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MILITARY MONOGRAPH

TITLE: A TEAM OF COMBINED ARMS OPERATING UNDER CONDITIONS OF EXTREME COLD

SCOPE:

I INTRODUCTION

II ORGANIZATION OF TASK FORCE FRIGID

III TOPOGRAPHY AND WEATHER

IV COMMON PROBLEMS

V OPERATIONS OF SEVERAL ARMS

VI ARMOR AND THE MOBILITY OF MOTOR VEHICLES

VII GENERAL EFFECTS ON TACTICS AND LOGISTICS

VIII CONCLUSION

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Captain

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A TEAM OF COMBINED ARMS
OPERATING UNDER CONDITIONS OF EXTREME COLD

I

INTRODUCTION

The best way to find out whether or not you can do something apparently difficult is to try it. At first you may find your task almost impossible, but with new techniques and new equipment it may become progressively less difficult. This, in brief, was the story of Task Force Frigid. At no time in the past had the army recorded the reactions of men and equipment to temperatures much below 0° F. It was thought, and later found to be correct, that new methods of fighting and new or specially prepared equipment had to be adopted. Following the tests of Task Force Frigid, and up to the present time, an added importance has been given by the army to cold weather fighting; service schools have increased several fold the time allotted to this subject; and officers and troops in increasing numbers have been sent to observe and participate in cold weather operations. Therefore, it seems timely to relate some of the problems encountered by the officers and men of Task Force Frigid, and discuss the attempts that were made to solve them.

This article does not attempt to give an overall solution to arctic operations, nor to summer operation in the same locality, nor to operation over the many varied types of terrain to be found in Arctic climates. It deals only with the activities of Task Force Frigid in the immediate vicinity of Ladd Field, Alaska, from September 1946 to April 1947.

II

ORGANIZATION

Task Force Frigid was organized so as to include many of the arms and services in a small unit. Included were a parachute infantry company, a tank company, a field artillery battery, a battery assigned to a forward observation battalion, an anti-aircraft artillery battery, an engineer company, a headquarters battery, a service battery, and an ordnance medium maintenance company. Companies and batteries were not organized according to standard tables of organization, but were grouped so that they could be equipped with many items of branch equipment. For instance the tank company possessed an M24 tank platoon, an M26 tank platoon, an M4A3E8 tank platoon, and an armored infantry platoon. Task Force Headquarters was composed of the Task Force Commander, an administrative staff and a test staff. The administrative staff was responsible for the conventional S-1, S-2, S-3 and S-4 duties; while the test staff was composed of officers representing the Army Ground Forces Boards, and was responsible for both the testing of Task Force equipment and the writing of test reports.

The Task Force was organized at Fort Ord, California, and moved by water to Alaska in September 1946. While at Fort Ord and during the few weeks following the Task Force's arrival at Ladd Field, physical conditioning was stressed almost to the exclusion of everything else. Although the condition of the men was excellent at the start of cold weather, the winterization of equipment was sadly neglected. Only a small percentage of the general purpose vehicles, and no full-track vehicles, were winterized. Also, the work was poorly done as the mechanics in the supporting ordnance maintenance company were not previously trained in proper methods of winterization. This lack of preparation resulted in the Task Force becoming all but immobilized during the first period of extreme cold.

Another major problem was the inability of many of the enlisted specialists to properly perform their jobs. Many of them were very young soldiers who had been in the army for only a short time, and who had not yet had time to learn their specialty. A case in point was a soldier whose military occupational specialty called for him to operate a bulldozer, but this man had never seen one. As a result of this situation, it was necessary to train the men in their jobs before they could be expected to perform efficiently under extreme conditions.

The commander who organized the Task Force lasted until November 1946. This officer apparently had no conception of the overall mission of the Task Force. He regarded physical conditioning and the tactical employment of his foot infantry as the only two operations worthy of effort. The planning for the complex testing of the variety of equipment in the possession of the Task Force was neglected; the Task Force Commander and the Test Staff were at loggerheads. As a result, the efficiency and morale of the unit sank to a very low ebb. An investigation was requested by a group of Test Staff officers, and a short time thereafter the Task Force Commander was replaced.

Still another problem was supply. Each Army Ground Forces Board desired to have each of its development items of equipment tested under extremely cold conditions. Planning was not done sufficiently in advance, and movement of supplies to the port was too slow to get many of the items to the Task Force in time to conduct proper tests. Large caliber ammunition did not arrive until late in January. Much important testing was impossible because the necessary supplies were not forthcoming.

III

TERRAIN AND WEATHER AT LADD FIELD

TERRAIN

Near the center of the Alaskan territory was the town of Fairbanks, the largest of the interior settlements. Ladd Field was located about two miles east of Fairbanks, with the Richardson Highway running along its southern edge, and the Tanana River a short distance to the south. (See Figure 1.) The Task Force's test and maneuver area was located south of the Tanana River in the Tanana flats which extended fifty miles to the south. Much further to the south, like lonely white sentinels, were the jagged peaks of the Alaskan Range; and north of Ladd Field rose a group of high hills covered predominately with white spruce and birch. In the maneuver area two types of terrain existed, the dry lowlands and the wet lowlands. Tall trees abounded in the dry lowlands. This area dried out much quicker in the summer than the wet lowlands, which were characterized by small, stubby tree growths and many streams meandering across the terrain. In the spring, when the snow began to melt and the ground to thaw, a great swamp existed over the entire area, making any cross-country or over-trail movement probably impossible.[1]

The Tanana River, which separated the base camp at Ladd Field from the test site, was a large swift river, varying in width from one-third to three miles.

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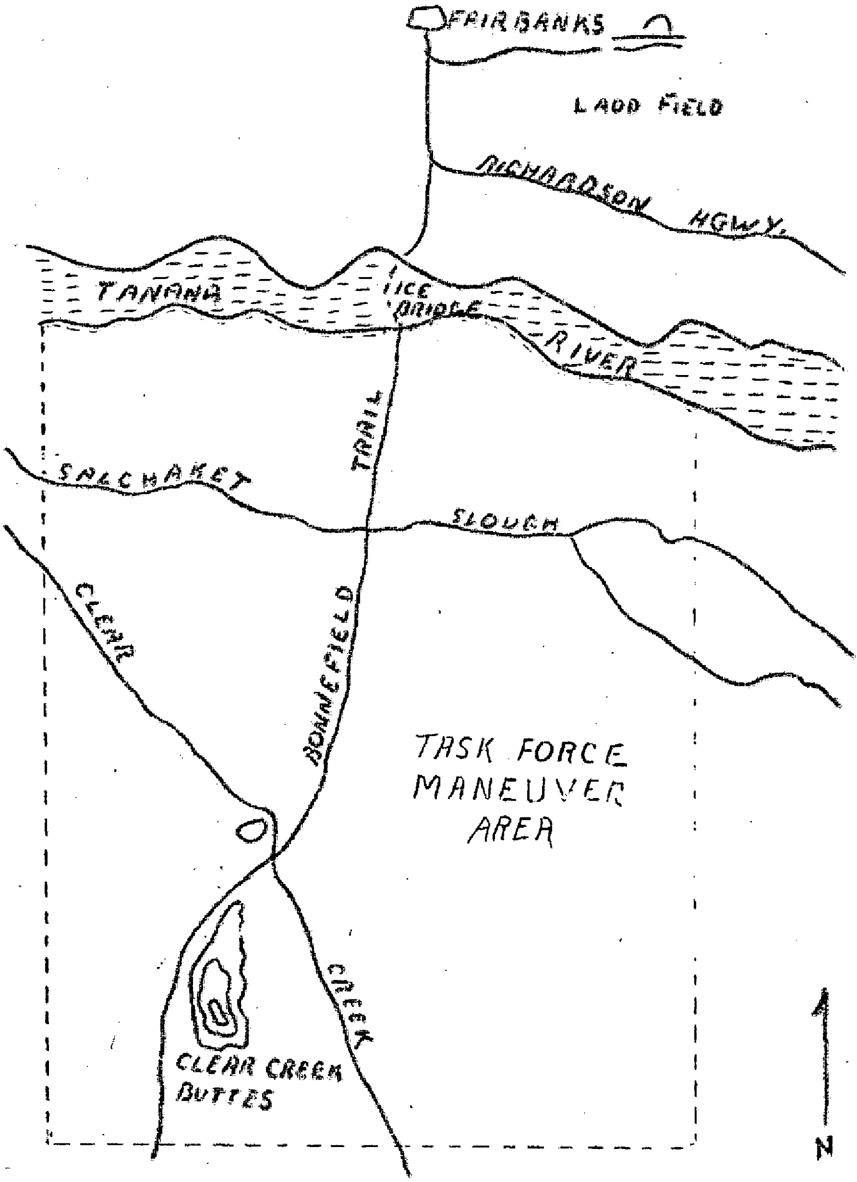
[1]AGF Task Force Frigid, Winter Test Program 1946-47, Chap. III, Weather and Terrain, pp. 39-49.

SCHEMATIC DIAGRAM OF FAIRBANKS, LADD FIELD, AND MANEUVER AREA



When the Task Force went into the field, it traveled south across the Tanana River to the Task Force maneuver area.

Figure No. 1

Due to its swift current, it was slow to freeze and formed a barrier to operations uhtil the middle of November. During the winter the thickness of the ice was measured periodically. By 1 January 1947 it reached its maximum thickness of fifty inches. Even when this thickness of the ice existed, some parts of the river failed to freeze completely, as swift upcurrents prevented the water from solidifying. About 1 November men crossed on foot when the average river ice was three inches thick; on 15 December a sixteen ton D7 tractor crossed where the average thickness was twenty-seven inches; on 1 January a forty-five ton M26 tank crossed when the average thickness was forty inches; and on 31 January a tank transporter carrying an M26 tank, the total weight being approximately seventy tons, crossed when the average thickness was slightly greater than forty inches. Near shore this transporter broke through where spring water had melted the ice. A rule of thumb that was safely used for crossing heavy vehicles was as follows: ice twenty inches thick will support a twenty ton load. For each additional inch of ice, an additional ton can be supported. However, somewhat heavier loads were crossed by the Task Force without mishap.[2] In considering the use of the large, swift rivers for avenues of military movement during the winter months, the fact that thin ice will exist in many places should not be forgotten. Care must be taken in crossing the ice at any time.

WEATHER

Throughout the winter the thermometer several times fell to many degrees

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[2] Ibid. pp. 42-45

below zero, but there were two periods of severely cold weather. (See Figure 2.) The first was from 2 December to 15 December when temperatures were consistently below -30° F. The second was from 16 January to 5 February when each day the temperature fell below -50° F., with a seasonal low of -62° F.[3] This was the longest period of temperatures consistently below -50° F. ever recorded at Fairbanks. During this same period the lowest temperature ever recorded on the American continent, -82° F., was recorded by the weather station at Snag, Yukon Territory.

Snow depth during the winter season varied from a minimum of ten inches in November to a maximum of thirty-three inches in January. The texture of the snow was light, loose, and powdery; and, due to the extreme cold, remained dust-like even when picked up and packed. Shallow snow did not seriously effect the traction of vehicles as happens in warmer climates, because a film of water turning to ice did not form between the wheel and the snow; in other words, it was similar to driving through deep dust.

Fortunately, the wind at Ladd Field was relatively still. When the temperature was very low, few cases were experienced when wind velocity was greater than two or three miles per hour. At one time, when the temperature ranged between 0° F. and -10° F., a twenty to thirty mile per hour wind arose. Walking in this wind was more uncomfortable than walking at -50° F. with no wind. The same chilling effect, known as wind chill, existed when men were forced to expose themselves to the wind while riding in open vehicles.

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[3] Ibid. pp. 23-27

TEMPERATURE GRAPH - WINTER, 1946-47 - FAIRBANKS, ALASKA

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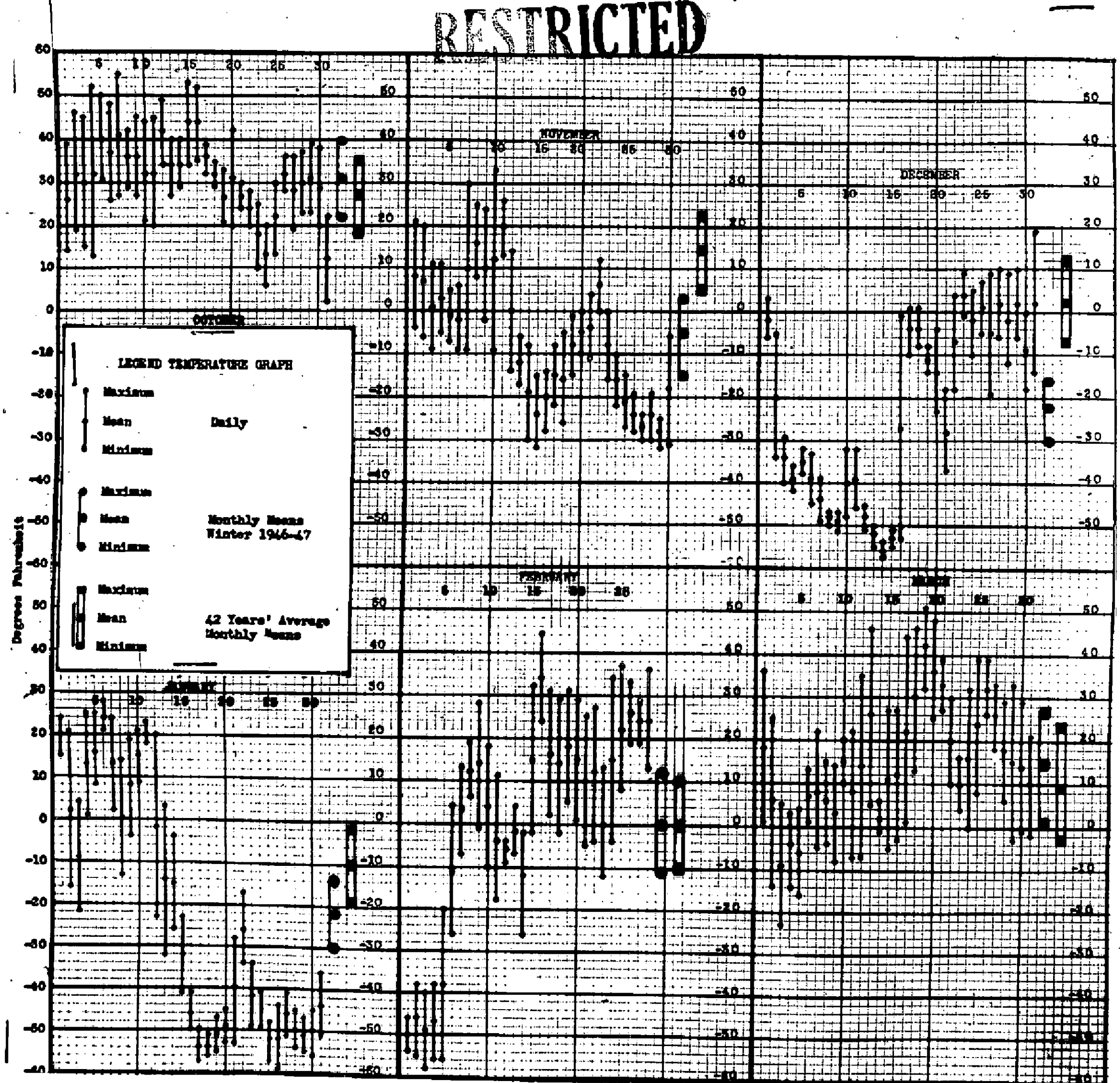

INCLOSURE ( ) Daily and Monthly Maximum, Minimum and Mean Temperatures - Winter of 1946-47 - Fairbanks, Alaska
(Data from U.S. Weather Bureau, Weeks Field, Fairbanks, Alaska)

The lowest temperature recorded by the Field Artillery Observation Battery Field Meteorological Station at Clear Creek Buttes was -62°F.

Figure No. 2

Very little daylight existed during the winter months. On December 21st there were less than four hours of daylight; it became light at 1000 and was almost dark at 1300. During December there were only eleven hours of sunshine, 10% of the total possible.

One of the most interesting of the weather phenomena was the formation of ice fog at extremely low temperatures. (See Figure 3.) This fog was composed of suspended ice particles, which glistened in the sun or moonlight. When these particles became dense, the ice fog took on the appearance of an ordinary moisture fog. It hung close to the ground, not existing for more than fifty feet above the earth's surface. At temperatures ranging between -30° F. and -45° F., this fog hung over inhabited areas and concentrations of troops in the field. It was supplemented by smoke fumes from heating units, vehicular exhausts, the firing of cannon, and mens' breath.[4]

It was observed by pilots over some uninhabited areas at a temperature of approximately -60° F. Its affect on military operations was great; observation of tank fire was difficult, concealment from air observation of troops in the field was impossible, and vehicular safety was jeopardized.

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[4] *Ibid.* p. 31

IV

COMMON PROBLEMS

CLOTHING

The clothing issued to Task Force Frigid consisted of the latest standard cold weather garments. (See Figure 4.) Body clothing consisted of woolen undershirts and drawers, woolen shirts and trousers, high neck sweaters, scarves, cotton trousers, pile lined field jackets, pile lined overcoats and pile lined parkas. Headgear consisted of either the pile field cap or the cotton field cap. Footgear consisted of cushion sole socks, ski socks, shoe packs, ski shoes, white felt shoes, and mukluks. Handgear consisted of woolen gloves with the leather shell, woolen mittens with the leather shell, or the arctic mitten. Special equipment in the possession of the men were ski parkas, overwhite parkas and trousers, and wet weather parkas and trousers. In general, the clothing worn by the men during the periods of extreme cold was unsatisfactory.[5]

The long drawers and undershirts shrunk when washed. Thus, when a man put on these garments, they restricted his circulation and hastened the chilling effect. Large, baggy sweat suits were tried and found to be much more successful.

Pile lined clothing "crawled" and "crept" during physical activity. This "crawling" and "creeping" was caused by the pile lining clinging to the garment underneath it. This could be eliminated by covering the pile with a slippery material.

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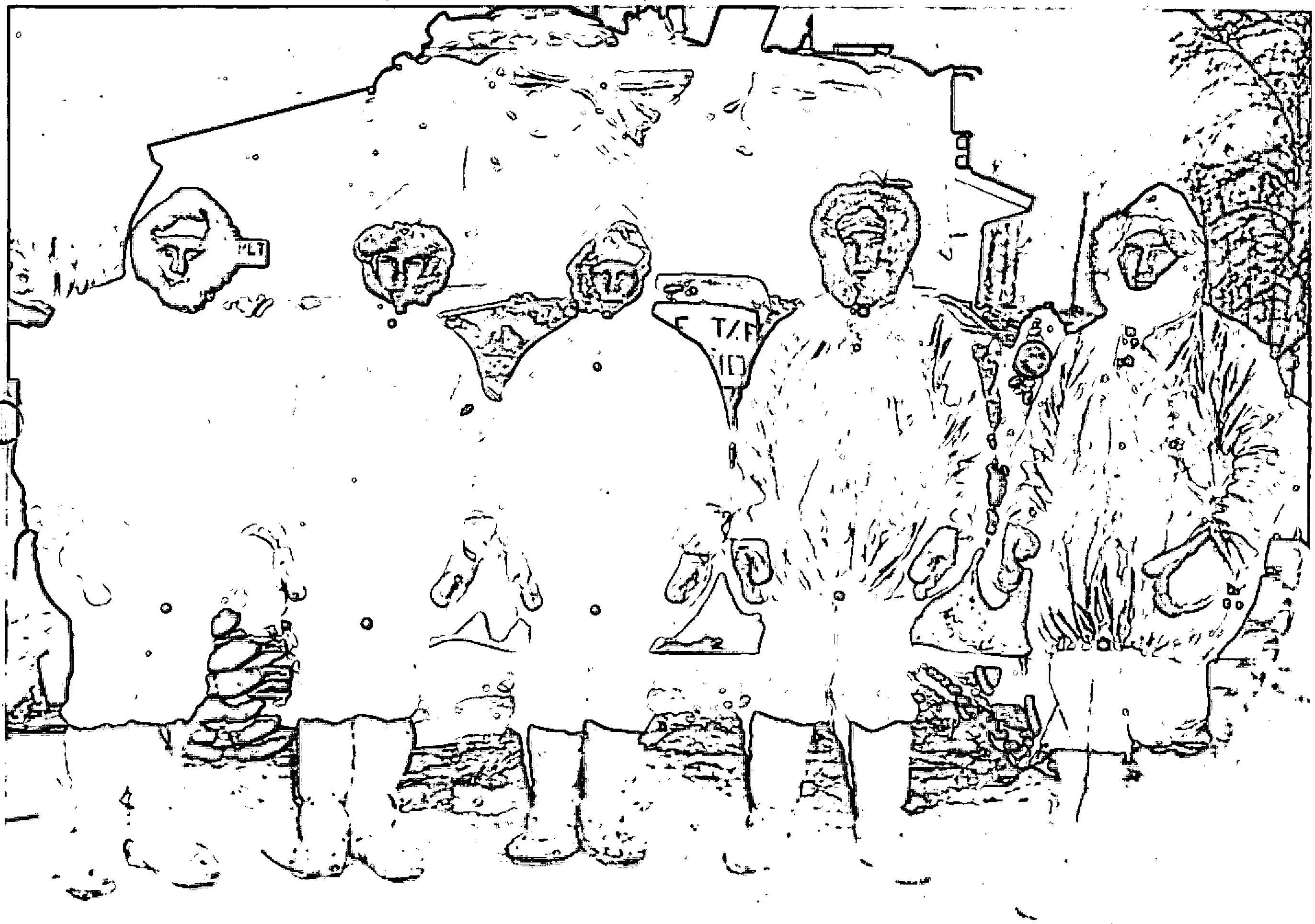
[5]AGF Task Force Frigid, Winter Test Program 1946-47, Chap V, Clothing, Sleeping Equipment, and Shelters, p. 70.



Tank Crew Dressed in the Warmest Standard Clothing Ensemble

Even when tankers were dressed in the warmest standard clothing available, they still became chilled when exposed to extreme cold for long periods.

Figure No. 4

The parka restricted the movement of a man engaged in physical activity, and was very difficult to put on and remove.

The trousers furnished were inadequate. Several truck drivers received frostbitten knees, as they were required to keep their knees bent for long periods of time while driving at temperatures between -50° F. and -60° F. Bending the knees drew the trousers tight and restricted circulation. Experimental, pile lined trousers which fitted snugly around the ankles, but which were baggy and fitted loosely around the knees, were found to be very satisfactory.

Footgear was probably the most serious clothing problem. When a man was active, sweat dampened his socks; and, during a period of inactivity, this sweat became cold and chilled his feet. Numerous cases were observed of men taking off their shoes and noticing ice on their socks. The mukluk, worn with one pair of cushion soled socks, two pairs of ski socks, and an inner felt boot, was the warmest footgear. The felt shoe, with one pair of cushion soled socks and two pairs of ski socks, was almost as warm. In both the mukluk and the felt shoe the sweat was absorbed by the canvas or felt and later evaporated by the outside air. Neither the mukluk nor the felt shoe had rubber soles, so the infantryman had great difficulty in keeping from slipping on a snow-packed trail, and the tanker risked his neck every time he crawled on or off a tank.

Handgear was another problem. The arctic mitten was the only glove sufficiently warm at temperatures much below -20° F. This mitten was so bulky that a man had great difficulty in performing any small operation such as knotting a rope, firing a rifle, adjusting a tank sight, or operating a radio.

The broader aspects of obtaining the proper clothing for each individual were much harder to solve. Proper clothing must take into consideration the physical condition of the man, previous exposure, length of exposure, degree of acclimatization, degree of bodily activity, wind velocity, materials, and fit. To illustrate each of these points, I shall cite an actual example.

Two men walked outside each morning to the latrine. One of these men, the company clerk, got his daily exercise walking from the barracks to the orderly room and return. For his trip to the latrine this man could never put on enough clothes to keep warm. The second man went out on strenuous infantry problems each day, pulling sleds, walking through deep snow, and entrenching weapons. For his trip to the latrine this man would wear only a sweat shirt and a pair of long drawers.

During one field problem, when the temperature ranged between -50° F. and -60° F., several men who had been out all day recovering disabled vehicles returned to their barracks. Three hours later they were called out again along with several men who had not been out at all. All men wore approximately the same clothing. The men who had been out previously became cold much quicker than those who had not been out, and it was necessary to evacuate one man to prevent ffostbite.

A truck driver, when making a long trip at very low temperatures, became cold regardless of how much clothing he wore. The cold would start in his feet, hands, or both, and spread throughout the rest of his body.

A group of observers accustomed to temperatures ranging from 20° F. to 40° F. arrived from the United States and were taken into the field when the temperature was -55° F. These observers became chilled in much less time than the men who had been in Alaska for several months.

When the tankers and the infantry went out on a combined problem, the tankers became much colder than the infantry, although the infantry wore less clothing. This was due to the difference in the bodily activity of the two groups. On one night when the temperature was -55° F., a plane crashed about two miles from the barracks. Several officers, including myself, dressed carefully in our warmest clothing and set out to find the plane. We traveled fast and through deep snow for thirty minutes. At the end of this time sweat was pouring off my face, running down my clothing, and saturating my gloves, even though the temperature was extremely cold. We stopped for a ten minute rest before starting back. At the end of this time I could feel that my sweat was turning to ice, and that I was very tired and drousy. If there had not been a warm barracks to return to, I believe that I could have settled down to that eternal sleep that is the fear of the North.

The material from which a garment is made controls its warmth. For instance, some of the men were able to purchase boots made from caribou skin to wear inside mukluks. These were much warmer than the standard felt boot. However, the purchase of furs to equip a large number of men is prohibitive due to their scarcity and cost.

Fit is important since tight clothing will cut off circulation and increase the chilling effect. One case in point was a man who, at -50° F., wore socks that were too small for him. This resulted in his developing frostbitten toes and having to be evacuated.

The examples cited above are meant to show that the problem of clothing in extreme cold cannot be solved by developing one clothing ensemble for each temperature. Clothing developed must be flexible enough to allow the hard working infantryman, the riding tanker or driver, or the sedative clerk to receive the protection he needs.

A uniform that would probably meet the essential requirements should consist of not more than three layers for the principal garments. (See Figure 5.) The first layer should consist of loose fitting, sweat suit type drawers and undershirts. Garments making up this layer should provide insulation free of constriction. They should be capable of being easily laundered without shrinking, or of being replaced by clean items.

The second layer should consist of a hip-length, parka-type jacket of 1/2-inch pile, covered to prevent twisting, and cut so as to allow complete freedom of the arms and shoulders. A removable pile-lined hood should be provided. Trousers should provide for the snapping in of a heavy pile lining in such a way as not to interfere with movement of the crotch; nor should the pile extend down so far as to cause a multiple layer of clothing around the lower leg.

The third layer should consist of a heavy pile parka of the front opening type, equipped with a zipper, and sufficiently large to avoid any constriction of the arms or shoulders. The hood should extend three inches beyond the face, with a wire inserted in the ruff to control the opening of the ruff to the desired degree. Pockets should be wool-lined to prevent chilling of the hands when reaching for cigarettes or other items. Slip-over trousers just longer than knee length, piled-lined, and made with wind repellant material should be provided. The bottoms of the trousers legs should be equipped with drawstrings

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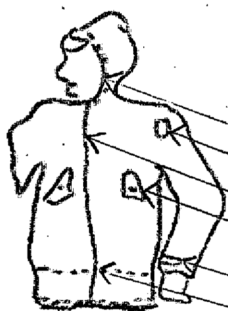
RECOMMENDED CLOTHING FOR ARCTIC SOLDIER

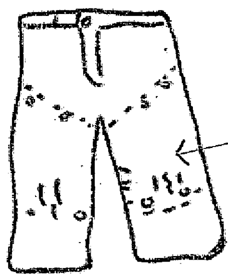
Layer One

Woolen undershirt
Woolen drawers
- Tie
- Overlapping fly
- Loose fitting legs
- Knitted cuff



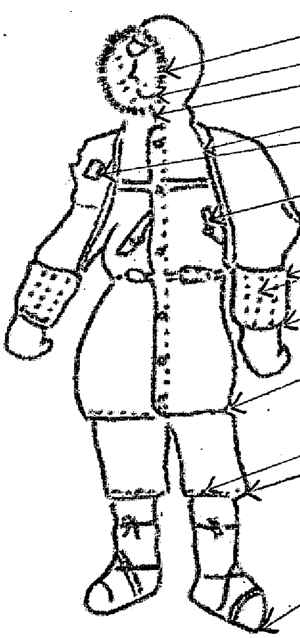
Layer Two

Inner parka lined with pile
Outer shell, wind, water, and wear resistant
- Drawstring closure
- Pencil pocket
- Heavy duty zipper
- Wool lined slash pocket
- Adjustable closure
- Drawstrings



Cotton field trousers with "snap-in" pile chaps
- Cut wider in front than in rear to give baggy knees

Layer Three



Heavy outer parka
- Wire ruff
- Drawstring
- Zipper
- Mitten harness
- Cigarette and pencil pocket
- Wool lined pockets
- Deep, stiff gauntlet
- Stiffening ribs
- Adjustable strap
- Drawstring

Overtrouser, lined with pile and covered with jo-cloth
- Drawstring
- Trouser leg wide enough to admit footgear
- Rubber sole

Figure No. 5

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so that they can be drawn in snuggly around the mukluk tops.

Easy access to the penis should be provided through all three layers of clothing, since urinating while wearing complete arctic clothing was a major chore for men in the field.

Handgear should consist of a loose-fitting, light woolen mitten next to the hand, covered by a ¼-inch pile mitten extending several inches above the wrist. Over the pile mitten there should be a leather palmed, wind repellant gauntlet extending up the arm at least half way to the elbow. This gauntlet should snap to the outside of the parka and should not allow snow to get between the gauntlet cuff and the parka arm.

There is a requirement for a small hand heater, about the size of a zippo lighter, chemically heated by expendable cartridges, and capable of retaining a temperature of 60° F. for three hours.

Footgear should consist of the felt shoe over which should be placed a mukluk with heavily insulated soles, pile lining around the foot and calf, and a hard rubber traction sole on the bottom of the foot.[6]

Several tests were conducted with electrically heated suits. (See Figure 6.) These suits had to be borrowed from the Air Corps since none were available to the Ground Forces. One crew of an M4A3E8 tank was equipped with electrically heated suits. When the crew wore issued arctic clothing, this tank could not be operated at temperatures below -4° F. due to the wind chill factor in the M4A3E8 tank. When electrically heated suits were worn, reasonably efficient operation

[6] Ibid. pp. 75-78

Tank Crewman Dressed in an Electrically Heated Suit

The Task Force recommended that tank crews, truck drivers, and others whose jobs do not require a high degree of bodily activity, be equipped with electrically heated suits.

Figure No. 6

could be obtained at -62° F.

The main disadvantages of the suits tested were that they worked only on a 24-volt circuit; that the heat into the suits could not be controlled; and that they were not sufficiently durable to withstand strenuous combat service.

The immediate development of electrically heated suits specifically for Ground Force use was recommended by the Task Force. These suits should be worn as an adjunct to the recommended clothing described above by such troops as are not engaged in strenuous physical activity. These troops include tank crews, truck drivers, and armored infantry riding in personnel carriers. In case the electrical source fails, other arctic clothing should be immediately available to keep the men from freezing. The suits developed should be lightweight and durable. They should be rheostatically controlled on a 12-or 24-volt DC current, and have zonal control so that additional heat could be applied to the feet, hands or other parts of the body. They should put out sufficient maximum heat to keep an inactive man warm at -70° F. for a period of at least six hours.[7]

SLEEPING GEAR

Sleeping in the field was very unpleasant for most of the men, since the sleeping gear furnished them was inadequate at very low temperatures. Two types of sleeping bags were furnished. One was the Mountain Sleeping Bag which was a canvas, mummy-shaped bag filled with down and feathers. The other was the Arctic Bag, M1942, which was a large Mountain Bag with a down filled liner inside of it.

[7] *Ibid.* pp. 79-80

When the temperature was -59° F., a group of men attempted to sleep outside in arctic bags. They were dressed in wool underwear, trousers, shirts, sweaters, pile caps, and ski socks. Insulation underneath consisted of a pile parka, shelter half, and an insulated sleeping pad. None of the men were able to sleep, and it was necessary to supplement the insulation with from three to five blankets in each case.

In the construction of an adequate arctic sleeping bag there are two conflicting requirements. The first is that it should be lightweight so an infantryman can carry it on his back. The other is that it should be warm enough to provide a soldier six hours uninterrupted sleep at -70° F. The Task Force felt that the second requirement is the more important. Very close logistical support of the front line soldier is necessary, so his arctic bag would probably be carried for him in a vehicle. Other thoughts on the subject are that the problem could be solved by integrating sleeping with heated shelters, or by providing electrical or chemical auxiliary heat for the sleeping bags.[8]

The men in the Task Force solved their problem by sleeping very close to their tent stoves, and having one man watch the stove with an eagle eye so as not to let it go out.

SHELTERS

Standard army tentage, including the two man shelter tent and the squad tent, were unsatisfactory at low temperatures. It was impossible to drive

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[8] *Ibid.* p. 81

wooden pins into the frozen ground without breaking them, and the snow did not provide sufficient bearing surface to hold them. Much trouble was experienced in folding tents that had been standing for several hours at low temperatures. The canvas was very stiff and more like wood than canvas. Also, insulation was insufficient to prevent the cold from coming in. In the case of the squad tent, a man became cold when he stood farther than two feet from the stove in the center.

The most successful tent tested was the five man lightweight pyramidal tent. This tent was provided with a good door, ground closures, an inner liner, an adjustable ventilation system, and a low crown. A small, pot-bellied, Yukon Stove produced sufficient heat to provide reasonable comfort at temperatures down to -55° F.

Another tent tested was the Two Man Mountain Tent. The parachute infantry company spent one night sleeping in these unheated tents when the lowest temperature was -62° F. Several men had to be evacuated to prevent frostbite. When two men with all of their equipment were inside the tent, there was insufficient room to dress or undress. Hoar frost formed on the outside and inside of the canvas and would fall down a man's neck while he was attempting to dress.

The most satisfactory troop shelter was built by the tank company. This was a sled-wannigan twelve feet long, ten feet wide, and seven feet high, equipped with five bunks and heated with a 1941 Tent Stove. (See Figure 7.) It was built of boards and carefully insulated from leaks. It was towed behind a tank; it provided adequate shelter for the tank crew; and did not require any time to set up.

Still another type of shelter used for aid stations, orderly rooms, and warming rooms was the Jamesway Shelter (16 feet by 32 feet). This shelter was highly desirable since it was easy to heat; it possessed an adequacy of insulation; there was abundant light; and erection was fairly simple. Six men could normally erect it in one hour. One 2½-ton truck was required to transport it. Its bulk and weight were its chief disadvantages.

One interesting tent tested was a Swedish tent. This was a decagonal-sided, pyramidal tent, approximately eighteen feet in diameter. Its center support served as both tent pole and smoke stack. Internal tension suspension eliminated the need for external guy ropes. The tempered steel pins were the only drivable pins in the Task Force.

The largest tent tested was the large Maintenance Tent. (See Figure 8.) It was large enough to hold a 2½-ton truck, and it provided sufficient room to perform second echelon maintenance on the truck. Most of the companies used this tent as a mess hall while they were in the field. It was heated by a gasoline tent heater (Herman Nelson).

The Task Force concluded that three categories of tents were needed by the army for operation in extreme cold. The first was an extremely lightweight, packable, sectional tent, adaptable for a small stove, and suitable for emergency use only. The second was a lightweight, liner-insulated, group shelter for four or five men, incorporating the good points of the Swedish Tent and the Small Pyramidal Tent described above. The third was a prefabricated type shelter, suitable as a mess hall, maintenance shelter, or hospital, much like the Jamesway Shelter described above, but having more space and less weight and bulk.[9]

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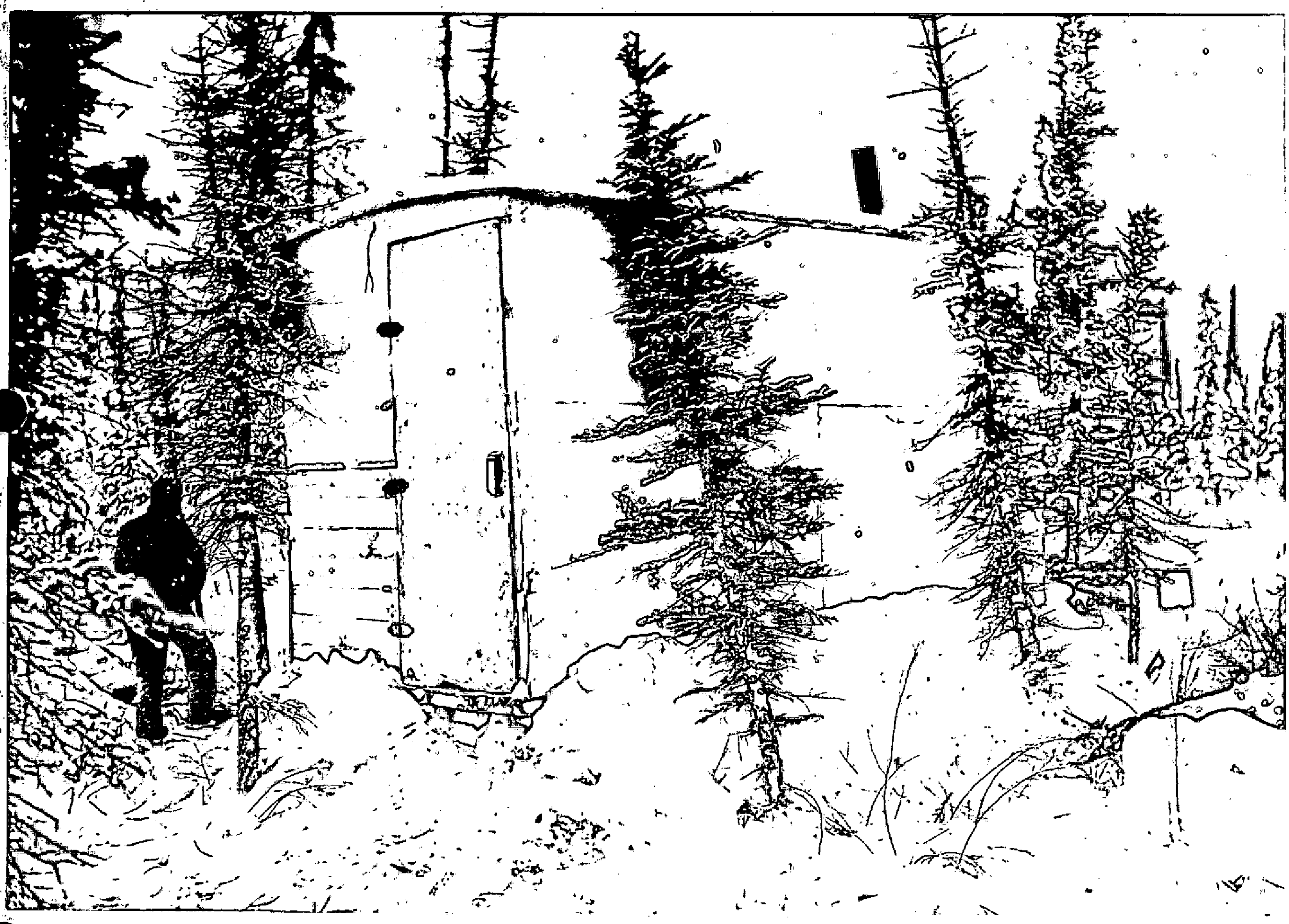
[9] *Ibid.* p. 90



Wannigan Shelter

The tank company constructed a wannigan shelter which could be towed behind a tank and which provided warm housing for the tank crew.

Figure No. 7

Large Maintenance Tent

This large tent, heated by one Herman Nelson Heater, was used to house trucks during maintenance periods. It was also used to shelter troops while they were eating.

Figure No. 8

RATIONS AND MESSING

The principal types of rations issued to the Task Force were types "A", "B", and "E". When the temperature was -37^{o} F., "A" rations were served in the normal manner; that is, men passed through a mess line and "hot" food was placed in their metallic mess kits. This method was unsatisfactory as ice crystals formed in the food within five minutes after serving.

Hot water was made available in which the men could dip their mess kits before being served, but this was impractical since the water turned to ice by the time the men reached the serving point. The Task Force concluded that the successful transporting of "A" rations in the field was contingent on having a heated warehouse, having the battalion breakdown agency in a warm shelter, and using heated vehicles to transport the ration to the field messes. Also, the preparation of the "A" ration in the field kitchen tents was very unsuccessful as frost would form on the canvas ceiling, melt, and drip into the food and on the kitchen personnel.[10]

Little success was achieved in heating "E" type rations individually. Heat tablets were dropped into a container of water and the rations placed in the container, but insufficient heat was generated to warm the rations. Also, lighting a small one-burner stove or a three-ounce can of alcohol and placing the ration over the flame was unsuccessful, as ignition was difficult, and the heat from the flame was rapidly dissipated. Heating individual "E" rations over a large stove was equally discouraging. In all cases that I experienced, the ration

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[10] AGF Task Force Frigid, Winter Test Program 1946-47, Chap V, Rations and Messing, pp. 93-97.

was frozen, and heating resulted in charring the contents near the bottom of the can before the food at the center of the can reached the thaw point.

The only successful method of feeding small groups of soldiers in the field was to transport hot food to them in an Insulated Hot Food Container. Twenty-four cans of "E" rations and a hot beverage remained at a palatable temperature after the container was exposed to a temperature of -54° F. for fourteen hours. (See Figure 9.)

The organizations found that their men could not eat their food in the open even though it was given to them hot. The tank company fed their men with questionable success under three large maintenance shelters put end to end, and heated by two Herman Nelson Heaters. As in the case of kitchen tents, water would drip into the food; and the assembling of an entire company under one tent was tactically dangerous. Later, when each tank crew was provided with either a wannigan type shelter or a small, heated tent, the most successful method of feeding was employed. The food, after being prepared in either the special kitchen trucks or sled kitchens, was placed in Insulated Hot Food Containers and distributed by weasel to the tank crews in their shelters. In this way the men were able to eat hot food in reasonable comfort, and the morale of the unit was improved.

Several types of company field kitchens were tested. In several cases, Ordnance Maintenance Shop Trucks were converted into kitchen trucks. In other cases, an entirely new kitchen-type body was constructed on the backs of $2\frac{1}{2}$-ton trucks. Generally, these kitchens were unsatisfactory because of the poor cross-country mobility of wheeled vehicles.

Soldier Ladling Coffee From a Hot Food Container

The Hot Food Container was used successfully to keep "E" Rations, coffee, and other food warm for several hours at temperatures as low as -55° F.

Figure No. 9

Another type tested was the sled kitchen. This kitchen was not large enough for an entire company and it did not track well behind any prime mover except the weasel. Besides, its high center of gravity caused instability, and moisture condensation resulted in frost and ice covering its floor and walls. In general, however, it was the most successful kitchen used in the field, since it could follow cross-country behind a tank or infantry unit.[11]

The supply of drinking water to personnel and kitchens was a difficult problem. At -33° F., it was possible to keep the water fluid in a 250-gallon water trailer by inserting an immersion heater into the water. However, this failed to keep the outlet valves and pipes from freezing solid and rupturing. The only method of obtaining water from the trailer's tank was to remove the bottom drain plug.

The standard canteen was unsuitable for obvious reasons; the water would freeze and rupture the metal. Water could be kept fluid when carried next to the body in a soft canteen, but these canteens were uncomfortable and sometimes would break. The process of melting enough snow to get a drink of water was tedious work, since a tremendous amount of snow was needed to get a very small amount of water. There is a definite requirement for an insulated, individual canteen that will keep water fluid at the lowest temperature expected. The melting of snow should be required only as an emergency measure.[12]

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[11] Ibid. pp. 101-102

[12] Ibid. pp. 98-100

MEDICAL CONSIDERATIONS

It is imperative that every officer and enlisted man working in the Arctic be well grounded in the principles of first aid, since any delay in treating a wounded man will result in his death. Emphasis must be placed on keeping casualties warm. Each front line soldier should carry his arctic bag with him or on his vehicle, and he should be placed in it immediately upon becoming a casualty. In addition, front line medical aid men should be equipped with a small vehicle, such as a weasel, in which they could carry several Casualty Evacuation Sleeping Bags.[13]

Each bag was equipped with five zipper slides through which an aid man could check or change dressings. These bags were found to be sufficiently warm to keep a man comfortable for one hour at temperatures below -40° F.

An Air Corps Evacuation Electrically Heated Blanket was used. At -40° F., it kept a man comfortable for two hours. This blanket was constructed for a 24-27 volt electrical system. Therefore, it was unsatisfactory for ground force use in its present form. A twelve volt blanket for a weasel or a 3/4-ton ambulance would be a great aid in keeping a patient warm.[14]

Rapid evacuation was considered essential for a wounded man's survival. Experiments were conducted using several methods. Skis were employed by placing an adapter and a litter on the skis. This conveyance was towed by two men.

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[13] AGF Task Force Frigid, Winter Test Program, 1946-47, Chap XVI, Medical, pp. 307-308.

[14] *Ibid.* pp. 308-309.

This method was not satisfactory cross-country since the patient's head or feet, being close to the snow, would act as a snow plow. In time, the patient would be completely covered with snow. When used on hard packed trails, this method was very satisfactory.[15]

The use of the weasel was a very successful method of evacuation. This small vehicle could carry one litter and two walking patients at one time, and could travel at 5 m. p. h. through the deepest snow encountered. When used as an ambulance, the weasel should be entirely closed in with side curtains and equipped with heaters, although care must be taken to prevent carbon monoxide poisoning.

Evacuation by sleds pulled by dog teams was attempted and found to have certain advantages over any other methods. Dog sleds could reach points closer to the front lines than weasels, since dog sleds made less noise and had lower silhouettes. Also, they were able to travel faster than ski litters towed by aid men.[16]

The fastest method of evacuation was by helicopter. On several occasions, a helicopter, equipped with two evacuation tubes, landed in deep, unbroken snow. It picked up two simulated casualties and in a very short time deposited them at a rear area medical installation. (See Figure 10.)

The 3/4-ton ambulance was immobile cross-country and on unimproved trails.

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[15] Ibid. pp. 310-311

[16] Ibid. pp. 312-313

Therefore, its primary use was in rear area evacuation where it could travel on good roads.

The standard hospital tent could not be kept sufficiently warm, even when its stove was red hot. On one occasion bottles of nose drops and boric acid placed within three feet of the stove froze and broke. The Jamesway Shelter could be made into a warm, thirty-two bed hospital ward. Its use as a battalion aid station is contingent on the rapidity of movement of the tactical situation.[17]

If a soldier is wounded in the front lines, somebody must be immediately available to take care of him. Therefore, the system of every man continuing on his mission to close with and destroy the enemy, allowing aid men to care for the wounded, must be modified to some extent. The system employed by the Task Force was to use a "buddy system" in which each man in an organization was paired with another man. If one man were wounded, the other would stop and look after him. It cannot be over-stressed that if a wounded man, even a slightly wounded man, is allowed to lie at -50° F. in the open and unattended, he will die.

Treatment to prevent shock is the single most important first aid measure. This consists principally of keeping the wounded man warm. All aid men should be equipped with one gallon thermos jugs, so insulated as to keep a stimulant hot at -70° F.[18]

Due to the many layers of clothing a man wears in the Arctic, wounds are

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[17] Ibid. pp. 306-307

[18] Ibid. p. 319

Evacuation by Helicopter

Evacuation of simulated casualties by means of helicopter was the fastest method of evacuation used by the Task Force. Two casualties could be evacuated at one time in casualty evacuation tubes.

Figure No. 10

difficult to reach. Each "buddy" must carry a sharp knife so that he can cut down to the wound quickly. Again, the man applying the first aid lacks the manual dexterity to work quickly, since his clothes are bulky. Aid men of the Task Force wore nylon gloves under their arctic mittens with which they could work five minutes at -30° F. without warming their hands. If a wound is exposed, the blood will freeze and bleeding can be controlled. However, care must be taken that the wound is covered as soon as possible, since exposed tissues will become frostbitten, and healing will be retarded. The tourniquet must be used with caution, as extreme cold will cut down the circulation to the extremity, and freezing may easily result.[19]

In using morphine the same principles apply as in temperate climates. However, the syrette will freeze unless kept close to the body. It can be thawed by placing the syrette with the needle covered in the mouth for approximately two minutes. Since the extremeties are covered with bulky clothing and circulation through the extremeties is slow in extreme cold, morphine should be injected into the neck.[20]

Let us consider the non-battle injuries that are peculiar to extreme cold. The most important was frostbite. (See Figure 11.) Eighty percent of the frostbite cases suffered by men in the Task Force occurred when the temperature was between -40° F. and -62° F. Frostbite occurred in one to two minutes when windchill was involved at temperatures under -40° F., but seventy percent of all

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[19] *Ibid.* pp. 319-320

[20] *Ibid.* pp. 319-320

cases occurred after three hours of uninterrupted exposure.[21]

Several men had severe pains in their chests after violent outside exercise when the temperatures was -50° F., and it was thought at first that these men had developed frostbitten lungs. However, it was later learned that the mucous membranes of the respiratory system were the only parts affected. No serious or permanent injuries resulted.

The most frequently frostbitten body member was the nose. Almost every man who worked outside during the long stretch of -50° F. temperatures contracted a frostbitten nose on several occasions. The "buddy system" worked very well in detecting this condition, since a man seldom realized that he had contracted a frostbitten nose until his "buddy" told him that the end of his nose was white.

Frostbitten feet was the second most prevalent injury. Generally, this can be prevented by insuring that footgear fits properly, and that the men have an extra set of clean, dry socks to change into when their feet become wet from perspiration. If a foot or hand becomes frostbitten, the best first aid measure is to thaw it by placing it in the armpit of a "buddy". A frostbitten foot should not bear weight, or be rubbed. It should not be rubbed with snow, or be dipped into warm water. Nor should it be brought close to a fire.[22]

Carbon monoxide was regarded as a potential killer, since men operated from tightly closed vehicles, and lived in quarters without adequate ventilation. Although there were several cases of monoxide poisoning in the Task Force, there

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[21] Ibid. pp. 320-321

[22] Ibid. p. 321

Frostbite of the Hand

The most prevalent injury suffered by men in the Task Force was frostbite, including frostbite of the nose and face, feet, hands, and ears.

Figure No. 11

were no deaths from this cause. On one occasion two officers placed the hot air duct of an Auxiliary Cold Starting Aid Kit inside their tent for heat, not realizing that the air coming out was polluted. Although they became sick, they were pulled out in time to escape death. On several occasions men became sick while riding in closed weasels. Care had to be taken to keep these vehicles ventilated, especially at the lowest temperatures.

Snowblindness, often considered one of the worst scourages of a snow-covered country, was not prevalent in the Task Force. Ice fog, scrub growth, and trees broke the glare, and the dark glasses furnished the men gave them adequate protection when gazing for long periods at snow fields.

The drinking of whiskey before going outside in the cold was considered very dangerous. It produced a dissipation of body heat and a rapid drop in deep body temperature. A man under the influence of alcohol can freeze to death in a very short time. Also, he loses his normal caution and fails to protect himself against the cold. On one occasion when the temperature was -55° F., one soldier went into Fairbanks and proceeded to drink heavily at one of the taverns. He had an argument with another soldier, and they went outside to fight. It ended by one chasing the other several hundred yards outside the tavern. Both men were found unconscious in the snow a few minutes later. Although neither man received a permanent injury, both received badly frostbitten ears, since their heads were not covered. Both were lucky that they were discovered quickly enough to save them from freezing to death.

One of the best attributes a man can have in the Arctic is the ability to think and act quickly, and take care of himself or his "buddy" in an emergency.

One case in point was told to us by a noted Arctic explorer who related an incident that occurred to him during one of his expeditions.[23] While crossing river ice with a companion when the temperature was -45° F., the ice gave away and he fell over his head in ice cold water, which penetrated his clothing to the skin. After getting out of the water he hopped around like mad to keep his blood circulating. At the same time he stripped off his clothes, handing them to his companion who brushed the already formed ice off of them. By the time he was completely undressed, he started putting the ice-free clothes back on. The entire operation took less than one minute, and his violent endeavor kept his body warm and probably saved his life.

SANITATION

Outdoor latrines similar to those used in temperate climates were totally unsatisfactory, since the ground was too hard to dig and men refused to defecate regularily in the open. The tank company constructed a very effective answer to the problem. (See Figure 12.) They built a wannigan-type latrine which was towed behind a tank. This latrine contained four seats and a stove which kept it comfortably warm. Removeable oil drums cut in half provided waste receptacles. Diesel oil was placed one-half inch deep in the bottoms of the drums. A mixture of gasoline and fuel oil was poured over the waste and then set afire. The waste was burned to a complete ash and then dumped on the ground.[24]

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[23] Sir Hubert Wilkins, Arctic Explorer

[24] AGF Task Force Frigid, Winter Test Program, 1946-47, Chap XI, Armor, p. 233.

Garbage disposal was handled differently in the Arctic than in temperate climates. No insects were present to visit the garbage, then visit the food being eaten. The garbage was placed on the ground and allowed to dehydrate, then it was saturated with gasoline and burned. Many times while it was dehydrating wild animals would eat it.

Personal hygiene was important but very difficult to accomplish in the field. There was a lack of water, a lack of heated facilities for bathing, and a feeling of inertia on the part of the men. In extreme cold it was difficult to get men to care for their teeth, wash their feet, and have a daily bowel movement. It is imperative that unit commanders take personal steps to make these routine matters as easy of accomplishment as possible. The automatic issue of clean underwear and socks with the ration is a step in this direction.

NUTRITION

The health of any command operating in the Arctic, from a medical standpoint, is directly dependent upon efficient messing procedures and an adequate supply of wholesome food. Assuming the availability of food in sufficient quantities, optimal caloric consumption is a function of expert preparation, efficient mobile heating and cooking equipment, and satisfactory mess gear. Five thousand calories per day per man are needed in the Arctic, while approximately three thousand are needed in a temperate climate.[25] Due to the added importance of nutrition in extreme cold, it behooves each commander to insure that an ade-

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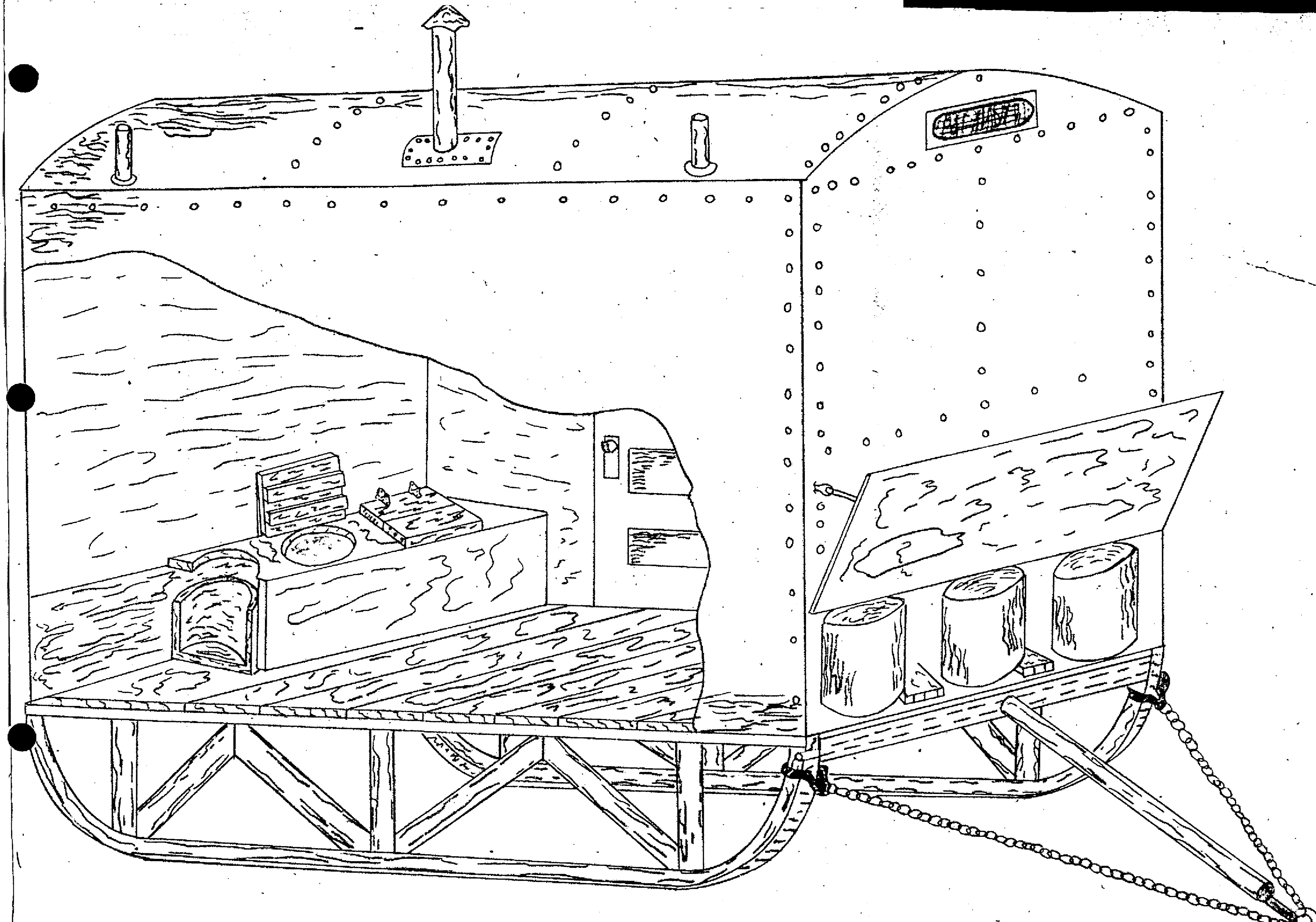
[25] AGF Task Force Frigid, Winter Test Program, 1946-47, Chap. XVIII, Physiological, p. 341.



ARCTIC WANNIGAN, LATRINE

Soldiers are unwilling to defecate in the open at low temperatures. A closed-in, heated latrine is an absolute necessity.

Figure No. 12

quate supply of wholesome food is forthcoming, and that the most efficient mess procedures are used.

TIME ENERGY STUDIES

Crews of M24 and M26 tanks engaged in maneuvering at temperatures between -10° F. and -50° F. were found to be in negative heat balance; that is, their bodily heat temperature was sub-normal. Among ten men riding in tanks for three uninterrupted hours at temperatures between -40° F. and -50° F., there were no frostbite casualties. Although all men complained of being cold, only one indicated that he was too cold to perform his duties. Men firing weapons, such as machine gun crews, became uncomfortably cold in one hour at temperatures between -40° F. and -50° F. Troops engaged in the same activity were comfortable after one and one-half hours when the temperature ranged between -20° F. and -25° F. These same troops, exposed to a temperature of -50° F. in the open for two hours, developed frostibte. Men who maintained a moderately high activity level, such as those engaged in snow-shoeing in soft snow or pulling toboggans, remain comfortable when exposed for at least two hours to temperatures as low as -50° F. At -40° F., troops were unable to prepare E-type rations in the open using a small one-burner stove. Troops transported in trucks at low temperatures arrived at their destination with considerable heat deficit and very poor mental condition, which greatly reduced their efficiency and predisposed them to frostbite.[26]

PRESELECTION OF INDIVIDUALS

Due to the rigors of living in an extremely cold climate, the Task Force

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[26] Ibid. p. 342

felt that men should be carefully preselected for Arctic service. The medical section studied individuals for the purpose of determining what factors should be considered in the preselection. Although their findings were not at all conclusive or final, they listed several criteria they believed important. These were as follows:

1. A minimum of twelve months military service.
2. High degree of physical fitness.
3. A minimum grade of IV on AGCT.
4. High motivation and incentive.
5. A "normal" score on psychological tests.
6. Origin from a small community.
7. Mechanical aptitude.
8. Previous experience with cold weather.[27]

TRAINING

The soldier in training for the Arctic should receive careful mental preparation in what he may encounter. Thus, he will withstand conditions which may seem, at first, terrifying to him. During his first contact with the cold, he should be taught to be cautious, but that with his training he can easily master the conditions he faces.[28]

The soldier must be trained to proficiency in his job before he can be ex-

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[27] Ibid. p. 342.

[28] AGF Task Force Frigid, Winter Test Program, 1946-47, Chap. XX, Training, p. 386.

pected to efficiently perform under conditions of extreme cold. For instance, the truck driver, who has not been trained to quickly and efficiently perform maintenance services in temperate climates, will neglect his vehicle under extreme conditions. His truck, in turn, will fail, since a high standard of maintenance is essential to operation in the cold.

Soldiers should be volunteers whenever possible. Job satisfaction is of primary importance, since the difficulties enoountered in operating equipment are many, and men will become discouraged and lie down on their jobs. They should possess higher than average standards of leadership and discipline. Ingenuity and the ability to meet unique problems should be developed during their training.[29] A case in point was a truck driver who on one extremely cold morning lit a blow torch in order to develop sufficient heat to light a small hand crank heater. He used the hand crank heater to warm a large Herman Nelson heater so that it would start. Finally, he used the Herman Nelson heater to warm his vehicle to a starting temperature.

In order to properly lead enlisted men under extreme conditions and develop in them the desired qualities mentioned above, it is essential that units possess a very high caliber of officer leadership. This statement can be illustrated by comparing two platoons that worked on building an ice bridge over the Tanana River. In one platoon the men were usually huddled around a fire, feeling miserable and very sorry for themselves. The platoon leader was the closest man to the fire and every seldom actively supervised the work of his men. In the second

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[29] Ibid. pp. 386-387

platoon, on the other hand, the men worked hard, very seldom warmed themselves near a fire, and their morale was high, even when the temperature was -50° F. Their officer was the most active man in the platoon. He continually encouraged his men, actively supervised their work, and contracted a frostbitten nose just as often as any enlisted man in his organization.

FIRES

Due to the large number of heaters used by the Task Force, and the lack of ventilation in living and working quarters, there was a constant danger of fire. As the temperature decreased, the fire danger increased, since fire fighting equipment often failed to work properly at very low temperatures.

On one occasion, when the temperature was 0° F., a Weasel was parked in a storage house in which were stored many critical items of Task Force equipment. This storage house was adjacent to the barracks area in which the entire Task Force was housed. The following morning, while the Weasel was being started, a spark ignited some inflammable material. In a few minutes the entire building was blazing. The tank company was alerted for the purpose of knocking down enough of the surrounding buildings to prevent the spread of the fire. However, the fire was brought under control and knocking down buildings was not necessary, although much valuable equipment was destroyed. At a later time the fire marshal stated that if the temperature had been -50° F., a critical situation would have existed, and approximately one-third of the entire barracks area would have had to have been leveled to control the fire.

Fairbanks had its troubles with fires also. On one occasion the telephone exchange burned completely, and the people of Fairbanks were without service for several months. The army came to the rescue by putting in some emergency field wire. On another occasion a liquor store caught on fire. Soldiers that assisted in fighting this fire were given as many bottles of whiskey as they could carry away.

Vehicular engine heaters frequently set vehicles on fire. At least twenty vehicles were badly damaged in this way.

Units preparing for Arctic operation should be specially trained in fire prevention and fire fighting. Commanders of all units in the Arctic must exercise personal and vigorous supervision to eliminate fire hazards and indoctrinate their men in proper fire discipline.

V

OPERATIONS OF SEVERAL ARMS

AIRBORNE

The paratroopers executed a combat exercise jump from four C-47 airplanes when the temperature was -26° F. On his back each jumper carried a rucksack containing a mountain sleeping bag, a poncho, additional warm clothing, one ration, ammunition, and water. Strapped to his harness on his right side he carried a pair of snowshoes. On the left side of his harness he carried his rifle. His outer uniform consisted of "over-white" trousers and parka, ski boots, pile cap, and white trigger-fingered mittens. The total weight of his equipment was sixty pounds. It was difficult for the individual to move, but the equipment carried was believed necessary for survival during the first twenty-four hours on the ground.[30]

Difficulty was encountered in preparing planes in the open for drops at low temperatures. In attempting to place masking tape upon the jagged projections near the jump door, the tape failed to adhere to the plane's surface. One ingenious individual dipped cotton waste in water and slapped it on the plane's surface where it froze and served as a substitute for the tape. The metal floors of the planes were not covered with rubber matting. Men would track in snow which would melt, then freeze, making the floor very slippery and treacherous during the jump exit. Due to these difficulties, planes should be prepared for

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[30] AGF Task Force Frigid, Winter Test Program, 1946-47, Chap. IX, Airborne Equipment and Problems, pp. 176-178.

an airborne operation in warm hangars whenever possible.[31]

Identification of the ground was difficult for jump masters, since the terrain did not possess the landmarks normally found in temperate climates. "Sticks" were slow in leaving their planes due to heavy equipment and slippery floors. A full second was recorded between the exits of individual paratroopers. This resulted in excessive dispersion on the ground. Since the preponderance of a man's equipment was lashed to the parachute harness, the opening shock was no different from that ordinarily encountered. Descent was extremely rapid, consuming from thirty-five to forty seconds, from the time the individual jumped at one thousand feet until he hit the ground. Hard landings were cushioned by two and a half feet of snow in the drop zone.[32] In fact, men stated that they would rather jump in the snow with heavy equipment than on hard ground when lightly loaded.

After landing, each man removed his parachute harness and put on his snowshoes. He then secured his rucksack and weapon and proceeded to a separately dropped bundle which contained the skis for the entire "stick". He removed his snowshoes, put on skis, and departed for his "stick's" assembly point. The average time required to complete an assembly of a "stick" from the time the jump commenced was one-half hour.[33]

The reserve parachute gave the paratroopers some trouble. The pack opening

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[31] Ibid. pp. 178-179

[32] Ibid. pp. 180-181

[33] Ibid. p. 181

elastics became stiff at low temperatures and lost their elasticity. Also, the elastic which holds the rip cord handle in position became hard and excessive pull was required to disengage the handle. Snow tended to seep into the folds and creases of silk of the reserve parachute. This snow would melt when in a warm place, then freeze into ice when taken outside, thus preventing the parachute from functioning. Even though the reserve parachute was not used during a jump, it was necessary to open it, shake it out, dry it, and repack it after each jump.[34]

When packing spare clothing, each man should carry extra headgear and arctic mittens. There were several cases of men losing these items as a result of the shock as their parachutes opened. These men developed mild frostbite on their exposed hands and ears.[35]

In one cross-country operation a three-day supply of gasoline for one hundred weasels was brought in by five CG 15A Gliders. These gliders landed, were unloaded, and were picked up again. A glider landing strip one mile long and fifty yards wide was cleared in one and one-half hours using two weasels. Air resupply was the fastest and most economical method found to resupply units operating cross-country at considerable distances from the roads.[36]

In conclusion, it can be said that the Alaskan terrain, lacking roads and railroads, and cross-country movement of vehicles being slow and difficult,

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[34]Ibid. pp. 184-185

[35]Ibid. p. 187

[36]Ibid. p. 189-190

lends itself readily to airborne and air-transported operations.

INFANTRY

The foot weary doughboy was much more tired after operating a day in the Arctic than he was after operating a day in temperate climates. His clothing and equipment were heavier, and he was often required to move cross-country through unbroken snow two or three feet deep. In addition, his output of energy to keep warm was great.

The maximum rate that infantry, equipped with snowshoes and skis, could move cross-country through two or three feet of snow, was one-half mile per hour. In traveling in column it was necessary to rotate the trail-breaker every twenty-five yards. Otherwise, the leading man would become exhausted. Due to their slow rate of travel and high energy expenditure, it was prohibitive to move infantry troops cross-country for distances greater than five miles and not sacrifice their fighting energy reserves. It follows that some means of transporting the infantry to a point close to the front lines must be adopted.[37]

The Task Force experimented with moving infantry in weasels. This method was very satisfactory due to the low silhouette, excellent oversnow mobility, and adequately heated interior of this vehicle. The main disadvantage was in the large number of vehicles required to transport even a small unit.

Another method attempted was "ski-joring", in which two columns, each of six to eight men on skis, were towed by ropes behind a weasel traveling at nine

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[37] AGF Task Force Frigid, Winter Test Program, 1946-47, Chap. VIII, Infantry Equipment and Problems, pp. 1[illegible]-156.

miles per hour. "Ski-joring" was considered the most rapid and practical means of infantry over-snow transportation, although it was very tiring for the men being towed.

Carrying infantry on tanks was a highly effective method of transportation, although windchill at low temperatures had to be guarded against during movement. Enough heat was generated by the engine to keep the doughboy's feet warm when he stood on the rear ventilator grate. This was an important factor in keeping the infantryman warm enough to fight. An unfortunate accident occurred during an infantry-tank training problem. Slipping on the ice on the rear deck of a tank, an infantryman fell off the tank, catching his foot in the tank track. Before the tank could be stopped, he was crushed to death between the sprocket and the track.

While wearing snowshoes and following in tank tracks made through three feet of snow, infantry could keep contact with tanks moving at three miles per hour. However, when the infantry deployed and broke its own trail, in order to maintain contact with the infantry the speed of the tanks had to be reduced to one-half mile per hour.[38]

Two methods of transporting individual equipment were attempted. First, equipment was packed on packboards or carried in rucksacks. Second, equipment was towed on individual toboggans behind each man. (See Figure 13.) The first method was preferred by the men for general use, as individual toboggans were

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[38] Ibid. p. 160

Infantry Squad on Snowshoes

Through unbroken snow infantrymen preferred to carry their loads on their backs rather than tow them on toboggans, since the toboggans acted like snow plows and hindered progress.

Figure No. 13

a hinderance when traveling through deep snow.[39]

For individual protection against small arms, mortar, and artillery fire, experiments were conducted with snow-foxholes and ice-concrete fortifications. Holes deeper than the depth of the snow could not be constructed without explosives due to the rock-like condition of the frozen ground. Snow, forming an embankment in fromt of a foxhole, was penetrated to a maximum depth of only five feet when struck by a .30 caliber bullet fired from an M1 rifle at short range. Mortar fire was completely ineffective when point detonating fuzes were used, as the snow completely blanketed the scattering of shell fragments. The Task Force felt that a dependable time or proximity fuze for mortar ammunition was necessary for effective mortar fire in deep snow.[40]

Organizations were required to build outdoor arms rooms for their small arms, since a weapon taken into a warm place from outside would "sweat" excessively and rust would result. On the other hand, a weapon kept in the cold after being fired would remain in satisfactory condition for further use. Small arms in the Task Force fired sluggishly at very low temperatures due to congealed oil. When re-lubricated with very light oil, they fired satisfactorily.

Another problem encountered, particularly in the firing of automatic weapons, was the obscuration caused by the condensation of water vapor. This resulted as a result of the burning of the cartridges' propellant, and the condensing of of the vapor into ice fog when it hit the air. At -20° F., this ice fog was

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[39] Ibid. pp. 160-161

[40] Ibid. pp. 162-164

obvious to an observer one thousand yards from the gun. At -40° F., a rapid burst of automatic fire caused the gunner complete lack of visibility for one minute.[41]

The emplacement and firing of crew served weapons was a difficult problem, since special measures had to be taken to provide a steady firing platform. The BAR and Light Machine Gun, M1919A6, were floated on the snow by placing special snowshoes on the bipod feet. This provided a reasonably steady mount. Due to its weight, the Heavy Machine Gun, M1917A1, had to be mounted on the frozen ground in order for it to have a stable mounting. This necessitated the clearing of avenues through the snow to provide this weapon with fields of fire. Mortars were successfully emplaced by cleaning away snow and placing the base plate on the frozen ground. As with other weapons, ice fog was produced when firing mortars. Therefore, it was necessary to place them in deep defilade to prevent detection by the enemy.[42]

The hand carrying of crew served weapons was not feasible except for very short distances, since the already overburdened infantryman could not stand the additional load. The use of hand pulled sleds and toboggans was not feasible in deep, soft snow since they sank deep and snow-plowed rather than gliding smoothly over the surface of the snow. Crew served weapons should be provided with a weasel and sled for carrying the crew and weapon. The sled should be capable of being dragged from defilade to a firing position in the front lines. The

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[41] _Ibid_. pp. 165-166

[42] _Ibid_. pp. 167-168

sled should also serve as a possible firing platform for the gun it carries.[43]

The fragmentation hand grenade, while mechanically satisfactory in extreme cold, was totally ineffective in deep snow. It lost between ninety and ninety-five percent of its effectiveness when it exploded under thirty inches of snow. When an air burst was obtained by holding the grenade for a certain number of seconds after releasing the safety lever, or using an M1 adapter, effect of fragmentation was normal.[44]

FIELD ARTILLERY AND GROUND TYPE AIRCRAFT

The primary difficulty encountered with field artillery cannon in extreme cold was the sluggish performance of the weapons in recoil and counterrecoil. Sluggishness was caused by the congealing of lubricants. This precluded the effective use of all towed field artillery pieces at temperatures below -40° F.[45]

The killing power of a 105mm HE shell burst was negligible in deep snow. Fragments were effective at a radius of only four feet when the shell burst under eighteen inches of snow. The VT fuze was found to be an answer to this problem, but it was necessary to transport it in preheated insulated food containers immediately prior to firing. Difficulty was experienced in untaping ammunition cases, as the tape became hard, unpliable and stuck like cement to the cases. Projectiles on the ground in the open had to be kept covered as uncovered

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[43] Ibid. pp. 167-168

[44] Ibid. p. 172

[45] AGF Task Force Frigid, Winter Test Program, 1946-47, Chap. X, Field Artillery, pp. 193-194.

rounds soon became coated with ice. This resulted in awkward handling and failure of the projectile to load in the chamber.

Forward observers had difficulty in locating shell bursts of 105mm and smaller caliber weapons in snow more than three feet deep. Several rounds had to be fired at one range and deflection setting before the observer could spot a round with which to commence his adjustment.

The field artillery firing battery in the Task Force was tied in with its fire direction center and the forward observation battery by wire. This communication worked well until the snowshoe rabbits, which abounded in the area, chewed the insulation off of the field wire. Also, moose and caribou dragged and broke lines, and the hard riding tankers drove over low hung wire with their tanks.

Artillerymen in the Task Force concluded that the most practicable field artillery weapon for use in the Arctic was a full-track, self-propelled weapon, firing ammunition equipped with VT fuzes at a high angle of fire.[46]

Ground type aircraft were used very successfully by the Task Force. Such missions as patrolling the Tanana River for the ice breakup, liaison between units in the field, and emergency supply and evacuation were executed. However, as with other equipment, trouble was encountered with both the L5Gs and the helicopters used. During the take-off snow that had packed around the brake drums of the L5G melted and the resulting water froze during flight. When the plane landed, the brake drums would be frozen in place, and the plane would

[46] *Ibid.* pp. 212-213

careen helplessly into a snowbank at the end of the runway. When skis were used, eight inches of snow was the maximum depth the plane could negotiate during the take-off. Navigation in the L5G was difficult as the movement of the compass was erratic, and orienting points on the ground were usually snow-covered and confusing.[47]

Two helicopters were used by the Task Force during the field exercises. When the cabin heater failed in one helicopter, the windshield frosted over in a very few minutes and the pilot was rendered blind. This did not occur in the L5G as no heater was provided for this aircraft. The helicopters were provided with both the wheel and float type landing gear. On hard snow or through shallow snow the wheels performed satisfactorily and the aircraft could be taxied. However, in deep snow the landing gear would sink; and snow would foul the engine accessories, clog the cabin heater air breather, and cause the pilot unending trouble. When the float type landing gear was used, the aircraft could not taxi on hard or shallow snow, but it could be used efficiently in deep snow.[48]

It was concluded that the rotary wing helicopter was more suitable than the fixed wing L5G for Arctic operation. It provided better visibility and a minimum of landing space. It provided a more expeditious means of contact with troops in the field, and could be used effectively for air evacuation.[49]

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[47] Ibid. pp. 215-216

[48] Ibid. pp. 216-218

[49] Ibid. p. 219

ENGINEERS

One of the major jobs assigned the engineers during the winter was the construction of an ice bridge over the Tanana River. The purpose of this bridge was to provide a crossing for heavy vehicles before the ice became thick enough to hold this equipment. It was constructed in two sections, each eighteen feet wide, and totaling 537 feet in length. Green trees, each having a minimum diameter of eight inches, were cut and dragged to the bridge site. These logs were laid in three layers, criss-crossed to form pockets. Water, pumped into the pockets, froze and provided an ice and log bridge sixty inches thick. Hand tools alone were used to cut the timber, and small vehicles were used to drag the logs to the bridge site. It required from 25 November to 15 January to complete the bridge. However, by this time the heaviest vehicles were crossing the river on the unsupported ice. Although it seemed that this project was a gross waste of time and manpower, it showed that a bridge like this could be built. If the river ice had failed to reach a safe thickness, this bridge could have been used to cross heavy vehicles over the ice.[50]

The Diesel Tractors, D7 and D8, were among the most useful pieces of equipment in the Task Force. They were used for clearing snow and ice to provide roads for the movement of wheeled vehicles. Also, they were used as prime movers fof artillery pieces, and for towing sled trains. The angle dozer was preferred to the bulldozer for clearing snow from roads and trails. With this piece of

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[50] AGF Task Force Frigid, Winter Test Program, 1946-47, Chap XIII, Engineer, pp. 255-258

equipment, it was possible to clear a trail of thirty inches of snow at the rate of one mile per hour.[51]

The amount of explosives needed for a particular operation had to be doubled to produce the desired results. This was due to the hardness of the frozen ground. The use of demolitions took on the aspects of quarrying operations. At low temperatures, Composition "C" became hard and brittle and lost its moulding property. Shaped charges were used successfully to blast holes in river ice. One such charge penetrated fifty-three inches of ice, making a hole forty-four inches in diameter at the surface and six inches in diameter at the exit.[52]

The use of mines and booby traps was considered unsatisfactory in deep snow and extreme cold, and more dangerous to the friendly troops laying the mines than to the enemy. Fuzes and firing devices could not be handled with arctic mittens; therefore, the soldier doing the demolition work would become careless and slipshod when his inadequately protected hands became cold. Mines and trip wires became buried, and the padding of the snow prevented the mines from being detonated and the wires from being tripped by men on snowshoes. When the snow was twenty-seven inches deep, two men on snowshoes walked through a minefield of eighty-seven booby trapped practice AP mines equipped with trip wires. None were detonated. Later, two men on foot walked the same route and detonated thirty-six mines. When the snow was thirty inches deep, a tank passed over a minefield laid several days previously. No mines were detonated.[53]

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[51] Ibid. pp. 258-261

[52] Ibid. pp. 264-265

[53] Ibid. pp. 266-267

An experiment was conducted with two demolition snakes, the two having a total length of four hundred feet and containing 4480 pounds of high explosive. (See Figure 14.) These snakes were pushed through a minefield by a tank. A gap sixteen to twenty feet wide was blasted through the minefield.[54] This experiment was so successful that a second experiment was planned in which two snakes were to be pushed under the Tanana River ice and detonated. When the people of Fairbanks were warned of this impending explosion, a great hue and cry arose. There was a meeting of the city fathers and a petition was presented the Task Force Commander. It was stated that a reaction would take place through the subterranean strata. The shock of the explosion would be transmitted to the city's basements causing dire damage to dwellings. Desiring to maintain amicable relations with the people of Fairbanks, the Task Force Commander regretfully gave in and called off the experiment. When this was announced, there was much rejoicing among the intrepid people of Fairbanks.

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[54] *Ibid.* p. 266

Engineers Assembling a Demolition Snake

One demolition snake was used successfully to blast a path through a minefield. Plans to explode a second demolition snake under the Tanana River ice were cancelled when the people of Fairbanks expressed concern that their basements would cave in.

Figure No. 14

VI

ARMOR AND THE MOBILITY OF MOTOR VEHICLES

IMPORTANCE OF ARMOR

Several writers in the Armored Cavalry Journal and other service magazines have stated in the past that the use of armor under conditions of extreme cold is impracticable. To assume this attitude is to make a fatal error! Admittedly, with present standard equipment, the use of tanks is difficult. However, the effect of tank action on an enemy in the Arctic is shattering to his courage and will to fight. The already great shock of the tank attack will be increased. The enemy soldier, with his efficiency and mental balance reduced, will hold the tank in mortal terror. Therefore, equipment must be improved and methods devised to fight this powerful weapon under the conditions of extreme cold that may be encountered.[55]

OVERSNOW MOBILITY OF TANKS

By 5 December 1946 the ground was so deeply frozen that the three types of tanks (M24, M4A3E8, and M26) with which the Task Force was equipped could maneuver in most areas in the vicinity of Ladd Field. (See Figure 15.) However, they could not negotiate snow covered slopes in excess of thirty percent. (See Figure 16.) Timber in the area did not seriously affect mobility, since frozen tree trunks would snap under very little pressure. However, tankers had to be cautious that they did not get hit over the head by a falling limb.

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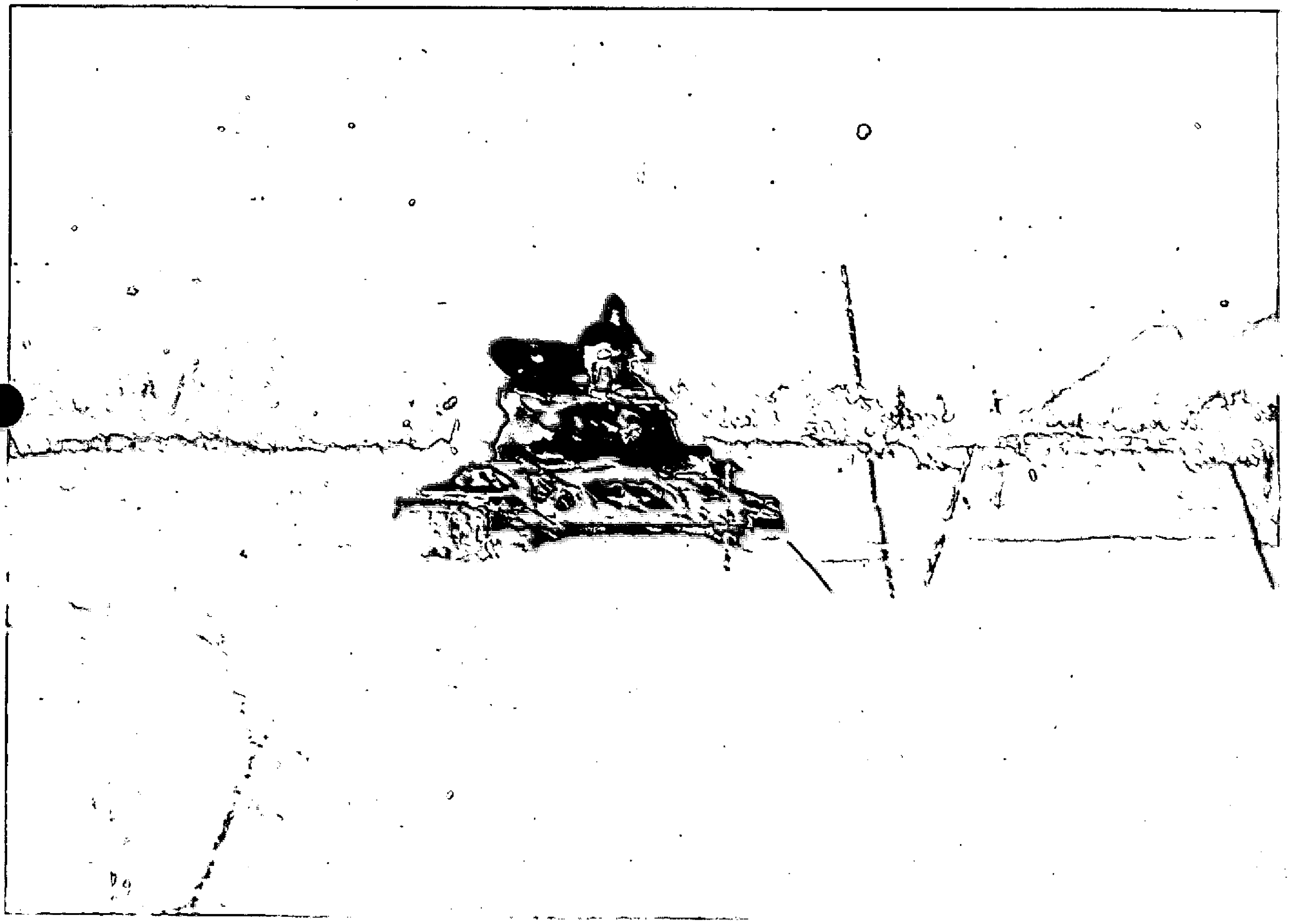
[55] AGF Task Force Frigid, Winter Test Program, 1946-47, Chap. XI, Armor, p. 221.



M24 Tank Negotiating Deep Snow

All tanks could operate through approximately thirty-five inches of snow at five miles per hour.

Figure No. 15

Throughout the training area meandered many small streams. These streams were bordered by sixty percent banks composed of gravel and alluvial silt. When crossing these streams, tank tracks failed to obtain traction, making it difficult to negotiate the slopes. These streams proved to be the most serious barrier to oversnow movement. Careful reconnaissance, preferably by liaison type aircraft, was desireable before crossing these streams with a tank unit.

The accumulation of deep snow reduced the speed at which tanks could advance. In moving across 6000 yards of snow thirty inches deep the maximum speed of the leading M26 was five miles per hour. Other tanks, moving in trace, could maintain higher speeds. When a well beaten trail was established, wheeled vehicles could follow with some difficulty. It should be remembered that among the standard vehicles with which the Task Force was equipped, <u>only</u> full track vehicles were able to negotiate deep snow. Wet snow like that found in the United States tends to pack and collect on tracks and suspension systems, impeding the movement of these parts. However, the dry granular snow found in the Arctic dropped off like dust.[56]

At temperatures below -40° F., ice fog, increased by the exhausts from tanks and the breaths of men, seriously reduced visibility. As a result, control of tank columns was difficult. The use of arm signals or other visual means to control column movement was practically useless. On a clear, cold day the presence of a tank column could be detected for several miles.

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[56] Ibid. pp., 222-224

ARMAMENT

The tank guns were the only large caliber cannon that fired satisfactorily at low temperatures. Comparing tanks with field artillery, the hydro-spring recoil system of tanks permitted the firing of ten rounds per minute, while the recoil system of the field artillery did not function nearly as well. When very light lubricant was applied to the breech block of the tank cannons, and to the moving parts of the tank machine guns, these parts operated efficiently.[57]

Below -30° F., turret equipment was practically useless, since the traversing and elevating mechanisms became so stiff that efficient operation of the cannon was impossible. At -55° F., the cannons on all tanks were fired, but the torque required to manually turn the handwheels was so excessive that laying the guns was slow and the gunners became quickly exhausted. Even when turret gear units were repacked with sparse amounts of light lubricants, the effort required to operate the armament was not greatly reduced. Below -30° F., the power traverse and gyro-stabilizer were not operable, as lubricants in the oil pump motor became stiff and bound the mechanism. The turret components of the M24 Light Tank operated more efficiently than those of the other tanks, since engine heat could be used to heat the turret. On the other hand, the Medium Tank, M4A3E8, was completely unusable at temperatures below 0° F. as cold air was sucked in through the turret by the cooling fan. This chilled the crew members in the turret to such an extent that frostbite resulted.

Little trouble was experienced with tank sights, except when the gunner's

[57] Ibid. p. 225

breath fogged the eye pieces. It was necessary to cover the gunner's nose and mouth with a scarf to prevent this fogging. The prisms in the tank commander's cupola frosted excessively at low temperatures and could not be used. The rubber eye cups that protected the sights became hard and distorted at low temperatures. This led to the improper spacing of the gunner's eye with respect to the sight lens. Traversing of periscopes was very difficult at low temperatures, as the mounts became excessively stiff.

Complete target obscuration was experienced when firing the 76mm or 90mm tank guns. (See Figure 17.) Ice fog, already present from the vehicular exhaust, was increased in front of the gun by the burning of propellant powder and the blast effect on the dust-like snow.[58] By working in pairs, one tank, located several yards from the second tank, adjusted by radio the fire of the first tank. This method of adjustment should be practiced in training since it is the only method to accurately sense rounds and rapidly bring fire on the target.

Mechanically, all standard ammunition functioned satisfactorily except the base emission smoke shell. This shell either failed to produce smoke, or produced a poor smoke screen. Rounds of large caliber ammunition were difficult to handle. They sweated and frosted profusely when taken from their containers and placed in a comparatively warm turret. The loader, wearing arctic mittens with slippery leather palms, often fumbled a round and dropped it on the tank floor.[59]

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[58] Ibid. p. 227

[59] Ibid. pp. 227-228

Rounds could not be placed accurately on targets located in the snow such as dug in machine gun emplacements, since the rounds would bounce and ricochet crazily when they hit the snow. Again, as with other weapons, the fragmentation effect of point detonating, high explosive ammunition was negligible. Consideration should be given to the use of time fire and VT fuzes in tank ammunition in order to increase its effectiveness for Arctic fighting.[60]

The use of plexiglas cupolas to place over the tank commander's hatch was investigated by the Task Force. (See Figure 18.) On the M24 Light Tank and the M26 Medium Tank only half of a blister was used over the tank commander's head. This prevented cold air from knifing him in the face. Complete cover was not necessary in these tanks since cold air was not drawn through the turret by the cooling fan. In one M4A3E8 Medium Tank the tank commander's hatch was completely enclosed by a blister, and the air passages in the bulkhead and the hatches were sealed. Also, crew members were provided with electrically heated suits. This preparation made possible the fairly efficient operation of this cold tank at temperatures as low at -55° F. The main disadvantage of plexiglas blisters was that they became brittle when extremely cold. As a result, they would crack or break when struck by a tree limb or some other object.

The operation of buttoned-up tanks was not extremely difficult, although the driver's periscope had the tendency to frost on the inside window and collect snow on the outside. When these windows were coated with chapstick or anti-dim compound prior to exposure, the frost could easily be wiped away.

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[60] Ibid. p. 228

WINTERIZATION KITS AND THE STARTING OF VEHICLES

Four conditions are necessary to permit an internal combustion engine to start. First, the engine must be free to rotate. Second, there must be a source of cranking power to turn the engine. Third, the fuel must vaporize and burn at specified temperatures. Fourth, the ignition system must provide the necessary spark to fire the fuel. Each one of these four conditions was drastically affected by the extreme cold. Therefore, starting was very difficult. The Task Force was immobilized on several occasions due to its inability to start engines on extremely cold mornings. During five days of temperatures below -50° F., not over five wheeled vehicles out of approximately four hundred were started.[61]

The congealing of engine oil was the primary reason that engines failed to rotate. (See Figure 19.) At -50° F. OE 10 had the consistency of taffy and could be moulded into any shape. The application of heat from a Herman Nelson heater on the oil pan and engine for an extensive period of time was the most efficient method found to loosen the oil so the engine could rotate. Some synthetic rubber fan belts became so hard and unflexible at -50° F. that they would break into several pieces before they would bend. When fan belts were this hard, it was like connecting the engine and the fan be means of an unbendable iron band. The engine could not rotate unless the fan belt broke.

To start an engine, cranking power must be furnished by the vehicular battery and the starting motor. At -40° F. a fully charged battery possessed

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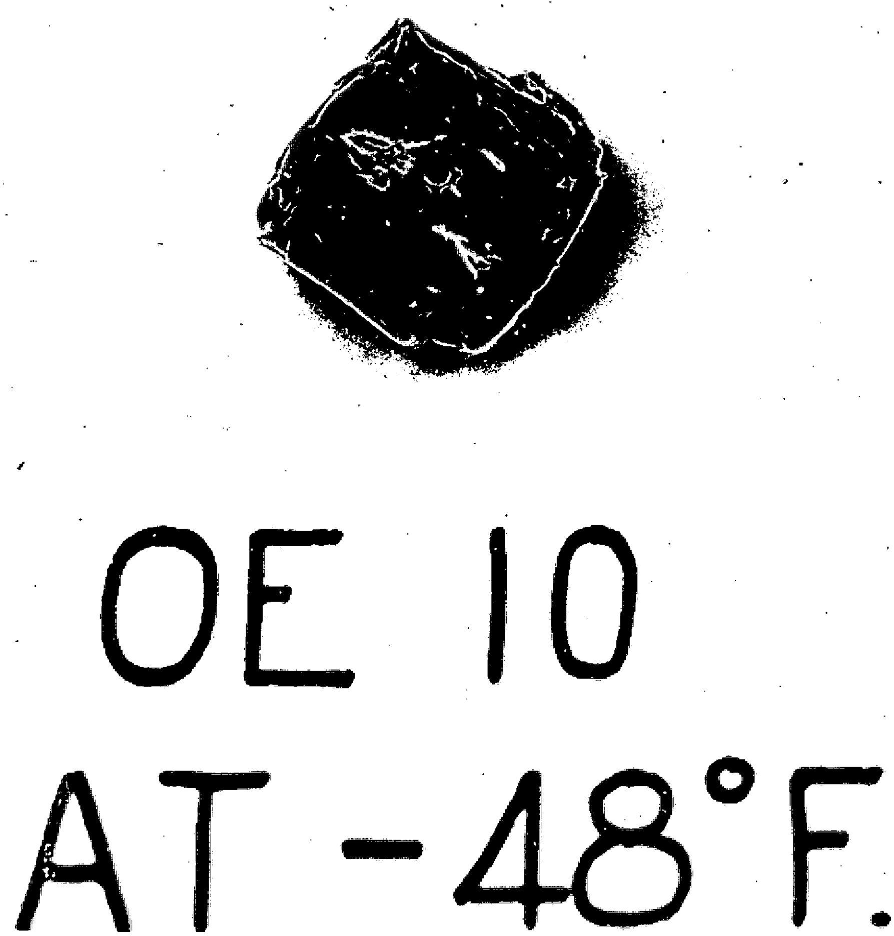
[61] AGF Task Force Frigid, Winter Test Program, 1946-47, Chap. VII, The Mobility of Motor Vehicles, p. 110.



Engine oil congealed into a taffy-like mass at very low temperatures.

Figure No. 19

EFFECT OF TEMPERATURE ON BATTERY CAPACITY[1]

Temperature	Percent of the 80° F., 8-hour rate that can be expected at various temperatures.	
°F.	1.210 sp. gr.	1.260 sp. gr.
77	100	100 (normal)
30	75	80
0	55	65
-20	0 (electrolyte frozen)	45
-30	0 (electrolyte frozen)	33
-40	0 (electrolyte frozen)	22

[1]Reproduced from TM 9-2857, "Storage Batteries Lead Acid Type."

This chart indicates that at temperatures of -40° F. or below, only 22% or less of normal battery capacity can be expected.

Figure No. 20

approximately one-fifth of its normal efficiency. (See Figure 20) Thus, if a vehicle with a cold battery did not start on the first attempt, the battery was too low for a second trial. The bendix gear in the starting motor was often over-lubricated. This resulted in trouble with this unit. Care must be taken in preparing the starting motor for cold weather operation that it is not over-lubricated.

For efficient starting, a fuel must be used that will readily vaporize and burn. A good, cold weather fuel was not used since a temperate climate gasoline (Grade A) was furnished the Task Force. When this gasoline was placed in a dish in the open at -59° F., a lighted match held against the gasoline would not ignite it.

For efficient starting, the ignition system must provide the necessary spark to fire the fuel. This was not satisfactorily accomplished due to the continual failure of coils and distributor breaker points, and the fouling of spark plugs. The exact reasons for these failures was not known, although they might be partially explained by the electrical overload on these parts.[62]

Standard winterization kits were installed in a few of the general purpose vehicles. In general, these kits consisted of engine heaters, radiator and hood covers, cab heaters, windshield defrosters, and high range thermostats. (See Figure 22.) The engine heaters were supposed to keep the engines warm enough overnight for quick starting the following morning.

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[62] Ibid. pp. 116-117

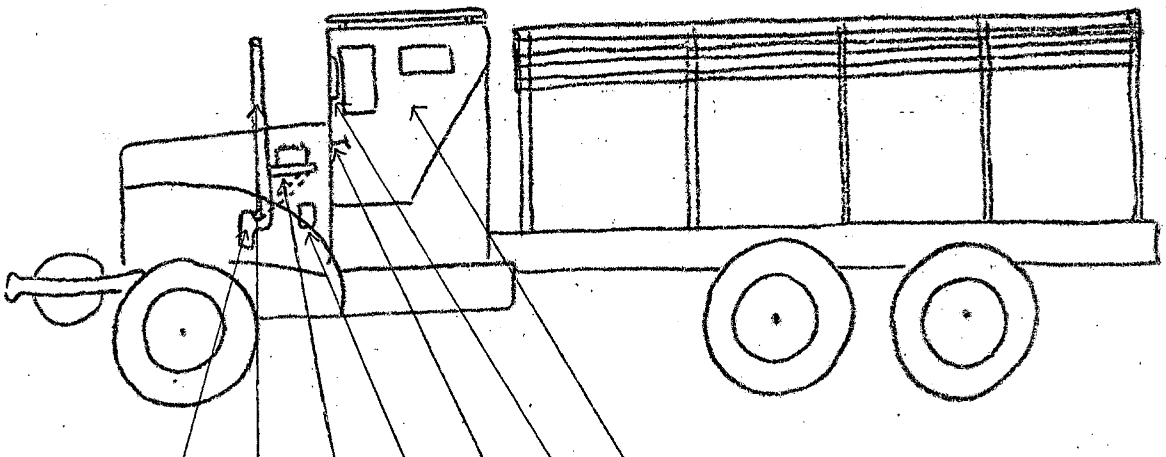
The only engine heaters that received a thorough test were the Superfex Models 454, which were standard for general purpose vehicles. These heaters were installed slightly below the engine block. One lead from the heater entered the top of the engine block, while a second lead entered the bottom of the engine block. The principle of heater operation was that of thermosyphon. Coolant, heated in the coils of the heater, passed upward into the bottom of the block, forcing the coolant in the block in a circular fashion. Cold coolant at the top of the block was forced into the tube leading to the bottom of the heater. The process would then start again. Heater exhaust passed into the atmosphere through a collapsible stack that extended above the engine hood.

The kits for 2½-ton trucks were equipped with battery pads. (See Figure 21.) Hot coolant from the engine heater passed through a tube coiled under the vehicular battery. Thence, the coolant entered the engine block. This pad assisted greatly in keeping the battery warm. For this reason, 2½-ton trucks could be started at lower temperatures than could the other general purpose vehicles tested.

At very low temperatures these heaters were completely unsatisfactory in that they failed to heat the proper vehicular parts. They were difficult to install, difficult to operate and maintain, mechanically unreliable, mechanically inefficient, and constituted a constant fire hazard.

A newer model of the Superfex Heater, the Model 460, was installed in a ¼-ton truck. (See Figure 22.) This was the most satisfactory heater tested by the Task Force. This heater also worked on the principle of thermosyphon. However, a small, electrically driven fan in the heater blew hot air and gasses

WINTERIZED 2½-TON TRUCK



A. Superfex Engine Heater, Model 454. (This engine heater warms the coolant in the engine block. It fails to warm the oil pan or intake manifold, and is completely unsatisfactory at very low temperatures.)

B. Heater flue stack.

C. Battery pad. (Warm coolant from the heater circulates through the battery pad, keeping the battery moderately warm at very low temperatures.)

D. Cab heater. (This heater blows warm air into the cab. However, the heater does not emit sufficient heat at very low temperatures.)

E. Primer. (The primer injects a vaporized stream of gasoline into the intake manifold to aid in starting.

F. Electric windshield defroster secured by rubber suction cups.

G. Canvas cab closure. (This closure does not seal properly and allows cold aid to enter the cab.)

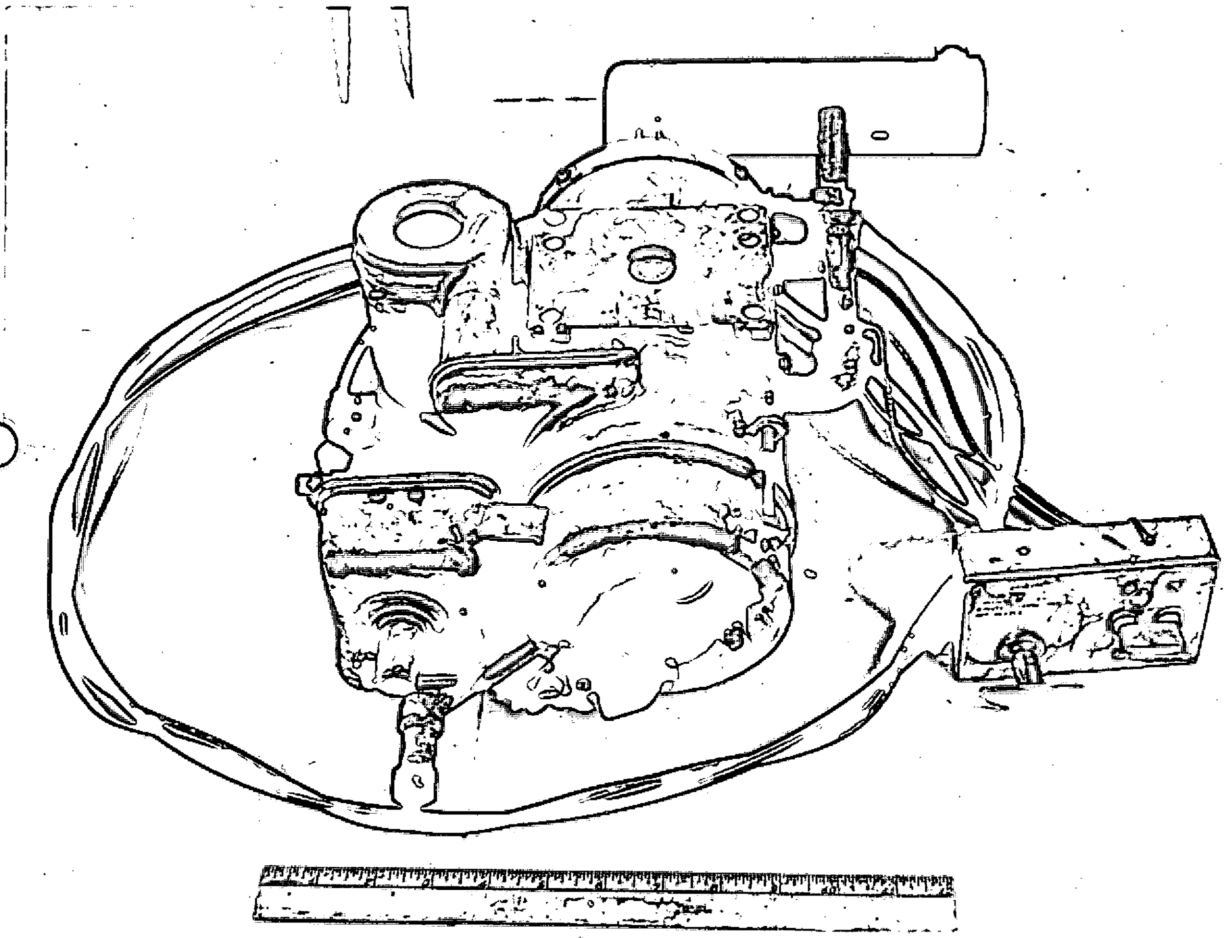
Figure No. 21

from the heater combustion chamber through a flexible tube. This hot air was directed against the oil pan. Rising from the vicinity of the oil pan, the air circulated throughout the engine compartment, keeping the battery warm and efficient. At -62° F., this ¼-ton truck was started immediately and without difficulty. (See Figure 23.)

Several expedients were tried by the Task Force in an attempt to keep vehicular engines warm enough overnight for efficient starting. Several vehicles were parked close together and covered by a large tarpaulin. (See Figure 24.) Ducts from a Herman Nelson heater were put under the tarpaulin and the heater was operated overnight. At very low temperatures this method kept vehicles warm enough for efficient starting. During the coldest temperatures, and when it was necessary to move the tank company out quickly in the morning, tank engines were cycled to reduce the labor attendant to starting. If engines were operated one hour out of four, they retained enough heat, and batteries retained enough charge to make starting reasonably certain. This method was used only as an emergency measure, since the expenditure of gasoline and the wear and tear on engines was high.

At low temperatures when the methods of starting described above were not used, external heat had to be supplied from Herman Nelson heaters or the Petro Heaters of the Auxiliary Cold Starting Aid Kits. When it was necessary to apply heat, between thirty minutes and two hours were required to start a single tank engine. Needless to say, the time required for the tank company to start all its tanks was measured in days rather than in minutes.

Besides the ability to supply heat, the Auxiliary Cold Starting Aid Kit

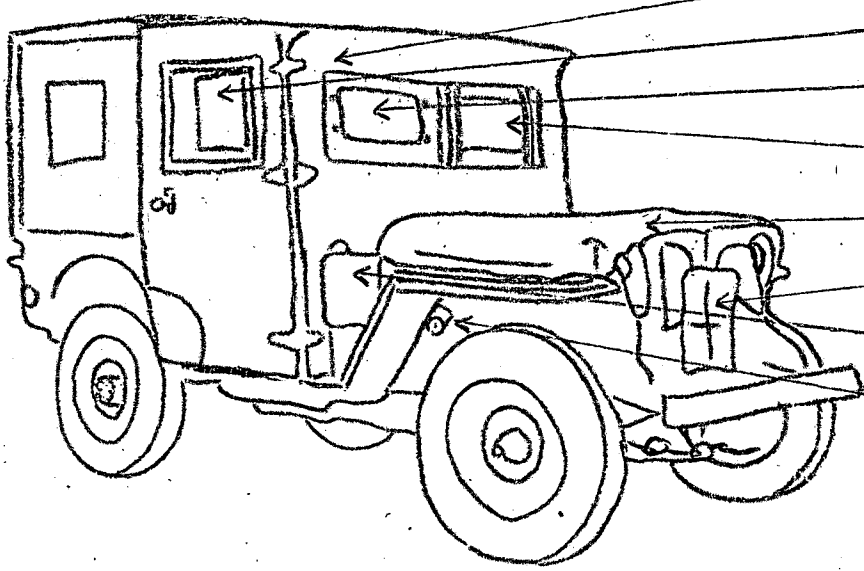


Superfex Engine Heater, Model 460

This was the only heater tested by the Task Force that kept a vehicle warm enough for efficient starting at -62° F. It was installed in a ¼-ton Truck.

Figure No. 22

WINTERIZED ONE-QUARTER TON TRUCK

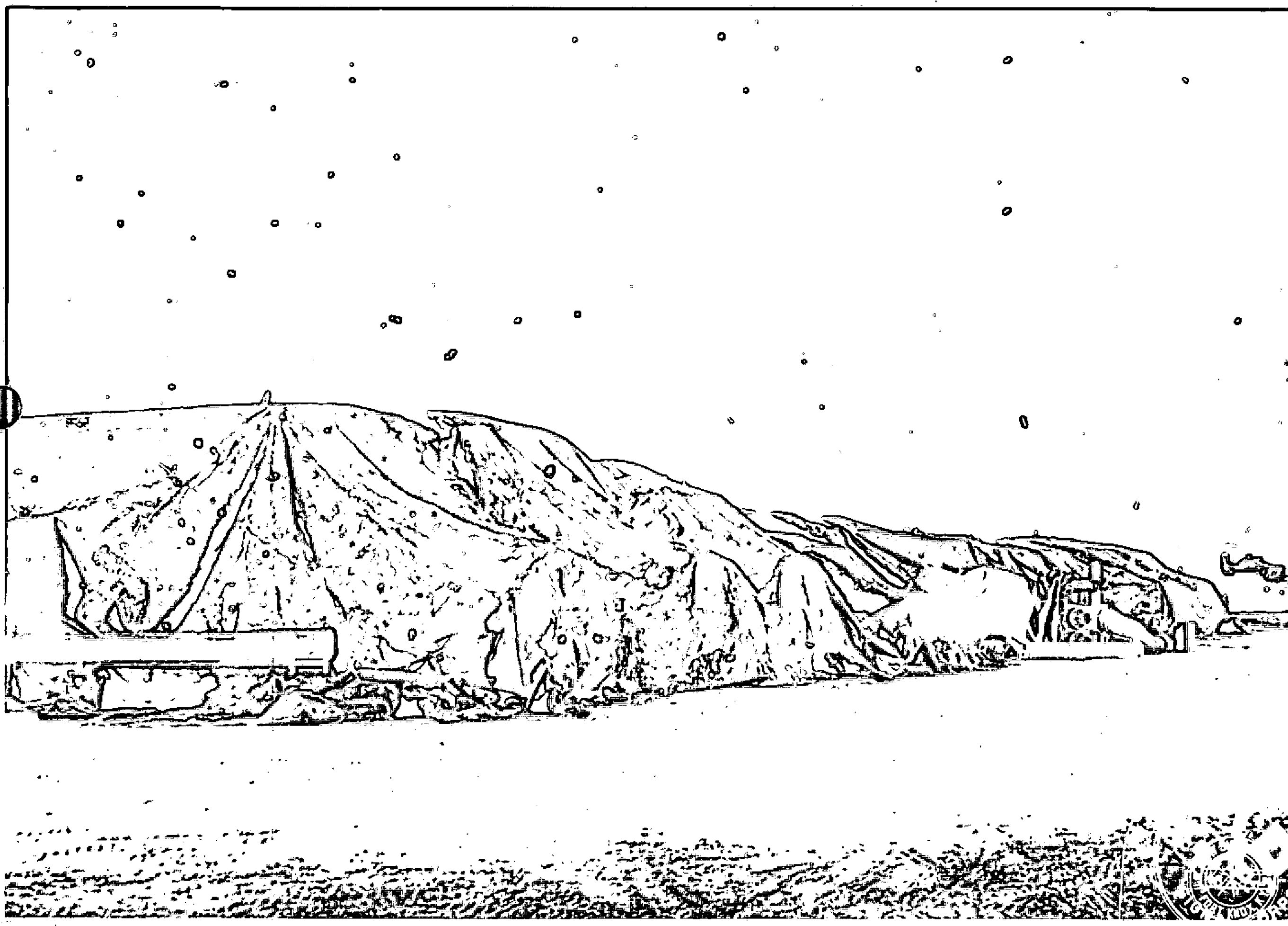


A Plywood body.
B Double-paned window. (This window was designed to prevent formation of ice which restricts side vision.)
C Electric windshield defroster secured by rubber suction cups.
D Electric windshield defroster bolted to windshield.
E Hood cover.
F Radiator cover with light and radiator flaps.
G Heater fuel tank.
H Slave outlet. (A slave cable is applied at this outlet to aid starting.)

Equipment Not Shown

I Superfex Engine Heater, Model 460. (This engine heater, located under the hood, warms the coolant in the engine block. Warm air and heater exhaust is conducted from the heater through a flexible tube to the oil pan. This warm air rises throughout the engine compartment, warming the battery and intake manifold, and permits immediate starting at -60° F.)
J Adjustable thermostat. (By manually adjusting this thermostat, safe operating temperatures can be maintained.)
K Cab heater. (This heater, located directly over the driver's feet, blows warm air into the cab. However, the heater does not emit sufficient heat at very low temperatures.)
L Primer. (The primer injects a vaporized stream of gasoline into the intake manifold to aid in starting.)

Figure No. 23



Covering Vehicles with Tarpaulins to Aid in Cold Starting

A group of vehicles could be kept sufficiently warm for efficient starting at low temperatures by covering them with tarpaulins and directing hot air from a Herman Nelson Heater under the tarpaulin.

Figure No. 24

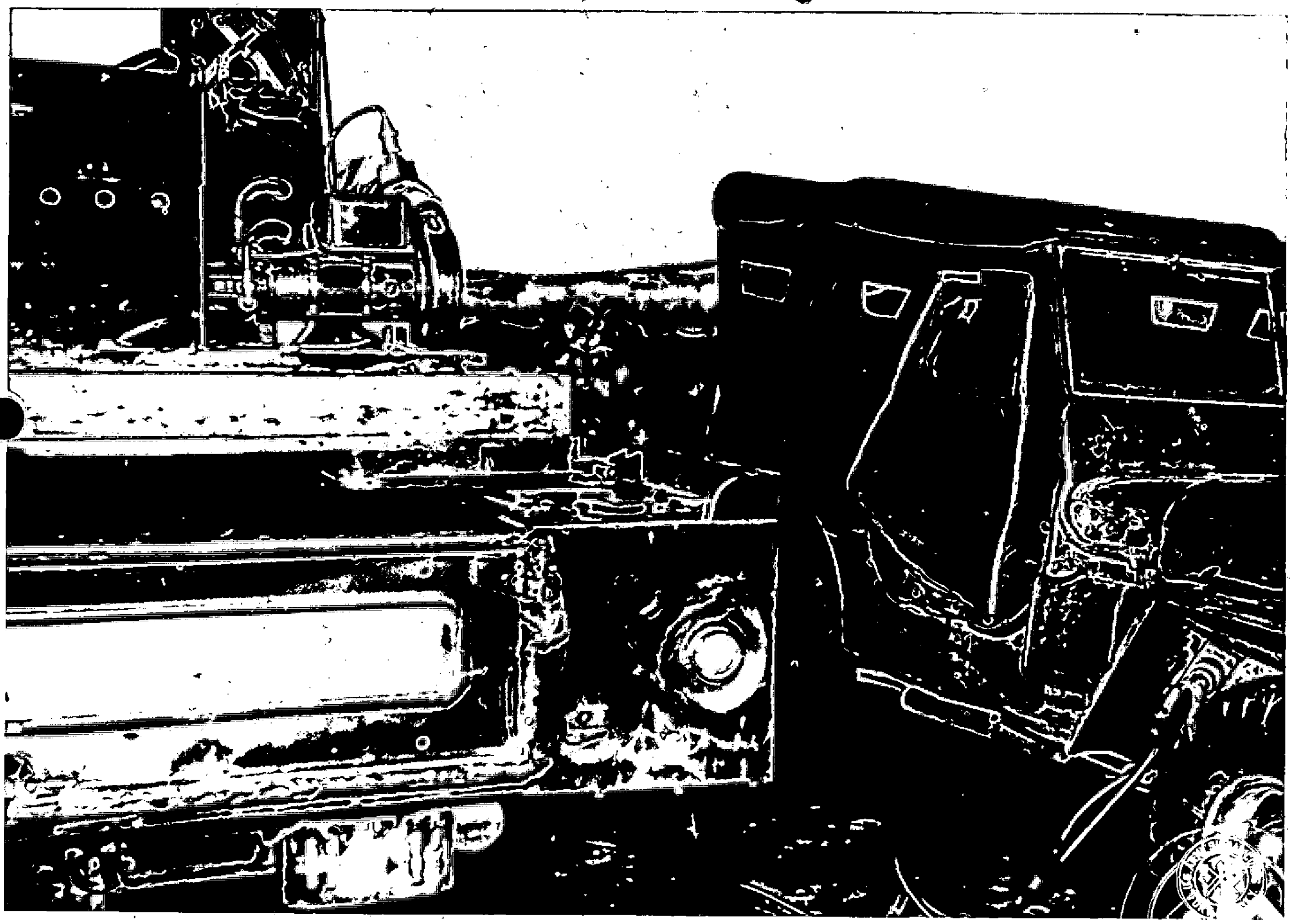
(Slave Kit) was useful in starting vehicles in that a boost could be given cold vehicular batteries by the six batteries of the Slave Kit. (See Figure 25.) During starting, a slave cable was extended from the kit to a receptacle in the vehicle, or to the terminals of the vehicular battery. Six, twelve, or twenty-four volts could be applied, depending on the electrical system of the vehicle being started. In one case, a truck driver, unable to start his vehicle with a six-volt boost, decided to shoot the works and put twenty-four volts into his six-volt battery. This blew one end completely off his battery. It follows that driver supervision and instruction must be stressed.

In concluding this section on the starting of vehicles, it must be stressed that to accept anything less than complete operability of combat vehicles within fifteen minutes is to court disaster in the Arctic. This can be done only with improved engine heaters, or improved methods of starting large groups of combat vehicles.[63]

OPERATION OF VEHICLES

After starting the engine, the next problem was to move the vehicle. In the case of wheeled vehicles, the grease around the wheel bearings became so stiff that it was necessary to put the transfer case in low and break the wheels loose with the clutch. Due to excessive wear, there were excessive clutch failures in the Task Force. There were cases of 10-ton Wrecking Trucks dragging $\frac{1}{4}$-ton trucks and even $2\frac{1}{2}$-ton trucks along snow covered streets during which the wheels of the trucks did not turn. In one case, when an M4 tank was dragged

[63] Ibid. pp. 114-115



Starting a $\frac{1}{4}$-ton Truck with the Aid of the Slave Cable of an Auxiliary Cold Starting Aid Kit

The Auxiliary Cold Starting Aid Kit consisted of a Petro Heater, an auxiliary generator, and six 6-volt batteries. The Petro Heater was used to warm certain vehicular parts during cold starting, while the six batteries were used to give the vehicle's cold battery enough current to crank the engine.

Figure No. 25

behind a Tank Recovery Vehicle, M32, the tracks of the M4 did not turn.

Due to the stiffness of GO 75 at low temperatures, gears were extremely hard to shift, until after several minutes of operation. If a truck were parked overnight in gear, it was almost impossible to shift it into neutral unless the transmission was warmed by external heat. Diluting gear oil with diesel fuel eased shifting to some extent.

Synthetic rubber became excessively hard at low temperatures. When a vehicle was parked overnight, the flat bottom portion of the tire would freeze in place and turn with the wheel when the vehicle was moved. This resulted in a bumpy and uncomfortable ride. The air was reduced to zero p.s.i. in one tire of a $\frac{1}{4}$-ton truck and the wheel taken off the ground with a jack. The following morning the jack was removed, and the tire supported the weight of the vehicle.

On several occasions when the temperature was below -50° F., the brake pedals of $2\frac{1}{2}$-ton trucks remained depressed when the service brakes were applied. It was found that the hydraulic brake fluid thickened, and was unable to flow from the wheel cylinders through the lines to the master cylinder.

On many heavy vehicles the failure of the vehicle to obtain and maintain safe operating temperatures was a serious problem. The failure of a large number of Hi-Speed Tractor engines was attributed to the fact that these vehicles were required to operate without attaining proper engine temperatures. On the Tank Transporter, M25, it was necessary for the driver to dismount and adjust his radiator cover frequently due to the fluctuation of engine load caused by climbing and descending hills. The installation of metal louvres adjustable from the cab would probably relieve this situation.

Safe operating temperatures could be maintained in tanks without difficulty once these temperatures had been reached.

The Weasel was the only vehicle in which provision was made for control of radiator cooling by the driver, who could control the flow of air by regulation of the door in the intake air duct. At temperatures below -30° F., safe operating temperatures could be maintained by closing this door. Also, the Weasel's gear cases were installed in a hull tunnel through which hot exhaust air from the engine passed, thus decreasing the warm up time for this vehicle. The Weasel's muffler and exhaust pipe were located directly behind the rear passenger seat. Thus, when the side curtains were closed, the vehicle was fairly warm, even during the lowest temperatures encountered. Due to its internal warmth, efficiency of operation during cold weather, and excellent over-snow mobility, the Weasel was considered the best all-around vehicle for command, liaison, and messenger purposes.[64]

The Armored Utility Vehicle, M44, could not be operated at temperatures below -30° F., as it was impossible to maintain oil temperature and pressure during operation. (See Figure 26.) Operating this vehicle at lower temperatures necessitated the opening of the bulkhead doors to obtain air recirculation. This resulted in a lethal concentration of carbon monoxide in the crew compartment.[65]

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[64] Ibid. p. 120

[65] Ibid. pp. 120-121

MOBILITY OF WHEELED VEHICLES
AND TRACKED VEHICLES OTHER THAN TANKS

Trucks larger than $\frac{1}{4}$-ton trucks could negotiate eighteen inches of unbroken snow with some difficulty, while $\frac{1}{4}$-ton trucks could only negotiate up to ten inches. While traveling on trails, it was risky and difficult for one truck to pass another coming from the opposite direction. One vehicle usually ended up in a snow bank and had to be pulled out. Before supply in the field could be efficiently executed by trucks, trails in and out of assembly areas had to be prepared by tanks or engineer bulldozers. Also, the trucks had to be equipped with chains.

One experimental vehicle, the Cargo Carrier, M8, offered the greatest promise for supply in the field in so far as mobility of the vehicle was concerned. (See Figure 27.) This vehicle was similar to the Armored Utility Vehicle, M44, except that it was equipped with a cargo body instead of a troop compartment. Although mechanically unsatisfactory, its cross-snow mobility was as great as that of a tank.[66]

An experimental type wheeled vehicle tested by the Task Force in extreme cold was the $2\frac{1}{2}$-ton Truck, T23. (See Figure 28.) This vehicle was a four-wheeled cargo truck, possessing large wheels and increased ground clearance. It also possessed a final gear reduction at the wheels, and a system for inflating and deflating the tires from the cab. After deflating the tires to approximately twelve pounds per square inch, this truck was operated through the deepest snow encountered. It was the only wheeled vehicle that was able to negotiate deep snow with success.

[66] Ibid. pp. 120-121

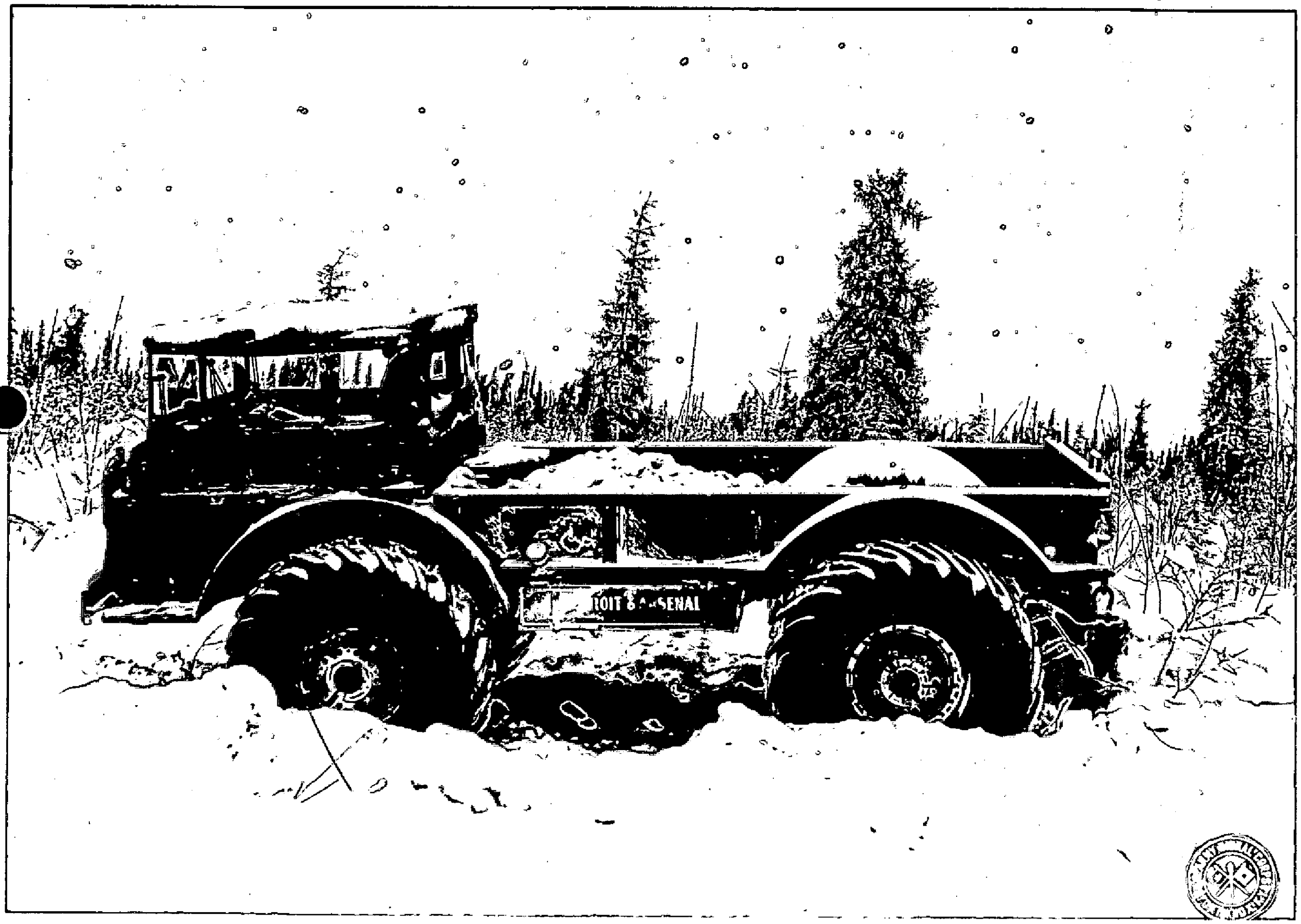
The Half-Track was not appreciably more mobile in deep snow than ordinary wheeled vehicles. Track chains were a necessity for gaining traction. However, one chain frequently would be thrown off when it started to spin during slope operation, or while the vehicle was crossing a small obstacle.

The Weasel was the most mobile vehicle in the Task Force for operation through deep snow in open terrain and over slopes. (See Figure 29.) Due to its low ground pressure, it did not sink deep, but was held up by the snow. In one case it towed a cargo sled loaded with 1000 pounds up a 34% slope covered with twenty-four inches of loose snow. In deadfall areas the Weasel's mobility increased with the depth of the snow, since the snow provided it a cushion to ride over the fallen logs. In heavily timbered areas, trails had to be cleared by hand in advance of the Weasel. Tanks were the only vehicles that could get through without assistance.

RECOVERY OPERATIONS

The problems encountered during recovery of vehicles in extreme cold assumed gigantic proportions. The primary requisite for efficient recovery was speed. If a vehicle was allowed to remain out all night, moving it the next day was similar to moving a vehicle without wheels or tracks. This was due to the wheels or tracks becoming frozen and failing to rotate.

In one case, an M26 tank broke through the ice over a small stream and sank into thirty inches of water. Two days later, when recovery was attempted, the stream had frozen around the tank and two hundred pounds of explosives were required to break the ice loose. Luckily, the temperature had not been so low as



$2\frac{1}{2}$-ton Truck, T23

This truck was the only wheeled vehicle in the Task Force that could operate through thirty-five inches of unbroken snow.

Figure No. 28

to freeze the lubricants in the suspension system. Therefore, the tracks would turn and recovery was accomplished.

In another case a Tank Transporter, M25, carrying an M26 tank, fell in a hole while crossing the Tanana River. (See Figure 30.) This occurred during the period when daily minimum temperatures remained below -50° F. for twenty-one days. The tank, having been improperly loaded, slipped to one side and could not be unloaded from the rear of the transporter. During the remainder of the extremely cold period, approximately nine days, attempts at recovery were futile. During the first attempts made, metal parts such as cable, towing hooks, and pintles failed. These failures were believed due to crystallization and weakening of metal, caused by long exposure to extreme cold. When three engineer bulldozers could be assembled at the location, the wheels of the transporter were frozen and the dozers pulled in vain. Since so much equipment was damaged through recovery attempts, operations were discontinued until the cold weather ended. Toward the end of the period of extreme cold, General Devers arrived at the Task Force, and his permission was requested to fire a 90mm AP round at the tank on the transporter. Since so much metal had failed during recovery operations, it was thought that extremely cold armor plate might shatter when hit. Although permission was granted, the cold weather ended the day before this experiment was to take place.

MAINTENANCE

The efficient accomplishement of driver maintenance in the open required a very high standard of training for the driver, and close supervision by his officers and non-commissioned officers. When a driver placed his bare hand on

Tank Transporter After Having Broken Through Ice Over the Tanana River

A seventy ton combination, consisting of a tank transporter carrying an M26 Tank broke through the ice while crossing the Tanana River. This occurred when the temperature was -55° F. Recovery could not be completed until after the temperature had risen to approximately 0° F.

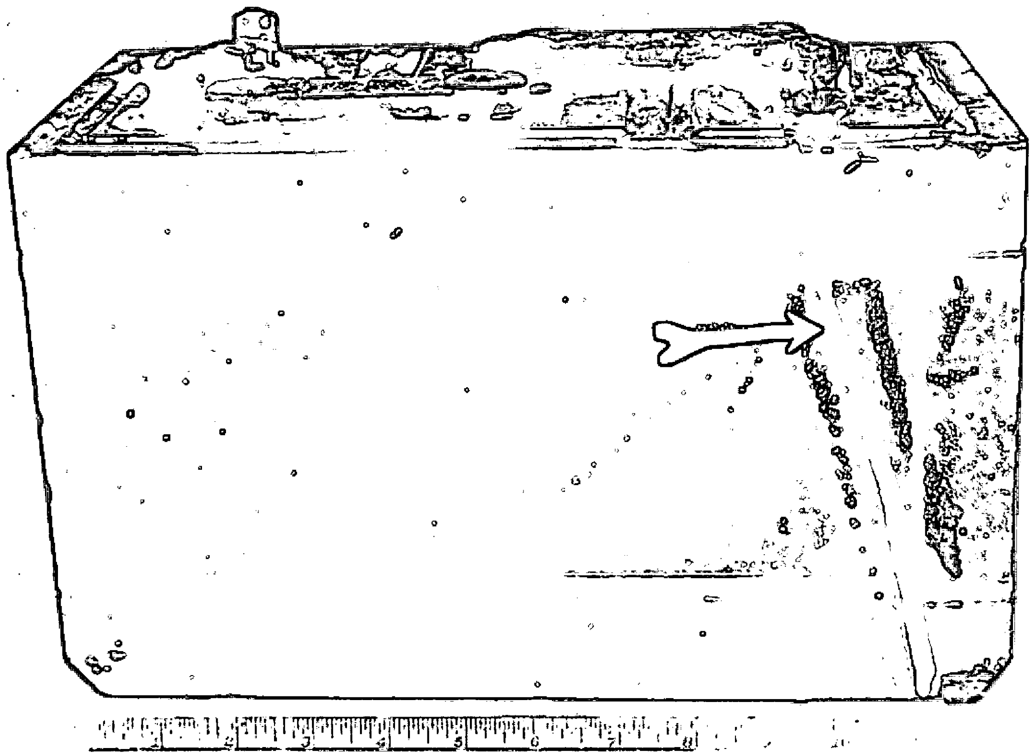
Figure No. 30

metal at temperatures as low as -50° F., flesh would remain on the metal when the hand was removed. Bulky clothing impeded his movements, and congealed lubricants prevented his vehicle from starting. Also, the extreme cold caused him no end of discomfort and mental anguish. For these reasons, among many, the average driver neglected his vehicle. However, to neglect a vehicle in extreme cold was far worse than to neglect it under normal temperatures. For instance, at low temperatures, if a driver failed to check his battery at night and place it in a warm place if it were undercharged, the following morning the battery would be frozen and cracked. (See Figure 31.)

Second echelon maintenance in the open was even more difficult since more accurate work had to be accomplished. A mechanic, trouble shooting on a stalled vehicle, could work only two or three minutes at low temperatures before he had to stop. One solution to this problem was to carry a Herman Nelson heater in the rear of a small maintenance truck. This truck would pull alongside the disabled truck, and hot air from the heater's ducts would be directed on the mechanic's hands and body while he repaired the vehicle. At -50° F., a mechanic could work for approximately one-half hour using this method.

The only suitable shelter for maintenance work in the field was the Maintenance Shelter Tent, heated by a Herman Nelson heater. Vehicles up to the size of $2\frac{1}{2}$-ton trucks could be sheltered in this tent, and fairly efficient work could be performed at all temperatures encountered.

All officers and enlisted men operating in the Arctic must be "maintenance minded", or the vehicles they depend on for combat and for transportation will become immobilized.



Cracked Vehicular Battery

At very low temperatures when a driver failed to remove an undercharged battery and place it in a warm place overnight, it would freeze and crack.

Figure No. 31

FREEZING POINTS OF BATTERY ELECTROLYTES[1]

Specific Gravity	Freezing Point °F.
1.100	18
1.120	14
1.140	10
1.160	5
1.175	4
1.200	-16
1.225	-31
1.250	-60
1.280	-90
1.300	-95
1.318	-81
1.330	-70

[1] Reproduced from TB ORD 193

This chart indicates that if temperatures of -50° F. or below are expected, a battery charge of at least 1.250 specific gravity should be maintained.

Figure No. 32

VII

GENERAL EFFECTS ON TACTICS AND LOGISTICS

OPERATIONS

Staff operation and planning were based on the fact that a terrific burden was placed on troops by the extreme cold and deep snow. Detailed and prior planning was absolutely necessary for successful operations.

The time required for a man to do a particular job in the Arctic was increased at very low temperatures. A group of twenty men required one day to do a job that in a temperate climate took ten men one-half day. There were no longer "little jobs" that could be expeditiously accomplished by one or two men. All tasks assumed major proportions. When the temperature fell below -50° F., it took everything in a man just to live. His efficiency, motivation, and desire to work were negligible.[67]

Orders had to be carried out to the letter or confusion and casualties resulted. For instance, a group of men were required to stand around in the open at -50° F. waiting for several trucks which arrived one-half hour late. Several cases of frostbite resulted.

Troops in field bivouac required about one hour to break camp and move out. This excessive amount of time was used to fold stiff canvas, stow large amounts of equipment in vehicles, start, and warm up cold vehicles. The time between the commencement of the breaking of camp and the time of moving out had to be

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[67] AGF Task Force Frigid, Winter Test Program, 1946-47, Chap. XVIII, Effects on Tactics and Techniques, pp. 345-34

carefully estimated. Men could not stand around in the cold for long periods before moving out and later be expected to perform their jobs efficiently.[68]

RECONNAISSANCE

The time necessary to conduct a reconnaissance that under normal conditions would take several hours to complete was measured in days in the Arctic. In one case, a seventeen mile trip required thirty-three hours to complete. There were several reasons for the excessive amount of time needed. Only three or four hours of daylight were available. Most of the area was not accurately mapped. Man-made landmarks, usable as navigational aids, such as buildings, roads, and railroads were non-existent. Many natural landmarks such as rivers, streams, and grasslands were obscured by deep snow. A trail made by a reconnaissance party might be the only means by which a command could move to an assembly area, attack position, or line of departure. It follows that faulty reconnaissance, while detrimental to a successful operation in any climate, might easily prove fatal in trackless tundra at -50° F.[69]

Reconnaissance parties in the Arctic should possess certain characteristics. They should be small, and should be equipped with long-range radios. Also, they should be self-sustaining for at least three days, and should move in darkness when practicable. A party should be mounted in a Weasel when possible. However, it must be remembered that this vehicle can easily be spotted

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[68] Ibid. pp. 347-348

[69] Ibid. pp. 348-350

for long distances at temperatures below -35° F., and can be heard for two or three miles as it labors through deep snow. When a commander is deciding whether or not to send out a patrol, the value of the reconnaissance must be weighed against the fact that a motorized party will almost always be seen or heard.

The helicopter was very valuable for reconnaissance of routes for ground units. The pilot could hover over questionable terrain, or land close by and make a dismounted study. He could then return to the motorized column and actually guide it over the best route.[70]

PROBLEMS OF FRONT LINE UNITS

Due to the extreme cold and inability of personnel to remain exposed for any length of time, frequent relief of front line troops had to be anticipated. If a unit had to relieve itself in a defensive sector, one-half the sector normally assigned a unit was used as a guide. Bivouacs should be set up behind the defensive sector so that units being relieved could move back expeditiously to a warm bivouac. One method attempted was to place one company on outpost and hold the remainder of a battalion in reserve. The outpost operated from ski patrols during the day. At night, when sound carried far in the cold, listening posts were established. Three to five miles in rear of the outpost, a main battle position was prepared by the remainder of the battalion. Troops to man the main battle position were kept in warm shelters in rear of the position, and access lanes were prepared from the shelters to the position to be occupied.

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[70] Ibid. p. 349

Multiple final protective lines were prepared by driving weasels through the snow. Dummy final protective lines were also prepared so as to confuse the enemy as to the actual defensive plan. The battalion reserve remained in heated shelters behind the main battle position. Sufficient oversnow transportation was available to move the reserve to any threatened sector.[71]

At temperatures around zero the absolute maximum time that a unit could attack without relief was twelve hours; while at lower temperatures this time was reduced proportionately. As in defense, very close logistical support had to be furnished the attacking unit, so that it could close into a warm billet without any loss of time.

Due to the complete inadequacy of roads, bridges and other lines of communication, engineer support had to be immediately available to front line combat units. Bulldozers were needed to clear roads. Pioneer equipment was needed to clear away trees and dig emplacements. Bridging material was needed to cross short gaps.

The primary mission envisioned fortanks supporting front line units in the defense was the counterattack to break up enemy attacks from any direction. The placing of tanks on the front line was not advocated. They should be kept assembled under their own unit control so as to insure that maintenance is performed and personnel are protected from the cold. Lanes of access over which the tanks can quickly reach their firing positions should be prepared for tanks firing in support of the main battle position. During the attack tankers must

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[71] Ibid. pp. 352-353

live in their vehicles until the objective is secured by the infantry. When the objective is secured, the tanks should be pulled back into a reserve position so that the crews can be warmed.[72]

When any unit secures itself against attack, a ski track should be established around the perimeter of the area being secured. This perimeter should be checked periodically by a motorized or a ski patrol for any crossings by the enemy. During the day, OPs overlooking the surrounding area can best accomplish this mission.[73]

LOGISTICS

Housekeeping troops must be provided to closely support combat troops. These troops should consist of additional personnel for the cooking and distribution of food and for the proper maintaining of vehicles, particularly in armored units. Also, they should break and set up overnight camps, thereby relieving combat troops of this time consuming activity.[74]

In the field close supply support was difficult due to the lack of an adequate road net, and the inability of wheeled vehicles to negotiate deep snow. It was necessary to use full track vehicles such as weasels to closely support dismounted units. Air resupply was attempted with moderate success,

[72] Ibid. pp. 353-354

[73] Ibid. pp. 355-356

[74] Ibid. pp. 356-358

although the locating of drop zones was difficult due to the lack of navigational landmarks.[75]

In planning any operation the staff should realize that an enormous amount of gasoline must be expended to accomplish any task. There is an increase of the amount of gasoline normally used by vehicles, and a tremendous amount of gasoline is burned by the large number of heaters used. Also, gasoline is used to operate stoves, generators, and other equipment. It was estimated that on a ten-day field exercise the Task Force exceeded normal consumption of gasoline by approximately three hundred percent.

[75] Ibid. pp. 358-359

VIII

CONCLUSION

In summary I shall list the high points of the foregoing discussion.

1. Winterization and preparation of equipment, training, and physical conditioning must be started early enough during the preparatory phase of cold weather operation to insure timely completion.

2. Before operation commences under conditions of extreme cold, each man must be adequately trained in his job.

3. Supply must be planned sufficiently in advance to insure arrival of all needed items before the onset of cold weather.

4. Due to the presence of marshes in the Ladd Field area, movement of vehicles off roads is limited to the winter months.

5. As a general rule, twenty inches of river ice will support twenty tons, and for each additional inch of ice an additional ton can be supported.

6. During the winter, ambient temperatures ranged down to -62° F., with several long periods during which the temperature remained constantly below -50° F.

7. Snow varied to a maximum depth of thirty-three inches. The texture of the snow was light, loose, and dust-like.

8. Although there was little wind at the extremely low temperatures, a wind at -10° F. was more uncomfortable than no wind at -50° F.

9. During the months of December and January, daylight lasted from approximately 1000 hours to 1300 hours.

10. At very low temperatures, ice fog, together with vehicular exhaust and steam from men's bodies, reduced visibility during the hours of daylight.

11. Improvements are needed to provide suitable standard clothing for the Arctic soldier.

12. A group of men equipped with Arctic Sleeping Bags failed to sleep warm in the open at -59° F.

13. The most successful tent used by the Task Force was a five-man, lightweight, pyramidal tent, heated by a small Yukon Stove.

14. The most satisfactory shelter used was a sled-wannigan, heated by a 1941 Tent Stove, and towed behind a tank.

15. The only successful method found to feed small groups of soldiers was to transport hot food in Insulated Hot Food Containers from the company kitchen to the group shelters.

16. Maintaining an adequate supply of drinking water was a sizable problem.

17. In the treating of casualties in extreme cold, emphasis must be placed on immediate first aid, keeping the patient warm, and rapid evacuation.

18. Frostbite and carbon monoxide poisoning were considered the two most prevalent non-battle dangers encountered.

19. All organizations constructed wannigan-type latrines since men would not defecate outside in the cold.

20. It was difficult to get men to take the care of their bodies in extreme cold that is essential to health.

21. The supply of adequate and wholesome food to men living in extreme cold was of primary importance.

22. The ability of a man to efficiently perform his job decreases proportionately with the fall in temperature.

23. Preselection of individuals to serve in units operating in the Arctic should be adopted.

24. Soldiers must be mentally, physically, and occupationally well trained before being required to do their jobs under conditions of extreme cold.

25. Officer leadership must be of the highest caliber.

26. In an airborne jump, although the descent of individuals was very rapid due to the additional equipment carried, landings were usually cushioned by the deep snow.

27. The assembling of paratrooper units was much slower than under normal conditions.

28. The movement of infantry cross-country through unbroken snow was exhausting and very slow, not exceeding one-half mile per hour.

29. The fastest method of transporting infantry was either inside or behind weasels.

30. The transporting of infantry on the backs of tanks was successfully accomplished.

31. Snow, packed by its own weight, was penetrated to a maximum depth of only five feet when struck by a thirty caliber bullet.

32. The effective bursting radius of a poiht detonating mortar shell was negligible in deep snow.

33. At low temperatures, vapor formed during the firing of automatic weapons and blinded the gunners and disclosed the positions of the weapons.

34. The congealing of lubricants precluded the firing of towed field artillery pieces at temperatures below -40° F.

35. When a 105mm shell burst under eighteen inches of snow, shell fragments were effective for a radius of only four feet.

36. A full track, self-propelled artillery piece, firing projectiles equipped with VT fuzes at high angles of fire, was considered the answer to the artillery's problem.

37. The helicopter was the most useful ground type aircraft used, since it could land and take off in deep snow.

38. An ice bridge, while requiring a tremendous amount of labor to build, will sufficiently thicken weak ice over a river to permit the passage of heavy vehicles.

39. The Diesel Tractors, D7 and D8, were among the most useful pieces of equipment in the Task Force.

40. The amount of explosives needed for a particular job was approximately double that required under normal conditions.

41. The use of mines and booby traps was ineffective, since deep snow prevented detonation of the mines, and buried trip wires leading to the booby traps.

42. The value of tanks should not be underestimated; their shock and speed against enemy soldiers would be shattering to the enemy's morale and will to fight.

43. After the ground was frozen, tanks could maneuver almost anywhere in the vicinity of Ladd Field.

44. Tank guns were the only large cannon that fired satisfactorily at low temperatures.

45. At temperatures below -30° F., tank turrets were stiff and very difficult to operate.

46. At temperatures below 0° F., the Medium Tank, M4A3E8, was too cold for efficient crew functioning.

47. When firing the 76mm or 90mm tank guns, complete target obscuration was experienced, caused by the ice fog present. It was necessary for one tank to adjust fire for a second one.

48. Electrically heated suits were used by tank crews with reasonable success.

49. Plexiglas blisters were used to cover tank turrets in order to prevent tank commanders from being struck by cold air.

50. The engine heaters included in the standard winterization kits furnished general purpose vehicle were completely unsatisfactory for keeping vehicles warm enough to start at temperatures below -30° F.

51. One experimental engine heater, mounted in a $\frac{1}{4}$-ton truck, maintained the vehicle sufficiently warm for starting at the lowest temperature encountered.

52. Starting of all vehicles was very difficult at low temperatures due to the congealing of lubricants, the hardness of fan belts, the low efficiency of batteries, the failure of fuel to ignite, and the failure of the ignition system to provide the necessary spark to ignite the fuel.

53. Experiments were conducted in which vehicles were covered by tarpaulins and heat from large capacity heaters placed under the tarpaulins. In this way, vehicles were kept sufficiently warm to start at low temperatures.

54. After starting, vehicles were difficult to move due to the stiffening

of gear oil and wheel bearing greases.

55. The Weasel was the most successful vehicle in the Task Force, both from the standpoiht of operation and mobility.

56. Wheeled vehicles and half-tracks were unsatisfactory for movement through deep snow.

57. At low temperatures, recovery operations were extremely difficult.

58. Second echelon maintenance was impossible in the open unless hot air from a heater was directed on the hands and body of the mechanic.

59. Staff planning and operating must consider the terrific burden placed on troops by the extreme cold and deep snow.

60. Reconnaissance required much more time than normal, since little daylight was available, landmarks were scarce, and the area was not accurately mapped.

61. In front line units, frequent relief must be effected since troops cannot remain in place for long periods of time.

62. During both the attack and defense, combat troops must be closely supported logistically.

63. The primary role envisioned for tanks in the defense is counterattack. They should remain in a centralized reserve position until ordered to move.

64. Mess personnel, mechanics, and rear area personnel should be increased in combat organizations. The difficult tasks of feeding, maintenance of vehicles, and setting up and breaking camps should be accomplished without calling on combat soldiers.

Operations in the Arctic present many and difficult problems. However, let us not forget that the Russians for many years have lived and fought in temperatures similar to those found at Ladd Field. It is, therefore, every soldier's duty to study the problems encountered in the past and prepare himself for the job that he might at any time be called upon to perform -- the role of the Arctic fighter!

** Finis **

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