APPALACHIAN SEARCH AND RESCUE CONFERENCE, INC.

M O U N T A I N R E S C U E

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M A N U A L

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I. INTRODUCTION

basic member by the ASRC Training Guide, First Edition. Several other technical procedures are also treated, but vertical rescue is not.

II. MATERIALS FOR MOUNTAIN RESCUE

Materials for mountain rescue generally fall into two categories: software and hardware. Software includes items like rope and webbing, and also things made from them. Universally, software items have limited life and therefore particular care must be paid to their maintenance and periodic inspection. Accurate and complete use records are essential to the maintenance program.

Hardware, on the other hand, comprises items like carabiners, chocks, brakes and pulleys, which are considerably more durable than software. Nevertheless, hardware items, too, demand care and frequent inspection, and must not be considered to have unlimited life.

The need for continuous vigilance in the care of mountain rescue equipment can hardly be overemphasized. The safety and success of any mountain rescue operation depend directly on the reliability of the materials used, and carelessness in maintaining those materials can have disastrous consequences. Take care of your gear.

A) SOFTWARE

Ropes and other software used in mountain rescue are almost always made of nylon (or "perlon" as it is called in Europe) with some special purpose items being made of polypropylene and other synthetic fibers. The chief advantage of nylon over other fibers is its combination of high strength, shock absorbing elasticity, and nice handling characteristics. Its chief disadvantage is a low melting point -- about 250 °C.

Natural fiber ropes are not even considered for use in mountain rescue: they have unreliable strength and stretch characteristics, absorb large amounts of water, and deteriorate through decay.

1) Rope

There are two general types of rope construction: twisted lay and kernmantel (core and sheath). These two types of construction are illustrated in figure 2.1.

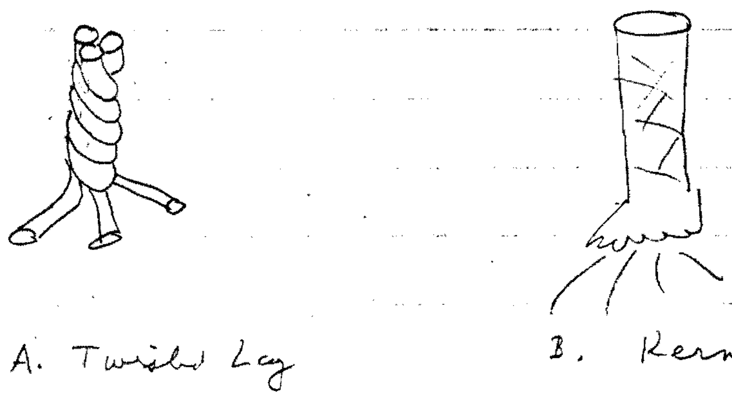

Figure 2.1. Rope construction types.

Twisted lay rope, of which the primary example is Plymouth Goldline, has several important disadvantages. Its worst feature is its great elasticity. Most of the stretch in a twisted lay rope is due to uncoiling of the strands as the rope is loaded; consequently the rope tends to twist as it is loaded and kink as it is unloaded. In most mountain rescue applications this elasticity is difficult to deal with.

Twisted lay ropes of mountaineering or rescue quality (such as Goldline) are also quite stiff, difficult to handle, and do not take knots nearly as well as kernmantel.

The great advantages of twisted lay rope are its low cost for high quality, and the property that the strands can be separated for internal inspection. This feature is deemed sufficiently important by some rescue organizations that Goldline is the only rope they will use, despite its many drawbacks.

Kernmantel rope is constructed of a core of parallel or loosely braided continuous nylon filaments covered by a close-fitting, woven nylon sheath. The core is the load-bearing element, while the sheath provides protection and an excellent handling surface. The smooth sheath of kernmantel rope slides more easily through hardware and over rock than does the corrugated surface of twisted lay rope, but at the same time it provides adequate friction for belaying. Since the core is braided rather than twisted, the elastic properties of kernmantel are due largely to the elastic properties of the nylon itself, and the rope stretches evenly without twisting or kinking.

The elasticity of nylon can be controlled during manufacture by a heat-treatment process called curing. When the fibers are first drawn, the long polymer chains making up the nylon are stretched out along the length of the fiber making it relatively inelastic. Upon heating, however, the polymer chains kink up to form microscopic springs, thus making the fiber more elastic. Using this process, manufacturers can produce ropes with different characteristics for different purposes. Mountaineering ropes are cured to have the right elasticity to provide a cushioning effect in a fall, while caving ropes (such as Bluewater and PMI) are cured to minimum elasticity and less pendulum from sides for ease in rappelling and ascending. The low stretch (and high strength) of caving ropes makes them nearly ideal for belaying litters in mountain rescue, but dangerous as climbing ropes. Mountaineering ropes, because of their greater cost, lower tensile strength and special elastic properties, are best reserved for belaying people rather than litters, although in a pinch they can be used for litter belaying.

Rope is manufactured in several different sizes, ranging from 4.5 to 11 mm for kernmantel, and 1/4 to 7/16 inch for Goldline. The smaller sizes are used mainly for slings and accessory lines while the larger sizes are used for belaying. The 11 mm and 7/16" sizes are the usual ones for belaying with the "single rope" technique used almost exclusively in America, while a doubled 9 mm or 3/8 inch rope is used for the "double rope" technique popular in Europe. A single 9 mm or 3/8 inch rope is adequate for top roping or low angle leading, but is not adequate for belaying a litter.

Standard climbing rope lengths are 120, 150, 165, and 300 feet, with the two most popular lengths being 150 and 165 feet.* The 300 ft length is usually 9mm for use as a double rope. Caving rope is supplied in 1000 ft. spools and cut lengths. For mountain rescue, 45 m lengths seem to provide a good compromise between length and manageability. Since caving rope is supplied in such long lengths, it contains core splices, which appear as sections of the rope slightly thicker than the rest. Although it can be quite unnerving to discover a splice while halfway across a tyrolean traverse, core splices are quite strong and should cause no alarm.

The manufacturing specifications and quality control of reputable rope manufacturers are very high, and consequently their products may be trusted fully. Good European

* Metric standard lengths are 25, 30, 35 and 45 m, and are becoming available in the US.

limbing ropes are manufactured to the specifications of the Union International d'Associations d'Alpinisme (UIAA) which requires that ropes ~~must~~ pass several tests before being approved. The two most important of these test for elongation under static load and for impact force in a hard fall.

In order to pass the static load test, the rope must elongate less than 6% under a load of 100 kg. This assures good prusiking and rappelling characteristics.

The UIAA maximum impact force test measures the rope's ability to properly cushion a severe leader fall. From a rigid anchor, 2.8 m of rope is run up through a carabiner 0.3 m above the anchor and thence to an 80 kg weight. When the weight is dropped, it falls through twice the length of free rope (5 m) before being caught, thus simulating the worst possible fall*. In stopping these

* Interestingly, the force required to catch

successive falls, the rope must not exert on the weight an impact force greater than 1200 kg.

Since they are not intended for belaying, caving ropes do not meet the UIAA specifications. These ropes are cured for low elasticity and consequently have very high impact forces.

Table 2 lists the characteristics of several common ropes.

Table 2. Rope Characteristics.

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a fall does not depend solely upon the height of the fall, but rather depends upon the ratio of the distance fallen (twice the runout) to the total length of rope in the system (at most, just the runout): the more rope there is in the system, the more cushioning it provides. The worst possible fall, therefore, is one in which the climber falls through a distance twice the length of rope in the system. This will occur whenever there are no anchors above the belayer.

2) Rope Care

Ropes (and other software) used in mountain rescue are susceptible to four categories of damage: chemical, radiation, thermal and mechanical. If a rope is to give long and reliable service, all of these agents must be guarded against in both storage and use.

The most common chemical agents responsible for rope damage are battery acid and petroleum products, both of which are found around cars. Accordingly, care should be taken to insure that ropes carried in car trunks are protected. In general, all chemicals should be considered harmful and should be kept away from ropes, with the exception that paints or dyes may be used to mark the ends of a rope. Fortunately, water does not permanently damage rope (although a wet rope is slightly weaker, a lot heavier and stiff when frozen), so one shouldn't fear wetness, except for the inconvenience.

Radiation damage occurs when a rope is exposed to the ultraviolet rays of sunlight. Fortunately, most of this damage takes place in the sheath, modern rope dyes mitigate the problem quite effectively, and at altitudes found in the mid-Atlantic region, the UV flux in sunlight is relatively low. Nevertheless, it is good practice to keep software out of the sun except when it is being used.

Thermal damage is a severe problem. Nylon melts at about 250°C, but structural damage (changes in the elastic properties and strength) can occur at much lower temperatures. Damaging temperatures can easily be attained in the careless employment of normal techniques, friction being the usual mechanism for generating the heat. The worst problem is nylon running against nylon, but nylon on bark can also result in serious "weld-abrasion."* To guard against thermal damage, brakes should be run slowly (a hot brake can melt right through a rope), nylon on nylon friction must be assiduously avoided, and the rope must be protected from hot objects.

Mechanical damage seems like an obvious problem, but actually can be quite subtle. An obviously cut or abraded rope <u>may</u> be safe if the damage is only to the sheath, whereas an obviously undamaged rope may have been grossly weakened by previous strain or by the insidious cutting action of dirt ground into the core. The only sure way to know

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* An interesting demonstration of the weld-abrasion phenomenon can be performed in the following way: take a short loop of webbing or light rope around your foot and then attempt to saw through it with another length of webbing or rope. The resulting failure of the nylon is rapid and awe-inspiring.

that a rope is sound is to know i
history and to know that it ha
handled competently.

Typical agents of mechanical damage are surface abrasion or cutting of the rope by sharp rocks or ice, internal cutting of core fibers by lint pressed into the core when the rope is stepped on, rockfall (which can produce severe core damage with no apparent sheath damage), wear from mechanical ascenders and brakes, and strain from hard falls or unusually heavy loads. These things must be avoided as much as possible, of course, but to a certain extent they are unavoidable. Consequently, all ropes eventually wear out. The decision to retire an old, but not obviously damaged, rope is a difficult one, but one which can be made much easier by the keeping of accurate records of rope use and wear. To insure their usefulness, these

these records must be faithfully made and periodically reviewed.

Although the comprehensive testing of a rope is impossible, inspection can augment history as a valuable gauge of a rope's integrity. In a visual inspection, one looks for any irregularity: abrasions, cuts, welded spots, discoloration and dirt. A twisted lay rope can be twisted apart to inspect the inner fibers. A kernmantel rope should definitely be retired if the core shows through the sheath anywhere, and a twisted lay rope should certainly be retired when a quarter of the fibers are worn to fuzz. For less extreme cases, some judgement is called for, but conservatism is the rule.

Just as important as visual inspection is tactile inspection. Touch is very sensitive to abraded or cut spots and allows one to detect telltale irregularities in diameter. The lumps sometimes felt in new caving ropes are splices, and are no cause for alarm; but a newly discovered lump or thin spot is cause for a rope's immediate retirement: these are places where the core fibers are broken.

Coiling of the rope provides frequent opportunity for both visual and tactile inspection.

It is possible to perform a limited test of a rope in the field by tying one end to a solid anchor and having five or six people pull on the other end. This is called "pull testing." A good pull test loads a rope perhaps 200 kg, or about 10% of its rated strength, thus ruling out failures at that stress and below. No attempt should be made to pull test at larger loads (by pulling with more people, for example) since if the rope should break, like a rubber band it will lash back at the pullers with vicious intensity.

Since a rope may be loaded above 1200 kg in severe service, pull testing is no great insurance against failure; but it is some. Frequent pull testing is therefore adviseable, but it should not lead to overconfidence. The purpose of pull testing is to reveal insidious damage, not to test a possibly injured rope. If a rope is damaged or strained, it must be considered faulty: successful pull testing does not guarantee its soundness. There is no substitute for proper rope care.

Although good rope care practices are largely a matter of common sense, a few points bear mentioning. Ropes should be stored neatly coiled and ready for use in a clean, dry, temperate place. A newly cut rope end must be treated to prevent the ~~very~~ spectacular unraveling process that would otherwise occur. Before cutting, the spot to be cut should be wrapped with tape (masking tape is good);

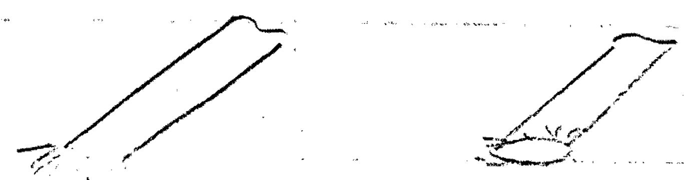
and after cutting, the end should be thoroughly fused (not burned!) in a match or candle flame. The singed tape can then be replaced with plastic tape of an appropriate color or bearing some identifying mark. Cut ends of webbing must also be fused, but taping is not necessary.

All software should be washed occasionally to remove the dirt which cuts core fibers. The wash can be done in an automatic washing machine; cold water and mild detergent must be used. Wet ropes should always be hung in the shade to dry.

A modern rope is a remarkably strong, resilient and reliable tool, but if it is to be trusted, its vulnerabilities must be respected. In using software, the mountain rescuer should cultivate the mountaineer's sense of jealous protectiveness of his gear -- a sentiment which is summarized by the ancient dictum, "Don't step on the rope!"

3) Webbing

Nylon webbing is manufactured in two forms: flat and tubular. See figure 2.2. Flat webbing is fairly stiff, so it is useful in applications where the webbing



Flat Tubular

Figure 2.2. Webbing construction

must hold its shape, as in etriers. It is most popular for straps on equipment because it holds well in buckles.

Tubular webbing is quite limp and easy to work. It is therefore more popular than flat for harness and general purpose applications. Both flat and tubular webbing hold knots well, but knots in tubular are easier to untie.

Webbing properties are included in table 1. Principles of care are covered in section 2, Rope Care.

4) Parachute Cord

The small-diameter (3.5 mm) braided nylon rope used for parachute shroud lines is very useful in mountain rescue. The genuine article is of high quality and has a rated tensile strength of 550 lb (250 kg). Most of the "p-cord" in circulation, however, is not genuine shroud line and has a much lower tensile strength. Although this commonly available cord is marvelously useful (and should be found in every rescue pack), it must not be trusted to hold a person's weight.

B) HARDWARE

The techniques of modern mountain rescue employ a bewildering array of sophisticated and often highly specialized tools. The description and usage of most of them is far beyond the scope of this manual; the items which are discussed have broad application and should be familiar to all ASRC members. The mountain rescuer who seeks to learn the use of other tools can find much information in the books cited in Chapter I, and can learn from his own experience and that of his colleagues. He should, however, take pains to guard against the temptation to trust his safety and rescue effectiveness to the fascinating accoutrements of technology. The most valuable of all the tools of mountain rescue are polished skill and prudent judgement.

1) Carabiners

The most important and frequently used article of climbing hardware used in mountain rescue is the carabiner. A carabiner is a strong metal snaplink used primarily for making convenient but high-strength connections among the various parts of a belay system, and to eliminate nylon on nylon friction. There are numerous other uses as well.

a) Construction. The parts of a carabiner are illustrated in figure 2.3. Carabiners are manufactured in many different shapes, but there are basically three categories of these: the oval, the "D", and the modified "D". These are illustrated in figure 2.4.

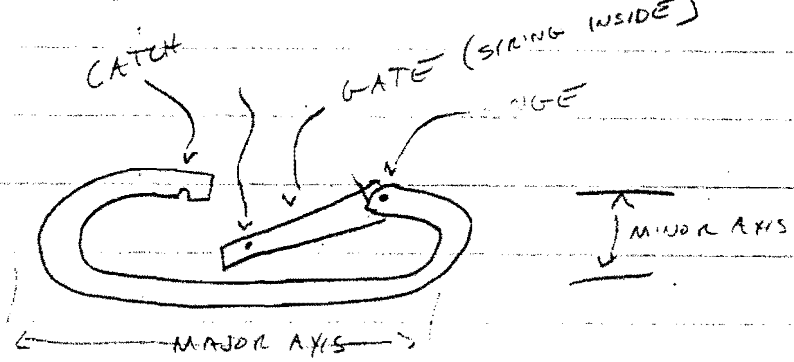


Figure 2.3. Carabiner construction

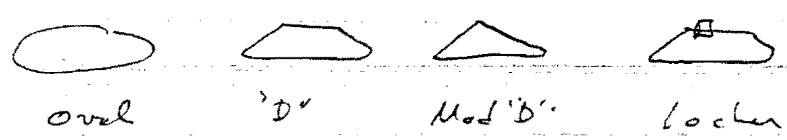


Figure 2.4 Carabiner types.

The weakest part of a carabiner is the catch. The "D" shape relieves stress on the catch, thereby increasing the major axis strength of the carabiner. The "D" types are therefore stronger than the ovals. The modified "D" shape reduces weight without sacrificing strength or accessibility.

The strength of a carabiner is reduced drastically (from above 2000 kg to below 1000 kg, typically) when the gate is open, so in applications where the gate might accidentally be opened, the locking (or "safety") carabiner is used. The locking sleeve screws down over the catch to keep the gate closed. On some lockers, the sleeve can be positioned to hold the gate open -- a feature which can sometimes be quite convenient.

Most modern carabiners are made from very strong aluminum alloys, but there are still a few steel carabiners available. Inexpensive steel carabiners are, oddly enough, not as strong as aluminum ones of similar dimensions, but there are available several steel models of very high strength.

Because of their excessive weight, however, they are used only in special applications.

b) Selection. In choosing a carabiner for rescue work, the main consideration is strength. In most applications, any well made carabiner will do, but in litter belay systems, forces can occasionally rise as high as 2000 kg under ordinary conditions. Since any available carabiner might be pressed into service in a litter belay system, 2000 kg should be regarded as the minimum acceptable strength (major axis, gate closed) for carabiners to be used in rescue work.

The gate of the carabiner should operate smoothly, and should be designed so that it will open freely while two 11 mm ropes are clipped in and while supporting a person's weight. Unfortunately, very few carabiners (except for some large steel types) will open widely enough to be clipped onto a litter rail.

A further desireable feature is a small protrusion near the catch to make clipping in easier to do by feel.

c) Care. In caring for carabiners, the main consideration is the smooth and reliable operation of the gate. Usually, very little maintenance is required, but occasionally grit must be cleaned from the hinge or locking sleeve. Petroleum solvents are good for this, but the solvent must be completely removed before the biner is used again. A very small drop of penetrating lubricant (such as LPS or CRC 5-56) may be applied to a stubborn hinge; but, in general, no lubrication is necessary or desireable.

If the catch or hinge of a carabiner is bent so that the gate does not work properly, the carabiner should be retired. Even if the part can be bent back into position, the biner will have been severely weakened.

Burrs are a threat to ropes passing through the carabiner; they may be removed with emery paper or a file.

d) Application. For the most part, the uses of carabiners are fairly obvious, but there are several dangers that must be avoided. The low open gate strength has already been mentioned. A locker kiner should be used whenever there is significant danger of a gate opening accidentally, but if a locker is not available, two regular carabiners with gates opposed make a good substitute (see figure 2.5). For true opposition,

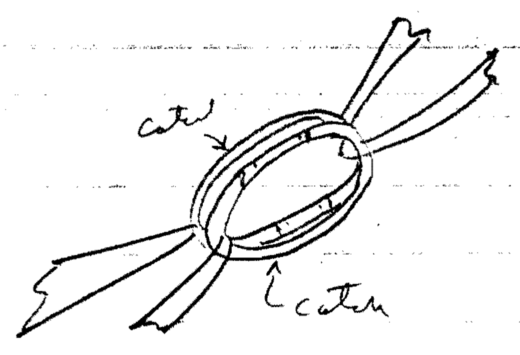


Figure 25. Opposed gates.

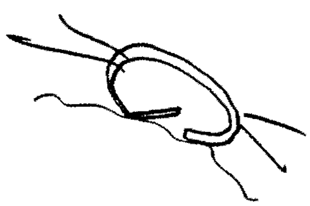
the catches of the two carabiners must be on opposite ends if one of the biners should accidentally turn so that the gates are together. Figure 2.6 illustrates the distinction.

True Opposition

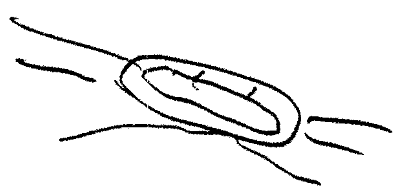
False Opposition

Figure 2.6. True and false opposition.

When a carabiner is used resting against a surface; the gate should be positioned away from the surface so that it will not be pushed open. Figure 2.7 illustrates.



Wrong



RIGHT

Figure 2.7. Carabiner against a surface.

The strength of a carabiner is very low for loading on the minor axis. This configuration, called cross loading, must not be permitted to occur. Figure 2.8 illustrates the two most common causes of cross loading.

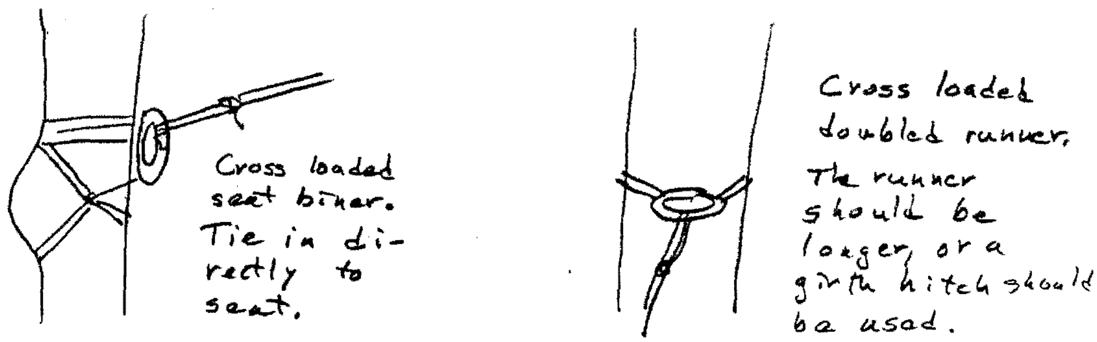


Figure 2.8. Cross loading.

The strength of a carabiner is also somewhat degraded when it is loaded in a way that tends to bend it, as in figure 2.9. This configuration is called side loading and should be avoided.

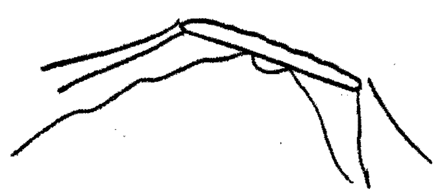


Figure 2.9. Side loading.

~~Burrs are a threat to ropes passing through the carabiners; they can be removed with a file or emery cloth~~

2) Pulleys

Although the friction of a kernmantel rope running over a carabiner is remarkably low, the use of pulleys can substantially increase the efficiency of a hauling system. A pulley designed for rescue service is illustrated in figure 2.10. Notice that the rope may be mounted or dismounted from the pulley without the need for threading the end through the block.

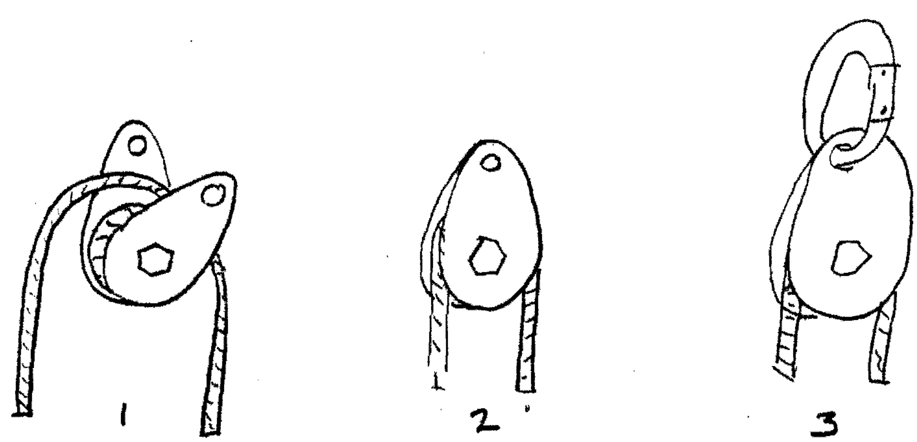


Figure 2.10 Rescue Pulley.

Both bushing and ball bearing sheaves are available for rescue pulleys; but it is not clear that the slightly better performance of the ball bearing models justifies their greater cost. Bushings are certainly more reliable in severe use.

The block pieces on better pulleys are made large enough to protect the rope from abrasion as it passes over the pulley, a feature which is rightly regarded as highly desireable. Nevertheless, narrow-block rescue pulleys should not be scorned on this account. Small, narrow-block pulleys are nearly as strong as their larger brethren, weigh and cost considerably less and remain safe and useful in applications where abrasion is not troublesome. Their major drawback is somewhat higher friction due to small sheaf diameter, but they are still much better than plain carabiners.

Rescue pulleys are generally strong enough that overloading is not a problem, but the user should keep in mind that the load on the pulley is twice the load on the rope passing through it. The anchor supporting the pulley should be made correspondingly sturdy.

Rescue pulleys require no routine maintenance or lubrication, but, like any other tool, they should be kept clean and should be checked frequently for proper operation.

3) Ascendeurs

A complete discussion of mechanical ascending devices is beyond the scope of this manual, but brief descriptions of the four principal types used are included for general information.

SPACE

a) Jumars. The original mechanical rope climbing device is the Jumar, illustrated in figure 2.11. It consists of a cast aluminum frame and a swinging cam which clamps the rope when the Jumar is pulled and allows the rope to slide when it is pushed. Although the Jumar is

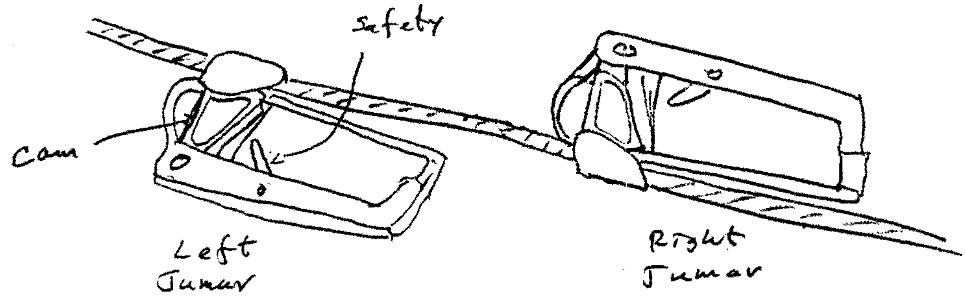


Figure 2.11. Jumar ascendeurs.

a highly efficient rope climbing device, its low strength makes it unsafe for use as a ratchet in a litter hauling system. Jumars have also been known to pop off the rope when improperly applied or loaded to the side.

b) CMI and Clog Ascendeurs. Two new ascendeurs, which are really modifications of the older Jumar design, are the CMI ascendeur and the Clog ascendeur. These are illustrated in figure 2.12. The main differences between the CMI and the Jumar are improved metallurgy and modification of the safety catch design. CMI guarantees

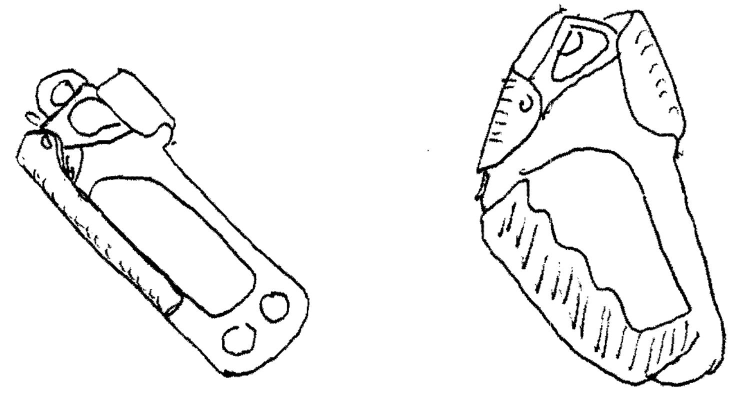


Figure 2.12. The CMI and Clog Ascenders

a strength of 2200 kg, which is quite adequate for litter hauling systems; but, as of this writing, insufficient experience has been gained to know whether the device is stable enough for such application.

The Clog ascender operates on the same principal as the Jumar and the CMI, but is designed more for efficiency as a rope climbing device than for safety as a general purpose ratchet.

c) Gibbs Ascender. The Gibbs ascender, which is very popular in caving circles, eliminates the problem of instability by having the rope entirely enclosed. This

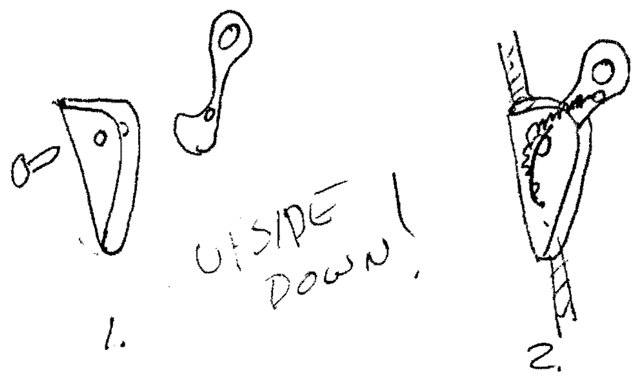


Figure 2.13 The Gibbs Ascendeur

design also increases the strength. See figure 2.13. Each Gibbs ascendeur is tested by the manufacturer to 450 kg, but the actual strength is certainly much higher than that. Unfortunately its wrap-around design makes the Gibbs more clumsy to rig than other ascendeurs because it must be disassembled before mounting, and then reassembled around the rope.

The Gibbs also differs from the Jumar, in that the load is applied not to the body, but to the cam itself. This design precludes the necessity of spring loading of the cam, but without the spring the device must be "set" with each advance of the rope. Newer models have spring loaded cams.

The reliability of the Gibbs ascenders has made them quite popular in technical rescue, but because they are somewhat complicated to rig and use, they should not be employed unless the user is well practiced in dealing with their idiosyncrasies.

4) Braking Devices.

INSERT IN CHAPTER I UNDER "BRAKING DEVICE

Over the years, a bewildering array of mechanical rope-braking devices has been offered for use in mountaineering, caving and rescue work. Each device, and the technique of using it, presents strengths and weaknesses, advantages and disadvantages, while the perfect brake has not yet been invented. The ideal brake would be lightweight, yet have a large heat capacity; it would be simple to use, yet provide a wide range of braking forces in a single configuration; it would be easy to lock and unlock, yet be resistant to jamming; and it would be strong enough to withstand heavy rescue loads. Six of the most commonly used braking methods are described in this section (the Figure-8 brake is also discussed in ?-?-?). The treatment is far from exhaustive, but covers the methods the mountain rescuer will probably find most useful.

a) The Carabiner Wrap

The simplest (and perhaps oldest) mechanical brake is the carabiner wrap, shown in figure 2.14.

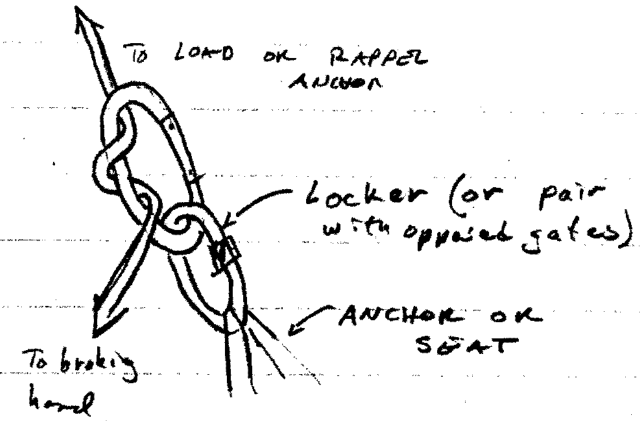
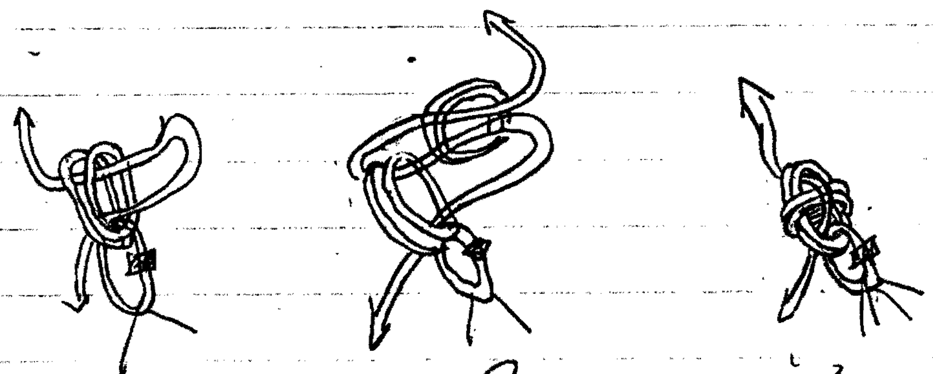


Figure 2.14. Carabiner-wrap brake.

The brake performs quite well with kernmantel ropes, but twisted lay ropes are somewhat more difficult because they tend to kink. The heat capacity of the biner wrap is relatively low, but is entirely adequate for rappelling. Additional biners can be ganged for more friction and heat capacity, however, making the system practicable, if not convenient, for litter braking. A double or triple wrap around the biner results in more friction but no more heat capacity. This trick is particularly useful when braking small-diameter rope.

b) The Six-Biner (Yosemite) Brake

The six-biner brake requires no specialized equipment, is strong, provides excellent friction and control, and has a high heat capacity, but it is somewhat clumsy to rig and requires four carabiners. (The classical version used two biners with gates opposed, rather than a locker. Hence the name.) The rigging



1. 2. 3.

Figure 2.15. The six-biner brake.

technique is illustrated in figure 2.15. The gates on both pairs of biners are in opposition; however, the rope runs over the backs of the two transverse biners.

D

c) The Brake-Bar Brake

The brake bar is a specialized rappel device which is light, easy to use, and effective on both twisted-lay and kernmantel ropes. However it can only be used on the oval carabiner for which it was designed, and oval carabiners are generally not strong enough to be trusted supporting a litter. The brake-bar brake also provides less friction than most other brakes, although it provides enough for rappelling. The heat capacity is greater than that of a biner-wrap, but less than that of a six-biner brake. Rigging is illustrated in figure 2.16.

SMC P's work

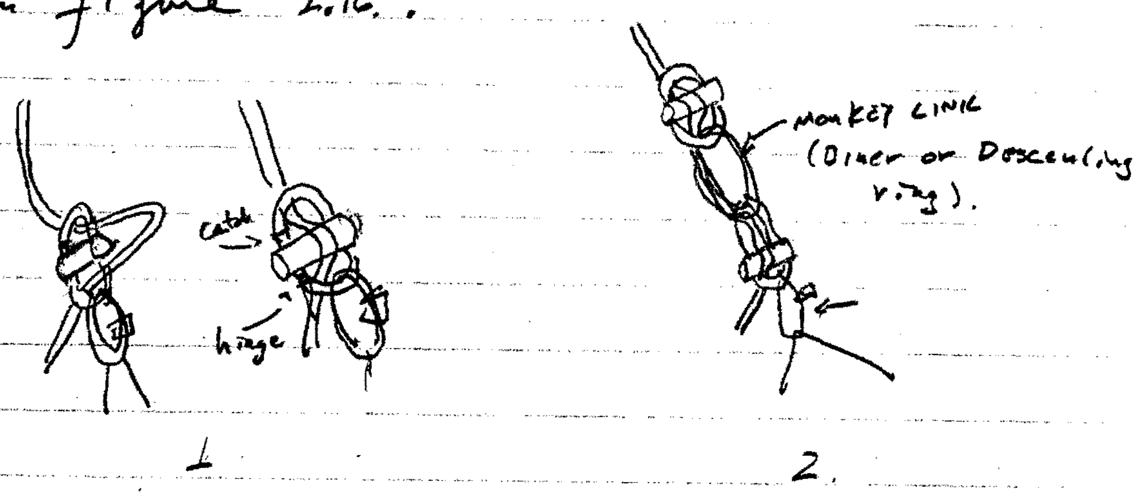


Figure 2.16. The Brake-Bar Brake.

Both the control range and heat capacity of the brake-bar rig can be enhanced by ganging brakes into a "brake-bar chain" as shown in figure 1.?. The entire load, however, still falls on a single oval carabiner, and consequently ganging brakes does not increase the strength of the system. Brake bar chains are most useful for long free rappels or for lowering a tragsitz.

d) The Rappel Rack

The rappel rack is a special purpose brake having the advantages of extremely high strength, range of control and heat capacity. It is well suited for long free rappels, hence its popularity among vertical cavers; and it is nearly ideal for vertical rescue applications. Its disadvantages are its weight and complexity. Rigging is illustrated in figure 2.17. Note that the rope does not run over the end of the rack itself, but over the last brake bar. This precaution prevents wear

F

of the rock at a critical point. It is also adviseable to tie the rock directly to the anchor, or to at least place a runner between the rock eye and the anchor biner. If a biner is clipped directly to the rock, the eye, because of its width, does not sit in the bottom of the carabiner; It therefore develops forces which tend to unbend the biner, thus degrading its strength.

yuk

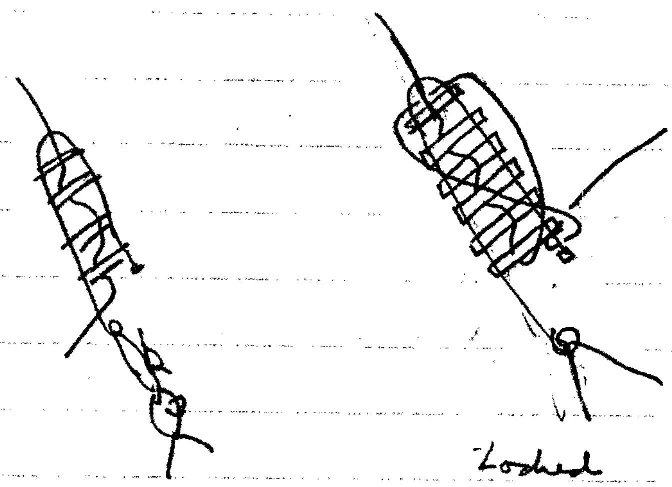


Figure 2.17 The Rappel Rack

The brake bars are pushed together to increase friction and separated to decrease friction. As necessary, the number of brake bars in use can also be changed, even while the rope is loaded. These manipulations require some practice, but a skilled operator can rig, derig and flip brake bars in and out with amazing facility.

The rack can be securely locked and tied off in the manner shown in figure 2.17.

e) The Figure-8 Brake

As a rappel device and as a brake for semi-technical evacs, the figure-8 brake (often called an "8-ring") is nearly ideal except for the peculiar drawback that it must be disconnected from the anchor to be rigged. Otherwise it is strong, light, provides a good range of control, works with all kinds of rope, can be locked and unlocked under load, and has a reasonably high heat capacity. A further desirable feature not to be overlooked is that its great popularity makes the figure-8 ubiquitous among climbers. It is

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a great advantage not to require exotic hardware to run an effective evac.

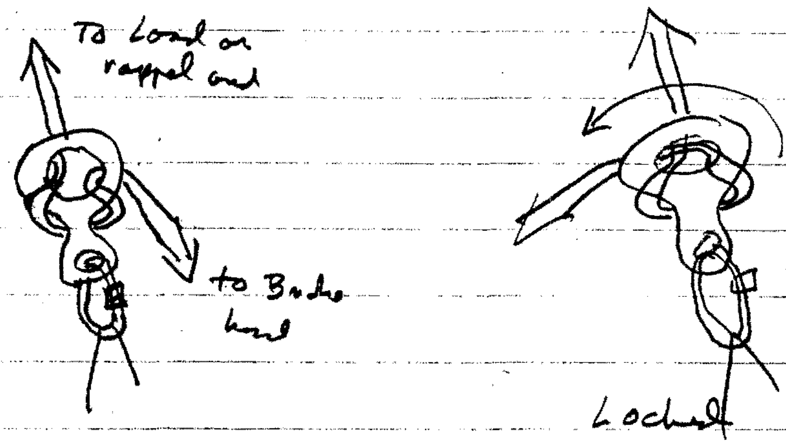

Figure 2.14. The Figure-8 Brake

Rigging of the figure-8 brake is shown in figure 2.14. It is further discussed in section VI-C-2.

III. ROPE HANDLING

The extensive use of rope is surely a hallmark of mountain rescue, and consequent the mountain rescuer prides himself in his rope handling skills. This chapter describes those rope management, knot tying and anchorage skills that are used in semi-technical rescue and general roped travel, and which form an essential foundation for techinical rescue. The specialized techniques required for high-angle rescue and fifth class climbing are beyond the scope of this manual. Further information can be found in the references mentioned in Chapter I.

A) ROPE MANAGEMENT

A flexible cylinder some 45 meters long and 11mm in diameter is bound to be somewhat awkward to manage, but with attention to detail, a little practice, and a measure of patience, the rope can be handled with remarkable ease and efficiency. Although the trouble taken in avoiding "rope schlock" consumes valuable time, the much greater time required to unscramble a wayward rope can be far more costly.

1) Stacking

The first step in preparing a rope for use is always to uncoil and stack it: the coil is held in one hand while the other carefully uncoils it and drops it onto the ground in a random pile or "stack." Amazingly, this stack will run more freely than the cleverest coil, and it will run from the top or the bottom. It is important, however, to pick a place for the stack which is safe from rockfall and errant feet, and which is free of projections on which the rope might snag. Ideally, the rope should also be stacked in a clean place, of course, but that is not always possible.

2) Coiling

There are far too many useful methods of rope coiling to describe them all here.

Nevertheless, three useful methods which, for the sake of uniformity, should be learned by all ASRC members, are described. Idiosyncratic coiling methods are not discouraged as long as they do not damage the rope or make it difficult for another person to uncoil.

Coiling provides an excellent opportunity for inspecting and cleaning the rope, and one should develop the habit of doing so every time the rope is coiled. With practice, it takes no extra time to run the hand over the entire rope, brushing off dirt, and feeling for cuts and the variations in thickness which indicate internal damage.

a) Speed Coiling. The easiest coil to do, and the best suited to throwing the rope, is the speed coil: the rope is simply folded back and forth across the hand in a series of large loops, as shown in figure 3.1.

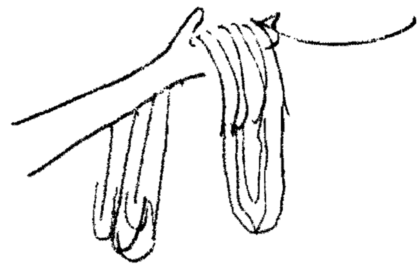

Figure 3.1. Speed Coil.

b) Mountaineer's Coil. For the mountaineer's coil, the rescuer kneels and wraps the rope from boot to knee. See figure 3.2.

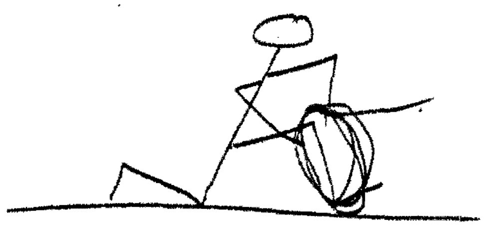

Figure 3.2. Mountaineer's Coil.

c) Lap Coil. For the lap coil, the rescuer wraps the rope from knee to knee while he sits with his feet together. See figure 3.3. The lap coil is especially well suited to people with short legs whose mountaineer's

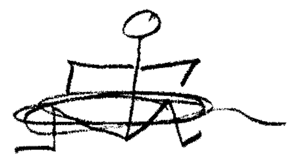

Figure 3.3. Lap Coil.

coils are too small for other people to carry. It has the disadvantage, however, that the person making the coil must sit, perhaps on wet ground.

d) Tying Off a Coil. A coiled rope will come apart and become tangled unless it is properly tied off. Idiosyncratic tieoffs are discouraged since it is easy to tangle a rope by undoing the tieoff improperly. The accepted method is shown in figure 3.4. First, one end of the rope is folded back on itself to make a loop. Then, the other end is wrapped around the coil and the loop, starting at the open end, continuing five or six

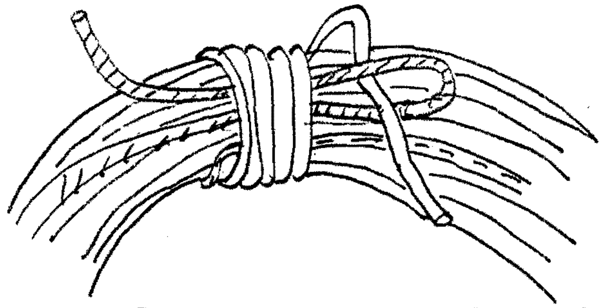

Figure 3.4. Rope Coil Tie-off.

turns and then being passed through the loop. Finally, the front end is pulled to cinch up the loop and hold everything firmly in place.

3) Throwing.

Several points should be observed when throwing the rope:

a) To avoid the embarrassment of throwing the rope away, (or throwing himself away), the rescuer must secure himself and his end of the rope before throwing.

b) The call "Rope!" is always used to warn those below that a rope is coming down. Responses to this call must be heeded. The end of a thrown rope snaps like a whip and can deliver a surprisingly forceful blow. It can also dislodge rocks onto the people below; it can also dislodge people.

c) The rope should be speed coiled before throwing since other coils are more likely to tangle.
d) The speed coiled rope is thrown hard, overhand, at the chosen target.

4) Carrying

A coiled rope can be conveniently carried slung over one shoulder and across the body to the opposite hip. Putting the tie-off just behind the shoulder helps to keep the coils from sliding down and getting in the way.

If part of the rope is in use, the excess coils must not be carried across the body, but should be carried hanging straight down from the shoulder. This precaution avoids the danger of strangulation should the rope suddenly be loaded.

B) KNOTS

When a straight rope is loaded, all its fibers share equally in supporting the applied tension.

If, on the other hand, the rope is loaded while bent over some object, such as a carabiner the fibers on the outside of the curve will support a greater strain than those on the inside and, consequently, the bent rope can withstand less tension than the straight one.

Although this phenomenon is of concern wherever it occurs, it is particularly problematic in knots. The presence of a knot substantially weakens the rope in which it is tied since, in the knot, the rope bends on itself. In fact, the weakest point in a well designed rope system is usually a knot. The fraction of a rope's straight strength remaining after a particular knot has been tied in it is called the efficiency of the knot — a figure typically in the 40% to 60% range.

Now the efficiency of any given kind of knot will be greatest if the knot is tied in such a way that the most heavily stressed parts make the largest radii of curvature in the knot. This condition can frequently be achieved by pressing the standing part of the rope into the outer contours of the knot and bringing the running part out of the middle*. A knot so tied is said to be "properly contoured." Contouring and neatness add materially to the strength of knots, but also the discipline required to properly contour knots helps to prevent tying errors. In the view of the conscientious mountain rescuer, a knot is not correctly tied unless it is neat and properly contoured.

A particularly annoying quirk of knots in nylon rope is that they untie themselves with amazing ease at the most inopportune moments. They can be effectively discouraged from this behavior, however,

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* The "standing part" is the part of the rope the end of which is inaccessible to the person tying the knot. Ordinarily it will be loaded. The "running part" is the end that is manipulated in tying the knot. Ordinarily it will be unloaded.

by tying the "tail", (or left over running") part, back to a standing part of the rope with an overhand knot.* No knot should be considered complete until its tail is tied off.

The essential mountain rescue knots are discussed below. Each of them has peculiar properties making it useful for certain kinds of applications. The knots shown make an incomplete list of all knots useful in mountain rescue, but they will accomodate most needs. Additional knots can be found in the references listed in chapter I.

1) Bowline

The bowline is surely the single most versatile and important knot in mountaineering and mountain rescue. It is used to put a non-slip, fairly high efficiency loop

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* The half-barrel (half-grapevine) is recommended by some as being even more secure than an overhand. This is doubtless true, but overhands are entirely adequate and easier to tie. The half-hitches recommended by others are nearly ineffective.

in the end of a rope. There are other knots with this same function, but the bowline enjoys the great virtue of being very easy to tie: with practice, it can be tied in the dark, one handed and while wearing mittens. The bowline (and its derivatives) also have a distinctive appearance which makes it easy to check visually.

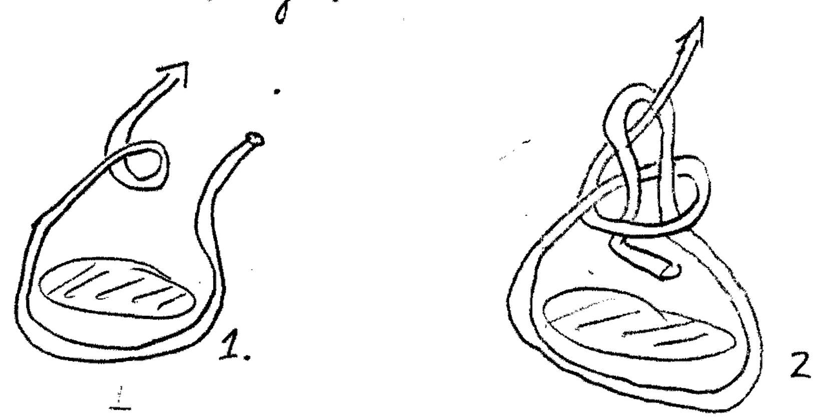


Figure 3.5 Bowline.

The bowline is illustrated in figure 3.5. Note that the tail comes out on the inside of the loop. If the running part passes the opposite direction around the standing part after passing through the bight, the knot is called a "left handed" bowline and is weaker than a "right handed" bowline. If two bights are taken, the knot is called a "high strength" bowline, and is slightly more efficient than the regular bowline.

The tail is tied off to the adjacent loop strand.

2) Bowline-on-a-Coil

The bowline-on-a-coil is essentially the same as a regular bowline except that it has more loops and, therefore, more settling area. It is much preferred to the plain bowline for waist loops and for anchors to trees.

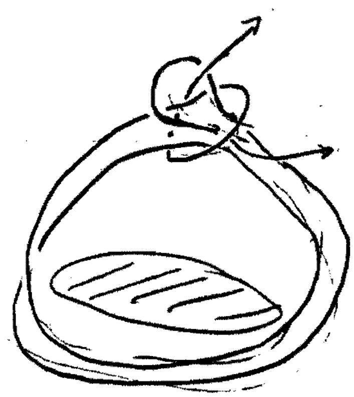


Figure 3.6. Bowline-on-a-Coil.

The bowline-on-a-coil is illustrated in figure 3.6. Any number of loops can be used, but three or four is adequate for most applications. Note that all the loops pass through the eye of the bight.

The tie-off may be made to one or all of the loop strands, but tying to only one is probably better.

3) Figure-8 Loop

The figure-8 loop puts a strong, fairly jam-resistant loop in the middle or end of a rope. It is somewhat more efficient than the bowline, but harder to tie -- especially when the end must be passed around or through something. Proper contouring

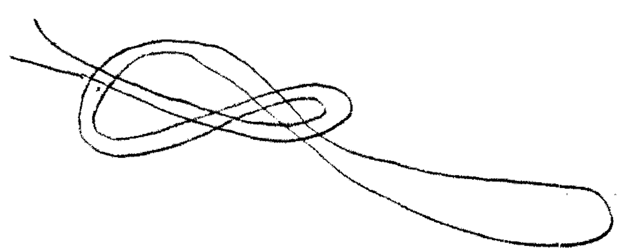


Figure 3.7. Figure-8 Loop.

requires care. The figure-8 loop is useful for putting a loop in the middle of a rope, but it tends to jam when the two standing parts are loaded collinearly, that is, all in one line with the loop in the middle. The butterfly is preferred in that case. The figure-8 loop is shown in figure 3.7.

4) Butterfly Knot

The butterfly is used to put a loop in the middle of a rope when the standing parts may be loaded collinearly. It is excellent for tying in to the middle of a rope or even for tying out a damaged spot in the rope. It is shown in figure 3.8.

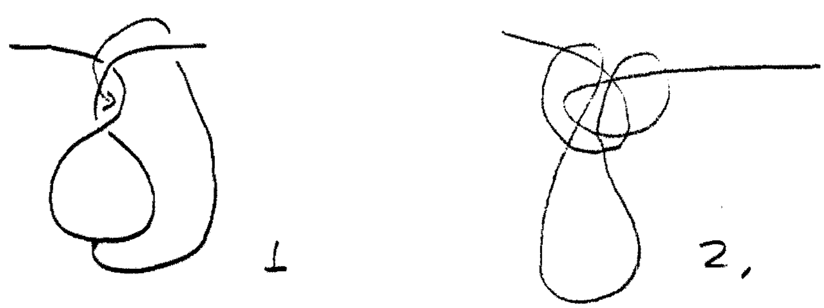


Figure 3.8. Butterfly.

5) Water Knot (ring bend, overhand bend)

The Water knot is used for joining ropes or webbing. It is fairly easy to untie, even after heavy loading, but if it is not carefully tightened before use, it is particularly prone to slipping, especially when wet. The water knot is illustrated, using webbing, in figure 3.9.

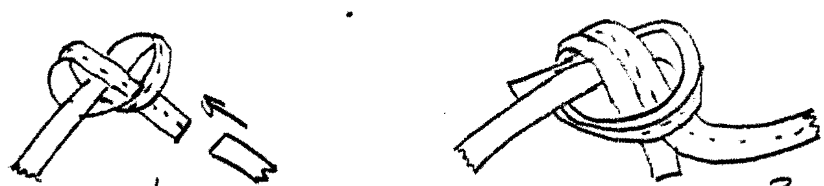
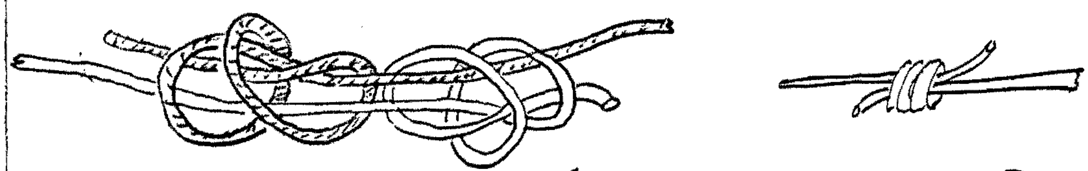


Figure 3.9. Water knot.

6) Grapevine Knot (barrel bend)

Like the water knot, the grapevine knot is used for joining ropes or webbing. It is completely immune to slipping, however, and, in fact, is usually considered permanent. It is, therefore, very useful for making slings and runners and its tails need not be tied off. It is shown in figure 3.10

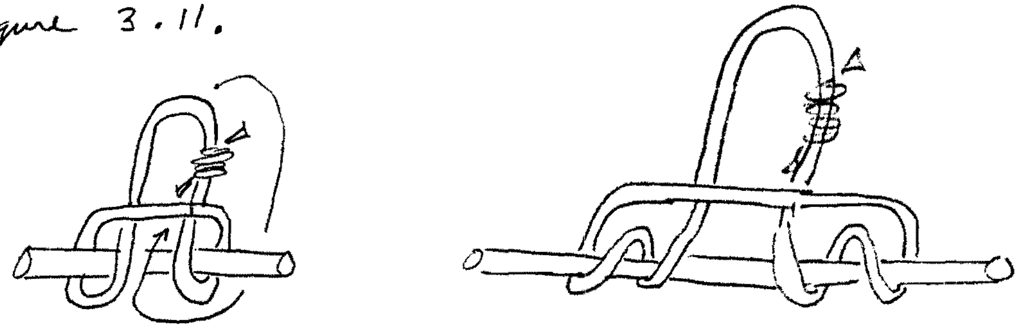


1. 2.

Figure 3.10. Grapevine knot.

7) Prusik Knot

The prusik is a ratchet knot: when pushed by the knot, it slides; when pulled by the loop, it locks. It is useful in hauling and ascending systems and also for belay backups in certain situations. The thinner the prusik sling rope size, the better the knot works, with 6 mm being about the maximum practical size of nylon for use on 11 mm nylon rope. Of course, thinner rope means a weaker system. Many cavers have found, however, that 7/16 inch polypropylene holds well on 11 mm rope and is very strong. The knot is illustrated in figure 3.11.



1. (Cat's Paw)

2.

Figure 3.11. Prusik knot.

8) Headden Knot

The headden knot is a prusik substitute for use with webbing. It is used when a strong ratchet is necessary, such as in a litter hauling system, but polypro is not available. Although the headden has great holding power and works with one inch webbing on 11 mm rope, it is directional and jams more easily than the prusik. It is illustrated in figure 3.12.

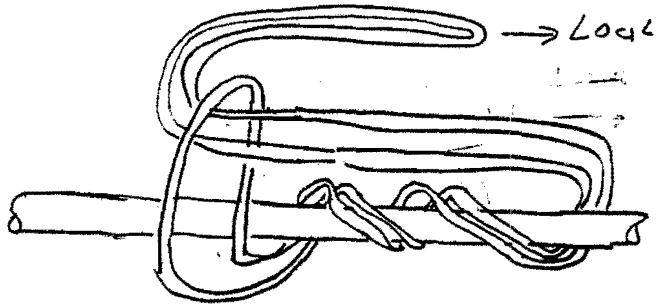


Figure 3.12 Heddon Knot.

9) Tautline Hitch

The tautline hitch is a ratchet knot similar to the prusik, but tied with an end rather than a loop of rope. Although useful in anchorage (see section III D3) the tautline hitch should not be used as a major load carrying component in a rope system. Its adjustability makes it excellent for tent lines, tying equipment to pack frames and car-top carriers and for tying patients in litters. The tautline hitch is illustrated in figure 3.13. Note that it is directional

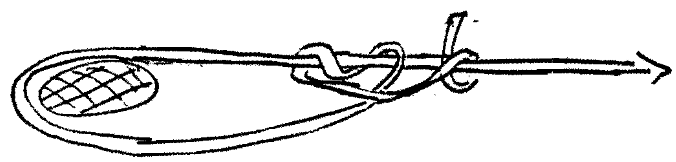


Figure 3.13. Tautline hitch.

C) SEAT HARNESSES

The seat harness is a critical item of personal equipment, and before selecting one, the mountain rescuer should carefully consider his options. Although the final decision well depend on very personal considerations, several points should be kept in mind when choosing a seat.

First, of course, the seat must be safe. This means that it must be strong enough not to break in a fall and that it must effectively transfer the load to some reasonably durable portion of the individual's anatomy. The waist and the male genitalia do not fall into that category; consequently the traditional swami belt and the venerable swiss seat are unacceptable. A second difficulty with the swiss seat is that it is fairly easy to end up hanging by ones knees from the seat, or even to fall out of it entirely. The swami belt severly impedes breathing and inevitably causes asphyxiation within a few minutes. A good seat will rely on a pair of leg loops to transfer most of the load to the legs and will use waist loops mainly for stability.

Another design feature considered important by many is that the seat should not fail completely if it is cut. The "ASRC Seat" was designed with the aim that it would not fail completely even if cut in two places.

A second major consideration in selecting a seat harness is that it must be comfortable, both to wear and to hang from. Wide webbing is greatly advantageous in this respect, although many people consider one inch webbing to be adequate for most work. The seat should fit snugly enough not to fall down around the wearer's knees, but should be loose enough not to restrict motion or impede circulation. It should also be convenient to put on and take off.

The UIAA requires that, for approval, a climbing harness must automatically support an unconscious climber in an upright position. Without the addition of a chest harness, no seat harness will meet this requirement, but in rescue work it is neither necessary nor particularly desireable. Nevertheless, the seat should be designed in such a way that the wearer can easily get himself and keep himself in an upright position. Occasionally, however, he will want to voluntarily invert, and that maneuver is impossible when wearing a chest harness.

1) Commercial Seat Harnesses

The commercial seat harnesses supplied by reputable manufacturers are all quite safe and effective. Research and experience both indicate that sewn seams and joints are very strong and that the buckles used do not slip under load. The main disadvantages of commercial seats are their expense and considerable bulk.

2) The ASRC Seat

The ASRC seat is a tied webbing harness with the virtue that it may be cut in any two places without failing completely. The seat is made from about five meters (more or less, depending on the size of the user and the number of waist wraps desired) of one inch tabular webbing. The seat is prepared as shown in figure 3.14 and is worn as shown in figure 3.15.

For rappelling and tying in to a litter, a locking carabiner may be clipped around all the waist loops and the short section between the leg loops. When tying in to the end of a rope, tie the rope directly to the harness with a small bowline; do not tie in to the carabiner or cross loading may result (cf. fig. 2.8).

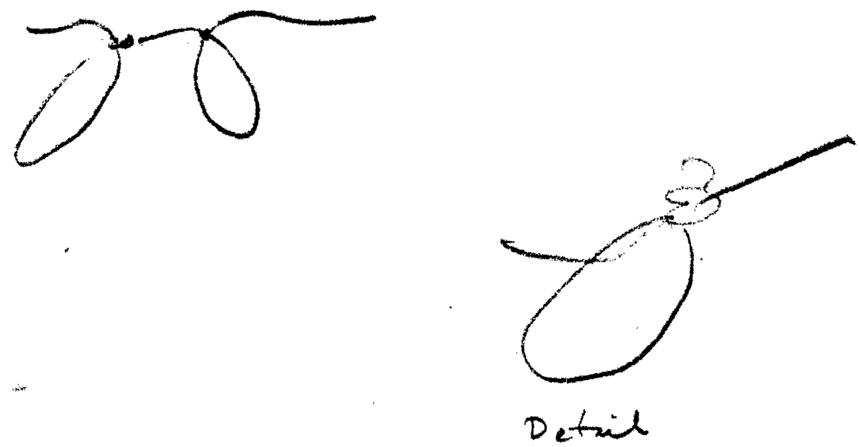


Figure 3.14. Construction of the ASRC Seat

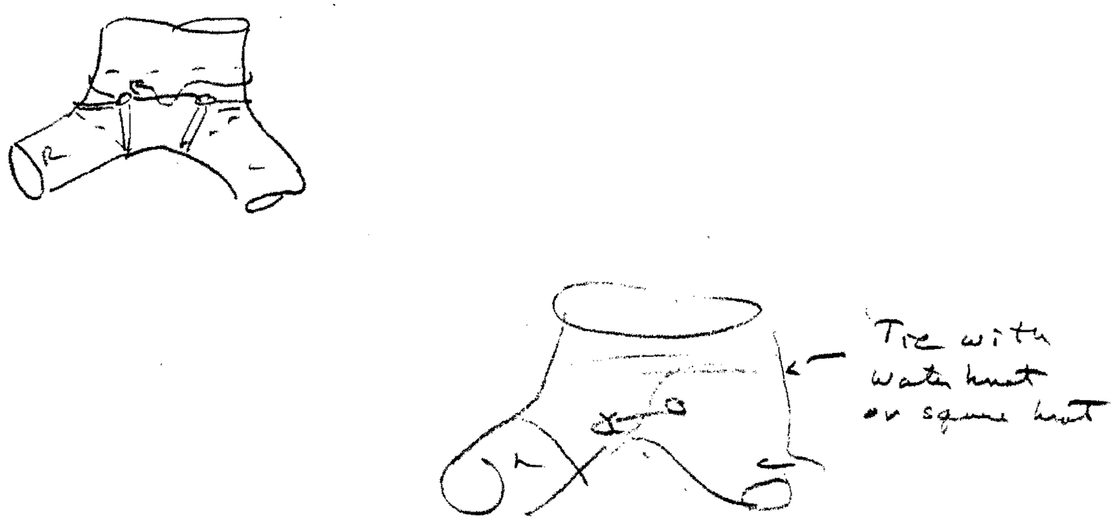


Figure 3.15. Use of the ASRC Seat

3) A Simple Tied Seat

A simple, but quite effective, tied seat can be made from a single piece of one inch (or larger) tubular webbing about five meters long and tied as shown in figure 3.16. This seat is as comfortable and strong as one made from one inch webbing can be, but unlike the DSRC seat, it does not enjoy the virtue of holding its wearer up after having been cut. Still, it has the advantages of simplicity, easy adjustability, and the fact that when the webbing is not in use as a seat it is available for other purposes.

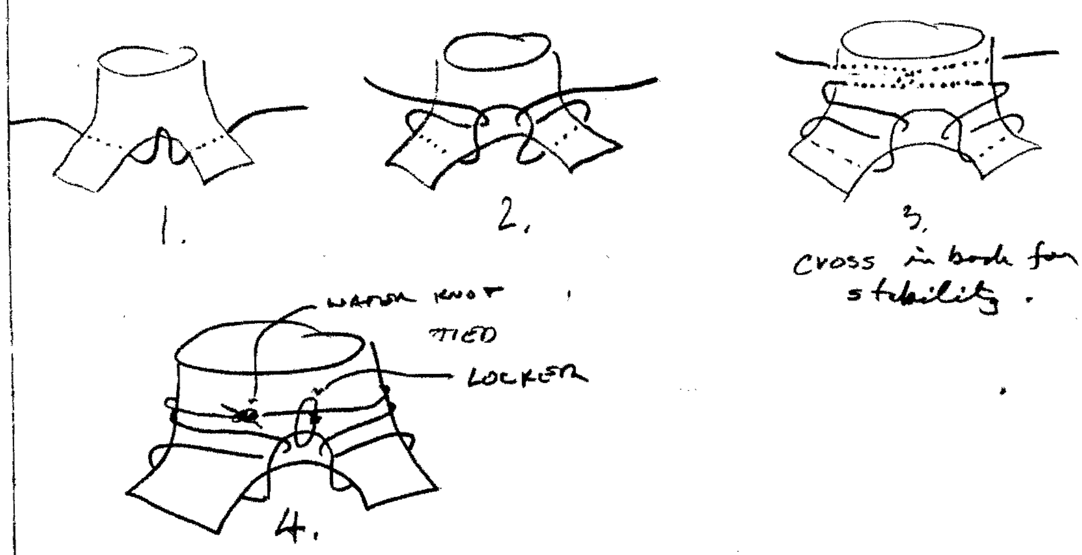


Figure 3.16. Simple tied seat harness.

The locking carabiner is for rappelling, tying in to a litter and similar uses; it is not for tying in to the end of a rope. When tying in to a rope, use a small bowline around both horizontal sections of the seat. This will preclude the danger of cross loading the locker in a fall (cf. fig. 2.8).

D) ANCHORAGE

The setting of strong and reliable anchors is a complex and subtle art which cannot be fully treated in this manual. All mountain rescue personnel should have, however, an understanding of the fundamental principals of anchorage, and should be able to competently rig the anchors discussed here.

Any anchor must be strong enough to withstand the load anticipated for it, and it must be reliable enough that minor disturbances, such as load variations, will not cause it to fail. The object being anchored to must be sound and secure, all materials must be in good condition, the anchor must be properly designed, and knots must be properly tied and carabiners properly positioned. Finally, the anchor must be properly used and frequently checked.

Selecting a solid object to anchor to is almost invariably the most difficult and uncertain part of setting an anchor. Boulders and rock outcroppings may seem obvious candidates for bombproof anchors, but they are often fraught with subtle instabilities detectable only to experienced eyes. When the rock is solid and the boulder heavy and well-planted, rock anchors are very strong, but still, rock is abrasive and hard on rope. Sharp edges (even dull edges!) can and do cut ropes, usually just when they are needed most. Such situations are to be avoided, of course, but when the rope must run over surfaces that can damage it, the rock should be padded with whatever is available. Rucksacks work nicely, as do articles of clothing, blankets and pieces of ensolite. Swatches of canvas or carpeting are ideal.

Trees, when they are available, are often preferable to rocks as anchorage sites, mainly because it is easier to pick a sound tree than a solid rock. Nevertheless, trees used for anchorage must be selected with care. Ideally, the tree should be healthy, well rooted and more than about 10 cm in diameter —— larger if the anchor is placed more than half a meter off the ground. Good judgement will allow for some flexibility in these principles, but one should think twice about dead trees, and be wary of the proverbial "tree rooted in solid rock:" frequently such a tree is barely rooted at all. Conifers often will secrete sap which is difficult to remove from equipment. Given a choice, take the deciduous tree over the conifer.

Inevitably, the mountain rescuer will sometimes be faced with a situation in which the need for an anchor cannot be escaped and yet no bombproof placements can be found. It is vastly tempting at the moment of crisis to make do with an inferior anchor, comforting oneself with the illusion of safety. But gravity cannot be deluded; neither does it forgive mistakes. If you need an anchor, you <u>need</u> an anchor; nothing less will do. The anchor's purpose is to forcibly thwart the will of gravity, not to persuade you to do something you would not do unroped. . . . As the old climbers used to say, "Beware the psychological piton."

When no bombproof placement is at hand, one must be constructed, sometimes elaborately, by backing up available sites, linking together weak sites or running long extensions to distant, but solid, sites further uphill. However the anchor is constructed, the finished product must be assessed rationally and objectively. Wishful thinking will not hold an inferior anchor together.

1) Runners

A runner is a piece of rope or webbing (usually one inch tube) tied in a loop with a water knot or grapevine knot. A runner long enough to fall to the waist when slung across the shoulder is called a single length runner; one twice that long is called a double length runner, and so forth. Very short runners are sometimes called "hero loops."

The simplest application of a runner is simply to hang it over a rock outcropping and clip on a carabiner (see figure 3.17). Made with new one inch tubular webbing, such an anchor has a strength of nearly 2000 kg if the angle (a) θ is small. The strength drops rapidly as (a) θ increases: for (a) $\theta = 90°$, the strength is 71% of that for (a) $\theta = 0°$; for 120°, it is only 50%. The strength

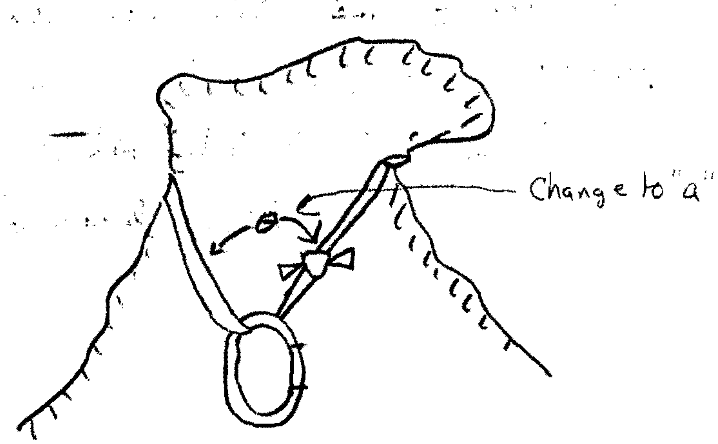


Figure 3.17. Runner

will also be degraded by sharp edges on the rock which could cut or abrade the runner. This kind of anchor is unreliable if upward pulls can occur.

To use the runner on an object (such as a tree) which cannot have things hung over it, two schemes are used: the girth hitch and the doubled runner (see figure 3.18).

Girth Hitch

Doubled Runner

Figure 3.18.

The doubled runner is approximately twice as strong as a single runner, but may be unreliable if it can slip up or down or if the carabiner can become cross loaded.

The girth hitch has the advantage of being very reliable but it is not as strong as the doubled runner, although it is fully as strong as a single runner with $\theta = 0°$. When made with 11 mm rope, the girth hitch is a superior anchor.

The best knots for tying in to a carabiner are the bowline and the figure-8 loop.

2) Tree wrap anchors

The end of a rope can easily be tied around a tree using a bowline or a bowline-on-a-coil, but a stronger anchor can be made by using a tree wrap as shown in figure 3.19. This anchor is nearly 100%

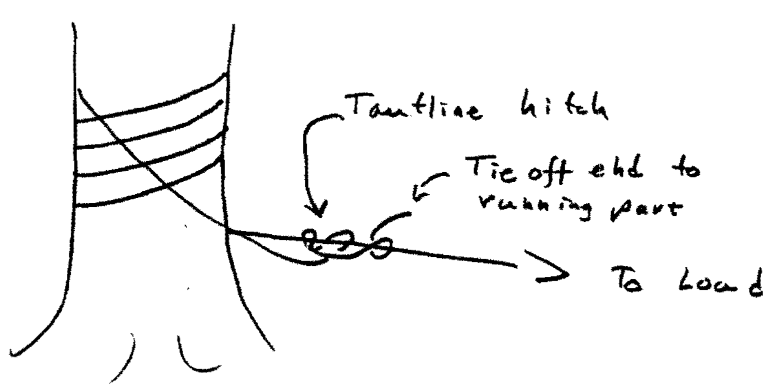


Figure 3.19. Tree wrap anchor.

efficient since all the tension in the rope is taken up by friction around the tree and there are no loaded, small radius bends. An added advantage is that the tree wrap can be rigged or derigged while the rope is taut (e.g. when rigging a tyrolean traverse).

On occasions when the tail is too long to conveniently tie a tautline hitch, or when the center of the rope is to be anchored, the rope can be wrapped double and tied off with two half hitches, the loop being clipped to the standing parts with a carabiner (see figure 3.20).

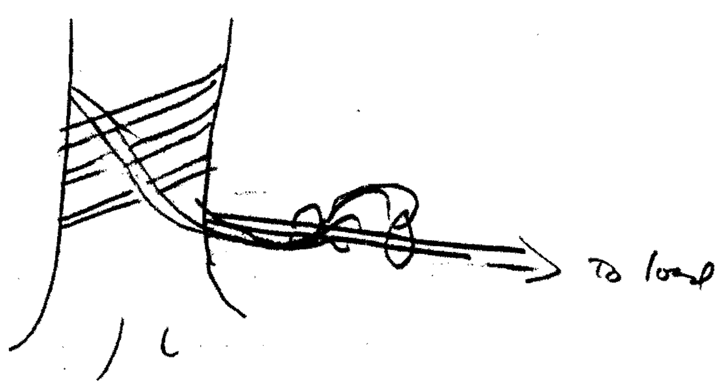


Figure 3.20. Tree wrap anchor in the middle of a rope.

IV. BELAYING

In mountaineering, rock climbing and caving, the terms "belay" and "belaying" are usually used only to denote the technique of using a rope to protect a climber in the event of a fall. In mountain rescue, however, the terms take on a somewhat broader meaning, referring not only to protection but also to the use of the rope in aiding the litter team to ascend or descend steep slopes safely and smoothly. The simpler braking and hauling systems used in mountain rescue belays are described in Chapter II. This chapter discusses the techniques employed by the belayer in managing the belay rope and supporting heavy loads, and it also treats the procedure followed in using any type of belay. The complete art of belaying a climber is more subtle and complex than the treatment here reveals, however, and the references cited in Chapter I should be consulted for more complete information on that subject.

It is very important in setting up and using a belay that the mountain rescuer view "it" as an integrated system consisting of many individual components, each of which must function properly and in concert with the rest of the system. In climbing and caving this is relatively easy to do since the systems are simple and usually involve only two people. In mountain rescue, however, the belay system will usually include several people with specific functions, and these people must work together smoothly if the belay is to be effective. Not only must the mechanical parts of the system be bombproof, but the sense of teamwork among the members of the "rope team must" be equally as rugged. This chapter concentrates on individual skills, but it should be borne in mind that the procedures and techniques treated are often used in the larger contexts discussed in subsequent chapters.

Belay systems are typically not highly redundant: the failure of any one of several vital components will precipitate a catastrophic failure of the entire system. Consequently, sound materials, sound technique, sound judgement and close attention to detail are all essential to the operation of a safe belay. Although exceptional circumstances will frequently call for extraordinary procedures, the use of the standardized techniques and procedures described in this manual will help to minimize error and enhance teamwork.

A) THE BELAY STANCE

When choosing and establishing his belay stance, the belayer's primary consideration is that tension in the rope must not pull him off balance or out of position. Mechanical brakes and belay devices present few problems in this regard since the belayer himself is not subject to the forces in the belay system, but frequently circumstances call for the simplicity and superior control of the traditional hip belay, a method which is considerably less secure than using mechanical aids. In any case, once an appropriate method has been chosen, the following three points should be considered to guarantee the belayer's security:

1) Aiming insures that tension on the rope will come from a single known direction, allowing the belayer to be prepared for it. Belays must always be aimed. If the belay does not have a naturally well defined aim, an anchor must be placed to provide one.

2) If the belayer will hold considerable force himself, he must be tied in securely. Tie-ins are nearly always necessary for belaying climbers, and certainly when the belayer is in an exposed position, but tie-ins are seldom necessary when using tree wrap belays or mechanical brakes. In doubtful circumstances, of course, a tie-in should always be used. It should be as short as possible to minimize problems with stretching and it should be directly in

line with the aim (see figure 4.1).

3) The stance itself should be chosen carefully. Good footing is important in both seated and standing belays. A small hollow to sit in, or a stump or rock to sit behind will substantially increase the security of a seated belay. Since the belayer may be in position for a long time, a reasonably comfortable stance should be chosen. The belay stance should not be placed in a precarious position in order to get a view of the climber or litter team; this is not necessary. If voice communication is a problem, someone can be suitably placed to relay calls — by radio, if necessary. The belayer should directly face the aim. The rope passes across the belayer's hips (not his waist or thighs) above the tie-in if the aim is below the belayer, or below the tie-in if the aim is above the belayer.

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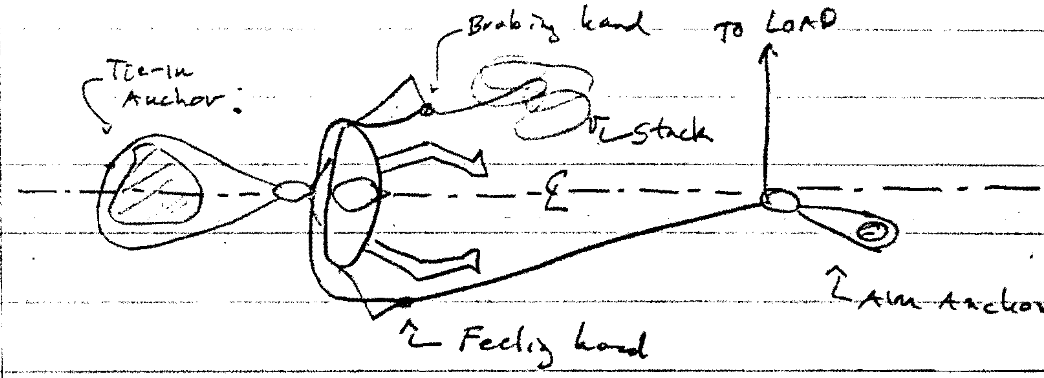

Figure 4.1. The belay stance.

B) TECHNIQUE

The belayer's function in the belay system is to control the tension and length of rope in the system, to brake the descending litter and to hold the rope during a fall. The use of mechanical brakes is treated in section VI- - ; this section is devoted mainly to the hip belay since it is the prototype of other methods such as the Münter hitch or the belay plate.

When the belay is employed strictly for protection, there should be no slack in the system, but there should be no tension either. When the belay is used for hauling or braking, the tension will, of course, depend upon the weight of the load, the angle of the terrain and the extraneous friction in the system. It can range from nearly zero to as much as 600 kg continuously with peak loads instantaneously above 2000 kg. The belayer must be quite attentive and sensitive to the changing demands of the load in order to run a smooth belay.

The loads mentioned above cannot be borne directly by the belayer, of course, but are offered to indicate the magnitude and range of force the system itself must be capable of holding. Even after moderation by tree wraps or friction devices, however, the continuous loads applied directly to the belayer can run as high as 100 kg, and instantaneous loads due to falls can exceed 1000 kg. Since the forces exerted on the belayer during a fall are so large, and since falls often occur suddenly and without warning, it is very important that manipulation of the rope not interfere with the belayer's constant readiness to catch a fall. Leather palmed gloves or mittens are essential, both to protect the belayer's hands and to provide friction on the rope.

The belayer's two hands are identified as the "feeling hand," which holds the rope going to the load and senses the tension of the belay, and the "braking hand," which holds the rope going to the stack and, in conjunction with friction around the belayer's hips or through a mechanical device, provides the braking force to hold a loaded rope. To prevent the braking hand's being pulled around behind the belayer's back, he keeps his elbows close to his body and does not allow them to pass behind his hips.*

While the belay is on, the braking hand must <u>never</u> leave the rope. This principle

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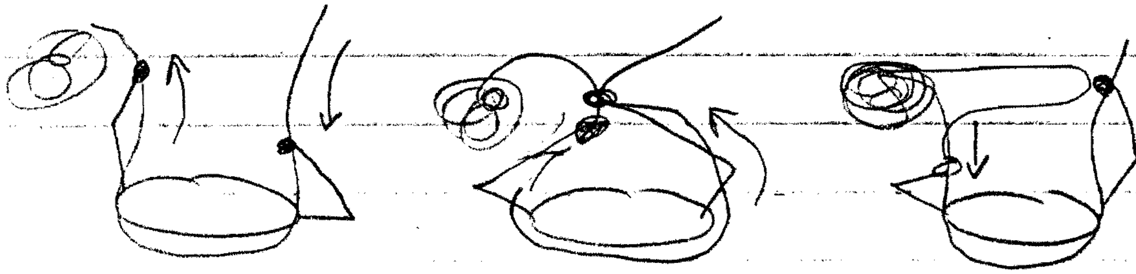
* When practicing, the student of belaying might imagine that he is inside a narrow box with one wall at his back and two others separated just widely enough to accomodate his shoulders.

cannot be overemphasized. With the braking hand off the rope, the belay is essentially non-existent: the rope moves too quickly and too forcefully during a fall for one to even hope to recapture it. The maneuvers described below are designed to provide the belayer with full control over the rope while never removing his braking hand or relaxing his vigilance for falls. They should be mastered with either hand as braking hand.

1) Catching a fall. Whenever the rope is heavily loaded (as during a fall), the braking hand quickly moves under the opposite thigh so as to maximize the amount of rope friction around the belayer's hips. Hang on!

2) Up-rope. The maneuver used to decrease the length of rope in the system is called "up-rope." It is carried out in three distinct steps, each of which is executed on one beat

of a smooth dactylic rhythm.* The steps are illustrated and described in figure 4.2. The braking hand may be thrust between the legs into the fall position at any time during the procedure. The braking hand never leaves the rope.



ONE — Both hands pull rope around body.

two — Feeling hand slides forward and grasps both ropes ahead of braking hand.

three — Braking hand slides back. Feeling hand releases opposite rope.

Figure 4.2. Up-rope.

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* When learning to up-rope, counting out loud, "One, two, three; one, two, three," or singing a waltz helps to maintain a good rhythm.

3) Slack. The belaying maneuver used to increase the length of rope in the system is called "slack."* The tension in the belay is usually enough that the belayer can simply pay out rope without removing either hand, or control the rate at which a heavy load draws rope into the system. However, the belayer never forces a climber to pull his own slack: the climber has enough of a problem overcoming friction in the rest of the system without having to pull rope around the belayer too. When a climber or litter captain calls for slack and it is not clear how much he wants, the belayer slacks about one meter. If more is needed, it will be requested.

c) BELAY DEVICES

The principale advantage of the hip belay is its inherent simplicity -- a great virtue -- but

* Note that when belaying a climber, the call for slack is "Slack," but when lowering a litter the call is either "Down Slow" or "Down Fast." See IV-D-2.

occasions will frequently arise when simplicity is not virtue enough. When the belay load is greater than the belayer's strength, or the stance is unavoidably precarious, artificial belay devices make possible as safe and effective, if more complex, belay.

1) The Münter Hitch. Figure 4.3 shows a method of tying the belay line to a carabiner which can be securely anchored independently of the belayer himself. The knot is called a Münter Hitch. With no tension on the

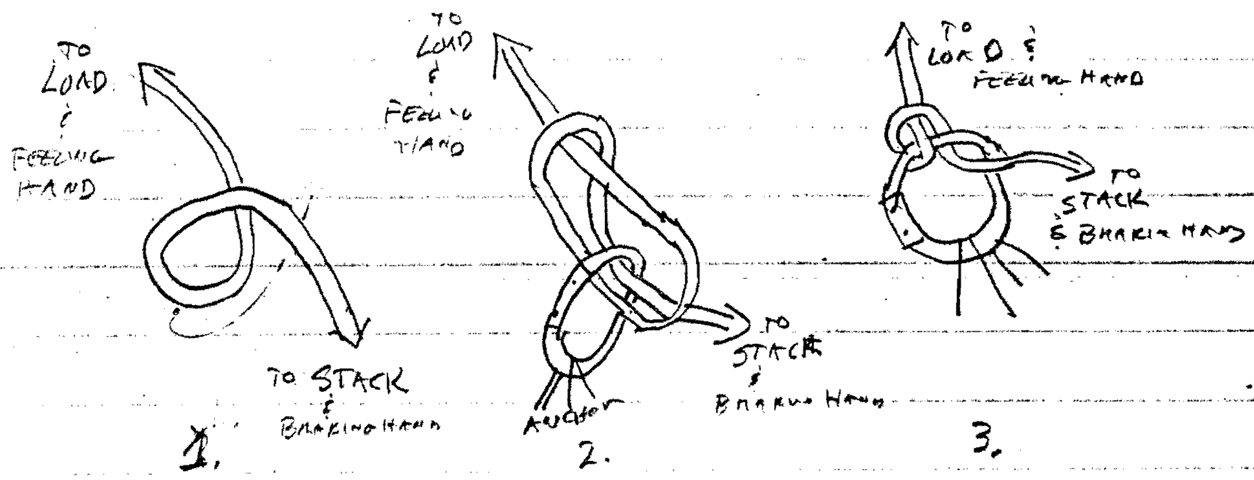

Figure 4.3.a. Tying a Münter Hitch.

braking hand, the feeling hand can pull slack through the biner fairly easily, but in a fall, the braking hand puts tension on the rope by pulling forward as in figure 4.3, tighting the hitch.

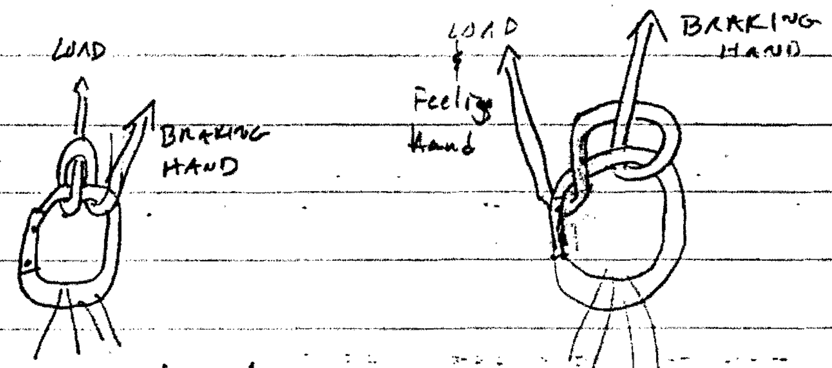

Figure 4.3.b. Using the Müntar Hitch.

During up-rope, the feeling hand relieves tension on the hitch and the braking hand pulls forward (against the anchor) to draw rope through the biner. As shown in figure 4.3, this causes the hitch to invert. If a fall should occur, the knot will revert and the braking hand is in position to tighten the hitch and catch the fall.

The Müntar hitch technique is easy to master, requires no special equipment and is effective enough to have been designated the standard belay technique of the UIAA.

2) The Belay Plate. Belay plates, such as the Sticht-Salewa brake plate and the MSR chain link enjoy considerable popularity among climbers and cavers mainly because they work more smoothly than the Münter Hitch and require less effort to move the rope. However, an item of special equipment is required which must be readily available when needed.

The brake plate is illustrated in figure 4.4. Up-rope and slack are

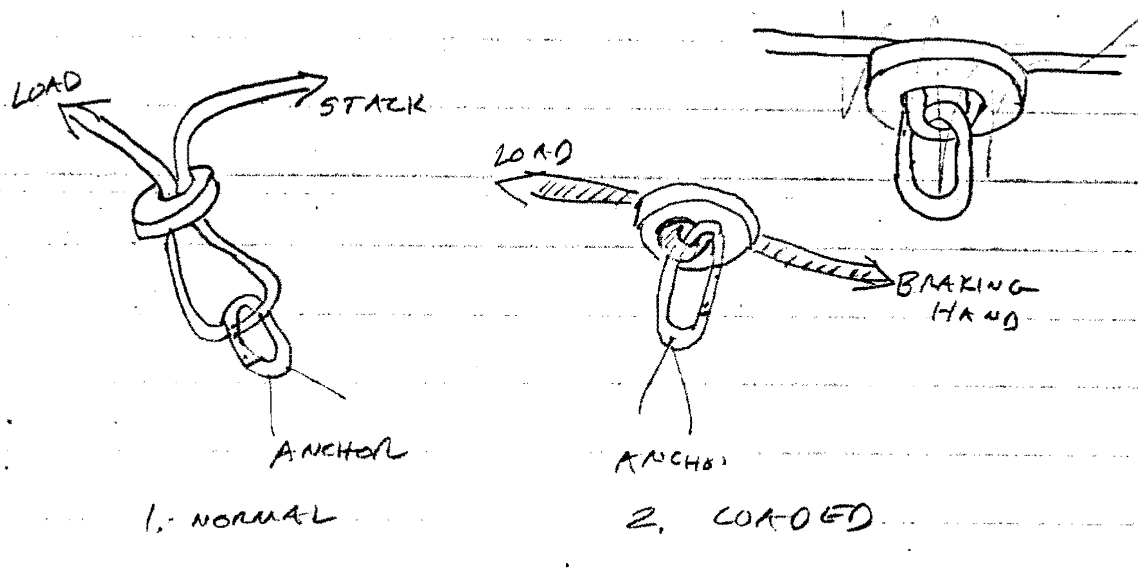

Figure 4.4. The Belay Plate

easily accomplished in the usual way. In a fall, the rope snaps into a straight line and draws the plate and biner tightly together. This provides enough friction to support a hard fall.

The main difficulty with the belay plate is that it tends to either wander away from the biner or to lodge too closely for easy up-rope and slack. The first problem is solved by the use of a short cord to keep the plate close to the biner. Some models solve the second problem with a large spring which properly spaces the plate and the biner when there is no tension, and which compresses under load.

D) PROCEDURES AND CALLS

If the belayer is to be responsive to the needs of the climber or litter captain, fast, accurate and succinct communication between them is imperative. Under the difficult conditions which prevail in the field, this communication is provided by a set of standard shouted signals or "calls." These calls are part of a rigid procedural framework which is designed to insure that both the belayer and the climber or litter captain always know the status of the belay. Since this communication is entirely aural, noise and confusion are a direct threat to the success of the operation and to the safety of the rescuers and the patient. Unnecessary noise in the vicinity of a belay is therefore intolerable. When there is difficulty in hearing calls, a rescuer should be placed as a relay.

A glossary of belaying calls with their associated procedural contexts is given below. Underlining indicates that, when heard, the call should be repeated back, or "echoed," as an acknowledgement. Note that most calls occur in pairs: a statement and a response, or in the case of readiness calls a call from each end of the belay indicating its status. The only exceptions are READY SWITCH, ROCK and FALLING, which require not answers but immediate action.

BELAYING CALLS

1) Readiness Calls.

a) ON BELAY is given by the climber or litter captain. It indicates his readiness to the belayer; it is <u>not</u> a question.

b) BELAY ON is given by the belayer to indicate his readiness to the climber or litter captain; it is <u>not</u> a question.

The belay is not operational until <u>both</u> (a) and (b) have been called. However, the belayer assumes the belay to be operational from his call of BELAY ON. The calls may be given in either order depending upon who is ready first.

c) OFF BELAY is given by the climber or litter captain when the belay is no longer required.

d) BELAY OFF is the belayer's acknowledgement of OFF BELAY.

The belay is not terminated until <u>both</u> (c) and (d) have been called. The belayer may withhold BELAY OFF until he is satisfied that the climber or litter is indeed secure.

2) Procedural Calls

a) CLIMBING is used by the climber to indicate that he is about to begin moving. It is redundant, but very useful nevertheless. It is not used by the litter captain.

b) CLIMB AWAY is the belayer's acknowledgement of CLIMBING.

c) <u>UP ROPE</u> is used by the climber or litter captain to indicate that there is unwanted slack in the belay. It is also used by the litter captain in place of CLIMBING or to request tension on a haul line.

d) SLACK is used by the climber or litter captain to request slack in the belay. If it is not clear to the belayer how much slack is needed, he gives about a meter. The climber or litter captain can always request more if he needs it.

e) TENSION is a climber's request for a rope assist. It is usually not considered sporting in recreational climbing, and in practice the mountain rescuer should not get in the habit of counting on it.

f) PRELOAD is given by the litter captain just before loading the rope before beginning a braked descent. The belayer stops the rope and the litter team loads it to get the stretch out before beginning their descent.

g) <u>DOWN SLOW</u> is the litter captain's request for a slow descent.

h) <u>DOWN FAST</u> is the litter captain's request for a fast descent. "Slow" and "fast" in this context are relative to the terrain.

i) <u>STOP</u> is the litter captain's request for a stop. It is also used by the belayer to indicate that he is stopping the descent because he is out of rope.

j) READY, SWITCH is used by the belayer in the "Brute Force Hauling System" to reverse the high and low groups of the haul team:

3) Warning Calls

a) ROCK: Something is falling! Shield the patient! Take cover!

b) FALLING. Catch me! Used by the climber or litter captain whenever appropriate. The belayer must not count on hearing this call before a fall.

c) HALFWAY is used by the belayer to warn that half the rope has been used up.

d) TWO-OH is used by the belayer to indicate that not much rope is left in the system and the next available belay site should be taken. This call derives from the old mountaineering signal which originally meant, "20 feet of rope left," but in rescue work, "not much rope" is a relative quantity which depends upon terrain and the

availability of good belay stances.
In straightforward circumstances,
10 meters is a good rule of thumb.

V. LITTER BEARING

Moving a litter patient over mountain terrain requires extraordinary teamwork and several special techniques. This chapter and the one which follows deal with the special techniques that litter-bearing in rough terrain requires. This chapter covers general principles and terrain not requiring the use of ropes -- non-technical terrain -- while chapter VI covers the technique of moving litters on terrain steep enough to require a belay -- semi-technical terrain. Vertical evacuation techniques are beyond the present scope of the manual. The interested reader should consult the references listed in chapter I.

Although several different kinds of litters can be used in mountain rescue, the single most popular and versatile is the Stokes Basket Stretcher*, and all of the techniques treated here assume the Stokes is being used. Nevertheless, of necessity, the

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* The Stokes Basket is described in section VI-B.

mountain rescuer will occasionally find himself using other stretcher types, and he should therefore be familiar with their peculiarities. The two other types most frequently encountered are the Army (or D-Ring) Stretcher* and the Neils-Robertson Stretcher. Most of the techniques used on the Stokes are easily applied to other types, but practice with the other types is necessary to enhance teamwork and keep the patient's ride smooth and secure.

The importance of teamwork cannot be overstated. A rapid smooth evac bears directly on the patient's prognosis, but speed and smoothness cannot be achieved unless all members of the evac team work together skillfully and conscientiously.

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*Rigging the Army Stretcher for semi-technical evac is described in Section VI-B.

A) THE LITTER TEAM

The basic litter team consists of six litter bearers, three on a side. On steep, semi-technical terrain, however, only four litter bearers need be used, and only three should be used when hauling the litter uphill, (these situations are described in chapter VI). The positions on the litter are denoted by "right front," "left middle," etc., where "front" means in the direction of travel and does not refer to the orientation of the patient.

The leader of the litter team is the litter captain, who is whichever litter bearer is in the left front ("driver's seat") position. As litter bearers rotate and the direction of travel changes, <u>any</u> litter bearer might be called upon to become litter captain.

At his discretion, the Medic may or may not serve as a litter bearer. In general, however, he will want to be free to attend the patient, manage medical equipment, and keep records.

A "seventh man" at one end of the litter is frequently helpful.

Additional team members should range themselves ahead of the litter, ready to rotate in. They should occupy themselves clearing trail (as necessary) carrying excess equipment and resting for the exhausting work of carrying the litter. When these additional litter bearers are included, the smallest complete team comprises nine people. This number is adequate to execute all non-technical and semi-technical evac techniques. In general, however, fifteen litter bearers is not too few.

B) LITTER HANDLING

The requirement of a smooth ride for the patient demands that the mechanics of litter handling be standardized and thoroughly practiced.

1) Lifting

a) The litter bearers arrange themselves two at the patient's head, two at his waist and two at his knees. It helps to evenly distribute the load if each pair is matched in height. Each litter bearer kneels on one knee as close to the basket as possible, facing in with both hands on the rail.

b) The litter captain surveys the team and says, "Ready, (pause) lift." Litter bearers not ready should indicate so during the pause. Counting ("one, two, three, lift") is unnecessary and is not used.

c) Litter bearers lift the litter, keeping their backs straight and pulling out rather than up. This technique not only promotes smoothness in the maneuver, it helps prevent strained bodies. The litter bearer keeps his butt down and raises with his legs rather than his back muscles.

d) Once up, all litter bearers must strive to maintain a slight head-up attitude on the litter.

2) Moving the Litter

a) Litter captain: "Forward."

b) Litter bearers walk out of step, keeping their arms bent. Once in motion, each litter bearer need keep only one hand on the rail. ^ INSERT FROM P 5,5½

c) A smooth ride is essential. The litter must be kept level or head up.

d) Forward litter bearers call out obstacles on their sides (e.g., "Rock on the right.")

e) Much of the strain of carrying a litter can be relieved through the use of load straps, as shown in figure 5.1. Load straps give a rougher ride to the patient, however, and should be used only when the Medic judges that the increase in litter bearer efficiency

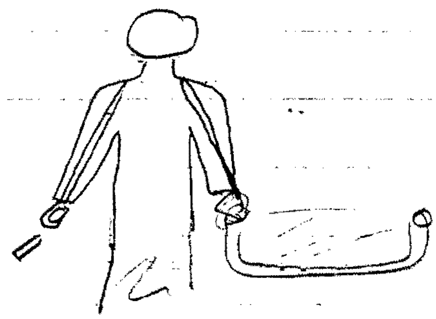

Figure 5.1. Load Straps

is worth the cost of a rougher ride. The strap is run across the shoulder and is held by the straight outside arm. Load straps must not be tied to the litter bearers.

f.) To stop, the litter captain calls, "Stop."

3) Lowering

a) The litter bearers face in, both hands on the rail.

b) The litter captain checks under the litter for projections which might hurt the patient.

c) Litter captain: "Ready, (pause) down." The litter is lowered using the reverse of the lifting technique.

d) Once down, the litter must be propped into a comfortable attitude for the patient.

C) NON-TECHNICAL EVACUATIONS

Non-technical terrain is level enough or smooth enough that a belay is not necessary. On non-technical terrain, a falling litter bearer poses no threat to the safety of the patient, the rest of the litter team, or to himself.

1) Rotation

During long evacs, litter bearers may be relieved by the procedure of rotation, described in figures 5.2 through 5.5. As was mentioned above, team members not actually carrying the litter should walk ahead of the litter. The two closest to the litter are designated relief bearers and should not get more than about ten meters ahead of the litter. When the litter captain (LC) decides a rotation is in order, he initiates the procedure described below, the two relief bearers are rotated in and the litter captain and right front are rotated out. The process is repeated as necessary to keep the litter team reasonably fresh. The entire procedure is carried out with the litter in motion.

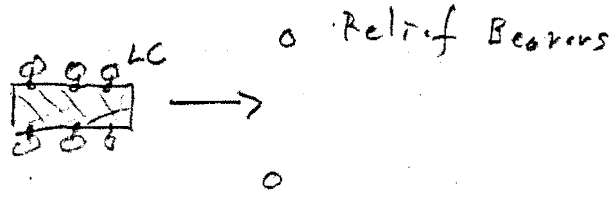

Figure 5.2. Litter Captain (LC): "Ready to rotate." Relief bearers stand off the trail.

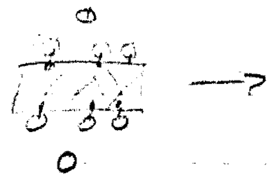

Figure 5.3. The litter passes between the relief bearers.

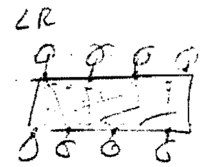

Figure 5.4. The relief bearers grasp the basket at the rear. At this point the left rear (LR), one of the relief bearers calls, "Rotate," the only time someone other than the litter captain gives a command. The basket is passed back and the two front bearers peel off.

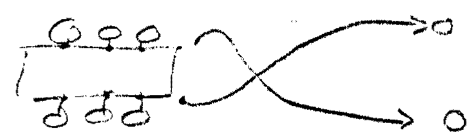

Figure 5.5. The new relief bearers cross the trail and move off forward. When they rotate back in, they will have exchanged sides on the litter.

2) Laddering

Laddering is a procedure for carrying the litter over (or through) obstacles which cannot simply be stepped over. It is described in figures 5.6 through 5.12. An important principle is that, while laddering, no one supporting the litter moves his feet.

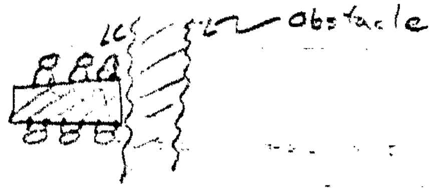

Figure 5.6. The litter is brought as close to the obstacle as possible before the litter captain calls, "Stop. Ready to ladder." The middle bearers reach back to accept the rear load. They <u>do</u> <u>not</u> <u>step</u> <u>back</u>.

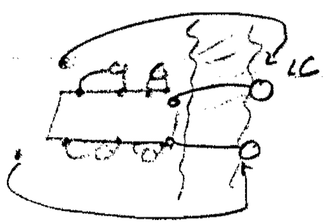

Figure 5.7. The two rear bearers peel off and go to the front of the litter. Note that there is now a new litter captain. The new litter captain calls "Ladder," and the basket is passed forward.

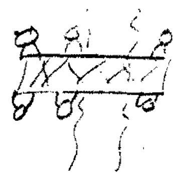

Figure 5.8. Again, the litter captain calls, "Ready to ladder," and the rear bearers peel off.

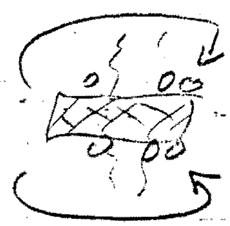

Figure 5.9. The rear bearers proceed to the front, the new litter captain calls "Ladder," and the basket is passed forward.

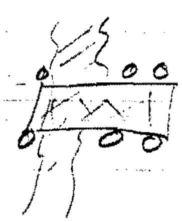

Figure 5.10. "Ready to ladder." Peel off.

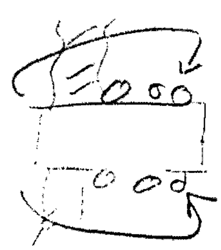

Figure 5.11. "Ladder!" Pass basket forward

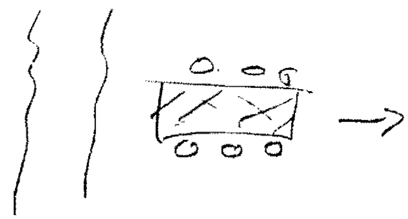

Figure 5.12. The litter captain calls "Forward," and the basket is again underway. The procedure may be repeated as many times as is necessary, of course, to cross a wider obstacle than the one shown in the figures.

3) Toenailing

A variation on the laddering technique useful for climbing short steep pitches is "toenailing" the head end of the litter into the slope while the rear litter bearers move up. The procedure is illustrated in figures 5.13 through 5.15.

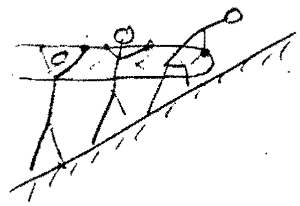

Figure 5.13. "Ready to ladder." Rear bearers peel off.

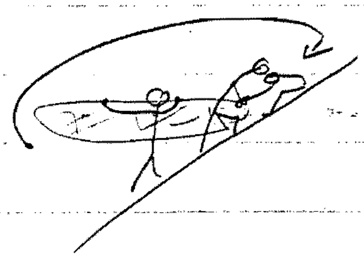

Figure 5.14. "Ladder." Pass the litter up. Don't jerk!

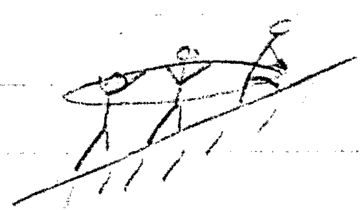

Figure 5.15. The process is repeated as many times as is necessary.

VI. SEMI-TECHNICAL EVACUATIONS

Semi-technical terrain is rugged enough or steep enough that it is difficult or dangerous to move the litter without a belay, but not so steep or exposed that individual rescuers need be belayed. In descending, the belay might more strictly be termed a braking system since it is used to control the descent of the litter, and in ascending, the belay sometimes takes the form of a rudimentary hauling system. Nevertheless, the term "belay" persists where it is not confusing.

A) THE EVAC TEAM

On semi-technical terrain, the standard evac team comprises nine members, usually arranged as a litter team of six and a rope team of three. On steep slopes, however, when much of the weight of the litter is supported by the rope, some variations are used.

Descending, only four are needed on the basket, and reducing the team to this size gives a lighter load on the belay and also better visibility for the litter bearers. The two excess team members can be well employed carrying extra equipment (which is particularly annoying on steep slopes). Ascending, using the "Brute Force Hauling System" (described in VI-C-5), the litter can be managed by only three, with the other six on the rope team. When the angle is steep enough that a reduced litter team can be used, the litter bearers tie in to the basket.

Extra rescuers should be deployed well off the fall line of the litter so as to avoid kicking rocks onto the litter team or catching the rocks inevitably knocked loose by the litter team.

If possible, the Rescue Specialist should avoid litter bearing and rope handling duties and concentrate instead on planning the route and directing the work.

B) LITTER RIGGING

The Stokes Basket Stretcher is nearly ideal for most mountain rescue applications. It is strong, stiff, reasonably lightweight and provides excellent stability and protection for the patient. The evac techniques described in this chapter have been designed with the Stokes basket in mind, but they are easily adaptable to other types of litters. In particular, a short description of rigging adaptations for the Army stretcher is included in section II-B-4.

The Stokes litter is illustrated in figure 6.1 along with its rigging.

1) The Yoke

The yoke is a loop of 11mm rope permanently attached to the head rail of the litter, with wraps as shown to minimize flexure of the buttweld. The yoke biner is a locking type and should never be removed. For

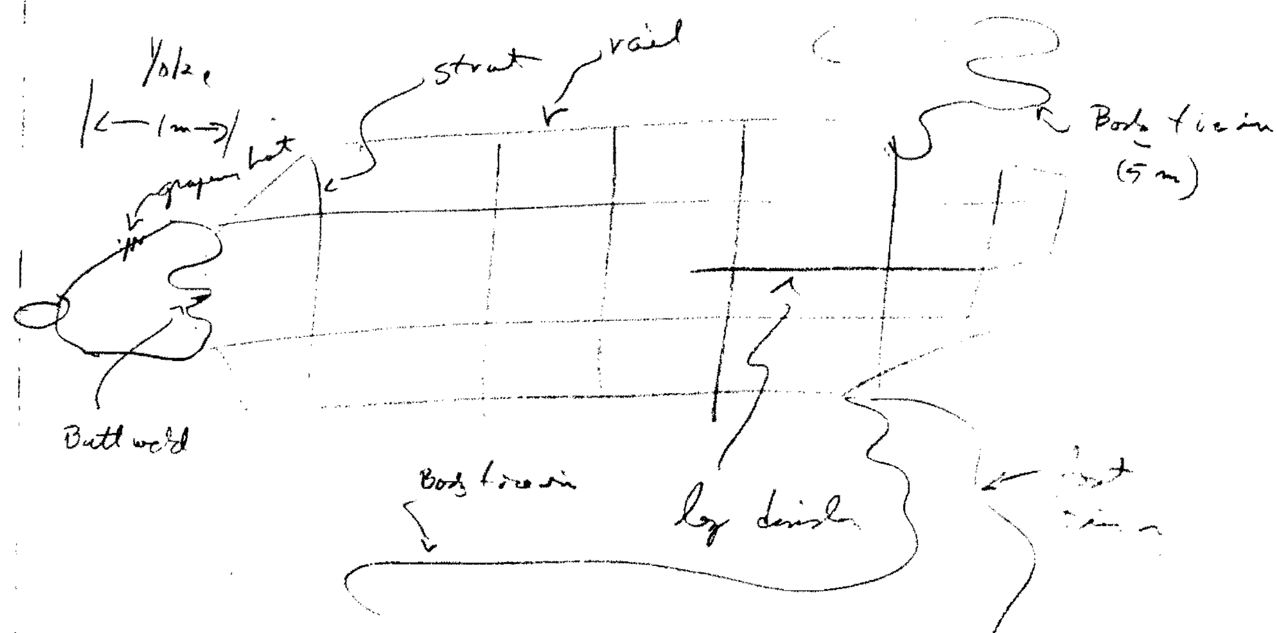

Figure 6.1 The Stokes ~~Basket Stretcher~~

storage and transportation, the yoke biner may be clipped to a strut.

The belay rope is clipped to the yoke biner with a figure-8 loop.

2) Patient Tie-Ins

There are three patient tie-ins permanently attached to the litter: two for the patient's body, and one for his feet. All are of 9/16, 3/4, or 1 inch tubular webbing, 5 meters long, and tied to the knee struts with overhand loops, one on one side and two on the other. For storage and transportation, they may be run to the forward strut and back a few times and tied off with half hitches. They are also very useful for securing equipment in the litter.

Figure 6.2 illustrates the basic patient tie-in scheme. Each tie-in starts at the knee strut, passes directly across to the opposite strut, diagonally up to the next strut, straight across to the opposite side and so forth. The patient is thus "laced" securely into the basket. The tie-in ends are tied to the head strut with trucker's hitches so that they can be easily adjusted. To avoid abrasion of the webbing, tie-ins are never run over the litter rail, but always to the struts instead.

A detail of the foot tie-in scheme is shown in figure 6.3. The tie-in begins at the knee rail, crosses diagonally over the shin and under the opposite foot. It then ascends to the knee rail and repeats for the other foot. The tie-in then passes directly down to the foot strut, across both ankles but passing under the leg divider, and finally ties off at the ankle strut with a tautline hitch.

In actual practice, of course, this basic patient packaging scheme will be

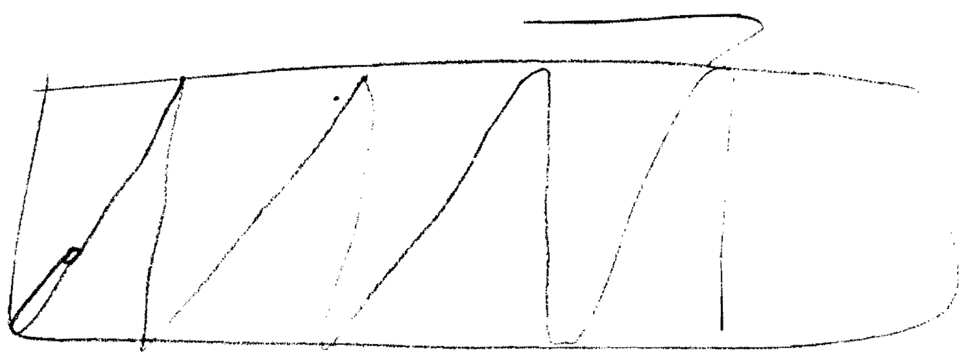

Figure 6.2. Patient Packaging

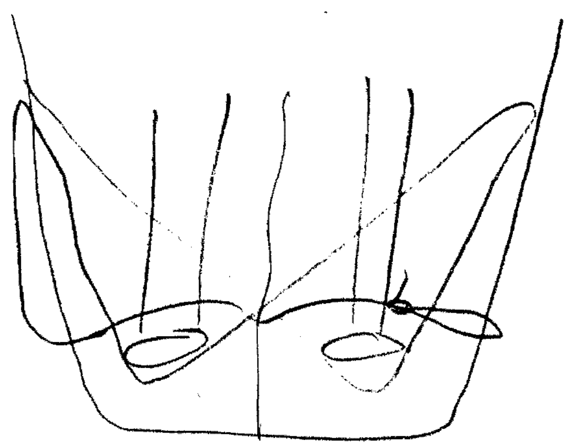

Figure 6.3. Detail of Foot tie-in.

varied to suit the patient's injuries. For example, crotch straps made from well padded cravats may be used to prevent a patient with leg injuries from sliding down in the basket.

3) Litter Bearer Tie-Ins

A litter bearer tie-in is an item of personal equipment that no one should lack. It is a 6 mm rope* loop approximately 50 cm long. When snapped between a litter strut and the litter bearer's seat harness, it supports the litter bearer's weight on steep slopes. See figure 6.4. The tie-in can be shortened by doubling one or both strands. If a carabiner is not available, the tie in can be girth hitched to the litter.

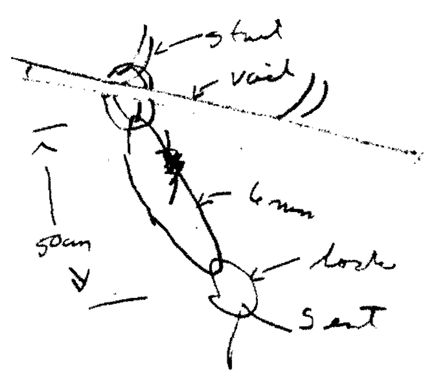

Figure 6.4. Litter Bearer Tie-In.

* [illegible]

4) Army Stretcher Rigging

Although it is not nearly as good as the Stokes basket, the Army (D-Ring) Stretcher may be effectively used for semi-technical evacs. Rigging is illustrated in figures 6.5 and 6.6.

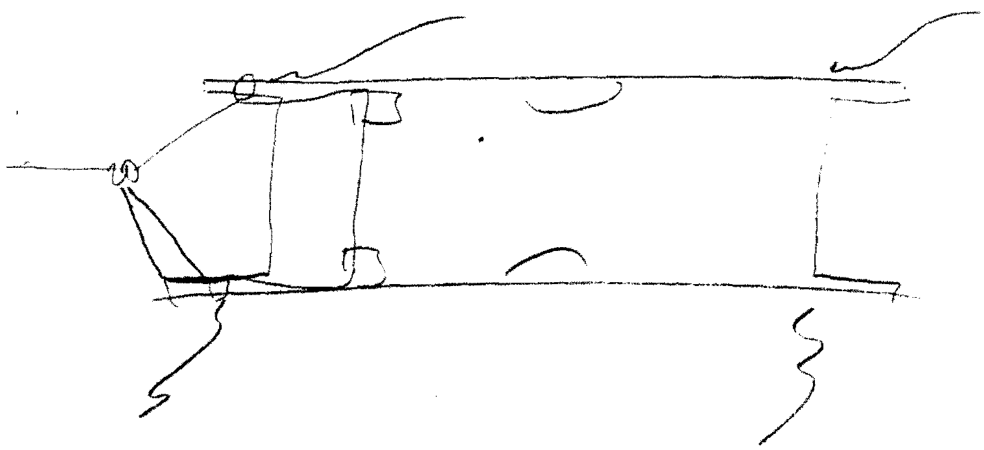

Figure 6.5. Army Stretcher Rigging

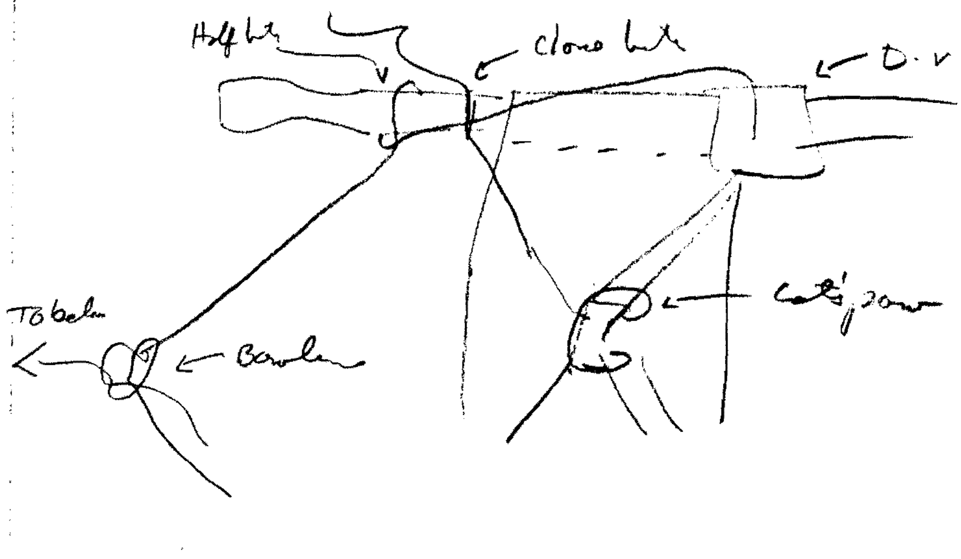

Figure 6.6 Detail of Rigging.

The patient tie-ins are made from 15 meters (each) of 7/16, 3/4, or 1 inch tubular webbing. The center of each piece is tied to the hinge of the spreader with a cat's paw and then each half is tied to a stretcher handle with a clove hitch. This arrangement prevents the stretcher from accidentally collapsing. It must be tight to be effective.

Instead of using a yoke, the belay rope is tied directly to the head end of the litter with a bowline. The loop of the bowline passes through the D-rings (which bear the load), and half hitches are placed around the handles for stability. Of course, if the litter is to be left permanently rigged, a yoke could be attached in the same fashion, but such an arrangement would be somewhat cumbersome for storage and non-technical use.

The patient is secured to the stretcher as shown in figure 6.7. Usually there

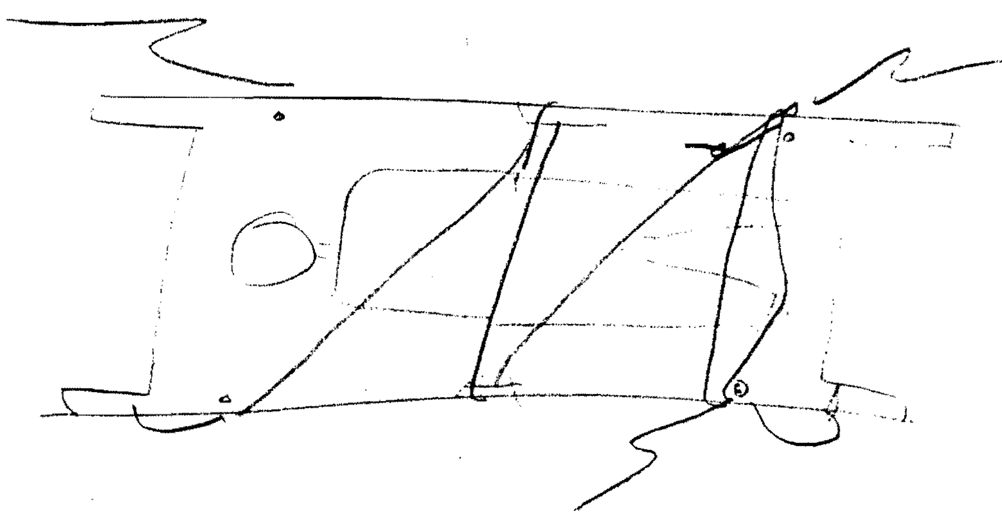

Figure 6.7. Patient Packaging with U.S. Army Stretcher

will be considerable excess foot tie-in. The reason the foot tie-in is made so long is that by making the two ends of the litter symmetrical there is no danger of loading the patient backwards. Also, plenty of webbing is available if the patient's injuries demand modification of the tie-in scheme.

C) BELAYS

Belay methods for semi-technical evacs fall into three categories:

a) Tree-wrap belays, which are used both to protect the ascending litter and to brake the descending litter;

b) Mechanical brakes, which are used on descents too steep for tree wraps to provide adequate protection, or when no trees are available; and

c) The Brute Force Hauling System, which is an aid used for steep ascents.

Because of their low stretch, high strength and excellent handling characteristics, 11 mm Bluewater or PMI caving rope is preferred for litter belaying, but Goldline or kernmantle climbing ropes are also useful (cf section [illegible]

1) The Tree-Wrap Belay

Sufficient friction for most evacs can be had by belaying to a tree, as illustrated in figure 6.8, but if the belayer feels the need for a tie-in, the

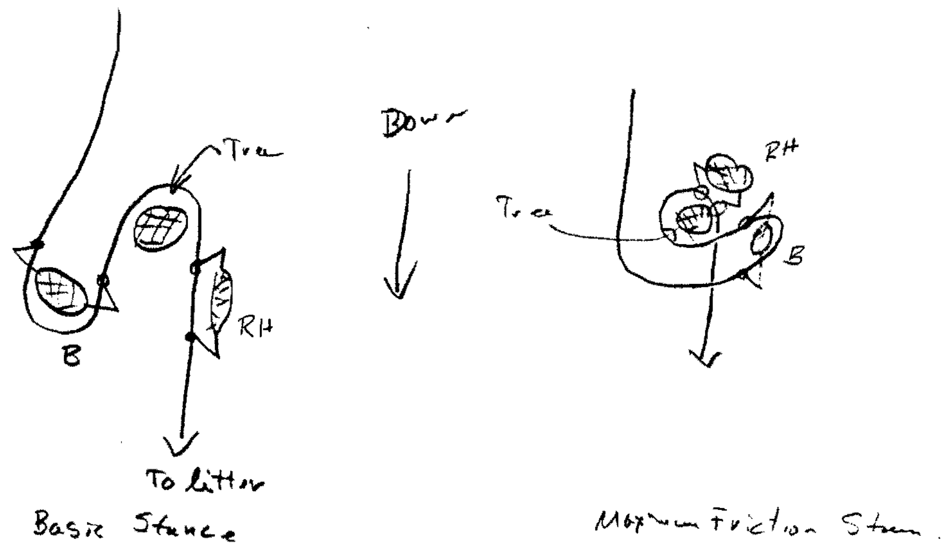

Figure 6.8. Tree-Wrap Belay.

tree-wrap should be abandoned in favor of a mechanical belay.

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¶ The tree must, of course, meet all the requirements for an anchor, but, in addition, the belayer should select as large a tree as possible, since larger trees will give him better control. A tree diameter of 35 to 50 cm is probably ideal. Also, hardwoods are to be preferred over conifers, since conifers secrete sap that is very difficult to clean off the rope.

Figure 6.8 illustrates tree-wrap belay configurations for an ascending litter; in a descent, the ropehandler (RH) is employed elsewhere. His purpose on the ascent is to relieve rope friction around the tree as the belayer (B) executes up-rope. On the descent, this function is unnecessary since the system is under constant tension and the belayer only slacks, using the tree to provide braking friction.

The belayer assumes a standing hip belay stance about 1 1/2 meters from the tree, and keeps the rope as close to the ground as possible. In a fall, if the belayer is in the basic stance, he will sometimes find that he must move rapidly (that is, dive desperately) into the maximum friction stance. Placing himself a meter and a half from the tree gives him enough rope that he will not be pulled into the tree before he gets enough friction to stop the fall, but also keeps reasonably small the distance he must move to get to the maximum friction stance. The rope is kept low on the tree simply to make it easier for the belayer to step across.

In the basic stance, the rope handler positions himself a meter or so below the tree and provides the force to pull the rope uphill. He must also keep the rope around the tree just slack enough that the belayer can up rope easily, but no more. When the litter team can move up the slope rapidly the ropehandler feeds rope at the belayer's maximum up-rope rate, but no faster: it is up to the litter captain not to overrun the belay. The ropehandler must watch both the litter and the belayer since it is he who controls the rate of ascent. He must pull rope as fast as the litter needs it pulled, but no faster than the belayer can up rope.

In a fall, the ropehandler must get out of the belayer's way in case he needs to go to the maximum friction stance. The reason the ropehandler stays close enough to the tree that he would be in the belayer's way is simply that if he gets too far below the tree he cannot effectively relieve friction around it.

In the maximum friction stance, the ropehandler crouches on the uphill side of the tree; this is the only effective position. It is also quite hazardous since, in a fall, his fingers could get caught between the rope and the tree. The ropehandler must therefore handle the rope carefully, keep a good bit of slack around the tree (this also helps the belayer), and stay alert for a fall. In a fall he must drop the rope immediately!

Fortunately, the maximum friction stance is rarely needed on ascents. Usually, when the slope is steep enough or treacherous enough that the basic stance with the potential for moving rapidly into the maximum friction stance is inadequate, then the Brute Force Hauling system is necessary. Nevertheless occasions arise when the maximum friction tree-wrap belay is the best choice. It is safe if everyone respects its hazards and the ropehandler stays on his toes.

2) Mechanical Belay

During descents over treeless terrain or over terrain on which tree-wrap belays provide inadequate security, mechanical brakes are necessary. The standard brake for this use is the figure-8 descendeur rigged with a locking biner and a runner made from 9 or 11 mm rope or 1 inch tubular webbing. The rigging is illustrated in figure 6.9. The kind

Figure 6.9. The Figure-8 Brakes.

of anchor used will depend mainly upon what is available, but in any event, the anchor must be bombproof.

The basic brake configuration of figure 6.9 is most frequently used but on steep slopes it quite often will provide inadequate friction. The maximum friction configuration, however, is nearly as easy to use and provides enough friction and range of control for vertical descents. Although no firm rules can be stated, it is usually advisable to reduce the litter team to four when the terrain is steep enough to warrant the maximum friction brake. For extremely steep or vertical slopes, the litter team should even be reduced to two. The idea is to keep the litter team as small (and light) as possible while still providing enough manpower to properly control the basket. As the angle increases, more of the weight of the litter is taken by the rope and fewer people are needed to control it.

The heat handling capacity of the figure-8 brakes <u>is</u> sufficient for most evacs, but there is no great margin of safety. The belayer must constantly monitor the brake temperature with his ungloved feeling hand, and if it gets too hot to touch, slow the descent and cool the brake with snow or water. Normally, excessive heating indicates excessive speed, and therefore can be avoided.

There are two different techniques for handling the figure-8 brake. In the more commonly used of these, the belayer adopts a hip belay stance (possibly tied in), and simply uses the brake for extra friction. Often, however, it is more convenient not to use a hip belay but to rely entirely on the friction of the figure-8. The belayer holds the rope in his hand and releases it to reduce friction or pulls it toward the anchor to increase friction. This second method is particularly effective with the maximum friction brake. The decision to use a particular technique on a particular occasion depends largely on experience and, to some extent, personal preference.

In addition to the figure-8 brake, several of the brakes described in section II-, F, are useful alternatives. By far the best of these is the caving rappel rack. It is exceedingly strong and provides an unsurpassed range of control, but is heavy and somewhat complex (although skilled cavers rig racks with marvelous dexterity). For routine evacs, the rack is inferior to the figure-8, but for very steep or vertical evacs of any length it is nearly ideal. One particular advantage in such circumstances is that one rack can accomodate a double rope (and even brake each independently), whereas a single figure-8 in the maximum friction configuration cannot.

The six-biner (Yosemite) brake is effective, although cumbersome, and has the advantage that it requires no special equipment. The carabiner wrap brake (made with a strong biner) is simpler and provides good control, but its heat handling capacity is low and consequently it must be used with great care.

Brake bar chains should be avoided. Although they provide good control, all the force in the belay falls on a single (usually oval) carabiner which is not strong enough to be relied upon to support a litter team.

D) EVACUATION PROCEDURES

The key to a successful evac is teamwork. The procedures which have evolved for the conduct of semi-technical evacs have proved to be very successful in promoting rapid, efficient and smooth transportation of the patient, but they work properly only if the team members are individually skilled and thoroughly drilled and disciplined to follow them and to work together. Semi-tech does not require high-powered mountaineering skills, but since it requires precise coordination among the nine team members, it is still not easy. If you want to get your patient off the mountain speedily and comfortably, you must concentrate, communicate and cooperate.

Although the Field Team Leader always retains overall responsibility for the operation of his Field Team, during a semi-tech evac the Rescue Specialist assumes the leadership functions bearing directly on the technical aspects of transporting the patient. He selects the mode of travel, assigns duties on the evac team, selects appropriate equipment, and generally supervises the ongoing operation. He must pay particular attention to matters of safety.

Even when the Rescue Specialist must supervise several evac teams at once, there is no particular leader in charge of each team. The litter captain manages the litter team, the belayer manages the rope team, and it is up to these two -- whoever they may be at any moment -- to keep the litter moving smoothly.

1) Descent Procedure

The deployment of the evac team for a descent is illustrated in figure 6.10. The tree-wrap belay is shown, but the same procedure is applicable when a mechanical brake is used instead.

The belayer (B) controls the rate of descent of the litter according to the requests of the litter captain (LC). (See section V-[illegible] for an explanation of the calls used.) As the litter descends, the downhill ropehandler (DR) scouts the route and watches for potential belay sites. The uphill ropehandler (UR) acts as "seventh man," keeps the rope clear and relays calls as necessary. When the belayer calls "Two-Oh," the downhill ropehandler indicates his choice of belay sites to the litter captain who then stops the litter just below it.

INSERT FIG 6.10 (See p 6.21½)

Once the litter is down, the litter captain calls, "Off Belay," the belayer answers, "Belay Off," drops his belay stance and clears the rope from around the tree. Immediately, the downhill ropehandler takes up the belay at the new site and, when ready calls "Belay On." Meanwhile, the former belayer is descending to assume the uphill ropehandler position and the former uphill ropehandler has already taken up his new station as downhill ropehandler. As soon as the litter team is ready (frequently the Medic will want to check the patient while the litter is off belay), the litter captain calls, "On Belay" and raises the litter. Before resuming the descent the litter captain usually calls for a preload to stretch out the rope and avoid a jerky start.

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The rotation procedure just described is diagrammed in figure 6.11. A useful mnemonic is "roll downhill." If the three rope team positions are visualized,

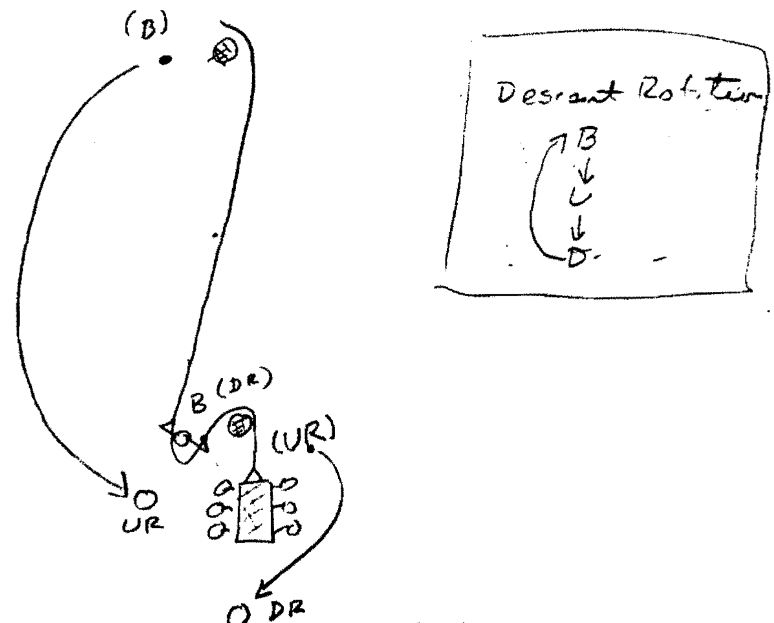

Figure 6.11. Descent Rotation.

the belayer is highest, the uphill ropehandler is in the middle, and the downhill ropehandler is lowest. During the rotation, each member drops to the next lowest slot except the downhill ropehandler, who rotates back to the top as belayer.

The litter may resume its descent as soon as the new belayer is ready. This takes only a few seconds. The old belayer (now the uphill ropehandler) will have to hustle to catch the moving litter, but he should swing wide to avoid kicking rocks on those below.

If mechanical brakes are being used each member of the rope team should have his own rig. However, if only two rigs are available, the evac can still run smoothly if the old belayer remembers to give his rig to the new downhill ropehandler during each rotation.

2) Ascent Procedure

The deployment of the evac team for an ascent is illustrated in figure 6.12. While the litter team struggles up the hill as best it can, the belayer (B) and the downhill ropehandler (DR) work the belay. The uphill ropehandler scouts the route uphill, carrying the end of the rope with him. He should keep in mind that, since he is trailing the rope, wherever he goes, the litter must go also,

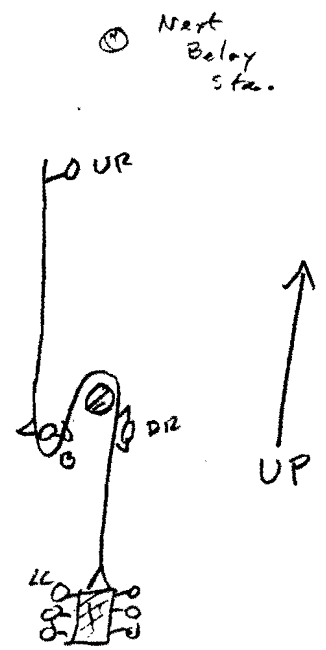

Figure 6.12. Semi-Technical Ascent.

When the litter arrives at the belay point, the litter captain (LC) calls for a stop, lowers the litter and calls, "Off Belay." The belayer answers, "Belay Off," drops his stance and clears the rope from around the tree. The uphill ropehandler, meanwhile, has heard these calls (they must be loud enough for him to hear), has chosen his belay site, and now establishes a new belay. As soon as he is ready, he calls "Belay On." The litter captain, when his team is also ready, calls, "On Belay," raises the litter and starts up.

The old belayer rotates into the downhill ropehandler position, while the old downhill ropehandler rotates into the uphill ropehandler spot. The rotation scheme is diagrammed in figure 6.13. The mnemonic is "roll uphill."

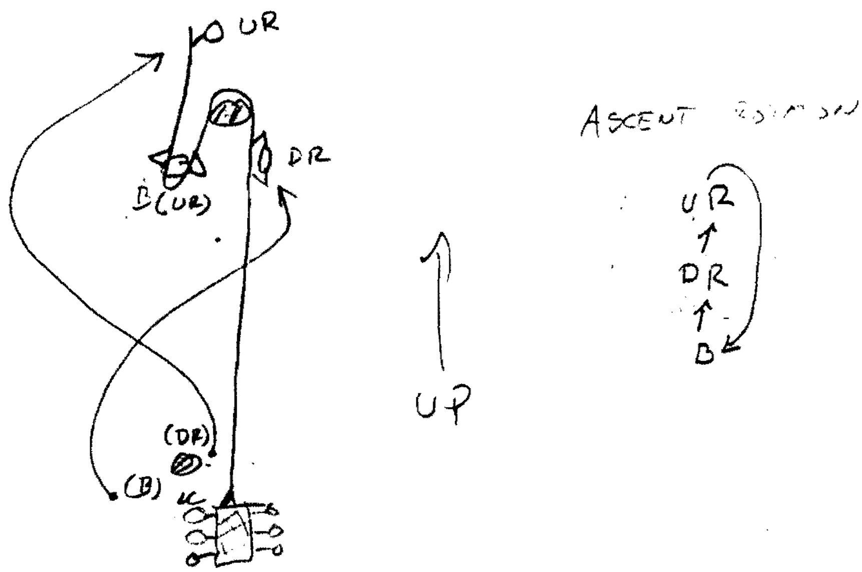

Figure 6.13. Ascent Rotation

A strong belayer can restart the ascent within a few seconds of the stop by belaying without a ropehandler. This is tiring, however, so the former belayer should hustle up to the new stance to relieve tree friction as soon as he can. Nevertheless, the two moving up should swing wide to avoid kicking rocks on the litter team.

If a fourth person is available to serve on the rope team, the efficiency of the ascent procedure can be enhanced considerably. The four rope team members form two pairs, each consisting of a belayer and a ropehandler. As one pair belays, the other carries the rope uphill to the next stance. Using this modification, the belayer need never belay unassisted.

3) The Brute Force Hauling System

When the slope is too steep or unstable for the litter team to ascend under its own power, the litter team is reduced to three (two at the shoulders and one at the foot), and the hauling system shown in figure 6.14 is used to forcibly raise the litter team up the pitch. Usually, the litter bearers will want to tie in to the litter.

The rope team divides itself into two groups (three per group is usually adequate), and each member ties in to the rope with a prusik knot on his litter bearer tie-in.

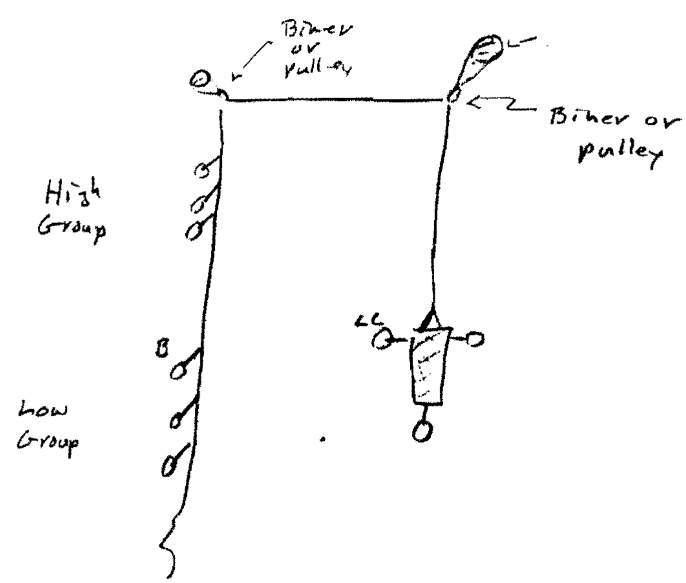

Figure 6.14. The Brute Force Hauling System.

The highest person on the low group is the belayer, since he can most easily judge the distance between groups and can be most easily heard by all of the rope team.

The belayer exchanges the usual calls with the litter captain, the litter team lifts and preloads, and, on "Up Rope," the low group locks prusiks and descends, hauling up the litter. After 20 or 30 meters, the belayer calls, "Ready, Switch," and the high group locks prusiks and descends while the low group unlocks and hand-over-hands up the rope. Just before the two groups collide, the belayer calls again, "Ready, Switch," and the procedure is reversed so the high group is climbing and the low group is descending. The cycle continues until the litter captain calls "Stop." On this command, the entire rope team stops and locks prusiks until the litter is off belay. The anchors are then cleaned and the rope team moves up to the next belay site.

During the ascent, the litter team's primary concern is providing the patient a smooth ride. This usually means that the litter bearers cannot assist the rope team in raising the litter, and, in fact, will usually need to lean into their tie-ins, thus increasing the load on the belay. A six-member rope team can supply enough force to raise a litter team under these conditions, but it is prudent to put light people on the litter team and heavy ones on the rope team,

VII. SOME COMMON TECHNICAL PROCEDURES

A) THE Z HAULING SYSTEM

A 3:1 mechanical advantage can be achieved on a haul line by the use of the Z System, illustrated in Figure 7.1. The Z is very useful for raising litters, tightening Tyrolean Traverses, and hauling equipment.

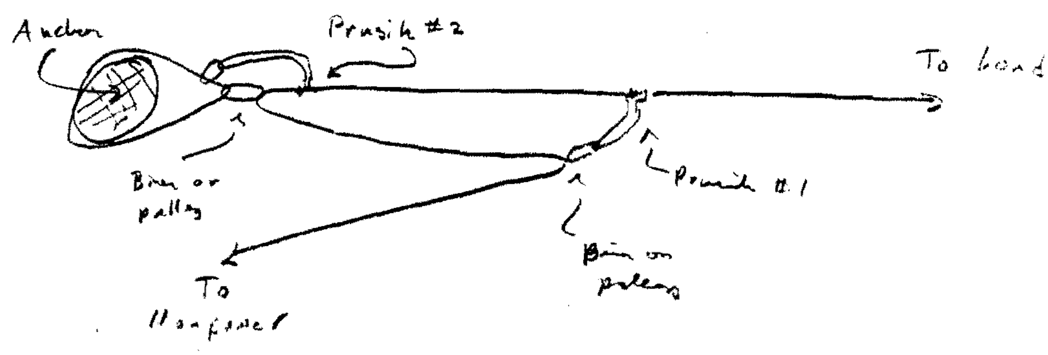

Figure 7.1. The Z Hauling System

The following points should be observed when using the Z:

1) Although the system's mechanical advantage is 3:1, its efficiency is reduced considerably

by friction of the rope running over rocks and the carabiners in the system. Using pulleys on the carabiners reduces friction substantially. Consequently, any means available for relieving friction of the rope against the rock is worth the effort. Running the rope over an ice axe shaft or through a freely suspended biner is a great help. These measures also protect the rope from abrasion.

2) For heavy loads (such as litters), high strength ratchet knots, such prusiks with 7/16 inch polypro or headden knots with 1 inch tabular webbing, must be used. Mechanical ascendeurs must not be used for hauling people.

3) As the rope is pulled, the distance between the two prusiks will, of course, decrease. The Z must not be allowed to straighten, however, or the mechanical advantage will be lost. The purpose of prusik #2 is to hold the system tight while prusik #1 is slid back out for another pull. Prusik #2 must not be permitted to slip through the anchor biner.

5) Sometimes it is necessary to add hauling force to a rope which is already in tension and cannot be bent into the configuration shown in figure 7.1. In such a case, a Z system made from another rope can be added on as shown in figure 7.2. This

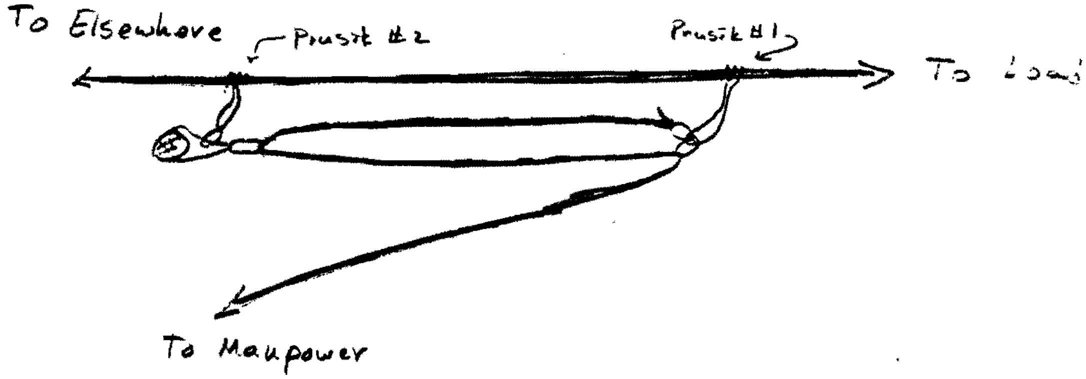

Figure 7.2 Snap-On Z Hauling System.

configuration is sometimes called a "snap-on Z," as opposed to the configuration of figure 7.1, which is called a "conversion Z."

B) THE ZIP LINE

The Zip Line is a quick method of transferring equipment (but not people) from the top of a cliff or steep slope to the bottom. A double rope is rigged from an anchor at the top to two people (or one person and another anchor) at the bottom. See figure 7.3. The equipment to be

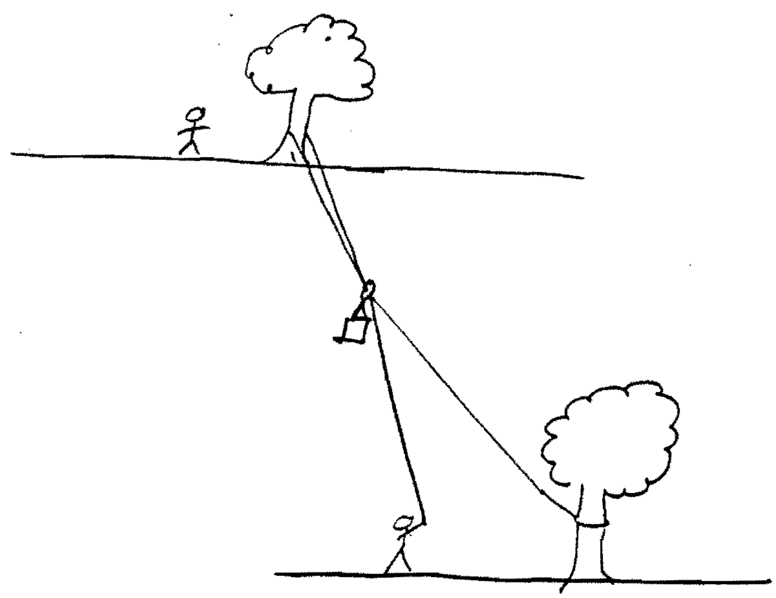

Figure 7.3. The Zip Line.

transferred is clipped to both ropes and allowed to slide down. The rescuers at the bottom can control the rate of descent of the gear by separating the rope ends to slow it, or bringing the rope ends together to let it drop more freely. It is usually necessary to let the load slide freely at first and then slow it near the bottom.

C) THE TYROLEAN TRAVERSE

A Tyrolean Traverse is a rope stretched tightly between two anchors and reaching across a difficult or dangerous obstacle such as a stream or deep ravine. The traverse is used to quickly and safely transfer people, litters and equipment across the impasse

1) Rigging

Unless the rope can be thrown to someone already on the far side of the impasse, one person must cross in order to rig the traverse. First, however, he loops the rope around the anchor on the near side and then carries the two ends across. Once on the far side he rigs an anchor, ties one rope directly to it and rigs the other in a Z System, which he then uses to tighten the traverse as much as he can. An example of a typical arrangement is shown in figure 7.4. It is highly desireable to rig the traverse to slope gently downward if possible. This makes crossing much easier.

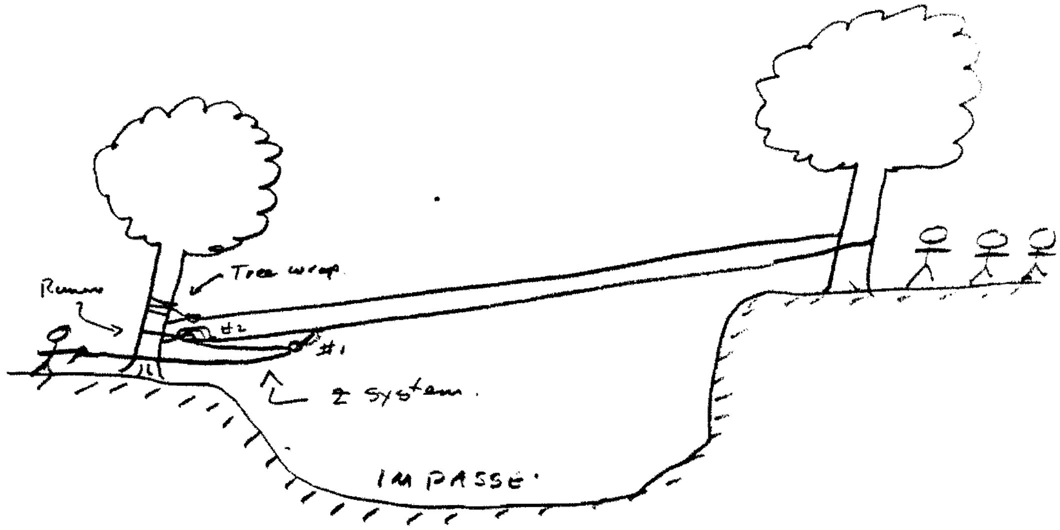

Figure 7.4. Rigging a Tyrolean Traverse.

When the traverse is tight, prusik #1 is removed and the free end of the rope is tied in to the hauling system anchor (or tree-wrapped to a tree) to back up prusik #2. Since prusik #2 must bear half the load of the traverse, a high strength ratchet knot (prusik in 7/16 in polypro or Headden knot in 1 inch tube) must be used there if the traverse will carry a litter.

The doubled rope scheme is used mainly to make the traverse retrievable once everyone is across. Single rope traverses are perfectly safe, and frequently necessary.

2) Traversing

a) Equipment

Equipment is simply clipped to the traverse and hauled or lowered by a tag line as shown in figure 7.5.

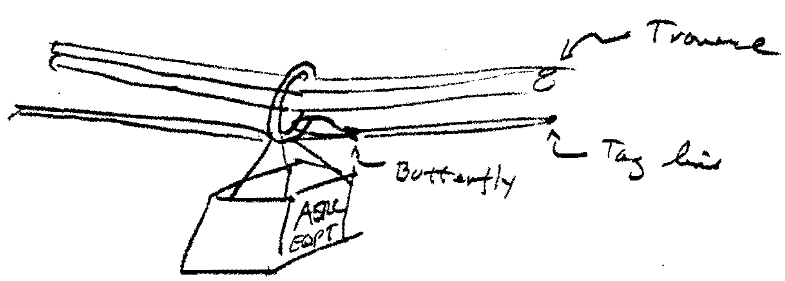

Figure 7.5. Transferring equipment on the Tyrolean Traverse.

b) People

The individual rescuer clips to the traverse as shown in figure 7.6. The extra carabiner makes it easier to get on and off the traverse, and also protects the seat locker

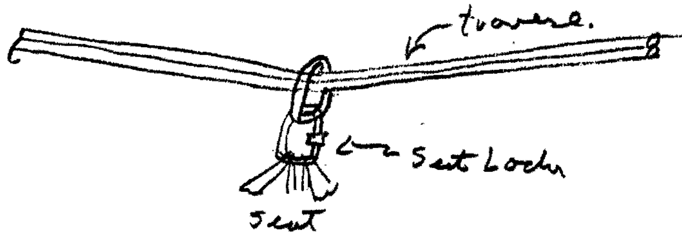

Figure 7.6. Clipping to a Tyrolean Traverse.

from overheating and melting the seat*. Gloves prevent rope burns and protect the hands when they (inevitably) get pinched in the rigging.

After mounting the traverse, the rescuer calls, "On Traverse" before starting across; he calls, "Off Traverse" when he has dismounted on the far side. An etrier at each end of the traverse facilitates the somewhat awkward processes of mounting and dismounting a high traverse.

Unaided uphill traverses are always ~~unpleasant, and become impossible at surprisingly low angles. Standard prusik~~

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*Traversing slowly is a better guarantee! Take it easy.

technique, however, is easily adapted to negotiating uphill traverses -- and even makes the process bearable.

c) Litters

The litter can be clipped to the traverse using four runners, or, better yet, a pair of spiders, as shown in figure 7.7 — The litter is hauled across the traverse by a tag line tied to both biners and running to both ends of the traverse. Pulleys are seldom really necessary.

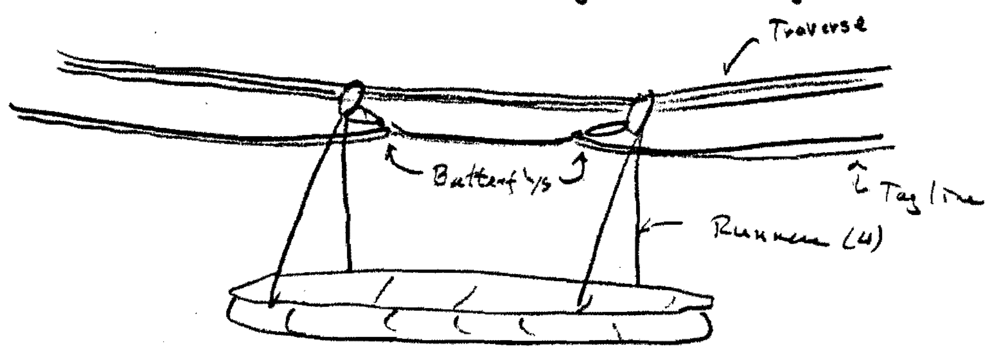

Figure 7.7. Rigging a litter to the Tyrolean Traverse.

If the medic wishes to ride along with the litter, he clips in in the usual way, or he may hang from one of the litter biners by his litter bearer tie-in.

D) RAPPELLING

Rappelling is a rapid and convenient means of using a rope to descend steep terrain. The rope runs from an anchor at the top of the pitch to the bottom, and the rescuer, by one of several methods, uses the rope to control his descent. When used cautiously and with close attention to the details of rigging and technique, a rappel is quite safe and efficient; used carelessly, it is exceedingly dangerous.

1) Rappel Rigging

A bottom-retrievable rappel can consist, quite simply, of a rope doubled and run around a tree or other secure anchor as in figure 7.8.
→ ☆ A single-rope rappel (not bottom-retrievable) can
INSERT FROM p7-9 be rigged by tying the upper end of the rope to any suitable anchor. (See figure 7.8.) In

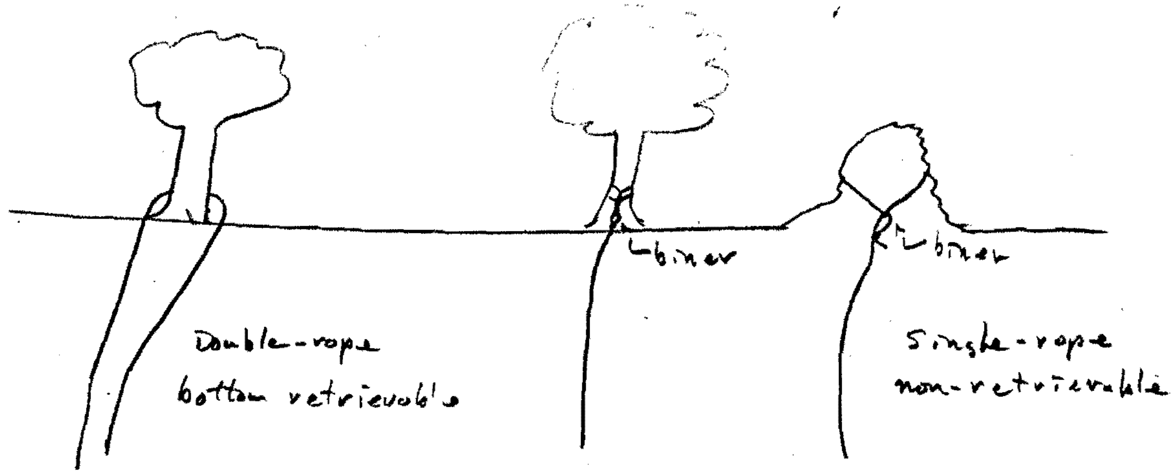

Figure 7.8. Rappel anchors.

either case, the anchor must be strong enough to withstand at least four times the weight of the user. Furthermore, the anchor must be checked frequently during use since, under the intermittent stresses of rappelling, knots loosen and anchors become misadjusted. Anchors, such as tree-wraps and girth-hitched runners, which are resistant to these unhealthy maladies, are, of course, preferred, but cannot always be rigged.

When the rappel is to be rigged from a fixed piton or a bolt, or when a runner and a descending ring can be sacrificed, a bottom-retrievable rappel using a single rope can

Check spelling

be rigged using a "reepschnür," or retrieving line. The end of the rappel rope is passed through the anchor ring and a stopper knot, such as a figure-8, is tied to keep it from slipping back out. To the knot, a reepschnür made of light rope or p-cord is tied and run down the pitch parallel to the rappel rope. When the rappel is no longer needed, the rescuers at the bottom simply pull on the reepschnür to retrieve the rope. The anchor is left behind.

In absolutely desperate circumstances, where the rescuer must rig a single-rope bottom-retrievable rappel and he does not have the materials for a reepschnür, he can use the "cut sheepshank" technique. The rope is anchored in the usual way, but just below the anchor, the rescuer ties a three strand sheepshank and cuts (!) the non-load-bearing strand. (See figure 7.9.) Being very careful to keep constant tension on the rope, so as not to allow the sheepshank to fall apart, the rescuer rappels. Once off rappel, a sharp shake of the rope from the bottom causes the sheepshank to disintegrate and the rescuer retrieves his rope. Again, this is a desperate, technique!

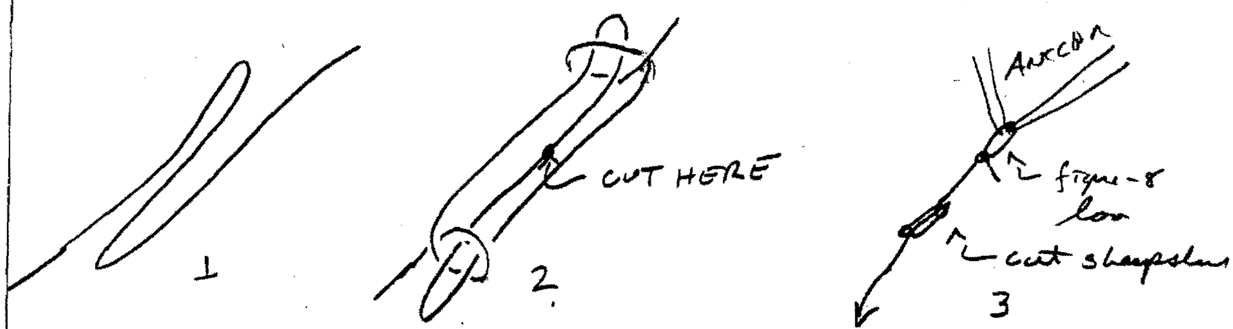

Figure 7.9. The Cut Sheepshank.

Whatever anchor or rigging system is chosen, the rappel must be placed where the inevitable motion of the rope will not dislodge rocks or cause dangerous abrasion. The abrasion problem is particularly severe: many a rappeller has been surprised by the rapidity with which abrasion can part a rappel rope as it scrapes, loaded, across even a dull rock lip. Side-to-side motion can often be avoided, but it is not the only culprit. Up-and-down motion caused by the rope stretching and relaxing is just as important and cannot be completely eliminated. When the rope must run over an abrasive rock formation, the danger can only be relieved by careful padding as described in section III - ? - ?.

Ordinarily, one has no difficulty insuring that the rappel rope actually reaches the bottom of the pitch, and it is important to see that it does. Whenever any doubt exists -- and sometimes such "blind rappels" are necessary -- a knot is tied in the end of the rope and the first person down goes prepared to prusik back up. The knot is to prevent him from accidentally rappelling off the end of the rope -- a maneuver which is considered exceedingly poor form.

2) Rappel Technique

The basic technique of rappelling consists in the rescuer attaching some kind of braking device between the rope and his seat harness, and then walking backward down the pitch using the friction of the brake for control. Rappel brakes are discussed in

Section II - ?.

It is possible, however, to rappel without mechanical braking device. Two rappel methods, the dulfersitz and the arm rappel, which rely upon direct friction of the rope on the user's body, are discussed in sections 3 and 4 below. The arm rappel is quite different from the others, but the dulfersitz utilizes essentially the same technique as the mechanically braked methods.

Proper rappelling form is illustrated in figure 7.10. The uphill hand is called the "balance hand," and generally serves no function except as an aid to balance. Consequently, it may be removed from the rope whenever the rescuer needs a free hand. The downhill hand is called the "braking hand," and serves to control the braking force, and thus the rate of descent. Under most circumstances it is best to have the thumb of the braking hand point downhill, and that of the balance hand point uphill, although many find it convenient, when using a high friction brake (such as a rack), to reverse the braking hand.

Some people prefer to run the rope through the crotch, since that configuration allows recovery to the dulfersitz in the event of a brake failure; others prefer to run the rope over the hip.

The attitude of the body is important. The shins are kept roughly perpendicular to the rock in order to maximize friction against the feet, the knees are slightly bent, and the back is straight. The temptation to try to stand vertically should not be yielded to except under unusual conditions. The rescuer looks down over the shoulder of the braking hand -- not between his knees. These points are mainly important to keep good control over the rappel, but also they help keep equipment, clothing and hair from fouling the brake.

On a free rappel, that is, on an overhanging face with the feet out of contact, the body position will be more upright, relieving stress on the balance hand.

All movements on rappel should be slow, deliberate and smooth. A jerky rappel puts unnecessarily high stresses on the system, loosens the anchor, abrades the rope, and knocks down rocks. A fast rappel can overheat the brake to the point of melting the rope, and it increases the risk of missed steps and loss of control. A "bounding" rappel is the worst combination of jerkiness and speed, and is an invitation to disaster. A useful technique is to take one step at a time, always leading with the foot on the braking hand side. This motion produces a smooth, graceful rappel -- the key to long life.

Getting started is usually the hardest part of a rappel because the rescuer must negotiate a lip at the edge of the cliff while the anchor is still too low for the rope to provide much stability or upward support. (See figure 7.10.) Getting started can usually be facilitated by spreading the legs wide apart and squatting over the edge as low as possible before stepping down. In more difficult cases one can try sitting on the edge and then slithering off sideways. In extreme cases it is necessary

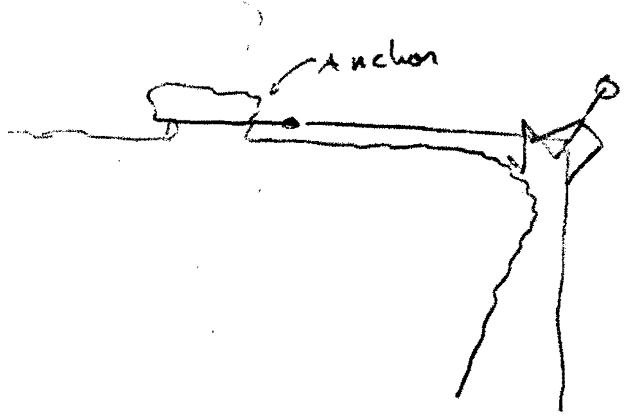

Figure 7.10. Starting a Rappel.

climb over the edge and take up the rappel below. Jumping off is extremely dangerous.

Should the rescuer need to stop partway down a rappel and attend to some business or other, he can tie off the rappel rope to completely support himself and then free his hands. INSERT FROM p 7-18½ There are several methods for accomplishing this end. Jam methods for the figure-8 descendeur and the rappel rack are described along with those brakes in section II-?-?. Any mechanical brake can be tied off by tying two half hitches on the loaded rope with a loop of the free end and then clipping a biner from the loop to the loaded line, but this tie-off can be difficult to undo. Some people like to tie off by tying a prusik loop to the rope and then clipping to it, but that scheme can be very difficult to get out of if the tension on the prusik loop cannot be relieved. Also, if the loop is too long, the knot can get out of reach.

All of these methods have their uses, but the simplest tie-off for a momentary stop is just to wrap the rope around one leg several times and throw the free end over one shoulder.

3) The Dulfersitz Rappel

The most elementary rappel system is the dulfersitz, or "hotseat" rappel. Its main attraction is its simplicity: since the entire braking force is obtain through friction between the rope and the rescuers body, the dulfersitz requires no special equipment. For the same reason, it also serves nicely to very directly impress upon the novice the magnitude of the forces and the quantity of energy involved in a rappel. It demands good technique.

The dulfersitz rappel is executed in essentially same manner as mechanically braked rappels except that the rope is passed around the body as shown in figure 7.11. The

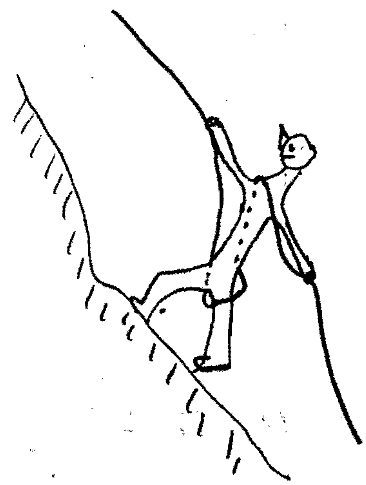

Figure 7.11. The Dulfersitz Rappel.

configuration shown is that usually preferred by right-handers, but each individual must decide for himself which hand to use for the braking hand and which to use for balance.

When rappelling with the dulfersitz, the rescuer should take care to keep the rope out of his crotch, and instead keep it running on the upper part of his thigh -- a somewhat more durable spot. He must also be particularly careful to keep his back straight, especially during a free rappel. Once bent over, it is very difficult to straighten up again.

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4) The Arm Rappel

The arm rappel, like the dulfersitz, is simple to implement and requires no special equipment, but is only suitable for gentle slopes. It is especially useful on easy slopes made treacherous by unstable footing, where its advantage over the dulfersitz is that it provides a more appropriate amount of friction as well as being easier to use and much more comfortable.

The arm rappel is illustrated in figure 7.12. The rescuer steps up to the rope backwards, reaches over and takes one turn around each arm. He then walks sideways down the slope.

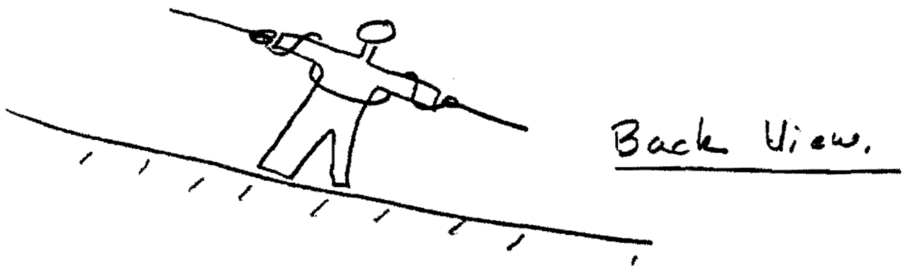

Figure 7.12. The Arm Rappel

5) Rappel Safety

Safety is of preeminent concern throughout mountain rescue, of course, but it becomes particularly problematic in the matter of rappelling. The trouble is not that rappelling is intrinsically dangerous, but rather that its supposed spectacle tempts the unwary into a risky imprudence -- and gravity does not forgive mistakes. Except, perhaps, in the view of the novice, a carefully executed rappel is not particularly spectacular or exciting. For a sensible person, the rush of adrenalin that accompanies the realization that one is hanging over the Great Abyss by a few threads of nylon soon gives way to a practical determination to keep control. Maintaining that control is, of course, the key to long life; consequently, the proficient mountaineer, caver, or mountain rescuer prides himself, not in skillful descent by death-defying leaps and bounds, but rather in the craftsmanship he demonstrates in assembling and executing a smooth and secure rappel. As the saying goes, "If rappelling is fun, you're doing something wrong."

In addition to the safety precautions already mentioned, a few other important points are listed below.

a) Always wear gloves or mittens, even when using a high-friction brake. Gloves give the hands some resistance to being pinched, and offer the chance of recovery to a dulfersitz should the brake fail.

b) Tuck in shirt tails, roll or button long sleeves, and tie long hair back out of the way. Clothing and long hair can easily get caught in a brake, jamming the rappel and discomfiting the user.

FOOTNOTE ON P 7-22½

c) Always belay beginners, and always honor anyone's request for a belay.* A rappel can always be belayed in the usual way with a separate rope, but a rappel using a mechanical brake can also be belayed from the bottom. In the event of a fall, the belayer quickly pulls the slack out of the rope and then applies his own weight to it. The tension thus created will clamp the brake.

d) Use the call "On Rappel" when beginning a descent to warn those below of the danger of falling rock and to warn them not to tamper with the rappel rope. Use the call "Off Rappel" after getting completely free of the rope to announce that it is again available.

e) Visually recheck the system -- anchor, rope padding, brake configuration, locker sleeve and seat knots -- just before starting the rappel. There are few opportunities to correct defects once the descent is begun.

f) Set an example of caution and craftsmanship for all those who watch.

E) Prusiking

Prusiking is the technique of ascending a fixed rope by means of ratchet knots (classically, the prusik knot) or mechanical ascenders. It makes possible the easy and convenient ascent of steep faces which would otherwise be difficult or impossible to climb.

The art of prusiking is very highly developed, particularly among vertical cavers, and many elegant methods have been devised to satisfy personal preference and the demands of special circumstances. For the sake of simplicity, however, only one very elementary method, the Texas Y, will be presented here. The reader interested in pursuing the subject further should consult the references listed in chapter I.

1) The Texas Y Rig

The Texas Y is simple, safe, reasonably efficient and can be used with either knots or mechanical ascenders. The rig is illustrated in figure 7.13.

The prusik slings themselves are ordinarily made of 5 mm nylon rope. Larger diameters do not hold reliably and smaller diameters have doubtful strength. Many vertical cavers, however, find that larger diameter (3/8 inch, or even 7/16 inch) polypropylene prusik slings

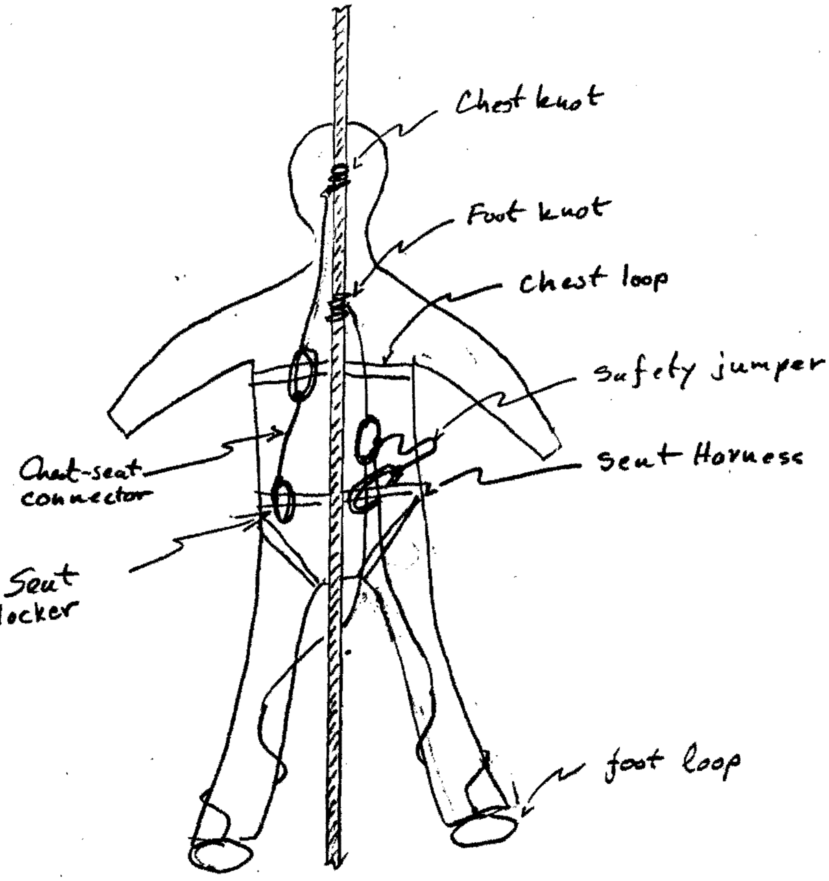

Figure 7.13. The Texas Y Prusik Rig.

hold very well, even on wet rope. Normally, the knots are prusiks, but if webbing must be used for prusik slings, heddon knots should be used instead. Mechanical ascenders used in place of knots increase the efficiency of the rig greatly.

The chest loop is tied to the seat through the chest-seat connector so that the rescuer is comfortable when supported only by the chest knot.

The name of the rig derives from the configuration of rope connecting the feet to the foot knot. Ordinarily, the "Y" passes through a biner clipped to the seat, but, in a pinch, it can simply pass under the seat webbing. Some people even prefer that configuration; the nylon on nylon friction problem not being severe. The foot loops should be snug figure-8 loops. Some people prefer to girth hitch around the instep to keep the loop from coming off, but this restricts circulation and can be dangerous in the winter. Passing the leg ropes around the calves (to the outside first) is sufficient to keep the feet in their loops.

Although the safety jumper is not essential to the operation of the rig, it is an important safety feature. Without it, should the chest knot fail, the rescuer might end up in a very ungraceful upside down squat. With it, he can be spared this indignity. Similarly, the simultaneously raise the chest knot as high as it will go. Again hang from the chest knot and repeat the procedure. Several cycles may be necessary to stretch the rope and actually get off the ground. To rest, simply straighten the legs and hang from both knots.

Spinning is often a problem, particularly with twisted lay ropes. It can be prevented by keeping the toes on the rock, but under an overhang there is not much help for it. Spreading the arms and legs will slow the spin, but not stop it.

Getting over the lip of an overhang is accomplished mainly by brute force. With both knots as high as possible under the lip, stand in the foot slings and with one hand pry the rope away from the rock while raising the chest knot with the other. It isn't easy. Gloves help. Exploit any available foot holds to their fullest advantage.

If this approach fails, tie a third prusik sling above the lip and hang from it while moving the other two knots over the edge. Jumars, and similar ascenders that chest-seat connector may seem a nicety useful only in making the rig more comfortable, but without it, should the foot knot fail, the chest loop would soon prevent respiration -- another unseemly embarrassment.

The whole rig must be adjusted to suit the individual user. The chest knot should be high, but not out of reach when fully extended. The chest-seat connector should be just long enough that the chest loop and seat comfortably share the load when the legs are flexed. The carabiner at the junction of the "Y" should be just barely above the seat when the legs are extended and the foot knot should slide to just below the chest knot when the legs are moderately flexed. The safety jumper should come taut at the same time.

2) Technique

Starting with both knots as high as they will go, hang from the chest knot, raise the feet and slide the foot knot up under the chest knot. Then, stand up (loading the foot knot) and can be operated with one hand, can simply be unclipped from below the edge and clipped back on above.

3) Prusik Safety

Prusiking is quite safe, but, as with all climbing techniques, small errors lead to large consequences. Some particular points to be watched follow.

a) Observe all the same anchorage precautions with prusiking as with rappelling.

b) Tie the prusik knots properly and neatly; and keep them neat on each new set. A distorted prusik will slip.

c) 7 mm is the largest prusik sling which is reliable on 11 mm rope; 5 mm is the largest on 9 mm rope.

d) Prusik knots and ascenders frequently slip on wet, icy, or muddy ropes. If prusiking on a slippery rope is the only means of escape from a desperate situation, try a multi-turn heddon knot; otherwise, go around.

e) Prusiking on a doubled rope works well, but watch the knots carefully: they tend to distort easily.