FM 31-72

DEPARTMENT OF THE ARMY FIELD MANUAL

MOUNTAIN OPERATIONS

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			Paragraphs	Page
CHAPTER 1.		GENERAL CONSIDERATIONS		
Section	I.	Introduction	1–4	2
	II.	Terrain	5–8	3
	III.	Climate	9–10	4
	IV.	Weather	11–22	4
	V.	Conditioning and acclimatization	23–31	9
CHAPTER 2.		OPERATIONS		
Section	I.	General	32–33	12
	II.	Troop movements and marches	34–44	12
	III.	Security	45–48	14
	IV.	Bivouacs	49–51	14
	V.	Offensive combat	52–61	15
	VI.	Defensive combat	62–68	18
	VII.	Supply	69–75	20
	VIII.	Tactical employment of climbers	76–83	22
CHAPTER 3.		EMPLOYMENT OF THE ARMS AND SERVICES		
Section	I.	Infantry	84–88	25
	II.	Field Artillery	89–100	26
	III.	Armor	101–102	29
	IV.	Army aviation	103–106	30
	V.	Engineers	107–112	33
	VI.	Signal	113–114	35
	VII.	Medical	115–127	38
	VIII.	Transportation	128–129	42
CHAPTER 4.		MILITARY MOUNTAINEERING		
Section	I.	General	130–133	45
	II.	Basic technique	134–140	45
	III.	Movement of trained personnel	141–142	67
	IV.	Unit movement	143–147	69
	V.	Evacuation	148–157	80
CHAPTER 5.		SNOW AND GLACIERS		
Section	I.	General	158–160	90
	II.	Classification of snow	161–162	90
	III.	Avalanches	163–170	91
	IV.	Movement over snow and ice	171–173	105
	V.	Movement over glaciers	174–178	110
CHAPTER 6.		FIXED ALPINE PATHS		
Section	I.	General	179–183	118
	II.	Erection	184–192	120
CHAPTER 7.		TRAINING		
Section	I.	Military mountaineering	193–198	133
	II.	Unit training	199–200	136
	III.	Exercises in climbing	201–208	137
APPENDIX	I.	REFERENCES	-------	141
	II.	MASTER TRAINING PROGRAM	-------	144
	III.	MENSURAL CONVERSIONS	-------	149
INDEX			-------	150

*This manual supersedes FM 31-72, 9 January 1959.

CHAPTER 1

GENERAL CONSIDERATIONS

Section I. INTRODUCTION

1. Purpose and Scope

a. This manual provides doctrinal guidance to commanders, staffs and subordinate leaders for operations in mountainous areas. The material presented in this manual is for use below division level, operations at division level and above will be essentially the same as those in other areas of the world. The manual covers the mission of the infantry brigade and supporting arms and services, as well as specialized techniques and training required for combat in mountainous areas. The material presented herein is applicable, without modification to both nuclear and non-nuclear warfare.

b. Users of this manual are encouraged to submit recommended changes or comments to improve the manual. Comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be forwarded direct to Commanding General, United States Army, Alaska, APO 949, Seattle, Wash.

2. Organization

The organization of the infantry division is suitable for operations in mountainous areas. Modifications will be required to fit specific situations. Normally these will take the form of additional emphasis on resupply and elimination of vehicles and weapons not suitable for the terrain. Emphasis must be placed on minimizing the load of the individual soldier in order to maintain adequate foot mobility at increasing altitudes. The airborne and the air assault divisions because of training and light equipment are ideally suited for mountain operations. Although lift efficiency decreases markedly with increase of density altitude, maximum utilization of available Army air vehicles must be effected to obtain tactical mobility and accomplish resupply and evacuation.

3. Tactics

The same tactical principles govern warfare in mountainous terrain as on any other terrain.

a. In rugged mountains there are limits to the employment of large forces. Deployment is greatly hindered and restricted. Often adjacent units cannot provide mutual support. Rapid employment and shifting of reserves are difficult in the more restricted positions. Small units have many occasions for sudden and bold action. Opportunities to deceive the enemy are many.

b. Small forces can prevent, impede, harass, or canalize the movement of the main enemy force so that when the decisive battle takes place enemy troop strength is dissipated and he is compelled to fight under unfavorable conditions.

c. Troops must be prepared to advance over narrow and twisting roads and paths, trackless terrain, steep and slippery slopes, ravines, and precipices.

d. The tank usually performs in a supporting role in mountain warfare. The employment of heavy infantry weapons and field artillery is hampered by their bulk and weight, by the considerable dead space in their fields of fire, and by the difficulties of observation due to bad weather and intervening terrain features. It is the infantry, above all, that must bear the brunt of the battle. The importance of close combat increases as the efficiency of other methods of fighting decreases.

e. The focal points of mountain combat are the heights. Gun emplacements and observation posts on commanding heights can dominate the foreground. Advances where possible are made along ridges.

f. Both friendly and enemy forces can be expected to use nuclear weapons in mountain combat. Rapid exploitation of these weapons, by ground elements, is difficult because of the rugged terrain. Surface or subsurface bursts may be employed by the attacker or defender to disrupt or destroy the usefulness of the few lines of communication that exist.

4. Logistics

a. Logistical considerations are greatly affected in mountain operations. Time and space factors are never fixed, but vary constantly with the configuration of the terrain, the altitude, the scarcity of roads, and the season. In general, a comparatively great amount of time must be allowed for the movement of troops and supplies. Distance is measured in time rather than kilometers. Gradients between points are often of greater significance than the horizontal distance.

b. Time permitting, supply officers at all levels must take appropriate steps to insure that specialized items of equipment and clothing are drawn and issued (TA 50–901).

c. The commanding officer must issue orders, fragmentary if necessary, to his subordinates early in the operation because of the time needed for movement of troops and supplies along the small number of steep and difficult routes, and because of the difficulties in bringing troops into position, in modifying their positions and in organizing supply functions.

d. Commanders and staff must make maximum use of locally available resupply means to include field expedients, such as pack animals, civilian bearers, tows and tramways (TM 5–270).

Section II. TERRAIN

5. General

Mountains are generally defined as land forms higher than 500 or 600 meters characterized by steep slopes. Slopes are commonly 4 to 30 degrees and locally, in cliffs and precipices, may be vertical or even overhanging. Mountains may consist of an isolated peak, single ridges or complex ranges extending for a thousand kilometers or more like the Rocky Mountains. Most of the terrain is an obstruction to movement; and mountains favor the defense. History records many cases in which forces inferior in numbers and equipment have held off superior attackers in mountainous areas.

6. Roads and Trails

Existing roads and trails offer the easiest routes in the mountains. Most follow valleys between ridges, crossing ridges and divides by passes. Detailed maps such as topographic quadrangles show roads and many of the trails. Terrain intelligence, photo interpretation, local residents, and other sources may supply additional information.

7. Cross-Country Movement

Where there are no roads or trails it is particularly important to have full knowledge of terrain to determine the most feasible routes for cross-country movement. Preoperations intelligence effort must be directed to compilation of topographic or photo map coverage and collection of detailed metro data for the area of operations. Intelligence reports may be available which show terrain features that may affect movement. When planning mountain operations it may be necessary to use additional information on size, location and characteristics of land forms and drainage, nature and types of rock and soil, and amount and distribution of vegetation.

8. Concealment, Cover, and Observation

Irregular mountain topography provides numerous favorable places for concealment and cover. Digging of foxholes and temporary fortifications is generally difficult because soils are thin or stony and bedrock is commonly hard. Some rock types, however, such as volcanic tuff are readily excavated. In other areas, abundant boulders and other loose rocks can be used for the construction of hasty fortifications like those used by German troops in the defense of Mt. Cassino in Italy. Observation in mountains is variable because of weather and ground cover. Range determination is particularly deceptive; observers must receive additional training in this area.

Section III. CLIMATE

9. General

Mountain climate has a very definite effect on the physiology and pathology of the individual because the human organism is sensitive to weather changes and differing climates.

10. Mountain Air

a. Mountain air is relatively pure. The higher the elevation, the more nearly pure it becomes. Above 4,500 meters it is practically germ free. The physical composition of the atmospheric air is practically the same at high altitudes as it is at sea level. The rarefaction of air at high altitudes is due to the decreased partial pressure of the atmospheric oxygen. The utilization of oxygen by the body is dependent upon the pressure under which it is forced into the tissues. Forests, especially those with coniferous trees, lessen the percentage of carbon dioxide, and thus do their part in purifying the air. Falling snow also purifies the air by capturing and holding many of the impurities which remain in the air.

b. High mountain air is dry, especially in the winter when the humidity in the air condenses into ice. This dryness increases with altitude. The amount of water vapor in the air decreases in geometric proportion as the altitude increases.

c. Atmospheric pressure drops as the altitude increases. The pressure varies, on the average about .95 cm of mercury for every 100 meter rise.

d. The temperature drops as the air becomes more rarefied. In an atmosphere containing a considerable amount of water vapor, temperature drops about 1° F., for every 100 meter rise in altitude. In very dry air it drops about 1° F., for every 50 meters.

e. An important characteristic of the atmosphere at high altitudes is its luminosity. The sun's rays are either absorbed or reflected by the atmospheric haze which fills the air above low country especially over cities. The rarefied dry air of the higher altitudes allows all the visible rays of the solar spectrum to pass in their entirety. However, only a fraction of the solar invisible rays can penetrate the atmospheric haze. In pure atmosphere, the proportion of ultraviolet rays remains constant, regardless of the altitude. These conditions increase the possibility of sunburn especially when combined with existent snow cover.

Section IV. WEATHER

11. Importance

a. Mountain weather can be either a dangerous obstacle to operation or a valuable aid, according to how well it is understood and to what extent advantage is taken of its peculiar characteristics. Trained men who are well clothed, equipped, and supplied may often convert such weather into an ally rather than an enemy.

b. Weather often determines the success or failure of the mission. Mountain weather is highly changeable. Military plans arranged in advance of an operation must be flexible. Every effort must be made to anticipate the weather, and also to allow sufficient latitude in the time schedule so that the leaders of subordinate units can use their initiative in turning the highly important weather factor in their favor. The clouds that frequently cover the tops of mountains, and the fogs that cover valleys offer an excellent means of concealing movements which normally would have to be made under cover of darkness or smoke. The harmful effects of cold can be prevented in large measure by the use of proper clothing and the conditioning of personnel. Advantage must be taken of every clear minute to do the things that cannot be done when observation is obscured.

c. The safety or danger of almost all high mountain regions, especially in winter, depends upon a change of a few degrees of temperature above or below the freezing point. The comfort and health of men are affected. Ease and speed of travel are largely dependent on weather. Terrain that can be crossed swiftly and safely one day may become impassable or highly dangerous the next because of snowfall, rainfall, or a rise in temperature. The reverse can happen just as quickly. The prevalence of avalanches depends mostly on weather factors.

12. General Characteristics

Mountain weather is erratic. Hurricane winds and gentle breezes may be found a few paces apart. The weather in exposed places contrasts sharply with the weather in sheltered areas. Weather changes in a single day can be so variable that in the same locality one may experience hot sun and cool shade, chill wind and calm, gusts of rain or snow, and then perhaps intense sunlight again. This variability results from the life cycle of a local storm or from the movement of traveling storms. In addition, the effects of storms are modified by the following local influences:

a. Variation in altitude.

b. Differences in exposure to the sun and to prevailing winds.

c. Distortion of storm movements and the normal winds by irregular mountain topography. These local influences dominate summer storms. During summer the weather fluctuations are at a maximum, although they are less severe than winter changes.

13. Temperature

a. Temperature Inversion. Normally, a temperature fall of from 3° F. to 5° F. per 300 meter gain in altitude will be encountered. Frequently, on cold, clear, calm mornings when a troop movement or climb is started from a valley, higher temperatures may be encountered as altitude is gained. This reversal of the normal situation is called "temperature inversion." This condition occurs because much of the heat of the earth's surface has been lost during the night through back radiation and the morning sun will strike and warm the higher (and easterly-side) slopes earlier than it does the valleys (and westerly-side) slopes. This inversion condition continues until the sun warms the surface of the earth and a lapse condition occurs.

b. Solar Heating. At high altitudes, solar heating is responsible for the greatest temperature contrasts. More sunshine and solar heat are received above than below the clouds. The important effect of altitude is that the sun's rays pass through less of the atmosphere and more direct heat is received than at lower levels where solar radiation is absorbed and reflected by dust and water vapor. There may be differences of 40° F. to 50° F. between the temperature in the sun and that in the shade. Special care must be taken to avoid sunburn and snow blindness which result from the combined action of intense sunlight and the reflected rays from snow fields or clouds. Besides permitting rapid heating, the clear air at high altitudes also favors rapid cooling at night. Consequently the temperature rises fast after sunrise and drops quickly after sunset. Much of the chilled air drains downward, so that the differences between day and night temperatures are greater in valleys than on slopes.

14. Cloudiness and Precipitation

a. Cloudiness and precipitation increase with height until a zone of maximum precipitation is reached; above this zone they decrease. Maximum cloudiness and precipitation occur near 1800 meters elevation in middle latitudes and at lower levels as the poles are approached. Usually a dense forest marks the zone of maximum rainfall.

b. Slopes facing the prevailing wind are cloudier, foggier, and receive heavier precipitation than those to the lee of the wind, especially when large bodies of water lie to the windward. However, at night and in winter, valleys are likely to be colder and foggier than higher slopes. Heads of valleys often have more clouds and precipitation than adjacent ridges and the valley floor.

15. Wind

a. In high mountains the ridges and passes are seldom calm; however, strong winds in protected valleys are rare. Normally, wind velocity increases with altitude, since the earth's frictional drag is strongest near the ground, and this effect is accentuated by mountainous terrain. Winds are accelerated when they are forced over ridges and peaks or when they converge through mountain passes and canyons. Because of these funnelling effects, the wind may blast with great force on an exposed mountainside or summit. In most cases, the local wind direction is controlled by topography.

b. The force exerted by wind quadruples each time the wind speed doubles; that is, wind blowing at 40 knots pushes four times harder than does a 20 knot wind. With increasing wind strength, gusts become more important, and may be 50 percent higher than the average wind velocity. When wind strength increases to the hurricane speed of 80 knots, men should hug the ground during gusts and push ahead in lulls. If a hurricane wind blows where there is sand or snow, dense clouds fill the air, and rocky debris or chunks of snow crusts are hurled along near the surface.

c. In general, the velocity of the winds accompanying local storms is less than that of winds with traveling storms. There are two winds which result from the daily cycle of solar heating. During calm, clear days in valleys subject to intense solar radiation, the heated air rises and flows gently up the valleys. This wind is called a "valley" or "up-valley" breeze. On clear nights the mountainsides lose heat rapidly and cool the surrounding air which settles downslope to produce the "mountain" or "down-valley" breeze. The down-valley breeze, by pouring cold air into a valley, is responsible for temperature inversions, in which temperature increases with altitude, contrary to normal conditions.

d. During the winter season or at extremely high altitudes, commanders must be constantly aware of the windchill factor and associated frostbite. Windchill is covered in detail in FM 31–70 and FM 31–71. During all seasons, exposed areas of the body are subject to windburn or extreme chapping. Although windburn is uncomfortable, it is seldom incapacitating.

16. Thunderstorms

a. Although thunderstorms are local in nature and usually of short duration, they can be handicaps to operations in the mountains. In the alpine zone above timberline, thunderstorms may be accompanied by driving snow and sudden squally winds. Ridges and peaks become focal points of concentrated electrical activity which are highly dangerous.

b. Purely local thunderstorms develop from rising air columns resulting from the intense heating by the sun of a relatively small area. They occur most frequently in the middle or late afternoon. Scattered fair weather clouds of the cumulus type often appear harmless, but when they continue to grow larger and reach a vertical depth of several thousand feet, they may turn into thunderstorms on very short notice.

c. Thunderstorms occurring at night or in the early morning are associated with major changes in the weather situation, which often result in a long period of foul weather before clearing on the high summits. Thunderstorms occurring at these times may also be part of a "line storm" and if so, are followed by a prolonged period of cool, dry weather.

17. Fog

On windward slopes, persistent fog, as well as cloudiness and precipitation, frequently continue for days, and are caused primarily by the local barrier effect of the mountain on prevailing winds. Any cloud bank appears as a fog from within. Fog limits visibility which, in turn, hampers operations by increasing the possibility of accidents. It also facilitates surprise attacks. If fog is accompanied by precipitation, additional clothing will be needed for protection against the uncomfortable combination of cold and wetness. When traveling without landmarks, it will be necessary to use a compass and a map to maintain direction.

18. Traveling Storms

a. The most severe weather conditions, storms involving strong winds and heavy precipitation, are the result of widespread atmospheric disturbances which generally travel in an easterly direction. If a traveling storm is encountered in the alpine zone during winter, all of the equipment and skill of the soldier will be pitted against low temperatures, high winds and blinding snow.

b. Traveling storms result from the interaction of cold and warm air. Although the heart of the storm is a moving low pressure area, the "warm front," which marks the advancing thrust of warm air, and the "cold front" of onrushing cold air are more important features than the center itself, from which they radiate.

c. In the northern hemisphere, the sequence of weather events with the approach and passing of a traveling storm depends on the state of the storm's development, and whether the location of its path is to the north or south of a given mountain area. Generally, scattered cirrus clouds merge into a continuous sheet which thickens and lowers gradually until it becomes altostratus. At high levels, this cloud layer appears to settle. Lower down, a stratus deck may form overhead. A storm passing to the north may bring warm temperatures with southerly winds and partial clearing for a while, before colder air with thunder showers or squally conditions moves in from the northwest. However, local cloudiness often obscures frontal passages in the mountains. The storm may go so far to the north that only the cold front phenomena of heavy clouds, squalls, thunder showers, and colder weather are experienced. The same storm passing to the south would be accompanied by a gradual wind shift from northeasterly to northwesterly, with a steady temperature fall and continuous precipitation. After colder weather moves in, the clearing at high altitudes is usually slower than the onset of cloudiness, and stormy conditions may last several days longer than in the lowlands.

d. Glaze is a form of precipitation deposited only under the special conditions found in traveling storms. When light rain or drizzle falls through air below 32° F., and strikes a surface that also is below 32° F., it freezes to the surface in the form of glaze. Glaze usually forms near the warm front of a storm and only persists if colder weather follows.

19. Weather Forecasting

a. The use of the portable aneroid barometer, thermometer, and hygrometer can be of great assistance in making local weather forecasts. Reports from other localities and from the weather service of the Air Force are also of great value.

b. In order to be utilized to its fullest extent, the resulting forecast must get down to the small unit leaders who are expected to make use of weather favorable for specific missions.

20. Bad Weather

Most of the bad weather experienced in mountain regions is a result of—

a. Local storms in the form of thunderstorms, with or without showers.

b. Traveling storms which may be accompanied by radical and severe weather changes, over a broad area. Usually, each type of storm may be identified by the clouds associated with it.

c. Seasonal moisture-bearing winds of the monsoon type which bring consistently bad weather to some mountain ranges for weeks at a time.

21. Cloud Types

It is possible to differentiate between local and traveling storms, and estimate their probable occurrence, by recognition of the various cloud types (fig. 1. The heights shown in the figure are approximate mean heights applicable in the temperate zone).

a. Cirrus clouds are composed of ice crystals and may occur from 6,500 to 12,000 meters high. They may be detached white clouds with fibrous structure, or they may be extensive thin veils.

b. Altostratus clouds are dark clouds that form a continuous uniform sheet at elevations of 2,500 to 6,000 meters. They may cover the sky completely and develop from the descending and thickening cirrus or the merging of high cumulus types.

c. Cumulus clouds resemble great patches of cotton or giant heads of cauliflower and form at any height from 500 to 4,000 meters. Their bases are flat, but their tops vary in size and height. Cumulus clouds are brilliant white in direct sunlight, but dark on the shaded side. Altocumulus clouds are similar in form, but smaller, and appear in uniform layer or cloud deck at 2,500 to 7,000 meters.

d. Cumulonimbus (thunderheads) are overgrown and darkened cumulus clouds that are yielding, or are likely to yield precipitation. A single cumulonimbus cloud mass may extend from a base at 800 meter elevation to a height of 10,000 or 11,000 meters.

e. Stratus clouds are similar to altostratus, but much lower. They may develop from a fog layer in which the bottom portion has evaporated, or where upslope winds are blowing. Often they are associated with moisture precipitation and usually are seen below 900 meters except where they are forced up over a mountain or lie in high valleys.

22. Weather Predictions

Each of the cloud types characterizes one or several phases in a given weather situation. The following are the most common weather indications, although they are not always applicable. An individual remaining in one mountain region for several weeks in any season can add indications for that area based on his own experience with local weather changes.

a. Traveling Storms. The approach of a traveling storm is indicated when—

(1) A thin veil of cirrus spreads over the sky, thickening and lowering until altostratus clouds are formed. The same trend is shown at night when a halo forms around the moon and then darkens until only the glow of the moon is visible. When there is no moon, cirrus only dims the stars while altostratus hides them completely.

(2) (a) Low clouds which have been persistent on lower slopes begin to rise at the time upper clouds appear.

(b) Confused layers of clouds move in at different heights and become more abundant.

(3) Lens-shaped clouds accompanying strong winds lose their streamlined shape and other cloud types appear in increasing amounts.

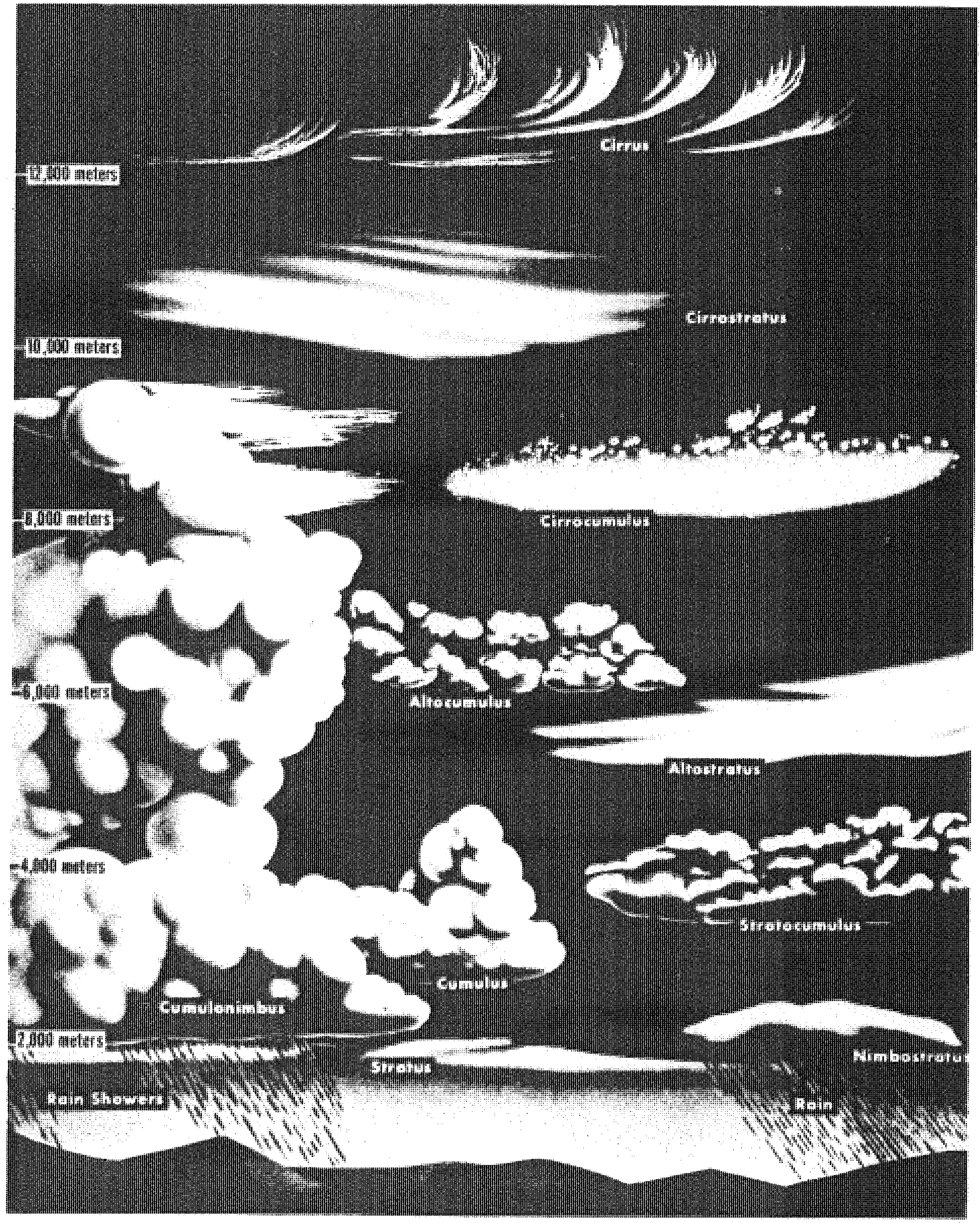


Figure 1. Cloud types.

(4) A change in the direction of the wind is accompanied by a rapid rise in temperature not caused by solar radiation. This may also indicate a warm, damp period.

(5) An intense green sky is observed shortly after sunrise in mountain regions above timberline.

b. Local Disturbances. Indications of local thunderstorms, showers, or squally weather are—

(1) An increase in size and rapid thickening of scattered cumulus clouds during the afternoon.

(2) The approach of a line of large cumulus or cumulonimbus clouds with an advance guard of altocumulus. At night, increasing lightning to windward of the prevailing wind gives the same warning.

(3) Massive cumulus clouds hanging over a ridge or summit both at night or in the daytime.

c. Strong Winds. Indications from strong winds seen at a distance may be—

(1) Plumes of blowing snow from the crests of ridges and peaks or ragged shreds of cloud moving rapidly.

(2) Persistent lens-shaped clouds, or a band of clouds, over high peaks and ridges or downwind from them.

(3) A turbulent and ragged banner cloud which hangs in the lee of a peak.

d. Fair Weather. Fair weather may be associated with—

(1) A cloudless sky and shallow fog or layers of smoke or haze at valley bottoms in early morning; or from a vantage point of high elevation, a cloudless sky that is quite blue down to the horizon or down to where a level haze layer forms a secondary horizon.

(2) Conditions under which small cumulus clouds appearing in the forenoon do not increase, but decrease or vanish, during the day.

(3) Clear skies, except for a low cloud deck which does not rise or thicken during the day.

e. During Precipitation. When there is precipitation and the sky cannot be seen—

(1) Very small snowflakes, ice crystals, or drizzle indicate that the clouds above are thin and there is fair weather at high altitudes.

(2) A steady fall of snowflakes or raindrops indicates that the precipitation has begun at high levels and that bad weather is likely to be encountered on ridges and peaks.

Section V. CONDITIONING AND ACCLIMATIZATION

23. Necessity for Conditioning and Acclimatization.

a. The training of soldiers in mountains of low or medium elevation does not require all of the special conditioning and acclimatization procedures discussed here. In some individuals, malaise and impairment of operating efficiency may occur at altitudes between 1,500 and 2,100 meters; above 2,100 meters, practically all unacclimatized soldiers may be expected to display some altitude effects.

b. There is a need, however, for a period of 10 to 14 days devoted to conditioning and acclimatization for troops to be trained in altitudes over 2,500 meters. After a week or two at high altitude, the soldier will find that he is less exhausted, he sleeps better, and his appetite is normal. He will soon find that life in the mountains is definitely exhilarating. Numerous bodily adaptations enable more oxygen to be carried from the lungs to the tissues of the body. During this period of acclimatization, the training program should provide for graduated physical exercises of various types including marches. In high mountains it is generally found that the air is dry and as a result perspiration is more quickly evaporated. This tends to mislead a person into thinking that he is not perspiring freely due to the fact that his clothes are less frequently moist even following strenuous exertion. This loss of body salt and fluid through perspiration soon leads to acute dehydration. This dehydration is recognized by muscle cramps and other symptoms normally identified with heat exhaustion. Treatment for this condition is simply replacement of salt and water which has been lost.

24. Psychological Adjustment

The psychological adjustment of the individual must be considered. Many persons who have lived in lower altitudes all their lives may have preconceived notions about the supposedly harmful effects of high altitude on the human organism. To them any illness however trivial may be construed as an ill effect of altitude which may cause them to become unduly concerned about their physical conditions. This can be prevented by educational programs in which it is shown that high altitudes have few harmful effects, and these are of short duration (see par. 30). Many men who have lived on flat terrain have difficulty when faced with the problem of learning to negotiate steep slopes or cliffs. They will develop a sense of insecurity and fear. These men must be gradually introduced to these new terrain features and encouraged to progressively develop their confidence until they can negotiate a passage across such obstacles with assurance and ease. Men must be taught the various climbing techniques used, be indoctrinated with the principles of mountain marching. These capabilities are attained only through constant training and application. There are many individuals who possess fear of height in varying degrees; many of these individuals may overcome this fear by familiarizing themselves with the problems through practice. The individual cannot be forced to disregard this fear.

25. Physical Conditioning

Regardless of previous Army training and the amount of flat cross-country marching practice, the soldier newly initiated into the mountains finds mountain marching arduous and tiring. New muscles are brought into play and these muscles must be developed and hardened. Furthermore, a new technique of rhythmic movement must be learned. This conditioning is attained only through daily marches and climbs which result in increased stamina and endurance. Simultaneously with this development men acquire increasing confidence and better ability to safely negotiate terrain which they had previously considered impassable.

26. Personal Hygiene

The principles of personal hygiene and sanitation that govern the operations of troops over more normal terrain are also applicable in the mountains. The same strict adherence to the policies prescribed in FM 21–10 must be enforced to insure the maintenance of the health of the troops.

27. Water Supply

There is a false concept held by many that mountain water is safe for consumption. This indicates the need for additional emphasis on training in water discipline to insure that the soldier drinks only water from approved sources. (See FM 21–10 for methods of purifying water.) Fluids lost through respiration, perspiration, and urination must be replaced if the soldier is to operate with normal efficiency. Necessary emphasis must be placed on each of the three rules of water discipline. The three rules are—

a. Drink only treated water from approved sources. Untreated water may be contaminated.

b. Conserve water for drinking. Potable water in mountains may be limited while physiologic requirements may increase (pars. 23*b* and 28*c*).

c. Do not contaminate or pollute water sources.

28. Personal Habits

Health maintenance of the troops is a command function at all echelons. Commanders must conduct frequent inspections to insure that personal habits of hygiene are not being disregarded. The soldier must be educated concerning the consequences of neglecting his personal hygiene habits.

a. Personal cleanliness is especially important in extreme cold. In freezing temperatures, the individual has a tendency to neglect washing due both to the cold and the scarcity of water. This may result in skin infections and vermin infestation. If bathing is impossible for any extended length of time, the soldier should at least examine his skin and stimulate and cleanse it as much as possible by briskly rubbing his body with a rough towel. This practice will help reduce the possibility of skin infection and will also make the individual feel better in general.

b. Particular attention must be devoted to the care of the feet to afford protection against cold injuries. The causative factors for these injuries are present throughout the entire year in high mountains. The feet should be kept dry and socks changed at least once daily. The principles of foot hygiene apply with greater force in high mountains than they normally do in any other terrain.

c. Under conditions of extreme cold, there is a general tendency for the individual soldier to permit himself to become constipated. This condition is brought about by the desire to avoid the inconvenience and discomfort of relieving himself. Adequate water intake is very helpful in prevention of constipation.

29. Waste Disposal

For methods which should be used under conditions of snow and extreme cold, see FM 31-70.

30. Mountain Sickness and Acute Pulmonary Edema

a. Mountain or altitude sickness is an acute temporary illness which may occur in mountains. The novice and experienced climber alike, are subject to this malady in altitudes as low as 2,500 meters. The cause is usually poor physical condition, lack of acclimatization, or both. Symptoms may be headache, nausea, vomiting, lack of appetite, insomnia, and irritability. This condition can usually be relieved by rest. In rare cases the patient must be taken to a lower altitude.

b. Acute pulmonary edema has been shown to occur in persons who undergo a rapid transition from low to very high altitudes (i.e., 3,000–3,600 meters). Especially prone are those who have experienced the disease before. Persons who have had acute pulmonary edema should not be assigned to units operating in high mountainous areas. The disease appears to be precipitated or aggravated by excessive early activity without gradual physical buildup and acclimatization. Pulmonary edema must always be considered a serious disease. Evacuation to a lower altitude is a routine part of treatment, and must be accomplished early.

31. Valley Sickness

Valley sickness may occur when an individual who is acclimatized to high altitude returns to a low altitude. It is a rare temporary condition.

CHAPTER 2

OPERATIONS

Section I. GENERAL

32. Terrain and Weather

a. Mountainous terrain is usually characterized by one or more of the following: exaggerated terrain features, heavy woods or jungle, rocky crags and glaciated peaks, compartmentation, routes of communication which are limited in extent and of poor quality, extreme weather conditions, or high altitudes. For terrain evaluation, see FM 5-15 and FM 100-5.

b. Mountain terrain lends itself particularly well to surprise, but successful surprise action depends on skilled troops and a commander who knows how to use them. Decentralization of control is forced upon commanders of large units by prevailing terrain and weather conditions. Hence, the initiative, resourcefulness and judgment of small unit commanders is taxed to the utmost, as they may be operating independently or semi-independently for extended periods.

33. Standing Operating Procedures

In order to facilitate mountain operations, a detailed standing operating procedure should be prepared by each unit, including the platoon. This standing operating procedure should cover the organization of combat teams down to and including the reinforced platoon, supply procedures, making bivouacs and emergency shelters, march rates and formations, and any changes in organization and equipment required for summer or winter operations.

Section II. TROOP MOVEMENT AND MARCHES

34. March Technique

a. Troops that have acquired the proper technique for marching in mountains are capable of marching many times the distance that can be covered by troops not so trained. The prime consideration is accomplishing the mission by conserving the soldier's strength and combat efficiency. The individual soldier must acquire a steady, rhythmic pace, decreasing in speed with the steepness of the slope. In addition to the effect of the terrain, the rate of march is further reduced by wind, rain, intense heat, and fog. When climbing, the length of the regular pace should be shortened, stepping around rather than over obstacles, and keeping the feet flat. Use of the balls of the feet alone should be avoided. The knees should be slightly bent, and footholds selected carefully. When traversing steep slopes on soft ground it is desirable to kick footholds and to take advantage of natural flat hummocks. When traversing steep slopes on hard ground the feet should be flat, rolling the ankle with slope. Logs, sticks, or small rocks should not be stepped on. When ascending steep slopes the rate may very from 40 to 85 steps per minute, depending principally on the altitude.

b. Over uneven or difficult footing, a 2-meter distance between men allows the soldier to adjust the length of his stride and to keep moving without being forced to halt by the varying speed of the man ahead. To conserve energy and wherever possible one should climb at an angle in a zig-zag fashion rather than directly up a hill.

35. Effects of Marching

Improper pace or cadence in marching up hill may result in serious injury to the heart and respiratory organs. Descending produces continuing jars, the severity of which is increased by the weight of a pack, resulting in strain on the legs, pelvis, and spinal column. Climbing tires the heart and lungs; descending causes great muscular fatigue.

36. Rate of March

The rate of march may seldom be calculated exactly. To estimate the time required to cover a given distance, add 1 hour for each 300 meters ascent or 600 meters descent to the time required for marching a map distance. For example, a 16 kilometer march on a hard surfaced road requires 4 hours. If there is a total climb of 600 meters and a total descent of 600 meters the march will take seven hours.

37. March Discipline

March discipline must be rigorously enforced in every aspect. If a man is forced to stop to repair or readjust equipment or because of illness or an injury, he should immediately fall out of the column, and should not try to regain his place until the next halt. All commanders must give continuous attention to keeping marching formations closed to proper distances especially when weather conditions deteriorate rapidly. Ordinarily this can only be accomplished at halts. Straggling must not be tolerated and the taking of short cuts should be forbidden.

38. Pace-Making and Halts

The march unit should be the company. An experienced noncommissioned officer, carrying the same load as the majority of the men and marching at the head of the company, maintains the pace ordered by the march unit commander. The pace of the column must be governed by the most heavily loaded element. It is advisable to make a 5 minute halt to adjust clothing and equipment after the first 15 minutes of marching, and 5 or 10 minute halts every half hour thereafter. At the regular halts, men should remove their packs and weapons. Lying down with the feet elevated will help freshen the legs and prevent stiffness. Troops should be trained to get off the trail immediately at all halts.

39. Column Length

When a narrow trail necessitates marching in single file, the length of an infantry battalion may approximate 8 kilometers. On a winding ascent, the main body may be closer to the enemy than the point and may be fired upon at the same time at the point, or even before the point is engaged.

40. Selection of Routes

a. Reconnaissance of routes of march should be made and the route selected on the basis of ease in marching as well as tactical security. Factors governing the choice are availability of ridge routes, good footing, contour travel, timber lines, and geological formations such as ledges. Primitive trails are usually found along ridges. Highways usually follow the valleys. Movement down a valley, without security on the high ground, invites ambush. Movement on the crest of a ridge, where some of the best trails are found, invites observed artillery fire. In an uncovered march, a unit should march below the crest of the ridge with flank security below both military crests observing the valleys.

b. Timing and planning are important in order to avoid halts or bivouacs on exposed terrain.

41. Selection of Objectives

Because of optical illusions created by clear air, looking down from the heights, and intervening depressions, time and distance will usually be underestimated. Particular care must be taken to select an objective which can be reached within the time available. The route and alternate route to the destination should be reconnoitered in advance. One unexpected extension of a march will often produce undue exhaustion which, in turn, may result in a late arrival, a poorly prepared bivouac, and inefficient security.

42. Movement Over Difficult Terrain

Movement over extremely difficult terrain such as cliffs, rocky crags, ravines, glaciers, or deep snow, requires special preparation, training, technique, and equipment (chs. 4 and 5).

43. Night Marches

When contact with the enemy is imminent or has been gained, most of the marching will be at night. Night marches in mountains are very difficult, often dangerous, and excessively tiring, and therefore should be attempted only when absolutely required by the situation. Daylight reconnaissance, the marking of routes to be used and the employment of competent guides are essential to the success of a night march. Distances between men and units are decreased. On occasion it is advisable to maintain physical contact with the man ahead. While bright moonlight makes a night march easier, it also improves enemy observation. It is extremely difficult to move along a rocky path at night without noise. Dislodging of a single rock may start a rockslide that can be heard over a mile away. When marching through woods or areas where trails are many and indistinct, numerous connecting files will be required between march units in order to maintain continuous contact. It is usually impossible for anyone to move up and down a column on a mountain path at night to check on distances and maintain march discipline. All orders must be relayed rearward and forward through the column.

44. Marches in Clouds or Fog

Marches in clouds or fog present the same difficulties as night marches. Keeping a sense of direction is more difficult, since clouds are often so dense that one can hardly see the ground. Such conditions necessitate even closer columns, a slower pace, and the use of audible signals. The crowding together of units may create serious tactical disadvantages when the fog or cloud lifts.

Section III. SECURITY

45. General

a. Mountain terrain offers many vantage points for enemy observation and ambush thus requiring the placing of added emphasis on security. Commanding ground must be occupied immediately by security detachments strong enough to hold it against hostile combat or reconnaissance patrols. Enemy positions, not readily accessible, may have to be neutralized and bypassed so as not to impede the progress of the main body. Neutralization can be accomplished by use of smoke, conventional fires, and nuclear fires. Smoke can be used to minimize enemy effectiveness when bypassing enemy positions.

b. When defending against well trained and aggressive enemy troops, no mountain range or terrain obstacle can be considered as insurmountable, and every conceivable approach must be guarded.

c. At night, and during other periods of restricted visibility enemy infiltration is a constant danger. The use of additional troops may sometimes be necessary in order to provide adequate protection for rear installations.

46. Listening Posts

A man's voice in a valley frequently can be heard on ridges 900 meters above. Consequently, valley approaches, as well as ridge approaches, are often covered by listening posts well up on ridges. However, thorough coverage of a valley approach may often require listening posts located in the valley. Mountain streams often drown out all noises for those near the stream when those higher on the ridge can distinguish each distinct sound.

47. Flank Security

a. Flank security is provided by forces occupying dominant terrain on the flanks of the main body. Flank security forces limited to foot mobility often move to vantage points well in advance of movements of the main body. In winter, ski troops may be used for this difficult mission. Flank security elements are transported by helicopters or vehicles when practicable. The number and strength of flank security elements is determined by the number of terrain features which must be occupied or patrolled and by the mobility of the flank security forces.

b. Commanders consider the difficulties imposed by terrain on movement of security forces and plan accordingly. The frequent lack of passable routes on the flank of the main body may limit flank security to helicopter borne patrols or aerial observation. However, strong ground flank security elements are used when practicable. Consideration must be given to ceiling limitations for the type helicopter used.

48. Antimechanized Security

Surprise raids by armored elements are rare, but should nevertheless be guarded against by means of road blocks, mines, and antitank guns.

Section IV. BIVOUACS

49. General

a. Most mountainous regions offer a few camp sites suitable for large units. The limited areas and the increased time lengths of columns will usually require companies, or even platoons, to bivouac separately on the nearest suitable spot to the halting point. This method will not necessarily expose subordinate units to any great danger, as even a platoon organized for all-around defense can successfully withstand an attack by a larger force and can easily be supported by adjacent units. The best campsites are on gentler slopes, near streams and in wooded areas. Above the tree line, tents must be well dispersed and camouflage discipline strictly enforced. In general, mountain bivouacs should be located on commanding ground with provisions for all-around defense of the area. Unprotected small units should never bivouac in a valley in the presence of the enemy, as they do not possess sufficient force to outpost surrounding high ground.

b. For bivouacs in snow and extreme cold, see FM 31–71, for bivouacs in jungle, see FM 31–30.

50. Formations

a. The company should bivouac in a formation suitable for perimeter defense. If sufficient overhead cover is available, the company should bivouac astride the road or trail being used, with trails made for the flank platoons. The use of platoon bivouacs will further reduce the time required to close up at night and to move out in the morning.

b. The force commander, when issuing his order to halt, should indicate whether to close into platoon or company bivouacs, depending on the density of cover, the time length of the column, and his mission the following day.

c. The actual setup of bivouacs will vary considerably due to the irregularities of the terrain. Living conditions are continually improved if the same area is to be used for more than one night. All types of shelters may be dug in the side of a slope, using shelter halves, ponchos or pieces of canvas covered with grass or branches for roofing. On a fixed front, bombproof caverns may be blasted out of bedrock and used for supply storage as well as living quarters.

51. Precautions

a. Smoke from a fire in a valley will often rise in a column that can be seen for several miles. Lights at night can be seen from distant visible peaks. Exposed lights or fires should never be permitted under combat conditions. If absolutely necessary to have fires in the mountains, it is best to put them in small depressions on top of the higher ridges. A pit for the fire about ½ meter deep should be dug and the fire only lit at night to prohibit observation of the smoke. If below tree line, it should be located among trees. The reflection of the sun or other light from equipment can expose an otherwise well concealed bivouac. The outside of all mess gear should be blackened, care should be taken in the use and disposal of ration cans, and no equipment which reflects light should be exposed.

b. Tents, equipment, and supplies should not be placed too close to dried-up stream beds during the summer months, as sudden rainstorms and cloud bursts may turn the beds into raging torrents.

c. Bivouacs should not be placed where rockfalls and avalanches threaten.

Section V. OFFENSIVE COMBAT

52. Influence of Terrain

a. Mountain combat lacks the unity characteristic of combat in rolling terrain, particularly in the offensive phase. The configuration of the terrain tends to give the battlefield a piecemeal character and to divide it into more or less isolated conflicts difficult to control by higher commanders. Subordinate unit commanders must maintain their initiative within the plan of the given mission and in accordance with the expressed intentions of the higher command.

b. Envelopments are executed where possible, often in conjunction with feints, demonstrations or frontal attacks designed to divert the enemy's attention. Airmobile assault forces are especially useful in executing surprise attacks and flanking maneuvers. In all offensive operations, the seizure of dominant terrain features as intermediate and final objectives becomes the core of the commander's plans. Specific effort to capture vantage points for artillery observation must be emphasized.

c. In order to advance successfully, troops should ordinarily work along ridges and high terrain features, avoiding natural corridors of approach, which are usually mined and easily defended. In this manner the enemy will be forced to abandon strongly defended positions in the valleys and natural approaches as they are bypassed. The peaks and ridges will generally be heavily defended by the enemy; seizing this high ground may necessitate a frontal attack. By moving up the noses of the subsidiary ridges instead of the draws, the cost of such an operation will be reduced. It must be emphasized that frontal attacks are attempted only as the last recourse.

53. Control Measures

Intermediate objectives, directions of attack, or axis of advance following ridge lines are frequently used control measures. Where lateral restrictions of fires or movement is necessary, boundaries are assigned.

54. Initiative

In rugged terrain, unusual and unexpected opportunities will often present themselves to small unit leaders. If these advantages are rapidly and aggressively exploited, the whole action may be influenced. Because of this, junior leaders should have knowledge of the overall situation; mission type orders are used allowing initiative on the part of subordinates. The higher commander must be quick to seize the advantage gained by one of his smaller units.

55. Detached Missions

Units operating independently or semi-independently should be of such composition that they can accomplish the mission without additional support from higher headquarters.

56. Approach March

a. In a march along a narrow ridgeline trail, the column length of a battalion may be as much as 7 or 10 kilometers and the time length, several hours. Deployment in width will take considerable time. The advance guard may be composed of one rifle company reinforced by elements of the battalion mortar platoon, terrain permitting, and a detachment of engineers. A rear guard may be necessary and is organized similar to the advance guard. This plan will apply when limited ridgeline trail nets prohibit the use of more than one trail. When more trails are available, or when combat is imminent, parallel columns, a wedge formation, or a formation with a unit on each ridge and the main body in the valley in rear can be used. In all cases, each unit separated from the main body must be capable of fighting without support. During the movement to contact, airmobile forces may be employed with the covering force, between the covering force and advance guard, with the advance guard and on the flanks of the main body.

b. Because of the time required to reconnoiter enemy positions and because of the constant threats of ambush, the rule, "Contact once gained should never be lost," is especially applicable.

c. Lateral contact between adjacent units is seldom continuous, and connecting patrols must be dispatched frequently. Combat patrols must be sent to the flanks to cover areas that have been bypassed.

d. Contact with enemy encountered during the approach march is maintained by the use of patrols and/or aircraft.

57. Attack

a. Flanking action sometimes will be impossible and the unit may be required to attack frontally.

b. Frontal daylight attacks in narrow sectors have little chance of success. Such attacks are bound to be canalized and observed, thus giving the enemy the opportunity to shift his reserves for counterattack. On the other hand, an attack launched quietly and stealthily at night, without initial supporting fires, has a greater chance of success by minimizing enemy observed fires.

c. Simplicity of plan is the essence of a successful night operation. Such planning must provide for continuous, effective control by the commander, and for alternate action in the event that unforeseen developments arise. Characteristics of night attacks in the mountains are—

(1) Difficulty in maintaining control.
(2) Slow and methodical movement.
(3) Difficulty in organizing the objective after a successful assault.

d. The attack of a very steep position is frequently made easier by the great amount of dead space. Halts should not be made on top of a ridgeline objective. Advance over crests should be made cautiously in a well-deployed formation. The attacker should continue to push the enemy toward the next objective, or dig in and reorganize well forward of the ridge crest. In case of a halt to reorganize, leaders of assault units should dispatch combat patrols to maintain contact with the enemy.

e. When the objective is beyond the range of supporting artillery, consideration should be given to phasing the attack to permit forward displacement and ammunition resupply.

f. The crossing of a lateral valley and assault of a well defended ridge are similar to the forcing of a river crossing. The purpose is to move a force across quickly and economically and establish a bridgehead to permit the crossing of the main body. This requires careful reconnaissance, coordination of supporting fires, and finally a carefully planned attack, preferably with the use of smoke or at night. *To move the entire force from the ridge into the valley before the next ridge has been secured is to invite disaster.*

g. An attack by vertical envelopment may overcome the defensive strength of an organized position that a ground force might find difficult to penetrate or outflank. In addition, airmobile forces can attack with greater speed than ground forces. They should be large enough to take advantage of the surprise gained. Multiple routes may be used to reduce the time troops and aircraft are exposed to enemy observation and fires during movement. Routes must be selected which do not overly divide supporting fires. Every effort is made to neutralize enemy fires while airmobile forces are flying over an organized position. If the air transported force is not employed in a vertical envelopment during the initial phase of the attack, it may be held in reserve to reinforce or exploit a penetration. A prerequisite for successful attack using transport aviation is that command of the air must be achieved prior to their entry into hostile territory. Command of the air is a term broader in scope and meaning than air superiority. Chapter 7, FM 100–1, defines command of the air as "the degree of one force over another which permits the conduct of air operations by the former at a given time and place without prohibitive interference by the air force, guided missile and/or air defense artillery action of the opposing force." Its two elements are—offensive counterfire means and active air defense means.

h. Command posts should be close to the front. This permits positive control of forward elements by making electrical communications more reliable and enables messengers to perform their missions more rapidly with less chance of being lost, and staff officers to give closer personal supervision to the operations. Although close to the front lines (200 to 500 meters), the pronounced defilade and the proximity of supports and reserve will often give the command post protection from enemy fire and infiltration.

58. Supporting Fires

a. Infantry heavy weapons, artillery forward observers, and survey parties should closely follow advancing infantry to commanding ground in order to give continuous support to the attack. All combat arms officers and NCO's, to include combat engineer officers and NCO's must be able to adjust the fire of supporting weapons.

b. Because of the difficulties of ammunition resupply, the standing operating procedure or field order should include the percentage of field artillery and mortar ammunition to be retained for close support of the assault and for breaking up a counterattack. In addition, a fixed number of rounds should habitually be kept in reserve to be used only on the order of the unit commander.

c. Maximum use must be made of Army and Air Force aerial fire support.

59. Use of Smoke

The use of smoke in various phases of mountain operations assumes a high degree of importance. Smoke must often be used in daylight frontal attacks, stream crossing, withdrawals, and for marking and identifying positions, targets, and objectives. Weather conditions such as snowstorms and fog may supplement smoke in concealing the attacker.

60. Exploitations and Pursuit

a. Each local success should be exploited immediately and vigorously by utilization of reserves for flanking attacks on adjacent enemy points of resistance, seizure of his communication centers, and cutting off the retreat of isolated enemy forces. By interdiction fire the artillery should cover to the limit of its range every conceivable escape corridor. Helicopters may be employed to shift artillery and forward observers rapidly, without regard to terrain obstacles. Airmobile combat patrols can be utilized to block retreat by employment at key terrain features, to create obstacles, emplace atomic demolition munitions, and in general, to cause harassment and disruption of enemy reserve and supply areas. Tanks may be utilized along the roads or trails to attack retreating enemy groups. Tactical air support, if available, should be called upon to attack retreating columns with its maximum strength, especially at centers of communications and defiles. During exploitation, the security of rear areas must be assured against action by bypassed enemy groups.

b. The fatigue of the attacking troops will exceed that of the defender. For this reason, the troops of the attacking echelon should not be used in the pursuit if it can be avoided. Reserve troops can be effectively used, particularly if committed just prior to the capture of the objective.

61. Attack Against a Fortified Position

a. Attack against a fortified position is extremely difficult in mountains and requires more time for planning, organization, and preparation than in ordinary terrain. Careful and continuous reconnaissance, supplemented by the study of vertical and oblique aerial photographs, is essential. The gaps between fortified positions, defended only by mobile troops, may be expected to be heavily mined and in a more irregular pattern than on ordinary terrain. For detailed instructions see FM 31-50.

b. Surprise flank attacks, coordinated with attacks on rear areas by airborne or airmobile troops and supported by highly concentrated artillery preparations at the critical points, may be employed in order to break through fortified positions.

Section VI. DEFENSIVE COMBAT

62. Advantages

a. Regardless of the size or composition of the units involved, defensive combat in the mountains has the following advantages:

(1) Dominant terrain provides the defender, and denies the attacker, observation and firing positions.

(2) The slopes and other terrain features impose difficulties on the attacker.

(3) There are areas which are either impassable or extremely difficult for the enemy to negotiate.

(4) The lack, or scarcity, of roads places restrictions on the use of tanks or other combat vehicles, and renders them extremely vulnerable.

b. The inherent advantages may be increased to a great extent by manmade obstacles combined with long-range nuclear and non-nuclear fire and aerial bombardment along enemy routes of advance. A small number of well placed demolitions is often sufficient to stop for a time all enemy movements on a large section of the front.

c. Mountainous terrain permits the defender to more easily deceive the enemy as to his strength, purpose, and dispositions. Although it is difficult to move reserve units, the defender can usually accomplish such movement more rapidly than the attacker, since the former has more time to prepare a network of lateral trails and his troops are ordinarily less fatigued.

d. Delaying action is particularly effective in mountains and can be accomplished by a much smaller force than is ordinarily needed. Roads and trails can easily be made impassable for a long time by creating rockslides and blasting craters on the steepest parts, in narrow passes and, in general, where the obstructions cannot be bypassed or easily moved.

63. Disadvantages

The disadvantages of defense in mountains are—

a. The compartmentation makes it difficult, or impossible to shift fires of supporting weapons readily.

b. It is often impossible to have grazing fire in rugged terrain.

c. Mountains with wooded slopes, and moderately difficult cliffs, enable the enemy to make decisive surprise attacks.

d. Difficulty of digging necessitates longer time for preparation and organization of positions.

e. Greater possibility of being bypassed and cut off by the enemy.

64. Selection of Positions

a. The selection of defensive positions is governed by the necessity for—

(1) Barring avenues of approach which the enemy might use.

(2) Protecting routes of communication for the defense, especially important crossroads, bridges, and lateral roads which might be used by the reserves.

(3) Protecting the flanks by placing them against deep ravines, vertical cliffs, or other areas difficult to penetrate.

(4) Covering all areas of the front, no matter how inaccessible to the enemy they may appear to be.

(5) All around defense particularly since terrain considerations may necessitate the organization of defensive positions on successive ridges.

(6) Covering ravines by direct and indirect fire and blocking them with antipersonnel mines, barbed wire or other obstacles. It may be necessary to position individ-

uals in valleys during the periods of low visibility.

(7) Effective observation of all hostile approaches in order to have early information of enemy movement and troop concentrations.

(8) Ability to resupply positions.

b. The use and location of automatic weapons is of vital importance in mountain warfare. Bare ridges can often be better covered by automatic fire from an adjacent ridge than from any position on the ridge itself. Lateral communication between these mutually supporting groups should be established. Visual signals such as smoke, flags, or pyrotechnics are usually the most dependable.

c. A reverse slope defense may be necessary when the occupation of a forward slope would subject the defender to heavy observed fire, or when the enemy has a known nuclear capability (FM 7–11, FM 7–20, FM 7–30).

65. Counterattack

Counterattacks, when launched down a descending slope, have the advantage of permitting more rapid movement. Counterattacks to restore a defensive position should be conducted as soon as possible following the loss of the position. This will prevent effective enemy reorganization.

66. Retrograde Movements

a. The usual difficulties encountered in any retrograde movements are increased when such an operation becomes necessary in the mountains. Pursuing troops can infiltrate and outflank if they advance rapidly on routes parallel to the route of withdrawal of the defender and emerge along lateral routes on the flanks or in the rear. In addition, limited trail and road nets hamper the withdrawal of equipment and supplies. However, careful planning and proper use of retrograde principles will enable a force to conduct successful retrograde operations.

b. The withdrawal of the forces engaged in the various terrain compartments must be closely coordinated to prevent the cutting off of some units, or sudden breakthrough by the enemy, which may result in the partial or total destruction of supply columns.

c. Helicopters can assist in retrograde movements by transporting units rapidly to new positions. In a daylight withdrawal they must be able to transport units that have broken contact with the enemy. Elements not able to break contact will withdraw on foot. In a night withdrawal, secrecy and stealth are paramount considerations and helicopters may be limited to withdrawing the detachments left in contact. This type of operation requires detailed plans, thorough daylight reconnaissance, and careful timing. Considerations for the withdrawal of elements in close contact with the enemy are similar to those for withdrawal of isolated units.

d. Artillery and aircraft should concentrate their fire and bombardment on points where the enemy must pass through narrow gaps or over obstacles.

e. For further information on retrograde movements see FM 7–11, FM 7–20, FM 7–30.

67. Fortified Areas

Mountain terrain lends itself to the establishment of strong fortified areas. For a discussion of the defense of fortified areas, see FM 31–50.

a. In valleys containing the principal routes of communication, strongly fortified areas may be organized. These defenses will generally consist of tiered works, beginning at the lowest elevation in the valley in order to enfilade the main route. Others on the slopes are usually responsible for the opposite slope and long range interdiction. In addition, all approaches to the valleys are covered with extensive fields of antitank and antipersonnel mines and other obstacles.

b. Because the gaps and flanks are the most likely points of attack, the bulk of firepower should be concentrated at such points. Every effort should be made to hold these positions at all costs.

68. CBR Operations and Nuclear Warfare

a. Chemical. The employment of chemical munitions in mountain warfare will be mostly by air-delivered weapons due to difficult logistic problems and increased munition requirements for cold weather employment (FM 31–70 and FM 31–71). The defense against chemical attack in mountainous terrain is the same as on flat terrain with similar temperatures. At high altitudes where the temperature drops below $-20°$ F., the protective mask must be winterized to prevent fogging of the lenses and frostbite to the face. At temperatures below $-20°$F., the mask should be carried under the parka and placed in the sleeping bag at night to prevent hardening and cracking of the rubber face piece. The procedure for clearing the mask under this temperature condition must be modified as specified in TM 3-4240-202-15.

b. Biological. Defense against biological agents in mountainous terrain does not differ in principle from that in flat terrain unless conditions of extreme cold exist. As in flat terrain, the individual soldier's first line of defense against biological agents in aerosol form is his protective mask. Troops suffering from dehydration, undernourishment, or lack of rest will be particularly vulnerable to biological attack. In defense against biological attacks, special attention should be given to the individual's maintaining a high degree of personal hygiene and the consumption of only purified, approved water. If a biological agent has been disseminated, drinking water obtained by melting snow is unsafe. In mountainous regions, water contamination may be encountered at sites far removed from the source. Contamination hazards may be created or lengthened when layers of snow or ice which are deposited on contaminated areas refrigerate certain agents, allowing organisms to remain alive and causing the agent to be hazardous when the area thaws. In general, biological aerosols may be more effective at lower temperatures because agent decay (dying of organisms) immediately following dissemination is decreased, causing the aerosol to remain effective over a greater distance as it moves downwind.

c. Nuclear.

(1) The defense against the effects of a nuclear attack in mountain operations will be more difficult than in flat terrain because of the lack of roads and trails and the slow speed at which troops can move. The construction of foxholes and other shelter for protection from fallout radiation will be difficult where the ground is rocky, or frozen. Improvised shelters constructed of snow may provide the only obtainable protection from radiation. In mountainous terrain the deposit of fallout will be very erratic if high wind conditions exist. The radiation dose-rate may be many times higher or lower short distances away from the nuclear detonation. Natural shelters such as ravines, walls or chimneys may provide shielding from radiation and deflection of fallout. Movement from a position to avoid fallout should not be attempted unless radiological survey information is available from unit or supporting radiological survey teams. Aerial radiological survey will be more difficult in rugged mountains and provides less accurate information due to the irregular deposit of fallout and the difficulty of maintaining constant flight altitude above the ground.

(2) The range of casualty-producing thermal effects from nuclear weapons will be extended by clear mountain air. Within this range casualties from thermal effects will be reduced by the added clothing required at high altitudes. If the terrain is covered by snow, a greater number of casualties will result from flash blindness.

(3) The primary and reflected blast waves resulting from the detonation of even a small-yield nuclear weapon may cause avalanches and rock slides up to distances of 30 kilometers or more from the point of detonation. Units operating under conditions of nuclear warfare should be particularly careful to select positions where they will not be hit or trapped by rock or snowslides.

Section VII. SUPPLY

69. General

a. Units operating in remote mountain areas usually cannot depend upon local sources of supply, since such sources usually provide only the bare necessities for the inhabitants. This means that troops operating in this type of terrain must depend entirely on transported supplies. The amount of supplies that can be moved is usually very limited since hand-carry must be used to a large extent. Ordinarily, three stages or means of transportation are required: vehicles wherever roads permit, aircraft, animal transport, and finally individual soldiers or porters. Since the combat unit in mountain operations will usually be a reinforced battalion with the resulting decentralization of command, there must be a corresponding decentralization of supply. In certain cases, supply points may be necessary for servicing isolated frontline units. The location of these supply points and the time that the various units will draw their supplies should either be incorporated in the field order or, in a rapidly changing situation, the information should be furnished in fragmentary form.

b. It may often be necessary to devise special combinations and methods of distribution. These will depend, to a large measure, on transportation facilities, location of combat units, and type of terrain in which operations are under way.

c. Traffic control, a responsibility of the S4, assumes major importance. A single disabled vehicle, or load, may block a trail and delay vital supplies at critical times. Traffic must be carefully controlled and adequate provisions made to clear roads and trails of disabled vehicles.

d. Supply operations in mountainous terrain are affected by the following additional factors:

(1) Ration and water needs of the troops are increased by the rigors of the terrain and, in cold weather, by the climate.

(2) The needs for equipment and fuel are increased.

e. Careful planning by all echelons of command is of the utmost necessity if supply is to function smoothly. Unless plans are carefully made, the rapidly changing tactical situations will cause a lengthening of supply lines which may result in a retardation of supply or its complete interruption. To prevent such occurrence, plans should be made to organize advance supply points for each tactical unit being serviced.

70. Special Clothing and Sleeping Equipment

The field uniform prescribed for infantry units is generally satisfactory for troops operating in mountains who are not specifically classified as alpine troops. The two most important items are footgear and headgear. The leather combat boot with good rubber composition soles and heels provide excellent traction on rock, and the steel helmet offers the best possible protection from falling rock. Troops operating in alpine mountains may be equipped with special mountain boots with rubber cleated soles and with the mountain type, down filled sleeping bag. For detailed information on clothing and sleeping equipment, see TM 10–275 and TA 50–901.

71. Bedrolls

Except in a coordinated attack on a limited objective, bedrolls or packs should be kept with the individual. Difficulties of supply will congest the limited road net so that bedding will seldom reach the troops at night.

72. Rations

Individual type combat rations will normally replace the field ration A and operational ration B, but one hot meal per day should be served if possible. Hot meals may be prepared in the rear and moved forward by vehicles, helicopters, or by individuals using packboards. Extra heating units from field ranges, or small detachment stoves, should also be brought forward so that the food may be reheated in the event that it cannot be consumed immediately. This is especially desirable when a unit is expected to be isolated from its lines of communication for an extended period. Food with greater caloric value is required for the strenuous work of mountain fighting and for maintaining body heat in cold weather. Every effort should be made to serve hot prepared meals at every opportunity to help conserve body heat. The mountain cook set and the one burner mountain stove, are a necessity for the rifle squads, outposts, patrols, and other small groups which have no other means of heating their food.

73. Ammunition

Ammunition distributing points must be moved forward frequently and kept relatively close to the front lines in order to reduce the difficulty and the delay in delivery that are usually imposed by precipitous terrain. The positions of emplaced weapons must be considered when selecting locations for ammunition distributing points in order to reduce the time and effort in supplying ammunition.

74. Water

In many mountainous regions, water is abundant during all seasons. No matter how pure and clean mountain water may appear to be, purification is necessary and should be accomplished by approved methods. In some mountainous regions where there is little or no water, provisions must be made for carrying great quantities by the already overtaxed transportation system. Organic vehicles and 5-gallon water cans can be used for this purpose. Whenever the use of any other type becomes necessary, the weight and bulk of the container should be seriously considered.

75. Movement in Rocky Terrain

In difficult terrain it may become necessary to move supplies up vertical cliffs or across deep crevices. This can be accomplished by constructing vertical hauling lines, suspension traverses and the use of engineer constructed cableways.

Section VIII. TACTICAL EMPLOYMENT OF CLIMBERS

76. Requirements for Qualified Climbers

Normally, the first units to be committed to operations in mountainous terrain would be those whose personnel have received specialized training in the techniques of military mountaineering. Units committed to prolonged operations in mountainous areas, whose personnel have not received this specialized training should have qualified mountaineers asigned to them as advisors. Depending upon the availability of qualified personnel, a number of experienced climbers should be assigned to each platoon, company or battalion sized unit prior to the planned operation.

77. Capabilities and Duties of Climbers

a. To properly perform their duties climbers must be familiar with and capable of—

(1) Assistance in unit movements in the mountains such as route selection, navigation and techniques applicable to the rugged terrain.

(2) Free and roped climbing.

(3) Rope installations such as fixed ropes, use of anchors, vertical hauling lines, suspension traverse, and rope bridges.

(4) Crossing techniques of mountain creeks with swift currents.

(5) First aid and evacuation techniques.

(6) Individual cooking techniques above and below timberline.

(7) Shelters and bivouacs.

(8) Snow characteristics and safety precautions from avalanches.

(9) Assistance in movements over glaciers.

(10) Characteristics of weather, especially protection from the sudden changes in temperature, high winds, blizzards, thunderstorms, and other adverse effects.

b. Climbers with sufficient training in military mountaineering and considerable experience should be used as guides and advisors to the units involved in mountain operations. They can also be of great value by serving the troops as observers and scouts, performing duties on patrols of various types, and assisting units in assault climbing.

78. Guides

Guides are primarily used as advisors to unit commanders and to assist troops over minor rock obstacles encountered in normally broken terrain. They should possess excellent route-finding and pace-setting ability and a thorough knowledge of the general practice and theory of mountaineering.

a. As advisors they should—

(1) Suggest best routes of march.

(2) Inform unit commanders of natural dangers and obstacles likely to be encountered.

(3) Be prepared to estimate the time and means necessary for the movement of troops or equipment between any two given points.

b. In assisting troops they should—

(1) Maintain a steady pace at the head of the column, to prevent bunching and straggling.

(2) Help maintain proper march discipline with respect to pace, cadence, and distance.

(3) Be stationed at obstacles along the line of march directing troops and indicating alternate routes over bottlenecks.

79. Observers and Scouts

a. The rules for the selection of scouts and observers (FM 21–75) hold true in the mountains. To the characteristics and abilities normally required of a scout must be added agility and thorough training in military mountaineering. The scout should also have a thorough grasp of mountain terrain and terminology, so that he can make accurate sketches and reports of his observations.

b. Scouts will ordinarily function in pairs. When a scouting mission requires crossing of precipitous terrain, appropriate climbing equipment will be carried.

80. Reconnaissance Patrols

a. Reconnaissance patrolling over precipitous rock terrain may best be accomplished by small patrols of one or two pairs of trained climbers.

b. Climbers may be used in day or night reconnaissance. Allowances must be made for the added difficulty limitations and reduced speed of night climbing.

81. Flank Patrols

a. Climbers may expedite movement of flank security elements over difficult rock terrain. One or two climbers should be attached to each element, depending on the size of flank elements and the difficulty of movement.

b. When ruggedness of terrain is likely to enforce a rate of march on the flanks that is slower than that of the main body, flank security personnel should be grouped near the advanced party. Smaller elements are then detached as necessary to reconnoiter and hold dominant terrain features on the flanks of the line of march. Flank outposts join the main body and proceed forward to rejoin the pool of flank elements.

82. Company Assault Climbers in Attack

a. One of the principal missions of military mountaineers will be to assist in the attack of very steep objectives. Generally, the forces required to secure this objective from counterattack will be small.

b. A suggested standing operating procedure for a company attack is as follows:

(1) The assault of the cliff will preferably be made during periods of low visibility. If the night is dark, ropes may have to be set up at dusk or just after dawn. The noise of the movement may be covered by direct and indirect fire. Undefended points should be selected for the attack. The use of at least two separated points increases the likelihood of success.

(2) Before the attack, a complete daylight reconnaissance by the company assault team is desirable. If possible, six routes should be chosen covering a front of from 200 to 400 meters. Of these, the two easiest routes should be picked for the in stallation of the first two ropes. Con cealed locations for mortars are chose and range cards prepared in advanc Platoon assembly areas are selected an routes to the foot of the cliff decided upo

(3) Under cover of darkness, the compan moves into its assembly area. Mortars g into position to deliver unobserved fire i the attack should be detected. Local se curity is posted around the assembly are The best adapted men are selected t climb the first rope. They are lined u back from the foot of the cliff and unde cover. The assault climbing team (of men each) will initially set up two rope at points as far apart as possible to giv dispersion and still retain control. Num bers 1, 2, 3 and 4 will establish one rop and numbers 5 and 6 the other.

(4) At the hour of the attack, numbers 1 an 2 climb the cliff, anchoring their clim ing rope at the top, and immediatel move out to provide security. Numbe 3 and 4 follow as closely behind number as possible, place pitons, and secure th first line. Numbers 5 and 6 climb to th top, place their pitons over a differe route, and secure their line. They the set up a hauling rope.

(5) Six riflemen selected for their agilit follow number 4 up the fixed assault ro and relieve numbers 1 and 2 as securit The riflemen are followed by two o servers with radio and wire reel to dire supporting fire. As soon as the haulin rope is set up, automatic weapons a hauled up and put in position to prote the climbing of the main body.

(6) When a rope has been established, o assault climber remains at the rope service the line and to aid the inexper enced climbers up the route. The oth climbers will set up other ropes until fo to six are in position, depending upon th ease of installation. If the terrain r quires, at least two of the routes shou have hauling lines which should manned by at least two men on each lin

(7) Following the observers and the aut matic weapons, a rifle platoon is move to the top as rapidly as possible. It reo

ganizes at the top and takes up a defensive position that will protect the climbers from observed small arms fire. The platoon leader commands all troops at the top of the cliff and integrates the direct and indirect fire.

(8) The assault platoon is followed by the company headquarters, artillery liaison party, ammunition, and the remaining riflemen. The 81-mm mortar units and their rifle security are the last troops to climb the rope. The ropes may be left in position for moving supplies or evacuating wounded, or may be taken forward to aid in the continuation of the attack.

(9) In using the above standing operating procedure, prior detailed planning and careful organization are essential to success. When additional ropes or climbers are required, these should be attached from other companies within the battalion. The initial troops to climb the cliff, including the first platoon, should climb with only their weapons and a minimum of ammunition. The remainder of their equipment will be brought up by hauling lines or carrying parties.

83. Combat Patrols

a. The climber team should be the nucleus of patrols operating over steep mountainous terrain. Nonclimbers may be added in varying proportion according to the estimated climbing difficulty and mission.

b. If more than one point of attack is to be used, or a more powerful patrol is needed, additional climbing teams can be employed.

c. The patrol leader, in addition to being a trained climber, should be familiar with abilities and limitations of company climbers.

d. Nonclimbers should be selected with careful consideration of their natural agility and endurance.

CHAPTER 3

EMPLOYMENT OF THE ARMS AND SERVICES

Section I. INFANTRY

84. Tactical Principles

a. Infantry, because of its versatility, self-sufficiency, and mobility, will play the dominant role in mountain operations. Small units must be capable of operation under decentralized control. The individual soldier must be dependable and resourceful when separated from his immediate superior.

b. As in other terrain, infantry units employ fire and maneuver. However, these principles have a somewhat different application in the mountains. In general, the effect of fire is less than in average terrain since mountainous regions offer considerable natural cover such as rocks and cliffs. Maneuver is constantly hampered by the difficulties of the terrain, and fire support from adjacent units cannot always be counted on. Movement will usually take the form of individual infiltration or successive rushes by small groups for short distances.

c. To offset reduced foot mobility and decreased effectiveness of direct fire, infantry must make maximum use of indirect and aerial fires and utilize Army air vehicles to increase mobility.

85. Factors Governing Use of Weapons

In the employment of infantry weapons the following factors must be taken into consideration:

a. The use of overhead and long-range fire can be greatly increased due to the great differences in elevation and the good observation afforded.

b. The slopes of the terrain greatly affect range estimation. An observer looking downward from a height tends to underestimate the range; an observer looking upward from low ground is likely to overestimate the range.

c. The steepness of slopes and irregularities of the terrain counteract the effect of the grazing fire of automatic weapons and limit the extent of beaten zones.

d. The existence of a great amount of dead space gives added importance to weapons with a high angle of fire, as well as to hand and rifle grenades.

e. The difficulties of ammunition supply make it necessary that all commanders enforce a strict economy of fire.

f. Mutual support from one terrain feature to another is facilitated by good observation.

86. Snipers

Because of good visibility and observation, frequent opportunities arise when snipers can be used. The development and effective use of snipers should be given special attention. Commanders must anticipate sniper requirements and secure appropriate equipment.

87. Grenades

The grenade launcher and hand grenades are particularly effective in mountain warfare. In the offensive the grenade launcher will supplement indirect fire particularly against open positions. The launcher and hand grenades are both effective in the defensive. Rocky pockmarked terrain will reduce effective bursting radii and increase ammunition requirements. Troops must be cautioned against throwing hand grenades uphill where they are likely to roll back before detonation.

88. Employment of Supporting Weapons

a. Automatic Weapons. In employing automatic weapons, frontal fire is the most commonly used and has the advantage of being effective deep in the region through which the enemy must operate. The terrain frequently permits sustained overhead fire. However, the best positions for frontal fire are often the easiest for the enemy to locate and the displacement of weapons on forward slopes is both difficult and dangerous. As the enemy closes in, the great amount of dead space and steep angle of fire render frontal fire less effective. Flanking fire may be delivered from ridges, gulleys, and passes protected from enemy fire and observation.

b. Mortars. Mortars of the infantry battalion are indispensable to mountain operations. Mortar fire may be massed through the use of map data, sketches, or M–16 plotting board. In the attack it may often be difficult to provide sufficient ammunition for all of the mortars. Under such circumstances it is better to advance fewer weapons. This can usually be determined in advance by considering how far from the nearest road the mortars will be expected to operate. Mortars, crews and ammunition may be displaced by Army air vehicles.

c. Infantry Medium and Heavy Antitank/Assault Weapons. In low mountain terrain, where road nets exist, the infantry medium and heavy antitank/assault weapons are excellent, high mobile weapons. In alpine terrain the weapo may be airlifted into position by helicopter; othe wise they will be limited in use by existing specially constructed roads. They may be en ployed as direct fire, close support weapons again enemy strong points on fortified positions, and antitank weapons.

d. 90mm Rifle. Because of light weight an maneuverability, the 90mm rifle is an excelle close support weapon in mountain operation The rifle can be used to reduce enemy fortifie positions and as an antitank weapon.

Section II. FIELD ARTILLER

89. Tactical Principles

a. The basic tactical principles for field artillery remain valid in mountains, subject to the limitations imposed by the adversities of terrain and weather. Howitzer battalions organic to division artillery may be attached to the brigade. Other field artillery of the division is also avaliable to the brigade on call through the division artillery commander.

b. All types of artillery and missiles can be used in the mountains. Light and medium field artillery may be brought into position with the aid of trucks, tractors, and by use of block and tackle or winches. Light artillery may be airlifted into positions by the helicopter. Heavy artillery will be limited to roads in their immediate vicinity.

90. Limitations

a. Generally, fire planning in mountain operations should be centralized to assure maximum coordination. The artillery commander at each echelon retains centralized control of subordinate elements to the desired degree through the assignment of tactical missions. However, terrain compartmentation to such an extent that communications are not practicable may require the attachment of artillery to small forces. In snow covered mountains, deep snow will cause a reduced lethality on impact bursts of artillery and mortars. The use of an increased amount of time and variable time fuze ammunition should be considered.

b. Occupation of positions and replenishment of ammunition are much more difficult and more time-consuming than in level country.

c. In order for the field artillery to perform its mission it will frequently be necessary to bring field pieces into posit ich can be reache only by manhandling or by aid of ropes. Al gun crews expected to operate in mountains shoul be trained to tie knots and rig equipment.

d. In order for the artillery to provide continu ous support it may be necessary to displace mor frequently than in average terrain.

e. The great majority of artillery fires in th mountains must be observed, especially close sup port and defensive fires.

f. Artillery emplaced with the aid of helicop ters will in all probability require further air sup port for ammunition supply. The commande must also consider that for displacement the piece will again have to be moved by helicopter.

g. Radar and sound ranging procedures are les effective in mountain areas and much relianc must be placed on shell reports.

91. Coordination With Infantry

Communication between artillery and the attacking echelon of the infantry and the coordination of its fires with those of infantry support weapons require special care. The attacking echelon needs highly effective support throughout the attack. Without such support it is likely to draw fire just before reaching its objective. An infantry attack over rising terrain is easier to support than one over descending terrain, although artillery fire may dislodge rocks which will endanger the advancing troops. In the final stage of the attack, infantry support weapons may be the only appropriate fire support.

92. Field Artillery in Pursuit

In a pursuit through mountains, artillery fire is needed to help overcome the resistance of enemy rear guards. In such action the mobility of the weapons and the timely resupply of ammunition become the critical problems.

93. Field Artillery in Defense

Artillery defensive fires in mountains must be carefully planned and prearranged. Plans should include artillery or mortar fire on the flanks and rear of units. Areas of enemy approach that are in dead spaces for field artillery fire can usually be covered by mortars.

94. Positions

a. Good howitzer positions are usually few in number. They should be selected for defilade, cover and accessibility to road nets. In general, gun positions on commanding terrain are preferable to low positions. They are less exposed to small arms fire from surrounding heights, have less chance of being caught in rock slides or avalanches and reduce the amount of dead space in the target area. Care must be taken, however, that positions on commanding terrain have defilade. When speed in the occupation of positions is essential, a unit must often take the most convenient available position, even a stream bed or the road itself. Reconnaissance for better positions should be continuous and intensive. Camouflage nets should always be used in open terrain. All men, vehicles, and equipment in proximity to gun positions should be kept in defilade. Map reconnaissance used in conjunction with trajectory charts, included with tabular firing tables, will provide an excellent indication of the coverage attainable from a firing position.

b. When time is available, prior to occupation, positions should be prepared, survey completed, and coverage diagrams prepared. Wire communications should be installed or a complete plan and reconnaissance made for their installation. Radio nets should be tested in their selected location. Gun positions should be completely prepared with emplacements ammunition pits, dugouts for personnel, posts for sentinels and complete camouflage. An initial supply of ammunition should be stored at the gun positions. Routes of approach should be pioneered and improved. Observation posts should be selected and prepared. Firing data should be prepared for all probable targets. Finally, a complete standing operating procedure for occupation should be developed and rehearsed in advance.

95. Observation

a. Normally observation posts should be on the highest practicable points. Care must be taken, however, to echelon them in height in order to avoid the possibility of all observation posts being blanketed by layers of clouds or fog. At least two forward observers per firing battery are desirable. In heavily wooded terrain, forward observers and liaison officers should be supplied with lineman's climbers.

b. In order that forward observers may reach the best points of observation, it is often necessary that they be qualified assault climbers. Forward observers and liaison officers and their parties, trained in assault climbing, can accompany the infantry in ascending and descending the most difficult mountains.

c. The use of aircraft for observation should be exploited to the maximum. Light aircraft should be assigned or attached to the artillery for observation purposes. In addition to adjusting artillery fire, such aircraft can also assist in establishing communication relays, reconnaissance for routes and positions, and identification of objectives. During winter months, good observation is limited to a few hours a day because of the short periods of daylight. Snow cover reduces depth perception and obscures ground features and landmarks. Glare of the sun upon snow is intense and unless personnel wear dark glasses, continued exposure will cause painful snow blindness. Amber filters for observing instruments are required to reduce eyestrain. Personnel operating observing instruments must be relieved frequently or provided with shelter.

96. Use of Vehicles

a. Motorized artillery will be confined to roads and trails. Since the road net is usually very limited, it is often advisable to strip batteries of as many vehicles as can be spared. Since the limited road nets of mountainous regions are especially vulnerable to enemy artillery fire and aerial bombardment, infiltration should be the normal method of march. It is often difficult to turn vehicles around on mountain roads; hence security and reconnaissance elements should be far enough ahead to determine the advisability of moving beyond each turnaround point.

b. Self-propelled artillery, although able to negotiate sharp turns and capable of ascending and descending steep slopes, is hampered by tracks slipping on icy roads. This disadvantage may be partially overcome by the use of grousers.

c. When there is sufficient traction, prime movers with howitzers in tow can be driven down most grades. The vehicles should be placed in lowest gear. A man with a large chock, stationed beside each wheel of the truck and howitzer, provides emergency stoppage for the vehicle. Two men should apply the howitzer brakes, keeping them as tight as possible but not letting them skid the wheel. A restraining rope or chain should be fastened to the muzzle end of the howitzer to prevent it from "jackknifing."

d. When the ground becomes too slippery or the grade too steep to provide traction, all prime movers and howitzers must be lowered by block and tackle or winch. In lowering by winch, care must be taken to see that the automatic brake does not overheat. Slow operation of the winch and proper adjustment of the automatic brake will prevent this condition. In all descents and ascents, weather and the steepness of the grade will be the limiting factors.

97. Targets

Because of the difficulty of supplying ammunition, the selection of targets and the allotment of ammunition are of great importance. Care must be taken to avoid wasting ammunition on unprofitable targets. Because of the decentralized nature of mountain operations, targets warranting great masses of artillery fire may be fewer than in other terrain. One type of target which will be especially profitable, however, is a narrow defile which is being used as a route of supply, advance or withdrawal by the enemy and upon which interdiction fire or heavy surprise concentrations can be placed. Another type of target often found in the more precipitous mountains is that presented by a large mass of snow or rocks above enemy positions. Such masses can be converted into highly destructive rock slides and avalanches by artillery fire.

98. Communication

The two principal means of communication, radio and wire, should be supplemented by visual signaling. Man portable FM radio sets should be used for the observer and survey parties and for liaison to the supported unit. Intelligent and energetic use should be made of all available means of communications. The use of the remote control unit will increase effectiveness of radio communication by permitting emplacement of antennas below the topographic crest of hill masses.

99. Fire Control

a. The problems of gunnery in mountainous terrain are characterized by large angle of site, large areas hidden from observation, and the increased amounts of dead space.

b. High-angle fire should be employed to the fullest extent.

c. The great majority of artillery fires in the mountains must be observed, especially close support and defensive fires. Unobserved fires are generally unreliable as meteorological conditions change rapidly and registration corrections for high-angle fire are valid for only short periods. Accurate transfer of fires is difficult since altitudes within transfer limits vary so greatly. If an observed firing chart is prepared without the aid of survey, the gun positions should be plotted on adjusted quadrant elevations as this will best account for the variance in site between targets and batteries. A grid sheet based on an accurate survey is the best firing chart. Survey should be initiated as soon as possible. Registration on numerous check points is essential.

d. Care should always be taken in measuring minimum elevation for all parts of the battery's zone of fire as all high points may be occupied by friendly observers.

100. Air Defense Artillery

a. Air defense artillery missions in mountains are the same as those in other terrain, subject to modification of techniques caused by climate, terrain, and nature of the operations. Lack of roads may reduce mobility and make resupply operations more difficult. Extremely cold weather causes longer warmup times for electronic equipment and use of special heating devices for ready missiles. Helicopter lift capabilities should be utilized for resupply of missiles, ammunition and rations.

b. The types of air defense artillery units employed in mountain operations are dictated by mission, terrain, and available transportation. TOE often must be augmented to accomplish the assigned mission. Personnel and equipment must be made available well in advance to permit training under conditions similar to those anticipated in mountain operations. Winterization and modification of equipment where necessary should be accomplished prior to entrance into mountainous areas.

c. Air defense artillery positions should be selected for their tactical utility and consideration of the logistical factors involved. Air defense missile units should, if possibe, occupy previously prepared positions. Light air defense artillery weapons mounted on full track vehicles may occupy hastily prepared positions and effectively accomplish their mission. In adverse terrain, or under winter conditions, it may be difficult to dig in positions. Explosives may be used to expedite protection of the position, or parapets may be built up from logs or from ice and snow. Alternate positions should be chosen early and prepared as time permits.

d. Signal communications between fire units and the Army Air Defense Command Post (AADCP) normally will be by wire and backed up by radio. Army aviation may be used to lay wire over otherwise inaccessible terrain. Masking of radio reception in mountainous areas is a factor to be considered.

e. Both friendly and enemy forces will use aviation to overcome lack of roads, strengthen signal communications, improve target acquisition, and to move and support small units. As forward area weapons units become available, they will be used to provide protection against all types of aircraft at low or medium altitudes.

f. Surface-to-air missile units using nuclear warheads provide protection from any high altitude threat. Due to the electronic type equipment for air defense artillery fire control systems, personnel must attain a high state of training to perform efficiently in mountain operations. Heated shelters will be required for maintenance personnel to perform their duties. Generators, fire control equipment, and launching equipment must be operated at frequent intervals under extreme weather conditions.

g. Commanders whose force includes air defense artillery weapons should not neglect the secondary ground support role of these weapons. In addition to their primary air defense role, NIKE-HERCULES missile units also furnish a surface nuclear capability.

Section III. ARMOR

101. General

a. Mountainous terrain generally limits the use of armored vehicles to roads and trails. Small areas may be found where armored vehicles can get off roads and fight across country, but these areas usually are few in number and may be mined. Many times a small amount of engineer work will permit tanks to move to advantageous firing positions in the roughest types of terrain. The normal mission of tanks in mountain operations is to furnish support either by direct fire, by counterattack, or by antitank defense.

b. Adequate logistical support for armor units engaged in mountain operations is extremely difficult. Roads are usually few in number and require a great deal of maintenance. It is often necessary to use helicopters to effect resupply.

102. Employment

a. In mountainous terrain, an armor attack must be planned in minute detail. The nature of the terrain may permit tanks to support attacking infantry with relatively long-range direct fire. This requires excellent radio communication and thorough coordination between the infantry and tank units.

b. Key terrain features are primary objectives. Attacks along low ground are usually costly because the defender has excellent observation. The route of an attacking force normally will be along ridge lines or on other elevated terrain. On such terrain, the attacking force in many cases will gain tactical surprise. A great deal of engineer work may be required in order to place tanks on high ground where they can closely support the attack. It may be necessary to build a trail from low ground to the attack position. When mountainous terrain contains corridors which are favorable to the attack and which permit employment of armor, armor may attack down the corridors while infantry units attack along the ridge lines.

c. Available roads and trails must be kept in as good repair as possible, to permit the movement of armor. Tank dozers and bridging material must be kept well forward.

d. No more armored vehicles should be taken forward than are required for immediate operation. Having uncommitted armor vehicles in forward areas causes unnecessary damage to roads and may create traffic hazards for resupply ve hicles.

e. If decisive armor action becomes possible, th armor forces are committed in mass, closely sup ported by artillery and engineers. Objectives ar usually critical points on the hostile routes o supply and withdrawal, the capture of whic would isolate the enemy forward position.

Section IV. ARMY AVIATION

103. Functions

Air vehicles are the only vehicles which can operate effectively in some mountainous areas. The location of landing areas and maintenance facilities in favorable terrain, often adjacent to virtually impassable ranges, makes it feasible to operate air vehicles in areas which can otherwise be traversed only by men and beasts of burden on foot. Operations involving helicopters and airplanes can be greatly simplified by use of a refueling and loading base which can be supplied by surface transport. The major functions of Army aviation in mountain operations are—

a. Command, Control, and Communications. Air vehicles, particularly helicopters, enable the commander and staff to make personal visits to subordinate units, and to observe the progress of operations. The degree of control is greatly enhanced by radio and/or visual contact with the elements of the command. Radio relay, provided by fixed wing and rotary wing air vehicles, will overcome most line-of-sight limitations imposed on radio communications by mountainous terrain. Wire can be laid from air vehicles over areas which are difficult to negotiate by surface means. Messages can be delivered after landing or dropped from air vehicles in flight.

b. Airlift of Personnel and Equipment. This includes the movement of units to execute air-landed operations, the shifting of units and individuals, and the movement of supplies and equipment. The helicopter's ability to use the landing sites available in mountains enables it to quickly move personnel and equipment into locations which otherwise could be reached only after the elapse of considerable periods of time. Where helicopter landings are impossible, personnel can be landed by rappelling. This is a technique which requires specialized training of aircrews and troops. Cargo nets and similar devices can be used to land equipment while the helicopter hovers nea the surface. Fixed wing air vehicles can airdro equipment when landing fields are not available.

c. Air Movement of Patients. Evacuation o patients by direct on-loading to a landed heli copter or by use of a hoist is usually possible i mountainous terrain. Ground movement of pa tients to points at which landings can be mad or pickup accomplished without landing may b necessary.

d. Observation, Reconnaissance, and Surveil lance. The versatility of rotary wing air vehicle makes them particularly useful in conducting ob servation and related tasks in mountainous areas Light helicopters may be able to land on promi nent terrain features and conduct observation fo the purpose of locating and evaluating targets, ad justing fire, studying the terrain, and obtaining information on both friendly and enemy forces Airplanes can be used to observe large areas o terrain within and adjacent to mountainous areas Both types of air vehicles have the capability o reporting by radio during the observation period Radio relay may be performed in conjunction with tasks of this type. Variations and combinations o Army aviation capabilities may be employed in support of missions in mountainous areas.

104. Weather and Terrain Factors

a. Weather. Weather conditions must be considered in the planning of any operation in which Army aviation is to be employed. This is particularly true of the relatively erratic and unpredictable weather found in mountains. Among the weather conditions to be considered are—

(1) *Density altitude.* Hazards to flying created by high density altitudes are encountered in most mountainous areas regardless of their geographical location. Pressure changes are very erratic and

density altitudes may vary as much as 2,000 feet during a 12-hour period. Altimeter errors are common in areas of low pressure and low temperatures. The ability of the air vehicle to operate at the point of discharge must be included in planning. The load which an air vehicle can lift from a landing area at a lower elevation may be far greater than the load which it can safely land at a higher elevation.

(2) *Temperature.* The low temperatures to be found at high altitudes in mountains must be considered in preplanning operations involving air vehicles. Intense cold may make it necessary to use winterization kits, personnel heaters and shelters, engine preheaters, and other special equipment.

(3) *Wind.* High winds are found at high altitudes. Tricky air currents form around the surface irregularities of mountain slopes and peaks. Changes in wind direction and speed may be frequent. Updrafts and downdrafts may be severe enough to complicate landings and other maneuvers conducted by air vehicles operating in close proximity to the terrain.

(4) *Visibility.* Visibility is excellent except when moist air is forced up the slopes to produce upslope fog and cumuliform clouds in summer and stratiform clouds in winter. The weather on the lee sides of mountains is normally clear and dry.

(5) *Icing.* Icing in mountainous terrain may be severe at high altitudes, especially when the temperature is low and moisture is present in the atmosphere.

b. Terrain. The fact that mountain slopes commonly are made up of gentle inclines separated by abrupt rises of sheer cliffs has led to a popular exaggeration of the extent of cliffs. Many of these gentle inclines are suitable as helicopter landing sites. Some can be prepared for use by fixed wing air vehicles although longer runways are necessary in the less dense air at higher elevations.

(1) *Vegetation.* The amount and type of vegetation in mountainous areas vary from sparse shrubs to closely spaced deciduous forests on higher mountain slopes. Extensive forests will limit the selection of landing areas.

(2) *Soil and surface.* The soil and surface of a mountain usually consist of volcanic rock and bare eroded soil except in those areas where precipitation is sufficient to provide a heavy growth of vegetation or a cover of snow. No general rule applies to the adaptability of such surfaces to landing areas.

(3) *Slope and elevation.* The rugged nature of mountainous terrain possibly affects more aspects of air vehicle operations than even the weather. Mountains reduce the availability of landing zones for extensive airmobile operations and increase the hazards of air vehicle operations.

105. Landing Site Selection and Preparation

In addition to the normal requirements for landing sites in any environment, consideration should be given to the following in the selection and preparation of landing sites in mountainous areas:

a. Landing Site Selection.

(1) *Concealment.* Landing sites and flight approaches thereto should be shielded from enemy observation by masking terrain or wooded areas. Consideration should be given to the use of camouflage devices to deny the enemy the capability of locating landing sites by aerial observation. Marking devices should be camouflaged when not in use.

(2) *Location.* Landing sites to be used primarily for supply and resupply should be located near desirable storage or dump areas to minimize ground movement of cargo after delivery.

(3) *Takeoff and landing direction.* Prevailing winds should be considered in laying out landing strips. Airplanes can take off and land more efficiently when headed into the wind. Helicopters can hover and take off into the wind with less power, hence with more allowable pay load. Landing sites should be selected to provide space for maneuvering into the wind in order to take advantage of this fact. In some cases the headwind advantage can overcome the disadvantage to both types of air vehicles due to decreased air density at mountain altitudes.

(4) *Soil condition.* Dry, barren ground should be avoided because dust clouds

may reveal activity to the enemy. Also such dust clouds may blind the rotary wing aviator and ground personnel in the vicinity. These unfavorable conditions also exist when operating in snow. Areas of hard ground, solid rock or grass are the best natural landing areas.

(5) *Topography.* Helicopter landing sites, to be used for continued or repeated operations, should be as flat as possible, generally not exceeding 4°. Slopes of 4° to 10° for observation and utility helicopters or 4° to 20° for cargo helicopters may be satisfactory landing sites on an emergency basis. Touchdown hovering, whereby only part of the landing gear is placed on the ground but a full landing is not executed, may be accomplished on sloping terrain in excess of these limits. Extreme caution must be exercised in this type of operation. Limiting factors in the maneuver are density altitude, the gross weight at which the helicopter must be able to hover, and sufficient ground clearance for the rotor system to operate in a horizontal position.

b. Landing Site Preparation.

(1) *General.* The amount of effort exerted toward improving landing sites will depend upon their intended use. Although no elaborate preparations are necessary for sites which are to be used infrequently, the unit commander should realize that the state of development of sites adjacent to his unit will greatly influence the reliability of support he receives from Army aviation units. As site locations will seldom be found that satisfy all requirements, some preparation will usually be required. It is important for sites to afford room for ready unloading and loading of air vehicles to keep down-time to the absolute minimum.

(*a*) Landing sites may be prepared on the sides of hills by blasting ledges.

(*b*) Even though the terrain surrounding the troop unit's position is hilly and wooded, suitable landing sites may be prepared as follows: First, enough trees are felled in the vicinity to provide a clearing for the site. These are then wedged among the stumps on the lower side of the slope to provide a foundation for the site. Earth above the proposed site is then dug out and filled in around the tree trunks on the site. The filled-in portion must be solid enough to support the weight of the heaviest air vehicle which is to use it. The site should not be cleared or filled more than is necessary so that its position will not be easily detectable by the enemy. Unnecessary digging should be avoided to minimize dust hazards or dust cloud which may be seen to a distance of 30 kilometers.

(*c*) Sites in cleared areas, fields, deserts, and roadways are easily prepared for landing. When dusty conditions prevail, preparation of the ground with oil or some other form of soil stabilizer may be necessary. Small trees are felled, holes filled in or marked, and all loose rubble or objects cleared from the area. Loose objects such as inadequately secured panels may be drawn into the rotor system and cause damage. Loose rubble or debris may be blown against personnel and equipment on the ground.

(2) *Special considerations.* Communications wires strung between trees or across valleys in the vicinity of landing sites should be removed or lowered to the ground. Wires which must remain in place should be marked with strips of cloth of highly contrasting color, or by other means, to make them clearly visible to the aviator during takeoff and landing, but not exposed to enemy observation.

c. Landing Site Marking. A boundary is outlined around the usable portion of the landing site and may be constructed of materials at hand that have definite color contrast with the surrounding terrain to permit easy identification within 500 meters distance. Appropriate materials include standard cloth panels, partially buried cans, lights, and flares. Any devices used must have sufficient weight or be adequately anchored to prevent displacement. Cloth panels should be so placed that the helicopters are not required to fly over them or land directly on them. This is necessary to insure that the panels will not be drawn into the rotor system thus causing damage or loss of control. Colored dye of the type used by naval forces to color water areas in rescue operations is ideally suited for marking snow-covered areas.

106. Reporting Establishment of Landing Sites

When a unit establishes a landing site, it should immediately report its completion to the appropriate aviation and ground command. A map is normally maintained to indicate all completed landing sites. Units concerned are informed of the identifying mark assigned each site as well as its location by grid coordinates.

Section V. ENGINEERS

107. Mission

a. The conditions of mountain warfare require that a large proportion of troops be engineers. Great emphasis must be placed on routes of communications, and defensive measures are also usually of measured importance. Mountain roads and trails require extensive construction, improvement, maintenance, and repair to withstand the increased traffic and severe weather conditions. The lack of local material and the difficulty in operating heavy engineer equipment, coupled with enemy defensive activities, such as destruction of bridges, construction of obstacles, and emplacement of mines complicate and increase the problems of maintenance and construction. Stream crossing operations become extremely difficult and must often be accomplished by expedient means. In extremely rough terrain, cableways and tramways often offer the most dependable means of supply and evacuation.

b. Engineers may assist in the organization of the ground and the layout of defensive positions. Well planned demolitions, both conventional and nuclear, obstacles, and mine fields are especially profitable in mountain warfare because of the difficulties encountered in their reconstruction and removal. Engineers will be extensively employed in these operations. Positions constructed in rock are strong and offer good protection but require considerable time and equipment. Most mountainous areas are poorly mapped, recovery and establishment of geodetic control is often a major problem. Other engineer missions which are emphasized in mountain operations include the construction of shelters, provision of landing strips, and, in some areas, supply of potable water. In order to efficiently accomplish the work assigned to them, engineers must be supplied with mechanical aids, such as compressors, power drills and saws, bulldozers, large amounts of explosives, and adequate transportation.

108. Training

The training of engineer troops in mountain operations should include, but not be limited to, the following:

a. Emplacing demolitions in rock formations.

b. Tramway and cableway construction.

c. Camouflage (especially in snow areas).

d. Physical conditioning.

e. Assault climbing.

f. Mountain road construction.

g. Use of helicopter aircraft in engineer operations.

h. Stream crossing operations, including the use of expedients.

i. Fixed and floating bridge construction.

j. Obstacles.

k. Mine warfare.

l. Field fortifications.

m. Water supply.

109. Engineer Reconnaissance

Engineer reconnaissance should precede all operations but not delay them. Rugged mountain terrain makes field reconnaissance time consuming and dangerous. Aerial reconnaissance is emphasized, although small dismounted details may be successful. Terrain analysis for routes, trafficability, and local materials is of special importance in mountain warfare. Specially trained engineer terrain analysts furnished with reconnaissance information and air photo coverage have the capability of furnishing information quickly and with a wealth of detail unavailable by other means. Relationships between vegetation and soil conditions resulting from terrain evaluation aid the engineer in his determination of trafficability and sources of materials. Stereoplotting instruments are used to furnish contour maps, while special engineer intelligence overlays may be prepared to give information of trafficability, construction sites, and materials.

110. Road Construction

a. Development of extensive road systems in mountainous regions should be avoided. Initial plans for road nets should include the improvement of existing roads and trails. Trails normally will be developed or improved to accommodate, initially quarter-ton trucks, and eventually, heavier vehicles. Turnouts installed every one-half kilometer or more frequently, will reduce traffic congestion on single lane roads or trails (TM 5–250).

b. The construction of roads in mountainous terrain is one of the most important duties of an engineer unit. Normally, roads should follow contour lines and avoid crests of ridges. However, in mountainous areas, terrain, weather, and other overriding reasons often require the use of crestlines for roads except when the tactical situation prevents their use. Routes should be selected with special regard to cover and the speed with which the roads can be put into service. Abnormal gradients on roads may be required initially to insure that construction will maintain pace with the tactical operations. Routes should bypass marshy spots and localities which require excessive rock blasting and movement of large boulders. Cut-and-fill type roads on slopes will usually result in the best road and most efficient employment of available equipment. If the road is to be used during the winter, plans for its location and alinement should include consideration for eliminating or minimizing snow drifting and possible avalanche protective measures where such danger exists.

c. Advantage should be taken of natural routes to reduce the amount of cutting and cribbing. Locally available timber may be used for cribbing both the downhill and uphill side of the road. The air compressor and bulldozer should be used to the fullest extent acknowledging that compressor efficiency decreases with increase in altitude. Drainage should receive increased emphasis due to abnormal slopes, damaging thaws, and heavy rains. Roadbeds on a hillside should be banked to the inside to eliminate cross road drainage and prevent loss of equipment over a bank as a result of skidding.

d. In certain mountainous areas it may often be impossible to make full use of normal engineer heavy equipment in road and bridge construction, execution of demolitions, and preparation of obstacles. In such cases, reliance must be placed upon hand labor and light equipment. It may often be necessary to add to the normal allotment of handtools and to supplement or replace construction machinery by special light equipment. The type and quantity of such special equipment will vary with the situation, but can usually be determined by proper prior planning and possible engineer reconnaissance.

e. Accumulations of surface water give considerable trouble to road builders. Localities where it is present should be prepared for drainage, either by placing a culvert across the road, or a heavy subcourse of large stones to allow underground drainage. This condition may be counteracted by corduroying the road in that locality with timber poles or logs. Maximum use must be made of crossing or bypassing expedients which require little material. Culverts, either prefabricated or built on the spot, and fills may often be substituted for bridges. Special attention will necessarily be given to snow removal during the winter months. This will entail the use of additional engineer troops and snow removal equipment.

111. Demolitions

a. For most demolition work in the mountains, the principles of FM 5–25 are adequate. A few variations are found to apply in the case of hardwood trees and in some types of soil. Blasting a hardwood tree with an internal charge gives excellent results; in such cases test shots should be conducted to determine additional amount of explosives required.

b. For demolition in rocks and rock soils, normal procedure applies, except that fissures are often found which have to be well filled and tamped with earth. A fougasse made with rock and explosive can be very effective if used on routes of approach in valleys. It may be command fired or set off by a firing device.

112. Obstacles and Mines

a. Obstacles, in conjunction with the natural ruggedness of mountainous terrain, can be effectively employed to deny the enemy key terrain locations and to delay and impede his movement.

b. An attacking force must know in what areas antitank or antipersonnel mines are likely to be used, and be prepared to deal with them. Mechanical mine exploders are of little use in the mountains and there is as yet no substitute for the removal of mines by hand or demolition in place after they have been located by the employment of detectors, visual inspection, probing, or a combination of all of these methods.

c. In general, a defending force lays antitank mines mixed with antipersonnel mines in the comparatively narrow approaches to its position which are passable to tanks. On slopes not passable to tanks it employs chiefly antipersonnel mines, paying particular attention to logical approaches for foot troops. In mountainous terrain, scattered mining techniques will be utilized more frequently than patterned mining techniques. In all cases mine fields will be sited to effect channelization of enemy efforts.

d. For details of obstacles, and mine laying and removal, see TM 5-220 and FM 5-31.

Section VI. SIGNAL

113. Communications Security and Use of Wire and Radio

a. General. In mountainous country a commander must give signal communications high priority in his planning and supervision. In most instances, communications can be maintained by TOE communication equipment supplemented with additional allowances of radios for establishing radio relays, and lamps and flags for visual signaling. For information on communications see FM's 7-10, 7-21, 7-24, 11-8, 11-50, 24-5, 24-17, 24-18, and 24-20.

b. Communications Security. Communications security is primarily a command responsibility. However, each individual user and operator is responsible to the commander for compliance with security regulations. Communications security has three essential components: physical security, transmission security, and cryptographic security. AR 380-5, AR 380-40, AR 380-41, AR 380-46, and FM 32-5 detail the communications security requirements.

(1) Wire communication is a very dependable means of communication and can be used to great advantage in mountainous areas. There will be encountered, however, problems in installing wire communication systems because of the terrain over which the wire lines must be laid. The installation of a wire system in mountainous areas requires careful planning and installation in order to insure that the wire is protected from avalanches, rock falls, landslides, severe storms, and deep snow. Because of the uncertainty of radio communication, it is important that the wire system function continuously during displacements, as well as during static situations.

(2) Wire may be laid using vehicles of various types; however, the ¼-ton truck is more adaptable to use on narrow and somewhat limited trails that may be encountered. If vehicles cannot be used it may be possible to lay wire lines from reel units RL-39 or MX-306 dispensers attached to packboards. If areas are encountered where it is not possible to lay wire from either vehicular mounted equipment or equipment mounted on packboards it may be possible to utilize aircraft, either fixed or rotary wing. If aircraft are used consideration should be given to the capability of the enemy to deliver fire against such aircraft. Kits are available for use in conjunction with aircraft in situations that require them.

(3) Particular care should be exercised in the selection of routes over which wire lines are to be laid. If possible, avoid roads that are being used as main routes of march. Roads and trails should be used as guides only; the wire should be laid at least 2 meters off. Where no trails exist, wire should be laid over the less accessible routes. This is to prevent troops from using the wire as a guide and consequently breaking it. With practice, wire teams can climb an easy route and swing the wire over an extremely difficult one. If a route becomes impassable due to chasms, etc., the gaps may be crossed by using the rifle grenade or rocket launcher methods of projecting the wire

If these methods are not successful the wire team may have to be assisted by either fixed or rotary wing aircraft.

(4) In an attack, wire should be laid, when practicable, immediately to the rear of the attacking echelons of each rifle company. This is accomplished by using wire-carrying parties equipped with dispensers mounted on packboards with a field telephone or a sound powered telephone attached to the wire. This affords continuous communication while the wire is being laid, thereby enabling the company commander to contact the battalion command post as necessary or at prearranged intervals. The wire carrying party should stay with the company commander at all times so that telephone communication is immediately available to him. When objectives are secured, lateral lines may be laid between companies.

(5) Care must be exercised in handling and laying wire in order to minimize breakage and damage because of abrasion. On steep slopes, wire should be tied and tagged frequently to prevent interruption and simplify maintenance. Shorts may occur frequently because of high winds, they may be found at points where the wire is tied in. A solution to this problem is to lay two separate wire lines as conductors for one circuit, several meters apart and then tie or peg down each line at regular intervals. This allows more conductors thereby increasing the transmission range and reducing the possibility of interruption of the circuit on account of trouble on the line.

(6) It may be possible to make one trunk line serve a number of units by installing a switchboard at the termination point and laying lines to the units to be served by the switchboard.

(7) The use of teletypewriter service is not limited by mountainous terrain, and should be utilized as frequently as possible. The equipment is portable and may sometimes function on a circuit not suitable for telephone communication. Streams can frequently be used to ground teletypewriter circuits.

d. Radio.

(1) Radio communications are frequently interrupted because of mountain or tree masses. High frequency (HF) tactical AM (amplitude modulated) sets using the sky wave mode of transmission which operate primarily between 3 and 20 megacycles are best for mountain communications. The use of a relay set on the top of the mask will aid high frequency sets in crossing these masks. Artillery liaison and forward observer radios should be packed on packboards, so that when it is necessary to move across country, time will not be lost in packing them. The satisfactory operation of radios in this type of terrain will depend, to a great extent, on the resourcefulness and perseverance of the operators. Transmission characteristics will vary, depending on such factors as time of day, season, ionospheric conditions, power output, and frequency of operation. The use of half-wave antennas at the proper height above ground and oriented to utilize the directional characteristics will also be of value.

(2) As a general rule VHF (very high frequency) radios, tactical FM (frequency modulation) radio sets in the frequency band 20 to 50 megacycles and higher, require a line-of-sight path between transmitter and the distant receiver for best results. Therefore increased ranges and reliability can be achieved if both terminals of a radio circuit are located just below the crest of a mountain peak. In the event that unavoidable intervening masks exist between the terminals, it may be necessary to rely upon an intermediate radio relay station. If the transmitter and/or the receiver and its antenna is imbedded in a deep ravine or gully or in a mass of humid, leafy woods, reduced strength of signals will result. Radio sets sited inside of rock tunnels become shielded and frequency can neither send nor receive. In situations where radio communications should normally be possible but difficulties develop, shifting the location of the set only a few feet often

improve VHF transmission and reception.

(3) Caution should be exercised in placing antennas in mountainous terrain to obtain line-of-sight transmission. Antennas must be so located as to avoid intervening land masks and yet so located that the antennas are not readily observed by air or ground observers. Antennas should not be placed on the crests of hills or mountains unless absolutely required to obtain satisfactory communications.

(4) The extreme and rapid changes in temperature encountered in mountains create a problem in keeping radio sets and batteries dry and at an even temperature. Battery failure, moisture, and cold are the principal causes of reduced efficiency of the standard portable radio. Radio operators should carry as many extra batteries as possible. In cold weather it may be necessary to wrap the set in a moisture-proof bag and keep it in a warm place. Extra batteries can be carried in the inside pockets. On warm days the batteries should be kept out of the sun.

(5) Certain of the heavier radio sets are capable of being broken down and transported by packboards. Drill in packing, unpacking, and the setting into operation of such sets must be practiced until each member of the team is thoroughly familiar with the packing of each part, and the placing of each in the proper place. This will develop speed in handling and insure against the loss of any vital part during a hurried move under difficult conditions.

(6) It is often difficult to establish air-ground radio communication because of the existence of dead space caused by intervening mountain masses. Ground plane antennas often improve poor radio communication.

114. Visual Signaling and Use of Messengers

a. Visual Signaling.

(1) Visual signaling assumes increased importance to the mountains. Long lines of sight afford many excellent opportunities for its use. Visual equipment, being light in weight, is more easily carried than other communication equipment. It can be easily improvised. Observation points are almost always available.

(2) The semaphore method of visual signaling has proven very successful, being both easy to learn and usable at distances up to 4,000 meters. It is desirable for all officers, noncommissioned officers, reconnaissance and communication personnel, and messengers of units operating in mountains to be able to read and send semaphore. It has been found that its use is not confined to communication personnel only, but that any soldier may have to send, however slowly, some important messages. A soldier may often be separated by only a short distance by impassable terrain from someone with whom it is necessary to communicate. The alphabet can be learned by the average soldier in 5 or 6 hours of proper instruction. Thereafter about 20 minutes of visual signaling drill daily will keep him in practice. Utmost precision in the execution of each move should be stressed from the beginning of the instruction. Care should be exercised in selecting the background for the flags, and in achieving all possible security from enemy interception. Wigwag is slow and clumsy, but can be read over somewhat longer distances and can be sent from less exposed positions. At night a hand lamp may be used.

(3) The blinker light can be read at least 1 kilometer in clear daylight and several kilometers on clear nights. Radio operators should use the standard procedure in sending messages by blinker; prearranged message codes can be flashed by an operator who does not know the international code. Signal lamp equipment or flashlights may be used to send international code or prearranged message codes.

(4) Lamps and flags for visual signaling purposes may have to be improvised or procured as additional equipment. If no standard equipment is available, strips of cloth tied toward the outer end of

sticks of wood or bayonets will serve for flags. For short ranges, when the use of flags would be unduly conspicuous, the waving of hands, arms, or handkerchiefs may be used.

(5) Under favorable conditions, the sun's rays can be caught and reflected by means of a mirror or heliograph device and used to transmit messages. Pyrotechnic devices can be used in the mountains as in normal terrain to send prearranged messages requiring immediate action or when other means of signal communication are uncertain or too slow. In order to insure transmission through mountain fog and clouds, it may be necessary to set up a chain of stations to relay pyrotechnic signals. Smoke signals can be used to attract attention, or as a substitute for pyrotechnic devices. Panels are used in the mountains as in the flatlands, although difficulty may be experienced in finding a suitable panel display ground.

(6) Because observers must be well forward and wire is limited, infantry heavy weapons personnel must often depend on visual signaling. In the commander's plans for coordinating supporting fires, he must provide for the use of visual signaling to complement other means.

b. Messengers.

(1) Messengers are necessarily slow in the mountains and require intensive training to become dependable. In rough heavily wooded country, ½ kilometer per hour is considered fair speed. Even a trained messenger with a map can became lost in the daytime. When visibility is poor, a messenger may find his way to a command post by following existing wire lines, however, messengers should not pick up wire lines for use as a guide.

(2) Messengers should be dispatched in pairs and should be taught to depend on natural terrain features for orientation, rather than relying too much on roads and other man made landmarks in finding their routes. When in a new position messengers should be sent to the command post to find the route prior to darkness. Since darkness will change the appearance of the trail, messengers should backtrack after dark in order to familiarize themselves with landmarks in darkness. When operating in snow covered terrain, all messengers should be proficient skiers and familiar with the hazards of avalanches and know the proper procedures to be followed when travelling in areas of such hazards.

Section VII. MEDICAL

115. Principles of Operation

a. The principles of operation which control the movement of troops in the mountains as prescribed in FM 100–5 hold true for the medical service as well as for the combat arms.

b. The principles set forth in FM 8–10 should be followed to the extent permitted by the situation, since central control when practicable is more efficient than decentralization. When combat units adopt tactics based on the maneuverability of semi-independent small units, either on the offense or defense, it is essential that the medical service be sufficiently flexible to adapt to the situation. The utilization of organic medical service personnel and equipment must be planned to provide the maximum unit level medical service under the given situation. The tactical situation, the nature of the terrain, and the need for rapid movement along the chain of evacuation, must be considered in planning the employment of unit level medical service.

116. Battalion Medical Platoon

The infantry battalion, when operating in mountainous terrain, is often decentralized to such an extent that a centrally located aid station may be impractical. In mountain warfare or similar types of operations, it may be necessary to divide the aid station section into two small sections, capable of minimal treatment, which will permit operation of two aid stations in direct support of the battalion. This division will limit the capabilities of the aid station section, and should not be adopted unless impossible to find other solutions to the problems. Additional equipment will be required if such a division of the aid station section is necessary.

117. Aid Stations

a. In mountainous terrain there is usually adequate concealment and defilade to allow the medical platoon to establish the aid station(s) close to the front line troops. If one station is operated, it should normally be located as close as possible to the fighting troops and generally in the center of the battalion area. If the medical platoon is required to operate more than one aid station, each aid station should be given a specified area of responsibility, and located centrally and as far forward as possible in support of the troops for which the station is responsible. The term "centrally located" does not necessarily mean the geographical center of an area. Many factors such as expected casualty rates, lines of drift, roads, or paths for evacuation of the station, terrain features having a direct influence on litter carry, and others, must all be considered in determining a central location for a given area. The following advantages are obtained when proper consideration is given to the location of aid stations:

(1) Relatively short or easier litter hauls.

(2) Closer liaison between the front line units and medical establishments in support.

(3) Closer contact with company commanders which affords greater ease in following changes in the tactical plan.

(4) Increased rate of evacuation.

(5) Additional adequate shelter.

b. Casualties will be sorted, given necessary emergency medical treatment, and if designated as evacuees, provided with shelter and warmth until transportation is available. Speed of evacuation is of paramount importance.

c. When the aid station section is divided, it is desirable that the evacuation section be augmented with additional 6-man litter teams. The additional service troops personnel required to augment the medical platoon litter squads may be recruited from all available sources, including the use of indigenous personnel, who must however, be familiar with military mountaineering techniques. This augmentation should be completed prior to its actual need.

118. Company Aid Men

As in normal situations, aid men will be furnished to the companies by the aid man section of the medical platoon. The normal distribution for aid men is four (4) per rifle company. When critically short of medical personnel, this allocation may not be possible. Reallocation of aid men to meet existing conditions may help in solving this problem. Insofar as possible, aid men should always be attached to the same company to encourage close relationships between them and the men of the company. Emphasis should be placed on training the aid man in hazards of cold and wind, relationship of these factors to the problem of shock, conservation of body heat and improvised methods of providing warmth, to include the construction of small windbreaks and shelters, and techniques of military mountaineering and mountain evacuation procedures.

119. Collecting Points

a. In mountainous terrain it will often be necessary to consider the establishment of collecting points. These collection points operated by medical aid men, are designated intermediate points along the route of evacuation where casualties may be gathered. Two of these collecting points may be operated by the aid men allocated to the headquarters company of the battalion. Whenever casualties are to be transferred from one type of transportation to another, there is a requirement for a collecting point of this type.

b. Defilade positions are abundant in mountainous areas. Collecting points should be established as far forward as possible, while maintaining an adequate contact between the battalion and the various medical services. A collecting point may be established behind each of the battalion aid stations, or a centrally located point may be operated, whichever will insure the most efficient medical service and provide the greater relief to litter bearer personnel.

c. The litter bearer haul should be kept to an absolute minimum and vehicular transportation used wherever possible. Maximum use should be made of helicopter evacuation, but the battalion surgeon should never limit his plan so that he becomes absolutely dependent upon evacuation by air. Evacuation plans must be sufficiently flexible to insure the accomplishment of the mission when helicopters are not available.

d. Collecting points should be movable and should be placed, whenever possible, away from any difficult terrain. Collecting points along routes of march should not be established routinely, but only if—

(1) It is certain that these points will be in territory under secure control of friendly forces.

(2) The number or severity of wounded justifies such a point.

120. Establishment of Litter Relay Points

a. It would be wise in many situations, if sufficient litter bearers are available, to establish a chain of litter relay points from the forward aid stations back to a point where evacuation can be taken over by ambulance.

b. Each relay point should be have one noncommissioned officer and four litter bearers. However, when short of personnel, one noncommissioned officer could be used to supervise more than one relay point. Each point is responsible for the evacuation of all patients received. When returning to their relay point, bearers bring back empty litters and other medical supplies which are required at forward aid stations. This will permit maximum use of available bearers because a given number of bearers operating in a chain of relay points can evacuate far more wounded than can be accomplished if each litter team attempts to evacuate the wounded from the front line aid stations to the rear, where ambulances can pick them up.

c. This system was frequently used in mountain fighting by both United States and British troops. It allows bearers to function continuously since each haul is relatively short, and the men become rested on their way back to their post. They also become familiar with the short section of mountain trail over which they travel. This makes it possible for them to operate over the trail at night, and gives the wounded a much smoother ride.

d. This system is also of value because it curtails straggling which may be encountered when the same litter bearers are used from the front lines all the way back to the ambulance loading point.

121. Medical Battalion

The tactical problems of the medical companies of the division medical battalion in mountain operations are similar to those encountered in flat terrain. Lack of good road nets will add to the difficulties to be encountered by the medical battalion. Basically, the battalion should establish one or more clearing stations in support of committed brigades. These should be as close as possible to the stations supported, yet must be situated so as to permit easy evacuation by the units in support. Utilization of the ¾-ton ambulance fo ward of the division clearing station may, at time be impossible. Personnel normally employed i this link of the chain of evacuation may then l used as litter bearers or as supervisors of litt bearers furnished from other sources. Problen will arise, but by maximum utilization of perso nel and equipment, the division medical battalic can give adequate support within its area (responsibility.

122. March Procedures

Company aid men accompany their respecti companies on any march. By map or route reco naissance, the battalion surgeon will establish p tient collecting points along the route of marc These collection points should be sheltered are which have been marked in such a way as to l easily recognizable by litter bearers. Enlisted pe sonnel of the medical platoon will be designated t take charge of these points. A minimum of tw men per point should be used. Just prior to th start of the march, the men who have been assigne as collection point attendants will join the hea of the column. As the head of the column pass each collecting point, the personnel who have bee assigned to the point will drop out of the colum and remain at their point until relieved. Specifi responsibility of the collecting point attendant should include administering necessary emergenc treatment, providing adequate heat and shelte and required supervision of patients evacuated t the collecting point. Patients who are evacuate to these collecting points may be evacuated b ambulances belonging to either the battalion o the division.

123. Equipment

a. Operations in mountains require medical per sonnel to carry additional equipment. Items suc as ropes, pitons, piton hammers, and snaplink are all necessary for the evacuation of patient and establishment of aid stations. All unneces sary items of equipment including those for whic substitutes or improvisations can be made shoul be left behind. Heavy tentage, bulky chests, extr splint sets, excess litters, and "nice to have" med ical supplies should be stored. Such medical sup plies, if stored should be readily available to th battalion surgeon by airdrop or other means o transportation upon his request. Medical item that are subject to freezing should not be expose to the low temperatures experienced in mountainous areas. When freezable items must be man carried, losses from freezing may be reduced by packing chemical heaters with the supplies or by having the individuals carry the items beneath the parka.

b. In order that forward medical installations may be able to maintain a satisfactory level of medical supplies, all personnel, vehicles, and aircraft going toward the front should, whenever possible, carry small amounts of medical supplies and equipment such as whole blood, blood substitutes, dressings, blankets, litters, etc. Equipment and supplies necessary for the establishment of a small aid station can usually be man carried. Smaller supplies and equipment may be rolled in blankets and these rolls either lashed to packboards or carried in partially folded litters. In addition to normal medical items, it is advisable to carry a few shelter halves, two hand axes, two or three nylon climbing ropes, and some snaplinks for each aid station to be established.

124. Shelters

Since the transportation of heavy tentage may be impracticable, shelter for patients must be improvised in order to prevent undue exposure of the wounded. In the summer or in warm climates improvisation may not be necessary, but since there is a close relationship between extreme cold and shock, medical personnel should always be conscious of the necessity of providing adequate shelter for patients. Satisfactory shelter may be found in caves, under overhanging cliffs, behind clumps of thick bushes, in ruins, etc., or they may be built using a few saplings, evergreen boughs, some shelter halves, or similar items. The time factor will often have strong influence on the type of shelter used. When patients are to be kept overnight, a better weather-proofed shelter must be constructed. Detailed information on shelter for cold weather operations may be found in FM 31–70.

125. Evacuation

a. The evacuation of wounded in mountain warfare presents varied problems. In addition to the task of carrying a patient to the nearest medical installation, there is imposed the difficulty of movement over rough terrain.

b. The proportion of litter cases to ambulatory cases is increased in mountainous terrain since even a slightly wounded individual may find it extremely difficult to climb over the rugged terrain. Because of this added exertion and increased pain, it may be necessary to transport a patient by litter who would normally be able to return to the aid station by himself.

c. In cold weather and in high mountains, speed of evacuation is vital as there is a marked increase in the possibility of shock among battle casualties when injuries occur in extreme cold.

d. Special consideration must be given to the conservation of manpower. Litter hauls must be kept as short as the tactical situation will permit. A litter team is not capable of carrying a casualty over mountainous terrain for the same distance as over flat territory. In order to decrease the distance of litter haul, all forward medical installations should be as close as possible to the troops supported.

e. It is important to be able to predict the number of casualties that can be evacuated with available personnel. It has been demonstrated that when the average terrain grade exceeds 20° to 25° the four-man litter team is no longer efficient and should be replaced by a six-man team. The average mountain litter team should be capable of climbing 120 to 150 vertical meters of average mountain terrain and returning with a casualty in approximately 1 hour.

f. Another factor to be considered is the problem of evacuation at night. Wounded should be located and evacuated during the day, as many would not survive the rigors of the night on a mountain during cold weather. Night evacuation over rough terrain is generally impracticable and the results are rarely commensurate with the effort. It should be attempted only when the route has been reconnoitered, marked with tracing tape, and a rope handline installed. If routes are exposed to enemy observation and fire by day, casualties must be removed from the area at night. When required, casualties should be moved only as far as necessary during the night. At the first point affording shelter from enemy observation and fire, a holding station should be established capable of providing shelter, warmth, food, and supportive care. Casualties should be brought from the forward areas to this point, held until daylight, then evacuated further to the rear.

g. The many difficulties of medical evacuation encountered in mountain operations emphasize the advantages of air evacuation of casualties. It cannot be assumed that helicopters or light aircraft will always be readily available for evacuation of casualties from front line areas. Both the helicopters and light aircraft which are organic to Army organizations provide faster, more economical transportation for casualties than other methods which might be used. The reduction of time lapse between injury and treatment has such a direct effect on the time required for recovery and the final results of the treatment that the use of the most rapid, most comfortable, and the safest means of evacuation is actually mandatory. The fact that airlift may not be available because of weather, enemy capabilities, terrain features, maintenance problems, and others, are the factors that prevent the surgeon from relying almost entirely on aircraft for the evacuation of casualties in rough, mountainous terrain.

126. Plan

The first and most important task, before evacuation can be instituted, is a thorough reconnaissance of the terrain features and the road network in the area. To this information is added a consideration of the prevailing climatic condition, the facilities and personnel available, and the tactical mission. Only after all these factors are assembled and evaluated can a sound medical evacuation plan be formulated. The following factors, peculiar to mountain operations, should be given consideration prior to making the final selection of evacuation routes:

a. Snow and ice are firmest during the early morning hours.

b. Glacial or snow fed streams are shallowest during the early morning.

c. Channels of mountain streams afford poor routes of evacuation because of rough slippery rocks and the force of the moving water.

d. Talus slopes should be avoided because they are difficult to traverse. Loose and slippery rocks on such slopes will often cause litter bearers to fall, drop the casualty, with possible injury to all.

e. When possible, routes should be chosen just below the crest of a ridge since these trails are usually easiest to follow and the ground affords the best footing in such areas.

127. Principles of Evacuation

Principles of evacuation in mountainous terrain are covered in detail in paragraphs 148 through 157.

Section VIII. TRANSPORTATION

128. General

a. Reconnaissance of the available road net will determine the type and the maximum number of vehicles that can profitably be employed in any particular mountain operation. Most of the heavy type motor vehicles are roadbound and limited to improved roads. Mountain roads or trails usually are unimproved. Bridges are often narrow, of flimsy construction, and require reinforcement before they are adequate for military traffic. Few roads are built on ridges where troops will operate.

b. Motor transportation in mountainous terrain is usually drastically reduced. Only those vehicles carrying loads which cannot be packed should be allowed beyond a previously designated truckhead. The list of trucks to be left behind, which may average two-thirds of the total, should be part of the standing operating procedure of each unit. When the mountains have been crossed and the road net branches out, the trucks left behind can be brought forward under convoy.

c. Full advantage must be taken of the limited motor transportation to move ammunition and rations as far forward as possible in order to reduce the high percentage of combat personnel required for packing and hand carry.

d. Motorized and air reconnaissance may be advantageously employed in the large valleys.

129. Specific Problems

a. Traffic Control. Traffic control must be rigidly maintained to prevent traffic congestion and delay. The responsibility for establishing and maintaining traffic control must be delegated to one person within the brigade and battalion and to the transportation officer in division or higher headquarters. Telephones or radios should be installed to provide traffic control on long stretches of one-way road. Traffic jams can be largely avoided if the following precautions are taken: constructing turnouts for single lane roads; establishing a block system for one-way roads; granting of priorities to only the minimum essential vehicles; preventing turnarounds except on places especially prepared and designated for that purpose; requiring troops to march off the roads.

When vehicles must pass each other on a narrow road, the one on the safer side should move forward only after that on the more dangerous side has pulled over as far as possible and has come to a full stop.

b. Maintenance. Maintenance of motor transportation assumes unusual importance in mountain operations. Prior to and during operations in steep terrain, the safety devices of all vehicles must be checked continually, since failure on the part of any may have disastrous results. Proper adjustment of brakes is especially important. The emergency brake must be adjusted so that it is capable of holding the vehicle on any slope without the aid of gears or foot brakes. One failure which is extremely dangerous when vehicles are descending steep slopes and depending on the braking power of the engine is the slipping out of gear of the transmission. Winches should be checked for proper lubrication and proper adjustment of the automatic brake. Engine coolant must be checked closely because of probable overheating of the engine when operating over steep terrain. For information on special care of equipment in extreme cold, see FM 31–70, and TM 9–207.

c. Movement on Steep Grades.

(1) Steep grades are constantly encountered in mountainous terrain. All grades should be negotiated, as far as possible, by driving; winching should be considered only as a last resort. Chains are frequently necessary because of the presence of ice or mud on the road surface.

(2) Short, steep pitches may be climbed by building up momentum in the approach. Generally, however, steep grades should be approached with a slow, steady pull; when this procedure is followed, the vehicle will normally go higher before traction fails and winching must be resorted to. When winching is necessary, the route selected should provide frequent anchor points in the form of trees or rocks. The more frequently anchor points are used, the greater the mechanical advantage that can be obtained by the use of snatch blocks. When trees or rocks are not available, the ground-anchor can be used. At each point where winching is necessary, the use of one prime mover to winch other vehicles or howitzers in turn as they arrive at that position is recommended. When howitzers are being winched up or down, the trails of the weapons should be downhill. When winching on steep slopes, less strain is placed on the winch if the gear of the vehicle being winched is placed in neutral, and the winch allowed to pull steadily. To save undue strain on the cable the power on the winch must not be engaged too suddenly. Care must be taken at all times to clear obstruction from the route in front of the wheels.

(3) Further information on movement of prime movers and howitzers on steep grades is contained in paragraphs 89 and 90.

d. Daylight Driving.

(1) In daytime driving on mountain roads, all vehicles should normally remain in open column because of their vulnerability to air attack. Extreme care must be exercised on all roads because of the many sharp, blind curves and steep grades. All curves must be taken at a speed which will enable the driver to halt the vehicle in half the visible road space. Either up or downhill grades should be taken in a gear ratio that will enable the vehicle to take the entire hill without shifting. Caution must be exercised to see that the speed of the vehicle does not exceed two-thirds of the speed (listed on the chart in the cab of the vehicle) for that particular gear ratio. Hills should be descended with a combination of braking and engine. Normally the same gear should be used in descending a grade that would be used in ascending the grade. Neither should be used alone to bring a vehicle downhill.

(2) Guides should be posted at dangerous places, especially when backing and turning are required, to give directions to each driver just before he starts to negotiate the difficult section.

e. Driving at Night. Because the danger of blackout driving in mountains will often exceed the danger of enemy action, driving without lights on narrow winding mountainous roads should be held to a minimum. When blackout driving is necessary because of enemy observation it should be limited to those stretches of road visible to the enemy. At these points signs and guides should be posted to give special instructions to each driver as he approaches. Trucks should be in close column. Only when the driver can definitely see the road or the tail light of the vehicle in fron is it safe to drive without an assistant driver pr ceding on foot. Lead vehicles should not excee 8 kilometers per hour.

CHAPTER 4

MILITARY MOUNTAINEERING

Section I. GENERAL

130. Importance

Military mountaineering provides access to otherwise inaccessable rugged mountainous terrain. In such terrain there are three adversaries—the enemy, the mountains, and the weather. These adversaries can be overcome by using troops with specialized training who are skilled in the use of special mountain climbing equipment and techniques.

131. How it is Used

Soldiers skilled in military mountaineering can perform many essential missions in difficult terrain. They can serve as guides, observers, snipers, and as patrols, security elements, and assault team members.

132. Effect on Deployment

An estimate of friendly or enemy capabilities in rugged terrain is possible only if the higher commanders are thoroughly familiar with the capabilities of the mountaineer. All officers who are to operate in mountainous terrain must be oriented in this respect. As many officers as possible, but not less than one per company or battery, should become skilled military mountaineers.

133. Training Requirements

a. Specialists. Troops preparing for operations in mountainous terrain should have climbing specialists in each company, battery or platoon. They will usually function as teams of three. The men must have reasonable athletic ability, normal resourcefulness, mental toughness higher than normal, and no fear of height. Prospective climbing experts should be selected with care.

b. Semitrained Climbers. Preparation for mountain operations is not complete until the unit commander knows how all his men will react to exposure to height and to the out-of-the-ordinary muscular effort. A few hours of climbing for all men provides a valuable index to each man's future reactions. Each man is exposed to the unknown, and therefore frighting, dangers. Fear of falling is a basic instinct, and may be as hard to overcome as fear of enemy fire. Analysis of the man's reaction to height will enable the commander to place those who do not overcome the fear of falling in a position where they will not jeopardize the safety of the unit.

Section II. BASIC TECHNIQUE

134. Mountain Walking

Mountain walking can be divided into four different techniques, dependent on the general formation of the ground to be overcome. Included in all these techniques are certain fundamentals which must be mastered in order to obtain a minimum expenditure of energy and loss of time. These are—that the weight of the body must be kept directly over the feet, and the sole of the shoe must be placed flat on the ground. This is most easily accomplished by taking small steps at a slow steady pace. An angle of ascent which is too steep must be avoided and small indentations in the ground or hummocks, however small they may be to set the foot upon, should be used to advantage.

a. Walking on Hard Ground. Hard ground is generally considered to be firmly packed dirt which will not give away under the weight of a man's step. When ascending, the above mentioned fundamentals should be applied with the following additions. The knees must be locked on every step in order to rest the muscles of the legs. Steep slopes must be traversed and if necessary climbed in a zig-zag direction rather than straight up. Turning at the end of each traverse should be done by stepping off in the new direction with the uphill foot. This prevents crossing of the feet and possible loss of balance. In traversing, the full sole principle is most easily accomplished by rolling the ankle away from the hill on each step. For narrow stretches the herringbone step may be used; that is, ascending straight up a slope with the toes pointed out and using all the other principles mentioned so far. Descending is most easily done by coming straight down a slope without traversing. The back must be kept straight and the knees bent in such a manner that they take up the shock of each step. Again it must be remembered that the weight to be directly over the feet, and that the full sole must be placed on the ground at every step. Walking with a slight forward lean and with feet in a normal position will make the descent easier.

b. Grassy Slopes. In mountainous terrain grassy slopes will usually be made up of small hummocks of growth rather than one continuous field. Therefore, in ascending, it will be found that while all the techniques previously mentioned are applicable it is better to step on the upper side of each hummock where the ground is more level than on the lower side. Descending is best accomplished by traversing; at times a hop-skip may be also be used to advantage. The hop-skip is a hopping motion in which the lower foot takes all the weight and the upper foot is used for balance only. The hop-skip is also useful on hard ground and scree when descending.

c. Scree Slopes. Scree slopes consist of small rocks and gravel which have collected below rock ridges and cliffs. The size of the scree varies from sand to pieces about the size of a man's fist. Occasionally it occurs in mixtures of all sizes but normally scree slopes will be made up of the same size particles. Ascending scree slopes is difficult, most tiring, and should be avoided whenever possible. All principles or ascending hard ground apply, but each step must be packed carefully so that the foot will not slide down when weight is placed on it. This is best accomplished by kicking in with the toe of the upper foot and the heel of the lower foot. Coming down a straight line again is the best way to descend scree (fig. 2). Here it is important to keep the feet pointed straight down as well as keeping the back straight and the knees bent. Since there is a tendency to run down scree, care must be taken that this is avoided and control not lost. By leaning forward, greater control can be obtained. When a scree slope must be

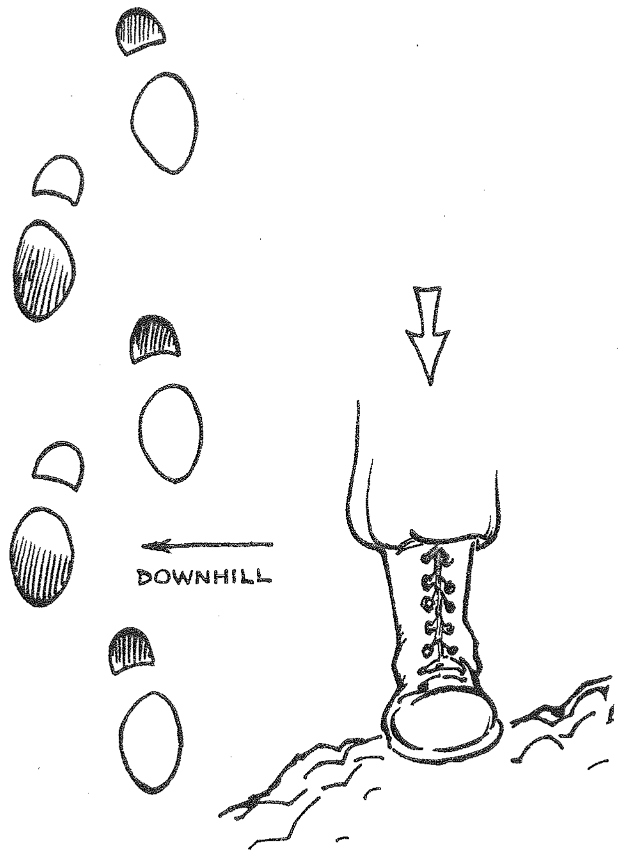


Figure 2. Correct placing of foot in scree slope.

traversed and no gain or loss of altitude is desired, the hop-skip method should be used.

d. Talus Slopes. Talus slopes are similar in makeup to the scree slopes, except that the rock pieces are larger. The technique of walking on talus is to step on top of and on the uphill side of the rocks. This prevents them from tilting and rolling downhill. All other fundamentals previously mentioned are applicable.

e. General Precautions. It is of the utmost importance that rocks are not kicked loose. Falling rocks are extremely dangerous to the men below and also make a great deal of noise. If during a climb a rock is kicked loose it is important that the warning word "ROCK" be given to allow those underneath an opportunity to move out of the path of the rolling rock. Carelessness by one in this respect can cause the failure of a well planned mission, since one rock no bigger than a man's head can kill or severely injure several men as well as ruin all security measures. Stepping over rather than on top of obstacles, such as rocks and fallen logs, will help much toward avoiding fatigue. Usually it will be found that talus is easier to ascend and traverse while scree on the other hand is a more desirable avenue of descent.

135. Rock Climbing

a. Balance Climbing. Balance climbing is the type of movement used to travel on steep slopes. It is a combination of the balanced movement of a tight-rope walker and the unbalanced climbing of a man ascending a tree or ladder.

b. Body Position (fig. 3). The soldier must climb with the body in balance, which means that the weight should be in poise over the feet as he moves. The feet, not the hands should usually carry the weight except on the steepest cliffs. The hands are for balance. Feet will not hold well when the climber leans in toward the rock. With the body in balance the climber moves with a slow, rhythmic motion. Three points of support, such as two feet and one hand, for example, are used whenever possible. Hand holds that are waist to shoulder high are preferable. Relaxation is necessary because tense muscles tire quickly; when resting, the arms are kept low where circulation is not impaired. Use of small intermediate holds is preferable to stretching and clinging to widely separated big holds. A spread-eagle position, in which a man stretches so far he cannot let go, should be avoided. In descents, the climber faces out where the going is easy, sidewise where it is hard, and faces in where it is difficult. He uses the lowest possible handholds (fig. 4).

c. Types of Holds.

(1) *Push holds* (fig. 5). Push holds are pushed down upon, help the climber keep his arms desirably low, but are more difficult to hold to in case of a slip. A push hold is often used to advantage in combination with a pull hold.

(2) *Pull holds* (fig. 6). Pull holds are those that are pulled down upon and are the easiest holds to use. They are also the most likely to break out.

(3) *Friction holds* (fig. 7). Friction holds are those dependent solely on the friction of hands or feet against a relatively smooth surface with very shallow holds. They are difficult to use because they give a feeling of insecurity which the inexperienced climber tries to correct by leaning close to the rock, thereby increasing his insecurity. They often serve well as intermediate holds, some of which will give needed support while the climber moves over them, but would not hold him were he to stop.

(4) *Jam holds* (fig. 8). Jam holds involve jamming any part of the body or extrem-

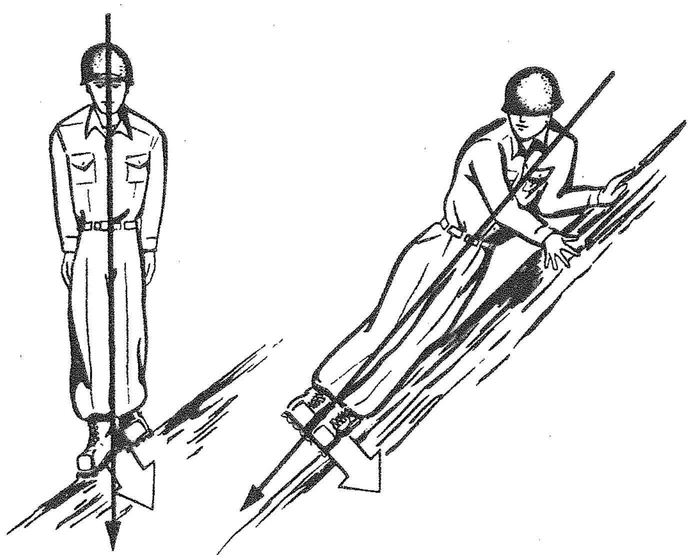


Figure 3. Correct and incorrect body position.

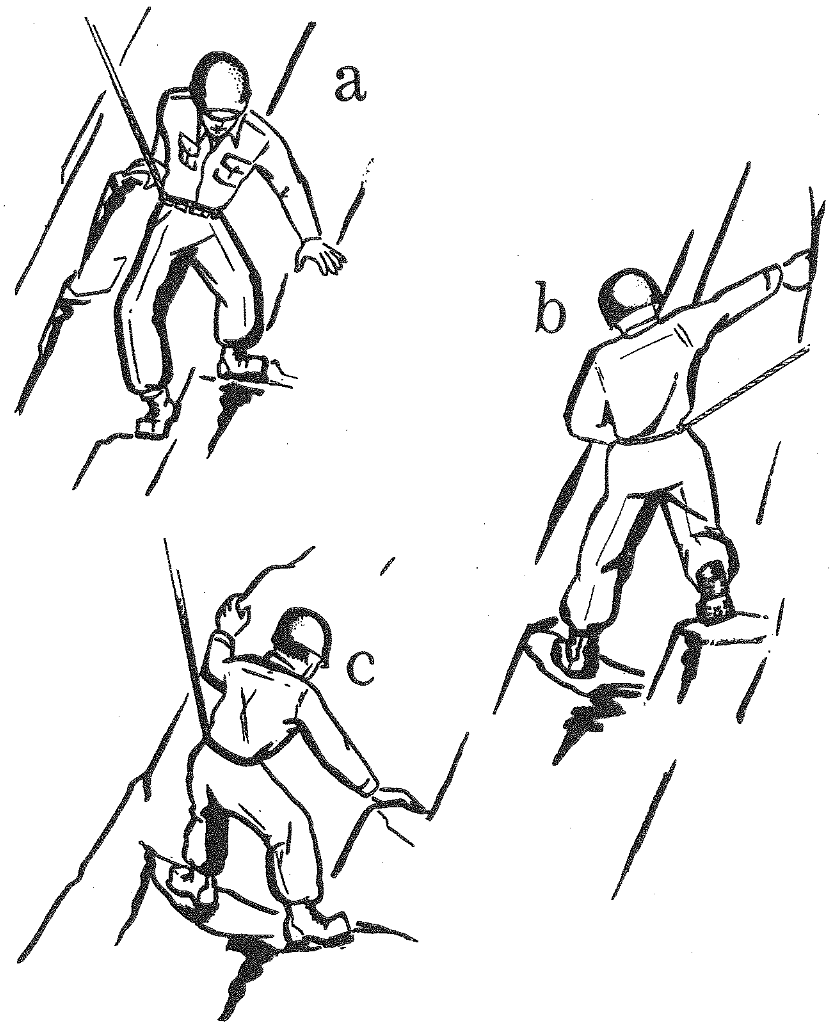


Figure 4. Descent.

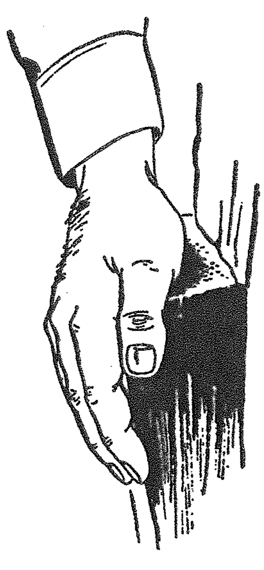


Figure 5. Push hold.

ity into a crack. This can be done b
putting the hand into the crack an
clenching it into a fist or by putting tl
arm into the crack and twisting the elbo
against one side and the hand against tl
other side. When using the foot in a jaı
hold care must be taken to insure that tl
boot is not jammed into the crack in suc
a way that it cannot be removed easil
when climbing is continued.

(5) *Combination holds.* The holds prev
ously mentioned are considered basic an
from these any number of combinatior
and variations can be used. The numbe
of these variations depends only on tl
limit of the individual's imaginatioı
Here are a few of the more commo
ones—

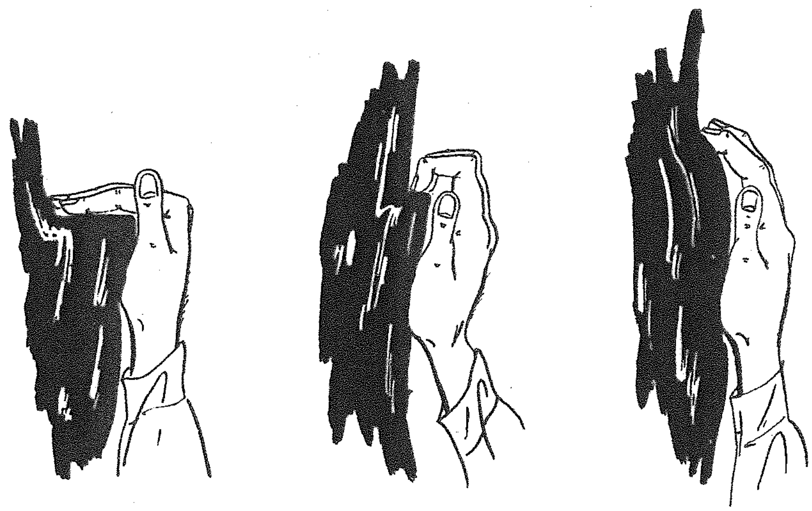


Figure 6. Pull hold.

Figure 7. Friction hold.

(*a*) The pinch hold (fig. 9), attained by pinching a protruding part between the fingers.

(*b*) Pressing outward or pulling inward with the arms.

(*c*) The lie-back (fig. 10) is done by leaning to one side of an offset crack with

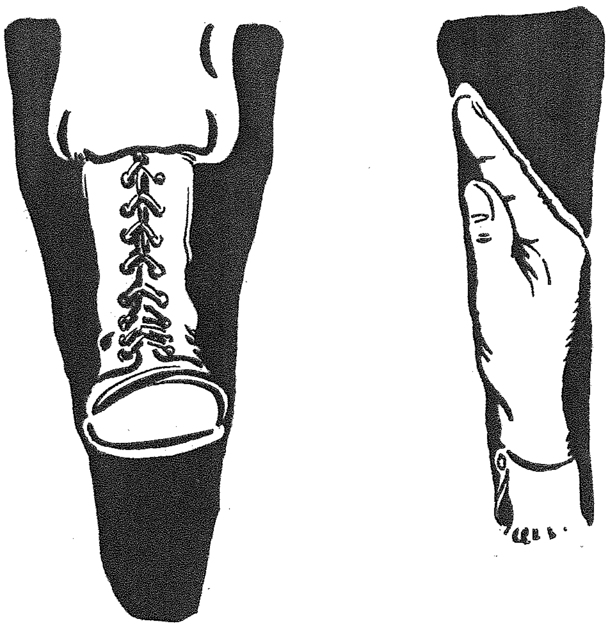


Figure 8. Jam hold.

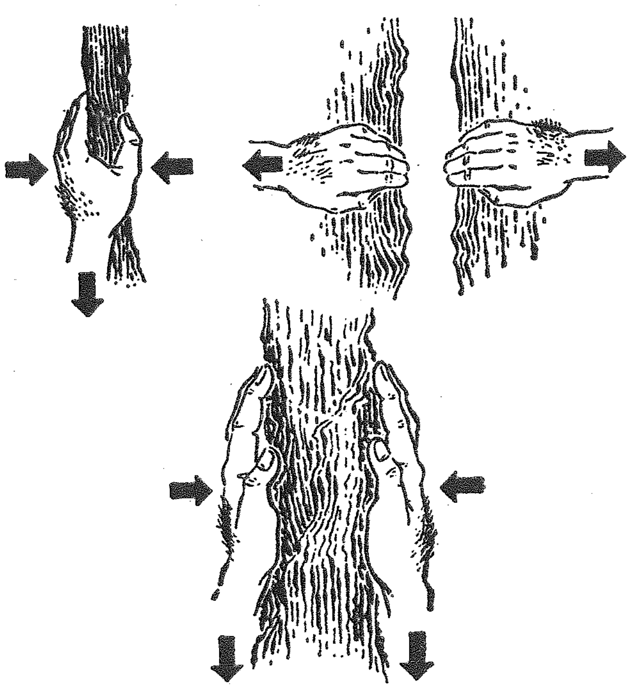


Figure 9. Pinch hold and cross pressure between hands.

Figure 10. Lie-back.

Figure 11. Inverted pull hold.

the hands pulling and the feet pushing against the offset side.

(*d*) Inverted pull or push holds (fig. 11), sometimes called underholds, permitting cross pressure between hands and feet.

(*e*) Chimney climbing (fig. 12) where cross pressure is exerted between the back and the feet or hands or knees.

(6) *Footholds* (fig. 13). The service boot with rubber sole will hold on slabs up to about 45°. On steep slopes the body should be kept vertical, with use being made of small irregularities in the slope to aid friction. Footholds less than 1½ cm wide can be sufficient for intermediate holds, even when they slope out.

(7) *Shoulder stand* (fig. 14). The shoulder stand or human ladder, is used to overcome a holdless lower section of a pitch in order to reach the easier climbing above.. The lower man is anchored to the rock and belays the leader who uses his body as a ladder to overcome the difficult pitch.

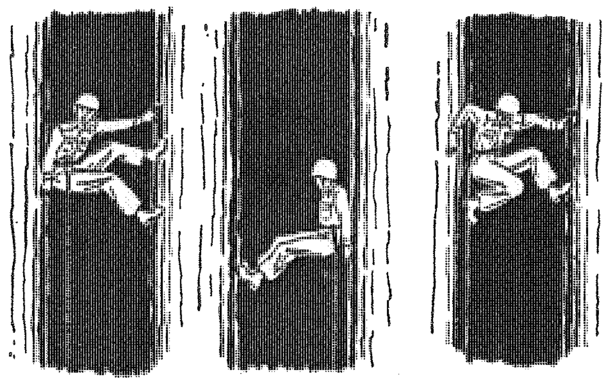


Figure 12. Chimney technique.

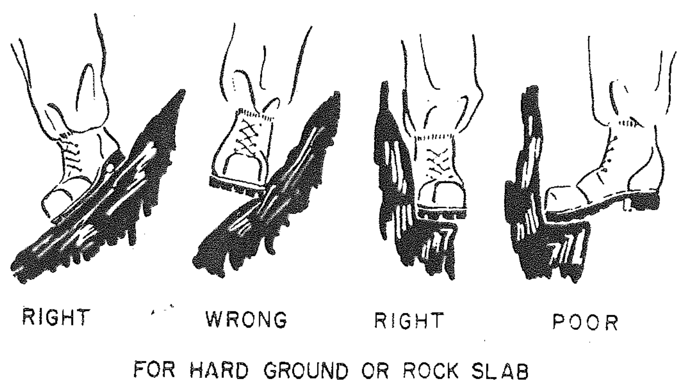


Figure 13. Footholds.

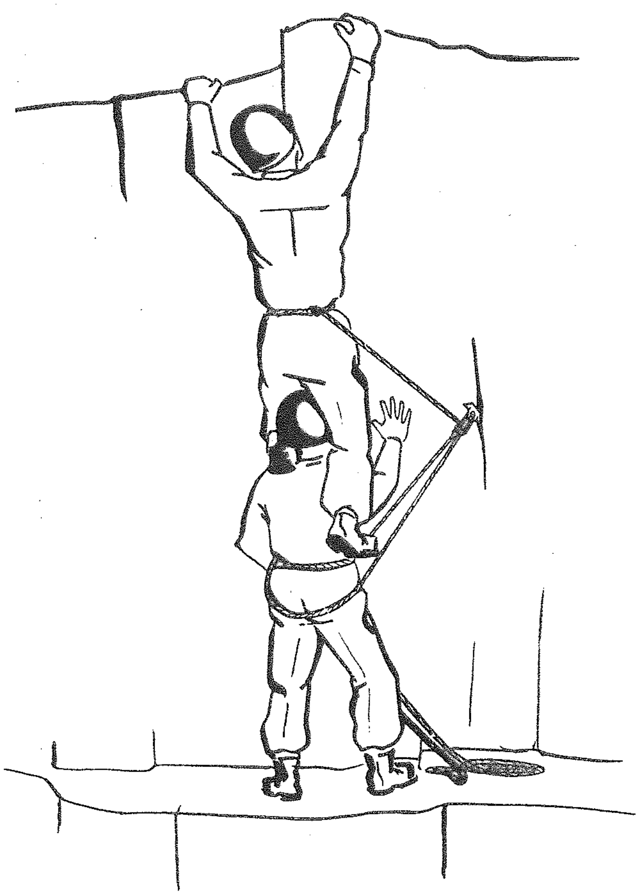


Figure 14. Shoulder stand.

(8) *Movement on slabs.* Slab is a relatively smooth portion of rock laying at an angle. When traversing, the lower foot is pointed slightly downward to increase balance and friction of the foot. All irregularities in the slope should be utilized for additional friction. On steep slabs it may be necessary to squat with the body weight well over the feet and the hands used alongside for added friction. This position may be used for ascending, traversing or descending. Do not lean back or let the buttocks drag as a slip will be the result. Wet, icy, mossy, or scree covered slab is most dangerous.

d. Use of Holds. A hold need not be large to be good. The climber must roll feet and hands over his holds, not try to skip or jump from one to another. It is, however, often desirable while traversing to use the hop step, in which the climber changes feet on a hold so that he may move sideways more easily. A slight upward hop followed by precise footwork will accomplish this useful step.

e. Margin of Safety.

(1) A margin of safety is the protective buffer a climber keeps between what he knows to be the limit of his ability and what he actually tries to climb.

(2) The climber learns his margin of safety by climbing close to the ground, or tied to a rope held or paid out by a trained man above. He climbs first on the easy and obvious holds, next on the more difficult ones, and finally on difficult pitches until he reaches the limit of his ability.

(3) The margin of safety should be calculated not only for the pitch immediately ahead but for the entire climb. The route and movements of the climber should be planned enough in advance so he never finds himself in situations beyond his ability to overcome. The leader of a group should know the capabilities of his men and make allowances for their limitations.

136. Climbing Ropes and Knots

a. Purpose. Much of the climbing in military operations may be free climbing; that is, without rope. However, on some steep unbroken cliffs, where exposure is great, climbing with rope is necessary. Fixed ropes and other aids may be needed as well.

b. Types and Characteristics of Ropes. Units engaged in mountain operations will find use for several different types of rope.

(1) Nylon rope is most commonly used in climbing. The rope is 1.1 cm in diameter and is issued in 36½ meter lengths. The actual breaking strength when dry averages 3,840 pounds (5 percent variable factor). Strength is reduced by 18 percent when the rope is wet.

(2) Nylon sling rope is commonly used in 4 meter lengths. It is the same diameter as the nylon climbing rope.

(3) Manila rope, 1.9 cm in diameter and larger will be used in the construction of various types of installations requiring great length. This rope is better than nylon for suspension traverses and rope bridges because it has less elasticity. When manila rope is bent sharply, as

around a snaplink, it loses a portion of its strength at the bend.

c. Care of Rope. Because the rope frequently is the climber's lifeline, it deserves a great deal of care and respect.

(1) The rope should not be stepped on or dragged on the ground. Small particles of dirt will be ground between the strands and will slowly cut them.

(2) The rope should not be in contact with sharp corners or edges or rock which will cut it.

(3) Keep the rope dry as much as possible. If it has become wet, dry as soon as possible to prevent rotting.

(4) Do not leave the rope knotted or tightly stretched longer than necessary, and do not hang it on sharp edges such as nails.

(5) When using rope in installations (suspension traverses, rope bridges, etc.), do not let one rope rub against another, this may cut and burn the ropes. Whenever such installation ropes are wet, tension should be relieved.

d. Rope Management (fig. 15). Before using a rope it should be inspected for frayed or cut spots, mildew, and rot. If such a spot is found, the rope should be whipped on both sides of the bad spot and then cut. Climbing rope should never be spliced, since it will be hard to manage at the spliced point.

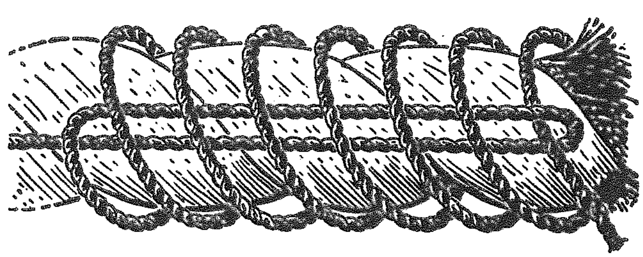


Figure 15. Whipped end of rope.

Rope should always be coiled except when in actual use. New climbing rope should be marked in the middle by tying a small piece of string around one of the strands. New sling rope as well as any other rope that has been cut from a long piece should be whipped at the ends.

e. Coiling. Two methods of coiling the rope are used—

(1) One end of the rope is taken in the left hand; the right hand is run along the rope until both arms are outstretched. The hands are then brought together forming a loop which is laid in the left hand. This is repeated forming uniform loops until the rope is completely coiled. If there is any tendency for the rope to twist or form figure eights, it may be given a slight twist with the right hand to overcome this. The rope should always be coiled in a clockwise direction.

(2) The rope is coiled around the left foot and knee while in the kneeling position with the left foreleg vertical. In coiling on the leg, start from the inside, bring the rope over the knee to the outside around the foot to the inside, and continue in this manner until the rope is coiled using the same technique as in the previous coil.

f. Tying of the Coil (fig. 16). In tying the coil, a 30 cm-long bight is made in the starting end of the rope and laid along the top of the coil. Uncoil the last loop and take the length of rope thus formed and wrap it around the coil and the bight. The first wrap is made at the open end of the bight in such a manner as to lock itself. Then continue wrapping toward the closed end until just enough rope remains to insert through the bight. Pull the running end of the bight to secure the wrapped rope. A rope properly coiled has from six to eight wraps. The coil can be carried either on the rucksack by forming a figure eight and doubling it, and placing the coil under the flap of the rucksack, or by placing it over one shoulder and under the opposite arm.

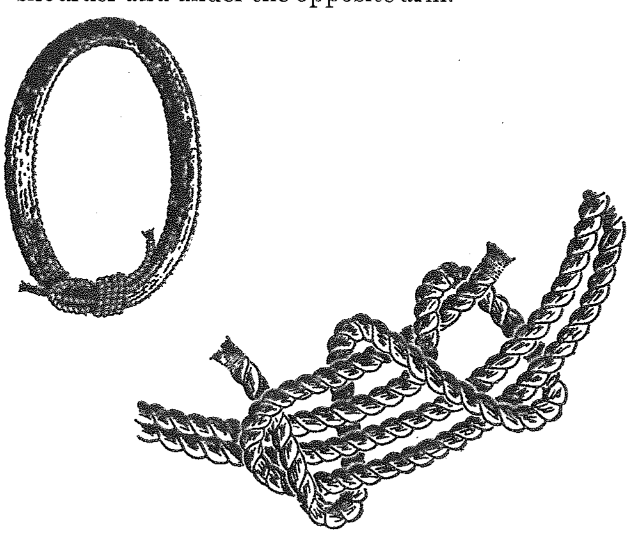


Figure 16. Tying of coil.

g. Rope Throwing. It will be necessary to carefully recoil the rope before throwing. In throwing the full 36½-meter rope, group the coil in the right hand and take the ends of the rope nearest the finger tips and anchor it. Take five or six loops from this end of the coil and hold in the left hand while retaining the remaining coil which will be thrown first, in the right hand. A few preliminary swings will insure a smooth throw. The swings should be made with the arm nearly extended, the coil should be thrown out and up. A slight twist of the wrist so that the palm of the hand comes up as the rope is thrown will cause the coil to turn, the loops to spread, and the running end to fall free and away from the thrower. A smooth follow-through is essential. As soon as the coil is thrown and spreading, the few loops held in the left hand should be tossed out. Where possible, the rope should be thrown with the wind so that the running end is to the leeward. As soon as the rope starts to leave the hand, the thrower shouts the warning "ROPE" to alert anyone below his position.

h. Terms Used in Rope Work (fig. 17).

(1) A bight of rope is a simple bend of rope in which the rope does not cross itself.

(2) A loop is a bend of rope in which the rope does cross itself.

(3) A half hitch is a loop which runs around an object in such a manner as to lock itself.

(4) The running end of the rope is the free end of the rope.

(5) The standing part of the rope is the static part.

(6) The lay of the rope is the same as the twist of the rope.

i. Knots. All knots used by the climber fall into four classes. They are—

(1) *Knots to tie the ends of two ropes together* (fig. 18). Example of this type of knot are—

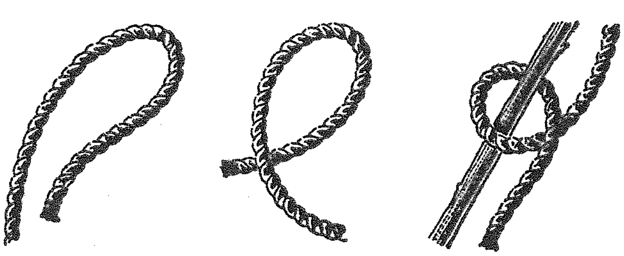


Figure 17. Bight. Loop. Half hitch.

(a) *Square knot.* The square knot is used to tie the ends of two ropes of equal diameter together and must be secured by a half hitch on each side of knot.

(b) *Double sheet bend.* The double sheet bend is used to tie the ends of two ropes together, whether of equal diameter. It can also be used to tie the ends of several ropes to the end of one rope. When two or more ropes are tied to a single rope the double bends are made with the single rope.

(2) *Anchor knots* (fig. 19). Anchor knots are used to tie the end of a rope to any object. An anchor knot is easy to tie and untie. Care must be asserted in selecting an anchor knot that will not work itself loose when alternate tension and slack are put on the rope. The round turn with two half hitches and the clove hitch may work loose under these conditions, whereas the bowline will not.

(a) The bowline is also used to tie the end man into a climbing rope and to tie stirrups in the end of a rope.

(b) The round turn with two half hitches.

(c) The clove hitch. Tension must be maintained to prevent slipping.

(3) *Middle rope knots* (fig. 20). Middle rope knots form a fixed loop or loops in the middle of a rope without using the ends. The butterfly knot is used for the middle man in a roped party and for tightening installation ropes.

(a) The butterfly will form a single loop.

(b) The bowline on a bight forms a double loop.

(4) *Special knots* (fig. 21). Examples of special type knots are—

(a) *Prusik knot.* The prusik knot is tied with a small rope around a large rope; for example, a sling rope round a climbing rope, in such a manner that the smaller rope will slide on the big rope if there is no tension applied and will hold if tension is applied on the small rope. It is tied with a bight of rope or end of rope. When tied with an end of rope the knot is finished off with a bowline. The prusik knot is used to anchor a fixed rope to various anchors and in crevasse rescue methods.

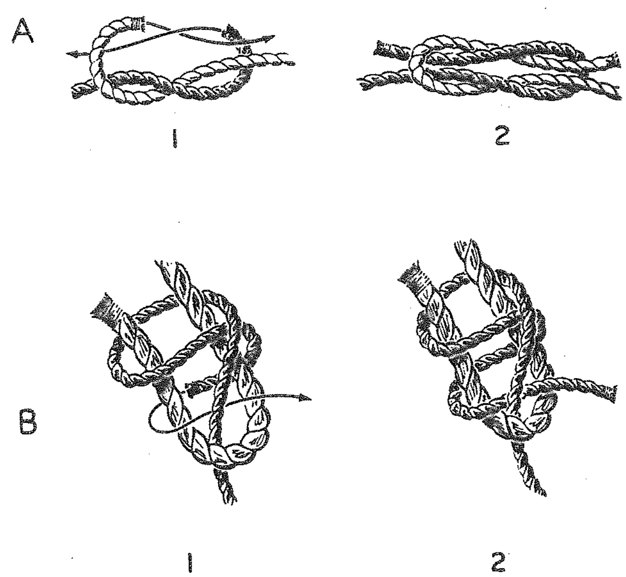


Figure 18. Square knot. Double sheet bend.

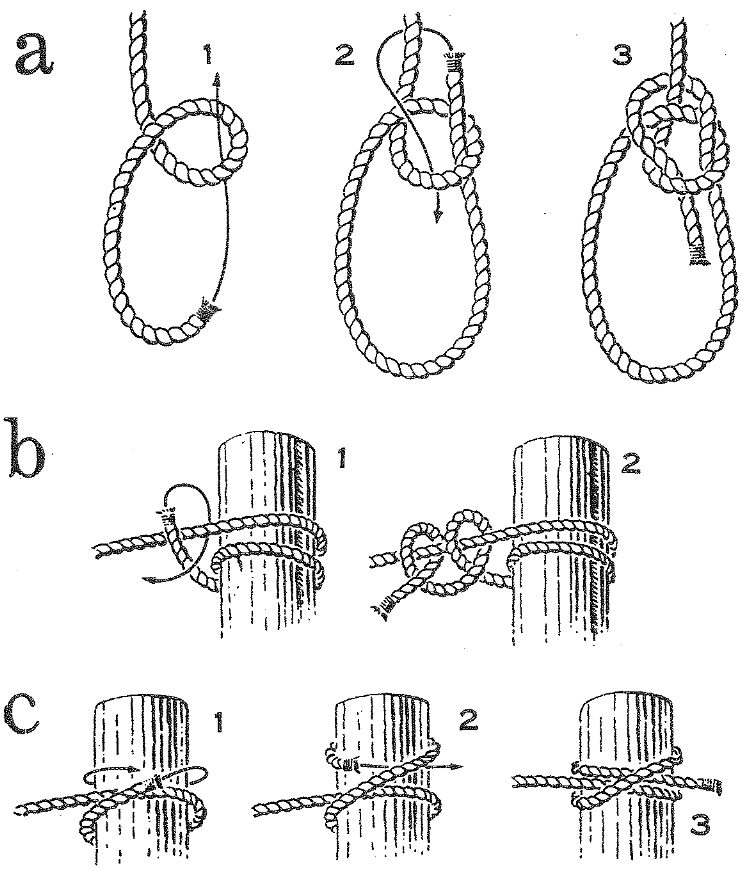


Figure 19. Bowline. Round turn with two half hitches. Clove hitch.

(b) *Overhand knot.* The overhand knot is used to make a knotted rope for a handline, to make the carrying rope for a suspension traverse, and stirrups in tension climbing. It is also used to temporarily whip the end of a rope.

(c) *Bowline on a coil.* The bowline on a coil can be used by the first and last man on a climbing rope to take up extra and unnecessary slack. A *half* hitch must be employed behind the knot.

(d) *Three loop bowline.* The three loop bowline will provide three bights, two of which can be adjusted against the other one. It is used mainly for a 4-piton anchor and in evacuation procedures.

(e) *Figure-of-eight slip knot.* The figure-of-eight slip knot is used as an anchor knot on fixed ropes.

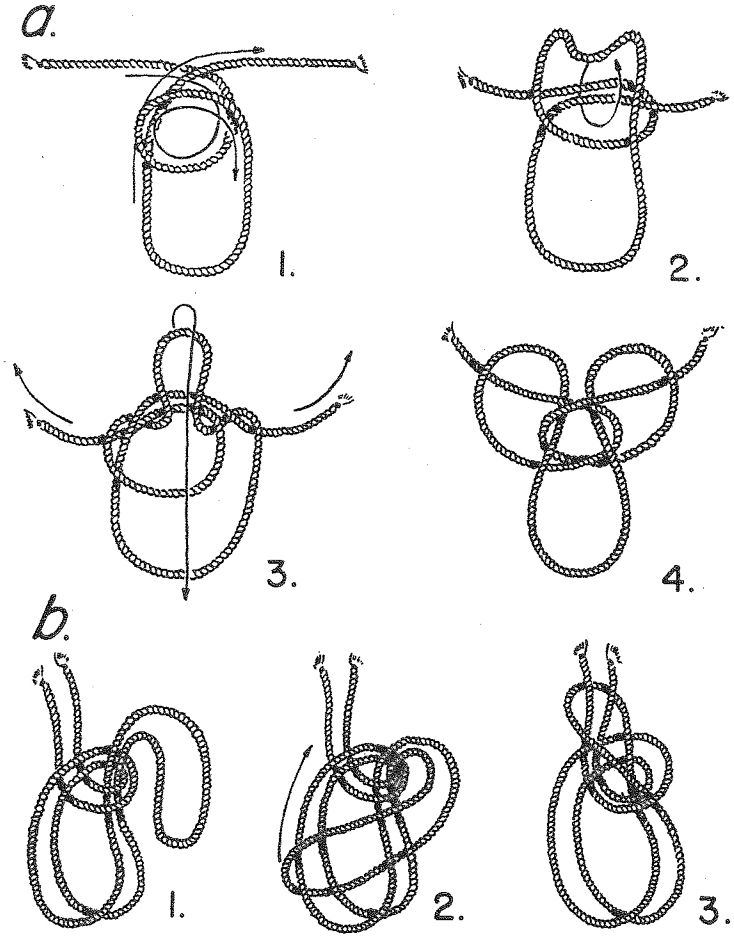


Figure 20. Butterfly knot. Bowline on a bight.

(*f*) *Transport knot.* The transport knot is used to secure the tightening arrangement on rope installations and consists of a slip knot and half hitch.

137. Pitons, Snaplink, and Piton Hammer

a. Purpose. In conjunction with rope climbing and rope installations, pitons are driven into cracks in the rock to provide—

(1) A secure point on the cliff to which the rope may be hooked by means of a snaplink. If the leading climber falls, he may be held, pulley-wise, by a man below him. Successive pitons are driven as the climber moves upward.

(2) Secure points along the course of a fixed rope so that it will give greater support to troops using the rope.

(3) Artificial anchor points for rope installations.

b. Pitons (fig. 22). There are four types of pitons for rock—

(1) Vertical, for flush vertical cracks.

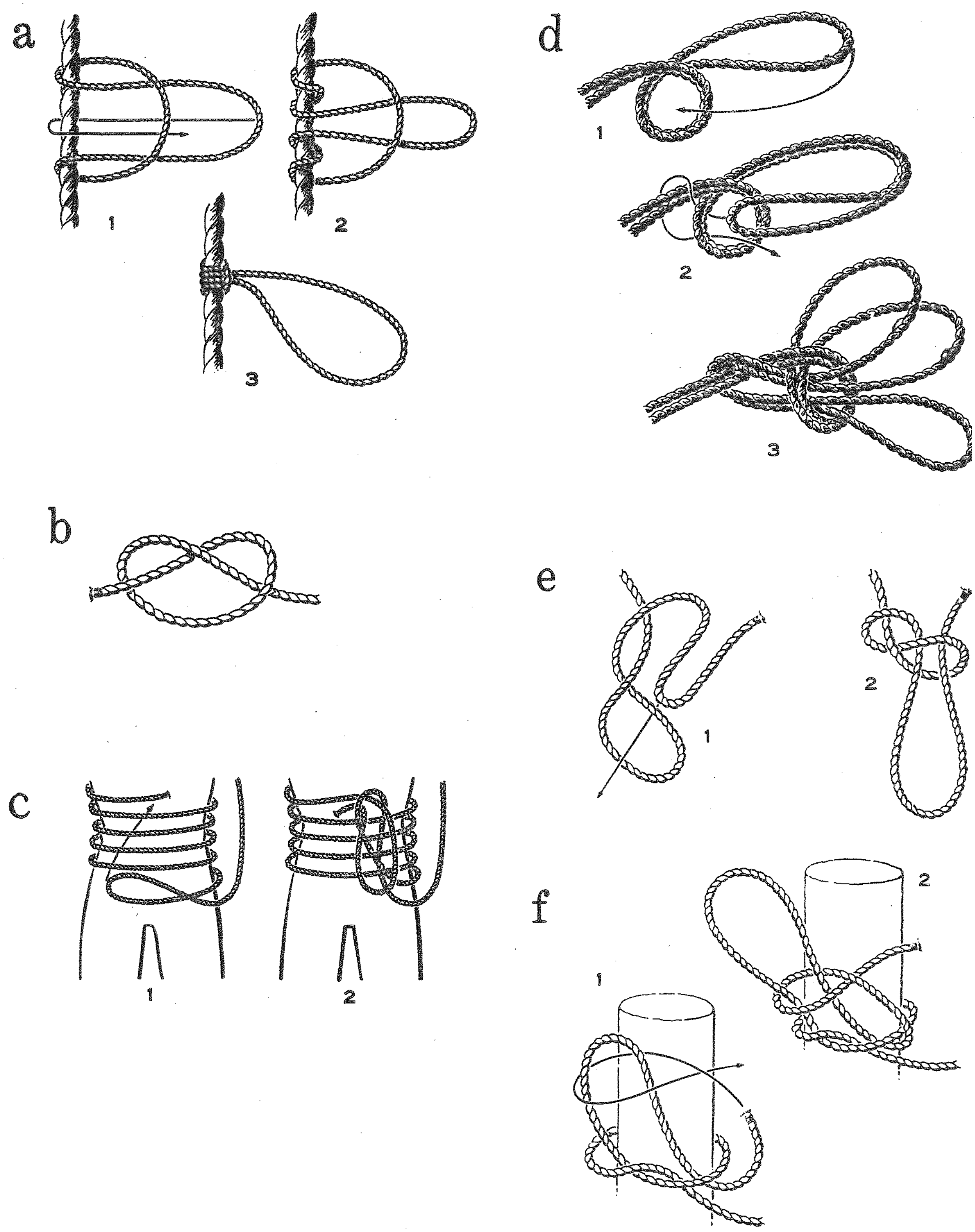
(2) Horizontal, for flush horizontal cracks and for offset horizontal or vertical cracks.

(3) Angle, for wide horizontal or vertical cracks. These must be placed with the wide or open side down in horizontal cracks and open side against either wall in vertical cracks.

(4) Wafers for shallow cracks, vertical or horizontal.

c. Placing of Pitons (fig. 23). Pitons are placed to increase the climbers safety. If well placed and tested they will limit his fall to twice the distance he is above the piton plus the amount of slack the belayer lets run. In placing pitons the climber should—

(1) *Study the rock.* See that driving of a piton will not split or weaken it. Test rock for soundness by tapping with the hammer. In hard, solid rock select a crack which is wide enough to admit 1/8



a - Prusik knot
b - Overhand knot
c - Bowline on a coil
d - Three loop bowline
e - Figure-of-eight slip knot
f - Transport knot

Figure 21.

to ½ of the piton shaft before driving the piton in. The driving of pitons in soft, rotten rock is not always practical. When this type of rock must be used, loose rock from the crack should be removed before driving the piton. In this type of rock it is not necessary to be able to insert the piton into the crack as far as in solid rock. Select the right piton; the one that the rock will support best and that the snaplink can be hooked into after the piton is driven in.

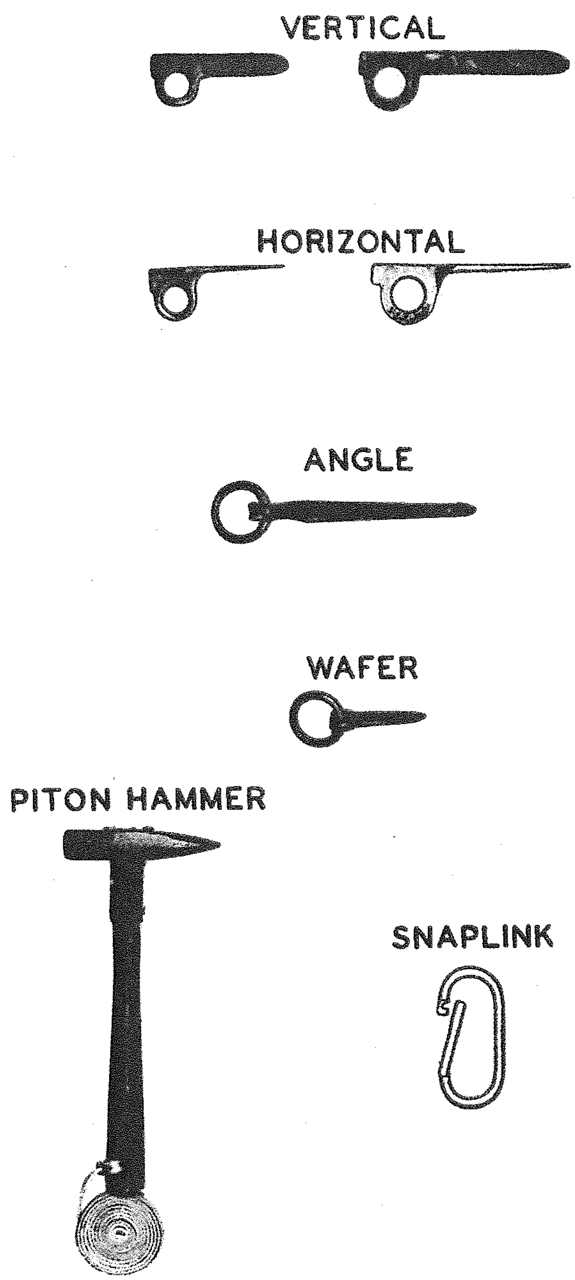


Figure 22. Pitons, piton hammer, and snaplink.

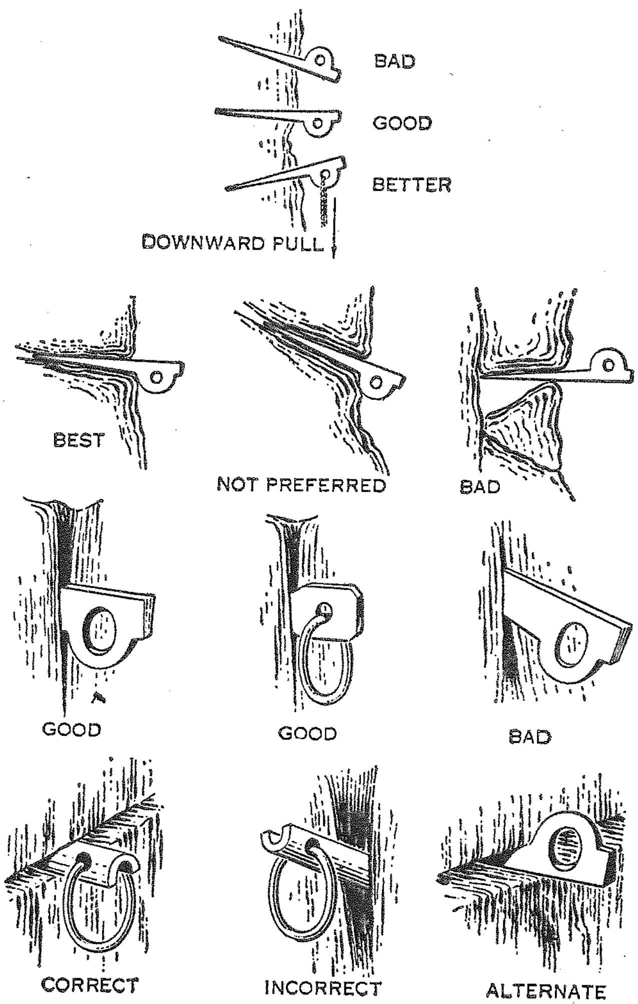


Figure 23. Placing of pitons.

(2) *Driving the pitons.* While driving watch the rock to see that it is not being weakened by further cracking. Watch the piton to see that it goes in smoothly and notice if the point hits a dead end. Listen to the piton's sound at each blow; good verticals and horizontals usually go in with a rising pitch; wafer and angle pitons will have no noticeable pitch so long as the ring is swinging free. Drive the piton with moderate strokes, similar to a finishing nail. It is advisable to have the piton attached to the hammer thong or to the sling rope. If the piton is then knocked out of the crack while it is being

driven, it will not be lost. The greater the resistance overcome in driving the piton, the firmer it will be. An appropriately placed and well-driven piton into rock of average strength will withstand a force of from several hundred pounds (wafer) to more than 2,000 pounds (angle) exerted in the direction a fall would take.

(3) *Testing of pitons.* Pull up approximately one meter of slack on climbing rope, or use sling rope or piton hammer thong; snap rope into snaplink; grasp rope at least ½ meter from the snaplink. Jerk vigorously outward, downward, and to each side, meanwhile observing the piton. Repeat if the test is questionable. Tap the piton. If the pitch has changed much, drive the piton in as far as possible; if the sound regains its original pitch the piton is good. If not, drive the piton in another place.

d. Snaplink. The snaplink is used to fasten the rope to the piton, and will hold a load of 2,000 pounds when the gate is closed. In snapping it into the piton, the climber should see that the snaplink will not cause unnecessary friction as he climbs beyond it, and that the gate is not likely to open accidentally because of pressure exerted by rock, rope, or piton.

e. Piton Hammer. The piton hammer is used to drive pitons. The point is used for chipping rock or ice and cleaning out piton cracks, and not for pulling out pitons. The hammer is too lightly constructed to stand the stress. It is provided with a leather thong to secure the hammer to the body. When not in use the hammer is carried in the hip or breast pocket.

f. Second-Hand Pitons. Pitons that have been used, removed, bent, and straightened should not be used. In training areas, pitons already in place should not be trusted, inasmuch as weathering will loosen them in time. They should be tested and redriven until the climber is certain of their safety.

g. To Remove Pitons. The climber should knock the piton back and forth in the crack with the piton hammer or rock, and when they are somewhat loosened, pull them out with a bight of the climbing rope or sling rope, or hammer thong, which has been hooked into a snaplink. It is advisable to be well braced when pulling out pitons, they sometimes tend to come out very suddenly, it is also advisable to see that no one is close enough to be struck by the extracted piton.

138. Belays

a. Purpose. In party climbing, two or three men are tied in to a 36½ meter climbing rope. Belaying provides the necessary safety factor or tension, enabling the party to climb with greater security. Without belaying skill, the use of rope in party climbing is a hazard, not a help. When one man is climbing, he is belayed from above or below by another man who may use any one of several belaying positions. Belaying is also used to control descent on fixed installations. A static belay is one which allows no running of the rope. A dynamic belay is one in which the rope is allowed to run slightly and the fall is stopped more gradually.

b. Procedure for All Positions. The belayer must perform the following duties:

(1) Run the rope through his guiding hand, which is the hand on the rope running to the climber, and around his body to his braking hand, and make certain that it will slide readily.

(2) Anchor himself to a reliable rock projection or well placed piton, with a portion of the climbing rope or his sling rope if his position is unsteady.

(3) Make sure remainder of ropes is so laid out as to run freely through the braking hand.

(4) See that the rope does not run over sharp edges of rock.

(5) Be constantly alert to the climber's movements in order to anticipate his needs. Avoid letting too much slack develop in the rope through constant use of the guiding hand. Gently tug the line running to the climber, thus sensing his movement. Avoid taking up slack too suddenly, to prevent throwing the climber off balance. When taking up slack the braking hand is not brought in front of the guiding hand, but just behind the guiding hand. This allows the braking hand to slide back and to remain constantly on the rope.

(6) Brace well for the expected direction of a fall, so that the force of the fall will, whenever possible, pull the belay man

more firmly into position. A climber should neither trust nor assume a belay position which he has not tested.

(7) Where necessary, seek a belay position that offers cover and concealment.

(8) Be able, in case of a fall, to perform the following movements automatically—

(*a*) Relax the guiding hand.

(*b*) Let the rope slide enough so that braking action is applied gradually. This is done by bring the braking hand slowly across the chest or in front of the body.

(*c*) Hold belay position, even if this means letting the rope slide a few meters.

c. Belay Positions (fig. 24). There are three main types of belay positions—the sitting, the standing hip, and piton belays. All of these may be made more secure when the belayer is tied with a section of the climbing rope or the sling rope into a belay. When the climbing rope is used, a clove hitch or a butterfly knot is tied into the rope which is secured with a snaplink and a piton. In using the sling rope, it is passed through the snaplink and around the belayer and then secured by a square knot. In both cases it is important that the anchor rope has the proper length without slack so that the belayer will not be pulled out of his position when holding a fall. The placement of the belay rope is determined by the directional pull of a possible fall of the belayed climber. If the pull is downward the rope is placed above the anchor rope and if the pull is upward the belay rope should be placed below the anchor rope.

(1) *Sitting belay.* This is normally the most secure and preferred position. The belayer sits and attempts to get good triangular bracing by his legs and buttocks. Legs should be straight whenever possible, and the guiding hand must be on the side of the better braced leg. The rope should run around the hips. If the belay spot is back from the edge of a cliff, friction of the rope will be greater and will simplify the holding of a fall, but the direction of pull on the belayer will be directly outward. The rope should not pass over sharp edges.

(2) *Standing hip belay* (fig. 25). This is a weaker belay position and is only used where the sitting belay is not possible. An anchor for the belayer is essential. The belayer takes up a secure, well braced position. If possible, the back or shoulder is braced against the rock. The rope is placed around the back above the heavy portion of the hips and in front

Figure 24. Sitting belay.

to the braking hand in such a way that the belayer is pulled more firmly into position when a fall is held. The climbing rope is placed either above or below the anchor rope according to the direction of pull of the belay rope.

(3) *Piton belay* (fig. 26.). As soon as the leading climber has placed a reliable piton and placed his rope into a snaplink which has been placed into the piton, the climber gives the signal "BELAY FOR PITON" to the belayer. The belayer should run the belay rope below his buttocks and a low anchor in line with the direction of pull. The breaking arm should be extended. When a fall occurs, both knees should be bent to prevent the rope from sliding above the buttocks. As much rope as necessary is allowed to slide through the hand while the braking hand is brought in with steadily increasing resistance across the body in a dynamic belay. A fall is easier to hold with a piton belay than with a sitting or standing belay because of the added friction between rope, rock, and snaplinks. For this reason it is essential that the belayer use a dynamic belay to prevent the fall being stopped suddenly. When belaying a climber in a traverse which is near or horizontal to the belayer, the belayer must anticipate a pull sideways and straight forward, and should place the climbing rope above his buttocks and be anchored in.

Figure 25. Standing hip belay.

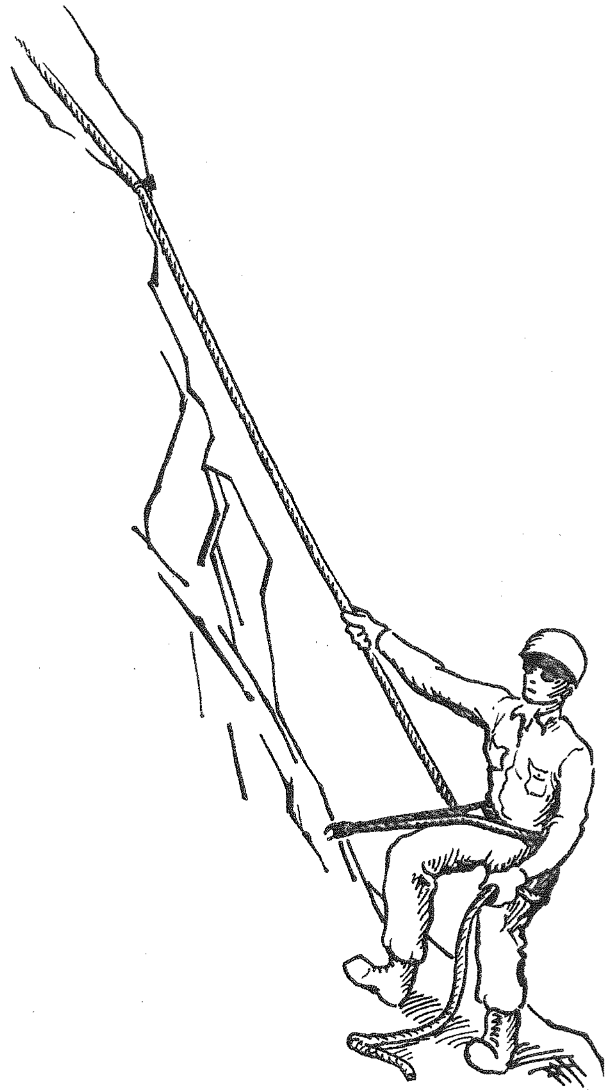


Figure 26. Piton belay.

(4) *Use of natural anchors.* Where possible, the leading climber should pass his rope behind rock projections or trees which can give the same protection as a piton. He should avoid passing the rope over sharp edges or small cracks where the rope could jam or cause too much friction. When a rock or tree belay has been established, the climber should signal "BELAY FOR ROCK, OR TREE" as the case may be and the belayer assumes a piton belay position. Likewise the belayer can increase his holding capability by placing the belay rope around a tree or rock nubbin in belaying directly to these natural objects.

d. Belaying. After the climber has taken up a belay position. he calls, "ON BELAY," "TEST," which is answered by the man being belayed in calling "TESTING" at which time he puts his weight gradually on the rope without going off belay. Care must be taken that the rope is not jerked suddenly when starting the test, as this might pull the belayer out of position. The test should be made if possible in the direction of a possible fall. If, during the test, the position is found insecure, the belayer will signal "OFF BELAY." The climber must release all tension at once and maintain his belay position. The belayer must then find another position and have the test procedure repeated. When the position is satisfactory, the belayer calls "CLIMB." The climber answers him with the signal, "UP ROPE," in order to have the belayer take up the slack before he climbs. This procedure must be followed to prevent accidents.

139. Rappels

a. Purpose. The climber with a rope can descend quickly by means of a rappel—sliding down a rope which has been doubled around such rappel points as a tree, projecting rock, or several firm pitons secured one to the other with a sling rope.

b. Establishing a Rappel.

(1) In selecting the route, the climber should be sure the rope reaches the bottom or place from which further rappels or climbing can be done.

(2) The rappel point should be tested carefully, and inspected to see that the rope will run around it when one end is pulled from below and that the area is clear of loose rocks which may be pulled off.

(3) If a sling rope must be used for a rappel point, it should be tied twice to form two separate loops.

(4) The first man down should—

(*a*) Choose a smooth route for the rope, free of sharp rocks.

(*b*) Place loose rocks, which the rope might later dislodge, far enough back on ledges to be out of the way.

(*c*) See that the rope will run freely around the rappel point when pulled from below.

(5) Each man down will give the signal "OFF RAPPEL," straighten the ropes and see that the rope will run freely around its anchor. When silence is needed a prearranged signal of pulling on the rope is substituted for the vocal signal.

(6) When the last man is down, the rope is recovered. The climber should pull it smoothly, to prevent the rising end from whipping around the rope, and he should stand clear of falling rope and the rocks which may be dislodged by it.

(7) Inspect the rope frequently if a large number of men are rappelling on it.

(8) Climbers must wear gloves for all type rappels to protect the palms from severe rope burns.

c. The Body Rappel (fig. 27). The climber faces the anchor point and straddles the rope. He then pulls the rope from behind, runs it around either hip, then diagonally across the chest and back over the opposite shoulder. From there the rope runs to the braking hand which is on the same side as the hip the rope crosses; for example, the right hip to the left shoulder to the right hand. The climber should lead with the braking hand down and should face slightly sideways. The foot corresponding to the braking hand should precede the other at all times. He should keep the other hand on the rope above him just to guide himself and not to brake himself. He must lean out at a sharp angle to the rock. He should keep his legs well spread and relatively straight for lateral stability and his back straight since this reduces unnecessary friction. The collar should be turned up to prevent rope burns on the neck. Gloves should be worn and any other article of clothing

Figure 27. Body rappel.

may be used as padding for the shoulders and buttocks.

d. The Hasty Rappel (fig. 28). Facing slightly sidewise to the anchor, the climber places the ropes across his back. The hand nearest to the anchor is his guiding hand and the lower hand does the braking. To stop, the climber brings his braking hand across in front of his body locking the rope and at the same time turns to face up toward the anchor point. This rappel should be used only on moderate pitches. Its main advantage is that it is easier and faster than the other methods, especially when the rope is wet.

e. The Seat Rappels. The seat rappels differ from the body and hasty rappels in that the main friction is absorbed by a snaplink which is inserted in a sling rope seat fastened to the rappeller. This method provides a faster and less frictional descent than the other methods. Gloves should be worn to prevent rope burns.

(1) *Attaching the seat.* The sling rope is placed across the back so that the midpoint (center) of its length is on the hip opposite to the hand that will be used for braking. An overhand knot is tied in front of the body. The ends of the rope are brought between the legs (front to rear), around the legs and over the hips and tied with a square knot and two half hitches on the side opposite the braking hand. The snaplink is placed through the single rope around the waist and through the two ropes forming the overhand knot. The snaplink is inserted with the gate down and the opening toward the body. The snaplink is then rotated one half turn so that the gate is up and opens away from the body (fig. 29).

(2) *Seat-shoulder method* (fig. 30). In facing the rappel point, the rappeller snaps into the rope which passes up through the snaplink. The rope is then brought over one shoulder and back to

Figure 28. Hasty rappel.

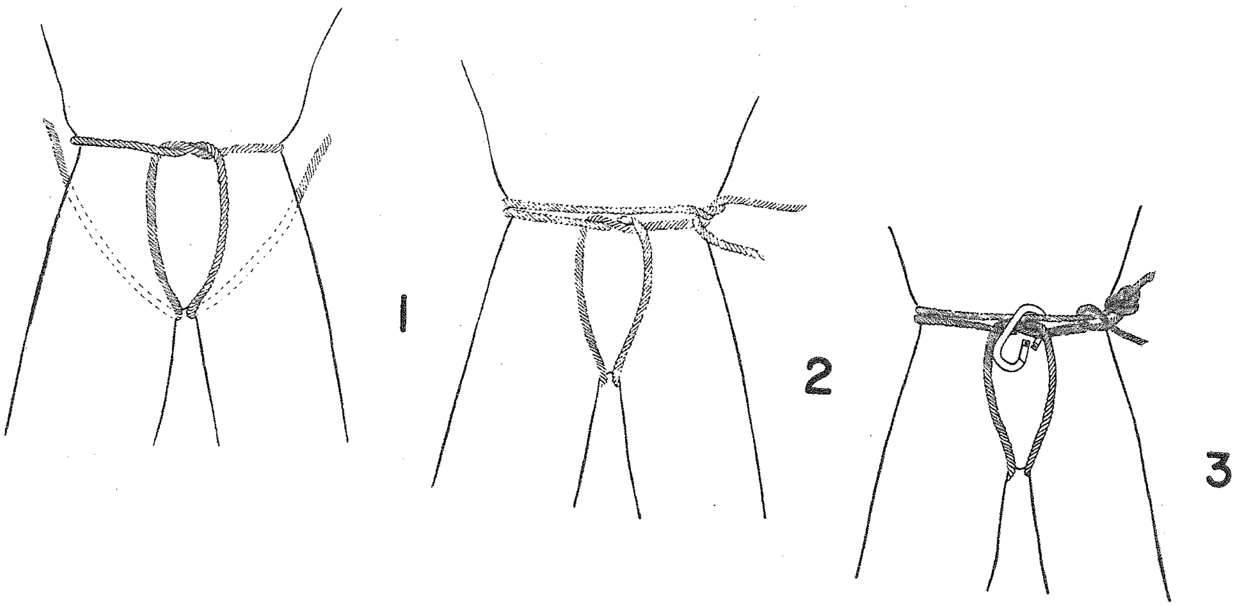


Figure 29. Seat and placing of snaplink in seat.

the opposite hand (left shoulder to right hand). The same techniques are used in the descent as in the body rappel. This method is faster than the body rappel, less frictional and more efficient for men with packs and during night operations.

(3) *Seat-hip method* (fig. 31).

(*a*) The rappeller stands to one side of the rope (when braking with the right hand on the left and when braking with the left hand on the right side) and snaps the rope into the snaplink. *Some slack between the snaplink and the anchor point* is taken up and brought underneath, around and over the snaplink and snapped into it again. This results in a turn of rope around the solid shaft of the snaplink which does not cross itself when under tension.

When a single rope is used two wraps around the snaplink are made to increase friction. Facing sideways, the climber descends using his upper hand as the guiding and the lower as the braking hand. The rope is grasped by the braking hand with the thumb pointing down and towards the body. The braking hand is held behind and slightly above the hip.

(*b*) Braking action is obtained by closing the hand and pressing the rope against the body. The rappeller should lean well out, at an angle from the rock, and make a smooth and even descent. This method is the least frictional and fastest. However, special care must be taken that the rope is snapped correctly into the snaplink to avoid the possibility of the gate being opened by the rope. Loose clothing or equipment around the waist is apt to be pulled into the snaplink locking the rappel. For these reasons the rappel must be checked carefully before each descent.

f. Helicopter Rappels (fig. 32). Rappelling from utility and cargo helicopters has indicated applicability for mountain operations. Small groups of men can be quickly landed on inaccessible terrain with minimum effort. In rappelling from helicopters, the rappeller uses a seat rappel and employs the shoulder method. Rappels can be made the full length of the 36½ meter climbing rope. For details of helicopter rappelling, see FM 31–71.

140. Route Selection

Terrain must be appreciated if an efficient route is to be found through it with necessary speed. Every mountain reconnaissance unit should include climbers experienced enough to be able to estimate friendly or enemy capabilities in the region. Consideration should be given to the time element and

Figure 30. Seat-shoulder rappel.

skill of the troops involved, equipment available, and the support required. Probable effect of weather on the mission must be studied and care used in route selection to avoid danger of rock slides and other mountain hazards.

a. Scope. The military mountaineer must make detailed reconnaissance, noting with respect to each rock obstacle, the best approach, height, angle, type of rock, difficulty, distance between belay positions, concealment along the route, amount of equipment, and number of trained climbers needed to accomplish the mission on or beyond the rocks. If the strata dips toward the climber, holds will be difficult as the slope will be the wrong way. However, strata sloping away from the climber and toward the mountain mass will provide natural stairs, with good holds and ledges.

b. Vantage Points. At least two vantage points should be used, so that a three-dimensional understanding of the climb can be attained. Use of early morning or late afternoon light, with its longer shadows, is helpful in this respect. Actual ground reconnaissance should be made if possible.

c. Dangers To Avoid.

(1) On long routes, changing weather will be an important consideration. Wet or

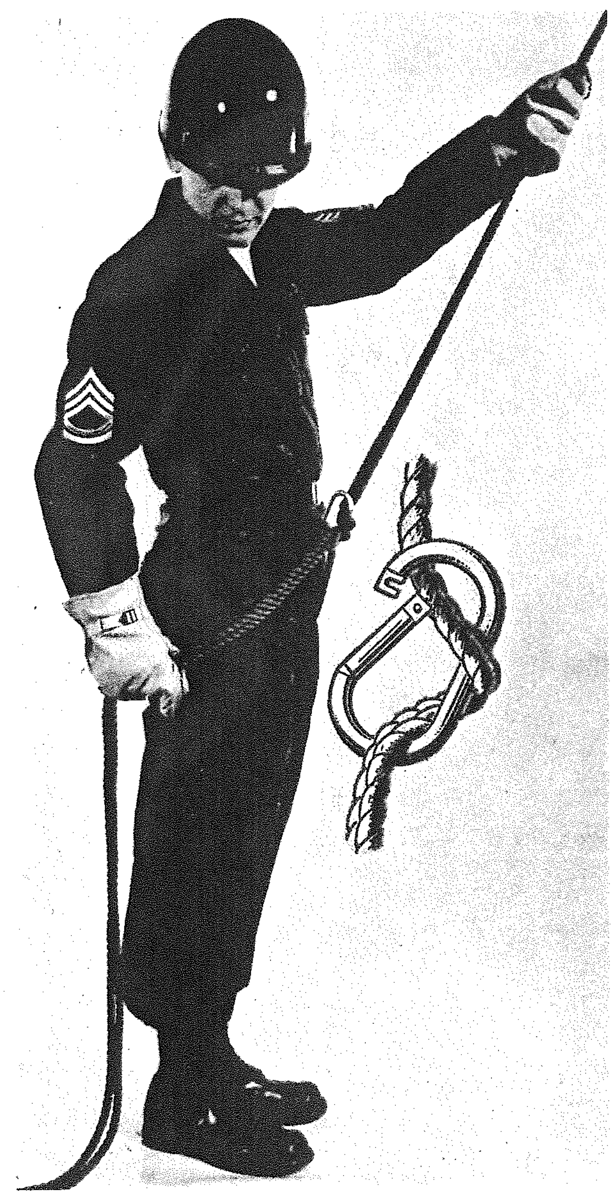


Figure 31. Seat-hip rappel.

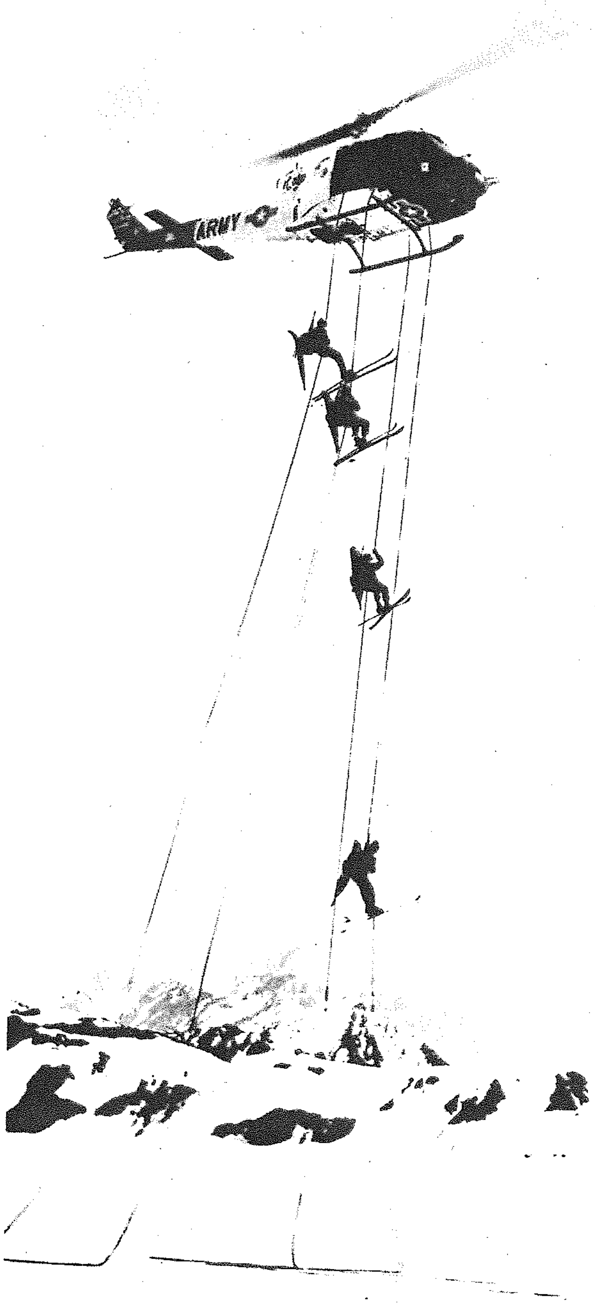


Figure 32. Helicopter rappelling.

icy rock can make an otherwise easy route almost impassible; cold may reduce climbing efficiency, snow may cover holds; a cloudy night may be too dark for travel; a lifting fog may remove necessary concealment too soon. A weather forecast should be obtained if possible.

(2) Smooth rock slabs are treacherous, especially when wet or iced after a freeze and rain. Ledges should then be sought.

(3) Rocks overgrown with moss, lichens, or grass become treacherous when wet. Cleated or nailed boots will then be far better than composition soles.

(4) Tufts of grass and small bushes that appear firm may be growing from loosely packed and unanchored soil, all of which may give way if the grass or bush is pulled upon. Grass and bushes should be used only for balance by touch or as push holds, not as pull holds.

(5) Gently inclined but smooth slopes or rock may be covered with pebbles that will roll treacherously underfoot.

(6) Ridges may be free of loose rock, but may be topped with the most unstable blocks in the region. Moreover, the climber is likely to skyline himself on a ridge. A route along the side of a ridge just below the top is usually best.

(7) Gullies provide the best defilade, and often the easiest routes, but are more subject to ambush and to rock-falls from natural or enemy sources. The side of the gully is relatively free from this danger.

(8) Climbing slopes of talus, moraine, or other loose rock is not only tiring to the individual but dangerous, because of the hazard of rolling rocks to others in the party. Climbers should close up intervals when climbing simultaneously. Large groups should attempt to find numerous parallel routes.

(9) In electrical storms lightning can endanger the climber. Peaks, ridges, pinnacles, and lone trees should be avoided.

d. Rock Falls.

(1) Falling rock is the most common mountaineering danger. The most frequent causes of rock falls are—other climbers; great changes of temperature in high mountains and resultant splitting action of intermittent freezing and thawing; heavy rain; grazing animals; and enemy fire.

(2) Warning of a rock fall may be the cry "ROCK," a whistling sound, a grating, a thunderous crashing, or sparks where the rocks strike at night.

(3) Rock falls occur on all steep slopes, par-

ticularly in gullies and chutes. Areas of frequent rock falls may be indicated by abundant fresh scars on the rock walls; fine dust on the talus piles; or lines, grooves, and rock-strewn areas on snow beneath cliffs.

(4) Immediate action is to seek cover if possible, to move if cover is not available. If enough advance warning is given, the climber should watch the falling rock until he knows he is out of danger, otherwise he might move directly into its path by blindly trying to avoid it.

(5) Rock-fall danger is minimized by careful climbing, and by judgment in choice of route.

Section III. MOVEMENT OF TRAINED PERSONNEL

141. Free Climbing

Much of the movement of a trained climber whose mission may be that of guide, observer, assault-team member, or security element will be without the aid or encumbrance of a rope. The terrain may not be difficult enough to require use of rope. Enemy action may require greater speed than will be possible with rope, the danger from enemy fire overbalancing the danger of unroped falls. Or, once the route for the main body has been selected and found relatively easy to travel, security elements may need to make only short scrambles to either flank. Free climbing will sacrifice the safety that results from use of the rope. In terrain so rugged that precise routes must be followed, or on which fixed ropes would be desirable for inexperienced men but are not available, the trained climbers can be posted as guides at critical points to coach or otherwise assist untrained men over steep, hazardous portions.

142. Roped (Party) Climbing

a. Purpose. Trained climbers tie together two or three men to the 36½ meter rope when, by so doing, they increase their mutual safety and ability on difficult rock. When one man is climbing he is belayed from above or below by another man. A two-man party is about three times as fast as a three-man party. The strongest team is made up of two parties of two.

b. Procedure.

(1) *Two-man party*

(*a*) One man chosen as leader because of his ability and experience will normally climb first. Both men tie in with a bowline on a coil. The second man takes a belay position and starts the test procedure. Having found his position satisfactory, he gives the order, "CLIMB." The leader will then climb to a suitable belay position. He should not take long leads, particularly where the climbing is difficult. If, because of the lack of a suitable belay position, he has to take a long lead, or if the climbing is precarious, the leader should use pitons for safety. In this case the belay man adapts his position to an upward pull of the rope. The use of too many pitons will cause excessive friction on the rope. The belayer should watch the slack and inform the climber by the call "6 METERS" when he estimates that there is only 6 meters of rope left. When the climber has reached a belay position, he calls "ON BELAY" and the test procedure follows.

(*b*) While the second man climbs to reach the new belay position he removes any snaplinks. When the second man has reached the belay position he will change position with the belayer, the first man, or if more convenient the climbers may bypass each other and lead alternately. This will speed up the climbing. The above procedure is repeated until the objective is reached.

(2) *Three-man party.*

(*a*) In a three-man party each man will have a number, the leader being number 1, the middle man, number 2, and the end man, number 3. The middle man must be a good belayer and the third man will usually be the least experienced man. If, as rarely occurs, a treacherous horizontal traverse must be negotiated, the least experienced man may be tied in the middle where he can be belayed from the man above him as well as from below. The signals are the same as for a two-man party, except that the number of the man involved must be used with the signal.

(*b*) For example, the middle man may give the order, "Number 1, CLIMB" or "Number 3, CLIMB," to which the proper reply is, "Number 1 CLIMBING" or "Number 3 CLIMBING." The leader climbs from the starting point to the first belay position, brings up number 2 and climbs up to a second belay position. He provides what security he can while number 2 brings up number 3. Number 2 then follows number 1, who then climbs to the third belay position. When not climbing, number 3 provides security either in the military sense or where desired as anchor man for number 2 when he is belaying. Similarly, number 1 man provides security while number 3 climbs. It must be remembered that no man climbs until so ordered by his belayer, and only one man climbs at a time.

(3) *General rope signals.* In addition to the belay signals, certain others are useful. The call "UP ROPE" is used when a climber discovers excess slack in his belay rope. The call "SLACK" is used when the rope is too tight for maneuver. If the climber is in trouble and wants a tight rope he calls "TENSION." The call "FALLING" should be used to warn the belay man if the climber believes himself about to fall. When silence is necessary or a high wind distorts vocal signals, information can be conveyed by a prearranged system of jerks on the rope.

(4) *Descent.* Where rappelling is not used, the party will descend in an order decided upon by the leader. If route selection is the primary consideration, the leader may want to go down first; if, however, it is more important to provide belay security, he will go down last. More often than not the latter will be the case. Security for the last man down can be provided by the use of pitons.

(5) *Simultaneous movement.* When the slope becomes gentler for a stretch, the movement of the entire party can be expedited by having all the men move at once. All men carry slack rope in neat coils which can be paid out or added to as the distance between the men varies. The rope must be kept off of the ground but not taut.

(6) *Tension climbing* (fig. 33). In tension climbing the belayer holds the leader to the rocks by means of the climbing rope and pitons, the snaplinks in each piton serving as a pulley. Thus the leader is able to move up, sideways, and even up an overhand by driving successive pitons for tension, even though the natural holds are inadequate. Since, at best, tension climbing requires long experience and considerable equipment and is very exhausting to the climber, it should be used only as a last resort. The tension climber should—

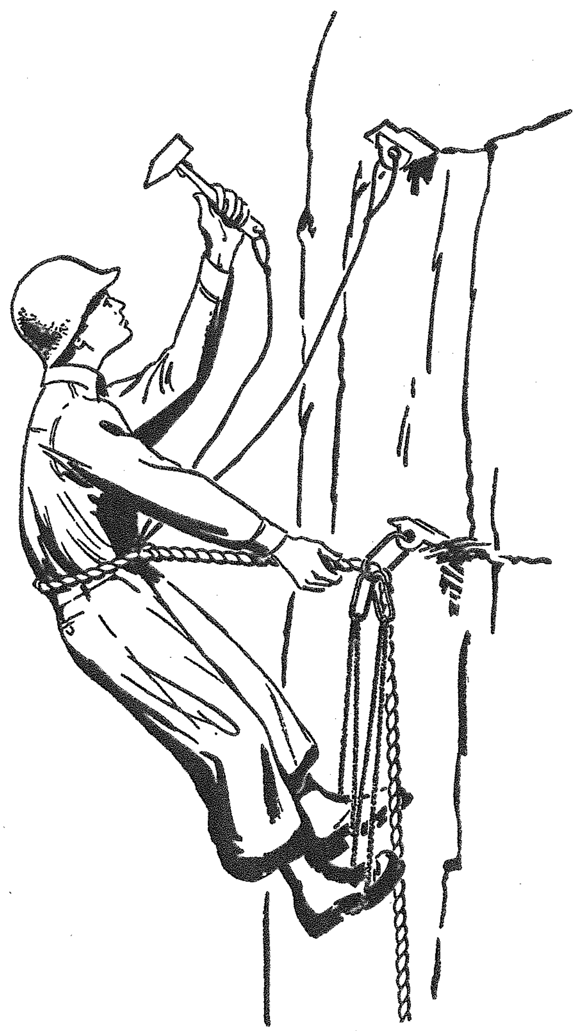


Figure 33. Tension climbing.

(*a*) Tie in with a bowline on a coil, finishing with a half hitch around the last single loop, leaving sufficient rope end to tie a bowline or figure-of-eight slip knot in the end of the climbing rope for a rest loop. A snaplink is placed in this loop and fastened to the piton in front of climber to give him security while he advances the rope and to allow the belayer to rest.

(*b*) Drive pitons no closer together than is necessary for safety.

(*c*) Never hook a finger in a piton, but put in snaplinks and climbing ropes and hold them.

(*d*) Use stirrups made from sling ropes for foot holds if their use is deemed necessary. To form a stirrup, the ends of the sling rope are tied together with a square knot. An overhand knot is tied in the middle of the loop thus formed but a little off center so that the knot at the bottom is to one side. Another overhand knot is tied at the top or opposite end from the joining knot and is again offset so that this loop hangs open. A snaplink is then inserted through the small top loop.

(*e*) Rely on the belayer's tension, keeping both hands free for the work above.

(*f*) Use alternate (two-rope) tension for the most difficult pitches. This is easier if there are two belayers. However, if there is only one belayer, the following method may be used: The rope from the leader's waist passes around the belayer's waist. The second rope, fastened around the leader's hips runs to the same side of the belayer as the first rope, and beneath his hips. The leader climbs, the belayer holding him to the cliff with tension first on one rope and then on the other, always keeping one of the ropes slack so that the leader can snap into the next higher piton.

(*g*) The belayer should anticipate the leader's needs so that few signals need be given.

(*h*) When the leader needs tension to climb a pitch, the second man will also need assistance on the pitch. This is furnished by rope slings left in the pitons or, if alternate tension has been used, one of the two ropes can be tied at the top as a handline.

Section IV. UNIT MOVEMENT

143. Basic Aids for Unit Movement

The capabilities and duties of trained mountaineers and their functions in assisting unskilled individuals and units in mountain operations have been covered in paragraph 77. The basic elements for the techniques applicable to movement are—

a. Anchors. In the setting up of all rope installations the problem of the main anchor is a great one. The ideal situation is to have some good natural object such as a firmly rooted tree or solid rock nubbin. Since this is not always available, anchors must be made or devised by artificial means. These are called "deadmen" and the leader of the installing party must decide which form is most efficient in regards to speed of installation, safety, and durability.

(1) *Natural anchors* (fig. 34). Since these are always preferable, their use should be studied with care. If a tree is to be used, its firmness is of the greatest importance. This is especially true if the

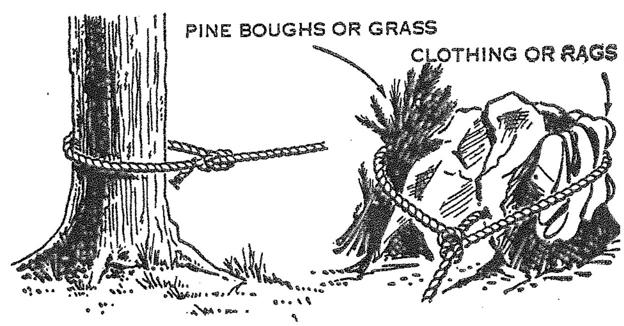


Figure 34. Natural anchors—tree—rock.

installation will be used for any length of time. Trees growing on generally rocky terrain should be treated with suspicion, since their roots normally are shallow and spread out along a relatively flat surface. If the tree has been found satisfactory, the rope may be tied to it with any of the anchor knots. If the installation is to be used for a great length of time, the bowline or the round turn with two half hitches is preferable to the clove hitch. If rock nubbins can be used, their firmness is again of primary importance. They should be checked for cracks or any other signs of weathering that may impair their firmness to any extent. If any of these signs exist on a nubbin, its use should be avoided except in cases of absolute necessity, and then only after careful and thorough testing. Sharp edges will almost always be found on nubbins and these should be padded carefully with extra clothing, rags, branches, or grass.

(2) *Artificial anchors* (fig. 35). Artificial anchors can be divided into two main classes. These are anchors that are installed in earth or dirt and those that are put on rock with pitons.

(*a*) Artificial anchors in earth are of two types. The single timber deadman is the safest type, although its construction requires considerable effort. A trench 2 meters long and 1 meter deep and wide enough to work in should be dug at right angles to the direction of the pull. The side of the trench towards the strain should be slanted so that it is at right angles to the pull. Another trench about 30 cm wide is dug so that it intersects the main trench at a 90° angle in the middle. The bottom of this trench should be parallel to the strain and should meet the bottom of the main trench. A log 2 to 3 meters long and 30 cm minimum in diameter is normally used for the deadman. The log is then put into the main trench and covered with dirt with the exception of the part adjoining the second trench. If the dirt is not firm, stakes the same length as the depth of the trench should be placed between the deadman and the slanted side in an upright position.

(*b*) The picket holdfast is easier to construct, but will not hold as much strain as the deadman. Two meter pickets, 8 cm in diameter, are driven into the ground a depth of one meter, one behind the other in the same direction as the pull. The head of each picket, except the last one, is secured by lashing it to the base of the next one in line. The lashings should be tight as possible and racked. The pickets should be driven at right angles to the line of pull and the distance between the pickets should be one to two meters. The anchor line is tied at the base of the picket closest to the load.

(*c*) The four piton anchor is the least desirable of all anchors and its use should be avoided whenever possible. At least four pitons are driven firmly and solidly into the rock. In the rope, one less bight than pitons are tied in such a manner as to leave a running end of

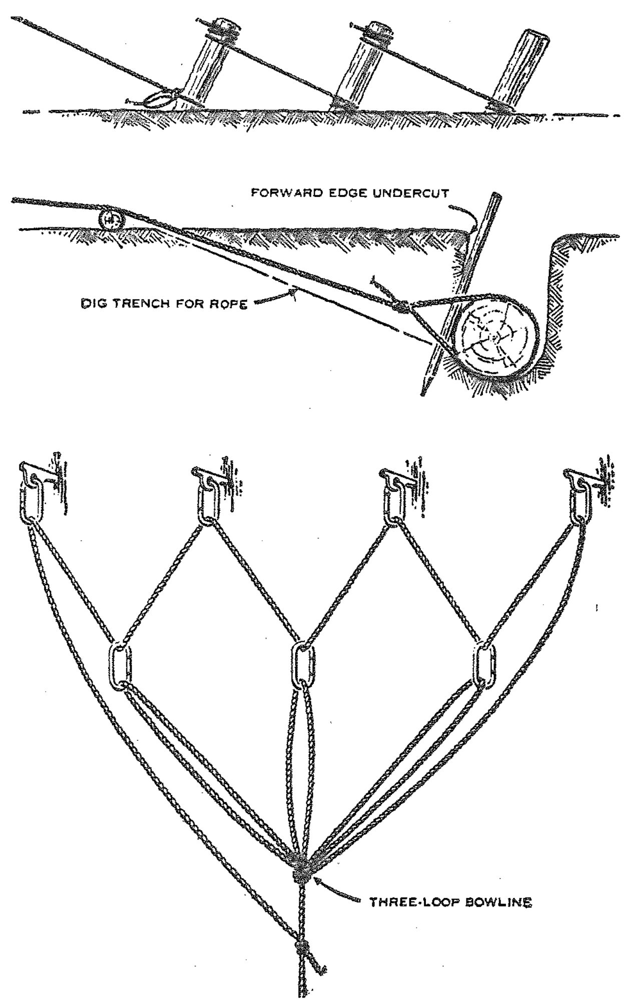


Figure 35. Artificial anchors—picket holdfast, deadman (timber in trench), pitons.

at least 5 meters (for instance, if four pitons are used, a three-loop bowline will provide the necessary bights). Snaplinks are placed in all the pitons and bights. Starting with a piton on either extreme end, the running end is placed in the snaplinks alternately between the pitons and bights. It is then tied in back to the standing part. This anchor must be checked frequently. If one piton should pull out, the strain will be equalized between the others; at the first opportunity the piton anchor should be set up again.

b. Tightening Knots. For tightening fixed ropes, suspension traverses, or any other similar installation.

(1) *Transport tightening knot* (fig. 21). A butterfly knot is tied in the static line far enough in front of the anchor to allow for tightening of the rope with the bight of the butterfly approximately 30 cm long. This knot should also be placed so that it acts as a safety factor for the man descending, preventing him from hitting the lower anchor. A pulley effect, for tightening the static line is obtained by inserting a snaplink into the butterfly, passing the running end around the anchor and inserting it through the snaplink. The transport knot is made by tying a slip knot secured with a half hitch.

(2) *Prusik tightening knot* (fig. 36). A butterfly knot is tied in the static line far enough in front of the anchor to allow for tightening of the rope, with the bight of the butterfly approximately 30 cm long. This knot should also be placed so that it acts as a safety factor for the man descending, preventing him from hitting the lower anchor. A pulley effect, for tightening the static line, is obtained by inserting a snaplink into the upper loop of the butterfly, passing the running end around the anchor and through a prusik knot in the bight of the butterfly, and finally through the snaplink. The prusik knot, as the static line is tightening through use of mechanical advantage, acts to cinch the tightening rope. The running end is then secured with a half hitch on the rope opposite to the prusik knot (fig. 37).

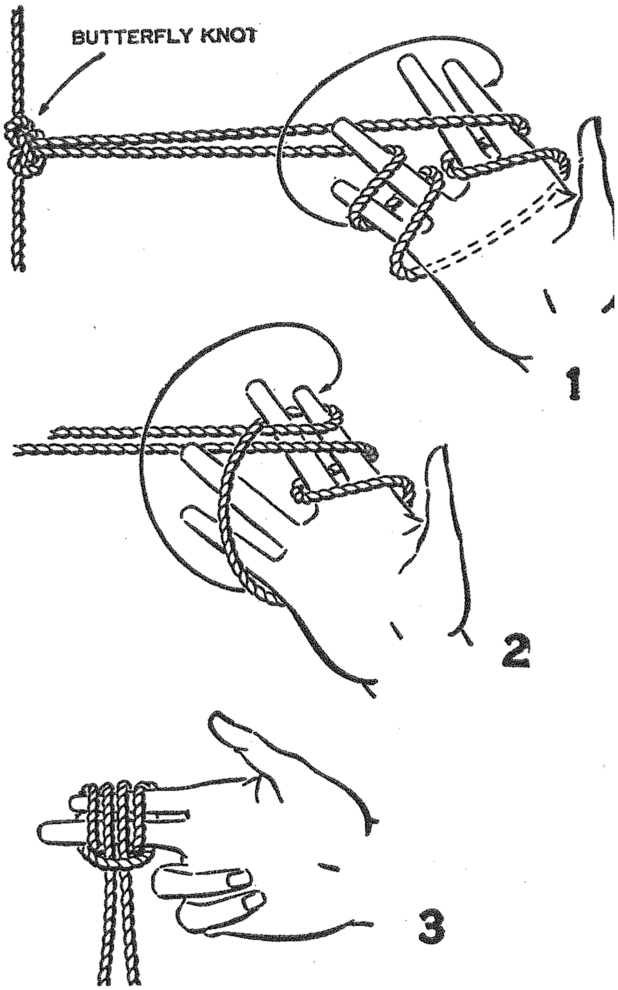


Figure 36. Prusik tightening knot.

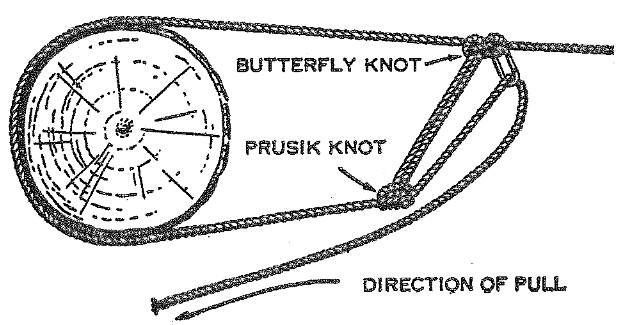


Figure 37. Use of butterfly knot and prusik knot in tightening.

c. A-*Frame* (fig. 38). An A-frame is constructed in the following manner: two sling ropes are tied together, secured to two sturdy 3 to 4 meter long poles (approximately 1 meter from the top) with a clove hitch on one pole and then wrapped horizontally around the poles six to eight times and vertically four to six times, and finally the ends are tied tightly with a square knot and finished off with half hitches. When the bottoms of the poles are spread apart, the resulting bipod forms the A-frame. To keep the bottom of the A-frame from spreading, the poles are braced by tying a sling rope between the two poles, securing it on each leg with a clove hitch or round turn and two half hitches.

144. Fixed Ropes

Once troops are familiar with the basic elements outlined in paragraph 141, the following fixed ropes may be installed to assist individuals and units in moving over difficult terrain with their equipment, weapons and supplies.

a. Simple Fixed Rope (fig. 39). Simple fixed rope is made by anchoring one end of a climbing rope and using the line thus formed to aid in climbing. The procedure is as follows: number 1 ties in, plans route, and climbs on signal from number 2 who belays, or sees that the rope runs free. At top of pitch number 1 takes up slack, either ties the rope to an anchor point, or gets into a body belay. After installation, the unskilled men then climb, using the rope for all desired aid. Only one man climbs at a time, and signals to the next man, "CLIMB," when he has reached the top. In difficult places overhand knots can be tied into the rope to assist the men climbing. The last man up retrieves the rope and coils it.

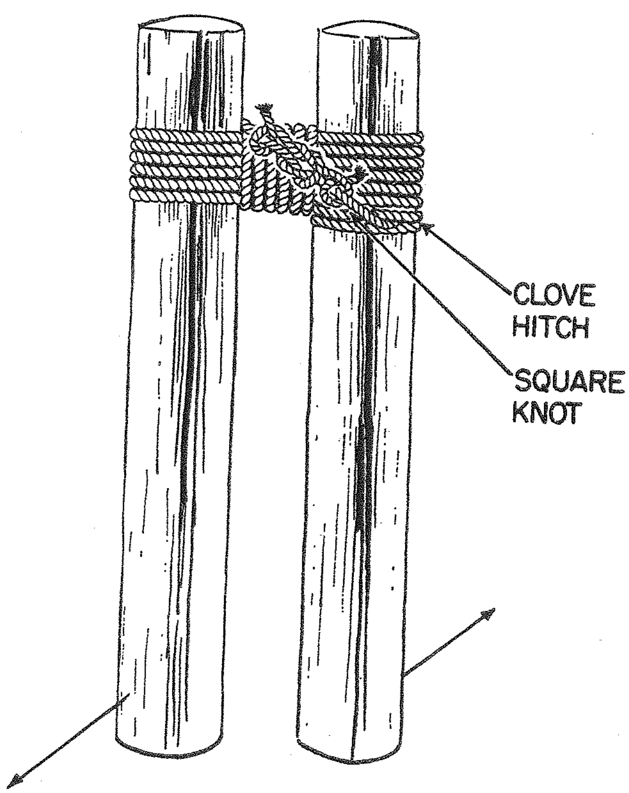


Figure 38. A-*frame.*

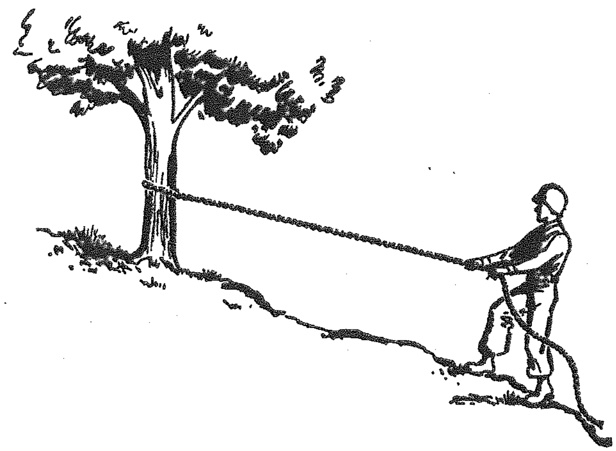


Figure 39. Simple fixed rope.

b. Fixed Ropes (fig. 40).

(1) Fixed ropes are installed by trained military mountaineering teams, and are used to assist untrained men, or trained men with heavy loads, over difficult terrain safety and quickly. This type of installation differs from the simple fixed rope in that it employs many anchor points and is of a more permanent nature. To install—number 1 ties into the leading end of the rope and moves up to selected route threading the rope through snaplinks inserted in pitons he has driven, or sling ropes tied to natural anchors. Number 2 remains at the starting point, belays number 1 and sees that the rope runs freely, warning the climber when only 6 meters of rope remains. Should more rope be required, another climbing rope is tied to the first rope. When the fixed rope is installed from above down, number 1 man secures the rope with an anchor knot to the top anchor. If descending he

then ties the fixed rope to the intermediate anchor points, tightening the rope with prusik knots to anchored sling ropes and figure-of-eight slip knots into snaplinks while he is still belayed by number 2 man. As he reaches the lower anchor point the fixed rope is then finished off with a transport tightening knot.

(2) When the fixed rope is secured from the bottom up, the number 2 man anchors the rope at the bottom anchor while the number 1 man secures the rope temporarily to the upper anchor. As the number 2 man moves up to the number 1 man he anchors the rope to the intermediate anchor points and the rope is then secured with a transport tightening knot at the upper anchor. When the installation team consists of several members, they assist in securing the fixed rope to the intermediate anchor points while the number 2 man moves up to join the number 1 man. In this manner each section between anchors is tightened independently. The prusik knots and the slip knots in the snaplinks serve both to increase the tension of the rope and to make each section independent. This is a safety factor—a break in one section of the rope will not affect another section. The prusik knot or slip knot should be tied slightly above the anchor point. The transport tightening knot is used to finish off the fixed rope. Emphasis should be placed on the use of natural anchor points throughout fixed rope and care taken in its installation to obviate the necessity of troops crossing it at any point. When snaplinks

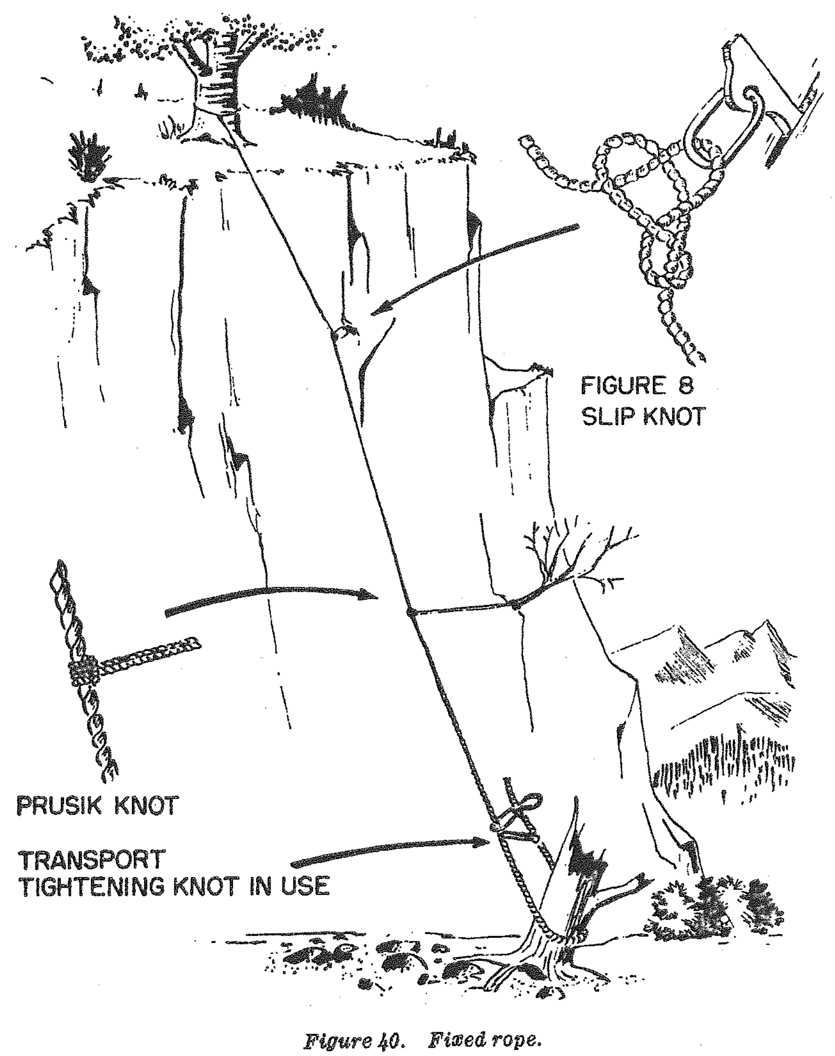


Figure 40. Fixed rope.

are unavailable, sling ropes in pitons may be used.

(3) Maintenance of the fixed rope is the responsibility of the team that installed it. It is also their duty to police the route, removing loose rocks, brush, and any other hindrance to the rope and troops, and to protect the rope with padding where necessary. A diagonal or traversing route should be chosen for reasons of safety. The route should not be so difficult that the troops arrive at the top too exhausted to complete their mission. Troops moving over a fixed rope must remember and use all the techniques of mountain walking and climbing. Use the fixed rope for direct aid only when necessary, but always have at least one hand on the rope. On difficult pitches employ friction footholds by leaning back and climbing hand over hand on the rope.

145. Hauling Lines

When inexperienced men carrying heavy loads are required to climb fixed ropes, it may become necessary to set up hauling lines to move the loads. The lines may be vertical hauling lines or suspension traverse. Expedients may often serve well for all described equipment except the rope.

a. Vertical Hauling Lines. A vertical hauling line is an installation for moving men or equipment up vertical, or near vertical pitches (fig. 41). It is often used in conjunction with a fixed rope where the fixed rope is used for troop movement and as a hauling line for their equipment. Generally three climbing ropes, sufficient snaplinks, and the equipment for construction of an **A**-frame are necessary for this installation, but any expedients may be used that will aid the construction.

(1) To install, select a route which has a good top anchor point, a natural loading and unloading platform at the bottom and the top, and which affords sufficient clearance for easy hauling of troops or equipment. The ideal platform at the top will allow construction of the vertical hauling line without use of an **A**-frame, otherwise the construction will be as follows: The anchor rope is doubled and the end with the bight placed between the top **V** of the **A**-frame so that a 30 cm long loop hangs down. A clove hitch is tied on each pole and the ropes tied to the same anchor. Another rope is then tied to the same or different anchor, passed through the top of the **V** of the **A**-frame, or through the **A**-frame, as appropriate; is then knotted with overhand knots evenly spaced and approximately 20 to 30 cm apart and then lowered. This is the rope used by the troops as a simple fixed rope as they are being hauled up the pitch. Two snaplinks are inserted in the loop hanging from the **A**-frame to form a pulley. A pulley rope is formed by tying the ends of a climbing rope with a square knot and half hitches, and inserting it into the snaplinks.

(2) There are several ways of tying into the pulley rope—with a sling rope seat attached to the pulley rope; with a snaplink inserted in a butterfly knot; or with two butterfly knots tied so that when they are passed around the body and connected with a snaplink a belt is formed. If only two climbing ropes are available the anchor rope and knotted rope may be combined, and a double sling rope used for the pulley loop. If equipment only is being hauled up, it is not necessary to use the knotted rope but it may be necessary to use a belay rope from the bottom to prevent equipment from striking the rock. To move materials or troops up on one side of the hauling line, the other side is pulled from below.

(3) Troops using the hauling line for movement must employ all applicable principles of climbing. At least one man should always be stationed at the top of the installation to aid men or retrieve loads when they reach the top. He should be anchored for safety reasons. In use, the **A**-frame should lean slightly over the edge of the cliff to prevent excessive wear on the ropes passing over sharp rocks.

b. Suspension Traverse. The suspension traverse is used to move men and equipment, over rivers, ravines, chasms, and up or down cliffs (fig. 42). The traverse may be made on a plane varying from the horizontal to the near vertical. To install a suspension traverse a suitable route

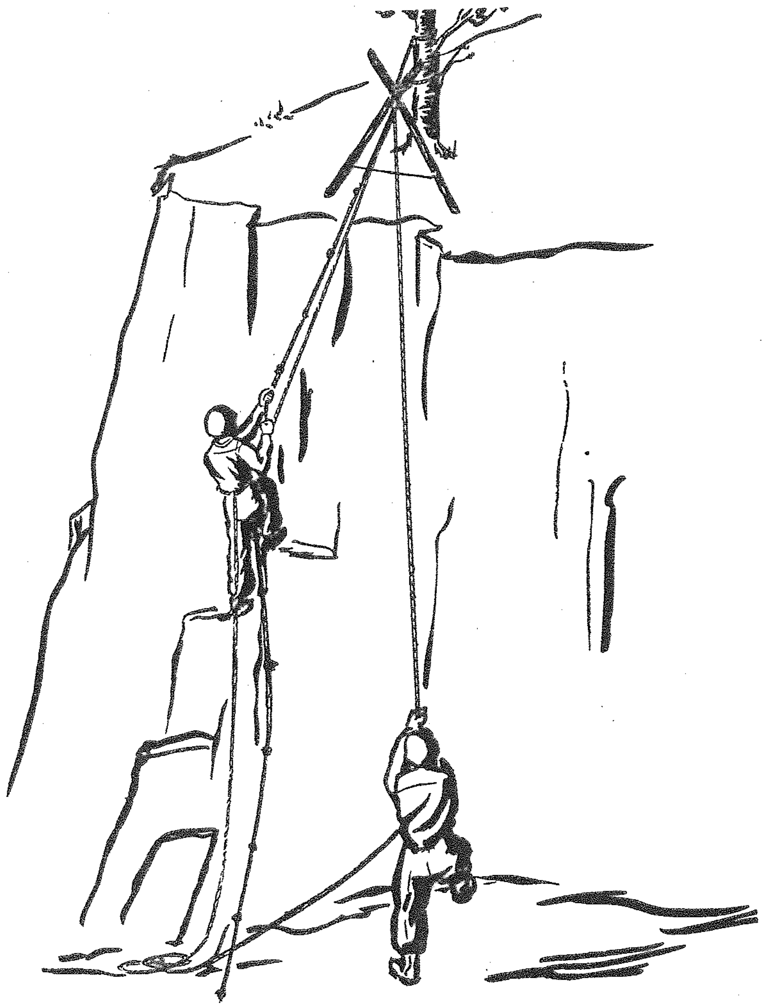


Figure 41. Vertical hauling line.

for the traverse must be reconnoitered with emphasis placed on the location of suitable anchor points. These must be of sufficient height to allow clearance of loads being transported over any obstacles. The static line must be carried to the upper or farther anchor by a single man or a climbing party, and secured. It is then secured to the other, usually lower, anchored and tightened by use of a tightening knot. If nylon climbing rope is to be used as a static line, it should be used double to minimize sagging and increase the safety margin. A 2½ cm manila rope should be used for installations which get heavy use. A carrying rope is now made by tying the ends of a sling rope with a square knot and half hitches, doubling the rope thus formed, and placing the square knot in the upper third. An overhand knot is tied into the loop above the square knot and a second overhand knot is then tied slightly below it. The belay rope is tied to the center of the three loops of the carrying rope and then a snaplink is inserted into the upper small loop and into the static line (fig. 43). To secure either the loads or the men to the static line this carrying rope is merely passed through the seat or lashings and the larger loop snapped into the snaplink or the static line. When the man or load has been hooked onto the static line, a belayer lowers the load by using a body belay, a belay through a snaplink, or around a tree, and stops him gradually as he nears the bottom. If it is a steep traverse, and the descent is rapid, protective padding must be used by the belayer to reduce the friction on the body. If the load is being raised or the traverse is horizontal, it will be necessary to have a belay rope from both anchor points and to pull the load up or across and retrieve the carrying rope.

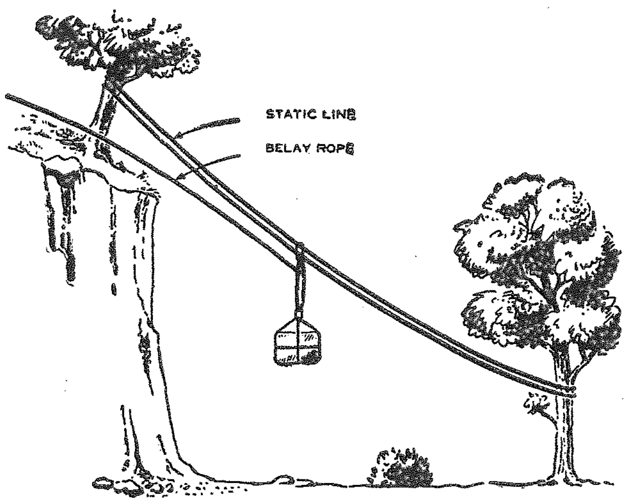


Figure 42. Suspension traverse.

146. Mountain Stream Crossings

a. The techniques of the trained climber may be used in crossing mountain streams. Sudden rains or thaws can change placid streams into roaring torrents. These may have to be crossed without special equipment or the assistance of specialized troops. All mountain soldiers should be trained in crossing mountain streams.

b. The best time for crossing is in the early morning when the water is low. As glaciers, snow, or ice melt during the day, the rivers rise, reaching their maximum height between midafternoon and late evening, depending on the distance from the source.

c. Prior reconnaissance of possible crossings must be made before the arrival of the main body, so that the best place for the crossing may be selected. A crossing point should be chosen, if possible at the widest point of the stream, or where it branches into several smaller streams. Cover should be available on the banks. Wherever possible, select a point where there are few, if any, large stones in the river bed. Water is turbulent over large stones, while it flows smoothly over small stones. Large stones increase the difficulty of maintaining an easy footing. The place for crossing should be clearly marked on both banks.

d. Shoes should be worn to prevent foot injuries, but socks should be removed and kept dry.

e. A shallow stream with a moderate current can be forded without the use of ropes or logs. Men should cross in a line four abreast without linking the arms or affording each other support. The strongest and most able men are placed at the ends of the line for additional safety. The river

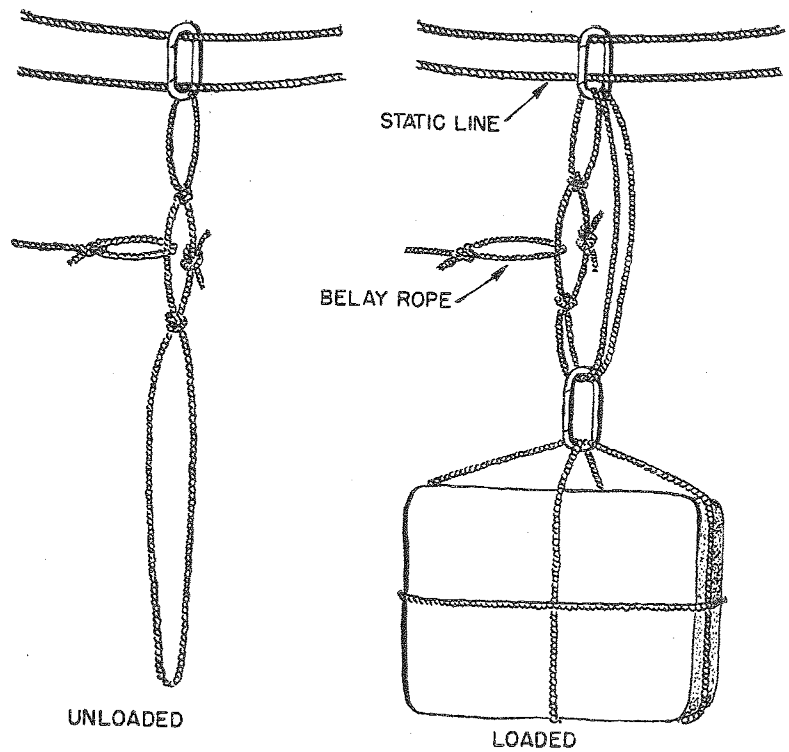


Figure 43. Carrying rope for use on traverse.

should be crossed at angle, upstream. The feet should be wide apart, and kept flat with the bed of the stream, and should always be set down on the upper side of any obstruction in the stream bed. The legs should be dragged through the water, not lifted, so that the force of the current will not throw the individual off balance and drag him under.

f. Swifter and deeper rivers may be crossed by groups of men assisting each other.

(1) To cross using the ring method, a squad of men form in a ring, locking hands with each other and placing the arms behind their backs. The body is bent well forward.

(2) In the chain crossing, a squad of men form in line, lock arms with each other, and then cross their own arms and lock their hands in front to give added support. The line then moves across diagonally downstream.

(3) Use of bridge and stream crossing expedients are covered in paragraph 147.

g. Wherever possible, and when the degree of experience permits, torrential streams should be forded individually in order to effect speedier crossing. If the current is moderate and the water less than knee deep, a staff or a walking stick may be used and worked ahead of the individual on the downstream side. Only experienced soldiers should attempt an individual crossing of a strong, deep current and then should proceed with utmost caution. A balance pole may be used and worked ahead of the individual, always on the upstream side. The weight of the body must be evenly distributed between the pole and the feet to maintain the necessary two points of support. The pole is first moved forward and planted, and the feet are then moved ahead.

h. (1) Rapids, or a fast-moving deep stream which is filled with large boulders, may be crossed by jumping from stone to stone. Logs or trees may be felled from the banks to facilitate the movement. As a safety measure, the rope should be used during the crossing. Individuals tie themselves in and are belayed by the security man who must pay the rope out gradually in order that the movements of the men will not be impeded. The bowline knot should be used for the tiein. The hip belay may be used by the security man.

(2) When jumping from boulder to boulder, the soldier should jump from a crouching position pushing off simultaneously with both feet, and landing with both feet flat on the rock.

(3) The first man to cross takes up a good belay position and helps to insure the safety of those following.

i. (1) If the current of a river is rapid and deep, and yet can be crossed by using a rope support, a handline is strung from bank to bank. The most experienced individual is tied into a rope and belayed across the stream. The rope is then tied into whatever supports can be found on each bank, and the unit crosses in column.

(2) When crossing it is imperative that each individual stay on the downstream side of the rope, as the current has a tendency to pull one under the rope.

(3) If equipment is being carried, it is advisable to use a sling rope around the individual's waist and attached to the handline with a snaplink.

(4) For carrying an injured man across, a rope seat may be made and attached to the individual who is to carry the injured man. The injured man is then hoisted to the back of the carrier and fitted into the rope seat. For additional security, a snaplink attachment is made to the hand line from a rope around the carrier's waist. The carrier then makes the crossing as prescribed for the other individuals.

(5) Rescue posts are set up at various points downriver on both banks. These posts should be manned with best men, equipped with ropes and poles. If the current sweeps a man off his feet and downstream, he is then rescued at the rescue posts.

(6) The last man to cross removes the rope from its belay point, ties himself in, and is belayed across the river from the opposite bank.

j. Where powerful torrents of water between sheer cliffs are encountered, a suspension traverse should be used.

(1) The individual selected to take the rope across must be the best trained, most ex-

perienced man in the unit. He ties himself in securely. The man crossing uses a balance pole as described in *g* above. The stronger the current, the greater is the angle at which the pole must be placed in the water.

(2) The crossing is assisted by the belayer who pays out the rope as the crossing man advances. If there are large boulders protruding from the river and lying in or near the path of the man crossing, he should utilize the rocks by crossing so that the rope falls against the upstream sides of the stones, thus affording himself an intermediate belay.

(3) As soon as the crossing man arrives on the opposite bank, he ties the rope to a solid anchor.

(4) Once the rope is tied in, it is so tightened from bank to bank that it is several feet above the water.

(5) Individual rope seats such as are used in rappelling with a snap link may be made up for each man. The snaplink in front of the rope seat is then snapped into the crossing rope and the individual swings out, pulling himself across. Only one man should cross at a time.

147. Bridge and Stream Crossing Expedients

Standard bridges and stream crossing expedients are described in FM 5–10 and TM 5–271. Special bridges and other crossing expedients useful in mountain operations are—

a. Branches Covered With Snow. Snowshoe, ski, and foot troops can use branches covered with snow as a crossing expedient to traverse shallo streams.

b. Ice. Ice bridges can be constructed and use as a crossing expedient. For details of construc tion see FM 31–71.

c. Rope Crossings. There are three accepte rope crossing methods, all of which require climber to establish the anchor on the other side c the crevice or ravine.

(1) *One-rope bridge* (fig. 44). The one rope bridge is constructed using the 36! meter climbing rope. Because of th stretch factor in nylon rope, gaps exceed ing 20 meters should not be bridged utiliz ing this method. The rope is anchore with a round turn and two half hitche and is tied off at the other end with transport knot. The method used t cross the one-rope bridge is known as th horizontal traverse. This traverse can b accomplished by three means—

(*a*) The crosser lies on top of the rop with the left instep hooked on the rop and the left knee bent, the right le hangs straight to maintain balance Progress is made by pulling with th hands and arms.

(*b*) The crosser hangs below the rope sus pended by the hands and heels crossec over the top of the rope.

(*c*) In the final approach, the same methoc used in (*b*) above is employed excep the crosser ties a rappel seat and ties into the one-rope bridge with a snaplink. Of the three methods employed, this is the safer one and hence the preferred (fig. 44).

(2) *Two-rope bridge* (fig. 45). This bridge is constructed similarly to the one-rope bridge, except two ropes are used. The ropes are spaced approximately 1.5 meters apart at the anchor points. For safety, a snaplink attachment is made to the hand and foot rope from a rope tied

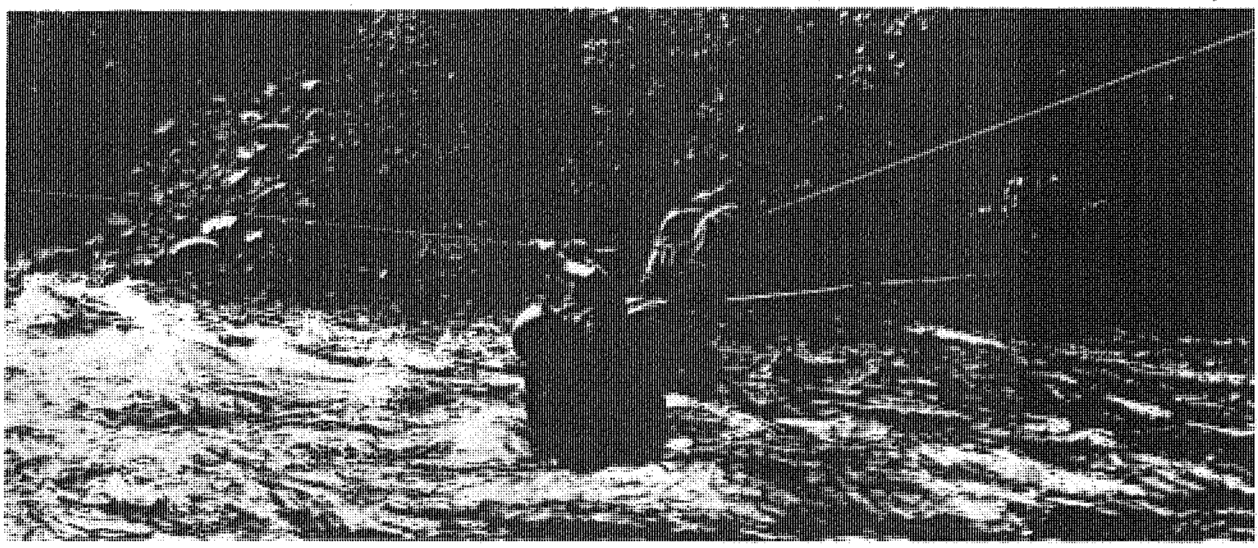


Figure 44. One-rope bridge.

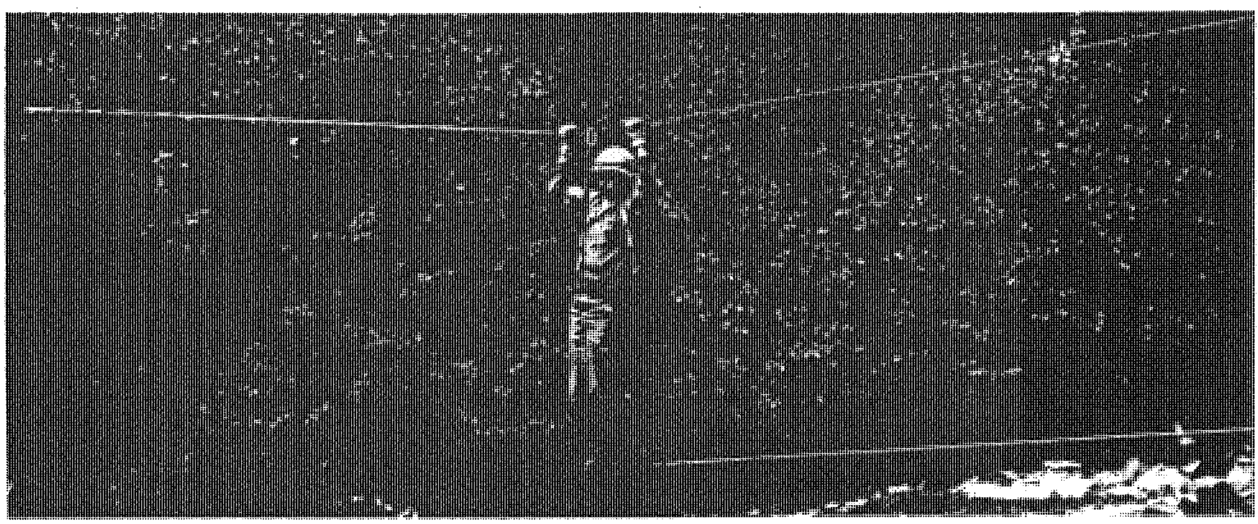


Figure 45. Two-rope bridge.

around the waist of the crosser. The snaplinks allow the safety rope to slide with the crosser as he progresses across the bridge.

(3) *Three-rope bridge* (fig. 46). Details of construction of the three-rope bridge are fully described in TM 5-279.

d. Suspension Bridges and Cableways (fig. 47). Suspension bridges and cableways are described in detail in TM 5-270.

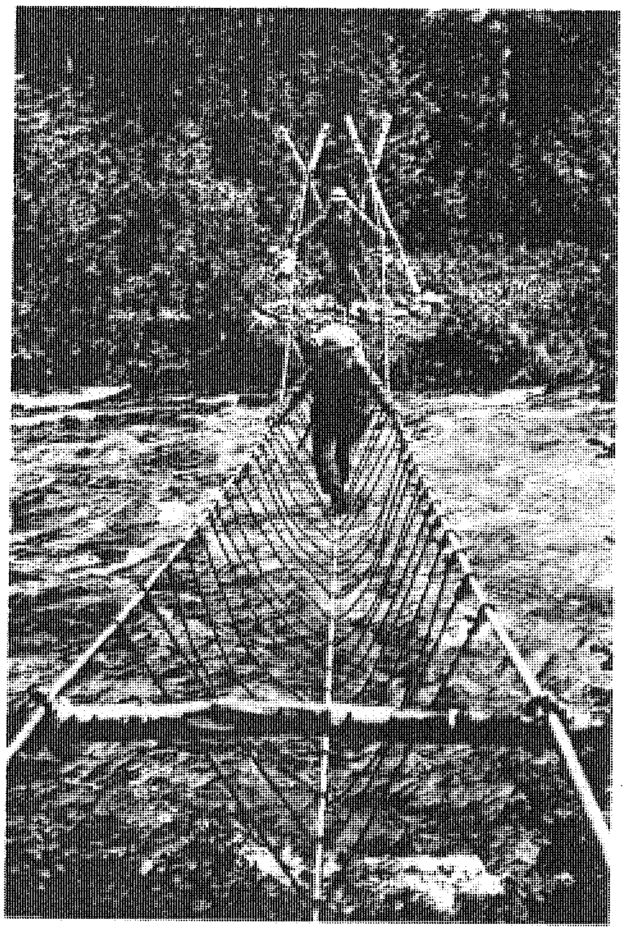


Figure 46. Three-rope bridge.

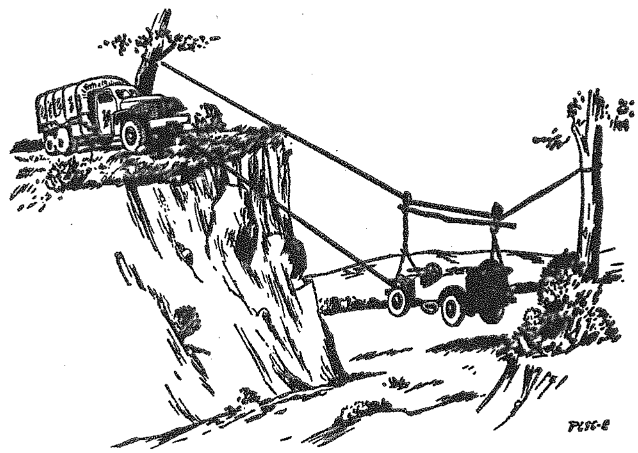


Figure 47. Expedient cableway.

Section V. EVACUATION

148. Principles of Evacuation

a. The methods of evacuation described in later paragraphs are not necessarily the only methods to be employed. Although they have proven themselves to be satisfactory, they are all subject to improvement and should be discarded as better methods of handling patients are developed.

b. In evacuating a patient from mountainous areas—

(1) Select the smoothest available route.

(2) Avoid unnecessary handling of the patient.

(3) Protect the patient from falling rock by placing his helmet over his head.

(4) When the route of evacuation is long and ardous, a series of litter relay points or warming stations should be established. These stations must be staffed with the minimum medical service personnel to permit proper emergency treatment of shock, hemorrhage or other emergency condition.

(5) When a patient develops new or increased signs of shock while being evacuated he should be treated and retained at one of these stations until such time as his condition warrants further evacuation.

(6) Ambulatory patients may move rapidly on skies. Skis are readily available as splints for suspected or actual fractures. Also several skis locked together may be utilized as a field expedient in lieu of a 200-pound sled. Skis covered by several field jackets make an adequate litter.

(7) Tracked heated personnel carriers or rotary wing aircraft should be utilized for evacuation whenever the situation warrants or the terrain permits.

149. Special Training

a. Prior to training in basic mountain evacuation, litter teams should receive instruction in military mountaineering.

b. Litter bearers and aid men must be thoroughly familiar with the use and care of rope as an item of equipment.

c. The members of litter teams must become throughly proficient in the technique of belaying, and in the choice of belay points. When evacuating a patient over extremely difficult terrain, this knowledge will often be required to give proper support and protection to patients and litter bearers.

150. Preparation for Evacuation

(fig. 48)

a. To prepare a litter for use in extremely rough terrain—

(1) Place a stick, 40 cm long and at least 3 cm in diameter along each hinge brace and fasten it securely to each stirrup with wire or strong cord. Lash the stick to the brace along the length of the stick to prevent the hinge joint from collapsing.

(2) Pass 2 to 3 meters of the end of a climbing rope through one litter stirrup, bringing it around and through again, forming a round turn.

(3) Secure a 3 cm by 40 cm stick in place against the litter brace by two half hitches, one on each side of the hinge joint.

(4) A round turn is then made on the opposite stirrup.

(5) Tie the end to the long part of the climbing rope with a bowline knot between the canvas of the litter and the upper ends of the handles. Insure the knot of the bowline is positioned so that it will clear the canvas of the litter.

b. The end thus prepared becomes the head of the litter.

c. (1) A patient may be lashed to the litter in a variety of ways depending on the route of evacuation, the condition of the patient and other similar factors. If the route is short and relatively easy and the patient is able to protect himself, no fixation will be necessary.

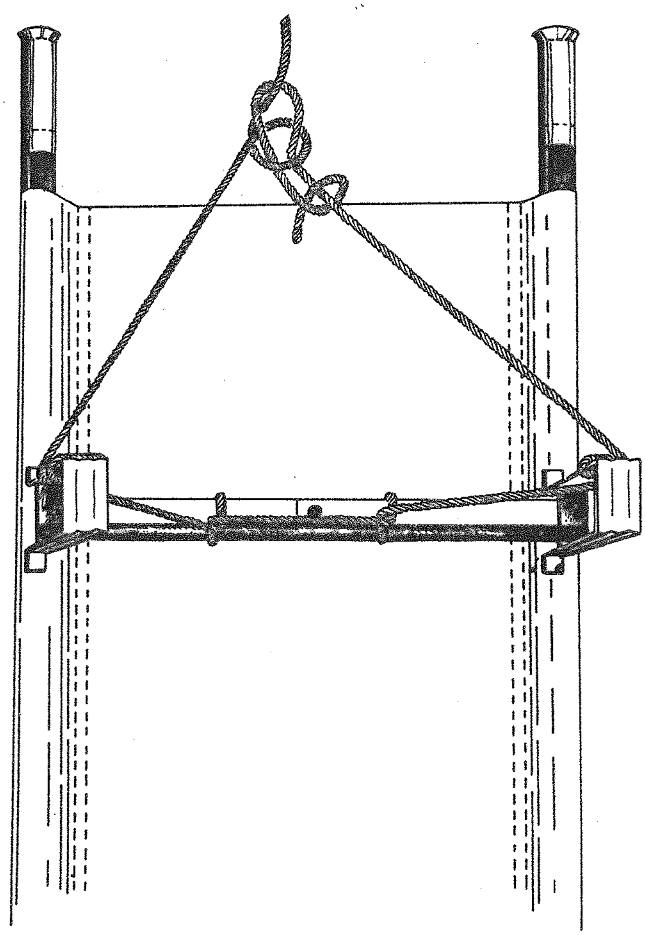


Figure 48. Method of fastening belay rope to litter.

(2) On the other hand, if the evacuation route must pass over a cliff, down a steep slope, or if the patient is unconscious, he must be securely lashed to the litter. In securing a patient to a litter, the pelvic bones lend themselves most favorably to the tie since injuries of the leg, abdomen, chest or arms will not be involved in the procedure. A blanket is folded like a diaper over his abdomen. This eases materially the pressure caused by the sling at the points of contact. Four 4-meter nylon sling ropes are used. Two to lash the upper part of the body and two for the lower part. A team of two men is most efficient, one man working on each side of the litter. The upper part of the body is lashed first. Two sling ropes are used,

tied with a bowline on the upper part of the legs in the crotch. One sling rope on one leg and the other on the opposite.

(3) The ends of the ropes are then brought diagonally across the body, under the arms, to the stirrups on the opposite sides of the litter, passed through the stirrup and a round turn formed, brought across the chest to the opposite stirrup, another round turn formed, the rope brought back across the chest and tied off with a square knot. If the ropes are not long enough to reach across the chest and back again, they will be tied off on the chest after the first round turn on the stirrup. To tie the lower part of the body, sling ropes are tied to each of the upper stirrups with a round turn and two half hitches, brought diagonally across the body to the stirrup on the opposite side of the litter at the foot, and round turns made on each stirrup. The knees of the patient are bent slightly and the feet drawn back. The ropes are brought from the stirrups and wrapped around the feet, bringing the rope across the bottom of the feet first, to act as a platform. Tie off with a square knot on the bottom side of the feet so that the knot will not form pressure on the arch of the foot. The knees are then pushed down tightening the ropes.

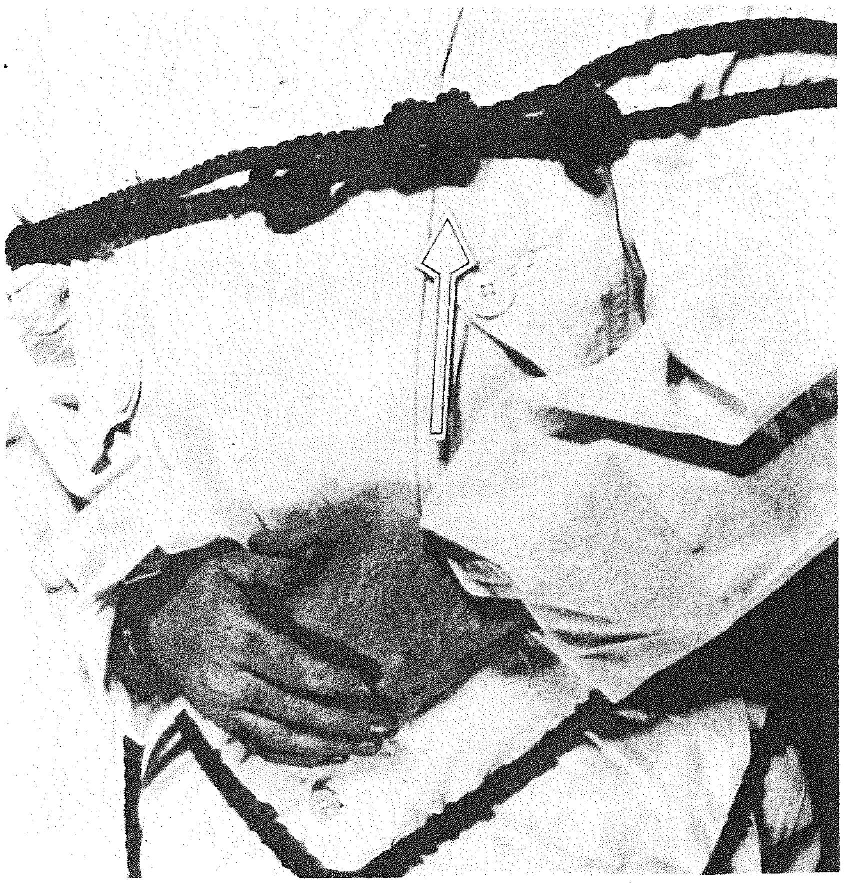
(4) In the event that the patient is wrapped in blankets or a sleeping bag, the above method cannot be used. A clove hitch is made with one loop about the small of the patient's back and the other loop about his hips, just below the buttocks. The running end from the upper loop is passed through the upper stirrups and across the patient's chest and secured. The running end from the lower loop is passed through the lower stirrups and secured over the patient's legs in a similar fashion (fig. 49).

151. Ascending and Descending Slopes

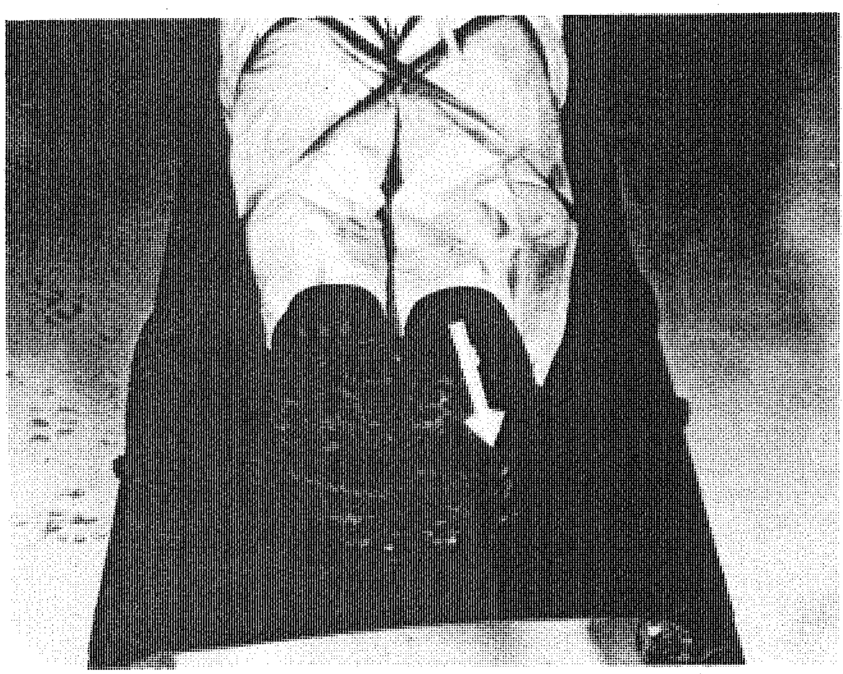
a. In ascending a steep slope the litter is prepared and the patient immobilized as described in paragraph 150 (fig. 50). Two litter bearers take their places at the head of the litter, and a third, using the litter sling, takes his place at the foot. A thin sapling passed through the stirrups and extending 45 cm on either side of the lines affords a more secure grip for the two litter bearers at the head of the litter. The fourth and fifth men take their positions along the extended rope which is in the hands of the sixth, or belay man. At the signal "UP ROPE," the fourth, fifth and sixth men pull while the others lift the litter and slowly climb. The men carrying the litter should not try to do all the work, but allow themselves to be pulled up the slope while they hold the litter off the ground. Men exchange positions at each halt so that the work will be distributed equitably. When each belay point is reached, the litter is placed on the ground and a new belay position farther up the slope is taken.

b. In making the descent, the litter and patient are prepared as described in paragraph 150 (fig. 51). One man acts as belay man and another takes his position on the rope, assisting him in lowering the litter. The three litter bearers take their positions as for the ascent. The sixth man may assist with the litter or precede the team, picking a trail, making the passage more negotiable by clearing away shrubs and vines, and making a reconnaissance so that the team need not retrace its steps if a cliff should be encountered. In making the descent, the most direct practicable passage should be taken. All available trees and rocks should be used as belay positions.

c. If the slope is relatively free of underbrush or trees, a three-man team may be used. In this procedure skids are placed under the litter. Two saplings, each 5 to 6 meters long and about 8 cm in diameter at the heavy end, are cut. The small ends are secured to the stirrups and litter brace at the foot of the litter; the butt ends are secured inside and to the stirrups at the head of the litter (1, fig. 52). In this manner, the butt ends of the saplings project about 2½ to 4½ meters beyond the head of the litter and act as the foot of the litter. The second and third men are belay men, relieving each other as the rope is paid out, by assuming successive belay positions (2, fig. 52). In this way the descent need not be interrupted while the belay position is being changed. Using this method of evacuation, it has been demonstrated that a casualty can be evacuated 60 to 70 vertical meters in about 10 minutes and that vertical faces of rock 1 to 2 meters high can be descended without difficulty.



Securing body to head of litter



Securing legs to foot of litter

Figure 49. Securing casualty to litter.

Figure 50. Steep slope evacuation—ascending.

152. Cliff Evacuation

a. Evacuation via cliffs should be used only when absolutely necessary and only by experienced personnel. The cliffs with the smoothest faces are chosen for the route. In this method, at least five 36½ meter ropes are necessary.

b. The preferred method to be used requires only four litter bearers, five 36½ meter nylon climbing ropes and four 4-meter nylon sling ropes. The litter is prepared by placing a stick at least 40 cm long and 3 cm in diameter along each hinge brace and fastening it securely to each stirrup with wire or strong cord. Two poles 2 to 3 meters long and about 10 cm in diameter are used as runners. The poles are attached to the stirrups by rope or wire; at the point of fixation, notches are made so that the rope or wire will not be worn unnecessarily by friction. The belay rope is attached and the patient secured to the litter as described in paragraph 148.

c. Two litter bearers remain at the top of the cliff, one to belay and the other to transmit signals and directions. The remaining two litter bearers,

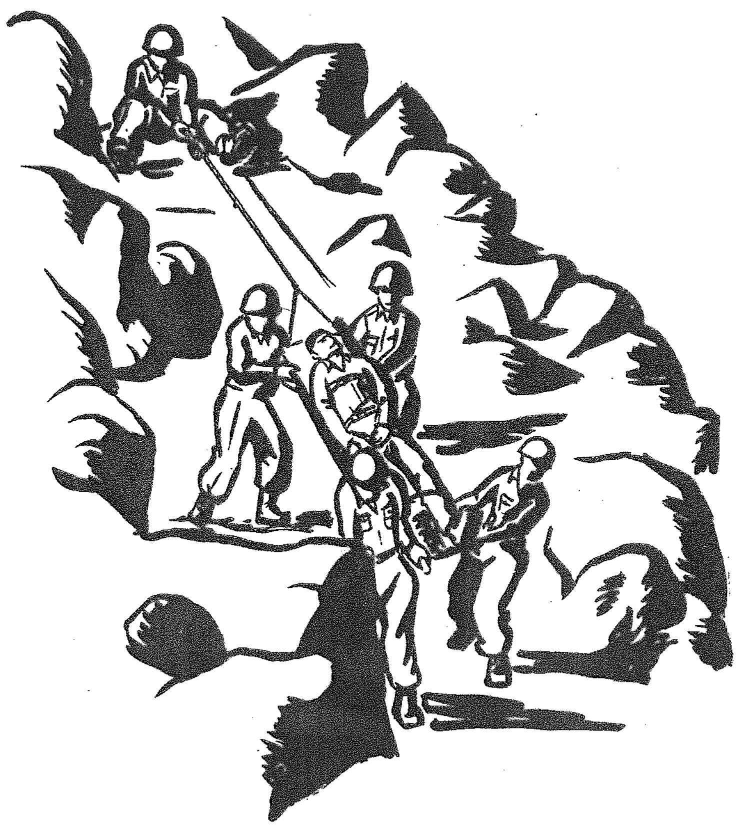


Figure 51. Steep slope evacuation—descending.

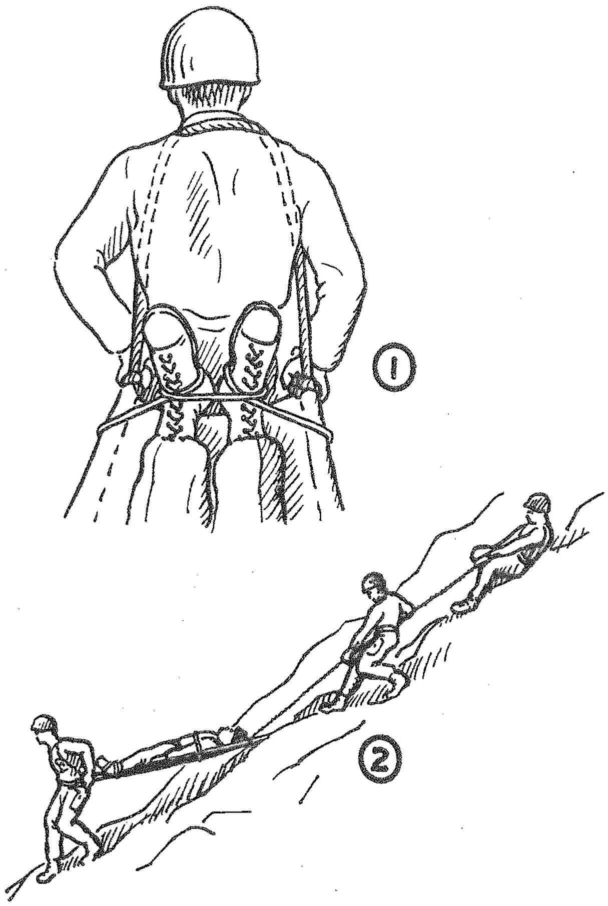


Figure 52. Litter travois.

after each secures two rappelling ropes to suitable anchors at the top of the cliff, each grasp one of the handles at the foot of the litter and working with the man on belay, ease the litter over the edge of the cliff. As the man on the belay follows the signals and directions of the litter bearer who remained on the cliff, either playing out rope or holding the litter in position, the two rappellers guide the litter down the face of the cliff (fig. 53). Upon reaching the base of the cliff the two rappellers carry the foot of the litter away from the cliff as the man on belay gently lowers the head of the litter until it too is on the ground. This method can be worked very smoothly by a trained team with no added danger to the patient or the bearers.

d. An alternate method which may be used is: The patient is secured to the litter in the usual manner. Two poles, 2 meters long, are cut from trees with a diameter of 10 to 15 cm, and used as runners. Both ends of the poles are beveled. The poles are attached to the stirrups by rope or wire; at the points of fixation, notches are made so that the rope or wire will not be worn unnecessarily by friction. A rope is attached to each stirrup at the foot of the litter for use as guy ropes in order to prevent the litter from spinning during the descent. The litter is lowered over the cliff by two men, while a third man belays it. Meanwhile a fourth man escorts the litter on the descent by rappelling down a rope which parallels the route of evacuation, and assists the litter over projecting obstacles. The guy ropes are held taut by the fifth and sixth men who take widely separated positions at the bottom of the cliff. They can also help to ease the litter over protruding rocks by stepping away from the cliff and adding tension to the guy rope. As the litter approaches the bottom of the cliff, the guy rope operators approach the litter, meanwhile maintaining tension on the ropes, and when close enough grasp the litter handles and lower it to the ground.

e. The same procedure can be used in evacuating a patient up a cliff except for the following variations:

(1) An additional man will be needed at the top of the cliff to help raise the litter up and over the edge.

(2) The guy ropes must be attached to the stirrups at the head of the litter, instead of the foot.

(3) In the case of an overhanging cliff, a shears (A-frame) must be constructed at the top (see FM 5–10 and TM 5–220).

153. Carriers

a. Casualties who are not seriously injured but cannot negotiate a descent by themselves may be carried down by a carrier who is belayed from above. The carrier, in making his descent, leans away from the slope as much as possible and walks sidewise allowing the belay man to support him. Facing the slope and descending backwards should be avoided since it leads to unnecessary falls. By keeping his lower leg well braced, keeping the weight of the casualty high on his back, and by grasping trees and rocks, he can descend very steep slopes with relative ease.

b. To secure the casualty to a carrier with a rope, the carrier rests on his hands and knees while the casualty straddles his back (fig. 54). A 4-meter length of nylon sling rope is used. The center of the rope is placed under the casualty's buttocks. The right loose end is passed under

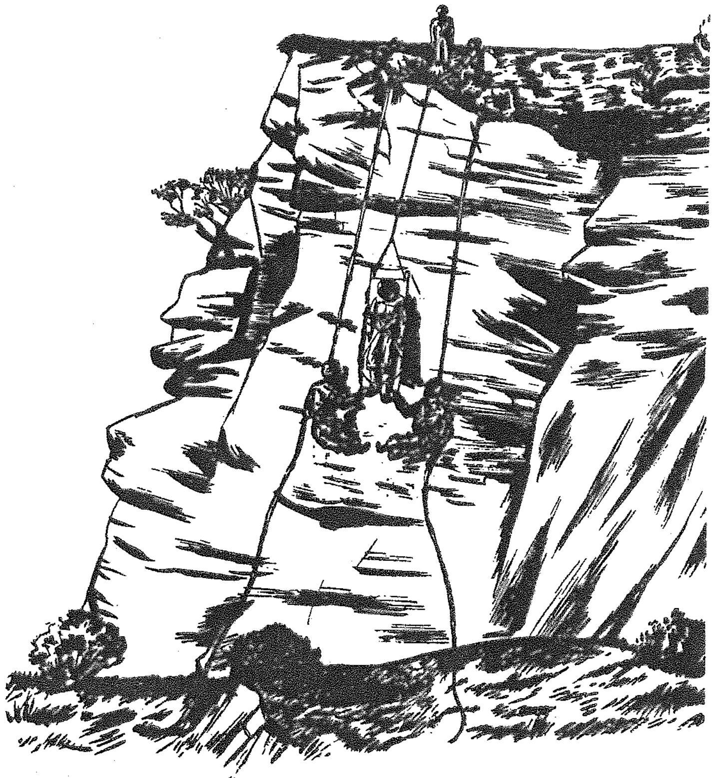


Figure 53. Cliff evacuation—descent.

the carrier's right armpit, across his chest, over his left shoulder, and under the casualty's left arm; the left loose end is passed under the carrier's left armpit, across his chest, and over his right shoulder, and under the casualty's arm, and the tie is made across the casualty's back. If the carrier suffers from the pressure of the rope against his chest, the rope may be crossed behind his neck instead of over his chest, before securing the ends around the casualty. The carrier's shoulders should be padded to prevent cutting by the rope.

c. An alternative method is to use two pistol belts hooked together and draped over the carrier's shoulders. The casualty straddles the carrier and the belay man secures the loose ends of the pistol belts under the casualty's buttocks. Slackness in the pistol belt sling should be avoided, since the carrier is most comfortable when the casualty rests high on his back (see FM 8–35).

154. Field Expedient

The pole-carry method should only be considered as a last resort, since it is very difficult for the litter bearers to handle, and very uncomfortable for the patient. Its use is advisable only when narrow ledges must be traversed. The patient is wrapped in two blankets and suspended from a 4-meter long pole by a rope, pistol belts, or web belts. In suspending the patient, all excess slack should be avoided, since it increases the sidesway

Figure 54. One-man carry using rope sling.

during carry. A two-man team, one on each end of the pole, carries the patient. If the pole is long enough, a four-man team may be used.

155. Evacuation From Trees

(fig. 55)

It is best to use two men for the evacuation of wounded from trees, although one can accomplish the task by himself if necessary. Casualties in trees are usually either tied in place and cannot help themselves, or else have fallen and become wedged in such a way that they are helpless. One man climbs the tree, taking one end of the rope with him. He passes the rope over a branch in the tree above the position of the casualty and then ties a bowline on a bight. He slips one loop over each thigh of the casualty and then with the same rope ties a butterfly knot around the casualty's chest. A man on the ground belays the casualty and lowers him from the tree. The first man escorts the casualty in his descent and prevents his movement from being impeded by intervening limbs or branches.

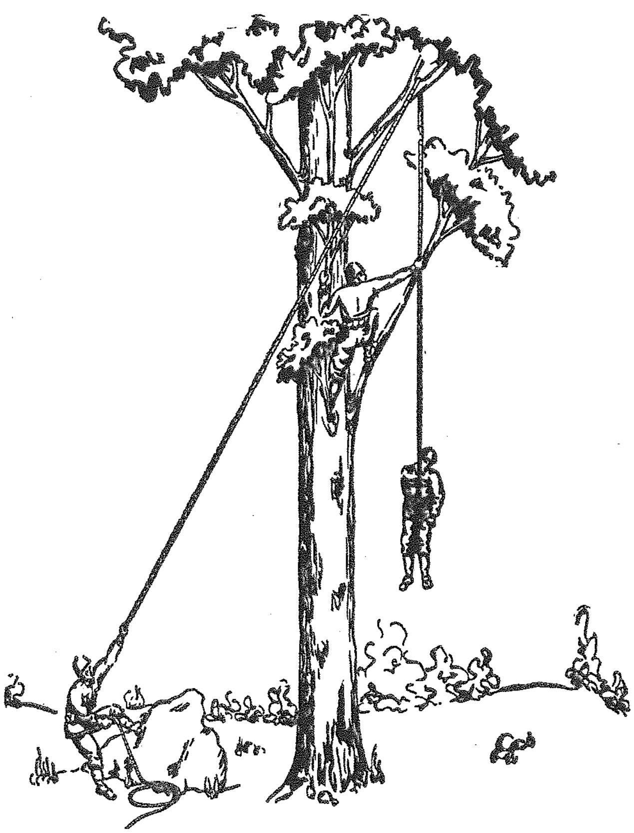


Figure 55. Tree evacuation—method of securing casualty with rope.

156. Horizontal Hauling Line

(fig. 56)

a. The horizontal hauling line is one of the most complex of the various methods of evacuation discussed so far. It is primarily used in those cases where a steep slope or cliff has to be passed and where, at the same time, there is an intervening obstacle such as a swiftly running mountain stream. It can also be used to span a chasm when bridges are demolished. This method should be instituted only where there will be a considerable number of patients, such as at a warming station or collection point, and should not be installed for the evacuation of only one or two. It can be used to lower or raise patients over the obstacles. The hauling line is installed as follows:

(1) By means of a bowline, a 3-cm manila rope is secured to a tree far enough from the edge of the cliff (2 to 3 meters) to permit freedom of movement by the medical personnel. On the opposite side, the other end of the rope is passed around another fixed point (tree, boulder, or possibly a vehicle) and, by means of a transport knot, is pulled as taut as is necessary. All traverse ropes should have a certain amount of slack. When manila or sisal rope is used, a 5 percent sag should be allowed to avoid undue fatigue from developing in the rope.

(2) (*a*) To suspend the litter, two snaplinks are placed upon the traverse rope and one long litter carrying strap attached to each. A lower and upper retrieving rope is attached either to the litter stirrup or to the respective snaplinks. In the latter case the loose ends of each rope are tied together above the center of the litter so that, when drawn up or down, both snaplinks move simultaneously.

(*b*) If snaplinks are not available, two empty adhesive tape spools, 3 cm wide, may be utilized and the long litter carrying straps affixed to them. If these are used they should be placed on the traverse rope before the rope is fixed at both ends.

(3) After the patient has been secured to the litter, the litter is raised and the litter carrying straps or suspension ropes are

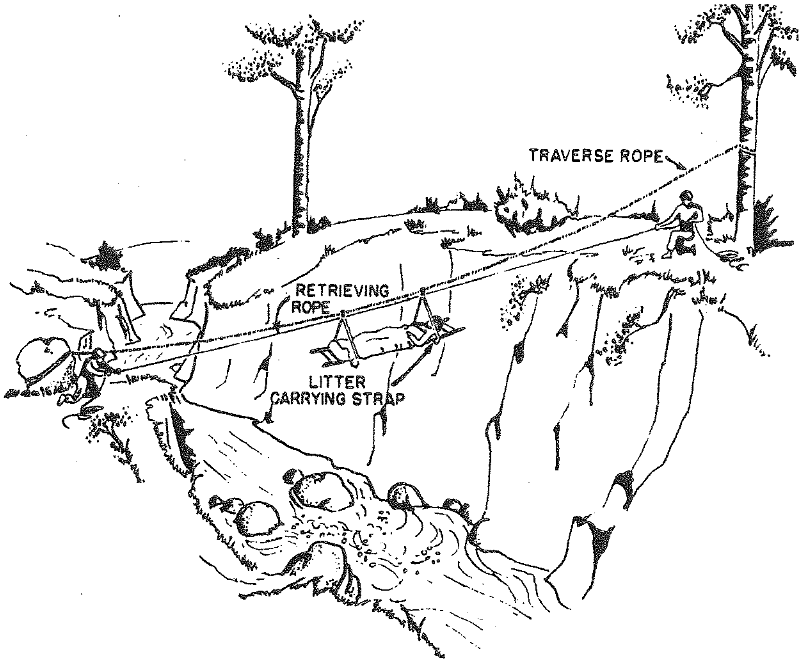


Figure 56. Evacuation by horizontal hauling line.

passed through the stirrups and fastened together or else secured to the opposite stirrup.

b. The operation of the hauling line is as follows:

(1) *Ascent.* Three men can easily raise the litter along the traverse by pulling on the upper retrieving rope. The pull should be steady and smooth in order to prevent jolting and sway.

(2) *Descent.* A gentle pull on the lower retrieving rope is enough to break the inertia and let gravity do the rest. During the descent, the men on the upper side should control the speed of the descent through their retrieving rope. It may be necessary to pull the patient the last few feet when the litter nears the low point of the slack in the traverse rope.

157. Expedients for Evacuation in Snow

(fig. 57)

Although litter bearers mounted in snowshoes will usually evacuate casualties on snow covered mountains, downhill evacuation can be speeded up considerably when litter bearers are equipped with skis and a 200-pound capacity boat-type sled. For details of evacuation in snow, see FM 31-70.

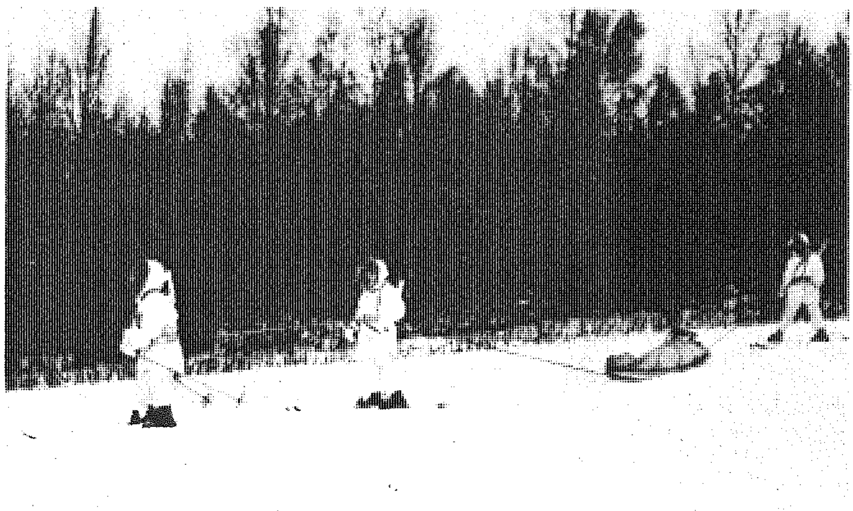


Figure 57. Evacuation using 200-pound sled.

CHAPTER 5

SNOW AND GLACIERS

Section 1. GENERAL

158. Reference

For a detailed description of operations in snow and extreme cold, see FM 31–71.

159. General Characteristics

a. Mountainous regions in cold and temperate zones are characterized during winter by the following:

(1) A great amount of snow, which remains during most of the year in the high regions.

(2) Extreme cold, often reaching 40° F. or more below zero in some areas, and severe snow storms which impose great hardship on the troops.

(3) Snow starts to fall at varying times in the autumn according to the geographical location, altitude, and exposure. The snow cover differs with the altitude and may also differ greatly from year to year. A deep snow cover greatly changes the problem of living in the mountains, especially by increasing the difficulties of communication, transportation, and sanitation. Even a small amount of snow restricts the movement of men and vehicles. The deeper the snow, the more it hampers and canalizes the movement of columns. If it is over 30 cm deep, movement by foot troops must be accomplished with the aid of skis and snowshoes. Wheeled vehicles will not be able to proceed any farther or any faster than the snow removal equipment will permit. The emplacement of artillery becomes an extremely slow and laborious process. In some cases, it may be necessary to transport the artillery on sleds or specially constructed runners. Heavy artillery must use track-laying vehicles as prime movers.

(4) A great many slopes which are easy to negotiate in the summer become difficult and even dangerous to climb in the winter because of frozen and snow-covered ground and the risk of avalanches. When winds reach a great velocity, traffic becomes almost impossible. Nevertheless, a great deal can be done to improve traffic conditions. If there is sufficient manpower and mechanical equipment, the principal routes can be kept clear. Snow removal is usually a continuous process because of drifting snow and frequent snowfalls.

b. Snow conditions are met in high mountains at all seasons of the year.

160. Effect of Special Training and Equipment

Small units of mountain troops, specially equipped, can carry out operations in the mountains during the winter, and because of their special training are aided, rather than retarded, by the snow. The importance and effectiveness of winter operations has taken on an added significance since the adoption of special clothing, skis, snowshoes, and track-laying vehicles. Such vehicles, within capabilities, can be used to haul personnel, supplies, equipment, weapons and in some cases are useful for packing snow. Such specialized equipment makes large scale winter operations in mountains entirely practicable.

Section II. CLASSIFICATION OF SNOW

161. Classification of Snow

a. The terms "snow" and "ice" have been used in a general sense to describe snow or ice forms. In order to clarify the danger inherent in snow and ice, it is necessary to outline the forms that snow assumes in its transition to glacier ice. Some forms of snow are of considerable benefit to the mountain soldier, others are a source of grave danger.

b. Snow is classified as powder snow and compact snow. Powder snow is snow in its early stages and is classified as new snow, settling snow, or settled snow. Compact snow is snow which has passed beyond the stage of powder snow.

c. New snow is snow that maintains individuality of flakes immediately following its fall. If new snow is dry, it is feathery; if damp, it quickly consolidates into settling, or settled snow.

d. In areas of extreme cold and at high altitudes, new snow not uncommonly comprises two forms—sand snow and wild snow.

(1) Sand snow falls at extremely low temperatures. As its name implies, it is sandy. Skis, sleds, and toboggans slide over it with difficulty.

(2) Wild snow is very dry new snow which falls during complete calms and low temperatures. It is extremely light and feathery and very unstable.

e. Settling snow is powder snow consisting of flakes which have begun to lose their individuality.

f. Settled snow is powdered or wet snow in which the flakes have interlocked and united. This is the settled powder to which skiers refer.

g. New firn snow is compact, granular snow that is composed of closely associated grains instead of individual flakes. Heat-softened new firn snow is referred to by skiers as spring or corn snow.

h. Advanced firn snow or neve consists of closely associated grains of ice, separated by air spaces.

i. Glacier ice is composed of crystals of advanced firn snow cemented by a film of ice. There are no air spaces between the grains and any air spaces present are within the grains themselves.

162. Snow Formations

The forms of snow described in paragraph 161 are subject to various modification during their transition from dry new snow to glacier ice. Temperature, humidity, and wind are important modifying factors in this transition. The following phenomena are important to the mountain soldier:

a. Sun crust is any snow the superficial layer of which has been melted by heat and subsequently refrozen. A layer of snow that is sun crusted and weathered throughout its thickness becomes firn snow. Sun crust commonly overlies powder snow.

b. Wind crust or wind-packed snow is usually found on windward slopes and is anchored firmly to the underlying snow. A moist wind blowing over snow slopes causes the surface snow to become compacted. Depositing of drifting snow is not involved. Inasmuch as the wind-packed snow has not been transported, the crystals are not greatly affected by abrasion. Consequently, they reflect much light. Wind crust is generally safe.

c. A wind slab is formed from snow transported and deposited by winds. While the slabs themselves are well compacted, they are loosely anchored to the underlying surface; in fact, all wind slabs have an air space between the slab and the underlying snow. Having been transported by wind, the component grains are rounded and do not reflect the light. For this reason the surface of a wind slab has a dull, chalky appearance. Wind slabs are extremely dangerous.

Section III. AVALANCHES

163. General

The danger of avalanches must be carefully considered when military operations are being conducted in the snow covered mountains. Avalanches occur when the weight and the pressure of the snow overcome the power of resistance and friction of the under layer, or the tension in the snow cover is disturbed. Several causes of avalanche "triggering" are explained in subsequent paragraphs. The danger of avalanches has become even greater in modern warfare because of the vibrating effects caused by nuclear detonations. These effects will cause severe snow and rock slides miles away from ground zero.

164. Basic Causes of Avalanches

a. *General*. Fundamentally there are only two causes of avalanches—terrain and climate; in everyday terms—plenty of snow and steep slopes for it to slide on. These two essentials, acting together, can produce an avalanche without any other assistance.

b. *Terrain*.

(1) Ground surface conditions have considerable effect beyond the snow in contact. A broken, serrated, or boulder-strewn surface provides a good anchorage for the snowpack as a whole. Slides breaking off at ground level are unlikely. Smooth,

even slopes of bare earth, solid rock, or shale favor the massive ground-level avalanches, typical of the high alpine zone.

(2) The contours of a mountain influence the avalanche; terraces, talus, basins, and outcrops are effective barriers. They either divert the moving snow or give it room to spread out and lose its momentum. Gullies collect and channelize the descending snow thus making favorable slidepaths (fig. 58) which must be carefully avoided. Ridges lying parallel to the slidepath, on the other hand, are relatively secure. The convex slope is more likely to avalanche because the snow layers settling upon it are placed under tension. Avalanches usually fracture at the sharpest point on the curve, get up to full speed instantly, and pulverize rapidly. The steepest part of a convex slope is generally near the bottom, leading to a sudden transition and poo anchorage at the toe of the snow laye On a concave surface, snow is under com pression. The steepest part of the slop is generally near the top; the transitio is more gradual and the anchorage at th toe is better than for a convex slope. Th dimensions of the slope (length an width), are other factors that determin the size of the snow slide and possibl destruction caused.

(3) All of the terrain features mentione above are less important than grade. Th higher the slope angle, the more likely i is to slide regardless of any other condi tion. The minimum angle favorable t avalanches is 25°. Slopes from 25° to 35 may avalanche, especially if stimulate by cutting action of the skier or som other outside disturbance. The critica zone lies above 35°. From this angle t the point where snow can no longer clin

Figure 58. Dangerous slidepath. Overhanging cornice on the sky line.

except by windpacking, slopes are apt to slide in some fashion with every storm.

c. Vegetation. Vegetation of any kind except grass has a restraining effect on avalanches. However, in general, the existence of heavy forest cover is an indication that slides in that location are rare or of minor importance. It is a mistake, however, to consider all forested areas as safe. Scattered timber is no particular deterrent. Slopes where the timber has been destroyed by fire offer good facilities for snow slides.

d. Exposure. Slopes facing the sun favor the avalanches produced by thawing. Loose snow avalanches are more common on the slopes opposite the sun. Cornices habitually form along ridges and crests lying at right angles to the prevailing wind. Lee slopes are the most probable locations for overloads of wind-driven snow and the formation of slab. On the other hand, snow is transported from the wind-beaten slopes and that which remains is thoroughly packed and stabilized.

e. Climate and Weather.

(1) In addition to the terrain factors, climate and weather are the other basic ingredients for the avalanche phenomenon.

(2) High rates of snowfall and storms which deposit up to 2.5 centimeters of new snow per hour in one storm, are not uncommon.

(3) Temperature fluctuates widely and rapidly in the mountains. Prolonged spells of extremely low temperatures occur and there are occasional intrusions of warm air masses, usually in connection with a storm. Rainfall may occur in the coastal zones and create an avalanche condition. The temperature greatly affects the cohesion of snow; a rise in temperature weakens the bonds, while a drop in temperature retards settlement of the snow mass and increases the brittleness and tension of a slab formation.

(4) Wind action during storms in the mountains is generally strong and its influence on snow is the most important of all the contributory factors. It transports snow from one exposure to another during storms and fair weather, thus promoting overloads on certain slopes. It also modifies the size and shape of snow particles.

165. Types of Avalanches

a. Classification. The avalanches may be classified in accordance with the type of snow involved, the manner of release, or the size. For practical purposes the classification according to the type of snow involved, is normally used, and all slides divided into the following two general groups:

(1) Loose snow avalanches.

(2) Packed snow avalanches.

b. Loose Snow Avalanches.

(1) *Characteristics.* An avalanche of loose snow always starts on the surface from a point or a narrow sector. From the starting point it grows fanwise, expanding in width and depth. The speed and nature of its development depend on whether the snow is dry, damp or wet.

(2) *Dry loose snow avalanches.* These are composed of loose snow, possibly drifted but not windpacked. They often start at a point, and travel at high speed on a gradually widening path, increasing in size as they descend (figs. 59 and 60; note the enormous cloud of snow dust involved). A dry loose snow avalanche is always shallow at the start and depends for volume on the snow it can pick up during its run. Thus, a dry snow avalanche of dangerous size can only occur on

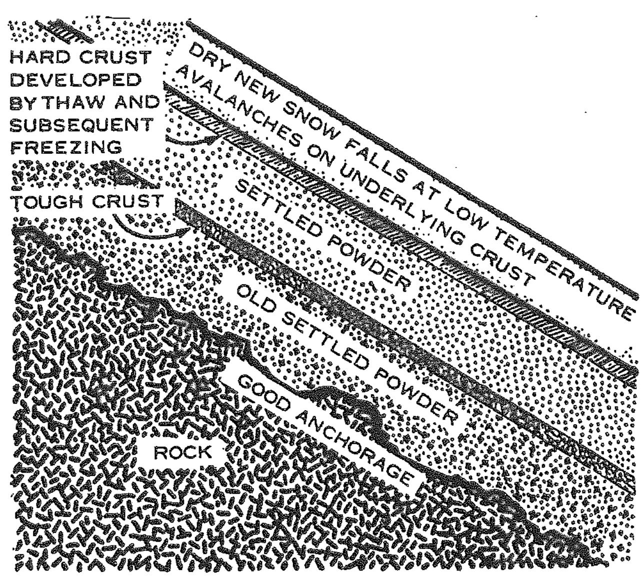
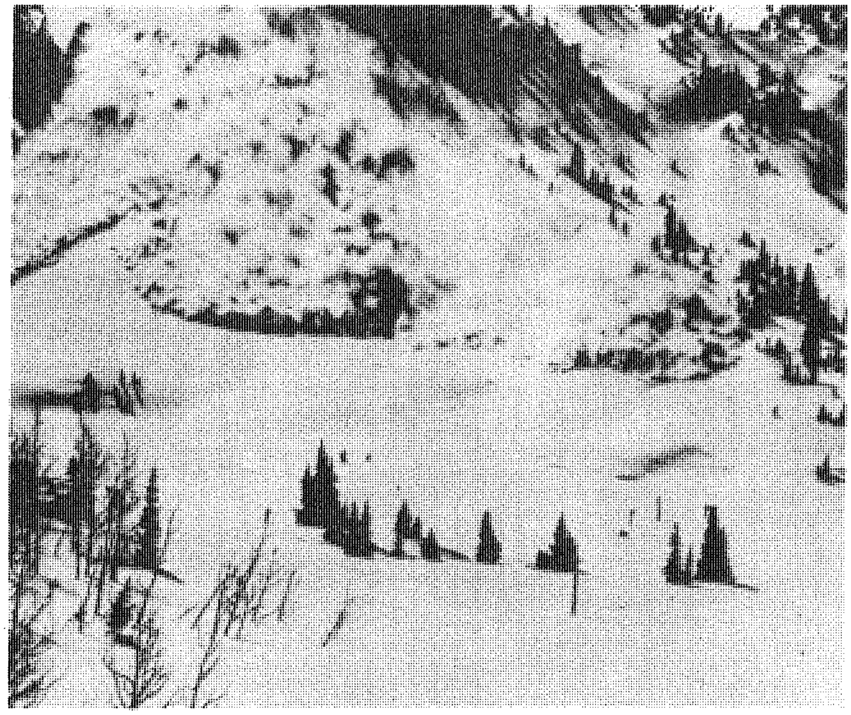
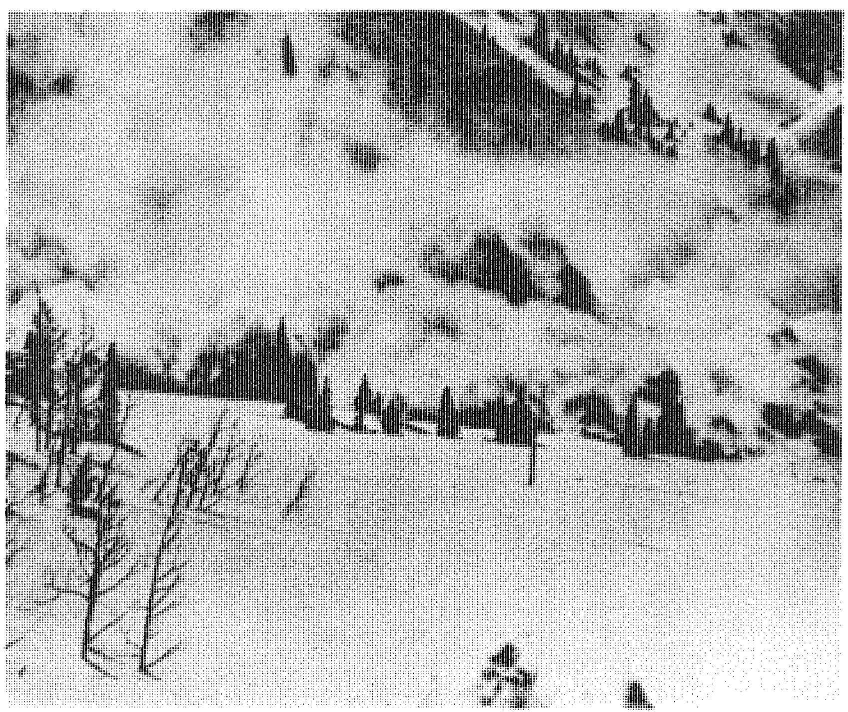


Figure 59. Dry snow avalanche—composition of snow layers.



First phase



Second phase

Figure 60. Dry, loose snow avalanche.

a long slidepath, or from a large accumulation zone with funnels into a constricted outrun. Occasionally heavy snowfall at low temperatures produces the phenomenon of the "Wild Snow" avalanche—formless masses pouring down the mountainside. They are actually avalanches of air and snow mixed. Windblast is a side effect of very large, high speed avalanches, powerful enough to damage structure and endanger life outside the actual avalanche path. It is characteristic that the hazard from loose snow avalanches is soon over one way or the other.

(3) *Damp and wet snow avalanches.*

(*a*) These resemble those of dry snow with the same arrowhead point of origin, gradually becoming wider. Their mass is many times greater than that of a dry avalanche and they are therefore much more destructive. Being heavier and stickier, however, they develop more friction and therefore travel at a slower pace. An alert and experienced skier can generally outrun them and the principal hazard is to fixed installations. The comparatively low speed causes them to stop rather suddenly when they lose momentum and to pile up in towering masses of boulders. This is in contrast to the dry slide which tends to spread out like the splash of a wave.

(*b*) Damp and wet slides (figs. 61 and 62) solidify the moment they are released from the pressure of motion adding to the difficulty of rescue or clearing operations. Wet slides have a distinctive characteristic of channeling. The moving snow constructs its own banks and flows between them like a river of slush, often in unexpected directions. The damp sunslides of midwinter are generally shallow. But the wet avalanches of spring, caused by deep thawing either from rain or prolonged temperatures above freezing, often involve enormous masses of snow and debris and have incalculable destructive power.

c. Packed Snow Avalanches.

(1) *Windslab.*

(*a*) The windpacked snow, called windslab, snowslab, or slab when sliding, is unquestionably the worst killer of all and

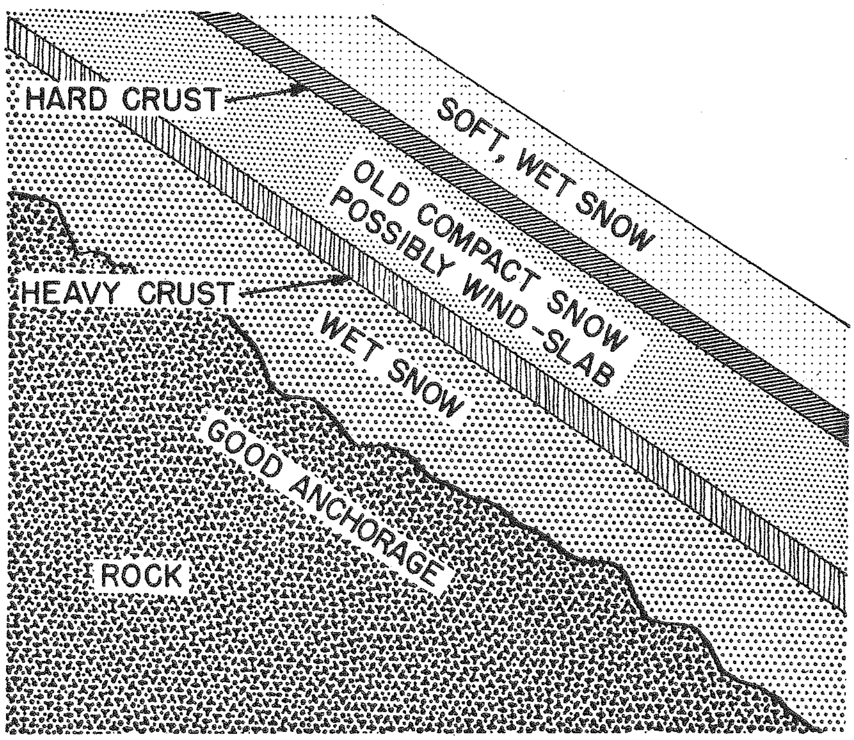


Figure 61. Wet snow avalanche—composition of snow layers.

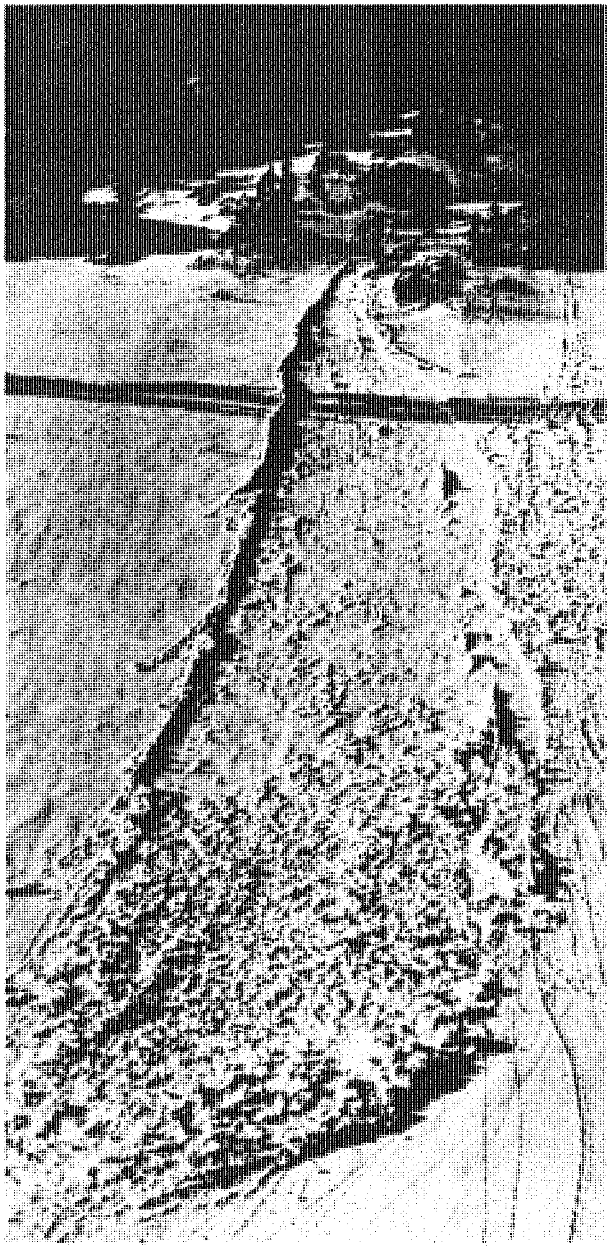


Figure 62. Wet snow avalanche.

equal to the wet spring avalanche as a destroyer of property. Slab may be hard or soft. Hard slab is usually the result of wind action on snow picked up from the surface. Soft slab is usually the result of wind action on falling snow. The windslab avalanche (fig. 63 (note the light snow-dust cloud in comparison to dry, loose snowslide)) behaves in an altogether different manner from loose snow. It has the ability tc retain its unstable character for days, weeks, and even months, thus leading to the release of delayed-action avalanches unexpectedly, and often from minor causes such as the addition of a small amount of new snow, a skier cutting across a hillside, sun action, or even a minor vibration.

(*b*) The windslab avalanche combines great mass with high speed to produce maximum energy. It may originate either at the surface or through the collapse of a stratum deep within the snowpack. It starts on a wide front with penetration in depth. The entire slab field—top, sides, and bottom—releases almost simultaneously. The place where the slab has broken away from the snowpack is always marked by an angular fracture line (fig. 64 (note that it broke at the sharpest part of the curve on a convex slope)) instead of a point roughly following the mountainside contour. In a packed-snow avalanche the main body of the slide reaches its maximum speed within seconds. Thus it exerts its full destructive power from the place where it starts, whereas a loose-snow avalanche does not attain its greatest momentum until near the end of its run.

(*c*) Due to the characteristic delayed release action as stated above, the slab avalanche is the most dangerous of all types. A series of slab avalanches may stabilize conditions only locally, leaving the slab on an adjacent slope as lethal as an unexploded shell. If found on the surface, snowslab has a dull, chalky nonreflecting appearance. It has a hollow sound underfoot, if the slab is hard it often settles with a crunching sound which an experienced mountaineer recognizes as a danger signal. The only way to insure that movement across slab formation is safe, is to break the slab by one of the stabilization methods described in paragraph 168*b*.

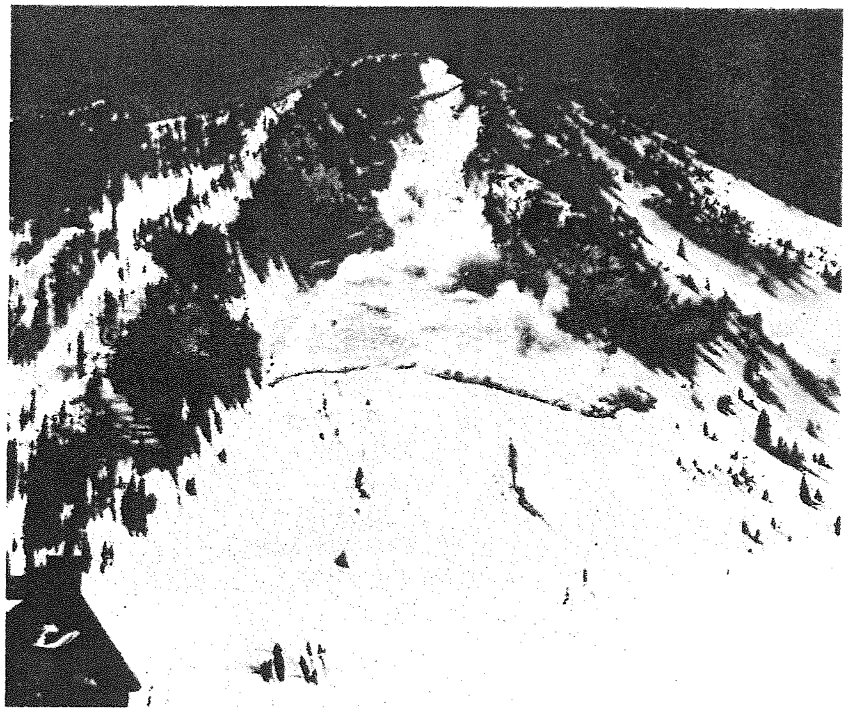


Figure 63. Slab avalanche.

Figure 64. Slab fracture.

(2) *Cornices.* A cornice (fig. 65) is a snow formation allied to the slab. They build up on the lee side of mountain crests and ridges which lie at right angles to the wind. Occasionally they are straight-walled, but their characteristic shape is that of a breaking wave. The obvious hazard from cornices is due to fractures of the overhang from simple overloading, weakening due to temperature or rain, or from sun erosion of the underside. These falling blocks are generally large enough to be dangerous themselves and may also release avalanches on the slope below.

d. Combination Avalanches.

(1) *General.* Combination avalanches are composed of both loose and packed snow formations making it more difficult to determine which part of the combination acted as the trigger and which is the main charge of the avalanche.

(2) *The climax avalanche.* The climax avalanche is a special combination type. The distinguishing characteristic of this type avalanche is that it contains a large proportion of old snow and is due to conditions which have developed over a considerable period of time—at least a month and possibly an entire season. Climax avalanches occur infrequently because they require an unusual combination of favorable factors. Whenever they occur, the penetration of a climax fracture is always in great depth, usually to the ground. They travel farther and spread out wider than ordinary avalanches on the same slide path.

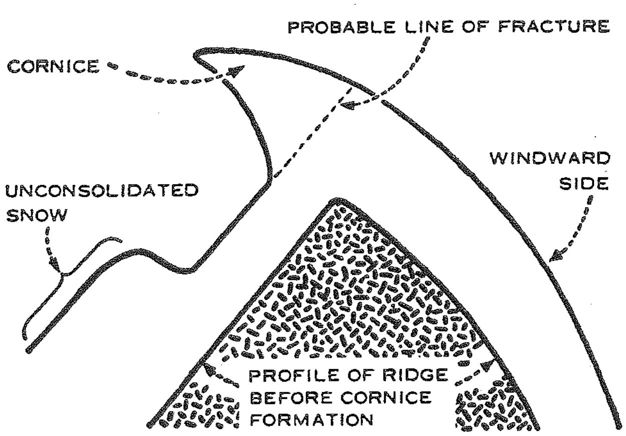


Figure 65. Cornice.

166. Avalanche Triggers

a. Triggering. A loose-snow slide usually occurs during or immediately after a storm or some other weather situation that creates instability. A slab avalanche may come as a delayed action. In any case, every avalanche must have a "trigger." There has to be some final nudge, some force or combination of forces, to account for the release of masses of snow at a particular time and place.

b. Classification. The following four avalanche triggers are recognized:

(1) Overloading.
(2) Shearing.
(3) Temperature.
(4) Vibration.

c. Overloading. Weight is probably the most frequent cause of avalanches. New snow piles up until it overcomes cohesion and the structure collapses of its own weight and begins to slide.

d. Shearing. This can be applied in various ways—the slicing action of a pair of skis, a wad of snow falling out of trees or over a cliff, or any exterior force that cuts the bond. A slide in motion has a shearing effect on the snow beneath, coupled with vibration.

e. Temperature. Temperature triggers more avalanches than any other factor, except weight, by its effect on the cohesion of snow. A rise in temperature weakens the bonds, while a fall in temperature retards settlement of the snow mass and increases the brittleness and tension of a slab.

f. Vibration. This factor is related to shearing, but it is treated separately because, unlike the other triggers, it can operate at long range. Avalanches may be released by thunder, shock waves originating from high speed aircraft, explosions of various types, by earthquakes and by other loud or sharp sounds—vibrations transmitted through the air. They may also be started by vibrations transmitted through the earth and snow by the movement of tanks, bulldozers and other heavy machinery, or by blasts. They can also be triggered by the primary or reflected blast waves resulting from the detonation of nuclear weapons.

167. Avalanche Hazard Forecasting

a. General. The accurate prediction of an avalanche occurrence either in time or location is impossible. The actual avalanche occurrence is governed by a set of variable factors which cannot be reduced to any mathematical formula at present. The experienced mountaineer can usually recognize the development of a hazardous situation in sufficient time to avoid the danger area.

b. Terrain and Climate. Terrain and climate are the two basic causes of avalanches. Terrain is a constant, always prepared to do its part; climate is the variable.

c. The Contributory Factors. The systematic avalanche studies conducted in the past have identified 10 factors which contribute to the avalanche hazard. These factors which are subdivisions of climate and weather are as follows:

(1) *Depth and condition of the base.* Sixty centimeters depth is generally sufficient to cover ground obstructions and provide a smooth sliding base. Greater depths will obliterate such major natural barriers as terraces, gullies, outcrops, and clumps of small trees. If the bottom snowlayer consists of granular snow (also referred to as depth hoar), the slope must be presumed to be dangerous, for the snowpack has no anchorage at its underside. Depth hoar is usually at the bottom of the snowpack, and can be detected by reversed ski poles, skis, probes, or vertical trenching.

(2) *Old snow surface.* A loose snow surface promotes good cohesion with a fresh fall but allows deeper penetration of any avalanche that starts, while a crusted or wind packed surface means poor cohesion with the new snow but restricts the avalanche to the new layer.

(3) *Depth of new snow.* The quantity of new snow sufficient to produce a dangerous avalanche is important. Based upon experience, 30 centimeters of new snow is regarded as the minimum requirement to produce by itself an avalanche of dangerous proportions.

(4) *Type of new snow (especially its free moisture content).* Very dry snow has few cohesion qualities and avalanches so readily that it seldom builds up to dangerous volume except under true blizzard conditions. The moisture in damp snow acts as a cement and improves cohesion, within limits. Wet snow is saturated and the water "lubricates" rather than cements. Transition snow (snow which is on the dividing line between dry and damp) is especially susceptible to the formation of slab under wind action.

(5) *Average density.* The average density (water content per centimeter of snow) of dry snow varies from .15 to .25 centimeters of water per 2.5 centimeters of new snow. The very dry snow, typical of the high alpine zones but found occasionally in other areas, is much lighter. Densities as low as .10 centimeters are common. Damp and wet snow in contrast has a density as high as .35 centimeters. These are normal average density characteristics and have no unusual significance. However, the important circumstance is a departure from the normal, for example, when the proportion of water in dry snow exceeds 10 percent, it becomes evident that its weight may be increasing faster than its cohesion, and a slide may occur.

(6) *Snowfall intensity (centimeters of snowfall per hour).* When the snow piles up at the rate of 2.5 centimeters or more per hour, the pack is growing faster than the stabilizing forces, such as settlement, can take care of it. Moreover, this sudden increase in load may fracture a slab beneath and result in a slide.

(7) *Precipitation intensity (moisture content per hour of snowfall).* Based upon experience it is concluded that with a continuous precipitation intensity of .25 centimeter of water or more per hour and wind action at effective levels the avalanche hazard becomes critical when the total water precipitation reaches 2.54 centimeters. This is one of the newest methods used in avalanche forecasting requiring interpretation by weather station personnel with special equipment.

(8) *Settlement.* Settlement of the snow goes on continuously. With one exception it is always a stabilizing factor. The exception is the shrinkage of a loose snow layer away from a slab thus robbing it of support. In new snow a settlement ratio less than 15 percent indicates that little consolidation is taking place; above 30 percent, stabilization is proceeding rapidly. Over a long period ordinary snow layers shrink up to 90 percent, but

slab layers may shrink no more than 60 percent. Thus abnormally low shrinkage in a layer indicates that a slab is forming.

(9) *Wind action.* Wind action is an important contributory factor. It overloads certain slopes at the expense of the others, it grinds snow crystals to simpler and less cohesive forms, it constructs stable crust and fragile slab, often side by side. Warm wind ("chinook" of North American and the "foehn" of Europe) is an effective thawing agent, even more effective than sunlight. By sudden changes in direction and velocity, wind can act as a shearing trigger on a layer of snow it has just deposited. Finally, it is essential to the formation of slab in ways which are not yet completely understood. An average velocity of 15 knots (in the mountains air currents are so erratic that they can only be samples) is the minimum effective level for wind's action in building avalanche hazards.

(10) *Temperatures.* Temperature directly influences the snow type. Dry snows normally fall at 25° F. and below. Temperatures above 28° F. promote rapid settlement and metamorphosis of the snow is sometimes too rapid. A sudden rise of temperature causes a loss of cohesion fast enough to trigger an avalanche. A sudden drop increases the tension particularly in slab. The gradual warming of the temperature in the spring leads to cumulative deterioration of the snow and to heavy, wet avalanches.

d. Avalanche Conditions. Avalanches obey mechanical laws which can be identified and evaluated by trained personnel with special equipment. The soldier in the field must generally rely on the following factors:

(1) Terrain—grade 20° or steeper.
(2) Old snow depth—enough to cover ground obstructions.
(3) Surface crusted—normally only new snow will slide. Surface loose—good cohesion between layers but both old and new snow may slide.
(4) New snow depth—25 centimeters or more.
(5) Snowfall intensity—2.5 centimeters per hour or more. Can be assumed when snowfall is heavy enough to restrict visibility to 100–200 meters.
(6) Precipitation intensity—.25 centimeter per hour of water or more plus strong wind action. Can be assumed if snowfall intensity is 2.5 centimeters per hour and snow is damp or noticeably heavy for dry snow, or dry snow is granular or pellet in type.
(7) Settlement—noticeably low. Watch the snow collars around the trees or posts.
(8) Wind—15 knots or higher average. Can be assumed if snow is blown parallel or almost parallel to ground.
(9) Temperature—any sudden change up or down. Thawing temperature day and night for 36 hours; that is, no overnight freeze.
(10) Depth hoar—must be assumed on any avalanche slope in the high alpine zone.

168. Protective Measures

Several methods can be used to reduce the effects of the avalanche hazard. Some of the protective measures that may be taken by units in avalanche areas are—

a. Restrictions. Based upon terrain analysis and reconnaissance, areas which are considered hazardous may be placed "off limits" for all troops for a certain period of time. This may affect only a few narrow avalanche paths, or an entire valley, or several valleys depending upon the terrain and weather conditions in the area of operations. Enforcement of restrictions may be a necessity even if the troops involved are required to conduct long and time-consuming detours.

b. Stabilization. In combat, individuals and units may be required to take calculated risks and enter areas described as hazardous. The risks can be considerably reduced by application of the following stabilization methods:

(1) *Stabilization by skiing.* By this means, the snow is caused to settle on the dangerous slope. Constant use of the hazardous slidepath area also prevents the snow from building up avalanche conditions. The work is done by teams of expert skiers (2 and 3 on each team). Great care, coordination between teams, and supervision must be exercised due to the dangerous nature of the work. The

leading man in the party, using the avalanche cord and being belayed by the other members of the team, skis the release points of the slope. The roped party proceeds in a similar manner as described in chapter 4. As a result of this skiing action the snow will be either stabilized or the slide triggered, in either case the avalanche hazard is removed.

(2) *Stabilization by means of explosives.* Under extremely dangerous conditions it may be safer to stabilize the snow by using hand-placed charges or hand grenades. The safest way to do this is to throw charges of approximately 5 pounds over the crest, having the electric wire coiled so that the charge lands on the slope 5 to 6 meters below the crest. The charge may then be safely detonated from behind the crest. Under certain snow conditions more powerful charges may be required. As a rule of thumb approximately 5 to 10 pounds of TNT controls 39 meters of slope width. Huge cornices are blasted by digging charges into the snow along the probable line of fracture. Individuals digging holes and placing charges must be belayed from the crest while working.

(3) *Stabilization by artillery and infantry weapons.* Carrying explosives and demolition equipment up mountain slopes in deep snow is hard work. An easy way to cause the snow to slide is to use artillery pieces within their range. Due to the difficulty of moving artillery pieces off the road or over secondary mountain trails, recoilless rifles become the handiest tool in campaigns against avalanches.

(4) *Stabilization by aircraft.* Due to the fact that the use of artillery pieces as well as recoilless rifles is limited within their range, avalanches may be set off against lines of communications deep in enemy territory by use of aircraft. The pilot selects suitable slopes and causes the snow to slide by using guns, rockets, or sonic boom.

c. Use of Barriers. Lines of communications as well as various types of fixed installations which are under avalanche threat can be protected by construction of avalanche barriers. Barriers can be formed by adding rocks and earth, concrete, or other similar materials to any natural obstacles existing in the area. This additional bulkhead will tend to absorb some of the tremendous energy of the slide. Diversion walls and piers may also be used to confine the avalanche to a certain path, or turn it away from the installation to be protected. Such work is normally undertaken only during static situations due to the amount of effort involved.

169. Safety Rules

a. General. Avalanches are one of the principal dangers of mountaineering. Many of the hazards peculiar to avalanche areas can be avoided or their danger greatly reduced by knowing and practicing a few simple, common sense rules. The following rules of conduct are adhered to whenever it becomes necessary, due to tactical or technical reasons, to negotiate snow-covered terrain which threatens to avalanche.

b. Adjusting Equipment. To insure freedom of legs and arms, the safety strap on the ice axe is removed from the wrist. When using skis, the bindings are loosened to facilitate their quick removal, and ski pole straps are removed from the wrists. Skis in particular tend to get tangled, restrict movement, and get dragged under the sliding snow. When snow conditions permit, such danger zones may be negotiated more safely on foot, carrying the skis. While skiing, falling is avoided and all movements are executed with caution.

c. Selection of Routes. Learn the avalanche paths and, whenever possible, detour around the hazardous slopes. The crest of a ridge is a safe route, but never move on the overhang of the cornice. Avoid moving along the bottom of narrow, V-shaped valleys (point X in fig. 66) where a disturbance of the snow could cause a double avalanche (from both sides) and fill the narrow valley floor with masses of snow instantaneously. Movement along the middle of wide, U-shaped valleys is less dangerous, since avalanches occurring there would tend to expend their force on the wide floor of the valley with little danger to troops moving in the middle. Do not move above natural barriers such as moraine (point Y in fig. 67) located on the valley floor, since the slide obviously collides with the barrier.

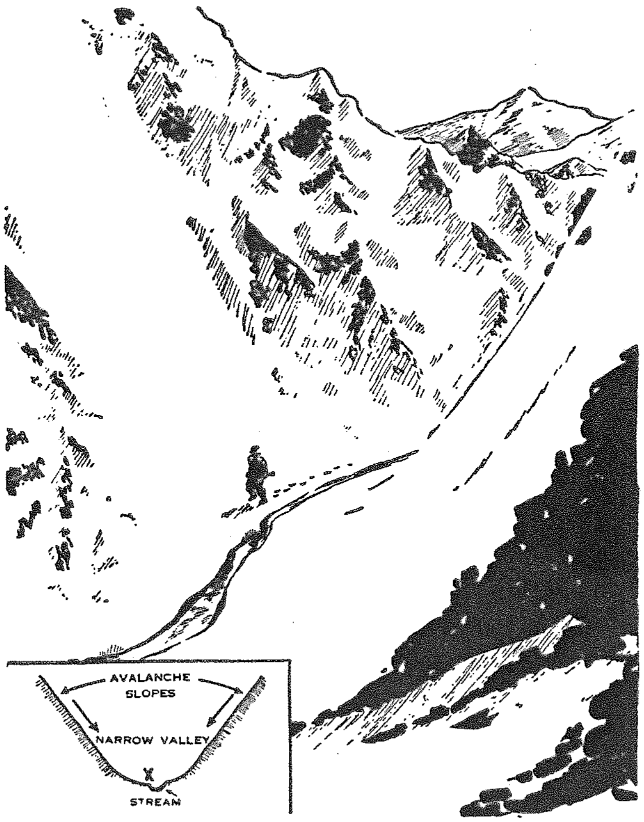


Figure 66. Danger of double avalanche.

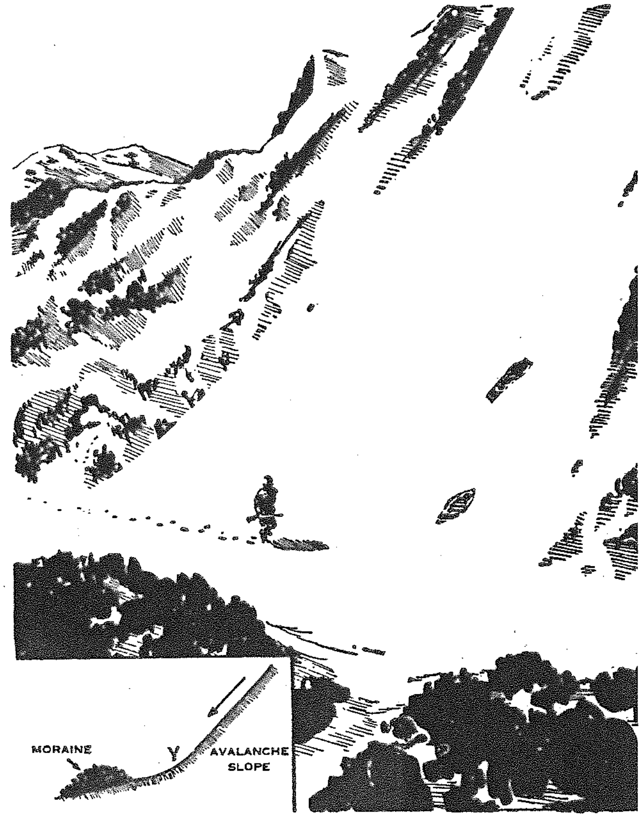


Figure 67. Danger of avalanche against moraine barrier.

d. Weather. Obtain the latest weather forecast from the best available sources prior to starting a move. During the move be alert for any signs of a change in the weather. Any sudden change can be dangerous.

e. Ascent and Descent. When avalanche slopes must be ascended or descended they are climbed as straight up or as straight down as possible, preferably along a line of protruding rocks, ledges, and trees where the snow cover is less likely to slide. Traversing back and forth is avoided since the snow cover is dissected and greatly distributed in this manner. Ravines, gullies, and low terrain features which are locations of snow deposits are avoided as much as possible.

f. Observation and Testing. The area to be traversed must be constantly observed for signs of danger. It should be tested whenever the tactical situation will permit. Before entering a dangerous slope, a small area of the same grade and exposure should be tested. Windslab formations should be avoided, since they give a false impression of their solidity. Watch the shadows; when they point at a slope like warning fingers, sun action is at its maximum. Seek the protection of heavy timber, windbeaten slopes, and terrain barriers.

g. Proper Timing. In movement over areas of avalanche danger, distance between individuals is greatly increased and maintained in accordance with prevailing conditions and the area to be negotiated. Only one or the least possible number of individuals are exposed to this danger at one time. If a dangerous slope, deep hollow, or gully must be traversed, let one man test the slope, belayed with the climbing rope by other members of the party. Visual contact is constantly maintained and, if necessary, warning posts are established or observers are stationed at safe locations along the route.

h. Use of Avalanche Cord. On reconnaissance missions in avalanche areas and especially when testing, one end of a brightly colored cord (15 to 20 meters in length) is tied around the body and trailed behind the individual. This brightly colored avalanche cord is an additional safety measure and facilitates location and rescue of individuals buried by an avalanche, since the cord ordinarily remains on or near the surface of the slide.

i. Action of Individuals Caught in an Avalanche. When caught in an avalanche there are certain actions that can be taken by the individual which will greatly increase his chances of survival and recovery. Most important is DON'T PANIC. Maintain self-control and attempt to stay on the surface and get out of the main slide path. Execute "swimming" motions to combat the tendency of the sliding, rolling snow to pull one underneath. Grab any obstruction to assist the fight to the surface. Kick off the skis. After being completely covered by the snow mass, both arms are held in front of the face and pushed against the covering snow in an attempt to provide an airspace before the slide hardens.

j. Selection of Tactical Locations. Great care must be exercised in the selection of battle positions, command posts, outposts, security elements, battery positions, bivouac sites, and administrative support bases in the areas where hazardous conditions exist.

170. Avalanche Rescue

a. Survival Margin. If an individual is caught by an avalanche, prompt and organized rescue operations offer the only hope of getting the victim out alive. There are records of persons who lived as long as 72 hours while buried. Ordinarily the victims are either killed instantly by crushing, or die within a short period from exposure, shock, and suffocation. Suffocation is the most important item. Based upon experiences in the past it can be concluded that two hours is the average survival limit. Snow is porous and ordinarily contains enough air to support life, though not consciousness. In about two hours an icemask, caused by condensation of the victim's breath, forms an air-proof seal around his face and he dies of suffocation. Rescue operations are therefore designed to get the victim out within the two-hour time limit. Because of some special circumstances which may prolong the life of the victim—he may be in an air pocket—rescue operations should not be discontinued for 24 hours at least.

b. Phases of Rescue Operation. Successful rescue operations depend upon decisive leadership, proficiency of the search party, and availability of special equipment. The rescue operation is divided into three phases—immediate action, followup, and evacuation.

(1) *Immediate action.*

(*a*) Surviving members of the unit, present at the site of the avalanche, are organized into the first rescue team and immediately start rescue operations. The well organized and immediate action of the personnel at the site of the avalanche generally constitute the main factor in successful rescue operations. The leader of this rescue team upon his own discretion must decide if a followup rescue party and any other additional help is needed; if so, it is sent for by the most expeditious means.

(*b*) The rescue party on duty, upon being alerted, is issued special equipment and provided transportation. This party is dispatched under command of the most experienced officer or noncommissioned officer available. The strength of the party should be at least one squad or, preferably, one platoon, and should include an aid man. This party should be on their way within 15 minutes after receiving the alarm. This rescue party moves out lightly equipped; speed is the first consideration.

(*c*) The first rescue team, in the meanwhile, has instituted rescue operations. The leader of this team posts an avalanche guard for protection of the search parties.

(*d*) The "last seen point" is located and marked so that it cannot be obliterated by wind or snowfall. In determining the "last seen point," eyewitnesses, if available, are questioned. Any eyewitness, even if in poor physical condition, should return to the scene of the accident to point out where the victim or victims were last seen. This is extremely important.

(*e*) From the "last seen point" downhill, the rescue team makes a hasty search of the slide surface for the victims or any part of their equipment.

(*f*) If any indication of the location of the victim is found, the probing starts in that vicinity. If no indications are found, the probing starts in likely locations, such as obstructions in the slide path. Trees, boulders, and transitions cause obstructions. The tip and edges of the slide are also searched. A human body is bulky and all being equal, is apt to be thrown toward the surface or the sides.

(*g*) If the victim is found and is unconscious, first aid (artificial respiration) must be administered at once.

(*h*) The alert rescue party, upon approval at the scene of the accident, reinforces the first rescue team.

(2) *Followup.*

(*a*) The strength of the alert rescue party is usually small to enable them to get ready and move out rapidly. If the area to be searched is extensive, a second or followup party must be sent to the accident scene as reinforcements. The second or followup party should move out in half an hour or not later than one hour. It carries a complete set of equipment including probes, shovels, 200-pound sled, radio, rations, and other items as required.

(*b*) In the 30–60 minutes at his disposal, the unit commander or his representative organizes and equips the followup party and notifies all necessary military authorities of the incident.

(*c*) If the first party has been unsuccessful, the followup party begins systematic probing of the slide, beginning at the tip and working up toward the "last-seen point" (fig. 68). Probers are spaced shoulder to shoulder and probe every square meter. Probes must be pushed through the snow very cautiously to avoid injuring the victim. If the last-seen point is known, a special group may be assigned to probe any sections of the strip from this point downhill.

(*d*) The first party may be relieved by the reinforcements if necessary.

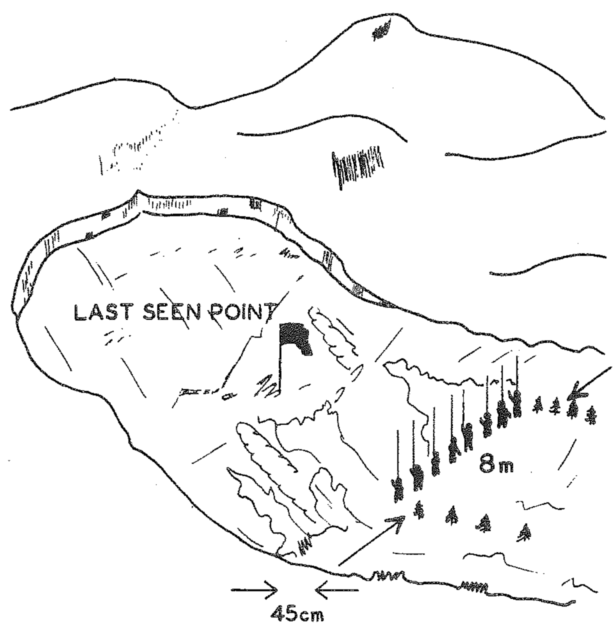
(*e*) Shovel crews are organized to assist the probers, relieving them at intervals and digging in any likely spots. They should be prevented from haphazard digging and wasting energy.

(*f*) Time spent in systematic probing should not exceed 3 to 4 hours. If this is unsuccessful, the slide must be trenched by the reinforcing elements.

(*g*) Trenches are dug parallel to the contour down to ground level or undisturbed snow at intervals of 2 meters. Digging begins at the tip of the slide and proceeds uphill. It is feasible to space the shovel teams along one trench with frequent intervals. In this manner snow from one trench can be thrown into the one just completed.

(*h*) If trenching is necessary, the operation ceases to be of an emergency type.

(3) *Evacuation.* Artificial respiration for suffocation is administered to the victim as outlined in FM 21–11. The evacuation is conducted as outlined in chapter 3 and in FM 31–70.



SKETCH SHOWING RESCUE
OPERATIONS IN A SNOW SLIDE
EIGHT MEN, SHOULDER TO SHOULDER PROBING SYSTEMATICALLY, ROW BY ROW WITH POLES. ROWS 45 cm WIDE. EDGE OF ROWS MARKED TO IDENTIFY ALIGNMENT.

Figure 68. Probing diagram.

c. Avalanche Rescue Equipment. The following rescue equipment is considered the minimum for organizations of battalion size; it should be readily available to the alert force at all times.

(1) 20 probes (sectional preferred—otherwise metal or wooden rods 1.30 cm in diameter, minimum 4 m long).
(2) 12 snow shovels or shovels, GP, round point, short D-handle.
(3) 12 flashlights with spare batteries.
(4) 6 climbing ropes, nylon, 36½ meters long.
(5) 6 avalanche cords, colored, 20–30 meters long.
(6) 2 sleds, 200-pound, with harnesses and tow ropes.
(7) 2 emergency evacuation bags or 4 sleeping bags, arctic.
(8) 1 set of first aid equipment to include chemical heating pads.
(9) Emergency rations.
(10) Stoves and cooking equipment.
(11) Skis, ski poles, and climbers for each individual.
(12) Tentage.
(13) Platoon and company radios.
(14) 20 marking flags (brightly colored).

Section IV. MOVEMENT OVER SNOW AND ICE

171. General

a. Movement over snow with the aid of skis and snowshoes is discussed in detail in FM 31–70.

b. The principles which apply to movement over rocky terrain also apply to over-snow travel when skis or snowshoes are not used. When snow lies over a foundation of other than glacier ice, and the terrain is not steep, no special techniques are called for. Efficient progress depends largely upon proper route selection and on using such procedures as minimize exertion. Rock climbing requires gymnastic agility, combined with good judgment in selecting a safe and direct route.

172. Equipment

a. Ice ax (fig. 69). The ice ax to the trained mountaineer is as important as any other piece of his equipment. Primary uses are discussed in the proceeding paragraphs; however, each man will find, through experience, other uses for the ax. Extreme care must be exercised at all times in handling and using the ax. If carelessly handled the ice ax becomes a dangerous weapon, not only to the owner but to others as well.

(1) *Primary uses.*
 (*a*) Cutting steps in ice and snow.
 (*b*) Probing for snow covered crevasses and obstructions.
 (*c*) Belaying in ice and snow.
 (*d*) Aid in steep terrain (third point of suspension).
 (*e*) Implement to stop falls (self arrest).

(2) *Carrying.* On fairly level, open trails the ice ax may be carried by grasping it at the balance with the head to the rear, pick down. It may also be used as a walking stick. When walking on snow, the head is grasped with the pick pointing forward; when walking on ice the adze is pointed forward. Alternately, the ice ax may be carried under the arm, in this method the head is to the rear, parallel to the ground with the pick pointing away from the body. If no need exists for the ax, it may be stowed in the ruck-sack head down with the shaft protruding.

b. Crampons (fig. 70). The crampon is used as an aid in securing additional traction on snow and ice. The standard 10-point crampon is issued in two sizes, small and large. Care must be exercised to insure proper fit. The crampon should fit snugly to the boot, the front spikes should not protrude past the toe.

(1) *Technique.* Balance is important, the ankle should be flexed so that the crampon points are at right angles to the slope, this applies in both the ascent and descent. On hard snow the points of the crampons will bite in easily, but on hard ice the foot should be stamped down hard to drive the points in.

(2) *Maintenance.* The crampons should be inspected frequently to make sure straps and rivets are secure and serviceable. The points should be kept filed sharp.

(3) *Field expedients.* The crampon may tend to break at the hinge where the front and rear spikes join. As an expedient, they can be wired together and used until replacements are obtained. In an emergency the two sections can be joined together with a snaplink.

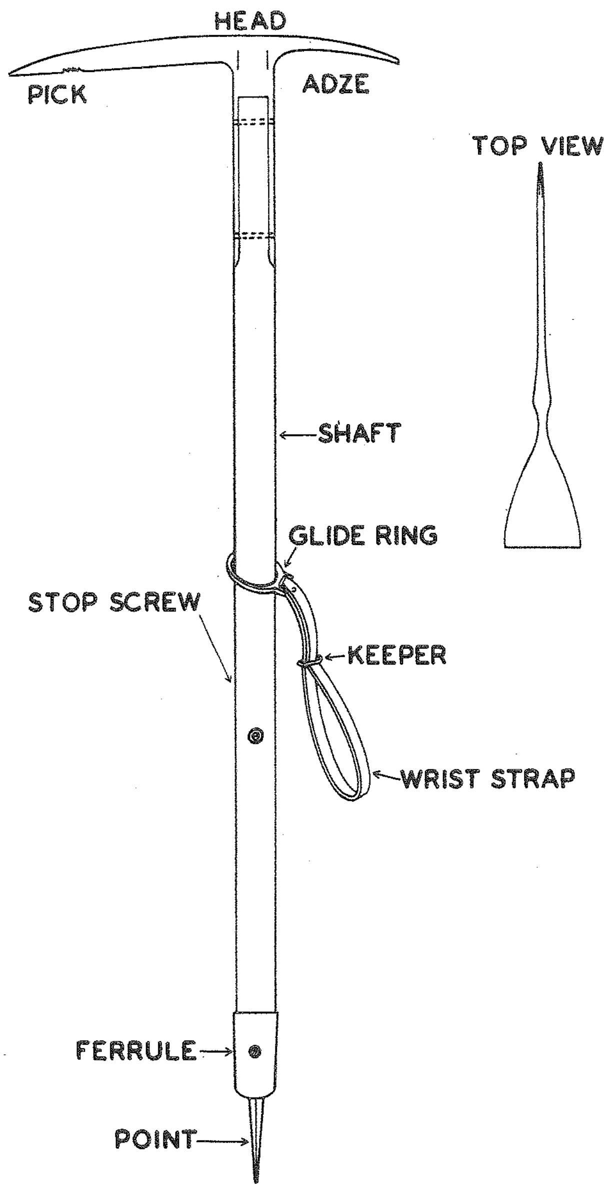


Figure 69. Ice ax.

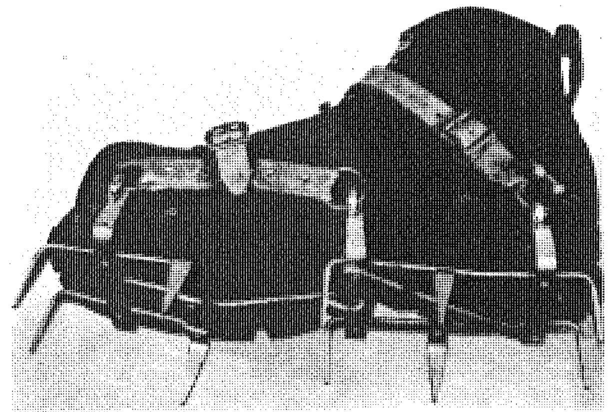


Figure 70. 10-point crampon.

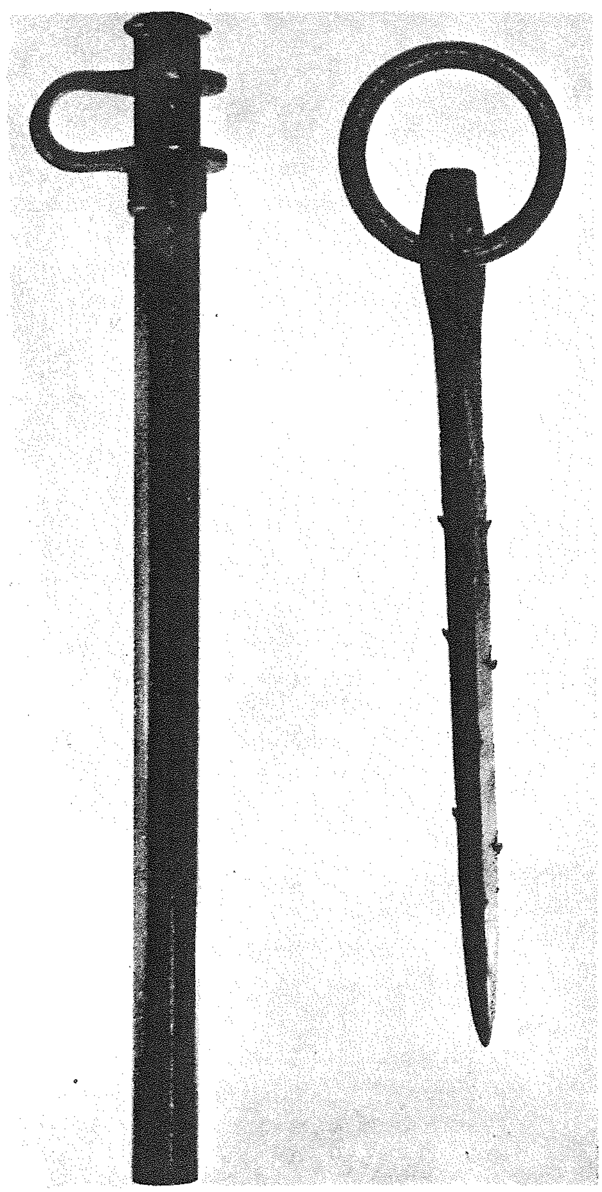


Figure 71. Ice pitons.

(4) *Safety.* Care should be exercised when wearing crampons to insure that they do not catch in the trouser leg when climbing. As a preventative measure, the trousers should be secured in the top of the boot with no blouse.

c. Ice Anchors.

(1) *Ice pitons* (fig. 71). Ice pitons are used mainly to establish anchor points. The ice piton is emplaced as follows:

(*a*) Cut a horizontal recess in the ice and remove all rotten ice.

(*b*) Drive the piton vertically all the way to the ring. Applied or expected pull should be at right angles to the piton shaft (fig. 72).

(*c*) Test the piton before putting pull on it to insure that it is properly emplaced (fig. 73). If the piton pulls out or appears weak, move to another spot and redrive it. In most cases it will be advisable, for safety, to employ the pitons in pairs. In this case the pitons should be driven at right angles to each other (fig. 74). Employing the pitons in this manner prevents either one of them from pulling out accidentally.

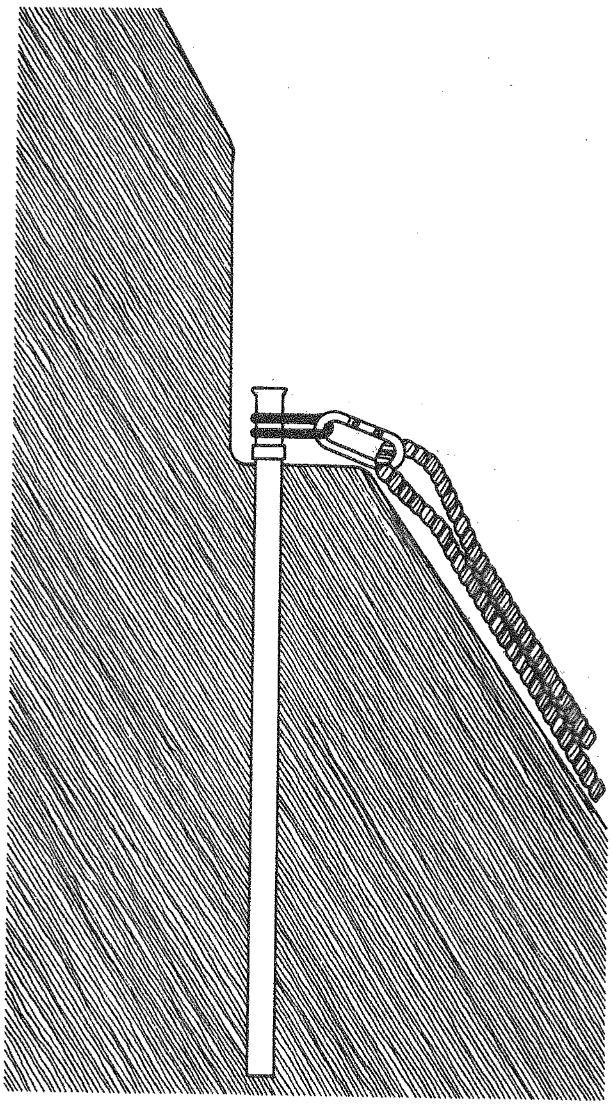


Figure 72. Proper method of emplacing the ice piton.

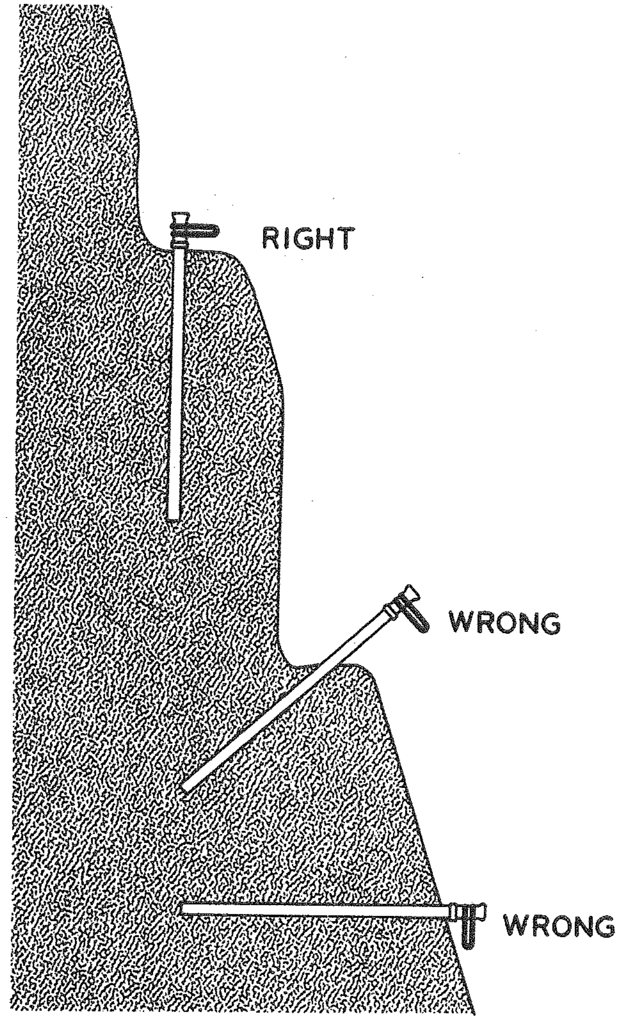


Figure 73. Right and wrong way of emplacing the ice piton.

(*d*) Use time of the ice piton is limited, the piton will heat from solar radiation or the ice will crack or soften. If considerable climbing is to be made utilizing ice pitons, the pitons should be inspected frequently and redriven when necessary.

(2) *Horseshoe anchor* (fig. 75).

(*a*) The horseshoe anchor is a horseshoe shaped projection fashioned from ice or snow and constructed by either cutting with the ice ax or stamping with the boots. When constructed of snow, the width should be not less than 1.5 meters. In ice, this width may be narrowed to 39 centimeters to 1 meter, depending on the strength of the ice.

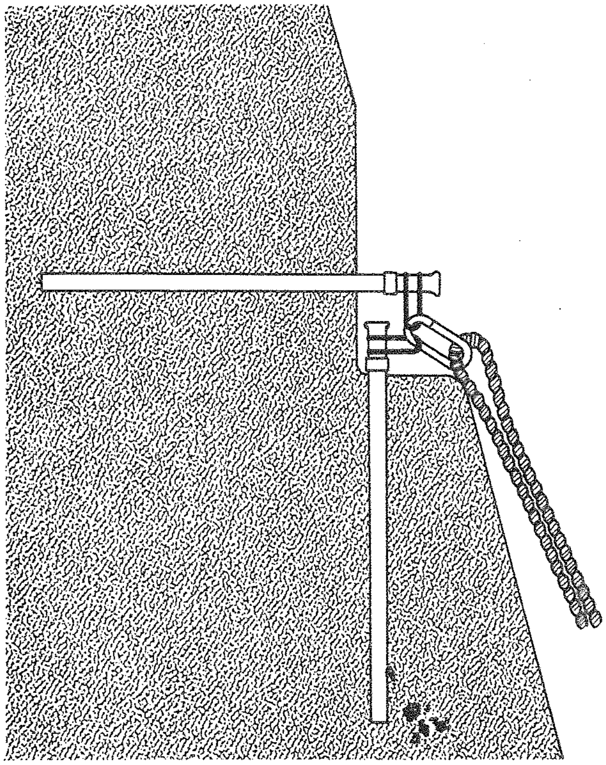


Figure 74. Ice pitons emplaced at right angles.

The trench around the horseshoe should be stamped as deeply as possible in the snow and should be cut to not less than 15 centimeters in ice.

(*b*) The properly constructed horseshoe anchor provides an anchor point always available and may be used for rappels and for fixed ropes.

(*c*) The horseshoe should be inspected frequently to see that the rope is not cutting through the snow or ice. If such is the case, a new anchor should be constructed in a new location.

(*d*) A horseshoe anchor constructed in snow is always precarious and its strength depends upon prevailing texture of the snow. For dry snow or wind-packed snow the reliability of the anchor is questionable.

173. Movement Over Snow and Ice

a. On very steep slopes in deep snow, the climber may climb straight up facing the slope. The ice ax driven directly into the snow provides a quick and effective protection in case of a slip. It is usually best, however, to climb snow slopes in a zig-zag fashion in order to conserve strength. If the snow is packed or frozen hard, the composition sole of the boot will generally hold by kicking steps, even in steep slopes. Where it is difficult to make an effective scrape with the boot, a scrape with the adze end of the ice ax makes an effective step. In these situations crampons should be used for faster and easier movement.

b. When descending in snow, one can usually come straight down even in steep terrain. Movement downhill should be slow and deliberate and with an even pace. The heels should be kicked vigorously into the snow wherever it is hard packed. The body may be kept erect with the help of ice ax, which may be jammed into the snow at each step for additional safety. Here again, crampons or step-cutting may be necessary.

c. Step cutting in ice (fig. 76) is done with the pick end of the ice ax. In cutting ice a blow directly in and another diagonally toward the first will usually fashion a rough step which may be finished off with the adze end of the ice ax. Black (dark) ice is harder and requires more blows. The

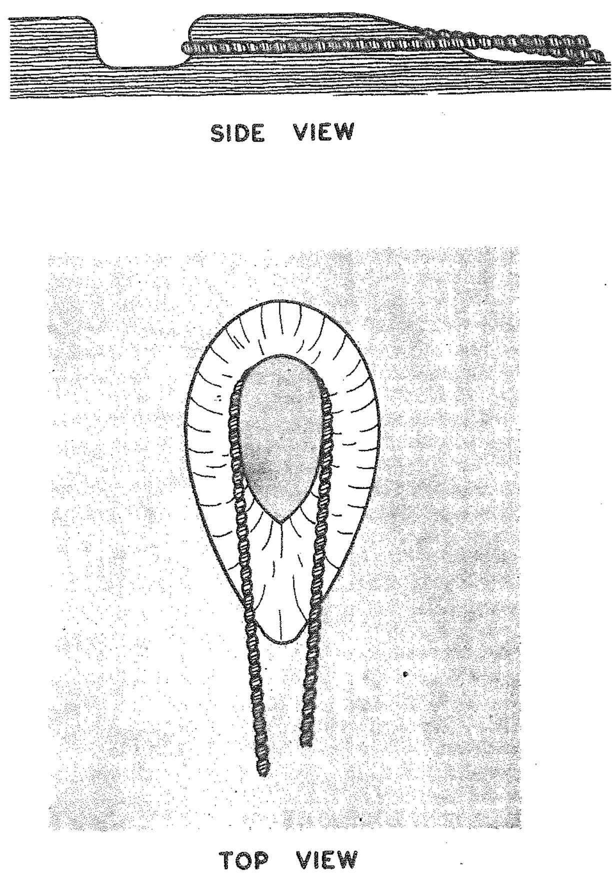


Figure 75. Horseshoe anchor.

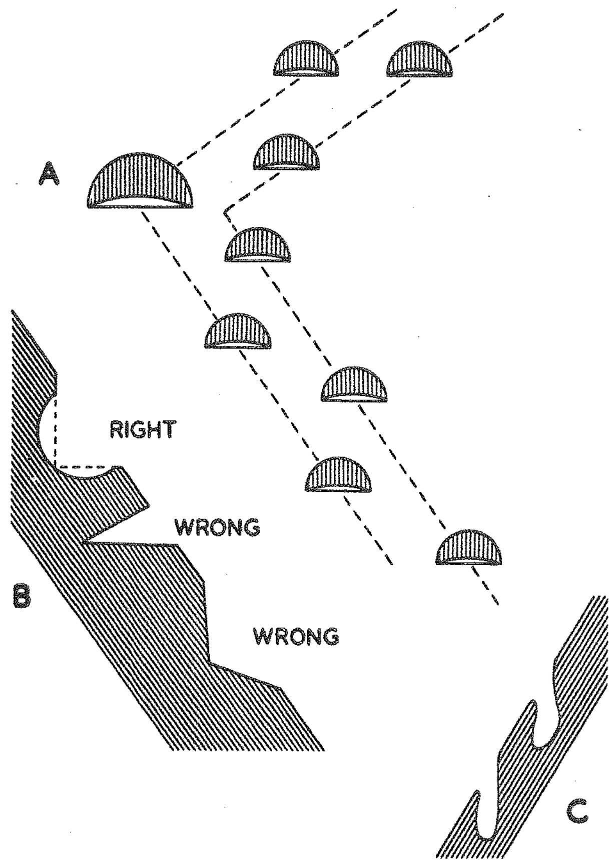


Figure 76. Step cutting in ice.

blows should be directed into the ice at as near a right angle as possible to reduce the danger of flaking off the outside layers. The step should slope slightly inward. It does not need to be commodious except at resting places. In climbing, steps may be cut straight up or on a diagonal to the line of ascent. In descending it is seldom practicable to do anything except to cut steps in a diagonal line.

d. Belays are more difficult to secure on ice and snow than on rock, but they are equally necessary In general they are obtained by use of the ice ax although ice pitons are also used; for rappelling, a belay point can be cut directly into the ice itself.

e. On hard packed snow slopes which can be seen from top to bottom and which are not too steep, it is possible to glissade (fig. 77). Glissading should not be attempted unless the bottom of the slope can be seen, otherwise unseen obstacles may result in serious falls. Glissading in a sitting position gives little control of descent. In the standing position, the body must always be kept erect, as nearly upright as possible, and with the ice ax firmly held in the hands. The ice ax is pressed back into the snow when necessary. Turning the toes to one side or the other changes the course of descent. Turning sharply to the side on which the ice ax is held increases the pressure on the ice ax and brings one to a stop. To slow down, pressure of the ice ax is sufficient. Glissading down solidly frozen ice slopes is dangerous, and should not be attempted.

f. Unforeseen falls are always a possibility when moving over ice or snow covered slopes. If the party is roped together, the faller can usually be arrested by other members of the party; however, if the party is traveling unroped the self-arrest system, using the ice ax, must be employed. After falling, roll immediately onto the stomach. If wearing crampons, the legs are spread apart and bent at the knee with the feet up in the air, if crampons are not worn, the feet may be dug in to assist in the arrest. The head of the ice ax is held with one hand shoulder high, the shaft of the ax is grasped with the other hand and held diagonal to the body. The ax is secured to the hand with the wrist strap. To arrest the fall, the head of the ice ax is pressed into the surface with increasing pressure until movement is arrested. If the fall occurs on ice the pick end of the ice ax should be used on the surface, if on snow the adze end should be used.

Figure 77. Glissading.

Section V. MOVEMENT OVER GLACIERS

174. Principal Dangers

a. The principal dangers of glacial regions are crevasses, icefalls, and ice avalanches.

b. Snow covered crevasses make movement on a glacier very treacherous. In winter, when visibility is poor, the difficulty of recognizing them is increased. Toward the end of the summer, crevasses are broadest and covered by the least snow. Snow bridges constitute the greatest potential danger in movement over glaciers.

c. In steep pitch of a glacier, ice pinnacles and towers may rise in a composition of criss-cross crevasses. These break off and fall because of gradual melting, their own weight, and the movement of the glacier, this condition is known as an ice-fall. Ice avalanches result and often threaten men at the foot of the ice wall. The greatest dangers lie in the gullies below hanging glaciers. Such threatened zones must be crossed as fast as possible. These zones are normally safer before sunrise.

d. Light and heat rays reflected from ice, snow, water, and bright rocks irritate and burn the skin very rapidly, causing glacial sunburn. Sunburn can occur on cloudy days. A strong wind will make the burn more severe. Sunburn cream should be used frequently on all exposed skin surfaces. It is particularly dangerous to expose parts of the body which are not accustomed to the sun's rays. As soon as any part of the body becomes burned, it should be protected from further exposure. Particularly bad cases of burn very often lead to fever and also to a lessening of muscular activity. It may often take several days before the casualty is fit for duty.

e. Snow blindness occurs when sun is shining brightly on an expanse of snow, and is due to the reflection of ultraviolet rays. It is particularly likely to occur after a fall of new snow, even when the rays of the sun are partially obscured by a light mist or a fog. In most cases, snow blindness is due to negligence or failure on the part of the soldier to use his goggles. Symptoms of snow blindness are sensation of grit in the eyes, pain in and over the eyes, watering, redness, headache and photophobia (distaste for light). Pontocian or butyn ointment and zinc sulphate drops are the prescribed treatment for snow blindness. A poultice of cold used tea leaves may be used to give relief if the drops are not available. Dark eye shades or bandages should be placed over the eyes.

175. Use of Rope

A roped party of two, while ideal for rock climbing, is at a great disadvantage on a snow-covered glacier, since it is almost impossible for one man alone to rescue another who has fallen into a crevasse. The best combination is a three-man party, tied in on a single rope. Each member should carry in a coil enough of the rope to eliminate a direct pull on his body loop. The rope should touch the snow as little as possible, since a wet rope kinks badly and may freeze and become unmanageable (fig. 78). It is best to travel roped at all times when on the snow-covered part of a glacier. Use of the rope on steep and/or heavily crevassed ice, however free of snow is almost always a necessity.

176. Routes

The individual operating in the mountains must appreciate certain limitations imposed by nature in glacier movement. Access to the end portion of a glacier may be difficult due to abruptness of the ice and possible presence of crevasses on this section of a glacier. Additional obstacles in getting onto a glacier may be swift glacier streams, steep terminal or lateral moraines and abrupt mountain terrain bordering the glacier ice. The same obstacles may also have to be overcome in getting on or off a valley glacier at any place along its course. Further considerations to movement on a glacier are steep sections, heavily crevassed portions, and ice falls which may be major obstacles to progress. The use of up-to-date aerial photographs in conjunction with aerial reconnaissance is a valuable means of gathering advance information about a particular glacier; however, they only supplement and do not take the place of on-the-ground reconnaissance conducted from available vantage points.

Figure 78. Method of carrying rope coil when moving on glaciers.

177. Crossing Crevasses

a. Crevasses which gape wide open are obvious, and their presence is an inconvenience rather than a danger to movement. Narrow cracks can be jumped, provided the takeoff and landing spots are firm and offer good footing. Wider cracks will have to be circumvented unless a solid piece of ice joins into an ice bridge strong enough to support at least the weight of one member of the party. Such ice bridges are often formed in the lower portion of a crevasse, connecting both sides of it.

b. In the zone that divides seasonal melting from permanent falls of snow, large crevasses remain open, though their depths may be clogged with masses of snow. Narrow cracks may be covered. In this zone, the snow which covers glacier ice melts more rapidly than that which covers crevasses. The differentiation between glacier ice and narrow snow-covered cracks is immediately apparent, for the covering snow is white, whereas the glacier ice is gray.

c. Usually, the upper part of a glacier is permanently snow covered. The snow surface here will vary in consistency from dry powder to consolidated snow. Below this surface cover of snow are found other snow layers that become more crystalline in texture with depth, and gradually turn into glacier ice. It is in this snow-covered upper part of a glacier that crevasses are most difficult to detect, for even wide crevasses may be completely concealed by snow bridges.

d. Snow bridges are formed of windblown snow which builds a cornice over the empty interior of the crevasse. As the cornice grows from the windward side, a counterpart is formed on the leeward side. The growth of the leeward portion will be slower than that to the windward so that the juncture of the two cornices occurs over the middle of the crevasse only when the contributing winds blow equally from each side of the crevasse. Bridges can be formed also without wind, especially during heavy falls of dry snow, and since cohesion of dry snow depends only on an interlocking of the branches of delicate crystals, such bridges are particularly dangerous during the winter. When warmer weather prevails during the summer, the snow becomes settled, is more compacted and has greater carrying capacity and firmer bridges.

e. Once a crevasse has been completely bridged, its detection is difficult (fig. 79). Bridges are generally slightly concave because of the settling of the snow, and this concavity is perceptible in sunshine, but impossible to detect on dull days or during a snowstorm. If the presence of hidden crevasses is suspected, the leader of a roped party must probe the snow in front of him with the shaft of his ice ax or with some similar instrument. As long as a firm foundation is encountered, the party may proceed, but should the shaft meet no opposition from an underlying layer of snow, a crevasse is probably present. In such a situation, the prober should probe closer to the standing place to

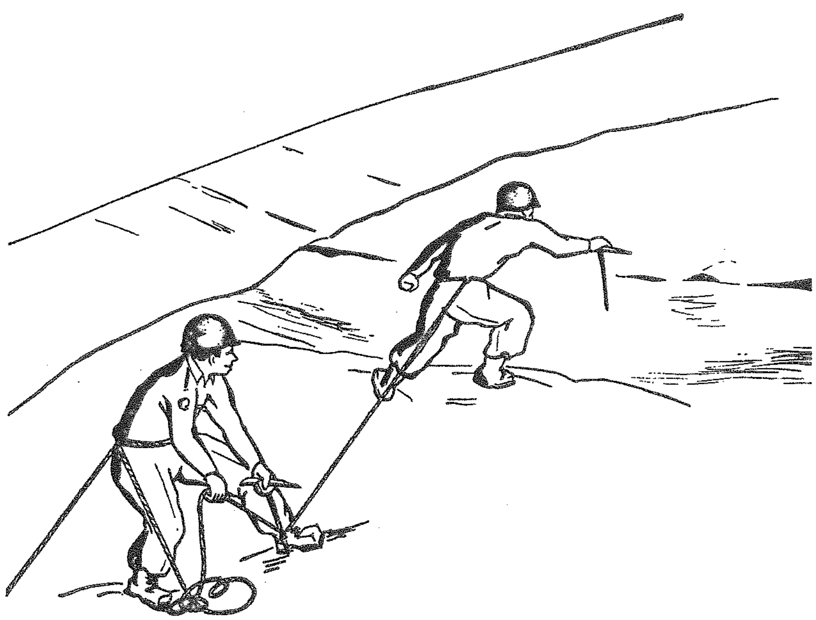


Figure 79. Probing for a crevasse.

make sure that he is not standing on the bridge itself. If so, he should retreat gently from the bridge and determine the width and direction of the crevasse. He should then follow and probe the margin until a more resistant portion of the bridge is reached. When moving parallel to a crevasse, all members of the party should keep well back from the edge and follow a course parallel to it.

f. A crevasse should be crossed at right angles to its trend unless a diagonal bridge is clearly visible. When a bridge which seems sufficiently strong to hold a member of the party has been located, proceed as follows:

(1) The leader and second man takes up positions at least 3 meters back from the edge of the crevasse. The third man goes into a belay some distance behind the second man.

(2) The second man belays the leader by plunging the shaft of his ice ax firmly into the snow surface, taking a loop around it with the rope, and paying out line as the leader advances. If the snow is too powdery to provide good anchorage for the ice ax, the second man should sit in the snow with his feet braced in front of him and use the hip belay prescribed for rock climbing.

(3) The leader should move forward, carefully probing the snow and evaluating the strength of the bridge, until he reaches firm snow on the far side of the crevasse.

(4) Having crossed the crevasse, the leader should belay the second man in the same manner as described in (2) above.

(5) When the second man has crossed safely, the leader should move forward to a secure position while belays are provided for the remaining members of the party by each succeeding climber.

(6) In case the rope interval is insufficient for the leader to reach firm snow, the third man moves up to the position of the second man, the second man must unrope, undo the knot, and have the third man move up to a position which will allow the leader to reach a secure position.

g. In crossing crevasses, distribute the weight over as wide an area as possible. Do not stamp the snow. Many fragile bridges have been crossed by lying down and edging over the other side.

178. Crevasse Rescue

a. To provide a quick means of holding an unexpected breakthrough the rope is always kept taut and the rope is secured to the ice ax handle with a small butterfly knot. As an unexpected breakthrough by the first man takes place, the second and third men thrust their ice axes immediately into the snow to arrest the fall. A fall through a snow bridge results either in the climber's becoming jammed in the hole broken by his feet, or in being suspended within the crevasse by the rope (fig. 80).

b. If the leader has fallen only partially through the snow bridge, he is supported by the snow forming the bridge. He should not thrash about. This will only enlarge the hole and result in deeper suspension. All his movements should be slow and aimed at rolling out of the hole and distributing his weight over the remainder of the bridge. Pulling on the rope with one or both hands is of great assistance. The victim can help himself more than he can be helped by the second man, whose duties consist primarily of belaying the rope firmly to check any further breakthrough on the leader's part. It generally is safer to retain the pack, as its bulk often prevents a deeper fall. Should a climber other than the leader experience a partial fall, the rescue procedure will be the same as for the leader.

c. (1) When the climber is suspended by the rope, the length of his fall depends upon how quickly the rope can be checked and where in the bridge the break takes place. If the fall occurs close to the near edge of the crevasse, it usually can be checked before the climber has fallen more than one or two meters. However, if he is nearly across, the fall will cause the rope to cut through the bridge, and then even an instantaneous check by the second man will not prevent a deeper fall.

(2) In such a fall, it is necessary to act promptly to relieve the constriction of the loop around the victim. The victim can ease the strain by lifting himself on the rope, but he can do so for only a very short period. A rest loop constructed from a sling rope and secured to the belay or climbing rope by a Prusik knot can be used as a stirrup to ease the constriction of the rope around the waist. This

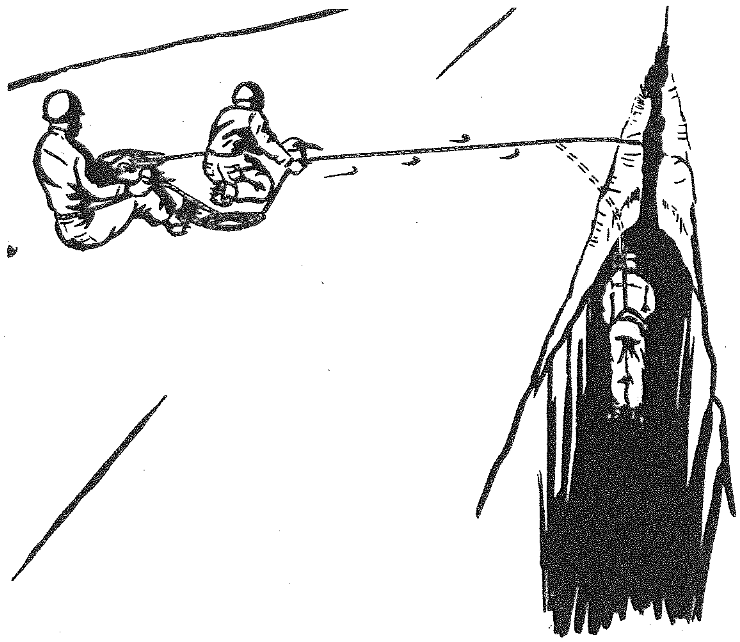


Figure 80. Belaying a leader who has fallen through a snow bridge.

method also frees the hands and enables the man to assist in further rescue operations. Personnel on the surface must ascertain the conditions existing in the crevasse. For example, where firm masses of snow clog the crack some distance below the surface, it is easier to lower the victim to such a platform and begin rescue operations from there. In estimating the conditions within the crevasse, it should be remembered that it is almost impossible to hear the voice of the victim even a short distance from the hole through which he fell. Therefore, one member of the party, while belayed by another, must approach the hole in order to gain the required information.

d. (1) Since a snow bridge is usually strongest at the edge of the crevasse, a fall is most likely to occur some distance away from the edge. In such places, the rope usually bites deeply into the snow, thus greatly increasing friction for those pulling from above. In order to reduce friction, place an ice ax or ski under the rope and at right angles to the stress (fig. 81). If a ski is used, place the running surface down so that the rope will not cut on the edges. Push the ice ax or ski forward as far as possible toward the edge of the crevasse. If the victim is able to reach firm footing within the crevasse, and thus relieve the strain on the rope, the support may be placed at the most advantageous point.

(2) Whether or not the victim is able to reach firm footing within the crevasse, the rescue procedure remains essentially the same. Spare rope should always be carried by a single rope party. If no spare ropes are available, as many members of the party as necessary will have to unrope to provide sufficient rope to reach the fallen man. The simplest and quickest procedure is to lower the loose end of this rope until he can reach it; it then is securely belayed on the surface. While he is being pulled up by this rope, he assists by attempting to pull himself up on the anchored rope. His progress is aided by the rescuers taking up the body line. Wherever possible, the party or parties following should move up to assist in rescue operations.

e. An alternate procedure is to tie a nonslipping stirrup at the end of the rope and let it down to the fallen man (fig. 82). He passes it inside his body loop, and down to a level where he can place

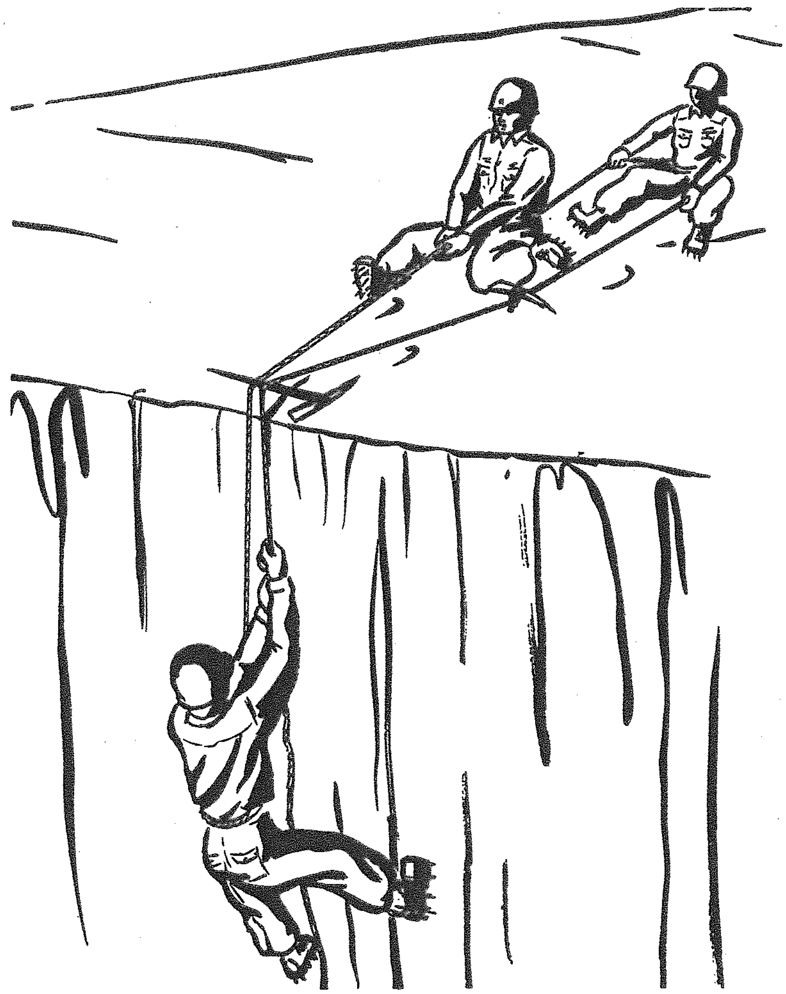


Figure 81. Ascending from crevasse on a fixed rope.

one foot in the stirrup and stand erect. By slackening the body line in this way, it can be taken in and made fast by the belayer. The fallen man then places his weight on the body line while the foot loop is raised from above and held fast. An upward step is thereby provided for him. By a repetition of these operations, he approaches the lip of the crevasse. If an overhang is encountered here, the best procedure is for him to grasp the fixed rope, place both feet against the snow or ice of the crevasse wall and "walk" out over the overhanging snow while the slack on the body line is taken in and belayed from above.

f. If the suspended climber is injured or unconscious and unable to help in his own rescue, additional assistance by one or more rope parties is then needed to recover the victim. To insure free movement and unnecessary strain on the lowered climber a three-loop bowline knot is used. Two loops are made larger and one is passed over each leg, while the third and smaller loop is placed around his chest. To facilitate recovery operations and for additional safety, it is advisable to secure him with an additional section of a climbing rope. As this climber is lowered, another rope which is also provided with three-loop bowline knot is passed down to him. The victim is tied to this rope by the rescuer in the same way. The rescuer helps the victim as both men are then pulled out of the crevasse by the belayers above. If feasible it will facilitate the recovery of the two climbers if the second rope securing the victim or the rescuer in the crevasse is managed from the opposite side of the crevasse where the necessary belayers take up their positions in advance. In this manner victim and rescuer are pulled free

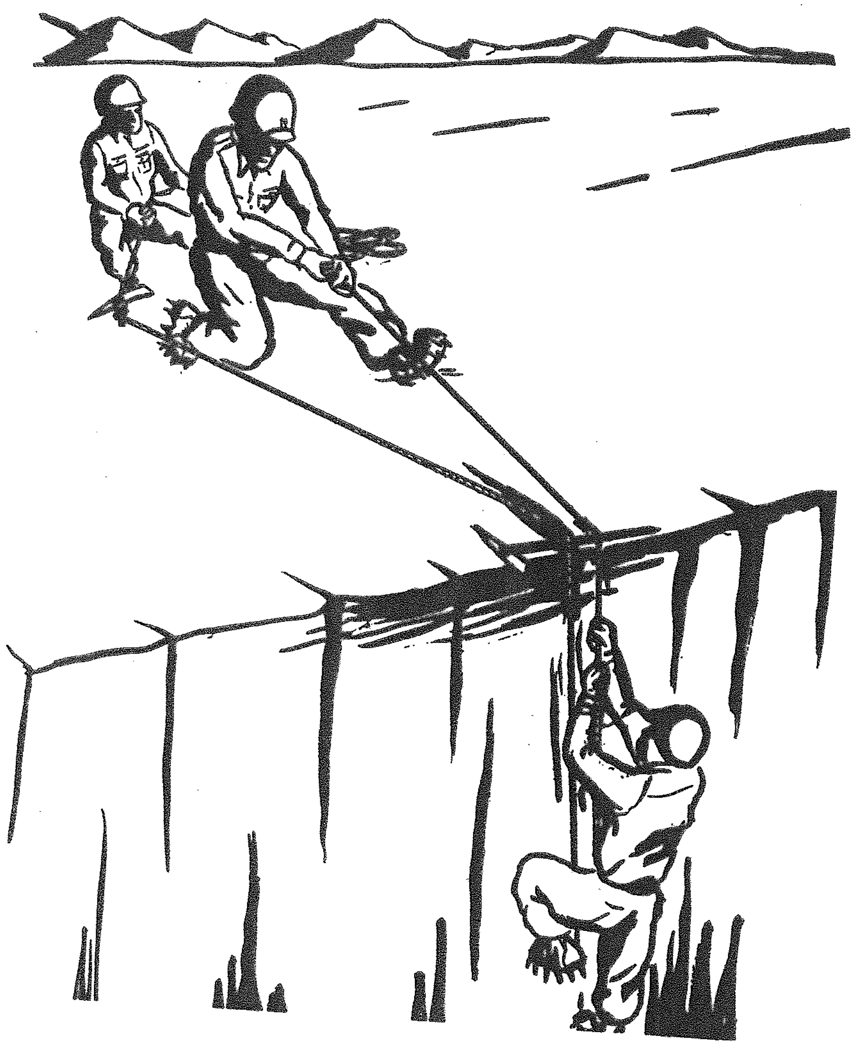


Figure 82. Ascending from crevasse by means of foot on fixed rope.

from the crevasse wall and as they reach the top of the crevasse the ropes on one side are slowly slacked off while both men are pulled over the opposite crevasse edge.

(1) When additional assistance cannot be secured, rescue operations are more difficult and actions taken depend mainly upon the circumstances. They must be made in the best interest of the injured man. It is most important that he is relieved from his suspended position as soon as possible.

(2) If the victim is injured so that he cannot use either leg in the stirrup method described in *e* above, the loop of the lower rope section is then made sufficiently large to be passed by the victim over his shoulders and around his chest. Secured in this manner he is then pulled up by both belayers. When the victim is unable to move or is unconscious, possibilities of lowering him to a firm snow bridge or shelf immediately below him are investigated by the second belayer while he is secured by the other climber. This possibility is only of advantage when additional help can be secured within a reasonable amount of time and the victim rescued. Prolonged exposure in such environment is prone to cause frostbite and shock in a relatively short period of time. If this procedure is not practicable the victim is pulled cautiously by both belayers out of the crevasse. An attempt

should first be made to lower a rope section with a large loop and pass it around the upper part of the victim's body in an effort to keep him in an upright position and for additional safety.

g. Usually a leader who has been extricated from a suspended fall should not be permitted to resume immediately the responsibility of route selection. A free fall of only a few meters and the resulting rescue operations are a severe strain on a man.

h. Should it become necessary for a roped two-man party to traverse a glaciated area, each man should have in his possession, and readily available, three 4-meter sling ropes, two of which are tied to form stirrups. If one man falls into a crevasse and is belayed by his companions, he affixes these stirrups with Prusik knots to the climbing rope above his head. The loose ends of two stirrups are passed down through the waist loop, and the man then places one foot in each of the stirrups. The third sling rope is placed around his body to form a waist loop and attached to the belay rope by means of a Prusik knot. By weighting one foot, he relaxes the other sling permitting the knot to be pushed farther up the rope. Thus, by alternate action with each stirrup and by pushing the waist loop knot even higher, the man extricates himself from the crevasse.

CHAPTER 6

FIXED ALPINE PATHS

Section I. GENERAL

179. Purpose

A fixed alpine path is constructed of materials at hand to assist troops in traversing rugged mountain terrain, ascending or descending steep mountain slopes, and to aid in transporting supplies. It should be constructed in a manner suitable for use by men carrying combat equipment or supply loads up to 50 pounds. If possible, it should be so constructed that movement is possible in both directions at once and that casualties can be evacuated over it on litters.

180. Description and Data

a. Description. A fixed alpine path is a combination of aids to movement, and may include steps cut into the ground or into ice or snow, hand lines supported by stanchions (fig. 83), hanging ladders (fig. 84) of wire or fiber rope up nearly vertical rock faces, stand-off type ladders (fig. 85)

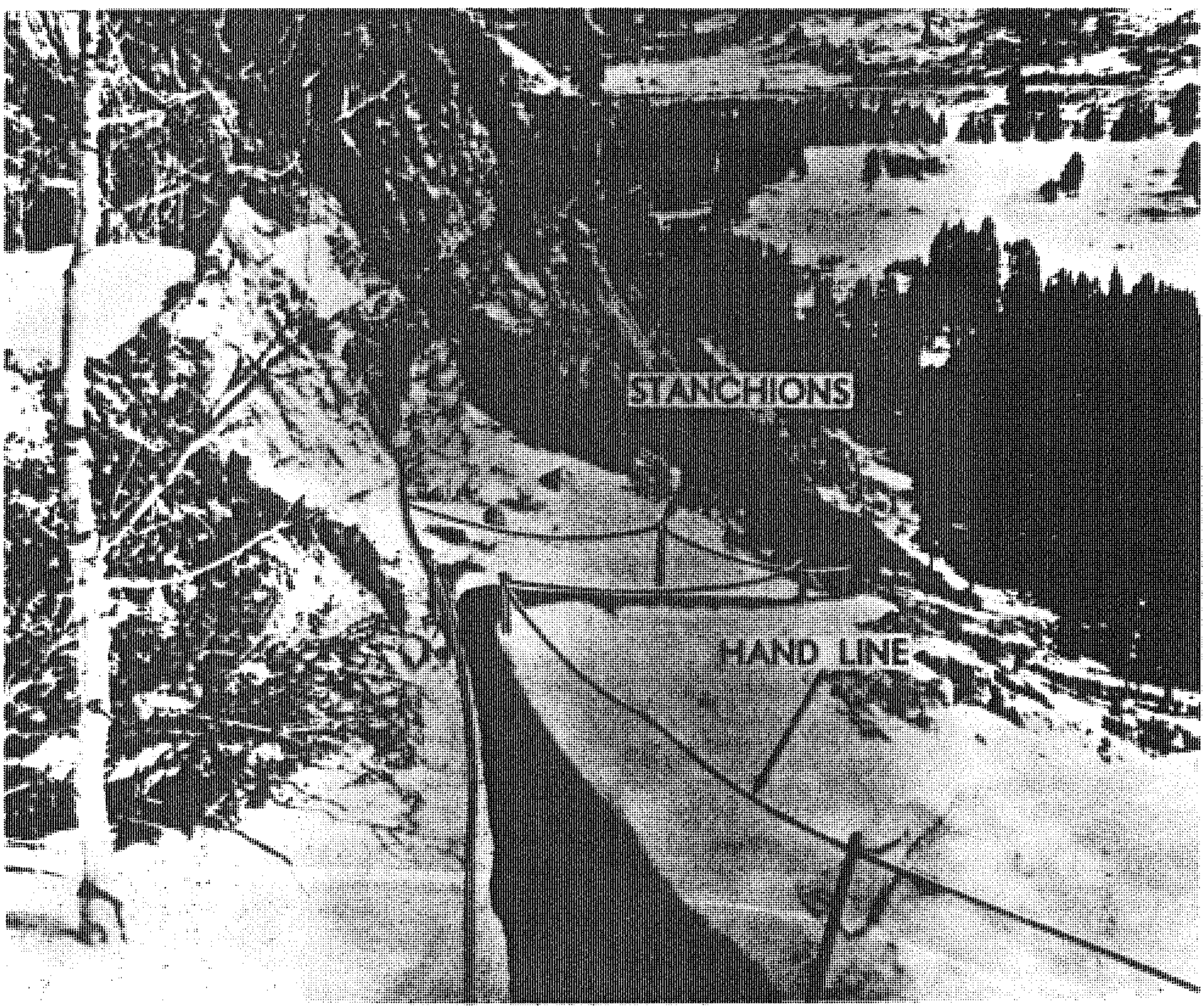


Figure 83. Hand lines supported by stanchions.

made of local materials, suspended walkways (fig. 85) to cross ravines, and hand-operated cableways.

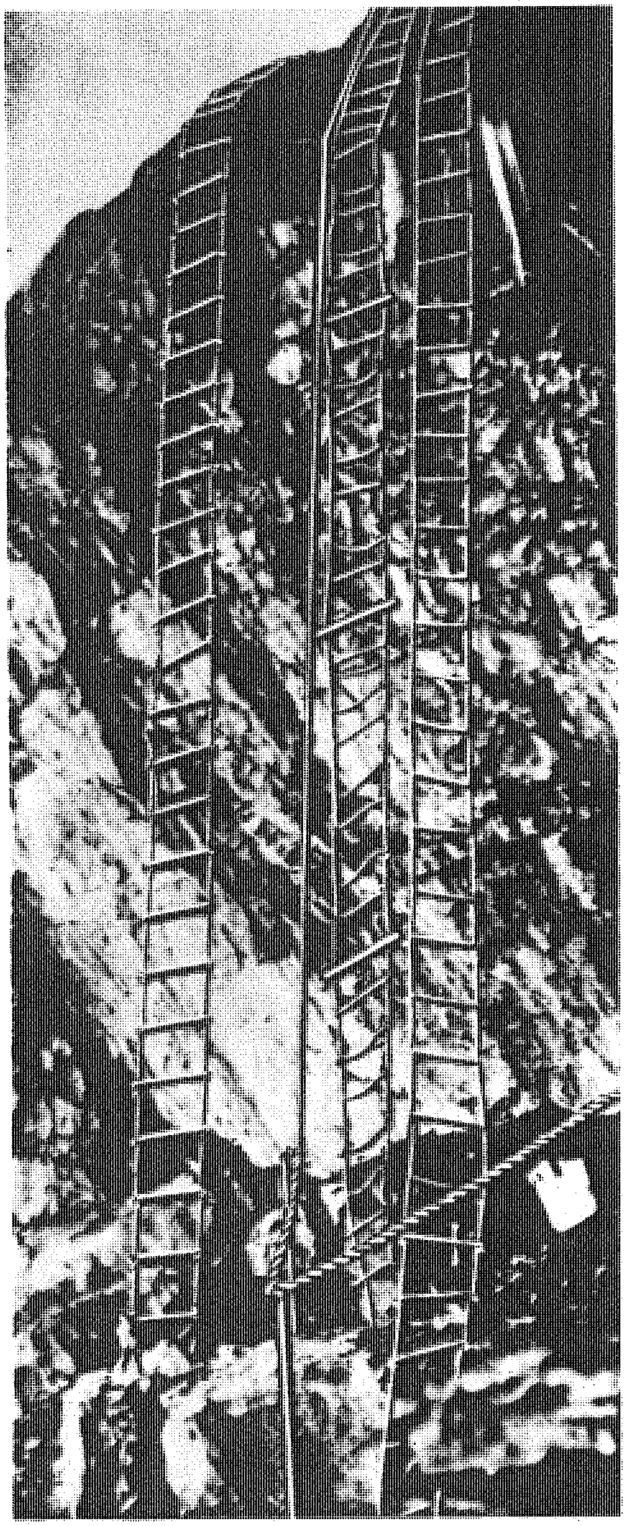


Figure 84. Hanging ladders anchored at top and bottom.

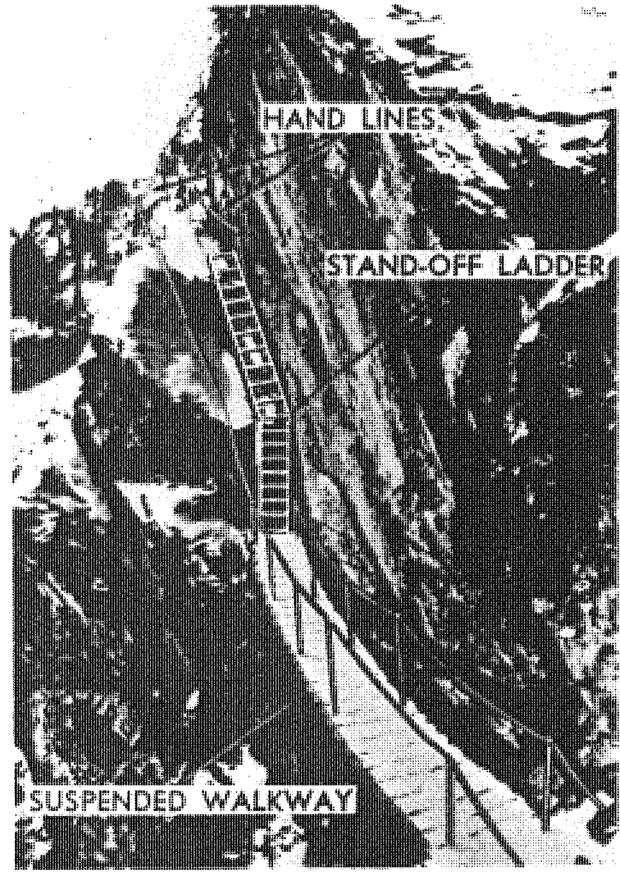


Figure 85. Suspended walkway and stand-off ladders.

b. Construction Requirements and Capabilities. Alpine paths can be constructed of almost any desired length. Terrain and weather conditions will affect construction time considerably, but under average conditions 900 meters of path can be constructed by a platoon of engineer troops in 50 to 100 hours, depending on the number of suspended walkways needed. If the men traversing the path are spaced at 4½ meter intervals approximately 200 men would be on the 900 meters of path at one time. Relative difficulty of the path would dictate their speed of travel. If travel is in one direction only and the path is of average difficulty, 400 men could traverse the 900 meters of path in 1 hour. Assuming that each man carries a 50-pound load of supplies, 10 tons could be delivered to the terminal in 1 hour. If the path is constructed so that traffic is free to move steadily in both directions at all points, 400 men or 10 tons of material can be delivered to each terminal every hour.

181. Site Conditions

a. Route Survey. A reconnaissance or route survey of the terrain over which the alpine paths is to be constructed should be made by experienced mountain climbers before construction of the path is started.

b. Route Requirements. Bypassing of obstacles and attempts at camouflage may require the path to traverse a greater distance but will reduce the construction time, increase the capacity of the completed path, and minimize delays due to enemy action.

(1) The route selected should be the shortest distance between the terminals and the easiest to traverse.

(2) The path should avoid steep or vertical cliffs and overhanging rocks, wherever possible because these will require ladders. Ladders slow down personnel using the path.

(3) Snow or rock in positions susceptible to slides must be avoided.

(4) The path must follow a route not visible to the enemy. It is easier to camouflage the route from observation if it follows ravines and rock ledges wherever possible.

c. Safety Lines. As a precaution, the personnel performing the route survey should erect safety lines along the route selected as an aid to less experienced men in the construction crew.

(1) In some locations, safety lines may consist of ropes strung outside the working party about 75 centimeters off the ground and securely fastened to bushes, trees, or temporary stakes.

(2) In hazardous locations, safety lines may consist of ropes with one end securely anchored. The free end of a rope is tied around the waist of a person engaged in erection. A convenient anchor for such lines can be made from a wafer piton driven into a convenient crack in the rock. The piton is made of malleable metal. When the blade of the piton is driven in a crack or fissure in the rock, it deforms to fill the interstice in the rock. The harder the piton is driven the greater is its holding power.

182. Material Requirements

a. Materials. When a route survey (par. 181) has been completed, an estimate of the number and length of each type of component can be drawn up. The materials required for each of the various components are set out in paragraphs 185 through 189. In addition to the equipment listed for the actual construction, erection tools and safety equipment will be required.

b. Erection Tools. An ample supply of the following tools should be made available.

(1) Drill, stone, hand 4.2 x 60 cm.
(2) Drill, triangular, hand 2.5 x 45 cm.
(3) Drill, triangular, hand, 1.9 x 45 cm.
(4) Hammer, double-face, striking, 4 pound
(5) Ladle, hand 10 cm diameter bowl.
(6) Pot, melting 18 cm inside diameter.
(7) Pumps, air, hand.

c. Safety Equipment. A supply of .95 or 1.25 cm diameter fiber rope will be needed for safety lines.

183. Transportation

The materials required for the construction of a fixed alpine path can be transported by vehicle or carried by men. When wire or fiber rope is to be carried by men, it may be impractical to cut the rope into sections which make suitable individual loads. In such cases, coil enough rope for an individual load in a figure-eight and leave about 3 meters of free rope before coiling the second load, continuing in the same manner for the succeeding loads. The loads are then carried in a chain fashion.

Section II. ERECTION

184. General

Size and organization of the working party used for erection will depend on the type of components to be installed, steepness of the terrain, and experience of the troops involved. If the men must carry the materials in to the site, allowance must be made for extra men to perform these tasks. A normal working party is a platoon of engineer troops. The men should be organized into groups and assigned to prepare the most difficult sections of the path first. If the men are inexperienced in mountain conditions, it will be easier to use a small working party because such a party is easier to control and accidents can be minimized.

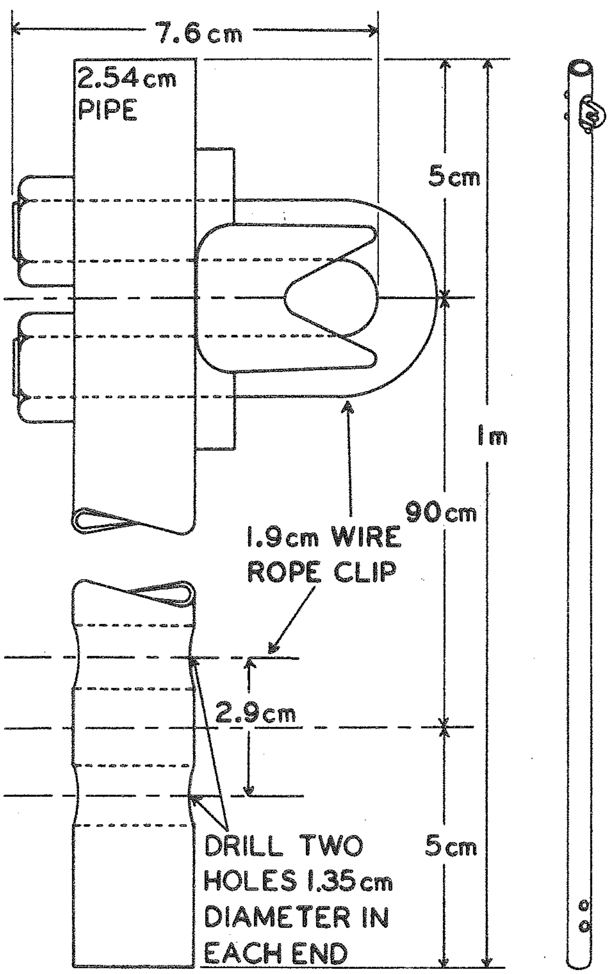


Figure 86. Details of an iron pipe stanchion.

185. Handlines

a. General. Handlines are supported by stanchions made of pipe or wooden posts fastened securely in the ground. The ends of the lines are fastened to rock anchors to maintain the proper tension in the lines. The lines may be of fiber rope or marline-clad wire rope.

b. Pipe Stanchions. The standard pipe stanchion is made up of 2.5 centimeter diameter pipe. Each stanchion is 100 centimeters long. Two 1.9 centimeter wire rope clips (fig. 86) are fastened through holes in the pipe with the centers of the clips 90 centimeters apart. Such a stanchion can be used as is for a suspended walkway which uses 2 wire ropes on each side, but for handlines the lower wire rope clip is removed or left off. Insert the bottom of the stanchion, without the wire rope clip, in a hole drilled at least 25 cm deep. Stanchions should be placed in rock wherever possible, using sulfur to hold them in place. Melt sulfur in a long-handled ladle over a gasoline fire pot and pour it into the hole (fig. 87) around the stanchion. If the stanchion must be placed in earth, make the hole in solidly packed ground. Fill the hole around the stanchion with concrete. Space stanchions approximately 10 meters apart on both sides of the path and 75 to 90 centimeters apart from one side of the path to the other.

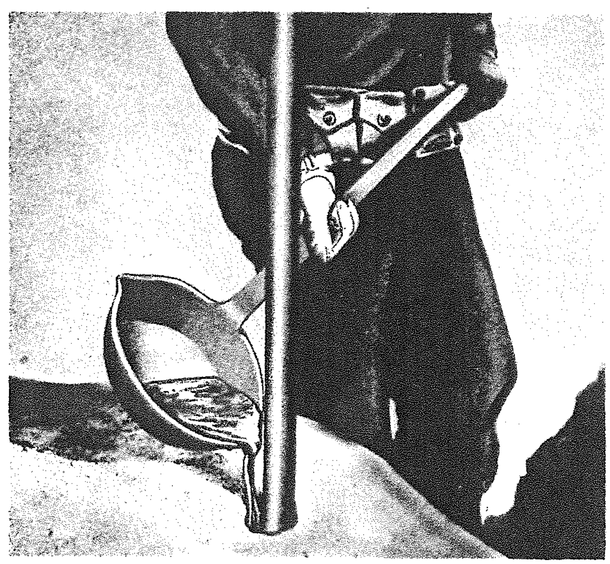


Figure 87. Pouring melted sulfur around pipe stanchions in rock.

c. Wood Post Stanchions. Wood posts can be used as stanchions (fig. 88) for handlines, or standing timber may be used if the path is through natural growth. Wood post stanchions should be 6 centimeters to 8 centimeters in diameter and should be notched near the top so fiber rope handlines can be tied to them with a clove hitch. To tie a clove hitch in the center of a rope, make two turns in the rope close together. Twist them so that the two loops lay back-to-back. Slip these two loops over the end of the stanchion to form the knot.

d. Rock Anchors. Rock anchors are used to hold ends of handlines or other cables. Where handlines are placed parallel to a vertical rock face, they can be supported by rock anchors placed horizontally in the face of the rock instead of by vertical stanchions. Rock anchors used in this manner should be spaced according to the contours of the rock and up to 9 meters apart.

e. Drilling Holes. There are three general methods of drilling holes in rock for pipe stanchions or rock anchors.

(1) *Hand drilling.* In hand drilling hold the drill steel against the face of the rock and strike it with a hammer. After each hammer stroke rotate the drill slightly so that a round hole will be drilled. One man can hold the drill and strike it with a short-handled hammer. An inexperienced man can drill a hole 25 centimeters deep in ordinary rock in 30 minutes to 1 hour. Faster work can be done if one man holds the drill and rotates it, while one or two other men strike it (fig. 89) with hammers. Three inexperienced men should be able to drill a hole 25 centimeters deep in about 15 minutes.

(2) *Gasoline-operated hammer.* A gasoline-operated hammer can be used for drilling

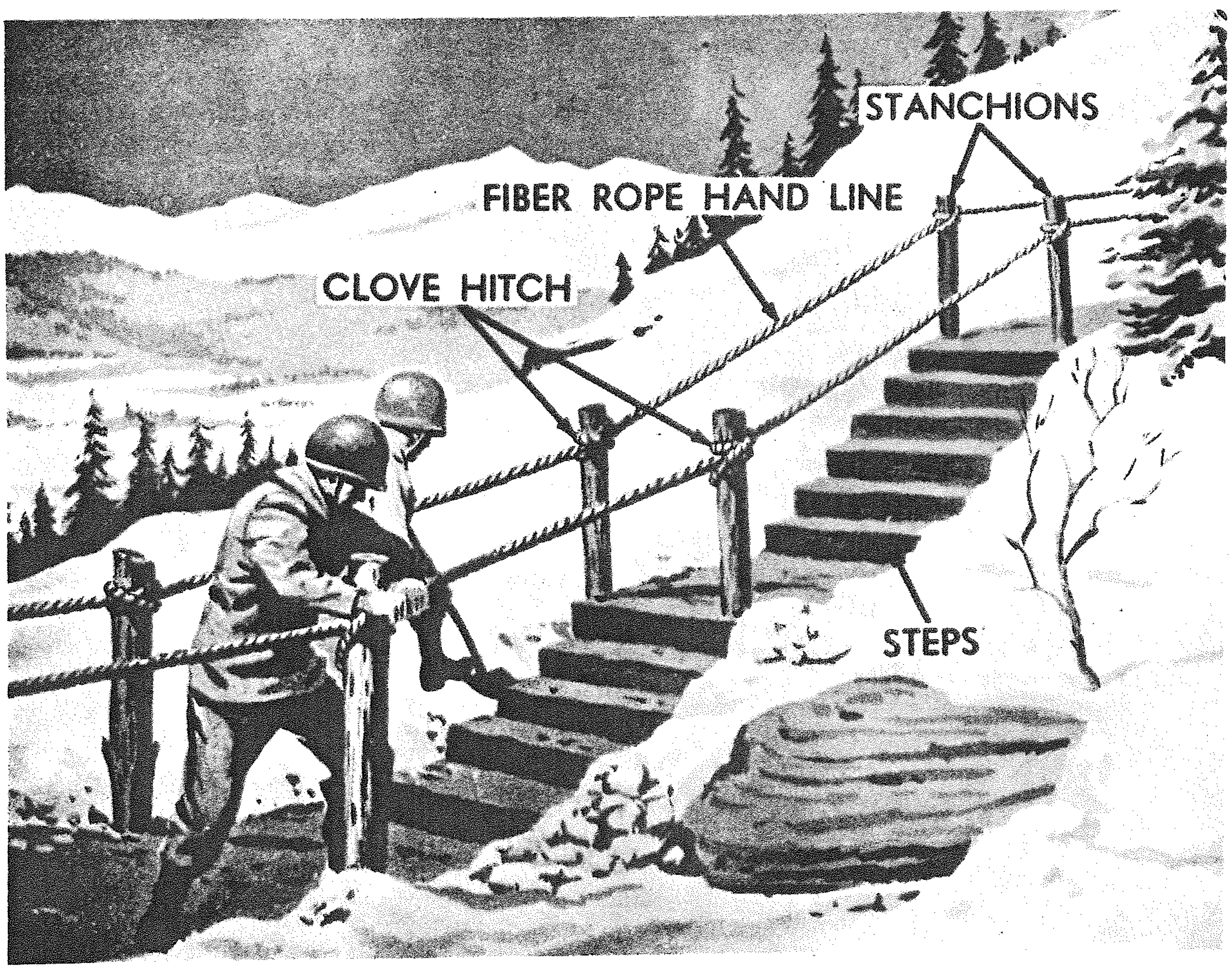


Figure 88. Wood posts used as stanchions.

holes in positions where there is sufficient room for it to operate and accessibility permits. It is faster than hand drilling under these circumstances.

(3) *Pneumatic drills.* Pneumatic drills can be used in more accessible locations and are quite fast. A small portable gasoline-engine-driven compressor is available for such drilling. Whenever the compressor can be moved close enough to the site for the hoses to reach, this is the most satisfactory method.

f. Rigging Lines. Wire rope or fiber rope can be used for handlines. However, wire rope is stiff and the ends of any broken wires will produce severe cuts on the hands, so that the wire must be served or wrapped before use. A marine-clad rope is available and is a satisfactory material for such uses. Both fiber rope of 1.9 centimeter diameter and marline-clad wire rope of 1.9 centimeters outside diameter have the necessary strength. Fiber rope weighs less and is more flexible but is not as strong as the same size of wire rope. The wire rope is more durable, resists weathering, and offers greater resistance to stretching. To rig either rope, pass one end through the eye of a rock anchor at one end of the handline and fasten this free end to the main portion of the rope to provide a firm hold. Fiber rope can be spliced or tied with a bowline knot, with the eye of the anchor in the bight of the knot. Wire rope can be fastened with wire rope clips or clamps or spliced, although splicing is too slow for most uses. The coil of rope is now rolled along the path at the

Figure 89. Three-man method of drilling holes in rock.

base of the stanchions. If wooden post stanchions are used with fiber rope, raise the rope to the top at each stanchion, pull it tight, and tie it around the top of the stanchion with a clove hitch. If pipe stanchions are used, lift the wire or fiber rope to the top of the stanchion and insert a wire rope clip over the rope through the stanchion. Place the nuts on the ends of the U-bolt of the wire rope clip and tighten them partially. Pull the rope tight past the stanchion and tighten the nuts on the wire rope clip securely. Continue along the path in this manner to the end of the handline or until the coil of rope is used up. Fasten the free end to a rock anchor in the same manner as at the beginning of the path. Where rock anchors are used to support the rope along vertical rock faces, the rope must be uncoiled at the first rock anchor and the free end of the rope is then fed through the eyes of the rock anchors. In rigging wire rope care must be taken to eliminate kinks when they develop along the path, since such kinks will cause stretching and deformation of the wire, weakening the line after erection.

186. Steps

Steep earth slope and moderate slopes covered with ice or snow make climbing difficult. This is particularly true at high altitudes, where less oxygen is available for breathing. Men tire rapidly under such conditions. Handlines (para. 185) are of considerable assistance but do not completely solve the problem. Steps cut in the slope (fig. 88) are of material assistance. These steps should be of normal dimensions. That is, the riser of the step should not exceed 20 to 25 centimeters. On gradual slopes a single 20 centimeter step can be cut every few feet and the surface between steps levelled. On steeper slopes the steps are closer together but should not be less than 25 to 30 centimeters apart. Each step should extend for the full width of the path. For snow and earth use a shovel or pickmattock to cut the steps. Steps in ice are harder to cut and an ice ax, pick, or pickmattock is used. The steps can be cut before or after hand lines are erected but it is easier to cut them after the handlines are up, since the handlines will be of assistance to the crew cutting the steps.

187. Ladders

a. General. Hanging ladders are made of wire or fiber rope anchored at the top and suspended vertically. They are difficult to ascend or descend, particularly for a man carrying a pack or load, and should be used only when necessary. Stand-off ladders have 2 wood or metal uprights holding them stiff and are placed at an angle which is easier to climb. Both types can be prefabricated to the required size and carried in to their final location. At most locations 1 or 2 stand-off ladders are adequate, but hanging ladders act as a traffic bottleneck and 3 or 4 of them should be provided at each location where they are used if possible.

b. Stand-Off Ladders. Stand-off ladders are built in dimensions to suit the circumstances. In general, the two uprights are 5 centimeter by 10 centimeter lumber placed on edge or 8 centimeter diameter poles roughly cut and dressed at the site. Such uprights are sufficiently strong to extend 5 or 6 meters. Place the uprights 45 centimeters apart and nail the rungs to them at 25 centimeter intervals. Use at least 2 nails at each end of each rung. For stand-off ladders made of finished material (1, fig. 90) make the rungs of 2.5 to 5 centimeter lumber. For ladders made of native material (2, fig. 90) make the rungs of 5 centimeter diameter logs. These logs should be carefully trimmed clean to avoid snagging the clothing of men using the ladder. Anchor each ladder firmly in place with wire or fiber rope fastened about the upper rung and through a rock anchor. The ladder should also be braced at the base, if possible, to eliminate all motion during use.

c. Hanging Ladders. Uprights of hanging ladders may be made of wire or fiber rope and both uprights should be anchored at top and bottom. Wire rope uprights with pipe rungs make the most satisfactory hanging ladders because they are stiffer and do not sag as much as hanging ladders of other materials. Wire rope uprights with wire rope rungs can be used. Fiber rope uprights can be used with wood or fiber rope rungs but should be use sparingly because of their greater flexibility, which causes them to twist under a climber and makes them difficult to use. A rock anchor should be used to anchor each upright of a hanging ladder at the top (fig. 91). Place a log at the break of the ladder at the top to hold the uprights and rungs away from the rock face so that better handholds and footholds are provided. A single rock anchor is usually sufficient at the bottom (fig. 92) of the ladder or a pile of rocks can be used as bottom anchor for fiber rope hanging ladders.

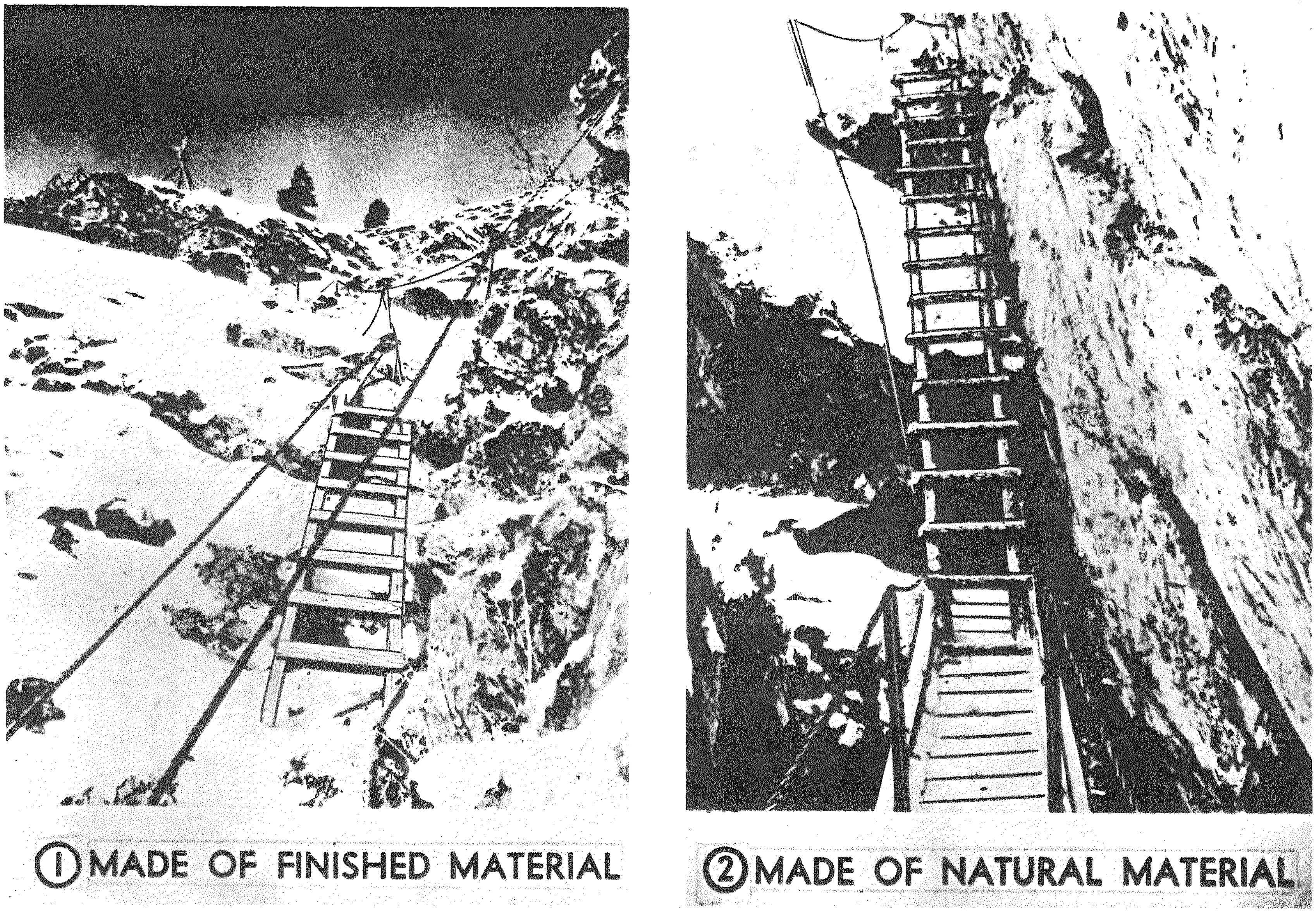


Figure 90. Construction of stand-off ladders.

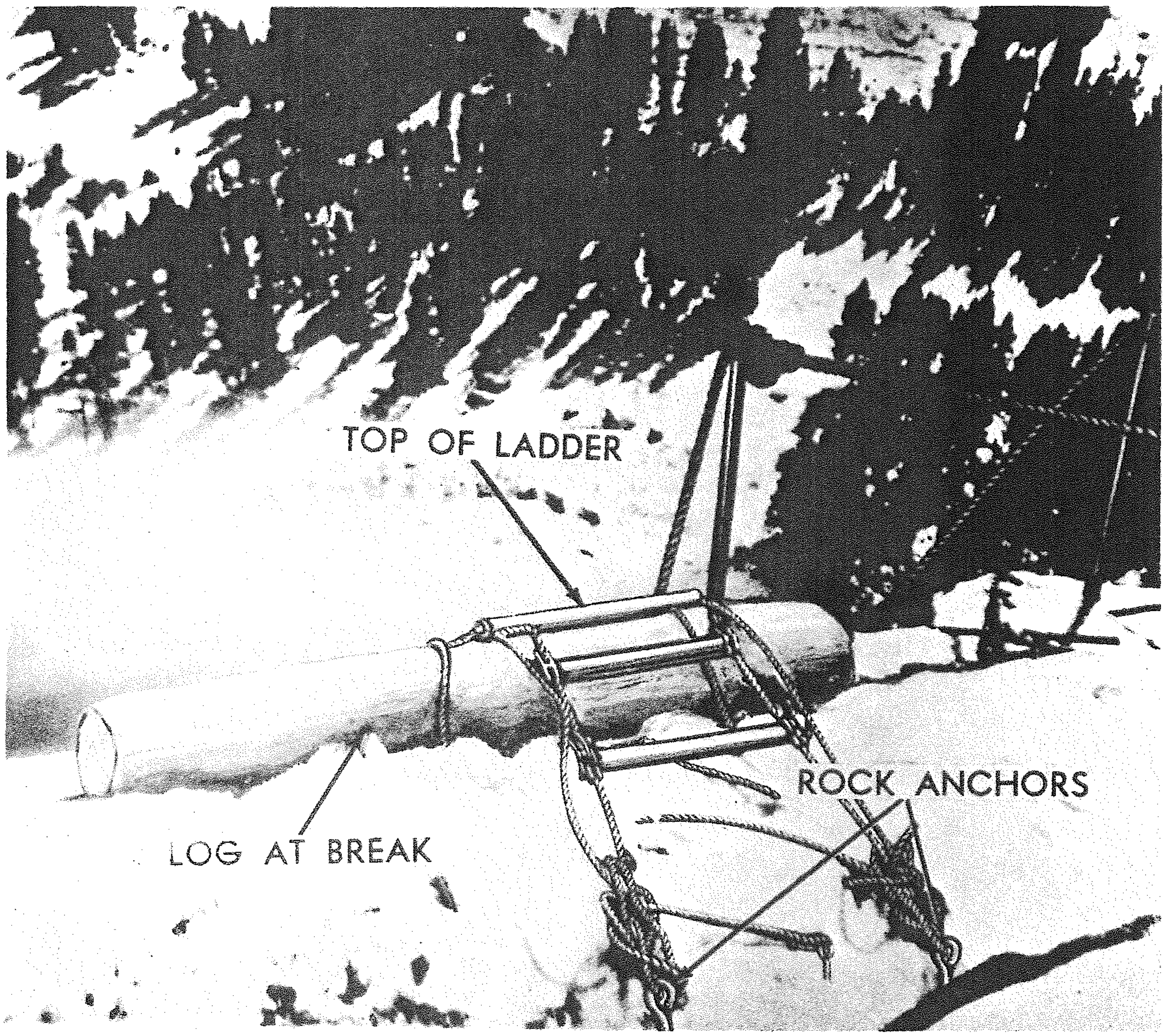


Figure 91. Method of anchoring top of hanging ladder.

(1) *Wire rope ladder with pipe rungs.* A wire rope ladder can be made using 2.5 centimeter pipe rungs or using 1.9 centimeter pipe rungs. The 2.5 centimeter pipe rungs are most satisfactory. For such ladders the standard pipe stanchion (para. 185*b*) is used. The pipe stanchions (fig. 86) are spaced 30 centimeters apart in the ladder (1, fig. 93) and the 1.9 centimeter wire rope clips are inserted in the stanchion over 1.9 centimeter wire rope uprights. If .9 centimeter wire rope uprights are to be used the 1.9 centimeter wire rope clips are removed from the pipe stanchions and .9 centimeter wire rope clips inserted in the pipe over the wire rope uprights. When 1.9 centimeter pipe rungs are used (2, fig. 93), the rungs are again spaced 30 centimeters apart in the ladder but uprights are spaced only 30 centimeters apart because of the weaker pipe used. The rungs may be fastened in place by two different methods. In one method a 1.1 centimeter diameter hole is drilled at each end of each pipe rung and .9 centimeter wire rope uprights are threaded through the holes. To hold each rung in place a .9 centimeter wire rope clip is fastened about the wire rope upright at each end of each rung after the

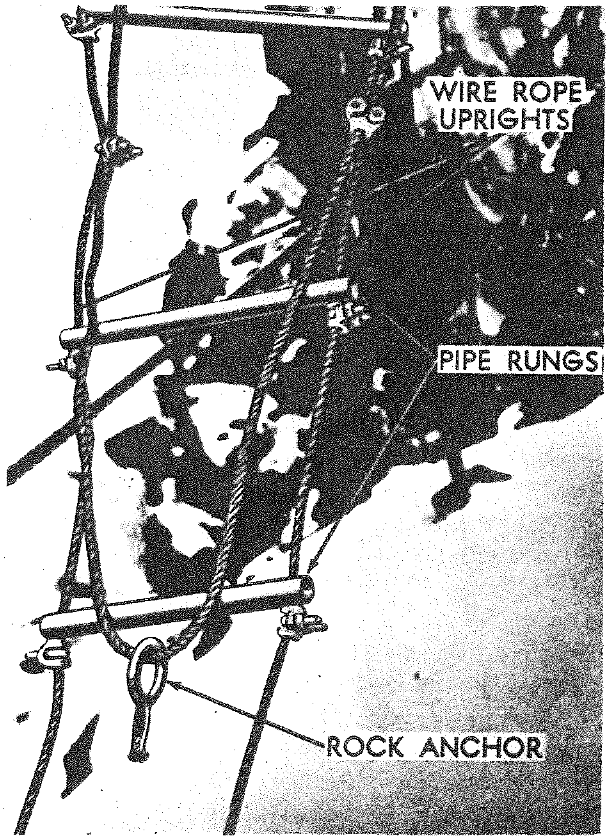


Figure 92. Rock anchor method of anchoring bottom of ladder.

rung is in final position. Another method is to cut the pipe rungs 30 centimeters long and weld the U-bolt of a .9 centimeter wire rope clip against each end. Space the rungs 30 centimeters apart on .9 centimeter wire rope uprights, place the base of the wire rope clips and the nuts on the U-bolts and tighten the nuts to hold the rungs in place.

(2) *Wire rope ladder with wire rope rungs.* To make a wire rope ladder with wire rope rungs, lay the .9 centimeter diameter wire rope uprights out on the ground. Lay the first length out in a series of U-shaped bends. Lay the second length out in a similar manner (3, fig. 93) with the U-shaped bends opposing those in the first series and the horizontal rung portions overlapping. Fasten a .9 centimeter wire rope clip about the overlapping rung portions at each end of each rung to hold them firm.

(3) *Fiber rope ladder with fiber rope rungs.* Fiber rope ladders with fiber rope rungs can be made using 2 or 3 uprights. When 3 uprights (1, fig. 94) are used a loop is made in the center upright at the position for each rung. The 2 outside uprights are spaced 50 centimeters apart. A loop and a single splice hold each end of each rung to the outside upright. A loop in the center of the rung passes through the loop in the center upright. If only 2 uprights are used the rungs are held in place by a loop and single splice at each upright. In this case the 2 uprights must be closer together, with

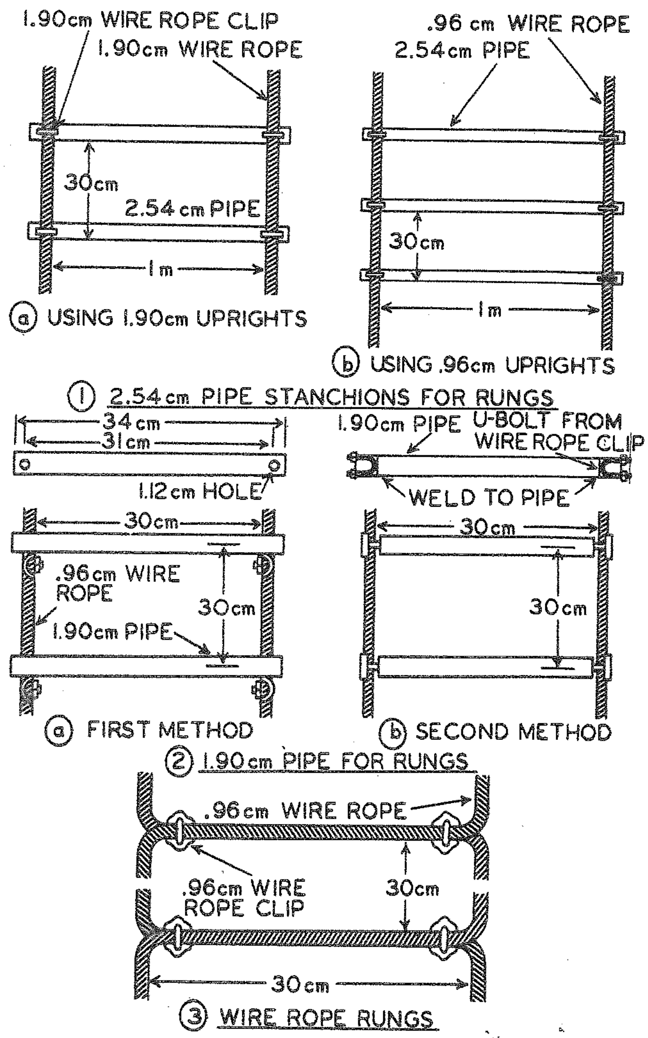


Figure 93. Wire rope ladders.

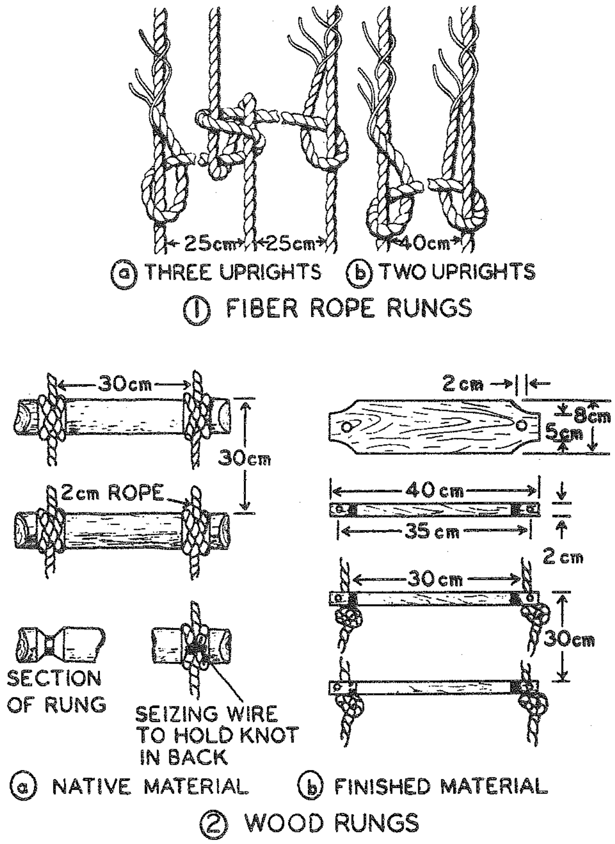


Figure 94. Fiber rope ladders.

shorter rungs, to stiffen the ladder. Ladders of either type are very flexible and difficult to climb.

(4) *Fiber rope ladder with wood rungs.* Fiber rope ladders with wood rungs (2, fig. 94) can be made using finished lumber or native material for rungs. To use native material, cut the rungs of 5 cm diameter material about 40 cm long. Notch the ends of each rung and fasten the rung in the fiber rope upright with a clove hitch. Space the rungs 30 cm apart from center to center. A piece of seizing wire twisted about the back of the clove hitch will make it hold better, but the wire must be placed where it will not snag the clothing of personnel climbing the ladder. If rungs are to be made of finished lumber, cut the rungs to size and drill a 1.9 cm hole at each end. Oak lumber is best for this purpose. Place a .64 cm by 6.3 cm carriage bolt horizontally through each end near the vertical hold to prevent splitting. Tie an overhand knot in the upright to support the rung and thread the upright through the 1.9 cm hole in the rung. Tie a second overhand knot in the upright before threading it through the next rung. Continue in this manner. Rungs should be spaced 30 cm apart.

188. Suspended Walkway

a. Description. A suspended walkway (fig. 95) consists of a treadway of either native or finished material suspended like a bridge over a ravine, rocky terrain, or a stream, by 4 wire ropes. The 2 lower ropes support the treadway. Two ropes at a higher level provide handlines, and are reconnected to the lower ropes by vertical stanchions. The wire ropes are rigged and anchored first in such a manner that the center of the ropes sag below a straight line between the ends. This sag prevents the tension in the rope from becoming great enough to snap the rope under normal loads and must be computed in advance.

b. Rigging Lines. Four rock anchors and 2 vertical stanchions are required at each end of the walkway. Drill the holes and place these at both terminals ((1) and (3) below) before rigging the wire ropes. Fasten each of the lower 2 wire ropes to its anchor at one terminal with wire rope clips, make a turn around the bottom of the end stanchion and pass the end of the rope across the gap to the other terminal. Make a turn in the wire rope around the end stanchion at the new terminal and fasten it to the anchor with wire rope clips. Adjust the wire ropes to the desired sag allowance ((2) below) and tighten the wire rope clips securely at both ends. The upper wire ropes are placed in the same manner, including sag allowance, except that each rope is fastened to its end stanchions with the clips provided on the stanchions.

(1) *Anchoring.* Drill the holes (para. 185*e*) and place the rock anchors. Wherever possible place the rock anchors so that a direct pull is exerted on them, as this develops greatest strength in the anchor. The angle made by the horizontal portion of the upper wire rope (fig. 95) and the portion of the rope leaving the anchor should not be greater than 34 degrees.

(2) *Sag allowance.* The span (sometimes called chord span) must be measured before the sag allowance is determined.

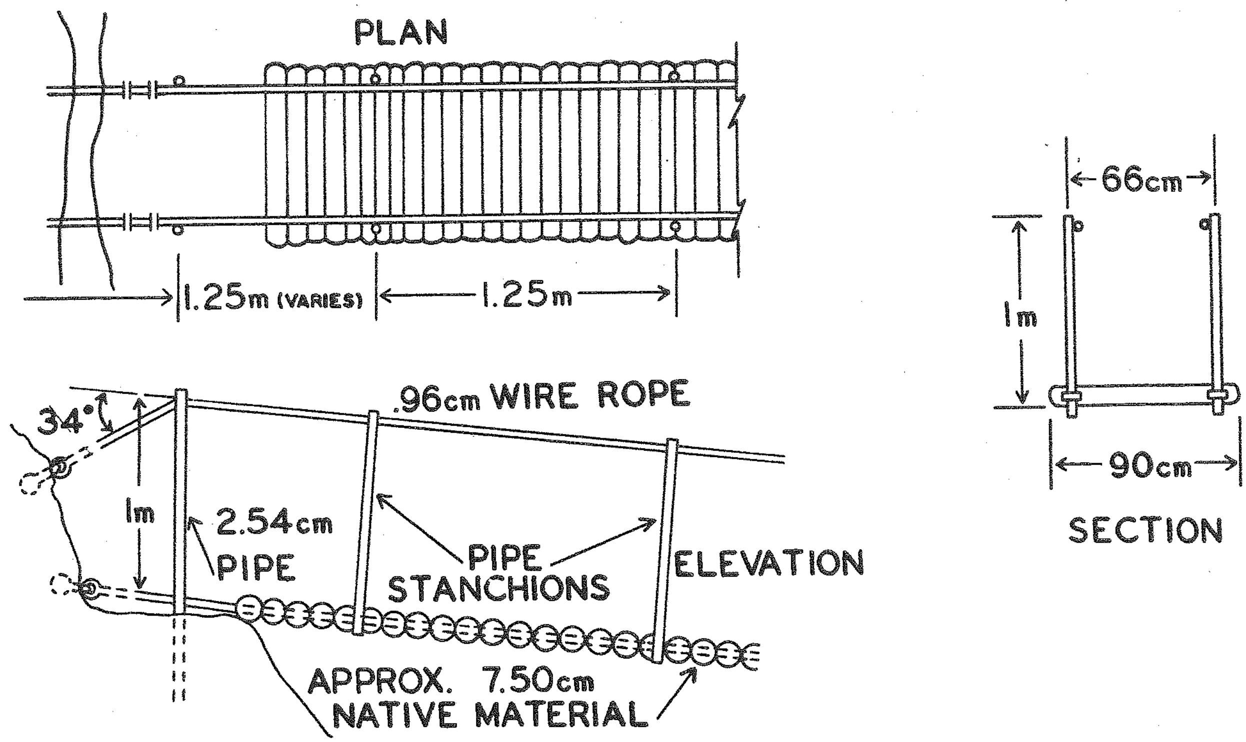


Figure 95. Suspended walkway of native material.

Sag is the vertical distance from the midpoint of the cable to the chord (fig. 96). Sag ratio is the ratio of the sag to the span. For spans up to 12 meters a sag ratio of 1 percent may be used. For spans between 12 and 20 meters, the correct sag can be determined from the formula:

$$\text{Percent sag} = 1 + 4/3\ \frac{(\text{Span} - 12)}{3}$$

With a maximum cable stress of 2,060 pounds for .9 centimeter wire rope, this formula allows a safety factor of 4, which is the minimum consistent with safety of personnel using the walkway. Where the span of the gap is greater than 20 meters or the chord slope is more than 20° from the horizontal, a suspended walkway shouıd not be used. Assuming a maximum 20 meter span, the formula above would apply as follows:

$$\text{Percent} = 1 + 4/3\ \frac{(20 - 12)}{3}$$
$$= 1 + 32/9$$
$$= 4.5\%$$

$4.5\% \times 20$ meters $= .9$ meter of vertical sag allowance in cables.

Note. Above computations are approximate and have been rounded off to the nearest whole number.

To install the cable with the sag allowance computed, measure the amount of sag allowance vertically below the wire rope at each end stanchion and mark it clearly. Adjust the wire rope until the line of sight between the two marks on opposite sides of the gap coincides with the lowest point on the wire rope. Sag is allowed in both upper and lower wire ropes in the same manner.

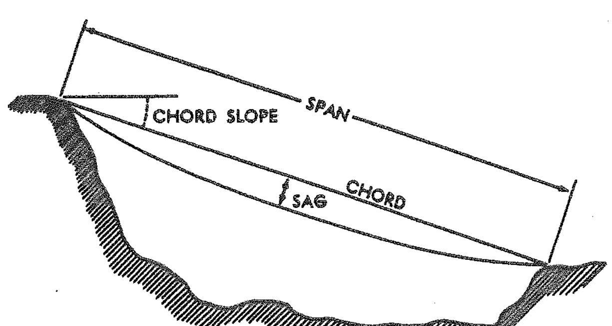


Figure 96. Method of computing span and sag of cable.

(3) *Stanchions.* Make up and set the two vertical stanchions at each end of the walkway as outlined in paragraph 185*b*. The lower clips are removed or left off these stanchions when they are placed. After the wire ropes are rigged and the correct sag allowance is set, place the remaining stanchions loosely on the wire ropes at one end of the walkway by placing the U-bolts over the wire rope and through the stanchions. Place the nuts on the U-bolts and turn each nut enough to hold it until the treadway is set, but do not tighten it.

c. Treadway.

(1) *Native material.* Use logs approximately 9 centimeters in diameter and 1 meter long. Smooth the logs carefully to prevent injury to personnel using the walkway. The supporting wire ropes are 65 centimeters apart. Cut a slot about 2.5 centimeters deep (fig. 97) in each end of the logs on the bottom to fit over the supporting wires. Place the logs progressively from one side to the other, pushing the vertical stanchions ahead of the work. As the logs are placed, weave No. 9 galvanized wire, or any similar wire, around them and the wire rope. Pass the first wire over the first log and the second wire under it, then cross the wires and pass the first wire under the second log and the second wire over it, as shown in figure 97. Continue weaving the wires in this manner. When the position for the first pair o vertical stanchions is reached, 1 mete from the end stanchions, place an additional vertical notch in the logs to go o each side of the stanchions, as shown i figure 97. At this point fix one pair o stanchions securely in place by tightenin the nuts on the U-bolts firmly. The place one notched log on the near side o the stanchion and one on the far side an weave the wire around them. Continu laying the logs for the treadway as befor until the position for the second pair o stanchions is reached. Repeat this procedure as necessary.

(2) *Native and finished material.* Finishec lumber 5 centimeters by 30 centimeter by 2.5 meters long will make a very satisfactory flooring for a suspended walkway in combination with native material. Cut and smooth logs approximately 12 centimeters in diameter and 1 meter long and square them on top for use as stringers (fig. 98). Cut a slot in each log a both ends to fit over the wire rope cables. Place one log over the lower wire rope at a convenient position near one end o the walkway. Place a second log ove the lower ropes with its center 1.5 meter from the center of the first log. Saw one 5 by 30 centimeter board in half and nail one 1.25 meter length in place between the centers of these two logs covering one half the width of the walkway (fig. 98). Nail 22.5 meter length of board in

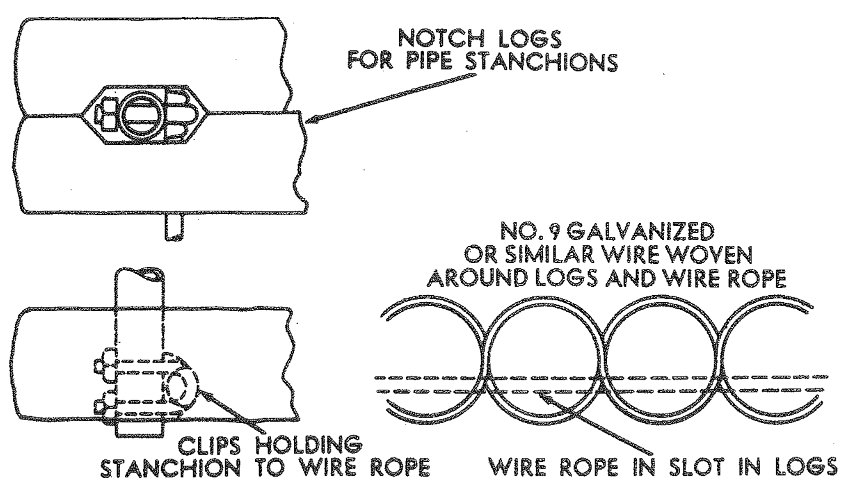


Figure 97. Fastening logs in place as treadway.

place beside it. Place another log under the free end of the 7.5 meter board and nail it in place. Additional 2.5 meter lengths and logs can now be added to cross the walkway. The joints in the boards will be staggered for greater strength, and an end of board will project each time to provide support for placing each new log stringer. Tie the log stringers at both ends with wire to hold them firmly to the supporting wire ropes and stanchions.

189. Three-Rope Suspended Walkway

A 3-rope suspended walkway (fig. 99) is made up of a tread rope and 2 handlines, connected together by stanchions. It is used as an expedient walkway and provides one-way traffic only. Because of the flexibility of fiber rope, wire rope is preferred for these walkways. Considerable motion of the ropes is possible in either case, and personnel using these walkways must proceed with care. When wire ropes are used, the stanchions may be made of wire rope fastened to the main ropes with wire rope clips. Such a walkway is much stiffer and easier to traverse if the stanchions are made of 2.5 centimeter pipe (par. 185b) securely clipped to the main ropes. In construction, the 3 main ropes are laid out parallel on level ground and the stanchions are secured to them in pairs at intervals of about 2 meters. The entire assembly is then dragged across the gap and fastened in place. Trees may be used as stanchions or anchors at either end, or pipe stanchions may be set as supports with rock anchors to secure the ends of the lines. One rock anchor is set behind each end stanchion for the handlines, and one is set in the center for the tread rope. Fasten the wire ropes to the anchors securely with wire rope clips at one terminal and adjust the tension to provide the correct sag allowance (para. 188b(2)) before clipping the ropes to the anchors at the other terminal.

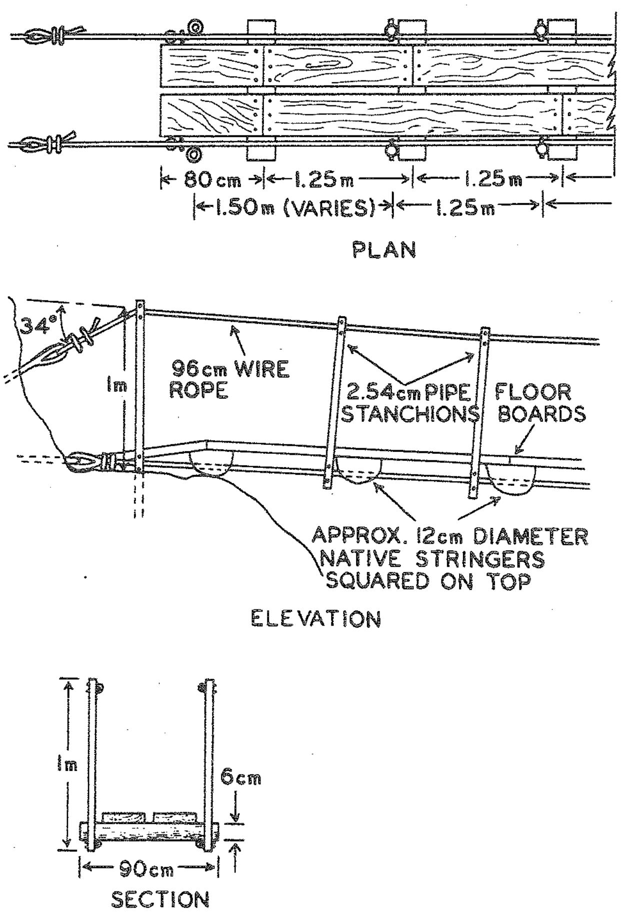


Figure 98. Placing treadway of native and finished material.

190. Cableways

Suspended walkways cannot be used to bridge gaps greater than 20 meters in length. A cableway can be rigged to span greater gaps, up to as great as 900 meters. Frequently, in constructing an alpine path, some portion of the route requires the erection of one of these cableways. An expedient cableway can be designed and rigged from materials at hand to meet special needs. Detailed construction of cableways is discussed in TM 5-270.

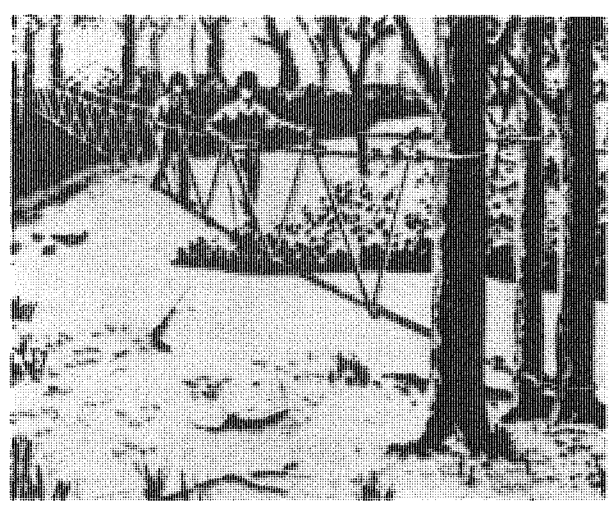


Figure 99. Three-rope suspended walkway.

191. Inspection

A properly constructed alpine path is capable of withstanding much hard use. However, it must be inspected at frequent intervals to determine the need for repairs. Frequency of inspection should be based on amount of use. If a path is operating at or near capacity, inspection may be required as frequently as twice daily. For lesser use, less frequent inspections are required. Hanging ladders, suspended walkways, and cableways require the most careful inspection. Inspect rope for stretching or signs of wear. Inspect all anchorages for signs of loosened anchors. Inspect wire rope clips for signs of looseness.

192. Repairs

Loose wire rope clips are repaired by tightening the nuts. Stretching of wire rope under load may not be objectionable if all lines stretch equally. Unequal stretch should be corrected by loosening the wire rope clips and adjusting the sag in the rope. Provision must be made to prevent the cable from falling before wire rope clips are loosened. Tighten wire rope clips thoroughly after adjustment. Stretched fiber rope in handlines may be tightened at the anchors. Worn steps cut in earth, snow, or ice must be recut when their shape is lost. Loosened anchors can be replaced or moved to new positions. If native material used in ladders or walkways is worn smooth it may be slippery and should be replaced. Frayed or worn fiber rope in ladders is an indication of a considerable loss of strength and they should be replaced.

CHAPTER 7

TRAINING

Section I. MILITARY MOUNTAINEERING

193. General

A carefully integrated, organized, and staffed military mountaineering school is the best means for developing expert military mountaineers. Training should be continuous and uninterrupted for best results. See appendix II for suggested training program.

194. Selection of Students

a. Enlisted Men. Student should be volunteers who understand what they are undertaking.

b. Officers. In the selection of officer students, mental traits should receive prior consideration. Steadiness and the ability to improvise are the most important; intelligence and physical endurance are only slightly less important.

195. Instructors

a. Selection. In addition to meeting the qualifications of prospective students, instructors should be able to explain clearly and demonstrate precisely both theory and practice when handicapped by lack of uniform instruction areas. Senior instructors should be personnel who have had vast experience as mountain climbers in civilian and/or military life.

b. Training.

(1) Instructors should be given a course closely resembling but in more detail than given to students, plus classes in military methods of instruction.

(2) Training may be considered complete only when a candidate cannot only do, but also can explain clearly every operation he has been taught.

(3) Care should be taken to acquaint instructor classes with varied rock terrain to include all areas in which he will teach.

(4) Safety precautions must be stressed. Avoidance of accidents depends largely on the instructor's understanding of their causes, and the enforcement of safety precautions.

c. Duties. The instructor is responsible for the safety and training of his class and the proper care of the equipment. Students should be graded on ability to perform required operations, understanding of subject matter, and special leadership or instructional ability. Continued unsatisfactory grades should result in the rejection of the student receiving them.

196. Supervisors

The supervisor oversees the conduct of training. He should—

a. Be an experienced and expert mountain climber.

b. Make sure that safety precautions are not being overlooked.

c. Correct errors of techniques and instruction.

d. See that grades and other necessary records are maintained properly.

e. Act on all complaints and suggestions personally if possible, or refer complaints to proper authority.

f. Solicit suggestions for improvement of training from instructors and students.

g. Assign areas fairly and insure that classes do not endanger or interfere with each other.

h. Encourage interchange of areas by instructors, and encourage regular exchanges of areas with other supervisors.

i. Acquaint himself with, and constantly seek to develop, improved techniques and training methods.

j. Organize; be prepared to present demonstrations.

197. Class Organization

The following organization is suggested:

a. The company, under the chief instructor, is grouped into an even number of groups.

b. Classes of approximately 6 men are grouped into platoons under the control of the platoon supervisor and his assistant. Size of platoons is governed by the limiting effect of terrain on control. Platoon size should not normally exceed 12 classes. Platoons should be kept intact so far as circumstances permit.

c. The basic class contains 6 men. At the beginning, classes may contain 10 men. Individual soldiers should be grouped according to organization. Officers should be grouped according to component and organization. No class should contain both officers and enlisted men until the climbing exercise phase of instruction.

198. Training Aids

a. General. Training aids should be used to supplement practical work, but not as a substitute for it.

b. Training Films. Training films and film strips should be used primarily for orientation. In the absence of appropriate films, conference supplemented by charts are an adequate expedient.

c. Practice Climbing Tower.

(1) *Function.* Cliffs suitable for practice of rappel and belay techniques and for safe holding of severe practice falls may seldom be available. The practice climbing tower will accommodate four classes concurrently.

(2) *Construction* (fig. 100).

(*a*) The internal frame of the practice climbing tower is constructed of heavy timbers appropriately braced. The front face is constructed of peeled native logs 20 to 30 cm in diameter. The front face of the tower has a 70° slope.

(*b*) The left and right faces of the tower are identical and are constructed of 5 x 30 cm planking. These faces are also set on a 70° slope.

(*c*) The rear wall of the tower is vertical and is covered with 5 x 30 cm planking.

(*d*) The top is floored with 5 x 30 cm planks and the safety railing is constructed of 6 cm iron pipe.

(3) *Employment.*

(*a*) Four basic classes may use the practice climbing tower concurrently, one on each face and one on the rear wall.

(*b*) Three ropes may be employed concurrently on each face. The rear wall is normally used for rappelling and for belaying of practice falls, while the three faces may be used for belaying and climbing practice.

(*c*) Instructors will normally take their place on top of the tower where they can observe and direct all activities of their particular class. Classes should be rotated from the left or right faces to the rear wall to the front face.

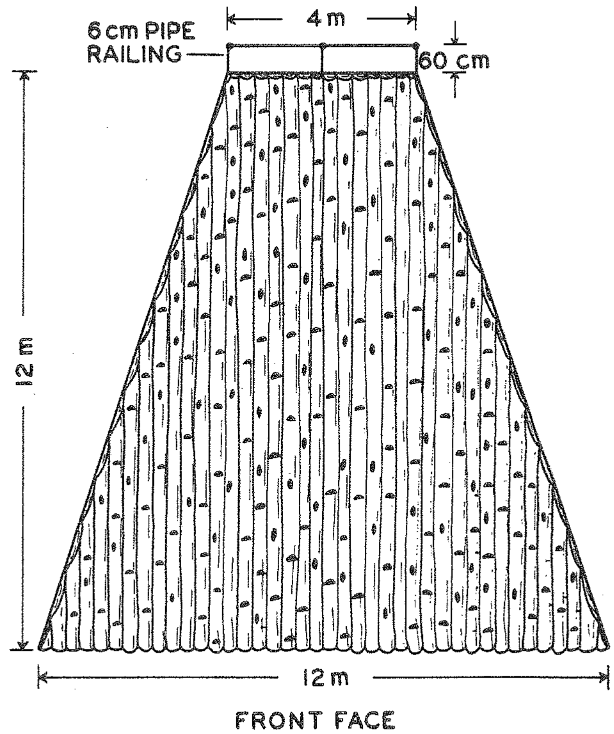


Figure 100. Practice climbing tower.

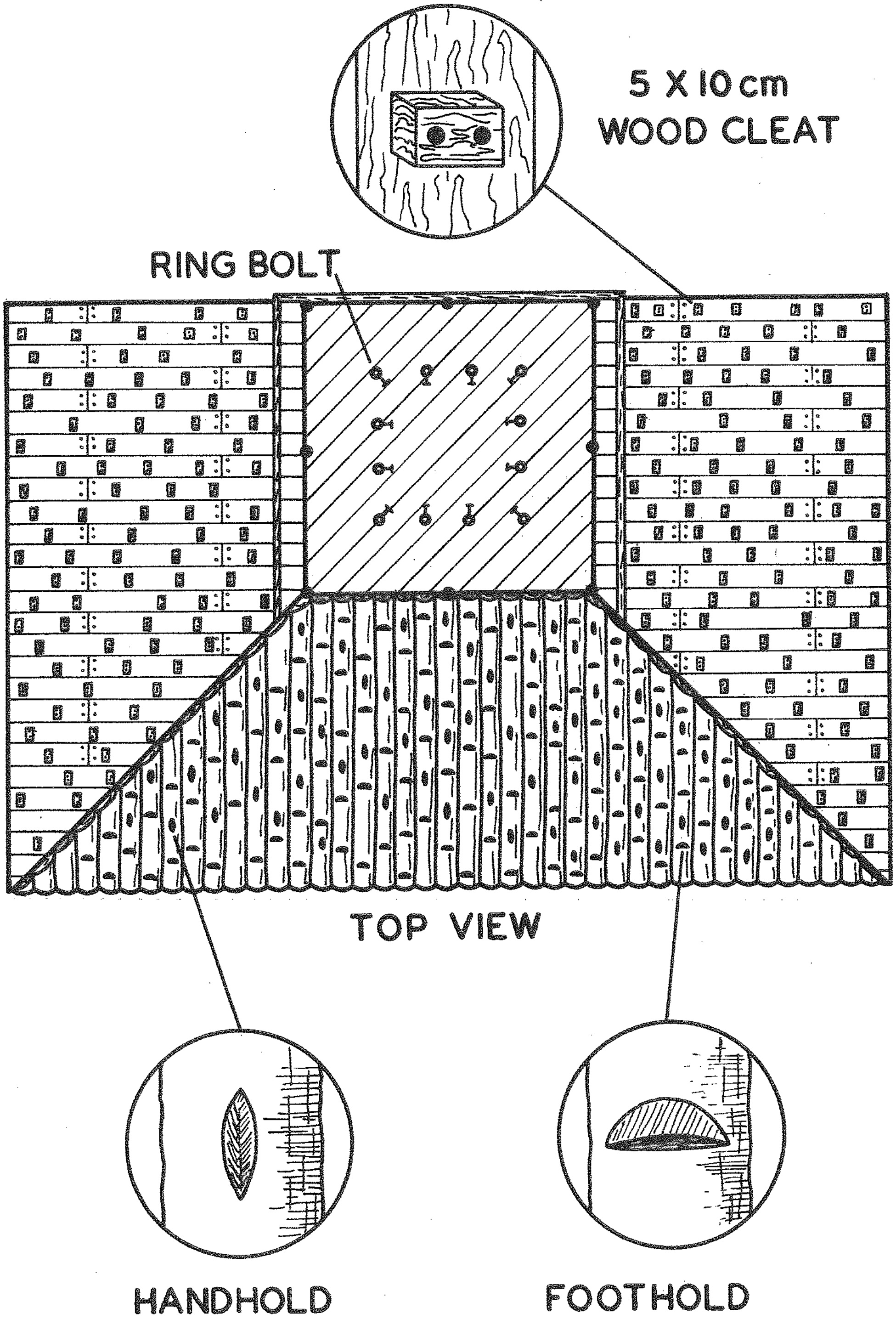


Figure 100—Continued.

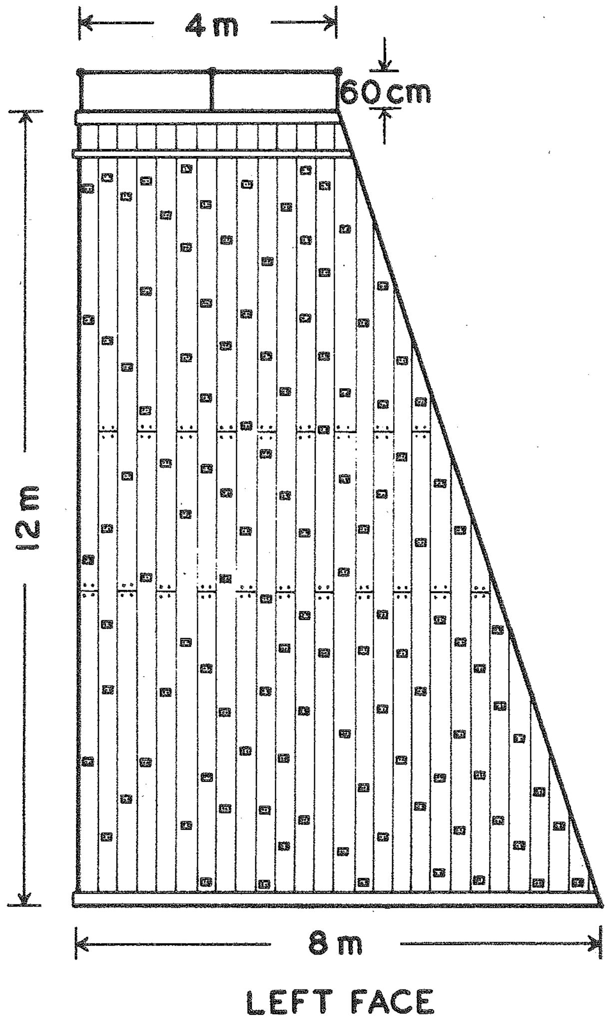


Figure 100—Continued.

Section II. UNIT TRAINING

199. Purpose

The function of unit training is to—

a. Familiarize unit commanders with military mountaineering.

b. Achieve coordination between climber teams and their units.

c. Recondition climbers who have long been absent from mountain terrain.

d. Provide necessary training for personnel who are not being trained as expert mountaineers.

200. Method of Training

a. Orientation. Troops and unit commanders can be orientated by means of a 1-day familiarization course, to include explanation and demonstration of all major phases of training. The demonstration may be spectacular, to hold audience interest, but it should not misrepresent either the skills or the proper employment of the climber.

b. Practical Work. Unit personnel should practice—

(1) Balance climbing on low pitches with safe landing spots.

(2) Hauling lines; students should be encouraged to haul each other up and down.

(3) Handling fixed ropes on a moderately difficult route calculated to increase respect for trained military mountaineers. This, and other phases of practical work, should be under the supervision of instructors and trained unit climbers.

c. Coordination. Having received training in military mountaineering, climbers of units should, in unit problems and maneuvers, be given the opportunity to demonstrate and develop their skill as climbers and their value to their unit when used as such.

d. Conditioning.

(1) Troops who are not accustomed to operating in mountain terrain or who have not done so for a long time will lose most of the benefits of specialized training if they are not in strong physical condition. Steep, rocky terrain, gravel pits, quarries, practice climbing towers, and cross-country marches with natural and artificial obstacles, are excellent conditioners.

(2) Every man must receive training in the use of fixed ropes.

(3) One company in 4 consecutive weeks, training twice a week on the course described below, can acquire the necessary proficiency. The company can be put over the course in 20 minutes. Tl course should include—

(*a*) A 12-meter suspension traverse betwee trees, poles, or rocks.

(*b*) A hand-over-hand rope climb ascending a low angle log ramp where feet and legs, and not the hands, are used to lift the body.

(*c*) Descent of low angle slope where a hand-over-hand climb down, or rappel, can be accomplished.

(4) Properly conducted mountain marches emphasizing proper pace, breathing, and technique of movement are valuable.

e. Climbing Instructors. Climbers may be used as instructors in mountain marching and over normally broken terrain. They should be allowed to practice mountaineering under the supervision of the company mountaineering officer.

Section III. EXERCISES IN CLIMBING

201. General

a. Purpose. Exercises outlined in this section are only suggestions and may require revision to suit them to existing terrain. They should be short, vigorously executed, and provide climbing action for all participating students. When action stops, students lose interest.

b. Instructors. All instructors charged with the duty of observation and criticism should be thoroughly familiar with the purpose and method of the exercise, as well as all climbing techniques and tactics concerned. They should make suggestions necessary for safety or to supplement data omitted from previous training of the students.

c. Orientation. Orientation of students with all phases of the exercise should precede the problem. Instructors who are charged with the responsibility of moving untrained troops during exercises should be cautioned against the possible reactions when untrained men are exposed to height and rock fall.

d. Critique. The critique should be held in view of the terrain used in the exercise. As a basis for the critique, errors commonly committed in each exercise should be discussed, and the students should be commended for absence of errors as well as critized for the errors committed.

202. Mountain Walking Course

a. Purpose. To indicate proper technique in travel through various terrain types and obstacles.

b. Method.

(1) The course should be laid out to include an ascent and descent of about 200 meters in 1 kilometer, passing over or through large and small talus, steep grassy slopes, woods, ledges, easy chimney, down timber, and scree.

(2) The student travels the course as part of a column of squads under squad control. He is given no coaching ahead of time, but is allowed to use his own judgment.

(3) Instructors should be posted at various obstacles along the course to observe proper and improper technique. They should make notes if necessary, and prepare to take part in the critique.

c. Common Errors and Corrective Action.

(1) *Talus.* Too much use of hands for balance; poor rhythm in pace, with stops and starts from rock to rock; and stepping too far and too high. The routes should be selected several steps ahead, and the climber should move with a confident rhythmic stride. Silent movement is desirable.

(2) *Steep grass slopes.* Failure to use uphill side of clumps for steps; selection of too steep a route; and leaning into the hill.

(3) *Woods.* Tendency on steep slopes to grasp small trees for support, thus shaking tree crown and disclosing position;

branches whipped in faces of others. Trees should be grasped at base, low enough to eliminate quiver. Branches should be pushed over the head and backward.

(4) *Ledges.* Tendency to walk toward inside, projections may throw soldiers off balance and where footholds are often poorer; tendency to lean in for protection. The climber should choose a route free from cliffs on uphill side, remain upright in posture, taking care not to step on small gravel that might roll underfoot.

(5) *Easy chimney.* Usually such an obstacle becomes a bottleneck, and delays entire column. Several routes should be taken over bottleneck to designated assembly point.

(6) *Down timber.* Entire body raised in stepping over log, loose bark on slippery surface used for foothold. The climber should walk around obstacles if they are at all difficult; step over it rather than upon it, leading with the uphill foot; if stepping upon it, he should not raise the entire body.

(7) *Scree.* Not enough care in selecting footholds with best support on ascents; leaning back on descents; failure to kick and pack a step properly in traverse to prevent sliding; failure to follow in packed footprints of man ahead.

(8) *Pace.* Too fast. Proper cadence on long steep marches may vary from 75 down to 40 and lower. Under heavy load, in high altitude, on 900–1200 meter climbs or at night, the rest step may be used (short pause after each step).

(9) *Distance.* Neither great enough nor properly used; excessive accordion action in column, with many starts and stops. With correct distance of 2 meters between men, 10 to 20 meters between squads, 30 to 50 meters between platoons, and with this distance slowly taken up or let out as the terrain requires, no man should have to stop anywhere on the course. Unit leader must anticipate closing of the gap between units, and shorten and slow his pace to delay or prevent closing of the gap.

(10) *Route.* Too steep, or failing to make good use of best footing. Route should be no steeper than permits walking with foot flat on slope rather than on toes. Lead man should select his footing carefully; others should follow in his footsteps.

203. Training of Company Assault Climbers in Attack

(para. 82)

a. Purpose. To indicate correct procedure for the company assault team in attack of a steep rock obstacle.

b. Method.

(1) *Obstacle.* A 30 to 60 meter cliff.

(2) *Situation.* Because of apparent inaccessibility of cliff, top of cliff is held very lightly. No recent enemy action has been observed.

(3) *Student team.* Six men with basic weapons and appropriate climbing equipment will—

(*a*) Make a visual reconnaissance of the cliff.

(*b*) Give an estimate of the time necessary to establish two fixed ropes up it.

(*c*) Make a plan of attack.

(4) *Instructor.* Issues fragmentary field order covering situation and hour of attack. He observes all phases of preparation and execution and prepares a critique with the aid of an observer on top of the cliff.

c. Common Errors.

(1) Lack of previous planning; estimate of time and equipment wrong or lacking.

(2) Poor reconnaissance; failure of reconnaissance to disclose best routes; noisy reconnaissance.

(3) Improper placing of fixed rope; operation noisy; pitons poorly placed; rope tied in poorly; poor route selected; security not established at top of cliff; inadequate organization.

204. Equipment Movement Course

a. Purpose. To indicate possible procedures for the movement of an 81-mm mortar over various types of terrain and obstacles.

b. Method.

(1) *Course.* The course should include—

(*a*) The ascent of a cliff 10 to 15 meters high, a cliff 20 to 30 meters high, and a steep talus slope over 50 meters long.
(*b*) The descent of a steep rock or dirt slope of 40° to 45°.
(*c*) The crossing of a gap, such as a steep walled ravine, or between a pinnacle and the main rock face.
(*d*) The descent of a 15 to 20 meter vertical rock face.

(2) *Student team.* Two men with equipment they have selected after ground reconnaissance, are charged with responsibility of the movement of an 81-mm mortar section over the prescribed course.

(3) *Instructors.* They are posted at each obstacle. They observe the solution of each problem by the student, and help prepare and assist in delivering a critique.

c. Common Errors.

(1) Faulty estimate of equipment needed.
(2) Best hauling line not used; lines not in best location.
(3) Insufficient use of mortar crews to assist in movement of weapons.
(4) Improperly tied knots or cinches; poorly anchored lines; failure to observe common-sense precautions.
(5) Failure to exercise proper care to avoid damaging weapons.

205. Establishing Observation and Sniper Posts

a. Purpose. To test individual climber's and two-man climbing team's ability to overcome difficult terrain obstacles quickly and silently in reaching designated positions.

b. Method.

(1) *Obstacle.* A face, ridge, chimney, or pinnacle (route boundaries may have to be defined), which will test the climbing team's or climber's ability. Probable direction of enemy designated.

(2) *Team.* Single climbers should not be used if climbing is exposed or difficult. The two-man team or combinations of two-man teams are ideal. Climbers armed with basic weapon proceed after visual reconnaissance to cliff and climb to designated position, using all possible cover and concealment. Climbers take up concealed positions and record presence of objects or persons visible using methods outlined in FM 21–75.

(3) *Instructor.* He observes and records the actions of the climbers from designated enemy position; helps prepare and may deliver a critique.

c. Common Errors.

(1) Failure to make adequate reconnaissance.
(2) Failure to select easiest covered route or covered position.
(3) Failure to maintain tactical silence.
(4) Unnecessarily slow climbing; poor rope management, causing rocks to fall.

206. Scouts

a. Purpose. To test the ability of individual climbers, or of two-man climber teams to select a suitable line of march over broken and steep terrain; to recognize those portions of the line of march which will require special aids; to recognize common dangers.

b. Method.

(1) *Course.* To include an ascent and descent of at least 300 meters and at least 2½ horizontal kilometers in length; broken and steep terrain, rock cliffs and other terrain obstacles; a wide selection of routes.

(2) *Student.* Equipped with basic weapon, compass, map, notebook, pencil, and climbing equipment, the scout team will proceed from the starting point (indicated on map) toward a designated objective. He will choose the best possible line of march, recognizing the special aids his unit will have to employ in following him He will make a sketch and make notes of obstacles and danger areas, such as those subject to rock fall from natural and artificial causes. Where terrain bottlenecks occur, he will reconnoiter them and adjacent terrain for alternate routes.

(3) *Instructor.* He accompanies scout(s), observing and recording mistakes. He assists in preparing and may help to deliver a critique.

c. Common Errors.

(1) Failure to make successive visual reconnaissance from commanding terrain features encountered in line of march.
(2) Poor choice of route; failure to go around, rather than over prominent ter-

rain obstacles; failure to avoid terrain features most subject to enemy observation or swept by rock fall.

(3) Failure to reach designated point.

(4) Failure to record obstacles encountered and alternate routes as required.

207. Scouting and Patrolling By Night

a. Purpose. To demonstrate the ability of the patrol to apply the principles of night scouting and patrolling (FM 21-75) to military mountaineering.

b. Method.

(1) *Course.* Laid out to include walking on leaf-covered slopes, talus, moderately difficult climbing, easy scrambling, setting up and use of rappel. Difficult climbing should be low (not higher than 3 meters above a good landing spot) and should not exceed a 70° angle.

(2) *Student.* Single climbers or groups, equipped with a climbing rope, travel course, maintaining tactical silence and light discipline.

(3) *Instructor.* Instructors are posted at frequent intervals along the course. They listen for unnecessary noises and direct patrol from station to station; prepare comments for use in the critique.

c. Common Errors.

(1) Rolling or kicking rocks, causing them to fall. This error can be corrected by keeping weight over feet, and by moving carefully with special attention to how the rear foot is raised.

(2) Shaking trees and branches, disclosing position.

(3) Failure to rappel carefully so that rocks are not knocked loose.

(4) Failure to avoid skylining.

208. Combat Patrol

a. Purpose. To give the climber team and attached elements practice in functioning as a climber combat patrol.

b. Practical Work. A tactical problem, in which the climber combat patrol, under control of the company mountaineering officer is called upon to eliminate an enemy combat outpost on dominant and precipitous terrain. For the problem a suitable terrain feature is selected, and a situation and fragmentary attack order are given.

(1) Terrain obstacles are a cliff or spur 15 to 60 meters high, and a talus approach of more than 30 meters.

(2) The situation is tactical. Enemy position is held by a light machinegun section and mortar section with rifle security, at a distance of 1,500 meters from friendly forward elements.

(3) The patrol leader is informed of situation and given attack order at H-3 hours. He makes a visual reconnaissance, forms a plan of attack, and briefs his element and climber teams.

(4) The mountaineering noncommissioned officer divides climbers into two units of two men each, and procures necessary climbing equipment, rations, weapons, and ammunition for climbers.

(5) The patrol leaders divides his patrol into two main elements—the assault element and security element—and attaches a climbing team to each. He draws necessary ammunition and rations.

(6) Combat patrol crosses line of departure at H-hour and attack continues according to plan.

(7) Instructors acting as observers accompany the patrol and are stationed with enemy detail on the objective. They record their observations and assist in preparing and delivering critique.

c. Common Errors.

(1) Failure to organize an attack effectively or procure necessary equipment.

(2) Assault teams are not coordinated well with the security element.

(3) Climbers do not attack aggressively.

(4) Climbers warn enemy of their presence prematurely by shouting or dislodging rocks.

(5) Climbers do not choose best routes; are stopped unnecessarily by difficulty or enemy fire through failure to use covered approach.

APPENDIX I

REFERENCES

	AR 40–501	Standards of Medical Fitness.
	AR 220–50	Field Organizations: Regiments; General Provisions.
	AR 320–5	Dictionary of U.S. Army Terms.
	AR 320–50	Authorized Abbreviations and Brevity Codes.
	AR 380–5	Safeguarding Defense Information.
	AR 380–40	Safeguarding Cryptomatter.
	AR 380–41	Control of Cryptomaterial.
(S)	AR 380–46	Radiation of Intelligence Bearing Information by Communications, Communications Security, and Duplicating Equipments (U).
	AR 600–20	Army Command Policy and Procedures.
	FM 1–100	Army Aviation.
	FM 3–5	Chemical, Biological and Radiological (CBR) Operations.
	FM 3–8	Chemical Corps Reference Handbook.
	FM 3–10	Chemical and Biological Weapons Employment.
(S)	FM 3–10A	Chemical and Biological Weapons Employment (U).
	FM 3–12	Operational Aspects of Radiological Defense.
	FM 5–15	Field Fortifications.
	FM 5–20	Camouflage, Basic Principles and Field Camouflage.
(S)	FM 5–26	Employment of Atomic Demolition Munition (ADM)(U).
	FM 5–29	Passage of Mass Obstacles.
	FM 5–31	Use and Installation of Booby Traps.
	FM 7–11	Rifle Company, Infantry, Airborne Infantry, and Mechanized Infantry.
	FM 7–15	Infantry, Airborne Infantry, and Mechanized Infantry Rifle Platoons and Squads.
	FM 7–20	Infantry, Airborne Infantry, and Mechanized Infantry Battalions.
	FM 7–30	Infantry, Airborne Infantry, and Mechanized Division Brigades.
	FM 8–35	Transportation of the Sick and Wounded.
	FM 11–50	Signal Battalion, Armored, Mechanized and Infantry Divisions.
	FM 17–1	Armor Operations, Small Units.
	FM 17–15	Tank Units, Platoon, Company and Battalion.
	FM 17–30	The Armored Division Brigade.
	FM 17–36	Armored Cavalry Platoon and Troop, Air Cavalry Troop and Divisional Armored Cavalry Squadron.
	FM 21–5	Military Training.
	FM 21–6	Techniques of Military Instruction.
	FM 21–10	Military Sanitation.
	FM 21–11	First Aid for Soldiers.
	FM 21–26	Map Reading.
	FM 21–30	Military Symbols.
	FM 21–40	Small Unit Procedures in Chemical, Biological and Radiological (CBR) Operations.
	FM 21–41	Soldiers Handbook for Chemical and Biological Operations and Nuclear Warfare.
	FM 21–48	Training Exercises, and Integrated Training in Chemical, Biological, and Nuclear Warfare.

	FM 21-50	Ranger Training and Ranger Operations.
	FM 21-75	Combat Training of the Individual Soldier and Patrolling.
	FM 24-17	Tactical Communications Center Operations.
	FM 24-18	Field Radio Techniques.
	FM 24-20	Field Wire and Field Cable Techniques.
	FM 25-10	Motor Transportation Operations.
	FM 30-5	Combat Intelligence.
	FM 31-12	Army Forces in Amphibious Operations.
	FM 31-30	Jungle Operations.
	FM 31-70	Basic Cold Weather Manual.
	FM 31-71	Northern Operations.
(CM)	FM 32-5	Communications Security (U).
	FM 41-10	Civil Affairs Operations.
	FM 44-1	US Army Air Defense Employment.
	FM 54-2	Division Logistics and the Support Command.
	FM 57-10	Army Forces in Joint Airborne Operations.
	FM 57-35	Airmobile Operations.
	FM 61-100	The Division
(S)	FM 100-1	Doctrinal Guidance (U).
	FM 100-5	Field Service Regulations; Operations.
	FM 100-10	Field Service Regulations; Administration.
	FM 101-5	Staff Officers' Field Manual; Staff Organization and Procedure.
	FM 101-10	Staff Officers' Field Manual; Organization, Technical, and Logistical Data.
	FM 101-31-1, 2, 3	Staff Officers' Field Manual, Nuclear Weapons Employment.
	TM 3-210	Fallout Prediction.
	TM 3-215	Military Chemistry and Chemical Agents.
	TM 3-216	Military Biology and Biological Warfare Agents.
	TM 3-220	Chemical, Biological and Radiological (CBR) Decontamination.
	TM 3-300	Ground Chemical Munitions.
	TM 3-366	Flamethrower and Fire Bomb Fuels.
	TM 3-376	M2A1 Portable Flamethrower.
	TM 3-4240-202-15	Mask, Protective, Field, M17.
	TM 3-522-15	Mask, Protective, Field, M9 and M9A1.
	TM 5-250	Roads and Airfields.
	TM 5-251	Army Airfields and Heliports.
	TM 5-270	Cableways and Tramways.
	TM 5-271	Light Stream-Crossing Equipment.
	TM 5-279	Suspension Bridges for Mountain Warfare.
	TM 5-315	Fire Protection by Troop Organization in Theater of Operation.
	TM 5-349	Arctic Construction.
	TM 8-501	Nutrition.
	TM 9-207	Operation and Maintenance of Ordnance Materiel in Extreme Cold Weather (0° to −65° F.).
	TM 9-273	Lubrication of Ordnance Materiel.
	TM 9-1300-203	Ammunition, Field Artillery.
	TM 9-1900	Ammunition, General.
	TM 9-1950	Rockets.
	TM 9-8662	Fuel-Burning Heaters for Winterization Equipment.
	TM 10-275	Principles and Utilization of Cold Weather Clothing and Sleeping Equipment.
	TM 55-404	Fundamentals of Army Airplane Maintenance.

TM 743-200-1	Storage and Materials Handling.
Pam 108-1	Index of Army Motion Pictures, Filmstrips, Slides, and Phono-Recordings.
Pam 310-1	Military Publications—Index of Administrative Publications.
Pam 310-2	Military Publications—Index of Blank Forms.
Pam 310-3	Military Publications—Index of Training Publications.
Pam 310-4	Index of Technical Manuals, Technical Bulletins, Supply Bulletins, Lubrication Orders, and Modification Work Orders.
Pam 310-5	Military Publications—Index of Graphic Training Aids and Devices.
Pam 310-7	Military Publications—Index of Tables of Organization and Equipment, Type Tables of Distribution, and Tables of Allowances.
TB Sig 189	Cold Weather Photography.
TB Sig 239	Maintenance Information for New Series Radio Sets.
TB Sig 271	Lubrication of Tactical Teletypewriter Equipment, Teletypewriters, and Reperforator Transmitters.
TB Sig 346	Maintenance of Radiac Equipment.
TA 50-901	Clothing and Equipment (Peace).

APPENDIX II

MASTER TRAINING PROGRAM

MILITARY MOUNTAINEERING AND GLACIER WORK

Item	Subject	Code ltr	Total hours	Weeks				
				1	2	3	4	5
1	Rope Management	RM	5	5				
2	Manpacking	MP	1	1				
3	Personal Hygiene and Sanitation	PH	1	1				
4	Use and Care of Climbing Aids	CA	1	1				
5	Preparation of Rations	PR	1	1				
6	Shelters and Fires	SF	5	5				
7	Mountain Weather	MW	1	1				
8	Communications	CM	5	5				
9	Maps and Compass	MC	6	2	4			
10	Individual Mountain Movement	IM	31	7	8	8	8	
11	Use of Rope Installations	RI	16	4	4	4	4	
12	Assault Climbing Techniques	AC	50	4	12	12	12	10
13	Mountain Marches and Bivouacs	MM	54		8	16	16	14
14	Evacuation	EV	6	2	4			
15	Glaciers	GL	14					14
16	Avalanches	AV	2					2
17	Commanders' Time	CT	21	5	4	4	4	4
	TOTAL		220	44	44	44	44	44

ROPE MANAGEMENT — CODE RM

Subject Schedule — Total Periods 5

Periods	Type of instruction	Subject	References and remarks
RM 1	Conference and practical work.	Types and characteristics of ropes used in mountaineering, care of ropes, proper coiling, tying off of coils, throwing and method of carrying.	FM 31–72
RM 2–5	Demonstration and practical work.	Terms used in rope work, method of GTA 5–8 tying knots used in military mountaineering, and their practical application.	FM 31–72

MANPACKING — CODE MP

Subject Schedule — Total Periods 1

Periods	Type of instruction	Subject	References and remarks
MP 1	Conference	Nomenclature, function and adjustment of rucksack components, and proper methods of stowing equipment.	FM 31–70 TM 10–275

PERSONAL HYGIENE AND SANITATION

CODE PH

Subject Schedule

Total Periods 1

Periods	Type of instruction	Subject	References and remarks
PH 1	Conference	Prevention and care of ailments peculiar to mountain operations. Personal cleanliness and action to preserve health under adverse conditions.	FM 21-11 FM 31-70

USE AND CARE OF CLIMBING AIDS

CODE CA

Subject Schedule

Total Periods 1

Periods	Type of instruction	Subject	References and remarks
CA 1	Conference	Familiarization with climbing rope, sling rope, pitons, snaplinks, piton hammer, leather gloves, and shoes.	FM 31-72

PREPARATION OF RATIONS

CODE PR

Subject Schedule

Total Periods 1

Periods	Type of instruction	Subject	References and remarks
PR 1	Conference and practical work.	Proper care, use, testing and repair of one burner gasoline stove. Components of field rations and their preparation under field conditions.	TM 10-708 FM 21-75 FM 31-70

SHELTERS AND FIRES

CODE SF

Subject Schedule

Total Periods 5

Periods	Type of instruction	Subject	References and remarks
SF 1	Conference and demonstration.	Use and care of 5-10 man tents, and the assembly and operation of the Yukon Stove.	FM 31-70 TM 10 735
SF 2-5	Practical work	Construction and proper use of various types of improvised shelters. Proper care and use of axe, knife, and the conservation of forest resources. Food procurement and care of the individual under unusual situations.	

MOUNTAIN WEATHER

CODE MW

Subject Schedule

Total Periods 1

Periods	Type of instruction	Subject	References and remarks
MW 1	Conference	The importance of weather in mountain operations, its general characteristics, types and prediction methods.	FM 31-72

COMMUNICATIONS

CODE CM

Subject Schedule

Total Periods 5

Periods	Type of instruction	Subject	References and remarks
CM 1	Conference	Wire, radio, messenger, and visual communications, and problems peculiar to their use in mountains. Communications security.	TB Sig 219 FM 24–18 FM 24–20
CM 2–5	Practical work	Visual Communications, semaphore and blinker lamps	FM 21–60* FM 32–5*

*5 additional hours to be given each succeeding week as integrated training.

MAPS AND COMPASS

CODE MC

Subject Schedule

Total Periods 6

Periods	Type of instruction	Subject	References and remarks
MC 1–6	Conference, demonstration, and practical work.	Review of basic map and compass reading and its application to the special problems caused by difficult terrain.	FM 21–26

INDIVIDUAL MOUNTAIN MOVEMENT

CODE IM

Subject Schedule

Total Periods 31

Periods	Type of instruction	Subject	References and remarks
IM 1–4	Demonstration and practical work.	Proper techniques of placing the feet and moving the body while ascending, descending, and traversing varied mountain terrain.	FM 31–72
IM 5–12	Demonstration and practical work.	Proper technique of using hands, feet, and body position while moving over varied mountain terrain to include rock faces and slab. Margin of safety stressed and students kept close to ground.	
IM 13–20	Demonstration and practical work.	Training in the proper technique of descent with aid of rope using all types of rappels.	
IM 21–28	Demonstration and practical work.	Selection of best routes through mountainous areas under all conditions, and proper marking of route.	
IM 29–31	Practical work	Techniques of mountain walking, emplacement of pitons, unroped balance climbing, two-man party climbing, and methods of rappelling.	FM 31–72

USE OF ROPE INSTALLATIONS

CODE RI

Subject Schedule

Total Periods 16

Periods	Type of instruction	Subject	References and remarks
RI 1–4	Demonstration and practical work.	Installation and use of fixed ropes and suspension traverses.	FM 31–72
RI 5–8	Demonstration and practical work.	Installation and use of vertical hauling lines.	
RI 9–12	Demonstration and practical work.	Installation and use of rope bridges.	
RI 13–16	Practical work	Movement over a course which requires the use of rope installations.	

ASSAULT CLIMBING TECHNIQUES — CODE AC

Subject Schedule — Total Periods 50

Periods	Type of instruction	Subject	References and remarks
AC 1–4	Conference and demonstration.	Demonstration of proper techniques in walking over various mountain terrain to include party climbing, belaying, rappelling, and use of fixed ropes.	FM 31–72
AC 5–8	Practical work	Proper techniques of placing the feet and moving the body while ascending, descending and traversing scree, talus, hard ground, and grassy slopes.	
AC 9–16	Practical work	Training in selection, placement, driving, testing, and use of pitons. Use and care of piton hammer and snaplinks. Proper techniques of ascending and descending with use of rope.	
AC 17–24	Demonstration and practical work.	Techniques for providing necessary safety factors by proper use of rope. Body, pitons, and natural anchor belay points for roped party climbing.	FM 31–72
AC 25–32	Demonstration and practical work.	Selection of best routes through mountain terrain and proper marking of route under all conditions.	
AC 33–50	Practical work	Proper technique of balance climbing and belaying on steep mountainous areas by parties of two or three climbers tied into and protected by climbing rope. Adaptation of techniques to overcome lack of various items of equipment.	

MOUNTAIN MARCHES AND BIVOUACS — CODE MM

Subject Schedule — Total Periods 54

Periods	Type of instruction	Subject	References and remarks
MM 1–8	Practical work	Marches through difficult terrain which necessitates application of mountaineering techniques and use of map and compass.	FM 31–72
MM 9–54	Practical work	Marches through difficult terrain which requires application of mountaineering techniques and construction and use of improvised shelters. Bivouac routine.	

EVACUATION — CODE EV

Subject Schedule — Total Periods 6

Periods	Type of instruction	Subject	References and remarks
EV 1–2	Conference and demonstration.	Evacuation of casualties over rough terrain cliffs, steep slopes, and across streams. Improvisation of litters and equipment. Use of rope installations as aid in movement.	FM 31–72
EV 3–6	Practical work	do	

GLACIERS

CODE GL

Subject Schedule

*Total Periods 14

Periods	Type of instruction	Subject	References and remarks
GL 1	Conference	Dangers of glacial regions. Mechanics of glacial ice formation. Effects of snow and ice on mountain operations under summer conditions.	FM 31-72
GL 2	Conference and demonstration.	Special equipment used for movements on snow and ice in high mountains (climbing rope, ice ax, crampons, and ice pitons).	FM 31-72.
GL 3-10	Demonstration and practical work.	Proper techniques of placing the feet and moving the body while ascending, descending, and traversing ice and snow surfaces. Use of ice ax and crampons. Glissading (standing and sitting). Use of rope for party movement. Method of self arrest. Route selection on glaciers.	
GL 11-14	Demonstration and practical work.	Proper techniques of crossing crevasses. Crevasse rescue.	

*Total of 14 hours to be devoted to glacier training.

AVALANCHES

CODE AV

Subject Schedule

Total periods 2

Periods	Type of instruction	Subject	References and remarks
AV 1	Conference	Basic causes of avalanches; types of avalanches; avalanche "triggers."	TF FB-78, Avalanche, running time 30 min. FM 31-72.
AV 2	Conference and demonstration.	Protective measures (avalanche hazard, forecasting, restrictions, stabilization, and barriers); safety precautions, (observation, route selection, timing, and self defense); techniques of avalanche rescue (equipment, immediate action, followup, and evacuation).	

COMMANDER'S TIME

CODE CT

Subject Schedule

Total Periods 2

Periods	Type of instruction	Subject	References and remarks
CT 1-21		Reserved for unit Commanders. Must include mandatory subjects such as character guidance, etc.	5 hour period 1st week, 4 hour period weekly thereafter.

APPENDIX III

MENSURAL CONVERSIONS

Multiply	*By*	*To obtain*
Centimeters	.03281	Feet
Centimeters	.3937	Inches
Meters	3.281	Feet
Meters	39.37	Inches
Meters	1.0936	Yards
Kilometers	.62137	Miles (statute)
Knots	1.1516	Miles per hour (statute)

INDEX

	Paragraph	Page
Acclimatization	23	9
Air:		
Borne forces	104	30
Defense artillery	100	28
Evacuation	125	41
Fields and strips	103, 106	30, 33
Ground communication	113	35
Landed forces	56–57	16
Lifted artillery	90	26
Supply	104	30
Air conditions	10	4
Aircraft:		
Capability	105	31
Ceiling limitation	47, 105	14, 31
Characteristics and uses:		
Multiplace	103	30
Rotary-wing	103, 105	30, 31
Two-place	103	30
Flying conditions	104	30
Helicopters	105, 125	31, 41
Air defense:		
Artillery	3, 100	2, 28
Command Post	100	28
Surface-to-air missile	100	28
Alpine path, fixed:		
Capabilities	180	118
Construction requirements	180	118
Description	180	118
Erection	184–190	120
Inspection	191	132
Maintenance	191, 192	132
Materials	182	120
Purpose	179	118
Repairs	192	132
Site conditions	181	120
Survey, route	181	120
Transportation	183	120
Altitude:		
Acclimatization	23	9
Air condition	10	4
Atmospheric pressure	10	4
Cloud formation. (*See* Clouds.)		
Effects:		
Aircraft	105	31
Individuals	24, 30	10, 11
Movement	13, 34, 36	5, 12
Sounds	46	14
Need for oxygen	10	4
Psychological adjustment	24	10
Variation in temperature. (*See* Temperature.)		
Ammunition:		
Chemical	68	19
Supply	58, 73, 90	17, 21, 26
Anchors:		
Basic aids	143	69
Natural	143	69
Artificial	143	69
Horseshoe	172	105
In belays. (*See* Belay.)		
Suspended walkway	188	128
Armor:		
Employment	102	29
Suitability	3, 101	2, 29
Surprise raids	48	14
Arms and services. (*See* Employment of arms and services.)		
Army aviation:		
Capabilities and limitations	103, 105	30, 31
Employment:		
Operations	104	30
Special considerations	105	31
Tactical aspects	105	31
Attack	57	16
Pursuit	60	17
Retrograde movement	66	19
Evacuation by air	125	41
Landing sites. (*See* Landing sites.)		
Ascent:		
In avalanche areas	169	101
In snow	173	108
Technique:		
Hauling line	156	87
Lowering a casualty	150, 151	81, 82
Marching	34	12
Assault climber	82	23
Atmospheric:		
Disturbances	18	6
Effects on operations	32	12
Luminosity	10	4
Pressure	10	4
Thunderstorms	16	6
Attack:		
Against fortified positions	61	18
Flanking	57, 61	16, 18
Frontal	57	16
Plans	57	16
Pursuit	60	17
Rules applicable	57	16
Supporting weapons	58	17
Use of assult climbers	82	23

	Paragraph	Page
Attack—Continued		
Use of smoke	59	17
Vertical envelopment	57	16
Avalanche:		
Action of individuals. (*See* Safety.)		
Basic causes	164	91
Climate and weather:		
Exposure	164	91
Terrain	164, 167	91, 98
Vegetation	164	91
Characteristics:		
Climax	165	93
Cornice	165	93
Damp and wet snow	165	93
Dry, loose snow	165	93
Classification:		
Combination	165	93
Loose snow	165	93
Packed snow	165	93
Contributory factors	167	98
Cord	169	101
Effects:		
Artillery fire	97	28
Nuclear weapon	68	19
Hazard forecasting	167	98
Occurrence	163, 167	91, 98
Phenomenon	164	91
Protective measures:		
Restrictions	168	100
Stabilization	168	100
Use of barriers	168	100
Rescue. (*See* Safety.)		
Settlement. (*See* Contributory factors.)		
Triggering	166	98
Types	165	93
Basic Aids:		
A-frame	143	69
Anchors	143	69
Tightening knots. (*See* Ropes and knots.)		
Basic technique:		
Mountain walking	134	45
Precautions	134, 135	45, 47
Rock climbing	135	47
Balance	135	47
Belay. (*See* Belay.)		
Body position	135	47
Dangers to avoid	140	64
Margin of safety	135	47
Rappel. (*See* Rappel.)		
Rock falls	140	64
Rope management. (*See* Ropes and knots.)		
Route selection. (*See* Route selection.)		
Scope	140	64
Use:		
Holds	135	47
Piton, snaplink, and hammer	137	56
Vantage points	140	64
Belay:		
Application:		
Crevasse crossing	177	112
Crevasse rescue	178	113
Litter casualty	151, 152	82, 84
Over snow and ice	173	108
Positions	138	59
Procedures to be used	138	59
Purpose	138	59
Technique	138, 173	59, 108
Bivouac:		
Defense	49	14
Formation	50	15
Precautions	51	15
Set-up	50	15
Types of shelter. (*See* Shelter.) Under various conditions	49	14
Bridge:		
Construction	147	78
Expedients:		
Branches	147	78
Ice	147	78
Rope crossing	147	78
Snow over crevasses	177, 178	112, 113
Suspension bridge and cableway	147	78
Bridging material	147	78
Cableway, use in fixed alpine paths	190	131
Camouflage.		
Artillery positions	94	27
Landing sites	106	33
Camp:		
Fires	51	15
Sites	49	14
CBR operations and nuclear warfare:		
Defense:		
Chemical attack	68	19
Biological attack	68	19
Nuclear attack	68	19
Fallout radiation	68	19
Thermal effects	68	19
Cleanliness:		
Care of feet	28	10
Constipation	28	10
Personal habits	28	10
Washing and bathing	28	10
Waste disposal	29	11
Climate:		
Cloudiness. (*See* Clouds.)		
Effects:		
Cold	11	4
Weather. (*See* Weather.)		
Luminosity	10	4
Mountain air	10, 23	4, 9
Precipitation	14, 18, 20	5, 6, 7
Rate of snowfall	164	91
Variation in temperature. (*See* Temperature.)		
Wind action	15, 164, 167	5, 91, 98
Climbing tower	198	134
Clothing:		
Effects of climate and weather	11	4
Requirement	70	21

	Paragraph	Page
Clouds:		
Cloudiness	11, 14, 18	4, 5, 6
Marches	44	14
Thickness	18	6
Types:		
Alto-stratus	21	7
Cirrus	18, 21	6, 7
Cumulo-nimbus	21	7
Cumulus	21	7
Stratus	21	7
Combat:		
Defensive:		
Advantages	62	18
Against CBR attacks	68	19
Counterattack	65	19
Delaying	62	18
Disadvantages	63	18
Fortified areas	67	19
Obstacles	62	18
Retrograde movement	66	19
Reverse slope	64	18
Selection of positions	64	18
Use of artillery	93	27
Withdrawal	66	19
Offensive:		
Advance	52	15
Approach	56	16
Assault	82	23
Attack	57	16
Contact	56	16
Control measures	53	16
Envelopments	52	15
Exploitation and pursuit	60, 92	17, 26
Formations	56	16
Infiltration	57	16
Influence of terrain	52	15
Initiative	54	16
Objectives	52, 53	15, 16
Seizure of dominant terrain	52	15
Supporting weapons	58	17
Use:		
Mountaineers	82	23
Smoke	59	17
Patrols	83	24
Command:		
Of air	57	16
Posts	57	16
Communication:		
Air-ground	113	35
Lateral	64	18
Methods of increasing range	113	35
Relay stations	113	35
Reliability	113	35
Routes	67	19
Signal:		
Messenger	114	37
Radio	98, 101, 113	28, 29, 35
Visual:		
Blinker	114	37
Heliograph device	114	37
Improvised methods	114	37
Communication—Continued		
Signal—Continued		
Visual—Continued		
Semaphore method	114	37
Smoke	114	37
Wigwag	114	37
Wire	98, 101, 106, 113	28, 29, 33, 3
SOI	106	3
Concealment:		
Availability	8	
Aid stations	117	3
Landing sites	106	3
Use of smoke	59	1
Conditioning:		
Acclimatization	23	
Fatigue	23, 60	9, 1
Fear of height	24	1
Personal hygiene	27–30	1
Physical	25	1
Psychological adjustment	24	1
Sicknesses. (*See* Medical.)		
Training	200	13
Water discipline	27	1
Cover	8	
Crampons	172	10
Crevasse:		
Bridging	177	11
Crossing	177	11
Detection	177	11
Rescue	178	11
Deception	62	1
Descent:		
Carrier technique	153	8
Casualty	151	8
Cliff evacuation	152	8
In avalanche area	169	10
In snow	173	10
March technique	34	1
Operation of hauling line	145, 156	74, 8
Rappel	139	
Roped movement	142	
Digging	8	
Driving	129	
Employment of the arms and services:		
Air defense artillery	100	
Armor	101, 102	
Army aviation	103–106	
Engineers	107–112	
Field artillery	89–99	
Infantry	84–87	
Limitations	3	
Medical	115–127	
Engineers (Combat):		
Bridging	147	
Demolitions	111	
Missions	107	
Obstacles and mines	112	
Reconnaissance	109	
Road construction	110	

	Paragraph	Page
Envelopment. (*See* Combat.)		
Equipment:		
Avalanche:		
Adjustment	169	101
Cord	169	101
Rescue	170	103
Camouflage	94	27
Chemical:		
Protective mask	68	19
Effects of weather and terrain	11, 42	4, 13
Engineer:		
Heavy	107, 109	33
Mine detectors	112	34
Snow removal	159	90
Medical	123	40
Ordnance:		
Explosives	111, 112	34
Fire control, electrical	100	28
Sleds and runners	159	90
Vehicles	128, 129	42
Quartermaster:		
Clothing	70, 160	21, 90
Cooking	72	21
Skis and snowshoes	160	90
Sleeping	70, 71	21
Special (climbing)	136, 137, 173	52, 56, 108
Tentage	51	15
Signal:		
Radio	113	35
Visual	114	37
Wire	113	35
Evacuation. (*See* Medical.)		
Exposure:		
Caused by an avalanche	164	91
Effect on body	174, 178	110, 113
Falls:		
Free	178	113
Suspended	178	113
Fatigue. (*See* Conditioning.)		
Fiber rope:		
Ladders	187	124
Rungs, for ladders	187	124
Field artillery:		
Coordination with infantry	91	26
Employment	3	2
Fire control	99	28
Limitations	90, 159	26, 90
Measuring elevation	99	28
Observation	52, 95, 99	15, 27, 28
Positions	94	27
Stabilization of snow	168	100
Survey	99	28
Tactical principles	89	26
Tactics:		
Defense	93	27
Pursuit	92	26
Targets	97	28
Transfer of fires	99	28

	Paragraph	Page
Field artillery—Continued		
Types:		
Air-lifted	90	26
Self-propelled	96	27
Towed	96	27
Use:		
Block and tackle or winch	96	27
Grousers	96	27
Sleds and runners	159	90
Field Fortification:		
Areas	67	19
Shelters. (*See* Shelter.)		
First Aid and Hygiene:		
Personal	26–29	10
Fixed alpine path	180	118
Fog:		
Marches	44	14
Signaling	114	37
Glacier:		
Crevasse:		
Crossing	177	112
Detection	177	112
Rescue	178	113
Dangers	174	110
Roped parties	175	111
Routes	176	111
Snow bridges	177, 178	112, 113
Glissading. (*See* Movement.)		
Hammer. (*See* Pitons, snaplink, and hammer.)		
Hand lines	185	121
Hanging ladders	187	124
Hazards:		
Avalanche	159, 167	90, 98
Cold injury	29	11
Contamination	68	19
Crevasse	177	112
Driving in the mountains	129	42
Flying conditions	104	30
Glacier movements	174	110
Landing facilities	106	33
Rock falls	140	64
Slab formation	162	91
Snow bridges	177	112
Terrain	24	10
Humidity	10	4
Iceax	172	105
Ice piton	172	105
Infantry:		
Application of tactics	84	25
Employment of weapons	3	2
Factors governing use of weapons	85	25
Stabilization of snow	168	100
Supporting weapons:		
ENTAC	88	25
Grenades and rockets	87	25
Machine guns	88	25
Mortars	88	25
Recoilless rifle	88	25
Snipers	86	25

	Paragraph	Page
Infiltration	57	16
Inteligence (Combat):		
Observers and scouts	79	22
Patrols, combat	83	24
Reconnaissance:		
Aerial	128	42
Engineer	109	33
Motorized	128	42
Patrols	80	23
Road	128	42
Knots. (*See* Ropes and knots.)		
Land mines:		
Antitank and antipersonnel	112	34
Mining technique	112	34
Removal technique	112	34
Landing sites:		
Approaches and exits	106	33
Concealment	106	33
Equipment	106	33
Identification	106	33
Location	106	33
Marking	106	33
Obstacles above ground	106	33
Preparation	106	33
Selection and considerations	103, 105, 106	30, 31, 33
Size	106	33
Soil condition	106	33
Takeoff and landing	106	33
Topography	106	33
Lines, hand	185	121
Logistics:		
Distribution	69, 73	20, 21
Effects of terrain	4, 101	3, 29
Means of transportation	69, 75, 105	20, 22, 31
Planning	69	20
Rations	72	21
Requirement for special clothing and equipment	70	21
Supply:		
Aerial	100, 104, 105	28, 30, 31
Ammunition	58, 73, 90, 100	17, 21, 26, 28
Factors affecting	69	20
Local sources	69	20
Location of points	69	20
Over vertical cliffs	75	22
Time requirement	4	3
Luminosity	10	4
Maintenance:		
Protective mask	68	19
Rope	136	52
Signal equipment	113	35
Fixed alpine path	191, 192	132
Maps and overlays:		
Contour	109	33
Coverage	107	33
Geodetic control	107	33
Overlays	109	33

	Paragraph	Page
March Technique:		
Ascending	34	12
At night	43	13
Column length	39	13
Descending	35	12
Discipline	37	13
Distance	202	137
Effects of	35	12
Halts	38	13
In clouds and fog	44	14
Pacing and speed	34, 38, 202	12, 13, 137
Rate of movement	34, 36	12
Selection of route. (*See* Route selection.)		
Timing and time length	40, 49, 50	13, 14, 15
Traversing	34	12
Use of feet	34	12
Medical:		
Adjustment, psychological	24	10
Ascending and descending	35	12
Cold effects	125	41
Equipment	123	40
Evacuation:		
At night	125	41
By air	125	41
Over vertical terrain	125	41
Plans	126	42
Principles	148	80
Speed	117	39
Techniques. (*See* Techniques of evacuation.)		
Installations:		
Aid stations	117	39
Clearing stations	121	40
Collecting points	119, 122	39, 40
Litter bearer posts	120	40
Litter bearer haul	119, 121, 125	39, 40, 41
March procedures	122	40
Personal hygiene	26, 29	10, 11
Principles of operation	115	38
Shelter	117, 118, 124	39, 40
Sickness:		
Mountain	30	11
Sunburn	13, 174	5, 110
Valley	31	11
Units and personnel:		
Company aid men	118, 119	39
Litter bearer teams	117, 121, 125	39, 40, 41
Medical battalion	121	40
Medical platoon	116	38
Water supply and discipline	27	10
Missiles	89, 100	26, 28
Movement:		
Driving technique	129	42
Effects of altitude	13	5
Objectives	41	13
Operating vehicles on steep grades	129	42
Retrograde	66	19

	Paragraph	Page
Movement—Continued		
Technique of marching. (*See* March Technique.)		
Trained personnel:		
Free climbing	141	67
Roped climbing	142	67
Unit	143–146	69
Basic aids. (*See* Basic aids.)		
Fixed ropes. (*See* Ropes and knots.)		
Hauling lines. (*See* Ropes and knots.)		
Stream crossing. (*See* Stream crossing.)		
Under various conditions:		
Along ridges and valleys	40	13
At night	43	13
Cross-country	7	3
In clouds and fog	44	14
In difficult terrain	42	13
On rock face. (*See* Basic technique.)		
Over snow and ice:		
Belays	173	108
Crevasses	177	112
Glissading	173	108
Step-cutting	173	108
Use of special equipment	173	108
Use of aircraft	105	31
Mountaineering:		
Application	131	45
Capabilities and duties of climbers	77	22
Employment of mountaineers:		
Assault climbers	82, 203	23, 138
Flank patrols	81	23
Guides	43, 76–78	13, 22
Observers and scouts	79, 205–207	22, 139
Reconnaissance patrols	80, 207	23, 140
Importance	130	45
Requirement for qualified climbers	76, 132	22, 45
Technique. (*See* Basic technique.)		
Mountain:		
Air. (*See* Climate.)		
Description	5	3
Transportation problems	75	22
Nuclear:		
Exploitation	3	2
Fire	62	18
Observation:		
Artillery	95	27
Establishment of posts	205	139
Signs of avalanche	169	101
Obstacles:		
Avalanche barrier	168	100
General	62	18
Glacier	176	111
Streams	146	76
Use of hauling line to overcome obstacles	156	87
Operations:		
Command of air	57	16
Decentralization of control	32	12
Defensive. (*See* Combat.)		
Effects of terrain and weather	11, 32, 52	4, 12, 15
Independency or semi-independency	32, 55	12, 16
Infiltration	57	16
Missions	55	16
Objectives	52	15
Offensive. (*See* Combat.)		
Standing operating procedures	33	12
Surprise	32	12
Orders:		
Fragmentary	4	3
Relaying during night movement	43	13
Types	54	16
Organization:		
Airborne, air assault and infantry division	2	2
Changes and modifications	2, 33	2, 12
Pitons, snaplink, and hammer:		
Hammer, piton	137	56
Piton:		
Placing	137	56
Removing	137	56
Types	137	56
Snaplink	137	56
Uses in belay	138	59
Precipitation	14, 18	5, 6
Glaze	18	6
Intensity. (*See* Contributory factors.)		
Moisture-bearing winds	20	7
Prediction	22	7
Psychological adjustment	24	10
Confidence	24	10
Pursuit	60	17
Rappel:		
Application of technique	152	84
Establishment	139	62
Helicopter	141	67
Purpose	139	62
Types:		
Body	139	62
Hasty	139	62
Hip	139	62
Seat	139	62
Shoulder	139	62
Rations	72	21
References	App. I	141
Repairs:		
Fixed alpine path	192	132
Rescue:		
Avalanche	170	103
Crevasse	178	113
Rigging:		
Suspended walkway	188	128
Roads and trails	6–7	3
Approach	56	16
Construction	107–110	33

	Paragraph	Page
Roads and trails—Continued		
Culverts	107–110	33
Drainage	107–110	33
Effects:		
Armor	101–102	29
Artillery	96	27
Location	40, 109	13, 33
Maintenance	102, 107–110	29, 33
Selection	40, 109	13, 33
Snow removal	107–110	33
Trafficability	107–110	33
Roped climbing:		
Descent	142	67
Signals	142	67
Simultaneous movement	142	67
Tension	142	67
Three-man party	142	67
Two-man party	142	67
Ropes and knots:		
Care of rope	136	52
Rope management:		
Characteristics	136	52
Fixed ropes	144	72
Hauling lines	145	74
Suspension traverse	145, 146	74, 76
Terms used	136	52
Vertical	145	74
Types of knots:		
Anchor	136	52
Double sheet bend	136	52
Middle rope	136	52
Special:		
Bowline on a coil	136	52
Figure-of-eight slip	136	52
Overhand	136	52
Prusik	136	52
Three loop bowline	136	52
Transport	136	52
Square	131	45
Tightening:		
Prusik	143	69
Transport	143	69
Route reconnaissance	40, 131, 176, 202	13, 45, 111, 137
Route selection:		
Factors governing the choice	40	13
Multiple routes	57	16
Natural routes	109	33
Study of rock	137	56
Under various conditions:		
Avalanche areas	169	101
Communication	67, 107, 109	19, 33
Evacuation	126	42
Glaciers	176	111
Laying wire	113	35
Night movement	43	13
Rock climbing	140	64
Stream crossing	107, 146	33, 76
Rungs, for hanging ladders	187	124
Safety:		
Adjustment of personnel	24, 25	10

	Paragraph	Page
Safety—Continued		
Precautions:		
Night movement	43	13
Operating vehicles	129	42
Rock climbing	140	64
Protection from:		
Avalanches	167–169	98
Cold injuries	11, 29	4, 11
Sicknesses	30, 31	11
Snow blindness	174	110
Sunburn	13, 174	5, 110
Vehicular accidents	128, 129	42
Requirements for landing sites	106	33
Rescue:		
Avalanche	170	103
Crevasses	177, 178	112, 113
Snow	162	91
Testing	169	101
Safety lines:		
Fixed alpine path	181	120
Sag, allowance:		
Suspended walkway	188	128
Security:		
Antimechanized	48	14
Bivouacs	49, 50	14, 15
Flanks	47	14
Landing sites	106	33
Listening posts	46	14
Marches	40, 45	13, 14
Observation	45	14
Restricted visibility	45	14
Self arrest	172, 173	105, 108
Shelter:		
Aid stations and collecting points	117, 124	39, 41
Natural	68	19
Protection from nuclear weapons	68	19
Types	50, 68	15, 19
Skylines:		
Use in fixed alpine paths	190	131
Smoke:		
Landing sites	106	33
Offensive use	59	17
Signals	114	37
Snaplink. (*See* Pitons, snaplink, and hammer.)		
Snow and ice:		
Characteristics	159, 165	90, 93
Classification (table II)	161, 167	90, 98
Density. (*See* Contributory factors.)		
Depth	167	98
Effect on training and equipment	160	90
Evacuation	157	88
Glacier ice	161	90
Intensity. (*See* Contributory factors.)		
Movement	173	108
Purification agent	10	4
Rate of snowfall	162, 164	90, 91
Slides. (*See* Avalanche.)		
Snow formations:		
Sun crust	162	90
Wind crust	162	90
Wind slab	162	90
Testing	169	101

	Paragraph	Page
Soil condition:		
Drainage	109	33
Ground surface	164	91
Landing sites	106	33
Rock	134, 135, 140	45, 47, 64
Terrain evaluation	109	33
Sound:		
Carrying	46	14
Mountain streams	46	14
Vibration effect	166	98
Span:		
Fixed alpine path	181	120
Stanchions, construction:		
Pipe	185	121
Wood post	185	121
Stanchions for suspended walkways	189	131
Stand-off ladders	187	124
Steps, in earth or snow	173, 186	108, 124
Stream crossing:		
Construction of bridges. (*See* Bridges.)		
Deep water	146	76
Fording	146	76
Rapids	146	76
Suspension traverse	146	76
Sun effects:		
Solar radiation	13, 15	5
Sunburn	13, 174	5, 110
Survey, route:		
Fixed alpine path	181	120
Suspended walkway	188, 189	128, 131
Suspended walkway, three-rope	189	131
Tactics:		
Principles	3, 84	2, 25
Small forces	3	2
Tanks:		
Suitability for mountain operations	3	2
Techniques of evacuation:		
Across streams	146	76
Alternate methods	152, 153	84, 85
Ascending and descending	151, 152	82, 84
At night	125	41
Cliffs	152	84
Expedients	157	88
Handling of casualty	150	81
Horizontal hauling line	156	87
In snow	157	88
Pole carry	154	86
Preparation	150	81
Securing of casualty	150	81
Trees	155	87
Use of carriers	153	85
Use of skids	151	82
Temperature:		
Effect on avalanches	164, 165	91, 93
Contributory factor	167	98
Trigger action	166	98
Inversion	13	5
Solar heating	13	5
Variation	10, 164	4, 91

	Paragraph	Page
Terrain:		
Concave and convex slopes	164	91
Description of mountains	5	3
Effect:		
Avalanches	164	91
Evacuation	125	41
Movements	34, 42	12, 13
Chimneys	202	137
Ledges	202	137
Scree	202	137
Steep slopes	202	137
Talus	126, 202	42, 137
Valleys	57	16
Woods	202	137
Operations	32, 52, 63, 64	12, 15, 18
Lack of passable routes	47	14
Roadnets and trails	6, 40, 101	3, 13, 29
Training:		
Aids:		
Practice climbing tower	198	134
Films	198	134
Assault climbers	203	138
Aviation personnel	105	31
Class organization	197	133
Climbing exercises	201	137
Combat patrols	208	140
Engineer	108	33
Equipment movement course	204	138
Instructors	195, 200	133, 136
Master training program for mountaineering and glacier work	App. II	144
Medical	118, 149	39, 81
Method	200	136
Climbing instructors	200	136
Conditioning	200	136
Coordination	200	136
Orientation	200	136
Practical work	200	136
Mountaineering school	193	133
Mountain walking course	202	137
Observation and sniper posts	205	139
Requirements	133	45
Scouting and patrolling by night	207	140
Scouts	206	139
Selection of students	194	133
Supervisors	196	133
Unit	199	136
Transportation:		
Means:		
Air	69, 72, 104	20, 21, 30
Block and tackle	75, 96	22, 27
Cableways	75	22
Hoists	75	22
Individual	69, 72	20, 21
Vehicular	69, 72, 128, 129	20, 21, 42
Winches	75, 96	22, 27
Road trafficability	128, 129	42
Traffic control	129	42
Treadway, for suspended walkways	188	128

	Paragraph	Page
Vegetation:		
Effect on avalanches	164	91
Vehicle:		
Ambulance	121	40
Armored	101, 102	29
Driving technique:		
At night	129	42
In daylight	129	42
On steep grades	129	42
Winching	129	42
Prime movers	129	42
Safety:		
Checks	129	42
Devices	129	42
Towing artillery	89	26
Visibility:		
Clouds	11	4
Darkness	43, 125, 207	13, 41, 140
Fog	11	4
Precautions	51	15
Security	45	14
Walkway, suspended	188, 189	128, 131
Water:		
Content of snow (density)	168	100
Discipline	27	10
Purification	74	21
Supply	27, 74	10, 21
Weapons:		
Air defense artillery	3, 100	2, 28
Artillery, field	3, 89	2, 26
Infantry	3, 87, 88	2, 25
Nuclear	3	2
Stabilization of snow	168	100
Surface-to-air missile	100	28
Tactical employment	57	16
Weather:		
Characteristics:		
Avalanche	169	101
Bad	20	7
Cloudy	11, 14, 21	4, 5, 7

	Paragraph	Page
Weather—Continued		
Characteristics—Continued		
Fair	22	7
Fog	17	6
General	12	4
Glaze	18	6
Cold front	18	6
Contributing factors. (*See* Contributing factors.)		
Effect:		
Avalanches. (*See* Avalanche.)		
Movement	34, 44	12, 1
Operations	11, 32	4, 1
Forecasting	19	
Precipitation	14, 22, 165, 167	5, 7, 93, 9
Prediction	22	
Sudden changes	11–13	
Thunderstorms	16, 18	
Warm front	18	
Winds and storms	12, 15, 18, 21	4, 5, 6,
Wind:		
Avalanche contributory factor	167	9
Effects of topography	12, 15	4,
Funneling	15	
Moisture-bearing	20	
Solar radiation	15	
Storms:		
Local (valley breezes)	15, 21, 22	5,
Prediction	22	
Thunder	16, 20	6,
Traveling	18, 20, 22	6,
Velocity	15, 20, 22	5,
Winterization:		
Air defense artillery	100	2
Protective mask	68	1
Wire rope:		
Ladders	188	1
Rungs, for ladders	188	1
Wood post stanchions	185	1
Wood rungs, for hanging ladders	188	1

By Order of the Secretary of the Army:

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