FM 31-15

WAR DEPARTMENT

BASIC FIELD MANUAL

OPERATIONS IN SNOW AND EXTREME COLD

September 18, 1941

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OPERATIONS IN SNOW AND EXTREME COLD

Prepared under direction of the
Chief of Staff

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WAR DEPARTMENT,
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FM 31–15, Basic Field Manual, Operations in Snow and Extreme Cold, is published for the information and guidance of all concerned. This manual deals primarily with the special conditions confronting troops in snow and extreme cold and the special measures required to meet those conditions satisfactorily.

Four major problems present themselves for solution in operations in snow and extreme cold:

a. Keeping men and animals warm.

b. Moving troops across snow and ice.

c. Transporting and preserving supplies and equipment.

d. Preventing the malfunctioning of weapons, instruments, engines, and other equipment due to cold.

The satisfactory solution of these problems enables the energetic commander to apply effectively the basic tactical doctrines of combat.

Success in operations in snow and extreme cold is dependent, fundamentally, upon two things: first, clothing and equipment suitable for use under such conditions; and second, thorough training of officers and men in how to take care of themselves, keep their weapons functioning, and themselves and their transportation mobile. Regardless of temperature, the basic tactical doctrines remain the same. In their application to combat in snow and extreme cold, they are adapted to local conditions of ground and travel.

Keeping these fundamentals in mind, and applying them with vigor, assurance, and common sense, commanders may enter a campaign in snow or extreme cold with every confidence that their men will be comfortable, that their weapons and equipment will function properly, and that success will repay their preparatory efforts.

This manual should be studied in conjunction with FM 100–5, Operations, and FM 100–10, Administration.

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BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

E. S. ADAMS,
Major General,
The Adjutant General.

DISTRIBUTION:

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(For explanation of symbols see FM 21–6.)

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BASIC FIELD MANUAL

OPERATIONS IN SNOW AND EXTREME COLD

CHAPTER 1

GENERAL CONSIDERATIONS

■ 1. During cold weather, certain general conditions will be encountered that profoundly affect the conduct of troops in the field. For successful operations, special equipment and a high state of training are of paramount importance.

■ 2. Some of the difficulties that must be met are as follows: Deep snow and drifts impede progress both off and on roads; motors are difficult to start; normal lubricants harden; bearings become stiff; the mechanism of oiled weapons does not function properly; fuel and Diesel oil does not flow through pipes; radiator and water jacket fluids solidify; oil in recoil cylinders hardens; frost fogs the lenses of optical instruments; water condenses and freezes in gasoline tanks, lines, and carburetors; fuel, gasoline, ration and forage consumption is increased; ice forms on the wings and other parts of airplanes; landing fields become blocked with snow; the ballistics of weapons are modified; some types of rubber and steel become brittle; both dry and storage batteries lose efficiency and defensive works and weapon emplacements are difficult to dig in frozen ground.

Men are subject to chilling, frostbite, freezing, and snow-blindness. When cold, they are less alert. Without proper shelter and covering they lose sleep and weaken. Their fingers may become numb from cold, resulting in poor handling of their weapons. They will seek sheltered locations and huddle together for warmth. There will be occasions requiring violent exertion resulting in their becoming overheated, followed by periods of inactivity during which they may freeze. They will lose articles of equipment in deep snow.

Animals will suffer from cold and frosted lungs. They will find difficult footing on ice and slippery ground. They are also subject to serious injury from drinking ice water when they are overheated.

In areas of snow and extreme cold, roads are ordinarily scarce, towns are small and far apart, and stocks of supplies suitable for military use are negligible.

■ 3. When the air is still and dry, men are apt to consider the temperature higher than it actually is and become careless in precautions against frostbite. During low temperatures sound carries farther than at other times. A man chopping wood can sometimes be heard at a distance of 10 miles. Smoke from fires and the exhaust of engines hang in a low, heavy cloud and a mist sometimes rises from men and animals. At minus 60° F., a flying airplane leaves a trail of mist behind it. The air is warmer at high altitudes than on the ground. Cold streams of air run down valleys. The coldest temperatures usually occur during clear, still weather. During blizzards, the temperature usually rises somewhat but men suffer in high winds. In mountainous districts, sudden and severe storms are common and snowslides constitute a frequent danger.

■ 4. In many parts of the Arctic and near-Arctic, the ground remains permanently frozen to great depths, thawing out on top during summer to a depth of 1 to several feet.

During warm weather, the water on level ground forms into lakes, puddles, and sluggish, meandering water courses. The ground is soft and swampy and covered with a growth of moss, grass, and other low vegetation. Clumps of roots, grass, and moss, called "nigger-heads," stick up above the mud. Holes several feet deep full of water or ooze occur everywhere. This type of terrain is known as "tundra." Tundra and other swampy ground form formidable military obstacles during summer but when frozen are easily crossed by troops and all forms of transportation including tanks, sleds, and trailers.

When snow covers the tundra it is easy to find landing fields for ski-equipped airplanes. Airplanes landing on wheels can use the frozen surfaces of lakes and water courses where the wind has swept the snow clear, or they have been otherwise cleared. Frozen streams frequently can be used as highways but snow-covered ice is treacherous and must be carefully reconnoitered. Shallow streams often freeze to the bottom in places and the water, being thus damned up, breaks out above and flows over the ice. A thin crust of ice then forms over the top of this water, and snow falling upon it conceals its weakness. Swift currents often make thin spots in ice. Aquatic animals frequently break the ice

to make "blow holes." After freezing, a stream may fall, leaving an air space under the ice which causes it to cave in when weight is placed upon it.

When deeply frozen ground begins to thaw, it offers great difficulties to transportation. Unpaved roads become quagmires and, except on surfaced roads, wheeled transportation stops. During the early part of thaws, solid frozen ground can be found a foot or less below the surface. Under these conditions roads can be made temporarily passable for wheeled vehicles by pushing the mud off the frozen ground with a bulldozer. This is only a short respite from difficulties, however, since the exposed frozen ground soon thaws out and traffic will again bog down.

Ordinarily, in colder climates, there is an increasing proportion of evergreen over deciduous trees. Birch, aspen, scrub willow, and some cottonwood are to be found principally among the deciduous species. Alder and small bushes grow in thickets which become difficult to penetrate. As the more northern latitudes are reached trees grow smaller and eventually disappear, leaving only brush and finally open tundra. On windswept coastal regions, trees are usually smaller and scrubbier than in protected inland valleys. In areas where there is a heavy precipitation of moisture, trees usually are larger and more abundant than in dry sections.

CHAPTER 2

FOOD, CLOTHING, AND SHELTER

SECTION I

GENERAL

■ 5. During operations in snow and extreme cold the production and conservation of heat are of primary importance and require proper food, clothing, and shelter.

SECTION II

FOOD

■ 6. Some foods produce more heat than others. Sugar and fats are high in heat-producing qualities. Consequently, the ration should include a greater percentage of these than is normally issued. The amount of food should also be increased. Corn bread is more heating than wheat bread. For animals, corn is more heating than oats. In the absence of drinking water, small quantities of snow may be eaten while troops are warm or on the move but eating snow in large quantities chills the stomach and materially reduces the body temperature. Alcoholic drinks cause the body heat to come to the surface, resulting in radiation and subsequent chilling. They are, therefore, dangerous during exposure to cold.

■ 7. Whenever possible, food, tea, coffee, and soup should be served hot. Cold mess equipment soon chills food. At the kitchens, it is desirable to provide means for heating cups and mess pans. This can be accomplished by dipping them into cans of hot water just before food is placed in them. It is better to serve each soldier with two small helpings of hot food than to give him all of his food at once and allow it to

chill before he can eat it. Whenever possible, meals should be served in heated tents or shelters, and arrangements made so that men will not have to sit on the snow. At outposts or where fires are not permissible, thermos containers are advantageous.

8. When the meal is finished, mess gear must be thoroughly cleaned in boiling water in order to remove all grease and other material which tends to cling to the mess kit. Mess gear which is not thoroughly clean may be the cause of diarrhea.

9. For patrols and other small units engaged in operations which separate them from the company (troop) kitchen for several meals, special provision for food and drink must be made. Since each soldier will carry his own food, it should consist of components which are not subject to freezing and which are highly concentrated. It should contain a high percentage of sweets and fats. Dehydrated, precooked soups, fruits, vegetables, and meats are highly satisfactory. Oatmeal, cornmeal, and bacon are recommended. Thermos containers should be provided for liquids. In very cold weather the liquid placed in the issue canteen will freeze.

10. In the absence of a normal diet, scurvy sometimes occurs. However, men can live indefinitely without ill effects upon a diet composed entirely of fresh meat. About 1⅓ pounds of lean meat and ½ pound of fat per man per day will suffice. This must be served rare. It is well to boil it for a short time and drink the water that it is boiled in. The necessary vitamins are destroyed by excessive cooking.

SECTION III

CLOTHING

11. A soldier must wear such clothing as is issued to him. Commanders will, however, have some option in the selection of what clothing is to be taken into the field and the manner in which it is worn. Tables of Basic Allowances provide for special clothing and equipment for troops operating in snow and extreme cold.

12. The human body is constantly radiating heat and moisture. Even in extremely cold weather, perspiration

leaves the body in the form of vapor. When this vapor comes into contact with cold air it condenses and, if closely confined, forms frost on the inner surfaces of the outer layer of clothing. Clothing that is impervious to water vapor soon becomes damp and soggy and, since water is a good conductor of heat, the moisture-laden clothing soon draws the heat out of the body. Paradoxical as it may seem, one of the principal causes of freezing to death results from becoming overheated. In such cases, the inner clothing becomes saturated with moisture from perspiration, conducts the heat from the body, and then freezes hard.

■ 13. A space of dry air next to the body keeps the heat in. Consequently, inner clothing should be of a loose, spongy weave, flexible and porous enough to hold a thick insulating layer of dead air. Outer clothing should not be heavy, stiff, or bulky, but should be of a texture that will act as a windbreak and inclose the warm air in the inner clothing. It should be loose enough not to interfere with free blood circulation and sufficiently porous to prevent the moisture of perspiration from condensing and freezing on the inner surface.

■ 14. Several layers of light clothing are very much warmer than a single layer of equal weight. In general, inner clothing should be fluffy and porous and outer clothing wind-resistant. A woolen sweater, worn as an outside garment over a light windbreaker will give little warmth. Worn under the windbreaker, it is very warm.

■ 15. Underclothing should be of pure wool with separate undershirt and long drawers.

■ 16. The usual pattern of overcoat allows air to escape at the bottom, wrist, front, and collar. A turned-up high collar collects snow like a funnel. For cold weather operations, the outer coat or the parka should have a hood and drawstring or belt. Provision should made made to close the front opening securely against air escape. Sleeves should close snugly but not tightly at the wrist. The reindeer fawn parka is one of the warmest of all garments. It is not entirely suitable for general military use, but issued in limited quantities for special purposes, it is a valuable adjunct to the regular equipment of troops operating in cold weather.

■ 17. The ordinary military breeches are too tight at the knee to allow proper circulation. Light windproof and water repellent cloth over porous wool is a good combination for trousers. Hard finished, closely woven gabardine is also an excellent material for use in extreme cold. For horse cavalry, breeches which are loose fitting, especially at the knee, with adjustable waist and leg are suitable. "Knee chaps" made of blanket-lined canvas fastened over the upper shin, knee, and lower thigh are a source of comfort to truck drivers.

■ 18. Tight shoes result in frozen feet. For temperatures of extreme cold, shoes, shoe pacs, or mukluks should be large enough to contain two pairs of light wool socks, a pair of heavy knitted wool socks, a burlap boot sock and an insole of felt or preferably of burlap. Too much emphasis cannot be placed upon the importance of having the shoe fit loosely. The average soldier will need shoes about two sizes larger than those worn during warm weather. If the shoes that he has are tight with all the socks that he would like to wear, it will be better for him to discard one pair of socks than to bind his feet too tightly.

■ 19. Shoes should not have a permanent lining of fleece, felt, or anything that will collect moisture. Moisture always collects and condenses inside of shoes. Everything in the shoe should be removable for drying at the end of a day's wear. Oil tanned shoes are colder than dry tanned. Hobnails, except when used with specially constructed soles, chill the soles of the feet.

■ 20. Shoe pacs with rubber feet and leather tops are the best footgear obtainable for mud, slush, and wet snow. They are suitable for use with snowshoes. With proper foot covering, they are amply warm for temperatures down to 0° F. Below zero, they are too cold when the wearer is not on the move.

■ 21. High overshoes with light rubber soles and buckled uppers, worn with insole, heavy socks, and burlap boot socks may be used as a substitute for shoe pacs, especially when there is a need for more wool foot covering than the shoe pac will accommodate. High overshoes are not so warm when ordinary shoes are worn under them. They can be worn with snowshoes.

■ 22. Moccasins, while warm in dry, powdery snow, are very poor in wet snow and slush. Even in cold weather they are likely to become saturated with water when soldiers congregate about fires or in tents where the snow is melted.

■ 23. The warmest of all footgear is the Eskimo "mukluk." This has a sole of rawhide made from the skin of the bearded seal, and uppers of reindeer skin ending in a drawstring just below the knee. The fur is on the outside. Rawhide thongs bind the mukluk snugly at the ankle. For extreme temperatures, a boot of commercially available substitutes should be made according to the mukluk pattern and issued to troops. Light rubber bottoms of the nonfreezing type of rubber and calfskin uppers, with the hair outside, should answer the purpose. Mukluks are suitable for snowshoeing.

■ 24. For skiing, there is no satisfactory substitute for the regular ski boot. Ski boots should be large enough to be worn over at least one pair of light and one pair of heavy wool socks.

■ 25. In the absence of a burlap boot sock, a strip of burlap cut from a gunny sack can be wound loosely outside the socks and over the feet and ankles.

■ 26. Dried grass stuffed loosely into the shoe outside of the socks also makes a splendid insulating material. Indians and Eskimos frequently employ this method of keeping their feet warm, throwing away the used grass every night and replacing it with fresh grass in the morning.

■ 27. Fingers numbed from cold greatly impair a soldier's efficiency and gloves warm enough for habitual wear are too bulky for the proper handling of instruments and weapons. Mittens are much warmer than gloves. Gauntlets which protect the wrist are essential in very low temperatures.

The most generally suitable protection for the hands and wrists consists of the following combination:

A loosely woven woolen mitten extending well above the wrist is worn next to the hand. This mitten should be so constructed as to provide three compartments; a thumb compartment, a trigger finger compartment, and a compartment large enough to accommodate all fingers comfortably when the trigger finger is not in use for firing pur-

poses. A closely woven light waterproof covering may be sewed over the mitten to prevent snow from clinging to or penetrating the loosely woven wool.

A gauntlet, made of soft, tough leather is worn over the mitten. This gauntlet should extend above the wrist and be provided with an elastic or buckle closure. A slit in the palm of the gauntlet will permit the wearer to fire his weapon without removing the gauntlet.

■ 28. Soldiers whose duties require them to use all fingers can substitute woolen gloves for the one-fingered mittens. These, however, will be less warm.

■ 29. On the inner surface of the wrist, the blood runs close to the surface, and cold wrists result in cold hands. A convenient and comfortable wristlet can be improvised by cutting off the toe of a woolen sock, pulling the leg of the sock up over the forearm, allowing the fingers to project through the toe of the sock, and making a hole in the side of the sock foot for the thumb. Knitted woolen wristlets can be made of similar design and will greatly aid in keeping the hands warm.

■ 30. When the hands are not in use, holding a handful of dry grass or straw in each hand will aid in retaining warmth. A pocketful of dried grass is well worth carrying along.

■ 31. Troops will be provided with a suitable warm head covering. Unless it is very windy or snowing, this headgear will ordinarily provide ample warmth while on the move. When necessary, the parka hood can be pulled up as additional protection for the head against the elements.

■ 32. Blankets are insufficiently warm for extremely cold weather. Sleeping bags are better. Down-filled sleeping bags are the warmest protection obtainable for their weight.

■ 33. In a properly made down-filled sleeping bag a soldier can sleep in the open in any temperature that he will encounter. The only draw-back to down is that moisture condenses in it. Down bags must be thoroughly dried at least every three days. Sleeping bags should be tapered and of the "mummy-case" type to cut down weight and bulk. Since a soldier will frequently be separated from his

transportation his sleeping bag must be of a type that he can carry in his pack. It should have a washable and removable lining.

■ 34. To reduce or eliminate the effect of glare from the snow and prevent snow-blindness, suitable pigmented glasses should be worn by personnel operating in snow. Even though glasses are so designed as to permit circulation of the air between the lenses and the eyes, there is a tendency for lenses made of glass to cloud over, especially after the wearer has exerted himself strenuously. A thin coating of glycerine rubbed on the eyepieces, "anti-dim" such as is issued with the regulation gas mask, or similar preparation, will prevent clouding. The skin must be protected from direct contact with metal parts of the glasses.

SECTION IV

SHELTER

■ 35. Where villages or buildings are available, they should be used to the greatest extent possible. Isolated buildings capable of being heated can be used to good advantage for drying wet or sweaty clothing and footgear.

■ 36. Large tents are better than small ones since the body heat of a number of men together raises the inside temperature. The pyramidal tent of the type normally issued was designed for hot weather. It is not a satisfactory shelter for operations in cold weather. On the other hand, a semi-pyramidal tent having a low, sloping roof, and with the stove located at the low end, is very warm. The heat of the stove is reflected downward from the roof and rises gradually to the peak, where clothing can be hung to dry. Two such tents can be pitched with a single pole and with one or two stoves will keep sixteen men very comfortable. Floorcloths should be provided to keep bedding off the ground; they should not be permanently fixed to the tent.

■ 37. When regular shelter tents are used, they should be pitched double so as to avoid having an open end. A couple of candles burning in tin cans will considerably raise the temperature in a small tent. A lantern may be used for the same purpose.

■ 38. Wooden tent pins cannot be driven into frozen ground. They can be used by driving holes for them with a steel spike, inserting them in the holes and pouring water around them. This is a wasteful method, since pins will be broken in later attempts to remove them. Iron or steel pins are better. Forty-penny nails or "bridge-spikes" make excellent pins for small tents.

■ 39. Another method of pitching tents is to fasten the guy ropes to poles buried in the snow.

■ 40. In open country, tents must not be pitched in the lee of sheltering objects. Snow drifts deeply in such places and is likely to bury the tentage. In the woods, this precaution is usually unnecessary.

■ 41. A lean-to can be made by constructing a framework of poles in the shape of half an A-tent divided longitudinally and covering its three sides thickly with evergreen boughs with the twigs pointing downward. The open side faces away from the wind and toward a fire. A wall of green logs behind the fire acts as a reflector and increases warmth.

■ 42. Canvas or paulins on poles, and banks of snow built in semicircular form are useful as windbreaks for men and animals.

To provide protection for animals in wooded country, the picket line should be pitched in a location protected from wind and air observation. On wind-swept terrain, such as prairie country, canvas shelter must be provided. Animals keep warmer when they are crowded. In temperatures of 20° below zero or more, bedding should be provided. If bedding is not available, animals must not be allowed to lie down, since the danger of freezing is too great.

The animal shelter should be 6 to 6½ feet high, banked around the bottom, and with entry (exit) opening to leeward. Horses should be tied on one side of the picket line only. If a heater is used it should be placed on the windward side of the shelter.

■ 43. At times, domed snow houses can be used by detachments of troops. If properly constructed, they are comfortable and difficult to locate from the air except by their cast shadows. A description of the construction of one of these shelters will be found in the appendix.

SECTION V

PRECAUTIONS AND SUGGESTIONS

■ 44. One of the dangers incident to operating in subzero weather is that of freezing. This may be caused by such conditions as exposure to cold and wind, diminished circulation due to pressure, contact with heat-conducting surfaces, and loss of heat by radiation. Contributing causes are fatigue, exhaustion, lack of proper food, and insufficient clothing.

■ 45. The parts most frequently affected by frostbite are the hands, feet, nose, cheeks, chin, and forehead. Men should, therefore, frequently examine the exposed parts of their companions to note signs of freezing. Freezing is not always accompanied by pain. It is evidenced by a grayish or whitish appearance of the skin. When exposed to extremely cold weather, one should, from time to time, wrinkle the face to discover any stiffness caused by freezing. The face may be thawed by placing the hand over the frozen area until circulation is restored. If freezing has just begun, this should require only a few seconds. If the hands become cold, they may be warmed by placing them under the armpits beneath the clothing.

■ 46. During cold winds, the face may be partly protected by pulling the parka hood forward on the windward side. Additional protection is afforded by greasing the skin with some fatty oil. Mineral oils are less effective.

■ 47. Tight shoes, straps or leggings, and too many socks or wrappings may reduce the circulation and cause the toes and feet to be frozen. Even a slight pressure may be dangerous, as a mere retarding of the flow of blood may lead to freezing. One of the most frequent causes of chilling results from wet clothing. Clothing may become wet from perspiration, melted snow, or direct immersion. In the event of direct immersion immediate steps should be taken to dry or replace the wet articles. A spare pair of dry socks and underclothes should always be carried by each individual.

■ 48. In order to prevent clothing from becoming saturated with perspiration, the greatest care should be exercised not to become overheated. When undergoing exertion, the

clothing should be unbuttoned or opened, and parka hoods should be removed from the head so as to allow free air circulation and permit the vapor of perspiration to escape.

■ 49. Cold metal should not be touched with the bare hands, tongue, or lips. The skin immediately freezes to such surfaces and, to be released, the metal should be warmed. Otherwise, the skin will be pulled off. Metal whistles and the mouthpieces of bugles must be carried in a pocket near the body so as to warm them before they are placed against the lips.

■ 50. Bits should be warmed before they are placed in the horse's mouth. Holding them inside the outer layer of clothing or against the horse's body is a satisfactory means of warming them. Should the personnel be provided with heated shelter it is good practice to take the bridles into this shelter.

■ 51. Freezing to death may come after prolonged exposure coupled with lack of food, extreme fatigue or exhaustion. Exhaustion is frequently caused by forcing one's self to keep going when a short rest should be taken. According to well-known Arctic explorers, going to sleep while cold and tired is not dangerous but, on the contrary, beneficial, unless the individual is already completely exhausted. The cold will reawaken the sleeper before he freezes. He may then move about to reestablish circulation and take another nap. Eskimos are known to have survived blizzards of three days' duration by sitting or lying down with their backs to the wind and their arms pulled out of their sleeves and held close to the body under their parkas. At such times, they usually sleep through more than half of this period.

■ 52. Wounded men are very susceptible to frostbite because of the loss of bodily heat attendant on shock, the loss of blood, and impaired circulation. Whenever possible, wounded men should be put into sleeping bags and moved to fires or heated shelters.

■ 53. The reflection from snow surfaces often results in snow-blindness. This is likely to occur in overcast as well as in sunny weather. Snow glasses should always be worn in snow during the daytime. If no glasses are available, some protection will be afforded by blackening the skin around the eyes.

■ 54. In temperatures below minus 30° F., deep, rapid breathing resulting from exertion sometimes causes frosting of the lungs. This is not usually fatal but often incapacitates a man for several days. The air entering the lungs will be less cold if men breathe simultaneously through the nose and mouth, placing the tip of the tongue against the roof of the mouth, and allowing the air to flow around it when inhaling.

■ 55. Men should not wear beards. Frost from the breath accumulates on beards and freezes the skin. Men should shave frequently or else keep the beard closely trimmed with clippers. For shaving, it is preferable to use a preparation rich in oil or grease, since the oil supplements the normal skin oil in protecting the skin against the weather.

■ 56. At halts men should avoid sitting down on the snow in order to prevent their clothing from becoming wet. If nothing else is available to sit on they should remove their packs and sit on them.

■ 57. When arising after lying down, sitting, or kneeling, men should dust snow from their clothing so that it will not thaw and cause dampness. They should be careful not to put their hands into their pockets or into mittens without carefully dusting off all snow.

■ 58. Sleeping bags should not be placed directly upon the surface of the snow. They should be separated from the snow or ground by evergreen boughs, small brush, grass, or whatever material may be found at hand.

■ 59. When sleeping in temporary shelter and a fire or other heating means is being used, the feet should be nearest the heat, since ordinarily the feet are the first part of the body to chill.

■ 60. Because carbon monoxide is exhaled from the lungs, it is not advisable to sleep with the head completely covered. Even in the severest cold, the nose and mouth should be uncovered.

■ 61. Men will occasionally find it necessary to wade across shallow streams or overflows while wearing shoes that are not waterproof. In temperatures of extreme cold, shoes may

be made temporarily waterproof by dipping them into the water and quickly withdrawing them so that a thin coating of ice covers the leather. Individuals can then wade quickly across. The ice will soon crack off the shoes. This is a well known expedient among the Eskimos.

■ 62. Always carry a waterproof box that will float—full of matches—and do not use it all the time, but keep it in reserve in case of accident. This is cheap life insurance.

■ 63. Each party, group, or unit must have at least one reliable compass.

■ 64. Drink sparingly of water in a strange country; it may cause dysentery or be very constipating until you get used to it.

If lost in unknown territory, find a stream and follow it down; it will generally bring you out near a habitation. Don't follow old wood roads; they generally wander around aimlessly and lead nowhere.

For traveling any distance into the mountains do not rely on an electric flashlight. Good candles are indispensable.

A sewing kit, containing safetypins, needles, thread, darning cotton, buttons, wax, etc., will prove invaluable.

The tail of a sweater is excellent for darning if a portion of it is unravelled.

Don't eat too heavily before a climb.

Don't neglect cooking. Take time to prepare at least two good meals daily.

Develop ingenuity and self-reliance.

CHAPTER 3

TRANSPORTATION

SECTION I

RAIL

■ 65. Railroad transportation is often interrupted by deep snow, drifts, and snowslides. Snowslides occur most frequently in mountainous regions when heavy fresh snow falls over a glazed crust or during thaws. In deep passes and defiles, snow will often form in drifts 50 or more feet in depth. During melting weather, slides are often started by the vibration from passing trains. They are more apt to occur in the daytime than at night since the drop in temperature after nightfall often causes a temporary freeze. When thaws are likely to cause snowslides, the safest period for running trains through mountainous districts is between the late hours of the night and sunup.

■ 66. An ample supply of rotary railroad snow plows should be held in readiness. They should be so located as to permit them to work simultaneously on both ends of probable drifts and slides. The cowcatchers of all locomotives should be provided with plates for clearing light snow from the track. The track should be kept under constant observation so that a timely warning of obstructions may be reported.

SECTION II

ANIMAL

■ 67. Horse- and mule-drawn vehicles on wheels find difficulty in moving over roads when the snow is as much as a foot deep. During subzero temperatures, wheeled vehicles are

harder to pull through snow than when it is warmer. (See FM 25–5.)

■ 68. The feet of animals slip on icy surfaces. All should be roughshod. The greatest care should be taken not to allow animals to become overheated. On long steep pulls, half of the vehicles should be pulled to the hilltop with double teams, all teams then being sent back to pull up the remaining vehicles in similar fashion.

■ 69. In snow, sleds are more easily drawn than wheeled vehicles. It is advantageous to place runners under the wheels of artillery and other weapons towed by wheeled vehicles.

■ 70. Animals should be given frequent rests. At such times sweaty patches under the harness should be wiped dry.

■ 71. Animals should not be watered when they are hot. Overheated animals drinking large quantities of ice water are subject to founder and other ailments.

■ 72. Frequently, the normal watering methods are inadequate or unsuitable in cold weather. Holes cut into the ice provide practicable watering troughs from which animals soon learn to drink without difficulty. The holes should preferably be about 18 to 24 inches square at the top, and shaped like an inverted truncated pyramid, about 6 inches square at the bottom. The basin thus cut will ordinarily fill with water, especially as the animals approach the edge. For a distance of about 2 feet from the edges the ice should be roughened to provide better footing and prevent the animals slipping into the hole. For watering purposes, good ice 3 to 4 inches thick will support three animals.

■ 73. To prevent warm animals from drinking too fast, bits should be left in their mouths, or straw, twigs, leaves, etc., should be thrown into the water.

■ 74. When animals breathe deeply from exertion, they are subject to frosting of the lungs. Balls of ice often form in their nostrils and prevent breathing. This condition can be prevented to some extent by tying burlap bags over their noses, but the frost forming on these nose bags should be beaten out on frequent occasions.

■ 75. Hoofs should be inspected at short intervals and balls of snow removed from the soles.

■ 76. When animals are unhitched or unsaddled they should be wiped dry, led until cool, blanketed, and, if possible, protected from the wind.

■ 77. Mules suffer from cold more than do horses.

■ 78. In winter operations, horses serve better than mules as pack animals, since mules have smaller hoofs and they do not stand the cold as well. Pack animals can travel 15 or 20 miles in a day. In the absence of grazing facilities and with the increased forage necessary, pack trains are the least efficient means of long-distance transportation during extreme cold. With no other useful load, a pack animal can carry approximately 10 days' forage supply for one animal.

SECTION III

SLEDS

■ 79. When weather and trail conditions are good, a dog team in top condition can pull its weight in cargo and average 50 miles a day. Seven dogs constitute an average dog team. Each dog will eat about 2 pounds of food per day. In 10 days, therefore, a team of seven dogs averaging 75 pounds each will cover, under the most favorable conditions, 500 miles and carry their own food weighing 140 pounds plus 385 pounds of cargo. Under average conditions they will give a much less favorable performance. They suffer very little from the cold and during blizzards will burrow into snowbanks and sleep comfortably.

The chief disadvantages in using dogs are that they must be fed, whether on the move or otherwise and that, when they are with security detachments, their frequent barking discloses their presence to the enemy. Furthermore, in deep snow, dog teams cannot move at all unless men on snowshoes walk ahead and break the trail for them. Dogs also at times become footsore. Under such conditions some relief can be given them by tying canvas shoes over their feet. They are constantly fighting and, unless precautions are taken, are likely to eat their leather harness. (See FM 25–6.)

80. Light hand-drawn sleds and toboggans are useful in transporting machine guns, mortars, ammunition, and rations as well as for evacuating wounded. In deep, soft snow, toboggans are more easily drawn than sleds. Men drawing sleds should ordinarily walk in tandem. The lead man, who must break the trail, is frequently relieved by one of the others. Small sleds or toboggans can sometimes be used as platforms from which to fire weapons. Sleds can best be lowered down steep slopes by ropes attached in rear. Men on snowshoes can draw sleds better than can those on skis. Ordinarily it is easier to carry individual equipment on a pack than to pull it in sleds.

When the temperature is below minus 30° F., sled runners do not pull easily over snow, since snow at such times has almost the resistance of sand. Metal runners are particularly hard to pull. Under these conditions it is desirable to lash wood over the lower surfaces of metal runners. If obtainable, black walnut is one of the best woods for this purpose. On light hand- and dog-drawn sleds, water may be poured from time to time over the bottoms of runners, thus giving them a surface of ice. This treatment is also suitable for toboggans.

SECTION IV

MOTOR

81. Motor vehicles with two-wheel drive operate with difficulty on roads in 1 foot of snow. Vehicles with four-wheel drive can usually run in snow up to about 1½ feet deep. Vehicles with caterpillar treads can move through much deeper snow. Snow plows should be available to all troops using roads in winter. Engineer troops will ordinarily be charged with the duty of keeping the roads passable.

82. To protect the engine block and all other parts of the motor and its connections through which liquid from the cooling system flows, an adequate amount of suitable antifreeze liquid must be in the radiator at all times. In an emergency, light cylinder oil can be used in radiators.

83. Moisture from the air has a tendency to condense on the inner surfaces of gasoline tanks and containers, and eventually freeze in gasoline lines and carburetors. This trouble can be alleviated to some extent by keeping contain-

ers as full as possible. Gasoline should be filtered through chamois to remove water before it is put into the tanks of vehicles.

■ 84. Lubricating oils and greases become thick when cold. Those issued for winter use should be thin enough to remain constantly fluid. Bearings will go dry and wear out if the grease is too thick to flow freely between moving surfaces.

■ 85. Starting cold motors is always difficult. Starting batteries are much less efficient when the weather is cold and engines are hard to turn over. To assure maximum performance from batteries, all battery connections should be cleaned frequently and the voltage checked to assure that the battery is properly charged. The liquid in the battery should cover the surface of the plates at all times. Water should be added to storage batteries just prior to running the motor, so that there will be complete circulation and mixing of all liquids in the battery. Water added to a battery which is to remain idle for some time does not circulate and will freeze in very cold weather.

■ 86. It is usually desirable to idle motors during short halts and to run them at intervals during long halts so as to keep the engines warm. Motors should not be raced. Radiators and engine hoods should be heavily blanketed when engines are stopped. Motors can sometimes be started by towing the vehicle but this method is not always effective. One of the best methods of starting a cold motor is to drain and heat the radiator fluid, replace it, heat the intake manifold with a blowtorch, turn the engine over several times with a hand crank, and then apply the self starter or tow the vehicle. When a blowtorch is used, a fire extinguisher should be held in readiness to extinguish a possible gasoline or oil fire. In extremely cold weather the crankcase oil should be drained upon halting, and heated and replaced upon starting. Diluting the crankcase oil with gasoline is injurious.

■ 87. There should be at least two drivers with each vehicle; they should alternate in driving.

■ 88. Drivers and passengers should avoid direct contact with metal. Metal seats should be well padded. A piece

of sheepskin or woolen cloth should be sewed around the steering wheel. The metal handles of tools should be covered with cloth or adhesive tape.

■ 89. Due to incomplete combustion, gasoline is apt to drain into the crankcase and dilute the lubricating oil. Consequently, crankcase oil should be changed more frequently than in temperate climates.

■ 90. As a result of idling, poor combustion, and driving through snow, normal gasoline consumption will often be quadrupled.

■ 91. Men riding in trucks will be aided in keeping their feet warm by putting straw or grass on the floor of the vehicle.

■ 92. Whenever possible, trucks should be provided with heaters and defrosters. When defrosters are not obtainable, the windshield may sometimes be kept free from frost by slightly opening the rear end of the engine hood, by using a piece of wood or paper to hold open a crack through which warm air from under the hood will blow back against the windshield.

■ 93. Where streams and lakes are to be crossed, open cabs are safer than closed cabs. The doors of closed cabs should be kept open while crossing ice to prevent the drivers from being trapped in case of a break-through.

■ 94. All wheeled motor vehicles should be equipped with tire chains.

■ 95. When halted, it is better, when possible, to "chock" the wheels than to set the brakes, since cold and condensed moisture often causes a set brake to lock. Air tanks on air brakes must be thawed frequently to drain condensed and frozen moisture. Rubber air hose and brake fluid tubes become stiff and hard and require constant inspection to determine any leakage.

■ 96. When stopping on snow, ice, or frozen ground, brakes should be applied gently. A sudden application of the brakes is likely to cause slipping, loss of control, and accidents.

■ 97. In driving through drifts, the vehicle should be put in low gear before entering the drift and then kept moving. Stopping or slowing up in a drift to change gears often results in stalling.

■ 98. Diesel engines are more reliable in cold weather than those using gasoline for fuel. At minus 30° F., Diesel oil becomes too sluggish to flow through pipes. An improvised wood stove made of sheet metal and built against the fuel tank is sometimes useful in warming the oil when starting. After starting, the fuel in most Diesel tractors is kept warm by the engine exhaust.

■ 99. Tractors with wide tracks are one of the most reliable and efficient means of transportation in winter campaign. They are not confined to roads, can run over deep snow, will knock down small trees, cross rough terrain, pull heavy weapons, sleds or trailers, and climb steep slopes. They travel at a rate of about 6 miles per hour. Preceded by bulldozers, they can make their own roads and are particularly useful where highways are scarce.

Each tractor should be equipped with a power-operated winch and heavy duty cable 250 to 300 feet long to move tows over otherwise impassable ground and to lower them down steep slopes.

When sleds or other trailers are being towed by tractors, it is usually easier to run over snowdrifts than to clear roads through them. In going down steep slopes with sleds in tandem, brakes may be improvised by wrapping chains around the runners. Sleds may also be kept from overrunning the tractor by attaching ropes in rear and having men hold them back.

SECTION V

AIR

■ 100. Troops temporarily cut off from their sources of supply by snow, severe weather conditions, or hostile operations can be supplied by air. If landing fields are available or can be cleared, the problem of supply by air is simplified. Otherwise, supplies can be dropped by parachute. Where the necessity for supplying detachments by air appears probable, transport airplanes with cargo parachutes should be kept in readiness and supplies assembled at the operating fields.

■ 101. Parachute troops and air landing troops may be effectively employed to seize or destroy installations and vital areas in rear of the enemy lines. In pursuit, troops transported by air are employed to block defiles, delay the enemy retreat and assist in his ultimate destruction.

In employing parachute troops on these missions, careful consideration must be given to the fact that ordinarily these troops will be separated from their skis or snowshoes when they first land, and that they may experience considerable difficulty in deep snow in reaching this equipment.

■ 102. Where movement is made by air all personnel, including plane operating personnel, transport with them the means (snowshoes or skis or both) for moving across snow-covered terrain.

SECTION VI

SKIS

■ 103. A part of each combat organization should be equipped with skis for raids, reconnaissance, security, and messenger service. Skis increase the mobility of foot soldiers who are proficient in skiing.

■ 104. For proficient skiing a uniform running surface on the ski is necessary. This surface is obtained by the proper use of waxes. In military use the following types of waxes are issued:

a. Base wax for use in repair and maintenance shops as a base for other waxes.

b. Dry snow wax for use during very cold weather.

c. Medium wax for weather near the freezing point.

d. Wet snow wax for use in melting snow.

Waxing serves three purposes: To lessen wear and lengthen the life of the ski by preserving and waterproofing the wood; to make for faster running by minimizing friction; and to give the ski a "grip" on the snow to facilitate walking and climbing.

After use all snow should be brushed off the skis. If the skis are removed only temporarily, they are stood vertically on their tips in a cool place, usually the shadow side of a building, and the melted snow allowed to drain off. Standing on the toes tends to improve the upturn, while placing them upright on the heels allows the water to gather in pools

and seep into and rot the wood. Warm skis should not be brought out into the cold snow for use, nor should cold skis be brought into a warm room. Sharp temperature changes adversely affect the wood. Care of the skis overnight and longer demands that they be blocked to prevent loss of camber. To block the skis, place the running surfaces together and tie with cord or with toe straps at the upturn and near the heel. Insert a wood block 2 inches thick between the toe irons to maintain the necessary 1-inch camber for each ski. Place the blocked skis in a cool, dry place, standing them vertically on the toes to prevent loss of upturn. Special racks should be made for storing skis over long periods of time, providing for proper blocking at the points to keep the upturn, and at the toe irons to maintain camber.

■ 105. The ski binding is a most important element in skiing—the agency of control between foot and ski. Commercial bindings are mainly of leather and metal. While leather bindings require some maintenance, metal bindings need no special care, but if broken they are not reparable and must be replaced.

Ski bindings are separate from the ski and must be installed. The efficiency of the binding and toeplate depends upon their adjustment to the foot of the user so that the toe has no up-and-down side play. This is effected by adjusting the movable flanges of the toeplate to the skier's shoes and fitting the binding onto the toeplate so that the heel is held firmly and the shoe does not extend more than ½ inch beyond the toeplate.

■ 106. Leather bindings require regular oiling with neat's-foot oil or dubbin. This should be applied in moderation, as too much oil or grease will, in extreme temperatures, cause the strap to crack. Spare straps should be carried in the field. In event of breakage without spare straps at hand, a makeshift binding may be improvised to serve temporarily. Strong cord or light rope will serve this purpose.

SECTION VII

SNOWSHOES

■ 107. Snowshoes require less skill to use than do skis. Training in their use should not, however, be neglected

because of this as there is considerable difference between a trained and an untrained snowshoer.

■ 108. In general, snowshoes are not as speedy as skis, the rate of march of troops on snowshoes being approximately that of foot troops marching under normal conditions. However, snowshoes are better than skis for towing sleds, for use in brushy and hummocky terrain and for climbing hills. Also, they lend themselves better to assuming a firing position and to advancing from one firing position to another.

■ 109. Snowshoes should be worn by the majority of troops marching on foot in snow 1 or more feet deep.

Snowshoes should be worn only on a snow cover of 3 inches or more; use over hard surfaces will shorten their period of wear. Soft-soled covering is necessary on the feet; never use a hard-soled shoe in contact with snowshoes.

A good coat of varnish is required at all times to protect the wooden framework. Stand snowshoes vertically on the tail so that moisture will not soak into the wood surfaces and destroy the framework. For preserving the shoes over long periods of time, they should be well-cleaned, varnished, bindings oiled, and hung in a dry, cool room.

■ 110. The same remarks on trail breaking that apply to skis apply equally to snowshoes. A man trained in repairing snowshoes and equipped with 10 feet of babish and a pair of sharp nosed pliers should march at the tail of each company or similar unit.

■ 111. The bindings for snowshoes should permit the rapid extraction of the foot without the necessity of using hands. The binding known as the "siwash knot" has been found very satisfactory. (See figs. 1, 2, and 3.)

To effect this binding, take a strip of rawhide, tanned hide or web cloth approximately ½ inch wide and about 1 foot shorter than the reach between hands of the person for whom intended. In one end of the thong cut a slit lengthwise about ¾ of an inch long. Thread the slit end of the thong down through (1) (fig. 2) up through (8) down through (7) and back up through (8) so as to form a half hitch. Leave the slit end protruding about 1½ inches. This distance regulates the position of the toe piece. Using the

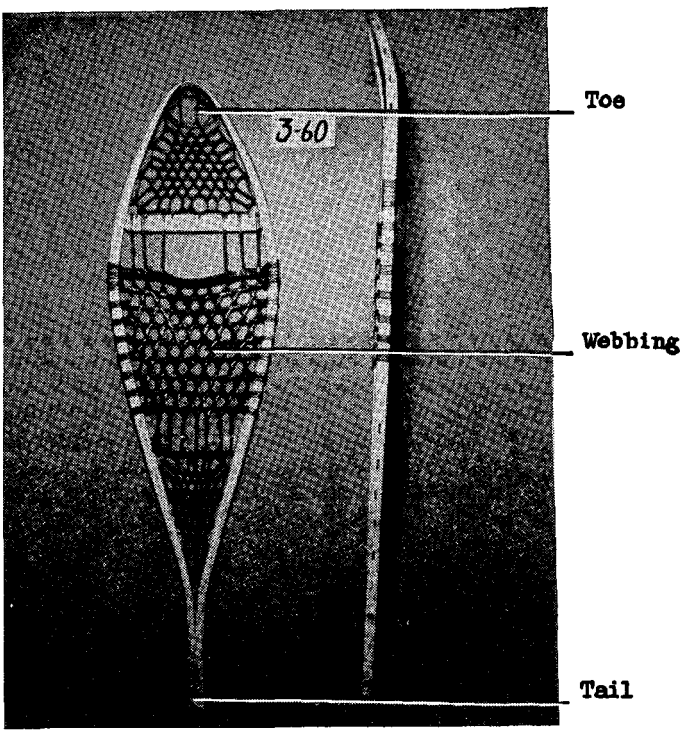

FIGURE 1.

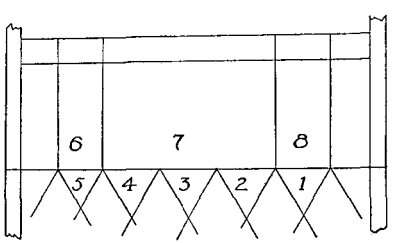

FIGURE 2.

other end of the thong, thread it through the slit until the slack is taken out. Thread the end down through (5) leaving about a foot and a half of slack for the heel binding, then up through (6), down through (7), and up through (6) forming another half hitch. Pass the end underneath the heel binding across to the slit. Tie it around the slit end just below the slit with a clove hitch or some other knot which can be easily untied. Place the foot through the heel binding. Move the foot to the right and back as far as it will go;

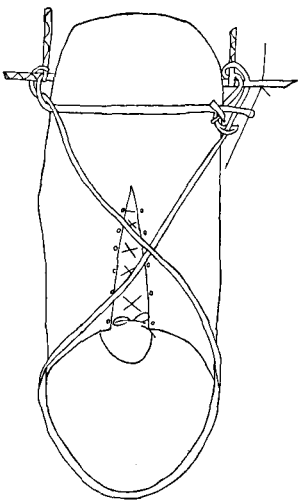

FIGURE 3.

then slide the toe to the left along the foot filling until it is under the toe piece. The binding may be adjusted to fit the foot by lengthening or shortening the heel binding loop. After being adjusted, the binding may be used over and over again without untying the knot. The foot should never be allowed to rest on the wooden crosspiece at either end of the foot filling. Many snowshoes have been broken in that manner. If the toe piece is too wide the difficulty may be overcome by beginning the knot at position (2) instead of (1) or (4) instead of (5) or both.

SECTION VIII

PACKS

■ 112. Special packs are required for soldiers operating in the cold since they must carry more bedding. It is important that the pack should not rest directly against the man's back. Air should circulate between the two or perspiration and subsequent chilling will result.

■ 113. The Norwegian type rucksack used by European mountain and ski troops is the best obtainable. It is well adapted to skiing and will accommodate the sleeping bag in addition to the rest of the soldier's normal equipment.

CHAPTER 4

MARCHES

■ 114. The provisions of FM 100–5 apply to marches. Special considerations applicable particularly in snow and extreme cold are discussed in this chapter.

■ 115. Preparations for a march in snow and extreme cold include a careful study of all weather reports and forecasts. It may be advantageous, under certain conditions, to delay the start of a march for several hours or longer because of temporary severe adverse weather conditions at the area of departure or along the route.

■ 116. Winter marches differ little from those in summer except for the fact that clothing, transportation, and equipment must be adaptable to cold and snow. Movement of marching columns in deep snow will be somewhat slowed down but the delays incident to mud and stream crossings will be reduced. Equipment must be on hand to clear the roads of snow. Just as peacetime highways are kept open for automobile traffic, so military roads must be kept clear of snow. Snow plows must be busy after every snowstorm. Snow plows should be well forward in the column. Some plows should accompany the advance guard.

■ 117. When the march starts from a camp or bivouac in the snow, it is well, conditions permitting, to break camp after daylight. Otherwise, many small articles of equipment are likely to be lost in the snow.

■ 118. Whenever foot troops have to break trail in deep snow, the leading men should be relieved at frequent intervals. When the snow is as much as 1 foot deep, foot soldiers should wear snowshoes. If there is a possibility of deployment in deep snow, troops on roads carry their snowshoes on their backs.

■ 119. Under excellent conditions, a highly trained ski detachment will average about 6 miles an hour and can travel as far as 60 miles in a day. The usual length of march of

a ski detachment will be from 25 to 30 miles a day. Breaking trail in soft snow is very fatiguing. Leading men of a ski column should be relieved by men in rear after approximately 20 minutes. When practicable, trail should be broken in advance of its contemplated use by troops. Breaking trail comprises the selection of the route to be followed, the removal of obstacles along the route and the marking of the trail. Generally an ax or bolo is sufficient to clear and mark a trail. Trails should be marked at all points where they are crossed by other tracks, including individual ski tracks and at any point a skier has turned off the trail. This may be done by closing the side track with branches or placing twigs and leaves across the tracks. When breaking trail for several parallel files of men, care should be taken to leave sufficient interval so that men using one trail will not interfere with those using another.

Ski trails should be made as straight as practicable. When possible, routes over open terrain are selected. Steep slopes and wet slushy areas are avoided. When sufficient men are available, the trail will be made by a detachment of from six to eight men. Those in rear automatically straighten the trail set by the leader. The last man in the detachment marks the trail.

A column of ski troops tends to become elongated. This may be partly overcome by having skiers march along the sides of the roads. When going down or up hill, skiers should be allowed to pick their own way, re-forming when the bottom or top of the hill is reached. When a man falls he should immediately clear the trail so as not to disturb those following.

■ 120. When climbing hills brief halts may be necessary. A brief halt also should be made when the top is reached so as to allow the column to close up. During long marches a rear detail under a noncommissioned officer should be provided. This detail will take care of men forced to fall out of the column and to assist in the repair of skis and bindings. The commander of this detail will be responsible that the men join the column as soon as practicable and he will see that, if unable to rejoin, they are provided with means of transportation to camp. When available, one or more rescue sleds should accompany this detail. When movements on skis are conducted at night, great care must be exercised to prevent men

from becoming separated from the command. Signals should be passed from front to rear and rear to front so that the column can be kept together. Such signals should be as noiseless and inconspicuous as possible. Because of the greater distances habitually used by ski troops, considerable practice should be had in passing signals.

■ 121. Small security detachments can operate on snowshoes or skis. Ski troops ordinarily can move cross country at a rate of speed higher than that of foot soldiers on the road. Advance guards should be strong in ski troops so as to locate hostile flanks promptly.

■ 122. Due to the short days in winter, marches will usually be shorter than those in warm weather.

■ 123. Halts will ordinarily be brief. Small columns should select halting places sheltered from the wind. During halts, men should not be allowed to sit in snow. By doing so they are likely to get the seats of their trousers wet and later frozen. They should sit on their packs if no snow-free surface is found. Men sitting back-to-back can lean against each other and keep each other warm. Hot soup, cocoa, tea, or coffee served at halts warms and revives men in very cold weather.

■ 124. While going up steep hills or when exerting themselves, men must open outside garments to permit the body to breathe freely and thus to prevent clothing from becoming soaked with perspiration. Sweat-soaked clothing is one of the greatest causes of freezing to death.

■ 125. All officers and noncommissioned officers observe their men closely at all times for frostbitten faces, hands, and feet.

■ 126. Due to the mobility of ski troops, the enemy is likely to be active with ski patrols charged with the mission of attacking marching columns in flank and causing delay and confusion. This generally can be offset by having the flanks well covered by friendly ski detachments. Trains are particularly vulnerable to attack by ski troops unless they are accompanied by suitable elements charged with their protection.

■ 127. Medical detachments and rear guards must be on the alert to pick up men who fall out due to cold, injury, or

exhaustion. Men falling out should remain at the roadside in plain view.

■ 128. Of primary importance is a thorough road reconnaissance coupled with conspicuous route marking. When troops march across treeless and roadless country, such markers can be set upon tripods carried for the purpose and later collected by rear guards.

■ 129. Stream and lake crossings over ice should not be attempted until the ice is carefully inspected. Men with ironshod poles probe the ice and watch for thin places and air under the ice. Troops and vehicles must avoid crowding on the ice. Until the ice is proved to be thick enough for the heavier vehicles, all passengers but the drivers cross the ice on foot. Snowshoes and skis aid foot soldiers in crossing thin ice. When ice is too thin for crossing, it may be reinforced by placing grass, hay, or brush on it and pouring water over this and allowing it to freeze.

When crossing shallow streams covered with snow, the snow should not be removed from the ice. The removal of an insulating blanket of snow sometimes results in causing the stream to freeze to the bottom and later to break out above and flow over the ice.

■ 130. When horse cavalry begins a march in extreme cold, it is advisable to start with approximately ½ to 1 mile leading. This allows the men to warm up and starts the horses working gradually so that "bivouac stiffness" is taken out. Care must be exercised to avoid overheating and perspiration with long-coated horses. This will occur in deep snow especially, and at temperatures which approach thawing. Galloping or too long trot periods in snow 12 inches or more in depth will cause the horse to become wet which will require a careful cooling out period.

■ 131. Both snow and extreme cold affect the marching efficiency of horse cavalry. As the depth of the snow increases, the rate of march must be decreased. Marching on ice or very slippery, muddy roads will require a slowing down of the rate. Officers and men must be trained to watch their animals even more closely than under any other conditions. When the snow depth reaches 8 to 10 inches average, the trot

periods must be of short duration. It has been found that a four to five trot and walk schedule will keep horses from overheating in an average snow depth of 12 inches. As the depth of snow increases, trotting periods must be shortened. At a depth of 18 to 20 inches, all work is done better at a walk in order to minimize fatigue, and at this depth short rest or lead periods should be introduced at the midhour.

In open prairie country where drifts can be avoided, the rate of march of horse cavalry is not greatly affected.

When marching over unbroken snow, it is necessary to change the leading horses frequently. Loose powdery snow of sandy consistency makes very poor footing. Old or set snow makes good footing. "Balling up" will occur, especially on shod horses, when the temperature approaches thawing. It is especially liable to occur in a light layer of snow.

When marching at severe temperatures, the feet should be removed from the stirrups at the walk; this will enable the men to move and manipulate their feet to keep them warm by increasing the circulation. Stirrups should be left a little long. Falls are frequent in snow-covered terrain where holes and ditches are hidden, hence the rider must be able to disengage his feet quickly.

■ 132. Extreme cold slows up the march of motorized or mechanized vehicles only to the extent of halts necessary to allow personnel in open or unheated vehicles to dismount and get warm by moving about and restoring circulation. Cold will increase maintenance difficulties and will further slow down the march. Drivers, operators, gunners, and, in fact, all personnel must become accustomed to driving and working on their vehicles in awkward clothing and mittens or gloves.

Snow is the chief deterrent to the march of wheeled vehicles. Long marches are extremely fatiguing to drivers unless the trail is very well broken. Normal distances can be maintained in snow marching except in blinding snow when the distances must be reduced. Since there is little likelihood of air observation during a snowfall, the columns may be shortened. Due to the almost constant need for chains or traction devices, the wear and adjustments are great. All personnel, therefore, must be trained to help the driver inspect the vehicle at every opportunity during the march. Per-

sonnel must be alert to detect trouble in the traction devices and to pull to the side of the road for repairs. Each man should know how to use or improvise emergency expedients to extricate stalled or stuck vehicles. Certain personnel must be familiar with the operation of the snow plows and their upkeep. Heavy vehicles will break trail better than light vehicles. Scout cars can break trail at 15 to 20 miles per hour up to a snow depth of 14 inches. Mechanical strain as well as driver fatigue requires that the leading vehicles be changed off frequently.

■ 133. Marches should be so conducted, tactical considerations permitting, that shelter for the night can be prepared before sunset.

CHAPTER 5

MAKING CAMP

■ 134. When conditions permit, camp should be made before dark, security detachments posted and any available supply of firewood collected at once.

■ 135. Since men are less alert when cold, sentinels must be relieved at short intervals, often every half hour. Frequent inspection of sentinels by officers and noncommissioned officers will be necessary. Double sentries should be the rule.

■ 136. Paths through deep snow should be cleared leading to kitchens, latrines, picket lines and other places habitually used by the men. Necessary paths are broken to facilitate movement to and between various elements of the outpost.

■ 137. At overnight bivouacs not to be occupied later, straddle trenches can be dug in the snow and when abandoned, covered with brush and marked. Latrines should be protected from the wind by brush, snowbanks, or canvas.

■ 138. When animals are unpacked, unhitched, or unsaddled, they should be wiped of sweat, led until cooled off, blanketed, and picketed in places sheltered from the wind. Saddle blankets, harness, and packs should be dried out at once.

By throwing a blanket or piece of canvas over a pack animal and his pack, the heat of the animal can be utilized to thaw out frozen pack harness.

Animals should not have their forage fed to them on top of powdery snow since they will eat a great deal of the snow with injurious results.

■ 139. Where tents are to be pitched, light, powdery snow should be cleared off and, if available, straw, leaves, grass, evergreen boughs, or light brush placed upon the ground to keep the bedding from getting wet on the under side. Snow banked around the lower edge of the tent wall will keep wind from blowing in under it. Sleeping bags must not be allowed to rest against the tent walls.

■ 140. Snowshoes, skis, and firearms are not taken into tents but are stacked neatly outside. Cold metal sweats when brought into a warm tent or building.

■ 141. If there is any frost in the outer layers of clothing, the frosted garments must be removed at once before they thaw. If opportunities for drying them thoroughly are not available, it is best to leave them outside and beat the frost out of them before they are put on next morning. Moist inner clothing should be removed for drying. Socks and insoles are always damp after a day's march. Under no circumstances should anything be left in the shoes when they are removed. If fires are available, dry everything out thoroughly. If they are not, damp underclothing and socks can be dried slightly, but not completely, by taking them into the sleeping bag but only at the expense of dampening the bag. The fewer clothes that are worn in the bag the better.

■ 142. Every opportunity must be used to dry out the sleeping bag; otherwise, moisture and frost will eventually form in the bag and the occupant will shiver in the dampness. Wearing frosted clothing in a sleeping bag is a sure way of becoming chilled. It must be remembered that the presence of moisture in any form is the main cause of chilling.

■ 143. A heavy fall of damp snow will often break tents down. This can be prevented by having details shake the snow off the tents from time to time.

■ 144. Charcoal burners and incomplete combustion in gasoline or oil stoves produces monoxide gas poisoning and suffocation in unventilated tents. This incomplete combustion usually occurs when a top covering is placed close down over the flame and touches it.

■ 145. Wood or coal stoves must not be placed directly on the snow or they will soon melt a hole and flood the fire.

■ 146. Care should be taken not to wade in the slush around camp fires with shoes that are not waterproof. Frozen feet may be the result.

■ 147. Warming the feet or drying shoes by placing them too close to the fire causes leather to dry and crack.

■ 148. Holes cut through the ice to obtain water from watercourses soon freeze up. An expedient for keeping a water hole open is to sink a barrel, with both ends knocked out, into the hole with the top rim of the barrel projecting above the ice and then pouring several inches of oil over the surface of the water rising into the barrel. Fresh water can then be pumped from under the oil if proper precautions are taken to keep the pump from freezing.

CHAPTER 6

COMBAT

■ 149. Troops fight in snow and extreme cold just as they fight in the temperate climates, the only essential difference being that in snow and extreme cold they take measures to keep warm and use weapons, transportation, and implements designed for snow and ice. It is a serious mistake to assume that tactical doctrines vary with the thermometer. The doctrines that have won battles at 40° above zero will win them at 40° below.

■ 150. In the preparation for and execution of plans for operations, the commander must constantly bear in mind that the normal rates of travel for troops and transportation are greatly altered by winter conditions. Deep snow slows down cavalry but it speeds up foot soldiers on skis. It frequently stops wheeled transportation but permits caterpillar tread vehicles to proceed. It makes the carrying of burdens difficult but it permits them to be drawn easily on sleds.

A second and equally important consideration is the effect of freezing upon terrain. Frozen ground eliminates swamps as obstacles and thick ice permits streams and lakes to be crossed or used as highways. On the other hand, deep snowdrifts and icy slopes obstruct movement. When the ground is frozen, defensive works and weapon emplacements are difficult to dig. The construction of trenches will often require the use of explosives. Tracks in the snow show up conspicuously from the air and long shadows frequently disclose camouflaged establishments.

■ 151. The three things that tend most to weaken the enemy's physical being and morale are cold, fatigue, and hunger. Wherever possible, he should be denied the use of towns and buildings; patrols and aircraft should be active against him when in bivouac so as to keep him awake and disturbed, and constant air and ski raids should prey upon his supply system. Every possible effort should be directed toward depriving him of food, rest, and shelter.

CHAPTER 7

OBSTACLES

■ 152. Deep snowdrifts form natural obstacles. The artificial obstruction of roads and defiles may be effected by piling up snow with bulldozers.

■ 153. Frozen lakes and watercourses may be turned into obstacles by breaking up the ice with explosives. This is best accomplished by planting the charges and exploding them just before the arrival of the enemy. Overflows may be created by damming up small streams. Even very shallow water on top of ice may cause hostile troops crossing it to wet and later freeze their feet.

■ 154. Wire entanglements should be placed so that snow will not drift completely over them or else men on snowshoes can cross them.

■ 155. It is impossible to screw the issue iron pickets into frozen ground. Poles made into tripods can be substituted. Chevaux-de-frise, loops, and cylinders of wire (concertinas) requiring no posts are often effective.

■ 156. Without a tremendous expenditure of time and effort, it is impossible to prepare pits, trenches, and posts, in deeply frozen ground, for protection against tanks. Concrete mixing is also difficult in extreme low temperatures.

■ 157. When available, water poured over steep parapets will freeze and make them difficult to climb. Street barricades can sometimes be improved in this way by the use of fire hose.

■ 158. Cable blocks on roads may be effectively employed to stop vehicles or deflect them off the road. A cable block consists of a piece of 1-inch wire (cable) stretched diagonally across the road and about 2 feet above the surface of the road, at or near a fill or on a hill. This type of block has the advantage of being easy to construct, it is difficult to see, and can be removed readily for the passage of friendly

vehicles or troops. Effectiveness of the block is increased by icy road conditions on each side of the cable.

■ 159. Antitank mines must be placed on a solid surface to insure that they will be detonated when the tank tread rolls over them. A hole may be dug in the snow down to the frozen ground surface, the mine placed, and the hole filled again with snow. Due to the cushioning effect of an overlying blanket of snow, it may be necessary to prepare the fuze so that less pressure than that ordinarily required will detonate the mine.

■ 160. Dead abattis road blocks can be readily constructed by using the bulldozer to pull over large trees. Barbed wire is then interlaced in the abattis to render removal more difficult. Trap mines are easily concealed in road blocks; these mines explode when an attempt is made to clear the road. (See FM 5–15.)

In snow and extreme cold the value of obstacles often is increased because bypassing may be more difficult and the cold decreases the capacity of men for removing road blocks and other obstacles. (See FM 5–25 and FM 5–30.)

CHAPTER 8

CAMOUFLAGE

■ 161. The fundamental doctrine in camouflage is to avoid the display of anything that appears unusual and to conceal military objects by making them resemble or blend with their harmless and commonplace surroundings. There is nothing occult or mysterious about it. The art of camouflage differs in no material respect from the ability to make good duckblinds.

■ 162. From the air, snow-covered ground has the general appearance of white spotted with black, the amount of black depending upon the depth of the snow and the number of evergreen trees and other snow-free objects projecting above the surface of the snow. In sunlight, paths cut deeply into the snow look like dark streaks. Trenches look even darker. Objects sticking up above ground, even though white or covered with snow, are made conspicuous by telltale shadows. On snow-free ground, dark objects are difficult to see if they are in the shade, but against a white background of snow they become conspicuous. When deep snow is beginning to thaw and is patchy, it melts last from paths and roads where it has been packed. At such times paths look like white streaks against a mottled background. Very light snow usually melts first on tracks and roads which then appear as dark lines. Tank tracks differ in appearance from those made by trucks in that their turns are more abrupt and angular. Wood and exhaust smoke looks gray against snow but shows up as a bluish haze among evergreen trees. Smoke from wood or coal is more conspicuous than that made by oil or gasoline stoves.

Keeping in mind the general appearance of the ground from above, camouflage from the air should be prepared accordingly. Artificial, regular and unnatural shapes, angles, and patterns should be avoided. Dark objects should be covered with snow or white cloth and their outlines altered so that their shapes will not be revealed by shadows. Evergreen brush used for concealment should be placed with the twigs pointing upward. Aluminum-colored airplanes do not show up conspicuously against snow. Paths in deep snow can be rendered less noticeable by dragging brush over them, thereby eliminating some of the shadows.

Complete concealment is almost impossible where large bodies of troops are operating. However, even though their presence be known to the enemy, the identity of weapons and establishments may often be concealed. Trucks covered with paulins and with oil drums set up vertically at the forward ends of their bodies are difficult to distinguish from tanks. Shallow trenches in the snow, filled with grass, leaves, or brush, look from above like deep defensive works. Regular patterns of dark brush may easily be mistaken for batteries. Brush piles with paths radiating from them greatly resemble command posts, supply or ammunition dumps. One of the best ways of making a dummy establishment is to examine and photograph an uncamouflaged establishment from above and then make something resembling it elsewhere. If it becomes evident that the enemy has located an establishment, it should be moved promptly but the original location should be left looking as it did when it was discovered. Since paths in the snow are hard to obliterate and attract the enemy's interest, dummy paths will serve to confuse him. The best test of camouflage is to have it observed and photographed by friendly aircraft.

■ 163. To camouflage against ground observation, the main objective should be to prevent uniforms, weapons, or vehicles of one color from being outlined against a background of some other color. It is just as conspicuous to have a white gun in front of a background of dark evergreens as it is to have a gun of olive-drab color in front of a snowbank. The same applies to the visibility of uniforms. Ordinarily, a white parka with the hood up makes men inconspicuous in snow. A more versatile garment is a reversible parka, white on one side and olive drab on the other. This can be made inconspicuous by wearing on the outside the color that blends best with the surroundings.

■ 164. Except when operating in completely snow-covered terrain which is devoid of natural growth, the camouflage of vehicles is most effectively accomplished by altering their outlines with a mottled pattern which is predominantly white. The other color used should preferably be light tan or olive drab in prairies or grasslands and dark olive drab or green in forested areas. Since it is easily and quickly removed, whitewash is suitable to obtain the white coloring.

CHAPTER 9

CARE OF WEAPONS AND EQUIPMENT

SECTION I

WEAPONS

■ 165. Oil or grease on the mechanism of weapons thickens and congeals at low temperatures and often prevents their proper functioning. Unless special cold-weather oils are provided, it is well to wipe the mechanism of such weapons dry. Powdered graphite rubbed upon bearing surfaces will cause them to work smoothly and tend to reduce wear. Rust does not form on dry, cold metal.

■ 166. The oil normally used in recoil cylinders becomes sluggish and must be replaced by thinner oils.

■ 167. Snow in the muzzles of weapons sometimes causes the barrels to burst when they are fired. For this reason, special care must be taken to insure that the bore is free of snow, ice, or other obstructions before the weapon is fired. Closing the muzzle with plugs of any kind is prohibited.

■ 168. Cold metal sweats almost to the point of dripping when it is brought into heated inclosures. Weapons should not, therefore, be brought into warm tents or houses, but should be stacked outside, their mechanism being protected from drifting or falling snow. Ammunition should also be left outside for the same reason.

■ 169. Gasoline can be used in lieu of water and sal soda for cleaning barrels. Water in the jackets of machine guns can be replaced with No. 10 crankcase oil. However, the packing must be watched closely and checked frequently.

SECTION II

EQUIPMENT

■ 170. The lenses and prisms of cold optical equipment fog up when brought indoors and also when placed close to the

face. Special eyepieces should be provided so as to allow circulation of air between the eye and the lenses. A thin coating of glycerine, "anti-dim" such as issued with the regulation gas mask, or a similar preparation, will assist greatly in preventing clouding.

■ 171. Dry batteries usually fail to give adequate current at temperatures below minus 20° F. Small flashlights can sometimes be kept warm enough to use by carrying them inside pockets.

■ 172. Storage batteries become less efficient when they are cold. If fully charged, they are less likely to freeze than if partly run down. Oversized or double batteries are desirable in cold weather. To restore a battery temporarily for starting vehicles or other purposes, it can be taken into a warm place. When water is added to a storage battery, the battery should first be warmed; otherwise, in extremely cold weather the water may freeze into lumps when it strikes the chilling battery fluid.

■ 173. Hand generators and other mechanically operated electrical devices sometimes fail to give satisfaction at low temperatures due to congealed oil on bearing surfaces. They can be made to operate by keeping them in heated tents or vehicles. Thin oil or graphite on the bearings will improve their performance.

■ 174. Drying fur clothing, particularly that made from reindeer skins, in too close proximity to the fire causes the hair to fall out. Shoe leather becomes stiff and cracks if similarly treated. Wet shoes may be dried by filling them with *warm* oats, corn, or gravel. If the filling is hot, stiffness and cracking of the leather will probably result.

Maintenance of clothing and shoes in an excellent state of repair is especially important. Small holes not only permit cold and moisture to reach the body more easily, but the exigencies of operations in snow and extreme cold require that all clothing be in first class condition.

■ 175. Snowshoes should be varnished frequently or melted snow will soak into the rawhide webbing and cause it to stretch out of shape. Every organization equipped with snowshoes should have several men trained in their repair and equipped with proper materials.

When snowshoes are stored, they should be stacked so as to prevent warping. It is best to hang them on pegs. If they are hung on nails by the webbing in warm or damp weather, rust spots are likely to form where the nail comes in contact with the rawhide, causing the webbing to break later. (See ch. 3.)

■ 176. The undersurfaces of skis should be kept smooth and coated with wax. This should be applied warm and evenly distributed. Occasional applications of running waxes will improve ski performance.

Men who are qualified and equipped for ski repair should always be available. Spare foot harness and aluminum tips for broken skis should be carried by ski troops.

When skis are stored, they should be lashed bottom to bottom with wooden blocks between them so that they will retain their camber. When skis are stood up on end, the toe should be downward so that the weight of the ski will aid in keeping the toe turned up.

Leather foot harness should be kept oiled.

Upper surfaces of skis should occasionally be varnished to keep moisture out. (See ch. 3.)

CHAPTER 10

SUPPLY AND EVACUATION

■ 177. In cold and snowy weather, there is no fundamental change in the normal system of supply. The problems to be solved result from transportation difficulties in snow, the necessity for increased amounts of certain items of supply, and the serious consequences of depriving troops, even for a short time, of food and fuel.

■ 178. Transportation problems must be solved by special equipment as outlined in chapter 3. Motor fuel should be increased from three to four times that normally used. Rations should be increased 50 percent. Large quantities of explosives should be carried to execute demolitions and aid in digging trenches in frozen ground. In general, the level of supplies required in forward supply establishments will be proportionately increased. This is particularly important when lines of supply are long or subject to possible interruption. Troops cut off from food suffer severely from the cold. All means of supply must be exploited. In many situations supply by air transport will be effective and expeditious.

■ 179. Perishable articles of food may be allowed to freeze without injury, if they are eaten immediately after thawing. Fresh meat, eggs, raw potatoes, most vegetables, and watery canned goods will keep indefinitely if frozen hard. However, they spoil soon after thawing, and subsequent freezing will not restore them. Once frozen, they should be kept so until cooked for serving.

■ 180. Ammunition should not be dumped directly on snow or ice but should be protected by boughs or paulins.

■ 181. Wounded men often freeze to death unless promptly cared for. To prevent a large percentage of deaths among the wounded in extremely cold weather it is necessary to insure the prompt collection of wounded on the battlefield and their speedy evacuation to places where they can be kept

warm. To this end, collecting parties will have to be increased above normal requirements and provided with special equipment.

■ 182. Litters are difficult to handle in deep snow but small sleds and toboggans provide an excellent means of collecting the disabled. Sleeping bags and fur robes must be on hand in ample numbers so that wounded men can be kept warm. Sleeping bags should be roomy, open on the side, and have removable linings. Heated shelter should be provided wherever possible, even in forward collecting stations. Drinking water for the wounded should be warmed. Ambulances should be heated and provided with warm bedding. Ambulance planes should be readily available for the speedy evacuation of serious cases.

■ 183. The evacuation of personnel other than those who are wounded follows normal procedure.

CHAPTER 11

SANITATION AND FIRST AID

SECTION I

SANITATION

■ 184. While the usual sanitary precautions apply equally to hot and cold weather, cold weather conditions require special provisions. Men show little enthusiasm over bathing in ice water. Consequently, they are likely to become dirty and infested with vermin. It is important, therefore, that heated shelter be furnished where men can at least take sponge baths with soap and warm water. Facilities for washing underclothing and socks should also be provided.

■ 185. Men are likely to feel that water flowing under ice is necessarily pure. Since this is far from being true, water purification precautions must be taken.

■ 186. In deep snow, men are inclined not to use the latrine, particularly if these are distant and unsheltered. It will be necessary for all commanders to take appropriate measures to prevent the ground from becoming polluted.

SECTION II

FIRST AID

■ 187. When an accident happens in the cold, the first consideration is the possibility and danger of shock. If there is considerable pain or severe hemorrhage, shock is almost inevitable. Shock in winter weather may easily become fatal unless definite measures are taken to combat it. The fundamental considerations in combating shock are the application of heat, elevation of the feet, and the administration of nonalcoholic stimulants. The victim should be kept warm by the use of available blankets, sleeping bags, or by the use of spare articles of clothing borrowed from nearby soldiers.

When available, chemical thermopads are of great value. If the wind is blowing, a small windbreak of any kind will aid in keeping the patient warm.

In stopping the flow of blood, care must be taken not to apply pressure for too long a period, otherwise freezing will result. Tight bandages and tourniquets impair circulation which is already below normal in wounded men. Should a tourniquet be necessary, provision should be made to warm parts of the body where circulation is restricted.

■ 188. Slight freezing of parts of the body to no great depth is, if promptly thawed out, little worse than severe sunburn. The longer the parts remain frozen, the more serious are the consequences. Frozen skin and flesh can usually be restored to normal, but when bones are frozen amputation often becomes necessary.

In treating freezing, the frozen part should be thawed as quickly as possible without injuring the tissue. This can best be accomplished by putting the frozen part of the body in lukewarm water. The patient, if brought into a warm room, should not be brought too close to the fire. He should be wrapped in warm blankets and given hot coffee or tea but never alcohol, as this interferes with normal circulation. Where severe freezing has affected an arm or leg, the limb should be elevated slightly to prevent an excessive amount of blood from collecting in it. Circulation can be restored by gently massaging the limb toward the body and away from the frozen part.

Do not rub the frozen part, and do not manipulate or bend frozen limbs or ears, as this may break and damage the tissues. Do not rub or apply snow or ice to the frozen part, since this may increase the freezing. Do not soak the limb in kerosene or oil, as oil freezes at lower temperatures than water, and the application of cold oil is more likely to injure than to help.

Thawing is very painful. The skin becomes red, or, in severe cases, violet. In time, blisters may appear. These may not show up until several days later and may be of great size. They should not be opened except under supervision of a doctor.

There is little that can be done in the way of first aid should the lungs become frozen. This condition is characterized by extreme pain in the chest, shortness of breath,

coughing, and the raising of bloody serous fluid. The patient should be kept quiet and warm and transported to an aid station as soon as possible. There is great danger of pneumonia following freezing of the lungs.

■ 189. Snow-blindness is caused by eyestrain due to the reflection of light from snow surfaces. It may occur even on dull overcast days. It generally comes on gradually. Its first symptoms are an inability to see the uneven places in the road or trail but actual blindness does not occur. Later, there is a burning sensation followed by intense pain. The pain may not develop for several hours after exposure. The eyes become inflamed and the sufferer may not be able to use them for several days.

The patient should be kept in a dark place until the pain leaves. If no such place is at hand, a dark bandage should be placed across the eyes. An ice compress will give some relief from the pain but this can only be used when there is no danger of freezing. A compress of tea leaves helps relieve the pain. Liquid albolene gives relief if 1 or 2 drops are placed in each eye once an hour. Argyrol should *not* be used.

Once having suffered from snow-blindness, the patient is more susceptible to future attacks. Suitable pigmented glasses are the best means of prevention. (See par. 34.)

■ 190. Training in first aid is highly important. The ability of each individual to administer proper treatment for frostbite, wounds, and shock will go far toward increasing the efficiency of the command and will be a valuable aid in the successful execution of operations.

CHAPTER 12

ARMS AND SERVICES—SPECIAL CONSIDERATIONS

SECTION I

INFANTRY

■ 191. Infantry, aside from performing its usual missions will, to some extent, be required to use ski troops as a substitute for horse cavalry. All organizations should have some of their members trained in the use of skis for patrol and runner service. It usually requires several winters of experience to obtain a high degree of proficiency on skis. Where time is pressing, special ski units should, when possible, be recruited from among men of previous experience.

■ 192. Ski troops used on patrol duty should be highly trained soldiers, picked for their excellent physique, and thoroughly prepared for their ski work by increasingly strenuous physical exercises and marches.

■ 193. Because of the independent type of missions which ski patrols perform they should be especially well trained in map reading, sketching, orientation, observation, scouting, and patrolling. Men should be trained to set and hold any prescribed march rate. By continued practical work on the ground, watching the map and rate of march, the ski soldier can be taught to know his exact location at all times.

■ 194. Special instruction in woodcraft should be given. The ski soldier should understand tracking, fire building under adverse conditions, construction of shelters and beds for use in subzero weather, camouflage, winter first aid, and emergency ski repair.

■ 195. Tactics to fit all possible situations should be practiced by squad and platoon teams. Problems should be executed on the ground in complete detail many times so that each man knows how to perform his assigned task automatically. Special signals should be worked out in detail so that the action can be controlled with the minimum of orders.

■ 196. Careful inspections and plans must be made prior to sending out patrols if they are to be successful. Any man who is not in excellent physical condition will hamper the patrol and may cause the failure of the mission or become a casualty. Consequently the patrol leader should personally and carefully inspect all men prior to departure. All equipment taken should be carefully prepared and inspected. On distant patrol missions a faulty weapon or defective piece of equipment may easily mean the loss of a man or possibly of the patrol.

■ 197. Care should be exercised in planning what food is to be taken, how it should be packed, and how carried. The food taken should be the minimum which is adequate and should also be as light as possible. Bacon, cheese, oatmeal, cornmeal, dehydrated fruits, vegetables, soups, meats, tea, prepared cocoa, and hard breads are recommended for patrol use.

■ 198. Patrols sent out on reconnaissance missions at distances from 1 to 10 miles from their unit should be small, numerous (to cover the area thoroughly), lightly equipped and armed (their information should be gained by stealth and without fighting), and their food should be an emergency ration carried on their backs. Special equipment, shelter, and heat are not essential, because of the short distances covered. Camouflage clothing is desirable. Where such clothing is not issued the use of a lightweight long white robe is recommended.

■ 199. Patrols sent out to reconnoiter at distances greater than 10 miles from the main body should be composed only of men who are well-trained skiers, excellent woodsmen, resourceful and with great initiative, who can, if necessary, accomplish the mission alone. All members of distant reconnaissance patrols must be carefully prepared physically by special food, rest, and adjustment of equipment

for their arduous task. Each man in the patrol must thoroughly understand all available enemy information, the tactics decided upon, and the route of the patrol; all men must know their individual tasks in case of any emergency, when and where to leave and enter the friendly outguards and, above all, exactly what information is vitally necessary and who wants it. This presupposes a trained team which has practiced all possible tactics in various situations many times and who have mutual respect and trust in their combined ability to execute their mission.

■ 200. Ski patrols can work from 30 to 50 miles in front of the main body on distant reconnaissance missions without transportation for 4 days. Because of their speed they can effectively perform distant reconnaissance missions in winter warfare. A light automatic weapon is necessary in each patrol to cover the patrol's advance or a withdrawal. Grenades are very effective if a patrol comes on an enemy unit unexpectedly or is able to locate and approach enemy command posts or supply dumps.

■ 201. Close individual combat at night may be necessary.

Self-sustained patrols should not normally be sent out for periods to exceed 4 days, although in an emergency they may be required to remain out for longer periods of time.

Snowshoe troops can perform close reconnaissance as effectively as can ski troops.

Counterreconnaissance is a difficult mission and some information will be obtained no matter how much care is exercised in establishing a screen.

Raiding operations with ski troops are very effective if the operation does not involve the carrying of much added equipment. The carrying of added equipment by ski troops is greatly restricted by the necessity for speed.

Speed and stealth are the two fundamental advantages of ski troops.

SECTION II

CAVALRY

■ 202. The main asset of horse cavalry, mobility, is adversely affected by deep snow, and the bulk and weight of forage are such an impediment to rapid movement that the mounted soldier is far less effective in a very cold climate

than elsewhere. His functions are normally performed by ski and mechanized units. (See ch. 4 and sec. I, ch. 12.)

■ 203. Mechanized cavalry, in order to be satisfactorily mobile, must be equipped with transportation specially adapted to movement through snow. Motorcycles will be practically useless in deep snow, and drifts will delay scout cars, trucks and other wheeled vehicles. Fast tractors drawing sleds are suitable for movements through the snow. Snow plows should always form a part of mechanized cavalry equipment. (See par. 66.)

SECTION III

ARTILLERY

■ 204. Horse-drawn artillery suffers under the same disadvantages as horse cavalry. Truck-drawn artillery has difficulty in operating other than on snow-cleared roads. The wheels of guns, limbers, and caissons are hard to pull through deep snow. To overcome these difficulties, runners can be placed under artillery wheels and caterpillar-tread tractors can be used as movers. Snow plows will be useful.

■ 205. Guns, aiming, illuminating, and range-finding devices must be provided with special lubricants. Recoil cylinder oil must be of a type that will not congeal at temperatures to be encountered. If the mechanism of guns will not operate due to frozen oil, the piece may be heated by covering it with a paulin and placing a gasoline or oil heater beneath it.

Metal seats should be well padded and eye and cheek pieces insulated against direct contact with the bare skin of cannoneers.

Hand-drawn sleds or toboggans should be available to carry ammunition and lay wire.

Special tools and explosives must be in readiness to prepare gun emplacements.

■ 206. Observers and others subjected to exposure and long periods of inactivity should have fur parkas.

SECTION IV

TANKS

■ 207. Tanks will be free from the troublesome effects of swamps and soft ground but their great weight will restrict

their use on any but extremely thick ice. Those operating on snow and ice should always be provided with grousers.

■ 208. Tanks will be subject to the same cold weather difficulties encountered by other motor vehicles and can overcome them in similar fashion. Gasoline-heating devices should be on hand to heat cold engines prior to starting. When combat or movement is imminent, engines should be kept warm by intermittent idling. This will cause a considerable increase in fuel consumption.

Maintenance vehicles should be on caterpillar tracks in order to reach disabled tanks.

Wherever possible, fighting compartments should be insulated and heated.

Vehicles which are equipped with tracks that have a tendency to be thrown in deep snow have no place in cold weather fighting.

Radio batteries should be oversize, kept well charged and with an ample supply of replacements on hand.

Light, fast, tractor-propelled sleds suitable in design for running in deep, soft snow are valuable in reconnaissance.

Individuals who habitually make reconnaissances on foot should be equipped with snowshoes.

■ 209. It should be kept in mind that tank noises can be heard at greater distances in very cold than in warm weather.

SECTION V

AVIATION

■ 210. Airplanes can operate successfully in extreme cold but only if they are specially equipped for the purpose. Airplanes for cold weather operation should be equipped and serviced as follows:

All aircraft must have complete frost covers made of lightweight densely woven material. These must be installed after each flight and removed immediately prior to flight to insure that the flight is not attempted with frost-coated wings.

Wheels should be equipped with large balloon tires for landing on soft or rough fields.

Complete de-icing equipment must be installed.

Close-fitting, padded engine covers with hood extending to the ground, reinforced by tubular members capable of at-

tachment to the engine cowl and securely attached to the ground to form a rigid framework should be provided. Any attempt to use this hood without the reinforcement results in fires, due to the hoods being placed in contact with the heater, if there is any wind blowing at the time of attempted operation, and with any heater other than the airmixt type used.

Nose hangars or other light tent shelters must be placed around engines and heat provided therein in order to enable personnel to work on aircraft or engines.

Heaters of the airmixt type should be provided at all stations for the heating of engines, aircraft and shelter, and for men working on aircraft in low temperatures.

Double burner fire pots should be available for emergency use away from the home stations. Single burner fire pots are not satisfactory and in many cases inoperative in the lower ranges of temperature.

Heat guns capable of producing a local application of heat in quantity should be available for thawing frozen instruments, lines, or other parts.

Engines should be equipped with shelters, either nose or split flap type, to conserve heat in extreme temperatures.

All push rod housing on engines should be lagged.

Positive means should be provided for the immediate application of heat in quantity direct to carburetor to eliminate carburetor icing.

Duplicate heater of the prestone or similar type should be provided to insure adequate cabin heating.

Heaters for instrument dash of the showcase light type should be provided.

Starters and generators should be cold packed.

Added battery capacity must be provided.

High-capacity defrosting units for pilot's windows and, in the case of bombardment aircraft, for the bomber's window, should be installed.

All hinges, pulleys, gears, and other moving parts should be thoroughly cleansed of all heavy grease and light oil substituted therefor.

Hydraulic fluids should be replaced with lighter fluids satisfactory for subzero operation.

Oil immersion heaters and power generating units capable of providing power for them must be available. For out-

lying locations where permanent source of power is not available, there should be provided a small, high-capacity type generator which can be ferried to such location by aircraft.

Gasoline systems must be provided with water segregators or, in lieu thereof, have standpipes installed in the bottoms of the tanks to eliminate the possibility of the collection of water, or frost in lines with subsequent stoppage due to freezing.

Oil tanks and lines should be completely lagged, and water segregators or standpipes similar to those for the gasoline system provided.

Oil tanks should be provided with large opening drains.

Oil dilution is necessary in temperatures below plus 18° F. to insure positive starting without unnecessary drain on battery systems. The amount of dilution will vary according to the temperature and can only be learned by practice of the individuals concerned. Engines can be operated satisfactorily using only the oil dilution system down to —20° F., but it is preferable that the oil immersion heater be used in conjunction with the oil dilution system at any temperatures below freezing, as more efficient operation and less wear results if this practice is followed. In equipment in which oil immersion heater units may not be available, application of external heat is necessary at any temperature below —20° F., and in the case of the larger liquid cooled engines, it may be necessary in temperatures below —18° F. At temperatures below —20° F., heat must be applied to the instrument dash either by means of built-in heaters or from independent sources in order to insure proper functioning of all instruments at the time of engine warm-up.

Carburetor temperatures must be maintained slightly above freezing if there is any moisture content or indication of carburetor icing, since it has been found that unless this practice is followed, a great deal of difficulty will be encountered in freeing carburetors once they have become iced.

Batteries must be removed from aircraft during inoperative periods in the more extreme temperatures and kept in a warm locality.

Mechanics working in propeller blasts in any area subjected to extreme temperatures must wear face masks to prevent immediate freezing of exposed parts.

Servicing trucks, if kept outside, will often require preheating of their working parts.

Disabled airplanes making forced landings in deep snow should land with wheels retracted. They will usually find the snow on wind-swept frozen lakes less deep than that on the ground.

■ 211. Light airplanes equipped with skis will be found serviceable where fields are scarce and snow deep.

■ 212. Emergency kits containing individual weapons, emergency rations, lensatic compasses, and sleeping bags should be permanently installed in airplanes, one kit for each occupant.

■ 213. Pilots and crews of airplanes should be warmly clad.

■ 214. A supply of machinery for snow removal from runways should be constantly available. It is better to remove snow from runways than to roll and pack it, since in the latter case a thaw may render the field unserviceable.

At appropriate times, runways should be marked by tripods of evergreen trees by day and by torches or flares by night.

■ 215. Pilots should keep in mind the fact that if their airplanes becomed iced in the far north they are more likely to find warmer strata of air above than below them.

SECTION VI

ENGINEERS

■ 216. In consequence of the necessity for snow removal on roads and the difficulties of making defensive works in frozen ground, engineer troops will ordinarily be required in larger proportions to other troops than in mild temperatures.

■ 217. For reconnaissance purposes, engineers should have snowshoes and skis. Snow plows, bulldozers, air compressors, and an exceptionally large quantity of explosives will be required.

■ 218. Engineers will be called upon frequently to blast out trenches and gun emplacements when the ground is frozen too deep for ordinary digging.

When the ground is not deeply frozen, the crust can often be broken up with air compressors and the rest of the digging done by troops with ordinary tools.

■ 219. Bridging of small streams will rarely be required but thin ice will often have to be reinforced by placing poles, branches or planks on it and pouring water over them.

■ 220. Powerful bulldozers are great time and labor savers in making roads, obstacles, excavations, and approaches to stream crossings.

SECTION VII

SIGNAL CORPS

■ 221. The principal effect of cold weather upon Signal Corps troops is to increase the difficulties of laying wire with normal vehicles and to cause low efficiency in unheated batteries and generating apparatus.

Batteries larger than those normally used, heated shelters for instruments, and ample recharging devices will be necessary. A large supply of replacement batteries should be available.

■ 222. Tractor-drawn, wire-laying trailers are highly desirable. Hand reels should be mounted on small sleds or toboggans. For messenger and wire inspection service, men should be trained to use skis.

Telephone receivers and headsets should be insulated so as to keep them out of contact with the skin.

Recovery of wire in snow will often be difficult. An extra supply must be carried for this reason.

Telephone transmitter diaphragms are likely to freeze up due to frost from the breath of the operator unless a thin piece of paper is tied over the mouth of the transmitter.

At unheated message centers, extra warm clothing should be on hand to throw over runners and messengers while they are awaiting further duties.

SECTION VIII

CHEMICAL WARFARE

■ 223. Smoke hangs close to the ground in cold weather and is therefore particularly effective. Other chemical agents do not volatilize below certain minimum temperatures. Chemicals issued for use in cold weather should be limited to those which will be effective at the temperatures to be expected.

For defense against chemicals, masks should be of a type that will not become stiff and fog or frost up in the cold. Canisters and tubes should be made so as to allow a free passage of air in subzero weather.

SECTION IX

MEDICAL CORPS

■ 224. The principal concern of medical troops is that men disabled by cold or wounds be promptly collected from the field and treated in warm places. To that end, their collecting parties in forward areas must be increased well above normal and their equipment augmented by hand-drawn sleds, sleeping bags, fur robes, heating pads, hot water bottles, tents, stoves, heated vehicles, and short-wave devices for treating frostbite.

APPENDIX

CONSTRUCTION OF DOMED SNOW HOUSES

Dr. Vilhjalmur Stefansson, the eminent Arctic explorer, describes the construction of a domed snow house as follows:

a. "Time and place for building.

"In the very early fall, while thaws still alternate with frosts, there is seldom any use trying to build a snow house—you then use tents. A little later, when thaws have ceased but temperatures still run as mild as only 10° or 20° below freezing, tents continue preferable and you would not use a snow house except in an extreme emergency. For even the heat from the bodies of the occupants would melt holes in the roof and the snow would be so damp in any case that it would be nearly impossible to keep your clothing dry.

"Since the finding of suitable snow is of some difficulty under the best of conditions, it is well when traveling to begin watching for suitable drifts as camp time approaches. It has been the practice of the Stefansson expeditions to camp as much as an hour before the time planned if the party found itself crossing a drift that seemed particularly good. It happened on other occasions that they had to keep traveling for 2 or 3 hours past the intended time before finding a suitable bank.

"The nearly perfect conditions for snow-house building are: That the terrain shall be level enough to permit strong sweeps of wind, yet with snags or other inequalities that will accumulate drifts 4 feet or more in depth. The winds that made the drift should have been strong rather than violent and the drift should have been made only a few days previously. However, a drift made yesterday by a terrific gale may be just right for house building, though a week or two hence it may have settled into such hardness that building is difficult.

"Terrific blasts continued for several days or weeks, with the snow then lying for some time, will make practically the equivalent of ice, so that you have to hack or chop your blocks out of the bank instead of cutting them. They are then heavy, likely to break, difficult to shape, slippery on the

wall, and are such good conductors that the dwelling erected will be a poor insulator from the cold.

"Under other conditions snow that lies for some time, instead of becoming a solid block of ice becomes a mass of ice granules, the so-called sugar snow, granular snow. In extreme cases you can't cut this snow into blocks at all—it is almost as if you were dealing with a bin of wheat. Under medium conditions, the blocks you cut are fragile. If they are strong enough to handle, and you get your house built, you have a poor one, for not only are the grains icy, and therefore good conductors, but the blocks are also likely to be so overporous that the wind blows through. This last can be remedied to an extent by heavy outside banking, as described below.

"The snows of early winter, except in areas of particularly strong winds, are so soft even in the best drifts that the blocks crumble in handling. When they are just strong enough to handle you can get your house up, but it would soon begin to cave in; for the lower tier of blocks would be compressed gradually by the weight of those higher up. That destroys the dome shape; and when any part of a snow dome changes from its spherical curvature to flat, the next stage is bulging in—which leads to an eventual full cave-in. This process is seldom rapid enough for you to see the motion; but it may be so rapid that views a quarter of an hour apart show a noticeable difference.

"The third Stefansson expedition reports taking such chances with soft snow as the following: When a house settled enough during the first 4 hours of occupancy that an inward bulge began to appear, they slept the night and got away 7 or 8 hours later with the sag of the roof still about 3 feet from the floor of what had been a 7-foot house. In practice a sag was sometimes slowed by using a T-shaped post for support where the sag first appeared—a rod with a board across the top. A pillar of snow blocks could have been used.

"Building a dome with snow is simpler than with masonry, for stone is intractable and has to be shaped according to mathematical calculation; snow is tractable. Place each block in its approximate position, lean it gradually against the block that next precedes it, and, by trial and error, snip off piece after piece, or scrape where necessary, until the

block settles comfortably into position. (See detailed description of method of building below.)

"The equipment needed for building a snow house is: A rod or cane 3 or 4 feet long and one-quarter to, at most, 1 inch in diameter, for testing consistency of snow; a knife with a blade 14 to 20 inches long for cutting blocks (a bayonet may be used instead of the knife), a shovel for piling soft snow on the completed house; a ball of string and two wooden pegs for determining the shape and size of the house when you are new at building—later you will judge by eye.

"With four men building, one usually cuts the blocks, a second carries them to the builder, a third (inside the circle) does the building, a fourth (outside the circle) follows the builder to chink crevices. If two men are building, one works inside the circle and the other outside. In such case, a number of blocks are cut by both men and placed inside the intended circle of the house wall before the construction begins. When one man builds, and if the snow permits vertical cutting of blocks (see below), he gets most of the blocks needed from the floor; otherwise he has to crawl out through a temporary door in the wall to get them.

"Select a snowbank 4 feet or more deep and of uniform consistency. Determine the surface hardness by walking on the snow. If the foot (softly shod in Eskimo boot or moccasin) makes no mark, the snow is too hard; if the foot sinks so that its entire outline is visible, the snow is too soft. If you see a faint outline (just enough so that another person could follow your trail), you assume the drift is suitable but you give it a further test.

"Drive the testing rod down into the snowbank with a steady shove. If it sinks with even pressure, the snow is the proper consistency. If varying pressure is needed, the snow is in layers and not good, though possibly usable by an expert builder. Whenever possible, the novice should find nearly perfect snow, for a defective block may bring his nearly finished structure down like a house of cards.

"We have described a drift permitting the cutting of vertical blocks, a great convenience especially when the builder has no assistant. If the snow has uniform consistency to four or more inches down but then begins to show stratification, it is still all right for horizontal cutting. In fact, a house can

be built of uniform 4-inch snow lying directly on the ground; but then you are likely to be troubled with grass or pebbles, and the blocks are seldom very good.

"When you find in one place a drift of suitable depth but unsatisfactory consistency, and shallow snow of better consistency elsewhere, it usually pays to carry good blocks even 20 or 30 yards to the snowdrift rather than to build a house on shallow snow. If you must build on shallow snow, your house will have to be of larger diameter than otherwise needed, for it must be of a certain height and must keep to its hemispherical shape.

"If you build right on earth, especially if it be on gravel, you must cover every part of the floor with at least 5 inches of snow; for the ground "radiates" cold. Try to see that the snow used for this purpose is not granular—if granular, it permits a draft up from the ground.

"Building blocks should be domino-shaped, from 20 to 40 inches long, from 12 to 20 inches wide. If your snow is both tough and light you can have the blocks large. When you first cut blocks they are any thickness from 4 inches up; if the block is too thick you trim it down so that when it is finished it is 4, 5, or 6 inches thick, according to your desire.

"According to their size and the density of the snow, the blocks will weigh from 50 to 100 pounds and must be strong enough to stand not only their own weight when propped up on edge or carried around, but, if they are intended for the lower tiers of the house, must be capable of supporting the weight of 200 to 500 pounds of other blocks resting upon them.

"You build the house preferably on a level part of a drift where the snow is three or more feet deep. In any case you either find a level spot or devise some common-sense way of overcoming inequalities or a slope. One way of handling a slope is to build the first tier as described below and then shave it off in such a way that the top of your wall is horizontal. This might mean cutting the blocks down to practically nothing along the uphill side. It may seem a waste of labor to build a full lower tier just to cut much of it away, but in practice doing so is easiest. Of course, you will be able to modify or even break many of the rules (including this one) when you become really expert.

"The first step toward cutting blocks vertically is to dig

a pit in your snowbank which, according to your tools and the circumstances, may be of any shape provided one side of it turns out to be straight, of a length equal to the blocks wanted, and as deep as you want them wide. You might keep in mind a block of standard size when cut, say, 36 inches long by 18 inches deep by 4 to 6 inches wide.

"To produce your first block you hold the knife vertically and make a cut parallel to, and 4 to 6 inches from, the side of the straight 36-inch side of the pit, its depth the full length of your knife blade. At both sides of the pit you cut downwards; 18 inches below the surface of the drift you slice with the knife horizontally, undercutting the block.

"Now you reinsert the blade of the knife into the lengthwise cut and pry by pulling the handle toward you gently. The block will come out full size and of fairly regular shape, even though in case of a 14-inch knife there were 4 inches at the lower side uncut.

"You pull the block away to where you can handle it and, if there are any notable roughnesses, you slice them off with the knife. Should a corner break, destroying the rectangular shape of the block, you restore it to rectangular shape by shortening it that much with a cut of your blade. If the break would necessitate a shortening to less than 20 inches, you discard the block and cut a new one. For unless you are very skillful, short blocks are more bother than they are worth.

"If the blocks are obtained by vertical cutting, it is usually best, when they are placed in the wall of the house, to have uppermost the edge that was the surface of the snowdrift.

"When the quality of the drift is not up to vertical block standards, you must cut horizontally. You start with the pit as before, only it need not now be more than 6 or 8 inches deep. The 36-inch cut is now 18 inches away from the face of your pit. When three cuts have described an 18 by 36-inch quadrangle, you undercut say 6 inches below the drift's surface. This block is not going to come loose as easily as in the vertical case, especially if your knife blade is less than 18 inches long. You therefore move the knife back and forth several times so as to widen the cut, and then very gently you kick with your foot into the cut at various points on the block. Of course, if the snow is really good, one sharp kick will bring the block out. Usually what you have to do with

your foot is something like pecking at a block of ice to make it crack along a given line.

"When the final kick loosens the block it sinks down a fraction of an inch, because of the undercutting. You now put your knife aside and slip your mittened hands under the edge of the block at points about 8 or 10 inches from either end. If the snow is very fragile, you can help by using one of your feet at the middle of the block so as to have three points of pressure in lifting it up.

"When this block, a good deal thicker than you want it and of somewhat irregular shape, is on edge you slice down what was the underside of it until you have the domino shape desired, about 36 by 18 by 5 inches, if the snow is of good quality, but somewhat thicker, if it is soft. Houses have been built of snow so fragile that the blocks had to be 8 inches thick. This would be comparatively new-fallen snow which had not been pounded by wind into a sufficiently hard drift and had not had time to settle.

b. "Ground plan.

"The easiest house to build is circular in ground plan; but for camping purposes a somewhat better shape is oval, the plan being to have the bed platform in the smaller end and the entrance in the larger one.

"For a beginner planning to make a house of 10-foot diameter the simple way is to describe a circle with a 5-foot string and two pegs. Even if the house is to be egg-shaped, this is a good way to start, since the big end of the house can follow one-half of the circle approximately.

"The larger the diameter of the house the more you promote ease of building by keeping to the circular form. If you intend a house of 15-foot diameter or more, even the most skillful builder is practically forced to conform to a circle. Houses that big are seldom used for dwellings or even for 1-night camps, since they have to be so high that before the lower half of the interior where the people are gets warm enough for them, the heat has accumulated just below the roof sufficient to melt a hole and escape.

"A house of 10-foot diameter is comfortably large for 4 sleepers, snug for 5. When the house is oval, the bed platform is placed in the small end because you sleep with your head towards the big end—your body being broader at the shoulders.

"When there are more in the party than can be accommodated in a house of 10- or 12-foot diameter, you can either build 2 houses and use them separately or you can build 2 houses adjoining each other and when they are finished cut a door in the walls between, so as to make a 2-room dwelling. Three- or four-room houses are sometimes constructed in this way. In fact, there is no limit to the extension on cluster principles.

"When skillful, you can build one house first and then build the second against it in such a way that if both hemispheres were complete they would intersect to an extent of 2 or 3 feet. Then you build the third house either against the first or second.

c. "Setting up the first blocks.

"With the finished dome house in your mind's eye, you set the first block on edge as a domino might be on a table. With your knife you then slightly undercut the inner bottom margin so as to make the block lean toward you—at a very small angle if the house is to be a big one; at a greater angle if it is to be small. The end of the second block is placed against the end of the first so that pressure from the outside would not push one over without pushing both over. In similar manner the other blocks are erected until the first circle is complete.

"Once you have the first block on edge it is a simple matter to prop all the other blocks up by leaning one against the other. The nature of snow is such that when a block has been in place for 5 or 10 minutes in frosty weather it is cemented to its adjoining block and to the snow below at all points of contact and can be moved only by exerting a breaking force.

"When the first tier is finished, you can start the second tier any place. Having decided where to begin the second tier, count three blocks to the left from this point. From the third block to the left remove the upper quarter, from the second the upper half, and from the first, about the upper three-quarters of the original block. For the first block of the second tier, take a block of ordinary size and insert it in the niche which was made when the upper three-quarters of the first block on the left of the starting point was removed. Be sure that the block inserted in this niche rests against the end of the whole block next on its right. (The assump-

tion here is that the builder is right-handed. A left-handed builder would do these things in reverse order.)

"Once the second tier is started, build it to the left, leaning each block against the one previously set up, so that the walls rise in a spiral. Since you are building a dome-shaped house, the blocks of the second tier lean in more sharply than those of the first tier.

"There is no change in method as the house approaches completion but, of course, the higher up the blocks are the more they lean in. If you lean each carefully against the one set up before it, no block can fall unless one or the other breaks. If the blocks are set up at all carefully and are of passable quality this will never happen.

"There will be crevices everywhere between the blocks, some narrow and some wide. These are filled in with soft snow from the outside. This must be done gently, for the wall is fragile at first. If the crevice is particularly large, you stick in first a slice of a discarded block and then tamp in soft snow around its edges.

"When the wall gets three tiers high it becomes difficult for the man outside to hand blocks in over it. The builder then cuts a hole in the wall and blocks are shoved in to him.

"Completing the dome looks difficult. Actually it is easy. If you take two dominoes and place them end to end so that they are nearly in a straight line, you will find it difficult to make them stand by leaning against each other. But the same two dominoes, leaning against each other at a sharp angle, will stand easily, supporting each other. The same is true of snow blocks—more so, for they meet on comparatively extensive surface while dominoes meet only on corners. Near the roof your circle is small compared with the ground tier. The blocks, therefore, meet at so sharp an angle that you can lean them together pronouncedly. They then support each other well.

"When the house is all but completed, the builder finds in the center of the dome above his head a little irregular open space where the blocks do not quite meet. With experienced eye he decides how to enlarge this hole so as to make it big enough for the block he wants to put in it. With his knife he snips off projecting corners and now has above him an opening of regular shape. He next takes up a snow block, trims it so that, for easy handling, it is a little thinner than

the average. It is, too, somewhat larger than necessary. This block the builder sets on end and lifts vertically through the hole, so that a person outside can see his two arms sticking up. He then places the block in a horizontal position and lowers it gently down upon the opening so as to cover it like a lid. The block is then trimmed down to size and slips into place.

"When all cracks and crevices have been filled, and the builder has, as well, filled in the hole through which blocks were passed to him, the men on the outside throw shovels full of soft snow up on the dome. None sticks except that which fills the outer part of the crevices that have been chinked from inside by the builder or from outside by his assistants. Sliding down the sides, the soft snow forms an embankment all along the bottom of the wall. Eventually, when the shoveling stops, the snow piles at the bottom make the walls there perhaps 3 feet thick. Two feet up the banking is only 8 or 10 inches thick, whereas the roof has a thickness of only the 4 inches or so of the original blocks.

d. "Door.

"What is to be the final door is made by collaboration of the builder within and his assistants without, and can be at any point except that, usually, it should not be where the temporary door was. For the original block of the lower tier was cut away at that place and replaced.

"Inside an 11-foot house the builder lays off 7 feet for the bed platform. In the remaining 3 feet he digs a trench toward the door, 3 or 4 feet wide and 3 or 4 feet deep (if the drift on which the house stands is that deep). The men outside have dug a matching trench. They know where to dig for the builder has poked his knife out through the wall at a point that is going to be centrally over the door. The door is, then, where the inner and outer trench diggers meet under the wall.

"No single block of the ground tier needs to span the trench, for it has taken about an hour to build the house and long before now the various blocks have coalesced so that the house is practically a one-piece structure.

"In a 1-night camp you often have the door to leeward, but for a semipermanent camp it is best to have it at right angles to the prevailing winds. Then at the end of your alleyway you make a turn in the trench, like an elbow joint

in a stovepipe, and have this open to leeward. Still more practical is to have a kind of T-joint trench at the end of your alleyway. Then you can open one end and close the other as the winds change, and have an open door to leeward with minimum trouble.

"If you are building a 1-night camp, very likely when the door is finished nothing further is done. But if the weather is bad, or threatening, and particularly if the camp is to be occupied for more than 1 day, a shed will be built over the trench outside the house. This is so small and therefore so easy to build that no directions for it are needed by men who have been able to erect the main snow house.

"The main factor in the control of temperature of snow-house interiors in very cold weather (for reasons given below) is that the top of the door should be at least 18 inches lower than the bed platform, on which the occupants sit or lie. Usually there are enough broken blocks left inside a house when construction ends to build up this platform 6 or 8 inches, which means the top of the door should be at least 12 inches below the surface of the drift on which you build. This is why the drift should be at least 4 feet deep; it is not easy to crawl in through a door which is less than 3 feet high.

"If the drift is so shallow that the above ends cannot be attained, and if you want maximum warmth in what amounts to the living quarters of your house, you must build up the bed platform correspondingly. Should this in turn be impossible, you are driven to the expedient of closing the door after the men have all come in, and may even have to open and close it as they go in and out. You use for this closure a block of snow just a little bigger than the door opening and beveled so as to fit snugly.

e. "Ventilation.

"Since, no matter how the house is heated, ventilation is necessary, you usually put a ventilating hole in the roof. Its diameter follows conditions of external temperature, abundance of fuel, and whether people are awake or asleep.

"By trial you find that, when neither CO nor CO_2 is being generated by a fire, a snow house is adequately ventilated by diffusion if it has been constructed as indicated in *a, b, c* above and if a door with an aperture of from 5 to 8 square feet is constantly open. When fuel of any sort is

being burned there should be additional ventilation through a hole at the top of the dome. If this is a mere aperture, the escape of warm air melts the snow and gradually enlarges the ventilator. For this reason you should carry a sort of wooden stovepipe to insert in the roof. (Metal does not serve, for the warm air heats through and that melts the snow which touches the metal.) When no ventilation except from the door is needed, you close this chimney, using any suitable material available. The size of the aperture is regulated according to desire. Common practice is to stick two mittens up into the chimney to block it completely, pulling out one or both as ventilation is needed.

"When a strong wind blows, gusts of it, and even swirls of snow, will enter through the door unless there is an alleyway as described. With such an alleyway the ventilation through the door is regular irrespective of winds. The cold, fresh air from outside rises from the door below into the house as fast as, and no faster than, is necessary to replace the warm air passing out through the ventilator at the top.

"If the house is of fairly soft snow, no banking is ordinarily thought necessary unless fuel is very scarce or lacking. But if the snow is hard, and particularly if it tends to be granular, then banking is something between moderately helpful and nearly essential. The best way for thorough banking is to erect a tier of average sized blocks around the house in a circle that is broken only by the doorway. These blocks should lean inward considerably and should be 18 inches or 2 feet away from the house. The space between them and the house is shoveled full of snow; more is shoveled on top of that so that the house is banked, but less and less thickly, for a total of 4 or 5 feet up.

"Strong winds are rare out on the sea ice, at least when you are more than 50 miles from shore. Nearer shore and land there are some districts where violent gales may cut your snow walls, largely by a sandblast effect. The danger line is near the ground.

"Banking for this protection must naturally be according to circumstances. Perhaps with the pickax you carry for making a road through rough ice, or with an ice chisel, you can cut blocks of ice and build something like a stone wall of them to windward; perhaps you can get water and pour over the windward snow banking of your house; perhaps

there are pieces of driftwood that can be used, or sods, willows, or grass that can be held in place by improvised means. Or you may have a piece of canvas that can be spread over the windward side of the house. (A canvas spread over the top of the dome may cause too much melting, but there is no corresponding danger for the lower part of the wall.)

f. "Platform inside the house.

"The house is now complete outside, with banking for warmth and protection against cutting winds. You will find on the floor, as we have said, fragments of blocks which, for one reason or another, the builder did not use. Out of these you make a platform a foot or so high and covering about two-thirds of the floor space. This is the bed platform which provides your sleeping quarters. It serves to elevate you still further above the top of the door.

"Over the bed platform you now spread a layer of caribou or other skins, with the hair side down. The hair side, if snowy, need not be brushed off, for it is against the snow and nothing will thaw; but the skin side, being upward is going to be warm and so must be brushed or wiped clean of all snow. On top of this is placed, hair up, another snow-free skin. Then come sleeping bags or blankets. The two layers of furs are put down not so much to protect you from cold as to protect the snow beneath from heat. The interior of the house is going to be warm presently and people are going to sit around on the bed platform and later are going to sleep on it. If the insulation were not practically complete, heat enough from the cooking and from the bodies would penetrate through the bedding to melt the snow and make the bedclothes wet.

"When the temperature of the air outside, and consequently of the snow floor and walls of a newbuilt house, is zero F. or lower, a double layer of deerskins will prevent any thaw underneath the bedding, the snow there remaining as dry as sand in a desert.

g. "Heating.

"When the platform has been covered and the bedding, cooking gear, and other things have been brought in, a fire is lighted—alcohol lamp, blue-flame (primus) kerosene stove, seal lamp, or similar heating unit. If there is fire enough, it will thaw the walls, but that is what you intend it to do. If

fuel allows, bring the temperature up to as high as 80° F.; meantime keep poking roof and walls gently with your fingers to keep track of the process of thawing. This, of course, is most rapid in the roof, for the hot air accumulates against it; usually the lowest tier of blocks, near the floor, does not thaw at all.

h. "Glazing.

"The thawing proceeds without dripping, because dry snow is the best sort of blotter and soaks water into itself as fast as it forms. When the inner layer of the roof approaches slushiness and the walls are damp to a less degree, either put out the fire or make a large hole in the roof, or both, and allow the house to freeze. This glazes it inside with a film of ice, giving it strength, with the further advantage that, if you rub against it, scarcely anything will adhere to your clothing. From the dry walls before the glazing you would get your shoulder white at a touch, with a good deal of snow perhaps falling on the bed.

"We think of this heating to the slush point and subsequent cooling as mainly to produce an ice glazing; but it has an incidental further benefit. Those snow layers of the dome structure which directly touch the air within the house are no longer of their former intense cold, same as that of the outer air, but now hold a chill which is only a little below the freezing point. Consequently the dome no longer "radiates" into the house the chill that it did formerly. The snow over two-thirds of the floor is still at its outdoors temperature; but it is powerless to chill your room because it is held prisoner underneath the skins that have been spread over the bed platform. The only part of the house that still remains at nearly outdoors temperature and in contact with the air is the floor in front of the bed platform. If this is of gravel, as sometimes occurs when you have to build in a shallow drift on a sand bar, there is a tremendous amount of cold "radiated" upward, so you had better do something about it—at a minimum, spread over it some soft snow. Frozen earth chills the room a good deal more than snow; so does ice if it is very thick.

i. "To prevent house melting.

"If the weather outdoors grows warmer than the temperature in which you made camp, your body heat may be too great or the cooking heat may raise the temperature high,

so that the roof will commence to melt. This is not so much a sign that the house is too warm as that the roof is too thick; so you send a man out with a knife to shave it thinner, perhaps from 4 down to 2 inches, giving the outside cold a chance to penetrate and neutralize the heat from within.

j. "Methods of dealing with dripping.

"We have said that during the thawing which precedes the glazing of a new house the thaw water is soaked up into the dry snow, blotter-fashion. After the freezing has changed this slush to ice a further melting will not result in dripping if the dome is nearly perfect in its curvature and free of downward projections; for the water, instead of dripping, will trickle down the sides. But, as also explained above, the temperature of the house decreases rapidly as you approach the floor. Accordingly, the water, as it trickles, will first reach snow that has not been glazed, producing by congealing there a new, somewhat irregular glazing. If there is enough water so that it continues running still farther down, it will either just freeze a certain distance above the floor or else it will trickle all the way down to the snow of the floor where it will certainly freeze.

"Because of this possible trickling, and also because snow might crumble down, the bedding usually should not go nearer the wall than about 6 inches, leaving an open space between.

"If unevennesses in the roof produce dripping, in spite of shaving the roof thin as explained above, there are two remedies. The first and better is to shave or chisel away the unevenness, restoring this part of the roof to an approximately perfect curvature. When that is impossible (as, for instance, when a cave-in has begun) you apply a temporary remedy by providing blocks of snow of shape and size anything between that of a house-building brick and that of a half-pound cake of soap. Press one up against the roof where it drips. The water will immediately freeze, causing the snow to adhere to a wet surface. As water now gathers in toward the dripping point it is soaked by this chunk of snow blotter. You have to keep a watchful eye; when the blocks are soaked nearly to capacity, and are about to drop, you replace them with others.

"The snow block blotters are indicated when you know that the house is going to be at an extreme heat for only a little while. For instance, a thaw during cooking will usually stop when the cooking is over.

k. "To prevent hoarfrost.

"It may happen that the weather turns enough colder than the temperature in which you made camp so that hoarfrost begins to form on the inside of the roof and to drop like snowflakes. On this sign that the roof is too thin, a man goes out with a shovel and spreads on a soft snow, enough to blanket it suitably.

l. "Lighting.

"One ordinary commercial candle gives more, or better, light in a snowhouse than a 50-candle-power electric bulb would give in a drab room. For the dome is practically a hemisphere of diamonds, every facet reflecting light, multiplying and diffusing it uniformly. This light is comfortable, easy on the eyes. The diffusion is so effective that if the single candle that lights the dome is behind you your body throws only a scarcely noticeable shadow on the book you are reading.

"When a snowhouse is heavily banked only 2 or 3 feet up and when, therefore, a good part of the dome is only 3 to 6 inches thick, you get enough light from outdoors, even on a densely overcast day, so that there is no need for a candle. You do not, in fact, need a candle for some time after sundown or before sunrise; a full moon in a clear sky will give you enough light for dressing and even for handling cooking utensils (but, of course, not enough for reading). When a house stands on sea or lake ice there may be considerable light in daytime coming up through the floor in front of the bed platform.

"The coming in of light from several or all sides has its drawbacks. The chief is that it may produce snow-blindness. Similarly there may be too much light when you are recovering from this eye trouble. In such cases you sometimes throw canvas over the house. This has the disadvantage that it blankets the snow so as to produce melting of the roof from the indoor heat."

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