. G. 59-60



Caravan E. G. I. G. 59-60



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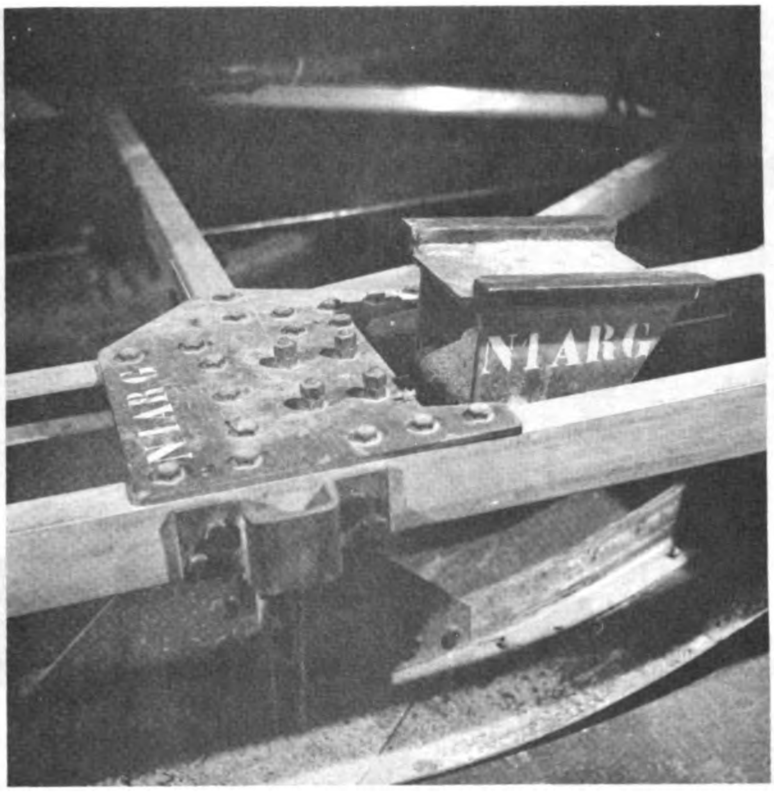
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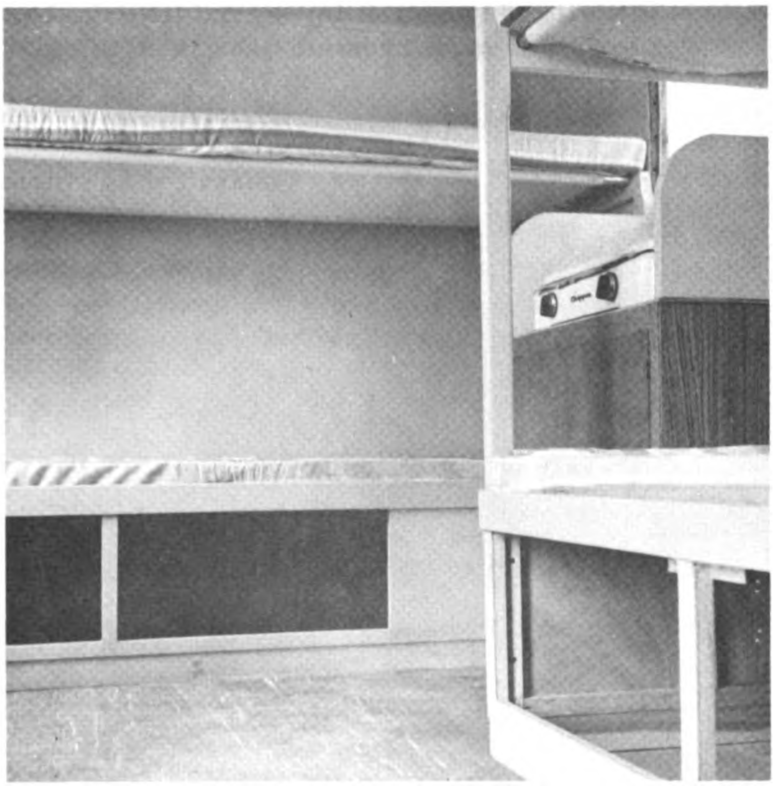
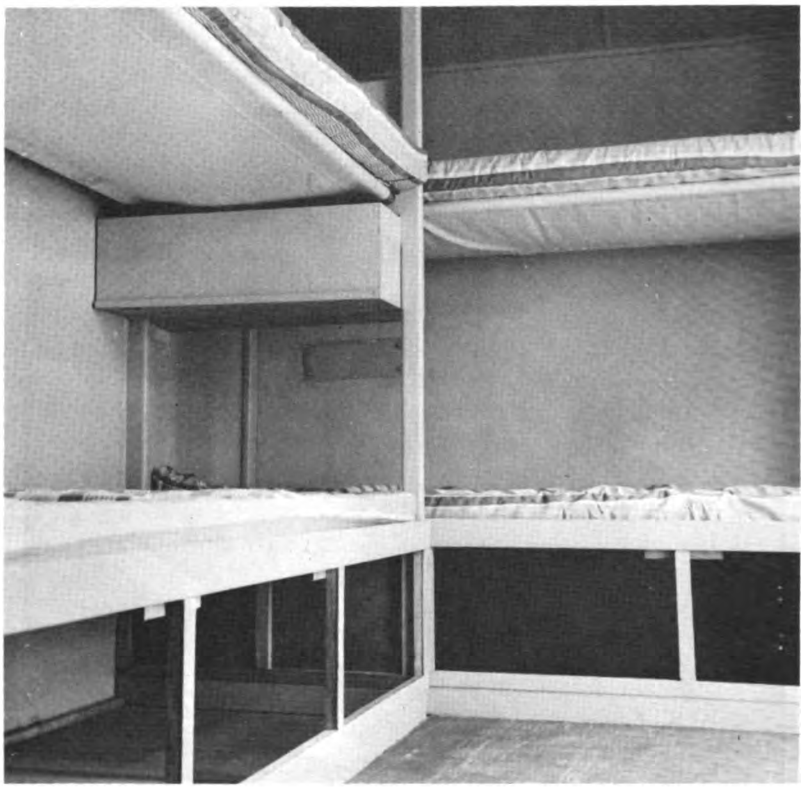




FOR THOSE WHO STILL USE DOGS AND SLEDS

Paul-Emile Victor

This type of sled, widely used by the undersigned on the Ice Cap of Greenland as well as in the rough glacial marginal zones, mountains and fjords marks a definite improvement on existing dog-sled.

Only the main different features of construction are described:

1. runners for hard surfaces (ice or dirt or even rock)

2. after part of skis to enable the man to stand on them

3. handles to lift sled over rocks when necessary

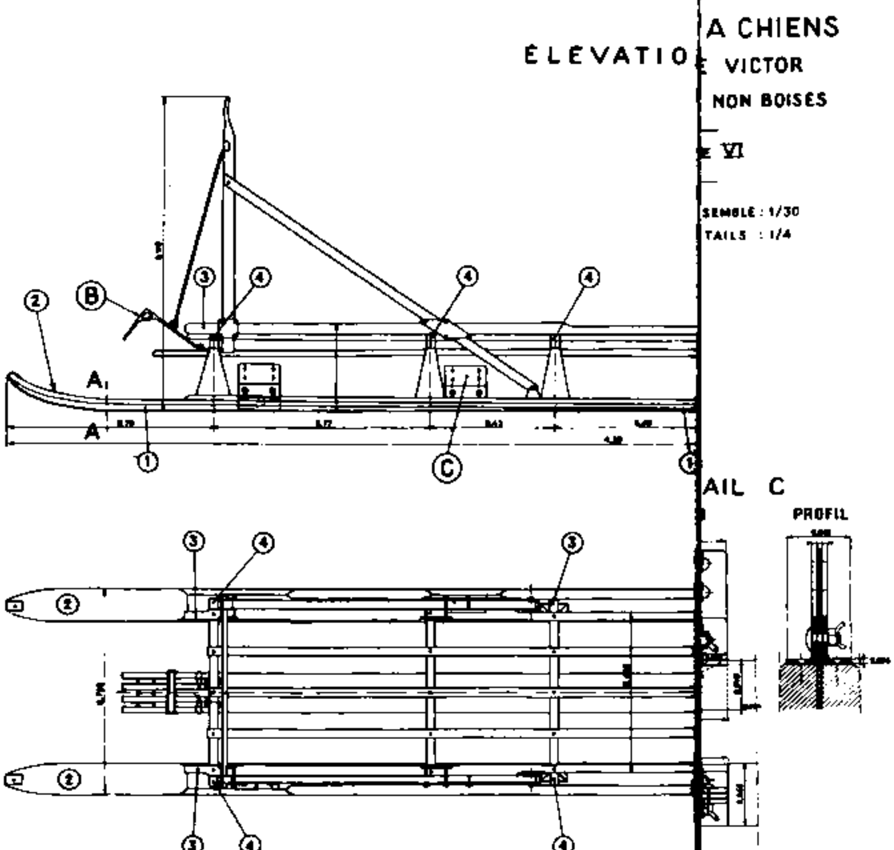
4. notched ends of transverse bars for fast lashing and unlashing

5. forward part of runners (much better over chaotic surface as conventional Nansen sled)

6. forward vertical bar permitting easy handling of sled and enabling man with whip to be at easy distance from dogs

B. brakes

C. adjustable slew brakes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VI
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ELEVATIO[N] … VICTOR

… NON BOISES

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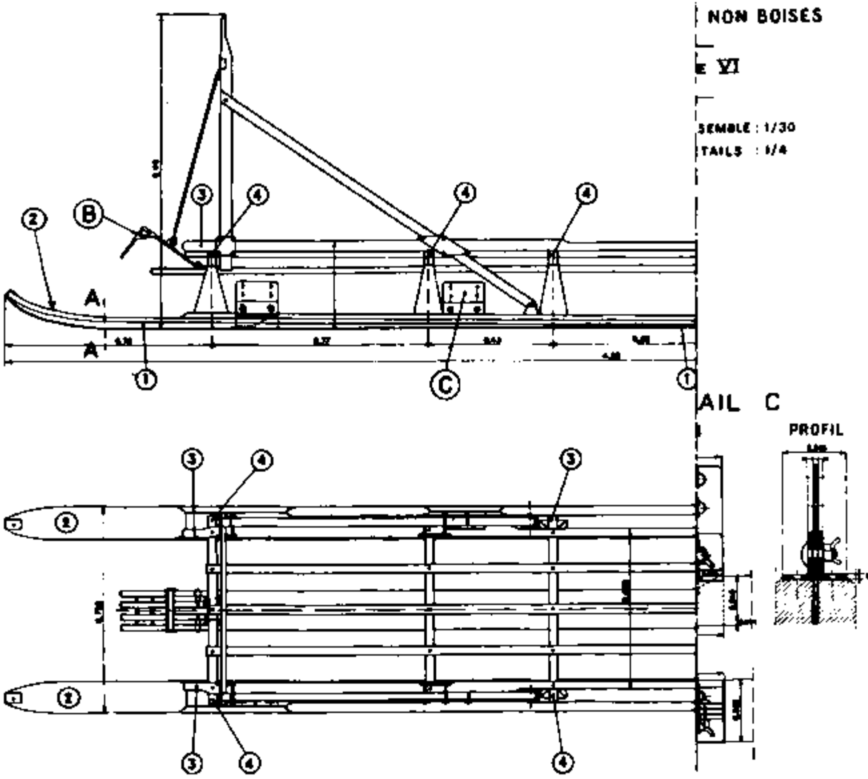

VEHICLES DESIGNED FOR AND USED IN J. A. R. E. 1956-62

M. Murayama
and
S. Maita

1. Introduction

When the Special Committee on Mechanical Engineering for J. A. R. E. and the J. A. R. E. Team started their preparations for the expedition and wintering in 1956, the geographical and natural conditions of the Prince Harald Coast were scarcely known. So, assuming the conditions, they designed and constructed vehicles and other machines for J. A. R. E. with the following considerations:[1]

a. The livelihood of 10-15 men while wintering must be secured through one or two years without any supply of material.

b. The total weight of materials to be transported from the anchoring point of the Soya to the base will exceed 200 tons for each expedition, and the transportation must be completed in a short time over the distance of 20-30 km. To satisfy these conditions, snow-cars, sledges, helicopters and other machines and equipments were prepared.

c. On one hand, snow-cars and sledges to be used for the field operations of the wintering members must be designed and constructed so as to overcome the severe natural conditions. The machines and vehicles to be used for this purposes must be operated satisfactorily even at temperatures lower than -40°C.

d. The main heat energy source at the base and for the field operation must depend on gas-oil. Kerosene and gasoline can be used only as supplementary fuels.

e. All of the vehicles and machines must be designed and constructed as light as possible. And, if it is possible, they must be of knock-down type to be easily air-transported by helicopters.

f. The classifications of machines must be kept at a minimum and their interchangeability is very important for decreasing the quantity of repair parts to be transported.

g. Vehicles and machines made and used in Japan are to be adopted preferentially except some newly designed ones and those imported.

Most of the vehicles and machines prepared for J. A. R. E. -I (1956-58) were transported to Syowa Base in the early part of 1957 and were of service to the construction of Syowa Base. The experiences obtained in J. A. R. E. -I contributed to the improvement of vehicles and other machines for J. A. R. E. and the improved models for J. A. R. E. -II (1957-58) were shipped to Prince Harald Coast, but not one could be landed because the hard ice preventing the Soya from approaching. They were shipped again for J. A. R. E. -III (1958-60) and some were transported by helicopters to the Syowa Base. The remained snow-cars and sleighs were transported on the ground to the Base in J. A. R. E. -IV (1959-61), and they were used for the trips inland in 1960-62.

2. Snow-Cars Used for J. A. R. E.

2. 1. Snow-Cars Designed for J. A. R. E. I (1956-58)

In the first expedition, two gasoline snow-cars, a gasoline snow-wrecker, and a diesel snow-car were landed and transported to Syowa Base. From the view points stated in article 1, the diesel snow-car was most desirable. But in the early part of 1956, the proto-type of the Komatsu "Ginrei" gasoline snow-car was the only one in service in Japan.

The Special Committee and Komatsu Manufactory designed and constructed new snow-cars for J. A. R. E. These were the "Ginrei" Model KC 20-3S gasoline snow-car, Model KC 20-3R gasoline snow-wrecker, and Model KD 20-1T diesel snow-car with torque converter. The dimensions and their performances are listed in Table 1, and their external views are shown in Figures 1, 2, 3 and 4.

The desired conditions for designing these snow-car were as follows:

a. The air temperature in February at Prince Harald Coast can be estimated as -5 to +5°C, but it will be lowered below -40°C at inland localities.

b. The mean wind velocity will be 5-10 m/s (experienced mean velocity, March, 1957 through Dec. 1957 was 7.2 m/s but it was over 10 m/s during 171 days and over 15 m/s during 34 days throughout one year). This means that some cares must be paid to the design of the radiator. The maximum wind velocity will reach 40-60 m/s, but in these storms, the vehicles will not be operated, generally.

   In blizzards, the tightness of the cabin of a car must be positively maintained to protect it from snow infiltration.

c. The snow will not be adhesive in the region. Generally, the path will be level, but in some places rock will be exposed.

d. The transportation distance between the Base and anchoring point will be 20-30 km.

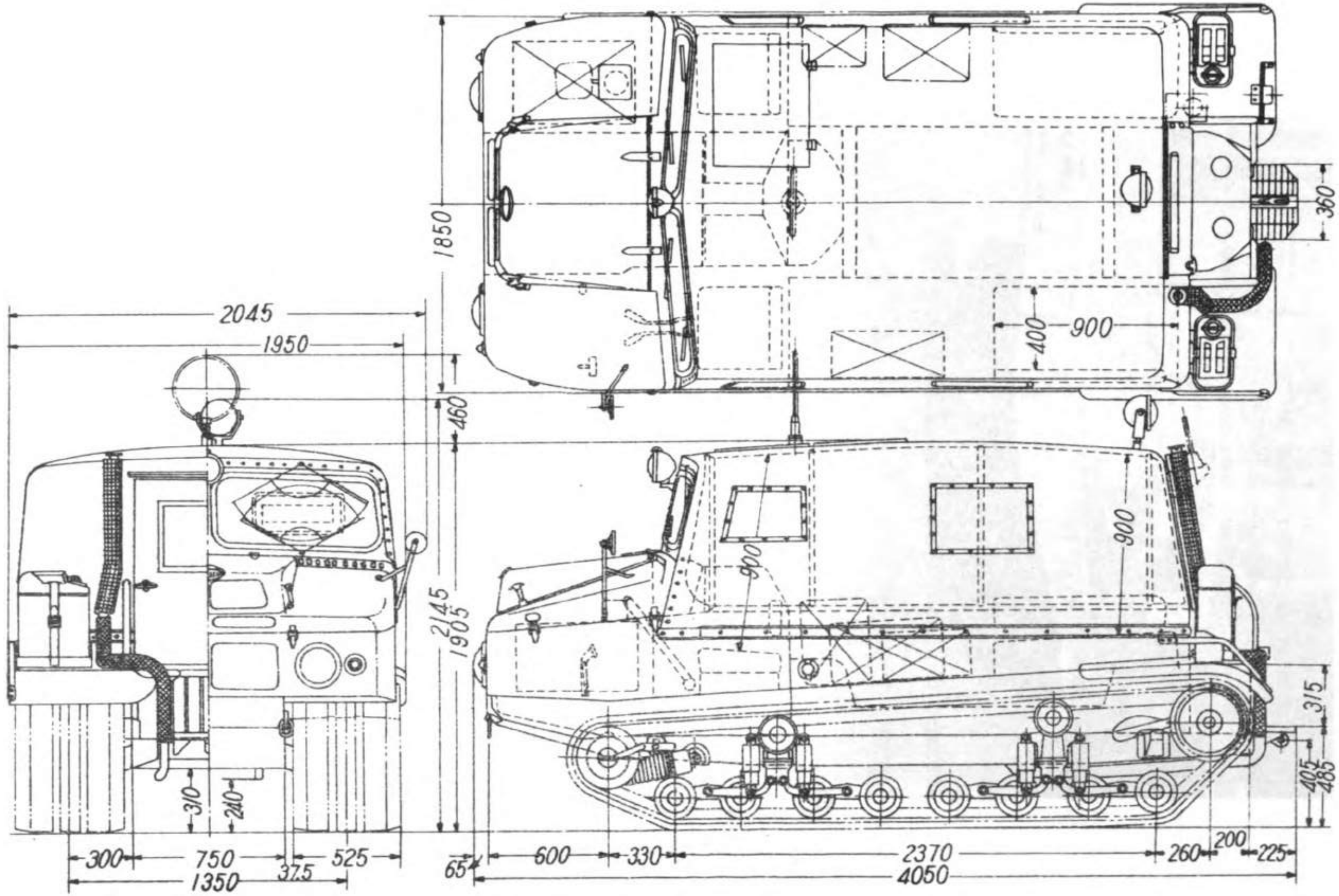

Figure 1. Komatsu "Ginrei" Model KC 20-3S gasoline snow-car prepared for J. A. R. E. -I

Figure 2. The feature of Komatsu "Ginrei" Model KC 20-3S.

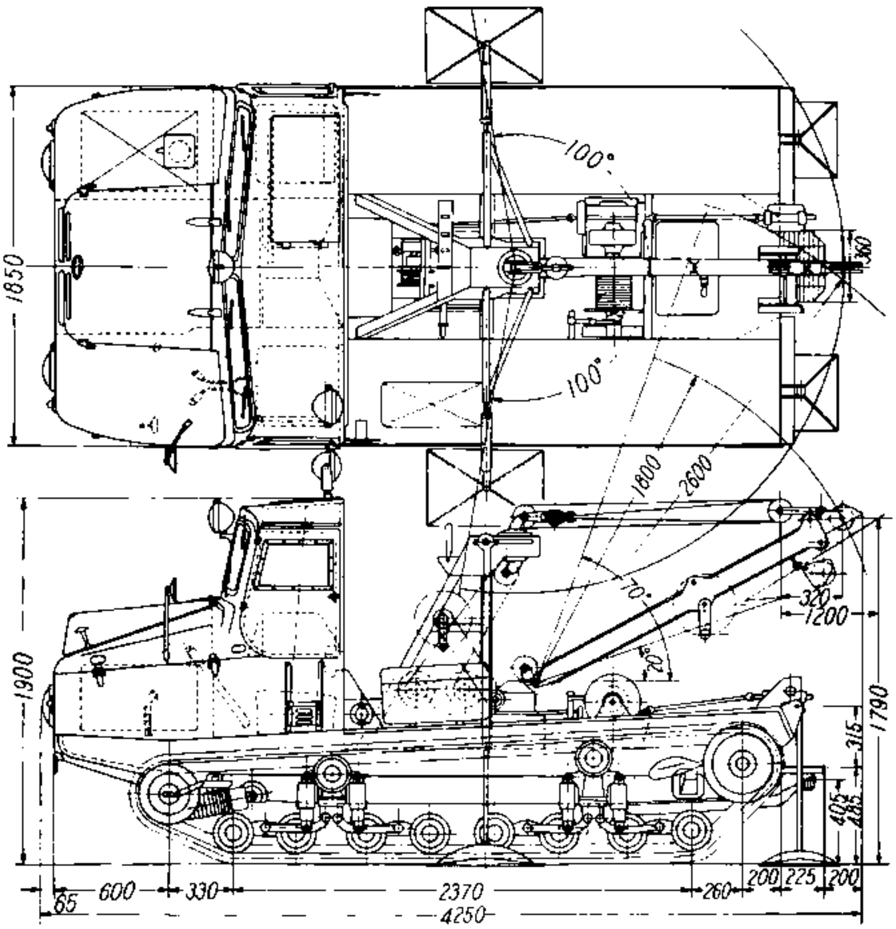

Figure 3. Komatsu "Ginrei" Model KC 20-3R gasoline snow-wrecker.

Figure 4. The feature of Komatsu "Ginrei" Model KC20-3R gasoline snow-wrecker.

e. The greater part of the cargo is fuel drums, each of them containing 200 l of gas-oil. The maximum load of a sleigh was determined to be two tons (equivalent to ten drums) and a snow-car must be able to pull two fully loaded sleighs.

f. The diesel engine for the snow-car must be the same one used for the diesel-electric generators (20 kVA) and for the diesel tractor.

g. The diesel engine must be coupled with a torque converter combined with selective-shifting type transmission gears, i.e., gears for two-speeds forward and single-speed reverse.

h. The cabin must be of the enclosed type and constructed of light alloy.

i. An amphibian type snow-car is more desirable.

j. Each wrecker has a loading capacity of 300 kgs and has a winch, the capacity of which is 2,000 kgs.

k. The number of crew members for a gasoline snow-car is five persons (the ground pressure is 0.116 kg/cm^2 with crew), and the number of crew members for a diesel snow-car is two (the ground pressure is 0.118 kg/cm^2).

The conditions mentioned above, except (h) and (i), were realized in KC 20-3S, KC 20-3R, and KD 20-1T "Genrei" snow-cars. Condition (h) was realized in KD 20-2T (improved type). The amphibian type was not necessary in the neighborhood of Syowa Base.

TABLE 1

Specifications of Snow Cars

	Gasoline Snow Car		Diesel Snow Car		
	For 1st Expedition	For 2nd Expedition	For 1st Expedition	For 2nd Expedition	For 5th Expedition
Model of car	KOMATSU KC20-3S	KOMATSU KC20-3 (Improved type)	KOMATSU KD20-1T	KOMATSU KD20-2T	KOMATSU KD20-2T (Improved type)
Model of engine	TOYOTA "F"	TOYOTA "F"	ISUZU "DA220"	ISUZU "DA220"	ISUZU "DA220"
Dimensions (in mm)					
Overall length	4, 050	4, 065	4, 065	3, 995	3, 960
Overall width	2, 045	2, 070	2, 045	1, 875	2, 140
Overall height	2, 145	2, 145	2, 145	2, 190	2, 100
Tread	1, 350	1, 350	1, 350	1, 350	1, 350
Shoe width	525	525	525	525	525
Length of track on ground	2, 370	2, 370	2, 370	2, 370	2, 370
Min. ground clearance	240	300	240	300	300
Weights					
Weight of vehicle (kg)	2, 580	2, 620	2, 830	3, 030	3, 050
Crew with driver	5	5	2	2	2
Gross weight of vehicle (kg)	2, 855	2, 895	2, 940	3, 140	3, 160
Ground pressure (kg/cm^2)					
for net wt.	0. 104	0. 105	0. 114	0. 122	0. 123
for gross wt.	0. 115	0. 116	0. 118	0. 126	0. 127
Performance (w/o trailer)					
Fuel consumption (km/l) on snow 50-300 mm sub.	1. 4 to 0. 7	1. 4 to 0. 7	1. 7 to 0. 9	1. 7 to 0. 9	1. 7 to 0. 9

TABLE 1 (continued)

Specifications of Snow Cars

	Gasoline Snow Car		Diesel Snow Car		
	For 1st Expedition	For 2nd Expedition	For 1st Expedition	For 2nd Expedition	For 5th Expedition
Max. speed (km/hr)					
on paved road	45	45	21	26	26
on snow 50 mm sub.	35	35	21	26	26
Climbing ability (degrees)					
on snow 50 mm sub.	25	25	25	25	25
Min. turning radius	Pivots in place	Pivots in place	Pivots in place	Pivots in place	Pivots in place
Capacity of winch (kg)	-	-	-	2,000	2,000
Max. ditch crossing ability (mm)	700	700	700	700	700
Fording depth (mm)	300	300	300	300	300
Engine					
Type	Water cooled, 4 cycle, valve-in-head Gasoline Engine		Water cooled, 4 cycle, valve-in-head Diesel Engine		
Total piston displacement (c.c.)	3,878		4,084		
Max. output (PS/rpm)	105/3200		80/2600		
Max. torque kg.m/rpm	27/2000		26/1300		
Engine starting system	Battery and starting motor		Battery and starting motor		
Starting motor	12V 1.6 PS		24V 5PS		
Charging generator	12V 660W		24V 350W	24V 300W	24V 300W
Battery	12V 150AH x 1		12V 150AH x 2		
Capacity of fuel tank	75	75	75	75	75
Auxiliary fuel container	18L x 2		18L x 2		
Power drive system					
Clutch	Dry single plate (foot control)		Dry, single plate (foot control)		
Torque converter			4-element, single-stage, polyphase		

TABLE 1 (continued)

Specifications of Snow Cars

	Gasoline Snow Car		Diesel Snow Car		
	For 1st Expedition	For 2nd Expedition	For 1st Expedition	For 2nd Expedition	For 5th Expedition
Transmission	Forward 4 speeds, reverse 1 speed, sliding mesh type		Forward 2 speeds, reverse 1 speed, sliding mesh type		
Gear ratio					
1st speed	6.31	6.31	1.66	1.94	1.94
2nd speed	2.68	2.68	1.00	1.00	1.00
3rd speed	1.53	1.53			
4th speed	1.00	1.00			
Reverse	5.66	5.66	1.58	1.86	1.86
Transfer gear ratio	0.974	0.974	1.54	1.26	1.26
Propeller shaft	Universal joint type		Universal joint type		
Final drive					
Type	Spiral bevel gear, 1 stage reduction. Split type, half-floating		Spiral bevel gear, 1 stage reduction Split type, half-floating		
Reduction ratio	4.667	4.667	4.667	4.667	4.667
Steering mechanism					
Type	Clutch-brake type hydraulic control		Clutch-brake type hydraulic control		
Brake system					
Main brake	Used together with steering		Used together with steering		
Hand brake	Band type, manual control		Band type, manual control		
Suspension system					
Type	Independent with coil springs		Independent with coil springs		
Driving system					
Type	Link-chain type, rear wheel drive		Link-chain type, rear wheel drive		

TABLE 1 (continued)

Specifications of Snow Cars

	Gasoline Snow Car		Diesel Snow Car		
	For 1st Expedition	For 2nd Expedition	For 1st Expedition	For 2nd Expedition	For 5th Expedition
Road wheels					
Type	Double ring type with solid rubber tire		Double ring type with solid rubber tire		
No. of wheels	8 on each side		8 on each side		
Tracks	Made of high tension steel plates with solid rubber rails and heels. Given tension by coil spring.		Made of high tension steel plates with solid rubber rails and heels. Given tension by coil spring.		
Frame	Ladder type		Ladder type		
Hook	Pintle hook type	Pin type	Pintle hook type	Pin type	Pin type
Winch				Reversible type	Reversible type
Cabin	Enclosed with hood		Enclosed with hood		
Door	One at rear	One each at both sides and rear	One at rear	One each at both sides	One each at both sides
Hatch	One for commander	One each for commander and driver	One for commander	One each for commander and driver	One each for commander and driver
Accessories and instruments					
Auxiliary fuel container	Yes	Yes	Yes	Yes	Yes
Radio	Yes	Yes	No	Yes	Yes
Window defroster	Yes	Yes	Yes	Yes	Yes
Quick charge receptacle	Yes	Yes	Yes	Yes	Yes
Inspection lamp receptacle	Yes	Yes	Yes	Yes	Yes
Antenna of direction finder	Yes	Yes	Yes	Yes	No
Compass	Yes	Yes	Yes	Yes	No

The cabin was warmed by hot air through the engine radiator. The rear part of the wagon was covered by a detachable canvas awning. The maximum speed of gasoline snow-car was 45 km/h, and the fuel consumption was 0.7 - 1.4 km/l (experienced mean value in the Antarctic was 0.98 km/l). The maximum speed of diesel snow-car was 21 km/h, and the fuel consumption was 0.9 - 1.7 km/l (experienced mean value was 1.39 km/l). This means that the diesel snow-car KD 20-1T can run 40 per cent longer for the same fuel consumption, by volume, than the KC 20-3S gasoline snow-car. The maximum speed of gasoline car was greater than that of the Diesel car, but we can elevate the maximum speed of the latter if it is so desired. In the Antarctic field, however, the speed generally used is about 10 km/h because various obstacles limit the car speed. Accordingly, the high maximum speed is not necessary for a snow-car, but it is more important that the speed of all cars be nearly the same. This means that the snow-cars must be unified for maintaining good team-work of snow-cars in field operations.

2.2 Snow-Cars Designed for J. A. R. E. -II (1957-58)

The improved types of two gasoline and five diesel snow-cars were constructed in the summer of 1957 and shipped to the Antarctic.

The main points of redesigning were as listed below:

a. There were many puddles on the route between the anchoring point of the Soya and Syowa Base, and snow-cars and sleighs frequently fell into them. To prevent damage of car and the engine failure due to falling into a puddle, some improvements were made.

    a-1. Water-proofing of engine and dynamo.
    a-2. Protection of wagon from damage.
    a-3. Providing an emergency exit for crew members.
    a-4. Mounting a winch on the rear part of the diesel car to pull up a car or a sleigh from a puddle.

b. In the summer season, mica powder was floating in the air at Syowa Base. Devices for shielding engines and cabins from the powder were devised.

c. To save fuel-oil, most of the snow-cars were dieselized.

d. Diesel engine- torque converter system was introduced to save labor in driving the car.

e. Reinforcement of weak points of the wagons.

These improved types were named KC 20-3S (Improved type) gasoline snow-car and KD 20-2T diesel snow-car. Their dimensions and performances are listed in Table 1, and the features are shown in Figures 5, 6 and 7. One of the improved gasoline snow-cars, No. 11, was transported by helicopter in the early part of 1959 to Syowa Base from the Soya and the remaining five diesel cars, Nos. 5 through 9, were moved to the base under their own power on the ground in J. A. R. E. -IV (1959-61). The performances of gasoline and diesel snow-cars are shown in Figure 8 and Figure 9.

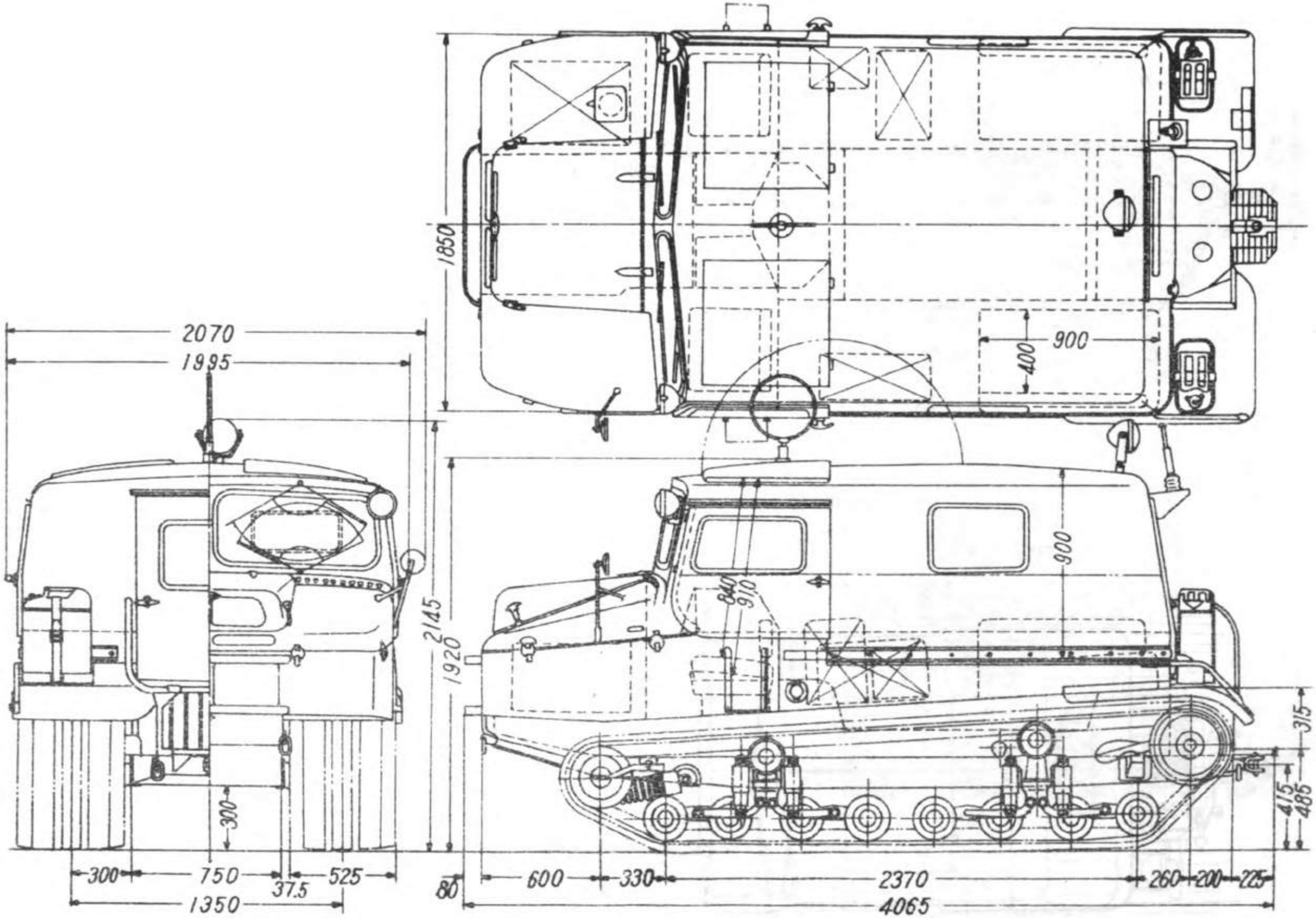

Figure 5. Komatsu "Ginrei" Model KC 20-3S (Improved type) gasoline snow-car.

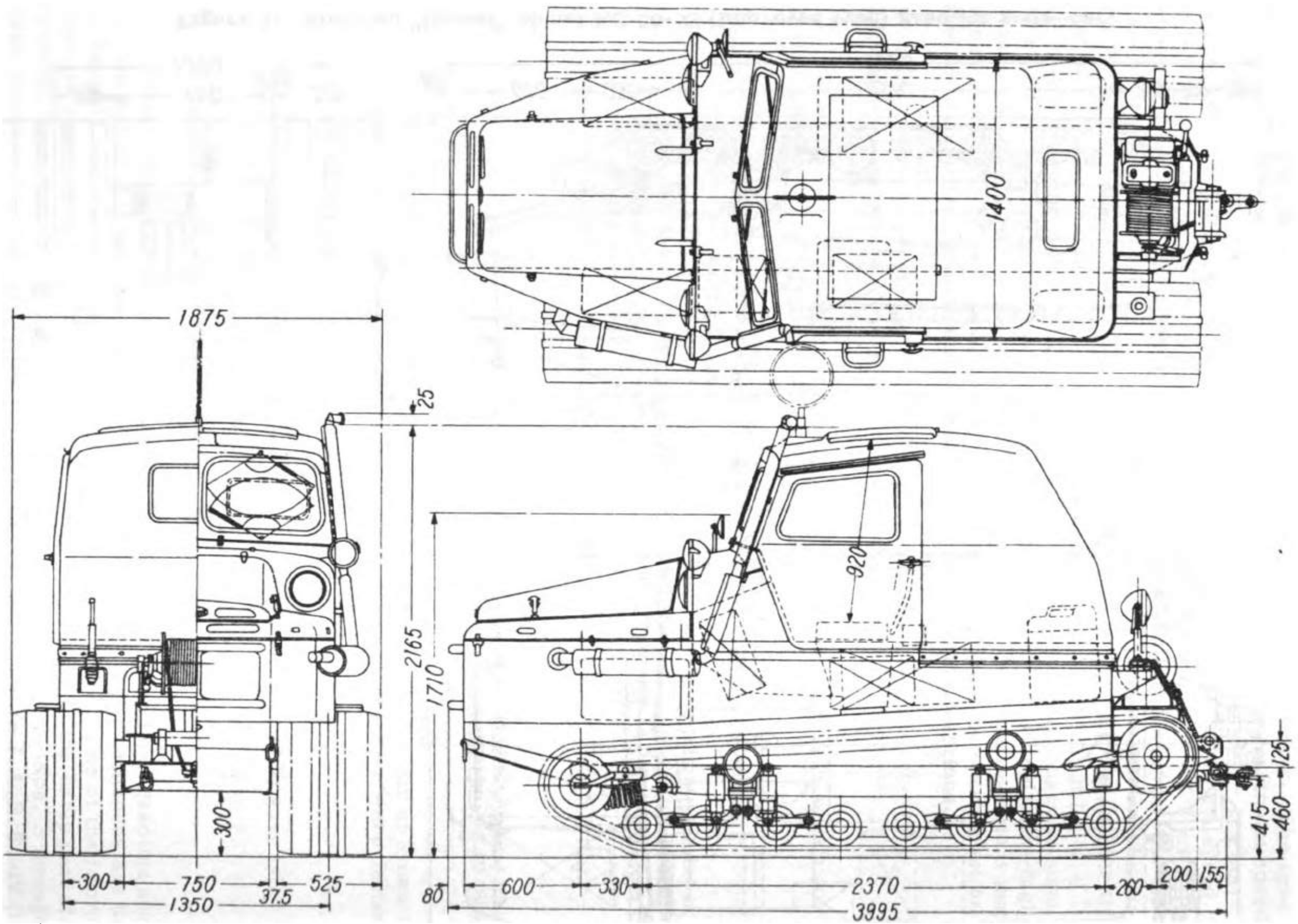

Figure 6. Komatsu "Ginrei" Model KD 20-2T (Improved type) diesel snow-car.

Figure 7. The feature of a Model KD 20-2T (Improved type).

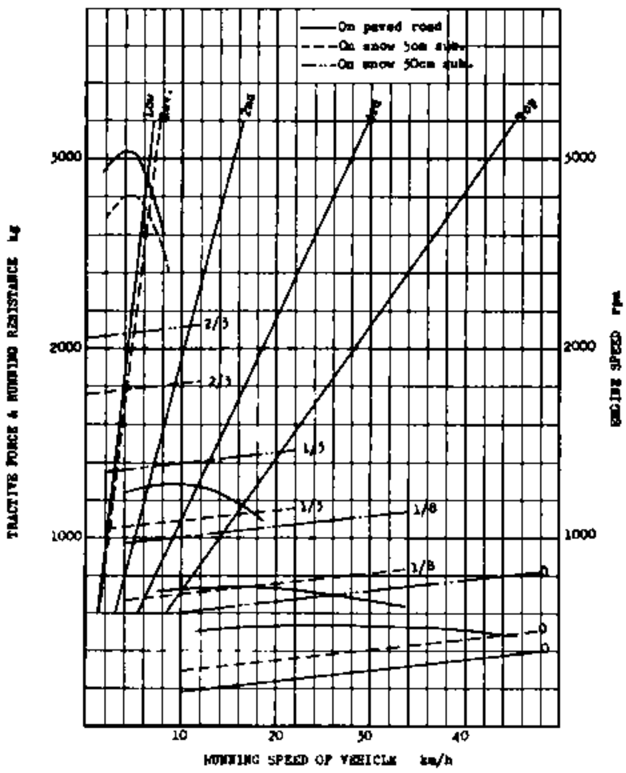

Figure 8. The performance curve of Model KC 20-3S gasoline snow-car.

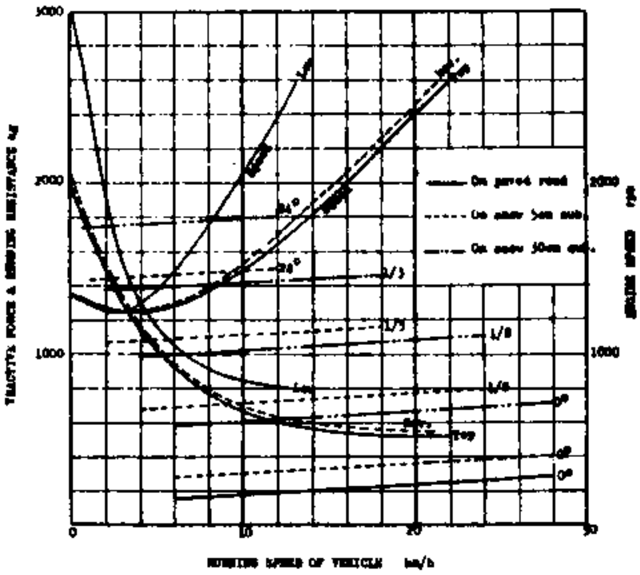

Figure 9. The performance curve of Model KD 20-2T diesel snow-car with torque converter.

2.3 Snow-Cars Designed for J.A.R.E.-V (1960-62)

Mr. Murayama ordered the reconstruction of two of the diesel cars to the cab-over type at the Base for the purpose of using them for a trip directed toward the south pole in his wintering period. According to his order, two sets of newly designed cab-over cabins were made at the Komatsu Manufactory in Japan, and they were transported by helicopter. The cabins of the No. 8 and No. 9 diesel cars were removed and replaced by the new cab-over type cabins.

Mr. M. Murayama and six wintering members travelled to a point at a distance of 836 km south from Syowa Base by using these diesel snow-cars KD 20-2T (cab-over type). The cars climbed up to 3,232m in altitude in 11th Nov. 1961, at which altitude, the power output of the engine was decreased to about 72 per cent of the output at the Syowa Base. The air temperature was below -37.4°C, and the atmospheric pressure decreased to 616 mB from 900 mB at the Base. The insufficiency of power-output and a crack found on a suspension bracket compelled them to give up continuing their further travel to the south pole. During this trip, the comfort and convenience of the cab-over type were recognized by the explorers because it was possible to inspect the engine and refuelling in the cabin even in blizzards.

The reconstructed cab-over type diesel snow-car KD 20-2T is shown in Figures 10 and 11.

2.4 Experiences Obtained in J.A.R.E. (1956-62) and Remaining Problems

Valuable experiences were obtained in J.A.R.E. and contributed greatly to the development of the performance of snow-cars in Japan. The summarized results of these experiences are as follows;

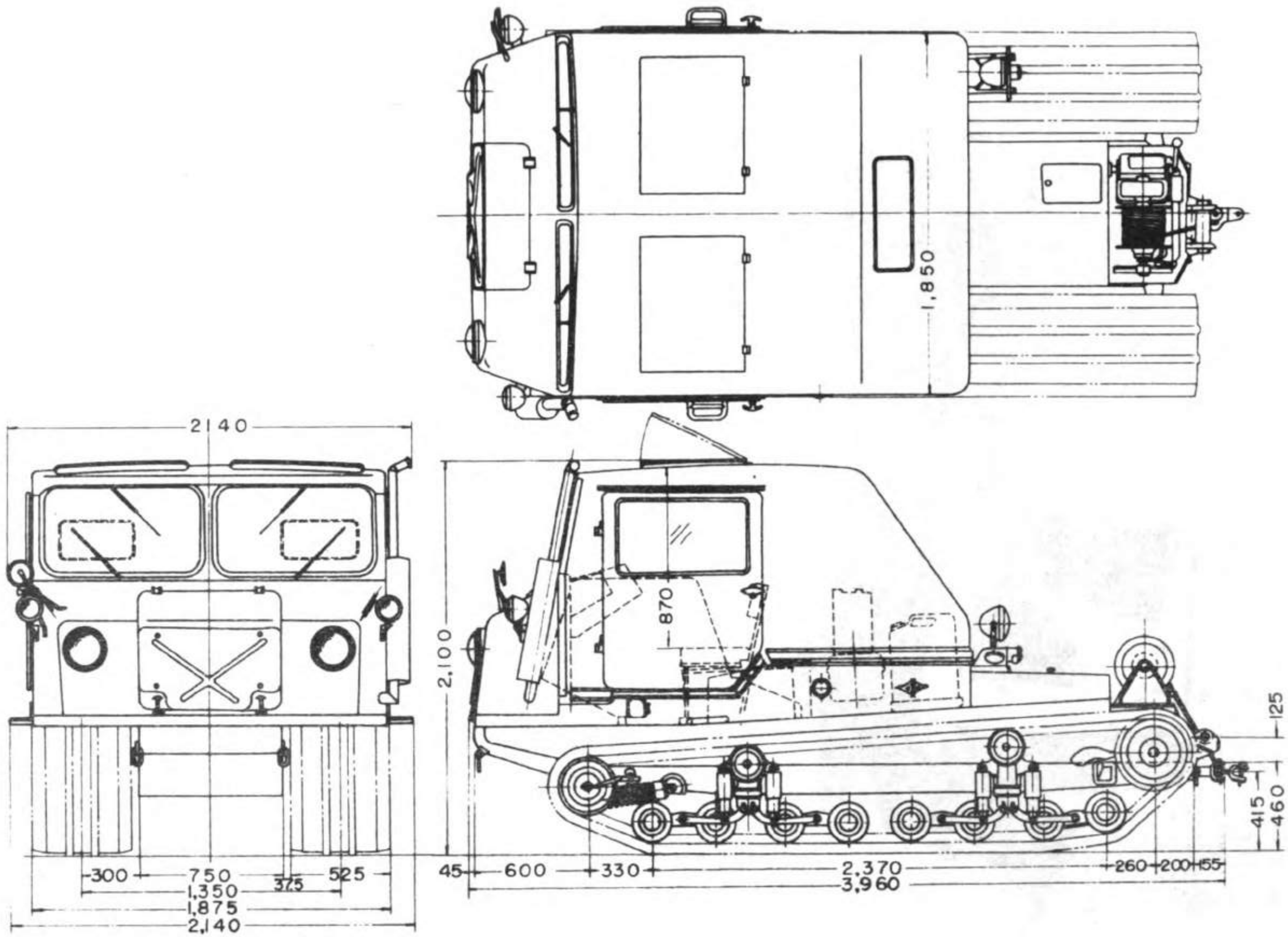

Figure 10. Komatsu "Ginrei" Model KD 20-2T cab-over type diesel.

Figure 11. The feature of KD 20-2T cab-over type diesel snow-car at the Syowa Base.

a. Gasoline Snow-Car KC 20-3S and KC 20-3R. Three cars of this type transported to the Base in J. A. R. E. -I (1956-58) were successfully used for the cargo transportation between the Base and the Soya. Head-lights, radiators and other parts were damaged by collision with ice when the cars fell into puddles. The hook-joints connecting the sleighs to the snow-cars were frequently broken or deformed. It was most effective to pull a sleigh by two, long, steel wire ropes. The imperfect action of springs was experienced at low temperatures, and this brought about trouble such as over-heating of a starter-motor by insufficient cut-off of its relay. Fuel and oil filters were clogged by slices of ice. This trouble was prevented by filtering the fuel and oil with deerskin while they were being supplied to their tanks and by keeping the oil in the tank at full level. Also, the mixing of a small amount of alcohol with fuel prevented formation of ice slices. At first, slip-preventing spikes (cleats) were not prepared for the caterpillar tracks. Hence, slipping of the cars on hard ice was experienced during the trip in-land. In J. A. R. E. -III (1958-60), spikes were attached to the tracks at an interval of one spike for every four blades of tracks. The spikes were very effective for preventing the car from slipping on hard blue ice.

A gasoline wrecker KC 20-3R is no longer used today because of cracks found in the chassis frame, but other gasoline cars can be used today in the vicinity of the Base.

An improved gasoline car KC 20-3S (Improved type) could climb the ice fields inland with the aid of spikes. Its engine was waterproof, and its chassis frame was reinforced to prevent cracks.

Seats and cabin arrangement were improved, but the air-conditioning in the cabin was not entirely satisfactory.

b. Diesel Snow-Car KD 20-1T and KD 20-2T. A diesel snow-car conveyed to Syowa Base in J. A. R. E. -I was the first diesel car with torque converter produced in Japan. Its low fuel consumption, safety against firehazard, ease of operation, ease of starting in extremely low temperatures, interchangeability of engine, and the merits of standardizing the fuel were recognized through actual experience during the 1st wintering period. Hence, five improved KD 20-2T type diesel cars were prepared for J. A. R. E. -II and conveyed to the Base in J. A. R. E. -IV (1959-61), and three of these were used satisfactorily for the trip to Yamato Mountain by the Torii Team. The comfort of the cabin was inferior to that of KC 20-3S (Improved type), and some cracks were found on the frame after the inland trips. In J. A. R. E. -V (1960-62), the weak point of the frame was reinforced at the Base, and sufficient durability was obtained. To improve the comfort, the cab-over type modification was made for the remaining two cars, and these were used for the long trip directed toward the south pole as stated before.

The operation record of snow-cars used for J. A. R. E. are summarized in Table 2.

c. The Remaining Problems of the Snow-Car. Although the experience on the snow-car in J. A. R. E. contributed to their improvement, some problems as shown below still remained.

c-1. The altitude performance of the engine must be improved so that the cars may easily climb up over 4, 000 m. To satisfy this demand, a turbo-supercharged diesel engine is thought to be the best as the power plant of snow-cars, and the superiority of the diesel car over the gasoline car can be fully exhibited through the use of such an engine.

c-2. The durability of materials in the extremely low temperature below -60°C must be assured.

c-3. A car which is more free from vibration must be designed.

c-4. An air-cooled engine is more desirable than a liquid-cooled engine.

c-5. A larger size snow-car, the tractive force of which is 5-6 tons, must be developed in Japan.

c-6. Cabins must be perfectly protected against blizzards. A detachable type canvas awning is inferior to a fixed type cabin.

TABLE 2

Operation Record of Snow Cars

No. of Car	Model of Car	Transport to Base After Landing	First Wintering	Second Wintering (Suspended Because of the Failure of Landing)	Third Wintering	Fourth Wintering	Fifth Wintering	Total Running Distance Km	Present Condition
1	KC20-3S Gasoline	Self-drive at 1st Expedition	Used for trip 1, 186 Km	Preserved at Base	Used for trip 130 Km	Reserved as Spare	Reserved as Spare	4, 220	Usable for trip. Preserved at Base after rustprevention.
2	KC20-3S Gasoline	Self-drive at 1st Expedition	Reserved as Spare	Preserved at Base	Reserved as Spare	Reserved as Spare	Reserved as Spare	1, 934	Usable for trip. Preserved at Base after rustprevention.
3	KC20-3S Wrecker Gasoline	Self-drive at 1st Expedition	Used for trip 949Km replaced by spare engine because of engine failure	Preserved at Base	Used for trip 796 Km Spike was fitted to track	Out of use after frame was broken 1, 315 Km		4, 094	Scrapped
4	KD20-1T Diesel	Self-drive at 1st Expedition	Out of use after engine was dismounted for use to No. 1 engine generator set.					1, 321	Scrapped
5	KD20-2T Diesel	Self-drive at 4th Expedition		Delivered by ship but brought back	Reserved in home country	Used for trip 3, 237 Km spike was fitted to track	Used for trip 475 Km	3, 712	Scrapped
6	KD20-2T Diesel	Self-drive at 4th Expedition		Delivered by ship but brought back	Delivered by ship but brought back	Used for trip 2, 366 Km spike was fitted to track	Used for trip 1, 658 Km	4, 024	Usable for trip. Preserved at Base after rustprevention.
7	KD20-2T Diesel	Self-drive at 4th Expedition		Delivered by ship but brought back	Delivered by ship but brought back	Used for trip 1, 074 Km	Used for trip 2, 351 Km	3, 425	Usable for trip. Preserved at Base after rustprevention.
8	KD20-2T Diesel	Self-drive at 4th Expedition		Delivered by ship but brought back	Reserved in home country	432 Km Reserved as Spare	Used for trip 2, 177 Km. Cabin was modified	2, 609	Usable for trip. Preserved at Base after rustprevention.
9	KD20-2T (Improved type) Diesel	Self-drive at 4th Expedition		Delivered by ship but brought back	Delivered by ship but brought back	219 Km Reserved as Spare	Used for trip 2, 489 Km. Cabin was modified	2, 708	Usable for trip. Preserved at Base after rustprevention.
10	KC20-3S (Improved type) Gasoline	Reserved in home country		Delivered by ship but brought back	Delivered by ship but brought back	Reserved in Japan			Reserved in Japan
11	KC20-3S (Improved type) Gasoline	By helicopter at 3rd Expedition		Delivered by ship but brought back	Transported by helicopter. Used for trip 1, 932. 5 Km	Used for trip 1, 381 Km Spike was fitted to track	Used for trip 1, 243 Km	4, 557	Usable for trip. Preserved at Base after rustprevention.

c-7. An air-conditioner and an air-compressor are desired equipment on each of the cars.

c-8. The radar and communication equipment must be more reliable and have higher performance.

2.5 Introduction of KD50, New Designed

In order to solve some problems mentioned above, c-3, c-5, we have developed KD50 type. The details are shown as below:

type	caterpillar drive, bonnet type, front engine open wagon	
dimension	overall length	5340 (mm)
	overall height	2200
	overall width	2500
	ground clearance	340
	tread	1710
	length of track on ground	3000
	shoe width	790
weight	weight without load	5150 (kg)
	gross weight	6430
	ground pressure with load	0.135 (kg/cm^2)
performance	fuel consumption at 25 km/h	1.4 km per a liter
engine	model Isuzu DA-120T	
	type 4 cycle water cooled vertical pre-combustion chamber super charged diesel engine with governor	
	total stroke volume	6,126 cc
	compression ratio	19.5
	maximum horse power	155 at 2600 rpm
	super charger	radial flow brower by exhaust gas turbine
transmission	type synchro mesh anexed sliding selection F 5, R 1	
suspension system	independent with torsion rubber	
electrical system	DC 24 V, Battery 12 V 150 AH x 2 generator 24 V 350 W	
Frame and Body	semi monocock scoop end, bonnet type open wagon	

3. Vehicles for Use Around the Base

As vehicles for use around the base, a diesel tractor and a small tractor were carried to the base in J.A.R.E.-V (1960-62).

3.1 Tractor and Trailer

To transport cargoes from the edge of the fast-ice to the Base on the rock zone, a diesel-tractor manufactured by Iwate-Fugi Ind. Co., Ltd. was prepared for J.A.R.E.-II, but it could not be transported until 1961. The same Isuzu DA 220 diesel engine as that of the snow-car was adopted as its motive power. Its rating horse power was 48 HP at 1800 rpm. An angle-dozer Model CF-25A was modified for use in the Antarctic, and forks for lifting were prepared for optional attachment to the tractor in place of the blade of the angle-dozer (Fig. 12, 13, 14). On one hand, semi-trailers, as shown in Figure 15 were prepared. On the semi-trailer, a sleigh loaded with cargo could be carried bodily.

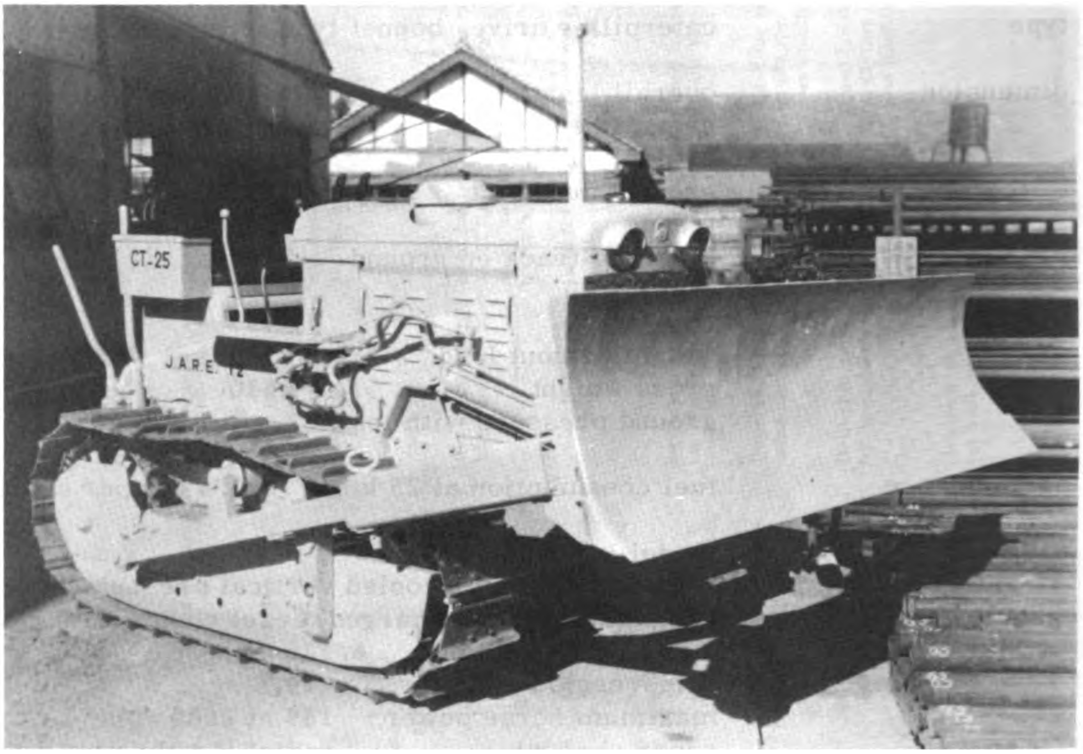

Figure 12. Iwatefugi Model CT-25A angle-dozer.

However, these ideas could not be tried out because the tractor and trailer were not transported until J.A.R.E.-V, and after J.A.R.E.-II, all of the transportation was changed to that by air. When this tractor was carried to the Base in 1961, its activity was remarkable. It was used as a fork-lift and transported cargoes and fuel drums. On another hand, it was used as an angle-dozer for dozing and scraping snow or dust at the Base.

3.2 Small Tractor

For J.A.R.E.-V, a Komatsu farmer's tractor was air-transported by helicopter and was used conveniently around the Base.

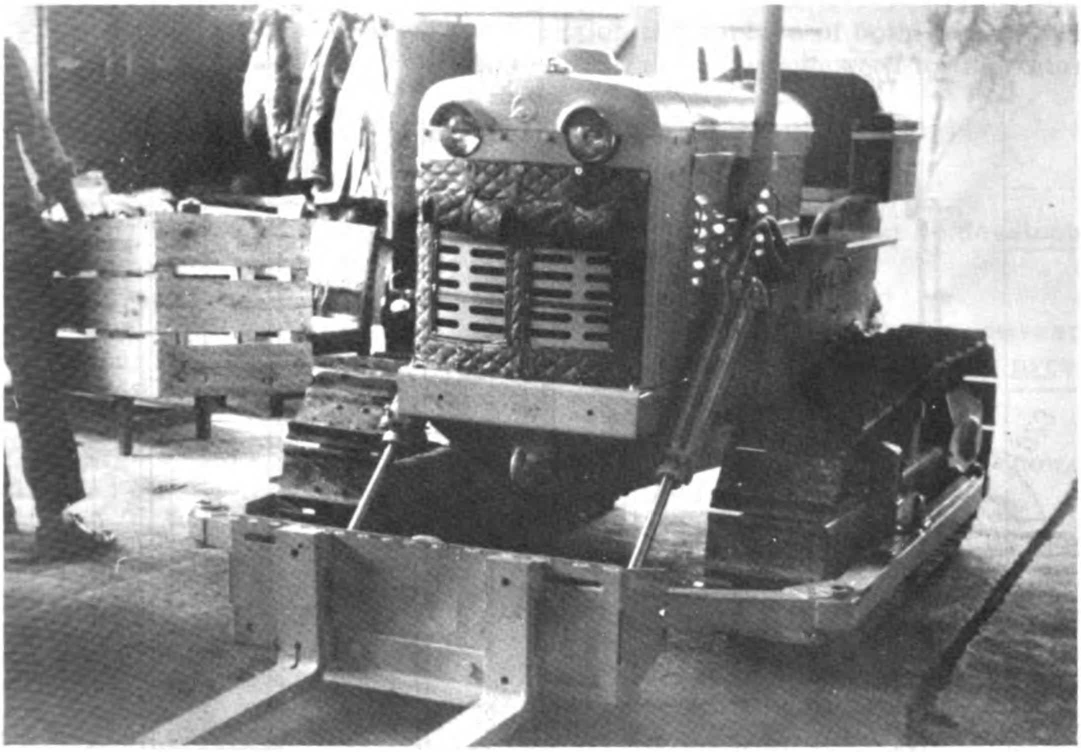

Figure 13. Iwatefuji Model CT-25A Tractor with loader forks.

Figure 14. The feature of an angle-dozer modified to cabin type.

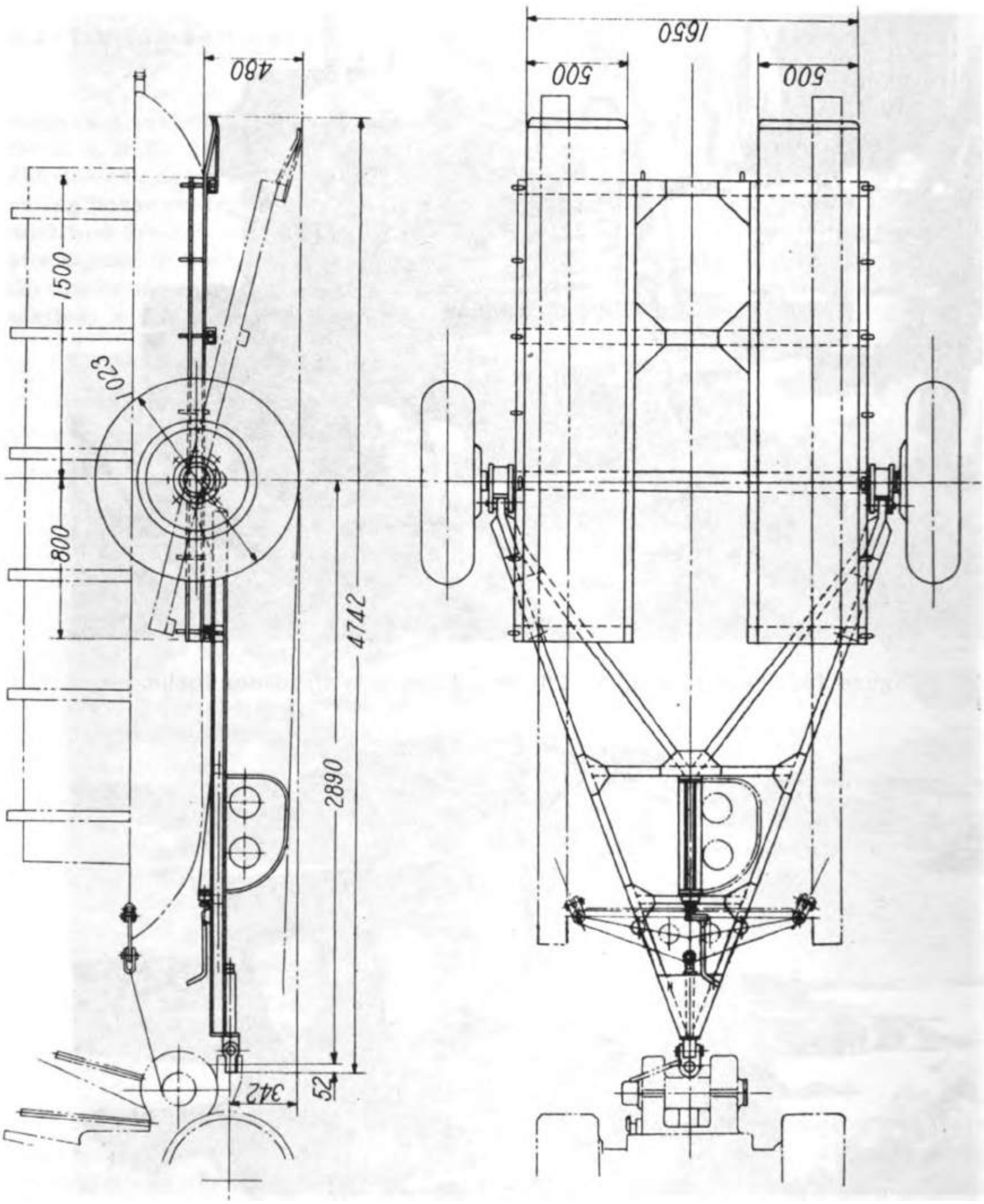

Figure 15. Trailer for transporting a loaded sleigh on the rock zone.

3.3 Propeller-Boat

For J.A.R.E.-IV (1959-61), a snow boat propelled by a propeller driven by an air-cooled gasoline engine was designed and constructed by Yokohama Yacht Co., Ltd.

This snow boat could travel by sliding on the surface of both the snow field and water at high speed. However, this boat was not transported to the Antarctic.

3.4 Problems Remaining

1. A tractor which is more adaptable for Syowa Base must be developed, and its number must be increased.

2. The small tractor cannot run on the snow. Hence a small snow-car, which is being developed at Hokkaido Internal Combustion, Co., Ltd. at present should be more useful in the future.

3. High speed vehicles, such as a snow-boat with air propeller, snow-auto-bicycle, and others are desired for scouting in field operations.

4. Auxiliary Equipment for Land Vehicles for Use in the Antarctic

4.1 Hot-Air Heater

For J.A.R.E., two kinds of hot-air heaters were prepared, one of which was the Webust Type, and the other was the Hamann Nerson Type. The gasoline snow-car was preheated for starting at temperatures below -30°C, and the diesel engine was preheated at temperatures below -40°C. There is little difference between these two kinds of heaters. The air-preheater is very important for field operation in the Antarctic.

4.2 Welding Machine

For J.A.R.E., a gas welding machine and Hitachi 13 KVA, 100 V, AC electric arc-welding equipment were prepared. A portable type welding machine was required for field operations.

4.3 Air Compressor

An air compressor is desired for fuel charging from a drum to a fuel tank and for inflating air mattress in the field.

5. Sleighs

5.1 Sleighs Designed for J.A.R.E.-I

The two kinds of sleighs were newly designed and constructed by the Special Committee and manufacturers at the beginning of May, 1956. One of these was an all-plastic sleigh constructed by Honda Gikan Kogyo Co., Ltd. and the other was a prototype wooden sleigh constructed by Yokohama Yacht Co., Ltd. The specifications of these sleighs are shown in Table 3. The former was the first all-plastic

TABLE 3

Snow Sleighs and Snow Boat

Items		Wooden Sleighs Prepared for Testing	Wooden Sleighs Prepared for the First Exped.	Wooden Sleighs Prepared for the Second and Third Expeds.	All-Plastic Sleighs (Caboose)	All-Plastic Sleighs (Big Snow Boat)
Maker (year)		Yokohama Yacht (1956)	Yokohama Yacht (1956)	Yokohama Yacht (1957)	Honda Giken Kogyo (1956)	Honda Giken Kogyo (1957)
No. of sleighs		2	16	18	2	2
Total length	(mm)	4200	4200	4200	4000	4000
Width	(mm)	1500	1500	1575	1500	1596
Height of floor	(mm)	350	350	365		(600)
Width of sliding plane	(mm)	150 x 2	150 x 2	225 x 2	150 x 2	1200
Weight						
Weight of chassis only	(kg)	191 (173)	260 (230)	437		
Total weight	(kg)	208 (182)	313 (282)	628		250
Runner		2.1 mm, steel plate (a) (2 mm celluloid plate) (b)	4.5 mm, steel plate (c) (stepped type) (d)	4.5 mm, steel plate (e)		1200 x 700 (f)
Pay load	(kg)	2000	2000	2000		1500

(The form of runner is shown in Figure 19) sleigh made in Japan. These sleighs could carry 10 drums of fuel, i.e., 2,000 kg. And for this purpose, it was decided to make the dimensions of each sleigh 4.2 m in length and 1.5 m in width. Each sleigh was designed to have sufficient strength and as low a torsional rigidity as possible and as low a weight as possible. When a snow-car pulling a loaded sleigh descended a slope, the sleigh occasionally skidded and collided against the rear end of the snow-car. To eliminate this difficulty, a special sleigh-brake was deviced which could brake the sleigh automatically when the tractive force became zero or negative. After these sleighs were tested at Tateyama Mountain in Japan, the plastic sleigh was redesigned to a caboose, two of which were transported to the Antarctic for J.A.R.E.-I (Fig. 16).

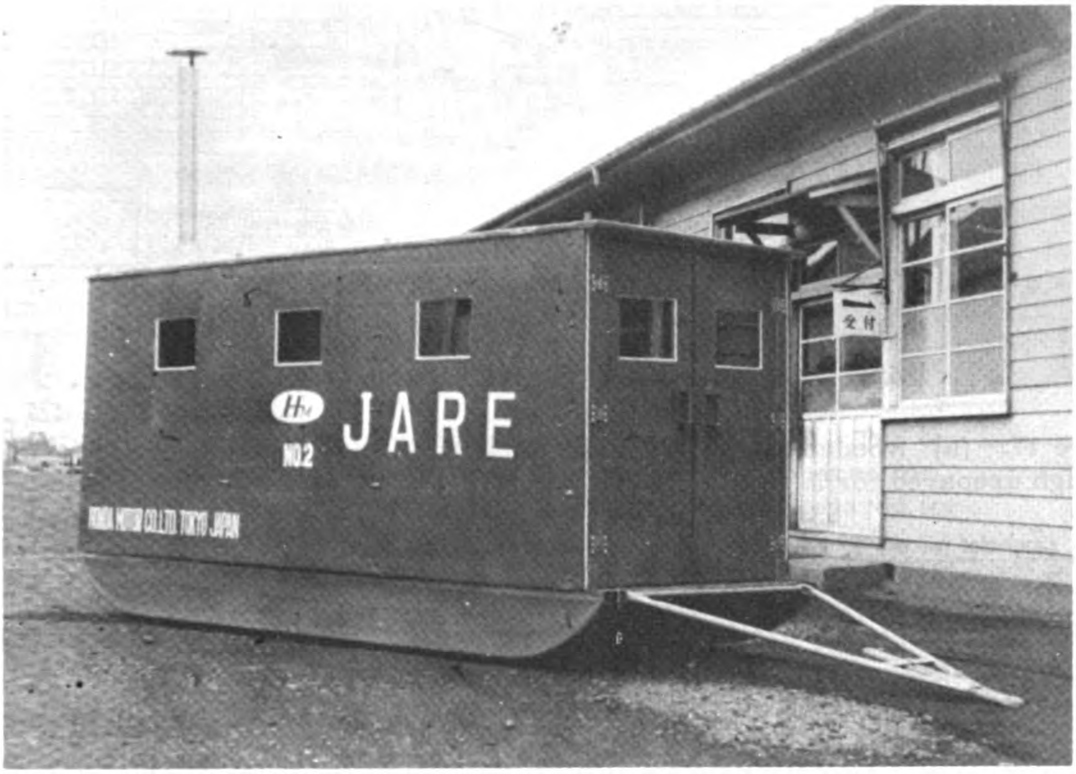

Figure 16. An all plastic caboose prepared for J.A.R.E.-I.

The other wooden sleigh was redesigned, and eight of this type shown in Figure 17 (a) were carried to the Antarctic and transported 200 tons of cargo in a short time in J.A.R.E.-I. On the route of the transportation, puddles caused difficulties and damaged the forward parts of runners when they fell into puddles. The sliding planes of the runners had the most important effect on the performance. Some of their types as shown in Figure 18, were tested at Tateyama, and type (d) was adopted. The sectional form (d) was utilized for half of the sliding planes of the runners, steel plate covering the center edge.

However, this anti-side-slipping central edge was removed during J.A.R.E.-I because it was not suitable for crossing temporary bridges built over puddles.

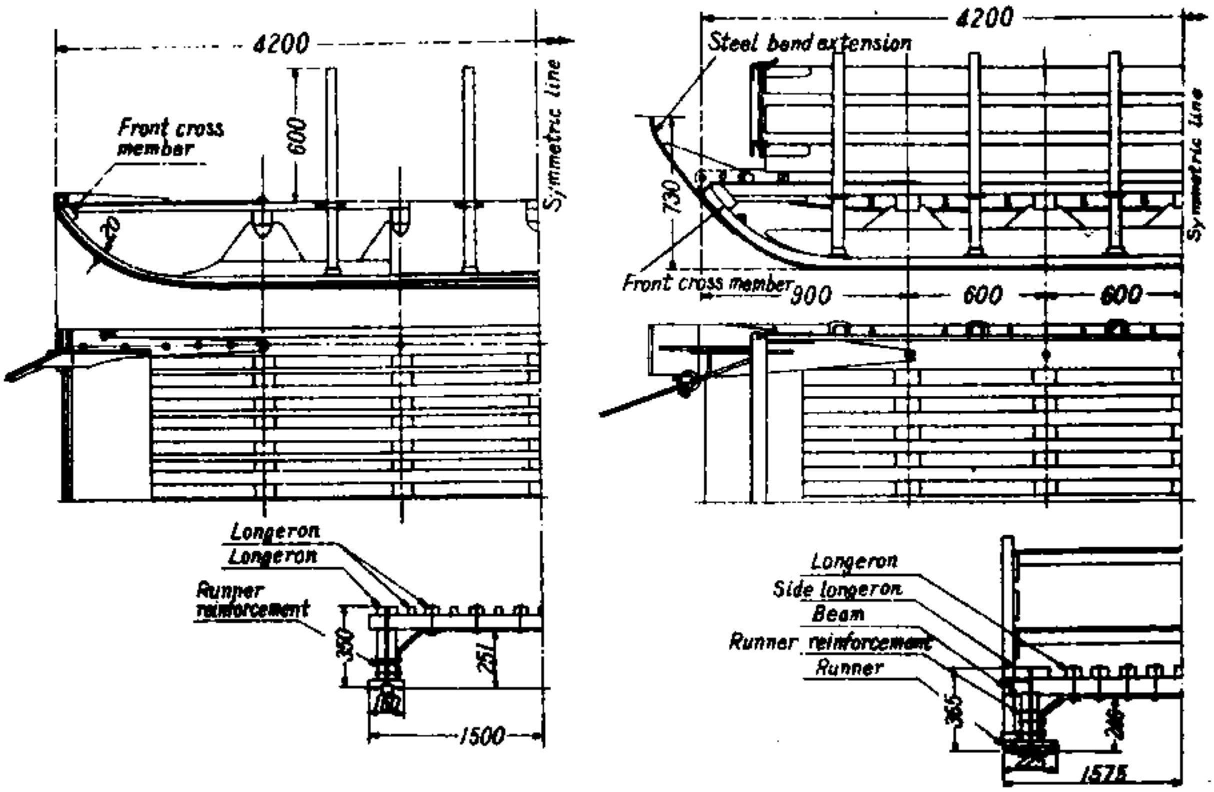

Figure 17. (a) Wooden sleigh prepared for J. A. R. E. -I; (b) Improved wooden sleigh prepared for J. A. R. E. II-V.

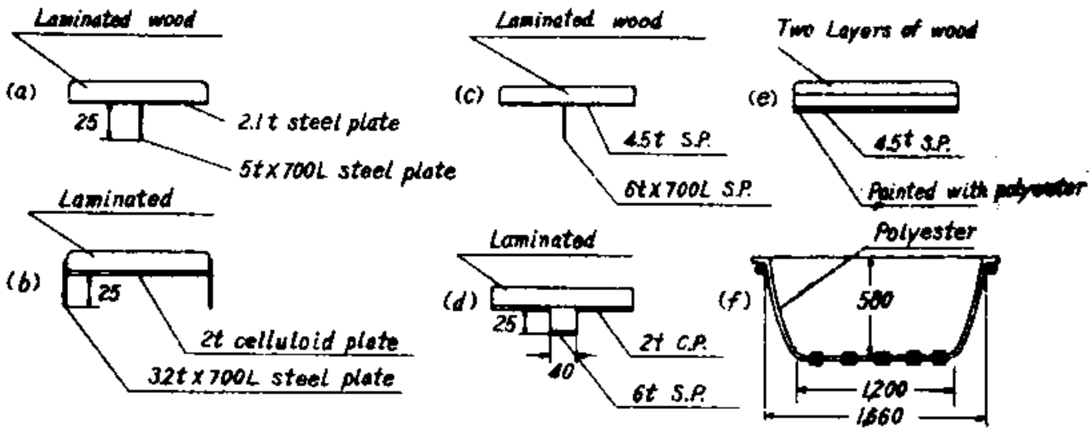

Figure 18. Sliding plane of the snow sleighs and the sectional form of a snow boat.

5.2 Sleighs Designed for J. A. R. E. -II

From the experiences in J. A. R. E. -I, the sleigh used for J. A. R. E. -II was improved as shown in Figure 17 (b) and 19. The points of improvement are:

a. All parts of the sleigh were reinforced.

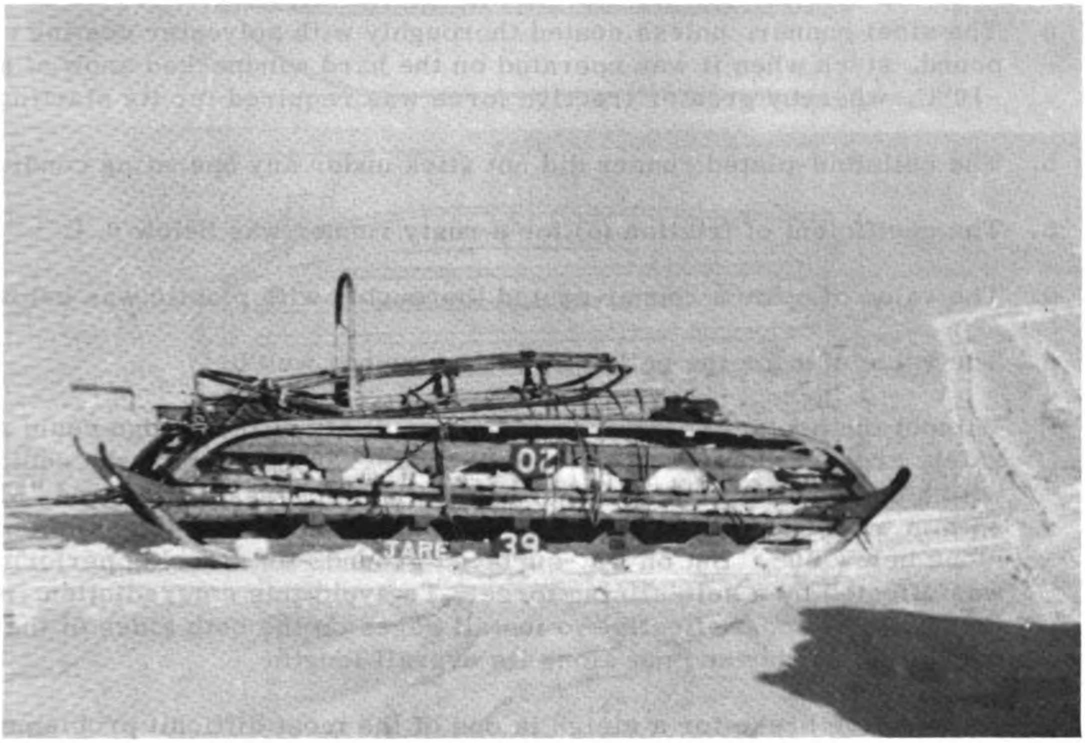

Figure 19. Three kinds of sleigh prepared for J. A. R. E. Top one is a sleigh pulled by men. Second one shows a sleigh prepared for J. A. R. E. -I. Bottom one shows a improved sleigh prepared for J. A. R. E. -II.

b. Steel extension bends were attached to each end of the sleigh, and by the aid of these steel bends, the sleigh could easily run over a puddle of about 50 cm depth without any aid. At the same time, these extensions acted as bumpers when the sleigh collided against the pulling snow-car or other objects.

c. The connecting rigid joints were removed and replaced by two steel wire ropes for pulling a sleigh.

d. The floor and other parts were improved, and detachable wooden side-panels were newly installed.

e. As for the brake, only hand brakes, and no automatic brakes, were prepared.

f. The weight of a sleigh was about 628 kg, about three times as heavy as that prepared for J. A. R. E. -I.

This improved wooden sleigh was excellent and could easily run over the very fast "sastrugis" found inland. The experimental results on friction performance obtained in the Antarctic are shown below:

a. The steel runner, unless coated thoroughly with polyester coating compound, stuck when it was operated on the hard windpacked snow at above -10°C, whereby greater tractive force was required for its starting.

b. The celluloid-plated runner did not stick under any operating conditions.

c. The coefficient of friction (μ) for a rusty runner was below 0.4.

d. The value of μ for a runner coated thoroughly with plastic was below 0.2.

e. The value of μ for the celluloid-coated runner was 0.1.

f. Without the protective central edge for side-slip, the sledge could not safely cross a slope covered with blue-ice. If the runner was equipped with a central edge, the sectional form of which was a reversed "M", 25 mm wide and 10 mm high, the sleigh was free from side-slip on a slope below 20°. But on flat-surfaced ground, its steering performance was affected by a self-alining force. To avoid this contradiction, it is thought to be most effective to install edges on the both sides of the rear half of the runner and not along its overall length.

g. An effective brake for a sleigh is one of the most difficult problems.

5.3 Caboose

a. All-plastic caboose. Two all-plastic cabooses reinforced with glass-fiber were carried to Syowa Base in J.A.R.E.-I. They were used effectively as an earthquake-observing cabin, and as a temporary field operation center, one which was equipped with long recording apparatus for meteorological observations being stationed at an inland site. Unfortunately, one of the cabooses was lost through fire on July 24, 1957.

b. Large caboose. A canvas awning was installed on a improved sledge, and this caboose was very effectively used for inland trips. It was used for carrying electric-generator, communication apparatus, hot-air heater, earthquake observing apparatus and other instruments.

c. Small caboose. In J.A.R.E.-IV, a small caboose was used as a mass-tent and as an earthquake observing cabin, but it was too small. The brake with which it was equipped operated very effectively.

d. Snow-boat. An all plastic snow-boat was designed and constructed by Honda Giken Kogyo Co., Ltd. for J.A.R.E.-IV as shown in Figure 20 and in Figure 21, but it was not transported and no experience was obtained with its use.

6. Navigation Instruments

The following navigation instruments were prepared for J.A.R.E.-V by Dr. M. Murayama.

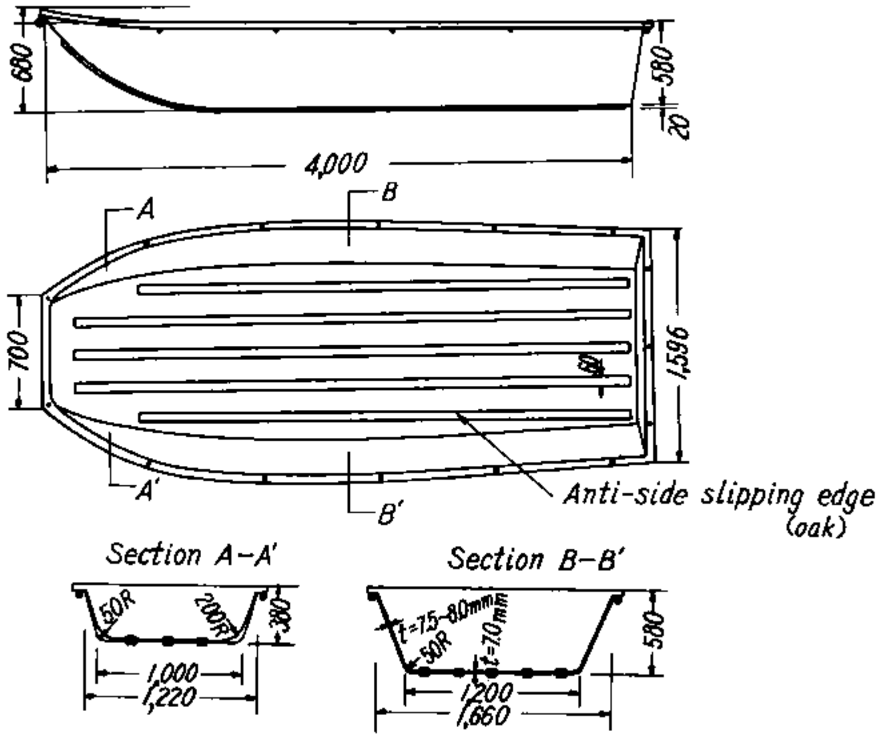

Figure 20. All-plastic snow-boat manufactured by Honda Giken Ltd. Co.

Figure 21. The feature of a snow-boat.

6.1 Gyro-Compass

a. A gyro-compass, type C-4 made by Sperry Co., Ltd. was installed on each of the two snow-cars for inland trips.

b. As it had to be used at high latitude, a long time was needed for stabilizing an indication.

c. A free gyro-compass was not suitable for use because of its high drift.

d. In the homing to the base, a gyro-compass was very useful and instrument navigation was possible because the indications of the compass was very stable when the car ran without stopping for a long distance.

6.2 Magnetic Compass

A magnetic compass was used effectively for the dog-sleigh. It was packed in a non-magnetic metallic box, and the box was mounted on duralmin bars for obtaining good direction indications.

6.3 Astro-Compass

This was not used in good condition because the anti-freezing oil used for it was not suitable.

A detachable suspending base enabled it easily to align the center line of the wagon to the zero-line of the meter indication.

Problems remaining are as follows:

a. A gyro-compass used for Antarctic operations needs a latitude correction device.

b. A radio-beacon device, which enables alignment of three snow-cars during running and homing, is desired. It may be realized as follows: The first car receives a directional radio beam emitted from the last car and aligns its path to the homing indication set to a certain direction. Instrument navigation on the snow field in the Antarctic is one of the most important problems remaining for solution in the future.

7. Conclusions and Acknowledgements

In this paper, outline descriptions of vehicles, sleighs, caboose, navigation instruments and other auxiliary machines designed, constructed and used for J.A.R.E. (1956-62) have been presented, and the actual experiences in the Antarctic and the remaining problems have been discussed.

At the start of J. A. R. E., we had little knowledge of the Antarctic logistics, but the designed apparatus and equipment were generally useful for practical purposes at Syowa Base.

The authors wish to thank the many manufacturing companies and other people who assisted this work and contributed to the success of the J. A. R. E.

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Members of Special Committee for J. A. R. E. of J. S. M. E.

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Osamu Hirao	Prof. of University of Tokyo, Engineering Dept., Committee secretary
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DIESELIZATION OF THE SNOW CAR AND THE ELECTRIC GENERATOR FOR THE JAPANESE ANTARCTIC RESEARCH EXPEDITION

Sumio Maita

1. Introduction

Prior to the beginning of scientific observations in the Antarctic, the Mechanical Engineering Committee for the Japanese Antarctic Research Expedition was established in 1956, and selection of the items of mechanical equipment of the Japanese observation team was carried out.

One of the major problems which became a controversial subject in the discussions during this selection was the question of whether to adopt the gasoline engine or the diesel engine for the snow cars, tractors, and engine-generator units.

As a result of studying the advantages and disadvantages of both types of engines, it was decided that the advantages of the diesel engine possessed many attractive features; and because, even with respect to its starting characteristic, which is generally considered to be its weakest point, a considerable amount of research had been carried out since about 1935 in our country on diesel characteristics under environmental temperatures as low as -40°C, and substantial practical experience had been accumulated, it was decided to adopt the diesel engine for the tractors and the engine-generator units, and on a trial basis, both the gasoline engine and the diesel engine for the snow cars.

More specifically, for the First Expedition (1956 through 1957) three gasoline snow cars, one diesel snow car and two diesel engine-generator units were transported to the Antarctic and put to actual use.

As a result, the practicability and numerous advantages of the diesel engine were proven under actual operational conditions. Accordingly, the land vehicles planned for the subsequent phases included five diesel snow cars, one gasoline snow car, and one diesel tractor. These were transported for the third, fourth, and fifth expeditions and produced satisfactory performance.

2. Advantages of Dieselization

The diesel engine, with a principle of operation differing fundamentally from that of the gasoline engine, has various merits and relative advantages, the most important of which will now be reviewed in the following description.

2-1. Low Specific Fuel Consumption

Because of its high compression ratio, the diesel engine has a high thermal efficiency, and its fuel consumption is from 50 to 70 per cent (by volume) of that of the gasoline engine. Furthermore, since a gasoline engine, for normal operation at low temperatures, must be operated with considerable use of the choke after starting until the cooling water temperature rises, this adverse effect becomes more pronounced in case the engine is operated at lower temperature. Therefore, for the same quantity of fuel, the distance a diesel-powered vehicle can travel is from 40 to 100 per cent longer than that of a gasoline-powered vehicle.

2-2. Facility of Transportation and Storage of Fuel

The fuel for diesel engine is diesel fuel oil (gas oil) which, as compared to gasoline, is less volatile and has a higher flash point and the property of not easily deteriorating. Accordingly, diesel fuel oil has a lower rate of natural loss due to vaporization, less fire hazard, and greater advantage in preservation for long periods. Therefore, diesel fuel oil is highly advantageous for transportation to the base and for storage at the base.

2-3. Less Danger in Operating

Because the flash point of its fuel is high, the diesel engine has less danger of fire during its operation or during its heating for the purpose of starting. (As compared to the flash point of gasoline of -40°C, that of diesel fuel oil is +60°C.) Furthermore, since diesel fuel oil does not contain any harmful substances such as lead tetraethyl, which contained in most gasolines, diesel fuel oil has almost no dangerous effect on the human body.

Moreover, since the exhaust gas from a diesel engine contains almost no poisonous gases such as carbon monoxide (CO) gas, there is no cause for concern over the possibility of physiological failure due to the exhaust gas. (As compared to a carbon monoxide content in the exhaust gas of 1.5 to 6.0 per cent in the case of a gasoline engine, that in the case of a diesel engine is 0.01 to 0.03 per cent.)

2-4. Freedom from Electrical Trouble under Wet Conditions

Since the diesel engine depends on compression ignition, it has no parts such as spark plugs and a distributor of an electrical ignition system. Accordingly, the diesel engine is not subject to the inconvenience of engine failure arising from wetting of the ignition system under such conditions as those encountered when the vehicle is driving into a snow drift or a puddle.

Furthermore, radio interference rarely occurs in the case of a diesel engine; and, moreover, thorough radio shielding can be easily effected at low cost and with little possibility of disorder.

2-5. Easy, Positive Starting and Running in Cold Weather

At low ambient temperatures, the gasoline engine often fails to start because, in addition to the narrowness of the range of its combustible fuel-air mixture ratio, the volatility of gasoline at low temperatures is low, whereby the spark plugs of the gasoline engine become wet, and the engine easily becomes impossible to start.

A diesel engine, however, can be easily started, even in cold weather, provided that cranking at a speed equal to or greater than the minimum limiting rotational speed for starting is carried out. Especially, in the case of an engine with auxiliary combustion chambers, since glow plugs (heater plugs) are provided in the auxiliary combustion chambers and become the sources of ignition, the engine starts with even greater certainty.

During the running immediately after starting, the gasoline engine is also disadvantageous in that it is subject to misfiring because of the poor volatility of gasoline until the cooling water temperature rises to a certain value, and it is difficult to impose a load on the engine. In the case of the diesel engine, however, its combustion is brought about by self ignition due to the fuel particles contacting compressed, high-temperature air. Therefore, once the engine starts, and its rotational speed increases above a certain value, its operation becomes normal, and a load can be imposed on it immediately after starting.

2-6. High Durability and Long Life of Engine

As compared to a gasoline engine of the same size, a diesel engine is designed more for heavy duty for reasons of its being used for various purposes. Accordingly, a diesel engine has higher durability than a gasoline engine.

Furthermore, in contrast to the case of the gasoline engine, dilution of the engine lubricating oil by gasoline does not occur, and, moreover, there is no possibility of the lubricating oil on the surface of the cylinder walls being washed off by gasoline. Therefore, there is no possibility of hastening of cylinder wear or seizing of bearings. Still furthermore, there is no possibility of the intake and exhaust valves being damaged by harmful lead deposits due to gasoline.

2-7. Ease in Handling

Since the diesel engine is a compression ignition engine, it does not have an electrical ignition system, which is troublesome for the layman, and the principle of running of the diesel engine is purely mechanical. Therefore, even a novice can easily understand its principle, and even if trouble occurs, it can be easily discovered and remedied.

2-8. Possibility of Installing a Turbo-Supercharger

The Mechanical Engineering Committee feels that the above superior features of the diesel engine are highly attractive. However, the following disadvantages of the diesel engine cannot be denied.

1. The engine weight per output horsepower of the diesel engine is somewhat higher than that of the gasoline engine.

2. For the same size of engine, the maximum power output is somewhat inferior to that of the gasoline engine.

3. Since the maximum explosion pressure is high, there is much vibration and noise during the running of a diesel engine.

Upon considering the above superior and inferior features, the Committee came to the conclusion that it is possible to adopt the diesel engine as an engine for use in the Antarctic and that it is superior to the gasoline engine.

3. Planning and Designing of the Diesel Engine

3-1. Planning

As a result of study by the Mechanical Engineering Committee for the Japanese Antarctic Research Expedition, the following policy for designing the diesel engine for snow cars and engine-generator units was decided.

3-1-1. The engine shall be commonly usable for the snow cars, tractors, and engine-generator units, thereby affording mutual interchangeability between the engines, interchangeability of parts, and unification of fuel in the field, and decreasing the number of classifications and quantity of spare parts and materials.

3-1-2. With full consideration of the required performance and conditions of transport and conveying arising from the conditions of use, the engine shall be designed to have a total piston displacement of the order of four litres, to be of the high-speed diesel type, and to be compact and light in weight.

3-1-3. With full consideration of use in extremely cold weather in the Antarctic, the engine shall be designed to be suitable for starting at low temperatures and running in extremely cold regions.

3-1-4. The Combustion chamber type of the engine shall be the Precombustion chamber with the glow plug, which has been developed through our experience and results obtained from long years of research in cold regions.

3-1-5. The engine for the snow car shall be equipped with a torque converter so as to enable easy operating by any member of the expeditionary team.

3-1-6. Such materials as fuel, lubricating oils, and torque converter fluid (oil) shall be specially studied and prepared.

3-2. Design of Engine

As a result of studying the engine in accordance with the above basic plan, it was decided to adopt the ISUZU Model DA 220 diesel engine. This is a four-cylinder, 4.1-litre, diesel engine which has been newly designed for research work in the Antarctic, utilizing the parts of the six-cylinder, 6.2-litre, diesel engine, ISUZU Model DA 120, manufactured by the Isuzu Motors Limited. The Model DA 120 engine was being most widely used at the time, within Japan, as an engine for trucks and buses.

External and cross section views of this new Model DA 220 engine are shown in Figures 1.1-2.2, and the principal particulars of its specification are presented in Table 1.

The following points received careful consideration in the design of the engine especially for use in the Antarctic.

3-2-1. Fuel System. A fuel injection pump of Bosch B type was used. In the case of the engine for the First Expedition, a smoke set release device was provided in order to facilitate starting and the fuel discharge rate was increased temporarily only at the time of starting. However, as a result of actual use during the First Wintering Period, it was found that the providing of this device is not necessary, and the use of this device was discontinued during the Second Wintering Period and thereafter.

The adjustment of injection timing was carried out manually by means of a button, and this method was found effective in facilitating starting. The injection nozzle was of the throttle type with an orifice of 1mm diameter and an injection angle of four degrees.

3-2-2. Electrical System. For all electrical equipment, a 24-volt system was adopted for compactness and light weight and positiveness of operation. A 5-hp starting motor for use at low temperatures, of low power consumption and, moreover, high torque at low speed, was specially designed and adopted. A generator of 300-watt output was adopted for battery charging, and in all cases was of dustproof, drip-proof construction. In order to improve the performance of the battery for quick discharge conditions at low temperatures, the number of plates in an SAE 4D battery container was increased, and 27 plates were placed therein, whereby a battery of a capacity superior to the SAE 8D battery at -30° was obtained.

With the above combination, it was possible to secure an engine-driving rotational speed of 120 rpm. or more at -30°C. While the limiting condition for possibility of starting of a diesel engine is determined by the cranking speed, and the higher this speed is, the easier is the starting, the minimum cranking speed at which this engine can start is 80 rpm.

TABLE 1

Specification of "ISUZU Model DA220" Diesel Engine
Used for Snow Car, Tractor and Engine-Generator Unit

Name and model of engine	ISUZU DA220	Governor	pneumatic type NEP/MN80B59
Kind of engine	diesel	Injection timing control	manual operation 22°-38° B.T.D.C.
Cooling system	water-cooled		
Number and arrangement of Cylinders	4 cyl., inline	Nozzle: Type	NDN4SD24 throttle nozzle
Type of Cycle	4 cycle	Number x dia. (mm) of orifice	1 x 1
Type of Combustion chamber	precombustion chamber	Injection pressure kg/cm^2	100
Valve arrangement	over head valve	Glow plug: Type	Bosch NGS2D6E
Type of Cylinder liner	wet type	Volt x amp.	1.7 x 40.3
Bore x stroke, mm	100 x 13.0	Air cleaner	oil bath or paper
Total piston displacement, cc.	4,084	Lubricating system	forced circulation
Compression ratio	19.5:1	Lub. oil pump	gear pump
Max. output, PS/rpm	80/2,600	Lub. oil filter	laminated filter element type
Max. torque, kg.m/rpm	26/1,400	Lub. oil capacity, L	7 to 5
Max. brake mean effective pressure (EMEP), kg/cm^2	8	Max. allowable engine inclination	30°, both forward-rearward and left-right
Engine dimensions (length x width x height), mm.	877 x 685 x 1,034	Cooling system	forced circulation
Engine weight, kg	365	Coolant capacity, L	18
Ignition system	compression ignition	Thermostat	bellows type with bypass
Firing order	1-3-4-2	Battery: Type	modified SAE 4D
Decompression device	yess	Number installed	2
Piston: form and type material	trunk, full floating "Low-Ex" alloy	Engine Starting system	battery and starting motor
Intake valve: opens closes	20° B.T.D.C 45° A.B.D.C	Starting motor	24 Volt x 5 PS specially designed for low temp. use
Exhaust valve: opens closes	50° B.B.D.C 15° A.T.D.C		
Valve clearance, mm	0.2	Generator for charging battery	24V x 300 Watt
Fuel injection pump: Model Plunger diam., mm. Cam lift, mm.	 NPE4B70E432S1 7 10	Voltage regulator	constant-Voltage, carbon-pile type

3-2-3. Changes in Materials of Parts

a. In the case of such components as the fuel feed pump in which precision functioning parts made of two or more different materials are assembled in combination, and in which defective function may be caused at low temperatures because of differences in the thermal expansion coefficients of these materials, the functioning parts were redesigned to be made of the same materials.

b. Vinyl resin products such as vinyl tubes and vinyl-covered electrical wires were all replaced by other equivalent products made of metal materials, cotton materials, or cold-resistant rubber. Cold-resistant rubber which had passed thorough tests in a laboratory to confirm absence of defects at -45°C was used.

c. It was decided to use an aqueous solution of ethylene glycol as the antifreeze fluid for the coolant of the engine. However, since laboratory test results indicated the possibility of such materials as steel plates being damaged by long use of ethylene glycol, all steel-plate parts to contact the antifreeze fluid were changed to brass, and the coolant circulation system was formed by parts made of only cast iron, copper, brass, and rubber.

3-2-4. Fuel. It was decided to produce a special diesel fuel oil (gas oil) for use in the Antarctic. This fuel is (a fuel) of naphthen base so as to provide it with as high a cetane number and as low a pour point as possible. The properties of this diesel fuel oil are presented in Table 2.

TABLE 2

The Properties of Diesel Fuel Oil

Specific gravity, 15/4°C	0.8580	Sulfur content, %	0.155
Reaction	Neutral	Diesel inded	47.9
Flash point, °C	87	Residual carbon, %	trace
Viscosity, at 30°C (centistoke)	2.03	Aniline point, °C	61.3
Fractional distillation, °C, 95%	30.6	Coloring (union)	1(-)
Pour point, °C	-55.0	Corrosiveness test (Copper sheet)	0

3-2-5. Lubricating Oil and Torque Converter Fluid. For the engine lubricating oil, a multi-grade, heavy-duty engine oil of SAE 10 W/30 viscosity was selected and prepared, consideration being given to the starting of the engine in cold weather and severe conditions of high-speed, continuous running. The properties of this oil are presented in Table 3.

TABLE 3

The Properties of Engine Lubricating Oil

Specific gravity, 15/4°C	0.870	Viscosity index	121
Flash point, °C	218	Coloring	1 1/2 (-)
Pour Point, °C	-45 or less	Stability test,	
Viscosity, (Centistoke)		170°C x 24 hrs	Satisfactory
at 0°F	8060	Neutralization number,	
at 100°F	122.0	KOH, mg/mg	1.09
at 210°F	14.5	Saponification number,	
		KOH, mg/mg	1.46
		Residual Carbon, %	0.81

For the torque converter fluid, consideration was given to the requirements of low viscosity even at low temperatures, yet sufficient lubricating property at high temperatures, and low pour point, and a fluid having the properties shown in Table 4 was prepared.

TABLE 4

The Properties of Torque Converter Fluid

Specific gravity, 15/4°C	0.8870	Viscosity index	182.0
Flash point, °C	161	Pour point, °C	-55
Viscosity, (Centistoke)		4-Ball test, kg/cm^2 at 200	
at 100°F	18.09	rpm	5.5
at 210°F	4.56		

4. Actual Operating Results and Improvements

4-1. Snow Car and Tractor

The total mileages (distances run) of ten snow cars and one tractor actually used throughout six Antarctic expeditions were as shown in Table 5. As further, detailed data, the operation record of the First Wintering Period is presented in Table 6.

TABLE 5

Operation Record of Snow Cars and Tractor
Throughout all Expedition Periods

No. of Snow Car	Team Bring in Vehicle	Type of Engine	Total Running Distance	Remarks
No. 1	1st Expedition	Gasoline	4, 220 km	
No. 2	1st Expedition	Gasoline	1, 934 km	
No. 3	1st Expedition	Gasoline	4, 094 km	During 1st Wintering, engine was damaged and replaced.
No. 4	1st Expedition	Diesel	1, 321 km	During 1st Wintering, engine was dismounted for use to No. 1 engine -generator set.
No. 5	4th Expedition	Diesel	3, 712 km	
No. 6	4th Expedition	Diesel	4, 024 km	
No. 7	4th Expedition	Diesel	3, 425 km	
No. 8	4th Expedition	Diesel	2, 609 km	
No. 9	4th Expedition	Diesel	2, 708 km	
No. 11	3rd Expedition	Gasoline	4, 557 km	
Tractor	5th Expedition	Diesel	145 hours	

TABLE 6

Operation Record of Snow Cars Through the Transportation Period
in the 1st Expedition (From January 24th to February 15th, 1957)

No. of Snow Car	No. 1	No. 2	No. 3	No. 4
Type of snow car	Gasoline car	Gasoline car	Gasoline car	Diesel car
Total running distance (km)	1530. 1	1709. 2	1668. 2	1096. 2
Total time for running (hr)	181. 10	238. 04	245. 29	162. 11
Total fuel consumption (L)	1420	1770	1914	785
Fuel consumption (L/km)	0. 93	1. 03	1. 15	0. 72
Mean speed (km/hr)	8. 45	7. 18	7. 10	6. 76
Total lubricating oil consumption (L)	45. 0	46. 6	51. 4	29. 0
Torque converter oil consumption (L)	—	—	—	72. 0*

*Including the new charge for its overhaul.

From the results of actual use in the Antarctic, the following statements may be made relative to the diesel car.

4-1-1. With respect to the objects which were expected to be achieved, the work accomplished was entirely satisfactory. During the two continental investigations carried out by the Fifth Wintering Team in the autumn (using snow car Nos. 6, 7 and 8) and in the spring (using snow car Nos. 7, 8 and 9), the average running distances were 640 km in the autumn and 1,935 km in the spring. Although minimum air temperatures of -42°C in the autumn and -53.3°C in the spring were experienced, the diesel cars performed satisfactorily.

4-1-2. It was very advantageous to adopt the same diesel engine for both the engine-generator unit and the snow car. During the First Wintering Period, an oil pipe of the engine on a 20-kvA engine-generator unit which was the main power generating apparatus at the base was damaged, and bearing seizure occurred. However, the engine on a snow car (No. 4) was immediately dismounted and used to replace the defective engine, thereby continuing the power supply without causing a major power shut-off.

4-1-3. The fuel consumption of the diesel car (0.72 litres/km), on the basis of distance traveled, was less than that of the gasoline car (0.93 to 1.15 litres/km).

4-1-4. The same diesel fuel oil (gas-oil) could be used for all of the diesel cars, the engine-generator units, and the room heating furnaces at the base.

4-1-5. In addition to its easy and safe handling at the base, diesel fuel oil is preferable to gasoline because of diesel fuel oil's lower vapor pressure and lower inflammability for safer shipping over the equator from Japan to the Antarctic.

4-1-6. As the diesel car did not have an electric ignition system, which was often affected by water in the case of the gasoline car, it withstood troubles due to puddles better than the gasoline car.

4-1-7. The diesel engine started with greater certainty and ease than the gasoline engine. At times of extreme cold, hot-air fans were used to warm the engines for starting, but when this measure was not taken, the limiting air temperature for the engine to start was -30°C to -35°C (not constant because starting required experienced skill) in the case of the gasoline engine. In the case of the diesel engine, we experienced during the Fifth Wintering Period that by using only decompression and glow plug it was possible to start a diesel engine, which had been left standing for three days, at an air temperature of -42.7°C.

4-1-8. The principal troubles experienced during the First Expedition were as described below. Most of these troubles, however, were remedied by improvements from the subsequent expedition.

a. The snow cars frequently fell into puddles, and their engines were immersed in water. As a result, the lubricating oil in the crankcase was contaminated by water, necessitating changing of the oil each time. As remedial measures, the following improvements were made.

   1. The insertion opening for the oil level gauge (dip stick type) was converted into a screw type and, with the use of a rubber packing, was made completely water-tight.

   2. The oil filler tube with crankcase breather was extended up to a level above the cylinder head so as to prevent infiltration of water.

   3. The water-tightness of the electrical equipment was improved.

b. The fuel filter and oil filter were choked by slices of ice with which they were filled to about half level. As a counter measure, whenever the fuel or lubricating oil was replenished, the oil was added as it was thoroughly filtered with filter paper to remove the slices of ice.

c. Leakage of water from the radiator due to vibration occurred.

4-2. Engine-Generator Unit (20 kvA)

Throughout the entire Japanese expedition period, the two engine-generator units transported to the base at the time of the First Expedition were used alternately, the engine on one of the two units being replaced every other year by a spare engine.

Throughout the First through Fifth Periods, the total power shutdown time due to equipment failure was less than 30 minutes, which was an extremely good record.

The average daily power generation was 110 kw hour in summer, 160 kw hour in winter, and 145 kw hour throughout the year. The operation record of these units is presented in Table 7. Each engine was replaced every 5,000 hours, approximately, but this replacement was carried out in order to be on the safe side. It was found, upon disassembling and checking the replaced engines, that the degree of wear in them were extremely low, and that these engines could have withstood much more use.

During the First Expedition, the engine of the No. 1 engine-generator set failed after 750 hours of operation because of seizure of engine bearings due to breakage of the copper pipe of the oil pressure gauge. Although an automatic alarm system for oil pressure drop and water temperature rise had been prepared, this failure occurred before this alarm system could be installed at the base. Accordingly, from the following period, the automatic alarm was changed to an automatic engine-stopping system, and the oil pressure pipe was changed from the copper pipe to a flexible pipe made of pressure-withstanding rubber.

TABLE 7

Operation Record of Engine-Generator Units

	No. 1 Set	No. 2 Set	Remarks
The 1st Wintering	2, 163 hrs	3, 380 hrs	No. 1 Set engine was replaced by engine of snow car No. 4 at 750 hrs.
The 3rd Wintering	5, 479 hrs	3, 116 hrs	July, 1959; No. 1 Set engine was replaced by overhauled No. 2 Set engine. Jan., 1959: No. 2 Set engine was replaced by spare engine
The 4th Wintering	4, 001 hrs	3, 138 hrs	Sept., 1960: No. 2 Set engine was replaced by overhauled, original engine of No. 1 Set.
The 5th Wintering	4, 596 hrs	5, 003 hrs	Jan., 1961: No. 1 Set engine was replaced by spare engine Aug., 1961: No. 2 Set engine was replaced by spare engine
Total	16, 239 hrs	14, 637 hrs	

5. Conclusion

The dieselization of the snow cars, tractors, and engine-generator units which was selected by the Mechanical Engineering Committee was more successful than was expected. Relative to proceeding with further dieselization hereafter, the Committee has no doubts and feels no anxiety whatsoever.

However, for the future diesel engines for snow cars, the Committee wishes to study the following points.

5-1. Hitherto, the snow car for the Japanese Antarctic Team was designed with emphasis on the requirements for transporting supplies from the land-approach point of the supply ship to the base. It is also believed, however, that hereafter a snow car for use in overland exploration of the continent must be considered. For this purpose an engine producing a higher power output which drops only slightly at high elevations, that is, a turbo-supercharged diesel engine, is required.

5-2. In the case of a water-cooled engine, troublesome problems, such as leakage of radiator water and control of the antifreeze fluid, must be solved. Therefore, the realization of an air-cooled diesel engine is highly desirable. In this case, however, extremely difficult problems such as, for example, that of effective cooling in the case of running with a following wind, and those of construction and materials of an air-cooled diesel engine to be used under severe conditions of use in the Antarctic where extreme differences in engine temperatures occur, are involved.

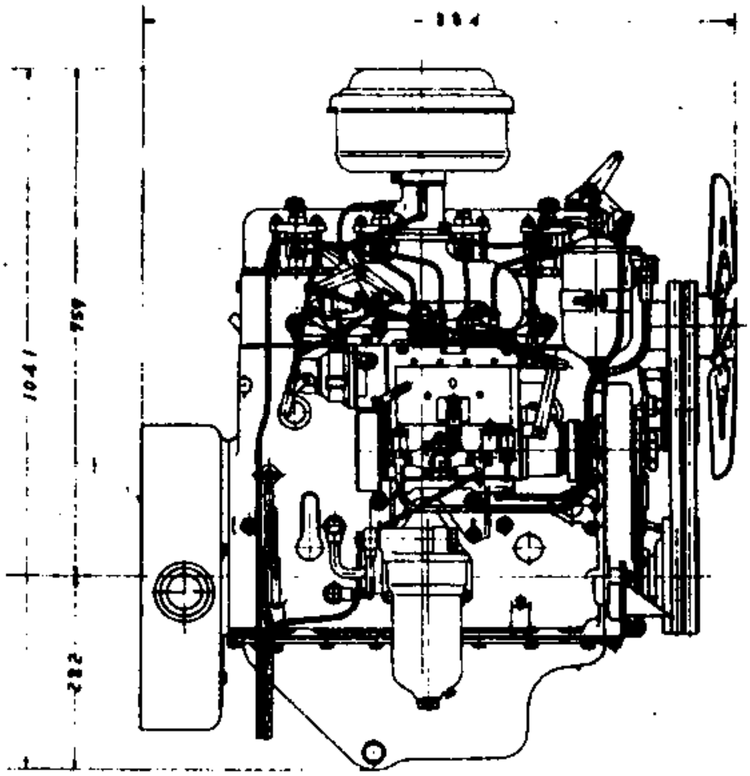


Figure 1. 1. General arrangement of "ISUZU DAZZO" diesel engine.

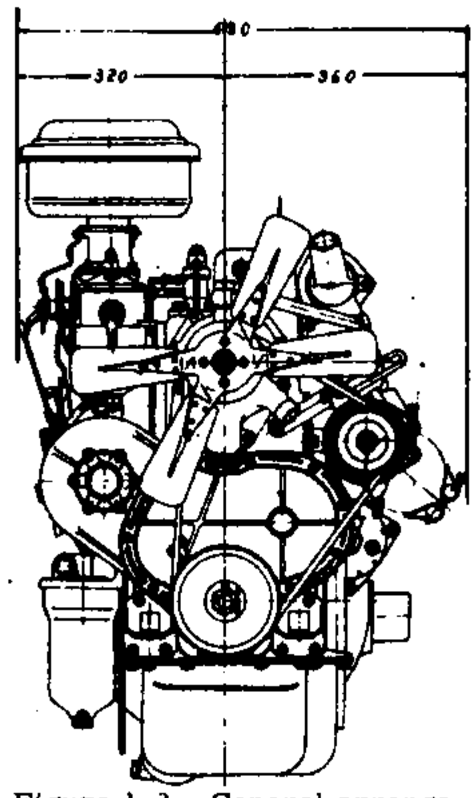


Figure 1. 2. General arrangement of "ISUZU DAZZO" diesel engine.

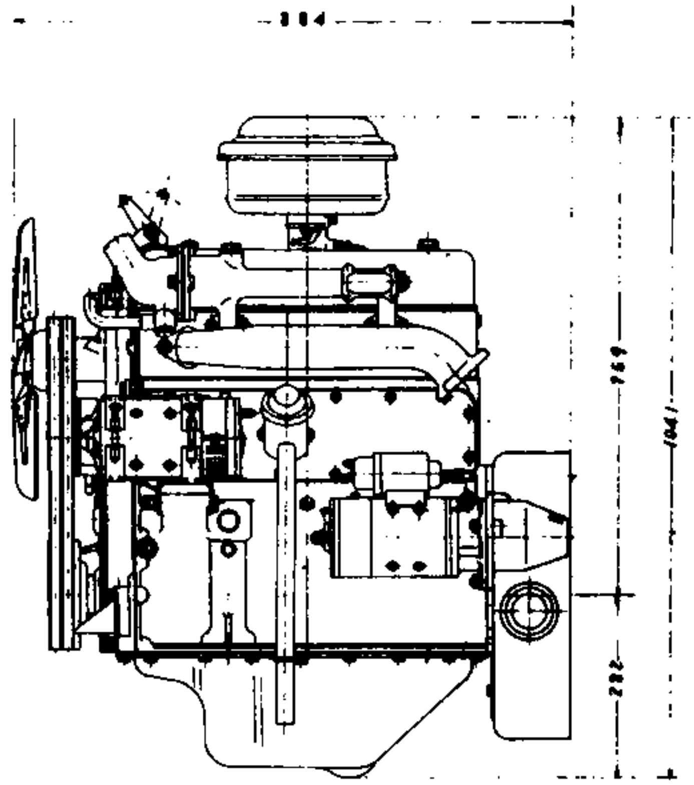


Figure 1.3. General arrangement of "ISUZU DAZZO" diesel engine.

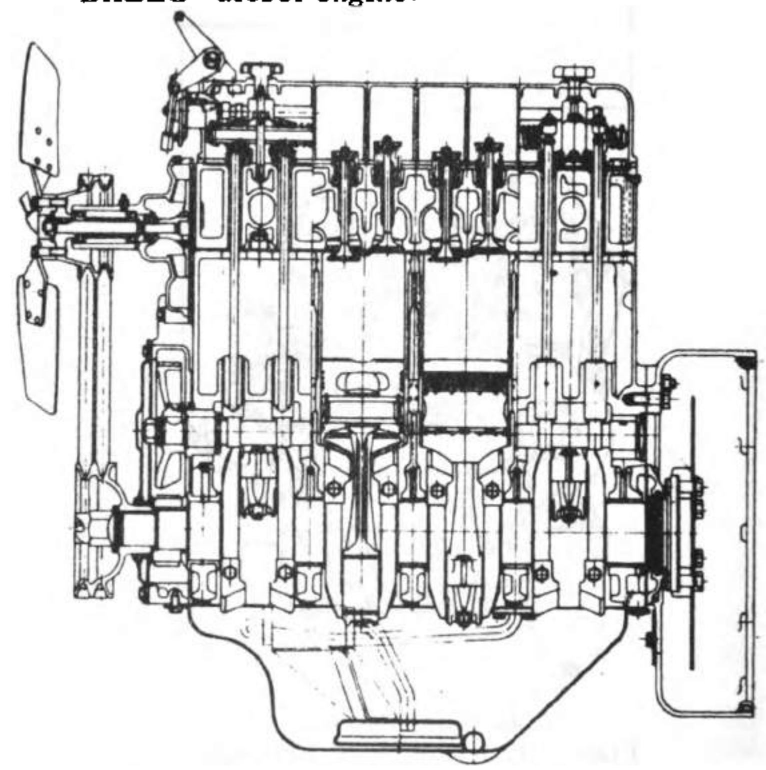


Figure 2.1. Cross sections of "ISUZU DAZZO" diesel engine.

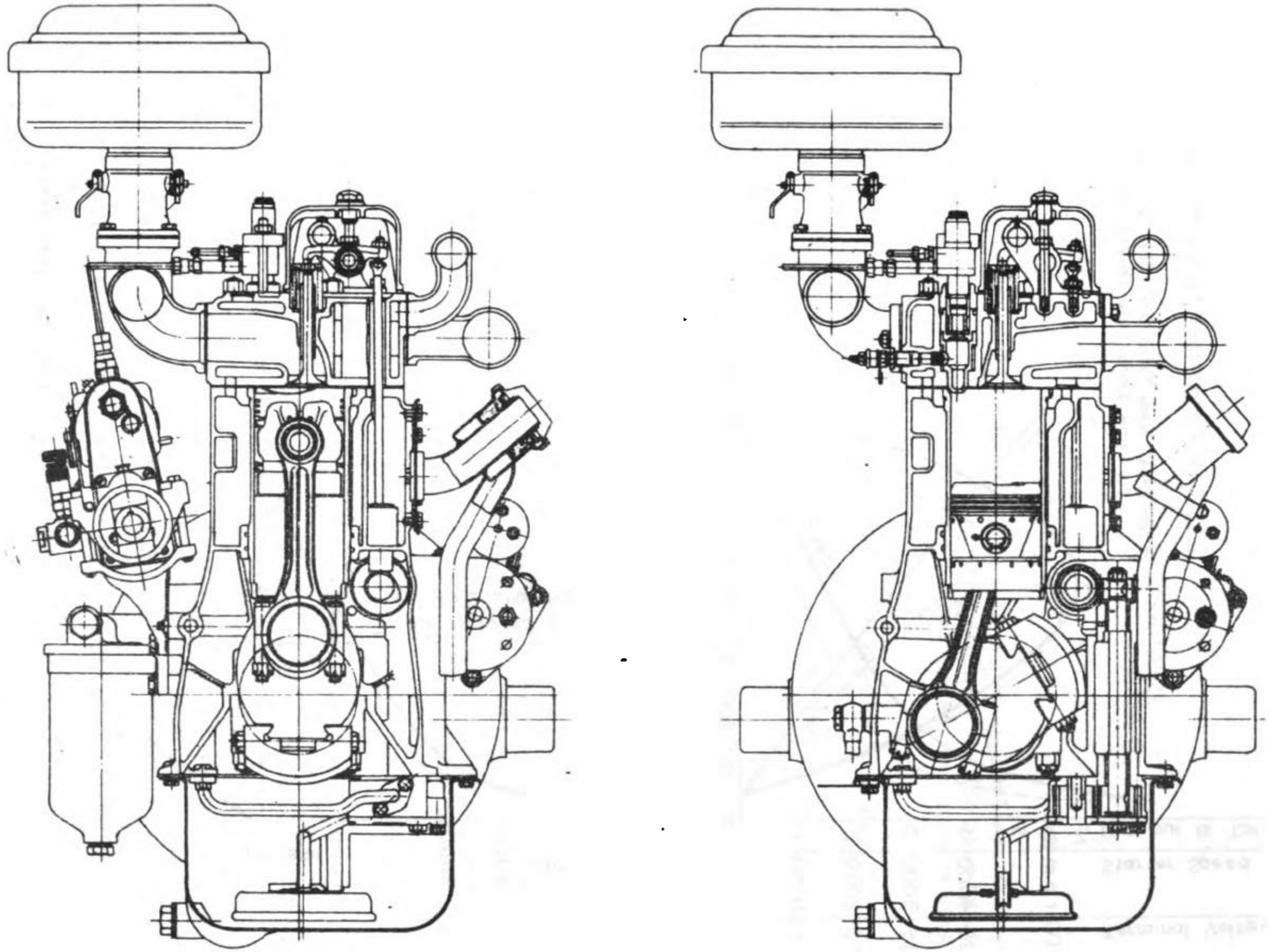


Figure 2. 2. Cross sections of "ISUZU DAZZO" diesel engine.

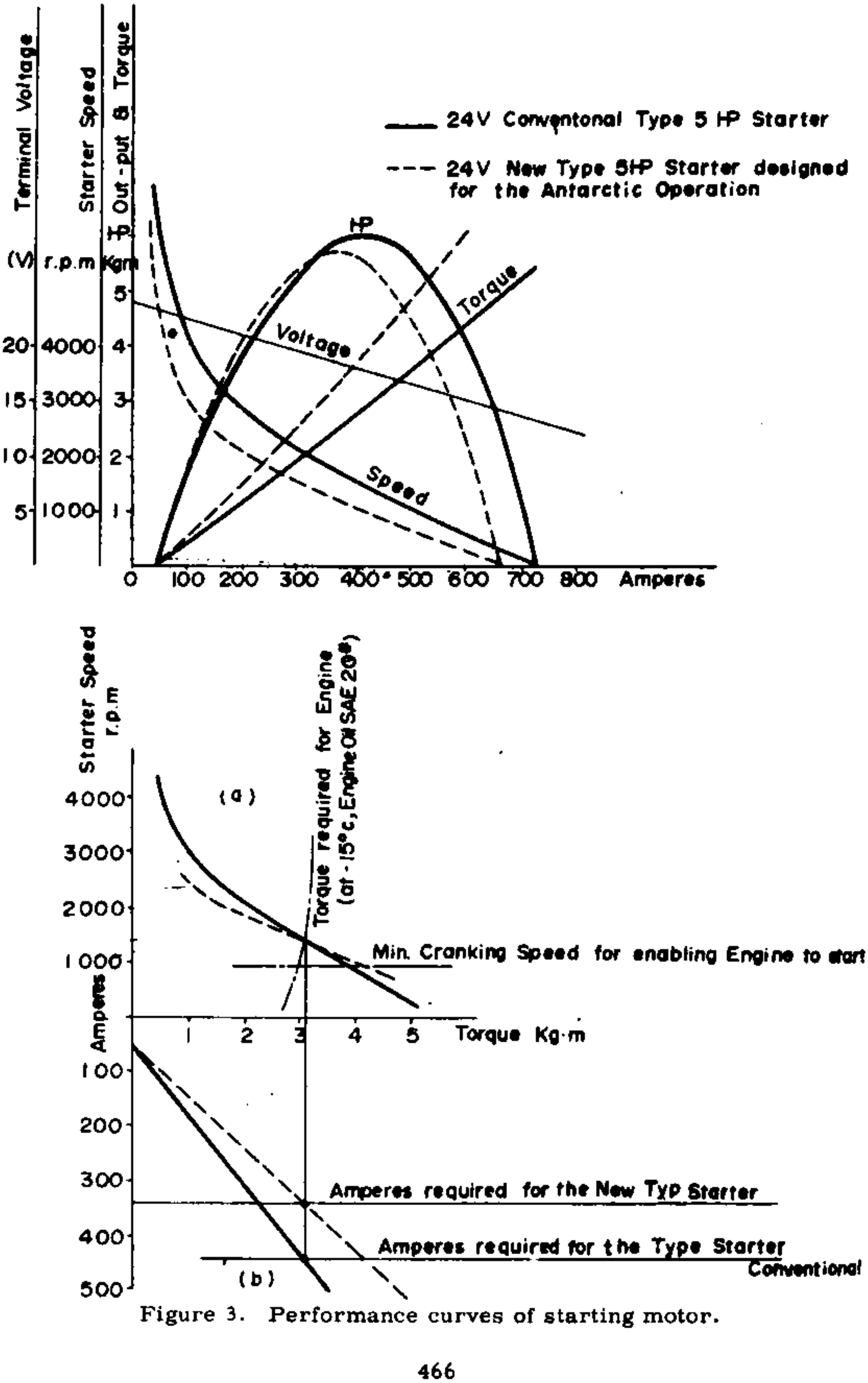


Figure 3. Performance curves of starting motor.

BASE TRANSPORT PROBLEMS

A. J. Heine

Introduction

Scott Base is built on the southern scoria slopes of Ross Island, at Pram Point. The area was originally snow-free in the summer, but the base buildings, generally grouped together, have created large drift areas, and snow is usually present throughout the year.

There are two main uses for mechanical transport at Scott Base:

1. Haulage of fuel drums and stores from ship to base.

2. Haulage of drums and stores in the vicinity of the base.

Ship to Base Haulage

Cargo ships reaching McMurdo Sound from New Zealand, usually tie up at the bay ice edge within several miles of the southern end of Ross Island. The vehicles used for cargo hauling across the sea ice are the full-track Ferguson tractors and one Tucker Sno-cat, Model No. 743. The journey of 6 to 10 miles one way, is across flat terrain and substantial loads (5-6 tons gross load) can be hauled. Some difficulty is experienced in mid-summer due to melt pools on the sea ice, and the lower ground pressure of the Sno-cat is preferable to the Ferguson. Solid runnered sleds are used for the cargo carrying and are described later in the paper.

Base Haulage

Scott Base is built on the flat ridges and terraces of Pram Point, about 50 feet above sea level. Roads have been constructed throughout the base, but for much of the year these are snow covered. A D4 Caterpillar tractor is used for snow clearing and general haulage as well as full and half-track Ferguson tractors. Sleds are used on the snow covered roads, and wheeled trailers during the snow-free summer months. Care is needed in the use of full-track Ferguson tractors on rock, as mud and grit soon causes excessive wear of the track joints.

Cargo Sleds

During the setting up of Scott Base, "Maudheim" type solid runnered sleds were used for cargo hauling. The lack of side gates proved a serious drawback, and many hours were wasted in tying on cargo. A more suitable sled was designed by Heine and was basically a drum carrier. With the addition of floor panels and side gates it was used for general stores haulage. As the ship to base trail is often over rough hummocked sea ice, it was essential that the sled be of flexible construction and could wrack up to 18 inches from diagonal corner to corner. A semi-flexible drawbar was used, mainly because of less starting strain and greater starting torque on the Ferguson tractors.

These sleds have been used for base haulage, but dragging over rock surfaces should be avoided at all costs as excessive wear on the runners soon takes place. Wheeled trailers require so much less pull on snow-free surfaces, that they are preferable in all cases.

Ferguson Tractors

Ferguson tractors have been used extensively since the setting up of Scott Base, and continue to give excellent service. Both full track and half track assemblies are used. For general transport requirements, i.e., visits to the U. S. base, the half track Ferguson with a light wheeled trailer proves an excellent combination. Tractors are returned to New Zealand for major overhauls, while regular general maintenance is carried out at Scott Base.

Personnel Transport

At times it is necessary to transport groups of men from Scott Base to the ships or U. S. air field. The Sno-cat is used for this purpose and as long as it is not taken on the Scott Base/NAF McMurdo road (which is part snow, part rock) gives excellent service.

THE REQUIREMENTS AND NATURE OF THE LOGISTIC SUPPORT FOR A SMALL NATIONAL ANTARCTIC EXPEDITION (C. Land Vehicles)

J. J. la Grange

Most of the smaller expeditions will probably need land vehicles of some or other type. Some stations on rock close to the sea and where no field work is being done, could probably do without tractors especially if the terrain is very rugged and supplies from the ship are moved by rail cars.

Every base at some distance from the sea will need vehicles for transport of stores. If the station is on solid ground, wheel tractors will be the answer. If however the station is on snow, tracked vehicles are essential. The smallest class tractor here is probably the Ferguson type tractor with tracks over back and front wheels. In a bit heavier class are the Weasel, Bombardier Muskeg and Japanese Snow-car type tractors. Bigger still is the American Snow-Car type tractor. The author thinks that still heavier tractors are not ideal for the "small" Antarctic Expedition.

Petrol vs. Diesel Engines

Many arguments have been put up for and against petrol and diesel engines. Briefly it seems that the petrol engine is lighter with bigger fuel consumption but easier to start in very low temperatures than the diesel engine. The latter again has generally speaking, less maintenance and problems such as snow on the spark-plugs, etc., are avoided. The choice seems to be about 50/50 with the author being slightly in favor of the diesel engine, mainly for economical reasons.

Ferguson-Tractor, Model TE 20

These small tractors have proved to be very successful on Sir Edmund Hillary's journey from Scott Base to the South Pole in the summer of 1957-58. They have also been used at Halley Bay and Shackleton and other stations. The Ferguson's best performance seems to be on hard snow—which rarely exists in summer when the unloading of relief vessels has to be done. The Ferguson has 28.2 horsepower at 2,000 rpm, it has four cylinders, a 4-speed gearbox, ground pressure of 1.3 psi and averages one to two mpg with very heavy load.

When using wheels on snow it is not much good and full tracks over the front and rear wheels have to be used.

In the same class are the Oliver OC6 tractors which were used at S.A.N.A.E. Here also the tractors had good performance on hard snow but in soft snow they were inclined to dig themselves in. In soft snow the Oliver could haul only one fully loaded Maudheim sledge (1 1/2-2 tons). Another drawback of the Oliver tractor is the fact that the driver's seat is behind the rear axle, if the tractor travels at a speed of more than say 5-10 m.p.h. it is inclined to bump so much that the driver is forced to stand upright with bent knees to act as shockabsorbers! This situation can of course not be tolerated in Antarctica.

The South African National Antarctic Expedition has a smaller type tractor, an Oliver OC3 which is very useful at the station for hauling light loads, digging in the snow and hoisting heavy objects. The Ferguson tractor can also be fitted with such digging, hoisting, bull-dozing and winching equipment and can be used in the same way as the Oliver OC3. A small tractor like this is strongly recommended for lifting fuel-drums, seal carcases, hauling light loads and to do the great number of light tasks that crop up at all times.

Removal of the bonnets of both Oliver tractors have helped to minimize accumulation of snow on the engine.

Weasel Tractor

With many Antarctic and Arctic expeditions the Weasel tractor has been a favorite for many years. Certainly it can haul a heavier load (2 Maudheim sledges) than the smaller tractors but its fuel consumption is also bigger. Several expeditions have found that maintenance on Weasels take up a lot of time. Spare parts have to be carried in great quantities especially where the tracks are concerned. Weasel spares are difficult to obtain. The Weasel has a Studebaker straight six engine and at sea level develops 75 horsepower (net) at 3, 800 rpm and at 3, 000 ft. altitude 55 horsepower (net) at 3, 600 rpm. It has a nominal ground pressure of 1. 9 psi and can obtain a cruising speed of 8 to 10 mph hauling loads on snow. Depending upon conditions it can average 0. 7 to 3 miles per gallon. The Weasel has a very spacious cab for the driver, it is usually heated and very comfortable; the tractor is also easy to drive. The author has however had so much first hand information (and to lesser amount, also experience) of "Weasel trouble" particularly with tracks, differentials and radiators that he would not like to recommend this type of tractor.

Muskeg Tractor

The Canadian Bombardier "Muskeg" tractor is a very suitable tractor. The driver's cab can be enlarged to seat three persons comfortably with a lot of packing space, it is also easy to heat. Outside, on the rear end, there is quite a big space for carrying fuel drums and other items. Cranes and power winches can easily be installed either at the back or in front. The muskeg is easy to drive, almost any mechanically minded person can in a short time learn to drive it and to do the maintenance such as refueling oiling and greasing.

Without a load the muskeg can travel at a great speed, even with a light load— the reason being that the synchronized gears can be changed at great speed. The

Muskeg tractor has a Chrysler straight six side valve engine, six cylinders and 115 horsepower at 3,400 rpm. The transmission is single plate, dry clutch to 4 speed synchromesh gearbox to controlled type front drive differential. Ground pressure is approximately 0.75 psi with a speed range of 25 mph maximum or when loaded and on snow cruising speed 10 mph. Hauling 2 tons petrol consumption is 1 to 2 miles per gallon.

The truck consists of rubber belts with steel cross-links. The belts are endless, and made from rubber and fabric reinforced internally with steel cables. Each track runs on eight Monopiece-drop centre wheels with 4.50 x 16 6-ply nylon tires.

The author would recommend this type of tractor for the "small expedition".

Sno-Cat Vehicle, Model 743

The Tucker Sno-cat is superior to the previous mentioned types in power—it can easily haul two Maudheim sledges with two and a half tons on each as well as one ton inside the vehicle, however its fuel consumption is also much more, coming to about one to two miles per gallon. The Sno-cat is a more complicated machine when it comes to driving and doing the maintenance; one virtually has to do a short training course on the tractor before one should set out with it. While on the "small" expedition just about every member should be able to drive all vehicles, persons who are not mechanically minded may find it difficult to handle the machine to its best advantage and could easily damage the steering mechanism. The author thinks that the Sno-cat is beyond the scope of the "small" expedition.

General

The number of "hints" from experienced men are so many that they cannot all be given here. Enough to mention that batteries should be of a low temperature type, proper antifreeze coolant and the correct lubrication oils and greases for low temperatures should be used, fuel should be well filtered when filling up the tanks and to prevent condensation forming inside the tanks refueling should take place immediately after a journey—the fuel tanks should be kept full as much as possible.

To avoid major overhauls being done in Antarctica (which sometimes could be difficult) a policy whereby one tractor is returned to the home country each year for a major overhaul should be followed.

Three Muskeg tractors and a smaller type for light work should be sufficient for off-loading a ship; with one returned to the home country the three remaining at the base should be sufficient for the work during the year.

Sledges

Different types of vehicle sledges are available. Some are constructed totally of metal, others of wood with metal parts. The ideal sledge for the "small" expedition seems to be the Maudheim type with taffenol or preferably PTFE runners. These sledges can carry a load of two tons. The frame work is of wood which makes it flexible for travelling over uneven surfaces.

Coupling one sledge behind the other is sometimes a problem. If all journeys are over level surfaces then steel cables will suffice; if there are steep downhills then a solid delta shaped steelbar between the tractor and the front sledge and between the following sledges are absolutely essential. A galvanized iron tube around the inner steel cable will to some extent also prevent the sledges from sliding to the front.

For light loads of numerous small articles a framework around the sledge is very handy. For fueldrums or boxes of similar shape, a single outer wooden frame of say four inches by two inches with top lashing across a center board will be enough. When however the load is heavy and articles are of all shapes a criss-cross zig-zag pattern of lashing is required. When travelling, it is advisable to look back now and again to see if everything is in order as proper lashing with not too many yards of rope is quite an art. Summing up, eight Maudheim sledges should suffice for a small expedition.

SOME ASPECTS OF TRACTOR PERFORMANCE

V. E. Fuchs

The following material is largely drawn from the experience of the Trans Antarctic Expedition of which the Chief Engineer was Dr. David Pratt.

The selection of appropriate vehicles for Antarctic work largely depends on the latitude and altitude of the operating area for these control the operational temperature range. The nature of the terrain may also dictate the weight and to some extent the track design. Crevassed areas can preclude the use of heavy tractors; soft snow demands a low ground bearing pressure; bare ice requires a track with grousers to ensure movement.

Types of Vehicle

Of the various types available the weights range from 500 lbs for a motor Toboggan to more than 30 tons for the D8. Clearly the heavier vehicles are less suitable for inland traverses through crevassed areas, unless time is available for the crevasse pattern makes this impracticable. It is, therefore, more likely that the smaller vehicles weighing up to three or four tons will be selected for traverse work.

Because snow is so variable in consistency the traction problem is a difficult one. In cold dry snow at, say, 60°F, friction is high, cohesion low, and traction is improved by a high ground bearing pressure. At temperatures above -40°F the friction is relatively low and cohesion much higher. In this case a large contact area and low bearing pressure are desirable.

For snow on a hard sub-surface, deep 'grousers' are useful because they penetrate to the surface below, but in deep snow they 'churn' causing the vehicle to dig in. The Tucker Sno-cat solves this problem by using tubes for traction on soft snow and small grouser blades for hard ice. The system also has the advantage that the under surface of the pontoon makes real the apparent bearing surface of the track.

In the case of two-tracked vehicles like the Weasel or Muskeg, the centre of gravity of the vehicle moves back under load and varies the bearing pressure. When travelling over undulating surfaces, the "plunging" of such vehicles may nearly double the bearing pressure as the front end lifts. As many people have found this turns them into excellent crevasse detectors! The following figures provide an interesting comparison:

	Apparent Pressure Unladen lb/in^2	Dry Weight lb
Sno-cat 743	0.71	7000
Muskeg	1.00	4600
Weasel M29C	1.91	4077
Ferguson full-track	1.38	3370
D8. LGP	4.00	70000
Man on skis	0.47	196
Man on foot	3.67	154

Diesel or Petrol Engines

1. Both petrol and diesel engines can be preheated, but the petrol engine is more likely to start in low temperatures if the heating system fails.

2. The pour point of gasoline is well below -112°F while diesel fuel is of the order of -60°F to -70°F.

3. The internal friction of the petrol engine is less than the diesel and therefore a given battery output provides a higher cranking speed.

4. A higher cranking speed is required by the diesel since the correct temperature and pressure are required for starting.

5. The diesel is somewhat more reliable but it is more difficult to repair.

6. The mixture tolerance of the petrol engine is greater than the diesel.

7. The diesel has the advantage of using about 1/3 of the fuel required by a petrol engine.

These points indicate that for long unsupported journeys by light vehicles in extreme conditions, the disadvantage of higher fuel load is outweighed by the favorable characteristics of the petrol engine.

Starting

At low temperatures the following factors influence startability:

1. The battery has a reduced output which in turn reduces the cranking revolutions per minute.

2. The engine friction is increased by the oil viscosity.

3. As (1) and (2) reduce the cranking rev/min, there is a lower manifold vacuum which with increased fuel viscosity reduces the emergence velocity. Coupled with the lesser amount of fuel vaporized, this results in a weak mixture.

To guarantee starting at -60°F these difficulties may be largely overcome as follows:

1. Increase the vehicle voltage to 24V to reduce the loss of available output capacity. The loss occurs because of rapidly increasing internal resistance of the battery with decreasing temperature.

By placing the batteries in lagged boxes the rate of cooling can be considerably reduced. By incorporating a battery heating system, the output for a low temperature start can be increased and the problem of charging is also overcome.

The difficulty in charging is partly due to the high electrolyte viscosity below -30°F. This causes frothing and the loss of electrolyte. The other aspect is the high resistance of the cold electrolyte which causes the voltage regulator to provide only a trickle charge.

Depending on engine design, hot air pre-heating or coolant pre-heating can be used. In the case of the Trans-Antarctic Expedition, 30,000 Btu/h coolant heaters were used for the Sno-Cats and 50,000 Btu/h air heaters for the Weasels. Both ran on kerosene. In addition to pre-heating the engine, these heaters were used to warm the batteries which were in 115 amp/h 6. V units with aluminium casing to permit maximum heat transfer. The rates of internal battery heating were 2.3°F/min for air heating, and 1.8°F/min for coolant heating. In practice the air heating is more efficient than coolant heating for batteries, but for engines the reverse is true.

2. In emergency estimation can be used for oil dilution, but this is undesirable as a practice. We have found the most suitable oil for low temperatures to be a thin mineral type corresponding to S. A. E. 5W/20.

3. As (1) and (2) should provide sufficient cranking rev/min the remaining need is a combustible mixture. A subzero grade of gasoline of specification DEF-2410A with octane number of 96 is suitable for compression ratios from 6/1 to 8.5/1.

Fuel

1. We have not found it necessary to use any anti-icing additive. To avoid condensation in the tanks vehicles should always be refuelled to capacity at the end of each day, since this minimizes the air volume from which condensation can occur during a long halt.

2. Occasionally carburettor icing may be experienced. It will often be found that this is due to drift or track-thrown snow getting into the engine compartment and increasing local humidity at times when the carburettor temperature is in the critical range. It is possible to devise ways of preventing snow entering in this way, but the method varies with the type of vehicle.

3. At high altitudes, say 8000 ft and above, vapor locking may be serious if a highly volatile fuel is used. This is especially so with totally enclosed engines.

Although we have not done so, it is suggested that this could be overcome by using a submerged pump in the petrol tank to force the fuel to the engine under pressure.

4. It is uneconomical to use the same carburettor jets at all altitudes and it has been found valuable to change the jets for every 2000 ft of altitude. At the same time ignition timing may be gradually increased or decreased.

Driving and Maintenance

The successful operation of mechanical transport largely depends on considerate driving and meticulous maintenance. In the Antarctic these two factors are of paramount importance. Driving speeds will be the subject of individual opinion, but discipline must prevail if mechanical failure is to be avoided. To ensure a long track life maximum speeds must be laid down for each vehicle type and these should be well within the vehicle's capability. In view of the low gear ratios and potentially high engine speeds, we have found it desirable to fit revolution counters. Thus drivers are aware if they are overworking the engines for lengthy periods. It is essential to establish a maintenance program for each type of vehicle and then to enforce it rigorously. However bad the conditions, however urgent the task, nothing must be allowed to interfere with maintenance. If these human responsibilities are fully accepted, the life and reliability of the equipment will certainly be prolonged and field operations will be more efficient.

OVERSNOW TRAVERSE VEHICLES AND SLEDGES, U. S. ANTARCTIC RESEARCH PROGRAM

C. R. Bentley and J. B. Long

Abstract

All oversnow traverses of the United States program in Antarctica since the start of the IGY have utilized Tucker Sno-Cats of various models. Until 1960 the standard model 743 with special enlarged cab and gasoline engine was used exclusively. In 1960 two 11-ton model 843 diesel-powered Sno-Cats, especially designed for long range operation on the high cold interior plateau, were first used. Three smaller diesel-powered Sno-Cats were put into operation in 1961.

The performance of these vehicles has in general been good. Large loads have been hauled, but at the expense of fairly high mortality rates of drive system components. Particular difficulty has been experienced with tracks of a new design on the model 843 Sno-Cats, and with differentials on the smaller vehicles as a result of the extreme loads (up to 13 tons) towed. Very little difficulty has been encountered with either the Chrysler Industrial gasoline engines or the Cummins diesel engines employed. Fuel consumption has been about one gallon/mile, and has not varied widely with different vehicles and conditions.

Otaco bob sleds of 2 1/2-ton capacity, towed behind the vehicles, have been used widely, and have given good service. In warmer climates there has been considerable difficulty with runners freezing to the snow. The spacer bar between runners has broken on a number of occasions. Simple two-runner, one-ton sleds have proven virtually maintenance free. In recent seasons three "Rolli-Trailers" have been used, each comprising four large tires, capable of holding 500 gallons of fuel apiece with a three-ton-capacity bed slung in between. These transporters have greatly increased the unsupported range of the traverses. However, in soft areas, which have been more wide-spread than anticipated, they are difficult to pull thus increasing fuel consumption and number of breakdowns. Because of their high ground pressure, they are unsatisfactory in crevassed regions. On several occasions a Rolli-Trailer towbar has broken off; other maintenance problems have been slight.

For survey, work begun 1961-62 on Roosevelt Island, three Thiokol Trackmasters were purchased. These vehicles sacrifice the drawbar capacity of the Sno-Cats, which is unnecessary for local work, in return for lower initial cost, greater ease of maintenance, and greater fuel economy.

Introduction

The geophysical field programs conducted by the University of Wisconsin in Antarctica fall into two categories with considerably differing transport requirements. First, there are the major oversnow traverses which are a continuation of the United States IGY program. For these traverses, vehicles are needed which combine large drawbar capacity with relative economy of operation and ability to travel with full load at five mph or more. It is also advantageous that they have cabs which provide reasonably comfortable and convenient living quarters, and in which scientific equipment can be mounted. Combined with these vehicles it is desirable to have towed cargo units of maximum possible capacity consistent with vehicle power. Ideally, the vehicles would be able to tow all the supplies needed for an entire traverse (of which fuel is, of course, by far the largest item), thus eliminating the need for any resupply in the field except in the case of emergency. The vehicles chosen for the U. S. traverses have to date been Tucker Sno-Cats of various models; towed units have included one and 2 1/2 ton sleds and Rolli-Trailers.

In the other kind of program, work is carried out near a single base camp to which party members return every day or every few days. In this case drawbar capacity becomes secondary, and low cost, ease of transport, ease of maintenance, and reliability are of primary importance. For some parts of the program it may be necessary to tow up to three tons of fuel, explosives, and equipment for short distances; for others only a few hundred pounds load is needed. Such a program is in operation on Roosevelt Island; for this work both light tracked vehicles and motor toboggans are in use.

Equipment

The traverse vehicles chosen for the U. S. IGY expeditions were Tucker model 743N Sno-Cats which had Chrysler Industrial gasoline engines and specially enlarged cabs extending over the engines and providing extra living room and space for scientific equipment. These vehicles were used exclusively for the oversnow program through the regular field season of 1959-60, and on one of the traverse in 1960-61. Care was taken at first to tow loads of less than 4 tons gross weight, but loads were gradually increased until on the 1960-61 traverse they exceeded seven tons with sleds or as much as 14 tons with a Rolli-Trailer. The latter loads produced drawbar pulls of two to three thousand pounds with average snow conditions. Such heavy loads caused considerable differential trouble, a good part of which might not have occurred had not the Sno-Cats been worn from two previous seasons of use. Several traverses required travel across extremely rough surfaces, resulting in breakage of suspension systems, fifth wheels, and even frames. No serious breakdowns of the Chrysler engines occurred in the several seasons during which they were in use. Gasoline consumption was around one gallon per mile without large variations between traverses.

In 1960 two 11-ton model 843 Sno-Cats were introduced into traverse work. These extra-large, diesel-powered Sno-Cats were designed for long range operation on the high cold interior plateau. With improvements in large capacity towed cargo units it was hoped that eventually these vehicles would make possible a full traverse without resupply. The 843 was a brand new model; not one of these units had ever been tested for an extended period under rigorous field conditions. A shake-down trip in March, 1960 disclosed several serious weaknesses aggravated by rusting which had occurred during shipment. Tracks of a new design proved to be unsatisfactory and have since been replaced with tracks of older and tested type. Other faults were corrected and the vehicles performed well during a traverse from McMurdo Sound to the South Pole.

The 843 Sno-Cats are powered by Cummins diesel engines. Diesel rather than gasoline engines were chosen because of greater reliability with less maintenance, less fire hazard, relative ease of altitude compensation by means of turbochargers, absence of fuel icing problems, and greater economy. These considerations were felt to outweigh the disadvantages of greater initial weight and expense, and the additional time needed for starting and stopping the engine. After proper pre-heating these engines started without undue difficulty in temperatures colder than -50°F. A total of only 60 minutes was lost on the McMurdo-Pole traverse owing to starting delays. No serious engine trouble occurred. Fuel consumption on these large vehicles also was about one gallon per mile.

In 1961 three smaller diesel-powered Sno-Cats (model D743-AN) were put into operation. These are built on the same size frames as the 743N Sno-Cats, but have strengthened suspension and drive systems, an enlarged box-like cab, and Cummins diesel engines. They were used for a full-sized traverse for the first time during the 1961-62 field season. Although operation on the whole was satisfactory, seven differentials were broken, mostly while pulling the Rolli-Trailer. It is hoped that new, heavier set of gears which will fit into the same housings will eliminate excessive differential wear. A flat-bed version of the same model with a drill rig mounted on it, was used on the McMurdo-Pole traverse.

The first traverses used only 2 1/2 ton bobsleds for cargo carriers. These sleds tow very nicely when properly adjusted; however, they require frequent adjustment to keep the runners properly in line. The bobsleds were soon supplemented by two-runner one-ton sleds which are virtually trouble-free.

In the 1960-61 season three Rolli-Trailers were introduced. A single unit comprises four large rubber tires, each with a capacity of 500 gallons of fuel, Between the tires a cargo bed with a three ton capacity is slung. Tires have to be maintained at at least five pounds/sq in pressure giving a ground pressure much higher than either sleds or vehicles. Refueling from a Rolli-Trailer is accomplished by means of compressed air.

For the survey program on Roosevelt Island, Trackmaster 4T10 carriers are being used. These are two-tracked vehicles of 2 1/2 ton net weight and 2 1/2 ton cargo capacity powered by Ford gasoline engines. They have ether boosters for cold weather starting, but no pre-heating since their anticipated use is limited to the summertime and to low elevations. In one season of operation they have given mostly satisfactory service. Fuel consumption was about two mpg.

Supplementing the Trackmasters on Roosevelt Island are Eliason motor toboggans which have given virtually trouble-free service. A motor toboggan was also used for work around Pole Station. A serious loss of power because of the high elevation was experienced. At temperatures below -30°F pre-heating was necessary to start the engine, and at -40°F the drive belt became stiff and also required pre-heating.

Sleds in use with the smaller vehicles are two-runner models ranging in cargo capacity from 1/2 to 3 tons. Maudheim sleds, rated at three tons, and U. S. Army Quartermaster Corps one-ton sleds are pulled by the Trackmasters. Nansen sleds of flexible construction and with bakelite coated runners are used with the motor toboggans. These sleds have a cargo capacity of 1/2-ton each, and two can be towed behind a motor toboggan.

Operation

Probably the greatest difficulty in the operation of powered vehicles in very cold weather comes in starting the engines. For ease of starting and for minimum strain on the engine some form of preheating is essential at temperatures less than -30°F, and advisable at warmer temperatures. Several methods of preheating have been tried on the U. S. traverses. The first Sno-Cats used were equipped with Southwind gasoline-burning heaters and ducts which carried the hot air to the carburetor and to the top of the oil pan. This heating method was too inefficient for satisfactory use at temperatures below -30°F. Later, electrical heaters were inserted in the oil pans to provide more efficient heating of the lubricant. The pan heaters proved quite successful, but since they drew 5 to 10 amps of current there was a serious danger of excessive battery discharge from accidental overuse. (The danger was greater than with the Southwind heaters which drew almost as much current since the pan heaters ran silently.) The traverse Sno-Cats now in use are equipped with diesel-burning engine coolant heaters in which circulation is maintained by gravity flow and no electrical energy is required. These heaters can economically be kept running all night providing quick and easy starting in the morning. Glow plugs are still installed in the oil pans, but the use of proper oils has largely eliminated their use. In extremely cold weather, or when other methods failed, a Herman Nelson 400, 000 Btu per hour heater was used.

Also essential to ease of engine starting is sufficient battery power. In our experience it has proven necessary to use 200 ampere-hour batteries for reliable operation; with the smaller capacity batteries used on earlier traverses constant trouble was encountered. However, it is probable that this trouble was partly the result of improper operation of the charging systems. When properly cared for the large lead-acid batteries provide entirely satisfactory service, and there seems to be no need for nickle-cadmium or other type batteries which are much more expensive and difficult to keep properly charged. Fully charged lead-acid batteries have been left in the field over the winter in temperatures down to -100°F without suffering any apparent damage. The use of acid with a specific gravity of 1.3 provides additional energy when the battery is cold and helps prevent freezing. Plugs connected across the battery systems and mounted externally on the Sno-Cats have made it easy to provide power from one Sno-Cat to another in the event of weak batteries.

A proper choice of engine oil aids greatly in cold weather starting. Multi-grade oils (5/20 for gasoline engines, 10/30 for diesels) are much more satisfactory for traverse use than the single grade oils which are available at the U. S. Antarctic stations, and which were used on the early traverses.

Once in operation the traverse vehicles behave nearly as they would in warmer weather. On the high polar plateau (and occasionally elsewhere) it is cold enough that an engine enclosure and a shutter in front of the radiator are often needed to maintain proper operating temperature. On the other hand, serious difficulty with over-heating has often been encountered when there was a following wind. In this case circulation of air through the radiators is greatly reduced, and it becomes necessary to travel with the engine hoods open causing uncomfortable heating of the cabs. Temperatures in excess of 90°F have been reached in a Sno-Cat cab even after opening all doors, windows, and hatches. In extreme cases of engine over-heating the vehicle must be stopped and headed into the wind. A dangerous situation results when there is a following wind with a velocity about that of the vehicles and the exhaust fumes are not blown away. Several cases of carbon monoxide poisoning have occurred, fortunately none serious. (A serious case of poisoning did occur on the Trans-Antarctic Expedition). On our newer vehicles the exhaust outlet is above the roof.

Difficulty has been encountered with the diesel-powered Sno-Cats of both types in maintaining engine revolution rates in the proper operating range. Transmissions supplied with the vehicles have steps between gear ratios which are too large, thus restricting vehicle speed to certain narrow ranges and making it very difficult to shift gears when pulling heavy loads. In the coming season automatic transmissions providing proper gear steps and instant shifts at full power will be tested in the 843 Sno-Cats as a means of alleviating this problem, and new sets of gears with smaller steps will be installed in the D743AN Sno-Cats.

Preventative maintenance is, of course, very important on a traverse, but produces few special problems. Daily inspection of the drive and track systems, in which most breakdowns occur, can save many precious hours of travelling time. Greasing is carried out about every 600 kilometers. For this it is usual to heat both the areas to be lubricated and the grease to be applied. In this way unwanted ice is melted, grease guns made to operate much more easily and quickly than when cold, and uniform lubrication obtained. A convenient method which has been used for heating a Sno-Cat is to tie tarpaulins around the vehicle enclosing the running gear which may then all be heated at one time with a Herman Nelson heater.

In towing sleds starting is again the most serious problem. In the warmer regions of West Antarctica a considerable amount of freezing of sled runners to the snow surface has occurred, and a large part of sled wear has resulted from breaking them loose. Teflon coating on sled runners has helped alleviate this difficulty. No freezing-in occurs with Rolli-Trailers, and their ease of starting constitutes one of their important advantages over sleds.

Once moving, little difficulty is usually encountered with either sleds or Rolli-Trailers. Figures from on West Antarctic traverse suggests that the Rolli-Trailers are between 50 and 100 per cent more efficient as cargo carriers than the sleds; fairly firm snow conditions were encountered on all but a small portion of this trip. However, on the polar plateau areas of soft snow much more extensive than anticipated have been encountered. Here, the high ground pressure of the Rolli-Trailers causes them to sink deep into the snow, becoming very difficult to pull. For travel in a crevassed region the Rolli-Trailer presents a serious hazard. Because of its high ground pressure (5 to 8 psi) it will break through a crevasse bridge which will easily support vehicles and sleds. A serious jolt to the Rolli-Trailer and towing vehicle occurs from a crack no more than half a meter across, and there is danger of breakage if the crevasse is a meter or more across.

Breakage on the 2 1/2-ton bobsleds has occurred chiefly in the chains and spacer bars between the runners. Although this has necessitated a considerable amount of repair work, it is worth noting that these sleds have lasted for as many as five complete traverses, or a distance of nearly 10, 000 km. Simple two runner one-ton sleds are virtually trouble free.

A tracked trailer will be tested in the field during the coming field season. It is hoped that this trailer will combine the efficiency of a rolling system with a low enough ground pressure to prevent serious sinking into soft snow. Low ground pressure and length of track should substantially improve crevasse-crossing capabilities.

LOGISTICS OF ICE CAP SURFACE TRANSPORTATION

G. W. Homann

In any discussion of this subject, the approach and many of the factors considered are, of necessity, based upon the conditions existing in the particular area of the world which serves as the locale of the operations. The U. S. Army Polar Research and Development Center operates primarily over the ice cap of northern Greenland. The base camp for the organization, Camp Tuto, is located approximately fourteen miles from Thule, Greenland, while the ice cap research base is the nuclear-powered Camp Century, located 138 miles away on the Greenland ice cap.

This is an area in which the winter temperature may drop to seventy degrees below zero Fahrenheit, and the winds reach a velocity of one hundred knots. White-outs and storms may occur at any season of the year, and plans for transportation across the ice cap must always include consideration of such possibilities. Conditions are more severe in the winter months due to the continuous darkness and lower temperatures, as compared to the twenty-four hour daylight and higher temperatures of summer. Many of these environmental conditions are common to those experienced in much of Antarctica. Our surface transport operations in Greenland may differ somewhat, however, from those carried out by most of the nations operating on the antarctic continent, in that the Army continues to travel on the Icecap throughout all seasons of the year.

The surface transportation which will be considered in this paper is the routine movement between Camps Tuto and Century, involving the crossing of 138 miles of ice cap. The first sixty miles of the trip going out from Camp Tuto crosses an almost continuous area of crevasses. The trail turns frequently to avoid the most treacherous areas. Crossings are established by blowing in the natural snow bridge and backfilling the crevasse with snow to provide a safe trail. The elevation of Camp Tuto is 1, 500 feet. The early miles of the trail rise rather steeply from this elevation up to 5, 000 feet. The last seventy miles cross a slowly rising plateau until reaching an elevation of 6, 500 feet at Camp Century.

The basic unit for heavy freight transport over the Tuto-Century trail is the heavy swing, composed of a number of tractor trains. Each of these trains consists of a low ground pressure tractor (LGP) pulling a combination of transport vehicles. Each swing includes one LGP pulling a series of wannigans as a command train. This train includes the command wannigan with communications equipment and control facilities, a mess wannigan to provide meals and dining area, a sleeper wannigan for rest during the trip, and a maintenance wannigan. The maintenance wannigan includes diesel generators for electric power, emergency heaters, welding and repair equipment, fuel transfer equipment, and spare parts. If fresh or perishable rations are being carried as part of the cargo a heated wannigan will be included in this train. The other trains making up the swing will consist of LGP's, each pulling four to six cargo units.

The prime mover for these heavy swings is the LGP tractor. These are usually D-8 tractors, with either the 342 or 353 diesel engine. The standard D-8 tracks are replaced with special extra wide tracks to reduce ground pressure. Each of these tracks is 54 inches in width and mounts 54 pads. The total weight of one of these tracks is 6,000 pounds. Fully loaded each tractor weighs approximately 34 tons, and the ground pressure varies from 3.7 to 3.9 pounds per square inch. The basic fuel tank capacity of 118 gallons is augmented by the addition of two special tanks. A bow tank on the front has a capacity of 650 gallons and a belly tank underneath provides another 150 gallons. This is a total fuel capacity of 918 gallons. Fuel consumption, depending upon the load and the trail conditions, will vary from 6.0 to 7.0 gallons per hour. The majority of the tractor generators have been replaced with alternators to provide better reliability in the electrical system. The completely enclosed operator compartment is well sealed and provided with high capacity auxiliary heating and defrosting equipment. The drawbar of each tractor is designed to be adjusted laterally by hydraulic rams, permitting a change of direction without loss of traction. Each of these tractors can pull a train of four to six separate units carrying from 40 to 70 tons of cargo. The load variation is determined by the trail conditions. Hard snow with a smooth surface permits a maximum load. Soft snow, or the presence of high sastrugi reduces the train capacity.

The wannigans of the command train are insulated, box-like structures, mounted on bunks and skis. The design of each wannigan varies with the purpose for which it was built but all are designed for simplicity and efficiency. The structures are strong, light in weight, and constructed with a low center of gravity to resist overturning by wind on the trail. The gauge of the skis is comparable to that of the LGP, both to reduce drawbar power requirements and to increase stability. The utilities installed, such as boilers, heaters, electrical system, and snow melter, are made as simple and reliable as possible. The mess wannigan in particular is designed and its equipment selected with continual attention to the problems of sanitation and cleanliness.

A variety of equipment is used for the hauling of cargo. Sleds of both ten and twenty ton capacity are used. Each type consists of a cargo bed with stake panels on the sides, carried on a system of skis, with towing connections front and rear. Due to the wider gauge of the skis and the all metal bed construction of the twenty ton sled it is preferred to the ten ton type. A wood deck is usually placed over the steel deck of the sled to provide a safer working area. Loads as high as 28 tons have been carried on these twenty ton sleds with no problems.

The newest cargo carrying piece of equipment used in our Greenland operations is the large wheel cargo transporter. This is a ten ton capacity carrier mounted on four large wheels. The tires of this transporter are 48 x 68 inches and stand 120 inches high. This transporter provides benefits of low pressure on the snow surface and a great reduction in the drawbar pull required for its movement. This carrier has a further advantage of importance in the operations. The material stockpiles are located in the base camp area at Camp Tuto and for sled transport must be loaded on trucks or trailers and hauled up an approach road onto the ice cap before loading on the over ice transportation. With the large wheel transporter it is possible to load the cargo directly from the stockpiles onto the over ice carrier and pull it up the approach road and onto the ice, saving a great amount of equipment and labor in materials handling. The carriers can also be placed to permit selective loading as shipments arrive at the base camp, this also reducing handling and storing problems.

For extremely large loads, such as very heavy items of equipment, or oversize items, special sleds are fabricated to meet the requirement. As an example a flat bottomed barge type sled was fabricated of steel I-beams and steel plate. With two LGP tractors pulling this sled it carried a load of 110 tons, consisting of a 25,000 gallon tank filled with diesel fuel. Other special sleds have been fabricated for smaller loads.

Transportation of bulk POL products, primarily diesel fuel and motor gasoline, is a major portion of the total transport load over the Tuto-Century trail. Initially various types of metal tanks mounted on skis were employed. These gave good service, but the unloaded weight of the transporters themselves was a major disadvantage. For this reason better solutions were sought. The Rolling Liquid Transporter, with its two tires each holding 500 gallons gave good promise, but for the quantities of fuel involved, the investment in rolling stock would be enormous. These may, however, prove extremely useful for traverse operations in Antarctica. The next step was to use 3,000 gallon neoprene tanks mounted on ten ton sleds. Unfortunately the material of the tanks was designed for static storage at temperatures above minus twenty degrees Fahrenheit. Movement and strain at temperatures of minus thirty-five and below resulted in frequent ruptures of the tanks. During the past winter new tanks were procured which were designed for flexible service at minus sixty degrees Fahrenheit. These are of 6,000 gallon size and are mounted on twenty ton cargo sleds. The slides of the sleds are lined with smooth plywood sheets and the framing structure is reinforced with nylon webbing and steel cable ties. These have given excellent service. The greatest advantage of these neoprene tank and cargo sled combinations is the reduction of weight and the availability of the sled for retrograde cargo after the fuel load is discharged.

We have considered the various types of transport equipment used in our operations. Our next consideration should be the trail itself and movement over it. The rapidity of weather changes in northwest Greenland makes it impossible to accurately forecast the trail condition. Since the condition of the trail has a major influence on the capacity of the LGP's to haul cargo, we have no alternative but to make the best estimate possible and load out the swing. If, on the trail, the load proves to heavy for the LGP a sled may be dropped to lighten the load. Another alternative is to double-head each train, using an additional LGP and a leapfrogging type of advance. This latter procedure is quite slow, but does permit carrying the full swing to its destination, rather then abandoning a part of the needed cargo.

Failures do occur in swing equipment, and most frequently they develop in the first mile after starting up the swing from a stop. This situation is the result of several factors. There is a tendency for the steel skis to freeze to the snow while parked, resulting in increased stresses during the process of breaking loose. Additionally, blowing snow drifts in, around and over the skis and sled frames, adding to the load and making towing more difficult. Such failures usually consist of breaking towing bars, cross chains, bunks, or even dismounting the skis from under a sled. A three step stopping technique has proven effective in reducing the ski freezing. This consists of pausing a few minutes between each of three successive stops, thus giving the skis a chance to cool down in stages rather than melting the snow and letting it all refreeze at once. The use of teflon coating as the contact surface between the skis and the snow is also effective in reducing this problem, and particularly reduces the tractive effort required to pull the sleds. The material is quite expensive and for that reason its use is limited to aircraft skis and a few special light weight sleds which are towed behind personnel carriers.

Two items of special equipment are included to assist in handling these problems on the trail. One of the LGP's is equipped with a dozer blade to dig out equipment that is drifted in or buried. A second LGP is equipped with an "A" frame hoist to lift disabled equipment for repair.

The trail between Camp Tuto and Camp Century is used so frequently that special techniques in marking it have been employed. The trail is marked by using colored flags supported on bamboo poles. The trail through the crevassed area is marked on both sides, using black and green flags in two lines. Crevasse locations and crossings are marked with orange flags, while other codings are used to mark turning points and mile distances. From Mile 60, the end of the crevassed area, a single row of black flags is used to mark the trail. The use of four inch diameter glass or plastic reflectors has proven very effective during the dark season, as they are much more readily seen than the flags.

Due to the repetitive traffic over the trail standards of trail discipline are established and rigidly maintained. Small vehicles, such as personnel carriers, are faster than the heavy swings and require a smoother trail. For this reason they travel on the upwind side of the trail flags, avoiding the drifts which result from the disturbance of the skis of the heavy swings. The heavy swings travel on the downwind side. All types of swings meticulously observe the trail markers when travelling through the crevasse area. Fresh snow for water supply is picked up on the upwind side of the trail, while all trash and refuse are disposed of on the downwind side. Since there is always a possibility that a major storm, fire in the train, or breakdown might strand a party on the ice cap, wannigans are parked every fifteen miles along the entire trail. These are mounted on skis to permit towing back up on the surface when they become drifted in by snow. They are stocked with emergency rations, fuel, sleeping bags, candles and matches, shovels, and are equipped with a small stove and bunks. These serve as survival huts for the Tuto-Century trail.

A major element of swing operations is the selection of personnel to operate them. The normal complement for a heavy swing includes the swing commander and his assistant, two shift supervisors, two qualified operators for each LGP, a cook, a radioman, and a medical aid man. If none of the operators are qualified as mechanics, a minimum of one mechanic will also be included. Any passengers are in addition to this operating staff. Usually passengers are carried in other types of equipment, either the Polecat, which is a small, two unit, six passenger machine, or the Mark II Polecat, which is a similar but much larger machine which can carry thirty-five passengers. The present discussion will be limited to the freight hauling heavy swing.

The usual operator's routine in the heavy swing is to drive for six hours and have six hours off duty. For some individuals the long hours of monotonous driving over an endless white expanse result in a condition best termed self hypnosis. In this condition the driver may lead his train off the trail with no realization that anything is wrong. If the inter communication system between the driver and the other elements of the swing fails, the only recourse is to pursue the errant train and rouse the driver. This problem becomes particularly acute if the afflicted individual is the driver of the lead vehicle. For this, and other reasons, good intervehicular radio communication on the heavy swing is essential. It provides the swing commander with a control system, helps the drivers by interrupting the monotony of the lonely vigil, and helps in maintaining morale during storm or poor visibility conditions. Such systems need only low power and a range of a few miles, but must be simple and rugged to withstand the jolting and pounding of being mounted in a tractor. The swing commander's communications system is designed to permit instantaneous communication with both Camp Tuto, Camp Century, and the organic aircraft of PR & DC. He reports at regular intervals, giving his position, a description of the trail and weather conditions, and any other pertinent information.

The LGP, while performing excellently, is not a perfect prime mover from the operator standpoint. The winch controls, for example, are so located that it is extremely difficult for the operator to handle the controls and also watch the load he is handling. Difficulties with the heating system are particularly annoying during the cold winter months, and the mass of the machine in front of the operator's compartment limits his forward vision. A forward mounted operator's compartment may be the answer to the visibility problem.

Still another element in the field of human factors is the provision of good food and adequate sleeping facilities. The swing personnel may be out on the trip for many days, and food and rest are vital to their well-being. Food consumption is measurably higher during the winter months in apparent reaction to the need for more body fuel. The average consumption is on the order of 7, 000 to 7, 500 calories per man each day. Although prepackaged or frozen foods may be used to provide some portion of the diet, thus reducing the work for the swing cook, the preparation of basic foods on the grill or range seems to be essential for the maintenance of good morale in the swing crew. The use of individual packets containing plastic knife, fork, and spoon, together with napkin, quick drying washcloth, and other small individual items has proven a good substitute for the usual tableware. This item not only saves much work, but assists in the maintenance of a high level of sanitation, which is absolutely essential in this type of isolated operation.

Allied to requirements of sanitation, but also important from the standpoint of prevention of cold injuries, is the proper selection and use of arctic clothing. Standard arctic clothing is used, but due to spillage of diesel fuel and the presence of other oily materials, adequate quantities of replacement items must also be available. This is particularly true of outer garments and gloves.

In addition to all the hazards introduced by winds, cold, and breakdowns of equipment, another ever present possibility is that of fire. The danger in the cargo trains is essentially limited to fire occurring in the LGP itself, usually in the operator compartment. The most frequent cause is failure of the insulation on the electrical wiring. The best control is frequent and thorough inspection of the condition of the electrical wiring. The standard CO_2 extinguisher is valuable for initial attack, coupled with quick disconnection of the power supply.

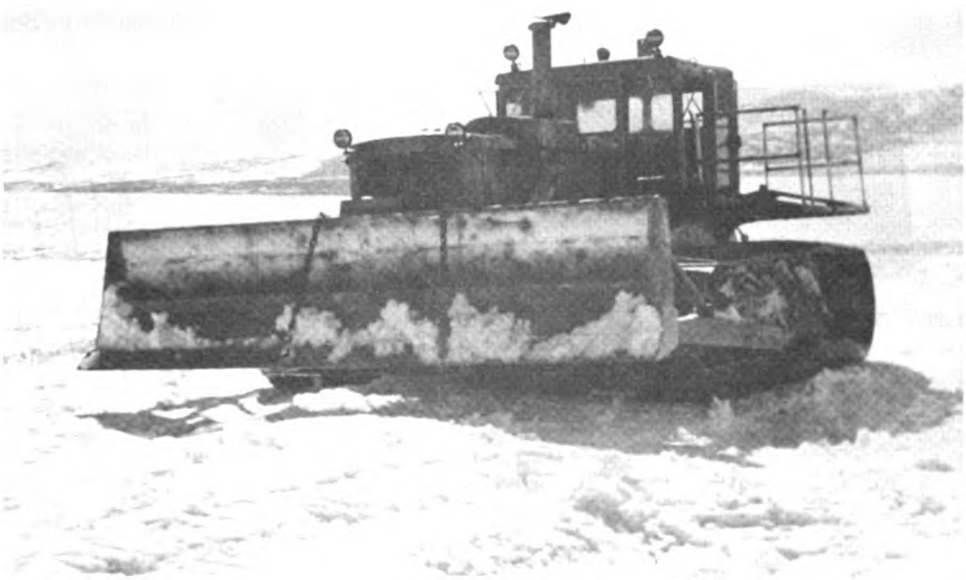
The most dangerous fire from the standpoint of swing personnel, is a fire in the command train. Due to the need for lighting, heating, snow melting, cooking, and communications, there are many potential sources of fire in this train. Again, the best control is disciplined fire prevention. The wannigans are kept clean and orderly, supplies are stored properly to avoid fire hazard, electrical wiring is checked, electrical appliances are well mounted and frequently inspected, and all heating systems are kept in the best of condition. Smoking discipline is rigidly enforced in all areas. Due to the usually warm interior of the wannigans, conventional fire fighting equipment can be used to advantage, but it must be frequently checked to be sure it is operational and the equipment must be located where it is readily available.

The heavy swings in Greenland operate the year around, from the darkness and cold of winter through the 24-hour sunlight and cold of summer. The quantities of freight moved give only a vague picture of the labor involved. In 1959, the last year of summer operation only, the swing freight across the ice cap totalled 1, 550 tons. During 1960, the first year that swings operated into the winter, a total of 36 heavy swings carried 6, 652 tons of cargo across the cap. This included all the materials for the construction of Camp Century. In 1961, the first year of twelve month operation, 16 heavy swings carried a total of 2, 800 tons of bulk cargo and 380, 000 gallons of fuel. The basic heavy swing of 1961 used eight LGP tractors, each pulling a capacity train.

With all this experience, and travelling over a well known and marked trail, each heavy swing is still an expedition of its own. Trail conditions change in the course of a few hours, storms occur at any season of the year, LGP's break down, ski gear breaks, —the list of possibilities is endless. In each case the swing commander and his crew meet the crisis as best they can. Sometimes new parts or other assistance can be flown out to the swing by air. Usually they must rely on their own professional knowledge, ingenuity, and the materials they have available. In the final analysis the swings do get through, regardless of the problems, which I state as an accolade for the men who man them.

This has been a short and general summary of the conduct of cargo transportation as a routine operation across the Greenland ice cap. Many details essential to the operation have not been covered here. The essence of the entire operation is planning and preparation. If these are done well, the chances of success in the execution are immeasurably improved.

The Command Train, Operational Headquarters of the heavy swing which supply Camp Century across the Greenland Ice Cap from Camp Tuto.



View of a D-8 LGP, Low Ground Pressure, Caterpillar used by U. S. Army Polar R & D Center, in Greenland operations.

A heavy swing on the trail between Camp Tuto and Camp Century.

A view of an LGP Caterpillar warming up before it starts its day's work.

GROUND TRANSPORT OF SOVIET ANTARCTIC EXPEDITIONS

Arctic and Antarctic Research Institute

During the IGY the Soviet Antarctic Expedition had to investigate vast areas of East Antarctica, establish new stations, transport a great quantity of different cargoes to the points located in hundreds and thousands miles away from the main base Mirny.

These complicated tasks were supposed to be fulfilled with the help of special ground transport facilities, capable to move along the snow wilderness of Antarctica, and to do a routine work in low temperatures and at high altitudes, and in these conditions to have enough tractive force to tag heavy loaded sledges with fuel and cargo.

For this purpose the Soviet investigators dispatched to the Antarctic the following transport facilities:

Tractors—S—80
Tractors—S—100 A, S—100 AB
Cross-country vehicle Gaz—47
"Pingvin" cross-country vehicle
Heavy-duty tractor
Heavy duty tractor "Khar'kovchanka"

The experience of the first journeys inland of Antarctica with tractor-trains showed how great is the importance of reducing the pressure gravity for heavy-duty tractors upon the snow while moving along the deep, dry snow.

Usually the serial-production tractors and heavy-duty tractors were produced by the Soviet plants with the tracks 500 mm wide.

For the Antarctic expeditions the track width was enlarged to 750-1, 000 mm. This enlargement of track's width considerably lowered the pressure of specific gravity on snow and rised the practicability of tractors and heavy-duty tractors. Inland research journeys with tractor-trains were made at altitude more than 3, 000 m above the sea level. Under such conditions the motors lost their great power and required more fuel. Having in mind these circumstances consequent heavy-duty tractors and tractors were fitted with a turbo-supercharger.

Here is the table of some technical features of ground transport facilities for the Antarctic expeditions:

Type of Machine	Hp of Motor	Track Width in mm	Super-Charging	Specific Gravity in kg/cm^2
Tractor S—80	80	500	no	0, 47
Tractor S—100 A	100	750	yes	0, 4
Tractor S—100 AB	100	1, 000	yes	0, 3
Cross-country vehicle GAZ—47	80	350	no	0, 19-0, 22
"Pingvin" cross-country vehicle	240	650	yes	0, 2
Heavy-duty tractor	400	750	yes	0, 5-0, 6
Heavy-duty tractor "Khar'kovchanka"	520	1, 000	yes	0, 3

Tractor S-80 is a general-purpose Caterpillar tractor in mass production; it was broadly used for unloading expedition ships, transporting sledges with cargoes from ships to the shore.

It was with these machines that the first tractor-train was completed, which crossed from Mirny for 375 km inland and the members of this party set up "Pionerskaya" station in April 1956.

Tractor S-100 AB is a modification of tractor S-80, adapted to work in boggy areas and in specific conditions of the Antarctic. It differs from the tractor S-80 as it has a 100 hp motor with supercharger. The S-100 AB track has been made wider by 400 mm, thus permitting the installation of tracks with symmetrical grousers 1, 000 mm wide, which provides the minimum of specific gravity upon snow with tractors of this type. The cabin, floor, fuel tank and fuel line are protected against cold. The tractor is provided with a solid floor with hatches.

The S-100 A tractors have the same track as the serial-production tractors. Their track is formed of 750, tracks positioned asymmetrically to rollers. Their motor, supercharger, cabin, equipment and other units are the same as in the S-100 AB tractor.

The use of superchargers with the tractors enables the motor power to be kept at 90 to 95 hp even when operating at an altitude about 4, 000 m, above sea level and in an ambient air temperature of -30°C.

The GAZ-47 is a light cross-country Caterpillar tractor. In the Antarctic it was used for local transporting small cargoes and people. Its body for six men is covered with tarpaulin and the tractor can trail a sledge with a small load.

The main transport for research inland journeys used by the Soviet Antarctic expeditions are cross-country vehicle "Pingvin", heavy-duty tractors and cross-country vehicle "Khar'kovchanka."

A tractor-train of three heavy-duty serial-production tractors (without any modifications) made a journey to the spot, where a research station "Komsomol'skaya" was set up. This station is at a distance of 870 km from Mirny.

During this tractor-train journey heavy-duty tractors trailed sledges housing living quarters, radio, galley, messroom, fuel, food, equipment, etc.

The first experience in using transport facilities inland of the Antarctic continent enabled the scientists to determine the technical requirements to be met by machines dispatched to operate in the Antarctic. These requirements were chiefly connected with reducing the pressure of tracked machines upon the snow, altering the track design to ensure better cohesion with the snow cover, and providing the motors with superchargers.

A journey to the "Pole of Relative Inaccessibility" area at a distance of 1, 410 km from Mirny was made in December 1957, with the same serial-production heavy-duty tractors and "Vostok" station was set up.

The tractors were modernized at the beginning of the third expedition. Their tracks were made up to 750 mm wide, by using special tracks which provided for better cohesion with the snow cover; the ground clearance was enlarged to the limit. The 400 hp motor was fitted with a supercharger, provided the working conditions of the heavy duty tractor at high altitudes without lowering its power with a great economy of fuel; the driver's cab was fitted with heating arrangements and had two hatches in the roof.

In February 1958 a journey was made with these machines and the station "Sovetskaya" was founded. In December of the same year a tractor-train of modified heavy-duty tractors reached the "Pole of Relative Inaccessibility". This journey took 87 days and covered the distance of some 4, 300 km.

The "Khar'kovchanka" vehicles with which the fourth expedition in 1958 was equipped, differed from the other tractors in their greater power (520 ph), with a supercharger, and enclosed body which is partitioned into eight separate living rooms, service compartments and facilities. The total weight of a "Khar'kovchanka" is 35 tons. The cabin is 8, 5 m long, 3, 6 m wide and 2, 0 m height. The overall height is about 4, 0 m.

At first the track width was enlarged to 1, 000 mm, but the asymmetrical positioning of the extension devices led to rapid wear of the pins, so during the journeys the track width was reduced to 750 mm.

The motor compartment is located in front and consists of a supercharged motor, a 5-speed gear box, steering gear, two electrogenerators, storage batteries, and controls. Inside the body, as it was said before, are situated eight rooms: driver's compartment, radio cabin, galley, service compartment, toilet, drying room and work room. All the rooms are separated from each other by partitions with doors.

On 26 December 1959 two "Khar'kovchanka" snow-vehicles and one heavy-duty tractor paid a visit to the United States Amundsen-Scott station, sited in the area of the South Geographical Pole at a distance of 2, 700 km from Mirny.

The main machine for the glaciological research journeys was light-weight "Pingvin" cross-country vehicle. These machines are distinguished by their high speed when travelling over snow and comparatively small specific consumption.

Various types of sledges were used for transporting cargoes. There were wooden, duralumin, steel sledges and trailers. The main sledges used were steel ones of 8, 8 m long, 3, 6 m wide. The duralumin sledges with a fluoroplastic coating; this coating provides a low coefficient of friction with the snow surface. The wooden sledges with steel runners are also used; they are much lighter in weight as compared with steel ones, but not so durable.

Steel trailers are used for transporting small cargoes within the area of the observatory and stations.

During six years the Soviet Antarctic expeditions have been acquiring the experience of exploitation the ground transport in difficult conditions of "Ice continent". From the period of one expedition to the period of another one separate parts and sometimes the whole machines were being modernized. The methods and technique of repairing heavy-duty tractors, cross-country vehicles, bulldozers, etc., were perfected and improved. Serial-production tractors were modernized according to the conditions of work in the Antarctic.

The organization of tractor-trains' work in the Antarctic was based on the main role of overland transport and air transport facilities.

All transportation inland of continent of great bulk of loads—building materials, equipment, fuel, food, was performed by tractor-trains, as well as set up and maintenance of research work at "Pionerskaya," "Komsomol'skaya," "Vostok-I," "Vostok," "Sovetskaya," "Novolazarevskaya," "the Pole of Relative Inaccessibility stations." Aircraft served as auxiliary means. The fuel, spare parts, repair teams of workers were delivered to the points of train-tractors' stops.

The main part of difficult cross-country route were made by heavy-duty tractors. These were the leading transport machines and they proved their capability to work in the Antarctic.

The overland transport in the Antarctic has a very great importance in the routine work of scientific-research stations and observatory, unloading of ships, transportation of cargoes and research work in the areas removed far away from the bases.

For the whole period of seven expeditions about 20, 000 tons of supplies were delivered from vessels to the shore. The distance covered by tractors with trailers was sometimes more than 40 km over the fast ice.

A great volume of work is fulfilled by tractors and bulldozers in preparing the runways for aeroplanes fitted with wheels.

The Soviet scientists of the Antarctic continue their work for improving overland transport, make use of experience acquired during their seven expeditions.

SECTION V

Antarctic Provisioning

NOTES ON ANTARCTIC RATIONS

Pedro Osvaldo Baeza

Supply of Food and Provisions in Bases

In planning the supply of food to the groups of personnel assigned to the Antarctic, one must first take certain factors into consideration. In the first place, the calorie requirements vary according to the type of physical work which the individuals perform and to the environmental temperature in which this work is carried out. Secondly, during the period of adaptation the individuals will need a quantity of daily calories greater than that required by those who have already become adapted, provided the environmental conditions and quantity of work are equal.

Taking these factors into account, one can draw up the following theoretical plan from the quantitative standpoint:

a. During the period of adaptation, for persons performing intense work outdoors: 5,000 to 5,500 calories daily.

b. During the winter, for persons performing intense physical work: 5,500 to 6,000 calories daily.

c. During the winter, for persons who perform relatively sedentary tasks because of their specialties: 4,500 to 5,000 calories daily.

It must be remembered that as a general rule the process of adaptation takes place during the summer months, a period which is not excessively rigorous on the periphery of the Antarctic. It must also be taken into account that the majority of persons go to the Antarctic by sea, this involving a not overly abrupt change in environment.

The calorie requirements can even be differentiated within the quantitative plan mentioned above, in accordance with the relative characteristics of environmental comfort of the housing utilized.

The organic combustion will logically be greater in persons facing the full hostility of the environment.

The qualitative aspect of Antarctic food supplying is appreciably more complex. Foods are proverbially defined as being designed to fulfil three functions:

a. Production of energy.

b. Securing of plastic repair.

c. Provision of the substances which the organism does not synthesize and which are essential for continuity of the normal physiological processes.

No food product, vegetable or animal, fully satisfies the organic requirements in these three aspects. All diets must be more or less varied in order to be adequate. Variety in nutrition, besides preventing aversion, ensures correct supply of all the indispensable factors.

The usually limited variety of the Antarctic diet makes necessary a careful study of what foods are to be consumed in this area and in what relative quantity. Although it is certain that both fats and carbohydrates or proteins are capable of meeting the calorie requirements, only a suitable balance of them assures maintenance of health. At the present time there is no unanimous agreement on the criterion for the optimum percentage in which the basic substances should occur. A diet exclusively of protein leads to death by "rabbit hunger". Nutrition with carbohydrates alone involves hypo- or avitaminosis and, in extreme cases, farinaceous edemata and serious or fatal states of malnutrition. Fats are highly productive of energy and have great satiating power, but in an exclusive diet they favor the appearance of acidosis and acetonemia.

The most suitable proportion to fill the Antarctic requirements would seem to be 15 per cent of proteins, 45 per cent of fats, and 40 per cent of carbohydrates.

The high percentage of proteins is justified for two reasons: the necessity of providing for the increased proteinic catabolism which accompanies physical labor in cold and the exclusive characteristic of the proteins termed "specific dynamic action". On the basis of this property the organism can increase the metabolic values up to some 30 per cent subsequent to the ingestion of proteins. Moreover, it must be remembered that the positive nitrogen balance is maintained better with smaller quantities of animal proteins than with similar values of proteins of vegetable origin.

As regards the elements in question, the usual organic requirements are maintained and even increased in the Antarctic climate. The vitamins have always been a cause of preoccupation, especially vitamin C. There are well grounded physiological considerations justifying a generous proportion of ascorbic acid in the Antarctic diet. Some countries rely on the vitamin C content of canned citric juices, but the tablet or capsule with dosage in milligrams is more certain, above all when it is not known with certainty to what extent the metal of the containers destroys the ascorbic acid.

At any rate, dehydrated vegetables may be taken into consideration as sources of ascorbic acid within the limits of what is accessible in the Antarctic. Thus, for example, dehydrated onions supply 26.37 mg of vitamin C per 100 grams and dehydrated potatoes 26 mg per hundred.

Similarly, provision must also be made for adequate supply of liposoluble vitamins, especially vitamin A. In ordinary nutrition this vitamin is found in milk and its derivatives, but in relatively small quantities. Egg yolk contains appreciable quantities of vitamin A; hence it is convenient to use powdered eggs, or better yet, fresh eggs. Unfortunately, the collection and consumption of penguin eggs are fairly generally neglected in the Antarctic. These eggs are easy to obtain during the spring and are palatable when correctly prepared.

Another problem which arises in study of nutrition at Antarctic bases concerns the schedule and spacing of meals. In contrast to the custom in Anglo-Saxon countries, Latins are accustomed to having a breakfast based on coffee, milk, and bakery products; that is to say, they ingest almost exclusively carbohydrates of easy and rapid organic combustion. This breakfast abruptly increases the glucose content of the blood and maintains it for a period of two or three hours. Then the glycemia drops, even to the point of hypoglycemia, a mid-morning meal then becoming necessary. Lunch is also very different; it is generally abundant and the digestive process long and laborious, involving postprandial dullness and somnolence, with an obvious decrease in the capacity for work for two or three hours.

The afternoon meal is also based almost exclusively on glucosides, and the rather late supper is similar to the lunch, but is much less abundant.

The system or spacing of meals which is normal in the Anglo-Saxon countries presents a number of advantages and is even more logical from the Antarctic standpoint. An abundant breakfast, solid and rich in proteins and fats, not only meets the nutritional calorie requirements, but also maintains the glucose content of the blood for a longer period, without abrupt rises or drops. It consequently impedes the appearance of hunger in mid-morning, increasing efficiency and capacity for work. A light lunch six hours after this breakfast assures four to six additional hours of work under excellent physical conditions, without the inconvenience of postprandial dullness and somnolence.

Supper should be rather early and abundant. In this way the organic losses occurring during the day are restored without the risk of the night's sleep being started in the middle of the digestive process or with insufficient provision of food for this prolonged period.

The advantages of this system of meals are quite evident during the winter period in the Antarctic, especially at the bases not too far to the south, at which maximum use must be made of the limited time with daylight only in order to carry out the necessary work on the outside.

In conclusion, mention should be made of beverages. Their consumption in the Antarctic is closely related to the customs of the different peoples. In Argentina it is almost customary to drink wine or beer with meals, in small quantities; hence at the Argentine bases it is also almost customary to drink beer or wine one or two days a week during meals. In England, whisky, gin, or brandy is drunk after the day's work has been finished, so that it is the custom at the English bases to drink these beverages once or twice a week.

The advantages or disadvantages of consumption of alcoholic beverages in the Antarctic are still a debated matter. As an indisputable advantage, alcohol occasions an appreciable muscular relaxation when ingested in small quantities, additionally contributing to peripheral circulation and maintenance of organic comfort. As the principal disadvantage, if it is consumed under extreme conditions of temperature and physical fatigue it can cause serious or even fatal disorders, since it rapidly leads to hypothermy.

The consumption of beverages such as beer, which has a low alcoholic content, is not inadvisable, within certain limits, because of the intense thirst which is usual when hard work is done outdoors. A generous supply of fruit juices is to be recommended for the same reason, rather than for the possible vitamin content of the juices.

Patrol Rations

What and how much should be eaten during patrols have long been known. Patrol rations are traditionally of high calorie content, easy preparation, limited variety, and low weight. The fundamental problem has been—and for countries still is—the system of preserving and packing of provisions.

A number of factors complicate the question: the containers must have minimum weight and maximum resistance to harmful agents. Special care must be devoted to sealing, since snow penetrates through the smallest of openings. The breakdown of the different provisions of the patrol ration should enable each person to cook what he is to eat inside his tent, without having to cut, weigh, or measure. At the same time, the patrol ration should not be excessively monotonous and should be reasonably appetizing.

It is obviously difficult to reconcile all these requirements, but the problem has been considerably simplified with the appearance of packaging systems in which use is made of polyethylene, or better still, thin sheets of aluminum lined with insulating resins.

Studies necessary for the adaptation to Antarctic use of a unified, even useful ration for various requirements outside the Antarctic are now being concluded in Argentina. The principal characteristic of this ration, designed by the author in collaboration with Lieutenant-Colonel Giovanini, Chief of Logistics at the Antarctic Division of the Army, is that provision has been made for packing of all the food items which comprise it in envelopes or tubes of sheet aluminum with an inner insulating lining.

Following are details on the content of this patrol ration, which is also a survival ration in cold zones:

Type "A" Ration

Sugar (refined and ground). Envelopes of 15 grams net weight, combined in groups of 4 envelopes. Material: aluminum, hermetic seal, natural exterior with legend in black indicating contents and quantity.

Candies (Butterscotch type). Each wrapped individually in cellophane and then placed in sealed aluminum envelopes with a content of 40 grams net weight. Natural exterior with legend in black indicating contents and quantity.

Charquican [saltless dried meat] (pemmican). 200-gram tablets, according to formula of the Frigorífico Anglo de la Argentina, 1961; packed in hermetically sealed aluminum. Natural exterior with legend in black indicating contents and quantity.

> Formula (in 300 grams of charquicán): onions, 40 grams; beef fat, 25 grams; lard, 30 grams; wheat flour, 30 grams; greenpea meal, 10 grams; powdered meat, 70 grams; powdered liver, 10 grams; powdered milk, 70 grams; and powdered yeast, 5 grams.

Chocolate. Milk chocolate type, of first quality, in 60-gram bars wrapped in hermetically sealed aluminum. Natural exterior with legend in black indicating contents and quantity.

Whole Crackers. In 60-gram packets (five units) wrapped in hermetically sealed aluminum. Natural exterior with legends in black indicating contents and quantity.

> Formula (in 250.3 grams, approximately 19 crackers of 13 grams): wheat flour, 114.28 grams; whole flour, 48.57 grams; malt extract, 4.45 grams; inverted sugar, 8 grams; glucose, 4.85 grams; oil, 24.57 grams; yeast, 3.42 grams; sodium bicarbonate, 0.85 grams; tartaric acid (sufficient quantity); and salt, 1.71 gram.

Meat Extract. Aluminum tubes with interior insulating lining, natural exterior, and legend in black indicating contents and quantity.

Raisins (sultana type). In hermetically sealed aluminum envelopes, contents 30 grams. Natural exterior with legend in black indicating contents and quantity.

Glucose/Grapefruit. Powder. Hermetically sealed aluminum envelopes, net content 14 grams, natural exterior with legend in black indicating contents and quantity.

Cereal Tablets. Units of 70 grams containing equal parts of wheat flakes, corn flakes, and stabilized wheat germ. Packed in hermetically sealed aluminum containers. Natural exterior with legend in black indicating contents and quantity.

Dried Soups. 80-gram aluminum envelopes in two flavors, meat and noodles and chicken and noodles (50 per cent of each), in aluminum containers similar to the commercial ones.

Instant Coffee (Nescafe). Hermetically sealed aluminum envelopes of three grams each, natural exterior with legend in black indicating contents and quantity.

Fine Iodized Salt (Cerebos type). Hermetically sealed 12-gram aluminum envelopes. Natural exterior with legend in black indicating contents and quantity.

Butter. From salted pasteurized milk. Hermetically sealed aluminum envelopes of 60 grams each. Natural exterior with legend in black indicating contents and quantity.

Peanut Butter. Hermetically sealed 60-gram aluminum envelopes. Exterior with legend in black indicating contents and quantity.

Cream Cheese. In Fontina flavor. Common package of 50 grams.

Powdered Milk. Hermetically sealed 60-gram aluminum envelopes. Natural exterior with legend in black indicating contents and quantity. The milk must correspond to the following approximate analysis: fats, 26.6 per cent; proteins, 20 per cent; carbohydrates, 38 per cent; water, 6.33 per cent; and calories per 100 grams, 496.

Rolled Instant Oats. Precooked. In hermetically sealed aluminum envelopes of 40 grams each. Natural exterior with legend in black indicating contents and quantity.

Dehydrated Potatoes. In cubes. Hermetically sealed aluminum envelopes with content of 40 grams. Natural exterior with legend in black indicating contents and quantity.

Dehydrated Onions. In hermetically sealed aluminum envelopes with a net content of 40 grams. Natural exterior with legend in black indicating contents and quantity.

Powdered Garlic. Hermetically sealed aluminum envelopes with net content of five grams. Natural exterior with legend in black indicating contents and quantity.

Quince Jelly. In aluminum tubes with interior insulating lining, each of 80 grams. Natural exterior with legend in black indicating contents and quantity.

Vitamin Tablets. Vitamin and mineral tablets packed individually in aluminum. Natural exterior with legends in black indicating contents.

Matches. Wood "safety" type. Five units in common container, small hermetically sealed polyethylene bag.

Alka-Selzer. Type with vitamin C, in common container.

Toilet Paper. In loose sheets. Hermetically sealed polyethylene packets of five units of 120 sheets each.

Chiclets. Packed individually in hermetically sealed aluminum. Natural exterior with legend in black indicating contents.

Soap for Sea Water. 30-gram cakes. Common commercial container repacked in hermetically sealed polyethylene envelopes with five units each.

Type of Packing for Rations

The aluminum envelopes containing the various items are in turn packed in a polyethylene pouch in the amounts necessary for one day per man.

The patrol box, of plywood, will contain twenty man-day pouches, as well as a "comfort" pouch which will contain matches, toilet paper, soap, quince jelly, and meat extract.

The cold zone survival rations may contain supplies for one, five, ten, or twenty days per man, as required. In the event the individual ration is selected, the polyethylene pouch will be enclosed in a corrugated cardboard box with waxed exterior.

Dietetic Evaluation

A quantitative and qualitative analysis of the items which make up this ration is given in Table 1.

TABLE 1

Racion Tipo "A" Para 20 Dias/Hombre = Type "A" ration for 20 days/man
Alimentos = Ration items
Cantidad diaria = daily amount
numero - porcion = Number - portion
agua = water
proteina = protein
lipidos = fats
glucidos = glucosides
sodio = sodium
potasio = potassium
calcio = calcium
magnesio = magnesium
hierro = iron
fosforo = phosphorus
azufre = sulphur
cloro = chlorine
varios = miscellaneous

azucar = sugar
caramelos = caramels
manteca = butter
manteca de mani = peanut butter
queso tipo Adler = Adler type cheese
leche en polvo = powdered milk

TABLE 1 (continued)

avena arroll inst = instant rolled oats
papa deshidratada = dehydrated potatoes
cebolla deshidratada = dehydrated onions
jalea de membrillo = quince jelly
pasas sultanas = sultana raisins
extracto de carne = meat extract
galletita integral = whole-wheat cracker
sopa desecadada = dried soup
char quican = pemmican
comprim de cereales = cereal tablets
sal fina yodada = fine iodized salt
nescafe = instant coffee
chiclets = chiclets (chewing gum)
ajo en polvo = powdered garlic
glucosa + pomelo (en polvo) = glucose + grapefruit (powdered)
con vit "C" = with vitamin "C"
vitaminas y minerales = vitamins and minerals
totales = totals

As may be seen from the table, the calorie needs, plastic requirements, and requirements for oligo elements are satisfied correctly. On the other hand, it should be explained that, insofar as the food items are concerned, there has been practical experience over several years in continuous use of the items by the Antarctic patrols of the Army. Almost the same items were provided as survival rations to the crews of the naval aircraft which made a flight to the South Pole during the summer 1961-62. The principal disadvantages which arose on this occasion were due to the fact that containers were employed which did not meet the appropriate conditions as do the ones discussed here.

THE ORGANIZATION OF SUPPLIES FOR AN ANTARCTIC STATION

P. G. Law and F. McMahon

Nothing is more vital for the successful operation of an Antarctic station than a meticulously organized supply system. For the A. N. A. R. E., the purchase and despatch of all stores and supplies for four stations are handled by a small group in the Antarctic Division and some details of the supply organization are given below.

Classification of Stores

Stores and accounting matters concerning the possible requirements of Australian stations and the Head Office organization are divided into 24 groups:

1. Generating plant, field vehicles, fuel storage and reticulation, ice drills, cranes and hoists, pumps, engineering spares.

2. Buildings, building materials, hardware, furniture, kitchenware, power and light reticulation, stoves, heaters, snow melters and boilers, fire prevention and fire fighting equipment.

3. Tools and workshop equipment, metal stocks.

4. Cameras, projectors, cine-film production, photographic materials.

5. Sledges, caravans, boats, tents, sleeping bags, field rations, dog food and harness, mountaineering equipment, marine stores, ropes and cordage.

6. Explosives, firearms, pyrotechnics and rockets.

7. Radio transmitters and receivers, antennae, teletypes, test equipment.

8. Surgical, medical and dental stores; carbon monoxide test equipment.

9. Scientific equipment and instruments concerned with upper atmosphere physics, glaciology, survey, cartography, biology and physiology.

10. Clothing.

11. Fuel, lubricating oils, paints.

12. Office machines, packing supplies, stationery and office requisites.

13. Books, periodicals, reprints, maps and charts, printing of publications.

14. Amenities including games, sporting equipment, films, records, liquor, sweets, cigarettes and tobacco.

15. Victuals.

16. Head Office transport and travelling charges, fares.

17. Cables, telephone charges, postage, petty cash.

18. Salaries and allowances.

19. Rental of office premises.

20. Scientific grants to Universities and Institutes.

21. New ship designs.

22. Purchase, hangarage and operation of aircraft.

23. Charter of ships for Antarctic voyages.

24. Advertising positions with expeditions.

Ordering

Requisitions for goods are raised by expedition staff and authorized by heads of sections or, for expensive items, by the Director. From these the Supply Section makes out official orders on local or overseas firms and these are signed by the Director, or by officers under him with appropriate delegations of responsibility. After the ordered goods are received and checked at the store, the storeman completes receipt dockets which are distributed to the supply officer and section leaders to ensure that items are entered into Head Office ledgers and station inventories and to enable accounts to be paid.

Packing and Despatch

At the expeditions' store, goods are packed for the most part in cases of standard sizes. Exceptions are large objects which generally come from the suppliers in their own robust crates. Standard A.N.A.R.E. cases are of two sizes: 24" x 11" x 10" and 24" x 22" x 20". Four of the small cases will stack in the same space as one large case. They are fitted with a lifting batten at each end and can be provided with waterproof sisalkraft envelope liners, or thin metal liners which can be sealed by soldering.

Packing notes in quadruplicate are made out to cover the contents of each case. One copy goes inside the case, one is nailed in a sturdy envelope to the end of the case, one goes to the man who will be O. I. C. of the Antarctic station and one goes to Head Office.

Each case is marked on the outside with various brands. First, a band of a certain color encircles the case to denote its destination (e. g. Mawson a red band, Davis a green one). A colored daub on one end of the case denotes the year of despatch. (This is especially valuable for victuals or other perishable goods which must be consumed before a given amount of time has elapsed). Upon two adjacent sides is marked the group number (in a circle) followed by the number of the case in that group. The contents of any case can be found by reference to the packing note held by the O. I. C. or that tacked to the end of the case. Cases are stacked according to group numbers, all cases for a particular station occupying one section of the store. These are transferred to the ship when it arrives to load for Antarctica.

Unloading at Stations

Unloading is carried out mainly by Army DUKWs which receive cargo at the ship's side and transport it direct to the door of the store hut at the station with no double handling at the water's edge. In some cases rafts made from inflated rubber pontoons are used, particularly for unloading heavy vehicles or aircraft which are beyond the capacity of the DUKWs, or for making landings on rough, rock-strewn, surf-thrashed beaches.

Store huts are organized on the group system and it is desirable that all stores be taken from DUKWs straight into their appropriate stores. Where speed of turn-around of DUKWs is urgent, cases are unloaded beside posted signs displaying group numbers and these can then be transferred later from such dumps into the store huts. The sorting of cases into groups as they are unloaded from DUKWs has been shown to save much time and labor later.

Where some article is needed urgently during the unloading period, a check through the packing notes of the group concerned and a search of the group cases to find the case number indicated on the packing note is all that is required.

Storage

The A. N. A. R. E. maintains both warm stores and cold stores. Cold stores (unheated, uninsulated huts) contain hardware, clothing, field equipment and other non-perishable goods in addition to certain items which require cold storage, such as films, certain canned and packaged foods, etc. Warm stores (insulated huts heated by electricity) are used to store beer and other bottled goods which would burst their containers if they froze, eggs, tinned cream and certain other tinned foods which are spoiled if frozen, etc. Such goods must be brought straight from the ship to the store without delay.

Stock Records

Stores and equipment are divided into "A" and "C" class items. The former are made up of fixed plant and valuable items which will not normally require replacement except over long periods, such as huts, engines, radios, cameras, power tools, fire-arms, etc.; the latter consist of all other items including those issued to personnel for private use and those available at stations for general or special use by individuals or sections.

Stock cards covering all "A" class items issued to stations are kept at Head Office and are checked with inventories and stock-take sheets which, certified by the officer-in-charge, are returned from each station at the end of the year.

Stock record ledgers at the stations list all "C" class items except food, amenities, fuel and lubricating oil: these give a description of each item, group number, quantity on hand and location. Generally bulk issues of items such as radio parts, engineering spares, medical stores, etc. are made to section leaders who are responsible for returning to the officer-in-charge monthly lists in duplicate showing consumption of each item. Provision stock sheets are kept for food held in the store and the quantities which are issued each month are entered so that, at any time, amounts which remain can be readily calculated. Monthly consumption sheets record quantities of fuel, lubricating oil and amenities consumed and are regularly inspected by the officer-in-charge to keep check on usage. Each year originals of these records are returned to Head Office and duplicates kept at the station are passed on to the newly arrived officer-in-charge for his information.

A "Write-off" sheet containing a full report of any "A" class item lost or damaged beyond repair must be completed by the person concerned and countersigned by the officer-in-charge to certify that the report is accurate and that stock records have been amended accordingly. When damage to equipment is such that repair at the station or after return to Australia seems possible, a report submitted by the person concerned with the damage is countersigned by the officer-in-charge. Originals of all "write-off" and "damage to equipment" sheets are returned to Head Office for further action.

Re-Ordering

The conscientious re-ordering of supplies by one Antarctic party to provide for the needs of the succeeding party is vitally important. The A. N. A. R. E. re-order system has developed certain important techniques:

a. Station leaders are asked to lodge re-orders by radiogram at the earliest possible stage in the year. By stocktaking in March and assessing consumption rates in March, April and May, it is possible to estimate consumption for the rest of the year and to re-order for many things in May and June. This gives the supply officer in Melbourne a chance to cope with with requirements. If in October or November some unforeseen deviation from normal yearly consumption is detected only a minor readjustment is generally needed.

b. Wherever possible, "establishment" lists are drawn up for the station (e.g. spares for radio equipment, tools and spares for engines, etc.). The section leader at the stations then merely re-orders goods to bring his stocks up to establishment level.

c. In some cases (victuals, domestic requirements such as soap and cleansers, etc.) yearly consumption figures expressed as "man-year" quantities, have been arrived at as a result of long experience. The annual requirement for a party of any number of men can then be quickly calculated. In these cases section leaders at stations merely send radiograms indicating stocks they estimate will remain at the end of their tour of duty and the H.Q. supply officer orders sufficient to bring these stocks up to the level required by the next year's party.

Clothing

Clothing issues are of three kinds:

a. Personal Issue. Before leaving Australia each man receives a basic issue of clothing sufficient for his immediate general needs.

b. Group Stock. Replacement garments, winter garments and special clothing for field use are issued to men by the O.I.C. from Group Stock at the station as required. Group stocks, made up to the correct sizes of the men at a particular station, are sent down each year and the unused remnants of the previous year's group stock are returned to Melbourne and used for general issue again.

c. Emergency Reserve. Sized clothing for each man on a survival scale is provided each year and is stored in an isolated, unheated, unwired building for use only if fire renders its use necessary. (In the same hut are stored emergency stocks of bedding, food, tools, kitchenware, medical stores and stationery. Reserve fuel is stored in a special isolated dump). Emergency reserve clothing, if not used, is returned unopened each year to Melbourne and used for general issue again.

The above system has enabled the Antarctic Division to effect considerable economies in the issue of clothing without in any way limiting the items available to the men at the station. By reducing personal issues to a minimum and leaving it to a man to apply for further issues only as he requires them one avoids providing men with articles that they do not require or have no desire to wear. Thus, a man who spends his whole time at a station is not issued with heavy winter field clothing, and a man who prefers Arctic boots is not issued with mukluks.

THE A. N. A. R. E. FIELD RATION PACK

P. G. Law and F. McMahon

1. The A. N. A. R. E. field ration pack has been designed for the following purposes:

(i) As a basic, adequate ration for parties travelling by dog sledge or man-hauled sledge;

(ii) As a survival pack to be carried on aircraft or motor launches;

(iii) As an emergency ration to accompany landing parties engaged in coastal exploration;

(iv) As a ration to be left at food depots or other emergency dumps.

In each of these uses economy of weight and space is a primary consideration. Convenience in handling, ease of sub-division into various man-day portions, and robustness of the package have all been considered.

2. The rations are completely adequate, in their man-day portions, to sustain health and strength for indefinite periods for dog sledging or tractor parties and have been used without supplementation for periods of up to three months. For man-hauling or other forms of extreme exertion experience has shown that extra calories must be provided.

Each man-day portion comprises:

Item	One Man-Day (oz.)	Protein (gms.)	Carbo-hydrate (gms.)	Fat (gms.)	Total Calories
Pemmican	8.00	108.0	6.8	97.0	1370
Butter	4.00	2.4	2.6	100.0	970
Biscuit	5.00	24.7	85.0	29.1	660
Sugar	4.00		114.0		450
Egg powder	1.00	11.3		12.6	170
Milk powder	2.50	20.6	25.5	19.1	350
Cocoa	1.00	5.7	9.9	7.4	130
Potato powder	1.50	3.6	34.5	0.2	160
Chocolate	2.00	4.5	25.3	19.2	310
Onion	0.33	0.3	6.2	-	30
Coffee	0.33	-	-	-	-
Vegemite	0.17	-	-	-	-
Rolled Oats	2.00	6.7	41.0	4.5	230
Salt	0.17	-	-	-	-
Pepper	0.08	-	-	-	-
		188	351	289	4830

Multiple vitamin tablets are supplied to be taken by men as required. The net contents totals 24 pounds and the whole package weighs 30 pounds.

3. The contents are sealed as follows:

Pemmican in one tin containing six one-pound blocks
Butter in four tins each 12 oz. ("concentrated" dehydrated butter)
Biscuits in 15 sealed packets each containing four biscuits
Potato powder in six packets each 3 oz.
Sugar in three tins each 1 lb.
Egg powder in sealed polythene envelope
Milk powder in sealed polythene envelope
Cocoa in sealed polythene envelope
Chocolate in six blocks each 1/4 lb.
Onion in sealed plastic container
Coffee in two tins each 2 oz.
Vegemite (yeast extract) in toothpaste type tube
Rolled oats in sealed polythene envelope
Salt in plastic cylindrical tube
Pepper in plastic cylindrical tube

A number of extra polythene envelopes is provided in each pack together with rubber bands so that, once opened, loose contents can be resealed or further subdivided as required.

The biscuits were specially designed by the Antarctic Division in collaboration with the firm of Swallow and Ariell Ltd. and are compounded from 72 per cent wholemeal flour, 21 per cent butter, two per cent salt, five per cent moisture, weighing 1 oz. each.

As Bovril Ltd. have recently ceased production of pemmican, the Antarctic Division has been experimenting with HF6 meat bars manufactured by Horlicks Ltd., with meat bars manufactured by Unilever and distributed by Batchelor Foods Ltd. of Sheffield and with accelerated freeze dried meats purchased from the Irish Sugar Company Ltd., Dublin. Sufficient tests have not been done to enable any final assessment to be made but interim reports indicate that although the HF6 bar is somewhat more palatable than pemmican, it is not as "satisfying", weight for weight. The HF6 is, moreover, more difficult to prepare for it requires soaking before cooking and this is awkward in the field.

4. Supplementary rations are added when weight limitations are not so strict. These generally comprise jam, tea, extra biscuits and chocolate, with perhaps some dehydrated vegetables. When travelling along coastal areas, seal and penguin meat provide welcome additions to the menu. At food depots the most acceptable supplementary food is tinned fruits.

5. Typical menus based upon this ration are:

Breakfast: Oatmeal porridge or scrambled egg or fried cakes compounded of oatmeal, egg powder, milk powder and onion powder. One biscuit with butter and yeast extract. Coffee.

Lunch Three Sledge biscuits with butter and yeast extract. Chocolate. Cocoa.

Dinner Pemmican stew mixed with potato powder, onion powder, a little oatmeal and a little dehydrated egg. One biscuit with butter and yeast extract. Coffee.

The addition of extra biscuits and chocolate, together with some jam, makes this a most satisfying ration even for men engaged in the most strenuous labor.

6. In 1961, for a three-man dog sledging journey from Mawson to Mt. Menzies (totalling 1,000 miles) the men made up their own sledge ration from bulk stocks as the ready-packaged A.N.A.R.E. rations were in short supply. The ration, which differed slightly from the A.N.A.R.E. ration, provided for one man-day the following quantities:

Pemmican	4.0 ounces	
HF6 meat bar	2.0 "	
Dehyd. vegetables	0.5 "	(mixed potato, cabbage and onion)
Egg powder	0.1 "	
Milk powder	0.5 "	
Sugar	4.0 "	
Oatmeal	1.5 "	
Biscuits	8.0 "	
Jam	1.0 "	
Yeast extract	0.25 "	
Butter	1.0 "	
Coffee	0.25 "	
Tea	0.1 "	
Salt	0.2 "	
Chocolate	4.0 "	
Vitamin capsule	1 capsule	
Total	27.5 ounces	
Total calories	3730	

Note the overall decrease in weight and the better balance obtained by cutting out cocoa (not as popular as tea or coffee) and increasing the chocolate and biscuits at the expense of the butter (seldom all consumed in the A.N.A.R.E. ration), the powdered potato, the egg and the milk. On the return journey the men added 4 oz. chocolate, 2 oz. biscuit, 0.25 oz. butter and 0.4 oz. jam to this ration giving 4690 calories. At the end of their 89-day journey they weighed roughly the same as at the beginning.

7. The ration could be further improved by redesigning the packaging, while further work is required to assess the adequacy of the various types of freeze-dried meats as substitutes for pemmican. The Antarctic Division is at present revising the contents along the lines indicated in paragraph 6 above.

8. A 12 man-day pack is exhibited. (At Symposium)

THE A.N.A.R.E. POCKET MEDICAL KIT

Phillip Law

When men are engaged in duties away from their bases in Antarctica it is important that each shall carry (a) some form of medical first-aid kit and (b) some candies, chocolate or other simple high-energy food, in case emergency prevents their return to base at the scheduled time. Bearing this in mind the Antarctic Division has designed a pocket medical kit for A.N.A.R.E. men. Whenever men leave a ship to go ashore with exploring or scientific parties, or leave a station for long or short periods, each carries in his pocket one of these kits.

More elaborate first-aid kits are provided on aircraft, on tractor trains and on sledges. The contents of the pocket kit have been reduced to the minimum to provide a compact, easily handled and generally useful emergency pack. In the early stages of development various forms of packaging were tried, also a variety of different contents. The present form has been used now for some years with little comment or criticism from the users.

The kit is in the form of a match-box type container made of cloth-covered cardboard whose dimensions are 4 1/4" x 3 1/4" x 1 1/8". When packed it weighs four ounces. On the lid is printed a list of the contents with instructions for their use. The contents are:

> Omnopon syringe, salt tablets, indigestion tablets, headache tablets, eye ointment, lanoline or white lipstick, bandaids and elastoplast dressings.

As items are used they are replenished from bulk supplies at the Station or on the ship.

One of the pocket medical kits is exhibited.

A LIGHT-WEIGHT INSULATING FIELD MATTRESS

F. Jacka

Summary

This note describes a light-weight insulating mattress found by A. N. A. R. E. dog-sledging parties to add considerably to personal comfort while sleeping in tents in Antarctica.

Introduction

For field parties without mechanized transport in Antarctica, weight of equipment must be carefully limited. But personal comfort cannot be ignored. To sleep in a tent pitched on snow and without an insulating mattress may cause serious loss of body heat with consequent discomfort and impairment of health.

Description

The mattress developed by A. N. A. R. E. for this application consists of a number of blocks of solid insulator sewn into a cotton fabric covering. The blocks measure 3 inch x 3 inch x 1/2 inch and are spaced about 1 1/4 inch apart to permit the mattress to be folded for packing. Individual units are 5 blocks x 5 blocks with overall dimensions 18 inch x 18 inch as laid out for use. Three such units (or even two, under hip and shoulder) provide adequate insulation under most conditions in which travel by dog sledge is feasible.

The insulating material used is "Onazote", an expanded ebonite of density four lb per cubic ft and thermal conductivity 0.19 Btu/sq ft hr ^{o}F/in. Some other insulators tested, notably expanded polystyrene, were unsatisfactory on account of gradual mechanical failure of the "cell" walls followed by moisture absorption and loss of insulating properties.

By comparison, air inflated mattresses are in general much heavier, less convenient and reliable, and provide no better insulation. With a good sleeping bag the hardness of the A. N. A. R. E. field mattress is, for most men, not uncomfortable.

THE USE OF WOOLEN GARMENTS IN ANTARCTICA

Phillip Law

Wool has long been established as an excellent apparel fibre because garments made from it have characteristic comfort, drape, laundering and handling qualities, shape retention, etc. However, its most important virtue is its warmth. It "feels" warmer than other materials and retains more of its insulating properties when damp.

The physical properties and configuration of wool fibres, yarns and fabrics are such that they entrap large volumes of air, and this leads to excellent thermal insulation. Furthermore, wool has a high affinity for water, absorbing up to 30 per cent of its own weight without feeling wet. This absorption is an exothermic reaction, i.e., it is accompanied by the evolution of heat. The practical significance of this is that on moving from a warm atmosphere at low humidity (e.g., a warm room) to a cold atmosphere at high humidity, moisture is absorbed by the wool with simultaneous liberation of heat, and this effect counteracts that of the cold atmosphere.

Woolen clothing as used by Antarctic expeditions has been criticized in the past for lack of resistance to moth attack, shrinkage during machine laundering, and to a lesser extent the "prickly" effect on certain skins.

The latter defect can be overcome by the use of fine, soft, high quality wool, and choice of suitable yarn and knit structures; and, as a result of technical developments within the last few years, it is now possible to obtain all-wool garments which are completely mothproof, machine washable and machine driable.

Mothproofing

Animal fibres in general, and wool in particular, are attacked by larvae which hatch out from eggs deposited by the adult female clothes moth. However, wool can be made resistant to such attack by depositing on it some substance which is toxic to the larvae, either as a contact or stomach poison. The main difficulty with this in the past lay in finding a material toxic to the larvae which was not removed during laundering or dry cleaning. This difficulty has not been solved.

For woolen garments which are subjected to only a moderate amount of washing, a very simple and inexpensive method of mothproofing is to use an insecticide called Dieldrin. The Australian C.S.I.R.O. has developed such a method, which costs only about 1/4d per lb of wool to give very effective protection.

Garments such as underwear and socks which require very frequent laundering can be given reasonable protection by the Dieldrin method, but a more stable treatment is to use a Swiss development called Mitin. This treatment has a greater fastness to laundering, but costs about 6d per lb of wool to apply.

There is little likelihood of clothing suffering from attack by moth while in Antarctica. It is in store at expedition Headquarters, or during transit in temperate regions, that the damage generally occurs. It is therefore recommended that all woolen garments purchased by an expedition should be mothproofed by the manufacturer. This can be done either before or after the woolen yarn has been made up into garments, but the process is somewhat different in each case.

Shrinkproofing

The surfaces of animal fibres such as wool have a scale-like structure which allows fibre movement and consequent shrinkage when agitated in the wet condition.

Several methods are now available for modifying the surface of wool in such a way that fibre movement is prevented, and in consequence garments made from such wool are shrink resistant. This new property is achieved without impairing the original desirable properties of the wool.

Performance Trials

In recent years a variety of woolen garments with the above new easy-care properties have undergone wearer trials by Australians in temperate regions and in Antarctica, with satisfactory results.

In addition, some trials were carried out by the U. S. Operation Deepfreeze at McMurdo on garments supplied by the Australian Wool Bureau. After thorough testing over a wide range of conditions, the condensed report of the trial was as follows:

> "Shirts and underwear comfortable and do not scratch, durability good, shape retention good, excellent stain resistance and always come out clean after washing in hot water from 10-30 minutes with detergent in an agitator type washing machine. Little evidence of shrinkage despite hard use and laundering".

Future Developments

In recent years underwear made from cotton or synthetic fibres has been manufactured with cellular knit structures or fluffy inner surfaces in an attempt to emulate the warmth characteristic of wool.

Theoretically it seems probable that cellular knit underwear manufactured from wool would be significantly warmer than similar garments from other fibres; or alternatively, an equivalent degree of warmth would be obtained from underwear very much lighter in weight than normal. This possibility is currently being investigated, as shrink resistant wool yarn of a suitable structure is being knitted into cellular-type underwear. Such garments will be subjected to wearing performance trials at our bases.

The collaboration of Dr. A. J. Farnworth of the Australian Wool Bureau is gratefully acknowledged.

A.N.A.R.E. Issue

The following list gives the types of woolen garments issued to A.N.A.R.E. men:

Balaclavas	Wristlets
Scarves, comforter type	Shirts, flannel
Sox	Shirts, worsted, drip-dry
Sweater, crew neck	Singlets, long sleeve
Sweater, roll neck	Drawers, long
Sweater, shawl neck	Drawers, pyjama type, flannel
Mittens	Pyjamas, flannel
Mittens—half finger	Blankets

A BLIZZARD VISOR FOR IMPROVED VISION

H. P. Black

Summary

A face mask enabling the wearer to perform relatively intricate operations, such as the reading and adjusting of instruments in conditions of heavy snowdrift has been devised and tested in winds up to 80 knots during 1960 at Wilkes, Antarctica. Constructional details and suggestions for further development are given.

1. Introduction

The Author's experience in conducting a wind and snow drift gauging programme during the winter of 1960 led to the development of a face mask of novel design.

The nature of the work demanded a device which maintained direct, unencumbered, vision to the maximum degree possible and yet afforded adequate protection from drift particles.

Conventional blizzard masks, designed to protect the face from the elements, failed to solve the problem of vision. Protective goggles tended to fog and freeze or to become encrusted with driven snow. Fur-trimmed parka hoods afforded a degree of protection under some conditions. Peaked ski caps provided a measure of protection from the direct blast while the head was kept averted. The problem of eddying drift particles, however, which minimized vision and in extreme cases impeded breathing, was not overcome by these means.

Literature published on the subject (Climatic Research Laboratory,[1] Environmental Protection Research Division,[2] Remington,[3]) examined since the author's return from Antarctica, consider masks primarily designed for wind chill protection. Protection against blizzard-borne snow does not seem to have been discussed except by Sapin-Jaloustre;[4] none of the masks described appears to be suitable for this purpose. These previous descriptions of polar mask designs refer to the susceptibility of transparent shields or lenses to the fogging process, a problem encountered also in the author's earlier experimental masks. The "open-front" principle of the blizzard visor, however, short-circuits this problem.

2. The Blizzard Visor

The new device is characterized by completely unobstructed vision over a restricted field of view.

The first feature is an upper visor of perspex or similar transparent material which shields the face from the direct blast of the elements. The dimensions of this visor must not be so large that excessive wind gusts are able to exert too much force upon it. The second feature is an "under-visor" which protects the face from the upward-sweeping eddies. Shaped to fit the face, the blizzard visor creates a micro-climate of clement air in front of the eyes and nose of the wearer. It is illustrated in Figures 1 and 2.

It can be designed to enclose the eyes only or, alternatively, both eyes and nose. The advantages of the latter arrangement include protection of breathing and a more comfortable fit, and in practice the model which accommodated both eyes and nose was found to be superior.

The wearer's normal field of vision is considerably restricted, peripheral vision in particular being completely blocked. It should be remembered, however, that the device is designed to provide excellent vision over a small field under highly specific conditions wherein other forms of visual protection may fail completely.

3. Operational Performance

The device was tested in blizzards ranging up to 80 knots and at times in visibility of one metre. Full facial protection was afforded under all conditions except when the visor opening was lifted to face directly into the wind stream. A degree of visibility, restricted solely by the quantity of blowing snow in the air, was obtainable through the open front of the visor. Under some conditions valuable additional visibility was available through the transparent perspex body.

A degree of icing-up occurred at times on the inside surfaces but did not come into contact with the face and no frostbite problem arose. Any accretion of ice was easily cleared from the non-porous material upon return to shelter. Rapid and effective sterilization is readily achieved if required.

Blizzards of severe intensity require the head and features to be entirely covered, mainly by a parka drawn tight to prevent the entry of the all-pervasive drift. This assists in anchoring the visor to the head, and prevents its loss or dislodgement in high velocity winds.

4. Construction

For maximum comfort and efficiency the visor requires nice accommodation to the facial contours of the wearer. Handmade masks can be moulded readily to provide this personal fit; however, a reasonably wide fitting range could be achieved with a standardized model by fastening to its inside edges a strip of foam plastic or similar material.

The original model used at Wilkes was fashioned from thick celluloid; a more robust successor was made from 2 mm perspex. It is desirable, although not essential, that transparent material be used in the construction. It is felt that further improvement could be achieved by the use of unbreakable transparent plastic in order to minimize fragility and simplify mass construction.

In order to produce a hand-made visor from perspex it is suggested that a cardboard model, cut to the dimensions given and fastened together with adhesive tape, be modified until it provides a close fit, enclosing the area of the nose, eyes and lower forehead. Two brass or copper "moulds" can then be shaped by hand to correspond with the upper and lower surfaces of the mask. The two outlines are cut from perspex sheeting, heated to 140°C, covered with cloth and easily shaped by hand over the moulds. Facial edges are padded with foam plastic after the two halves have been cemented together with ethylene dichloride.

The mask is anchored firmly by means of adjustable elastic straps passing behind the head, one at the top and one above the neck. In an emergency a rough visor can be fashioned from any material on the spot which meets the requirements of strength and malleability.

The dimensions of the upper and lower visors of the pilot model are recorded in Figure 3.

5. Adaptations

Despite its open form of construction, the blizzard visor was also found to offer substantial protection against wind chill because its minute micro-climate is readily warmed by exhalation and, to a lesser degree, by body radiation. It is likely that small changes in design would develop an alternative mask which would be of value in solving the wind chill problem in non-blizzard conditions. A greatly-increased field of vision would, however, be required by appropriate enlargement of the facial aperture. Wind chill performance of this mask could not be adequately assessed because the ambient temperature did not fall below zero degrees Fahrenheit in blizzard conditions at Wilkes.

A wind chill mask incorporating oval lens-less individual eye shields on the double visor principle is suggested as a further profitable line of experiment. Another improvement might be the addition of a detachable apron, along the lines of recent U. S. experiments, to cover the lower face and mouth without restricting breathing; ice accretions are collected in a pad of "steel wool" located in front of the mouth. Clearance is achieved by crushing the ice out of the steel wool.

It is possible that a modified form of the visor might also be adapted for sandstorms and dust storm conditions, although it might not function efficiently with particles of such different characteristics.

6. Conclusions

The double visor principle provides a sound basis for an efficient blizzard mask which can materially improve the comfort and efficiency of work in Antarctic blizzard conditions.

With slight modifications the same principle might also contribute to the solution of the wind chill protection problem.

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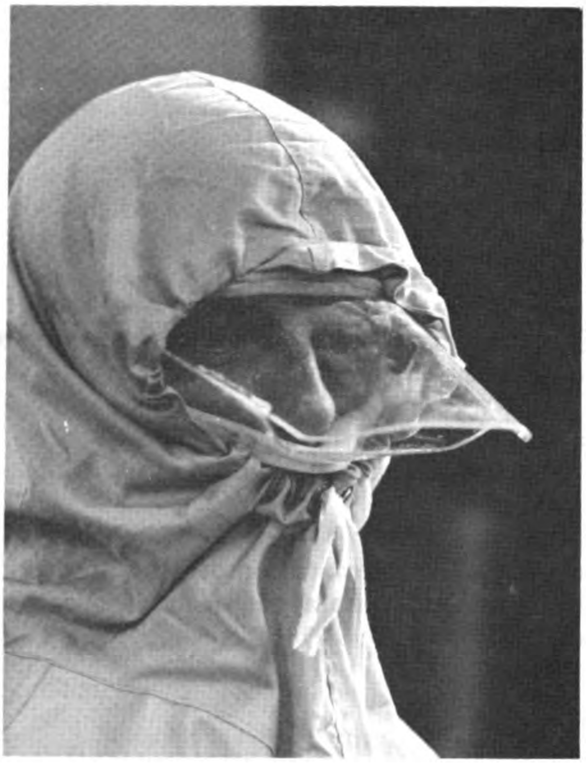


Figure 1. Visor worn with parka.

Figure 2. Visor showing construction and straps.

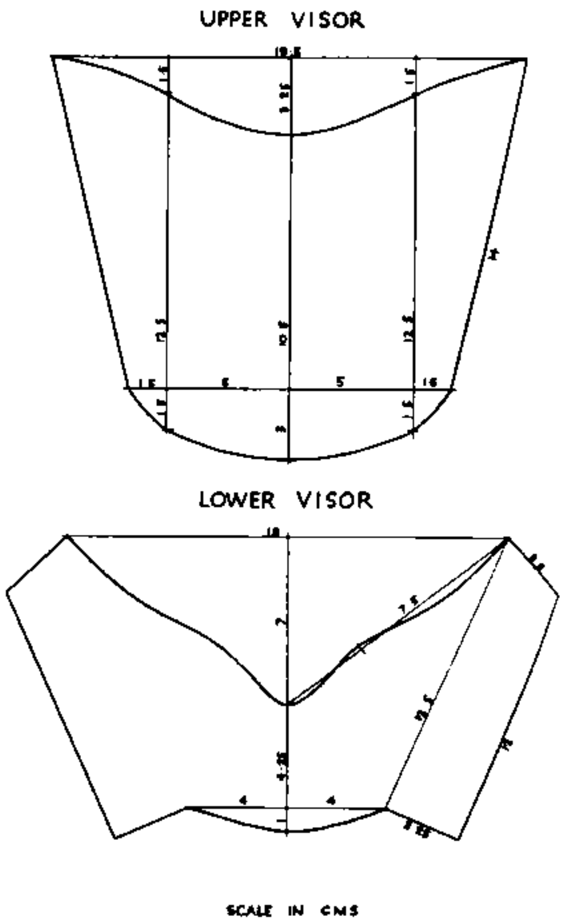


Figure 3. Upper and lower sections showing dimensions.

THE A.N.A.R.E. UNIFORM

Frank McMahon

A.N.A.R.E. men are provided with the uniform shown below. This suit, tailored to measure for each man, serves a double purpose: besides being used as a uniform for formal occasions (such as the departure and return of the expedition ship, formal dinners on board, parties and other celebrations at A.N.A.R.E. stations), it is worn as a semi-working dress or lounge suit by men at stations when they are not involved in heavy outside duties.

The garments are made at the Commonwealth Clothing Factory, South Melbourne, to a design provided by the Antarctic Division. The material used is a sturdy, green, 17-18 oz., water-repellent worsted venetian manufactured to specification by the Yarra Falls Mills, Abbotsford, Melbourne.

Features of the design are: Loose fitting, "action" type, unlined jacket with deep scye raglan sleeves; full belt with buckle and eyelet holes; full zip closure in front; two breast and two skirt flap pockets bagged 8" deep and fastened with leather buttons; snug fitting trousers with side and hip pockets and wide bottoms to allow them to be pulled on over boots or slippers; tabs and buttons to allow loose trouser cuffs to be clasped around ankles; zip fly.

A.N.A.R.E. uniform.

PACKING FOR AIR-DROP

Expeditions Polaires Françaises
Bureau Technique

1. Free-Dropping

For the realization of the International Glaciological Expedition in Greenland 1957-1960 (E.G.I.G.), the operation plan foresaw the delivery of nearly all the equipment and food supplies for the wintering and the summer expedition exclusively by air the total being approximately 5,000 parcels of which more than 4,000 boxes.

Experience gained in the free-dropping technique by the French Polar Expedition between 1949-1951 in Greenland, permitted to adopt this method in an endeavor to generalize its application for the reasons quoted below:

> Economy of parachutes (expensive equipment);
>
> simplification of aerial operations by the suppression of the preparation of parcels; facility of loading the aeroplanes; saving in cargo weight and volume, however, part of this advantage is absorbed by the necessity of providing special packing; facility of dropping; saving in flying hours by a reduction of time actually spent above the dropping zone;
>
> simplified picking-up procedures; no parachutes to be seized and recovered; dropping possible even in strong wind.

When it was decided to generalize free-dropping methods it became necessary, for reasons of safety, to reconsider the packings used previously. In fact, although free-dropping methods of gasoline containers had been fully developed in 1951, the dropping of boxes had given too irregular results and required perfecting.

2. Packing Tests in France

These tests involved the types of boxes as well as the packing materials inside the boxes.

The dropping tests were made from the twin-boom box-car of the type Nord 2,501 plane to be used in Greenland. These tests took place in winter, in the mountains, under more severe conditions than in Greenland (drop zone too short, inadequately cleared, limiting possible changes in aeroplane altitude and speed while repeatedly passing over the dropping zone; surface of snow very irregular).

These tests gave the following results:

2-1. Box Test

Ordinary crates of wooden boards, even stiffened, must be discarded because they burst open at the impact (this bears out evidence obtained in Greenland in 1951).

Plywood boxes gave the best results, although irregular, seemingly bursting open whenever one of the corners of the box struck the ground.

The cylindrical drums in peel wood gave good results, but the cover had a tendency to come off under the impact (this bears out evidence collected in Greenland in 1951). These very drums, protected by wooden bars nailed cross-wide on the bottom, the cover and four generatrixes of the cylinder, gave excellent results (packing already used in Greenland in 1951). But this packing method is not very convenient (cylinder) being responsible for a substantial lost in volume (wooden bars) and a high cost of labor.

Excellent results were obtained with a type of box not available on the market in 1951: light boxes, in peel wood, reinforced with iron wire. It is this type of box which was adopted.

2-2. Tests of Packing Materials

It was confirmed that all elastic materials (such as foam rubber) must be discarded because of rebound shocks.

Granulated materials seemed to be very little reliable, in view of possible changes in the homogeneity of stuffings during transport (apparent shifting due to vibration).

Fiber gave good results variable, however, with the quality (uniformity) of the stuffing.

The importance of a constant thickness of the material to achieve the most regular shock-absorbing action throughout was substantial, by the excellent results obtained with the "Fibrenap" which was adopted as the packing material.

2-3. Other Evidence

Ball-accelerometers, placed in the boxes so as to record accelerations along the three axes at the time of impact, revealed large differences in accelerations, of from 125 g to 300 g. The contents of the boxes of food rations submitted to accelerations of 300 g were nevertheless found intact.

The box shape which, for a given volume, seemed to give the best results was that nearest to a cube.

The best results were obtained with boxes of approximately 20 kg.

The most satisfactory dropping altitude for parcels of this weight ranged from 25 to 30 meters, the speed of the aeroplane with the respect to the ground being as low as possible (about 200 km/h for the NORD 2, 501).

3. Packing Adopted for Free-Dropping

The packing method was therefore as follows:

3-1. Box (see photos)

Light boxes in peel wood (4 mm thick), all sides being connected by three or four parallel wire strands, clamped onto the wood. These boxes are delivered flat, and are assembled by folding the iron wires around the side joints. The box is closed by slipping the free end of a wire into the loop of the other end. Thus, once closed, the box is surrounded by three or four iron wires.

At each end perpendicular to the direction of the wood fiber the box panels are bounded by wooden bars. These bars, once the box is assembled by folding, form a frame which stiffens the two sides of the box.

In addition to its very low weight (1.700 kg for the box of 60 dm^3 capacity) this box is also remarkable for its great resilience which enables it to withstand large deformations without damage.

Built on mass production lines, it has moreover the advantage of being very cheap.

3-2. Packing Material "Fibrenap" (see photo)

The Fibrenap has the aspect of a sheet of wood fibre of constant thickness, little compressed, very flexible, enclosed in a sheet of kraft paper. There are several widths (12, 20, 30, 40 and 50 cm) for a single, constant thickness of 5 cm. It is delivered in rolls of 30 meters and is easily cut with a blade.

The use of this material warrants packings of constant thickness with correspondingly uniform storing and propping.

3-3. Conditioning (see photos)

3-3-1. Padding of Cases. The assembled cases are padded with two strips of "Fibrenap": one strip covers the three lateral sides; another strip covers the bottom and the fourth lateral side and is folded over the box content to pad the cover.

3-3-2. Packing of Products. Every product to be packed is wrapped up individually in a strip of "Fibrenap" of appropriate size (for the padding of E. G. I. G. food rations prefabricated standard strips were the only one used). This wrapping method is expeditive, and there is no need of wrapping by crossing the strips as long as the width of the single strip widely overlaps the packed item. If the cases are not packed right away, rubber bands are used to keep the "Fibrenap" in place.

For the packing of complete cases of tins (cases of beer and wine in tins for the summer expedition and all the cases of tinned food for wintering) a single strip of "Fibrenap" is used, following a sinusoidal pattern between the cans.

3-3-3. The closed case is circled with two metal bands whose sole purpose is to avoid the opening of the cover at the impact on the ground. These bands in no way increase the resistance of the case.

4. Obtained Results

Out of 4, 000 cases of E. G. I. G., 3, 000 were of this type, prepared to be dropped; 2, 800 were free-dropped.

4-1.

The general results were excellent, since the constitution of all the depots of the summer expedition and the delivery of all the food supplies for the wintering, were effected according to plan. The total loss averaged 5 per cent, although losses during each dropping differed widely.

The loss was nil under the most favorable conditions quoted below achieved as a rule in the central part of the Inland: density of snow to a depth of 0. 50 m, between 350 and 370 g/dm^3; speed of aeroplane, 200 km/h; dropping altitude 30 meters.

The scoring of good results is therefore directly related to compliance with dropping instructions given by the aeroplane pilots, who should rely on direction broadcast from the ground: estimation of dropping altitude, of the quality and condition of the snow surface, compliance with speed instructions and stacking of successive runs over the drop zone to avoid dropping on equipment already on the ground, etc...

4-2.

Products contained in the burst cases were retrievable, the tins of food or other packages having little suffered in general or no damage at all.

4-3.

Particular attention should be given to the conditioning of certain products: items packed in tubes are fragile and may be crushed by near-by tins; it is therefore preferable to use, for example, concentrated milk in tins rather than in tubes. Paper boxes are not to be used or if this cannot be avoided, it is imperative to provide extra packing so that the food stuff may be retrieved (e.g., macaroni); polyethylene bags used for that purpose during E. G. I. G. were satisfactory, but they should be considerably larger than the boxes which they surround, and they should be flattened before sealing to expel air.

4-4.

The boxes should be tightly packed and the hoops drawn reasonably taut. Transport and handling cause a settling of packing material and the hoops become loose.

5. General Conclusions

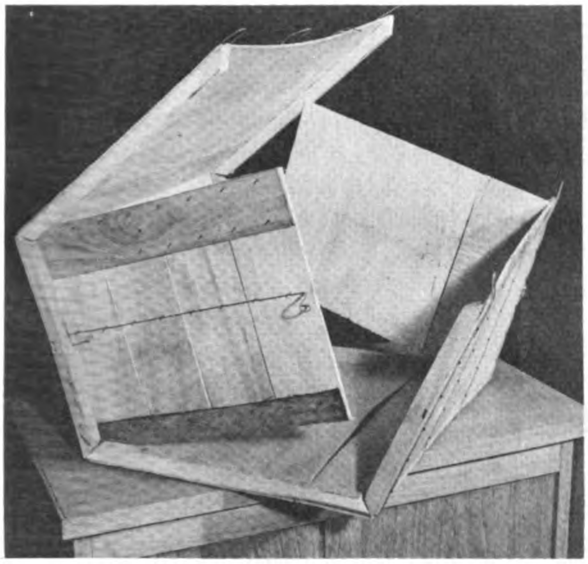
Free-dropping is of indeniable interest both in the field and financially speaking.

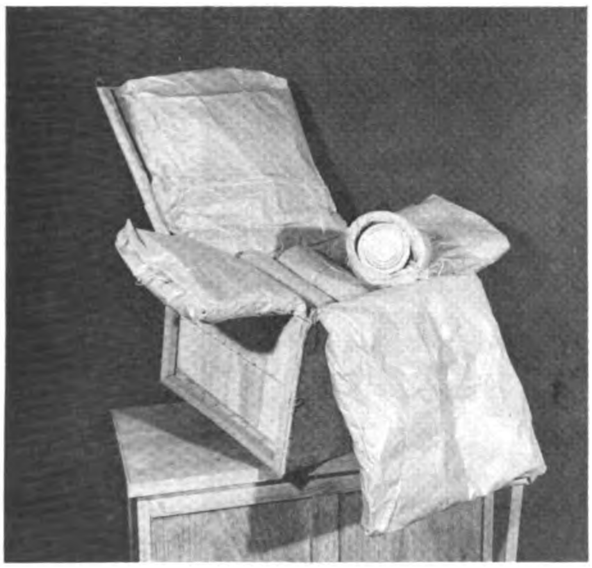
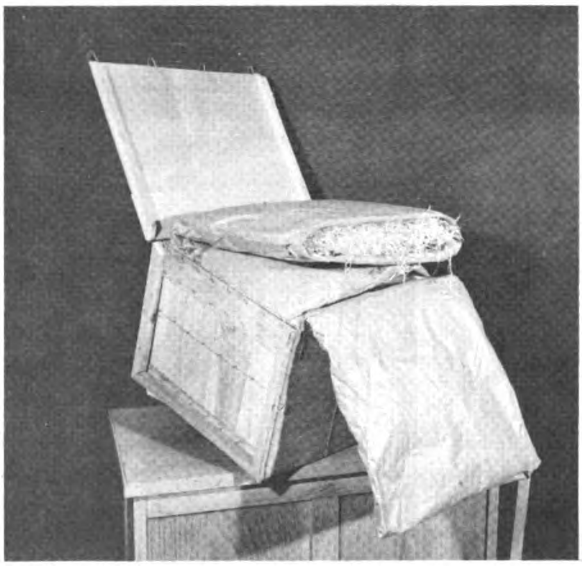
Its use can be extended in polar operations to a large variety of products representing heavy tonnages and large bulks, provided the following two conditions are strictly complied with:

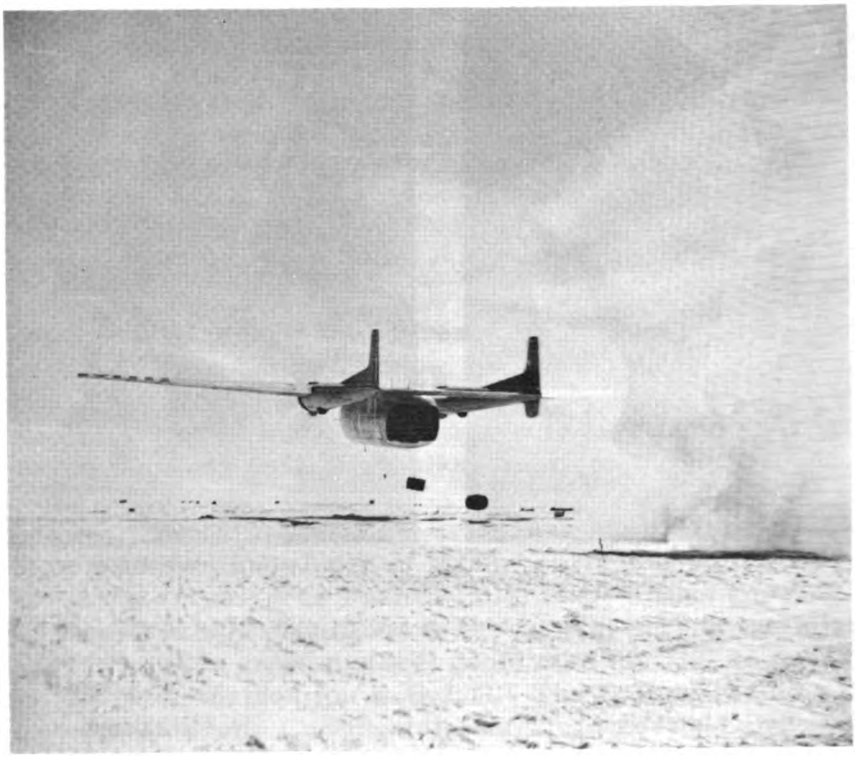
1. To have a perfect knowledge of ground surface conditions prevailing in the dropping areas. The French Polar Expeditions knowing, by experience, these surface conditions in the central part of the Inlands of Greenland (good powder snow surface) could take the risk to generalizing the use of dropping method for E. G. I. G. The E. P. F. would not take this risk on the Antarctic Continental Plateau in Adelie Land: on the greater part of the territory, the neve surface, extremely hard, furrowed by deep sastruggi, would cause a prohibitive percentage loss. The nature of the snow is the first cause for deception.

2. Good crews proficient in this method of operation is essential. A missed dropping is the second cause for deception.

If the two series of conditions are fulfilled, the described packing method (cases and packing materials and methods of use) should be satisfactory for the free-dropping on snow.





NOTES ON THE "ANTAR" AND "ASTROLABE" TENTS

Expeditions Polaires Françaises
Bureau Médico-Physiologique

1. The Antar Tent

This tent was perfected and tested by its constructor (Monsieur Robert ANDRAULT) and by the "Expeditions Polaires Françaises".

It was used by all the polar expeditions in Adelie Land and to a greater extent during earlier expeditions which used dog teams to pull the sledges.

It has always proven highly satisfactory under all conditions.

For example, a tent of this model was put up on the antarctic continental shelf north of Port-Martin and left uninhabited for a year. Next season it was found absolutely intact.

It meets the following specifications:

Resist to winds up to 150 km per hour
Very rapid and simple assembly
Easy transport by dogs sledges
Blizzard proof

This tent has many other characteristics which are less important but nevertheless essential but it is not our purpose to describe them here.

The ANTAR tent is a four sided regular pyramid, square base: 2.20 m, height: 2.20 m.

Framework

Entirely in harden duralumin AU 4G; diameter: 20/22 cm; weighing 178 g to the meter; resistance: about 50 kg. The four masts forming the ribs of the tent are hinged to a summital compass with four directions.

For the transport the masts are separable in two parts; upon arrival they are mounted and attached to the tent by covers. The lower base of these masts are terminated by a 10 cm long steel tip which goes through the ground protection cloth by means of eyelets set for this purpose at each angle.

The compass is crowned by a 10 cm diameter wood sphere supporting the tent and with enough surface to resist the effort at the top of it. This compass is extended through the sphere by a strong tubular element receiving the mooring guys.

The tent and the ground protecting cloth is one piece which takes its pyramidal form when the interior framework is set completely.

Tension of the cloth is easy to obtain along the masts but it is much more difficult to get complete tension on each triangular side. That is why the following devices are added: to each mast two tabular lodgings are attached; their axis are parallel to the one of the mast. They are situated approximately half way between the summit and the base; these lodgings receive four tubular bars, called tension bars, which are parallel to the base of each side when in position.

They have a triple role:

1. greatly reinforce the strength of the frame;
2. give the tent its perfect shape;
3. allows maximum tension of the cloth, favorable to good resistance to the wind in increasing the tightness.

The setting of these tension bars is easy because of the rotation of the two lodgings around the axis of the mobile part of the masts. When the four bars are set you obtain the maximum tension of the cloth of each side by rotating the lodgings of the masts in the opposite way than the one to set them on the first place.

All these maneuvres are very easy to do even with mitts.

Note that all metallic parts which might have a chance to be handled are isolated with cotton tape covers impregnated with stabilized linseed oil in order to prevent frost-bite even to bare hands.

Tent

The ANTAR pyramidal tent is built in high resistance cotton cloth of orange coloring, dynamometric resistance: 120 kg, square meter weight: 300 g, double nylon sewing.

The ground protectory cloth is in synthetic material and is coated. Dynamometric resistance: 150 kg, square meter weight: 370 g. It is set to the tent in the form of a wash basin with 20 cm elevated sides.

The center surrounding of the tent is fringed with a large "bib" in the same cloth as the ground protection. It has fixation straps and rings. The fringe is foreseen to subdue the base of the tent by weights as the sledges, cases, containers and of course snow or ice.

In order to obtain a certain isothermy the ANTAR tent has double walls. It is doubled on the inside by a vellum with a homothetic form to the one of the tent

(Egyptian cotton; "Super Thibet", 120 g to the square meter). The base of the vellum is hooked permanently to a small hand of cloth parallel to the bottom of the tent and at about 5 to 6 cm from it.

The top of the vellum is tied to a woven cotton tubular cable which slides in a ring hooked at the base of the tent's compass. To lift the vellum just pull the cable.

Note that the vellum being set only when the tent is in place there is all the possible room needed for the assembling. This vellum is detachable and therefore clearable.

The access to the tent is by an elliptical opening followed by a tunnel 1.50 m long which is rolled on itself and closed by a string, giving therefore an absolutely perfect closure.

The vellum has the same kind of opening with the same kind of tunnel situated inside the tent's tunnel. Needless to say that one can shut the access to the vellum without shutting the access to the tent.

There is a ventilation at the top of the tent which can be closed with a system similar to the door, that is with a rollable tunnel which can be operated either from inside or from outside.

Note: The ground protecting cloth has two diagonally disposed strap-doors: one to pick up snow or ice, one used as garbage hole; when it is impossible to go out. Series of rings is provided for between the tent and the vellum to hook the dogs harnesses or any other things not needed immediately, leaving the most possible living space.

Mooring

It is supported by four guys which are 10 m long nylon cords, red colored and being 6 mm in diameter. Resistance: about 400 kg for a weight of 16 g to the meter.

They are connected on one side to the extreme part of the mast compass, on the other to steel pegs in the ice. Swiveling around the mast tip they can be oriented at any moment.

Assembly

The ANTAR tent is created for three persons but can eventually admit a fourth one.

When packed it has the shape of a small boat 2.80 m long, thin at one end, 40 cm in diameter at the other. It is transported like that. Its weight about 20 kg.

The assembly of the ANTAR tent can be done very rapidly by three persons even with strong winds (10 minutes).

Put the four nylon guys flat on the ground ready to be stretched when the tent is upright. Maintain the tent vertically—two persons—and open it as umbrella as fast as possible to allow the third man inside where he spreads the masts towards the outside helped by the two others remained outside. The limit of the four masts is the ground protecting cloth which then takes its square shape.

Then hook the four guys and stretch them properly—the two men outside.

If the wind is terribly strong, the man inside can help by pulling with all his weight the cord which is used to lift the vellum, previously noted this cord slides at the base of the summit compass.

This man, finally, sets the four tension bars which give the final shape and assure the tension of the cloth.

The two men after finishing the mooring can enter the tent.

2. The Astrolabe Tent

This tent was designed to operate scientific measures and still being relatively protected.

The ASTROLABE tent is built the same way as the ANTAR tent but has these particularities:

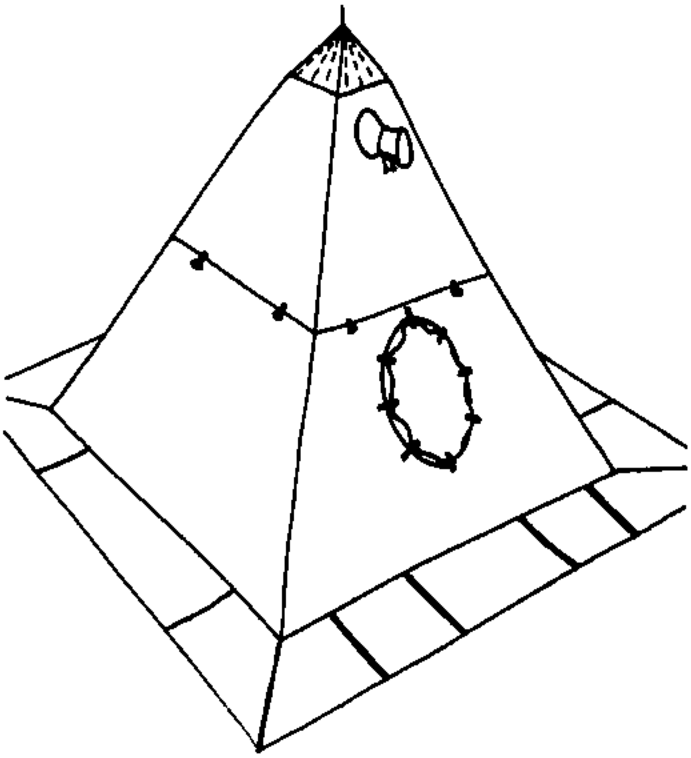
The extremity of the masts, the compass side, is foldable towards the outside.

When the roof of the tent is open, it looks like two pyramid frustums opposed by their small base. The superior part of the tent is therefore liberated completely allowing the use of scientific instruments.

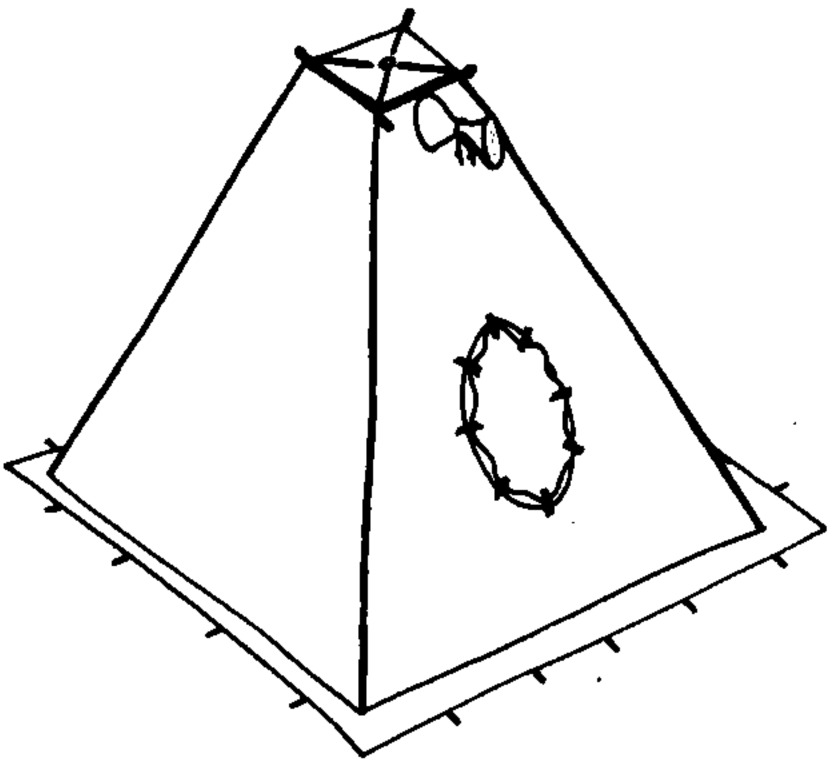
In other circumstances the ASTROLABE tent is used as an ANTAR tent; the superior parts of the masts are folded towards the inside joined together at one point.

The tightness is obtained by adding a sort of a cap which covers all the tent summit and which is hooked to it by cords, specially, along the masts.

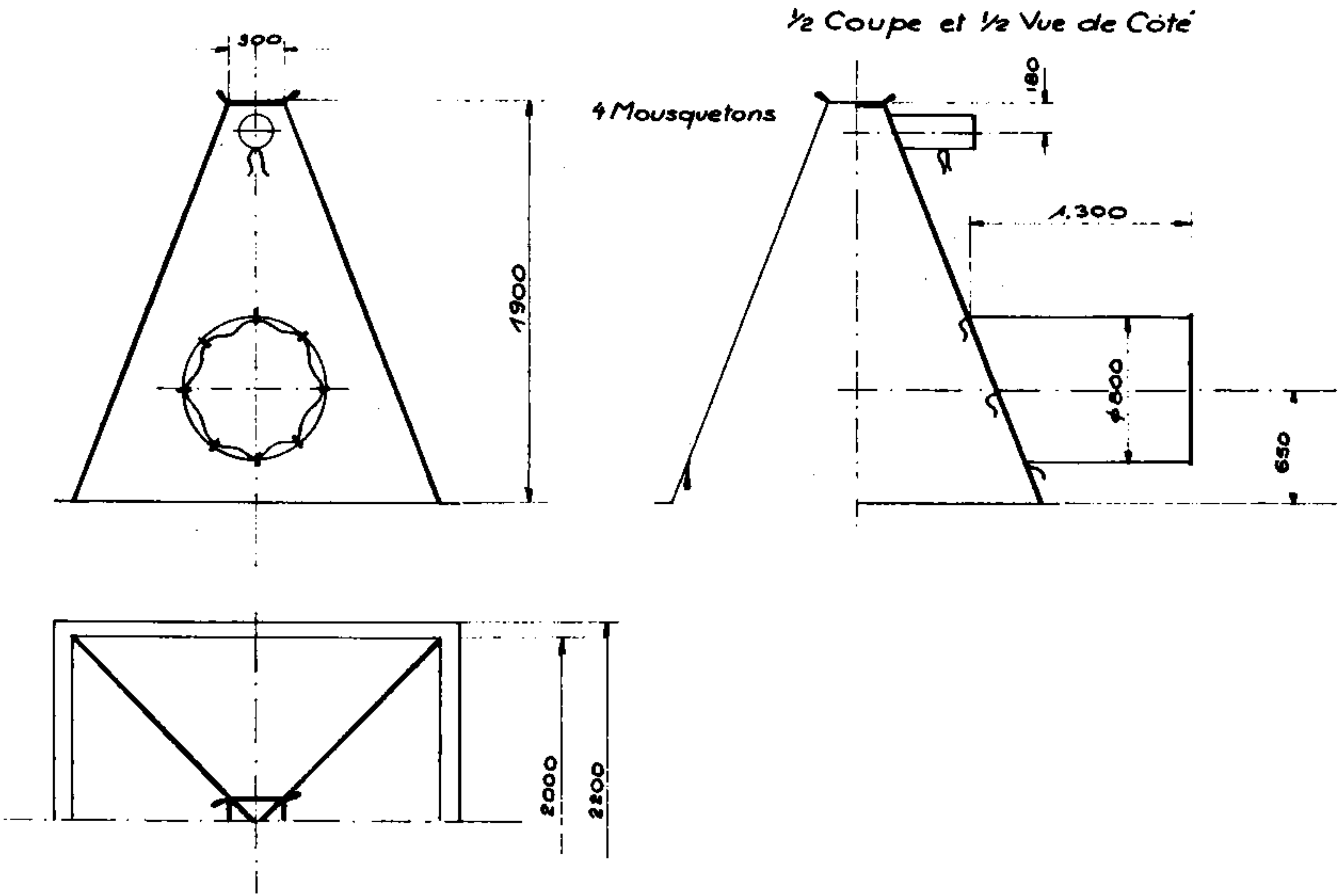
It is obvious that this tent does not give the same security or living space as the ANTAR for personnel who would have to live in it.



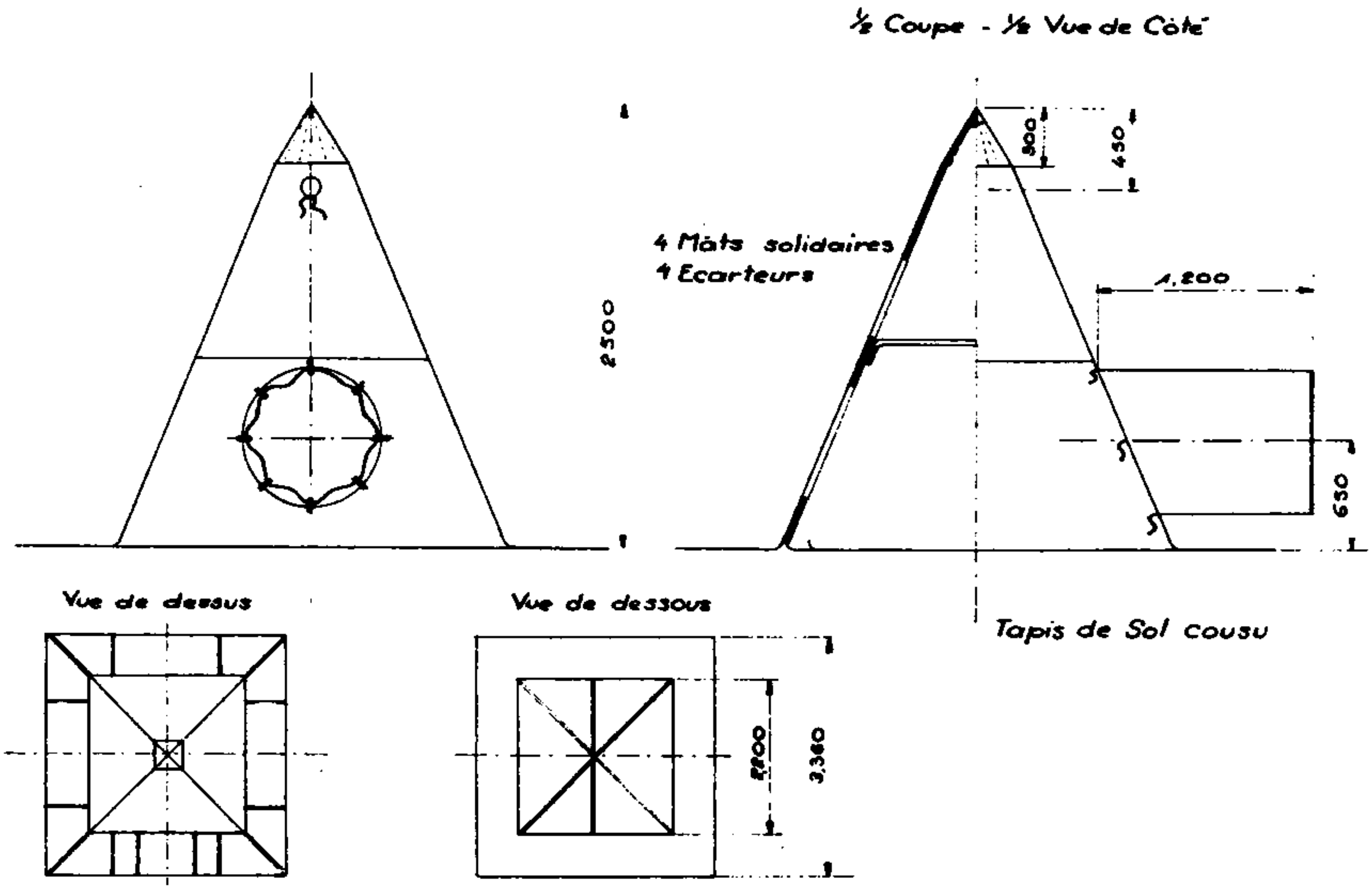
Tente Pyramidale—Typé Adelie. Tapis de Sol cousu à la tente.



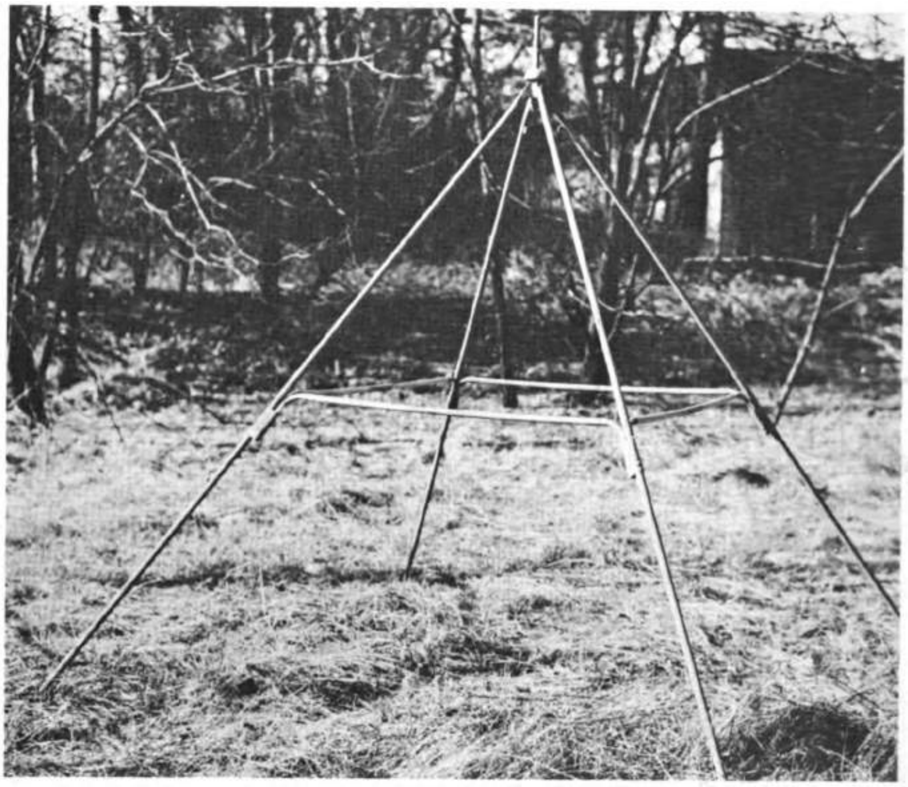
Velum Tente Pyramidale Type Adélie.

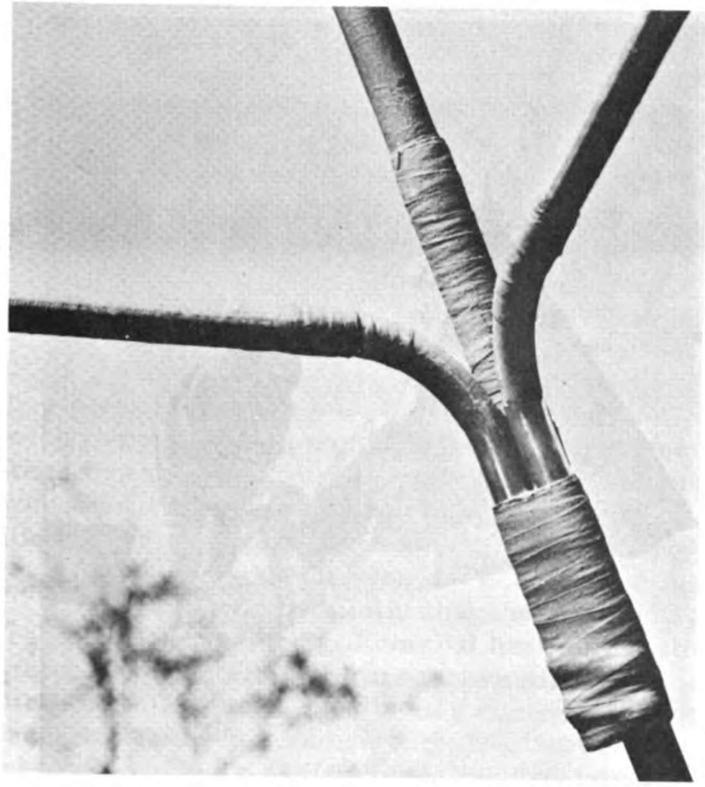


Velum Tente—Pyramidale—Type "Adelie".

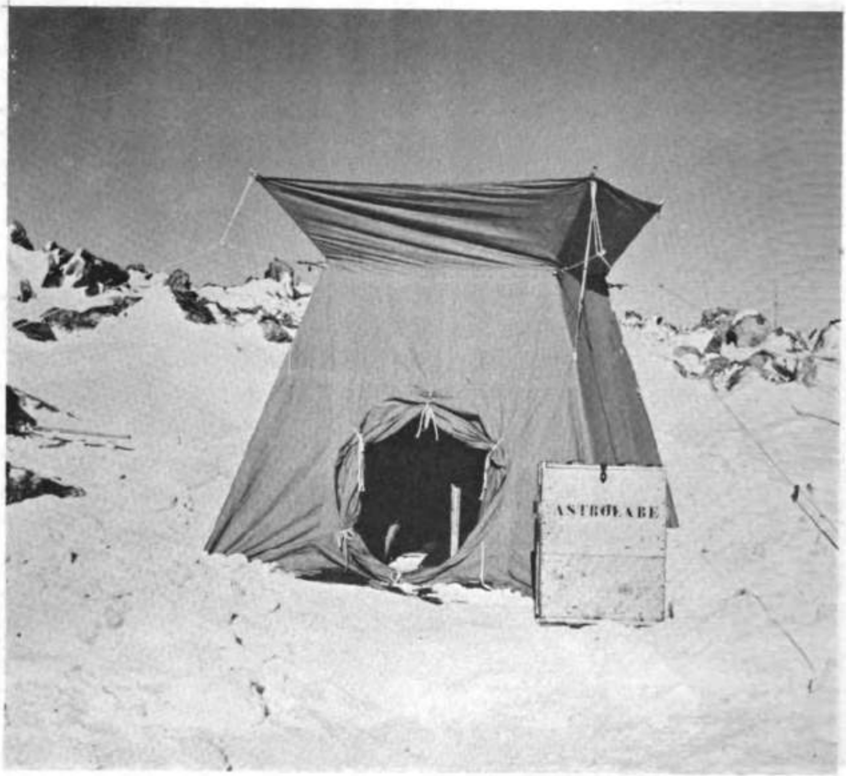


Velum Tente—Pyramidale—Type "Adelie".






M2


ASTROLABE

E. G. I. G. RATIONS

Jean Rivolier

1. The Problem

We wish to present this paper because it represents the report of a logistic study related to rations for tractor land traverses. This has many aspects of interest both from a practical and methodological point of view by presenting a type of given solution to an exact problem whose objectives are established in advance. It is of interest also because of the type of research the means of control and the exploitation. We certainly do not claim that the solutions given here are the best, and even less, that the methods of control have any statistical value. What interests us is to show the intellectual process applicable to a problem such as food in polar countries, which has always been a controversial question. For us it is not a medico-scientific problem, nor a sample dietetic one, which we seem to have been solved for food, but a psychological and technical one. That is when we wish to open the discussion once again on the question of food, which we would never do if it were a matter of again discussing the problem from a scientific and nutritional point of view. We thought it useful to present this study in a complete form with all details, without which it would not be of interest for the other members of this symposium.

1-1. The Expedition

The International Glaciological Expedition in Greenland (E. G. I. G.) during the summer campaign, was composed of 52 members, ranging from 19 to 57 years of age, out of which only 45 had been given the referendum, namely 34 French and 18 Germans, divided into eight groups. These groups lived in wannigans tracted by weasels going towards the Ice Cap, that is to say, with simple culinery equipment during an expedition that spent most of its time in travels. The trip lasted 180 days. The supplies were assured by air-planes which dropped the consumable material, that one of the group stored in a depot. This food was shipped to Greenland by boat the year before and stocked during a year.

1-2. The Choice of the Rations

a. Due to reasons given above, we rejected the method of supplying food in bulk, since it appeared that an unequal supply of food to the various groups during the course of the journey would occur very quickly. We adopted the idea of a full ration, which would be a real meal and not simply snacks prepared in advance and supplied in a certain quantity in proportion to the number of people and the days of land traverse. A ration of 3 men/2 days was chosen. This unity corresponded to the largest number of men per group, to the most common commercial presentation of the products and to the simplest packaging (Mussy crates of 12 to 13 kg and a volume of 20 dm^3). This presentation had the advantage of having great solidity, which was extremely important, because of the dropping of the rations.

b. The theoretical ration was established to around 4, 000 calories per man per day, with the idea that no set proportion would be established for the use of various principal foods, as we simply tried to make the meals as close as possible to those in ordinary life. Nothing was provided regarding special or concentrated food, as we tried to present the food in its normal appearance, the matter of weight was only relative importance in this type of tractor expedition.

c. On the other hand, it was understood that the desired aim was acceptability. Not wishing to exaggerate by using the term gastromic, we nevertheless wanted the food used during this expedition to be pleasant to conform to the tastes of the nationalities in the group. The problem was this: on one hand, to give homogeneous prefabricated rations which would not allow individual selection; but on the other hand, we must repeat, to satisfy the taste of all the participants. Three corollaires made up and complicated this assumption:

Ease of cooking and of preparation

Satisfactory preservation and resistance to the cold

Buying of ordinary produce at normal prices corresponding to the usual criterium of manufactured foods:

8.14 NF per man per day for the ration
0.32 NF for condiments and alcohol
0.80 NF for wine and tobacco

The ration of surviving amounted to 11, 36 NF.

1-3. The Controls

We made a control, so that the experience was not in vain and we arrived to a methodological end. During the expedition, one of the doctors interviewed several times the groups, so that he knew the immediate reactions of the people to the food given to them. When they were back, a referendum questionary was sent to all the members of the E.G.I.G., in order to have precise and personal details. Finally, some rations which remained another year in the area, were brought back to France and sent to a laboratory in order to study the state of conservation.

It would have been desirable to submit a detailed questionary to all the participants before leaving, not for choosing the items of the rations, but to compare it to the return questionary. This would have been a very interesting psychological experiment: however, this was not possible due to lack of time.

1-4. The Results

In general, the rations have been a pleasant surprise for the participants and the general opinion on it was excellent. But regarding particulars, there were many criticisms, as could be expected. We are presenting here, only this critical aspect, but since it is understood, in spite of everything, on the whole, "the client was satisfied."

This experiment lead to practical results (manufacturing of new rations for the future and packaging) as well as to psychological, logistical and methodological results.

2. The Rations

2-1. Packing

Having to send the rations Inland by plane, the packing was specially prepared to allow the best use of free-dropping, the use of parachutes being impossible because of their excessive cost.

For the choice of the boxes and the outside packing, some tests were made with the help of the technical service of the Army and with the use of some planes as those used afterwards in Greenland. After these tests, the following types of packing were adopted:

> Boxes made in peel-wood reinforced with an iron wire, bearing the best resemblance to a cube, bound with 2 strap-irons to avoid opening at impact.
>
> Individual packing with "Fibrenap" of each item in the box and padding of the box with "Fibrenap" (the "Fibrenap" is a mat of wood fibre of uniform thickness wrapped in kraft paper).

A packaging track has been set up at the E. P. F. for packing 1, 200 boxes of rations for the land traverses, 311 boxes of beer, 158 boxes of wine (and 1, 116 boxes of food for the wintering).

Some products (either too many originally in one ration, or not solidly enough packed) were repacked with polythen.

2-2. Menus and Rations

1. The rations contained approximately 4, 200 to 4, 400 calories per person per day for a weight of about 1.400 kg to 1.600 kg per person per day.

The choice made was for a type of ration made unvaryingly for three persons for two days, for the following reasons:

Short stay rations (two days) to avoid waste; the food not used immediately of each open package was considered as lost on the way.

Uniform rations of 3 men x 2 days, in order not to add to the types of rations.

A type of rations more satisfactory 2 men x 2 days (easier utilization with multiple of 2) could not be retained; the weight of the canned food necessary for this type of ration does not correspond with these usually found in shops.

To diversify the meals, five different rations were established, named M1 to M5. Each ration was established according to a standard menu given only as an explanation.

A stock with complementary base products (butter, pastes, jams, sugar, cheese, concentrated milk) was at the disposal of the people when passing through the wintering station. Some products were taken out of the rations, to avoid waste and package difficulties. They are:

Alcohols and condiments (salt, spices, sauces, etc...). These products were divided at the departure from BW 8 at the rate of one box per wannigan for 6 men x 10 weeks, that is about the middle of the summer campaign. A second box per wannigan covering the needs until the end of campaign was put at the disposal of each group when passing through the wintering station which was always located approximately at the middle of the summer campaign.

Drinks: They are composed of beer in cans of 35 cl and concentrated wine of 21^{o} in cans of 1 kg (content 0.800 l, which mixed with water gives two litres of wine of 10^{o}). The daily ration per man is 1/4 l of wine and one can of beer. The user can choose either 1/2 litre of wine or two cans of beer. The boxes of wine stamped M7 contain ten cans, the boxes with beer stamped M6, 20 cans.

It is noticed that the food rations (M1 to M5) contain tea, Nescafé, Ovomaltine, concentrated milk or soluble powders to make orangeades and lime-ades.

Tobacco: The daily ration is one packet of cigarettes per day per man (or the equivalent in tobacco).

The dividing of English or American tobacco and French tobacco was done at the proportion of 45 per cent against 55 per cent.

The tobacco is divided among the various groups, according to the number of people, in two:

at the junction, at the beginning of the summer campaign;

at the passage of each group at the wintering station, about the middle of the campaign.

It is to be noted that some canned foods originally selected for certain rations were replaced by others at the last moment, because of supply difficulties. The result was an error in certain products by the duplication of the contents of rations which theoretically were supposed to be different (for instance the lentils).

2. Survival rations. To insure the security of the crew and helicopter passengers in case of accidents, and to assure also additional security at the terminal points of the axis N-S and W-E (junction—North Point—Cecilia Nunatak), a survival ration was made, composed exclusively of very concentrated food.

The content is given below.

A ration covers the minimal survival food needs for two men for two days. There are four rations by box.

Composition of the Rations

Menu M1

Composition of the Meals:

	First Day	Second Day
Breakfast:	Milk Nescafe Ovomaltine Strawberry jam Butter Sugar Biscuits	Milk Nescafe Ovomaltine Strawberry jam Butter Sugar Biscuits
Snack:	Tea Milk Chocolate Coppa Biscuits Lemon soda Pears with syrup	Tea Milk Chocolate Coppa Biscuits Lemon soda Pears with syrup
Lunch:	Mackerel Beef with carrots Camembert Biscuits Fruit sweets	Sardines Sauerkraut Camembert Biscuits Fruit sweets
Supper:	Meat extract Pemmican Sausages Beans Biscuits Sweets Camembert	Meat extract Pemmican Chitterlings Spinach Biscuits Sweets Camembert

Composition of the Ration:

Designation	Weight in g
Biscuits	720
Sugar	300
Butter	400
Concentrated milk	330
Nescafé	50
Tea	25
Strawberry jam	500
Pears with syrup	500
Eating chocolate	300
Candies	150
Meat extract	40
Pemmican	450
Camembert	480
Ovomaltine	400
Lemon soda	300
Coppa	500
Beef with carrots	900
Mackerel fillets	125
Sardines with olive oil	125
Sauerkraut	870
Spinach	870
White beans	900
"Frankfort" sausages	350
Chitterlings	350
Total	9,935
Total Calories	27,305

Menu M2

Composition of the Meals:

	First Day	Second Day
Breakfast:	Nescafe Tea Oat flakes Milk Butter Soluble cocoa Sugar Biscuits	Nescafe Tea Oat flakes Milk Butter Soluble cocoa Sugar Biscuits
Snack:	Raspberry jam Hazel nuts, almonds Dry sausage Orange soda Biscuits	Raspberry jam Hazel nuts, almonds Dry sausage Orange soda Biscuits
Lunch:	Tunny with oil Sausages with lentils Goat cheese Sweets Biscuits	Mackeral with "milanaise" Sausages and beans Goat cheese Sweets Biscuits
Supper:	Chicken soup with vermicelli Egg powder Tripes Green peas "Mont Blanc" cream Biscuits	Bok soup Potatoes Kidneys with mushrooms Goat cheese Biscuits

Composition of the Ration:

Designation	Weight in g
Biscuits	720
Sugar	300
Butter	400
Tea	25
Nescafé	50
Concentrated milk	330
Orange soda	300
Soluble cocoa	125
"Mont Blanc" cream	350
Nuts and almonds	300
Chicken and vermicelli soup	150
Bolk soup	150
Goat cheese	480
Candies	150
Oats flakes	300
Egg powder	200
Sausages	500
Sausages with lentils	860
Tunny with olive oil	125
Mackerel	200
Sausages and beans	870
Green peas	870
Tripes	450
Kidneys with mushrooms	870
Raspberry jam	500
Total	9,800
Total Calories	27,750

Menu M3

Composition of the Meals:

	First Day	Second Day
Breakfast:	Tea Milk Nescafe Ovomaltine Chestnut cream Butter Sugar Biscuits	Tea Milk Nescafe Ovomaltine Chestnut cream Butter Sugar Biscuits
Snack:	Milk Figs and dried currants Potted mince (pork) Orange soda Peach jam	Milk Figs and dried currants Potted mince (pork) Orange soda Peach jam
Lunch:	Mackerel Cold chicken "Munster" Biscuits Toffies	Meat pie Marengo veal Vegetable hotchpotch "Munster" Biscuits Toffies
Supper:	6-vegetables soup Corned-beef "Munster" Biscuits Toffies	Mushroom cream Pork "Soma" "Munster" Biscuits Toffies

Composition of the Ration:

Designation	Weight in g
Biscuits	720
Sugar	300
Butter	400
Nescafé	50
Tea	25
Concentrated milk	330
Ovomaltine	400
Orange soda	300
Chestnut cream	350
Figs, dried raisins	300
Toffies	150
Peach jam	500
6 vegetables soup	150
Munster cheese	480
Mushroom cream	150
Rillettes	420
Chicken with jelly	720
Mackerel fillets	125
Pies	140
Marengo veal	440
Vegetable hotchpotch	500
Dehydrated powder potatoes	150
Pork cutlet	450
Corned beef	340
Total	7,890
Total Calories	25,980

Menu M4

Composition of the Meals:

	First Day	Second Day
Breakfast:	Nescafe	Nescafe
	Ovomaltine	Ovomaltine
	Milk	Milk
	Sweet orange jam	Sweet orange jam
	Butter	Butter
	Sugar	Sugar
	Biscuits	Biscuits
Snack:	Tea	Tea
	"Nougat"	"Nougat"
	Cooked ham	Cooked ham
	Biscuits	Biscuits
	Lemon soda	Lemon soda
	Raspberries with syrup	Raspberries with syrup
Lunch:	Bologna sausages	Tunny fillets
	Braised beef	Pork with lentils
	"Petit Bourgogne" cheese	"Petit Bourgogne" cheese
	Biscuits	Biscuits
	Assorted sweets	Assorted sweets
Supper:	Onion soup	Asparagus cream
	Black pudding	Sausage with lard
	Pastes	Precooked rice
	"Petit Bourgogne" cheese	"Petit Bourgogne" cheese
	Biscuits	Biscuits
	Assorted sweets	Assorted sweets

Composition of the Ration:

Designation	Weight in g
Biscuits	720
Sugar	300
Butter	400
Nescafé	50
Sweet orange jam	500
Nougat	300
Onion soup	150
Asparagus cream	150
"Petit Bourgogne" cheese	480
Assorted candies	150
Ovomaltine	200
Lemon soda	300
Cooked ham	450
Braised beef	900
Pork with lentils	900
Bologna sausage	150
Tunny fillets	125
Black pudding	200
Pastes	250
Sausages with lard	350
Precooked rice	250
Concentrated milk	330
Raspberries with syrup	500
Tea	25
Egg powder	200
Total	8, 330
Total Calories	26, 875

Menu M5

Composition of the Meals

	First Day	Second Day
Breakfast:	Nescafe Tea Milk Honey Butter Sugar Biscuits Soluble cocoa	Nescafe Tea Milk Honey Butter Sugar Biscuits Soluble cocoa
Snack:	Chocolate Beef tongue Biscuits Orange soda Prunes jam	Chocolate Beef tongue Biscuits Orange soda Prunes jam
Lunch:	Sardines with tomato sauce Lentils with lard Camembert Biscuits Sweets	"Petit Bourgogne" Jugged hare Green beans Camembert Biscuits Sweets
Supper:	Meat extract "Pemmican" Chicken with rice "Soma" Camembert "Mont Blanc" cream Biscuits	Egg powder Meat extract "Pemmican" Ham Precooked rice Camembert "Mont Blanc" cream Biscuits

Composition of the Ration:

Designation	Weight in g
Biscuits	720
Sugar	300
Butter	400
Tea	25
Honey	500
Chocolate	300
Ox tongue	300
Orange soda	300
Sardines with tomato sauce	150
Potted pate	290
Lentils with bacon	900
Jugged hare	420
Green beans	500
Camembert	480
Candies	150
Pemmican	450
Ham	450
Precooked rice	250
Dehydrated powder potatoes	200
"Mont Blanc" cream	700
Concentrated milk	330
Chicken with rice	420
Meat extract	40
Mirabelle plum jam	500
Soluble cocoa	125
Total	9,200
Total Calories	27,959

Addition for Reid Rations

Seasoning and Alcohol (drinkable): (Contents of One Case for 6 Men x 10 Weeks)

Designation		Weight (in Kg)
White mustard	7 tubes 100 g	0.700
4 herbs mustard	4 tubes 100 g	0.400
Salt	6 cans 250 g	1.500
Pepper	6 cans 20 g	0.120
Dehydrated onions	2 cans 350 g	0.700
Tomato concentrated	60 cans 150 g	9.000
Garlic powder	1 can 125 g	0.125
Various sauces	12 cans 125 g	1.500
Celery salt	3 cans 20 g	0.060
Spices	3 cans 20 g	0.060
Total		14.165

		Quantity (in liter)
Oil	plastic bottles	2.00
Vinegar	plastic bottles	0.75
Total		2.75
Rum	plastic bottles	2.00
Cognac	plastic bottles	1.00
Vermouth	plastic bottles	1.00
Pastis	plastic bottles	1.00
Total		5.00

Surviving Rations: 2 Men x 2 Days

Designation	Weight (in Kg)	"Calories"
"Pemmican"	0.400	2,072
Bar biscuits 4 packages 120 g	0.480	1,736
"Mont Blanc" survival food 2 tubes 175 g	0.350	1,100
"Nougat" 4 bars 100 g	0.400	1,800
Totals	1.630	6,708

3. The Investigation

3-1. Types of Investigation

We said that we have interviewed at the place of the expedition each group, several times, so that we knew the point of view of the participants. These opinions were registered by one of the doctors in the expedition.

On their return, a referendum questionary in two languages was sent to the different participants.

3-2. Food Questionary

Name:
Nationality:
E.G.I.G. group:

1. Give your general opinion on the food.

2. Did you have a general impression of insufficiency of food? at the beginning of the campaign: at the end of it:

3. Which items not listed in the rations would you have liked to have?

4. Did the five rations M1, M2, M3, M4 and M5 seem different to you, or too alike?

5. Which ration did you prefer? Please classify them by order of preference:

6. Did you get tired of these five menus?

7. What additional items did you ask for at the wintering station?

8. Did you have enough to drink?

9. Did you find that some of the drinks should be in a larger quantity? Which drinks? How much a day?

10. Did you have to utilize survival rations? What do you think of them? Were they ingestable?

11. Did you have enough condiments? Were some of them supplied in too large quantity?

12. About how many meals with fresh food did you have during the campaign? Which foods were these?

3-3. The Answers

We have received about half of the answers of the participants—an equal number for French and Germans. This questionary has therefore small value, because of the few answers. As we shall see individual criticisms cause out in the details, and the general impression was good. It was printed out also that a number of the participants who did not answer the questionary gave us their oral opinion. They did not find it necessary to fill out the questionary, since the rations were sufficient and pleasant.

4. Results

Analytical lists of the food mentioned by those who utilized it—opinion of the quantity, the taste, the packing, the preservation. The foods not mentioned in this list and appearing in the menus have been considered either unimportant or without any problems.

The different opinions of the people who used the food appear in each column, the last three columns to be filled in by organizers.

Questions About Rations (ration M1)(+)

Designation	Quantity		Bad Distribution		Faulty Packing	Faulty Conservation	Taste		Use	
	Not Sufficient	Too Much	Minus	Plus			Agreeable	Unpleasant	Easy	Difficult
	1	2	3	4	5	6	7	8	9	10
Biscuits										
Sugar										
Butter										
Concentrated milk										
Nescafe										
Tea										
Strawberry jam										
Pears with syrup										
Chocolate to eat										
Assorted sweets										
Meat extract										
Pemmican										
Camembert										
Ovomaltine										
Lemon soda										
Coppa										
Beef with carrots										
Mackerel fillets										
Sardines with olive oil										
Sauerkraut with meat										
Spinach										
White beans										
Frankfurt sausages										
Chitterlings										

(+)Five sets of questions were sent to each participant so that they could give their answers by rations. We reproduce here the set of questions for ration M1 only.

Questions About Rations (ration M1)

Products	Quantity		Taste		Packing		Conservation		Synthesis	Remarks
	French	German	French	German	French	German	French	German		
Biscuits	not enough +++	too much ++			faulty	faulty			antinomy	change packing
Sugar	not enough +++	too much ++				faulty			antinomy	change packing
Concentrated milk	not enough +++		unpleas-ant		faulty	faulty			insufficient quantity for French	beware of conditioning
Ovomaltine	not enough +++	too much							antinomy	
Soups	not enough +++								insufficient quantity for French	
Pastes	not enough +++	not enough ++			faulty	faulty			agreement	change packing
Jams	not enough ++	too much ++							antinomy	too much currant and mirabelle plum
Fruits in syrup	not enough ++	not enough ++							agreement	necessity for variety
Sardines	not enough ++								insufficient quantity for French	
Sauerkraut	not enough ++	too much ++		unpleas-ant					antinomy	look for fac-tory quality

Products	Quantity		Taste		Packing		Conservation		Synthesis	Remarks
	French	German	French	German	French	German	French	German		
White beans	not enough ++	too much ++		unpleas-ant					antinomy	
"Mont Blanc" cream	not enough ++								insufficient quantity for French	
Tunny olive oil	not enough ++	too much ++							antinomy	Germans don't like fish very much
Sausage with beans	not enough ++								insufficient quantity for French	
Green peas	not enough ++								insufficient quantity for French	
Chestnut cream	not enough ++								insufficient quantity for French	
Figs, dried currants	not enough ++	not enough ++	unpleas-ant		faulty	faulty	faulty	faulty	agreement	change packing
Toffies	not enough ++								insufficient quantity for French	
Cold chicken	not enough ++			unpleas-ant					insufficient quantity for French Antinomy taste	

Products	Quantity		Taste		Packing		Conservation		Synthesis	Remarks
	French	German	French	German	French	German	French	German		
Marengo veal	not enough ++			unpleasant					insufficient quantity for French Antinomy taste	
Corned beef	not enough ++			unpleasant					insufficient quantity for French Antinomy taste	
Vegetable hotchpotch	not enough ++			unpleasant					insufficient quantity for French Antinomy taste	
Green beans	not enough ++	too much ++		unpleasant					antinomy	
Meat extract	not enough ++	too much ++							antinomy	
Beef with carrots	not enough +			unpleasant					insufficient quantity for French Antinomy taste	
Tripes	not enough +			unpleasant					insufficient quantity for French Antinomy taste	

Products	Quantity		Taste		Packing		Conservation		Synthesis	Remarks
	French	German	French	German	French	German	French	German		
Mackerel fillets	not enough +			unpleasant					insufficient quantity for French Antinomy taste	
Pork	not enough +								insufficient quantity for French	
Nougat	not enough +								insufficient quantity for French	
Cooked ham	not enough +								insufficient quantity for French	
Braised beef	not enough +								insufficient quantity for French	
Bologna sausages	not enough +								insufficient quantity for French	
Tunny fillets	not enough +								insufficient quantity for French	
Dehydrated onions	not enough								insufficient quantity for French	
White mustard	not enough								insufficient quantity for French	

Products	Quantity		Taste		Packing		Conservation		Synthesis	Remarks
	French	German	French	German	French	German	French	German		
Oil	not enough								insufficient quantity for French	
Vinegar	not enough								insufficient quantity for French	
Vegetables in general	not enough								insufficient quantity for French	
Pepper and salt	not enough								insufficient quantity for French	
Butter	too much +++	not enough +++	unpleas-ant	unpleas-ant				faulty	antinomy	faulty conservation
Nescafe	too much +++	not enough +++	unpleas-ant						antinomy	
Tea	too much +++	not enough +++	unpleas-ant			faulty			antinomy	change packing
Chocolate to eat	too much +++	too much ++			faulty				agreement	change packing
Sweets	too much +++	not enough +++	unpleas-ant	unpleas-ant	faulty	faulty		faulty	antinomy	change packing look for fac-tory quality, faulty conser-vation
Pemmican	too much +++		unpleas-ant	unpleas-ant					agreement	to suppress from mech-anized rations

Products	Quantity		Taste		Packing		Conservation		Synthesis	Remarks
	French	German	French	German	French	German	French	German		
Cheese	too much +++	not enough +++	unpleas-ant	unpleas-ant			faulty	faulty	antinomy	faulty conser-vation
Coppa	too much +++	not enough +++	unpleas-ant	unpleas-ant			faulty		antinomy	faulty conser-vation
Egg powder	too much +++	too much ++	unpleas-ant	unpleas-ant			faulty		agreement	change packing faulty conser-vation
Sausage with lentils	too much +++	too much ++	unpleas-ant						agreement	too much len-tils. Look for factory quality.
Lentils with bacon	too much +++	too much ++							agreement	too much len-tils. Look for factory quality.
Soluble cocoa	too much ++		unpleas-ant		faulty		faulty		too much for French	change packing faulty conser-vation
Oat flakes	too much		unpleas-ant	unpleas-ant	faulty	faulty		faulty	too much for French	change packing faulty conser-vation
Pork with lentils	too much ++	too much ++	unpleas-ant						agreement	too much len-tils. Look for factory quality.
Black pudding	too much ++		unpleas-ant	unpleas-ant					too much for French	look for fac-tory quality

Products	Quantity		Taste		Packing		Conservation		Synthesis	Remarks
	French	German	French	German	French	German	French	German		
Soma	too much ++	not enough +++	unpleas-ant		faulty	faulty			antinomy	change packing
Spinach	too much +	not enough ++	unpleas-ant	unpleas-ant					antinomy	look for factory quality
Sausages	too much +	not enough ++	unpleas-ant	unpleas-ant			faulty		antinomy	look for factory quality
Hazel nuts almonds	too much +		unpleas-ant		faulty	faulty	faulty	faulty	too much for French	change packing faulty conservation
Kidneys	too much +		unpleas-ant	unpleas-ant					too much for French	look for factory quality
Sardines with tomato	too much +								too much for French	
Rice		not enough +++			faulty				not enough for German	change packing
Honey					faulty					change packing
Soda		too much +++					faulty		too much for German	not enough orange soda for Frenchs. faulty conservation
Dry sausage		too much ++		unpleas-ant			faulty	faulty	too much for German	faulty conservation
Jugged hare							faulty			faulty conservation

Products	Quantity		Taste		Packing		Conservation		Synthesis	Remarks
	French	German	French	German	French	German	French	German		
Concentrated tomato	too much								too much for French	
Pig meat in general	too much								too much for French	
Meat in general	too much								too much for French	
Various seasoning	too much								too much for French	
Onion soup		too much ++							too much for German	
Meat pie		too much ++							too much for German	
Chitterlings				unpleas-ant						look for factory quality
Mushroom soup				unpleas-ant						look for factory quality
Potted mince (pork)				unpleas-ant						look for factory quality

5. Interpretation

5-1. Analytical and Synthetical Examination of the Investigation:

The interest of this analysis is to show a certain number of things allowing an opinion for clearing and rectifying the content, the supply and packing of rations. As a matter of fact, some products seemed not well preserved, packed in a bad way or in inferior quality. The conclusions are easy to be found out. A certain number of products in the rations were too many and this was approved by everybody. On the other hand, there were not enough other products in those rations and that was also given a general approval. Finally, according to the nationality of the people of the expedition, different opinions were given. We so set off quantitative and qualitative antinomies per nationality of the people and even hyper or hypo opinions, given only by one of these two nationalities. There again, the practical conclusions are easy to be found out according to the people's nationality.

You'll find below the schematic explanation:

a. Food badly preserved: Figs, dried grapes, butter, sweets, cheese, copra, egg powder, soluble cocoa, oats-flakes, sausages, nuts and almonds, sodas, jugged hare.

b. Products packed in a bad way: Biscuits, sugar, concentrated milk, pastes, figs and dried grapes, potatoes (dehydrated powder), tea, eating chocolate, sweets, egg powder, soluble cocoa, oats-flakes, soma, nuts and almonds, rice, honey.

c. Products of bad quality (manufacturies to be changed): Sauerkraut, sweets, sausages with lentils, bacon with lentils, pork with lentils, black pudding, spinach, sausages, kidneys, chitterlings, mushroom soup, rilletes.

d. Products in a too large quantity for a ration (agreed by everybody): Chocolate, pemmican, egg powder, sausages with lentils, bacon with lentils, pork with lentils.

e. Products in a too small quantity provided for a ration (agreed by everybody): Pastes, fruits in syrup, figs and dried grapes.

f. Quantitative antinomies: Biscuits (+ for French, - for German), Sugar (+ for F, - for G), Ovomaltine (+ for F, - for G), Jam (+ for F, - for G), Sauerkraut (+ for F, - for G), Beans (+ for F, - for G), Tunny (+ for F, - for G), Meat extract (+ for F, - for G), French beans (+ for F, - for G), Butter (- for F, + for G), Nescafé (- for F, + for G), Tea (- for F, + for G), Sweets (- for F, + for G), Cheese (- for F, + for G), Copra (- for F, + for G), Soma (potatoes dehydrated powder) (- for F, + for G), Spinach (- for F, + for G), Sausages (- for F, + for G).

g. Qualitative antinomy: Canned fish (+ for F, - for G), Frosted chicken (+ for F, - for G), "Marengo" veal (+ for F, - for G), Vegetable hotchpotch (+ for F, - for G), Corned beef (+ for F, - for G), French beans (+ for F, - for G), Beef with carrots (+ for F, - for G), Tripes (+ for F,

- for G), Fillets of mackerel (+ for F, - for G), Nescafe (- for F, + for G), Tea (- for F, + for G), Dehydrated potatoes powder (- for F, + for G).

h. Products being in a too large quantity printed out only by French people: Soluble cocoa, oats flakes, black pudding, nuts and almonds, kidneys, sardines with tomato, concentrated tomato, pork-butchery, meat, condiments.

   By Germans: Sodas, sausages, onion soup, pies.

i. Products being in a too small quantity printed out only by French people: Concentrated milk, soups, sardines, "Mont Blanc" cream, sausages with beans, green peas, chestnut cream, toffies, frosted chicken, "Marengo" veal, vegetable hotchpotch, corned beef, beef with carrots, tripes, fillets of mackerel, pork cutlets, nougat, ham, braised beef, bologna sausages, fillets of tuna fish, dehydrated onions, vegetable in general, pepper and salt, white mustard, oil, vinegar, orange soda.

   By Germans: Rice.

5-2. Practical Interpretation

a. It is obvious that there were too many kinds of certain products and not enough of others, and this is only because of a bad theoretical concept of the ration. These products are very few, and the practical rectification in the future is absolutely necessary.

b. There seemed to be a lack of the products because of bad packing or bad preservation, these deficiencies going sometimes together. As a matter of fact certain foods not canned were only packed in "polyethylene" bags or fixed into the rations boxes. Either when dropped or because humidity, some foods were damaged. We concluded that when these rations are dropped, certain packaging has to be avoided. Before utilized by the members of the E.G.I.G. these rations were stocked during a year at BW 8 in depots, piled from top to bottom in columns. We have learned afterwards that these shelters were heated during winter, the rations on the upper sides were therefore in danger. This explains in a way the bad preservation of some products as for instance the butter.

c. Other products were not accepted by the people, because of their bad quality. Though our french canned products are in general good, there are some manufacturies where the taste of food has nothing to do with fresh food. That is why food was not appreciated for its taste. We have therefore to change the supplies for certain products, but without forgetting that many tasteful canned food can become inedible because of the change of weather due to heat or freezing.

d. Each nationality's opinions are distinctive and we may keep them in mind. One can notice that this problem is not easy to solve with international expeditions, if we wish to maintain the gastronomical point of view.

e. All products were not used, the ration being too copious, as it was said, we have gone beyond our theoretical number of 4, 000 calories, we can therefore say, that without taking any risk, rations of 3, 800 calories would be sufficient. Two objections could be made: on one hand, the abundance is always favorable on a psychological point of view, even when it is wasteful; on the other hand, if certain products of a ration were not tasteful to everybody, as it happened during this expedition, certain members of the expedition may have not enough to eat or have to eat food they don't like.

5-3. Some other Generalities were Also Set Off by this Questionary

Bad repartition and bad packing of condiments.

Products which the people suggested for future: milk in powder, gruyere cheese, chocolate with milk (these three items were eliminated by us because of difficulties of separate packing), fruit juices and canned fruit, (the members wished more of it), dehydrated vegetables, (eliminated by us because of difficulty of preparing), flour (same remark), anchovies, olives, canned bread, (eliminated by us because of difficult preservation), sweet biscuits, powdered sugar.

In general, the preferred ration was the M3 and also either M1 or M5 (the other rations seem to have been refused because of the abundance of lentils).

6. Laboratory Analysis

Rations were packed on July 1958. They were stocked up to April 1959 in heated shelters. They remained in cold weather until September 1960 (two frosts and thaws); afterwards they were stocked in Paris. Analysis made in December 1960.

Report of these analysis: Marks of humidity were found out inside and outside the boxes:

a. Concerning contents:

Products packed in bags with "polythene" were well preserved (matches, tea, instant sodas, sugar, sweets, honey, rice); concentrated milk (in tube) and nescafé (box) were also well preserved.

Products not packed under "polythene" bags were badly preserved (Liebig soup, biscuits, pemmican, cocoa, eating chocolate), only the eating chocolate was partially recovered.

The pemmican put in bulk in the box being mouldy, soiled the packing of other products and partially damaged them.

The cans are all rusted outside (cans made of white iron) including a can made of fold varnish (salted butter) excepted aluminium cans ("Mont Blanc" cream).

No special strain is to be noted for the cans (well preserved when dropped in their cover of cutting).

b. Concerning the Contents of Cans:

Satisfactory in general; however, it is to be noticed: light smell and rancid flavor for the butter. one dished can for the 4 cans of "Mont Blanc" cream controlled. soft consistence of cheese.

c. Concerning the Inside Condition of Cans:

1. Gold varnish covering are undamaged (salted butter cans, chicken with rice and curry, munster cheese of Alsace, camembert of Normandie).

2. Good conditions of the inside of "Mont Blanc" cream cans (aluminium cans).

3. Certain cans present a normal tinning appearance (aspect of marble), they are: jam cans, green beans, beef tongue, ham.

4. Some cans give the appearance of a tinning like marble (lentils cans with lard).

5. Other cans have a bitten tinning:

   Cans of jugged hare
   Cans of pork pie
   Cans of pilchards (very bitten tinning)

7. Conclusion

7-1. It is possible to foresee rations for tractor land traverses by supplying ordinary foodstuff, taking in consideration the taste appearance and even nationalities difference.

7-2. These rations could be prepared in advance, stocked and dropped when needed to be utilized without damage, provided that the packing is studied.

7-3. The analytical researches on food are interesting, either for practical details they set off, or for psychological ends showing the importance of food for the participants and the complicated problems of taste.

7-4. From this study it results that if food can be prepared in advance in simply packed rations for a modern mobile expedition, the gastronomical aspect must never be neglected.

TWO PROBLEMS OF MEDICAL LOGISTICS

Jean Rivolier

We wish to raise two points:

The logistical problems of medical selection,
The logistical problems of medical protection and prevention in polar bases.

1. Logistical Problems of Medical Selection

We are not concerned here with commonplace ideas about medical tests before departure, test carried out as a matter of course to eliminate all unfit persons, or anybody liable to develop, during his stay in polar countries, sickness which might be detrimental to himself, his colleagues, or the running of the base.

We would like to emphasize certain special points which our 15 years' experience have brought to light, as have also certain conditions concerned with the evolving of polar bases.

1-1.

In many cases, we find ourselves confronted with expeditions that we might term routine (as opposed to dynamic expeditions, either mobile, or conceived with a view to a new lay-out and which are quite another matter). Each year a certain number of people have to be sent for a wintering whose characteristics of hardship and protection are clearly pointed out. It is a case of technicians, scientists or non-specialists whose only "polar" experience will be this one trip. It is recommendable to put them through a medical test, likewise routine, but which, however, should have the aim not only of eliminating unfit persons, but also to select persons most likely to develop no organic medical incident during their stay, and who are the best from a psychological standpoint. Now, it is often a case of personnel "from here and there", hired at the last moment, and not having at their disposal, because of technical preparation stages, more than a short time, and for whom, as a rule, a final medical decision must be made at once so that engagement contracts may be signed and so that those chosen may give notice to their former employers. Need, we add that, at least in France, summer is a vacation period, and under these conditions a selection which has to be made immediately before the Antarctic is very difficult to carry out. Another important point is that this type of personnel, from here and there, does not possess a well-developed "polar spirit", that is to say that at any time we may come up against sickness or stoppage of work for minor reasons, and the psychological factor may become evident the instant a polar base becomes a kind of little factory, re-stocked each year with men and material. Paradox is thus certain.

On the one hand, people from here and there, with very little time at their disposal, about whom on-the-spot decisions must be made in spite of all, within reasonable financial limits.

On the other hand a near-insoluble medical problem: make a selection of organically healthy men, while making sure that they have every chance of staying that way during the winter; further, make a psychological selection to ensure that their immediate reactions are such that it may be assumed those reactions will remain the same in abnormal circumstances, that is to say, on the terrain itself.

It is this aspect of selection which seems to us a logistical problem, and about which we would like to have a discussion, and have the opinions of other participants.

1-2.

As for us, on an organic scale, we give all candidates a clinical examination with a detailed questionnaire, a pulmonary radio test, an electrocardiograph, laboratory tests and special examinations (ophthalmology, oto-rhino-larynology, stomatology). We insist especially on the cardiovascular test, on the teeth and on the problem of appendicitis. We advise (without insisting), a systematic appendicitis preventative. But where are we to end this medical investigation? For instance, recently, a member of the E. P. F., completely passed by the medical test, had, during the crossing, an intestinal obstruction, cured in 24 hours by medicines. He was sent back to Paris for further examination. A fault coupling malformation was found on the right-hand colic angle. Should we take systematic, complete digestive radiograms before departure? Would anything have been noticed if attention had not been later drawn to this, as was the case, by an acute episode?

We think it would be of interest to publish exact statistics of medical incidents which happen during the expeditions, in the form of a medical information bulletin where each case would be presented in its pathological context (antecedents, tests undergone before departure, etc.). This might lead us to devote more time to a precise item in the medical investigation. We think it would be of interest to compare our selection methods so as to try and find something more rational.

1-3.

As regards psychological selection, the problem is much more complex. In France it is not the custom, nor has it any practical interest to make an investigation into the professional of family past of an individual, apart from plain technical references; likewise, to a considerable extent, the person must be accepted at face value, on seeing him for the first time and trying to appreciate him. For the last five years, all E. P. F. personnel engaged for a wintering have been examined on a psychological basis, by specialists, before departure and on return. This examination does not aim at selection (apart, of course, from eliminating a really mentally sick person) but aims at getting a preliminary idea in view of a selection we hope to make in the near future. The examination includes a clinical interview, tests

(Rorschach, TAT, Rosenzweil, MMPI) and an electro-encephelogram. With the same idea in mind, we sent a psychiatrist to Terre Adélie during the winter of 1960-1962. On that occasion, an investigation and some very much more complete research work were intended, so as to finalize this problem. Works of elimination are under way.

In fact the difficulty is doubled. It is difficult to appreciate the character value of a person, and to foresee how he will behave in circumstances different from those to which he has been accustomed; moreover, it seems to us that group problems greatly over-estimate the problem of the individual. The individual reacts in such and such a way according to the spirit and reactions of the group itself, if the latter truly represents the expression of an assemblage of individualities under the direction of a chief, has, in spite of everything, a certain psychological autonomy which is independent of individual contacts. Our logical evolution is thus to envisage also the psychological on a group level, and that poses almost insoluble problems, at least in France. Because, apart from individual selection, we must consider groups of diagnoses of winter candidates in their proper setting, relations between the chief and the group, formation of training groups, etc...

There also, we would be glad to know the methods applied in this field by other participants.

2. Logistical Problems of Medical Protection

We will not return to the classical aspect of medical protection, that is to say, medical selection of persons, medical material for stations or long-distance trips, the use of medicines at the base (though it may be worth while to point out the considerable difficulties we have at the moment in engaging a winter doctor because of the great demands for surgical and psychological doctors, while at the same time we can only offer them only an average situation for a long stay, which invariably means an unfavorable break in his career). We would like to insist on certain further points.

2-1.

In fact, during the wintering, the doctor has to treat for the most part, traumatological cases, urgent surgical operations of psycho-pathological problems. And yet, side by side with this pathology it is necessary to examine the problems of infection of polar stations occupants at the time of being relieved after the wintering, and also the hypothesis of seeing appear, in endemic fashion, certain illnesses which formerly did not exist in these stations.

On principal, people who have just occupied polar stations are healthy men, medically selected before departure; but more and more frequently, in particular during the summer seasons, men may come who have either totally or partially avoided a medical check, a phenomenon which arises in the Antarctic on the occasion, above all, of visits of inspection, sojourns of observers or short-term assignments. One can thus picture a number of morbid possibilities of plausible appearance. Serious sicknesses, later strongly epidemic, may be introduced by a member of an expedition who arrives at the station in the incubation stage of the sickness, having contracted it, for instance, in the course of the voyage. One can easily imagine the ravages which the outbreak of typhus could create in a polar station. Less serious but far more frequent is the possibility of the appearance of everyday sicknesses, for instance of the respiratory type (influenza), the infectious character of which is enough to produce an endemic disease in a region which till now has not witnessed the appearance of a real epidemic at the moment when, in summer, the boat arrives and disembarks its reliefs. On this principle, one can imagine a certain number of germs or viruses transmitted by healthy carriers, and the creation of a continual cycle of infection in the course of the year.

In fact, all sicknesses transmitted by the parasites of man, be they occasional or chronic, from simple scabies to certain intestinal infections or even of rickets.

These morbid possibilities seem just as imaginable and frequent in the future as, which has already been said, visits are more and more numerous in the Antarctic, that people have very often passed through tropical regions before reaching these stations, that their journey may have been very short and that air transport does not, as a rule, allow, during the flight, of the complete development of incubation together with the appearance of the first stage of the sickness, and that above all, if in most cases wintering subjects have had a careful medical examination before departure, there exists, for most of the time, no control on arrival.

2-2.

We therefore have to consider as of now a systematic mean of prevention and prophylaxis. These medico-hygienic methods could roughly be the following:

Systematic medical examination of all participants before departure and also upon arrival at the polar base, with sanitary controls turned towards the research for a latent infection.

Systematic disinfection of the rhino-pharynx upon arrival and during the change of personnel period.

Disinfection of the luggage and equipments as soon as landing. Search for parasites.

Periodical disinfection of the barracks and equipment stocked at the base.

Systematic struggle against parasites which could develop at the base.

Application of general hygiene measures at the bases (for instance in regard to used water and substances).

To conclude let us say that if certain points seem mere hypothesis it is true nevertheless that these points can become a reality in the near future. The problems of the development of certain diseases in a polar base ask for the setting of a well studied system of control and prevention. This system should be thought on the international level and deserves an exchange of ideas between the different international polar medical services in order to succeed rapidly in the definition and the realization of means of controlled prophylaxis.

TEXTILE GOODS USED IN J. A. R. E. 1956-62

Tetsuya Torii

1. Introduction

Japan has sent four wintering teams to Syowa Base during the period 1956-61. All articles of clothing used by these teams were home products, except for socks and a few other items. The Equipment Section (Head: Dr. T. Torii), National Antarctic Committee, Science Council of Japan, was in charge of the planning and the preparation of the clothing.

No one had ever been to Prince Harald Coast, which is in the neighborhood of where our base was to be established. Hence the clothing for the first wintering team 1956-58 was prepared taking into consideration the experiences of Himalayan expeditions on the one hand, and the information on the weather and the clothing of the Australian Mawson Base on the other hand. The lowest temperature and the maximum wind velocity we would have to stand were estimated at -50°C and 50m/s respectively. As our knowledge of the weather conditions at Syowa Base and our experience on polar clothing increased, the succeeding teams adopted more and more synthetic fiber products. The Synthetic fibers mainly used in our clothing and field gear are:

Polyacrylonitrile	("Kanekalon", "Vonnel" and "Cashimilon"),
Polyvinylchloride	("Teviron"),
Nylon 6	("Amilan"),
Polyester	("Tetoron"),
and Polyvinyl alcohol	("Vinylon").

This paper will describe the outline of clothing and other textile goods employed by J. A. R. E. teams. Stress will be laid on discussing the comparative merits of synthetic fabrics.

2. Base Clothing

All articles of clothing used by the wintering team 1960-62 at Syowa Base are given in Table 1. Some sweaters, trousers, socks and underwear were made of natural fibers such as wool and cotton, but all other items were made exclusively of synthetic fibers. These synthetic fiber goods proved as good as those of natural fibers in touch, comfort and warmth. Besides, synthetic fabrics were far superior in durability—which is a matter of importance in Antarctica where everyday life is necessarily accompanied by hard outdoor work.

TABLE 1

Base Clothing

No.	Name of Article	Material	Remarks
1.	Briefs	Cotton, Kanekalon	White
2.	T-shirts	Cotton, Kanekalon	White
3.	Air-net shirts and long pants	Kanekalon	White, air-net is trade mark
4.	Underwears (Shirts and long pants)	Kanekalon, Exlan 50 Cotton 50 blended Teviron	Beige
5.	Underwear (heavier) (Shirts and long pants)	Kanekalon, Vonnel, Exlan, woollen	Beige
6.	Haramaki	Kanekalon, mohaire	Beige, wide belt for the belly
7.	Cutter shirts	Kanekalon, Exlan, wool flano	Plaid
8.	Trousers	Wool serge	Dark blue
9.	Sweaters	Kanekalon, Exlan, woolen	Red, yellow, light blue
10.	Balaclava cap	Kanekalon	Various color
11.	Skiing caps	Wool serge, interlining: Kanekalon boa, Teviron boa	Black, Beige
12.	Gloves	Kanekalon, Exlan, Cashmilon, Urylon, woollen	Various color
13.	Gloves	Leather	Black, cover gloves
14.	Working gloves	Vinylon	White
15.	Socks (heavier)	Kanekalon Pile, woollen	Beige, light blue
16.	Socks (thin)	Woollen	Beige, light blue

The air-net shirt (called "brynge" in Norway where it was originated) is excellent underwear to use in the base as well as in field work. We prepared two kinds of this underwear, one of cotton and the other of "Kanekalon". Most members preferred the latter.

The following is the reason for this. In the case of ordinary underwear, the diffusion of moisture from the skin to the outside takes place through the yarn as well as through the mesh of the fabric. In order that diffusion or permeation of moisture may take place through the yarn, this should be able to absorb water—as cotton yarn does. Thus most people like cotton underwear. In air-net shirts, however, the situation is drastically different: moisture can get out quite freely through large meshes. The hygroscopic property of the yarn is not only ineffective for increasing the permeation of moisture but it may do more harm than good, because the heat conductivity of any yarn is appreciably increased when it absorbs moisture. Thus for air-net shirts for use in cold conditions synthetic fibers which do not absorb water, such as "Kanekalon", are more suitable than cotton.

Some members found it most effective to wear an undershirt of synthetic fiber over a "Kanekalon" air-net shirt. Neither of them get wet or stick to the skin, even when one works hard and perspiration is frozen on the inside of the windproof.

In conclusion it should be said that the "wash and dry" property of synthetic fabrics was most welcome by wintering members. Everybody used to wash their vests quilted with "Tetoron" staple in the electric washer. No one would have dreamed of this ten years ago when no quilting ranking with eiderdown was known.

3. Field Clothing

It has been proven that articles of synthetic fibers including those used in field gear like tents and ropes (see Table 2), can well stand a temperature as low as -50°C. The field party of J. A. R. E. 1960-62 has reported that their clothing, which consisted mainly—in some cases entirely—of synthetic fabrics, kept them warm enough throughout their 77 day journey. The lowest temperature they experienced was -53.3°C.

Some details of our experience are described in the following lines:

1. Quilted Jackets, Trousers and Underwear

No members of the field party cited above carried eiderdown jackets, trousers or underwear with them, although there were plenty of these in the base. Everyone preferred those quilted with "Tetoron" staple, which proved superior in the power of keeping warmth, though slightly inferior in the facility of action.

Long-sleeved underwear and underdrawers quilted with "Tetoron" staple were habitually used by wintering members. They are superior to eiderdown ones in feeling and touch, and are washable. Irritation by feathers coming through the cover, an unavoidable trouble with eiderdown, has been eliminated.

TABLE 2

Journey Necessaries

No.	Name of Article	Material	Remarks
17.	Quilting jackets and trousers	Cloth: Nylon and Tetoron Filling: Tetoron	Maroon, light beige quilting
18.	Underwears (Jackets and trousers)	Cloth: Tetoron taffeta Filling: Tetoron	Light beige quilting
19.	Snow boots	Cloth: Vinylon canvas Socks: Wool felt or Tetoron quilting	Orange
20.	Overshoes	Cloth: Tetoron or Nylon Filling: Tetoron	Dark blue, orange
21.	Sleeping bags, double	Cloth: Nylon Filling: Tetoron	Maroon, dark blue quilting
22.	Tents	Pyramid type (for 5 persons): Tetoron Whimper type (for 5 persons): Vinylon	Green, dark blue Orange
23.	Mattresses	Cloth: Vinylon Filling: "Hamafoam"	OD Foam rubber
24.	Balaclaba cap	Kanekalon	Maroon
25.	Mittens	Cloth: Nylon Filling: Tetoron or eiderdown	Yellow, dark blue
26.	Rope	Tetoron	White, green; for fasten sleigh, dog sleigh, tents, liferope
27.	Rope	Nylon, Tetoron	For anseilen, nylon: red, Tetoron: green
28.	Canvas	Vinylon	Orange
29.	Mark flags	Tetoron	Red, yellow
30.	Work clothes	Kanekalon	Grey
31.	Cold weather vests	Cloth: Nylon Filling: Tetoron, Vonnel, Urylon, Cashmilon	Maroon Quilting
32.	Base jackets and trousers	Cloth: Nylon Back: Kanekalon boa, Teviron boa	Maroon, dark blue
33.	Windproof jackets	Nylon, Tetoron, Vinylon	Orange, yellow, dark blue
34.	Windproof trousers	Nylon, Tetoron, Vinylon	Orange, yellow, dark blue
35.	Base boots	Vinylon canvas, with liner: (Kanekalon boa)	
36.	Rubber boots	with liner (Kanekalon boa)	Green
37.	Beddings	Filling: Tetoron, Teviron	
38.	Cushions	Filling: Teviron, "Hamafoam"	Green, "Hamafoam": foam rubber

Remarks: 1. Kanekalon, Exlan, Vonnel and Cashmilon are polyacrylonitrile fiber. 2. Tetoron is polyethylene terephthalate fiber. 3. Teviron is polyvinyl chloride fiber. 4. Vinylon is polyvinyl alcohol fiber. 5. Urylon is polynonamethylene urea fiber. 6. Nylon is nylon 6

2. Windproof Jackets and Trousers

Windproofs of "Nylon", "Tetoron" and "Vinylon" were used. The former two are light in weight, and are good for use in and around the base site as well as in the field. They have a drawback, however—they are rather easily torn. In this regard, "Vinylon" windproofs are superior. These are recommended for use in heavy work.

3. Boots

Snow boots, knee-length boots of "Vinylon" with "Vibram" rubber soles, were employed by field parties in very cold conditions, together with inner shoes. Two kinds of inner shoes had been prepared: those quilted with "Tetoron" staple and those of felt. Both proved equally good.

In geological surveys to rocky areas, we used to put on ski boots with seal skin lining instead of snow boots. Ski boots were protected against cold by overshoes quilted with "Tetoron" staple.

In addition to these two kinds, we used what we called "winter boots" in the field as well as in the base site. These were lined with synthetic boa.

Photographs of these three kinds of boots will be exhibited at the Symposium.

4. Tents

We used to employ pyramid type tents ("Tetoron" or "Nylon") in the caravan, which are the easiest to pitch. Whymper tents, of "Vinylon", were preferred when staying at a place for several days. There was no difference between the two types in regard to the ability to withstand strong wind. Both easily withstood furious blizzards.

It is difficult to compare the "Nylon" and "Tetoron" tents, but we prefer the "Tetoron" type. In field surveys in the Antarctic, it is inevitable that steam from the cooking apparatus freezes on the inside of the tent. In general this forms a very thin sheet of ice on "Nylon" walls, while on "Tetoron" walls steam is habitually frozen in small ice-droplets. Accordingly, "Tetoron" tents are easier to handle. At present, the best solution to this problem is believed to be the use of a silk-lining. Ice is not readily formed on silk, and if formed, it can be cleared away most easily.

Our caboose was made of "Vinylon" canvas. As has been stated before, this fabric is superior in mechanical strength to "Nylon" and "Tetoron". The "Vinylon" cover of the caboose underwent practically no deterioration in two years of hard work (see Table 3). According to our experience, we conclude that the days of cotton and hemp tents are over in so far as the Antarctic journeys are concerned. They are heavy, and hard to handle when frozen.

5. <u>Sleeping Bags</u>

In the field surveys in spring and autumn, when it was very cold, every member used to sleep in a double sleeping bag with a "Hamafoam" mattress and an air mattress underneath. Double sleeping bags quilted with eiderdown were used by most members. But three members of the trail party in spring, 1961, used those quilted with "Tetoron" staple in their 77 day journey and found them satisfactory.

It used to be a problem for every survey party in Antarctica that sleeping bags were very likely to become frosted. Everybody suffered from heavy ice on the sleeping bag, especially around their faces. We have tested some sleeping bags with their "Nylon" outer covers replaced by "Breathtex", * and confirmed their superiority against frost.

6. <u>Ropes</u>

"Tetoron" ropes were found to be excellent for use in the field as well as in the base site (e.g., for life ropes around the base houses). They are superior in tensile strength, and are easy to handle in cold conditions.

A 14 mm "Tetoron" rope could be employed for securing the luggage to the sledge, with no misgivings as to its being slackened by violent vibrations during the journey.

4. Results of Tests After Use

Some articles have been brought home and have been subjected to various tests. The details are given in Tables 3 and 4.**

The results can be summarized as follows:

1. Those articles of synthetic fabrics which had been made waterproof before use have lost this property completely after use.

2. Insofar as one wintering is concerned, one need not have misgivings as to deteriorations in mechanical properties of any synthetic fabrics described above.

*"Nylon" coated with a kind of synthetic rubber. Claimed to have some permeability for air.

**In regard to the deterioration of "Nylon" and other synthetic fabrics due to ultraviolet rays, note that the intensity at Syowa Base of the solar radiation in the ultraviolet region during the period October-December, in which the trail party used to be underway, is more than twice as high as that in Tokyo.

TABLE 3

Performance Test After Use

No.	Name of Article	Material	Using Condition	General Comment	Remarks
33.	Windproof jackets	Nylon twill	About 150 days used for journey, and working at the base.	Water proofing lost. Little damage.	Orange dark blue
34.	Windproof trousers	Nylon twill	About 150 days used for journey, and working at the base.	Remarkable damage in appearance. Loss in strength Ca. 50%	Orange, dark blue
34'	Windproof trousers	Face: Tetoron plain Back: Nylon plain	About 150 days used for journey and working at the base.	Remarkable damage. Tetoron is slightly superior to nylon	Orange, dark blue
17.	Quilting Jackets and trousers	Face: Nylon twill Filling: Tetoron	For journey in cold weather	No damage recognized in appearance Water proofing lost.	Maroon
20	Overshoes	Face: Nylon or Tetoron Filling: Tetoron	For journey, about 80 days, and used for tent shoes	Partial damage. Still usable.	Dark blue, orange
21.	Sleeping bags	Cloth: Nylon Filling: Tetoron	For journey, about 80 days.	Partial damage	Maroon, dark blue
22.	Tents, pyramid type, (for 5 persons)	Tetoron plain	During the 74 day journey, the tents were transferred from place to place approximately 50 times.		Green, dark blue
22'	Tents, pyramid type, (for 5 persons)	Tetoron taffeta	Cooking is done in caboose, but water is boiled inside the tents Instantaneous maximum wind 30.3 m/sec. Lowest temp. -33.5°C	Deteriorated in strength, but still usable. Water proofing lost.	Green, dark blue
28.	CANVAS	Vinylon canvas	Exposed outdoors 262 days in 1960 180 days in 1961 442 days in total For journey: 118 days Instantaneous maximum wind 47 m/sec. Lowest temp. -42.1°C	Little deterioration in strength. Still usable. A small increase in weight was recognized.	Orange
28'	CANVAS	Vinylon canvas	Exposed outdoors from Feb. in 1957 to Jan. in 1960 New cover is hanged on it from Feb. in 1960 to Jan. in 1962 Instantaneous maximum wind 40.6 m/sec. Lowest temp. -42.1°C	Weight decreased. Water proofing decreased Ca. 50% No recognizable loss in strength.	Red
27.	Rope (dia. 9 m/m	Nylon	For anseilen in journey	Partially stiffened. Loss in strength in stiffened sections Ca. 70%	Red
26.	Rope (dia. 12 m/m	Tetoron	Continuously stretched for 198 days at the base. From June 10 in 1960 to Dec. 25 in 1960, for life rope. Average wind 5.7 m/sec.	Partial damage. Still usable.	White
27'	Rope (dia. 9 m/m)	Tetoron	For anseilen in journey	Partial damage.	Green

TABLE 4

Test Result

No.	Article		Yarn Denier (Both Warp and Filling)	Thread Count Number/Inch Warp	Thread Count Number/Inch Filling	Thickness ***JISL-1032 mm	Weight g/m²	Tensile Strength kg/5cm Width Warp	Tensile Strength kg/5cm Width Filling	Elongation % Warp	Elongation % Filling	Tear Strength (Elemendorf) ASTM D-1425-59 kg Warp	Tear Strength kg Filling	*Surface Abrasion ASTM D-1175-61T Cycles	**Flex. Abrasion Cycles Warp	**Flex. Abrasion Cycles Filling	Water Proof (Spray)	Hydrostatic Pressure ASTM D-583-58 mm	Air Permeability ASTM D-1282-61T ft³/ft²/min
	Windproof	Before Use						122.0	94.0	30.0	28.0	4.00	2.30						
	Jackets	Seriously damaged part	75D-34f	248.7	122.3	0.22	138	120.5	62.7	41.5	27.7	3.90	2.29	2,850	5,000		0	0	14.7
33.	(nylon	Change in %						-1.2	-32	+38	-1	-2.5	-0.4						
	twill)	Slightly damaged part	75D-34f					154.1	78.0	56.0	36.5	3.93	2.59	4,060	5,000		0	0	13.3
		Change in %						+26	-15	+87	+30	-2	+13						
	Windproof	Face Cloth																	
34.	trousers	Seriously damaged part	110D-30f	99.5	119.5	0.26	249	23.0	31.4	14.3	21.0	2.47	1.73	1,230	5,000		0	0	12.3
	(nylon	Slightly damaged part	110D-30f					91.7	55.5	31.3	26.0	2.16	1.47	1,340	5,000		0	0	11.1
	twill)	Lining Cloth	70D-34f	113.3	95.3	0.11	70	68.8	55.0	18.5	17.7	2.02	1.93	230	5,000		0	0	
	Windproof	Before Use		227.8	110.2			88.5	46.7	42.1	26.9	1.16	0.60				100	260(590)	
	trousers	Face Cloth																	
	Face:	Seriously damaged part	50D-24f	227.3	113.0	0.13	91	54.4	30.2	32.2	16.3	0.81	0.59	770	1,190	1,400	50	23(30)	
34'	"Tetoron"	Change in %		-0.2	+3			-38	-35	-24	-40	-29	-1.7				-50	-92	
	plain	Slightly damaged part	50D-24f	226.6	112.3			57.5	36.5	29.7	10.2	1.06	0.71	840	1,490	2,040	50	33(40)	
	Back:	Change in %		0.3	+2			-35	-22	-29	-32	-7	+18				-50	-88	
	nylon plain	Lining Cloth	50D-17f	242.7	111.7	0.15	90	115.8	58.0	54.0	35.8	2.25	1.13	650			50	53(65)	
	Sleeping	Face Cloth	75D-34f	249.0	119.3	0.22	113	146.9	75.2	52.9	41.5	3.88	2.06	2,240	5,000		50	80(150)	19.1
21.	bags	Lining Cloth	75D-34f	243.0	122.3			146.5	77.4	55.6	42.6	4.25	2.40	1,920	5,000		70	159(170)	10.3
	Pyramid	Before Use	50D-17f	227.8	110.2			88.5	46.1	42.1	26.9	1.14	0.60				100	250(590)	
	type tents	Seriously damaged part	50D-17f	227.6	113.0			57.5	14.5	28.3	8.1	1.22	0.61				50	24(50)	
22.	(5 persons)	Change in %		-0.1	+3			-35	-70	-33	-70	+7	+2				-50	-91	
	"Tetoron"	Slightly damaged part	50D-17f	227.2	118.0			72.0	39.3	32.8	17.1	1.31	0.67				50	50(74)	
	plain	Change in %						-19	-15	-22	-36	+15	+12				-50	-80	
	Pyramid type tents	Before Use	W. 100D-40f F. 150D-40f	142.0	87.0		139.5	106.7	124.3	39.2	28.8	1.69	2.02				90	19	
22'	(5 persons)	After Use						85.1	76.0	33.8	17.1	1.15	1.15				0	10	
	"Tetoron" twill	Change in %						-20.2	-38.9	-13.8	-17.0	-32.0	-43.1				-90	-47	
	Canvas	Before Use	20/3s	48.0	31.0	0.61	536	106.0	95.0	31.0	25.0	6.90	8.30					805(850)	
20.	(for	After Use	20/3s	49.0	41.0	0.65	610	97.8	73.0	32.0	22.0	10.10	12.20				50	429	
	caboose)	Change in %		+2	+32	+3.3	+15.3	-8	-23	+3	-12	+46	+47					-46	
	Canvas	Before Use	20/6s	36.0	25.0	0.92	787	199.8	175.0	30.0	21.0	15.50	13.50					700(850)	
	(for power	After Use	20/6s	32.0	24.0	1.22	560	81.0	135.0	22.0	12.0	6.20	4.70					340	
	hut)	Change in %		-6	-4	+33	-29	-59	-23	-27	-43	-61	-65					-51	

No.	Article		Diameter (mm)	Tensile Strength (kg)		Elongation (%)	
		Before Use	9.0	1500	1700	50	50
	Rope	Seriously damaged part					
27.	Nylon (9mm)	After Use		566	629	56.7	59.3
		Change in %		-62	-63	-0.6	+3
	Rope	Before Use	12.0	2400		30	
26.	"Tetoron" (12mm)	After Use	12.7	2400		30.0	
		Change in %	+6				
		Before Use	9.0	1310		20.0	34.0
	Rope	Seriously damaged part					
27'	"Tetoron" (9mm)	After Use		470		31.6	
		Change in %		-64		-10	+8

Notes: *Sand paper: USA -0, Air pressure: 4 lbs.
**Standard is over 5,000 Cycles
Tension: 7 lbs.
Load: 3.5 lbs.

All tests were carried out at 20°C, 65% RH.

***Japan Industrial Standard

5. Concluding Remark

It has been seen in the preceding sections that synthetic fabrics can keep abreast with those of natural fibers in field uses in the Antarctic region.* There might be some danger in presuming that the same will hold true in other cold regions, e.g., in high altitudes of Himalayan Ranges, because there are differences in the intensity of solar radiation, in humidity, etc. We are sure, however, that we can, with confidence, depend on synthetic fabrics in Antarctic expeditions.

We are ready to admit that synthetic fabrics have some drawbacks. They are admirably resistant against wear; but sometimes clothes of synthetic fabric are liable to become unsewn, presumably because the thread is worn out by rubbing against the fabric. They can be made waterproof; but at present we have no means of rendering them permanently waterproof (Par. 4). Some synthetic fibers are sensitive to ultraviolet rays.

Another drawback often referred to concerns the comfort of the clothing made of these fibers. We have to admit that there were a few members of J.A.R.E. who preferred woolen underwear and socks to those of synthetic fibers. Most members preferred eiderdown sleeping bags to those quilted with "Tetoron" staple.

We believe, however, that most of these drawbacks will be overcome before long. There seems to be a variety of possibilities for improving synthetic fabrics. Blending with some kind of natural fiber would be the most satisfying solution. But substantial improvements could also be brought forth by other methods, for instance, by modifying the method of weaving, by changing the cross-sectional shape of the fiber, by giving a permanent twist to the fiber, etc. Search for new materials is of course desired. I believe it is quite possible that we may see, in the very near future, a party equipped exclusively with synthetic fabrics.

*A reservation might be necessary in that our experience is limited to the temperature range 0^{o} — $-50^{o}C$.

REPORT ON THE FIELD RATION, J. A. R. E.

Masayoshi Murayama and Tatsuro Matsuda

1. Composition of the Field Ration

The composition of the field ration.was based on the number twelve, being keyed to the number of men who occupy each tent and vehicle. Thus, in field parties, three or four men occupied a tent, and two or three men rode in a vehicle. The food ration to be eaten in the vehicles while underway consisted of rye biscuit, frozen bread, dried fruits, dried meat and sweets, etc., three days' ration—a set of three packages for two men—were packed in a paper box marked "AB". The foods for breakfast and supper (both to be cooked in camp) were prepared and packed in a set of ration packages labelled as "C", "D" and "S" boxes. Each box contained enough food for 12 man-days (four men for three days, or three men for four days according to the number of men in the tent). The "C" box contained staples, including alphered rice, our special field food which has been used by the Japanese Himalayan Expeditions as well as by the Japanese Antarctic Expeditions. This is made by promptly drying after pressure is reduced on boiled rice. The "C" box also contained corn-flake, sugar dried vegetables, etc. The "S" box contained frozen beef, pork, chicken and fish, so that each might be prepared every four days, and bacon, ham and powdered eggs for breakfast. The "D" box contained seasonings, tea, coffee, etc. For details, see the attached table.

TABLE 1

i. "AB" box: To be used in the vehicles—18 men meal in three packs, each six men meal, weight per box about 4.5 kg.

Item	Weight Per a Meal	Item	Weight Per a Meal
rye biscuit	37 gr	dried meat	27 gr
sembei, rice cracker	33	cheese	15
peanut +	5	chocolate	10
mixed nuts	13	bean sweets	17
arare, cracker	11	rock sugar	10
honey ++	3	orange, milk, mixed juice +++	15
raisin	10	chewing gum	7
dried pineapple	10	frozen bread	
salami sausage	16	total	239 gr

Remarks: +a box contained one of them
++every five boxes contained a piece
+++every two boxes contained a piece

ii. "C" box: To be used in the tent for breakfast and supper—12 man-day, 5.0 kg, 16 man-day, 6.5 kg.

Item	Weight Per a Man-Day	Item	Weight Per a Man-Day
alphered rice	200 gr	powdered dried potato	4
corn-flake	40	seaweeds	5
sugar	80	miso, soybean mash	20
powdered milk	40	dried bonito	7
dried onion	4	tinned rice cake, mochi	13
dried spinach	1	total	418 gr
dried cabbage	4		

iii. "D" box: To be used in the tent combined with "C" and "S" 12 man-day, 3.6 kg, 16 man-day, 4.7 kg.

Item	Weight Per a Man-Day	Item	Weight Per a Man-Day
ajinomoto	4 gr	cigarette	19
salt	10	roll-paper	10
soy	10	ketchup	4
instant soup	8	mustard, pepper	1
butter	60	seasoned seaweeds	3
black tea	8	pickled radish	25
green tea	10	wheat flour	20
nescafe	8	baking powder	1
ovaltine	13	sweets/fruits +	75
		total	289 gr

Remark: +to be contained in accordance with option, tinned fruits, peach, orange, pineapple.

iv. "S" box: To be used in the tent combined with "C" and "D"—contained 2 packs, 12 man-day and 16 man-day, 6 kg.

Item	Weight a Day	Item	Weight a Day
frozen beef +	100 gr	powdered egg	100 (4 days)
bacon	100 (2 days)	tinned beef	40 (4 days)
frozen pork +	100	corned beef	30 (4 days)
ham	100 (2 days)	ice cream powder	
frozen chicken +	100	frozen noodles	
tinned crab	30 (4 days)	chicken fat	
frozen fish +	100	total	200 gr

v. "E" box: For emergency.

sugar	18 kg
zamppa	15 kg

TABLE 2

	Case	"AB"	"C"	"D"	"S"	"E"	Total
i.	use	Lunch	Breakfast and Supper			Emer-	
ii.	content	18 men meal in 3 packs	12 man-days	16 man-days	12 & 16 man-days packs	gency	
iii.	weight (approx.)	4, 5 kg	5.0/6.5	3.6/4.7	6.0		
iv.	number of case	40	25 + 25	25 + 25	25	2	167
v.	total weight	180 kg	288	208	150	23	859 kg
vi.	per a meal:						
	weight	239 gr	418	289	200		1, 146 gr
	cal.	842	1810	881	764		4, 297 cal
	prot.	27.4	46.7	25.3	53.5		152.9 gr
	fat.	29.0	4.6	5.3	59.9		144.8 gr

2. Packing

Careful consideration must be paid to packing, with proper regard for such factors as coldness, damp-proofing and possible damage. As packing material, a thin polyethylene sack was found to be superior to cellophane or thick polyethylene, which are easily broken by shock or vibration caused by sledges. Besides being able to withstand cold and being damp-proof, thin sack has an additional merit—it can be heat-sealed after packing. It was found useful to insert a polyethylene sheet between pieces of frozen meat or fish in the ration package; this kept pieces from sticking to each other and prevented trouble in the cooking process. Seasoning such as ajinomoto or salt, only a little of needed at each meal, were packed in four days' quantity and kept in a small polyethylene bottle for instant use.

In order to arrange the 700 man-days' rations for the 1961 spring traverse, 400 man hours of preparatory work were required at the base. In addition to the foods mentioned above, two cases of zamppa (Tibetian instant baked flour which was popular on the Himalayan Expeditions) and sugar were prepared as an emergency ration. Thus, the 700 man-days' ration amounted to 849 Kg in 167 cases in total.

The details are as follows;

Case	Total No. of Case	Total Weight	Amount Consumed c/s	Amount Consumed Weight	Amount Remaining c/s	Amount Remaining Weight
"AB"	40	180 kg	27	122 kg	13	58 kg
"C"	50	288	38	219	12	69
"D"	50	208	38	165	12	43
"S"	25	150	19	114	6	36
"E"	2	23	0	0	2	23
Total	167 c/s	849 kg	122 c/s	620 kg	45 c/s	229 kg

3. Menu

A typical daily menu follows:

Morning	potato soup with bacon or ham, cornflakes, coffee
In vehicle	bread, biscuit, sembei (rice cracker), chocolate, cheese, and sweets
Evening	boiled alphere-rice, soybean soup (misoshiru), beef/pork/chicken/fish in turn during 4 days, takuan (a kind of pickle), green tea
Night	ovaltine or black tea

Special attention was paid to the selection of the foods chosen for the use of the wintering team even for trail party. Because of the variety of foods that Japanese like, European and Chinese dishes were included as well as Japanese dishes. So, we enjoyed steak, fried sweet-sour pork, and sukiyaki even in our trail camp dinner.

Frozen bread which had been baked at the base was most popular for our lunch in the vehicles, and we enjoyed frozen boiled noodles which had also been prepared at the base for our camp menu.

Generally speaking, most members of the field party considered that fish was inferior to meat, in terms of both cooking problems and taste. We would prefer to take meat, even though it costs much more, for our inland trip.

As the ration consists mainly of frozen foods, it is hardly possible to bring it in the original form from home country. In preparing the field rations, it is of course necessary to pay due regard to cooking and taste as well as to the packing materials.

DOG PEMMICAN

V. E. Donnelly

Introduction

The pemmican described has been used by New Zealand expeditions since 1959 and has been found adequate under extremely severe conditions. Primarily designed for use on the trail it has also been used for supplementary feeding at Scott Base in conformity with seal conservation policy. The relatively high unit cost has up until now precluded its use as a standard winter diet. However, bulk preparation and improved packaging techniques have changed the position considerably and subject to certain biological experiments it could well become accepted for feeding out, 12 months of the year.

Formula

Dr. Muriel E. Bell, of the Nutrition Research Department, Medical School, University of Otago, was consulted in regard to the specific ingredients making up the pemmican. They were:

Meat Meal	31%
Liver Meal	11%
Tallow (beef)	40%
Whole Wheat Meal	10%
Wheat Germ	5%
Molasses	2%
Vitamin Additives	1%

(Rose hip powder at 3 oz. per 100 lb is included in the Pemmican, but Vitamin D capsules (Adexolin) are administered to dogs separately.)

Constituents

Protein	25%
Carbohydrates	17%
Fat	47%
Bone	1%

(The bone provides some minerals for growth of adolescent dogs.)

Suppliers of meat and liver meal are required to meet the following specifications:

	Meat Meal	Liver Meal
Moisture	6%	3 - 7%
Fat	9 - 11%	13 - 17%
Bone	3% (max.)	3%
Meat Protein	60% (min.)	73 - 75%

Feeding

A daily ration of 1 1/2 lbs has been fixed as a standard that has met with general acceptance. Circumstances have sometimes resulted in the standard being achieved by a variation to one pound and two pounds a day. Dogs have retained their condition after months of hard work and long mileages.

Packaging

Two alternatives are available:

a. One pound blocks, each wrapped in greaseproof paper and packed in 52-56 lb lots in tin lined cases (approx. 20" x 10" x 10") and crated for shipment.

b. Waxed cardboard containers approx. 8 1/2" x 9" x 10" deep, containing in the vicinity of 24 lbs of pemmican made up of 12 layers, each weighing 2 lbs. The layers are separated by a sheet of waxed paper. Two of these primary packs are then packed into a corrugoid box and lid container with an overall measurement of approx. 20" x 10" x 10" deep. The container is suitable for shipment without further crating. In both instances the size of the container has primarily been made to conform with loading requirements on a "Nansen" dog sledge. Variation of container sizes is contemplated for bulk shipments. Magazines or other suitable reading matter has been used as packing material.

Cost of Manufacture

The ex-factory price in New Zealand for pemmican in one pound blocks, tinned and crated, has remained fairly steady at around 2/- per pound. A substantial reduction is anticipated for the pemmican prepared in two pound blocks and packed in corrugoid box and lid containers. The New Zealand orders on which the above price is quoted varied between 6-9, 000 lbs. This compares more than favorably with specially packed carcase mutton supplied for base feeding at an average cost of 1/3d per pound.

Conclusion

Close observation of dogs at Scott Base has resulted in the general conclusion that the pemmican is possibly superior to seal meat as a basic diet and mutton is inadequate even when fed out with a proportion of either seal meat or pemmican. During the 1962/63 season a biologist at Scott Base will carry out specific research on the diet of huskies so that a sound evaluation can be made of the dietary value of seal, pemmican and mutton.

MAN RATION SCALES FOR DOG AND MAN-HAULING FIELD PARTIES

A. J. Heine

Introduction

During the 1957/58 summer, there were a number of New Zealand parties in the field. The first group, as part of the Trans-Antarctic Expedition, were working in areas of the Ross Dependency from 75°S to the South Pole, while the second group explored an area around Cape Hallett and the Tucker Glacier. Dog and vehicle transport was used by the first group, with the second group using man-hauling techniques. Ration scales were largely based on the standard F.I.D.S. scale, with modifications made in light of the experiences of the previous summer's reconnaissance parties.

"Dog Team" Man Ration Scale

A ration scale used by a "dog team" party was as follows (in actual fact, some modification was probably made in the field):

Item	Oz./Man/Day
Meat Bar	5.6
Rolled Oats	2.4
Butter	4.0
Dried Onions	.4
Potato Powder	1.6
Bacon	1.6
Biscuits	4.4
Sugar	4.0
Egg Powder	.4
Soup Powder	.4
Cheese	.8
Sultanas	1.6
Milk Powder	2.0
Cocoa	.8
Chocolate	4.0
	34.0

(Not included in weights: Tea, Nescafe and Salt)

Total Calories: 4825

Ratios: Protein - 139 gms
Fat - 276 gms
Carbohydrate - 408 gms

"Man-Hauling" Ration Scale

The ration scale for the man-hauling parties was based in part on available Antarctic trail rations, but mainly on Heine's trans-alpine experience in New Zealand. The scale as used (with slight variation in the field):

Item	Oz./Man/Day
Meat Bar	8
Meat Bar Additives	.8
Butter	3.2
Biscuits	4.8
Rolled Oats	2.4
Milk Powder	2.4
Sugar	4.0
Chocolate	4.0
Bournvita	1.6
Coffee/Tea	.6
Salt	.4
	32.2

Total Calories: 4387
Ratios: Protein - 121 gms
Fat - 243 gms
Carbohydrate - 434 gms

One notable difference between the two scales is that the man-hauling parties used more "hot drink" material, as they were hauling for 7-10 hours in contrast to the "dog team" hauling day of 5-7 hours.

Although a higher energy expenditure is obvious while man-hauling, it is also necessary to keep the total sled weight to a minimum.

During the 1958/59 summer, only man-hauling parties were used, and the ration scale was modified to the following:

Item	Oz./Man/Day
Butter	2.4
Peanut Butter	.4
Cheese Spread	.4
Biscuits	4.8
Rolled Oats	2.4
Coconut	.2
Egg Powder	.4
Bacon	1.6
Soup Powder	.8
Milk Powder	2.4
Sugar	4.8
Chocolate	4.0

Item	Oz. /Man/Day
Bournvita	1.6
Nescafe/Tea	.4
Flaked Rice	.8
Raisins	.6
Salt	.4
	28.4

Ration A

Meat Bar (Man Pemmican)	8

Ration B

Dehydrated Meat	4.0
"Shreddo"	1.4
Potato Powder	1.2
Mixed Dehydrated Veges	.8
	7.4

Total Calories: Ration A - 4969
Ration B - 4831

Ratios: Ration A - Protein - 136 gms
Fat - 271 gms
Carbohydrates - 417 gms

Ration B - Protein - 128 gms
Fat - 256 gms
Carbohydrate - 427 gms

As well as the field rations, a special "goody" box was supplied to last approx. 40 man days. This did not need to be used in its entirety, but items taken to suit the requirements of a particular party.

Contents of Goody Box

Item	Quantity
Jam	1 lb
Honey	1 lb
Pudding (tinned)	1 lb
Jelly Crystals, "Instant" puddings, "Dessert" pudding mixtures	2 pkts
Condensed Milk - sweetened	1 tin
Barley Sugar	1 pkt
Dates	1 pkt
Raisins	1 pkt
Sultanas	1 pkt
Dried Apricots/Peaches	1 lb
Tinned Fruit—Peaches/Apricots/ Pineapple	2 tins

Item	Quantity
Tinned Meat—various types	4 tins
Salmon, tinned	1 tin
Herrings and Tomato Sauce	1 tin
Curry Powder, Chili Powder and Dried Onion Flakes	
Sweet Biscuits	2 lbs

Following the 1958/59 summer, field parties have used dog teams, but ration scales have generally followed the same pattern as given in the last scale above. Field party leaders have made slight alterations both to the basic ration and the "goody" box content, to suit personal requirements.

The basic field ration is made up in a 20 man day sled box, and the "goody" box is packed in tins or an additional sled box.

FIELD CLOTHING FOR ANTARCTIC USE

A. J. Heine

Introduction

This paper summarizes the types of windproof and down clothing used by New Zealand field parties.

Windproof Clothing

The 1956/57 New Zealand field parties were issued with some F.I.D.S.-type parkas and over-trousers made from "Ventile" material. During the following winter Heine tried out a number of designs in varying snow and blizzard conditions on Mount Ruapehu and the final design was manufactured in New Zealand from "Wyncol" material. Bright colored material was used to present a distinctive pattern on the otherwise monotonous terrain, whether snow or snow and rock.

The parkas and over-trousers have been used on each succeeding field trip, with minor modifications. One of some importance was to place a strip of fur inside the hood, about two inches in from the outer edge. This provides additional protection for the wearer's face. Main features of the parkas are:

1. They have drawstrings around the waist and skirt. They have a hold-down strap between the legs for use in high winds. Although the parka can be worn inside the over-trousers, in the case of man-hauling or heavy physical work this is much too hot and it is worn on the outside.

2. They have "bat wing" sleeves. This means that the wearer's arms can be withdrawn from the sleeves without removing the parka; this is a distinct advantage when trying to keep the hands warm.

3. They have a long double cuff, so that this can be pulled over gloves and prevent any loss of heat around the wrists.

4. They have a large hood to give adequate face protection.

Down Clothing

Down clothing has been used extensively by all field parties. The clothing, as well as Antarctic sleeping bags, is all manufactured in New Zealand.

1. Down Jackets and Trousers

Down jackets are used by surveyors and field personnel who are obliged to occupy stations for several hours. The jackets have a large fur-trimmed hood and give adequate protection, although the use of survey equipment does present some frostbite risk. Down-filled trousers are seldom used in the field and, with the jacket, are more suited for drivers of vehicles with inadequate wind protection.

2. Down Vest

This vest is used extensively by both field and base personnel. The down-filled body and woollen material sleeves of this garment can be worn under the parka and provides an ideal combination for many Antarctic activities. It is important that the vest reach below the wearer's hips to prevent chilling of the lower back.

3. Down Gloves and Slippers

Down-filled mitten-type gloves have been made and have a limited use, particularly for men in a static role, e.g., tractor drivers. The gloves are bulky but extremely effective.

Down-filled slippers are used by the field personnel as tent footwear. They can be worn outside for short periods, and are light enough in construction to wear inside a sleeping bag.

Down-filled clothing has reached a high standard of design and manufacture in New Zealand, and is an important feature of the Antarctic clothing issue.

THE REQUIREMENTS AND NATURE OF
THE LOGISTICS SUPPORT FOR A SMALL
NATIONAL ANTARCTIC EXPEDITION
(D. Antarctic Provisioning)

J. J. la Grange

To see that sufficient provisions are supplied (together with sufficient fuel) is probably the most important item when one prepares for an expedition, as men can easily survive without their scientific programs but without sufficient food and fuel an Antarctic winter may be very trying. It can be argued that if, for example, the dried pears or the custard powder is left behind, it would not matter too much. On the other hand men at an Antarctic Base will find any missing items in the food-lists a good excuse for never-ending complaints.

Now it is impossible to satisfy the varying tastes of all the members of an expedition. Even the taste and requirements of one expedition following another of the same nationality, will be different. One group will possibly bake much more bread than another, one group will prefer coffee to tea and vice versa, etc., etc. And as it is impossible to know beforehand what the tastes will be (provisions are bought and packed several months before the ship sails) it is possibly the best policy to standardize provisions. In this case items which are not really liked can stay over for the next expedition.

Different nationalities will of course, be fond of certain dishes which again are totally disliked by others. The following list is indicative of the items and quantities of foodstuffs provided for a ten men expedition in our case.

Item	Quantity
Beef rolls, tinned in 1 Kg tins	20
Tinned beef sausages, Hereford, in 16 oz. tins	12 doz.
Tinned steak and vegetables in 16 oz.tins	96
Tinned Pork sausage, in 16 oz. tins	72
Pork luncheon rolls in 11 oz. tins	312
Sausages, Vienna in 10 oz. tins	120
Scotch Kippered Herrings in 14 oz. tins	60
Snoek in 8 oz. tins	30
Butter canned in 1 lb tins	120
Margarine	100 lbs.
Steak and gravy in 10 oz.tins	250
Steak and Kidney pudding in 10 oz.tins	216
Steak and onions in 10 oz. tins	250
Spaghetti in tomato sauce in 1 lb tins	120
Cooked shoulder Ham	150 lbs.
Braised steak in 10 oz. tins	228

Item	Quantity
Bacon in 1 lb tins	252
Crayfish in 8 oz tins	96
H. P. Sauce	20 bottles
Gravy powder	10 lbs.
Lamb tongue in 12 oz tins	120
Pink salmon in 8 oz. tins	120
Pilchards in 15 oz. tins	24
Sardines in 9 oz. tins	98
Sweetmilk cheese	80 lbs.
Cheddar cheese	72 lbs.
Egg powder	130 lbs.
Lard in 1 lb packets	200
Dripping in 1 lb packets	50
Biltong	60 lbs.
Baking yeast	16 lbs.
Potato powder	150 lbs.
Lemon powder	25 lbs.
Onions, dehydrated in 4 gal tins	15
Potatoes, dehydrated in 4 gal tins	28
Rice	264 lbs.
Carrots, dehydrated in 4 gal tins	4
Green beans, dehydrated in 4 gal tins	13
Cabbage, dehydrated in 4 gal tins	10
Turnips, in 2 1/2 lb tins	24
Split peas, dry yellow	100 lbs.
Asparagus in 1 lb tins	120
Soup, canned celery in 1 lb tins	48
Soup, canned peas in 10 1/2 oz tins	48
Soup, canned vegetables in 10 1/2 oz. tins	72
Soup, chicken in 10 1/2 oz tins	72
Soup, canned tomato in 10 1/2 oz tins	48
Potatoes diced in brine, in 2 lb tins	20 doz.
Boilings mixed	30 lbs.
Peel mixed, candied	2 lbs.
Almonds ground	10 lbs.
Spices mixed ground	1 1/2 lbs.
Mixed herbs	12 oz.
Nutmegs ground	2 lbs.
Gelatine edible, granulated	2 lbs.
Essence, assorted flavoring in 1 oz. bottle	12
Mushrooms dehydrated	100 lbs.
Christmas mince meat in 8 lb tins	3
Christmas pudding in 2 lb tins	12
Peanuts, salted	50 lbs.
Caju nuts	40 lbs.
Dates, stoneless	40 lbs.
Raisins	30 lbs.
Sultanas	28 lbs.
Almonds	20 lbs.

Item	Quantity
Currants	12 lbs.
Walnuts	27 lbs.
Celery in 29 oz. tins	48
Brussel sprouts in 29 oz. tins	60
Pickles sweet Branston	48
Honey in 1 lb jars	48
Coffee, Instant in 8 oz tins	60
Coffee ground	120 lbs.
Guava juice in 18 oz. tins	192
Lime juice	120 bottles
Orange squash	240 bottles
Capucijner beans	50 lbs.
Chutney Banana	12 bottles
Chutney Mango	36 bottles
Sweet branston pickles	24 bottles
Beans in tomato sauce in 28 oz. tins	180
Peeled tomatoes, canned in 28 oz. tins	504
Sweet corn in 1 lb tins	250
Green peas, canned in 28 oz. tins	216
Beetroot slices, canned in 16 oz. tins	228
Carrot slices, canned 30 oz. tins	120
Quince slices, canned in 29 oz. tins	144
Grape-fruit segments in 20 oz. tins	40
Guavas, canned in 30 oz. tins	120
Apricots, canned in 30 oz. tins	72
Fruit salad in 29 oz. tins	48
Pineapples, canned in 2 lb tins	96
Plums, canned in 2 lb tins	24
Peaches, canned in 30 oz. tins	140
Pears, canned in 30 oz. tins	120
Bananas, dehydrated	90 lbs.
Peanut butter in 13 oz. jars	52
Marmalade jam in 32 oz. tins	72
Marmalade jam in 5 Kg. tins	3
Melon and ginger jam in 5 Kg. tins	12
Ripe fig jam in 5 Kg. tins	6
Peach jam in 5 kg tins	4
Grape jam in 5 kg. tins	12
Apple jam in 5 kg. tins	4
Apricot jam in 5 kg. tins	4
Illovo Golden Syrup 5 kg. tins	48
Lyles golden syrup in 2 lb tins	30
Condensed milk in 12 oz. tins	668
Powdered milk	400 lbs.
Cream in 11 1/4 oz. tins	96
Horlicks milk in 1 lb bottles	30
Ovaltine in 1 lb tins	30
Cocoa in 1 lb tins	24
Tea in 1 lb packets	135

Item	Quantity
Corn flour	15 lbs.
Oats	150 lbs.
Mealie meal	150 lbs.
Barley	25 lbs.
Rice pops in 1/2 lb packets	60
Corn flakes in 1 lb packets	30
Kaffir corn meal	60 lbs.
Cake flour	80 lbs.
Meal unsifted	250 lbs.
Meal sifted	800 lbs.
Macaroni	50 lbs.
Mustard	6 lbs.
Marmite in 4 oz. jars	216
Oxo in 4 oz. jars	90
Vinegar	24 bottles
Piccalilli in 20 oz. jars	24
Worcester sauce in 26 oz bottles	12
Tomato sauce	72 bottles
Pickled onions	48 bottles
Mayonnaise	36 bottles
Assorted jellies	144 packet
Pudding powder, almond	240 packets
Pudding powder assorted	140 packets
Pudding powder, caramel	336 pkts.
Pudding powder, chocolate	192 pkts.
Custard powder in 16 oz. tins	54
Baking powder in 16 oz. tins	48
Ground ginger	14 lbs.
Cinnamon	3 lbs.
Curry powder	21 lbs.
Cream of tartar	5 lbs.
Bicarbonate of soda	10 lbs.
Icing sugar	25 lbs.
Pepper	5 lbs.
Table salt	30 lbs.
Coarse salt	100 lbs.
Ground cocoanut	10 lbs.
Weetbix	60 lbs.
Cerix	63 lbs.
Cooking oil	8 gal.
Boiled sweets assorted	60 lbs.
Brazil nut chocolate	120 slabs
Fruit and nut chocolate	120 slabs
Whole nut chocolate	120 slabs
Dairy milk chocolate	120 slabs
Mint crisp chocolate	84 slabs
Honey crisp chocolate	42 slabs
Dried pears	40 lbs.
Dried peaches	40 lbs.

Item	Quantity
Dried apricots	40 lbs.
Dried apple rings	80 lbs.
Dried prunes	60 lbs.
Rusks	96 lbs.
Biscuits, various assortments	250 lbs.
Sugar	600 lbs.

Fresh Foodstuffs

Chili	7 lbs.
Garlic	14 lbs.
Onions, dry	67 lbs.
Potatoes in 37 1/2 lbs pockets	24
Pumpkins dry	4 bags
Sweet potatoes	6 bags
Cabbage	12 cases
Hubbard squashes	4 bags
Carrots	6 bags
Gem squashes	4 pockets
Apples	20 cases
Pomeloes	20 cases
Grennadillas	20 pockets
Beef fresh, hind quartes	700 lbs.
Mutton fresh	600 lbs.
Pork fresh	100 lbs.
Fresh sausage (Boerewors)	135 lbs.
Poloni French	35 lbs.
Poloni German	35 lbs.
Eggs fresh	420 doz.
Chickens fresh	24
Turkeys fresh	4

So much for food stuffs at the main base. These provisions will allow a small surplus for the time when visitors call in at the station and have to be treated to a decent meal.

A system which is strongly recommended is that the small expedition should not have a permanent cook but that each member takes a turn at cooking. The author has had reasonable experience of expeditions with and without full-time cooks. It is admitted that on a bigger expedition of say 15 men or more a permanent cook or steward is required. On the smaller expedition where there will necessarily be fewer dishes to wash, etc., and where serving up and mealtimes themselves take less time, it is possible for an expedition member with a little help from the others, to do almost all of his normal work and to do the cooking provided that such a period does not last too long; experience has told that a cooking turn of four days is the ideal period. There are very few men who like to cook but if they have experienced both the cook and non-cook systems most people prefer to take a turn and thus avoid the boring menus which arise from the fact that, as usually will happen, one knows for weeks or months ahead what exactly the cook will prepare on for example Monday night or for Tuesday's lunch, etc. The excuse that a person does not know how to cook does not hold in very much, the author has seen fellows who were unable to boil an egg or make a cup of tea and yet with time developed into excellent cooks. It does of course take a lot of hard trying on the cook's side and sympathetic reception by the others. In this way one finds that the feeling of the cook against everybody and everybody against the cook, disappears as everybody gets a turn to be at the shortest end.

Liquor, Tobacco and Cigarettes

One of the major-problems on an expedition is sometimes the matter of supplying liquor, or how to supply it.

After various "experiences" on former expeditions the author found the system of putting out liquor for special occasions or else on Saturday nights, to last for the whole week to work very well. More important is that everyone could drink as much as he liked but all liquor was to be drunk in the living room. This prevented anyone from over indulging and during a whole year there was not a single case of misbehavior. The total amount of liquor for this year was 720 pint tins of beer, 72 bottles brandy, 72 bottles gin, 60 bottles sparkling wine, 20 gallons sweet wine, 5 gallons dry wine, 72 bottles whisky and an assortment of lemonade and soda soft drinks. These supplies were for ten men.

A free issue of 20 cigarettes per day and ten lbs of tobacco per person per year worked out very well. Smokers request their brands before they leave their home country and after arrival in Antarctica should be handed their whole year's supply.

Toilet and Kitchen Items

For toilet, kitchen and general house cleaning purposes there is such a big variety of modern super-wonderful items and aids available on the market that every expedition will probably arrive on Antarctica with a new device which will make things still easier. The author thinks that items such as brushes, brooms, dishcloths, scouring pads, etc., could best be provided as thought necessary by the various expeditions. The following is a short list of some of the items necessary for a small expedition. Toilet paper 144 rolls, Vim 234 packets, Persil 288 packets, matches in packets of 12 boxes each 520, Toilet soap 216 cakes, yellow soap 140 lbs, tooth brushes 24, toothpaste in tubes 144, disinfectant eg. Jeye's Fluid 12 gals., Gillett's Javel 100 pts.

Travelling and Camping

It is accepted that each travelling party will be equipped with either caboose or antarctic windproof tent and the necessary sleeping bags, pillows, sheepskins, rucksacks, rope, cooking utensils such as pots, pans, plates, spoons, forks, primusstoves with spare burners and prickers, thermos flasks, hurricane lamps, paraffin, methylated spirits, matches, etc., etc.

Dog food is usually provided in ready packed blocks, each dog gets one at the end of each day.

Food for fieldworkers have been an interesting topic of conversation on probably all expeditions. When tractor vehicles are used and a few hundred pounds of extra weight for rations do not make a big difference to the total load then just about the normal Base food can be used except that time for cooking purposes will always be limited.

If the travellers can take only a light load, the rations will have to be concentrated and as fuel will also be limited, cooking time will have to be short. Further, any amount of steam produced by cooking will prevent the maximum drying of clothes inside the caboose or tent.

Very concentrated rations which of necessity will usually be rather unappetizing, after several months on end tend to become boring and even nauseating. If the basic rations can be supplemented in some or other way with something appetizing it would make a world's difference—the problem naturally is that of weight. The author feels that with the system of depot laying by tractor it is worth while to allow a few pounds in weight for delicacies such as egg powder, a few tins of vegetables and canned fruit and even half a bottle of liquor or so for festive occasions in the field. Sliced biltong, dried fruit and nuts are nice to chew while travelling along.

Ration boxes are usually made up to contain the rations for two men for ten days. Several different types of these balanced rations are available of which the one compiled by the Medical Research Council, England, has the advantage that most of the rations for one day are packed separately, pemmican is replaced by a very palatable minced meat and cooking time is cut down to a reasonable minimum. Each box contains the following:

1 tin 24 packets Biscuits
10 x 10 oz. tins Meat Bars
1 tin 20 x 1 oz. Fruit Bars
8 x 2 oz. Chocolate Bars
1 tin 12 x 2 oz. bars Chocolate
10 packets. Knorr Soups
1 x 8 oz. tin Dried Onions
1 x 1 oz. tin Salt
1 tin 4/15-1/2 oz. pkts. Cube Sugar
1 x 4 oz. tin Tea
1 tin 3 lb block compressed Oats
2 x 1 lb tins Milk powder
1 x 8 oz. tin Potato Powder
1 x 12 oz. tin Cocoa
1 x 16 oz. tin Bacon
6 x 16 oz. tins Butter
1 x 2 oz. tube Marmite
1 Tin opener

One important matter that must not be overlooked is the fact that the "small Antarctic expedition" which will most probably not have the services of an Ice-breaker as relief vessel, should always be prepared to stay on for a second year if the relief vessel, due to heavy ice conditions, cannot reach the station to bring supplies. The year's provisions should therefore be duplicated and stored for the second year.

Clothing and Sleeping Outfit

Six woolen blankets, two pillows, four pillowslips and three flannel bedsheets should be sufficient at Base if a bed or bunk and mattress are provided. Sleeping bags should be used for fieldwork only; at other times they are to be kept in a safe place or emergency hut in case of fire in the sleeping quarters.

To the author's knowledge there is no final list of clothing items for an antarctic expedition member that will be perfectly suitable for all weather conditions. The problem of keeping the body warm has been solved to a reasonable degree by providing various layers of light garments that can be increased when necessary, with suitable windproof outers. Even the feet are well catered for by various types of boots for summer and winter and the accompanying inner boots, slippers or socks. Similarly various types of headgear for the head and neck are available for different conditions. Coming to the face and hands we are still in trouble. The problem is that one cannot continue putting on extra gloves as the fingers then become immobile. One of the fundamental principles is that all garments and gloves should be loose fitting otherwise the circulation will be affected. The S.A.N.A.E. has found that during warm weather for general outside work a pair of duffle or woolen gloves together with an outer leather fingerless glove (except for a thumb) is sufficient. For fingerwork a woolen glove or loose fitting thin leather glove is useful but then the hand has to be put back into the big leather glove from time to time. In colder conditions for finger work, finger leather gloves with inside padding and built in electric heating element were very useful—the gloves' leads were then connected to an outside power supply socket with a lead of say ten yards. For general outside work the heat content of gloves will be greatly increased by a long windproof sleeve reaching up to near the elbow. An additional glove of thin felt or woolen material will also help.

A woolen wristlet to keep the wrists warm, could be worn at all times with great success.

A lampwick harness around the neck fastened to the gloves, is often a nuisance but will prevent the gloves from being blown away in a blizzard—something which could have very unpleasant results.

A blizzard mask and goggles covering the face and eyes often bring other problems such as icing or freezing up. A simple but very effective type of blizzard mask is an ordinary woolen scarf wrapped around the face, it can easily be moved with a gloved hand if required.

In summer when tinted glass has to be worn to cut out some of the ultraviolet light the problem of frosting-up will arise unless provision is made for ample ventilation behind the glasses. Goggles should be cut open on the sides, bottom and top for this reason. If ordinary glasses are worn all metal parts should be covered by an insulating material to prevent frostbite.

Due to acclimatization the items worn after winter will be lighter or fewer than before the winter.

Psychologically it is a good thing if there could be variety not only in articles, for example different types of jerseys and trousers, but specifically in colors. Shirts, jerseys, woolen caps, etc., should be of varying colors; it has been found that bright colors provide a boost in morale. And just as people in civilization prefer to wear something "different" to the next fellow so also on Antarctica one man would prefer something a bit different from the other's.

The following issue should be enough for two years. Part of it should be set aside during the first year, if the person does not stay on for a second year then these items can be returned.

Anoraks sledging	2
Anoraks Base	2
Drawers short	6
Drawers long	3
Gloves chamois	3 pairs
Gloves heavy duty, pony skin	8 pairs
Duffel inners to suit gloves heavy duty	10 pairs
Helmets Balaclava, long neck	2
Jerseys, all wool	4
Knife, clasp	1
Knife, sheath	1
Mittens, woolen, thumb only	2 pairs
Mocassins	6 pairs
Mukluks complete with Duffel sock inners and felt inner sole	6 pairs
Comforters (scarves woolen)	2
Scarves (neck, squares)	2
Shirts, woolen	4
Socks, woolen for bottom layer	10 pairs
Slippers duffel, various sizes	4 pairs
Snow goggles plus amber, green and sandy grey color lenses	4
Stocking seaboot	8 pairs
Towels hand	2
Towels bath	2
Trousers woolen	2
Trousers windproof, light	2
Trousers windproof, heavy material	2
Putties	2 pairs
Gloves woolen with fingers	4 pairs
Housewife outfit (men's)	1
Handkerchiefs	12

Caps, fur lined	1
Ski caps	2
Kit bags, Seaman's	3
Pyjamas, thick	2 pairs
Vests string	4
Vests, woolen, long sleeves	4
Boots, ski-climbing	1 pair
Aircraft flyboots rubber	1 pair
Aircraft flyboots felt slippers	1 pair

For doing outside work in winter and for tractor fieldwork, the station should have a few warm nylon or eiderdown jackets and trousers.

It should be remembered that some members for example the diesel mechanics will need over-alls and additional clothing items, while those who are mainly confined to work inside the station will not need all the above listed items.

Clothing items especially head and foot gear should fit properly.

BRITISH SLEDGING RATIONS, RECENT DEVELOPMENTS

H. E. Lewis, A. B. E. de Jong and J. M. Harries

Introduction

In this paper we bring up to date the work on sledging rations[1] undertaken in the Division of Human Physiology, National Institute for Medical Research, London. Special emphasis is given to technological developments in food and packaging and to studies on consumers' reactions recorded in the field.

Modern polar expeditions have two distinct aspects: the epic of man against nature, and the scientific achievement. The latter is, in the long run, the acid test of a successful venture. In the words of Apsley Cherry-Garrard[2] who was a member of Scott's last expedition—"....whilst we knew we had suffered and risked better than anyone else, we also knew that science takes no account of such things; that a man is no better for having made the worst journey in the world, and that whether he returns alive or drops by the way will be all the same a hundred years hence if his records and specimens come safely to hand...."

Accepting, therefore, that the raison d'etre of a polar expedition is to increase scientific knowledge, this will more likely be achieved by men who have enough to eat and are not preoccupied by hunger or discomfort.

Energy Requirements

Polar journeys are characterized by hard work in an extremely cold environment, man-packing and man-hauling requiring the greatest maintained outputs of energy. High rates of work are required in dog-sledging over glaciers and hummocked snow or if the dog teams are not well-trained. Even with mechanical vehicles, hard work is often necessary because all mechanical 'aids' need complex maintenance involving man-hauling of fuel, digging vehicles out of snow and rescuing them from crevasses. Work on nutritional requirements of polar travellers was initiated on the British North Greenland Expedition 1952-54,[3] and has been continued on the British Antarctic Survey and on other expeditions over the last seven years.

However, even before the nutritional program was formulated on the Greenland expedition it was noticeable that husky dogs voraciously ate human faeces, sometimes in preference to dog pemmican.[4] As the men were eating large quantities of fat, it was thought that undigested fat might appear in the faeces and attract the dogs, but when the faeces were analyzed no excessive amounts of fat were found, and when nutritional balance studies were made it was shown that the large amounts of fat and protein eaten were completely utilized. The mean daily intake for men sledging was about 4,800 kcal[5] and the energy expenditure during sledging was found to be of the order of 5,000 kcal/day. The standard ration used on the expedition yielded 4200 kcal per man/day and men restricted to it lost weight and became hungry. Similar observations have been reported on other expeditions[6] and are confirmed by the findings of Johnson and Kark[7] who showed that the voluntary food intake of servicemen in the Arctic is as high as 4,500-5,000 kcal/day.

Earlier Developments

The Greenland findings therefore warranted a review of the existing ration scale. There had also been criticism of the manner in which sledging rations were packed, particularly in the light of the many advances in food and packaging technology since World War II.

These facts were put before the Climatic Physiology Committee of the Medical Research Council who gave generous encouragement to the development of a modern ration. In the past, the same rations had been taken time after time to avoid the risk of an untried innovation because immediate plans left no time for experiment. More often, it was a task relegated almost entirely to a storeman rather than to a nutritionist.

With adequate time and generous terms of reference, it was possible to plan to the following criteria:

1. High calorie yield
2. Low weight
3. Small bulk, governed by a box to fit on the Nansen sledge
4. Strong but low-weight packaging
5. Rations to be palatable and varied, and suitable for eating raw in an emergency
6. The packaging should permit easy sharing among a party and be easy to unwrap. Dead weight of packaging should be minimal.
7. The gross weight of a 20 man-day box should not exceed 50 lb.

The Prototype Pack

An approach was made to the Ministry of Food, whose Experimental Factory at Aberdeen had been improving techniques in dehydration. Among their products was a dehydrated meat bar consisting of approximately 60 per cent fat and 40 per cent dehydrated minced beef. The meat bar could be eaten as it was or easily reconstituted into a palatable mince stew. In the past, the traditional staple in the sledging diet had been pemmican, a generic name for a homogenized mixture of fat and meat. It has a very high calorific value (159 kcal/oz), but the taste has to be acquired, so as a first step in modifying the sledging ration, it was decided to substitute the meat bar, which is of similar calorific value.

The most economical method of increasing the calorie yield in terms of weight would have been to add more fat to the ration. However, only a little more fat could be tolerated, and the bulk of the increase had to be distributed between carbohydrate and protein.

Increases were made in chocolate, milk powder, rolled oats and cocoa, now in the form of drinking chocolate. Sweets, cheese and dehydrated soup, (listed in order of total calorie yield), were introduced. The following items, though not yielded calories, were included to increase the variety of the fare: curry powder, "Marmite", salt and pepper. Finally, tea and coffee were introduced as drinks, both in a soluble form which considerably simplifies preparation. The first prototypes, resulting from these changes, were made in 1956-57, in close collaboration with Mr. T. C. Gallant of the Research Division of the Metal Box Company. They were followed in 1958-59 by a Mark II pack. Included in each of these sledging boxes was a copy of the questionnaire shown in the Appendix, and subsequent modifications to the ration were based on the completed user reports. However, it was only when Mark III was being prepared that the first reports from the Antarctic were available. There were criticisms of far too many small units, that the items could not be identified in the dark, and that foods became lost in the tent with the result that men occasionally did not eat their full ration. For this reason, a pre-packed 2 man-day unit was devised. Innovations included a variety of soups, drinking chocolate, glucose lemon drink and pumpernickel slices. About 100 boxes, each containing ten of these units, were sent to the Falkland Islands Dependencies and to South African polar stations in the Antarctic. (Extracts of a film[7] will illustrate this phase of our work.)*

Commercial Arrangements

Now that the phase of early development was complete, it was important that the M.R.C. Sledging Rations should be put on to a commercial basis, and arrangements were made with Messrs. Horlicks Ltd., who had considerable contact with the polar world. Largely through the efforts of William Horlicks, this firm had been associated with the polar expeditions which were carried out in the early 1900's. Roald Amundsen used their malted milk during his navigation of the Northwest Passage, and during his successful expedition to the South Pole in 1911. Rear-Admiral Robert Peary, during his expeditions from 1891 to 1906, also used the product in particular during his attempt on the North Pole in 1909, as did Captain Scott during his two Antarctic expeditions in 1901-4 and 1910-12. Rear-Admiral Richard Byrd was also supplied, not only with the firm's products but also with equipment for his various expeditions in the Arctic and Antarctic. His naming of the Horlick Range of Mountains in Marie Byrd Land during his second expedition was in honor of his friendship with one of the company's founders. Even the containers served a purpose: Vilhjalmur Stefansson,[8] in his book "The Friendly Arctic", made particular mention of the tins, which had a multitude of uses after they had been emptied. He used them for the protection of records left behind in cairns, but mainly as containers of alcohol for preserving small zoological specimens.

*Not included in this volume.

ı 1939 the Company supplied composite ration packs for the Armed Forces, __r the War their policy was to help university and other expeditions, since they provided the field testing for newer products under development for the Services.

In view of the above history, it was appropriate that the Company should co-operate in the development of a modern polar ration.

With commercial production now undertaken, it was possible to continue the modifications. At a Symposium on Polar Medicine,[9] aspects of the design of the box were discussed, and for the Mark IV a clearer picture of requirements was now emerging. The containers, which have to be dog- and bear-proof, were now to be fitted with a detachable lid. There was a trend back to bulk packaging, especially for beverages and sugar. Certain products were changed; natural cheese was found not to keep well, and processed cheese was substituted. Complaints about the soup powder stimulated a change to a more expensive quality. Table 1 shows an analysis of the contents of the Mark IV pack.

TABLE 1

Sledging Ration Mark IV (1959), Medical Research Council London

The ration is packed in 2 man-day units, each well over 5,000 kcal and weighing about 2 1/4 lb. Adequate provision has been made for tasty extras at no serious cost to the total calorific value.

Percentage								
Protein	Fat	CHO		kcal/g	kcal/oz	g/day	oz/day	kcal/day
0.4	99.6	Tr.	Butter	7.9	225	141.8	5.0	1125
53.5	46.5	Tr.	Meat	5.7	162	170.1	6.0	972
8.7	37.3	54.0	Chocolate	5.8	164	113.4	4.0	656
Tr.	-	100.0	Sugar	4.0	112	90.7	3.2	358
28.4	31.0	40.6	Milk powder	5.3	150	56.7	2.0	300
42.4	57.6	-	Cheese (Cheddar)	5.0	142	56.7	2.0	290
			Wholemeal biscuits	4.9	139	56.7	2.0	278
7.6	23.3	69.1	Plain biscuits	4.9	139	56.7	2.0	278
12.8	9.4	77.8	Instant oats	4.5	128	56.7	2.0	250
Tr.	Tr.	100.0	Sweets	3.3	93	28.4	1.0	93
8.7	37.3	54.0	Drinking chocolate	4.5	128	42.5	1.5	192
-	-	100.0	Potato powder	5.5	156	28.4	1.0	156
Tr.	-	100.0	Glucose lemon	4.1	112	28.4	1.0	112
16.7	7.7	75.6	Soup powder	3.5	100	28.4	1.0	100
Not estimated			Fruit bar	2.5	70	21.3	0.75	52
52.3	-	47.7	Soluble coffee	0.9	25	7.1	0.25	50
Not estimated			Pumpernickel	2.0	56	12.8	0.45	25
-	-	-	Soluble tea	-	-	7.1	0.25	-
-	-	-	Curry powder	-	-	7.1	0.25	-
-	-	-	Salt	-	-	11.3	0.4	-
21.1	Tr.	78.9	Onion flakes	-	-	2.8	0.1	-
100.1	Tr.	-	Vegetable extract	-	-	2.8	0.1	-
13.8	25.3	60.9	Total			1027.9	36.25	5287

The Present Pack

In 1960-61, the Mark V ration box was developed. A new concept was now introduced because of complaints from the Falkland Islands Dependencies bases in the sub-Antarctic that men did not want the full ration of 5, 000 kcal+ and they tended to waste food. (Originally the ration was based on experience gained at very high latitudes, e.g. Greenland (79° N) or the Commonwealth Trans-Antarctic Expedition).

The packaging was re-arranged in the following way. A unit ration yielding about 4, 500 kcal was packed and designated as 'Summer Sledging Ration'. For men travelling in colder regions, a supplement of butter was provided of approximately 1. 5 kg (3 lb) for a 20 man-day pack. This gives the extra 500-600 kcal/man daily.

These Mark V boxes and the supplement have been supplied to the British Antarctic Survey, the Belgian, and the South African Antarctic Expeditions. The present cost of the ration is about £25 (approximately $75) for a box of 20 units of more than 5, 000 kcal. This is roughly 25/- ($3. 50) per person per day. This is more than the usual subsistence allowed by the British Antarctic Survey. The food itself represents 60 per cent of the cost. If, however, it were bought in bulk the price could be reduced to about £20 (approx. $60) and this would be practically identical with the British allowance (15/- daily for 4, 000 kcal). To achieve this, production runs of 1, 000 boxes are necessary.

Consumer Reports

The development of the Medical Research Council polar rations depends on regular reports from the field. It is well known that anecdotal memory is notoriously fallible in gastronomic matters, and we have ensured, as far as possible, that comments be committed to paper immediately. Appendix I is a fascimile of the descriptive leaflet and questionnaires packed in each box. The following summary of comments has been made in respect of the Mark V rations.

1. Outer Box

   a. General Design. Good to excellent, but many reports ask for the box to be slightly longer and some suggest a respacing of the chocks. Fastenings are an improvement on Mark IV but they are rather weak and liable to bend during use.

   b. Effect of Low Temperature. None was noticed.

   c. Temperature Range. The extreme experience for any one box in the Antarctic was from -30°F to +50°F, but all boxes had to pass through tropical regions on the way to their destination. The temperature range most commonly quoted in the reports is from about -20°F to about +40°F.

d. There were no reports of the outer materials affecting the foodstuffs.

e. No damage to the box was reported, but there were some reports of damage to the catches.

2. Liner Bag and Wrappings

Most reports say that these were excellent, with the exceptions that some complain of too many inner wrappings, some complain of brittleness of certain wrappings in cold weather, and many reports state that juices leaked from the sultanas, which usually made the toilet paper sticky. There are two reports of the inner wrappings affecting the butter.

3. Items

i. Milk Powder. Acceptability was generally good; Quantity was generally insufficient; Packaging was generally unsatisfactory.

ii. Sweets. Acceptability was generally good, though some users ask for other types. On the whole, the quantity seems to be excessive. One report states that sweets were used to level the cooker in the tent.

iii. Instant Oats. Packaging and quantity were generally satisfactory, but acceptability very low. A cri de coeur for rolled oats came from the majority of users.

iv. Potato Powder. This was generally good and sufficient, with some adverse reports on the packaging.

v. Soup Powder. Most reports ask for these to be replaced by a Swiss brand, mainly for the reason that the present brand is insipid and takes too long to cook.

vi. Biscuits. Palatability, quantity and packing were generally good to excellent, though there were some complaints of the biscuits being broken. One user stated that the wholemeal biscuits were more prone to be broken than the plain biscuits.

vii. Processed Cheese. This item received good reports in all respects.

viii. Nescafe. Palatability was good. What comments there were on quantity state that there was too much. Many reports ask for one container instead of several sachets, but some users think that individual packaging is justified for this item.

ix. Glucose Lemon Drink. There were no adverse reports on this item. A few asked for more.

x. Chocolate. All reports described this as good or excellent, with no very definite order of preference for the three varieties.

xi. Sultanas. On the whole these were very well received, apart from the packaging (see 2). Three reports say they are better than the Mark IV fruit bar, two that they would prefer the fruit bar.

xii. Butter. The quantity was generally considered to be insufficient, even for summer sledging. Most reports ask for fewer, larger packs. Apart from two complaints of the butter being tainted by the inner wrapping, the palatability was generally good.

xiii. Dehydrated Meat Bar. Palatability was generally good, but some reports appear to admit this grudgingly.

xiv. Drinking Chocolate. This item was mainly good to excellent in all respects. One or two reports ask for bulk packing.

xv. Tea Powder. Palatability was generally considered to be good, with many reports adding "as a substitute for real tea". Quantity was excessive for the majority of users. Packaging received some adverse comment because the wrapping tended to crack, and because bulk packing would be preferred.

xvi. Sugar Cubes. The packaging was almost invariably cursed. Most reports suggest that cubes could be left loose in the polythene bag without being paper-wrapped. Some reports ask for granulated sugar for use in porridge.

xvii. Salt. The quantity tended to be excessive, but the majority of reports considered the salt to be adequate in all respects.

xviii. Curry Powder. This was very welcome in the interests of variety. Apart from two people who disliked curry, there were no adverse reports.

xix. Marmite. Most users thought this was good in all respects. A few asked for more.

xx. Jam (pineapple). This item received an excellent overall rating. Some asked for more, weight and space permitting.

xxi. Onion Flakes. There was an almost invariable request for more. Palatability and packaging were described as good to excellent.

xxii. Sundries. Comments were generally favorable, sometimes hilarious. The plastic spoon was unnecessary to some, interesting to others for various uses.

General Comments

It is very difficult adequately to summarize the users' general comments. Most were complimentary about the quantity and variety of the food, though there were criticisms of "overpacking."

As it is desirable to avoid "impressions," an attempt has been made to give a numerical value to the food votes in respect of Mark V and its immediate predecessor (Table 2).

The replies were classified separately for each food item into those where the general assessment was excellent (or very good), good, fair, poor (or bad), and very poor. Such a classification omits much of the detailed comment and criticism contained in the replies, but permits an overall judgment on the acceptability of each item. By allotting arbitrary scores of +2, +1+ 0, -1 and -2 to the five columns respectively an average score can be calculated for each foodstuff, and this is shown in Table 2.

Only two items in the Mark V pack—instant oats and soup powder—received a negative average score, only the instant oats being generally disliked. This was to be expected because the intention was to reduce the cooking time of both these products to the minimum. A pre-cooked instant oatmeal and soups requiring a cooking time of only 10 minutes were supplied. Reduction of cooking time has the advantage of minimizing condensation in the tent but inevitably leads to some loss of quality of these particular products.

The highest score was given to pineapple jam, but several other items were rated very highly on average.

In the Mark IV pack, three items—oats, tea and pumpernickel—gave a wide scatter of results. This is understandable for pumpernickel, where the taste has to be acquired, and it may have been the form in which the tea was provided—powder rather than leaves—which resulted in controversial replies. One might expect to find a clear difference of opinion also with curry powder, but this is not so.

It is interesting to note the attitude of sledging parties to the more highly flavored items in the ration pack, because of the controversy regarding the influence of climate on food habits. At one time it was suggested that the diet of inhabitants of the tropics was more highly flavored than the diet of inhabitants of colder countries because the difference in environmental temperature made stronger flavors necessary in tropical regions, since it was thought that higher temperatures reduce the sensitivity of taste buds. The predilection of Indians for curries, and of Eskimos for blubber, and the generally higher consumption of spices in the tropics, were often advanced as evidence of this, but an alternative explanation of the phenomenon was the greater need for preservative spices in the tropics. More recent writers have concluded that availability is the main determinant of this particular dietectic difference. It is therefore noteworthy that curry powder was much appreciated by most users, though it was left unused by quite a high proportion of Mark IV consumers.

TABLE 2

Sledging Rations: Acceptability of Food Items

Item	MARK IV PACK Frequency of Reports						MARK V PACK Frequency of Reports					
	Very Good 2	Good 1	Fair 0	Poor -1	Very Poor -2	'Score' (see text)	Very Good 2	Good 1	Fair 0	Poor -1	Very Poor -2	'Score' (see text)
Milk powder	5	22				+1.2	1	13	1			+1.0
Sweets	5	19				+1.2	3	9	2			+1.1
Instant oats	1	3	11	2	10	-0.6			2	6	7	-1.3
Potato powder	4	18	2	1		+1.0	2	11	1			+1.1
Soup powder		Few general comments*						2	7	3		-0.1
Biscuits		Few general comments*					2	10	1			+1.1
Processed cheese	10	12	3	2		+1.1	6	6	3			+1.2
Nescafe	6	20	1	1		+1.1	2	12	1			+1.1
Glucose lemon drink	16	8	4			+1.4	7	8				+1.5
Chocolate		Few general comments*					5	7				+1.4
Sultanas			Not included				5	8	2			+1.2
Butter	11	15	1			+1.4		11	4			+0.7
Dehydrated meat bar		Few general comments*					5	7	3			+1.1
Drinking chocolate	15	11	1	1		+1.4	7	6	2			+1.3
Tea powder	5	13	6	2	2	+0.6	5	10				+1.3
Sugar	4	23				+1.1	1	14				+1.1
Salt	2	26				+1.1	2	13				+1.1
Curry powder		17	1	1		+0.8	1	13				+1.1
Marmite	7	21				+1.3	3	11				+1.2
Jam (pineapple)			Not included				13	2				+1.9
Onion flakes			Not included				13	2				+1.1
Pumpernickel	2	12	6	3	1	+0.5			Not included			
Dehydrated fruit bar	1	11	3	1		+0.8			Not included			
Mean Score Over-All						+0.9						+1.01

*Most comments on the palatability of these items were confined to the expression of preferences for the different varieties.

Where several varieties of the same food were included in one pack, the consumers were asked to give an order of preference. A clearly defined order of preference for the different soups was established for the Mark V pack. Chicken soup came first, followed by mushroom, tomato and oxtail, in that order. In the Mark IV pack, the order was chicken, tomato, mushroom, oxtail, but this ranking was not nearly as well established and of doubtful significance.

Preferences for plain or wholemeal biscuits were equally divided in the Mark IV pack, and nearly so in the Mark V pack.

An order of preference was also requested for the different types of chocolate supplied, and the overall order of popularity was fruit and nut, milk, and plain in the Mark V pack.

The mean overall score for all the food items in the Mark IV pack was +0.9, that in Mark V +1.01, a small but significant improvement in acceptability, indicating something better than 'good'.

Future Developments in Packaging

At present, attention is being given to the design of an expendable refill unit for a primary box that might be carried permanently on the sledge.

Originally we worked within the fairly rigid confines of requirements for dog sledging, and our starting point was the Falkland Islands Dependencies Survey sledging box with dimensions that we were not permitted to alter.

The use of modern packaging techniques, particularly laminated metal/plastic films, enabled us to store a wider range of foods in good condition for long periods of 2-3 years, which is an essential prerequisite of polar logistics. We were able both to reduce the dead weight of the packaging and to increase the calories, but found ourselves with space to spare in the box. The decision was made not to waste this space but to use it for delicacies providing extra spice and variety, and to include a pleasant surprise such as a paperback book. This brought the gross weight to a little over the 50 lb limit, and it is understood with sympathy that extra weight is operationally embarrassing, especially at the beginning of a sledge journey before any food is eaten and the dogs have yet to reach peak performance. However, we stress that the polar rations are in constant development.

We now have to expect the fuller use of tracked vehicles and air travel. This still requires the outer weight of ration boxes to be reduced, and the retention of weather- and animal-proof qualities, but the traditional 20 man-day scale (two men per sledge) may be modified. Similarly, dimensions will be different for accommodation in stowages or on roof racks. A basic survival pack for all Sno-Cats would be fitted under the seat.

The problems of tent living remain the same, but even for man-packing new thinking is needed. The 20 man-day unit is too bulky and a better modulus may be a five or six man-day unit, with due provision for avoiding the breaking up of carefully packed rations.

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Appendix

"Summer" Sledging Rations MK V 1960

The MK V ration is designed for summer Antarctic conditions, providing an individual daily intake of 4, 447 calories for two men over a ten day period.

When sledging in severe winter conditions it is advisable to increase the daily intake to over 5, 000 calories, the extra 600 calories can be most conveniently supplied by butter; i.e., for 20 man-days take an extra three lbs of butter for severe winter sledging—(1 oz of butter gives 225 calories).

These rations have been developed from four previous prototypes as a result of reports sent from the field. The first three marks were composed of small unit packs; the fourth mark was modified to reduce the large number of small packs, and was assembled into two man-day packs with supplementary packs containing butter, meat bars, condiments and beverages.

The MK V ration has been further modified and now contains two man-day packs containing all basic foodstuffs, together with two sundries packs containing condiments and beverages for five days, and one random pack which also contains instructions for use of the ration.

Outer cases are provided with a detachable lid which can be used as a tray inside the tent.

Details of Rations and Instructions for Use

Each wooden sledging box contains rations for 20 man-days:

1 outer case
1 Polythene snowproof liner
10 x 2 man-day packs
2 x 2 man 5-day Sundries and beverage packs
1 Random pack

Details of these packs are given below:

Two Man-Day Pack

Dehydrated Meat Bars	2 x 5-oz vacuum packs
Instant Quaker Cooking Oats	1 x 3-oz packet
Horlicks Glucose/Lemon Drink Powder	1 x 2-oz packet
Thatchers Soup Powder	1 x 2-oz packet
Butter	2 x 2-oz vacuum packs
Mitcham Processed Cheese	2 x 2-oz
Spray dried Full Cream Milk Powder	1 x 2-oz packet
Symbol Plain Biscuits } Symbol Wholemeal Biscuits }	2 packets containing 2-oz of each variety
Sugar (lump)	2 x 3-oz polythene packs
Instant Potato Powder	1 x 2-oz packet
Sweets	2 x 1 1/2-oz packets
Comfort Packs (containing 2 x 2-oz chocolate, 1 x 1-oz sultanas, Toilet paper)	2 packs

Sundry and Beverage Pack	Two Man-5 Days
Drinking Chocolate	2 x 6-oz packets
Tea Powder	1 x 2 1/2-oz packets
Nescafe	40 x 1/16-oz sachets
Salt	1 x 4-oz packet
Onion Flakes	1 x 1-oz packet
Curry Powder	1 x 1/2-oz packet

Random Pack

Marmite	1 x 2-oz tube
Jam	1 x 8-oz tin
Comfort packs	2
Penguin Book	1
Plastic Spoon	1

Random Pack

Tin Opener	1
Razor Blades	1
Contents List	1
Questionnaire Forms	2

On opening the random pack you will find on top two comfort packs (one for each man) each containing chocolate, sultanas and toilet paper. These are for use on the first day's march. Two similar packs are included for use each succeeding day, in the 2 man-day packs.

Notes

Plastic Bags are difficult to tear open. Best to slit with razor blade provided. The polythene case liner has been designed so that it can be folded over after first opening in order to obtain a snow-proof seal. Polythene bags can be resealed in the flame of a candle.

Beverage packs should be opened at the end bearing the label to expose the open end of the inner boxes.

Dehydrated Meat Bars

Dehydrated Minced Beef and Pork. Vacuum packed blocks each containing 5-oz. Daily requirement for one man.

Directions for use are on the containers.

Thatchers Quality Soup Powder. Cooking instructions are shown on the packs. Will be a selection of four varieties as follows:

Tomato
Chicken
Mushroom
Oxtail

Mitcham Processed Cheese

Each two man-day pack will contain 2 x 2-oz vacuum packs.

Hint: Cut across packet (not right through) and peel cheese away from foil.

Instant Quaker Oats

This requires only addition of about one pint of boiling water or milk. Stir well, salt to taste. After 60 seconds serve with milk and sugar. In order to prevent feeling of hunger two or three hours after breakfast, add some butter to the porridge which will help the stomach to retain it longer.

Kestreline Leafless Tea

This dried tea extract is immediately soluble in hot water, about half a teaspoonful of the powder making a large cup.

Glucose Lemon-Drink Powder

Each packet contains sufficient for one pint drink, either cold or hot at night.

Colmans Instant Potato Powder

Creamed potato may be made by adding small quantity of boiling water and stirring. May also be used as a thickener for meat bar or soup.

Summer Sledging Rations MK V 1960

Questionnaire

The successful development of these prototype rations depends on your reports. We would particularly like to know about the packaging, the food itself, how it compares with the standard sledging rations and how you think the M. R. C. ration could be improved; e. g., what items would you substitute? Criticize as severely as possible.

I. Outer Box

a. General design

b. Effect of low temperature on box

c. Temperature range

d. Has material any effect on foodstuffs?

e. Details of damage to box and conditions of use, e. g., height dropped on occasions, immersion in water, etc.

f. Date of journey and length of time in use

g. Tested by:

II. Polythene Liner Bag—and Other Foil—Polythene Wrappings and Comfort Pack

III. In the Following, Comment on Packaging, Quantity and Palatability of Food and Preferred Substitutes

1. Milk Powder

2. Sweets

3. Instant Oats

4. Potato Powder

5. Soup Powder — Indicate order of preference
   - Tomato
   - Chicken
   - Mushroom
   - Oxtail

6. Biscuits — Indicate order of preference
   - Plain
   - Wholemeal

7. Processed Cheese

8. Nescafe

9. Glucose-Lemon Drink

10. Chocolate — Indicate order of preference
    - Plain
    - Milk
    - Milk Fruit and Nut

11. Sultanas

12. Butter

13. Dehydrated Meat Bar
    Beef and Pork

14. Drinking Chocolate

15. Tea Powder

16. Sugar Cubes

17. Salt

18. Curry Powder

19. Marmite

20. Jam (Pineapple)

21. Onion Flakes

22. Sundries
    Tin Opener
    Plastic Spoon
    Books
    Razor Blade
    Instructions

23. General Comments

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PHYSIOLOGICAL RESPONSES TO COLD

R. A. Millington

Introduction

Man's response to cold has long been of interest. It had been realized even before commencement of polar exploration that an individual's ability to lead a healthy and productive life in a cold environment was dependent on his successful adjustment to those physiological and psychological stresses peculiar to such an environment. Although it is nearly impossible to divorce completely the physiological effect of cold from its psychological effect because of the great influence each exercises on the other, an attempt will be made to limit this discussion to the former.

All mammals are homeothermic organisms. The maintenance of the internal body or "core" temperature within a minimal range of variation, independent of ambient temperature, is the major factor responsible for the normal pattern of biochemical reactions in man. The biochemical reactions responsible for metabolism impose several requirements upon the mechanisms regulating body temperature. Since most biochemical reactions are effected through action of enzymes which are particularly sensitive to temperature change, a fall of only a few degrees of core temperature may so retard metabolism that normal behavior is impossible and death may ensue. In the course of biochemical oxidations heat is liberated, and unless provision is made for its dissipation, overheating of the body may occur which could cause death as a result of irreversible damage to the various enzymatic systems and cells of the central nervous system. It is mandatory therefore, that thermal equilibrium of the body be maintained.

Thermal Equilibrium

Thermal equilibrium is preserved by the body's ability as a whole to alter its rate of heat production and heat loss. Since body temperature is really a measure of heat content or storage, a fall in temperature indicates a decrease while a rise denotes an increase in the total heat content of the body. Although the core temperature varies normally over a range of only a single degree, the variation in temperature of the exposed portions of the body reflects its continual effort to achieve equilibrium as first the rate of heat production and then the rate of loss is altered by environmental and/or physiological changes. A normal sized, unclothed man at rest in a post absorptive state can, with minimum body effort, reach thermal equilibrium at a room temperature of 86 degrees F (30 degrees C). Under such conditions the individual retains only that amount of heat formed by his basic metabolic processes which comprises normal storage, and loses the remainder to the environment without utilization of any of his reserve mechanisms of heat loss. The preceding example is only one instance of countless states of thermal equilibrium. Its significance arises from the fact that no reserve mechanisms of heat production or heat loss are required to achieve equilibrium. Under different conditions of clothing, activity or environment, additional physiological adjustments would be needed to maintain an equivalent state.

Heat Loss

Physical mechanisms. Heat is lost from the body by several different physical processes: radiation, conduction and convection, and the vaporization of water. The relative importance of each varies widely with climatic conditions.

Radiation is the transfer of heat from the surface of one object to another without physical contact between the two. The magnitude of heat loss in man is directly dependent on skin surface area and the average temperature gradient between the skin and surrounding objects. As already indicated, the heat loss from radiation varies widely with environmental conditions. In a temperate climate, a resting individual, wearing ordinary clothes, loses about 60 per cent of his heat production by radiation. At temperatures of 90 degrees F this loss may drop to zero. Conversely at sub-zero temperatures heat loss by radiation may reach levels higher than 60 per cent.

Conduction and convection are less important methods of heat loss in a temperate climate but assume major roles in polar climates. By conduction the cold air in immediate contact with the skin is warmed; the heated molecules move away and cooler ones approach to take their places; these in turn are warmed and the process perpetuates itself. The air movements constitute convection currents. Any process, such as wind, which tends to increase the rate of movement of the ambient air relative to skin surface intensifies heat loss. This phenomenon has been incorporated into the concept of wind chill by Siple. A unit of wind chill is defined as the amount of heat that would be lost in an hour from a square meter of exposed skin surface which has a normal temperature of 91.4 degrees F. Given a hypothetical situation wherein the wind velocity is 20 miles per hour and the temperature is 34 degrees F, reference to a Table of Equivalent Temperatures on Exposed Flesh at Varying Wind Velocity discloses that at the given wind and temperature conditions of the hypothetical situation, the rate of cooling of all exposed flesh is the same as at minus 38 degrees F with no wind. It is easily concluded that under the climatic conditions observed in Antarctica, conduction and convection are significant causes of heat loss and potential contributory factors in the causation of cold injuries.

Heat loss by conduction also occurs from transfer of heat to tidal air as it is warmed in the respiratory passages and lungs, water and foodstuffs taken into the gastro-intestinal tract, and waste materials (urine and feces) as they are eliminated.

Vaporization of water removes heat from the skin surface and the moist mucous membranes of the respiratory epithelium because when one gram of water is converted into water vapor, 0.58 calories of heat must be supplied from the surroundings for the conversion to occur. Although the actual amount of heat loss depends on the ambient relative humidity, in Antarctic, where humidity is very low, respiration alone may account for 10 per cent (375 calories) of an individual's total daily heat loss. Insensible perspiration, which consists of an unseen and unfelt passage of water by diffusion through epidermis, accounts for an additional loss of 400 calories. Insensible perspiration does not come from sweat glands and is produced at a relatively uniform rate independent of environmental conditions.

Loss of heat by vaporization of perspiration from eccrine sweat glands may account for almost the total heat loss at temperatures of 93 to 95 degrees F, but in polar climates it assumes importance only under certain clothing conditions which will be discussed later.

It can be seen, then, that loss of heat from the body occurs primarily at two surfaces, the skin and the epithelium of the respiratory system; and under constant environmental conditions the amount of heat lost depends upon surface area, temperature gradient and humidity, and the rate of air flow over the surface.

Hypothermia

When heat loss exceeds heat production hypothermic injury may develop. Hypothermia is classified as general or local depending on whether the injury affects the individual as a whole or affects only a particular part of the body.

General hypothermia. General hypothermic injuries result from total immersion at sea in the higher latitudes and exposure to extreme cold ashore. Water, because of its heat conductivity, has a cooling power 23 times that of air. Immersion in water at 28 to 35 degrees F may result in death in 7 to 15 minutes. Prolonged exposure to cold results in vasoconstriction which drastically reduces the flow of blood in the skin and extremities and ultimately causes tissue anoxia. When skin temperature reaches approximately 50 degrees F, hypesthesia develops and is followed eventually by loss of sense of touch and pain. Muscular activity becomes weak which causes further diminution in blood flow. As tissue temperature is further decreased, oxyhemoglobin dissociates less readily and the pre-existing tissue anoxia becomes greater. Once core temperature has dropped to 95 degrees F, thermal control is lost and the body is no longer homeothermic. Coma occurs and death ensues when body temperature reaches 79 degrees F.

Local hypothermia. Local cold injuries most frequently affect the face, ears, hands or feet. The principle forms of local cold injury are immersion foot and frostbite. "Trench foot" is a mild form of immersion foot. "Chillblains" is the itching sensation and associated cutaneous lesion frequently present in tissue chronically injured by cold with no tissue lost.

Frostbite is the most frequent local injury observed in Antarctica. The actual mechanism of injury in frostbite, although still not clearly defined, apparently depends on at least three processes. The first is the actual disruption of cellular and tissue structure by formation of ice crystals. In addition there is apparently some direct injury to protoplasm which is due in part to extensive dehydration. The third type of injury is due to impaired blood circulation and subsequent oxygen—starvation of the tissue which results in localized tissue death. It is the latter which serves mainly to delineate the physiological differences between general and local hypothermia.

It has been shown that human flesh freezes at cooling values of 1,300 to 1,500 calories per square meter per hour. With a wind velocity of 22 miles per hour, exposure at temperatures of 17.6 degrees F for one hour, or minus 22 degrees F for one minute will cause human flesh to freeze. This graphic demonstration emphasizes the importance of wind chill as a causative agent in frostbite.

Heat Conservation

How then does the human organism react to maintain thermal equilibrium under stressful conditions of sub-zero temperatures which threaten its very existence? What physiological mechanisms are initiated and what other assistance may be invoked for his protection?

Physiological Mechanisms

Some of the physiological methods used to diminish heat loss observed in lower mammals are unsuitable or impractical in man. Such procedures as rolling up into a ball and thereby markedly decreasing the area of exposed skin, or diminishing heat loss from vaporization of water at respiratory surfaces by cessation of panting, obviously have little application in human beings.

Regulation of skin temperature. Since approximately 80 to 85 per cent of heat loss occurs from the body surface, any reduction in skin temperature should conserve body heat. Changes in the temperature of body surfaces are mediated through the activity of three physiological mechanisms. Unfortunately, one of the three mechanisms, although of some value in retaining body heat, is of greater importance when heat dissipation is desired.

The first mechanism depends upon the means by which heat is transported from the depths to the surface of the body. Blood is 80 per cent water by volume, and because of the water's high heat capacity, circulating blood is the primary source of heat transfer to the body surface. The total amount of heat brought to a given area is a function of the rate of blood flow through the area. If the rate of flow is retarded by local constriction of the superficial arterioles, the total heat transfer from blood to skin tends to be small and the skin remains cool thereby decreasing the temperature gradient between it and the surrounding cold air. Although this physiological mechanism is an important means of heat conservation, a certain minimum blood flow must be maintained through the skin to prevent localized anoxia and cellular death.

The second mechanism is dependent on the phenomenon of horripilation, or erection of body hair, which increases the thickness of the layer of non-conducting air entrapped between the hairs. Since surface temperature depends upon the ease with which heat is transferred from the body to the environment, horripilation affords a satisfactory method for retarding conduction by reducing the temperature gradient between the skin and environment even though the skin temperature may remain at a high level. Due to evolutionary processes man is poorly equipped to take advantage of horripilation. Nevertheless he utilizes the principle by substituting a different insulating material for the hair he lacks in the form of clothing. A single layer of clothing limits heat exchange by replacing the single temperature gradient between a nude subject and his environment with three such gradients. One of these three exists between the skin and the inner surface of the insulation, another exists between the outer surface of the insulation and the environment, and the third gradient is found between the inner and outer surfaces of the insulation. The effectiveness of clothing in decreasing heat loss is proportional to the magnitude of this third gradient, which in turn depends upon the nature and thickness of the non-conducting substance.

A third mechanism modifies the temperature of body surfaces by varying the amount of moisture available for vaporization. Since heat loss due to insensible perspiration and respiration is not subject to wide variation, the primary value of this mechanism is in the dissipation of body heat rather than its retention.

Increased Heat Production

When heat loss exceeds heat production in spite of utilization of the previously discussed physiologic mechanisms, the body, in an effort to regain thermal equilibrium, increases heat production. Heat production is essentially chemical in nature and is developed from at least two different sources. When body temperature decreases in a resting human exposed to cold, involuntary muscular contractions (shivering) ensue. Since only 25 per cent of the energy liberated by chemical changes in contracting muscle is converted to work, heat production is equivalent to three or four times that of the muscle at rest. Even more efficient in heat production than isotonic involuntary exercise is voluntary isometric exercise (contraction of both extensors and flexors simultaneously) which converts all of the energy produced to heat.

Another source of heat production which does not involve skeletal muscle contractions has been demonstrated by various investigators in both animals and man. Small experimental animals like the rat are able to vary their rate of heat production within several hours by some mechanism in which the hormones of the thyroid gland, the adrenal cortex and, possibly the adrenal medulla participate without any detectable change in either voluntary or involuntary muscular activity. Both the adrenal cortex and thyroid undergo changes which can be detected histologically and by chemical analysis. A similar non-shivering induced increase in heat production has been demonstrated in man by Davis and other investigators. At this time insufficient information exists to describe the mechanism involved in man.

Cold Acclimatization

Much of the recent investigative effort in the physiology of cold has been directed toward the interesting problem of cold acclimatization. Acclimatization has been defined as a state of successful physiological adaptation of the individual to new climatic conditions. Although true physiologic adaptation to a hot environment was well established many years ago, the existence of cold acclimatization in man has not been universally accepted or demonstrated.

Investigators of cold acclimatization in man have generally utilized one of four different methods of approach. One group has artificially acclimatized their subjects in cold chambers; a second group has used deliberate exposure to natural conditions of cold weather; a third group has investigated the responses of the indigenous people of Arctic and subarctic areas and compared them to those of non-native controls; a fourth group has attempted to detect differences in the same group of subjects during different seasons of the year.

A true cold acclimatization has been well established in animals. Blair found that rats who had been cold acclimatized by exposures to 23 degrees F for fifty days withstood five hours exposure to five degrees F without harmful effects, whereas non-acclimatized rats suffered progressive hypothermia and frostbite when exposed to the same temperature for an identical period. The ability of animals to acquire an unusual resistance to the pathological effects of severe cold exposure (after appropriate conditioning to moderate cold) provides interesting avenues for speculation. Should true cold acclimatization be demonstrated in man, could it be reasonably anticipated that he too would develop a comparable ability to withstand severe cold exposure? Having become adapted to cold in this manner man could be expected to demonstrate greater endurance, efficiency and resistance to cold injury under conditions of extreme cold exposure.

Many indices have been used to define cold acclimatization in man. These have included skin and rectal temperatures, basal and cold induced metabolic rates, shivering, "comfort", "tolerance", hormonal changes, fluid balance, hematological changes, cardiovascular responses, etc. This variation in criteria demonstrates the difficulty in defining human cold acclimatization.

Much of the current cold adaptation investigation in the United States is being performed by Davis and his co-workers at the U. S. Army Research Institute for Environmental Medicine. After exposing 10 nude subjects in a cold chamber at a temperature of 11.8 ± 0.46 degrees C eight hours daily for 31 days (excluding Sundays) they found that shivering decreased significantly after the tenth day and remained depressed for the remaining period of exposure. Throughout the period of exposure, heat production remained significantly elevated above basal. On the basis of these observations they concluded that man can be artificially cold-acclimatized. Furthermore, failure of cold-elevated heat production to decrease in the face of a significant decrease in shivering was interpreted to indicate the presence of non-shivering thermogenesis in man.

Several groups of subjects were tested once monthly for response to a one hour exposure to an air temperature of 14 to 15 degrees C for five months (October to February). This was their only deliberate cold exposure. Shivering after December fell to three to six per cent of the October value and heat production decreased from a mean of 60 per cent above basal in October to 28 per cent above basal in February. These studies seem to demonstrate a natural seasonally induced cold acclimatization in man which results in a decreased energy expenditure for maintenance of thermal equilibrium. It would appear that seasonal acclimatization takes place in man, but that it is not retained over the summer.

Additional studies by Davis suggest that appropriately clothed individuals become acclimatized to cold at nearly the same rate and to the same degree when compared to any pre-existing acclimatization regardless of the environmental temperature. It would appear that in order to achieve faster or greater acclimatization, subjects must be deliberately exposed in an unclothed, unprotected condition.

Retention of cold acclimatization apparently is dependent upon the rate and degree of acclimatization, and that if the degree is sufficiently great, acclimatization is little influenced by environmental temperature.

Davis concludes that "these studies appear to demonstrate that man has a physiological adaptation to cold, that this can be artificially induced at a faster rate and to a greater degree than naturally occurring cold acclimatization, that acclimatization in clothed individuals is similar in rate and degree regardless of ambient environmental temperature, that heat acclimatization does not affect either artificial or natural cold acclimatization and that artificial cold acclimatization is retained through the summer months while seasonal acclimatization is not".

Cold Weather Clothing

The biophysics of clothing has become singularly significant in recent years because it is an interdisciplinary approach (physiology, psychology, physics, clothing design, and textile science) which relates human work efficiency and comfort to a specific task in a particular environment. Prior to this realization the physiologist was consulted for information about the man and the climatologist was sought for his knowledge of the environment. Little was known about the physics of how clothing materials interacted with each other or with the complex man-clothing-environment system. Most experimental measurements utilized "steady state" conditions for simplicity and the reduction of variables. Utilization of the biophysical approach should result in an end product clothing system in which man, environment and clothing are united into a functional and comfortable whole.

In Antarctica an individual frequently finds himself wearing more insulation than he needs during work and less than he needs at rest. This is readily explained by considering the biophysics of the situation. For maintenance of thermal equilibrium in any given environment, the optimum insulation is five to six times as much at rest as at work. The problem, then, is to design clothing which optimizes the balance between static and dynamic insulating efficiencies. Specifically, the rate of heat loss must be minimized when activity level is low and increased when activity level rises.

Primary functions of protective clothing are to insure adequate ventilation for the escape of both insensible and sensible perspiration, and to provide around the body an insulating zone of dead air space which is compartmentalized in sufficiently small pockets so that currents of air will not be set up by movements of the body and thus disperse heat.

Polar explorers have cautioned repeatedly against the danger of sweating profusely, because during later periods of diminished activity, excessive heat loss occurs when the vaporized perspiration condenses out on the cold outer cloth, thereby permitting direct heat transfer by conduction. Because retention of vaporized perspiration in clothing diminishes the effectiveness of the sweat mechanism in cooling the skin surface, increased production of perspiration ensues and a potentially dangerous situation develops.

Application of the biophysical approach to clothing problems, continued research and testing in the laboratory and field, and development of new textile materials can be expected to solve many of the difficulties experienced with cold weather clothing during previous polar operations.

Summary

Basic physiological responses to cold, the pathophysiology of hypothermic injury and the primary mechanisms for the maintenance of thermal equilibrium have been reviewed. Recent studies in cold acclimatization and their possible influence on future polar operations have been discussed. The broad physiological principles underlying the development of adequate cold weather clothing have been presented.

Only through continued research into man's response to cold, and sound application of the knowledge of physiology gained therefrom, will man be able to achieve in Antarctica his goal of a productive existence under conditions of safety and comfort.

COLD WEATHER CLOTHING FOR SOVIET ANTARCTIC EXPLORERS

Arctic and Antarctic Research Institute

The USSR scientific institutions active in Arctic and Antarctic research pay much attention to designing of cold weather clothing which should guarantee health and capacity for work under all conditions.

The Arctic and Antarctic Research Institute of the Chief Administration of the Northern Sea Route, Ministry of Sea Transport, with large experience obtained during many-yearly Arctic research under very hard Arctic conditions leads these activities.

Soviet polar explorers applied their experience when preparing Antarctic expeditions using the best models of the cold weather clothing, which proved their quality in the Arctic.

And this is the brief description of several types of the clothing, taken for the equipment of the Antarctic expedition.

The clothing worn by a member of the Complex Antarctic Expedition consists of a jacket and trousers. The upper layer of the clothing is made of cotton water-proof fabric lined with cotton elastic material. The suit is lined with camel wool combed to downlike pattern, with high warm quality. The wool is quilted on the both sides with thin cotton cloth by through stitches placed obliquely thus the stitches form rhombs. To increase cold and windproof qualities the suit is supplied by:

1. The hood, warmed by the thin wool layer with the moving lacing at the edge.

2. Wide breast wind-protective flap, sewn on the left lapel of the jacket with the prolongation, covering the chin. This flap is buttoned to the inner side of the right lapel.

3. At the waist level there is a pulled in rubber lace.

4. Cuffs with rubber lace are sewn on the inner side of the sleeves.

5. The low part of the jacket has a moving lacing (it is adjustable).

6. The bodice of trousers is high and quilted with the thin wool layer.

7. The flap of the trousers is warmed by the wind-protective valve.

Storm windproof clothing consists of a jacket and trousers, made of dense hard wearing impregnated cotton fabric with elastic cotton lining.

The jacket consists of the back, hood and blind front. The front part of the hood has a zipper or a pulled in lace and inner fanlike wind-protective flap. The jam of the hood is regulated by the moving lace sewn on the edge. For the better fitting there is a belt on the waist and the low part of the jacket has a moving pulled in lace.

Storm waterproof clothing consists of a jacket and trousers made of thin dense tanned cotton fabric with aluminium ice preserving coverage. This clothing is made likewise the storm windproof suit.

Cold weather clothing consists of jacket and trousers. The outside is suspended made of dense cotton fabric with watertight impregnation, it is wadded or has sheet wadding. Wadding or sheet wadding quilted by through stitches, cotton lined.

To increase cold and windproof qualities the clothing is supplied by:

1. The hood warmed by the thin wadding layer or sheet wadding with the moving lacing at the edge.

2. Wide breast wind-protective flap sewn on the left lapel of the jacket buttoned to the inner side of the right lapel.

3. There is a belt with a belt buckle at the waist level.

4. Cuffs with rubber lace made of elastic flannel fabric or knitted cuffs are sewn on the inner side of the sleeves.

5. Trousers with high quilted bodice and warmed wind-protective valve at the flap.

Short coat is made of fine, fleeced or merino sheepskin with the cotton two layer coverage.

Wide breast warming wind-protective flap buttoned to the left lapel with stand up fur collar.

On the left side of the undercollar there is a warm flap, buttoned to the right lapel.

The belt tightens the waist on the back.

The short coat is characterized by its warming and wind-protective qualities.

Leather suit. Jacket and trousers are made of high quality kid with flannelette lining, has zipper fastening. On the lower part of the jacket there is a belt with two straps regulating fitness. The high bodice of the trousers is quilted of two flannelette layers.

The lower parts of the trousers legs with flannelette adjustable cuffs.

The cuffs of the trousers are meant to be hidden in a top of a boot. This suit is notable for its wind-protective and water tightness.

Cloth suit consists of a sports shirt and ordinary trousers, it is made of soft elastic woolen fabric. The shirt is zipped. At the edge of the sleeve there is a strap with regulating fastening. The lower part of the shirt is belted with two straps on the both sides with regulating fastening.

Fur flying boots are made of two layers of dog's fur, hair being on both sides. Dog's fur is characteristic of slight moisture absorption. The cap of the boots is skinned by fatted high quality Russia leather (yuft). The sole of the boots is of pure woolen sole thick felt. The boots together with woolen stocks preserve the heat well.

Rubber warmed boots. The outer and inner layers of these boots are made of rubber with intermediate layer of rough woolen cloth. The boots are up to the knees. The boot-legs are steady. The size of boot-caps and boot legs is meant for warm trousers hiding and woolen or fur socks.

They are necessary under conditions of snow and ice melting. Valenki (kind of high felt boots) with rubber overshoes.

Valenki are made of pure sheep wool. They are frost-resistant. Rubber overshoes prevent valenki from moisture. They are easy to dry under any conditions.

Leather boots. Boot-legs and boot-caps are made of high quality fatted Russia leather by means of stretching without any stitching in. To strengthen the water-proof property of the boots the cover of ox-bladder is stitched in as an intermediate layer. And the sole is mounted on cork.

Fur-lined sleeping bags are made of dog's fur. The exterior of the bag is covered (flesh side) by dense cotton fabric with waterproof impregnation. There is a hole for entrance at the top of the bag, which is laced. The rear part of the bag has a prolongation head to cover.

The second inner bag is made likewise the upper fur bag of light solid fabric. The intermediate layer of camel wool and sheet wadding is placed between outer and inner cover of this bag. The camel wool and sheet wadding is quilted with thin light fabric at the both sides. At the top there is a hole for entrance, the hole is zipped. For the warming of the hole there is protective woolen, flap and a hole for the face.

Fur and leather cap. The cap of the hat is of leather. Between the leather and lining there is a thin stuffing of woolen wadding. The cap is edged with beaver lamb fur. The flesh side of the fur is covered by the leather. The fur edges and ear flaps may be lowered to protect the head and ears from the frost.

Fur cap is made of deer-calf fur. Between the flesh-skin and lining there is a layer of woolen wadding. The cap is edged, the edge may be lowered to protect the head and ears from the frost.

This cap is not heavy and is notable for its warming quality.

Woolen underwear, socks, gloves, scarfs are of fine fleeced wool made to special order, considering local requirements to increase their warm qualities against ordinary standards.

SECTION VI

Field Operations

THE ECONOMICS OF A D4 TRACTOR TRAIN TRAVERSE

N. R. Smethurst

Introduction

Between the 17th of October, 1961 and the 3rd of February, 1962, a D4 tractor train with a team of six men reached a point 350 miles South of Wilkes station. On this journey ice-depth measurements were made and studies were carried out in glaciology, physiology and meteorology.

The polar plateau south of Wilkes station (Lat. 66° 20'S, Long. 110° 36'E) rises steadily to an altitude of 9, 800 feet at the southernmost point of the traverse. This area is featureless, and at one point the bedrock lies 10, 500 feet below the ice. Surface conditions vary considerably over this summer period. In October the surface is hard and broken by sastrugi which reach a maximum height of eight feet. During late November and December considerable accumulation occurs, filling in sastrugi troughs and giving a relatively smooth and very soft surface.

Equipment

Two D4 caterpillar tractors each hauled a train comprising up to five sledges while two Weasels were used as reconnaissance vehicles. These Weasels normally travelled up to one mile ahead of the tractor trains in order to select and flag a suitable route; because of their weight and length, the trains had limited maneuvrability.

Plant Characteristics

D4 Tractor	Weight:	6 1/2 ton
	Track Width:	24 inches
	Ground Pressure:	5 lb. /sq. in.
	Belt Hp:	57

Both tractors used were equipped with cabins, heater, fan and turbo chargers. One tractor was equipped with a snow blade, electric generator and welder. The second tractor had a winch and hydraulic pump for powering the ice drill. Reference should be made to the paper submitted under Section 4 "The Performance of D4 Tractors on Plateau Traverses".

Weasels	Weight:	2 1/2 ton
	Ground Pressure:	1.9 lb. /sq. in.
	Rated Hp:	21

Caravans

A four berth accommodation caravan was taken. See paper titled "The Design of Field Caravans" submitted under Section 4. This caravan and sledge weighed approximately four tons. A three berth plywood sleeping caravan weighing approximately 800 lbs. was also taken. Three men slept in each caravan.

Sledges

Five small cargo sledges each weighing approximately 300 lbs. were hauled. Of the two types used the semi-rigid Norwegian cargo sledge proved to be the superior. An Australian designed steel articulated sledge weighing approximately two tons carried the large accommodation caravan and another was used for fuel and general stores. The seismic ice drill and recording cab were mounted on a Canadian "Otaco" sledge giving a total weight of approximately four tons.

Loading

The plan below shows the position of sledges in the trains and the major items carried on each.

D4 tractor with blade	D4 tractor
Australian steel sledge 18 x 44 gal. drums of fuel Mechanical spares	Canadian Otaco sledge Seismic drill Cab stores
4 berth accommodation caravan Bulk food	3 berth plywood caravan
Small sledge 9 x 44 gal. drums of fuel	Small sledge 9 x 44 gal. drums of fuel
Small sledge Generator Heater tools	Small sledge 8 x 44 gal. drums of fuel
	Small sledge 11 x 44 gal. drums of fuel
Total weight approx. 12 1/2 tons	Total weight approx. 10 tons
Weasel Small sledge 11 x 44 gal. drums of fuel	**Weasel** No load

Steel wire rope was used to couple sledges permitting them to be pushed close together, so that on the initial start the tractors could pick up the weight sledge by sledge rather than pulling the train off as a dead weight. This system proved most satisfactory in soft snow areas. A flexible coupling was also used to connect the tractor to the train enabling the driver to exercise some choice of route when bogging occurred. Instead of having to disconnect his tractor from the train he could reverse and select a fresh route.

A large number of small sledges were preferred to a few heavily loaded sledges as the smaller ones allowed more flexibility in balancing loads between tractors in the varying conditions.

Fuel

Apart from oil, sixty-six drums of diesel fuel and petrol were carried. Weasel fuel consumption averaged 2 mpg (Imperial) while tractor consumption tended to vary considerably with load, grade and surface. Most of the outward journey travel was done in second gear with some in third. Over a distance of 120 miles, when fully loaded and steadily climbing on a firm surface, the tractors average 1.3 gallons per mile. Later, performance improved and up to 2 mpg was registered with an overall average of 1 mpg for the whole journey.

As the tractor was required to power the hydraulic drill, five gallons of diesel was used per hole. As expected, temperatures did not fall to the extremes experienced at other stations and it was not necessary to run tractors overnight. No fuel was allowed for this purpose, although additional petrol at the rate of two gallons per day was allowed for pre-heating vehicles before starting.

On previous journeys, much time and fuel had been wasted as a result of snow melting for water supply. A satisfactory melter was made by encasing the Weasel muffler with a water-tight tank into which snow was shovelled. This melting device produced 10 gallons of water in five miles of travel.

In order to dispense with the need to run a separate generator for charging spare vehicle batteries and batteries in scientific use, a special generator was fitted to one of the tractors. Batteries requiring charging were placed on the sledge behind, and charged while travelling by a take-off line from the tractor generator.

Stores Carried

a. Food—105 days fresh and 10 days emergency rations were carried
b. Mechanical spares and tools—see Appendix A
c. Medical supplies—see Appendix B
d. Emergency and General Equipment—see Appendix C
e. Clothing—see Appendix D
f. Navigational equipment—see Appendix E
g. Radio Equipment and spares—see Appendix F

Stores Packaging

Food

Food was packed in accordance with a recurring menu attached as Appendix G. Boxes containing 14 days food were stowed on the roof of the four berth accommodation caravan; one box containing seven compartments was kept inside the galley and this was replenished each week, one day's ration being placed in each compartment. This system allowed a strict check to be kept on the consumption of rations and avoided confusion arising between men who cooked each day in turn. Certain commodities such as sugar, oatmeal and condiments were drawn from a bulk source.

The recurring menu was designed to allow a substantial breakfast, a mid-day meal which could be prepared quickly, particularly when travelling, and a substantial three course meal at the conclusion of the day's work. This menu proved to be most satisfactory.

Sufficient food was carried in each vehicle as an emergency supply in the event of the main stock being lost and for men travelling in the vehicle should they become separated from the main party.

Clothing

An initial issue of clothing sufficient to last four weeks was made to all men. Prior to departure additional clothing was tried on for size; this was marked and packed in boxes to be supplied on a one-for-one replacement basis each month. This system avoided cluttering up caravans with surplus clothing and ensured regular re-supply of clean clothes.

Sleeping bags were issued on the scale of three per man. Two were normally used for caravan sleeping while the third was carried in the member's vehicle as an emergency in case the vehicle became separated from the main party.

Vehicle Spares and Tools

All spare parts and tools were inventoried and packed in drift-proof boxes. These items offered less scope for distribution than other stores. Each vehicle was issued with a basic tool kit and, where possible, spares likely to be required were carried in the vehicle or on one of its sledges.

Navigational Equipment

Two complete sets were carried in separate vehicles.

Medical

As well as the comprehensive supplies listed and located as in Appendix B each vehicle carried a personal first-aid kit.

Weather and Rates of Travel

Eighty-nine days were spent in the field; of this total twenty-eight days were lost as result of weather conditions and four as a result of mechanical failure. Extremely poor weather conditions occurred in October and November; between 9th December and 3rd January only three days were lost due to poor conditions and these were all severe whiteouts. A time and mileage schedule is listed below. When evaluating the rate of progress achieved it should be remembered that all work was performed on the outward journey and accounted for seventeen days.

	Miles Travelled
7th October 21st November	170
22nd November 6th December	80
7th December 19th December	100
20th December 3rd January	350

Mechanical Troubles

Only four days were lost as a result of mechanical failure. In the D4 tractors the only major trouble was one broken main spring. In the rough conditions Weasel suspension trouble caused the greatest time loss as a result of spring breakage, drive sprocket wear and three track breakages.

Value of Tractor

Under a variety of conditions experienced on this journey the D4 tractor has proved itself capable of hauling a train of up to 12 tons.

Appendix A

Mechanical Spares and Tools

D4 Tractor

Oil filters	4	Bolts and Nuts	Large Assortment
Fuel filters	6	Nylon Cord 5/16" Diam	20 ft.
Track grouser plates	4	Starting engine starter belts or belting	2
Track grouser plate bolts and nuts	24	Track rollers	2
Starting engine sediment bowls and washers	2	Track idlers	1
Fuel injector valves	4	Cylinder head gaskets	2
Master clutch disc	2	Manifold and Flange gaskets	2
Fan belts or belting	3	Tow-bar pins	2
Starting engine spark plugs	8		
Starting engine magneto points, sets	2		
Master pins (Tracks) and plugs	2		

Weasels

Repair chains for tracks	2	Distributor	1
Springs (Main)		Thermostats	2
Idler springs	2	Radiator hoses (top/btm.)	2 ea.
Drive Sprockets	2	Cylinder Head gaskets	2
Bogie Wheels	2	Manifold and flange gaskets	2 ea.
Front idler wheels	1	Universal joints (Drive shaft)	2
Guide bogies	2	Clutch	1
Support arm bushings	6	Oil filters	4
Spring yoke bushings and bolts	6	Clutch cables	2
Spark plugs	12	Water pump	1
Distributor points, sets	2	Fuel pump	2
Dist Condensers	2	Flexible fuel hoses	4
Coils	2	Drive axles	
Fan belts or belting	3	Clutch pres plate springs and levers	
Generator belts or belting	3		
Starter motor	1		
Generator	1		

Herman Nelson Spares

Spark plugs	2
Hose	1
Starter drives (complete)	1
Small hose adaptor	1
Small hoses, sets	3

Generator Spares

Oil filter	2
Spark plugs	4
Magneto Point (complete), sets	1
Sediment bowl and gasket	1 ea.
Electrical leads	
Hand extension lamps	2

General Spares

Fillers Assorted	4

Tools

Half inch drive socket, set complete	1
3/8" drive socket, set complete	1
Open spanners 3/8 - 1", set	1
Pliers assorted, pairs	6
Feeler gauges, sets	2
Screwdrivers asstd.	12
Chisels and Punches asstd.	
Drills 1/32 - 1/2", set	1
1/2" and Crow bars assorted	
Hammers Assorted	
Hacksaw and blades	2
Rulers	2
Magnet	1
Adjustable mirror	1
Adjustable wrenches	4
Masking tape, rolls	2
Stillson wrenches	3
Jacks, heavy duty	4
Vice, portable	1
Files, asstd.	12
Wire brush	1
Track spanner (D4)	1
Assorted Rods	
Spare glasses for mask and goggles	
Drill 1/4"	1
Drill, Heavy Duty	1
Ring Spanners 7/16" - 1"	
Spanners, Heavy Duty	
Heavy Duty adjustable Slide hammer	1
Grease gun	1
Flaring tool set	1
Lug All	1
(G) Clamps	
Vice	
Insulating Tape	
Emery Tape	
Gasket Cement	
Solder	
Oxy Hoses and Regulators	
Oxy Welding Rods	
Goggles	
Striker	
Electric welding cables	
Mask, Gloves, Wire Brush and Chipping Hammer	
Battery jump cables	
1 Bottle Oxy	
1 Bottle Ace	

Appendix B

Medical Supplies

Antiseptics	Caravan Box	Reserve Box
Phisohex detergent 5 oz.	1	1
Tincture Benzalkonium chlor. 1/1000 (General purpose)	1	1
Merthiolate capsules	3	
Benzalkonium chlor. concentrate 1/10, 4 oz. (Instruments)	1	
Hexachlorophene soap, cakes	1	1
Antibiotics		
Achromycin 250 mgm caps 16s	1	
Ledermycin 250 mgm caps 16s	2	
Penicillin Procaine (Cilicaine) 1 M units	12	
Ointments		
Tetracaine Soothing	1	1
Undecylinic acid (Fungicidal)	1	
Teramycin (Healing)	1	
Eye Sedative—Butyn and Metaphen	1	
Antibiotic—Bacitracin	1	
Sunburn cream Parasol	3	3
Lipstick tubes	3	3
Tablets		
Calcium phosphate 100		1
Pyribenzamine (Antihistamine) 100	1	
Ephedrine 3/8 grain 50	1	1
Chloroquine 250 mgm 100	1	1
Miltown (Meprobamate)—Tranquilizer 100	1	
Ascorbic acid 100 mgm	2	
AC Troches (Sore throats) 24s	1	
Veganin 100	1	
Aspirin 5 grain 100	1	
Saridone 50	1	
Dextro amphatamine sulphate 100	1	
Aluminium Hydroxide Tablets 3 gm 100		1
Caseara Tablets .25 gm 100	1	
Surgical		
Forceps Mosquito	1	
Scissors surgical	1	
Needles Surgeons Regular	2	

Surgical (continued)	Caravan Box	Reserve Box
Pkts. catgut 2 0 plain	4	
Amps. black 2 0 silk armed with reg. surgeons needle	4	
Suture breakers pr.	1	
Scissors, dressing	1	

Miscellaneous

Motor vehicle first aid kit, complete	1	
Pocket warmer (Hand warmer)	1	5
Book, First aid to the injured, St. Johns Amb. Association	1	
Eye shield	1	
Assortment of bandages, cotton wool, gauze, strapping		
Foot powder 1 oz.	3	3
Oxygen Cylinder 13 1/2 cu. ft. and take off	1	1
Thomas Splint	1	

Appendix C

Emergency and General Equipment

Carabiners		5
Crampons	prs.	6
Flags Aust.		1
Flags U.S.A.		1
Nylon rope 120 ft		2
Sisal rope 2 inch	coil	1
Sisal rope 3 inch	coil	1
Block and Tackle		
Snatchblock		
Banana Sled		1
Rucksack		1
Skis	prs.	2
Alum. ladder		1
Tent, Polar Pyramid		1
Jerrycan—Oil		
Jerrycan—Glycol		
Axe, 1 per vehicle		
D Shackles		
Shovel		1 per vehicle and Seismic van
Primus		1
Spare Pins for Sleds		
Binoculars		1
Verey Pistol		1 per Weasel (20 cartridges per pistol)
Ice Axes		3
Trail Markers distributed between all vehicles		
Jacks		3 (2 in OIC Weasel)
Drum Key		
Drum Pump		2 (1 each Weasel)
Towing Slings,		
Nansen Sling Long		1 each Weasel
Nansen Sling Short		2 each Weasel
Tractor hauling		1
D4 less blade lower sling		1
Wire for drum marking		
Wooden Blocks		

Caravan Messing

Stoves, 2 Burner, with funnel (1 each van)
Cooking Pots and Pans
Pressure lamp and spare mantles (both vans)
Miscellaneous kitchen equipment
4 gal. Jerrycan for White Gas

Appendix D

Clothing

Initial Clothing to be Carried by Member

Sets Windproof	2
Mittens	4
Heavy Outer Mits	1
Balaclava	1
Hat Jaeger	1
Long Johns or Pyjamas	2
Shirt or Pyjama Coat	1
Mukluks or Thermal Boots	1
Sox Norw. Long	2
Sox Army	2
String Singlet	1
Towel	1
Trousers	1
Pullovers	2
Face Mask	1
Goggles	1
Wristlets	1
Overalls	1
Padded Suit	1
Sleeping Bags	2
Inners	1
Spare Boot Laces	1
A. N. A. R. E. Knife	1
Toilet Gear	
Slippers	1
Scarf	1
A. N. A. R. E. Cap	1
Mukluk Inners and Soles	2

Monthly Clothing Re-Supply

Sets Windproof	1
Mittens	4
Light Leather Outer Mittens	1
Balaclava or Hat Jaeger	1
Shirt or Pyjama Coat	1
Mukluks with 2 spare inners and soles	1
Sox Norw. Long	2
Sox Army	2
Singlets String	1
Towel	1
Overalls	1
Spare laces	1
Long Underwear	2

Spares to last whole trip and packed in second monthly box

Trousers	1
Pullover	1
Windproof Heavy	1

General

Hats Jaeger packed in second monthly box
Mending kit to be held in accommodation caravan
Medical sleeping bag (zipped all round)
Spare goggles
Large Mukluks for medical purposes.

Appendix E

Navigational Equipment

Navigation Equipment

Nautical Almanac 1961	
Star Almanac 1961	
Star Finder and Identifier	
Tables of computed Altitude and Azimuth 60 to 80 deg. incl.	1 set 2 Volumes
Plotting Charts	
Compilation Charts	
Position Line Forms	
Dividers	1
Protractor	1
Astro Compass	
Theodolite and legs	
Stop Watches	2
Compass, Magnetic, Primatic, Hand	1
Course Steering Device	
Binoculars	
Ruler	
Pencils	
Rubber	

Reserve Equipment

Bubble Sextant	
Nautical Almanac 1961	
Tables of computed Altitude and Azimuth 60 to 70 deg. incl.	1
Divider	1
Protractor	1
Astro Compass	
Ruler	
Pencils	
Rubber	

Appendix F

Radio Equipment and Spares

Mess Caravan

T.C.S. 12 Transmitter
T.C.S. 12 Receiver
Antenna loading coil
D.C. Power supply
40' Whip antenna
Remote control unit
1 Headset
1 Microphone
1 Telegraph key
1 Telephone handset L.P.

Small Caravan

1 Telephone handset L.P.
1 Aegis Loudspeaker

Weasel 10

AN/GRC9 Trans/Revr (Crystal 5400)
D.C. Power Supply
1 Headset
1 Microphone
1 Whip aerial, roof mounted

Weasel 11

AN/GRC9 Trans/Revr (Crystal 5400)
D.C. Power Supply
1 Headset
1 Microphone
1 Telegraph Key
1 Whip aerial, roof mounted

Spare Parts

2 Boxes BX-53-D complete, plus
1 1L4 and 2 IR5 tubes
2 tubes 1625
1 tube 12SA7
1 tube 12SK7
3 tubes 12A6
2 tubes 12SQ7
2 5A fuses
6 20A fuses
6 15A fuses
6 30A fuses
2 plug adaptors, large to small and small to large
Small quantity resistors, nuts, bolts, screws, solder
1 Microphone
1 Phone plug
1 Telegraph key
1 Phone pushbutton
3 cables for TCS Power Supply
1 TCS Power Supply

1 Whip aerial, 5 sections
2 insulators
1 Long wire aerial suitable for attaching to 40' whip

30' hookup wire
1 roll black friction tape
1 roll Red Tape

Tools

1 Screwdriver, Phillips
1 Screwdriver, Large
1 Screwdriver, Small
1 Soldering iron and spare bit

2 Spanners 5/16, 11/32, 3/8, 7/16
1 Pliers L/N
1 Pliers
1 Sidecutters

Stationery

1 Doz. pencils, A. N. A. R. E. code, 1 1/2 A. N. A. R. E. message pads, 3 plain message pads, 1 A. N. A. R. E. Logbook, 1 P. M. G. handbook, 1 TCS12 handbook, 1 ANGRC9 handbook.
AN/GRC9 used for Seismic work to be considered as spare radio.

Appendix G

Weekly Recurring Menu Used on Three Month Field Traverse, 1961

	1	2	3	4	5	6	7
Breakfast	Rolled oats Powdered egg Bacon	Farina Sausages	Rolled oats Powdered egg Tomato	Farina Pancakes Butter Syrup	Rolled oats Powdered egg Bacon	Farina Tinned fish	Rolled oats Pancakes Butter Syrup
Lunch	Scotch broth Trim Brown bread Sledging Bis. Dehydrated potato Dehydrated vegetables	Chicken soup Cold roast lamb	Asparagus soup Tongue	Scotch broth Tinned Frankfurts	Chicken soup Tinned Braised steak	Chicken noodle soup Tongue	Tomato soup Corned beef
Dinner	Chicken noodle soup Steak (frozen) Dehydrated potato Quick frozen beans Peaches	Tomato soup Tinned Braised steak Dehydrated potato Tinned corn Plum pudding	Mushroom soup Tinned hamburgers Dehydrated potato Dehydrated onion Tomato Pears	Ham and pea soup Steak (frozen) Dehydrated potato Quick frozen beans Pineapple	Chicken noodle soup Fish or lamb chops Dehydrated potato Quick frozen peas Apricots	Tomato or onion soup. Ham chunks Dehydrated potato Tinned Cauliflower Fruit Salad	Mushroom soup Spagetti Cheese Dehydrated vegetables Plum Pudding

Unlimited amounts of sledging biscuits, sweet biscuits, butter, jam, honey, tea, coffee, powdered milk, sugar. Limited amounts of peanut butter, sardines, dry biscuits of cracker type and club cheese, raisins, figs, prunes, nuts, cooking fat, brandy, rum. Also rice, dates, tomato sauce, pickles, chocolate, toffee, fruit cake.

Deep frozen bread prepared by the Station cook remained fresh throughout the journey.

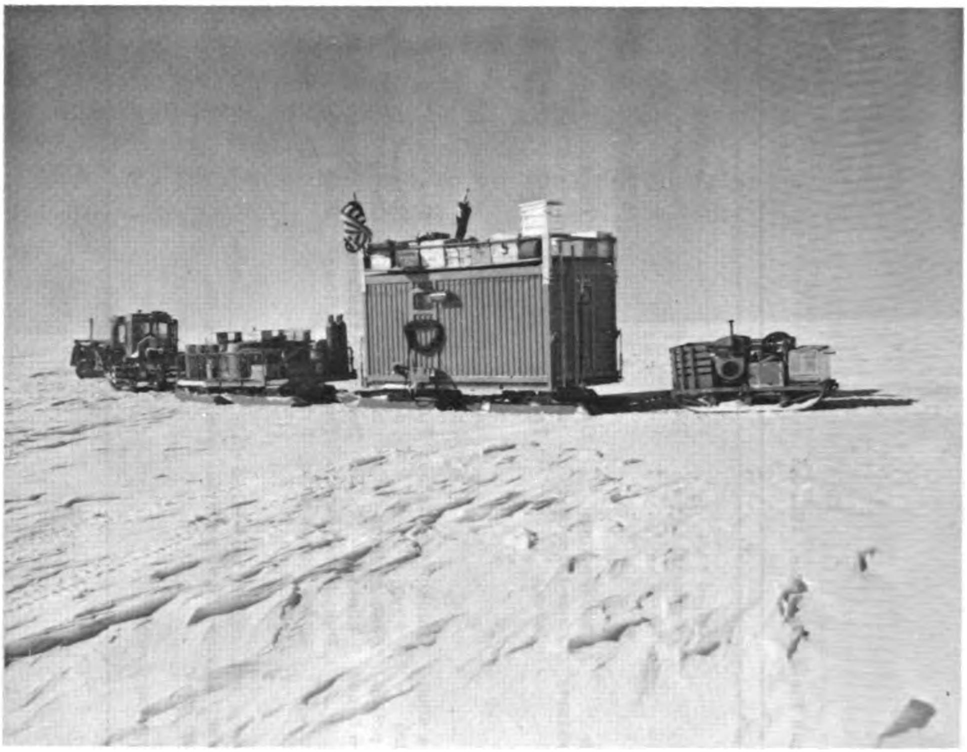


Figure 1. Tractor team south of Wilkes showing loaded sledges and accommodation caravan.

Figure 2. D4 caterpillar tractor hauling seismic drill cab, living caravan and fuel.

A SIMPLE DESIGN FOR A PORTABLE CATAMARAN

L. Hedges and F. Jacka

Summary

A lightweight, powered catamaran used for limnological investigations at Macquarie Island is described. It provides a stable platform from which two men may work comfortably.

Introduction

Extensive limnological studies now being carried out on Prion Lake, Macquarie Island, necessitated a stable vessel from which two men could work safely. As the vessel had to be transported by manpower alone from the coast a distance of about three miles over rough terrain to Prion Lake at an elevation of about 600 ft, light weight was an important consideration.

Any usefully-sized single hulled vessel would be much too heavy to be readily portable. The catamaran form was selected as being readily assembled from light-weight components and also as offering greater stability with a large working platform.

Construction

The main features of the vessel are illustrated in Figure 1. The hulls are formed from a 1/8-inch plywood shell with light timber framing and filled with a post expanding grade of polyurethane foam of density about 2-lb per cubic ft. The deck, in three panels, is similarly formed from plywood on a timber frame 2-inch deep and foam filled. The upper surface is of 3/16-inch plywood to better resist impact and compression loads in service. The deck carries inserts to receive the fixing plates and stanchions.

Life line stanchions were required to be simple and light but capable of carrying a man's full weight in case of accident. This is attained with 1 inch x 16 G stainless steel stanchions encastre some 2 1/2-inch into the holes where local stiffening effectively distributes the stresses.

The forward-mounted 5 1/2 hp outboard type motor gives a clear after working area and good maneuverability. With two men on board, plankton nets, etc., may be towed at speeds up to about five knots and no difficulty is experienced in maintaining a straight course.

The weight of the vessel, complete with motor, is approximately 350 lb. This is made up of two hulls of about 70 lb each, three deck panels of about 35 lb each, bulwarks, equipment box and hardware totalling about 55 lb and motor of about 50 lb. These were carried as separate units and assembled on the site in about one hour.

A minor fault with the present design is its wetness on deck with wind and sea off the bow. This is due to the over simple "swim end" design of the bows. This trouble could be avoided with more "ship shape" bow-lines which would tend to throw the bow wave down and away from the low decks.

The design offers a valuable research vessel for use in small bodies of water and its easy portability and inherent safety recommend it for Antarctic use.

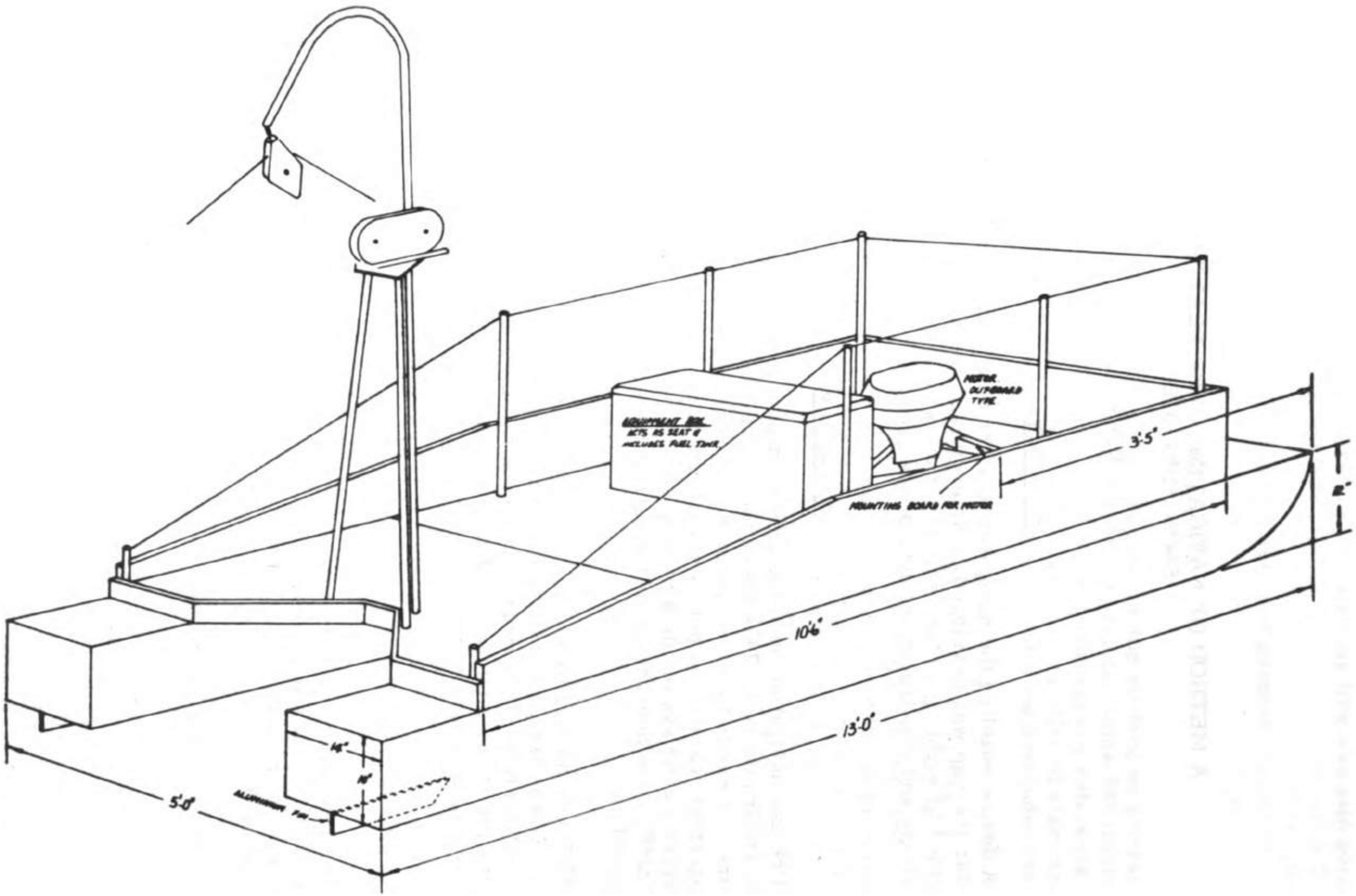


Figure 1. A. N. A. R. E. catamaran two man research vessel.

A METHOD OF NAVIGATING OVER FEATURELESS SNOW SURFACES

H. P. Black

Summary

A device enabling the navigator to steer an accurate course on the surface of the Polar ice-cap was developed in Antarctica in the Spring of 1960. Course is maintained by sighting on the vehicle's track with a system of mirrors. Operating instructions and constructional details are given.

1. Introduction

Precise navigation upon the ice-cap depends largely upon the accurate steering of a chosen course. This operation can be rendered difficult by three major problems commonly faced by Arctic and Antarctic expeditions: firstly, the absence of topographic features as points of reference; secondly, the loss of precision of the magnetic compass inside a moving vehicle and in areas adjacent to the Magnetic Pole; thirdly, the dependence of the astrocompass and similar instruments upon an unobscured sun.

A simple method by which these difficulties are overcome will now be described. It was tested and found satisfactory during an inland traverse from Wilkes Station in November-December 1960 into an area not previously explored by land. The principle of the method is to make the vehicle's track visible ahead of the driver by means of a periscope-like arrangement of mirrors.

2. Construction

The rear vision mirror taken from a "Traxcavator" was used as the main "Track mirror". It was pivoted at its centre point through the shorter axis. The mirror was mounted on a frame of two half-inch steel pipes bolted on to the vertical wall of the well between the windscreen and the forward hatch of the Weasel. This frame was secured by means of two brackets fastened to the front panel above the windscreen and braced with steel wires for rigidity.

A small "Driving mirror" was pivoted on a bracket near the base of the uprights, directly in front of the driver, and square with the long axis of the vehicle. The mirror mountings were made adjustable in order to provide both vertical displacement and inclination fore and aft. All mountings were made relative to a straight line drawn along the top surface of the roof, passing through the centre of the driving seat and parallel to the longitudinal axis of the vehicle. At the rear of this line was bolted a vertical sighting rod; a thin sighting line was laid centrally through the long axis of the driving mirror.

The dimensions of the installation are given in Figure 3.

3. Operation

a. Course Laying. The course was laid out on the surface as a straight line between a series of flags. Alternatively, a second vehicle, some 500 metres in the rear, was precisely positioned by radio to provide the necessary reference mark. Course marker stakes set out at the end of the day's run facilitated starting procedure next day, particularly when marginal weather conditions precluded the use of astro sightings.

b. Driving on Course. The driver maintained correct heading by means of his straight line track projected forward into the driving mirror and lined up with the image of a sighting rod mounted on the rear of the vehicle's roof and a reference mark on the driving mirror itself. Simultaneous attention to the mirror image and to the rough surface of the plateau was accomplished quite successfully after a little practice; in dangerous areas a slow speed was called for, or a person acting as lookout. Oscillation of the mirror image caused by vehicle movement was soon accommodated by human reflexes. The inverted image presented in the driving mirror did not provide any visual difficulty.

A second vehicle faithfully following the tracks of the navigation vehicle was found to provide a superior reference mark to the track itself, being much easier to "sight" in the driving mirror and allowing accurate registration under "whiteout" conditions. It was possible to compensate for natural obstacles by lining up the "true" track on the far side of the obstacle with the trailing vehicle. The navigating driver regained the line of the track and re-adopted his true heading as soon as possible, easily discerning the altered silhouette when the second vehicle straightened and thereupon re-registering upon it.

A certain degree of teamwork was required in the operation. The rear vehicle adjusted the separating distance to the terrain. Whenever the trailing vehicle was obscured by surface undulations the navigator was forced to register upon the less visible line of tracks.

c. Course Adjusting. Periodic checks of track were carried out in order to minimize course error, the interval being dictated by the degree of accuracy required. The driver aligned the vehicle precisely along the line of his track as the vehicle came to rest. Reference to the astrocompass or magnetic compass (at rest) then demonstrated any deviation from the planned course. A compensating slight alteration of heading over a calculated distance corrected any error.

4. Results

Traditional methods of steering course relative to terrestial features such as dunes or sastrugi, and to transient features such as cloud formations, introduced errors of magnitude. Lining up stakes in rear with binoculars proved impracticable over long distances. These stakes could not be sighted satisfactorily from a moving vehicle and, because of exaggerated perspective, course fluctuations were extremely difficult to assess, leading to frequent re-correction. On the other hand, with the new navigation device and reasonable driving care under average conditions of surface and visibility, each leg of a traverse was maintained within 2^{o} port and starboard, and, with compensating action following frequent checks of heading, within 0.5^{o}.

5. Conclusion

In areas like the Antarctic or Greenland ice-caps where a lack of topographic features inhibits accurate steering of course, where the proximity of the Earth's Magnetic Pole renders the magnetic compass unreliable (particularly for vehicle use), and in marginal weather which prevents travel based upon celestial observations, a navigating vehicle's own track offers a valuable means of maintaining an accurate "Dead Reckoning" course. This method was successfully employed in Wilkes Land in 1960; although other expeditions may have utilized the same principle no published reference to the method appears to exist. The simple pioneer device here described could no doubt be improved by the use of more sophisticated optical equipment. It can be fitted to any kind of vehicle and might also prove useful over deserts or wide, featureless plains.

Figure 1. Navigation weasel, showing installation.

Figure 2. Mounting of mirrors.

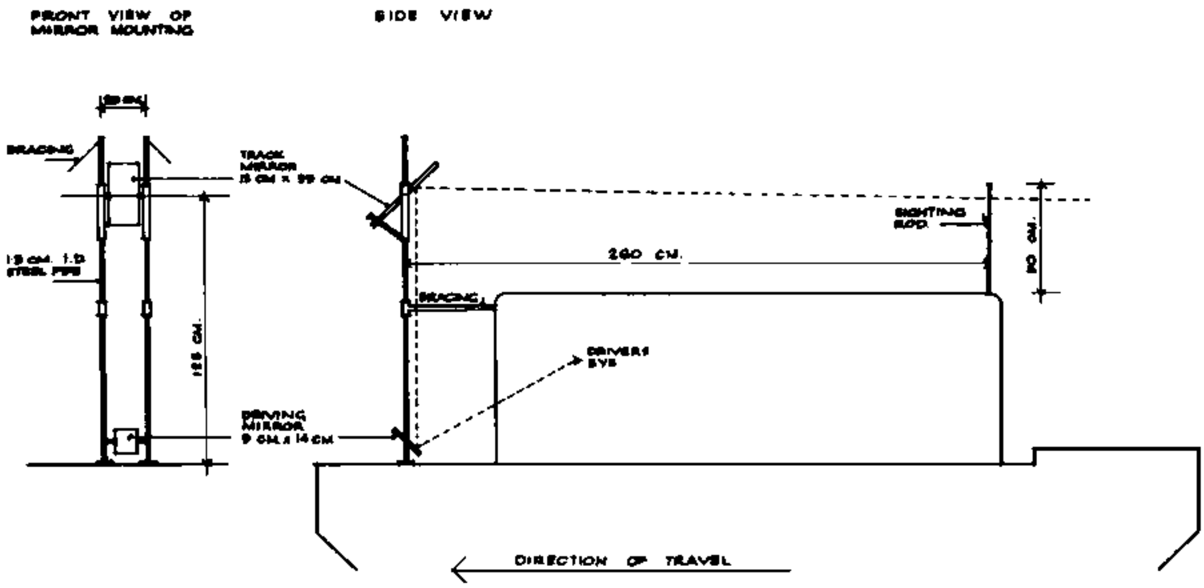


Figure 3. Sketch and dimensions of pioneer model.

NOTES ON AIR-DROP TECHNIQUE ON ICE-CAP

Service Operations
Expéditions Polaires Francaises

1. Introduction

1-1.

The following is based on the experience acquired:

a. During some 200 air supply flights (2, 700 hours) over the Greenland Ice Cap;

b. During some 1, 220 hours helicopter flight in Greenland and in Adelie Land;

c. From detailed reports concerning other Ice Cap air support operations (U. S. A. F., R. A. F. and Danish Air Force).

1-2.

The experience thus acquired since 1948 has been made on the following types of aircraft:

Airplanes:

LB 30 (Liberator) - DC 3 - DC 4 - DC 6 - PBY (Catalina) - B 17 (Flying Forthers) - C 119 - SA 16 - Norseman - C 130 - NORD 2, 501 - BREGUET 765 -

Helicopters:

Bell - Alouette - Djinn

2. Dropping Zone

a. The main Camp marks the beginning of the dropping zone (D. Z.) and should be on the pilot's side of the plane (generally left hand side) as the plane approaches the dropping zone, heading into the wind.

b. About 1/10 mile from the main Camp, to leeward, a first weasel or a sledge or tent or any other large marking should be placed to mark where the drop signal should be started and to give height perception. A smoke bomb should be placed at this point and lit before the first passage of the plane.

c. In the main Camp, on the D. Z. side, the radio weasel (2nd weasel) should be placed. The man in charge of the operation on the ground should be at this point, and in continuous radio contact with the aircraft.

d. About 1/10 mile from the main Camp, to windward, a third weasel or sledge or any other large marking should be placed to mark where the drop signal should be stopped and to give height perception.

e. About 1/10 of a mile from the third weasel or sledge, in the same direction (to windward) a fourth weasel or sledge or any other large marking providing height perception is necessary when the pilot pulls out of his run.

3. Axis of Flights

3-1. Free Drops

The axis of the flights (axis of D. Z.) for free drops is parallel to the line made by the main Camp, and the weasels or markings. The first run is at a distance of about 100 feet to the right of that line. Following runs should be 30 feet from first run and from each other, to the right (note: it is very important that each run should be separate from the previous one to avoid loss from collision between parcels being dropped and parcels already on the ground).

3-2. Parachute Drops

To determine the axis of the flights for parachute drops, the speed and direction of the wind have of course to be taken into consideration. Standard techniques are used. Observations made from the ground for correction of flights are important.

4. Drop Signals

4-1.

The signal for starting the drop should be given when the plane passes the first weasel. The signal of stopping the drop should be given as the plane passes the third weasel. In this manner all the supplies dropped will be concentrated in a dropping zone the length of which will not be more than 1/4 mile and the width not more than approximately 150 feet.

4-2.

a. About 30 seconds before arriving at the first weasel (or marking) give 4 or 5 short rings of the bell to tell the drop master that dropping will begin about 30 seconds later.

b. Start ringing the bell when passing the first weasel (or marking) and continue to ring the bell continuously until the plane gets to the third weasel (or marking).

c. Stop the ring of the bell at that point.

d. As long as the bell rings the drop master can push the material out. When it stops the drop master must immediately stop all out-going material.

5. Pull Out

The plane should pull out of its run when passing the third weasel or marking (when the drop signal is stopped) and start climbing level to about 300 to 400 feet above the ground before beginning its turn to the left. (It should never start a turn before having climbed at least 300 feet above the ground).

In this manner the pilot will always have Camp and D. Z. on his left, which is best for good visibility (this assumes of course that the pilot's seat is on the left hand side of the cockpit).

6. Height of Runs for Drops

6-1. Free Drops

Regardless of what has to be free-dropped, regardless of the type of snow surface, the height of the runs for free drops can be considered as having to be as low as possible. But for better results, the height of the runs for the drops must take in consideration the true speed of the aircraft, the nature of the snow surface, the nature of the parcels to be dropped, and if they are dropped from a side door or from the aft opening of the plane (see examples).

6-2. Parachute Drops

Runs for parachute drops should never be made higher than 300 to 400 feet.

Note: As a whole it can be said that the runs, were they for free drops or for parachute drops, are always too high above the ground and it is most certainly in this error that the reason for high percentage of losses has to be looked for.

7. Speed of Plane During Drops

For free drops as well as for parachute drops the plane must of course fly as slow as possible (mixturn rich, flaps more or less down in relation to conditions, etc...). But the gear must never be put down to slow the plane, because if a forced or crash landing had to be made, this would certainly mean disaster.

8. Control Approach

The best results are obtained when the approach is controlled either from the ground or by a third person in the plane sitting between the pilot and the co-pilot.

8-1. From the Ground

The control men should be in radio contact with the pilot from the radio weasel situated in the main Camp on the D. Z. side (2nd weasel on flight plan). He gives indications to the pilot for direction and height above the ground in a similar way as is given in G. C. A. procedures. He also gives the orders for starting the drop signals.

8-2. From the Air

The control man sitting between the pilot and the co-pilot gives similar indications of bearings and height to the pilot. He himself gives the different drop signals. In this manner the pilot has his mind free of all considerations other than flying the plane and controlling his instruments, and the co-pilot of all considerations other than having his hands on the throttles and his eyes on the instruments.

9. Dummy Run and First Run

It is advisable to free-drop a first load of "jerricans". This will mark the axis of flight, or permit correction if, for instance, the axis of the flight was made too far or in an inaccurate heading. To facilitate this the plane should always make a dummy run during which conditions should be carefully observed from the plane and from the ground, these observations being coordinated after this dummy run is completed. In this manner (after the first drop of a first load of "jerricans") the pilot will establish the axis of the D. Z.

10. Conclusion

The principal elements of success are the following:

a. Speed of plane: as slow as possible

b. Height of drop over snow surface: as low as possible but varying with the weight-volume factor of the parcel (never to be more than 30 m - 90 feet)

c. Density of snow measured in the first 50 cm of depth: from 0.35 to 0.37 if snow-density higher: parcels will deteriorate, if snow density lower: parcels will sink into the snow

d. Each line of drop should be distant from the preceding one by approximately 10 m (30 feet).

e. Control should be made by experienced man on ground.

Example 1. Gasoline Drums

Altitude of D. Z.:	2, 965 m
Type of snow surface:	good, snow-density on 0. 50 m depth from 0. 35 to 0. 37
Type of drums:	heavy gauge reinforced gasoline drums, full. weight: 182 kg, volume: 287 dm^3 (ϕ 62. 00 x 84. 00cm)
Number of drums:	55
Type of aircraft:	NORD 2, 501, aft opening
True speed over D. Z.:	110 knots
Air temperature on ground:	-28°C
Wind:	W 10 m/sec.
Sky:	7/8
Horizontal visibility:	800 m
Ceiling:	varying during runs from 20 to 100 m
Height of runs over snow surface:	3 to 10 m
Loss:	none

Data: 14 May 1959
Station: Centrale
Greenland Ice Cap
Long.: 40° 37' 25"
Lat.: 70° 54' 44"

Example 2. Gasoline Drums

Altitude of D. Z.:	2, 870 m
Type of snow surface:	good, snow-density on 0. 50 m depth: from 0. 35 to 0. 37
Type of drums:	light gauge gasoline drums, 85% full (170 liters for 200 l drum) weight: 163 kg, volume: 254 dm^3 (ϕ 59. 0 x 89. 5cm)
Number of drums:	12
Type of aircraft:	NORD 2, 501, aft opening
True speed over D. Z.:	110 knots
Air temperature on ground:	17°C
Wind:	NW 2 m/sec.
Horizontal visibility:	5 km
Sky:	5/8
Height of runs over snow surface:	5 to 8 m
Loss:	none

Data: 27 May 1959
Station: Jarl-Joset
Greenland Ice Cap
Long.: 33° 28' 10"
Lat.: 71° 22' 00"

Example 3. Light Wooden Crates Containing Food (Tins, Plastic Bags, Paper Bags, Carton Boxes)

Altitude of D. Z.:	2, 870 m
Type of snow surface:	good, snow-density on 0.50 m depth from 0.35 to 0.37
Type of crates:	light wooden crates ("Mussy"; "fiber nappe"; see description in paper on "packing for air drop"), weight: from 6.5 kg to 11 kg, volume: 38 dm^3 (35.7 x 31.2 x 26.8 cm)
Number of crates:	517
Type of aircraft:	NORD 2, 501, aft opening
True speed over D. Z.:	110 knots
Air temperature in ground:	-23°C
Wind:	N 3 m/sec.
Horizontal visibility:	good
Sky:	8/8
Height of runs over snow-surface:	30 m
Loss:	none

Data: 11 June 1959
Station: Jarl-Joset
Greenland Ice Cap

Long.: 33° 28' 10"
Lat.: 71° 22' 00"

Example 4. Cardboard Boxes (Containing Explosives for Seismic Soundings

Altitude of D. Z.:	2, 965 m
Type of snow-surface:	good, snow-density on 0.50 m depth from 0.35 to 0.37
Type of crates:	two cardboard boxes, one in the other, closely fitted with a wooden crate around. weight: 25 kg, volume: 60 dm^3 (45.00 x 40.50 x 33.00 cm)
Number of crates:	85
Type of aircraft:	NORD 2, 501, aft opening
True speed over D. Z.:	110 knots
Air temperature on ground:	-21°C
Wind:	WSW 5 to 7 m/sec.
Horizontal visibility:	good
Sky:	2/8
Height of runs over snow-surface:	30 m
Loss:	none
Remark:	all wooden crates broken—all cardboard boxes intact.

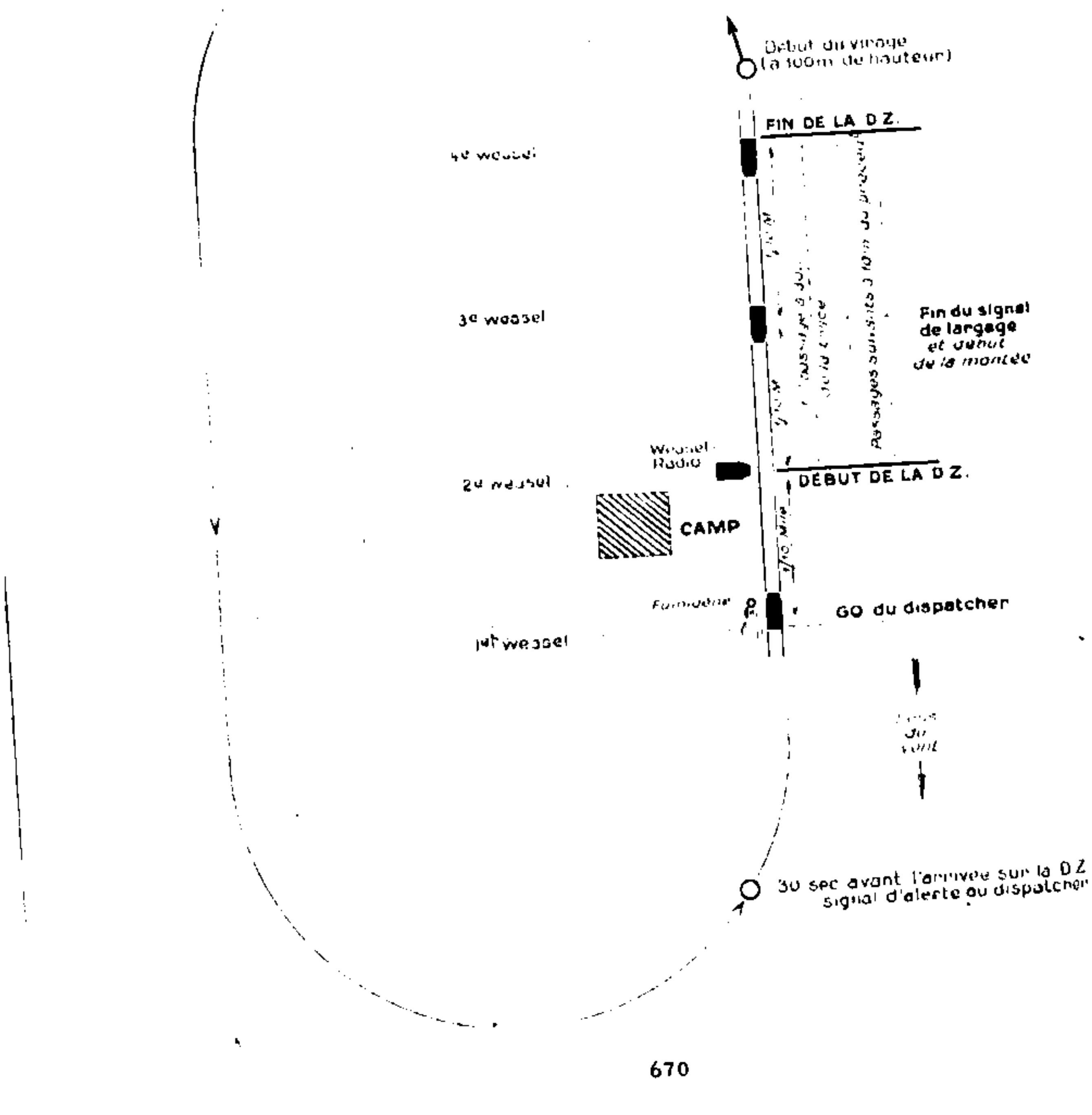
Data: 13 May 1959
Station: Centrale
Greenland Ice Cap

Long.: 40° 37' 25"
Lat.: 70° 54' 44"

EXPÉDITIONS POLAIRES FRANÇAISES
Missions Paul-Émile Victor

RAVITAILLEMENT AÉRIEN DES EXPÉDITIONS FRANÇAISES AU GROENLAND 1949 - 50 - 51

PLAN DE VOL DU LARGAGE AÉRIEN



OPERATIONAL PLAN OF THE INTERNATIONAL GLACIOLOGICAL EXPEDITION IN GREENLAND

Service Operations
Expédition Polaires Françaises

1. Introduction

The Expéditions Polaires Françaises (Missions Paul-Emile VICTOR) were entrusted in 1956 with organizing and assuring the technical direction of the International Glaciological Expedition in Greenland (E. G. I. G.). Five countries participated in this expedition: Germany, Austria, Denmark, France and Switzerland. The operations included: three preliminary reconnaissance expeditions in 1957 and 1958, a main summer expedition from March to September 1959, a winter season for six men on the Ice Cap in 1959-60, and a small summer expedition from April to September 1960.

To carry out this expedition, especially the main 1959 summer expedition, the E. P. F. established a "Manual of Operations", complete and detailed, and which clearly illustrates the E. P. F. 's overall logistic outlook.

This 200-page document will not be able to be reproduced or translated for the Symposium. Copies in French and German will be distributed during the session.

This notice will give an indication only of the general outline of operations, methods and organization adopted for carrying out the E. G. I. G., without entering into details which can be found in the "Manual" itself.

2. General Outline

The general outline of operations was determined by studying the various data of the problem, such as were made evident by:

the scientific program
the geographic and climatic conditions
financial means and availability of materials.

2-1. Scientific Program

2-1-1. Concise Report of the Program. The E. G. I. G. scientific program was determined by an International Direction Committee, and included works in geodesy (geodesic triangulation, geometric levelling), geophysics (seismic soundings, electrical soundings, gravimetry), glaciology, meteorology (including also barometric radiation and levelling).

These studies had to be made on the Ice Cap in the zone of maximum glacial activity. They were concentrated on two axes: one crossing Greenland from the West Coast to the East Coast, 800 km in length; the other, North-South, near the western border of Inlandsis, 300 km long.

These studies on the Ice Cap had also to be done in coordination with the hydrologic, glaciological and coastal geodesic studies conducted at the same time on the West Coast.

Some of the studies had to be continued during the winter:

2-1-2. Operational Exigencies

a. In order to perform the planned scientific works, the route to be taken in covering the two axes, in both directions, amounted to 2, 500 km. To accomplish these works over such a distance during one summer expedition necessitated a maximum increase in the summer expedition's length.

   It had to begin the earliest possible, in April or May, bad weather making it impossible to continue the works in September.

   The adopted solution was in direction relation to the access conditions of the Greenland coast (see below 2-2-1).

b. To heighten the chances of achieving the whole program, it was necessary to step up as much as possible the speeds of vehicle convoys on the Ice Cap.

   It was therefore decided to use once again the techniques employed and developed by the E. P. F. since 1948 in Greenland: convoys composed of light vehicles (weasels) drawing lightweight equipment and supplied by airplane.

c. The scientific works, quite different, imposed different travelling speeds to the convoys.

   It was therefore decided to create specialized groups according to the nature of the works (geophysics, levelling, geodesy-polygonation, etc...).

d. Those specialized groups were autonomous and independent, but it was also decided to have them be independent of aerial support, thereby creating supply depots distributed along the two axes.

   Moving from one depot to another, the scientific groups did not therefore risk being obliged to interrupt their work for long periods, i.e., while waiting for a delayed parachuting (e.g., because of bad atmospheric conditions).

   It was therefore possible to forecast the advance of these groups on the two axes, and also to establish a travel graph for each group. The travel graphs being known, the depots could then be located accurately according to actual necessities. The necessary aerial support for the founding of these depots could also be reckoned accurately.

e. For the creation of depots on the two axes, it was decided to organize two specialized groups, exclusively technical, entrusted, at the beginning of the expedition and before the other groups, with marking out the two axes, receiving parachute drops and locating the depots. These groups were named: "transport groups".

This method allowed the work groups to move on prepared ground, to concentrate themselves exclusively to their jobs in complete safety, not having to worry about supply problems, and it also allowed for the reduction to a minimum of the time of presence in Greenland and thereby the time of mobilization of supply planes of the French Air Force, necessary only at the beginning of the expedition.

f. To keep track of the distribution of works, the activity moving between the two axes, coordination exigencies, it was decided to create a mobile command post (C. P.) for the leader of the expedition. He could be present in the regions of greatest concentration and greatest activity and therefore of greatest risks; especially in the zones where helicopters were used.

For these reasons the doctor of the summer expedition was attached to the C. P.

2-2. Climatic and Geographical Conditions

2-2-1. Access to the Coast and to the Inland

2-2-1.1. The Problem. The East Coast of Greenland is not accessible until after the breaking up of drift ice which occurs at the top of the East-West axis at the end of May or the beginning of June. This breaking up of drift ice is accompanied by the quickened melting of surface snow in the coastal area, where the surface soon becomes chaotic and ravined, rendering the crossing of vehicles and sleds impossible. To race against the melting of the snow it is necessary to reach an altitude of 1,800 meters in eight days, which point is at about 100 km from the coast. Such conditions bring on fatigue of personnel, wearing of materiel and delays at the beginning of the scientific work.

2-2-1.2. Solutions Adopted. To avoid these difficulties, the solutions adopted for the E. G. I. G. consisted of:

Transporting by boat and stocking on the coast of the largest part of the expedition equipment, the year preceding the main expedition.

Crossing the cracked marginal zone by vehicles before the melting period, therefore in March-April 1959 the transport of technical personnel necessary for this operation to the site was carried out by plane.

Transporting the scientific personnel later by plane from France to Greenland, afterwards by helicopter from the coast to the Ice Cap, to join the vehicle convoys.

2-2-1.3. Operational Exigencies. For the adoption of this solution it was necessary to find an entrance to the Ice Cap, starting from a serviceable airfield on the West Coast.

The Danish and American authorities authorized the use of the airfield at Sondre-Stromfjord.

Two reconnaissance missions carried out in April and July 1957 by plane and helicopter led to the finding of a passage to Inland open to vehicle convoys.

This solution made necessary the stocking of material eight months in advance. Some equipment not being ready on this date, others not mobilizing for such a time (scientific equipment), it was necessary to plan for the transporting of this equipment to Greenland by plane. A small "aerial bridge" between France and Greenland was organized at the beginning of 1959.

2-2-2. Scientific Works in the Coastal Areas

2-2-2.1. Statement. Certain glaciological and geodesical studies had to be made on the West Coast (to connect the East-West axis to the coast), and at the northernmost point of the North-South axis (for similar connection to the coast). The Inland marginal zone being cut up after the melting by many dangerous cracks and inaccessible to vehicles, the works to be carried out in these areas could only be done by helicopter.

2-2-2.2. Operational Exigencies. To keep the helicopters in Greenland for the shortest time, these studies were concentrated at the beginning and at the end of the expedition when the helicopters had to be in Greenland anyway, as mentioned above, to have the personnel cross the marginal zone.

The moving of the scientific groups having to participate in these operations, was organized in coordination with the helicopters so that everybody would be present at the same time, in the same place at the beginning and at the end of the expedition. The movement graph for these groups (geodesics, geophysics) was established therefore with these exigencies taken into consideration.

2-3. Material and Financial Means

The E. P. F. being in charge of all the material organization, and the contribution of other European countries being exclusively scientific, the financial and material means were limited to French resources only. These circumstances involved:

The limitation of personnel on the Ice Cap to a strict minimum adequate for carrying out the studies. The summer expedition of the E. G. I. G. in 1959 was therefore limited to 51 men including six for the winter season (divided into 23 scientists and 21 technicians, to which were added successively at the beginning and at the end of the expedition two crews of 6 men for the helicopter groups).

The limitation of the number of vehicles, taking into consideration the needs as estimated to a strict minimum, and the equipment available to the E. P. F.; the expedition was therefore composed of 14 weasels (plus two ex-U. S. A. weasels which were recovered on the Ice Cap), 9 wannigans with 6 places and 9 sleds.

The limitation of the use of parachutes, reserved for scientific and winter equipment (nevertheless more than 2, 000 parachutes were used, the winter station was made entirely by parachuted: buildings, equipment and fittings). Free dropping was therefore generalized for all the supplies (motor oil, food), especially for the constitution of the summer expedition depots. This free dropping was done by using a method already employed in Greenland by the E. P. F. in 1951. But to generalize this method it was necessary to perfect the packing material of the 1, 600 boxes of food rations of the summer expedition and of the 1, 200 boxes of food for the winter expedition.

3. Establishing the Operational Plan

3-1. Constitution of the Groups

Each independent and itinerant group was equipped with the necessary vehicles in sufficient number—weasels, wannigans and sleds—for accomplishing the works planned and ensuring the housing of personnel. The groups were therefore constituted as follows:

3-1-1. Technical Groups

East Transport Group (entrusted with receiving parachute drops, setting up the depots of the East-West axis and building the winter station), six men, vehicles: 2 weasels, 1 wannigan, 2 sleds.

North Transport Group (entrusted with setting up the depots on the North-South axis, and transporting the Inland glaciological group on the East-West axis), four men, equipment: 2 weasels, 1 wannigan, 2 sleds.

The expedition leader's command post—four men; equipment: 1 weasel, 1 wannigan, 1 sled—covers the two East-West and North-South axis, travelling with another group.

Helicopter group—seven men—to ensure the housing of personnel during the stay on the Ice Cap, this group used a wannigan moved by another group.

3-1-2. Scientific Groups

Geodesic Polygonation Group—nine men, equipment: 4 weasels, 2 wannigans, 2 sleds—working on the two East-West and North-South axis.

Geodesic Levelling Group—six men; equipment: 2 weasels, 1 wannigan, 1 sled—working exclusively on the East-West axis.

Geophysics group—six men; equipment: 3 weasels, 1 wannigan, 1 sled—working on the two East-West and North-South axis.

Inlandsis Glaciological Group—six men; equipment: that of the North Transport Group, plus another wannigan—working exclusively on the East-West axis.

Coastal Glaciological Group—three men—this group staying in the coastal area has no available means of transport, being brought to the spot by helicopter.

3-2. Sequence of Works and Group Travel Graphs

Each group being independent, its travelling was determined exclusively in relation to the time necessary for the performance of its job.

Travel graphs were established in the following way:

3-2-1. Technical Group. These only had to mark out the axis during their journey, a speed of 100 km per day was admitted by experiment; the time of halt, at every point where a depot was set up, was determined in relation to the weight of dropped equipment which was to be gathered and stored.

3-2-2. Scientific Groups. Their travelling speed was determined either by previous experience or, for new methods of measurement, by theoretical calculation. The following paces were adopted:

Geodesy with tellurometer: East-West axis (succession of quadrilaterals): 30 km per day, North-South axis (polygonation): 20 km per day.

Levelling: East-West axis: 14 km per day.

Geophysics: East-West axis (refraction): 100 km per day between firing points. North-South axis (reflection): 40 km per day.

3-2-3. Modifications for Bad Weather. For taking into consideration delays due to bad weather, a coefficient was assigned to the above mentioned scientific groups' speeds.

The following coefficients were adopted:

In April and May: 40 per cent bad weather
In June, July and August: 20 per cent bad weather.

Having fixed the chronological order in which the works should take place and the theoretical travelling speeds having been accepted, the attached graphs were established.

They constituted the basic documents of all the operational preparation of the E.G.I.G.

3-3. Composition and Setting-Up of the Depots

3-3-1. Choice of Sites for the Depots. The operational plan provided for the setting up of nine depots on Inlandsis, located at the points of extended halt of several scientific groups. In order to avoid the waste inherent to the multiplicity of depots, the relatively light provisions, such as food rations, were concentrated in only six depots.

During works, four extra depots for motor oil were created.

3-3-2. Composition of Depots. The composition of the depots was reckoned to include all supplies (food, motor oil, fuel, survey poles, etc...), taking into consideration the travel graphs of the groups, which give the stopping time at each point and the travel time between depots.

This reckoning was therefore done by taking into consideration:

The number of itinerant groups and the number of persons having to pass by or stay at each depot,

The number of days spent at each depot,

The deductions made by each group to cover the needs of the next distance.

The detailed means of reckoning depot composition are given in the "Operational Manual".

3-3-3. Setting up of the Depots. The systematic use of parachute would have been prohibitive for the supplying of the summer expedition (160, 000 liters of meter oil, 1, 600 boxes of food and drink) as well as for the winter station (20, 000 liters of motor oil and fuel, 1, 200 boxes of food and drink).

It was therefore decided, for the above-mentioned supplies, to generalize the "free dropping" at low altitude, method already used by the E. P. F. in 1951. The technique of dropping drums had already been developed, but it was still necessary to improve methods of packing food. Tests, conducted in France, allowed for the choice of a type of box, a packing material and a dropping technique adapted to the surface conditions of snow, usually powdery, above 1, 800 meters in May-June.

3-3-4. Management of the Depots. The depots having to be used by itinerant groups, isolated one from the other and which had to be able to find the necessary supplies in the places provided for in all certainty, it was necessary to organize and supervise requisitions in order to avoid unexpected stock shortages.

The expedition leader had therefore to maintain and supervise material accounts for the depots, the daily requisitions made by each group in each depot were transmitted by radio each day.

3-4. Aerial Support

3-4-1. "Nord 2501 Planes. The calculation of the extent to which aerial support would be needed was done on the basis of group travel graphs and the tonnage to be placed in each depot.

The travel graphs allowed for the determination of airplane use:

For parachuting and dropping, according to the progress of the transport groups;

For the transport done by helicopter in Greenland or to their home station according to the progress of the scientific groups concerned (coastal glaciology, levelling and geodesy).

For the transport of men and equipment from France to Greenland following the expedition's overall plan.

The tonnage and size of the depots to be set up had to be determined, and the necessary number of flying hours to this end was reckoned according to the distance to be covered and the load to be transported over such distance.

The operational plan provided for:

The constant use of two "Nord 2501" planes for a month and a half at the beginning of the expedition (April-May) and for two weeks in July.

A potential of 320 flying hours for dropping and parachuting.

A potential of 420 flying hours for transport from France to Greenland.

In other words, a total of 740 planned flying hours.

3-4-2. Helicopters. The general planning of the expedition provided for the use of helicopters in the following way:

A group of two "Alouette II" turbine helicopters, continually flying together over the Ice Cap. Total crew: seven or eight men.

Utilization at the beginning of the expedition (one and a half month) to facilitate the transport of scientific personnel on the Ice Cap over the marginal zone (over a distance of 100 km) and to assure scientific works in the west-coastal area of the East-West axis (over a distance of 100 km situated at 350 km from the starting base).

Utilization at the end of the expedition (one and a half months) to facilitate the performance of scientific works in the north-coastal zone of the North-South axis (over a distance of 150 km situated at 600 km from the starting base) and to permit the evacuation of all personnel from the Ice Cap to the coast, over the marginal zone, at the end of the expedition.

The dates and time of presence on the Inlandsis were determined on the basis of the travel graphs for the scientific groups concerned.

The distances to be covered and potential flying hours (estimated 230 hours) were calculated on the basis of the works to be performed. They allowed of the determination of stocks of kerosene to be placed in the depots of the North-South axis.

3-5. Radio Communications

Radio communications were of the greatest importance for assuring:

The coordination of works of the different stationary or itinerant field groups;

Inventorying and managing the depots;

Communication with the helicopters, maintained in permanent radio contact during their flights;

Communications with supply planes during their approach or operations over the dropping zone;

Regular communications between France and Greenland.

To cover these needs, a radio station was installed at the Sondre-Stromfjord airfield; it was entrusted with assuring radio communications between France and Greenland, maintaining contact with all groups and staying in contact with supply planes during their missions.

Communication between groups on the Inlandsis was assured exclusively with seven "single side band" (S. S. B.) transmitter-receivers of 10 watts distributed among the independent groups and the C. P.

The groups working in collaboration with the helicopters as well as the two transport groups were issued special supplementary radio equipment for their communications with the supply planes.

The winter station was also equipped with "S. S. B."

The forecasts for ionospheric propagation for the time of the expedition permitted the choosing of appropriate frequencies and the equipping of the groups with the corresponding quartz crystals.

4. The Winter Station

As with all the E. G. I. G. operational plans, the winter station conceived with a definite and limited program, realized with lightweight equipment brought in exclusively by air.

4-1. Scientific Program

This was limited to very complete glaciological studies on the surface, in pits and in laboratories dug in the neve, and to meteorological observations.

4-2. The Winter Station

Designed to accommodate six men, it was set up as follows:

To be installed completely under the snow level, like all the stations built by the E. P. F. since 1949 on an ice cap.

To be transported entirely by plane and dropped by parachute (building, equipment and materials) or by "free drop" (supplies).

To be used for one season, but which could be located and reoccupied five years later.

4-2-1. Setting Up

An "igloo" building, built entirely of "reinforced plastics" (which is the subject of a separate paper for the Symposium). All the prefabricated parts were parachuted on platforms.

A glaciological laboratory dug in the neve (24 x 2.50 x 2.75 meters) covered by the parachute platforms (sandwich panels: aluminium/expanded rigid polyvinyl chloride).

Three prefabricated shelters in sandwich panels (aluminium/expanded rigid polyvinyl chloride/fiberglass polyester resin), used for: glaciological laboratory (2 x 2 x 2 meters), shelter for generator unit (4 x 2 x 2 meters), room for storage batteries (5 x 2 x 2 meters).

125 meters of corridors (1.20 meters wide and 2.75 meters high), dug in the neve by a snow milling machine, joining the buildings to each other and used for the storage of food and motor oil.

4-2-2. Power. To lighten fittings and supplies to the utmost and to make the best use of local resources, power was furnished by an aeolian generator, 5KW 110/160 Volts, designed especially for the wind and climatic conditions on the Inlandsis, taking into account the tests performed in 1949-51. This machine is a variation of the aeolian generator used at the Charcot Station in 1957-58.

It feeds a lead storage battery composed of 60 cells and with a total storage capacity of 470 amperes per hour.

The installation was completed with an additional generator unit of 4.5KW, 110/160 Volts.

The aeolian generator, batteries and generator unit were parachuted on platforms.

4-2-3. Radio. Radio communications were assured by:

One "single side band" transmitter-receiver of 100 watts;

One receiver, type BC 342;

One transmitter-receiver AN/GRC 9.

Forecasts of ionospheric propagation were also done for the winter season to facilitate the choice of the best frequencies.

All the radio equipment was also parachuted.

4-2-4. Building the Station. The East Transport Group was in charge of receiving parachuted equipment and materials, digging excavations according to plan (from 1,500 to 2,000 m^3 of ice or snow) and constructing all the buildings. Helped afterwards by the winter team, this group made all the fittings (electrical layout, radio installations, interior fittings for the buildings), in order to leave for the winter team, at their departure, at the end of the summer expedition, a fully equipped station.

5. Realization

5-1. Operations Carried Out According to the Plan

5-1-1. Scientific Program. The scientific program as planned and established by the International Direction Committee was entirely fulfilled.

The geometric survey was carried out at the winter station only (instead of joining the East coast); this decision was taken before the start of the expedition, the survey group program being overloaded.

5-1-2. Operational Sequence. The operations followed the established plan with some changes in detail. The actual travel graphs for the East-West and North-South axis (joined hereto) showed, by superimposition of those predicted in the operational plan, long delays at the beginning of the operations and which were filled up by degrees through a progressive speeding up of operations.

These delays are due neither to a lack of organization nor to bad weather, but correspond to the delay which appeared necessary for the perfection of scientific equipment and work methods under actual conditions of use. The progressive adaptation of equipment, methods and men during the coming operations allowed for the complete recovery of time lost at the beginning.

5-1-3. The Groups. The groups were constituted according to the plan and at the established date, especially for the scientific groups (May 1st at Camp 6).

A total distance of 42, 000 km was covered by the vehicles on the Inlandsis during the summer expedition in 1959. Some mechanical incidents occurred at the beginning of the operation (water pumps of the weasel), later on the groups' stocks of spare parts and tools appeared to be quite sufficient.

5-1-4. Depots. All the depots were constituted according to plan; four extra depots, exclusively for motor oil, were created. The "free dropping" of motor oil and food supplies was satisfactory, the percentage of loss being lower than that predicted by the plan.

The calculations used as a basis for setting up the depots were born out by experience; no difficulty in supplying provisions having been encountered and the amount of motor oil having been increased (see below).

5-1-5. Aerial Support. Aerial support given by the French Air Force took place with complete regularity and according to the planned chronology.

France-Greenland shipments were assured by eleven "Nord 2501" planes in 330 flying hours.

Dropping and parachuting on the Inlandsis (210 tons for the summer operation among which 120, 000 liters of gasoline, 40, 000 liters of kerosene and 65 tons for the winter station) were carried out by a total of ten "Nord 2501" planes, in successive rotations, two by two, over 120 missions totaling 600 flying hours.

The overall total of flying hours accomplished (930 hours) was higher than the total predicted by the plan (740 hours).

The difference being due to the fact that dropping operations had been largely underestimated by the plan (420 hours instead of 600).

The underestimation was due to:

Supplementary drops as mentioned below;

Interrupted flights and cancelled drops because of bad weather conditions and which had not been taken into account for the calculation of potential flying hours.

Helicopter operations over the Inlandsis were carried out without incident. Once again they confirmed the excellent adaptability of turbine helicopters to polar regions.

Four "Alouette II" helicopters (two in April/June, two in July/September 1959), stayed on the Ice Cap through all kinds of weather for three months, and covered nearly 50, 000 km during 290 flying hours.

The estimates of potential flying hours included in the operational plan appeared therefore to be once again underestimated.

5-1-6. Radio Communications. Radio communications between groups by S. S. B. 10-Watt transmitter receivers gave complete satisfaction.

Communications done by radiotelephone, with very simple equipment, were carried out with complete regularity and safety over distances which in some cases exceeded 800 km.

The use of this radio equipment has now been extended to field operation vehicles of the E. P. F.

The Sondre-Stromfjord radio station and the winter station (equipped with a 100-Watts S. S. B.) were in constant and direct radiotelephone communication with the Paris E. P. F. office throughout the operations.

5-2. Operations Carried Out in Modification of the Plan

5-2-1. Supplementary Vehicles. Two weasels having been salvaged on the Ice Cap, with the agreement of the U. S. authorities, they were assigned, one to the geophysical group and the other to the Inlandsis glaciological group. This necessitated an increase in the quantity of gasoline in the depots.

Moreover, the increase in flying hours for helicopters brought about a corresponding increase in the amount of kerosene to be stocked.

These two increases were responsible, for the most part, for the increase in the above-mentioned transport plane flying hours.

5-2-2. Sending Home of the 1959 Summer Expedition Personnel. The operational plan provided for: the return of summer expedition groups to the point of arrival on the Ice Cap at the beginning of the operation; the storage of transport equipment; the evacuation of personnel over the marginal zone to Sondre-Stromjford by helicopter.

The possibility of using a Danish ship allow for the evacuation of personnel to the westernmost point of the East-West axis, the helicopters carrying personnel over the marginal zone of the Inlandsis.

Transport equipment was therefore stored in Camp 6, and only the East Transport Group came back to the point provided for in the operational plan, from whence it was evacuated by helicopter.

5-2-3. Homeward Transport of Winter Personnel and Equipment. The operational plan provided for the organization of a smaller summer expedition in 1960, in order to assure the return of the winter team by the same route as on arrival, and the storage of equipment near the Inlandsis until the following spring.

The American authorities having given their consent, the evacuation of personnel and transport equipment was done at the end of August 1960 by C 130 cargo plane, directly from the Ice Cap to Sondre-Stromfjord. Personnel were sent back to France by plane, equipment by boat.

The expedition for equipment recovery planned for the spring of 1961 was therefore cancelled.

6. Conclusions

The E.G.I.G. operational plan illustrates the E.P.F. logistical outlook: systematic use of lightweight land equipment for outfitting independent groups, all supplies coming by air; establishment of a small winter station on the Ice Cap, built under the surface of the neve and transported entirely by air.

This concept requires a strict and precise definition of the scientific observations and work programs to be accomplished during the summer expedition, and also requires a limiting of winter work on the Ice Cap to only those scientific observations necessary for the completion of works performed by the summer expedition.

Following these detailed scientific programs, it becomes to set forth an operational plan, both precise and detailed, leaving the least amount of elements possible to chance or improvization.

This concept offers the advantages of:

Lightening as much as possible, on unprepared ground and in polar regions, of difficult land operations wherein any slow down necessarily brings on others.

Transferring transport duties to aerial support (quick, simpler, based on prepared ground, necessarily in coastal areas with more or less diminished polar characteristics) whose weight can be localized.

Getting the most possible from the means put in service through preparation of details, allowing for the adjusting and limiting of means to needs.

On the other hand, this concept presents the following disadvantages:

It necessitates adapting land operations to available aerial means and requires increasing aerial support with the progress of operations.

It involves a lack of flexibility in field operations, which have to be carried out according to the pre-established plan. At a certain stage of execution (when the depots are set up), the operational plan can no longer be modified except within certain limits.

It requires preparation which may take a long time, which must be precise, centralized and coordinated, and which therefore involves risks of error.

It ends up as an operational plan resembling a codified text which, insofar as it be well prepared, takes away considerable initiative from the participant, which may bring about problems of a psychological nature and difficulties in the adaptation of personnel.

In carrying out the E.G.I.G., these disadvantages were relatively slight because of:

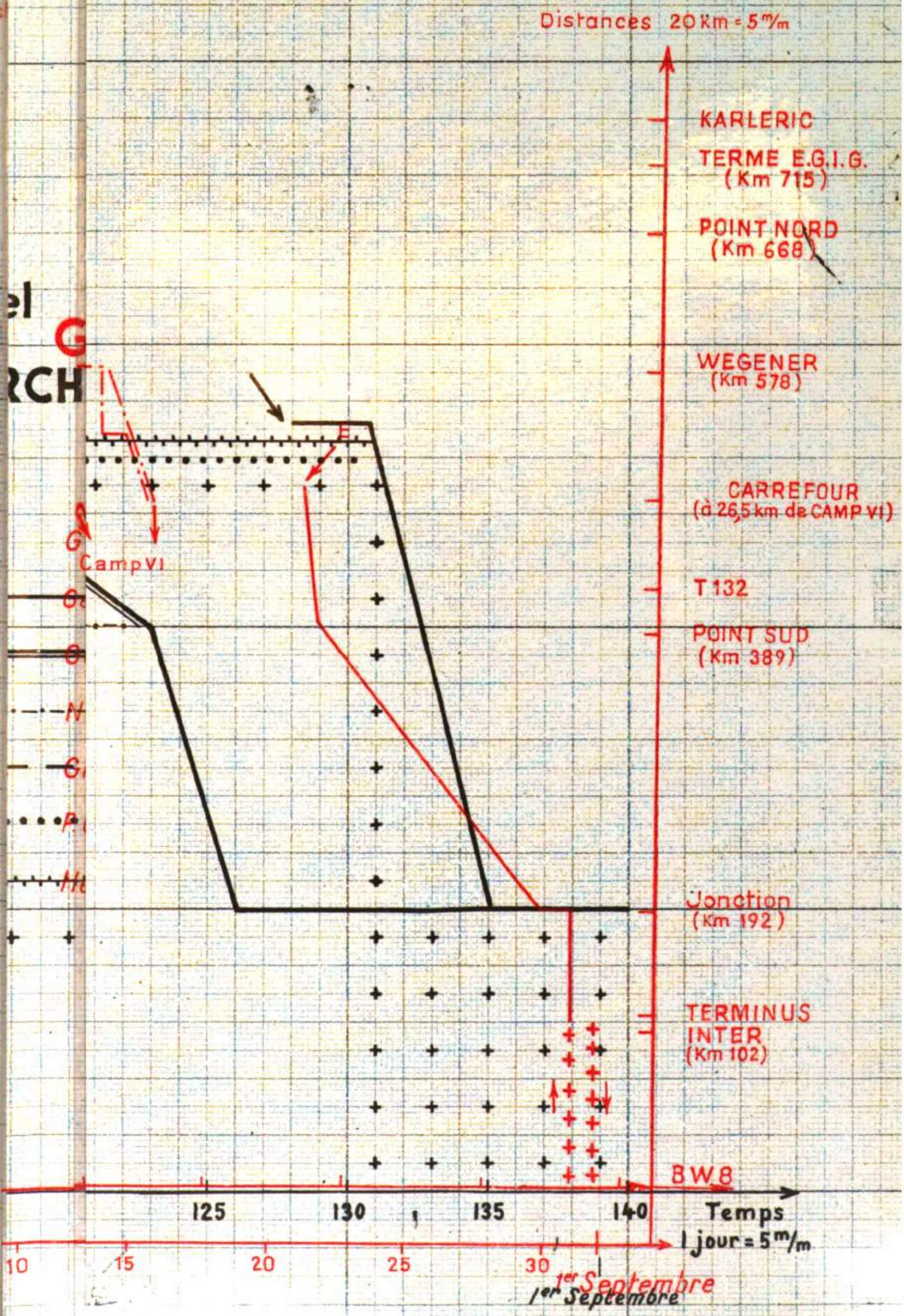
Material means (especially aerial support) were available;

The scientific program having been firmly established, lack of flexibility was not to be feared;

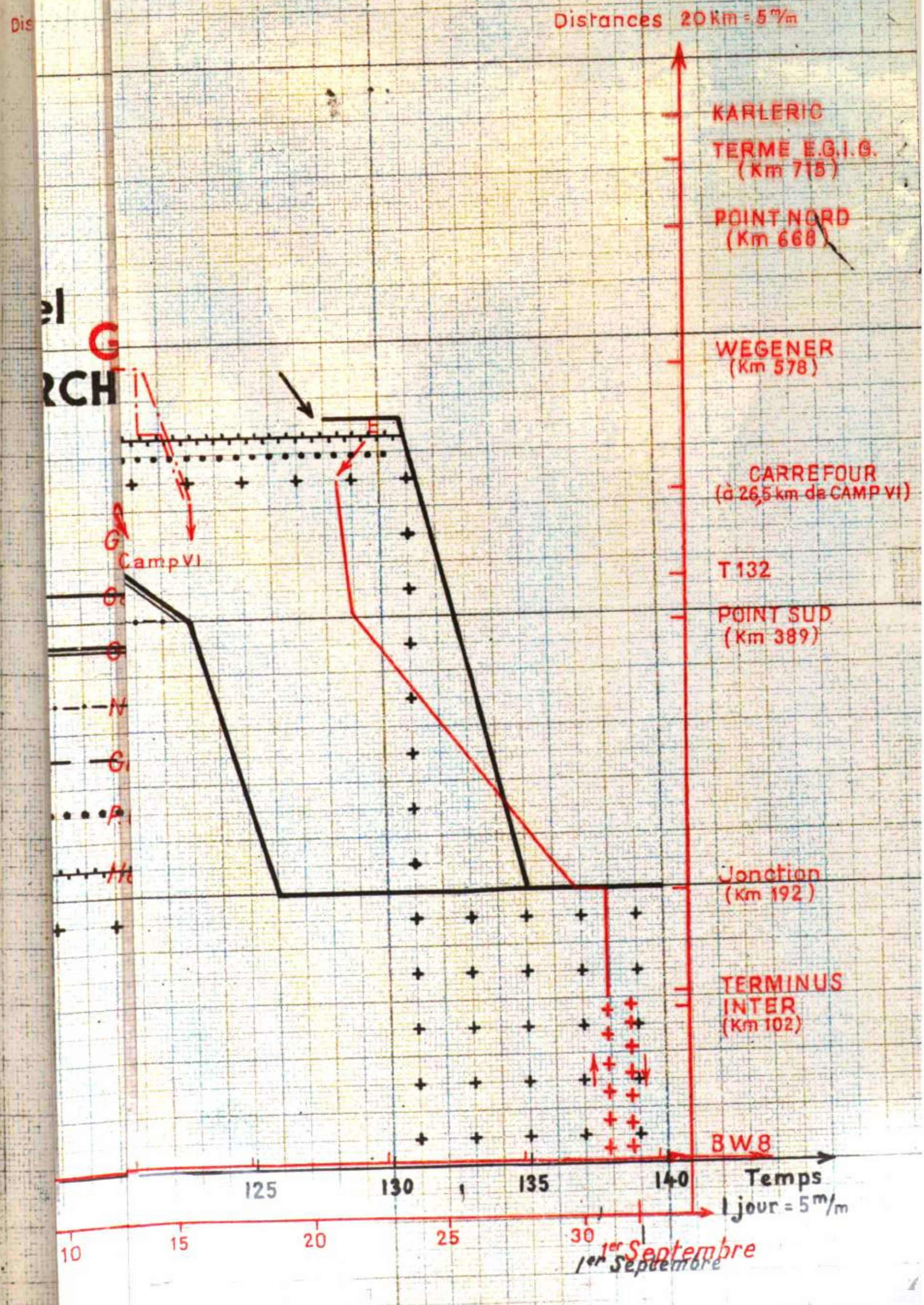
Preparation time was not limited;

The operational plan, distributed to all personnel, was used as a means of information and communication to keep every one informed on the preparation. This method was all the more indispensible since the participants were spread throughout five different European countries.

E.P.F. Novembre 1957



E.P.F. Novembre 1957

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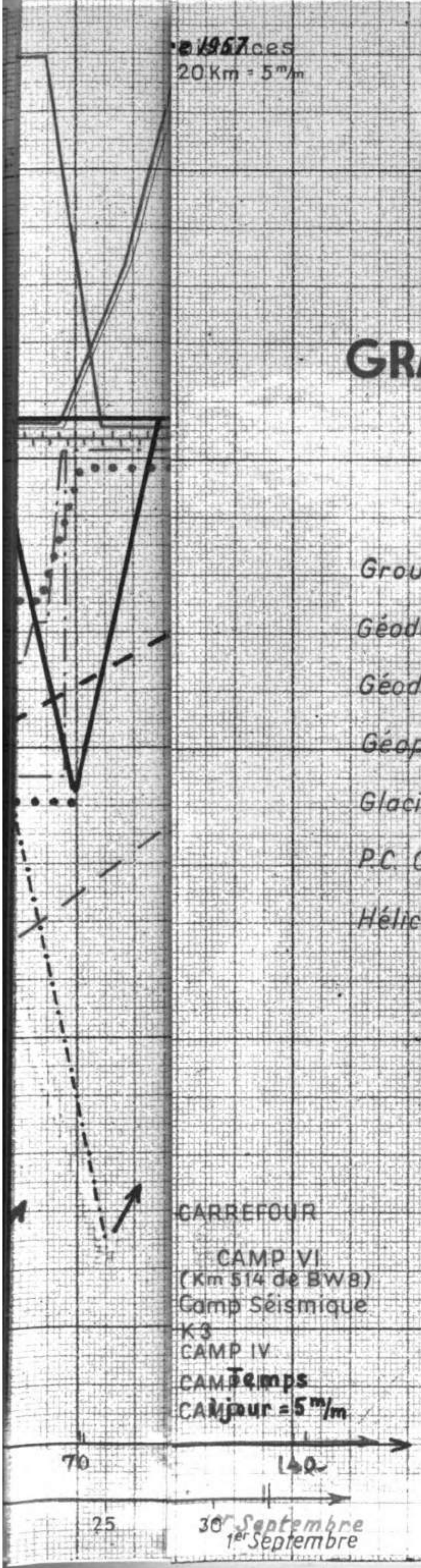

E. G. I. G.

1959

GRAPHIQUE DE MARCHE AXE E-W

Groupes transports

Géodésie Polygonation

Géodésie Nivellement

Géophysique

Glaciologie

P.C. Chef d'Expédition

Hélicoptères

FIELD OPERATIONS IN J. A. R. E., 1956-62

Masayoshi Murayama

1. Principal Features of the Field Operations of the Japanese Antarctic Research Expedition

The Syowa Base is located at 69°0'22" S Lat., 39°35'24" E Long., on the East Ongul Island, along the Prince Olav Coast on Lützow-Holm Bay. Because of its location, transportation from the relief ship to the base has been a difficult task. The ice in the Lützow-Holm Bay is so thick that an icebreaker cannot always break through close to the Syowa Base. In fact, transportation from the ship to the base of men as well as cargo during most of the period 1956-62 depended exclusively on the Sikorsky 58's. The only two exceptions were in 1957, when complete surface transportation was possible, and in 1960, when some surface transportation was feasible (see report on Section 2).

Accordingly, our vehicles must be of such a size that they can be transported by helicopters (see report on Section 4). At the same time, because of the limited station facilities (owing to the fact that we had no means of supply from the relief ship other than airsupply), it was not possible to keep any aircraft at the base during the winter. As a result, our field activities were restricted entirely to over-snow traverse using light snowcars and dog teams.

The traverse programs of the Japanese Antarctic Research Expedition were scheduled from a regional point of view, as shown below:

Section	Region
1	Prince Olav Coast, 38°E Long. - 45°E Long.
2	Prince Harald Coast, 30°E Long. - 38°E Long.
3	Between the Syowa Base and the A. N. A. R. E. Mts. (1956) on the Queen Maud Land, 39°E Long., 69°S Lat. - 45°E Long., 70°S Lat.
4	Yamato Mts. via the head of Shirase Glacier, 35°E Long., 72°S Lat.
5	Mizuho Highland via Yamato Mts., 35/40°E Long. - 90°S Lat.

Besides the snow traverses projects by wintering parties, field mapping operations in the region of Yamato Mts. were carried out in the period from

December 1960 to December 1961 in order to prepare for future aerial photography. For the same purpose, position and elevation determinations were made at several points in the region of Prince Olav Coast as well as of Prince Harald Coast. In addition, aerial surveys were made in the area between 38°E Long. and 45°E Long. by several summer parties.

2. Outline of the Field Activities During 1957-61

Year	Region	Means	Observations						
			Met.	Seis.	Geol.	Glac.	Grav.	Geog.	Geom.
1957	Mt. Botnunten along Lutzow-Holm Bay, 70°25'S, 37°55'E Total distance traveled 435 km	dog sledge	x		x			x	
1957	Olav Coast up to 68°08'S, 42°37' Total distance traveled 638 km	dog sledge	x		x			x	
1959	Olav Coast up to 70°06'S, 38°38'E Total distance traveled 328 km	dog & man-hauling	x					x	
1959	Syowa to 70°24'S, 46°50'E, Total distance traveled 735 km	2 snowcars	x	x		x		x	
1959	Harald Coast up to 69°40'S, 38°10'E Total distance traveled 278 km	snowcar	x					x	x
1960	Glav Coast up to 70°08'S, 39°13'E Total distance traveled 455 km	2 snowcars	x		x	x		x	
1960	Yamato Mts. 71° 45'S, 35°45'E Total distance traveled 1200 km	2 snowcars	x	x	x	x		x	
1961	Harald Coast up to 69°11'S, 35°11'E, return along Lutzow-Holm Bay to Syowa Total distance traveled 670 km	2 snowcars	x			x	x	x	x
1961	Syowa to 75°00'S, 38°02'E, return via Yamato Mts. to Syowa. Total distance traveled 2200 km	3 snowcars	x	x		x	x	x	x

3. Communications in the Field Parties

3-1. Station Facilities

Radio communication facilities at the Syowa Base were as follows:

1 KW transmitter	A1 x 1
400 W transmitter	A1, A3 x 1
100 Kc/30 Kc range receiver	x 3
50 W transmitter-receiver	A1, A3 x 2
15 W GRC9 transmitter-receiver	A1, A3 x 4

3-2. Field Communications

The base and field parties communicated with each other through 400 W transmitter and 15 W GRC9 transmitter-receivers. Generally, regular contact with field parties was carried out on the frequencies 5947 Kcs in A3, A1 with reserve of frequencies 2130 Kcs in A1, A3. There was a regular once-a-day contact between the base and field parties, with provision for twice-a-day contact if necessary. Communication by GRC9 was generally good for such a small power set up to 1, 000 Km distance of our trail, with frequencies and times selected in consideration of ionospheric conditions. Using a whip antenna on sea-ice a long wire antenna on the continental plateau, we got QRK 4 to 5 by A3 on magnetically quiet days and QRK 2 to 3 by A1 on magnetically disturbed days. However, a drop in voltage and capacity of batteries occurred in the case of extreme low temperature.

For the future, consideration is being given to providing a trail party with a A3 transmitter of single side band, SSB, 50 W transmitter-receiver.

3-3. Telegraph Code

The following code was used in field communications.

3-3-1. In the Case of Movement (8 words):

(1)	(2)	(3)
Telegraph Number Month Day Time	Noon Position of the Day Latitude	Longitude
X X X X X	X X - X X	X X - X X

(4)	(5)
Course in Distance from True Direction Camp Left	Camp No. Time Left Left
X X X X X	X X X X X

(6)	(7)	(8)
Optional Camp Distance from No. Syowa	Position of the Camp Latitude	Longitude
X X X X X	X X - X X	X X - X X

"00112 73-45 36-15 18050 20073 20730 73-20 36-15"

Meaning: sending on October 1, 1200, noon position is 73°45' S Lat., 36°15' E Long., now moving on a course of 180 degrees, 50 Km covered by noon from Camp-20 from where started at 0730. Camp-20 is 730 km from the Syowa Base and the position is 73°20' S Lat., 36°15' E Long.

3-3-2. In the Case of a Stay (5 words):

(1) Telegraph Number Month Day Time	(2) Sign of Stay	(3) Optional Distance Camp No. (Staying) from Syowa
X X X X X	C H I N X	X X X X X

(4) Position of the Camp Latitude	(5) Longitude
X X - X X	X X - X X

"93012 CHINx 20730 73-20 36-15"

Meaning: sending on September 30, 1200. Now staying at Camp-20. Camp-20 is 730 Km from the Syowa Base and the position is 73°20' S Lat., 36°15' E Long.

4. Navigation Instruments

In order to steer an accurate course on the Antarctic plateau, a C-4 Gyrosyn Compass System for directional reference was used in the 1961 field operations. Certain troubles with the gyrosyn compass were encountered as follows:

1. An excessive time was needed to synchronize the gyro to the flux valve magnetic reference. It took over two hours in the worst case.

2. After synchronization, the compass system operated well while the vehicles were running, but when the vehicles stopped, the compass indication gradually drifted to a new heading in a short time (perhaps 10 minutes).

The possible cause of the first trouble was the reduction of the slaving speeds. The normal slaving speeds of the C-4 gyrosyn compass is 60° to 120° per minute for fast slaving mode and 2° to 4° per minute for slow slaving mode. Because of power voltage drop, slaving speeds were probably reduced to almost 30° for fast slaving and 1° for slow slaving. The second trouble was probably caused by the magnetic field variation that resulted when the vehicles stopped.

It is considered that the following instruments should be attached to the C-4 gyrosyn compass*;

a. Synchronization indicator: This indicator would show when automatic synchronization does not work well, so that manual synchronization might be used.

b. Latitude compensation: When flux valve does not work well, the C-4 gyrosyn compass will be used as a free gyro for directional reference. Thus, the C-4 gyrosyn compass will be useful as a polar compass so as to steer an optional accurate course.

5. Possible Future Field Activities

There are two possible future projects proposed at present. One is a field mapping operation in the region of Prince Harald Coast, between 30°E Long., and 37°E Long. Position and elevation determination based on solar observation will be used in conjunction with future aerial photography to prepare maps of the area. The second activity is an oversnow traverse operation on the Mizuho Highland, between Yamato Mts. and the South Pole. Observation will include altimetry, seismology, geology, glaciology, gravity and geomagnetic measurements and cartography.

*C-4 Gyrosyn Compass. The flux valve continuously sends a signal to the flux valve synchro which represents the flux valve's orientation with respect to the earth's magnetic field. Any deviation in indicated magnetic vehicle heading from that detected by the flux valve causes an error voltage on the flux valve rotor. This signal is fed to a gyrosyn compass amplifier and the output of this amplifier drives the slaving torque motor through relays, to press the gyro until the flux valve synchro output is at null. This feature insures that the gyro constantly remains slaved to the flux valve signal.

The rotor of the heading synchro which is mechanically secured to the gyro, turns with the gyro, thus providing a stable heading reference for the repeaters, automatic pilot, or other equipment that requires accurate heading information.

An optional annunciator to provide a visual indication of system status as well as slaving cut-out and set heading switches for manual slaving can be used, if desired.

THE NAVIGATION SYSTEM FOR STRAIGHT STEERING ON THE ANTARCTIC PLATEAU

T. Yoshino

1. Introduction

The most simple navigation control for straight progress on the ice cap, is a method that applied by radio beacon system for aeronautical navigation. So we are developing these apparatus.

2. Principle

The antenna system consisting of two beam antennas, has the directivity which is transmitted each different coding signals to right and left. But each directivity is overlapped in the region of ± 3 degrees for the front direction. So the both codes are received at the same time in this region. Figure 1 shows the relation of this antenna directivity.

At the start, the position of top and last vehicle must be preset to be adjusted the conjugation line between them and the line for object direction. As the result of this arrangement, on the top vehicle, the signal - —— - —— - had to be received. On the trips the top vehicle must keep being able to receive this signal at the same volume, and continuous vehicles go along this trace faithfully, on the last vehicle always confirm this direction.

When the top vehicle shifts to the right, the signal of last vehicle will be received —— —— so must be corrected to be received - —— - —— - —— and in the same principle it shifts to the left, the signal will be received - - - -, so be corrected - —— - —— - —— - ——.

Also in such cases, if the last vehicle has a shift character, or it must turn to avoid obstructions on the snow surface, must stop the top vehicle for correction of last vehicle by voice modulation.

And then if the same control apparatus are set on the top vehicle too, and check the direction every thirty minutes, will get higher accuracy. But the accuracy of longitude and latitude must be obtained by astronomical survey in every day.

The interval between top and last vehicles is determinated by visual distance for commanding of convoy. For example, the longest is 1 Km, the shortest is 200 m. In this method the longer span get the higher accuracy.

3. Apparatus

3-1. Frequency

The success or failure of this method depend on the directivity of this antenna system. The complicated and large antenna system cannot set on the roof of the snow car. The frequency must be chosen on the U. H. F. band, over 300 Mc, to get necessary directivity by small antenna. To using frequency of this apparatus is determinated by the kind of transmitting tube. For example, if we choose a 6J6 tube, that is easily obtained, using frequency must be determinated about 400 Mc, to get sufficient power for 1 Km distance.

3-2. Antenna

When using U. H. F. band as the simplest antenna that has necessary directivity. We are developing such an antenna that consists of two corner-reflectors and one whip antenna. This construction shown in Figure 2. By this construction, the horizontal polarization directivity is made sharp and vertical polarization directivity is made broad against the effect of variation of radiation power intensity by vibration of snow car.

3-3. Transmitter Power

The field intensity of 50 μV/m on the point of 1 Km distance from transmitting antenna is calculated as the free space intensity. Because on the ice cap one can neglect the effect of reflection of snow surface.

where

- Pt: transmitting power
- Pr: receiving power at 75 ohms load
- d: distance between transmitter and receiving antenna
- Gt: transmitting antenna gain
- Gr: receiving antenna gain

where

$$\frac{Pt}{Pr} = \left(\frac{\lambda}{4\pi d}\right)^2 Gt \cdot Gr \qquad (1)$$

free space field intensity at Pt = 1 watt, d = 1 Km and 400 Mc

$$Pr \fallingdotseq 80 \text{ dB} \qquad (2)$$

Now output power 1 watt, transmitter antenna gain 4 dB and receiving antenna gain 0 dB

$$Pr = 80(dB) - 4(dB) - 0(dB) = 76(dB) \quad (3)$$

Transmitter power at 50 μV/m

$$Pt \doteqdot 80\ mW \quad (4)$$

So output power of single tube 6J6 push-pull operation at 400 Mc get about 0.2 watts, considering under the low plate voltages.

3-4. Transmitter and Receiver Circuits

Figure 3 shows the block-diagram of this transmitter and receiver with all vacuum tube design.

Figure 4 shows the block-diagram of this transmitter and receiver with a part of transistorized design.

3-5. The Characteristics of Transmitter

The characteristics of transmitter is described as follows,

Frequency range:	400 Mc to 450 Mc
Out-put power:	0.5 watts
Input power:	150 V 120 mA
Power supply:	24 V.DC about 75 watts

3-6. The Characteristics of Receiver

The characteristics of receiver is described as follows,

Frequency range:	400 Mc to 450 Mc
Sensitivity:	20 μV/m at S/N over 20dB
I.F frequency:	30 Mc
Band width:	2 Mc 6 dB down, 3 Mc 20 dB down
Power supply:	24 V.DC about 35 watts

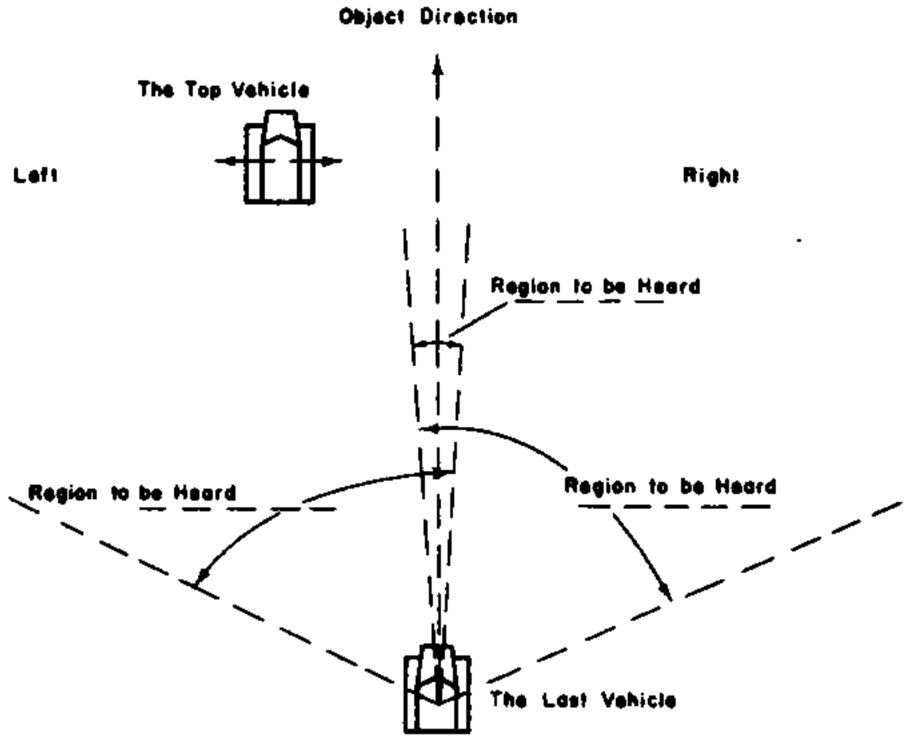

Figure 1. The relation of this antenna directivity.

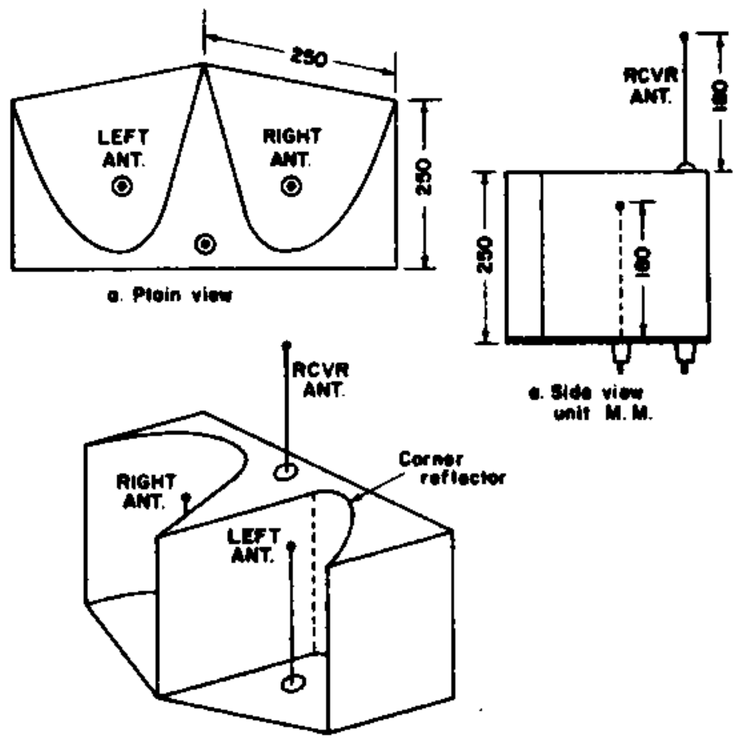

Figure 2. The construction of antenna system (for 400 Mc).

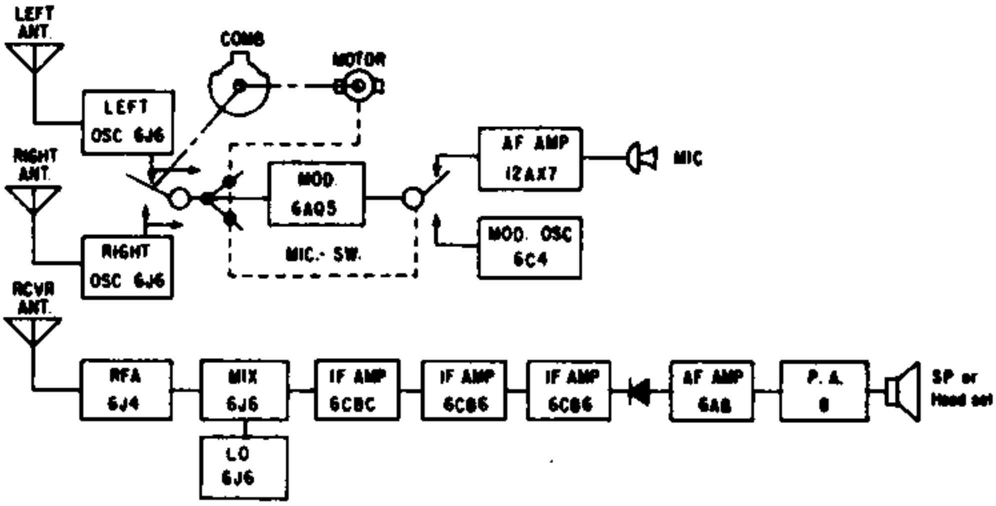

Figure 3. The block-diagram of all vacuum tube design.

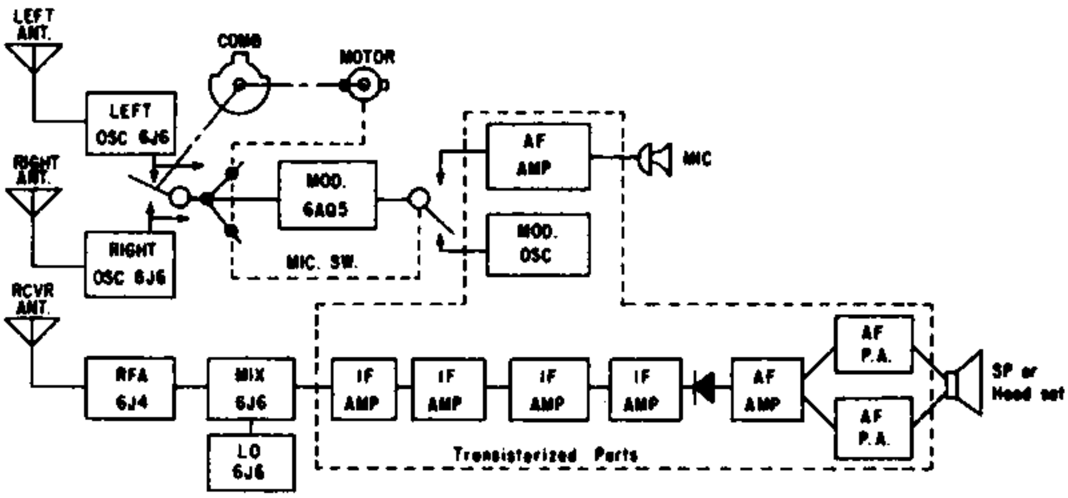

Figure 4. The block-diagram of a part of transistorized design.

4. Dimension of Cabinet

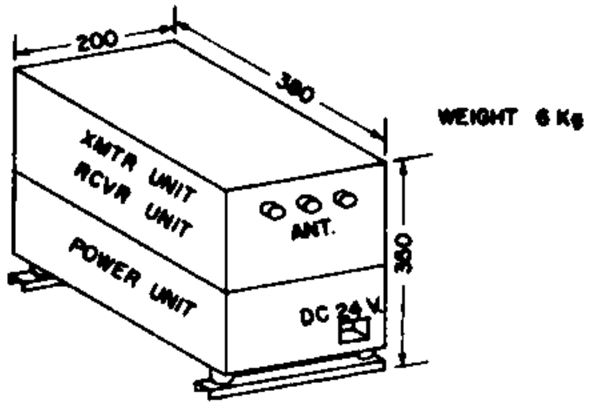

Figure 5. (a) All vacuum tubes design.

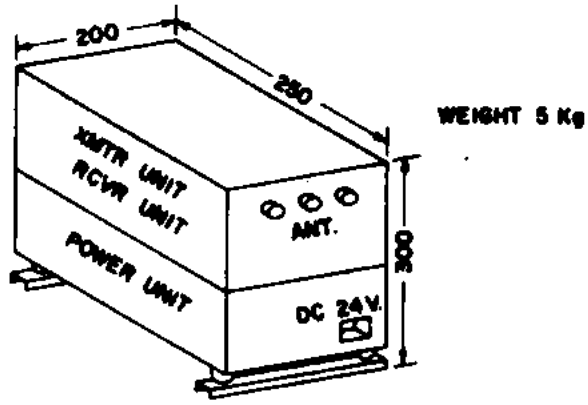

Figure 5. (b) A part of transisterized design.

SEARCH AND RESCUE PROCEDURE AND SAFE PRACTICE IN ANTARCTICA

L. D. Bridge

1. Introduction

1-1.

The need for safe practice in every field of Antarctic activity will be appreciated by most people concerned with the organization of Research Programs. Many readers of this paper will be exceedingly experienced and it is accepted that they could well have a different but equally effective approach to all aspects of safety procedure.

1-2.

Comments made are the result of many years experience with search and rescue organizations, from experience gained in mountaineering and from observations in Antarctica. Aspects of safety and search and rescue are dealt with under specific headings and set out more or less in chronological sequence. No attempt has been made to provide detailed lists of equipment, methods of training or instruction programs. Detailed explanation of search practice either by air or by land operations is omitted; patterns of search are well established and what is applicable elsewhere is applicable in Antarctica. Indeed the technical process of searching is probably easier here than elsewhere.

1-3.

If this paper merely provides a basis for establishing a generally accepted system of SAR in all Antarctic research work, its purpose will be well served. Inevitably interpretation will vary, but alignment of safety procedure from group to group must enhance the value of human life in scientific research projects.

1-4.

The danger of treating Antarctic Exploration with familiarity is very real today, constant attention must therefore be directed to see that proper and realistic standards of safe practice are observed. Use of ice breakers and air facility has simplified entry, lengthened the period of summer operations, and tremendously increased the annual visitation of scientists and technicians. The building of extensive bases necessitating employment of technicians and assistants with virtually no knowledge of essential snow and survival skill has produced problems non-existent in earlier days of hardy exploration.

1-5.

Time was when the arduous approach itself provided the necessary appreciation and apprenticeship in basic survival craft—to all intents and purposes this age is past. Our advancement in transportation and general logistics has, however, increased the need for personal skill, attention to safety aspects must be paid in the planning stage of all expeditions.

1-6.

Advancements have also been achieved in "the field"—rations, cold weather clothing, communications, technical equipment are all greatly improved. Re-supply by tactical use of aircraft and other mechanical transport, has given greater mobility. In "the field", however, life remains much the same—snow, storm, blizzard and intense cold demand the same degree of hardiness: survival depends on the skill of men trained and prepared to meet whatever condition prevails. A system which disregards this fact will sooner or later have dire results.

1-7.

From my observation field operations ill prepared either by personal skill of the men employed, or by provision of essential safety equipment have been organized. Occasions have arisen in remote places when one man operations have been conducted; under no circumstances could this be considered safe practice. Supply aircraft, to save weight, have discarded essential safety equipment when on supply missions. Under these circumstances prevention of mishap must rely on mechanical efficiency and good luck—not good practice really.

1-8.

These incidents give ample evidence of familiarity, and could indicate a lack of responsibility on the part of sponsor organizations. If they are not corrected, inevitably the lives of those directly concerned, and of those who must come to render aid, will be endangered. This could adversely affect the scientific programs of many units. Antarctic exploration today is interrelated and an incident to one group may have wide repercussions.

1-9.

Disregard of basic safety principles at Antarctic bases, while not as serious as shortcomings in the field, could endanger a number of men. To me it is an essential requirement that every member of an Antarctic Research party should receive familiarization, survival, and elementary snow training. The inculcation of safe practice as an automatic attitude in the mind of every party members should be a prerequisite to all Antarctic activity.

2. Procedure

2-1.

For successful Search and Rescue operation a clearly defined, simple procedure is essential. This should define responsibility for the direction and control of rescue operations. In all probability this duty will devolve on the party leader though in some cases a specially appointed officer may be named. It will be the duty of this officer to decide when assistance from other field teams, or assistance from other parties or nations, is required. Successful operations also demand co-ordination in the use of manpower and facilities. Unless action from the field end is clear-cut, direction from the control officer will be necessary.

2-2.

Search and Rescue will fall into three main classes:

1. Simple rescue from a known location.

2. Search and Rescue operation demanding the use of support aircraft and men.

3. Search and Rescue operation demanding extensive use of sea and aircraft.

These classes can be further divided into:

a. Those which can be handled within the resources of the party concerned.

b. Those operations when limited assistance from other nations would be necessary.

c. Those operations necessitating extensive use of air, sea, and manpower beyond the resources of the party concerned.

2-3.

Contemplation of these points will immediately highlight the need for careful planning of field operations. From the outset the possibility of search and rescue operations must be reduced to a minimum. Further, to retain the initial safe approach, adherence to the plan of operation decided should be regarded as a sound principle. Obviously times will arise when alterations to plans will be necessary, on these occasions consideration of all possible implications must be given.

2-4. Control

2-4-1. The person responsible for control would have an up-to-date detailed record of facilities available, e.g.,

Reserve manpower
Rescue equipment
Communication equipment
Rations
Aircraft
Seacraft

From regular situation reports he should have up-to-date information on the location of field parties operating within the area of his responsibility.

2-4-2. Paragraph 2-4-1 suggests that situation reports from all field parties within the area of responsibility should automatically be made known to all other organizations directly concerned. Three different national groups could well be involved. Information should be kept in log form, deputies to the control officer (should the need arise) will then have access to correct information in chronological sequence. From this a quick appreciation of the situation can be gained.

2-4-3. A situation map, constantly amended, should be kept; this should show the location of field parties, depots, beacons and other facilities.

2-4-4. On no account should equipment reserved for search and rescue be used for other purposes. The availability of essential gear may be a critical factor when emergencies arise.

2-5. Control Personnel

Persons selected for control positions—field or base—must be of the highest standard and in every way suitable for the work to be undertaken. Failure to observe this could prejudice an operation and have the same wide effects as neglect in any other aspect. Incompetence can endanger many. All concerned with the direction of field operations should have a deputy fully briefed on all aspects of the program.

2-6. Communications

It is not the province of this paper to discuss types of radio but the question of frequencies reserved for Search and Rescue must be considered.

2-6-1. Ideally, separate frequencies from ordinary traffic should be set aside—these could well be international or at least zonal. In New Zealand the success of this approach is apparent, the facility of passing SAR messages in channels uncluttered by other traffic is most effective. Experience in Antarctica of seeing SAR traffic competing with heavy general operational traffic showed this as a real weakness in the communication system. In times of great emergency (often coinciding with poor signal strength) this could well have serious implications. In small

Bases where a listening watch is not possible, this could well produce problems; in the larger stations however this should not be difficult to arrange.

2-7. Reports of Distress Incidents

As much information as possible must be recorded by the Base Station or other recording unit. The following points are pertinent:

a. Identification of reporting group.
b. The nature of the emergency—all essential details.
c. Significant information from operation, or flight plan.
d. Position, or last known position.
e. Time last communication received and frequency used.
f. Action taken by reporting unit.
g. Meteorological conditions.
h. Problems of terrain, if known.
i. Condition of those involved, if known.
j. Any other pertinent information.

Information obtained must be carefully considered before arranging a relief operation plan.

2-8. Search and Rescue Technique

Search and Rescue technique in the field—either by aircraft or land operations—would follow the well established patterns already commonly used. Details are therefore omitted. From a search point of view, Antarctic terrain is probably easier to achieve a satisfactory coverage over than is found in verdure covered or habitable lands.

3. Operational Instructions

3-1.

Clearly worded instructions for field operations are essential; much thought should be put into these. A conventional directive schedule drawn up on general lines will receive far less heed than a directive completely pertinent to a particular situation.

3-2. Instructions to Field Parties should Include:

a. Details of the task to be undertaken;

b. Geographic details of the area involved;

c. Information gleaned from earlier operations;

d. Information on parties operating in nearby territory;

e. Instructions on emergency procedure;

f. Location of emergency depots;

g. Notes on advanced first-aid;

h. Details of equipment designed especially for rescue and emergency use;

i. Details of radio equipment and of emergency communication procedure;

j. An outline of the overall SAR plan;

k. Action to be taken should support by other groups or facilities be impracticable, this would outline alternative escape routes in so far as they were known.

3-3. Safety Instructions in Regard to Field Resupply Operations

This would mainly concern aircraft crews, but in some localities sno-mobiles of one sort or another will also be used for resupply operations. Instructions should include:

a. A properly prepared flight or route plan;

b. Geographic details of the area concerned;

c. An instruction when not to proceed, e.g., visibility, weather conditions, mechanical fault, etc. (Under ordinary circumstances, resupply by aircraft should not be attempted unless visibility is very good.)

d. Brief instructions on the emergency procedure to be adopted should a forced landing be necessary;

e. Action to be taken should support from other groups be impracticable.

3-4.

Safety Instructions to Drivers of Vehicles and Others Engaged on Limited Operations, e.g., cargo trains, oceanography projects, biological projects, and other expeditions of a minor nature which are frequently made from base station. (It is suggested that all vehicles operating at any distance from Base should be equipped with radio.)

In these operations instructions would cover:

a. Procedure to follow when mechanical failure occurs and assistance is required;

b. Procedure to follow on sea ice when vehicles break through or partially break through;

c. Instruction on what to do when 'lost' through no visibility;

d. Information on emergency supplies;

e. Information on essential safety procedure.

3-5. Safety Instruction to Base Personnel

To safeguard relatively unskilled men the system of numbering weather conditions according to the activities which can safely be carried out has much merit. The decision on classification would be fixed by the leader or deputy, and the definition made known to all concerned. Strict observance of the order by all party members is essential.

3-6. Classification Would be on These Lines:

Condition I. Clear, all concerned able to carry out any allotted task.

Condition II. Limited operations only. No movement beyond prescribed limits; strength of wind, snow, visibility, or state of ice, could be factors governing this.

Condition III. Outdoor operation restricted to those with the necessary skill to operate or navigate under difficult conditions.

Condition IV. No outdoor operation permitted.

3-7.

Builders, ships crewmen, maintenance staff and tradesmen would be the men principly concerned in this last section. To be successful the system adopted must be simple and the fact that it is designed especially for their safety appreciated by all concerned.

3-8. General

It is suggested that the general use of bright clothing, colored tents, painted boxes and drums would facilitate quick recognition. Panels of Day-Glo (flourine dyed) material should be an essential item in all field kits. Colors best seen are the yellows, oranges and reds; flame orange or fire red being best of all.

3-9.

No attempt is made to list a detail of action to be taken to ensure survival: similarly, details of action required under other instructions is not detailed. It is presumed such skill is known to readers of this paper. Should further information be required it will gladly be supplied.

4. Search and Rescue and Safety Equipment

4-1.

Operational planning should always make provision for a reserve of equipment sufficient to cope with any mishap which could occur in either field or Base activities. Obviously it is not possible to list items or quantities—this depends entirely on projected research programs, type of country, and numbers engaged. The rule, however, always applies. On no account should the reserve be drawn upon for replacement purposes when routine resupply of field items is organized. SAR equipment must be regarded in exactly the same way as fire fighting gear—it is there to meet an emergency at any time.

4-2.

Much the same applies to snowmobiles and aircraft used for Antarctic work—cargo haulage, resupply, reconnaissance or traverse expeditions—in these cases the reserve gear carried must be considered as essential safety equipment. On no account may it be discarded for space or weight reasons. Antarctica is perhaps unique in that the vast expanse of sea ice, polar plateau, innumerable snow fields and glaciers, provide emergency landing areas should the need arise. What must be allowed for is the equipment and rations to enable the men concerned to move safely on the ground, make camp and safely exist until assistance arrives.

4-3.

Items and quantity could vary from place to place. The following is suggested as a minimum for all aircraft:

Emergency rations for at least four days;
A supply of meta fuel or small cooking stove;
2 x 100 ft standard climbing rope;
Two ice axes;
Two pairs of crampons;
Two pairs of ski;
One one-man Fibre glass sledge;
One first-aid kit;
One small radio Transceiver or SARA equipment;
One snow shovel;
One tool kit including a snow knife or saw;
One sun compass;

Adequate clothing for all on board;
The best available map of the area.

4-4. Rescue Aircraft

4-4-1. The role of rescue aircraft is more clearly defined; on receiving a call for assistance it should be equipped to meet any requirement the incident may demand, including provisions for at least a 48 hour stay at the scene of the mishap. All rescue crews should be equipped with:

- Cold weather clothing;
- Snow and ice equipment (ice axes, crampons, ski and if necessary, high altitude boots);
- Ample cordage—climbing ropes and slings;
- Karabiners and ice pitons;
- Tentage for themselves and those to be rescued;
- Sleeping gear for all concerned;
- Rations for themselves and those to be rescued;
- Cooking stoves and equipment;
- An adequate first-aid kit;
- Stretchers of Neil Robertson type;
- At least two fibre glass sledges;
- Communication equipment—this should be adequate to contact either the Base or an arrange relay station.

4-4-2. On no account should SAR aircraft leave on rescue missions without carrying the means of survival for themselves and those to be rescued. All too easily (through snow, weather, human error, or mechanical fault) can a simple mission turn into a serious problem with wide implications. Better by far to have equipment unused than to go off half-cock—indiscriminate haste is not part of sound Search and Rescue procedure.

4-5.

Snow vehicles engaged in limited activity in the vicinity of Bases should be provided with:

- Snow shovel;
- Small bar;
- Ice axe;
- First-aid kit;
- Tool kit;
- Length of rope—say 100 ft.

If the vehicle goes beyond visual contact with the Base station it should also have:

- Sufficient cold weather clothing for those on board;
- A small radio transceiver;

A small stove and cooking pot;
Emergency rations for at least 24 hours.

4-6. Field Parties

4-6-1. Field parties should (in addition to the equipment provided to complete the requirements of their assignment) have emergency equipment to provide for replacement in case of breakages. Emergency gear so used must be replaced whenever resupply is arranged. A supply of emergency rations should always be allowed for.

4-6-2. In planning Antarctic traverses, survey, glaciology, or geologizing scientific expeditions which move over extensive territory, consideration should be given to the setting up of emergency depots within the area concerned. The facility of resupply by aircraft is generally so effective that many take for granted delivery of resupply will occur at regular intervals throughout the operation. Problems elsewhere in the area, mishaps to aircraft, fuel, or weather, separately or collectively, could produce a situation where resupply would be beyond the resources available—in this event, at the season's end a field party could be in a difficult position. The establishment, early in the season during good weather, of a depot sufficient to cope with an emergency could be a decisive factor to the safety of personnel concerned.

4-6-3. When mishaps occur intelligent action on the part of all concerned is essential. No set routine or plan as to what should be done can be given, the circumstances of each mishap are usually particular to that incident alone. The following points will form a sound background:

a. Safeguard what is left—party, equipment, rations, etc. Prevent as far as is possible a worsening of the situation.

b. Render aid to those requiring it. Ensure that any immediate rescue is safely carried out.

c. Make the best possible camp. Shelter is essential—even when conditions are good do not neglect to attend to this requirement.

d. Carefully assess the situation in terms of personnel, rations, equipment, location, degree that self-help is possible, possible nearby assistance, etc.

e. If communication is possible give brief exact advice and request acknowledgement that your message is understood.

f. If it is decided not to move, take steps to:

(i) clearly mark your camp,
(ii) seek and flag a safe route from the camp,
(iii) locate and mark either a landing strip or dropping zone.

g. Wait for assistance to come. Conserve fuel and food if necessary.

h. If for safety reasons movement to another camp is necessary, move with utmost caution. Keep Base or other reporting unit regularly informed of your position and general condition.

i. If communication is not possible, carry out a, b, c, provide clear marking and wait for assistance. Remember your recent position will be known and that your failure to communicate will be investigated as soon as practical.

j. Never leave an injured person alone, ensure also that all movement of personnel from camp is safely carried out.

5. Rescue Personnel

5-1.

Section 4-1 explains the need for a reserve of equipment to cope with emergency situations. Parallel with this is the need for skilled personnel. Sound planning must provide for a reserve of skilled personnel to cope with any call for assistance which may be received. Ideally in any Base this should consist of the party leader and four other men. It should never drop below two men (allows one to lead a support team and one to remain at Base).

5-2.

Two men (the minimum) preferably the leader and deputy, should be well skilled in all aspects of snow and icecraft and also in safety and search and rescue procedure. Technical skill should be at a level which permits safe travel over difficult broken terrain; able to cope with snow from a "living" point of view; (camping or snow caving); competent at route finding; and able to effect rescue from crevasse or difficult situations.

5-3.

Generally speaking in isolated localities four men should make up a rescue team, this will provide sufficient strength to cope with any problem, fundamentally it is a safe unit. Ideally all should have had experience in snow and ice craft, failing this, men physically fit, and able to quickly assimilate lessons taught should form the rescue team. Emphasis is placed on the word team—rescue is not the place for solo experts attempting ill considered antics.

5-4.

In the case of nations carrying out major research operations using a great number of men, a fully competent rescue team of either 8 or 12 men could well be considered an essential part of the organization. It would be advantageous if all or some of the rescue personnel were trained as parachutists (though wherever possible a conventional landing is to be preferred). Every endeavour must always be observed to prevent additional incidents or accidents adding to the search and rescue incident in hand.

5-5.

Parachute ability has been mentioned as a desirable skill, however the essential requirement is skill on the ground. Where operations are of such magnitude that a rescue team is necessary, all of the team must be absolutely skilled in snow and ice craft and in all aspects of survival practice. It would be stupid to parachute a man who became virtually a liability once he was on the ground. This conception is most important—the mechanical aspects of various techniques can be learned fairly quickly by a fit man of average intelligence, experience however can only be gained by a very great deal of practice in all sorts of conditions.

6. Training in Snow Craft—General

6-1-1. Field Parties. It is suggested that four men is the minimum safe number for a field research team working in snow and ice covered terrain. This is based on the opinion that it requires more than the strength of one man to assist a companion in distress, also the basic fact that an injured man should never be left alone. Four men (two pairs) provide a strong unit from every point of view.

6-1-2. In such a team at least one and preferably two should be skilled in snow and ice techniques to a degree which will enable them to safely complete the assignment given. All of the team members should be reasonably skilled and training to achieve this before starting the research program is essential. In all aspects of Antarctic activity a degree of discipline must be observed, when difficult country is traversed the direction of a leader is essential.

6-2.

Rescue Personnel. This is covered in the preceding section 5-4—5-5.

6-3.

Rescue Field Support Personnel. This is covered in the section 5-1—5-3.

6-4-1. Base Personnel. It is desirable that all members of Antarctic research parties, scientists, technicians, tradesmen, base staff, etc., should receive some training in safe practice. Preferably this should be achieved prior to going to Antarctica; demands of the program make it extremely difficult to provide the necessary time when the party is at the Base station. Failing better arrangements—lectures, demonstrations and, possibly, basic printed instruction should be given to all concerned.

6-4-2. Orientation or familiarization courses given in plenty of time will give all party members an understanding of the real need for safe practice. Thus acceptance of direction when conditions are poor will be understood and accepted. Demonstration and practice in elementary snow craft, tent erection, and preservation, will also be most valuable. Everything that can be done to minimize the need for research and rescue should be done. Training for the conditions pertaining would from a cost point alone be infinitely cheaper than search and rescue operations resultant from poor preparation. The upset to scientific programs which could occur through faulty action caused by lack of knowledge must be avoided so far as planning makes this possible.

6-5.

No attempt has been made to list the snow craft skills required by personnel engaged in Antarctic activity—this paper is presented as a suggested approach to safe practice. Should further details of a training program in regard to Field Activity be desired, a suggested detail will be prepared.

7. Mental Attitudes

7-1.

All men participating in Antarctic activity should be inculcated with two fundamental attitudes:

a. A positive attitude is basic to success in every activity.

b. Constantly and without variance safe practice must be adopted as routine procedure. Risk taking is a common failing of most men, and in temperate zones this rarely produces problems—indeed it is the basis of much achievement. Problems arising from ill considered action in Antarctica can, however, be very great. Therefore, by pre-expedition training, demonstrations and lecture, every effort should be made to give an understanding of Antarctic conditions, of the operations planned, and for the precautions deemed necessary in the implementation of the program.

7-2.

The need for everyone to care for himself in preventing injury and illness must not be neglected. Failure by a member could mean failure of a project. Largely all that is called for is common sense and a feeling of responsibility for an important part in the program.

7-3.

It is suggested that a simple sheet of instructions should be issued to every party member regarding the need for safe practice. These could cover in simple terms all the main items that must receive attention in the Antarctic, to achieve maximum effect they should be issued just prior to boarding the transport aircraft or on ship on the day the ice is reached.

7-4.

Safe practice will reduce the need of search and rescue to a minimum. When the need arises, search and rescue must be a deliberate methodical system. Consideration to every factor must be given; finally, a coordinated effort should be directed to achieve relief or rescue. Assistance should never be haphazard.

THE 557 HF POLAR SLEDGE RADIO SET

Part I
Design Construction and General Specifications

E. J. Hird

Part II
Operation and Performance

P. A. Yeates

Part I

Design Construction and General Specifications

1. Introduction

This section deals with the development, design, construction and performance features of equipment manufactured in New Zealand specifically for use in vital radio communications service with small sledging field parties operating under rigorous polar exploration and scientific survey conditions.

2. Reception

In May of 1957, a request was received from the New Zealand Post Office to undertake the production of six transceivers for use during the summer season of that year in Antarctic regions. A brief specification drawn up by N. Z. Post Office engineers was made available, this data being the practical result of their knowledge at that time of Antarctic conditions as related to field radio equipment generally.

3. Specifications

The abridged specification called for the following features:

a. General

Self-contained radio transceiver for Antarctic operation complete with antenna and operating accessories.

b. Transmitter

Morse transmission, power output of five watts on any of three crystal controlled operating frequencies—3990, 5400 and 7490 Kc/s. Tuning controls fitted with locking facilities. Indication of correct transmitter tuning.

c. Receiver

Tuning range 2 to 16 Mc/s. Morse or radio-telephone reception. Sensitivity 5 microvolts or better for 10 d b signal to noise ratio. Headphone output.

d. Antenna

Dipole antenna with coaxial cable feed, adjustable tuning for the three transmit frequencies.

e. Power

Dry battery operation for both transmitter and receiver essential. Batteries to be built into the equipment and readily replaceable. Battery cable length to permit separation of batteries and transceiver proper if necessary, to allow for warming of batteries. Battery life to provide for a minimum operating period of 25 hours, on a schedule basis of 1 hour per day with a 3 to 1 receive/transmit ratio.

f. Controls

All controls arranged for operation by gloved hands if necessary.

g. Temperature

Equipment to be unimpaired by storage/transit temperatures of -50°F, and to operate normally at temperatures between -20°F and +40°F. Antenna and coaxial cable to withstand temperatures down to -50°F.

h. Mechanical

Equipment to be contained in a light durable housing as an essentially portable unit, with stowage for antenna and accessories. Maximum total weight desired, 50 lb. A canvas carrying container to be supplied. All metal parts of operating controls, morse key and headphones to be protected against contact with the operator's skin in order to prevent frostbite if gloves should not be worn.

4. Transistors Versus Tubes

A major initial design decision facing electronic and radio engineers today involves the appropriate selection of transistors or tubes for specific equipments or parts thereof.

The transmit power level of 5 watts and a paramount necessity throughout for maximum efficiency related to battery consumption were the main factors to be considered first in this case; ultimately the possibility of employing transistors was ruled out insofar as adequate power levels would not be achieved.

Previous experience with portable equipment over a number of years indicated a choice of B7G 1.4 volt filament battery tube types as being the best choice.

Conditions of operation, bandswitching and power output requirements, etc., led ultimately to the selection of three DCC90 tubes in neutralized parallel operation for the transmit final stage, six individual triodes being actually involved.

With the receiver, the decision against transistors for main functions was not so easily made. However, after careful consideration, B7G 1.4 volt tubes were again selected, 25 MA types being specified wherever possible for minimum battery drain.

In 1957 it was still not easy to provide full performance operation up to 16 Mc/s in a readily reproducible transistorized receiver, and the well known temperature susceptibility of transistors posed an additional time consuming development problem.

Also, apart from economic factors which invariably demand attention, a major consideration throughout the whole development program concerned ease of field maintenance, and whereas a virtually unskilled person is able to locate and replace a faulty tube, the same cannot be said regarding the majority of transistor fault location and correction operations.

In addition, the overall design was already committed to tubes for the transmit section involving a substantial battery supply requirement, and calculation showed that although rejection of transistors for the receiver would undoubtedly result in an appreciable receive condition battery drain, this could be accommodated.

Finally, a hybrid design involved a battery source of some 6 or 12 volts, and parallel operation of both L. T. batteries and tube filaments was already established as being highly desirable.

Subsequently, at a later date, transistors were introduced successfully to the 557 equipment to provide modulator power for radiotelephone transmission and a morse side-tone facility. These modifications are dealt with elsewhere.

The 25 M. A. 1.4 volt tubes possess a relatively delicate filament structure, and it is a recommendation for the filament suspension design of these tubes that they prove extremely robust in service. Originally used principally in domestic portable receivers before the advent of the transistor era, this general family of tubes in some countries developed an undeserved reputation for premature failure, due in many cases to series operation of the filaments from improperly smoothed on regulated A. C. voltage sources.

One important point in respect to low temperature battery tube operation concerns the necessity for strain free glass envelopes on all tubes, to avoid risk of fracture in service.

5. Power Source

Although the dry expendable type of battery was specified at the outset, it was not known what capabilities suitable types would possess at low temperatures, and adequate information was not available.

Assessment of the overall voltage-current requirements of the equipment coupled with long-term field experience indicated the use of 45 volt E.R. type 482 and 1.5 volt E.R. type 742 batteries as basic units.

Low temperature and recovery tests were conducted on samples of the above standard batteries. In the first test, batteries were held at -20°F for 16 hours and subsequently brought down to -40°F for 3 hours before being removed into an ambient of +60°F.

A fixed resistive load was employed.

The following were the results of this test:

	Type 742	Type 482
Normal load at +60°F ambient	260 MA	28 MA
Available current at -40°F	40 MA	5 MA

Readings were then taken at the time intervals as follows:

After 6 minutes	105 MA	8 MA
After 11 minutes	170 MA	
After 16 minutes	210 MA	18 MA
After 26 minutes	235 MA	21 MA
After 36 minutes	240 MA	24 MA
After 41 minutes	245 MA	25 MA
After 46 minutes		26 MA

A second test to obtain the capability figures as specific battery temperatures was made:

-40°F	40 MA	5 MA
-20°F	155 MA	10 MA
0°F	255 MA	27 MA
+60°F	260 MA	28 MA

The recovery from -20°F in an ambient of +55° approx. was as follows:

-20°F	155 MA	10 MA
Time lapse 5 minutes	200 MA	16 MA
Time lapse 10 minutes	220 MA	20 MA

A total of nine type 482 and four type 742 batteries fulfilled the power supply requirements, and although because of the many variable factors involved no accurate prediction of battery life was possible, calculation and test indicated a reasonably generous safety margin over the minimum 25 operation period specified.

L. T. batteries are all connected in parallel, and H. T. batteries in three parallel groups of series connected units. This provides an insurance against entire equipment failure if one battery unit should develop open circuit conditions prematurely.

6. Component Selection

After determining in each case the appropriate component required to fulfil the various electronic and mechanical functions in a normal environment, it was necessary in many cases to conduct specific tests to ensure proper operation at low temperatures and under vigorous handling, transportation and operating conditions.

Particularly, many components involving moving parts, bearings with rotary shafts, etc., were found to utilize unsatisfactory lubricants, and where no substitute was available, these units were stripped and modified accordingly.

Undesirable effects resulting from differential shrinkage in complete or mating components employing various materials in their construction were checked for, a useful test employed being the thermal shock associated with moving small components from a -40°F to +60°F ambient. Standard fixed capacitors and resistors of various types were all found generally satisfactory, and where a component value showed temperature dependence, due allowance made in associated circuit design sufficed to ensure normal performance.

The two panel meters employed were specially obtained from Germany, being lightweight units featuring torsion wire suspension for the movement, thus avoiding jewelled bearing and pivot problems associated with conventional meter movements involved in rough service.

Standard wafer and toggle switches of good design proved adequate, providing that moving parts incorporated correct clearances and lubrication.

Insulated wire capable of full flexibility down to temperatures of -50°F presented a problem, insofar as the bulk of wire produced today employs a plastic sheath or covering exhibiting considerable stiffening at low temperatures.

Local stocks were finally obtained of a rubber covered wire with a 40/.0072" flexible conductor and this proved to be most satisfactory, both for the antenna radiator and all interconnecting cables subject to movement.

Special arctic grade coaxial cable was obtained from the U.K. for the antenna feeder, and although this cable does stiffen somewhat at low temperatures, no trouble is experienced in practice providing that small radius bends are not attempted.

The keying relay is an open type, and no field problems relating to this important component employing vital moving elements have been reported to date.

7. Electronic Design

a. Receiver

An entirely conventional superheterodyne circuit is employed, with one R. F., two I. F., separate mixer and oscillator and two A. F. stages. R. F. timing is accomplished with standard air dielectric gauged variable capacitors with a nylon cord driven vernier control. The B. F. O. consists of a Colpitts oscillator with variable capacitor pitch control. H. T. potential is 90V.

b. Transmitter

A total of four stages comprising crystal oscillator, buffer, driver and final amplifier, and involving five B7G twin triode tubes of the same type provide the required 5 watts R. F. output. Parallel operation of the final amplifier stages permits operation of the transmitter with reduced power if one final amplifier tube should fail. Both driver and final amplifier stages are neutralized, and these two stages are keyed via H. T. relay switching for morse transmission. The keying relay is of the open balanced armature type with needle type bearings, and is the only relay used in the equipment. Modest energizing power for this relay is employed in the interest of efficiency and battery drain. Final amplifier efficiency is of the order of 45 to 50 per cent. H. T. potential is 135V.

8. Mechanical Construction

In order to provide the best strength to weight figures consistent with fabricated construction, metalwork employs sheet steel and aluminium, with extruded hidummium alloy sections and corners forming the cabinet main framework.

The cabinet is constructed in two sections split laterally and joined by quick release pull down toggle fasteners and indexing alignment pegs. The roof of the cabinet is reinforced by a steel member, and two large collapsible handles are fitted to the top surface to provide ease of handling.

Batteries are housed in the lower section, together with the battery/transceiver unit linking cable and power supply fuses. Connection to individual batteries is made by means of "ganged" connector plates in order to discourage accidental discharge or improper connection. Movement of batteries is arrested by three spring phosphor bronze internal panels.

The transceiver unit is enclosed by the upper cabinet section, all components being mounted on or under a conventional horizontal style steel chassis equipped with side members, these simultaneously providing protection of components during service and four securing points for captive screws from the rear cabinet surface. Transceiver controls are situated on a recessed front panel, protected in transit by a close fitting steel cover with a rubber gasket. This cover may also be positioned during operation of the equipment in such a manner as to provide a horizontal shelf below the operating panel, and an indexing device prohibits proper re-fitting of the cover after use unless the equipment has been correctly switched off. All main sections of the equipment may be separated by means of cable end plugs and sockets, and the transceiver can be operated in an exposed and fully accessible position during maintenance or test activities. On the internal side walls of the transceiver cabinet, a full complement of spare tubes is provided in protected spring clip racks. Thus, at all times, equipment dispatched into the field is capable of carrying 100 per cent spare tubes.

All access screws, etc., are captive, and cover plates removed in the normal course of operation are tied to the unit with brass chain to avoid accidental loss. Jointing of sheet metal parts is achieved by spot welding or metal thread, and most aluminium parts are secured by rivetting. All metal threads employ lock washers and in critical cases, varnish sealing. Where necessary, cabinet panel joints are sealed against ingress of moisture, and the whole unit is designed to prevent infiltration of fine drift snow particles. Those movable and threaded parts associated with covers, fasteners, etc., are lubricated with silicone grease.

Standard fixed wiring techniques are used within chassis, employing P.V.C. covered multi-strand wire and due regard is given to the mechanical stability of components. All cables subject to movement in the field are fully flexible down to at least -40°F.

The finish of the majority of steel parts is cadmium plating, and cabinet parts are sprayed with a durable silicone base hammer finish stoving paint.

9. Antenna

From the original information supplied by Post Office engineers, satisfactory operation of a dipole antenna resting on the surface of the Antarctic ice was possible, due to the relative radio frequency transparency of the ice, and the consequent effective elevation above any conducting ground surface.

Accordingly, dipole lengths for the three transmit frequencies were initially cut for free space operation with normal end effect allowance. However, experience showed it desirable to shorten H.F. dipoles somewhat in order to obtain resonance in typical field sites. This is due in part, no doubt, to the fact that the H.F. antennas experience additional end effect from the proximity of the lower frequency sections, separated only by antenna insulation blocks, these latter being fitted with movable shorting links to provide the means of changing the physical length and resonant frequency of the radiator as required. 75 ohm coaxial feeder length is kept to a minimum consistent with operational convenience. The radiator sections consist of 40/.0072" flexible rubber covered wire, and the extremities are provided with lengths of nylon cord for tying off if necessary.

10. Controls

The recessed panel controls provided for operating the equipment are minimum in number and color coded with a rubber dip coating, this process also providing protection against frost-bite. Control knob design eases the problem of operating with gloves, the switches for example being fitted with radial lever type knobs. A main function switch selects OFF, RECEIVE, or TRANSMIT positions, and a flashing red neon lamp operates when this switch is in the receive or transmit position. The repetition rate of flashes is a guide to battery condition, being proportional to battery voltage, and also warns that batteries are discharging.

Metering is provided continuously for transmit final amplifier plate current, and a switched supervisory meter enables accurate measurement of L.T. and H.T. battery voltages under load, plus three transmitter stage grid currents. Receiver tuning is conventional, the total range being split into two bands, and A.F. and R.F. volume controls are provided. For morse reception, the B.F.O. on/off switch and note pitch controls are combined on the same rotary shaft.

Transmitter tuning is simple, requiring only the correct selection of CHANNEL FREQUENCY, ANTENNA DIPOLE LENGTH, and proper timing of the TX TUNE (final plate circuit) knob to the minima of a dip on the TX METER (final plate current) scale.

Color coded indications on both the TX CHANNEL SWITCH and ANTENNA DIPOLE CONNECTOR/INSULATORS are provided to promote ease of correct channel/antenna selection.

After use, the panel cover plate may not be fitted correctly unless the function switch is in the OFF position, this being a safeguard against failure to observe the most crucial rule of operating battery powered equipment.

Morse keys are of the conventional armed services type, fitted with suitable clip for knee operation.

11. Radiotelephone Transmission

A request to provide radiotelephone transmission facilities for the 1959/60 season resulted in the development and production of a 4 1/2 watt A.F. modulator unit, and minor modifications to the original 557 transceivers to provide for the additional facility. The modulator package consists of a self contained unit, powered by nine E.R. type 742 batteries, and connected by flexible cable to the transceivers as required. Change-over from morse to radiotelephone operation is achieved automatically by removing a bridging plug at the rear of the transceiver, and connecting the modulator cable in at this point.

The modulator employs two Class B transistors with one single ended driver, and a single batton carbon microphone converts speech energy. Proper temperature stabilization of the transistor circuitry ensures normal operation from below 0°F to +125°F. The battery couplement is somewhat in excess of that required to match the transceiver battery life. However, the desirability of employing the same type of battery outweighs the consequent increased weight and size factors.

As an indication of normal operation, a red neon lamp is fitted to the modulator panel, and this flashes as speech peaks are reached while modulating the transceiver. The modulator is not equipped with any form of control or switch, and is automatically energized by the transceiver controls when connected to that unit. Robust steel construction is employed, and the unit is provided with a flax canvas carrying bag with handling straps and drift snow protection.

At this same time, a small transistor audio oscillator was installed in the 557 transceivers to provide a side-tone signal in the headphones while transmitting morse code, as an assistance to less skilled morse operators. This unit was energized from H.T. via the keying relay.

During 1960, a number of 557 transceivers were produced and supplied to U.S.A.R.P. through the Arctic Institute of North America, and all earlier modifications for radiotelephone operation, etc., as outlined above, were included with these equipments.

12. Equipment and Accessory Stowage

A strong flax canvas bag possessing an internal padded lining is provided, and this is equipped with handling straps at the sides and an accessory pocket for headphones, morse key, antenna, etc.

Drift snow protection is afforded by an internal lightweight cover arrangement closed with a drawstring. Early production bags used japara for this purpose, but lightweight canvas has since proved more durable.

Leather straps with buckles are used to fasten down the outer "lid" type flax canvas covers.

13. Performance and Physical Specifications

In the Appendix is given typical test performance figures of the equipment, together with physical sizes, weights, etc. Additional data including schematic circuit diagrams, etc., is contained in Bulletin Nos 175 and 187, by Collier & Beale Ltd, New Zealand, the manufacturers of the equipment.

14. Acknowledgments

The author wishes to thank the above Company for permission to submit this paper through the courtesy of the Antarctic Division, Department of Scientific and Industrial Research, New Zealand.

Appendix

1. The 557 H.F. Polar Sledge Radio Set

Performance Specifications

90-v. H.T. 1.4-v. L.T. Signal generator
G.R. 805C 1000 cps 30% mod.

Receiver

I.F. Sensitivity

455 Kc/s	V4 grid	7500 u.v.
	V3 grid	135 u.v.
	V2 grid	12 u.v.

I.F. Selectivity

f - 20 Kc/s	-3 Kc/s	455 Kc/s	+3 Kc/s	+20 Kc/s
db -80	-4.8	0	-4.8 db	-76

Frequency Response
Overall, 3 Mc/s

400 cps	-4 db.
1000 cps	0
3000 cps	-4 db.

Signal Sensitivity for 10 db S to N. 30% 400 cps modulation.

	f 2.3 Mc/s	3.5 uv.
5 M.W.	4.0 Mc/s	3.5 uv.
o/p	5.5 Mc/s	3.0 uv.
	6.0 Mc/s	9.0 uv.
	11.0 Mc/s	5.0 uv.
	15.0 Mc/s	4.0 uv.

Max. A.F. O/p 50 mw.

A.V.C. 60 db input change for
13 db output change
3 Mc/s, 5 uv. to 5000 uv.

B.F.O. Frequency Control Range 6 Kc/s

RX Osc. grid current RX f	2.0 Mc/s	120 u.a.
	4.0 Mc/s	150 u.a.
	5.5 Mc/s	145 u.a.
	6.0 Mc/s	110 u.a.
	11.0 Mc/s	145 u.a.
	15.0 Mc/s	118 u.a.

Battery Drain		C.W.	R.T.
Full sens. no signal	L.T.	230 M.A.	210 M.A.
	H.T.	10.5 M.A.	10 M.A.

Transmitter			Supervisory Meter		
1.4-v.	"L.T."	TX L.T.		0.65	
130-v.	"H.T."	TX H.T. (Loaded)		0.66	
			H.F.	M.F.	L.F.
V9A	"OSC"	Grid current M.A.	.15	.17	.3
V9B	"OSC"	Grid current M.A.	.06	.09	.17
V10	"BUFR"	Grid current M.A.	.12	.13	.13
V11, 12 & 13	"DRIVE"	Grid current M.A.	.52	.52	.5
			TX Meter		
"	"TX MTR"	(resting)	5	5	8
"	"TX MTR"	(loaded to outputs below)	87	90	92
Power output in 72 ohm watts			5.5	6.0	5.8
Battery drain	L.T.	1.2 amps			
Fully loaded	H.T.	110 M.A.			

Physical Characteristics

Unit complete in cabinet: Height overall 16 inches
Width overall 15 3/4 inches
Depth overall 9 7/8 inches

Weight including batteries:	51 lb	15 oz.
Haversack weight:	4 lb	8 oz.
Accessories:	6 lb	7 oz.

Unit complete, packed in haversack ready for transport:

Height overall 17 inches
Width overall 16 1/2 inches
Depth overall 13 1/2 inches

All up weight: 63 lb 4 oz.

2. Modulator 16645 for the 557 H.F. Polar Sledge Radio Set

Performance Specifications

Test conditions: Nine fresh type 742 E.R. batteries,
1400 ohm load resistor.

Continuous sine wave power output, 10% total distortion:		4.5 watts

Frequency response	f	db
2 watt output level	3000 cps	0
	1000 cps	0
	300 cps	0

Input at microphone terminals for maximum O/P:	-12 dbm
Microphone carbon current:	2-5 M.A.

Combined OC30 collector current versus temperature:	0°F	11.5 M.A.
	15°F	14 M.A.
	26°F	23 M.A.
	67°F	20 M.A.
	100°F	29 M.A.
	125°F	32 M.A.

Depleted Battery Test

Battery voltage of 9 v. loaded
produces 2.0 watts output.

When the battery voltage falls to approx. 9.5 v. under load, the neon modulation indicator lamp will fail to ignite.

Physical Characteristics

Modulator complete in cabinet: Height overall 5 inches
Width overall 8 1/2 inches
Depth overall 13 1/2 inches

Weight including batteries: 23 lb 2 oz
Haversack weight: 2 lb

Unit complete, packed in haversack ready for transport:

Height overall 6 inches
Width overall 10 inches
Depth overall 15 inches

All up weight: 25 lb 2 oz.

Part II

Operation and Performance

1. Introduction

The field communications equipment and problems reviewed here relate to field parties using vehicles or dog teams up to distances of 500 miles from base for three to four months, as well as to static observers and small parties using man-hauled sledges at short range.

2. Operating Factors

The experience gained from New Zealand field operations showed that however robust and efficient the radio equipment, however simple to operate, successful communications depended finally on the human element—the operator. If, therefore, training and actual practice in the use of the radio equipment by field personnel are omitted, curtailed or put on a "time available" basis, reliable communications cannot be expected. Such a lack of training cannot be overcome or compensated for by still more elaborate attempts to simplify the design and operation. That is to say, radio communications of the type considered here cannot be reduced to the level of a short-range, very high frequency push-button service, since the very nature of the operations demands certain minimum facilities. These include frequency changing, the provision of morse as an alternative to voice communication (especially in auroral zone conditions), the ability to meet unusual circumstances (as in rescue operations), and the necessity for making it possible for unskilled personnel to carry out simple repairs and maintenance in the field.

Two important factors, from an operational viewpoint, became apparent in the early stages. The first, and perhaps the most important, was that the majority of the men in the field had no previous practical experience of radio communications, or of operating radio equipment; in addition, their ability to use the equipment effectively bore no relation to their educational and scientific qualifications. The second factor was that in the specially arduous conditions of the Antarctic where man-power is at a premium (for example, striking camp in a blizzard or in emergency conditions), equipment incorporating a hand-cranked generator and requiring two men to operate it was impractical and highly unsatisfactory.

Another manifestation worth noting here was an indifference, on the part of some field personnel to the principle of regular radio contacts with the base station. This was attributed partly to a desire for complete independence from base control, and partly to a desire to emulate, or to be on a comparable footing with, the explorers of the heroic age.

Other equipment investigated in the field included some designed for use in World War II aircraft. While acceptable because of its light weight construction, satisfactory results were obtained only when mounted as a permanent installation in a specially constructed vehicle. From this point, the view was inescapable that equipment designed for another purpose and subsequently modified for use in the Antarctic would have to be replaced by equipment especially designed and built for

Antarctic field operations. This decision resulted in the 557 HF Polar Sledge Radio Set, and the decision was justified by the excellent results obtained wherever a reasonable operating standard was maintained.

3. Minimum Equipment and Operating Requirements

The experience gained in the field and the foregoing considerations indicated the following minimum requirements:

a. The equipment must be capable of being erected and operated by one person without difficulty.

b. The transmitter and receiver controls must not be too complex, but at the same time they must not be over-simplified to the point where flexibility is lost.

c. The equipment must be of rugged construction and capable of withstanding rough treatment, jolting and very low temperatures.

d. The equipment must permit of simple repairs and maintenance in the field of unskilled personnel, either by reference to a detailed fault chart, or according to instructions received by radio from the base station where the receiver is still operative.

e. The transceiver chassis and its power supply must be capable of being separated and examined with a minimum of tools and effort. Under no circumstances must the carrying case or protective haversack permit the entry of find drift snow.

f. All members of a field party must be conversant with its practical operation, and high priority should be given to allotting time for training, demonstration and practice. This need not be lengthy, and should take place at the base immediately before the party's departure for the field. Where possible, all members of the party should attain a morse speed of not less than eight words per minute.

g. The operating personnel should be provided with a practical guide to operating procedure, but it should not be exhaustive or too detailed. An informal and personal atmosphere should be maintained during the radio schedules, and opportunity taken to pass on news of other parties, or of general interest.

h. The necessity for strict discipline and absolute punctuality in meeting the radio schedules with base must be strongly impressed on all field parties, and the effect of failure to do so—the initiation of search and rescue operations—must be emphasized. (It was understood that circumstances could occur which would make it impossible for a party to call base at the appointed time. In this case, use would be made of the emergency listening watch, described later in this text).

4. CW (Morse) and Voice Operation

At first, the type 557 equipment was capable of CW (Morse) operation only, and all members of the field parties were required to attain a morse speed of at least eight words per minute (sending). Replies from the relatively high-powered base station were invariably made by voice, and the parties were not required to read morse.

The theory behind this was that unnecessary communications from the field parties would automatically be cut to a minimum, and that battery life would be prolonged. This latter was regarded as important, since the weight of the batteries, including a complete spare set, was nearly fifty pounds, and accounted for more than half the total weight of the radio equipment.

In practice this system worked, but could not be described as ideal. The multitude of tasks confronting the field parties, the lack of time available at base for the practice of morse code and operating instruction, and the not infrequent "last-minute" arrivals of some members before departure for the field, resulted subsequently in difficult communications between base and field party. The base operator would have difficulty on occasion in reading the slow and indifferent morse sent to him, and the receipt of a relatively brief report from a field party would become a prolonged and tedious affair. In addition, the field party would regard the periodic radio schedule as an unpleasant chore—as indeed it was.

These difficulties were eliminated when the equipment was later modified for voice operation by the addition of a transistorial, plug-in modulator unit complete with microphone and its own batteries, contained in a separate haversack and weighing some twenty-five lbs. The low current drain by the transistorized unit made the provision of spare batteries in the field unnecessary, unless long and frequent use was contemplated. The increased battery drain in the transceiver unit resulting from voice operation had no discernible effect, but it must be remembered here that the normal radio schedules operated by Scott Base with its distant field parties were limited to two a week. (The pattern of radio schedules is to be discussed below). The practice adopted was to fit the spare set of batteries as a matter of course after some six or eight weeks in the field, though there is no recorded instance of the batteries having fallen below operational level at this stage. The field parties themselves contributed by not abusing the voice facility and by restricting their communications.

When the modification to voice operation was decided upon, it was hoped that reliable communication would be possible over distances of up to 200 miles across the Ross Ice Shelf and to the Polar Plateau, and over shorter distances when working from Scott Base into mountainous country and the Dry Valleys west of McMurdo Sound, and along the coastline of Ross Island. This proved to be the case. The nearer parties, at ranges of up to 100 miles from base, were sometimes barely readable on voice, or would have to revert to morse operation on rare occasions. Raising the dipole aerial some ten feet above the rock or scoria surface would usually effect a noticeable improvement. On the other hand, good voice communication was maintained at distances exceeding 400 miles when working across the Ross Ice Shelf to parties in the vicinity of the Beardmore Glacier or on the Polar Plateau. However, this proved to be the maximum effective range under favorable ionospheric conditions; adverse conditions, combined with the base electrical noise level, would compel the parties at maximum range to use the morse code.

5. Operating Frequencies and Problems

Three frequencies were provided—3990 Kc/s, 5400 Kc/s and 7490 Kc/s, and of these 5400 Kc/s was by far the most satisfactory throughout the Antarctic season. Due regard must be paid here to the latitude of Scott Base, at approximately 78°S, and consequently the almost total absence of long-distance interference even at the start and end of the season. There can be no doubt whatsoever that successful communications with the field parties overall resulted in large measure from the use of an exclusive and interference-free channel for all field operations, including light aircraft of the Royal New Zealand Air Force, and also from the provision at base of a 3-wire folded dipole receiving aerial for each of the three frequencies, in conjunction with good communications receivers.

However, in general the higher frequency of 7490 Kc/s was rendered useless by long-distance interference, and the lower frequency of 3990 Kc/s suffered from absorption and a higher base electrical noise level. It was also evident that little would be achieved by attempting to run field communications on a frequency already in use for other services by high-powered stations, especially where emergency calls from field parties were to reckoned with. Receiver sensitivity at the high-powered stations would inevitably be set at too low a level to detect an emergency call from a distant low-lowered field radio. The use of single sideband equipment was not considered in the particular circumstances since, where an exclusive interference-free channel is available, it could be said to be unnecessary; the cost factor, and increased operational and maintenance difficulties were also taken into account.

6. Operating Schedules

Radio schedules with the main field parties were arranged on a twice-weekly basis, usually in the late evening commencing at 8.0 p.m. This allowed time for camping after the day's run and also for warming the batteries when temperatures at or below -20°F were experienced. Several parties would be worked at half-hourly intervals. If air or other operations affecting a party were planned or envisaged before the next schedule, an additional contact would be arranged as required. The base radio operator at the same time maintained three brief emergency listening watches every day on the assigned frequency (5400 Kc/s) throughout the season's operations (usually 8.15-8.45 am, 1.15-1.30 pm and 7.30-7.45 pm). At these times, therefore, any field party could contact base for emergency or special reasons, but the field parties themselves were not required to listen for calls from base. This system was regarded as providing an adequate safety factor for the field parties with a minimum of hindrance or interruption to their work, and also had the advantage that the communications could be maintained by one base radio operator. However, its effectiveness is entirely dependent upon absolute regularity of watchkeeping by the base operator.

Where a field party was prevented for any reason from attending regular bi-weekly schedule, it was obliged to call the base during the next emergency listening watch. Similarly, where a party expected to be unable to meet a schedule, or wished to appoint another time because of its work in hand, it was required to advise base during a preceding emergency listening watch.

Where parties were split into two or more groups from time to time in the field, the Type 557 was used as a base station at the main camp. Communication was then maintained according to a strict discipline of schedules between the main camp and the various groups, who were themselves equipped with small lightweight packsets capable of voice and morse operation. These schedules were also arranged so that immediately prior to the bi-weekly contacts with Scott Base the main camp would have a detailed report on all its isolated groups.

A detailed Operator's Manual and pamphlets containing a technical description and brief operating procedure accompanied each set of equipment into the field.

A SUGGESTION FOR OPERATIONS RESEARCH ON FIELD OPERATIONS

G. W. Markham

1. The purpose of this note is to ask but not answer the question:

Is a collective evaluation of current field operations necessary to determine:

a. whether present methods are operating at efficiency in terms of man-power, material and time,

b. what changes in operation might achieve greater efficiency,

c. whether the balance sheet of logistic expenditure and scientific receipts is producing an optimum scientific return.

2. No attempt is made to answer these questions for the collection of the data and its evaluation is beyond the scope of the present Symposium. It is realized that this proposition and its implementation is open to criticism but it is nevertheless suggested that it is worthy of examination.

3. Undoubtedly the Symposium discussions will produce partial but generalized answers to some aspects of these questions. What is proposed, however, is an operations research study of selected field operations which have taken place. The result might well produce results of value to present and future operations and yield factual answers to the questions posed.

4. Field operations can be divided into three broad categories.

a. Area coverage,
b. Linear operations for scientific studies enroute,
c. Linear operations for static scientific studies at the end point.

5. Assuming acceptance of these categories, two or three operations of each type would be selected by mutual consent for detailed study. The data required for comparative evaluation would have to be determined. Such factors as man power, fuel rations transported, means of transport, distances travelled are obvious items for consideration. Study would doubtless reveal other items on which data would be necessary while units of measurement and the means of scoring variants, etc., would require determination. Finally, a comparative assessment of the scientific task accomplished would be necessary.

6. The composition and selection of the study group would require careful consideration. Their ability to devote substantial time and collective study would be an important factor.

7. It is conceded that in many cases the operation method employed is finally determined by the resources of the country concerned. Hence, although the results of the study might show the optimum method to be beyond the resources of a particular country, it would also show where existing methods might be improved.

THE REQUIREMENTS AND NATURE OF THE LOGISTICS SUPPORT FOR A SMALL NATIONAL ANTARCTIC EXPEDITION
(E. Field Operations)

J. J. la Grange

Field Operations

Our knowledge of Antarctica has increased to such an extent that even the small Antarctic expedition can no longer be content with the observations at the station alone but has to move further inland for biological, geological, cartographic and other work.

Whether a full seismic program should be included in the work of a small expedition, is debatable, the author thinks it should not.

A gravity survey does not require bulky equipment and could easily be undertaken. This program will be carried out by one person in a specific party—the equipment can be carried either on a dog sledge or in a vehicle. It is necessary to do these observations say every 10 to 15 miles or at the most every 20 miles and at any other interesting sites to get a full coverage. The transport must thus be so that the tractor or dogsledge can stop at the required distances. If the logistic support is of such a nature that "stops" can be made only here and there, say every 40 to 50 miles then it is almost a waste of time as far as gravity is concerned. And the gravimeter operator must not be under a continuous pressure of him having to "hurry up".

Topographic survey requires a team of two of whom at least one person will be a surveyor. For survey work it is possible to travel great distances, say up to 30 miles, without having to stop for any length of time, but then they may need a day or so for survey purposes. If the visibility is not good, they may have to stay at the same spot for several days. It is therefore a good arrangement if the survey team could have a dog sledge or a vehicle tractor for themselves. The author would think a dog team the best here as this will enable them to get closer to nunataks than is often possible with tractors. With a dog team they can easily carry a few days' rations and make such detours as are necessary. Such a dog-sledge team would of course need a tent, sleeping bags, cooking equipment, rations for men and dogs, etc. The author thinks that if two members can use a tellurometer, this instrument can be included with a tractor party, but if a team of three or four operators are required then it is going a bit beyond the scope of the "small expedition" except of course if the expedition specializes in survey work at the cost of other programs.

Geology. Whether one or two geologists should accompany the expedition depends upon the intensity of geological research to be carried out. To the author's mind, if the geological work is not totally dominating in the field operations then one geologist should suffice. In this case a team consisting of surveyor and geologist who between them will also do the gravimetric observations, are amply provided for logistically, if they have a good dog team. From time to time they can pick up provisions and leave collected samples at main depots. The geologist will probably also do observations or make collections for paleomagnetic studies.

Biology. As it is unlikely that a "small" expedition will have a full-time biologist year after year, biological observations will probably be done by one or more of the expedition members who work in other specialized fields already. The logistic support required for biology is therefore virtually nil as it will amount to the transport of a few notebooks and possibly a couple of polythene tubes or specimens.

Meteorology. As it is important to do meteorological observations both for the sake of meteorology and for general height determination (for survey, geology, glaciology and other subjects), meteorological instruments such as aneroid barometers and thermometers at least, must be carried by field parties. As these instruments are delicate, special provision should be made for boxes or other containers which will carry the instruments as shock-free as possible. In a vehicle tractor, such instruments have to be protected against too much heat. These instruments will also take up a lot of space and should be kept in a place where they are easily accessible at any time that a height determination or ordinary observation has to be done. On the S. A. N. A. E. a specially devised box containing these instruments, was carried near the rear end of the dog sledge without forming part of the main lash-up load.

Glaciology. In many of the smaller expeditions a geologist or meteorologist, or the two in a combined effort do the glaciological observations. For field work in any case a large number of stakes are required for markers whether to determine ice movement (especially on glaciers) or accumulation or ablation. These stakes can be about 3/4" diameter but should at least be about six feet long. Provision has to be made for carrying about 50 such stakes or more. For digging snow pits a shovel is required but this is usually carried in any case. In the "small" expedition it is most unlikely that microscopic work will be done in the field or that heavy drilling equipment for deep holes will be used. If necessary a drill of the S. I. P. R. E. type can be carried on both tractor sledge or dog sledge.

Photography. Photographic records in fieldwork are an absolute must and dog sledges or tractor vehicles should be fitted out with containers which can keep cameras, films, exposure meters, note books, etc., in an easily accessible place. The same applies to binoculars, compasses, etc.

Other observations. There may be a few additional types of observations but it can be assumed that the equipment required will be small in comparison with that of the major subjects so that no special provision need to be made.

Routemarkers. Apart from the glaciological stakes, a number of stakes are required for route and crevasse marking, etc. For identification such stakes should have different colored pennants e. g. black, red, green, chequered or such like. These pennants should be ready on arrival in Antarctica.

Thus we see that the field programs which the author envisages for the "small" expedition, will be amply catered for if it has at its disposal one or preferably two vehicle tractors each hauling at least two Maudheim sledge-loads of provisions and equipment. A third sledge carrying a framework in the form of small stables, each containing a dog, can transport the dog team if the party have to travel over long distances to get to the actual "field" or from there back to the Base. If the party has to travel over a hundred miles or more of area already covered by field parties, then the dogs can be transported over such long distances in relatively short time. If tractor vehicles have already laid sufficient depots in advance, then one dog team will suffice but even in this case it is advisable to have one tractor with sledges and a dog team operating together. In this case it is also advisable to have a caboose or form of hut mounted on a sledge. Such a hut can easily be made from thin layered wood or a material such as South African Masonite and could be well insulated. Such a hut as is used by the S. A. N. A. E. provides built-in bunks for four men, kitchenette with two primus stoves, small table and a reasonable amount of storing space. Occupied by four men this caboose is no more cramped than four men in two pyramid shaped tents would be and there is not the task of setting up or breaking camp which in the case of a tent could take 2 hours.

Dogsledge. The well known Nansen type sledge is recommended. Apart from the towrope which should be fastened to all the upright frame carriers, it should have a sturdy upright frame at the back. A footbrake is absolutely necessary as well as a peg of at least 12" long—this hit into the snow through a short loop will act as a handbrake. A sturdy bit of thick rope is necessary to tie around the runners when travelling down a steep hill. Different materials can be used for runners, the newest type P. T. F. E. seems to have several advantages such as durability and low friction.

Ample lashing rope as well as a steering compass mounted on the rear frame where it can be comfortably watched while skiing alongside, are essential.

Dogs. A dogteam and sledge remains to the author's mind the most dependable type of light transport for Antarctic usage. Of course it has its limits, it is impossible to do an intensive seismic program for example, or to travel many hundreds of miles without an intensive depot laying system; but for the "small" expedition which is usually small because of available funds, the dogteam remains a very economic means of transport. Once a team has been built up, future teams can be bred on the expedition. Looking after the dogs and caring for them is at times an arduous task—but at the end of the year seems to have been a pleasant one. Now it can be argued that the system of picking up seals in the pack-ice sometimes takes up a lot of valuable ship's time; it is quite easy and cheap to pick up a certain minimum amount of whale meat (in for example Cape Town or South Georgia) on the way south.

A well balanced team will probably exist of ten strong dogs hauling a heavy load on a reasonable surface. It is hardly economical to have more dogs in a team as the weight of food to be carried increases and handling of such a large team becomes difficult. Eight dogs are probably the smallest number to make up a strong working team.

The general rule is that each dog can pull its own weight in a load for 20 miles a day. Thus ten dogs weighing from 60 to 80 lbs can haul a load of say 700 lbs., however if the dogs are healthy and strong the load can be increased to about half a ton for short periods.

Whether dogs should be inspanned in "fan", paired, tandem or mixed pattern depends upon the terrain and also upon how well the dogs have been trained.

Puppies should not be trained before they are about one year old, otherwise they will not grow up fully. One to two month's training after the winter is usually enough to get a previously trained team in proper shape again. Training a team boils down to the task of repeatedly inspanning the dogs and making short runs with a sledge. First only a few dogs will be taken, later the whole team. Training is rather hard work as the dogs are unaccustomed to the whole process and dog-fights will break out at the most inconvenient times and places. Those who have had experience know that to break up such a fight is no easy matter, it usually leaves several bloody ears, cut skins, a general shambles of harnesses and traces all mixed up and on the side of the trainer a bad temper and at the end of the day a sore throat and tired body. The golden rule is to apply a firm discipline, lots of patience and even lots of love towards the team. The dog whip to which some people take a refuge is of no use to enforce discipline, it is only good to crack on the side of the team to work them in another direction while they are taught to obey the various commands to go left, right, etc. If a dog is to be punished it is best to do so with the trainer's hand. Never kick a dog! If the weather during winter is not too severe, dogs can be used throughout the winter and thus kept fit. In the past few years it has become practice to provide some form of protection, usually a tunnel in the snow, during the winter, especially during blizzards.

It is advisable that a team is trained and handled by one or two but at the most three persons.

The British Antarctic Survey has, after much experimental work, devised a well balanced pemmican ration which goes under the trade-name of "Nutrican" and seems to be good enough for many months in the field. If tractor vehicles lay supply depots in the field it is a good thing if a few feeds of seal meat can be deposited as well. At Base seal or whale meat will probably be the main supply. Once dogs have been used to seal meat they do not like dried fish. At Base 2 1/2 to 3 kilograms of seal meat every second day is a good ration. To feed dogs every day brings a lot of extra work while the author thinks that if dogs are fed every third day, the interval becomes too long. The easiest way to cut seal carcasses is to cut cross sections about six to eight inches wide, these "chops" can then easily be cut up longitudinally with an axe. A chain-saw is highly recommended as this will save several hundred man hours per year.

Huskies do not require drinking water if they are on snow as they will then eat enough snow to provide the required water intake.

There is a choice of harnesses to be used. The simplest, cheapest and most efficient type is one made of lampwick strips about one inch wide or any other equally strong soft material. The harness exists mainly of two big loops through which the front legs go. On the dorsal side of the animal these two loops are connected by a cross piece across the neck and another cross piece behind the shoulders. Similarly the loops are connected by a cross piece on the ventral side of the neck and between the front legs. On the back a short piece of material about nine inches long has a ring at the end for the clip-on buckle fastening the dog to the trace.

Dog harnesses can be made by expedition members on the relief vessel or else on bad weather days at the base. Usually this is one of the more pleasant chores. As some dogs have the habit of chewing through the traces, it is advisable to treat all traces beforehand with tar or some suchlike substance, but it must be ensured that the rope will remain soft afterwards.

Each dog should have a strong collar by which it can be fastened to its chain at Base, or to the centre trace at night when on a journey. In the latter case an extra peg for fastening the front end of the centre trace as well as a sledge hammer have to be taken along.

Men using a dog team should have a good portable radio receiver and transmitter with which they can contact Base or other field parties at pre-arranged times from inside the tent. Obviously these sets must be as light as possible. A large variety of commercial sets to choose from, are available.

Any travelling party must have a pair of skis, ski-sticks, crampons, ice-axe and climbing rope for each member, they should also be fully conversant with the use of these items especially the various types of knots such as bowline, reef, etc. Getting experience in crossing crevasses, saving a man or a dog from a crevasse and suchlike techniques which fieldworkers should know, are probably beyond the limits of this paper.

Every party should also carry a first-aid kit to treat minor injuries and ailments. Before a field-party leaves Base it is essential that the members get experience in these matters and also a detailed system should be worked out as to the arrangements for action in case somebody should be seriously injured and a rescue party from Base has to set out. It cannot be stressed enough that these sort of details should be worked out beforehand so that everybody is clear as to what is required at any moment especially to ensure that at the critical moment no panicking will result.

If tractor vehicles (one or more) are used, it is essential to have a qualified person with detailed mechanical knowledge (an engineer or a mechanic) in the party. Enough spares, fuel, etc., have to be carried to meet the common breakdowns. Towrope and cables for salvaging vehicles must be carried. A detailed discussion on the various types of spares and other items such as refuel pumps, etc., etc., will be too long for this paper. Enough to say that drivers should have reasonable experience in travelling techniques, navigating (by magnetic and sun compass), rescue techniques, handling their radio transmitter and receiver sets, general camping, etc., etc.

A final point. The logistic support for field operations heavily burdened as it may be, should endeavor to be ready to set out as soon after the winter as possible and to stay in the field as deep into the summer as possible; in other words tractors, dogs, etc., should be able to operate in "winter" conditions in September and March and possibly even August and April.

TOWARD THE INCREASED EFFICIENCY OF LOGISTIC SUPPORT

Philip M. Smith

While earlier U. S. polar expeditions especially the U. S. Navy High Jump operation in Antarctic in 1947 had relied upon large scale logistic support, the scientists of the U. S. like those of other nations had not, prior to the IGY, required such ambitious staging bases for the implementation of research programs as were required during the 1957-59 worldwide scientific effort. In Antarctica the U. S. scientist was fortunate to have at his side a large team of naval and other military personnel whose specialized skills included knowledge of ice strengthened transport and cargo ships, ski aircraft operations, air drop capabilities and various oversnow transport capabilities which permitted the movement of great quantities of materiels, fuels, and general cargo between ships, coastal staging bases and inland stations. From the beginning the U. S. logistic program, while it was large and sometimes in its impressiveness overshadowed the scientific work, was looked upon as a method of providing platforms or stations for scientific observations and support for occasional field parties.

The endeavors of the late 1950's emphasized station observations. The concepts of materiél support relied on an ability to supply large quantities of fuel to Antarctic coastal stations and to support aircraft in flights from other continents to Antarctica and within the Antarctic itself. These factors more than others signalled the success of the U. S. IGY program which included two stations on the ice cap in a seven station program. Though much experience had been gained in the large scale operations previously, the IGY period provided the opportunity to perfect technique and to train younger personnel in the management and execution of the logistic effort.

Knowledge in the support of field parties developed less rapidly partly because of the greater emphasis on station operations in the IGY but also because of the more slowly developing techniques for support of field parties. Further equipment for field work and its support was not as adequate as it later was. The field support endeavors like those of other nations working in Antarctica in IGY included the traverse programs. Some equipment and experiences with it are described elsewhere at this symposium. Traverse activities provided opportunities to develop techniques of air support by DC-3 type aircraft including resupply and terrain reconnaissance.

New research added to the U. S. program since 1959 has prompted considerable change in logistic technique and has lead to a refinement of thinking on the part of the U. S. scientists and logistic planner. The programs which have prompted changing techniques are geology and biology, both of which require for their optimum execution long periods of field work during the austral summer. Further, under the most ideal conditions it is desirable for the investigators to have the opportunity to come into the Antarctic in the austral summer and return at its end without wintering on the continent. In addition to the changes prompted by the initiation of these two programs U. S. logistic activity has been greatly effected by the introduction of mapping. Finally new logistic requirements have emerged from program developments in the upper atmosphere sciences.

In the last three years, establishment and resupply of geological field parties at remote points several hundred miles from a main station has been a large challenge to the U. S. logistic planner. Equally challenging has been the need to find ways of supporting 12-15 biological programs working within a radius of 200 miles of the biological laboratory at McMurdo Station. There it has been necessary to find methods of efficiently combining laboratory research with field collecting. Rapidly developing knowledge in the upper atmosphere sciences has suggested the need for new experiments executed almost immediately. These experiments have precluded the use of older concepts and forced the development of new techniques permitting a quick implementation of upper atmosphere studies.

It has been noted by A. P. Crary that mobility will keynote the future of science in Antarctica. Requirements for mobility will challenge the Antarctic logistician who correspondingly must develop new techniques of support. The support must incorporate rapidity of planning, speed in the implementation of plans from their fiscal conception to field execution, and dependence on station facilities and related ground support equipment which are of such comparatively modest costs that they can be abandoned if need be on conclusion of work at any one point on the continent.

The need for mobility is met to a great degree by introduction of the ski-equipped C-130 Hercules cargo aircraft which can support small field parties at distances of 900-1, 000 miles from a staging base and which can provide a mobile supply line for other aircraft and for moving field parties. The requirement for mobility lead also to the introduction of the highly successful turbine helicopter into U. S. operations during the 1961-62 austral summer.

It is anticipated many refinements in logistic technique will be possible in the days ahead. Attention must be given especially to fuel handling and related ground support equipment which permit improved aircraft operations. Surface transport for personnel and cargo has not kept pace with air capability. It is possible to spend as much time moving materiél between McMurdo Station and the ice runway (some five miles in distance) as is required to fly cargo from McMurdo Station to the South Pole. Logistic support and hence science will be served by the development of adequate techniques for the transport of fuel and cargo efficiently over short distances from ship to base to aircraft.

New packaging concepts are needed in the years ahead. Helicopter operations in support of the McMurdo Station biological laboratory have made it possible for the scientist to travel between his laboratory and collecting sites 150-200 miles from the laboratory in a matter of a few hours. This access to field sites for collecting purposes has reduced tentage, rations for sustained field living, surface transport such as toboggan or dogsled and other accouterments of the usual field operation. Mobility has been achieved; efficiency has not been entirely achieved for the scientists equipment is ill suited for flight operations. Improved packaging or boxing techniques which permit the assembling of all the necessary gear in compact, flexible units, the equipment within the individual packages itself interchangeable, must be developed if optimum efficiency is to be developed in the operation of a laboratory such as the one cited. There must also be a capability for shifting the equipment of one field party from the aircraft in order to immediately undertake a second air support of operation if the most efficient air operations are to take place.

The requirement for improved packaging is not limited to the example mentioned. Packaging must provide some efficient means of transport of dry stores, permit continuing reuse of containers so as to cut down on total cost of support for package and dunnage and must depend on versatile multiuse concepts to provide use of the same techniques with a variety of support equipment, ships, planes and surface transport ranging from the large cargo aircraft to the small motorized toboggan.

Construction techniques must also meet the requirements for mobility and efficiency. Traditionally polar camps, although prefabricated, have been built on the site requiring a staff to assemble and erect them. It would seem that the prefabrication and assembly might well be done in warmer climates with the preassembled equipment moved from point to point in Antarctica as required by air and surface transport for which the buildings are especially designed. A major step in this direction will be taken during the 1962-63 austral summer when the U. S. Naval Support Force, Antarctica will move an air-transportable camp for 12 men from McMurdo Station to Eights Station, a distance of 1600 miles. The concept of air-transportable camps is not new and on a more modest scale has been employed by several other expeditions to both polar regions. Its large scale employment depends of course upon a logistic tool such as the C-130. For the large scale operation the technique is new and its efficiency will grow with knowledge.

Highly mobile camps are required for upper atmospheric studies, for geology and for biological research. These facilities are expected to be used at one point for a few years and moved a matter of 100 or more miles where collecting of new data begins. Whereas the geological and upper atmosphere research will involve mountainous areas and ice cap terrain both of which are now familiar to the U. S. support force, the new biological research which may be undertaken will involve coastal facilities and the ocean. The ocean is a new medium in U. S. Antarctic research. The concepts which we would hope to develop will emphasize ventures such as the U.S.N.S. Eltanin, the U. S. Antarctic Research Program research vessel which is a multi-disciplined research platform. While the ELTANIN works far out at sea, similar concepts of movable stations might be employed in coastal waters. There suitably strengthened floating research platforms could be frozen-in, serving for a time as stations for biological research and in other seasons moved to new locations. Other suitably equipped coastal research vessels might support a number of still smaller research boats which could steam independently in the manner employed by surveyors of the British Antarctic Survey. To support the newly developing coastal programs, attention needs also to be given to smaller aircraft whose terminal facility requirements are less stringent than the larger aircraft and to suitable surface transport.

In past years, scientists' desires for research on new logistic vehicles have often been ahead of technical development. The situation is changing and the scientists working in Antarctica have a new responsibility to develop the most imaginative ways in which scientific research can be carried out with the rapidly developing and newly available logistic tools. The limiting factor in many instances is not the aircraft or ship capability but the imagination of the investigators who wish to use it. In the days ahead, scientists must be aware of the new developments in logistics and must turn their attention toward solutions of research problems that fully utilize the rapidly expanding knowledge of ways to work in Antarctica. Conferences such as the present one may have in fact, their greatest value not for the logistic planner, but for the scientist who needs to be appraised of the technical capabilities available to him.

COMMUNICATIONS PROBLEMS IN ANTARCTICA

Fred Mason

In November 1959 a formal inspection of communication facilities at all U. S. antarctic stations was carried out. The purpose of this inspection was to determine (a) why wasn't communication capability both on and off the ice more reliable and (b) what could be done to improve the communication reliability?

In general, the results of this inspection revealed that on the ice the U. S. stations were primarily equipped with older models of equipment which were obtained at the beginning of the International Geophysical Year and that the antenna fields were hastily installed to meet the short-term IGY requirements.

Based on an analysis of the inspection report, major alterations of communication facilities at all U. S. bases were undertaken. Antennas of proper design were installed. Modern receivers and associated terminal equipment together with transmitters of appropriate power output were provided to replace older models.

The inspection and subsequent installation of properly designed antennas and equipment of modern design have made a decided improvement in communications reliability but, I hasten to add that the improvement is not so great that as a result of our efforts that there is nothing left to be done. Actually there is still much to be done. We have greatly improved communications reliability by the application of well understood communication engineering principles; but we have not by any means solved many of the antarctic communication problems. Let's examine some of these.

Without any doubt the largest problem and one we won't readily solve is the matter of generally unpredictable behavior of the heaviside layer. As all of you know, high frequency radio communications over distances in excess of line of sight, depend on bouncing the signal from this ionized layer some 50 miles above the earth's surface. There are times when this layer does open up and radio blackouts result. These occur over all parts of the world but their duration and frequency is greatly exaggerated over the polar areas. For example, a blackout that may last a few minutes or a few hours at the equator may last several days over the pole. At the higher frequencies, other than by the use of scatter techniques, there is no easy solution to this problem. When the layer opens up HF radio communication stops and remains out until the layer is again established.

1. One solution to the problem might be to employ low frequencies or even very low frequencies that are affected to a lesser degree by the ionosphere than is HF. This solution is not without problems. Operation on these frequencies requires gigantic antennas and extensive ground systems. This means high cost. In any event a proposal for establishment of an Antarctic/New Zealand radio circuit to operate at the very low end of the radio spectrum is presently under study. Whether

or not this project will be adopted will depend purely on the economics involved. Also, the application of ionospheric-scatter propagation techniques should not be overlooked as a possibility to increase reliability during blackout periods and other forms of disturbances associated with high geomagnetic latitudes. In fact, a preliminary study was conducted in the U. S. during the IGY regarding the application of ionospheric scatter to certain antarctic radio circuits and results of this study are indeed very promising but economics are again involved.

2. There has also always been a problem of reliable communication between bases and trail parties. The installation of single-side-band equipment in the trail party vehicles has made a large improvement in trail party communications but the reliability is still well below what should be achieved.

There are several reasons for this relatively poor reliability. Two that have been readily apparent are:

a. Inability of trail party personnel to master the operating techniques of the equipment. It is necessary for day/night communication to employ more than one frequency; this requires some equipment tuning. The tuning procedures have not been mastered by trail party personnel. The answer here is either send an electronics man on the party or further simplify the gear. Electronics people are scarce so simplification of the equipment seems to offer the most promise. It is fortunate that when the answer to the second problem is found we may also solve the first one. As it is, the antenna tuning procedure seems to be the main difficulty. An improperly tuned antenna coupler will not permit radiation of the generated energy. The trail party people seem to find tuning an antenna coupler pretty difficult.

b. An improved antenna system: This is a rather simple statement but the answer becomes very complex. To satisfy trail party requirements, the radio antenna should be an existing part of one of the trail vehicles. To satisfy the operational requirements, the antenna must be a very efficient broad band non-directional radiator. These two requirements are miles apart so something must give on both sides. We obviously can't cause part of an existing vehicle to become an efficient radiator, nor could we haul around, under trail party conditions, the electronics engineer's concept of the required antenna. The problem is further compounded by the fact that in general the requirement for low-angle, non-directional radiation indicates a vertical radiator. In general a vertical radiator is a high Q device, which means it is not a good radiator over a broad frequency band. It further works well only over a ground plane. This latter statement means that if a highly conductive area such as sea water is not present under the antenna, an artificial ground plane consisting of a quantity of lengthy wires must be provided. With this, it is easily seen that there are some difficult requirements that must be met before the problem can be solved.

Considerable progress on the problem has already been made. We have, on paper at least, an antenna that will satisfactorily cover the required band of frequencies, and work with acceptable efficiency. It can be employed with a ground plane consisting of a minimum of four 30-foot wires that can be placed on top of the snow. These wires can be very flexible and readily coiled or rolled up to get under way. As stated above, the antenna is designed to cover the required frequency band and will therefore not need an antenna tuner. This then eliminates the main source of "cockpit trouble" previously mentioned. To satisfy trail party operational requirements, the radiator portion of the antenna can be collapsed and almost become part of the vehicle on which it is mounted when not in use. We are hopeful that this antenna can be made available for use during the 1962-63 season.

3. Another problem is related to the collection and passing of meteorological data to the International Antarctic Analysis Center. We would recommend that radio-teletype be used to pass all weather information rather than by the slower manual radio telegraph means. This presents the matter of teletype equipment compatibility. Teletype systems are pretty well synchronized to both definite speed and pulse information, and in general permit very little latitude in either for proper operation. A possible solution to this problem would be to insure that all major antarctic stations are equipped with compatible teletype equipment.

It is not the intention of this brief paper to convey the impression that this is a summation of all the communication problems in the antarctic continent. As a matter of strict fact, all of the communication problems on bases that operate without contending with the rigorous antarctic conditions haven't yet been solved. We are striving to reduce the problem areas and with each operating season the problems become fewer, and I feel sure that most of the future communications problems that are generated by the U. S. antarctic research program will be solved.

SEARCH AND RESCUE IN THE ANTARCTIC—UNITED STATES

Edwin A. McDonald

Surely, it is a recognizable fact that the antarctic area with its frequent instances of crevassed ice fields, sea-ice under pressure, severe weather, and sudden break-up of bay-ice has the potential and capability of imposing itself upon ships, aircraft and individuals in a manner sufficient at times to require some form of external assistance. Because of the severe penalty which may be exacted due to lapses in judgment and caution, relatively few incidents do occur which result in rescue or assistance. Fortunately most of the endings are happy. Some, however, are not. A resumé of such cases may be of interest in reviewing the especial circumstances of each.

Ships

Ships become beset in the ice, or unable to move freely because of changes in ice conditions (brought about usually by wind shifts or weather reversals). In the old days, continued besetment (Shackelton's Endurance in the Weddell Sea, 1915) and Nordenskold's Antarctic in the same sea (1903) east of the Antarctic Peninsula, often resulted in the complete loss of the ship itself. Today, with the advent of the icebreaker, and the building of stronger ice-reinforced cargo ships, the danger is not so great. However, assistance has been required in spite of ship building advances.

Assistance by the United States began with the Japanese expedition ship Soya, which upon finding itself locked in the ice at Lutzow-Holm Bay during January 1958, requested aid in reaching her antarctic base on the mainland. In response, the USS Burton Island, then completing operations at the U. S. Wilkes Station, was dispatched. The latter was able to effect rendezvous on 6 February. The two ships in company reached a position approximately 70 miles northwest of Showa Base a day later from where the 11 men of the Japanese wintering-over party were evacuated by Soya's ski-equipped aircraft. Weather and ice conditions thereafter prevented cargo and new personnel from being landed, although a new position 53 miles north of the base was reached. On 24 February, further attempts to continue wintering-over operations at the base were abandoned, and both ships sailed for home.

In 1959 the Glacier, aided at one point by the Edisto, spent approximately two months in operations freeing the tiny 1, 000 horsepower Belgian expedition ship Polarhav and transporting men, equipment, and supplies to the King Baudoin Base at Breid Bay in the quadrant opposite Africa. Edisto and Northwind later aided the British Falkland Islands Dependencies survey ship John Biscoe in evacuating and resupplying various bases on the western side of Palmer Peninsula. The most severe ice conditions on record and extreme low visibility made the task a doubly difficult one.

During the following year, in late February 1960, the Glacier proceeded to the rescue of the Argentine icebreaker General San Martin in response to a request that the latter was in serious trouble in Marguerite Bay (west coast Palmer Peninsula) and also required aid in evacuating personnel from a nearby station. Subsequently, after rendezvous was brought about on 5 March (General San Martin having freed itself the day before) it was learned that 100 knot winds had forced the vessel on her side, bent and dished-in 30 frames along her starboard side and knocked off one blade from her starboard propeller. About 500 tons of cargo was jettisoned during the emergency. Following this, Glacier assisted the FIDS-leased ship Kista Dan, a small ship beset in heavy ice 47 miles away to the southward.

In four of the above cases a small ice-configurated cargo ship was involved. Each was beset in heavy pressure ice and thus prevented from conducting a mission of relieving personnel and supplying cargo to a distant antarctic base. In the other instances a ruggedly built ice-breaker got into trouble, proof indeed of the Antarctic's sudden reversal in operating conditions.

On 8 March 1962, South Africa requested U. S. icebreaker assistance for the small expedition ship Republic of South Africa which was trapped in the ice with a damaged rudder at 68°40'S, 03°30'W. The Japanese-built ship had relieved and supplied the South African antarctic station of SANAE. The USS Glacier as the rescue icebreaker and USCG Eastwind as the back-up ship departed on the rescue mission on 15 March with 6 months' supplies aboard. Reportedly, as a result of shock waves from volcanic eruptions in the Sandwich Islands, the Republic of South Africa was able to work itself free into open water on 23 March. The Glacier then was directed onward to Capetown whereas the Eastwind was sent to Sydney, the first ports of call on their voyages back to the United States.

It is known that the other countries having icebreaker type vessels, Argentina and the Soviet Union, have also given assistance to beset ships.

On 1 March 1957, the ice-strengthened ship Ob gave aid to free the beset Japanese ship Soya, the latter having established the Japanese antarctic station of Showa on Ongul Island, Prince Harald Coast before reaching an impasse in heavy ice. In January 1960, Ob again helped the Soya proceed through the ice pack thus enabling the latter to reach Showa base and pull free of the ice pack. At the time the Soviets established a gasoline cache for future flights.

On 31 December 1959, the Argentine icebreaker General San Martin, then on its way in to relieve Ellsworth Station, diverted from its route to lend aid to the Norwegian-South African expedition ship Polarbjorn. With the assistance of the icebreaker, the Polarbjorn was then able to reach the Norwegian and later South African antarctic station along the coastline. An ironic note was added when the General San Martin was later unable to reach its own goal, Ellsworth Station, located in the deepest recess of the Weddell Sea, because of unusually heavy ice conditions en route.

Because of the non-emergency nature of ship besetment and the limited number of participating nations which possess ice-breaker type vessels, no international procedure for requesting assistance has ever been set up. In some instances, ships in trouble request help direct from icebreaker types working a mission in close proximity. Usually, however, the request for assistance is made through official government channels.

The author, who was in charge of four assistance missions mentioned previously, believes that in general the icebreaking capabilities of small cargo ships operating in antarctic waters could be improved by changing the presently installed propellers with larger tug-boat-pitched propellers and by carrying aboard a small helicopter for ice reconnaissance purposes.

Planes

The most frequent cause of plane mishaps in the Antarctic is a "whiteout" condition brought about by low cloud layers and snow surfaces, a situation which permits sun rays to be reflected back and forth between the two mediums. Loss of shadow and perception which results create serious problems for the pilot. Suspended ice crystals intensify the effect. Other causes have been pilot error and mechanical failure. Potential causes, of course, lie with the peculiarities of antarctic weather, sudden changes, ranging from icing conditions to unfavorable high winds.

In actuality, there have been few cases where strict search and rescue missions by aircraft have been required or utilized. Of the few, the following qualify:

On 30 December 1947, a PBM plane departed from the USS Pine Island, then in the vicinity of 66°57'S 101°13'W, with a flight crew and the commanding officer of the Pine Island. This was the third of a series of photo flights. The plane subsequently reported that the ceiling was from 600 to 1000 feet and the sky completely overcast, and objects were not visible beyond two miles in snow and sleet. A short time later a further radio message was received on the Pine Island as to worsening weather. After that there was only silence. Snow storms, high winds, and poor visibility prevented an immediate aircraft search. It wasn't until January 11 that a search plane was able to get off and make its way to the scene of the crash, 10 miles inland from the coast. A later plane with a rescue crew was finally able to bring five survivors of the original eight back to the ship. The plane had struck the snow surface in a "whiteout" and exploded.

In February 1956 all radio contact with an Otter aircraft which was evacuating a trail party of four to Little America from Marie Byrd Land, a distance of 420 miles, was lost. As a result a trail party of one officer and six men were hastily dispatched in two weasels from Little America Station, and orders were given for the remaining members of the original trail party to back track toward Little America in a search. Three attempts to get an Otter in the air from McMurdo to effect search and rescue from Little America were unsuccessful due to unfavorable weather. Additionally, two R5Ds in Christchurch were alerted to proceed to the Antarctic, and a P2V plane from the United States was authorized to proceed through South America to the Antarctic. Three days later the latter plane made a forced landing in a jungle clearing in South America. The crew was successfully evacuated by helicopters from the Carribean Command. However, the icebreakers Glacier and Eastwind were successful in bringing Otter planes and helicopters to Little America. One of the Otters located the missing Otter, then following sledge marks in the snow finally overtook the victims of the crash who were walking in the direction of the Ross Sea. Again a "whiteout" condition was responsible.

Usually, rescue flights have been brought about as the result of mishaps or emergencies occuring at or in the vicinity of antarctic stations. Instances of these have been the evacuation of an Australian scientist from Wilkes in November 1960 and a USSR scientist from Byrd Station in April 1961 by long range planes. In both instances the planes were flown from McMurdo, then to New Zealand. Similarly, the surviving members of fatal aircraft accidents have been evacuated successfully by helicopters and planes.

At McMurdo and at Pole and Byrd Stations, detailed procedures are laid out to cope with aircraft emergencies in their respective areas. These involve assistance which includes medical, navigational, crash-fire and rescue, and communication aspects.

Search and rescue procedures have been set up to apply both to flights between New Zealand and Antarctica, and to flights strictly within the confines of the latter. Normally, Christchurch-based aircraft is responsible for the northern half of the flight route between New Zealand and the Antarctic. Search and rescue south of the midpoint (60° latitude) and within the Antarctic is provided by aircraft based at McMurdo and Byrd.

Conditions of readiness which are usually specified are: Condition IV—No air operations are being conducted or anticipated for a period of twenty-four hours. Condition III—Air operations are being conducted or anticipated within three hours. The search and rescue aircraft and aircrews are in a state of readiness to become airborne in one hour. Condition II—Air operations are being conducted and doubt exists as to the safety of an aircraft or an aircraft is overdue or unreported. Normally an aircraft will be considered overdue when its position report is thirty minutes late or when it fails to arrive within thirty minutes of its ETA. Search and rescue aircraft and aircrews are in a state of readiness to be airborne in one-half hour. Condition I—Concern exists for the safety of an aircraft because of lack of information of its progress or an aircraft is known to be in distress. The search and rescue aircraft shall become airborne immediately.

The Royal New Zealand Air Force at Auckland has a search and rescue capability utilizing Sunderland's, Hasting's, Bristol, and DC-6 type aircraft. All of these are not available at any one time but the alert aircraft can arrive at Christchurch in about four hours upon request.

To provide weather in its area, give navigational guidance, and act in a search and rescue capacity, if needed, a small escort type ship is stationed near the midpoint of the New Zealand-Antarctica flight route when flight operations over this route are in progress.

Miscellaneous

At the United States antarctic stations, particularly at McMurdo and to lesser degrees at Byrd and Pole stations, planes, helicopters, vehicles, medical and parachute teams are available for assistance when weather permits. U. S. icebreakers are operating in antarctic waters from early November to March; long range planes operate from October to March.

With the thought that an ounce of prevention is worth a pound of cure, emphasis is being placed by the U. S. more and more on safety precautions, the observance of which should keep emergencies which require assistance to a minimum. Measures along the foregoing lines have been initiated for tractor and traverse parties, scientific groups, and logistic support teams. Thus, when certain conditions apply such as: (1) when position is unknown, (2) serious mishap or injury has occurred, or (3) when loss of radio contact has endured for five consecutive days, the party has been directed to: (1) lay out identification panels (markers) for contacting aircraft, (2) conserve fuel and rations, and (3) don't stray from position.

Ships and stations employ a logging-out and logging-in system whereby the whereabouts of all those whose duties require leaving the ship or station are known at all times. The "buddy" system, where not less than two men are permitted to leave a station together, is also enforced.

It must be emphasized that probably all accidents which have occurred in the Antarctic have been the result of solo efforts, departure from well recognized safety rules, the exercise of faulty judgment, insufficient preparation. The Antarctic is frequently severe and tough, but man can be surprisingly just as tough and enduring if he follows good common-sense rules of logic and safety.

SECTION VII

Discussion Summary, Conclusions and Recommendations of the Symposium

GENERAL RECOMMENDATION
OF THE LOGISTICS ANTARCTIC SYMPOSIUM
TO THE SCAR WORKING GROUP ON LOGISTICS

This Symposium was the first occasion on which Logisticians have had an opportunity of discussing common problems and experience. It was unanimously agreed that the series of meetings were highly successful and provided a valuable forum for discussion.

The Symposium, therefore, strongly recommends to the Working Group on Logistics that similar meetings should be held in the future, but that special attention should be given to holding informal meetings on specific subjects with technologists expert in the chosen subjects.

SECTION 1
SCIENCE AND LOGISTICS

Discussion Summary, Conclusions and Recommendations

Moderators: M. Paul E. Victor (France)
Dr. Albert Crary (U. S. A.)

Discussion Summary

Part I: Papers by Dr. A. P. Crary and M. P. E. Victor

1. Dr. A. P. Crary, in addition to what is already said in his paper, emphasized the following points:

   a. Descriptive studies in many fields will be completed in the coming ten years, but operations will continue in basic research and will possibly intensify (because basic research produces new basic research).

   b. As a consequence, many disciplines will see diminishing returns for continued endeavor, e.g., geology, meteorology (as a science), some phases of upper atmosphere physics.

   c. In certain fields (such as earthquake seismology, glaciology) long range projects in the field will continue.

   d. Upper atmosphere physics will need rockets, satellites and the development of conjugate point studies; use of rockets will become more and more important.

   e. Biggest operations requirements (and consequently biggest logistic support) will fall in next sunspot maximum period (1968-1970).

   f. Satellites will be utilized (and necessary) in the study of the extent of sea ice and cloud cover.

2. M. P. E. Victor, in addition to what is already said in his paper, emphasized the following points:

   a. Present basic research studies (which are generally only data collecting) will give way to the concept of "concerted" (or inter-disciplinary) research for solution of specific problems.

b. The need to bring Antarctic research in line with the new themes of global research, space research, and the study of the oceans.

c. The growing importance of human sciences and biology.

d. The necessity to shape the logistics to cover the gradual evolution of the applied and technical research needs.

e. The imperative need for the logistician to have more precise guidance in what will be asked from him in coming, say, ten years; this guidance being the only way for him to become more rational and more efficient, not only technically and operationally speaking, but also financially.

3. Discussion

The main trends in the discussion can be summarized as follows:

a. In what manner does the mobility (or fluidity) required by science manifest itself in logistics?

The general opinion appeared to be that there would be two types of general requirements.

1. Small operations for short periods in remote areas by small groups of specialists.

2. Large operations where locations are not now known and which might be of several year's duration.

Both requirements will need main permanent bases to operate from. These bases would, of course, as in the past, continue basic scientific research, the smaller operations (1) could generally be handled, even with the present bases, but the larger operations (2) involving movement of large single items to unknown areas require careful consideration, and advance planning in particular in reconstruction of bases that will be needed in the near future (five to ten years). The conception of these bases will be different of what they are today. The general lines have to be fixed without delay.

b. Could not the scientist have more realistic plans for future needs, such as five or ten year plans?

The general opinion appeared to be that:

1. More types of research plans could be defined than at present.

2. However, in general, this is not possible as future research plans depend on the results of previous year's research.

The need for the upper atmosphere scientist to have plans for the specific locations of such large scale operations as rocket launching sites was emphasized.

In view of the probable inability of the scientist to give long range guidance to the logistician, it was agreed that it remained the responsibility of the latter to anticipate the demands and prepare for their fulfillment.

c. Does the value of logistics in Antarctica depend wholly in its use to serve the needs of the scientist, or is there not some merit in the independent "science of logistics"?

The general opinion appeared to be that while logistics in Antarctica was officially required, only to serve the needs of the scientist, optimum results would be achieved without restraint on logistics studies as an independent objective. Since science cannot be predicted in advance, logistics improvement should be strived for and scientists should be kept informed of the new logistics.

4. Summary

From the preceding it appears that if the logistician wants to be more rational, more efficient and more economical, i.e., fulfill the demands of science and fit better in the restrictions of finance, he will have to act more and more independently not only for the conception of his work, but also for the improvement of his techniques.

Part II: Papers by Mr. J. J. LaGrange (South Africa) and Dr. P. A. Siple (U.S.A.)

1. Mr. S. A. Engelbrecht (South Africa) said the South African paper stressed the need for team work and leadership as well as, in some cases, the need for special instructions and orientation for the leader plus training and indoctrination for the members.

2. Dr. P. A. Siple, in addition to what is already said in his paper, emphasized the following point: From his experience in Antarctica under wide variations in the approach to logistics support of scientific programs, it appeared that the approach was relatively unimportant provided the spirit of cooperation and mutual respect was achieved.

3. The main point raised during the discussion was the following: The ability to fly to the continent is probably the largest factor in the whole operation of science in Antarctica. To be able to spend four to six summer months instead of the usual one or two (or even wintering over) to carry out a summer program, meant a great increase in efficiency and quality of available personnel. An effort to make such summer months available to scientists of all countries was urged.

Conclusions

1. Ask the scientists to give a more precise guidance in what will be required in five to ten years, and more specifically for the probable lines of research during the next solar maximum period (1968-70).

2. If—what is probable—the scientists will not be able to give such a guidance, the logisticians will have to assess the requirements, resolve the problems themselves and be prepared to meet the demands in the most efficient way.

3. To attain this aim a much greater cooperation between logisticians is needed and should be developed.

Recommendation

In view of the conclusions, the Antarctic Symposium recommends that the SCAR Logistics Working Group consider ways and means of intensifying technical research on logistic problems.

SECTION 2
AIR OPERATIONS

Discussion Summary, Conclusions and Recommendations

Moderator: Comdr. M. D. Greenwell (U. S. A.)

Discussion Summary

1. The meeting was called to order at 0900 on August 14, 1962, by the moderator who introduced the subject for discussion and invited the delegates to present a summary of their papers. Following the presentation of papers, discussion from the floor was invited and the symposia group was encouraged to engage in informal discussion during free time and evening hours.

2. In the discussion, greatest interest was demonstrated in the following:

   a. The operation and maintenance of helicopters and of light and medium aircraft.

   b. Radio navigation aids.

   c. Aircraft configuration.

   d. Aircraft equipment including oxygen and JATO installations.

   e. The functional use of aircraft for direct and indirect scientific and logistic needs.

   f. The security of aircraft on the ground during periods of high winds.

   g. Airstrip preparation.

   h. Airstrip markings.

   i. The exchange of information regarding aircraft facilities.

   j. New developments.

Conclusions

1. The helicopter, though of short range, provides the most versatile air logistic support capability of all aircraft considered. The Japanese success in utilizing helicopters for ship to shore personnel and cargo movement was recognized as an excellent example of exploiting the capability of the helicopter when other methods could not be used.

2. The helicopter is a special purpose aircraft which can be operated in confined areas without the need for elaborate preparations but is less economical than the conventional aircraft when conventional aircraft can be used.

3. Turbine driven helicopters are superior to others in performance and ease of maintenance. Preheating of the engine and components is not required, starting in cold weather and at high altitudes is not difficult and maintenance is facilitated by the relative lightness of the engine parts. The capability of the turbine engine to develop rated power at high altitudes permits the turbine driven helicopter to be landed on mountain peaks and in areas that preclude the operation of any other type aircraft. The high rate of fuel consumption of the turbine driven helicopter was noted as a factor to be considered in their use.

4. The key to safe aircraft operations in Antarctica is

   a. careful flight planning;
   b. meticulous flight plan execution;
   c. close adherence to the proposed route;
   d. regular reporting of progress and intentions.

5. ICAO regulations and procedures of flight are followed in Antarctica.

6. Low frequency radio homing signals are unsatisfactory for general Antarctic navigation purposes since radio wave propogation from a station located on the plateau or on deep snow is inadequate for homing at ranges greater than 10 or 15 miles. Low frequency radio homing signals from stations located over sea water or exposed earth are excellent for navigation purposes at ranges of 30 to 100 miles.

7. Very high frequency and ultra-high frequency radio signals are satisfactory for navigational purposes but special, high-cost receiving equipment within the aircraft is required.

8. There is no single aircraft that will accommodate all tasks required in the Antarctic. Due to prohibitive cost, a special Antarctic aircraft is not feasible. Aircraft used in Antarctica must be an "off the shelf" model which is configured for cold weather operations and usually should be equipped with skis.

9. Skis coated with PTFE such as "Teflon" should be used to reduce friction and to minimize the freezing of the skis to the snow surface.

10. All aircraft should be equipped with a polar path compass and long-range radio equipment. The United States uses single side band, long-range radio with great success.

11. JATO provides the additional thrust required for high gross weight and high altitude take-off performance. The JATO installation must provide for an adequate capacity of bottles, the number of which is dependent upon the load carried and the altitude and condition of the airstrip surface. The need for a minimum of an eight JATO bottle installation on C-47 aircraft for use on the plateau was offered as a guide.

12. As a means of providing mapping, reconnaissance, fast point to point transportation of personnel and priority cargo, utility service for field camps and trail parties and for most search and rescue service, the aircraft remains unexcelled.

13. High winds are a constant threat to the safety of aircraft on the ground. Careful preparations are required for the mooring of aircraft. Methods described in the forgoing paper presented by Dr. Philip Law are excellent.

14. A promising method of airstrip construction by snow and ice compaction was presented by the United States delegate. The use of a snow compacted runway by wheeled aircraft operating on the plateau is the desired objective.

15. The standardization of airstrip markings in Antarctica is necessary. Methods of marking using poles with flags, dye marker, fuel drums, vehicle tracks, panels of paulin and others were discussed. The use of drums for markers which provide a radar and visual target from any angle was accepted as the best method.

16. A method for the exchange of information regarding established aircraft operating facilities has already been promulgated. The routine exchange of information regarding open snow and ice landing areas was considered to be of no advantage since conditions change too rapidly. It was agreed that prior to using the facilities of another expedition, the latest information regarding the condition of the facility should be requested.

17. In discussing new developments, the use of aircraft for

    a. detecting crevasses by an analysis of simultaneous readings of the pressure and radar altimeter;

    b. collecting air samples, airborne organisms, and airborne particles;

    c. recording albedo and magnetic data, was described.

Recommendations

The Symposium recommends to the SCAR Logistics Working Group:

1. A standard method for the marking of airstrips be studied and promulgated for universal Antarctic use.

2. That the application of hover craft for use in Antarctica be studied and that the results be distributed.

SECTION 3
BUILDINGS

Discussion Summary, Conclusions and Recommendations

Moderator: Mr. W. F. Ponder (New Zealand)

Discussion Agenda

Discussion was channeled within the limits of the following agenda:

A. Permanent Establishments

(i.e. (a) housing of personnel, including living and recreational facilities, laboratories, offices, hospitals.

(b) workshops, garages, hangers, storage buildings).

1. Site Selection and Development

   a. Use of mechanical equipment

   b. Methods of shifting ice, snow, and permafrost

   c. Holes required for foundations, etc.

   d. Desirable site requirements.

2. Factors Affecting the Design and Siting of Buildings

   a. Site conditions and weather problems and drift

   b. Foundations (ice, permafrost, soft snow)

   c. Fire precautions—their effect on design and material

   d. Communication between buildings

   e. Erection problems in cold conditions and the effect of this on selection of materials.

   f. Heating and ventilation

g. Living conditions, decoration

h. Recommended standards of accommodation for average base wintering scientific personnel

i. Siting of buildings

j. Transportation of components (sledge, air drop, etc.)

k. Water supply

l. Waste disposal

m. Behavior of basic materials in cold conditions

n. Fueling and precautions.

3. Construction Methods

   a. Materials, insulation, etc.

   b. Fire treatment of materials and components

   c. Construction systems.

4. Fire Precautions

   a. Alarm systems, manual and automatic

   b. Compartmentation and escape

   c. Fire drill

   d. Fire equipment

5. Maintenance Problems

   a. Deterioration of materials

   b. Problems of snow loading and wind

   c. Dry atmosphere

   d. Wear and tear of components

6. Site Contamination Problems

   a. Disposal of waste products from immediate vicinity of buildings.

   b. Removal of rubbish

c. Cleanliness in base buildings and contributing factors in design and materials used.

B. Portable Buildings. Small Buildings for Occasional Use.

1. Construction methods

2. Site erection limitations.

Discussion Summary

1. Site Selection and Development

a. The importance of pre-planning in site selection to insure that areas are set aside to provide freedom of action for scientific activities while ensuring that clean areas are available for snow procurement, etc.

b. Necessity of siting buildings with due regard to prevailing winds to insure minimum fire hazards.

c. That proper consideration be taken of roof levels to avoid unnecessary drifts and snow accumulation.

d. Proper site discipline to avoid unnecessary snow accumulation.

2. Design Factors

a. The value of modular coordination in design of buildings and furniture.

b. Floor heating combined with adequate ventilation as a basis for an ideal heat source and the value of humidification. The necessity to prevent stratification by adequate induced air movement.

c. The necessity to carefully consider design and decoration inside buildings.

d. A solution to the water supply problem, disposal of waste products, and the use of wind for power generation is emphasized and urgent.

e. The architect and designer to have a clear understanding of all base activities and examine the design solution to ensure fire hazards are eliminated.

f. The necessity to take into account drift problems.

3. Construction Methods

Various construction methods have been discussed and examined. There is no doubt that there is a great need for a closer exchange of information in this field. A suitable material for panels could be a molded plastic with a light metal or other hard wearing facing material. Difficulties in working with metal sheathing were stressed.

4. Fire Precautions

a. Emphasis was made that the architect or designer has a large part of the solution of this problem in his hands in the design stage.

b. The proper briefing of visitors to bases on fire hazards was considered essential.

c. It was pointed out that in extreme cold, fire, once established, will gain complete control quickly; even if hoses are available, a major fire is unlikely to be quelled under these conditions.

d. Reliable fire prevention measures at base include good housekeeping and a well-drilled team to extinguish the fire with first stage fire equipment.

e. The base leader must ensure that all escape hatches and curtain smoke stops in passages are kept clear of obstructions at all times.

f. The need for a special depot remote from base, to contain materials for shelter, food and clothing was emphasized. Likewise, remote repositories for scientific records was important.

g. Of particular importance is the provision of suitable smoke-stop doors, alarms in tunnels, and effective smoke masks and oxygen respirators.

5. Maintenance Problems

a. A high expenditure in the first place will frequently avoid greater expenditure at a later date with recurring maintenance.

b. There is great difficulty in keeping timber straight and true to shape in the dry atmosphere of Antarctica.

c. Snow loading and structural requirements vary according to locality and solutions vary according to whether the buildings are on permafrost, rock snow, or ice, and whether the buildings are near to the coast or subject to large snow accumulation.

6. Site Contamination Problems

It was agreed that this problem is one of the most challenging facing the nations who intend to occupy bases permanently.

7. Portable Buildings

In the section dealing with light portable buildings, emphasis was made of the necessity for components to be air-dropped and quickly assembled. The igloo type of building erected by the Expedition Polaire Francaise was discussed and it was agreed that this form of building has great possibilities. Other buildings that involve sectionalized transport over land were also considered.

Conclusions

1. This is the first occasion when there has been an exchange of Antarctic building problems at an international meeting. It has been most fruitful and instructive for all concerned, while the papers presented expressed an eagerness by all countries to exchange information.

2. This has become a beginning for the collection and correlation of sound and tried principles of design and will become a starting point for architects and designers to reconsider the vast problems posed of permanent building and associated construction in Antarctica.

3. There must be an understanding of the human element in the planning of a building and related facilities and while detailed research on individual aspects of materials is useful and necessary, it is only by giving the architect and designer a full brief of requirements to allow him to produce a complete solution, that satisfactory living conditions will result.

4. Now that this Symposium has highlighted the problems, there must be a followup of a meeting of designers, e.g., Architects, Heating and Ventilating Engineers, etc., and supported by advisors on future scientific requirements and logistic restrictions. Such a meeting is essential if there is to be a real end result from the foundation laid at this Symposium. A design group under the auspices of SCAR or another international body that could include Arctic design problems, would achieve valuable results for the minimum of effort. As there is an inevitable time lag between the completion of a design and construction, and if the present phase of permanent reconstruction is to benefit, such a design group must be convened as soon as possible.

5. The opportunity offered by exchange of information at this Symposium has been of considerable value as it sets the basis for the analysis of future building and associated facilities.

6. If solutions to future problems are to be found, then it is emphasized that the architect or designer must have an over-all responsibility for design

and implementation of construction. His task must be to provide buildings that are comfortable, convenient, carefully designed with proper care and attention to detail including color, and decoration, planning of recreation facilities and the integration of the many specialized engineering services required.

Recommendations

The Symposium recommends:

1. The SCAR Working Group study the formation of a design group to establish: (a) building standards, (b) common modular coordination, (c) direct research into more profitable channels e.g. materials most likely to be of use in Antarctica, (d) design recommendations.

2. Further research on (a) stressed skin panel construction with the object of reducing weight and thickness and improve fire rating, and (b) fire precaution methods generally.

3. Further investigation is necessary into water supply sources in the varying types of conditions experienced in Antarctica.

4. Waste disposal methods should be reconsidered. Present method employed by Australia which has been operating for eight years deserves study.

5. The Logistics Working Group recommend to SCAR that a special recommendation should be passed to the World Health Conference at Geneva which is to discuss health problems in cold areas (held late in August) pointing out the concern felt at this Symposium of site contamination problems developing at Antarctic bases in continuous operation.

SECTION 4
LAND VEHICLES

Discussion Summary, Conclusions and Recommendations

Moderator: Dr. C. R. Bentley (U.S.A.)

Discussion Summary

1. Near Station Vehicles

It is important in considering vehicles to keep clear the use which will be made of them. The vicinity of most stations includes areas both of exposed rock and of snow. As a vehicle which will operate both on snow and rock, the weasel has been widely used in the past, but it was generally felt that better vehicles are now available. The chief present support is for the Bombardier Muskeg tractor and the Nodwell tractor, especially model RN 110. If use is to be limited to areas bare of snow, wheeled vehicles are advantageous; those in actual use include the Unimog, the Land Rover, and the Dodge Power Wagon.

On sea ice and other flat bare ice areas, the Australian expeditions have found motor bikes (with side-cars for stability) to provide convenient and rapid transportation.

For use on snow and ice alone, only tracked vehicles were discussed. Tucker Sno-Cats, models 443 and 743, have been widely used. However, their use must be strictly limited to snow-covered regions. They are fairly complicated to maintain, a fact which, together with high initial cost, may limit their usefulness at small stations.

2. Scientific Traverse Vehicles

The weasel has logged thousands of kilometers on over-snow traverses and is still in use, particularly by the Expeditions Polaires Francaises. With proper care and maintenance, and when no other vehicles are available, weasels can perform very well. However, load capacity is small and maintenance problems large; consequently, all expeditions plan to use other vehicles in the future.

The Japanese Snowcars, similar to weasels but with improvements in the track and suspension systems, some powered by diesel and some by gasoline engines, have been successful. The Japanese found that diesel engines were easier to start in cold weather than gasoline, contrary to other experience; because of having pre-combustion chambers. The normal difficulty in producing a proper cranking speed was relieved by providing for initial compression release. The diesel engines were further useful in being interchangeable with the station power plant.

Regardless of the engine type, proper battery power will greater facilitate easy starting.

Australian expeditions have used Caterpillar D-4 tractors for traverse work. The advantages of large load capacity and very little maintenance have outweighed the disadvantages of high ground pressure; crevasses should be avoided by proper scouting. United States expeditions and the Trans-Antarctic Expeditions preferred to sacrifice some load capacity and freedom from maintenance in return for low ground pressure (since routes cannot always avoid crevassed zones or soft snow regions), large cabs replacing wannigans, plus uniformity and flexibility of equipment. The Australian expeditions may try out Nodwell 110's in place of D-4's; however, at the same time the USSR is tending toward the use of prime movers rather than load carrying tractors.

It was noted that a 743 Sno-Cat can haul nearly as much as a D-4, but with a cost in breakdowns. Precautions against overloading vehicles should be observed. Four-tracked vehicles are superior to those with two tracks in crossing crevasse bridges. Two-tracked vehicles tend to dig down in the rear when under heavy load; this can be overcome by counter-balancing the vehicle with a bulldozer blade with fuel drums loaded on it, and by lowering the towbar as far as possible. In any vehicle a wheel base as long as possible is vital for crossing crevasses and for decreasing pitching.

A few suggestions for traverse operation were made:

a. Investigate keeping batteries warm by alternating current flow.

b. Install a tachometer on all vehicles for proper control of engine r.p.m.

c. Refuel immediately after stopping, to prevent, if only even briefly, moisture condensation in fuel tanks.

d. Change carburetor jets on gasoline engines every 2000 feet change in elevation.

For light traverse, motor toboggans hold promise. A motor toboggan weighs about 700 pounds and will pull up to a 2000 pound load. Toboggans have been used quite extensively on the Ross Ice Shelf with excellent results. Their hill climbing ability needs further testing. The New Zealand and British expeditions will try them out in conjunction with dog teams to see if the latter can be entirely replaced.

Polecats have been used very slightly in Antarctica but have proved useful in Greenland. The smaller model has required little maintenance. The larger, Mark II, has an improved suspension system and can carry 35 passengers.

New vehicles of interest include the "Gamma Goat", an articulated 6-wheel jeep-like vehicle built by Pacific Car and Foundary Corporation, and an articulated vehicle being developed by Polaris Industries which has interchangeable tracks and low-pressure tires. This may provide the answer to the need for an all-surface vehicle.

In all vehicles, proper training of drivers is of utmost importance, as is continual attention to proper maintenance. All expeditions require the demonstration of some degree of proficiency in drivers; some permit only one driver to a vehicle. One old vehicle can be provided for general use, the others driven only by their own drivers. Repairs are reduced by putting the chief mechanic in charge of the transportation fleet.

The need for development of better vehicles and the importance of having specific vehicles for specific purposes were noted. The suggestion was offered that each expedition submit a list of desirable specifications or requirements for Antarctic vehicles.

3. Sledges

For snow-free areas, wheeled trailers are recommended.

The Maudheim-type sled was described as having the best load to weight ratio, weighing 450 pounds and normally carrying a two-ton pay load. Two runner sleds are preferred to four runner bobsleds unless tight maneuvering is required, even if this necessitates the use of more sleds.

Coating of sled runners is definitely advantageous in reducing sliding friction. Some comparative coefficients of friction in the paper by Murayama and Maita. Tests show Teflon (PTFE) to have a substantially lower coefficient of friction than Tufnol (bakelite).

For ease in breaking a sled train loose, the Australian expeditions tow all but the first sled by a cable. With rigid connections, it is still possible to break loose one sled at a time by backing up if there is an inch or so free play in the hitch. The suggestion was made that a winch cable from the towing vehicle be run through fair leads on intermediate sleds to the last sled. In this way, spacing of sleds can be changed, the vehicles can be started before the sled train, and the load can easily be winched through soft snow areas.

Aluminum sleds of the Expeditions Polaires Francaises have worked well. Also successful were wannigans having an outer covering of fiberglass—polyester resin, insulation of polystyrene foam, and an inner plywood wall. They have shown no cracking from stresses developed by working of the sledges.

Mounting of scientific gear in the vehicles gives greater flexibility of use, but mounting in a wannigan gives a smoother ride and decreases the chances of going into a crevasse.

Conclusions

1. There is obvious need for further development of vehicles for the Antarctic. No fully satisfactory vehicle, either for use around base stations or for use in the field, has been developed. The suspension and track systems are consistent sources of trouble. It is noteworthy that a vehicle has yet to be designed specifically to operate under Antarctic conditions.

2. With a number of different types of vehicles in use, and being considered, it is important that a uniform system of tests and reporting of such tests be developed.

Recommendation

In view of Conclusion 2 above, it is recommended that the SCAR Logistics Working Group prepare a plan for the establishment of a uniform system of testing and reporting of tests and for the exchange and discussion of results.

SECTION 5
ANTARCTIC PROVISIONING

Summary of Discussions

Moderator: Dr. P. G. Law (Australia)

1. Rations

The moderator pointed out that, from an examination of the papers submitted, it was apparent that the development of field rations had followed similar lines in most countries and he asked speakers to direct their remarks to those points of difference which existed.

M. P. E. Victor (France) said that in designing the E. G. C. for Greenland, a different policy had been followed. Instead of taking a basic "hard ration" and adding extras, the designers had started with normal foods and, to avoid waste, and to facilitate speedy handling, had arranged five standard menus. The use of aircraft and vehicles as support for the ground party had made strict regard for economy in weight unnecessary.

Discussion ensued concerning the importance of weight and bulk in various situations. Sir Vivian Fuchs (U. K.) and Mr. G. W. Markham (New Zealand) said their expeditions were still very much concerned with economy in bulk and weight and the moderator pointed out the importance of such economy in rations used in survival packs for aircraft. The chairman (Admiral D. M. Tyree, U. S. A.) stated that, in any set of Antarctic circumstances, some regard had always to be paid to the question of weight. It was generally agreed, however, that in most circumstances today, some latitude could be allowed for the provision of supplementary items of the "goody" type. Dr. H. E. Lewis (U. K.) and others, considered that a "basic" designed ration ensured that men obtained a better balanced diet than if they simply chose their own items.

The moderator asked for comments as to preferences between pemmican, dehydrated meat bars, and accelerated freeze-dried meats. His own opinion was that the latter offered very interesting possibilities but that at present considerable variations in quality were apparent in products from different manufacturers. A. N. A. R. E. field parties had found meat bars more palatable, but less sustaining than pemmican. Other speakers expressed unqualified preference for meat bars and, while appreciating the weight economy of freeze-dried foods, pointed out that they were bulky in volume. Rear Admiral R. N. Panzarini (Argentina) said that Argentine parties used "charquican", a pemmican specially made for his expeditions.

Mr. M. Murayama said the Japanese liked variety and generally provided European, Chinese and Japanese foods. Fresh bread was baked and deep frozen at the base for supply to field parties and frozen fresh meats also formed part of the field rations. Sea-weed was used to provide variety and flavoring. Samples of pre-cooked ("alphered") rice were distributed at the conference. M. P. E. Victor described the wooden boxes in which the E.G.I.G. rations were packed and stated that they were robust enough to be free-dropped from aircraft.

Dr. H. E. Lewis showed a film describing the British steps in improving both the contents and packaging of sledge rations. He said that British opinion had moved away from the concept of elaborate individually wrapped portions and more items were now being provided in bulk. Expedition men were asked to fill in questionnaires in the field giving their impressions of the rations provided.

The moderator drew attention to the recently developed "instant potato" which he recommended as superior to potato powder and said that dehydrated butter had certain advantages over ordinary butter.

2. Clothing

Dr. T. Torii described Japanese Antarctic clothing and exihibited a number of items made from modern synthetic materials which he submitted were superior to materials made from natural fibers such as wool and cotton. Of special interest to the audience were:

a. Air-net underclothing made from "Kanekalon" which does not absorb moisture and has a softer, more pleasant feel than cotton;

b. Tetoron (terrylene) "down" to replace eiderdown in quilted jackets and sleeping bags;

c. Tetoron tents and ropes.

Speaking on woolen garments, the moderator questioned the superiority of synthetics for certain uses, particularly external garments. He informed members that recently developed processes had removed the disadvantages of shrinkage in woolen garments and such treated clothing could now be washed without any ill effects in washing machines. He exhibited a "drip-dry" worsted woolen shirt of fine quality.

The moderator drew attention to the Russian paper and expressed regret that no Soviet delegate was present to answer questions which members raised concerning items of leather clothing used by the Russians.

The Chairman asked for comments upon zipp fasteners and a number of speakers commended their use provided that the mesh teeth were robustly made and not too fine. It was stated that zipps should be backed up with buttoned flaps in case of zipp failure. Recent coarse-mesh plastic zipps were particularly good. The moderator directed attention to the "press-on" type of nylon fastener which had valuable application in polar clothing.

Some discussion of hoods ensued. Sir Vivian Fuchs and the moderator supported the use of a stiffened flap around the edge of the hood which could either fold forward to provide a funnel to protect the face against wind or fold back out of the way when not required. Mr. G. W. Markham recommended wolverine fur for edging hoods and the moderator suggested detachable fur edging. Mr. R. Faylor (U. S. A.) suggested the use of "press-on" plastic fasteners to enable easy fixing and removal of such edging.

3. Toilet Facilities

An interesting discussion was held concerning difficulties involved in defecation:

a. When traveling, it is convenient to attend to such matters either in the morning or the evening while the tent is erected to provide shelter. Clothing is loosened before emerging from the tent and refastened after returning so that the time of exposure is kept to a minimum.

b. M. P. E. Victor referred to a strip of canvas supported on three sticks which could be erected or a V-shaped screen for shelter. It is important to leave an air gap of about six inches between the canvas and the surface of the snow to allow the wind to sweep through, otherwise eddies will swirl snow around the back of the screen.

c. Sir Vivian Fuchs said he had not considered that the matter provided any great problem. A loaded sledge itself provides a reasonable screen.

d. It was generally agreed that numbing of the fingers is the most unpleasant result and that regular habits simplify the problem.

4. Tents

M. P. E. Victor, in describing the French pyramidal tent, explained the advantages of rigidity resulting from the insertion of stiffening bars to connect the corner poles about half way up. Commander J. Lennox-King (New Zealand) pointed out that such a tent would lack some of the lower space which results from a center guy drawing out the center of a tent face. The moderator drew attention to the use by the Japanese of a bar instead of a point for stretching out the face by a guy rope.

Dr. Torii described stainless steel poles, hinged at the top, which, although expensive, were superior to duraluminum. It was generally agreed that duraluminum poles were not as good as the best quality bamboo.

Discussion ensued concerning the best color to use for a tent. It was agreed that very dark colors should be avoided because of lack of light within the tent and that orange should be used to enable tents to be seen best from a distance, particularly from the air, in which case tents were hard to distinguish from rocks. The use of strips of alternate light colored and vividly colored pieces of material was suggested as a way of increasing both the light intensity within the tent and the visibility of the tent at a distance.

5. Physiological Responses to Cold

Following Dr. R. A. Millington's (U. S. A.) paper, there was discussion concerning acclimatization to cold. Millington referred to recent experiments which demonstrated that such acclimatization occurred and the moderator suggested that short-term acclimatization was more psychological than physiological and could be achieved by short exposures of about an hour per day over several weeks. British physiologists were now concentrating on the measurement of the precise exposure to cold experienced by men in Antarctica. When this work had been completed, scientists would be in better position to assess cold acclimatization.

Dr. Lewis said that cold acclimatization was relatively unimportant logistically. The benefit to the individual was relatively small and man had to rely upon the protection of clothing and shelter to allow him to operate in polar regions.

SECTION 6
FIELD OPERATIONS

Discussion Summary and Recommendations

Moderator: Sir Vivian Fuchs (U. K.)

Discussion Summary

1. Navigation

From the discussion, the general view was taken that magnetic compasses were of assistance. M. P. E. Victor (France) described a sun compass mounted on a clock mechanism which kept it correctly orientated with the passage of time.

Mr. M. Murayama (Japan) reported that the C-4 gyrosin compass had been difficult to operate with vehicles because of power fluctuations and the change of magnetic field when the vehicles stopped. It was suggested that a straightforward gyro could be used to keep the vehicle heading constant.

Mr. Murayama's ideas regarding a beamed aerial system seemed likely to have the capability of maintaining the vehicles in a straight line, but some speakers considered there would be constant deviation of the whole train from the intended course. Mr. Murayama agreed that a stop for course correction would have to be made at frequent intervals.

Dr. P. G. Law (Australia) presented Mr. Black's paper on a method of navigation using mirrors. Discussion indicated that in spite of being unable to see the tracks behind at times, the ability to see the vehicles or their lights and perhaps periodically planted flags, made this system worthy of further development. Dr. J. Mooney (U. S. A.) offered to arrange for a booklet on traverse navigation by U. S. Antarctic Projects Office to be circulated.

2. Logistics Support in Antarctic Service

General discussion of Mr. P. M. Smith's (U. S. A.) paper indicated that in the event of scientific disciplines being unable to give forecasts of their logistic requirements, it would be necessary for organizations to diversify their potential supply and transport. Although this would be less efficient, it was probably inevitable.

It was thought desirable to call the attention of SCAR working groups to the need for making as long term scientific planning as possible.

A suggestion was made that nations should put down stored advance stations at strategic points for search and rescue and with the object of having facilities available in areas which were bound to be studied. It seemed likely that the restricted budget and facilities of most nations would preclude this.

3. Communications

The two types of field radio used by the New Zealand dog sledge parties were described and displayed. The larger type 557 HF set was thought to be too heavy at 85 pounds, and, unless the dry batteries could be brought into a tent, difficulty might be experienced at low temperatures. The smaller pre-set dual frequency pack-set weighing 12 pounds seemed very suitable for use by off-shoot groups reporting to a main camp.

In presenting his paper on communications problems in Antarctic, Mr. F. L. Mason (U. S. A.) explained how the use at base and in the field of single side band equipment had improved communication reliability from 33-1/3 per cent to 90 per cent. A new type of portable resonator antenna had been designed which it is hoped will improve trail party communications still more. A single side band, portable, 100 watt transmitter receiver, weighing only 41 pounds, was available. Mr. Mason stressed the importance of using the same type (i. e. vertical or horizontal) of aerial at base and in the field. The French had turned over, in 1958, entirely to single side band equipment for base, vehicle parties and aircraft and M. P. E. Victor (France), in strongly recommending others to follow suit, explained how impressed he had been with its performance under all conditions and over long ranges. For field use, they found a ten watt set weighing only 21 pounds was completely adequate. They had used both Collins and Thomson Houston sets of this type as well as the 100 watt version described above.

The symposium felt that this improvement in communication was a good example of the application of technological advances towards easing logistics problems.

The limitations of homing devices were explained and discussed. In order to compensate for the loss of ground wave propagation over snow and the consequent marked reduction in range of effectiveness, it would be necessary to build large and complicated systems on the snow surface, but once these became snow covered, they would begin to drop off in efficiency. This was a serious problem which deserved further attention. It was recommended that all nations should encourage scientific research into the factors affecting antennae laid on snow and that this problem should be referred to the SCAR working group on communications.

The U. S. change-over from HG to UHF and VHF equipment in their aircraft had resulted in considerable improvements.

4. Search, Rescue, and Assistance in Antarctic Areas

The papers by Captain E. A. MacDonald (U. S. A.) and Mr. L. D. Bridge (New Zealand) were discussed. There was agreement on the necessity for international standardization of procedure.

Commander M. D. Greenwell (U.S.A.) emphasized the need for field parties to make a careful plan and to advise base of changes without delay. At base a search and rescue potential should be maintained. It was recommended that all field parties be equipped with the ICAO ground/air signal card since, generally, all aircraft operating in the Antarctic kept to this procedure. The essentials of a rescue operation were to find the parties and provide survival material. The recovery of the party could then be effected without pressure.

5. Operation Plan of E.G.I.G.

The plan was briefly described by M. J. Vaugelade (France). It provided support for ice cap traverses and he explained how the depots were laid out by air along two axes at right angles for field parties traveling at different speeds. The plan and its implementation, plotted in graphic form, had proved most useful in evaluating the effectiveness of the logistics. Logisticians in general might find such an analysis valuable.

The discussion centered on the merits of pre-air support vis a vis continuous air support. For this particular purpose, pre-support had been more economical despite the need to allow a calculated percentage of reserve at each depot.

6. Trail Markers

M. P. E. Victor considered that all nations should use a common stake so that when previous trails were encountered or glaciological investigations resumed, the flags could be raised or extended without difficulty. In answer to a question, he explained that the need had arisen in Greenland and once in Antarctica and that he was looking to the future for more frequent requirements in Antarctica.

7. General

The meeting was asked to consider whether an international basis for summer operations might be profitable. There were no immediate reactions except that it was agreed that substantial difficulties would need to be overcome and time should be allowed for consideration.

Sir Vivian Fuchs described an experiment in bridging crevasses carried out by the British Antarctic Survey. The equipment was basically a low pressure sausage-shaped balloon. This was inflated in the crevasse by means of the vehicle exhaust and held in position by ropes attached to "dead-men". The top was then packed with snow up to trail level and the vehicle driven over. The experiment had been successful in a four foot crevasse and tests would need to be made in wider crevasses. The meeting expressed interest in this new development.

Recommendations

The Symposium recommended to the SCAR Working Group on Logistics:

1. All nations should encourage scientific research into the factors affecting antennae laid on snow and that this problem should be referred to the SCAR Working Group on Communications.

2. Field parties of all nations be equipped with the ICAO ground/air signal card since, generally, all aircraft operating in the Antarctic adhered to this procedure.