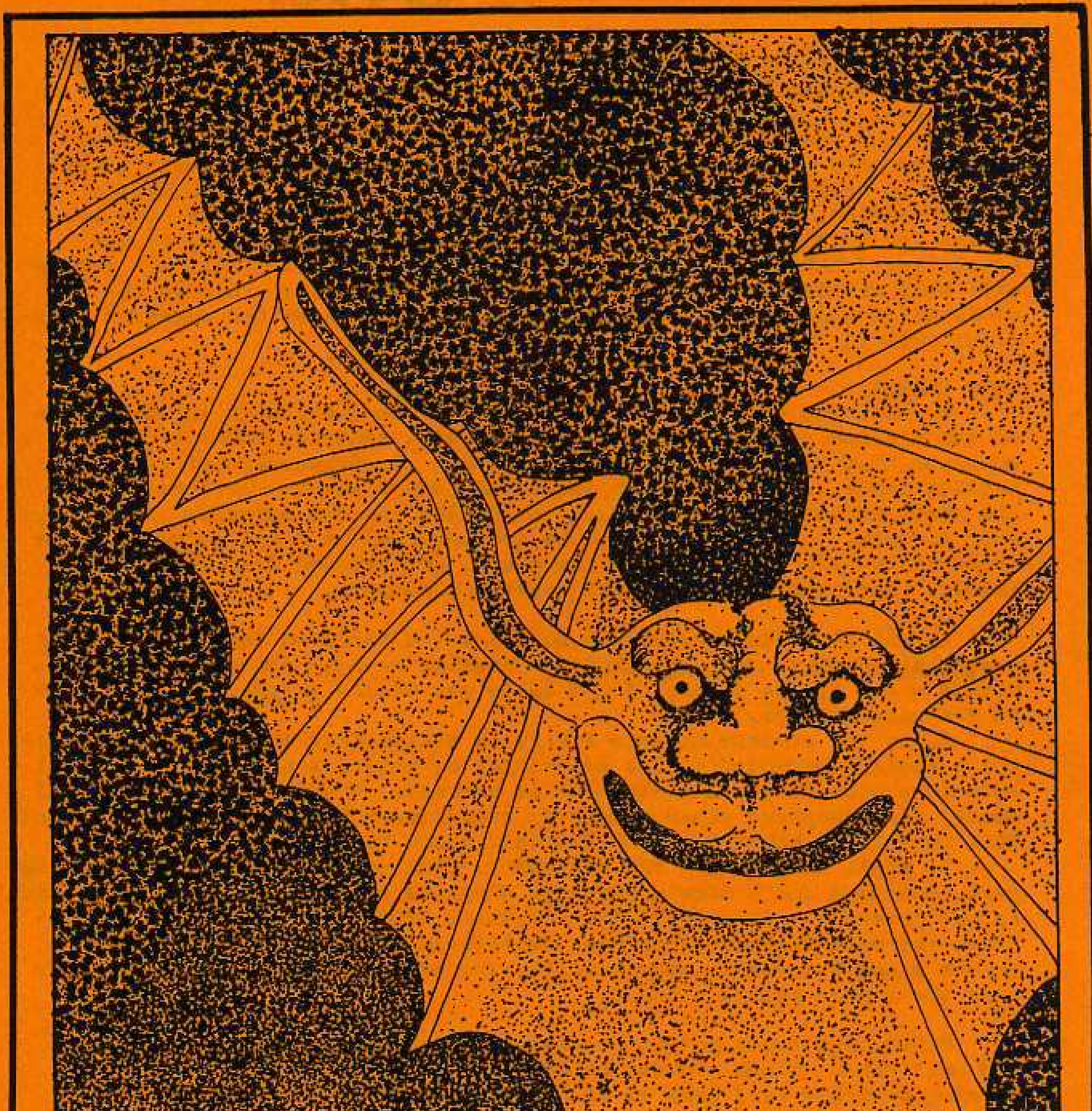
NYLON HIGHWAY 6

...especially for the vertical caver



Nylon Highway 6

March, 1977 publication of the NSS Vertical Section

Inside

vertical section officers 1976-77

Kyle Isenhart - Chairman
Kirk MacGregor - Secretary
Bill Cuddington
Pete Strickland
Allen Padgett
Cheryl Jones - Editor & Treasurer

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Appalachia, VA 24216

cover

Cover drawing by Jan Davis, NSS 12667, of Arlington, VA. Resemblence to any Vertical Section member is purely coincidental.

details

DEADLINE for NYLON HIGHWAY #7 is May 16, 1977. Articles need to be typed double spaced if at all possible, and illustrations, graphs, etc., inked, ready for final copy. Correspondence should be addressed to the editor. One need not be a Vertical Section member to contribute material. Letters to the editor are welcome.

NYLON HIGHWAY is published by the NSS Vertical Section, and available to non-members at a rate of $3.00 per year. Grottos may receive issues for the cost of postage. $1.00 deposit required. Frequency of publication is based on the availability of material.

OPINIONS EXPRESSED herein are credited to the author and do not necessarily agree with those of the Vertical Section or its Executive Committee. Unsigned material may be attributed to the editor. Reprinted material must give credit to the author and source to prevent an unhealthy curse from descending upon your evil publication.

Pros and Cons

As a result of a bylaw passed in 1976 (see minutes in this issue), I sent the Section's executive committee copies of articles to appear in this issue. Of the five committee members, three responded (one by phone); only one by the established deadline. Their comments follow. The bylaw only established that committee members pass judgement as to whether an article should appear in the NYLON HIGHWAY (hopefully for safety reasons, although not specified by the bylaw), not edit the articles for word choice, syntax, etc. Although their interest is appreciated, I believe this is a job of the editor. After all, six people will very rarely agree upon word phrasing, usage, etc. This is the individuality expressed by the author. I do try to keep the author's character intact.

Dear Cheryl,

My comments on the articles are written on them, with the exception of the trolley article, which is written on a seperate sheet of paper. I hope you find them agreeable. I was unable to adequately reference the trolley paper, so I took it to one of our super smart engineers here at the tech. center. He went over it carefully and the comments are his (Mr. Jonh A. Jones). I feel they must be included in the final printing. Not necessarily as an appendum but can easily be included into the article itself. Most can go on page 3/8 under assumptions.

1. All the calculations and formulas are based on the assumption of a weightless cable with no stretch. However on long separations between points A and B, the weight of the cable can become extremely significant in the calculations.

2. In the summary on page 8/8 it is stated that the cable tension is not basically affected by the seperation of points A and B. For the calculations used in the article this is correct. However in the practical sense, since support cable weight is significant as stated above, the fact that weightless cable is assumed should again be pointed out.

3. Again on page 3/8 the statement, "The cable provides the main support, guides A and B merely serve to displace the trolley from equilibrium" is not correct. It should read something like: The support cable provides the main support at or near equilibrium, but the tension in the guides A and B reaches, and generally exceeds, that of the support cable near the anchor points A and B.

Other than those points he sees the rest of the article as correct and well done. Thank you for cooperating with us in the matter of reviewing articles as I know it is difficult at times.

Sincerely,
/s/ Kyle Isenhart

~ Thanks Kyle. Anyone else have a comment? -- Ed.

Dear Cheryl,

Thanks for the articles to review. Good luck on getting an issue together. A few comments on the articles:

I do hope and insist that articles in the N.H. be signed. My question is who wrote all this stuff?

The Australian Foot Harness sounds good, though a better explanation-diagram of the actual "C" clip would prevent use of an inferior/dangerous clip. Also I have been using a very similar foot loop for years and it was printed in the Caver Information Series (How to Assemble a Mitchell System Climbing Rig) years ago.

I like the Tension Sensitive Gibbs article. Good technique and rig.

The Cable Tension Generated in a Trolley Traverse could be a lot better. It is in effect, by the vertical caver, unreadable and unusable in its present form. Physics textbook language has its place, but not in N.H. The NYLON HIGHWAY should contain articles showing origionality and practical usage. It would take a physist to understand and put to use this article in its present form. I recommend a rewrite in practical usage and terms or nix on the whole thing.

Hopefully in the future, more articles can be obtained from members. I like big fat NYLON HIGHWAYS. As always, I'll try and help.

Sincerely,
/s/ Allen Padgett

~ I, too, would like big fat N.H.'s! Thanks for your interest and comments; however, as far as the trolley article, let's give our members and readers some credit! Who knows where their heads are? -- Ed.

A MARGIN OF SAFETY may be easily obtained when using tubular webbing by running a next smaller size webbing inside the main load bearing sling. The interior webbing should be slack enough so as not to take a full load, leaving this to the exterior webbing. In many vertical rigs, sling is used in such a way that abrasion frequently occures, i.e. at a carabiner, box, etc., and redundancy may keep your vertical rig from failing as a result of sling abrasion. An example of this appears in this issue, used in a foot harness.

ROUGH EDGES on buckles, ascender boxes, and any other hardwear which comes in contact with rope or webbing should be filed to a smooth rounded edge before use.

To be kept in good working condition, QUICK RELEASE PINS on Gibbs ascenders should be throughly cleaned and lubrucated when other caving gear is cleaned and checked. This is best done by working the pins in water, often with the aid of a toothbrush, then working a dry lubricant (such as WD-40) into the pins. As with other equipment, proper cleaning and care will keep the QR pins from jamming while in use.

Modifications to the Speleoshoppe Deluxe Caving Helmet

Allen Padgett

The Speleoshoppe Deluxe caving helmet is an excellent caving hat offering good protection, light weight, and modest price. Though excellent, certain modifications make the helmet easier to use and possibly safer.

First there's the matter of a lamp bracket. If you are total electric, mount the smallest bracket you can. A small metal clip offering no target for falling objects would be best. If you are using a carbide lamp, a different bracket should be used. The large black bracket from Speleoshoppe may be used, but I prefer the small grey Universal lamp bracket. This bracket must be filed down to fit the slope of the helmet. To install this, place the bracket on the lamp, then on the front of the helmet pointing at the proper angle, marking its position. A small nail can be heated and used to make the holes to mount the bracket. For electric cavers, mount the leather cable clip on the back the same way using a phillips head screw driver to spread the rivet.

The chin strap assembly supplied with the helmet lacks ease in adjustment. This is due to problems with government patents restricting some methods to certain manufacturers. But the purchaser can make these modifications with a minimum of trouble. All that is needed are two Camp Trails sleeping bag lashing straps. These are nylon and have excellent sliding buckles attached. The approximate cost of these is $1.50. The existing chin straps should be cut off approximately two inches below the attachment points on one side and four inches on the other side. Save two of the metal adjusters from the origional assembly as they will be used in the new rig. Cut the slide buckle from the lashing strap placing it on the four inch leads on one side. Double these and sew the strap so that the buckle is two inches below the rim of the hat. Now sew the remaining long nylon straps to the two inch leads. Using the metal adjusters, place both long straps through them so that an adjuster is on either side of the chin. Thread the straps through the slide buckles and place the helmet on your head. Adjust the slides and straps for a comfortable fit under the chin. Loosen the straps and remove the helmet, cutting the surplus strap material away, being careful not to cut too much. As a final improvement, add small strips of reflective tape around the brim to aid in being seen in caving situations.

A single Gibbs is still a Gibbs. As obvious as this may seem, cavers seem to frequently miss the obvious.

Head Protection for Cavers

Allen Padgett

If you have ever hit your head on a kitchen cabinet door, you realize how fragile the human head is. Injuries to the head are always serious because the control center of the body lies exposed up there on your shoulders. Ancient warriors realized the need for protection. Think of the gladiator's helmet or of a soldier's helmet for bullet protection or of a motorcyclist's helmet for wreck protection. But the image of a caver's helmet is some muddy shell to hang a carbide lamp on. This needs to be changed.

If, as cavers, we stayed on our knees in a low crawlway, head protection wouldn't be such a big problem. Venturing into deep pits, gaping canyons, and breakdown cliffs, we place ourselves into a hazardous zone. The ultimate in protection would be a SNELL approved faceshield motorcycle helmet. But other factors enter into our choice of headgear. Some of these factors are: degree of protection, comfort when in use, and purchase price. (See Figure I.) The ideal hard hat should have good crown strength, a four-point chin strap, and energy absorbing foam liner, and an acceptable overall weight.

To realize what an adequate degree of head protection is, the situations where a helmet is used caving need to be analyzed. First, the helmet is a lamp platform. Some style of bracket must be attached to the shell to hold the light. This bracket should hold the lamp close to the cap and without dangerous internal projections. The helmet needs to hold the lamp so that the additional weight added can be carried comfortably. The second use of a caving helmet is protection from ceiling bumps. The impact here is related only to how fast you can run into the wall. Falling rocks though, present an entirely differe t situation. The impact here is gauged by the size of the rock and how far it falls. The helmet must absorb as much impact as possible. The last situation is the fall or trip. If the helmet can absorb impact, yet does not remain on the head, it is useless. An effective anchoring system is a must, therefore a chin strap is a must.

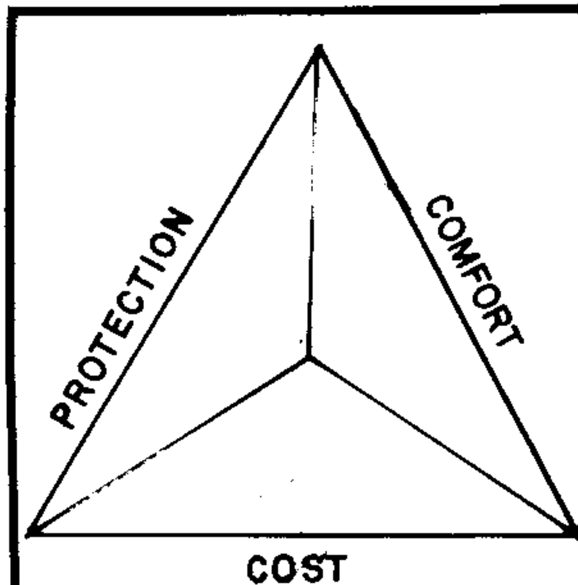


Figure I

But what constitutes an effective chin strap? Is a rubber band effective? Certainly not. At the least, a solid chin strap should be used in conjunction with a nape strap. Elastic chin straps are a contradiction of terms. Elasticity to make it easy to come off, yet with the need to hold firm. The sellers of speleo-stuff should not sell these unsafe chin straps. The best chin strap is a multi-point attachment passing under the chin, with an adjustable tension system. (Figure II.) Studies have shown that the helmet strap should pass under the chin, and not pivot on the chin. The jaw bone is not a fixed point, therefore the attachment can fail because of a movement of the chin. The suspension and chin strap assembly should prevent the helmet from rotating off the head. The best chin strap system cradles the back of the head and meets in front of the ears to pass under the chin. Side to side rotation is controlled if the helmet is held on the shape of the head by a non-elastic chin strap.

Because all impacts are not on the top of the head, side and nape protection is an important factor. Helmet construction and shape are the factors affecting the protection available both to the sides and on the crown. A rounded top allows objects impacting to veer off, dissipating the force. Flat top miner's caps cannot offer this veer advantage. In addition to the basic shell strength, a crushable foam liner can absorb additional impact. A specifically designed deforming suspension (such as on the Mountain Safety Research (MSR) helmet) can also absorb impact.

Several commercially available hard hats are useful caver's helmets. The Speleoshoppe Deluxe Polyethylene caving helmet fits the criteria in Fig. I quite well. This author recommends it highly, with only slight modifications to the chin strap assembly, making it easier to adjust properly. The MSR helmet is excellent, though only slightly more expensive. Several other models are available that are acceptable, but are somewhat harder to come by. The American Safety Climbing Helmet and other brands are good buys as caving hats because of their four point chin straps, impact resistance, suspension design, weight of the hat, and cost of purchase.

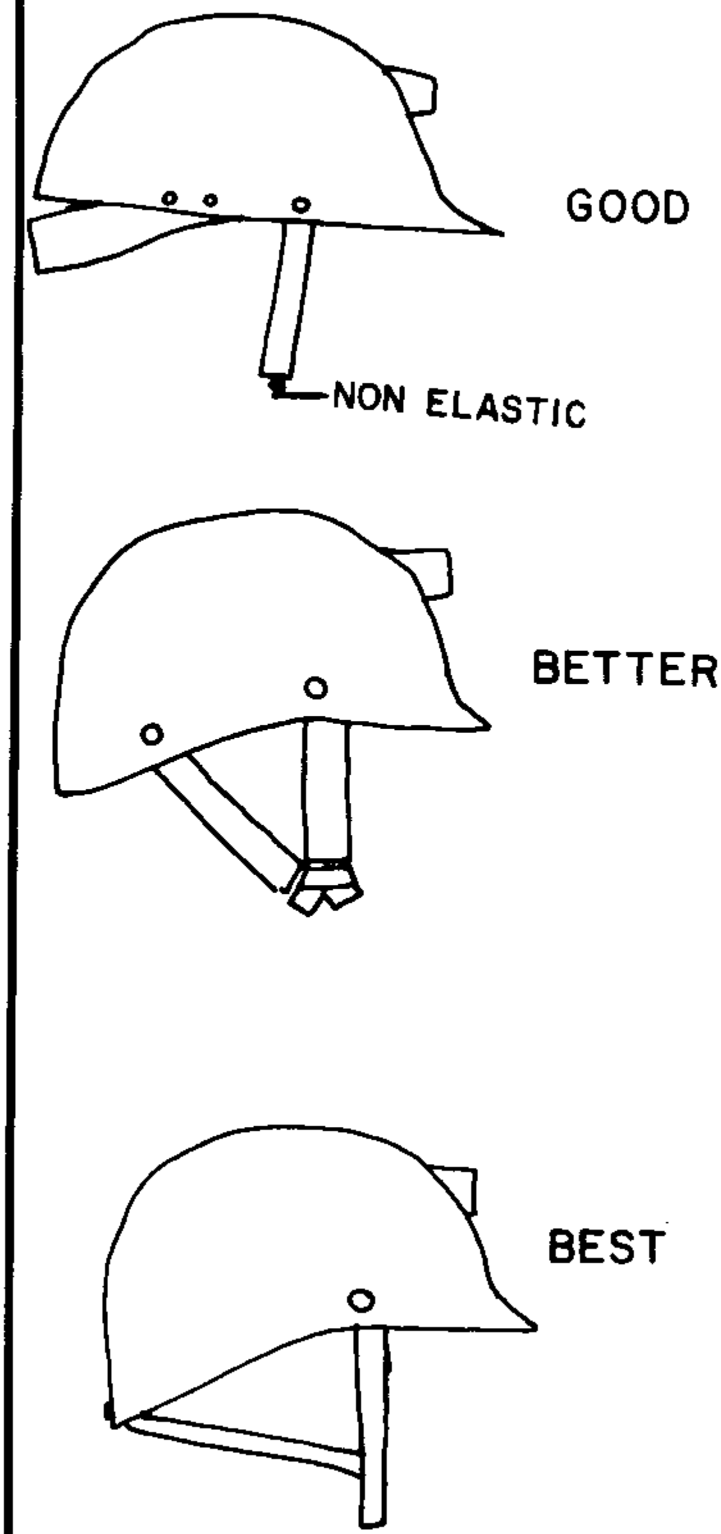


Figure II

The best thing to do is buy a new hard hat with these features, but the least you can do is upgrade your old one. First check that lamp mount for sharp screws on the inside. Then throw away the old elastic chin strap, cutting it in half to keep some poor fool from using it. With this gone, add a four point chin strap using sleeping bag lashing straps and a pop rivet gun. (Use short pop rivets to avoid projections inside hat.) Then add a crushable foam liner (available at this time from Speleoshoppe) above the suspension inside the helmet. Do you know why motorcycle helmets don't have fixed bills over the eyes? It's to prevent leverage from causing neck injuries. To upgrade your hat, take a saw and cut off most of the bill. This will allow you better vision in crawlways and pits, and with better protection.

Once you upgrade your hard hat, protect and use it. A hard hat only works on your head. Don't place it beside you while sitting waiting to climb. Don't sit on it since weird forces and torques can result in cracks and weaknesses in the shell. Watch paint, as certain chemicals can weaken helmets. Also rear decks of cars can be a source of intense heat, and this can weaken the hard hat. For this reason, hard hard hats should not be left here. If the hard hat takes an impact of any size, retire the helmet as you would a belay rope.

Several types of hard hats a are inadequate for caving use. When considering a caving hat, think of its intended use. A motorcycle helmet is simply for riding a mororcycle. A miner's hat is just that. A Tonka hat is a toy. A bymp cap is to keep chicken pluckers from cutting their foreheads. Climbing helmets are for rock climbers. Cavers just have to improvise a helmet for their uses.

In vertical caving, we expose ourselves to increased hazards, and due to this we should upgrade our head protection gear as we upgrade our climbing hardware. Clinging to our old construction hats is like clinging to our old manila rope! The elastic chin strap should go the way of the Army helmet liner. Upgrade now!

Take the time to SPREAD THE WEAR on your rope over a wide area. After one or two climbers have reached the top, re-rig the rope so that another section receives wear at the lip, various ledges and projections. This will keep your rope in a good overall condition, without highly worn or cut sections so often appearing in cavers' ropes.

GIBBS ASCENDERS have been recently modified by the replacement of the avalanche cord with one-half inch webbing to attach the cam to to the shell. The webbing is attached to the cam by a self taping screw in a hole drilled in the center of the top of the cam, and to the shell at the usual hole, but on the inside of the shell.

When machine WASHING ROPES and webbing, be sure to use a front loader. Pack the ropes in loosly and use cold water. Top loaders have a tendency to damage ropes, and will not clean as well as the front loader. A glass window in the door is preferred over plastic, as the rope may become glazed when in contact with the plastic during the spin cycle.

Australian Foot Harness

Neil Montgomery

For several years now, vertical cavers in Sydney, Australia, have been using a simple, easy-to-operate foot harness for prusik rigs whose stirrups need to be atached securely to the feet.

Construction and use of the harness are shown in Figures I and II. The sewn loop of 9/16 inch webbing is made just large enough to easily slip on the boot, and is pulled down tight with the buckled strap around the heel. The harness is now very secure and will not slacken, providing suitable buckles are chosen. I find crampon strap buckles to work well. Small, strong stainless steel "C" clips can be bought from most boating shops.[1]

For the sewn loop, 2400 lb. test webbing should be used for maximum strength and durability. Though the harness has not been tested, the bend at the "C" clip is not severe enough to cause a drastic strength loss in the webbing, and the "C" clips and buckle will probably be the weakest links. Strong makes should be chosen.[2]

The harness is secured to the foot at the first prusik encountered in a cave, and can be worn continually until the last prusik is completed. The 9/16 inch webbing will sit tight in the boot instep, protecting it from most rock surfaces you will walk over. The tubular webbing around the 9/16 inch webbing in the instep takes care of what little abrasion does occur. At each pitch, the foot stirrup is quickly attached by coupling the "C" clips, and is just as quickly removed by uncoupling.

The harness should endure about two years of frequent caving use. In Australia, we have never had one break or come off the foot. The only problem we have observed is that very occasionally the "C" clips will jiggle undone when the stirrup is slack, but this has only occurred while resting on the seat harness or walking across ledges.

---

[1]Buckles should hold 1000 lbs. or more. Strengths of "C" clips are hard to obtain, but the stainless steel varieties should hold in excess of 1000 lbs.

[2]Another option to buckles is the use of two metal circular or "D" rings, as are used in parachute harnesses. --Ed.

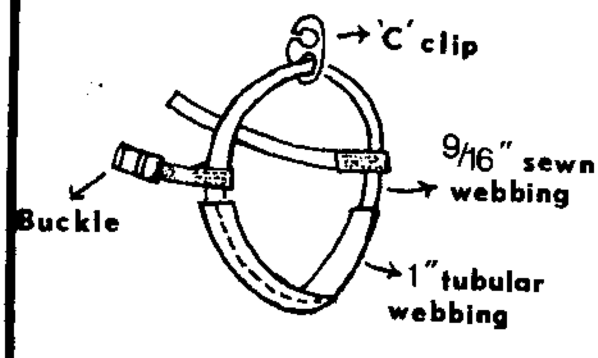


Figure I

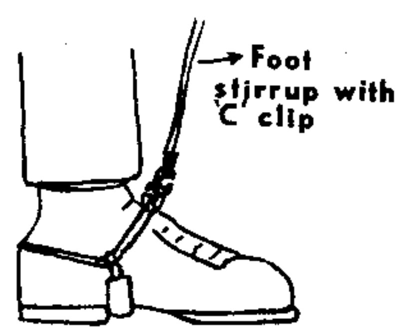


Figure II

A Tension Sensitive Gibbs

Lyle Moss

I would like to share some ideas which should promote safer vertical travel. Serious accidents which occur to experienced people participating in hazardous activities, such as rock climbing in remote places and hang gliding, are often due to modification and experimentation with existing equipment. I therefore recommend great mistrust of any technical modifications until well proven by time.

I have been using a Gibbs modification for six months on several pit caves and numerous trips up and down a third story balcony. The device has not been formally tested with dummies, nor been used on very muddy ropes.

This modification has advantages over the Safety Rappel Cam as discussed in an excellent article by Don Davison, Jr., in the NSS NEWS ("Safety Rappel Cam", Vol. 34, #8, Aug. 8, p. 138.) With the use of the Tension Sensitive Gibbs (of this article) for a rappel safety device, the need for an additional cord (the avalanche cord to the "pressure pin") used with the Safety Rappel Cam to the chest area is eliminated, thus simplifying rigging and derigging under adverse conditions (Fig. I). The Tension Sensitive Gibbs is attached to the chest harness portion of a combined (and securely connected) seat-chest harness system. If one were willing to sacrifice the increased shock absorbing qualities of a 15 cm length of laid climbing rope for a 15 cm length of one inch doubled webbing sewn crosswise in 2 or 3 cm intervals (similar to the Forrest "Daisy Chain"), one could obtain a quick locking-carabiner adjustment of the chest harness-Gibbs attachment length. This length could then be adjusted for various cavers and various rappels. I use a system of ascending similar to the Mitchell system, and use the triggered (released) Tension Sensitive Gibbs as my top ascender.

The activation of the Gibbs is by either 1) falling backward, 2) bringing the forearm or hand across the chest, 3) a failure of the attachment of the brake bar system or rack, causing the friction device to slide into the Gibbs, or 4) accidental release due to dragging the Gibbs on rock, such as at the lip of a pit. Upon activation, the caver remains in an upright position and breathing is not impaired.

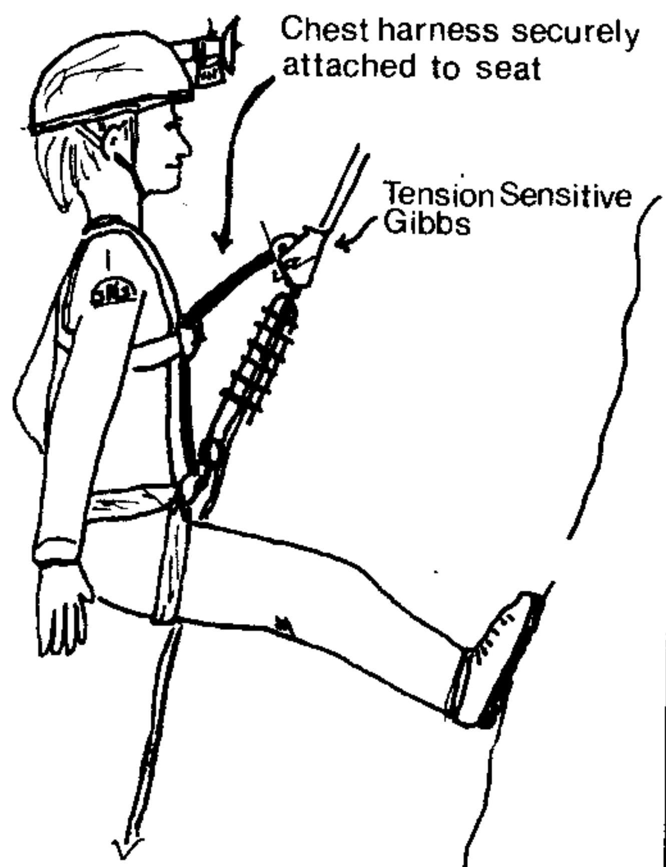


Figure I

Regaining a controlled rappel is accomplished by tieing off the friction device, releasing tension to the Gibbs by using another ascender or stepping into a loop formed in the rappel line, resetting the Gibbs, and "unlocking" the friction device.

Details of the Tension Sensitive Gibbs are shown in Figures II, III, and IV.

Placing the shock cord through the eye of the cam permits 1) acceptable friction of the cam on the rope, and 2) easier assembly onto the rope than a standard quick release Gibbs. This is due to the shock cord and red cam retaining cord both acting to orient the cam and keep it in close proximity to the shell. Either a carabiner or doubled one inch tubular nylon webbing fits through the cam eye with the shock cord in place.

A piece of cloth adhesive tape is placed as shown in Figure II-A to ease in removal of the shock cord from the quick release pin. This also helps to keep the shock cord from slipping through the cam eye, thus helping to maintain the cam's position while assembling. The Gibbs may be used without cam tension by releasing the shock cord from the end of the quick release pin.

The placement of cloth adhesive tape as shown in Figure III-B permits adequate leverage to keep the cam away from the rope while in the "set" position (Fig. IV). The spring clip (Fig. III-C) can be constructed from piano wire or a cotter pin. The cam is "set" by snapping the clip over an 8/32 inch by ½ inch bolt (Fig. IV); the head being filed down so as not to occlude the inside of the Gibbs shell.

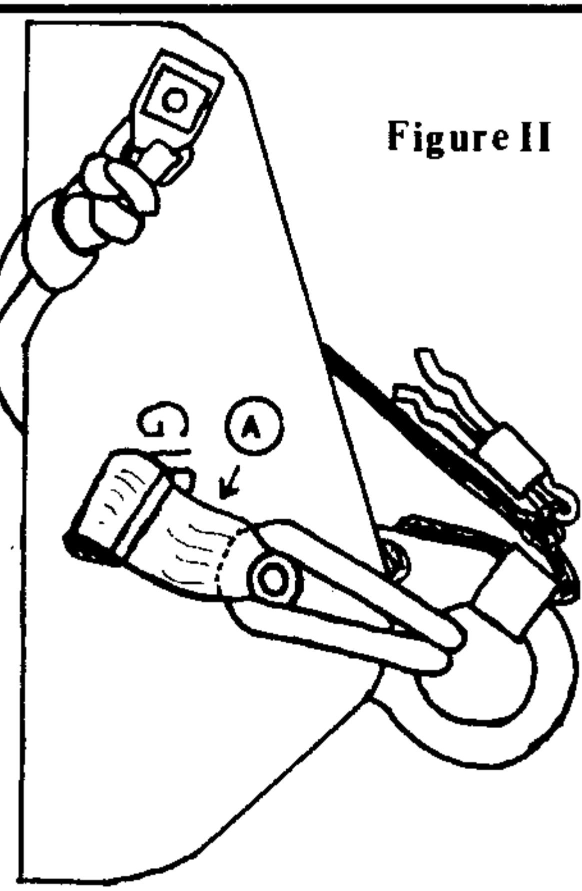


Figure II

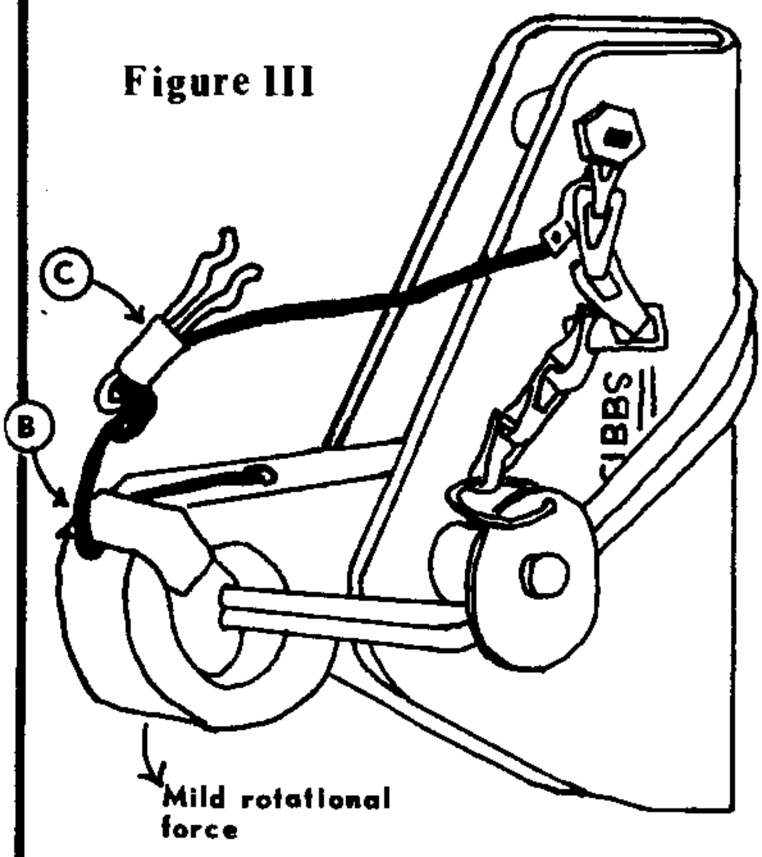


Figure III

As with the Safety Rappel Cam, the Tension Sensitive Gibbs can be incorrectly assembled upside down on the rope, and the shock cord can be placed so the cam is forced into the open position. As with all vertical techniques, care should be taken to see that equipment is properly assembled. Inspection and cleaning of vertical gear should be done regularly.

I feel the Tension Sensitive Gibbs offers a most secure protection for rappels; and as a versatile piece of equipment, can serve for other uses, such as ascending.

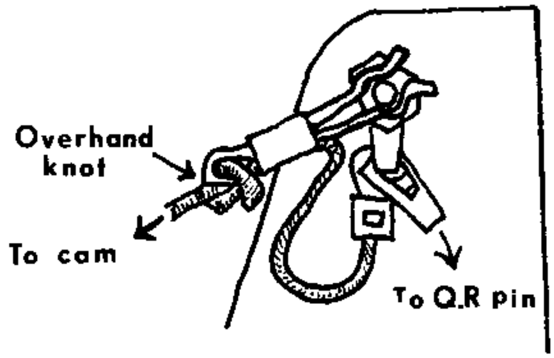


Figure IV

BUILDING A NEW VERTICAL DEVICE?

TESTING SOMETHING?

MATHEMATICALLY MODELLING SOME ASPECT OF ROPE WORK?

THINKING ABOUT VERTICAL CAVING PHILOSOPHY?

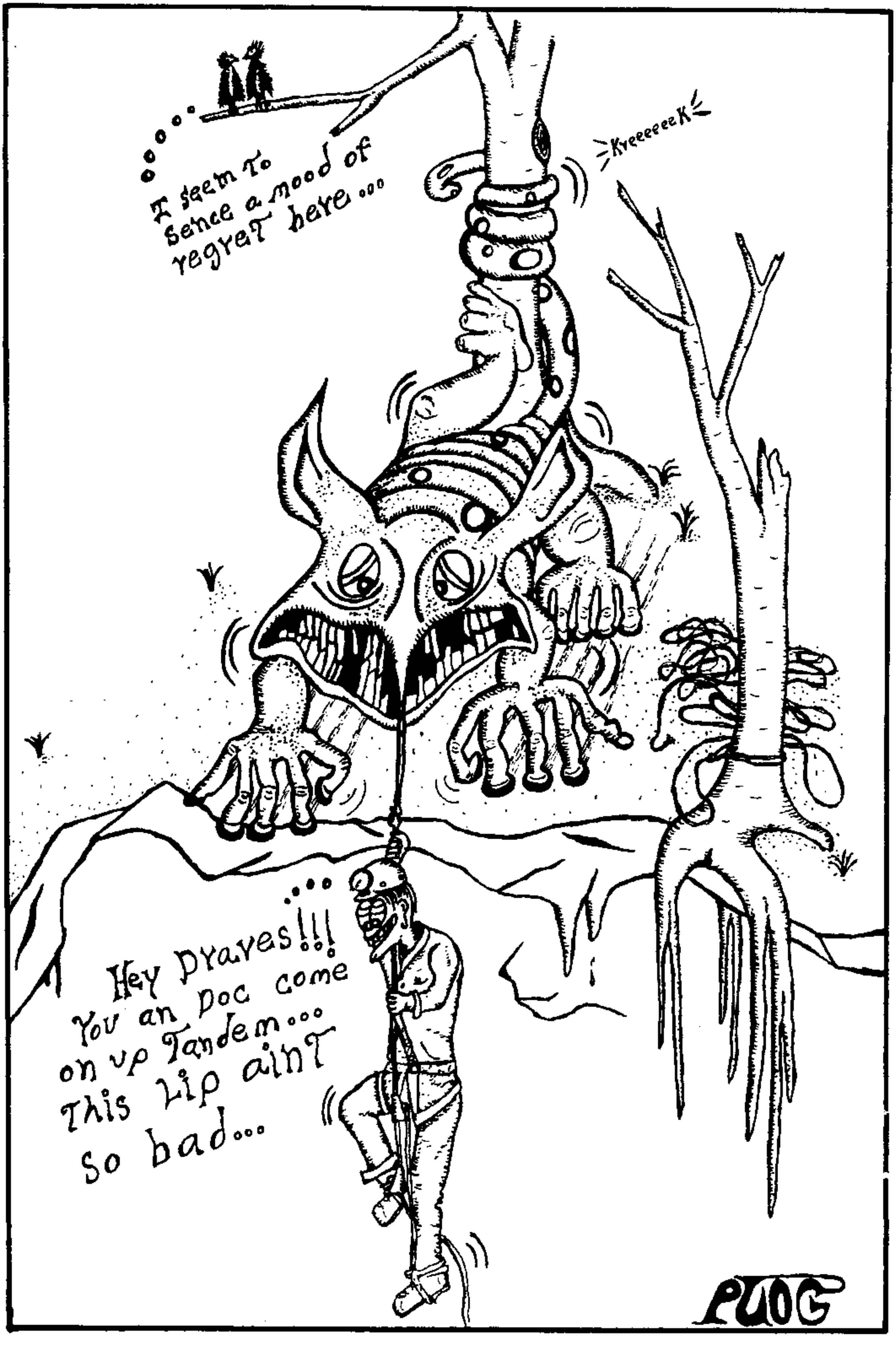
Let us know about it at the 1977 Vertical Session during the NSS Convention! The session is an open forum for the presentation of ideas on rope work, including views that disagree with the Section "party line" (Lets hear more of these!)

If possible, we'd prefer that you send in an abstract to be published in advance in the convention program. However, If this isn't possible, just show up before 2:00 pm, Wednesday, August 3, (according to the tentative convention schedule) and get your name added to the session program.

Should your presentation require any facilities beyond a short fixed rope and a 35 mm slide projector, be sure to contact the session chairman well before the convention to see if arrangements can be made. If you are using 35 mm slides, please contact the session chairman no later than Tuesday, August 2, to allow for organization of slides before the session starts. (however, if you are organized enough to have slides, how about sending in an abstract in advance?)

Direct your abstracts, questions, etc., to the session chairman:

Kirk MacGregor
78 King High Ave.
Downsview, Ontario
Canada M3H 3B1
Ph: (416) 630-6976



I seem to sence a mood of regret here...
Kreeeeeek
Hey Draves!!! You an Doc come on up Tandem... This Lip aint so bad...
PUOG

Minutes '76:

bylaws, ballots, & b.s.

The 1976 Vertical Section Meeting was held in Morgantown, West Virginia, starting at 4:30 pm Wednesday, June 30. Executive Committee[1] members present were: Bill Cuddington (Chairman), Kyle Isenhart (Secretary), Del Province, Pete Strickland, and Jim Gossett.

After Kyle Isenhart opened the meeting by briefly describing the Vertical Section and introducing the five committee members, Bill cuddington suggested forming a "Contest Committee" to run the Vertical Contest. It was quickly decided that the Executive Committee could appoint people to this committee after the meeting, and Bill concluded with an appeal to the section members to come and help with the Vertical Contest.

Kyle then spoke on the NYLON HIGHWAY for a few minutes, pointing out that it took a lot of work to put out an issue, that there were varying opinions on the quality of the HIGHWAY, and that editor Bruce Smith was willing to resign. Don Davison noted that errors liable to cause accidents had been published in NYLON HIGHWAY, and advocated that material to be published in the HIGHWAY be reviewed by the Executive Committee to avoid repetitions of this in the future. After a bit of discussion, nominations for editor were opened. Those nominated were Bruce Smith, Cheryl Jones, Marion Smith, and Allen Padgett. (Only Allen was present at the meeting.) During the nominations, Kyle pointed out that the editor maintains the Section membership list and treasury, as well as producing NYLON HYGHWAY . Voting was by show of hands, and resulted in a tie between Cheryl Jones and Marion Smith. A second round of voting left Marion elected as editor, if he accepted the job upon hearing of it. It was agreed that the editorship would go to Cheryl if Marion declined.

At this point, Jim Gossett proposed that material for NYLON HIGHWAY be reviewed by the Section Executive Committee. After several minutes of discussion, during which about four prople supported the general idea, and two people felt a less editor-restricting approach would be better, Jim Gossett moved that:

> Materials to be published in the NYLON HIGHWAY will be reviewed by the Vertical Section Executive Committee. Those items not unanimously agreed on by the Committee will be published with the dissenting arguments appended. Further, a similar arrangement for NSS NEWS articles dealing with vertical work will be recommended to the Board of Governors.[2]

A show-of-hands vote carried the motion 17 to 7.

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[1] This group of five people has sometimes been called the Vertical Section "Board", but the term used in the Section Constitution is "Executive Committee", so that term is used here.

[2] As more or less agreed at the meeting, the above written version of this motion is somewhat "neater" than the spoken version, without changing its meaning.

In the next few minutes, Allen Padgett suggested that vertical demonstrations put on by the Section should be less dogmatic about which equipment to use than has been the case. Kyle suggested that a reading list of good vertical books and articles could be published in the NSS NEWS to help people who might lack this information. Kirk MacGregor suggested that the section write Bluewater a letter asking them to attach labels to their boxes warning of the need to smooth the sharp edges before using them. This provoked a few minutes of discussion of equipment safety and Bluewater's quality control, which ended when Allen Padgett moved that:

> The Vertical Section will use all avenues available to it, including the Safety and Techniques Committee, letters written by individual members, and letters written by the Section as an official body, to urge producers of speleo equipment to ensure that all their products are safe.[3]

The motion was carried by a show-of-hands vote of 21 to 0.

While ballots were being prepared and counted for the election of the new Executive Committee, Kyle announced that section dues and NYLON HIGHWAY subscriptions were $3.00 per year (as in the past), and there was a discussion of some aspects of Vertical Contest safety. During this discussion, Bill pointed out that requiring hard hats in the contest would reduce safety there, as hats reduce the body's ability to get rid of heat, thus increasing the risk of contestants collapsing from overheating. Don Davison (STC Chairman) repeated his demand that arrangements be made to have two Emergency Medical Technicians, oxygen, and an ambulance at the Vertical Contest to deal with any heart attack which may occur.

When the ballots were counted, there was a tie for fifth place between Allen Padgett and Richard Schrieber. Richard resolved this by declining in favor of Allen, leaving the new Executive Committee composed of Allen Padgett, Pete Strickland, Kirk MacGregor, Kyle Isenhart, and Bill Cuddington.

The meeting ended about 5:45 pm.

Immediately after the meeting, the new Executive Committee met and selected Kyle Isenhart as Chairman, Kirk MacGregor as Secretary, and Bill Cuddington as Chairman of the Contest Committee.

/s/ Kirk MacGregor[4]
Vertical Section Secretary

---

[3]As agreed at the meeting, this is a heavily rewritten version of the impromtu spoken motion which reads better, but retains the origional intent.
[4]My thanks go to Bruce Herr for lending me his tape of the Section meeting, without which these minutes could not have been written.

Cable Tension Generated in a Trolley Traverse

Gene Harrison

The traverse is analyzed, a general formula is developed.

The worst case is considered.

A relationship is established enabling rapid, reliable determination of worst case parameters.

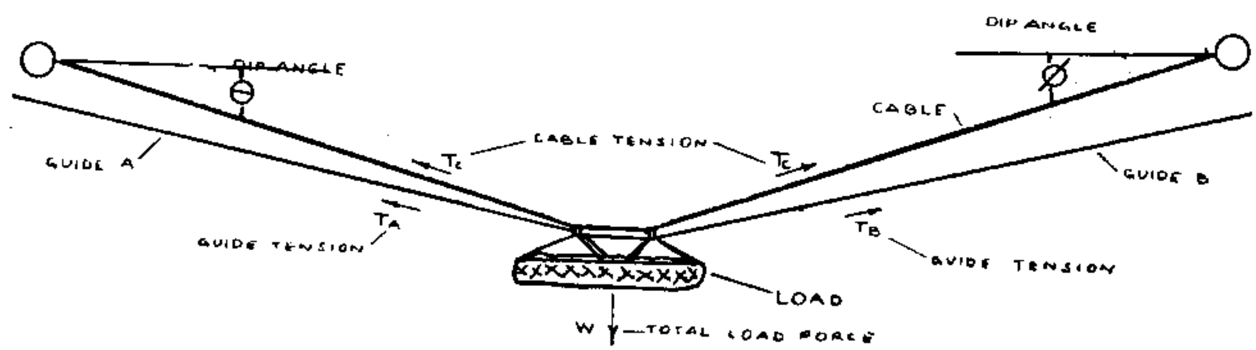


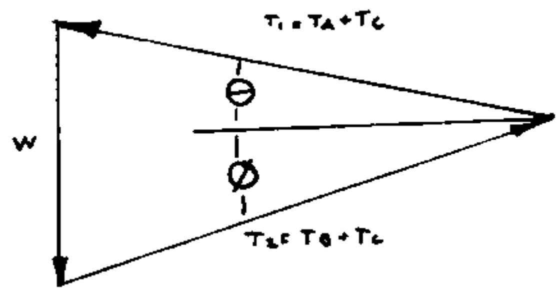
Figure I - Trolley

W = Total Load Weight
T_A = Tension, Guide A
T_B = Tension, Guide B
T_C = Tension, Cable
θ = Dip Angle at A
ϕ = Dip Angle at B

T_1 = Total Tension toward A = $T_A + T_C$
T_2 = Total Tension toward B = $T_B + T_C$

Assumptions:

The trolley moves without friction. Its two contacts on the cable provides the main support, while guides A and B merely serve to displace the trolley from equilibrium.



Force triangle at trolley

Figure II

From the force triangle (Figure II), we can derive the following:

$$W = T_1 \sin\theta + T_2 \sin\emptyset \qquad T_1 = T_A + T_C \qquad T_2 = T_B + T_C$$

$$W = T_C \sin\theta + T_A \sin\theta + T_C \sin\emptyset + T_B \sin\emptyset$$

$$W = T_C(\sin\theta + \sin\emptyset) + T_A \sin\theta + T_B \sin\emptyset$$

$$T_C(\sin\theta + \sin\emptyset) = W - T_A \sin\theta - T_B \sin\emptyset$$

$$\therefore T_C = \frac{W - T_A \sin\theta - T_B \sin\emptyset}{(\sin\theta + \sin\emptyset)}$$

General Case Formula

Let the worst case be the condition in which the cable tension T_C is greatest. In this case, the guides A and B are slack; i.e. $T_A = T_B = 0$. From the force triangle, it is seen that a condition of equilibrium will be reached where $\theta = \emptyset$. In practical cases, θ and $\emptyset$ are small, θ $\emptyset$ 30°, when the system is at rest.

$$\therefore T_C \approx \frac{W}{2\sin\theta} - \frac{T_A}{2} - \frac{T_B}{2} \qquad \text{Where } \theta \approx \emptyset$$

$$\therefore T_C \approx \frac{W}{2\sin\theta} \qquad \text{Where } \theta \approx \emptyset,\ T_A = T_B = 0$$

Note that in this case, where $\theta \approx \emptyset$ and there is little or no guide tension, the cable tension is dependent on two variables; one of which would be known in an actual case (W). Let m, a multiplier substitute for $\frac{1}{2\sin\theta}$. $\therefore T_C = Wm$ (Figure III).

WEIGHT MULTIPLIER m

FOR VARIOUS ANGLES OF θ Ø

$T_C \approx Wm$ for θ≈Ø

θ ≈ Ø	m	m
2.5°	11.5	12
5.0	5.75	6
7.5	3.83	4
10.0	2.88	3
12.5	2.36	2.4
15.0	1.93	2
20.0	1.46	1.5
25.0	1.18	1.2
30.0	1.00	1
35.0	.87	.9
40.0	.775	.8
45.0	.71	.7
50.0	.65	.7
60.0	.58	.6

Figure III

COMPARISON OF WEIGHT

MULTIPLIERS $\frac{30°}{\theta}$ (HYPERBOLIC)

AND $\frac{1}{\sin\theta}$ (COSECANT)

θ≈Ø	$m=\frac{30°}{\theta}$	$m=\frac{1}{\sin\theta}$
2.5°	12.0	12.0
5.0	6.0	6.0
7.5	4.0	4.0
10.0	3.0	3.0
12.5	2.4	2.4
15.0	2.0	2.0
20.0	1.5	1.5
25.0	1.2	1.2
30.0	1.0	1.0
35.0	.86	.9
40.0	.75	.8
45.0	.67	.7

Figure IV

Figure III. It is noted that m=1 at θ=30°. Note that submultiples of 30° produce multiples of m=1. This is due to the fact that the function $\frac{1}{\sin\theta}$, properly cscθ, closely approximates a hyperpobla over a limited range and, for angles less than about 35°, a direct substitution can be made.

$$\therefore T_C \approx W\frac{30°}{\theta} \qquad \text{For } \theta\approx Ø,\ \theta<35°$$

A comparison of $\frac{30°}{\theta}$, from the hyperbolic approach, and $m = \frac{1}{\sin\theta}$, the trig approach is in Figure IV.

SUMMARY:

1. Basically, cable tension T_C is dependent on the load W, the angles θ+Ø, and the guide tension T_A and T_B, rather than the separation or heights of the anchors A or B.

2. General Case Formula:

$$T_C = \frac{W - T_A\sin\theta - T_B\sin Ø}{(\sin\theta + \sin Ø)}$$

3. The state of equilibrium is also the worst case, i.e., T_C at A maximum:

$$\theta\approx Ø \qquad T_A = T_B = 0 \qquad T_C = \frac{W}{2\sin\theta}$$

4. In a worst case, $\frac{1}{2\sin\theta}$ can be replaced by a multiplier $m=\frac{1}{2}\csc\theta$: $T_C = Wm$.

5. In a worst case, θ≈Ø, θ<35°, multiplier m may be replaced simply by $\frac{30°}{\theta}$: $T_C = W\frac{30°}{\theta}$

6. In use, the load W and the maximum working tension T_C are established, yielding a minimum permissible mutual dip angle θ≈Ø, from the formula $\theta = \frac{W}{T_C}(30°)$.