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Message from the Editors

Wm Shrewsbury, NSS #22677RL
Liz Shrewsbury, NSS #35939FR

It has been an exciting year. I have been appointed the new Nylon Highway editor, and my wife Elizabeth has spent a large portion of time typing in the handwritten articles we've received. We have a lot of catch up to do.... Starting with this issue, an author's location will be published. Some of the articles we have received use terms and principles that are just plain different from other areas. This issue's feature article is from Kenneth Laidlaw. A little technical in nature, but a good article for the techies out there.

Our past editor, Jeff Power, has left the NSS (the BOG actually rescinded his life membership due to theft of moneys from the Vertical Section) but more tragically he took all of your articles with him. Money we can raise - your articles can only be replaced by you.

If you have sent something for publication, please resend it. I use MS-Word, but can read most formats. Reasonable handwriting is gladly accepted. E-mail submissions are even better. We can only print what we receive. Please take a couple of nights and tell us about your latest discovery or modification. It is in our best interest to be as skillful and knowledgeable as possible. Looking forward to printing your submissions!

We need photos! Have you taken a photo that raises eyebrows at your meetings? How about one that gets good laughs? Maybe a cave oriented cartoon? Send them in, or else you'll get stuck with whatever I find or take.....

Thanks,

Wm & Liz Shrewsbury

Front Cover
Big Horn Cave, Wyoming - Drawing by Linda Heslop.

Right
Editor exiting a pulldown through Carpenter-Swago, a wet multi-drop system in West Virginia. Photo by Liz Shrewsbury.

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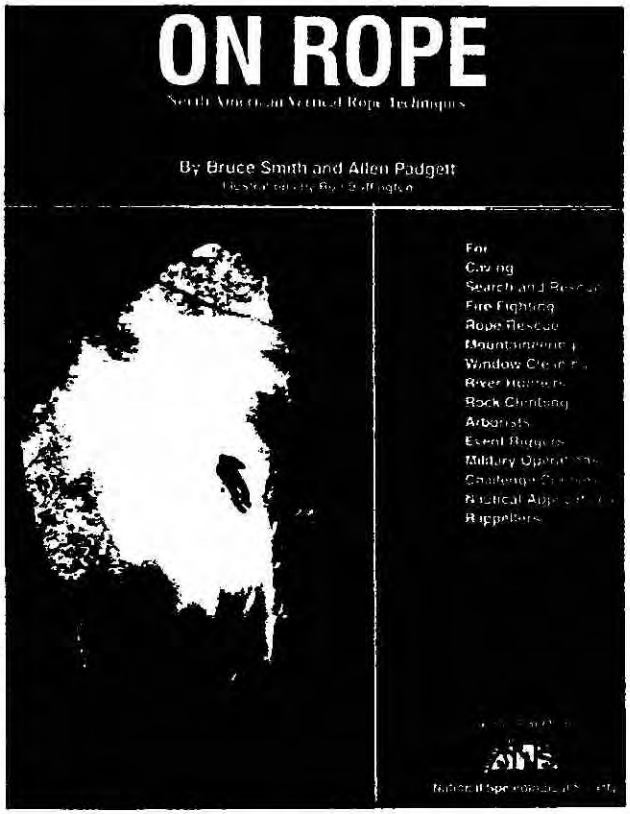

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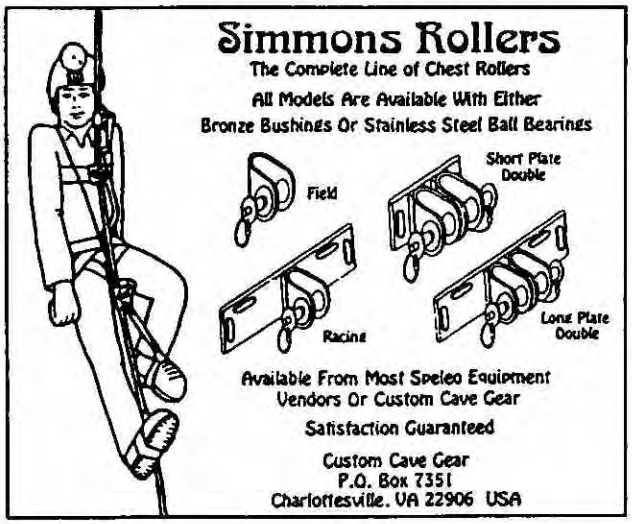

Beginning Vertical Work

by G.T. Sanford III, NSS #39350 (Nolensville, TN)

At the 1994 annual convention of the Nature Conservancy in may, a friend of mine and I were privileged to participate in numerous activities sponsored by the Conservancy at Fall Creek Falls State Park near Pikeville, Tennessee. Two of the activities that appealed to us were rappelling and caving. The rappel activity was limited to 12 people and would involve going down a 40 foot drop. The caving activity would be exploring Indian Cave near Sparta, Tennessee where there are pictoglyphs dating back to the 1400's.

I won't relay all the specifics of those two days except to say that my friend and I fell in love with both activities and decided to actively pursue the acquisition of knowledge and equipment in both areas. Our first stop was at a local sporting goods store where we inquired about rappelling lessons. We were given the name of the local guru whom we would contact later.

While we were at the store, we started looking at the plethora of items available to the rappeller/caver. Wow! Who would have thought that such a large quantity of similar items existed? We were overwhelmed. There was a whole wall covered with just harnesses. Another with figure eights, carabiners, pulleys and other unidentified hardware. Yet another had helmets, lights and canvas bags. We decided that we didn't know enough about this business to start the learning process. It was kind of like that saying "You can't get there from here." We collected some catalogs and went home to start learning not only what was available, but what it was to be used for. We also bought a most excellent book, "ON ROPE". ON ROPE is published by an organization called the NSS: National Speleological Society.

From the book we learned that it was possible to combine our two new-found interests by rappelling into caves! What a concept! We decided that the 90 minute drive to Huntsville, Alabama to visit this society was the next order of business. We did this and we found the two ladies there to be very congenial and we joined up on the spot. We also acquired more catalogs, pamphlets and flyers listing even more things that piqued our interests. We learned of an annual convention by the NSS and that groups called "grottos" held local annual conventions and caving events, and that we lived half-way between two of them!

By this time, we had read quite a bit of ON ROPE and had learned some amazing things, such as "going up a rope". Our first encounter with a rope and hardware at Fall Creek Falls had been limited to the use of gravity in going down the rope. Going up the rope was never even mentioned. As we continued reading the book, we realized that there were simply too many variables, too many choices, too many decisions for novices to have to make in light of the seriousness of hanging your life on a small length of nylon.

We finally contacted our instructor and set up a date to go for our first lesson. It would involve multiple rappels down a 90 foot vertical face. I also called a couple of equipment suppliers to get updated catalogs. One of the suppliers told me that during our first class, we should try as many different harnesses and hardware combinations as possible to find out which one suited us best. Aha! Our first clue to solving the correct choice of equipment: find the one that suits us best! We were not quite sure what this meant, since the harnesses we had seen so far have been adjustable, and hardware is designed for a certain purpose; but, we would see what we would see, and we decided to try everything we could.

We have been thinking a lot about getting our own equipment and what we should buy. There is such a large quantity of things available, and each one of those comes in different sizes, compositions and colors. We have been reading everything

we could get our hands on about going up and down rope. We have studied hardware specifications and combinations and practical applications and scrutinized drawings and listing and comparisons and and and...and we still don't know what to do. As an example, we decided that we would buy only stainless steel carabiners. We determined that we wanted the strongest materials available in the hardware we would use, and from all indications, stainless steel was at least twice as strong as aluminum. Even after discovering that stainless steel was more than twice as expensive as aluminum, we still didn't want to settle for second best; more on this later.

The day of our first class finally arrived. We met at a Waffle House and then drove for about half an hour to the site. It was a manmade bluff with caves where there used to be an underground restaurant. From the base of the cliff, we were disappointed that it looked so small. It was a considerable hike to the top of the bluff, following an old cow trail twisting through trees laden with poison ivy.

Reaching the top we discover that the place is used so often that there is a permanent rope pad of old carpet attached to the top and side of the site. We get into the basics of knot tying and which knots are appropriate for different applications. We then rig two ropes to a large tree, using a tensionless attachment to eliminate the rope having to turn sharp corners. One rope will be used for descending/ascending and the other will be used as a belay. About 10 feet from the edge, we tie a butterfly knot into the belay line and attach a small rack and ascender. The rack will be used as a belay device and the ascender will lock off the belay line should the need arise.

To our dismay, there was only one choice of harness to try out, but after using it, we realize that it is the only one we will want to use (having already tried two others at Fall Creek Falls). Now we are ready for the first rappel of the day.

Being a short drop, the instructor hands me an aluminum figure 8. It is showing signs of wear from previous drops, and I think I recognize small parts of it that are now being used to add color to the rope. I attached to the rope and back down the slight incline to the edge of the drop. I am amazed at how ninety feet can look like so much more from a different perspective. With the instructor guiding me, I lowered my rear-end until it is even with my feet and I started my descent. The first drop was as exhilarating as I hoped it would be.

This sport is so much fun. When I reached the bottom and started to release myself from the ropes, I made two observation. The first is that this figure 8 is hot enough to burn bare fingers (thank goodness mine are covered), and the second is that my nice new gloves are now stripped with the same color as this hot piece of aluminum. This drop is a little over twice the distance that we dropped at Fall Creek Falls, but I don't remember any heat at all during that descent. This little bugger is HOT. I tried to speed up its removal so that the rope doesn't melt. As I leave the base of the drop, I yell "Off Rope" to signal that I am safely away from the rock fall zone so that the belay line can be hauled up and the next rappeller can start their descent. I asked the instructor about the heat buildup and he assured me that there is nothing to worry about. Friction and heat go hand in hand with rappelling devices.

After a few more drops with the figure 8, I switch over to a 6 bar rack. The instructor explains its theory and use and shows me how to adjust the bars to create more and less friction. After attaching to the rope, I started to back down the incline just as I have been doing all morning. But something is wrong. I had to use a lot of effort to back up. I realized that the rack is generating a lot more friction than the figure 8, so I tried separating the bars to eliminate some of it. I was able to progress a little faster, but I still felt as though I am having to feed the rope into the rack all the way down the drop. With my weight on the rack, it was nearly impossible to move the upper bars, so I resigned myself to a slow rappel. (After further reading on the subject, I discovered that most people use spacers between the

upper three bars to eliminate the problem I was having.)

It was at this point that I decided I wanted to try going up the rope. The instructor recommended a ropewalker system with a chest roller. He followed me down the rope and just as he was about to touch bottom, he turned to look at the approaching ground and got his hair caught in the rack. Ouch.

As I approached him to help, he was standing on his tiptoes trying to relieve the pressure on his hair. I put my weight on the rope, which stretched just enough for him to release the rack from his harness and free his hair. He then proceeded to tell me of the hazards of long hair and rappel racks.

I don the ropewalker system, consisting of a left knee harness, a right foot harness, a chest harness with roller and an ascender connected to my seat harness for safety. It takes a few minutes to get each of the devices attached to the rope, but I finally did and I started to climb. I didn't go anywhere. As I lift my foot, the rope comes up with it. The instructor showed me how to pull the end of the rope up to simulate the weight of the rope and I slowly started up. This is work!

The first few steps are required to take the stretch out of the rope before I actually started making progress. It takes a little while before I can judge the correct size of step to take so that I am somewhere between too small to make any progress and too large to be able to lift my weight with one leg. The bluff is too close not to pay attention to, and I have to keep one hand on it so that I don't spin around and hit it with my back. Negotiating the lip was rather awkward with the chest roller, but after pulling the pin and releasing it, I am able to stand to a crouch and make it over.

I was now completely worn out and ready to call it a day. The numerous rappels, the numerous tenth mile hikes up to the top of the bluff, the one rope climb and the ninety-five degree heat have all taken their toll. But, I now have some good instruction and practical experience under the belt which will enable me to go further with my education. I was ready to order my own equipment and continue my practice.

Deciding which equipment to purchase was not an easy task. There are many points to consider for each item. My first step was to list all these items and the requirements for each.

I found myself tending to overlook the single most important piece of equipment for the rappeller - the rope. Your life will hang by this thread, and when you are backing off a cliff you will question the integrity of the rope as well as all the rest of the hardware. It is possible to rappel with nothing but a rope, using your body instead of a metal descender. It will not be as comfortable, as convenient, nor nearly as safe as when using hardware, but it can be done. Therefore you must be sure of your rope above all else. I recommend buying a new rope when you start out; refrain from asking your instructor if he would like to sell that old rope he has been carrying around in his trunk for the last hundred years; your life is worth much more. Be sure to buy enough for allow for a belay line, if needed.

A good rope is not always your friend, as you will experience if you go down one without proper clothing and gloves. It is important to protect your hands, since they are used for guiding and braking. Rope burns are very uncomfortable and can ruin an otherwise wonderful outing. Get a pair of gloves made for rappelling and wear them.

The second toughest question in equipment selection I had to ponder concerned the selection of a descender. Do I get a figure 8 or a rack? Whichever I choose, do I get aluminum or stainless steel? Here again I found myself very concerned with the strength issue. Stainless steel is my obvious choice, but are there other things to consider? What about wear? When metal starts wearing down, where does the worn away metal go? I remembered the gray stripe on my gloves and answered my own question: it goes on

and in the rope. That can't be good for the rope.

I decided that I didn't want the wear on one item to adversely affect the life of another, so I went for the rack with stainless steel bars and a stainless steel figure 8. Costs more now, but in the long run it will be well worth the extra dollars. I got both types of descender for a very good reason; for short drops I wanted something that could be attached to the rope very quickly, which the figure 8 can do. For longer drops, I wanted something that would allow a greater range of speed control and heat dissipation. A six bar rack meets this need very well.

Choosing the right harness for you will require some trial by fire. The only way to know if one fits is to try it on and the only way to get the feel of it is to go down a rope. Most stores don't have any provision for actually trying out their equipment. They also don't want to take back any used equipment. Maybe you'll be lucky and find a great harness the first time like I did. Maybe you'll also be lucky enough to live near the guy that makes the harnesses and can have him do some custom stuff for you.

What was it that my boss once said? Oh yeah, it was "We don't have problems, just opportunities". Well, just as going down a rope has its own set of "opportunities", going up a rope has its own set too. There are lots of different ascending systems in use today, and deciding which one you will use must be done before you can buy any equipment for it. I liked the ropewalker system that I used on my first course, but I wanted to be sure that there wasn't one better.

Above all, an ascending system must be efficient. You don't want to work yourself to death just to gain a few feet of rope. Even with an efficient system, it takes lots of practice to make the overall system efficient since you are adding your body into the equation. You want a system that gives you the most distance from a given amount of effort. The company that I got my harness from also makes a complete line of components for a ropewalker system. It consists of a chest harness with a Simmons roller, a right foot harness with a Gibbs ascender, a left foot harness with a knee-height Gibbs ascender, and a "cow's tail" to prevent a heel hang.

Carabiners. Who could have imagined the range of selection available? There are locking and non-locking; aluminum, steel, stainless steel, galvanized and mixtures of different alloys; oval, rectangular, D-shaped, and twisted; small, medium and large; and a host of colors. How is the novice supposed to chose the correct ones? I tried asking some salesman and I soon discovered that they tend to recommend what they have in stock, not necessarily what is best for the application.

After much thought, deliberation, an research, my friend and I decided to use a stainless steel locking D carabiner as the main attachment point on our harnesses. We would use aluminum ones for all other attachments, and the non-locking aluminum ones would only be used to hold extra equipment to our belts. We would also use stainless steel locking D's in our rope rigging. Should anything go wrong, we didn't want a carabiner to be the weak link in the chain.

Perhaps I have rambled on enough about my beginning experiences with vertical rope work and the decisions that the beginner will be faced with. I urge everyone to investigate the possibilities open to them and judge for themselves in the best course to follow. There are may good books and publications available to aid in the journey. One of the best sources of new equipment information that I found was the PMI Catalogue and Equipment Guide. It was free from my local supplier. It has page after page of very useful information.

(Editor's Note: A really great place to try out different climbing systems is at the annual NSS Convention. The Vertical Section's Training Course includes an afternoon of station swapping. Come try something different!)

Spacers for the Rappel Rack

by Mark Jancin, NSS #13011RE (Bellefonte, PA)

Recently I saw one of our grotto members had spacers on his rappel rack. He wondered what the optimum dimensions for spacers are, and if their use is generally a good idea. The following is my opinion on spacers for standard, 14-inch rappel racks.

Two spacers are used to fix a minimum distance between the top two brake bars. The spacers are of equal length, with one on both the short and long rack legs.

My motivation for using spacers came from sporadically poor performance of the rack on what should otherwise have been continuously smooth rappels. I (and others) have found that sometimes the two top brake bars move a little too close together, and the rope becomes pinched and stops moving smoothly through the rack. Although this never has proved to be a stopper to the rappels, it was an occasional inconvenience.

If you have four or more brake bars engaged, it is very hard to have your cradling hand move the second bar downward sufficiently to stop pinching the rope. One typically tries to overcome the problem by bouncing in the seat harness, feeding the braking line, decreasing rack friction, and so forth. This pinching problem may well be more typical for aluminum brake bars, as opposed to stainless steel.

Spacers will eliminate the potential for this pinching problem. The spacers on my rack are 18 mm long and made of heavy-duty nylon or plastic laboratory gas tubing that is internally reinforced with nylon thread. This tubing has an outer diameter of 14 mm and an inner diameter of 9 mm. This tubing fits quite snugly on the rack legs, but not so tightly as to be difficult to slide along the legs.

In general, spacer length should be between about 13 mm and 20 mm; I have seen spacers as short as about 10 mm. I consider my spacers' 2.5 mm wall-thickness to be about minimal. Maximum wall-thickness probably should not exceed about 4.5 - 5.0 mm -- generally, you do not want the rope to be in contact with the spacers during rappelling.

The exact nature of the spacer material is not terribly important, although heavy-duty air hose or lab gas tubing are good choices. The spacer material must be fairly rigid when loaded along its length, but it also must be flexible enough to go over the top of the rack on its journey to emplacement on the long leg. Alternatively, rigid metal spacers can be used, but this usually requires crimping the spacer onto the long rack leg. If you use metal be sure there are no sharp edges or points that can touch the rope.

I have heard some people opine that spacers are used to improve heat distribution among the top bars. I do not know whether use of spacers significantly affects the heat distribution -- regardless, I use spacers to eliminate the sporadic pinching problem. I have also heard folks maintain that using spacers decreases rappelling control unless you compensate by adding one or two extra bars. In my experience, if the spacers are of the appropriate dimensions for you (aye, there's the crux), this is not a problem. In fact, I find that spacers improve the degree of frictional fine-tuning I achieve through varying the spacing between the bottom two brake bars with my cradling hand.

Spacers unfamiliar to you can constitute a danger. Obviously, longer spacers decrease the inherent friction contributed by the top two brake bars. This decrease must be carefully attained. I recommend that if you put unfamiliar spacers on your rack you should practice rappelling under highly controlled, belayed circumstances until you have a good feel for the resultant friction. No one should ever rappel using less than three brake bars.

You must ensure that your spacer length is not so long as to make the use of three bars (with the fourth bar clipped in) too fast to be safe, if you are light enough to occasionally use three bars without spacers.

I am not convinced that all people need spacers. However, if you have had some encounters with the top two brake bars pinching the rope, consider trying spacers.

Editor's note: I use spacers made of rubber automotive gas line. It has thick walls, is nylon reinforced, is easy to obtain and readily field modified (a pocket knife removes it in a hurry.) One set of spacers has outlived 2 sets of stainless bars. Most people who use spacers place them between the first and second bars. Two spacers on each side is *normally* not used for short racks and is not recommended. Long expedition racks are an exception to this.

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Rope Coiling or Packaging Ropes

by Vance Nelson NSS #12853RL (La Canada, CA)
Drawings by Nancy Pistole
Suggestions from Mathew Oliphant

Have you ever carried a rope into a cave or in the cave and had the coils snag or start to come apart?

I believe that all rope users should know how to package (coil) a rope, for storage and easy handling. It's better for the rope and for the disposition of those handling or carrying the rope, it the rope stays in the configuration intended.

Making the Loops of a Coil

Two Knees - Sit and spread your knees to make the size coil you desire. Wrap your knees with the rope, keep tension on your spread knees consistent so that the coil will be uniform.

One Knee & One Foot - Wrap your foot and knee for a smaller coil. The size of the coils can be adjusted to some extent by how much you bend your knee and how far up your thigh you make the wraps. (Editor's note: for larger coils, both knees and feet can be wrapped.)

One Hand - Drape the loops over your left hand with your right hand, hold the loops with the left hand as you pull up more rope for the next loop. Regulate the size of the loops by how far you pull your right hand away to the side and the distance to the other hand that is holding the coils. With care, you can get a decent coil. There are two ways to reduce the twisting tendency of the loops.

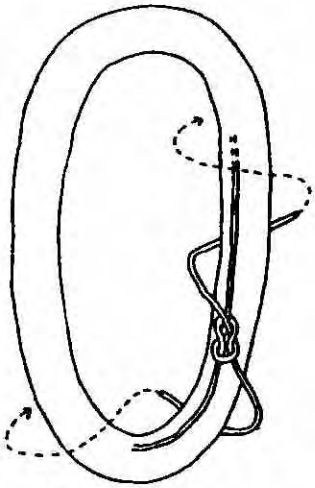
1. Twist the rope as you make your loops so they will lie flat.
2. Alternate one loop to the front of the coil and the next loop in back of the coil or as the rope dictates.

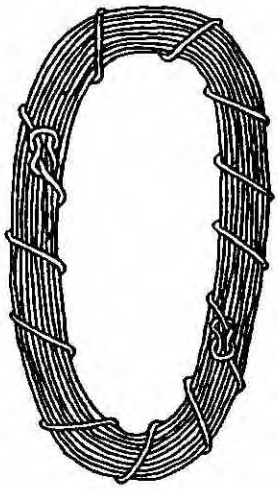
Stuff In Bag - Tie one end of the rope to the bag (through a grommet or other attachment) or ties a stopper loop in the end of the rope and let it protrude as you pack the rope. As you stuff the rope into the bag from the tied end, just cram it in. Don't be too neat. As you need to, put your foot into the bag and force the rope down by compressing it (with clean boots, I hope). When you get to the end of the rope, tie it to the bag or leave the end so it can be easily found.

Two Loop Mountaineers Coil -or-
The No Tangle Coil - (This makes a double coil.) Start one loop over the thumb side of your hand. Next make a loop over the opposite side of your hand. Keep alternating this until you have the correct amount left to tie off the coil. Some climbers double the rope before coiling, so the rope can easily be clipped to an anchor at midpoint. This is handy in a pull down situation.

Chain - This can be started from one end or from the center of the rope. Make a small loop on the top of the rope. Pull the rope through a small bight, then continue pulling a small bight through the previous bight until the end of the rope is reached. Pull the end of the rope through the last bight to lock the end. This is very easy to pull out unless you start at the wrong end or don't lock properly.

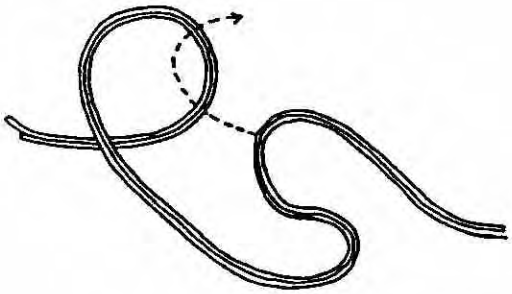
Editor's note: I spoke with Vance about the following drawings. He references a 'Climber's Coil' also as a 'Caver's Coil', and the 'Wrapped Coil' as different method. In California, this is indeed what they are called. Here in the East (at least in TAG) a 'Caver's Coil' is the same as his 'Wrapped Coil'. We have used it for decades to facilitate moving ropes through multi-drop systems. The 'Climber's Coil' is a method to itself. Read the description about 'Chaining' rope - it is correct. You will find his illustration shows the bight being pulled all the way through. Don't do this! The rope should 'unzip' when chained correctly. Remember to go over the basic terms of rope work when working with someone from another area. One man's coil is another man's nightmare!

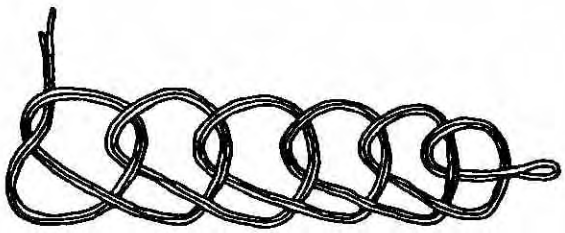




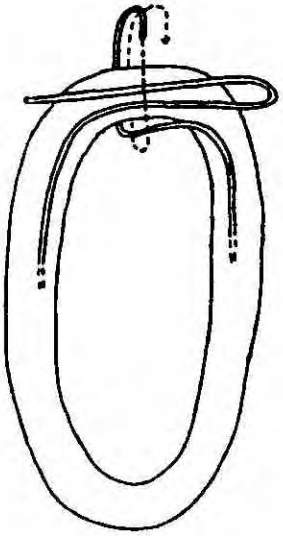
WRAPPED COIL

ROPE BAG

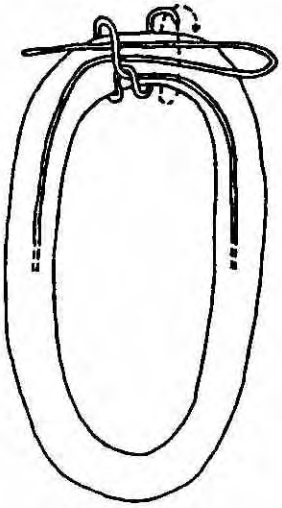




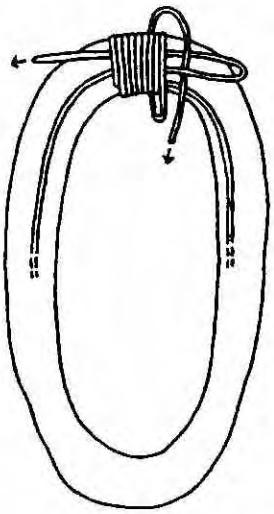
CHAIN - can be single, double or quadruple



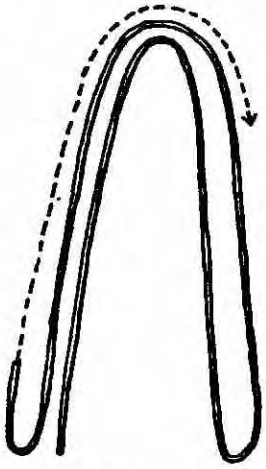
1st variation



2nd variation



CAVER'S COIL OR CLIMBERS COIL



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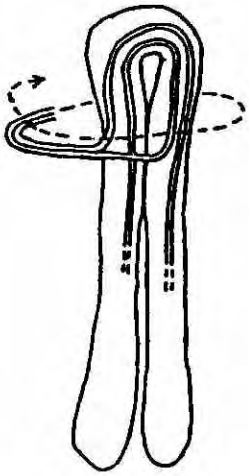

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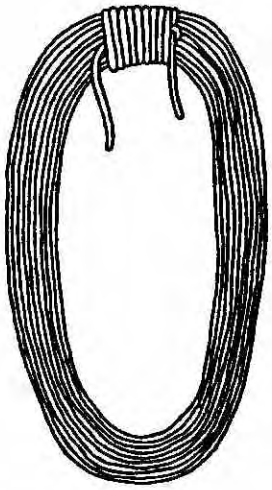
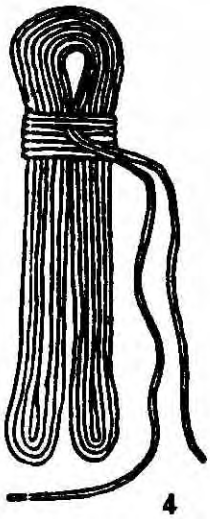
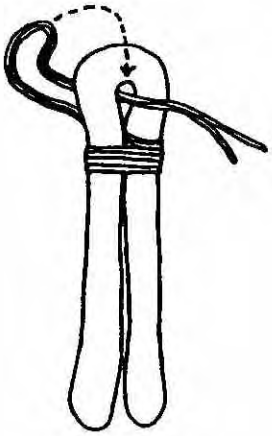




4

LOOP MOUNTAINEERS COIL (NO TANGLE)
with ends left long for tying to pack or other.



3

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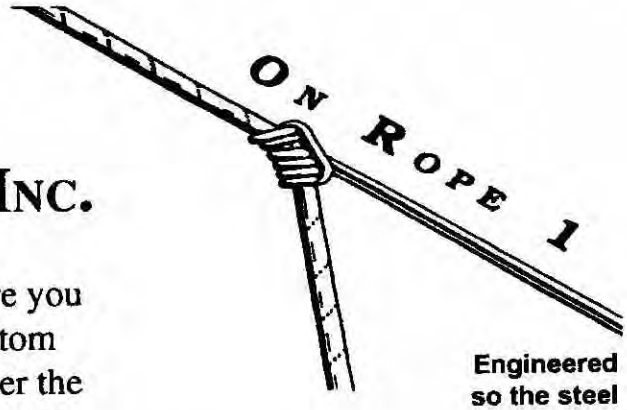

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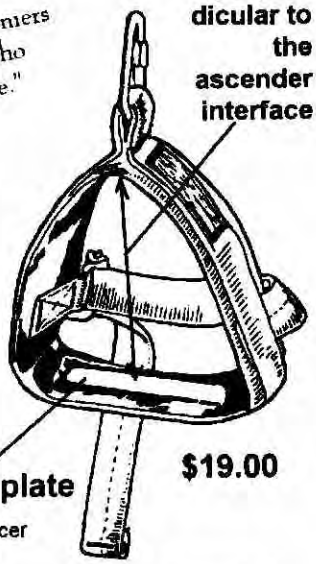

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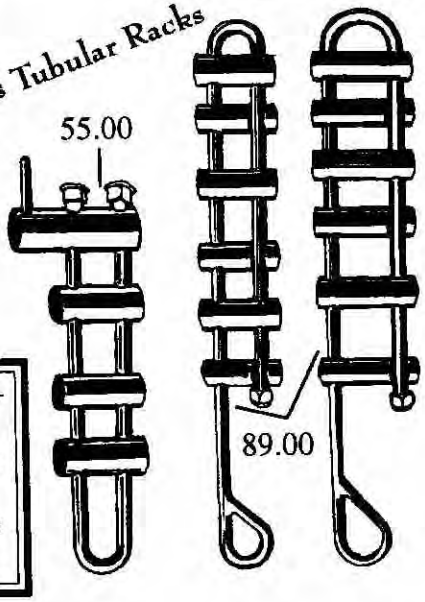


CONSIDERATIONS FOR TECHNICAL ROPE RESCUE
and introduction of TAC ROPE KIT

Mountain Rescue Version / *Fire Service Version*

by Kenneth N. Laidlaw, NSS #5664RL (Berkeley, CA)
Illustrations by John Carnes

WARNING: Rope rescue is a very dynamic experience and what may be considered safe today, may be determined inappropriate tomorrow. If you have an earlier version of this paper, destroy it. Check date of your edition or on INTERNET www.basarc.org/papers/TACRopeKit/techrope.html.
NOTE: An effort has been made to use the historically correct terms and scientific measurements for all components to accommodate both North American and European interests.

Ropes

Only low stretch kernmantle rope should be used. Kernmantle design consists of a central core or kern of parallel fibers which supports the load. This core is covered with a woven sheath or mantle. Low stretch is a type of rope that typically stretches less than 2% when a 2 kN force is applied. A NEWTON is a unit of force---mass times acceleration---equal to about .225 of a pound or the weight of an average apple. A KILONEWTON would be equal to about the weight of a 225 pound person. Remote area rescue usually uses an 11 mm. (7/16") size because of weight. *Fire Service must use 12.5 mm. (1/2") size because of the NFPA.* Two versions of low stretch kernmantle are often available and a stiffer type, with a more abrasion resistant sheath, is best for main lines. A more flexible sheath version is best for the working components. Both versions should have a breaking strength of at least 26.7 kN (6000 lb.) If ropes pass over rough edges, provide padding to prevent abrasion. Avoid getting grease and pitch on the ropes. Do not allow people to walk on the ropes. Regularly wash dirt and grit off the rope with a rope washer. Store in rope bags, in a dry area, out of sunlight. Ropes are the life line to success for the patient and the rescuer. All of the 8 mm. 13.3 kN (3,000 lb.) *and 9 mm. 20 kN (4,500 lb.)* rope used should have the more flexible sheath for increased friction or the Prusik hitches may not hold.

The larger rope manufacturers make excellent products. If you choose the Pigeon Mountain Industries' line, their MAX-WEAR has the more abrasive resistant sheath. Their E-Z BEND is a more flexible rope. PMI's price list talks about Rescue rope and Sport rope. Unless you must have designer colors, buy the Sport rope version which is cheaper. It has more white strands and is made for the more frugal cave explorer market, hence the cheaper price. All of their 11 mm. (7/16") ropes are rated for 27.51 kN (6,185 lb.) *and their 12.5 mm. (1/2") ropes for 40.48 kN (9,100 lb.).*

Many of the test scenarios using Prusik hitches were been done on 11 mm. PMI E-Z BEND with 8 mm. MAMMUT and EDELRID accessory cord. PMI now makes comparable climber's accessory cords. They are colored blue, pink, black; or yellow, black, blue and are rated at 13.50 kN (3,035 lb.) Older PMI catalogs described them as 8 mm. but the latest catalog lists them as 7 mm. The ratio of the size of the Prusik cord to the main rope is critical. Generally, two cross sections of the Prusik cord should equal the cross section of the main line. With many products 8 mm. is the accepted size to use on 11 mm. rope. *9 mm. might be a better choice for 12.5 mm. rope.* Do not use PMI's RESCUE accessory cord, which is orange and blue, as it has a stiff, thick sheath and will not be suitable for Prusik hitches.

Anchoring Your System

Anchoring With a Round Turn

Using a shorter piece of rope, take two wraps around a upright. This is defined as a round turn. The objective is to have the rope around the upright absorb the tension of the load with friction so that the running end of the rope will have no tension on it. It is interesting to note that on a smaller diameter upright the rope will exert greater pressure on the upright's surface. There should be no rope crosses in the turns. With the running end tie a clove hitch around the standing part of the rope and finish off using a double overhand back-up knot. Keep the tangent short but do not deflect the standing part. Do not use this type of anchor tie off if the upright has sharp

edges. The standing part can be used for a single application or in the standing end place a loop using a bowline or figure-eight-on a bight and a double overhand back-up knot. This loop can be attached to working components or it may be clipped to a rigging plate at a designated anchor focal point. With 11 mm. E-Z BEND the backed up bowline uses .9 m. of rope *(12.5 mm. uses 1 m.)* while the figure-eight knot will require a minimum bight of .75 m. (30") and uses a total of 1.2 m. of rope *(12.5 mm. uses 1.45 m.)*. The figure-eight and the Yosemite version of the bowline are the most efficient choices. Good procedure provides loops only as large as are needed by a device.

A round turn type anchor can also be created with webbing. For rescue loads place two loops of webbing around an upright. Tie the ends together with an overhand bend follow-through using safety knots. Locate the bend on the load or front side of the anchor and pull a loop out to clip a carabiner to. WRAP TWO, PULL ONE. Make sure the interior angle, where the load attaches, is less than 90 degrees which would have a strength of 20 kN. (4,500 lb.) *For extreme rescue loads WRAP THREE, PULL TWO for a strength of 40kN (9,000 lb.) at 90 degrees.*

A Versatile Anchor System

Take 100 m. or more of 11 mm. (7/16") rope. Divide into four equal parts. Using the side with one loop and two ends, tie a loose figure-eight knot. Lay the four lines around several acceptable anchor points. Taking the side with two loops, complete a figure-eight-follow-through bend. Position the bend to the side of further action. You have created four independent anchors. Recommendations are to clip carabiners into one pair for your working components and the other pair for your belay unit. Make sure the interior angle, where the loads attach, is less than 90 degrees. A smaller system can be tied around another anchor for placing a pair of directional pulleys, if needed, to take advantage of a good flat working area. A pre-quartered rope with the first figure-eight can be stored in a rope bag for rapid deployment. This anchor is not appropriate with two anchor points that form an isosceles triangle with the load. In that case, or with anchor points scattered out, connect runners using round turn anchors to an anchor focal point. This concept is defined as a "load sharing anchor." In the past a "load distributing anchor" was discussed, but there are so many variables connected with its use that it is no longer recommended for general use.

Another alternative anchor that John Punches offers for use in areas without trees involves running a line through the brush. Have at least five Prusik loops attached to the line. With webbing, do 'wrap two, pull one' anchors around five brush trunks. Attach each anchor to a Prusik loop and adjust each for tension beginning nearest to the load.

Anchor Focal Point

After a patient has been located the rigger should look for a location that is relatively flat and generally free of obstructions to deploy the raising and lowering equipment. If directional pulleys are needed, they should be located. A distance of 17 m. (55') should be paced off and the anchor focal point established. Anchor leads that share the load should then be provided to this spot and connected to the back side of the rigging plate. The front of a rigging plate should be securely tied off to a suitable anchor, possibly using a pretension back tie consisting of a three line, 3:1 'Z-rig', using carabiners. Have someone vector the lines to allow increased pretension.

Lowering a Load With a Brake Bar Rack

A brake bar rack, invented by John Cole, a cave explorer, is an individual descending device that allows the amount of friction to be ADJUSTED when under a load. The common design has a welded eye on one leg and a nut on the other leg. These devices have become popular in technical rope rescue. Though these welded eye versions are rated around 44.44 kN (10,000 lb.), during testing with a load of about 10 kN (2,250 lb.) it has been discovered that the rack frame deforms and the bars will bind. At 26.22 kN (5,900 lb.) a standard folded SMC steel bar is said to have collapsed. Some versions have a wrapped eye, but they tend to unwrap with a 5.33 kN load (1,200 lb.). A knowledgeable welder, familiar with racks, can retrofit the wraps and weld an eye.

An improved rack design is now available that is more appropriate for rescue loads. It is U-shaped with nuts on both ends and is anchored from the bend in the frame. In testing, the nuts did not fail until 62 kN (14,000 lb.) of force was applied. It will take more skill to operate this style of rack as three brake bars are fixed to the frame. Current practice favors using only stainless steel bars in rescue. With standard bars, the first bar has about 90 degrees of contact with the rope. The second through the sixth bar each have about 180 degrees of contact. The first three bars will equally take the majority of the load (50%). Bar four less (25%), bar five still less (10%), and bar six the least (5%). The idea is that there is more friction absorbed by the first bars. A small amount of the load is also taken by the brake person (10%.)

As an enhancement, an oversized stainless steel bar can be placed in the second bar position. This large bar will increase the rope contact to more than 200 degrees and thus provide greater friction, but develop more heat. This bar should be hollow to help dissipate the heat. Do not use an oversized aluminum bar in the second bar position, as it will absorb too much heat. Nylon will start to melt, glaze, or become tacky at about 250 degrees F. During a 70 m. rappel, with a descent rate of one meter a second, an aluminum bar has been measured by Bruce Smith at 300 degrees F, but the heat dissipated quickly. Always pass the rope OVER the first bar when you attach the rack. With the traditional racks orient the short leg away from you or on the bottom to allow the rope to be passed back and forth when bars are added or subtracted. Bars three through six should pivot on the long leg so when they are not being used they can be stored in the well.

Another adaptation for the first bar is to place a snug fitting, extended steel bar in that position. This modification was developed by Larry Howell. (Editor's note: Larry did not actually invent the extended bar. It has been used by others (with a hole in the end for a carabiner) for many years. The version he gave a name to is modeled after the steel bar with posts I had Gerald Moni make for my bluewater rack in the early 80's. Larry did, however, name it and bend the posts in at a later date.) The bar, referred to as a hyper-bar, extends about one inch past the short leg and has a vertical steel pin in the end. This allows the rack to be tied off with ease and offers another friction point, if needed, to more efficiently increase the friction created by the regular bars. If this technique is used, bar six should be a round steel type rather than a folded steel type. Pure aluminum brake bars may generally create more friction but wear excessively, absorb more heat, and transfer aluminum oxide to equipment and clothing; but they make excellent wind chimes.

Bars with titanium over aluminum have been experimented with, but in practical use it was discovered that the bars wore out quickly on excessively dirty ropes. Heavier gauge titanium is prohibitively expensive. The improved U-shaped rack is the standard width of SMC racks and comes with a hyper-bar that extends on both sides of the frame. A current version with heavy gauge stainless steel bars is manufactured by BMS and is comparably priced to the traditional racks. For increased efficiency an oversized steel bar can be placed in the second position. Figure-eight's cannot be adjusted under load, tend to twist the rope, must be unclipped to attach, and are not a good choice for use in technical rope rescue. Remember to engage ALL available bars before using a rack and check that the rope is threaded properly. Always have the rack set up and off to the side in case a change of direction is required in any exercise.

Belaying The Load

A general philosophy is that the belay line is only used for the belay function and it is never used in shifting the load during a working operation. During World War II, for airborne operations, testing by the US Army determined that the human body is usually damaged when it experiences a force of about 12 kN (2,700 lb.) which is now the UIAA standard. It can be concluded that all belay techniques and devices must allow a dissipation of force before 12 kN is experienced or injury will occur. You might equate this to being hit by a load of 12,000 apples, that might be painful.

As an accepted testing model, using 3 m. (9.8') of 11 mm. (7/16") low stretch nylon kernmantle rope tied between a 200 kg. (440 lb.) mass to be dropped, and an anchor, a one meter (39 in.) fall must be sustained. Afterwards, any releasing hitch or other device must be easily

undone and used to lower the weight under the control of one person. A successful belay allows less than one meter of additional travel and less than 15 kN (3,400 lb.) of force to the load. OSHA has been interpreted to apply a factor for stopping human weight due to flexibility and compression of the human body. They estimate this factor to be 1.4. This factor considered using a waist belt only and a full body harness or litter may reduce this factor to 1:1. *It is interesting to note that the 1.4 factor times 200 kg. will equal 280 kg. or the 600 lb. two person load required by the NFPA.*

Traditionally, firefighters have always worn ladder belts around the waist to attach themselves to trucks, ladders, and rescue ropes with a Pompier hook. By definition, the mountain rescue community considers 80 kg. (175 lb.) as a one person climbing load, 200 kg. (440 lb.) as a two person rescue load, and 280 kg. (600 lb.) as a three person extreme rescue load *or NFPA two person load.*

A popular belay involves the use of a Munter or Italian hitch on a large steel carabiner. When applied correctly it can provide friction in both directions. For some applications it will be an excellent choice. However, informal tests have repeatedly shown that many persons cannot control the 200 kg. load using a Munter or Italian hitch once it starts to move. During a .75 second reaction time an object will travel 2.4 meters in free fall, less with friction. Further testing by Kirk and Katie Mauthner has shown that there is a wide range of gripping abilities among the general population, ranging from 46 N. (10 lb.) to 426 N. (96 lb.) The average person has a gripping ability, holding force after applying strength, of about 209 N. (47 lb.). The angle of the rope in and out of the Munter or Italian hitch, edge padding, presence of a shock absorber, and the length of the rope all may increase the effectiveness of this belay. It is best applied with a 0 degree angle on the ropes and the load rope dragging over a padded edge surface. In conclusion, it is unlikely that an average person can hold a rescue load on a Munter or Italian hitch and be able to tie the hitch off.

Canadian practitioners of Munter or Italian hitch belays advocate placing an additional bight around the standing part on the rope and passing it through the carabiner a second time to create a double Munter or Italian hitch for any two person loads. This hitch may require an extra large steel carabiner to allow it to change direction. Test data is unavailable for this hitch variation. Another idea to make the Munter or Italian hitch safer is to use a tied off Prusik hitch on the control side of the Munter or Italian hitch. Without modifications, the fact that a Munter or Italian hitch belay works is conditional on the belayer holding on to and controlling the rope.

Belay Experience Is Essential

A variety of other techniques and devices are often also described as belays. They may be satisfactory for their intended use for a single person load of 80 kg. (175 lb.) in rock climbing. But in rope rescue, they are also conditional at best. A proper belay should pass the "critical point test", that asks, 'Is there any one point in the system, that were it to fail, it would lead to catastrophic failure?' For maximum safety the belay device should also engage without attention. The "whistle test" or "hold up" is for objective hazard and asks, 'What happens to the patient, attendant, and other rescuers if everyone were to let go?' At the sound of a whistle have everyone let go of the rope and hold up their hands. If the belay holds, it should be safe to proceed. In spite of its popularity, a regular Munter or Italian hitch fails this test.

Tandem Prusik hitches may be the safest technique to use, but also may require the most training and skill. Use two pieces of 8 mm. rope, 1.35 m. (53") and 1.65 m. (65") long. Each loop is joined by a double overhand bend. Tie three wrap Prusik hitches with each loop.. Tie them neatly with the hitches' bridges matching. When properly positioned and equalized, the hitches will be about 10 cm. (4") apart. Generally, when engaged, at about 1/3 of their breaking strength the Prusik hitches will slip slightly. During informal tests conducted by Kim Aufhauser, one of the tandem Prusiks begins to slip with a steady pull of about 5.33 kN (1,200 lb.) The hitches were then thought to work in tandem and sustained a load of 13.33 kN (3,000 lb.) which was the maximum pulling force generated during this informal test.

In reality, it appears that one Prusik hitch took most of the load. As it grips, it bends the line being engaged, at an angle. The second Prusik hitch is then unable to bend the rope and therefore is not effective in gripping. Other tests by Arnor Larson have shown that the first Prusik

takes between 7.0 kN and 9.5 kN of force (90%). The second Prusik only increases that force to 10.5 kN (10%). More observation of how Prusik hitches work may be warranted. Belayers must be very attentive and keep the hitches snug but free running. A properly tied Prusik hitch will make a noise as the rope is pulled through it. On a lowering, the belayer should hold both hitches with one hand and pull out some belay rope using the wrist and thumb to form a bight of slack. As the load takes the slack the hand rotates and slides back to pull out another bight of slack. Avoid allowing the rope to feed straight into the tandem Prusik hitches, they may not grab. Flake the rope so it will enter the tandem Prusiks from the side. The friction of the rope will then more efficiently activate the hitch. When belaying a haul, the tandem Prusiks are held by one hand and the belay rope pulled up so as to prevent any loop of slack. On a long haul the belayer may need help bringing up the rope. The rope may be tended by a Prusik minding pulley as the belay rope is pulled through it.

For optimum efficiency the lengths of the Prusik loops should be shortened to fit to the size of the pulley you use. For a ROCK EXOTICA Prusik minding pulley and PMI accessory cord the ideal lengths appear to be 1.1 m. (43") and 1.35 m. (53"). The long loop is placed on a carabiner first, then the short loop, and finally the pulley. If you have two sets of loops available you will be able to safely pass a bend. Never-the-less, if the belayer is distracted or is not attentive, one or both of the hitches will lock and cannot be released if under a load.

Load Releasing Hitch

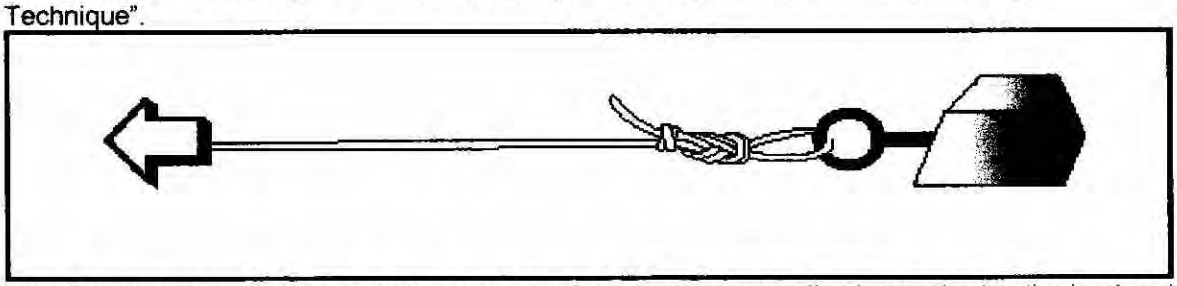
To correct the problem of the hitches locking at the wrong time, place a load releasing hitch above the tandem Prusik hitches so they can be released. This hitch, developed by Arnor Larson, exceeds the accepted testing model. The hitch will also act, to a degree, as a shock absorber, increasing the safety factor of the unit. Use 10 m. (33') of 8 mm *or of 9 mm.* line and two carabiners. One carabiner is at the midpoint bend of the line. The two loose ends are tied with a double overhand stopper knot The other carabiner, closest to the anchor, has a Munter or Italian hitch tied using the double line. Pull the mid-point carabiner through the Munter or Italian hitch until it touches the other carabiner. Reverse direction and you have about 12 cm. (5") difference. Make three wraps around the long axis of the device. Tuck a portion of the doubled cord through the bight and tie off with an overhand knot. Chain the excess rope. Place the loop formed with the tied loose ends in the anchor side carabiner to prevent losing the hitch as the load is released.

The distance necessary to release a load may be roughly estimated. If 50 m. of rope is in use, it will require 1 m. to remove the rope stretch and at least .3 m. more to release the hitches. (A total of 4'.) A more compact alternative is to use a Mariner's hitch with 5 m. or more of 1" tubular webbing. The Mariner's hitch does not use a Munter or Italian hitch, but after the midpoint bend, wraps the webbing through both carabiners twice. The excess is tucked and chained. Remember, the use of tandem Prusik hitches require skill and careful attention. A BELAYER SHOULD BE YOUR MOST EXPERIENCED PERSON. After using the load releasing hitch always retie it, so it will be ready for its next application.

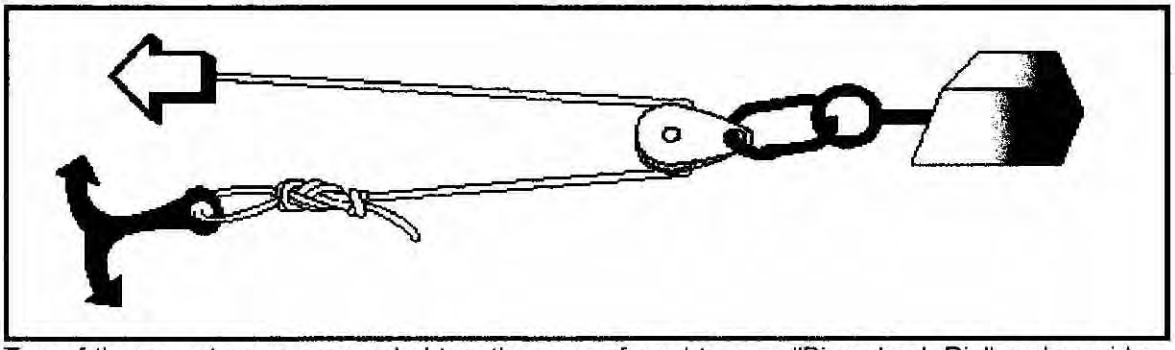
Raising a Load

Mechanical Advantage Concepts

1:1 - Without any mechanical advantage: A direct pull is called the "Armstrong Technique".

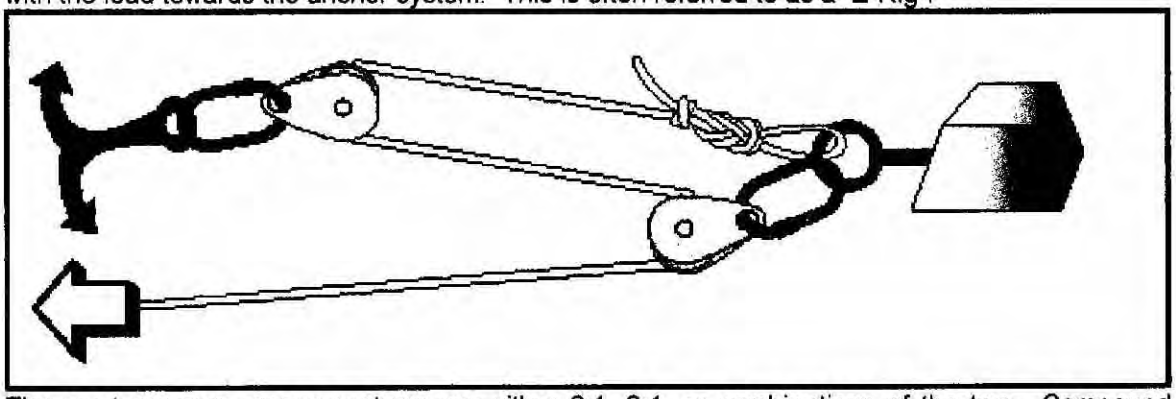


2:1 - Mechanical advantage: In order to have a 2:1 advantage, a pulley is attached to the load and it travels with the load towards the anchor. Watch for rope abrasion on the static side.



Two of these systems compounded together are referred to as a "Piggy-back Rig" and provide a 4:1 mechanical advantage.

3:1 Mechanical advantage: In order to have a 3:1 advantage there must be two pulleys. The first pulley, when following the load rope away from the load is attached to the anchor. The load rope is directed back to the load and the second pulley is attached to the load and travels with the load towards the anchor system. This is often referred to as a "Z-Rig".



The most common rescue systems are either 2:1, 3:1, or combinations of the two. Compound systems must be multiplied together, NOT ADDED. Additional pulleys that are added, usually just change directions of the haul for convenience. To get the greatest mechanical advantage with the smallest number of pulleys compound several 2:1 systems. The average haul person will probably pull about 20 kg. (47 lb.). If a dynamometer is available, have team members pull on a rope, first with one hand, and then with both hands. Generally with both hands an athletic person can apply a force equal to their body weight.

The size of a pulley should be four times the diameter of the rope for about 85% efficiency. For 11 mm. (7/16") rope use a pulley with a 2" tread. Beware, some 2" pulleys are turned out of 2" stock and the tread is actually closer to 1 1/2". Ball bearing pulleys have an efficiency of .95, oilite bronze bearing pulleys .85, and a common carabiner .60. Place the best pulleys you have closest to the haul position or in the moving pulley positions for the maximum efficiency. Always apply your pull at 0 degrees to your other lines.

If it is necessary to prove the amount of mechanical advantage being used, the most effective way is to measure the distance of the pull in relation to the distance the load moved. If you pull three feet and the load moves one foot, the mechanical advantage will be 3:1.

Mechanical advantage systems are either simple, with all moving pulleys moving at the same speed as the load; compound, with moving pulleys moving at different speeds; or complex. It is always safest to use available personnel and pull the load up without using any mechanical advantage or the least mechanical advantage needed.

Attaching To The Main Line

Use a three wrap Prusik hitch, for the haul system, tied with 1.1 m. (43") of 8 mm. rope. The rapid release version of the Prusik hitch with the double overhand bend forming the bridge

might be a good choice. The Prusik hitch is chosen because of the characteristic that it will slip when a force of about 5.33 kN (1200 lb.) is applied. During a haul sequence, if it does slip, STOP the operation and determine what the problem is. Have several units available, as this loop may start to glaze during the resets after about 100 m. of use. In the past, a dog-n-tails or rat tail hitch was offered but informal tests have shown that this hitch did not slip with a pull of 16.44 kN (3700 lb.). In a hauling application it would be safer to use a hitch that slips.

An alternative is to use a Rescucender in place of the hitch. In informal tests, the Rescucender generally slipped about 10 cm. (4") whenever a pulled load reached about 5.33 kN (1200 lb.). The Rescucender success varies, however, with different brands of rope. A new Rescucender has also been known to cause failures. New Rescucenders should have 100 m. of rope run through the device to smooth out any possible burrs near the wear pin. The Rescucender should also be connected by a soft link using 0.8 m. of 8 mm. *or 0.9 m. of 9 mm.* rope to eliminate potential binding.

Gibbs ascenders are not recommended for use in technical rope rescue. With an 8.88 kN (2,000 lb.) pull they cause the sheath and then the core of the rope to fail. In 75 cm. (30") drop tests, with a rescue load, the rope was cut. Both ascenders come with warnings that they are designed for one person loads and are pull tested to 4.45 kN (1,000 lb.) ONLY. They should NEVER be used in a dynamic belay situation. In practice however, for specific applications, the Rescucender tends to slip, on most ropes, reducing the load, while the Gibbs tends to destroy the rope.

Capture The Distance The Load Is Hauled

There seems to be a philosophic difference of where the progress capture device is located. Mountain rescue trained personnel place it back at the anchor. Cave rescue people place the progress capture device in front of everything, usually at the edge of the drop. Some literature describes this device as a 'safety cam' or a 'ratchet cam'. The correct name should be 'progress capture device' as that describes its function. Placing the unit closer to the edge allows that person to provide communication between the litter attendant and the haul team. The progress capture device should use a single three wrap Prusik hitch, on a 1.1 m. loop, attached to a load releasing hitch. A second 1.35 m. Prusik loop should be available in case a bend must be passed. An alternative is to use a Rescucender, with a soft link, in place of the hitch. Gibbs ascenders are not recommended for use in technical rope rescue.

When the command SET is given, the progress capture unit attendant must pull all the slack out of the line as the device is set, otherwise the load will settle and progress will be lost. If an attendant is not available the capture device can be automatically tended by using a Prusik minding pulley since the loop lengths have already been custom fitted or the Rescucender can be tied off to work automatically.

The second set of tandem Prusik loops with the belay unit should be connected by their carabiner and one loop attached to the progress capture unit anchor. Until they are needed for passing a bend on the belay line they can be used for shifting the load under other conditions.

The Commands

"HAUL" or "HAUL SLOW" **2 whistles** Team begins hauling.
"SET" Team stops and the progress capture device is set.
"SLACK" Signals the haul team to reset the haul system for a new bite.
"STOP" **1 whistle** Movement stops and tension is held until any problem is resolved.
"DOWN" **3 whistles** Lower the load.

Usually a "leader" wants to give all these commands, but it may be safer for the person performing the function to shout the command when their device is set and their fingers are clear.

Connections Using A Soft Interface

Whenever a knot is used in the end of a rope to make a loop we know that the strength of the rope is reduced between twenty to thirty percent. The use of the round turn eliminates using a knot in many applications, however sometimes a knot cannot be avoided. By using a soft interface, with a knot, the full strength of the rope can again be reached. After the chosen knot

has been tied, take a loop made from 1.65 m. of 8 mm. cord and tie a Prusik hitch around the standing line. Attach the other end of the loop to your anchor. Tighten the Prusik hitch so a loop of slack is in the standing line. The characteristic of a Prusik hitch is that it will start to slip when a force of about 7 kN is reached and will sustain a total force of about 9 kN. At that point the strength of the knot comes into play. Between them the full strength of the rope is restored. Also, the loop in the rope, created by the soft interface, will act as a 'poor man's' dynamometer and will visually indicate when a force of about 7 kN has been exceeded.

This same concept can be used If you have to lengthen a main line or a belay line and use a double overhand bend, back the bend up with a loop using 2.5 m. (8') of 8 mm. cord that will place a three wrap Prusik hitch on each side of the bend. Practice this before you need it as one hitch will be difficult to tie. You can tie both Prusik hitches around your fist, put a stick in them beforehand, and set the unit aside for use when needed. Slip the ends of the main line through the Prusik hitches in place of the sticks before you join them with the double overhand bend. Tension the Prusik loop to carry the load rather than the knot.

Packaging In A Litter

The two most common litters being used are, the older chicken wire Stokes type basket and the Ferno-Washington plastic model. Some Stokes litters have a leg divider. A person skillful in technical welding can remove this divider and use the pieces to replace any damaged bottom cross pieces. A section of EMT tubing can be added on the bottom to improve strength and provide a skid. With a small propane torch the soldered chicken wire can be modified and soldered to a new central wire. The US Coast Guard recommends wrapping a piece of 2.54 cm. tubular webbing around the top rail for added security.

The acceptable Ferno-Washington litters are orange in color, Model 70. Some look-a-like units are still in service that are red colored, Model 71. The plastic in these is affected by sunlight and they have been known to abruptly fail. They should no longer be used in rope rescue. The Ferno-Washington litter comes with a 5 m. (16') piece of rope laced around its perimeter. This rope should be replaced by a piece of 8 mm. rope that has a figure-eight knot at each section along the inside of the litter. The presence of the knot makes it easier to pass a piece of webbing under it. To accommodate the 20 required knots add 3 m. (10') to the original 5 m. Use 9 m. (29') to be safe. It is good practice to keep all litters covered and away from weather and the sun. The SKED litter has proven to be an excellent choice for use in caves and other confined space situations. Easy to follow instructions accompany each SKED.

Described in the equipment section are a spider attachment for high angle vertical rescue with a horizontal litter orientation. The four adjustable legs of the spider hang from an extra large steel carabiner and attach to the litter rail with large carabiners. These carabiners are always orientated so the gate is on the inside and the locking screw rotates down. The main and belay lines are connected to the large steel carabiner by interlocking long tail bowlines. The main line tail is for attendant use and the belay line tail is for patient use. There is also a bridle attachment for low angle incline rescue, or vertical orientation of a litter for a short distance. The bridle is tied to the head end and uses 4 m. (13') of 11 mm. (7/16") rope. Half of a double overhand bend is tied in one end. A clove hitch is placed around the litter rail. The rope passes inside across to the other side of the litter with a figure-eight knot tied at the mid-point. Another clove hitch is tied around the opposite side rail. The ends are joined completing the double overhand bend. The ropes are aligned and a figure-eight-on-a-bight is tied in the end of the loop. The figure-eight at the midpoint in the litter will provide an attachment point to grab or to connect a carabiner to in close quarters.

Packaging the patient will be the same in both applications. The following procedure would be used for the most extreme conditions found in a cave, mine, or other high hazard area; but can be modified, as needed, for other situations.

Using the available litter, place a vapor barrier down first. With a 3 m. by 4 m. piece of plastic tarp, lay it diagonal, with a point at the head, foot, and at the sides. Next lay down a blanket, as a thermal barrier, also in a diagonal fashion. Prepare to place the patient in the litter.

Using a 6 m. (20') piece of webbing tie one of a variety of known harness styles on the patient. For a superior style that will not adjust and constrict use 4.5 m. (14.5') piece of webbing for an average sized person. Tie the mountaineer or Star-Bird style seat harness on the patient. Create a bight at the midpoint and form a .2 to .25 m. (9" to 10") loop using an overhand bend follow-through. About .25 m. (10") down one tail form another .2 to .25 m. loop with another overhand bend follow through. This allows a .25 m. gap between the loops. These loops go over the thighs and the tails wrap around the waist and are finished off with a snug overhand bend follow-through. For the chest, use a 3.5 m. (11') piece of webbing and tie an overhand knot at the mid-point. Wrap one tail around the chest and finish off a overhand bend follow-through. With the other tail, pass it over a shoulder, under the webbing across the back, and back across the opposite shoulder. Complete an overhand bend follow-through with both tails. With a 2 m. (6') piece of webbing connect the seat harness and the chest harness with a loop joined by an overhand bend follow-through. Position the patient in the litter and wrap in the barriers.

Using a second 6 m. (20') piece of webbing tie a round turn with a half hitch opposite one knee. Pass it under both feet and up to a spot opposite the other knee. Pull it tight under the instep of the feet, or single foot if one leg in injured and secure with a half hitch. Feed the webbing back down to a spot opposite the ankle and loop it through the litter, over the ankles, through the other side of the litter and back across the ankles. Pull very tight and secure with two half hitches.

Using a third 6 m. (20 ft.) piece of webbing, find the mid-point. Place the mid-point on the navel and begin lacing the webbing towards the head end. At each contact with the side of the litter push a loop under the knotted rope and pass the free end through the loop creating a Munter or Italian hitch. As you get closer to the head region be careful not to compromise the neck. Secure the ends to the chest harness webbing using half hitches.

Using a fourth 6 m. (20 ft.) piece of webbing, again find the midpoint. Place the mid-point on the ankles and lace the webbing towards the waist as before, securing with a baker bowline.

Provide the patient with a helmet and some sort of eye protection. Let the patient determine whether or not their arms are secured. Padding in various places, as behind the knees, under neck, may also be appropriate. The head can be secured with duct tape.

Under less hazardous conditions, other straps might be more appropriate. Use buckles that allow the loose end to be secured by passing it back through the buckle. Avoid using buckles with a button release.

The test for a properly secured patient is to stand the litter on end. If the patient slips down, the packaging was inappropriate.

Appoint A Safety Officer

Whenever you must perform a raising or a lowering, appoint your most experienced person to perform the role of SAFETY OFFICER to check everything that the team does. All carabiners should be squeezed and knots checked. Rotate this assignment to prevent a person from becoming unpopular.

Everyone working near the edge should be tied in using a Quick Attachment Safety or Q.A.S. An adjustable unit, using a personal ascender of your choice and a locking carabiner, can be made using 2.1 m. (7') of 8 mm. rope and 1.1 m. (43") of 6 mm. rope. Tie an overhand knot near one end. Pass the running end of the rope through the bottom of an ascender, back through the overhand knot, and tie a double overhand knot around the standing part. This is also called a slip hitch. At the other end form a bight fitted around a nylon rope thimble. Tie a double overhand bend around the standing part but leave a tail. With a bight from the 6 mm. rope tie a three wrap Prusik hitch around longer 8 mm. rope. This allows length adjustment of the unit. Connect the loose ends of the 6 mm. rope by a double overhand bend to the tail of the 8 mm. rope.

Always have climbing gear available. A set of three Purcell Prusiks made out of 6 mm. rope is a compact alternative. Two are tied the same. For an average height person, each uses 5 m. (16') of 6 mm. rope. With each piece form bights in each end of the rope. Choose one end and tie a double overhand knot around the two ropes. Pull out a .4 m (17") bight on one side. On the longer bight form a three wrap Prusik hitch around your fist and pass all the rope through the hitch

wraps. Return to the .4 m bight and tie a figure-eight knot in the three ropes. For the longer Purcell Prusik unit keep adjusting the figure-eight knot until the top of the small loop reaches the nipple line when the Prusik hitch loops are secured over the boot. On the medium unit keep adjusting the figure-eight knot until the top of the small loop reaches the crotch when the Prusik hitch loops are secured over the boot. When both are adjusted, finish off the units with a second double overhand knot securing the bend. The medium unit should have about a 1 m. tail. Place a Yosemite version bowline in the end that can be attached to your harness for safety purposes. The third Purcell Prusik is made from 1.9 m (6') and a simple loop is formed with a double overhand bend. The sequence for attaching to the rope to climb is: short loop, long loop, and medium loop – SLM.

If you want to make marks on a rope do not use a product that contains phenol. If the ink smells like Pine-Sol it should not be used. If the ink smells like alcohol it is safe to use. SANFORD'S Rub-A-Dub laundry pen is okay, but SANFORD'S Sharpie marker is NOT.

Anytime you are near a drop zone wear a UIAA approved helmet with the chin strap connected. Most deaths of rescue workers can be attributed to one of the following conditions:

1- Ignorance about environment,
2- Casual attitude,
3- Distraction.

Some Thoughts In Review

Your goal is to get the maximum potential with the minimum of equipment. A general concept is to keep the main line and the belay line in the best condition and not to use them for any working component functions or for the anchor. Another concept allows for a soft or a hard approach of attaching to the main line. Extra equipment should be available to pass a bend. The functions should be spaced about 3 m. (9') apart to allow functional operations without conflict. The belay line should not be used when the load must be shifted.

Carabiners should be chosen with care. Besides locking, the gate design should assure that it will catch when the long axis is stretched. Make sure the carabiners are placed with the gates up and the lock screwing down towards the load. Only hand tighten the lock. Most working component lines should use a backed up bowline or figure-eight-on-a-bight tied at the ends. Each unit can use a different colored rope or the knots at the end of each unit can be colored coded with a 15 cm. piece of colored webbing. Possible colors are showed later in parentheses. The main line, usually white, and the belay line, usually red, should also be very distinctive from each other to avoid any confusion.

In the interest of compactness and weight, the load releasing hitches described below are one/half the usual lengths, however they will meet the needs of the 60 m. of rope used.

The safety factor is described as a ratio between the breaking strength and the force you intend to put on it. All the components of this presentation exceed 10:1 *or 15:1*.

Following is a description of the components of a **TAC ROPE KIT** that is specifically designed for **t**actical, **a**daptable, and **c**ompact use in remote areas such as caves, mines, and wilderness settings. *A version for fire services with 12.5 mm. rope and steel carabiners is described in Italics.*

Listed items are divided into two groups, the basic kit and the accessories. A rigging plate for an anchor focal point is listed, but other anchoring hardware or anchor ropes are not included.

(See next page for an easy to copy layout)

TAC ROPE KIT **Tactical Adaptable, Compact Rope Kit for Technical Rope Rescue**

Mountain Rescue version / *Fire Services version*

Rack Unit: (blue)

- 5 m. - 11 mm. PMI E-Z BEND service rope / *12.5 mm. PMI E-Z BEND*
- 2 - SMC LOCKING D carabiners / *SMC LOCKING D lite-steel carabiners*
- 1 - BMS RAPPEL RACK with J-bar, SS oversized bar and 4 SS bar

Belay Unit: (red)

- 60 m. - 11 mm. PMI MAX-WEAR belay rope / *12.5 mm. PMI MAX-WEAR*
- 1 - LOST CREEK medium rope bag
- 1 - SMC LOCKING D carabiner / *SMC LOCKING D lite-steel carabiner*
- 8 m. - 11 mm. PMI E-Z BEND service rope / *12.5 mm. E-Z BEND*
- 1 - SMC LOCKING D carabiner / *SMC LOCKING D lite-steel carabiner*
- 1 - load releasing hitch
  - 2 - SMC LOCKING D carabiners / *SMC LOCKING D lite-steel carabiners*
  - 5 m. - 8 mm. PMI accessory cord / *6 m. - 9 mm PMI accessory cord*
- 1 - SMC LOCKING D large steel carabiner / *SMC LOCKING D extra large steel* for Munter or Italian hitch if a CONDITIONAL BELAY is satisfactory

  and/or
- 2 - tandem Prusik sets for REAL BELAY with
  - 2 - SMC LOCKING D carabiners / *SMC LOCKING D lite-steel*
  - 2 - 1.35 m. x 8 mm. PMI accessory cord / *1.55 m. x 9 mm. PMI accessory cord*
  - 2 - 1.65 m. x 8 mm. PMI accessory cord / *1.85 m. x 9 mm. PMI accessory cord*

Haul Unit: (yellow) (Using a compound 4:1)

- 30 m. - 11 mm. PMI E-Z BEND service rope / *12.5 mm. PMI E-Z BEND*
- 3 - SMC LOCKING D carabiners / *SMC LOCKING D lite-steel carabiners*
- 2 - SMC 2" pulleys / *SMC 2" steel pulleys*
- 1 - RESCUCENDER with soft link 0.8 m. - 8 mm. / *0.9 m. - 9 mm.*

  and/or
- 2 - Three wrap Prusiks with 1.1 m. x 8 mm. PMI accessory cord / *1.35 m. x 9 mm. PMI accessory cord*

Progress Capture Unit: (orange)

- 17 m. - 11 mm. PMI E-Z BEND service rope / *12.5 mm. PMI E-Z BEND*
- 1 - SMC LOCKING D carabiner / *SMC LOCKING D lite-steel carabiner*
- 1 - load releasing hitch
  - 2 - SMC LOCKING D carabiners / *SMC LOCKING D lite-steel*
  - 5 m. - 8 mm. PMI accessory cord / *6 m. - 9 mm. PMI accessory cord*
- 1 - RESCUCENDER with soft link 0.8 m. - 8 mm. / *0.9 m. - 9 mm.*

  and/or
- 2 - Prusik loops using
  - 2 - SMC LOCKING D carabiners / *SMC LOCKING D lite-steel*
  - 1 - 1.1 m. x 8 mm. PMI accessory cord / *1.35 m. x 9 mm. PMI accessory cord*
  - 1 - 1.35 m. x 8 mm. PMI accessory cord / *1.55 m. x 9 mm. PMI accessory cord*

Direction Unit: for both main line and belay line

- 2 - SMC LOCKING D carabiners / *SMC LOCKING D lite-steel carabiners*
- 2 - ROCK EXOTICA 2" Prusik minding pulleys

Main Line Unit: (white)

- 60 m. - 11 mm. PMI MAX-WEAR rope / *12.5 mm. PMI MAX-WEAR*
- 1 - SMC LOCKING D carabiner / *SMC LOCKING D lite-steel carabiner*
- 1 - LOST CREEK medium rope bag

TAC Rope Kit Bag: - PMI large rope bag with shoulder straps

Accessories

Spider Unit: Incline application: (white)

4 m. - 11 mm. PMI E-Z BEND rope for bridle and/or

Vertical application: (white)

1 - SMC LOCKING D extra large steel carabiner for main
4 - SMC LOCKING D large carabiners for litter
6 m. - 8 mm. PMI E-Z BEND rope for 3 m. head and foot parts
4 - 1 m. x 6 mm. of PMI accessory cord for Prusik loops
1 - PMI accessory pouch

Other:

1 - Rigging plate
1 - SMC rope washer
1 - pair leather gloves
2 - SMC LOCKING D carabiners
1 - PMI accessory pouch

Litter Unit:

1 - Litter of your choice: Stokes, Ferno-Washington, SKED
1 - 3 m. x 4 m. plastic tarp
1 - wool blanket
5 - 6 m. x 2.54 cm. pieces of tubular webbing
1 - helmet with goggles

Acknowledgments

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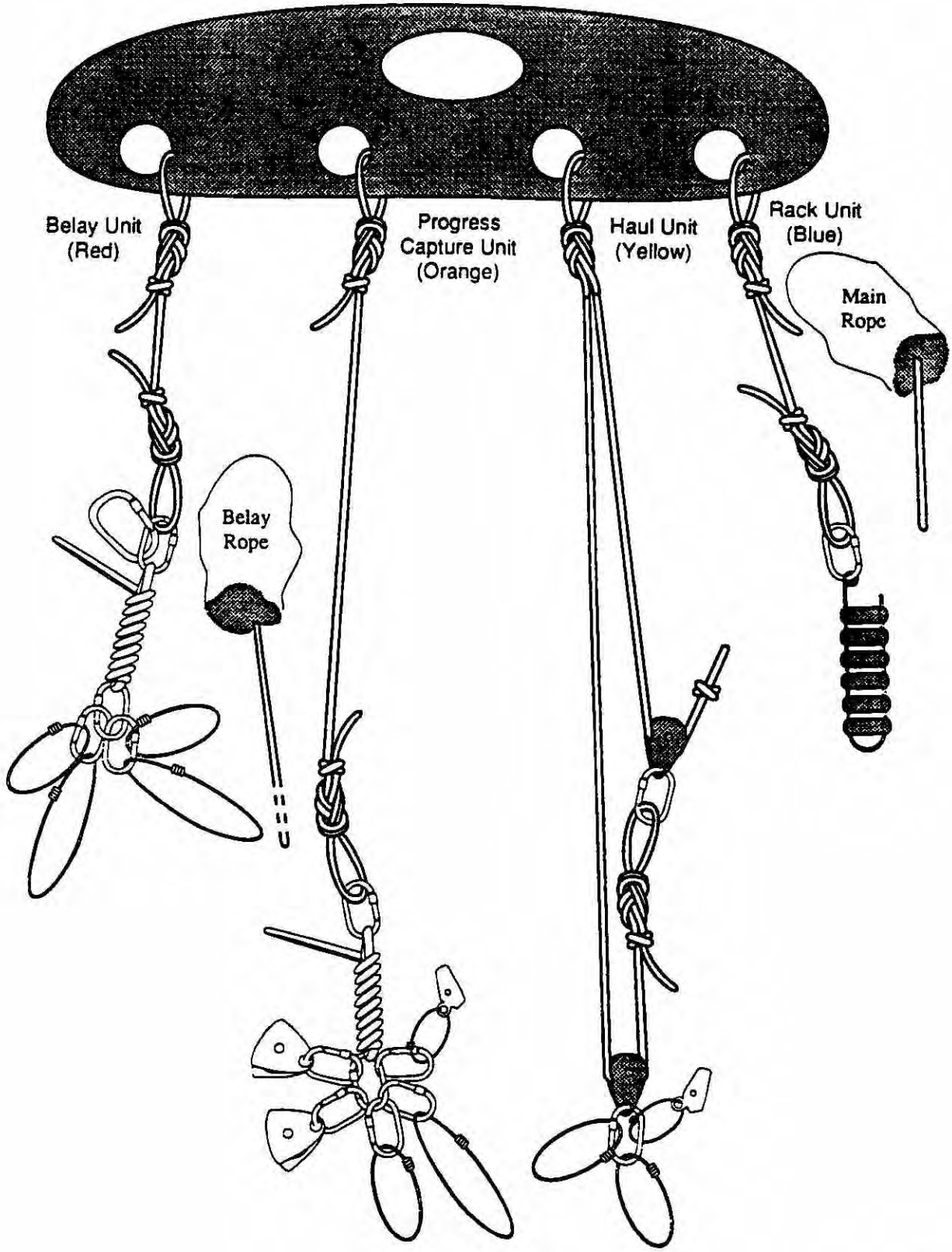
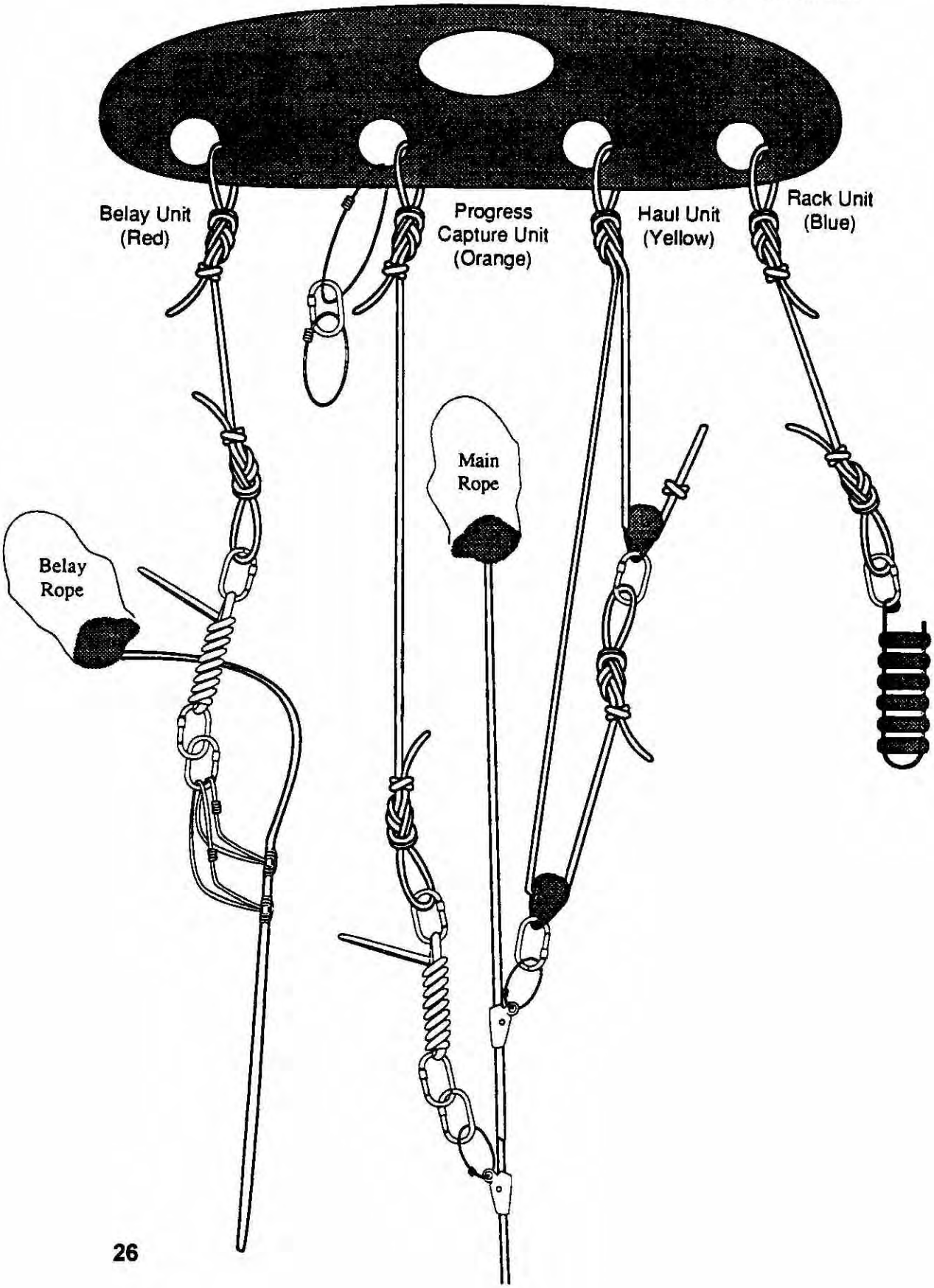
TAC Rope Kit


Belay Unit
(Red)
Progress
Capture Unit
(Orange)
Haul Unit
(Yellow)
Rack Unit
(Blue)
Main
Rope
Belay
Rope

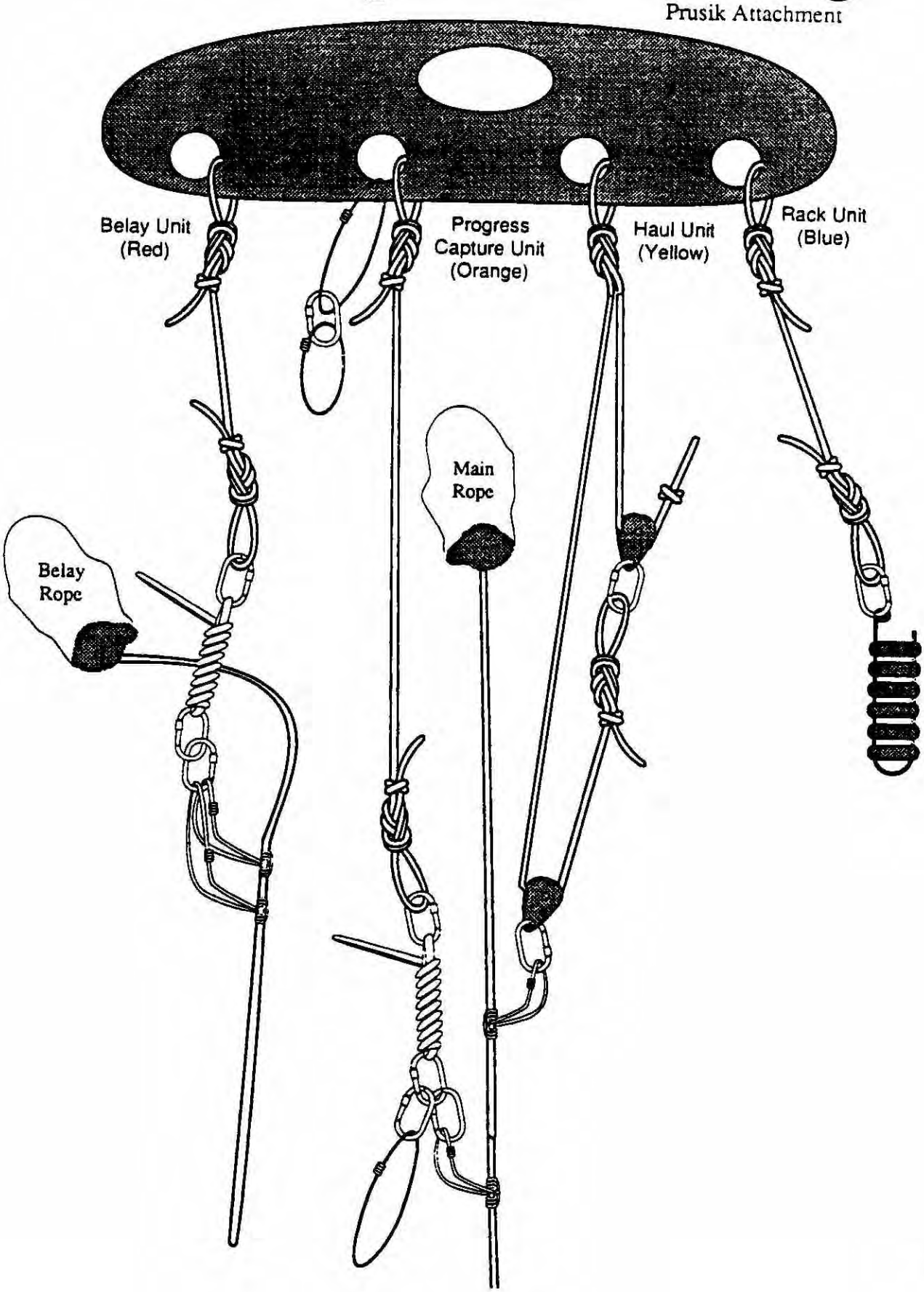
TAC Rope Kit-Raising

Rescucender Attachment

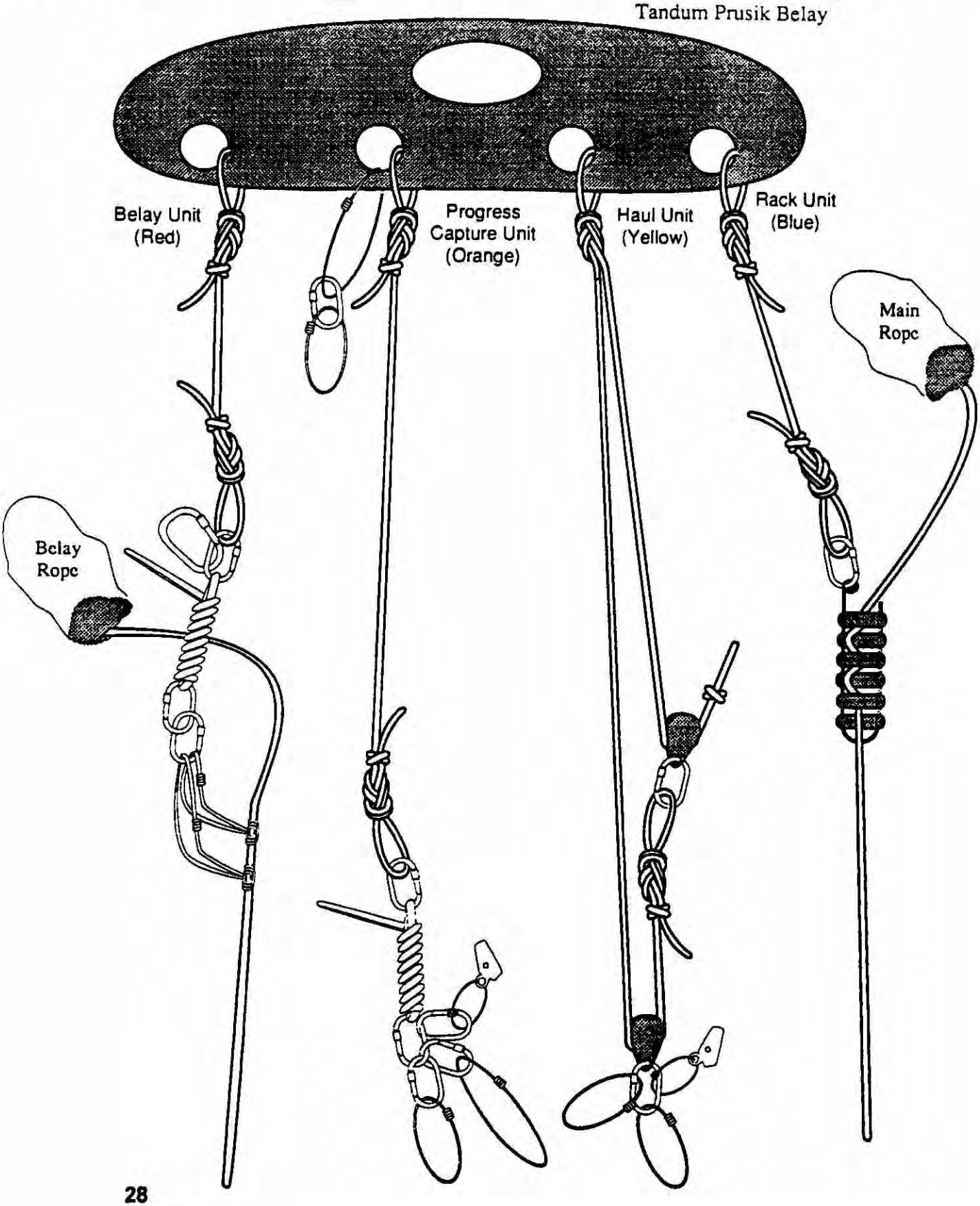


TAC Rope Kit-Raising

Prusik Attachment



TAC Rope Kit-Lowering



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