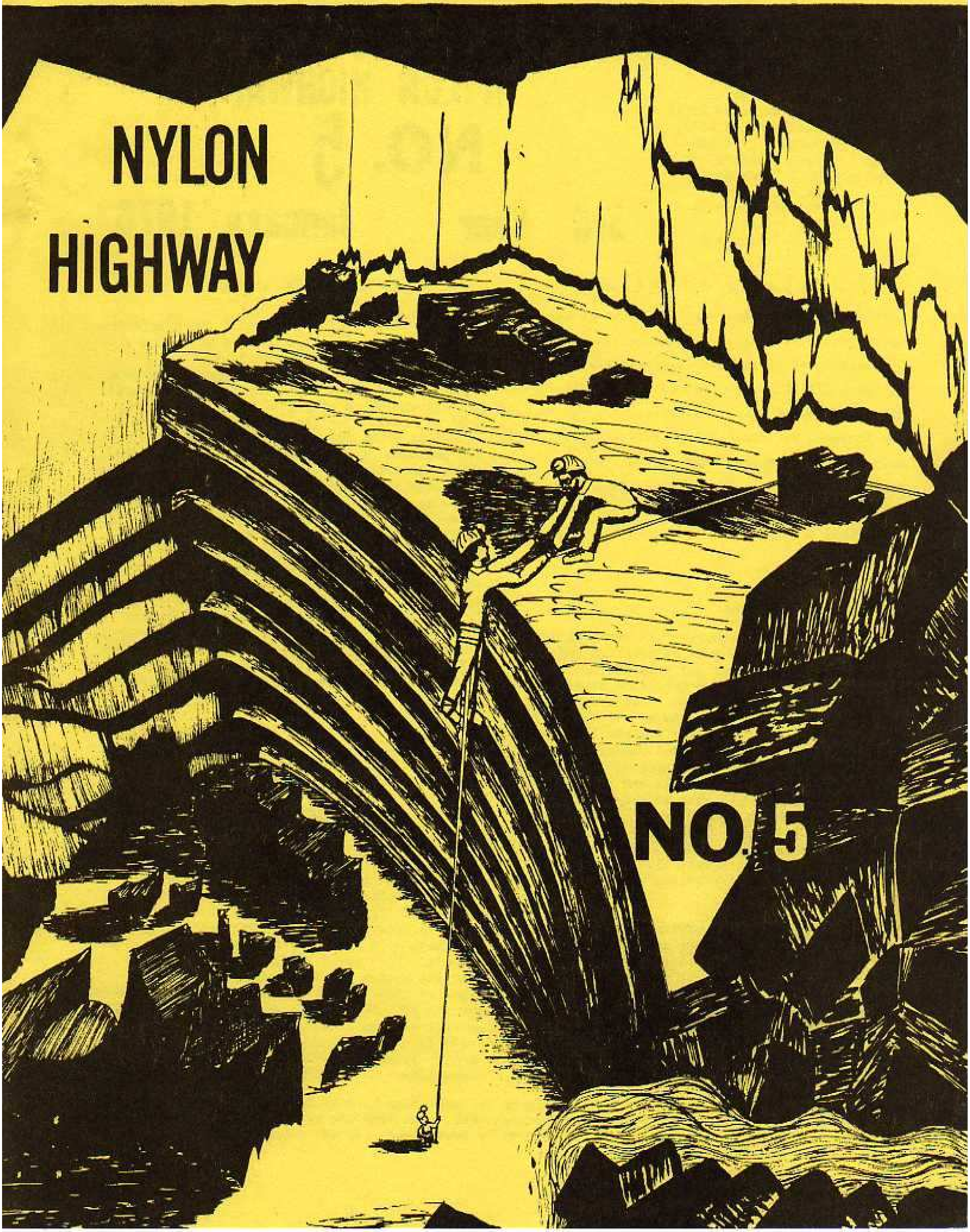
NYLON
HIGHWAY
NO. 5

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NYLON HIGHWAY
NO. 5
3rd Year January 1976

T A B L E O F C O N T E N T S

HOW TO SUBMIT MATERIAL

In able to have an authoritarian vertical oriented newsletter we need good material on the subject of vertical travel and related topics. These articles can be reprints from other newsletters or original material. Letters to the editor are encouraged but the editor claims the right to censor or alter any article in a way as to fit the publication without changing the intent of the article. We do request that new material be supported with tests and field usage records. Let's please stay away from politics. All pictures are requested to be black and white pen and ink drawings. The editor is able to redraw upon request any pictures of explanation that are unclear. Please submit all material to Bruce W. Smith, 1745 Woodside Drive, Westland, MI 48185

The NYLON HIGHWAY is an official publication of the Vertical SEction of the National Speleological Society; published at least twice, but not more than four times a year by the annually elected editor. Subscriptions are $3.00 a year while membership dues are $3.00 a year. To enstate oneself as a member of the Vertical Section one will need the endorsement of two charter members or two non-charter members who have been members for two or more years.

LETTER FROM THE EDITOR

First of all I want to apoligize for the lateness of this issue. But it's out and if anyone's curious, postage has gone up by 50%.
Being the editor of the Nylon Highway has been a prestigious honor with many personal rewards. With my increased work load in my job and the lack of interest on the part of the section I intend to print one more Nylon Highway and open the position up for other talent to take over. Think about it and consider the responsibility. Of course the files of the section will be passed on to my predicessor. I sincerely hope that whoever decided to take on the responsibilities holds with the total technical nature of the newsletter and avoids politics of all types. Nominations for a new editor will be open to the floor at the convention and there will be an election as there was in 1973. For my last issue I've got some European devices planned for publication, if I receive the information in time. I hope it will be one of the best issues yet. I hope I receive some good domestic work as well. I'm looking forward to hearing from you.

Sincerely,
Bruce W. Smith

NO. 1 REPRINTED

Believe it my friends Nylon Highway #1 is being reprinted this week. If you have paid for your reprinted issue it will be in the mail this week. If you care to order a copy to complete your set the price for all old issues 1 through 4 is $2.00. I have about 5 copies of #2 left. The reason it has taken so long is that the entire 40 page issue had to be retyped so that it could be photgraphically reduced. Several of the illustration had to be reduced as well but the actual content of the first issue is complete and correct.
We also intend to sell past issues at the convention.

COVER Depicted here is the likeness of the famed 60' wall drop in Walt Allen Cave, W. VA., somestimes referred to as the Baxter or Beveridge Cave. Its been the sight of many exhausting experiences including a serious injury sustained by Beveridges' son who fell from the top off a ladder while unroped.

LIFTING WITH PULLEYS

by Bruce Smith

It often becomes necessary, often under much less than ideal conditions, to raise heavy loads and/or victims from the depths of a deep shaft. In Nylon Highway #2 several methods were discussed but here, let's discuss various lifting methods using pulleys. Carabiners can be used in place of pulleys but the friction developed by carabiners almost negates any intended mechanical advantage. A good oiled pulley with a small axle develops about 10% friction while a carabiner will develop between 30 and 60 percent, depending on the rope and its condition i.e.,(muddy, stiff, etc.) A large hayfork pulley or pulley of comparable size would make a nice addition to ones car trunk. These large pulleys not only produce less friction than the small one but provide a much larger margin of safety with regard to their actual ability to hold weight. Carrying these large pulleys deep inside a cave becomes cumbersome, but so is a stokes litter.

BLOCK AND TACKLE

There are two basic pulley configuration. The most common is commonly referred to as the block and tackle. The ideal mechanical advantage is determined by counting the actual number of support lines. Figure #1 shows one support line. By this I mean the actual load is being supported by only one line. There is no mechanical advantage in a system of this nature unless you are the hauler and the load; then you will find it relatively easy to lift yourself. See Figure #2 showing a mechanical advantage of two.

Figure #3 shows a better way to orient one pulley enabling one man to lift another (excluding frictional forces). Notice there are two support lines which can be equated to the mechanical advantage. Figures 4,5, and 6 show other configurations of Block and Tackle arrangements and their designated mechanical advantage.

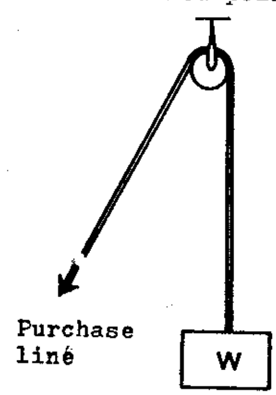


Fig # 1. No mechanical Advantage

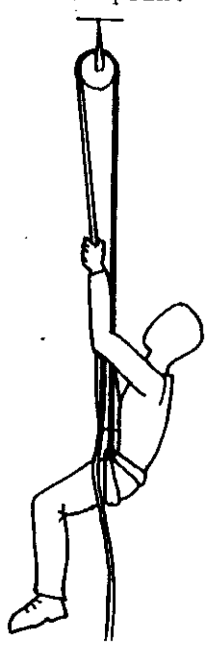


Fig # 2. Mechanical Advantage of 2. When the weight to be lifted supplies the force of the lifter, the ideal mechanical advantage is one half of the normal mechanical advantage of the system being used.

While Block and Tackle is probably the easiest to understand it is probably the most impratical for cave situations. First of all the rope needed for block and tackle arrangements if often unavailable. Second, the mechanical advantage obtained is often negated by the weight of the pulleys the rope and friction in the pulleys.

Let's take a hypotheical situation of a 200 pound load with a mechanical advantage of four (see figure #5). The person hauling should ideally have to pull 50 pounds on the purchase line. But each pulley produces approximately 10% retardation in frictional losses. That would be 10% of the combined tensions on each line coming into or going out of the pulley. Let's diagram this 4 to 1 system another way. (Figure #7), so that we may see tensions on each line and each pulley. It is evident that each line coming in or out of a pulley has 50 pounds of tension on it; making a total of 100 pounds in the pulley. Ten percent of 100 pounds is 10 pounds of frictional loss in each pulley. How much force will actually be needed to lift 200 pounds in a 4 to 1 system?....

50 lbs.	+	3	X	10 lbs.	=	80 lbs.
(The original force needed on the purchase line)		(Pulleys)		(Frictional force in each pulley)		(Force required to lift 200 lbs. with a 4 to 1 system)

See the graph (figure #8) illustrating the pull force required to lift 200 pounds in various rated block and tackle systems.

PIGGY BACK

The other pulley system and by far the most practical is commonly referred to as the piggy back system. A far greater mechanical advantage can be obtained with fewer pulleys. With two pulleys one can obtain a mechanical advantage of four while three will produce an advantage of eight. Figure #9 shows a mechanical advantage of 4 and all the related tensions on each line. Let's determine the force necessary to lift 200 pounds. Ten percent of the 200 pounds in the first pulley plus 10% of the 100 pounds in the second pulley plus the purchase 50 pounds totals 80 pounds necessary to lift 200. Trying any other piggy back system we come up with exactly the same figures found in the graph in figure #8.

Comparing the two basic methods of lifting we find no significant difference, except the piggy back method uses less pulleys to get the same amount of work done. Of course, by using less pulleys then you have negated the force necessary to lift all the pulleys necessary with block and tackle systems.

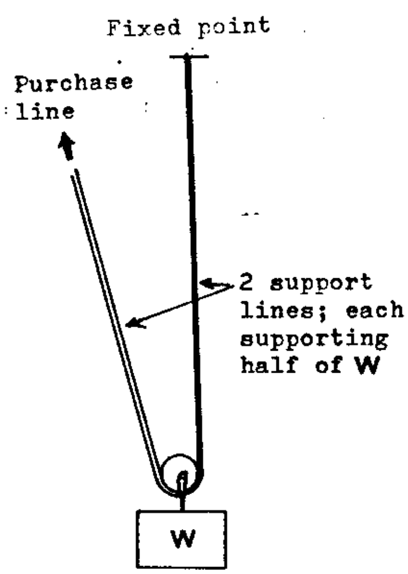


Fig. # 3
2 to 1

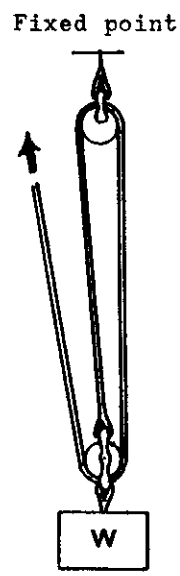


Fig. # 4
3 to 1

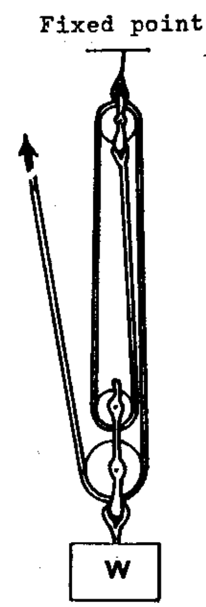


Fig. # 5
4 to 1

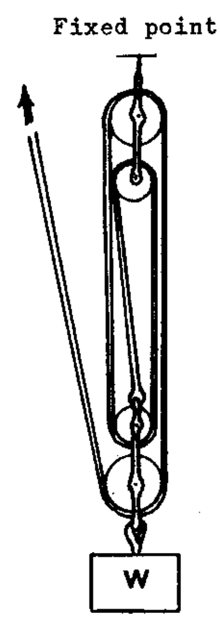


Fig. # 6
5 to 1

RESCUE SITUATIONS

By now I hope we have both come to the similar conclusion that the piggy back method is more pratical because it uses less pulleys. Under actual situations though, two additional factors must be incorporated into any hauling system. The first is the development of a purchase system while the second is the need for a method to capture progress once it has been made.

PURCHASE SYSTEM

Often time space limitation and the shortage of long rope requires the use of a purchase system whereby a litter or gear can be pulled up in short methodical hauling sessions. These systems can be easily set up in any small space. Please see Figure #10. The system is shown

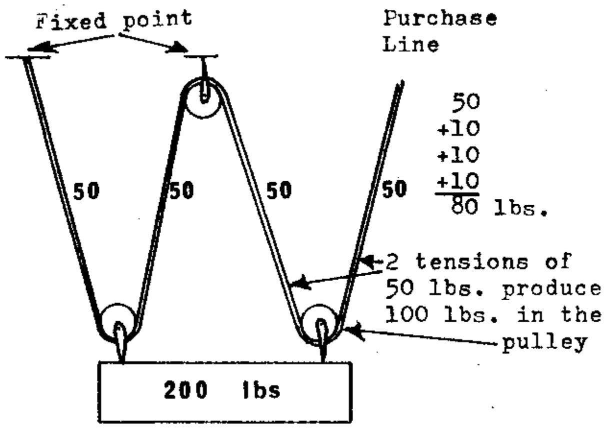


Fig. # 7 An alternate way to look at a 4 to 1 mechanical advantage

ready for a hauling session. Figure #11 shows the system at the completion of a hauling session when it collapses. Here progress must be captured and the pulley system re-extended to appear as Figure #10. Please make note here that your gain is only half the distance of your total hauling system set-up. See Figure #11.

Figure #10 depicts properly the orientation of the pulleys. Figure #2 and Figure #3 in NYLON HIGHWAY No. 2, page 4 and 5 depicts a top pulley, which is unnecessary.

Of course as previously stated it is necessary to capture all your progress. This is done with a prusik knot, Jumar or even better a stop cam. It will be necessary for someone to tend the stop cam to insure maximum progress unless perhaps someone has an elastic knee piece from a floating knee cam off a Gibbs floating system (See NYLON HIGHWAY #1) See figures 10 and 11 for set-up details of this elastic piece. Surgical tubing would also work very well.

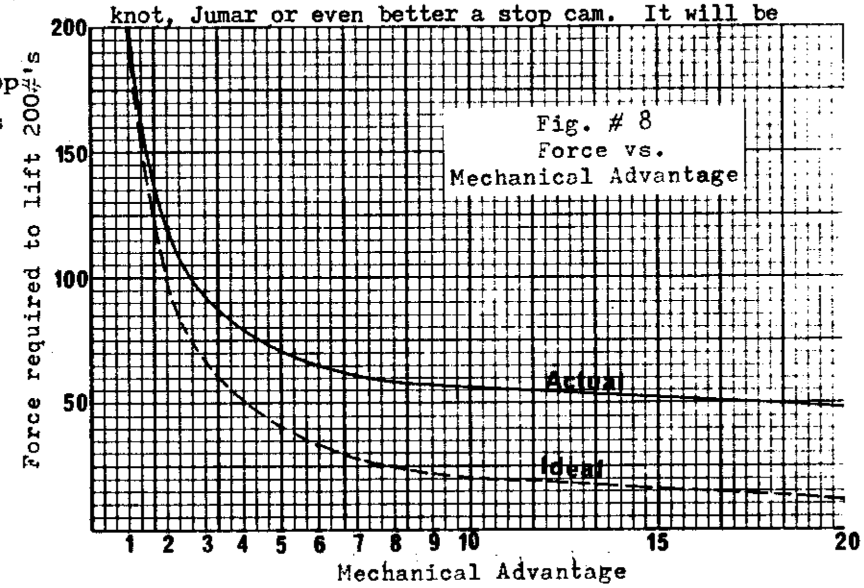


Fig. # 8
Force vs.
Mechanical Advantage

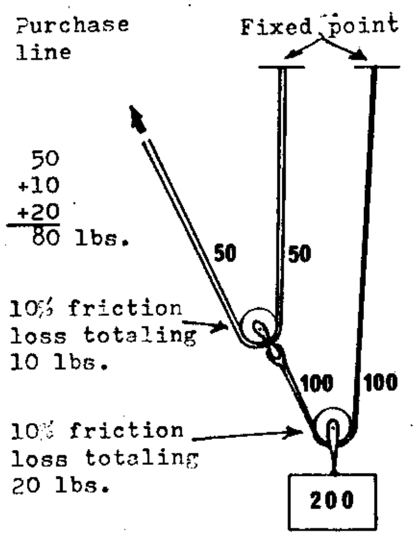


Fig. # 9 Piggy back pulley system showing no noticeable difference in the force required to lift 200 lbs.

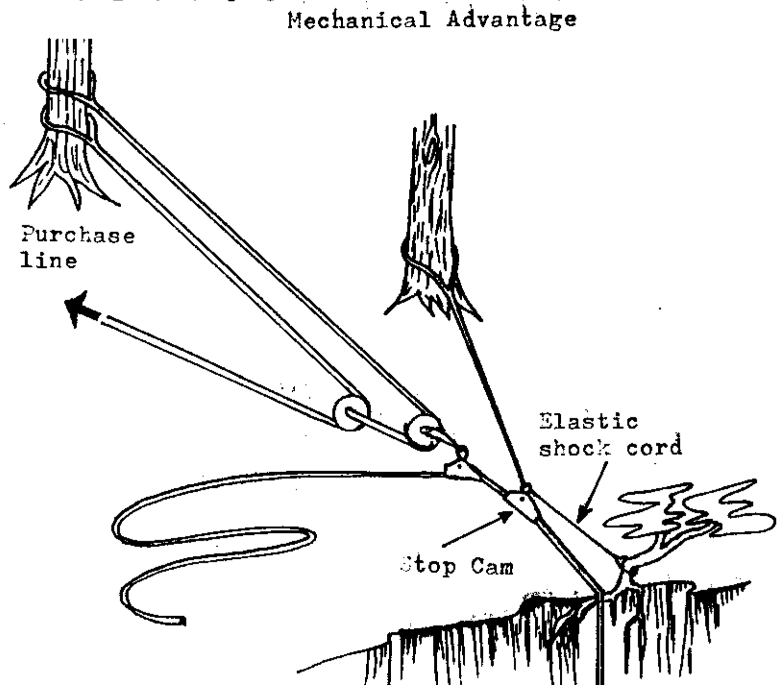


Fig. # 10. Piggy back pulley system with a stop cam cocked for a hauling session

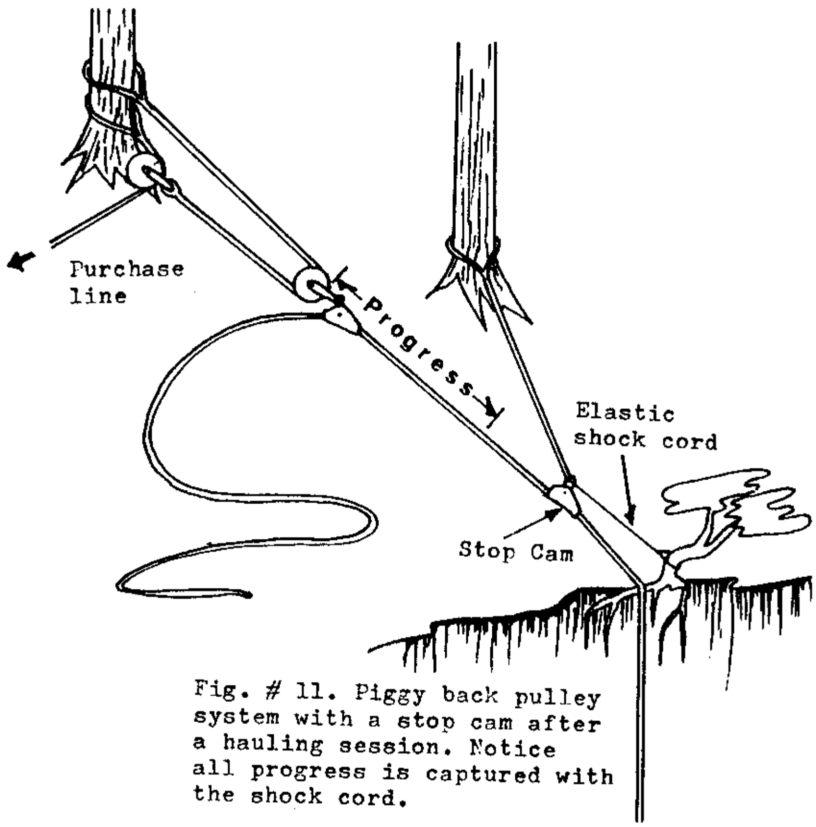


Fig. # 11. Piggy back pulley system with a stop cam after a hauling session. Notice all progress is captured with the shock cord.

MINUTES

Minutes of the meeting of the Vertical Section of the National Speleological Society held Friday June 27, 1975 at Frogtown near Angels's Camp, California.

The meeting was called to order by Kyle Isenhart. Board members present were Pete Strickland, and Kyle Isenhart. Those absent with proxies present were: Bill Cuddington whose proxy was Delbert C. Province and Allen Padgett who was proxied by Jim Gordon. Absent without proxy was Kirk MacGregor. The financial statement submitted by Bruce Smith was presented by Kyle Isenhart, Section Secretary. The Section newsletter, The Nylon Highway was discusses. It was decided to thank Bruce Smith for his excellent work as Editor and ask him to continue. His wife, Barbara, the Assistant Editor was also thanked for her work. The section members were urged to submit articles to be considered for publication in the NYLON HIGHWAY. The board requested that more of the section members assist with the contest and training sessions. The board also urges members of the section to work toward the development of better vertical equipment and techniques. It was announced that no dues increase would be necessary this year. The floor was then opened for nominations for ellection to the Board for the coming year. A secret ballot was taken and those elected were Bill Cuddington, Kyle Isenhart, Delbert Province, Oscar J. (Jim) Gossett, and Pete Strickland. Bill Cuddington will continue as chairman and Kyle Isenhart as Secretary. It was announced that dues would be collected and new members accepted immediately after the meeting. The meeting was then adjourned.

Respectfully submitted by
Kyle Isenhart, Secretary
Vertical Section of the N.S.S.

DEVELOPMENT OF CAVING ROPE

by J. R. Newell, Jr., President Blue Water Ltd.

The purpose of this paper is to explain the characteristics of several ropes that have been or are being used for caving. Since I am most familiar with the development of Blue Water II & III ropes, emphasis will be placed on how these ropes perform with regard to caving and how these results were obtained. I have found that cavers are becoming much more sophisticated with their rappelling and prussiking techniques and thus seek more knowledge about the types of equipment that are available for caving today. No longer can companies that supply equipment to cavers expect to have their products accepted unless they meet the specific requirements for caving. Gone are the days when cavers accepted equipment designed for other activities that only particially meet the requirements for caving. Many items are being offered today either by cavers or by companies prompted into the manufacture of these items by cavers. A case in point is the rope that I manufacture today.

Eight or ten years ago, the main ropes used for caving were the braided rope manufactured by Samson Cordage, the twisted rope called Goldline and the various braided ropes manufactured in Europe. When I first joined the West Georgia Grotto, I ran into a third rope that had been obtained by some of the members from a local textile mill. This rope had many of the qualities that we felt were desirable for a caving rope such as low stretch and good resistance to abrasion. However, this rope did have its drawbacks and was finally discontinued because of them. Being a textile engineer and active in the textile business at that time, I felt that a rope could be developed for caving using the facilities already available in my plant. Thanks to the suggestions and active participation of the West Georgia Grotto members, the Blue Water II rope was finally developed and tested in the field. Many cavers still aid in the further development of the rope as I feel that we should continue to seek to improve its construction and manufacturing procedure. In order for you to understand some of the background of the rope, let us look into the same areas that were examined when the rope was first developed.

Our first thoughts were directed toward what we felt a caving rope should be. The properties that we felt were desirable were (1) High Strength (2) Low Stretch (3) Long Wear (4) No Spin (5) Constant Characteristics and (6) Reasonable Price. We then looked at the various ropes being used and how they met these requirements. The laid Goldline had good strength, good abrasion resistance but had excessive stretch and did spin when used on a free-fall drop. One draw-back of all twisted ropes is the wear that takes place on the inside of the rope due to the rubbing of the strands against themselves when the rope is loaded. It is very difficult to evaluate the strength remaining in this type of rope after it is used for a period of time as this type of wear is not easily seen. Also on the laid ropes, any wear is on the load-bearing strands since all strands are load-bearing.

The next type of rope evaluated was the braid on braid type of construction used in the Samson rope. While the strength was good and the rope did not spin on a free fall drop, this rope was very stretchy and tended to swell to a larger diameter after use making the use of mechanical devices such as Jumars very difficult. The construction of the rope left a lot to be desired since the manufacturer did splice the individual strands in both the core and sheath by just braiding the loose end of the fiber into the rope without a knot being tied or attached in any manner.

We also looked at the climbing ropes made in Europe and found them to have less strength that either the Goldline or the Samson rope plus the fact that a very thin sheath was used which gave them very poor resistance to abrasion. These ropes were also very stretchy but did have the no-spin characteristic.

So now we asked ourselves "What do each of these ropes have that we want and how are these properties obtained?" We like the high abrasion resistance of the Goldline, the no-spin characteristics of the Samson the the European ropes. We like the high strength of the Goldline and Samson as well as their price but none of these ropes could offer all of the desirable properties that we wanted.

Now let's see how each of these ropes obtained the desirable characteristics that we wanted. The high strength of both the Goldline and Samson was the direct result of the amount of nylon used in the manufacture of the rope plus the type of nylon used. There is no way to obtain equal tensile strength without using the same amount and the same type of nylon. You can obtain a high impact strength through a construction that will absorb loads by stretching which is how the European ropes rate so high on impact loads although their tensile strength is lower than other ropes. The Goldline rope will also do this by stretching whereas the Samson rope could do this same thing to a point. In fact MSR offers the Samson type of construction for a mountain rope. After looking at this information, our decision was to use the high strength nylon offered for cordage use and use enough of it to give us the strength desired.

Next we approached the high stretch characteristics. Goldline and Samson both stretched quite a bit but each stretched in a different manner. The Goldline stretched since the individual strands tended to unwind when loaded and the Samson stretched due to the loose manner in which it was braided. Our approach was to use parallel strands of nylon so that there would be no mechanical let out when the rope was loaded. The only stretch that we would have then would be the inherent stretch present in the nylon yarn itself which is very small on a 400 pound load. In order to obtain the 7/16" diameter rope we wanted, a very large number of individual fibers would be required which created a problem in just the handling of them. We found that 760 strands would be required to give us the proper diameter and tensile strength just for the core of the rope. In order to handle this number of strands, it would be necessary to twist a number of them together but anytime you add twist you create a torque which causes the rope to spin. There is a way around this problem so what we did was to work with ten core supply packages twisted in a clockwise direction and ten packages twisted in a counter-clockwise direction. The torque generated by the first ten packages was off-set by the reverse torque generated by the second ten packages. This gave us a low-stretch zero-torque core. The third property we wanted was long-wear which means a high resistance to abrasion in a caving rope. The Goldline seemed to have the highest degree of resistance when compared to the Samson or European ropes. I felt that the factor that gave Goldline the edge over the other ropes was its high twist in the individual strands. As twist is added, the length of the individual fibers exposed is shortened at the point of contact thus making it more difficult to break the fiber. The tightness of braid in the sheath also added to the resistance to abrasion. For those who have climbed on the loosely-braided Samson, you will remember how Jumars tended to catch on the rope strands. The rocks act in the same manner and tended to catch on the individual fibers and break them. In a short time, the Samson rope could become fuzzy from broken fibers. There is an interesting point about this fuzz that was formed on the Samson rope in that it offered a cushion effect against further abrasion but the rope did become larger in diameter and made the use of Jumars on the rope more difficult. In view of the above observations, our approach was to cover the core strands with a tightly braided sheath exposing as little of the fiber as possible. We further improved on the abrasion resistance by twisting each sheath strand. The final sheath strand ended as actually three strands made by twisting a small strand and then combining three of these together with a twisting operation in the opposite direction from the first twisting operation. The result was a zero torque strand with very short segments of the individual fibers exposed. The resultant size (15,000) denier was about twice as thick as the sheath used on the European climbing ropes. The construction using the thicker, double-twisted sheath strands coupled with the closeness of the strands in relation to each other gave us a tough sheath which resisted abrasion better than any of the other ropes and as an added factor, protected the load bearing core strands much better than any type found.

Another property desired was the maintenance of constant characteristics. This could only be obtained by using the same raw materials, some machine settings and constant checks by the machine operator. The only way to obtain this is to use people who care about the product they make and take pride in their work. For this reason, cavers were used when I could not make the rope myself.

To attempt to tie all of this information together, let me outline the Blue Water II construction. The core consists of twisted nylon strands of type 66 nylon; one half twisted clockwise, one-half twisted counter-clockwise. The sheath consists of double twisted three ply strands (a total of 16) from type 66 nylon. The breaking strength under ideal lab conditions is approximately 7000 pounds but we rate the rope under conditions similar to caving conditions. We ran tests with the rope tied around a 1" diameter steel bar using a mid-shipman's knot and averaged 5400 pounds for the tensile strength in a dry condition. Tests showed that the core itself contributed about 70% of the total breaking strength. The tightness of the braid construction offered the high resistance to abrasion and also prevented the sheath from slipping over the core in the event it was cut. I found that a Jumar would slip only 8" if placed on the rope and the entire sheath was cut just above the Jumar. Tests conducted by Charlie Gibbs showed that the Blue Water construction resisted cutting by his ascenders better than did the Goldline or Samson construction. From my own experience, I have no fear of rope damage from Gibbs or Jumars when used properly.

All of the previous information given was for the original rope, Blue Water II. During the past year, we began production of Blue Water III rope. The only difference between the two ropes is the type of nylon used in the sheath. The two constructions are identical but we use a new type of nylon manufactured by DuPont known as their Super Blue 707 nylon. According to DuPont, tests have shown with regard to weathering, that a 20% increase in outdoor durability can be expected for Super Type 707 versus present type 707 ropes which is the standard type 66 nylon. Their tests also indicated improved abrasion resistance over ropes of their standard 707 in a laid construction. While we can not state for a fact an exact percentage improvement for abrasion resistance, we do know that it is better. However, the new rope also obtains another characteristic over our original rope. It tends to be much faster when new. Some cavers find that this is somewhat of a disadvantage so we continue to offer the original rope and plan to continue to offer it in the future.

There is really no secret to our rope construction unless it is the fact that we take a lot of time and care in its construction. The larger companies can not warrant the labor costs involved for such a specialized product for what they consider to such a small market. For our small company the market is considered to be large and we appreciate the confidence the cavers have in us. We will always appreciate your ideas, your suggestions and also your complaints in hopes that we can continue to improve our rope.

INCHWORM CLIMBING

by Bruce Smith

Basically, inchworming comes to us from the West. Some of the well known inchwormers are Charles Townsend, Toni Rowe, Pete Strickland, and Richard Weisbrod. Incidently, Richard Weisbrod happens to be the person who has given me the bulk of my inchworm knowledge. Without going into great depth, my primary objective is to present a basic exposure (no relation to the sickness) to the inchworm method.

The foot piece is the only part of the system that must be homemade and is unique to the inchworm method. Aluminum "L" stock or channel stock have been used in the past. I've depicted (Figure 1) the attachment of a channel piece to the base of the Jumar. Richard calls this foot piece a Mar-Bar. (Short for Jumar Bar) He also recommends "L" stock attached with "U" bolts as shown in Figure # 2. The strap is usually made of one inch tubular webbing and riveted or bolted to the ends of the bar. Figure #3 depicts the actual system. This upper Jumar must be extremely tight and as Richard mentions, you can walk with difficulty but it should be vertually impossible to stand straight up. It's important that the seat carabiner be placed in the bottom hole of the Jumar, chances of it riding up and unclipping your safety latch become more pronounced. Figure #4 and #5 show the actual climbing cycle. Very basic, up-down-up down yawn! In tight chimneys Richard recommends that the Mar-Bar be removed and used above the climber as a chinning bar. Obviously, this could be for short distances only.

The Mar-Bar has several other very praticial uses besides climbing which became very attractive after I looked them over. (1) To haul a rope out of deep pits. (2) To provide a better grip on the rope for a belay from below on rappels. (3) To hold the rope when helping someone to Jumar off the ground.

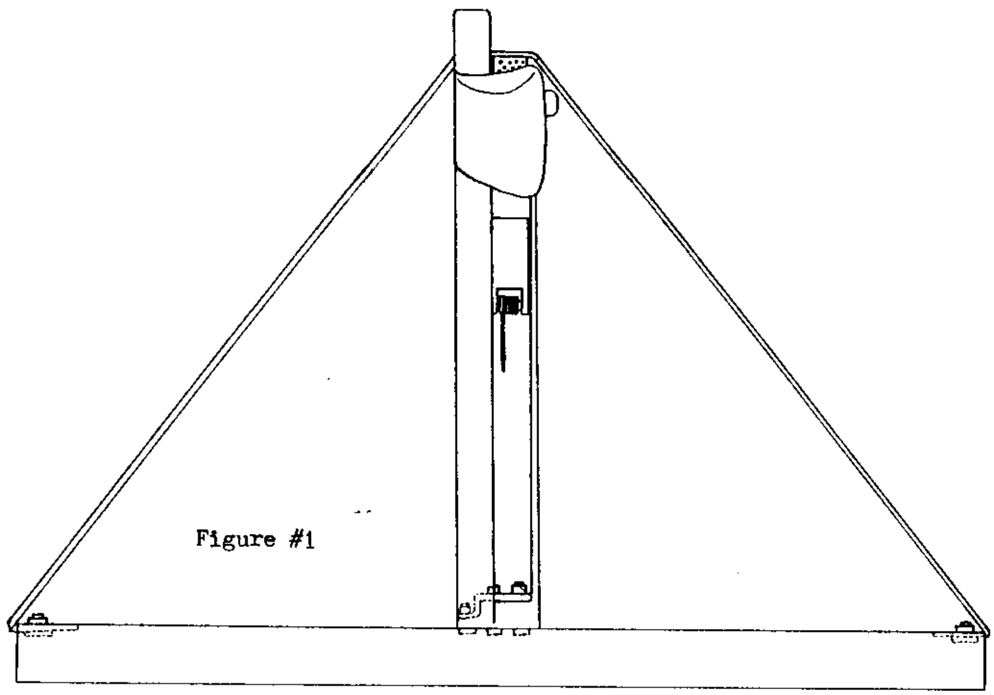


Figure #1

Mar-Bar depicting 1" tubular webbing and channel construction.

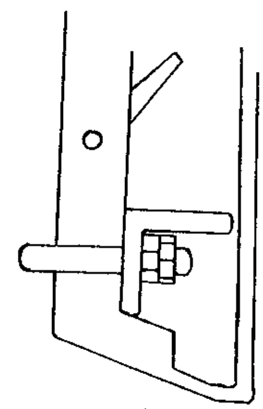


Figure #2

"U" bolt arrangement on a Mar-Bar using "L" stock.

The inchworm method is a fast efficient way of vertical travel but not without disadvantages. It works best on long free drops. But it's bulky. The bar is usually about a foot long and takes up considerable room in a cavers pack. For a short drop cave, it is to your advantage to use Prusik slings or another compact climbing system. The second disadvantage is climbing in tandem. The system affords so little slack that any rope motion from below is transmitted directly to your body and usually results in the need for Pepto-bismol or dramine. No system is perfect and none contains all the advantages that we would like but an exposure to all the various systems can only broaden our knowledge of vertical work and make us more effective safe vertical cavers. (See inchworm modification in the article <u>Attach Three For Safety</u>

References: <u>Cal Caver</u>, Vol. 22, No. 5, Octobert 1971, <u>AN ALTERNATE INCHWORM TECHNIQUE</u> by Richard Weisbrod.

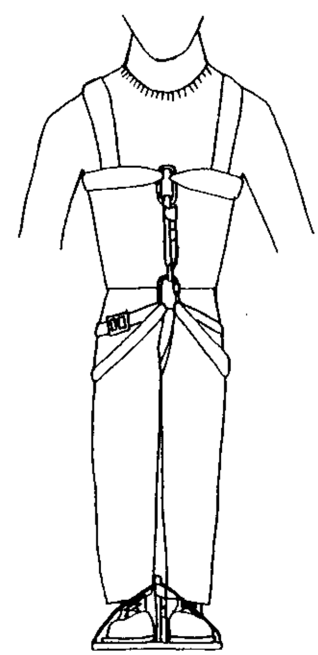


Figure #3

Inchworm System

FINANCIAL REPORT

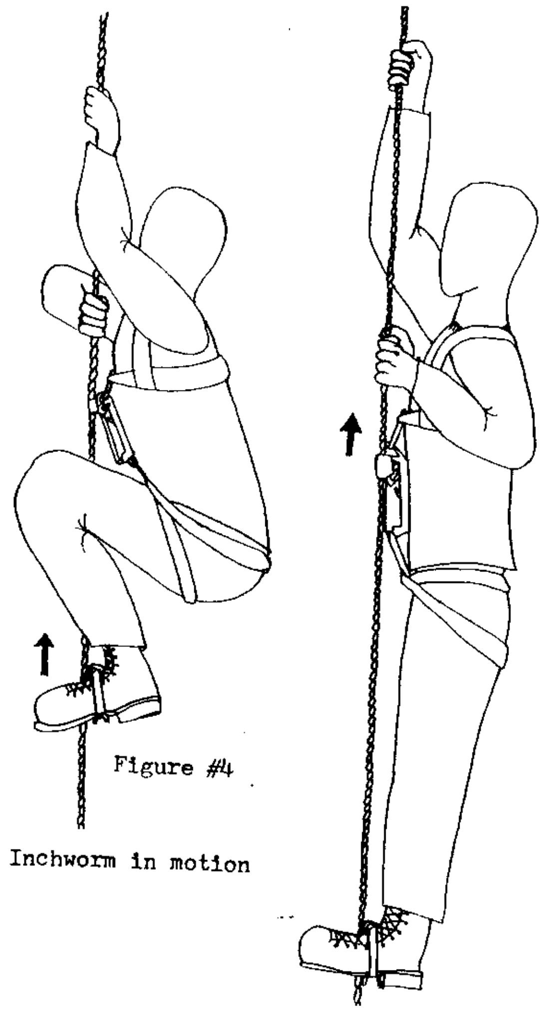


Figure #4

Inchworm in motion

ACCOUNTS RECEIVED

Dues & Subscription	$327.00	73.6%
Donations	42.00	9,5%
Back Issues	53.00	11.9%
Issue #1 Paid, Not sent	10.00	2.3%
1975-76 Dues in Advance	12.00	2.7%
Total Assests	444.00	100.0%

ACCOUNTS PAID

Balance brought forward	$ 11.62	3.1%
Printing of Newsletter	223.95	58.6%
Postage	70.86	18.5%
Supplies	71.85	18.8%
Printing dues reminders	3.90	1.0%
Total Debits	$382.18	100.0%

Balance brought forward into next years budget: $61.82

It now becomes evident that the Nylon Highway could not have made it without the additional sales of back issues and the generous donation of Bruce Herr and Kirk MacGregor.

Let's compare this years expenditures to last years expenditures under the major categories of interest.

1973-74	Category	1974-75	% Inc./Decrease
60.0%	Printing and Paper	58.6%	-2.3%
25.0%	Postage	18.6%	-26.0%
10.8%	Supplies	18.8%	+74.1
$228.40	Assets	$444.00	+94.40%

Supplies Category Include:

Mailing Envelopes
Mailing Labels
Staples
Typewriter Rental
Rub on Letters
Paper for Masters
Tipe
Ink
Return Postage Guaranteed Stamp
Glue

Respectfully Submitted by
Bruce W. Smith, Editor & Treasurer
Vertical Section of the N.S.S.

Bruce W. Smith

THE STRENGTH OF YOUR RIGGING

by Ed Schott

In rigging ropes the tension in the ropes can be much larger than the actual weight of the object being suspended.

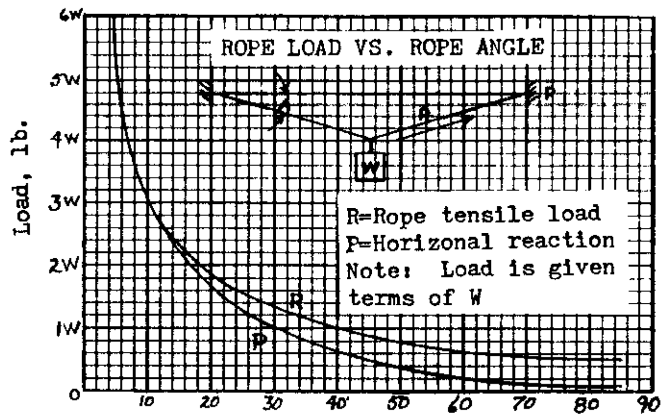
The relationship between the force in the rope and the load being suspended is determined by the geometry of the situation. Only the loading of straight stretches of rope is discussed here. Due to the complex nature of stresses in knots they are not discussed although the knot rather than the straigh section of rope may well fail first.

The graph shown below shows the relationship between the weight, W and the rope tension, R and the horizontal reaction force, P. It should be noted that for angles less than 30 degrees that the tension in the rigging rope is greater than the weight.

Highly stretchable rope like nylon is somewhat self protecting because as it stretches the angle increases and the weight supported for a given rigging tension increases.

Two things should be noted carefully when using this graph. One, the angle is the angle of the rigging rope from horizontal and two, the tension is the rigging rope tension and not the vertical rope tension.

An especially dangerous situation would occur if one rigged a tight rope, which would not stretch much, over a pit and then fastened a main vertical rope to the center of it.



The geometry of this situation may also be applied to a rope tied around a tree or other object although the possibility of a dangerous situation is probably less there.

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BOLT INSTALLATION MADE EASY

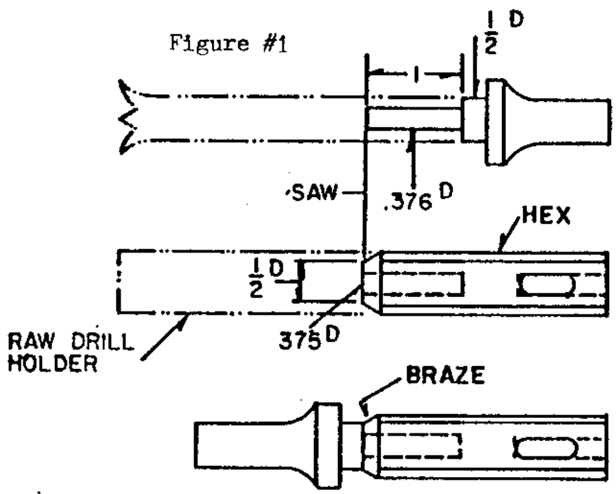
by Kyle Isenhart

How many times have you wanted to set an anchor at a pitch in order to make it safer but the thought of all that work prevented you from doing it? The placement of anchors such as rawl drive-in studs or self-drilling anchors is a slow and strenuous task. While the actual amount of time and effort necessary to drill a hole for an anchor 3/8" diameter by 3" deep varies greatly with the hardness of the limestone it rarely takes less than 30 minutes and often as long as an hour. As if this weren't bad enough the optimum location for the anchor is often extremely awkward to reach or requires the person placing it to be supported by some sort of make-shift belay during the operation. Often bolts are placed in compromise locations because of these difficulties. It was for the preceeding reasons that I made the piece of equipment described in this article. At first glance you may feel that the additional equipment needed would make the system impractical but the fact is that due to the time and equipment involved most of the bolts that are in caves were put in on trips designated for that purpose. For that reason alone the system is practical.

Instead of everyone wearing out their arm, a couple of people just carry an extra piece of equipment. The time saved in placing the anchors is astronomical! The system is based on the use of a small pneumatic hammer and a specially constructed rawl drill holder. The pneumatic hammer is about the size of a small ¼" electric drill and operates on about 80 p.s.i. of compressed air. With a small pressure regulator and a standard scuba diver's 72 cubic foot tank you can drill from 8 to 12 3/8" by 3" deep holes in most limestones. The great part is that it only takes from 20 to 35 seconds drilling time to make the hole. The utility of such a unit especially during rescue operations when time is a major factor makes it worthwhile for every group to have one.

The drill holder is made as shown in Figure #1. Step #1. Take an attachment for the hammer and saw it off approximately 1½" in from of the flanged collar. Put this piece in a lathe and turn it a .376" diameter section approximately 1" long leaving the shoulder in front of the flanged collar for the tool retaining spring to rest against. Step #2. Take a standard rawl drill holder and cut it off retaining approximately 1½" beyond the slot into which the frift pin fits to dislodge the drill. Drill a .375" diameter hole in this end approximately 1¼" deep. Step #3. Drive the two pieces together and braze. I also made a small wrench as shown in Figure #2, which is extremely useful. The drill works so fast that without a mechanical lever you cannot rotate it while drilling. A box end wrench or adjustable open end also works. For this operation, with the wrench illustrated the box end fits over the rawl drill holder and is used to rotate it while drilling. The two open end wrench cut-outs on the other end fit the nuts on ¼" and 3/8" rawl drive-in studs. If you prefer self-drilling anchors, attachments are commerically available to hold them while drilling with this type of pneumatic hammer and the same type of time savings is realized.

Figure #1



The drill holder with appropriate alterations.

This information is presented in hope that it will help expedite the placement of those necessary anchors which are needed underground. I do not wish to encourage the indiscriminate placement of anchors underground by making it a quick-and easy operation. Before placing anchors remember that they are only semi-permenant but the damage to the underground is permenant. Use good judgement and happy drilling.

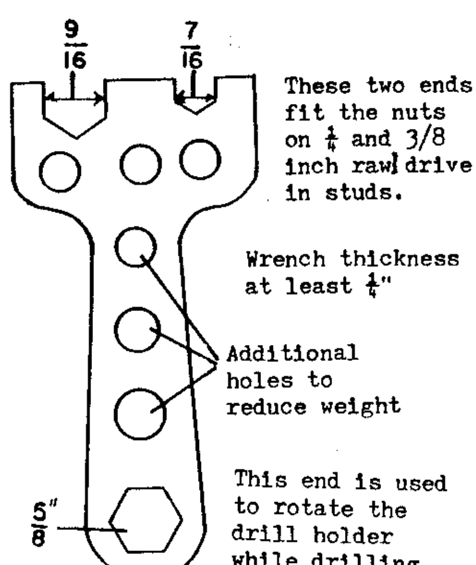
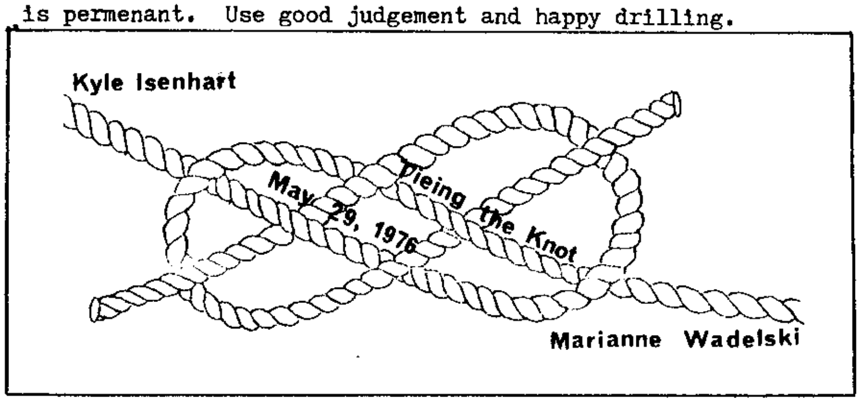


Figure #2

Pneumatic hammer wrench



BOLTS

by Kyle Isenhart

The placement of semi-permanent anchor bolts in caves is a point of some controversy. Many people say they are never justified and conversly others say they are always needed. Neither of these viewpoints are correct. The indiscrimenate placement of unnecessary hardware underground in not only in violation of N.S.S. conservation policies but can lead the unknowing to place lines in improper places simply because rigging points are available. The criteria that should be used in deciding whether or not to place anchor bolts are: First; Is it absolutely necessary to do the pitch safely? If the answer is yes bolts should be installed. The other criteria that should be considered if the answer to the first one is no is: Will the improvement in the rigging point by installation of the bolts justify the permanent defacement of the cave? It requires considerable thought and judgement to make such a decision and it should not be made lightly. If the pitch can be done at all it should be before installation of bolts to improve it is considered. Often the best place to rig a pitch cannot be determined from the top and hence this intitial descent is necessary to prevent installation of anchors which will either have to be removed later or cause further difficulties due to their improper placement. If it is decided that bolts should be placed the most desirable location must then be determined.For further suggestions on this matter one may wish to refer to the author's article entitled, <u>HOW TO RIG A VERTICAL PITCH</u>, <u>Nylon Highway</u> No. 2.

One of the most important criteria is that the line should be near the desired location. By far the most important factor in placing bolts is that the matrix in which the anchors will be set must be solid. Thin flakes, and soft or crumbly areas should be avoided. Often solid rock underlies thin and stable surface layers. Conversly thin but solid appearing flowstone etc., is occasionally deposited over clay or unstable underlying layers. The best designed anchors will not support loads if placed in an unsuitable material under most circumstances more than one anchor should be installed. Whenever possible they should be placed in different bedding planes to lessen the chance of simultaneous matrix failures.

After a suitable location for placement has been determined you must then decide which of the several types of anchors to use. The one thing they all have in common is that they work by expansion of the anchor against some part of the hole in which they are placed. The most popular anchors in use

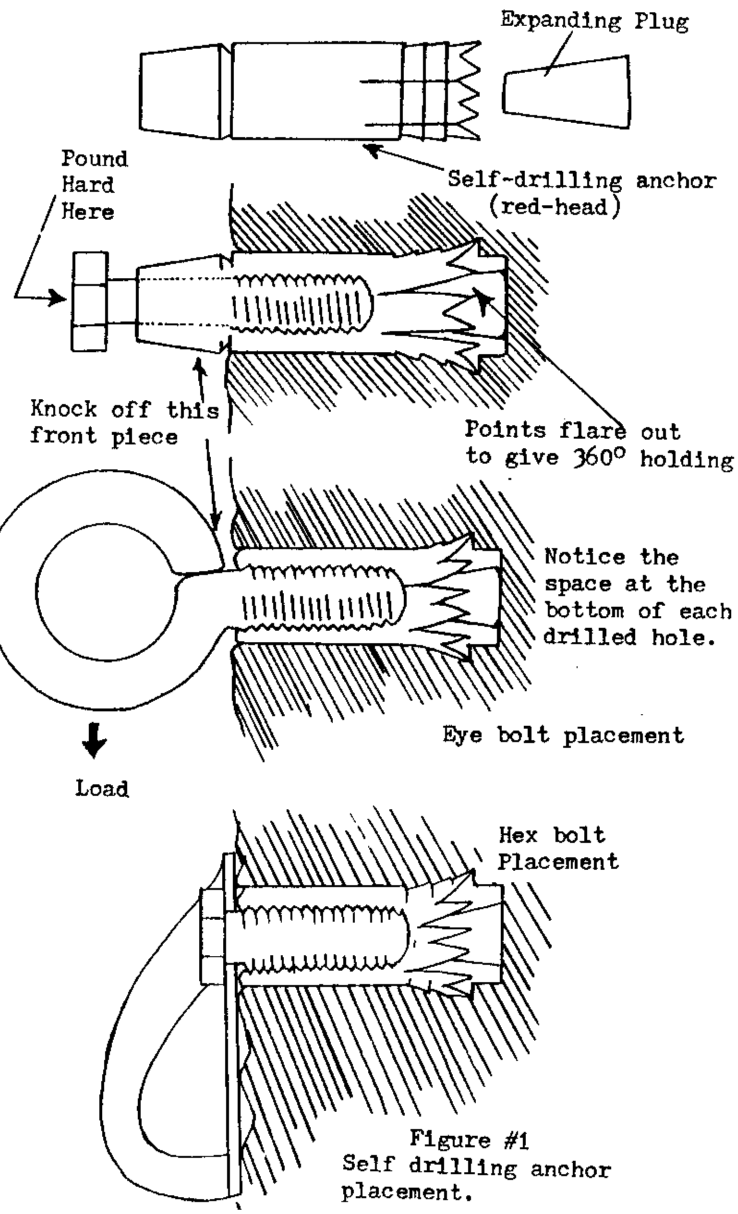


Figure #1
Self drilling anchor placement.

by cave explorers in this country are manufactured by the Phillips, Star and Rawl companies. Each of these companies produce different styles of anchors. The Star "nail-in" anchors as many refered to them are seldom used now. They, as well as the use of any anchor which used lead as the expanding medium is not very desirable due to the extreme softness of the lead. Their holding power is not high when compared with some of the other types. The use of plastic sleeves is not popular for the same reason. The most common and best readily available anchors are the Rawl drive-in studs and the self-drilling anchors which are produced by several manufacturers. It is these two types that will be discussed in the remainder of this article.

The self-drilling anchors need a special attachment to hold them while drilling the holes, but as the name implies a serparate drill is not necessary. The inexpensive brands often do not drill well because the metal is either too soft or brittle, then a separate drill is necessary. They derive their holding power by enlarging at the end in the base of the hole and hence require good solid holes near the bottom. (See Figure #1) Because they expand outward in a complete circle they give equivalent results when loaded in any direction. They are generally short (less than 2 inches long) and this can be a disadvantage in areas of soft or crumbly rock. The self-drilling anchors generally have the best holding ability of the various anchors especially when loaded parallel to their axis. High strength bolts should always be used with self-drilling anchors and care must be taken to be sure they aren't too long or they can actually loosen the anchor while being installed.

The rawl brand drive-in studs are the other most popular type of anchor used by cavers. They require a drill to make the hole for installation. The author has had better performance from the specially manufactured rawl brand twist type percussion drills then from regular star type drills in drilling limestone. The rawl drive-in studs are available in different diameters and lengths but the most common ones are ¼" or 3/8" in diameter in length from 1 to 3". They derive their holding power by pressing outward against the central portion of the hole and hence the hole needs to be solid in that area to use this type of anchor. Because of the split nature of this anchor it only forces against the hole on two opposite sides and whenever possible should be loaded perpendicular to these sides. (See Figure #2) These anchors hold best when loaded perpendicular to their axis.

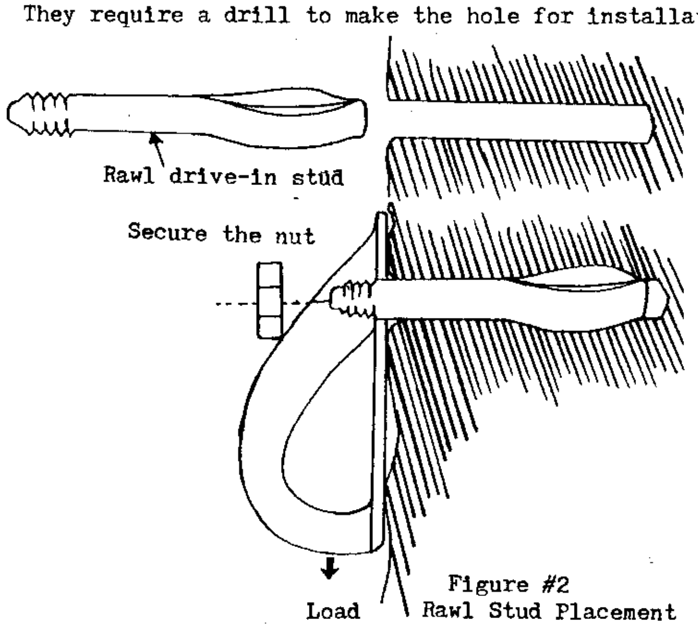


Figure #2
Rawl Stud Placement

When drilling holes with either a precussion drill or a self-drilling anchor keep the hole as free of dust and other particles as possible. This is easily done by blowing out the hole often with either a small enemia syringe or a piece of small diameter tubing and the mouth. If you use tubing be sure it is long enough that the particles don't get in your eyes. ALWAYS wear safety glasses or goggles when using precussion drilling equipment. Many serious accidents have been caused by

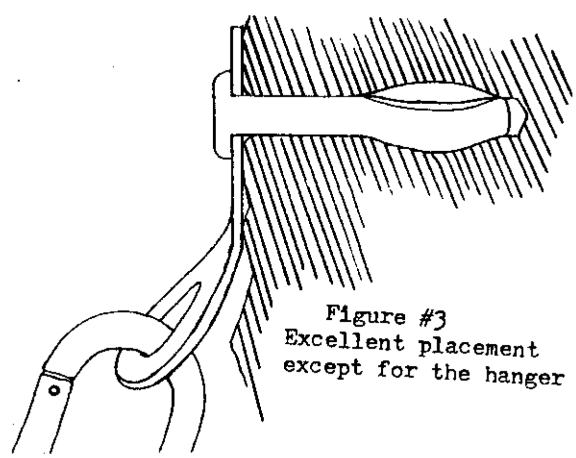


Figure #3
Excellent placement
except for the hanger

flying fragments of rock or metal from this operation. Use a heavy hammer, (at least 16 oz.). Most piton hammers are too light for efficient drilling. Rotate the drill constantly for faster operation This is important for all types of precussion drills. Do not put water on the drill. This causes conglomerates to form of the pulverized particles which clog the drill flutes and the hole and are difficult to remove. When installing either self-drilling or rawl drive-in stud anchors the hole must be the right diameter and depth. With the self-drilling anchors the diameter is determined by the anchor itself but care must be taken to drill to the correct depth. After the expanding plug has been installed and the anchor completely driven in and seated it should be flush with the surrounding surface. (See Figure #1) This is particularly important when loaded perpendicular to the anchor's axis to achieve optimum holding power and causes proper placement of this type anchor to be difficult for many people. With the rawl drive-in studs the diameter of the hole is very important and the rawl corporation recommends a drill slightly under 1/4" for the 1/4" anchors and one slightly over 3/8" for the 3/8" diameter anchors. Since these anchors do not seat against the bottom of the hole, the hole can be too deep without harm. The thing to remember is not to drive the anchor in too far but to leave sufficient shank exposed for the hanger and to sent the nut completely on the thread.

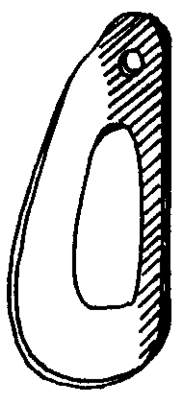


Figure #4
SMC Hanger

Having selected the location, drilled the hole, and properly seated the anchor, the next thing to be done is attaching the proper hanger. Hangers of the type shown in Figure #3 should not be used because they cause excessive outward forces to be unnecessarily applied to the anchor when loaded. Commercially available or homemade hangers of good quality steel similar to those in Figure #4 are excellent. When loaded parallel to their axis heavy duty lifting eyes and not standard eye bolts or hangers should be used with self-drilling anchors. When the placing of rigging bolts is justified both they and the hanger should be left intact. Do not remove hangers from good bolts. The use of a material such as locktite brand bearing mount can be helpful in preventing vandals from removing hangers and nuts from inadvertently working loose.

When ever possible identify bolts as to, by whom and when they were placed. This can avoid much worry and unnecessary duplication of placements. If you make your own hangers you can stamp your grotto's initials for example and the month or year the anchor was placed. If you use commercial hangers which are hardened a small engraved aluminum tag with the information can be attached with a short piece of small wire cable. Editor's Note: During the rerigging of Schoolhouse Cave, it became necessary to manufacture some very special Mud Pitons. I'm sharing them here with you now so if the situation ever pops up at least you have heard it works. We used 3 foot long #5 steel reinforcing rods and bent and welded an eye in one end (See Figure #5). We needed a three pound sledge to get them in place but rest assured the judgement seat can be safely reached with the hardware additions. We removed the questionable hardware.

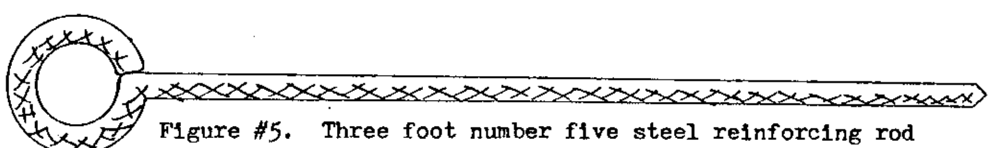


Figure #5. Three foot number five steel reinforcing rod with welded eye makes a good mud piton.

In conclusion the proper placing of anchors in caves requires considerable judgement and great care but the results can save lives and open new areas of exploration without causing excessive damage to the underground wilderness.

ATTACH THREE FOR SAFETY

by Bruce Smith

At the 1975 Convention a major discussion on the cause of several recent accidents let the Vertical Section to recommend the condemnation of two point climbing methods. A two point climbing method implies only two points of contact that a climber is attached to the rope. The major method of climbing discussed were the popular Mitchell system, the Texas system and the Inchworm method. In order to promote safer climbing techniques these are the findings and recommedations of the vertical section.

The Texas system has always been so inherantly easy to rig that it's been used without question for years. Among climbers, simplicity has always been an objective but it's time to take a closer look. Several accidents, near accidents and deaths have occurred again and again using the Texas system. The primary reasons why accidents occurred was that every different Texas system had some place where there was a built in failure point. If you are a user of this type of system you should be taking the following precautions. (1) Seat harness is secure, sewn well and has a built in redundant system. (2) A strong locking carabiner. (3) A secure double line to the top climber. (4) A top ascender that is clean, works well and is not worn out. (5) A strong double line running from one or two feet that connects with the lower ascender. (6) Chicken loops. (7) A bottom ascender that is clean, works well and is not worn out. (8) A connection line between the bottom ascender and the seat harness in case the top ascender fails.

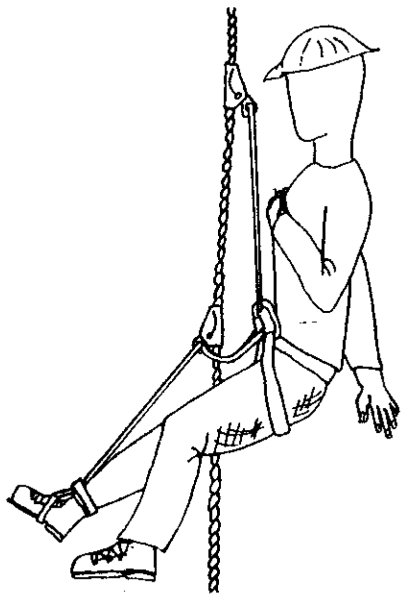


Figure #1
Texas system with all eight safety points built in.

These eight safety points are already hopefully incorporated into your Texas system. (See Figure #1) The Vertical Section recommends a third ascender. This is the most difficult system to modify since anywhere you put that third ascender it becomes awkward and begins to complicate the simplicity of the system. It's recommended to place a Gibbs ascender atop the top ascender and have it float along. The attachment of this safety Gibbs becomes the next problem. The best method would be a direct second line to the seat harness. This becomes a matter of personal choice. It's been also recommended that the top floating cam be attached to a chest harness. (See Figure #3) Even though this latter suggestion invites bulkiness of equipment and added hassles it increases your chances of serious accident or death from 99 to 1 as before to 999 to 1. Admit it we all play the odds in caving adventures. Let's keep them in our favor.

The Mitchell System - Again, the Mitchell systems two climbing points of contact have caused serious accidents and one death that I know of in Puerto Rico. Making it a safe system is easy, and affords a much more practical climbing method. Attach a floating Gibb to a secure seat harness and place it on the rope below the bottom Jumar. When it becomes time to rest just sit down in your seat harness. It's no longer necessary to attach your third seat Jumar to the rope

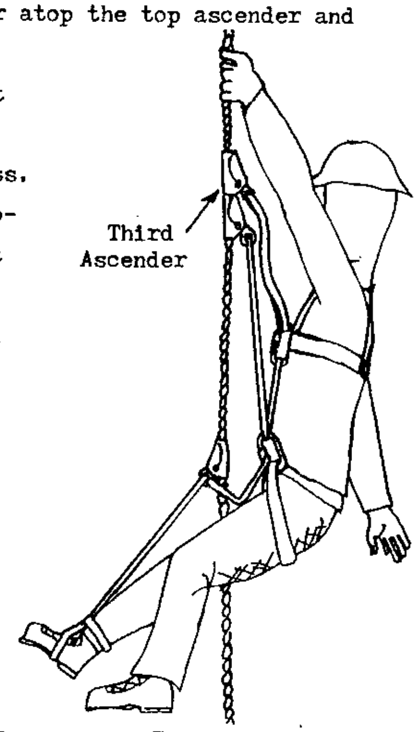


Figure #2
Texas system with a third contact point.

because youv'e already got your safety Gibb on the rope. Possibly you will find it may work better to shorten your foot Jumar about 4 inches and attach the Gibb to the rope between the box (See Figures #4 and #5) and the lower Jumar. Of course, all 8 points of safety that were mentioned under the Texas system, modifications are important here as well, with the following additions. (1) Be sure the chest harness is secure, tight and can hold your weight. (2) Be sure your box is in good working conditon and screwed down tight. (3) Dangerous times to beware are the moments at overhangs where it's necessary to come out of the box to make the appropriate maneuvers. Another very positive solution to the Mitchell system and the incorporation of the third contact point would be the Pygmy Prussik System dicussed at length in Nylon Highway No. 2, Page 19.

The inchworm deserves mention because it too has only two points of contact. Even though very few people actually use this system, I've seen it work well for people who were somewhat over-weight and females who weren't as physically fit as some of the males on a particular trip. (See Figure #5) A floating Gibbs again is the answer attached to the seat harness and positioned midway between the two Jumars.

It should also be mentioned that if you're using one of the popular step climbing methods with Gibbs that a shoulder cam or chest cam should be a very important third point of contact that should absolutely be incorporated into your system. I've seen and used an additional fourth hand held Gibb with a small wrist loop used which aids in pulling oneself up the rope.

The Vertical Section feels that if climbers were to make these essential safety modifications from two point to three point climbing technique that the number of accidents among climbers could be greatly reduced.

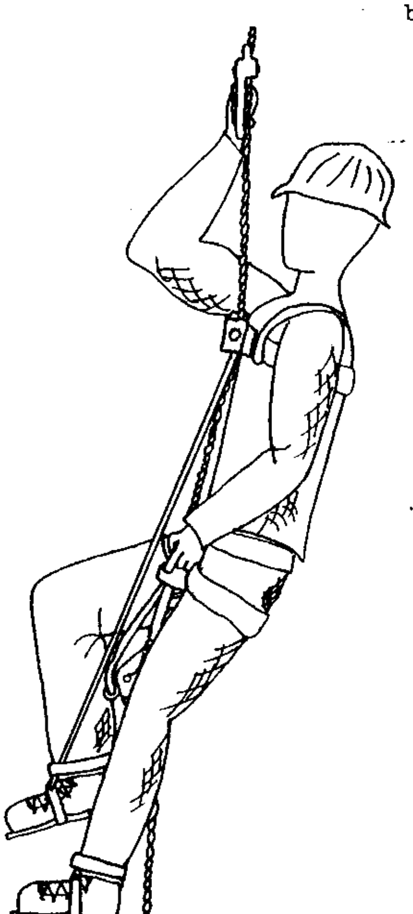


Figure #3
Gibb floats below the lower Jumar

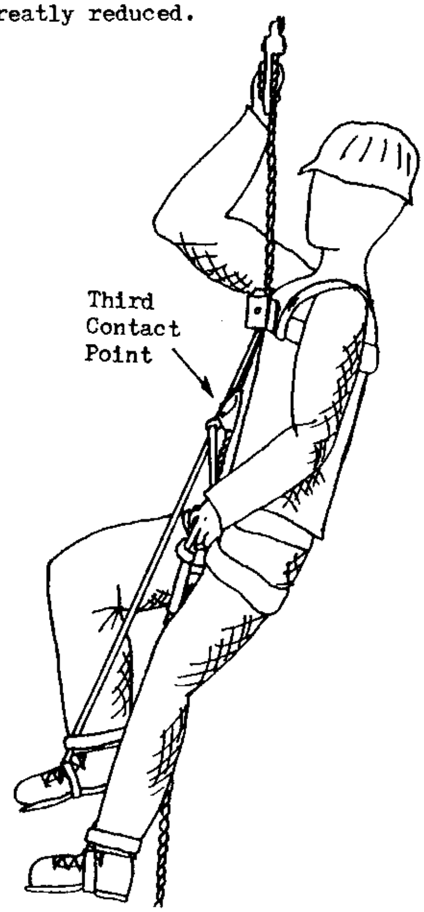


Figure #4
Gibb floats between the box and lower Jumar.

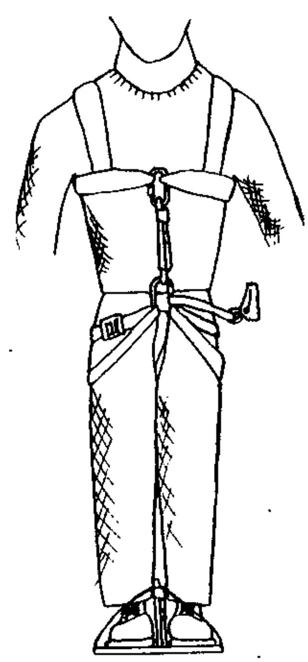


Figure #5
Inchworm with a 3rd contact point-a floating Gibb.

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