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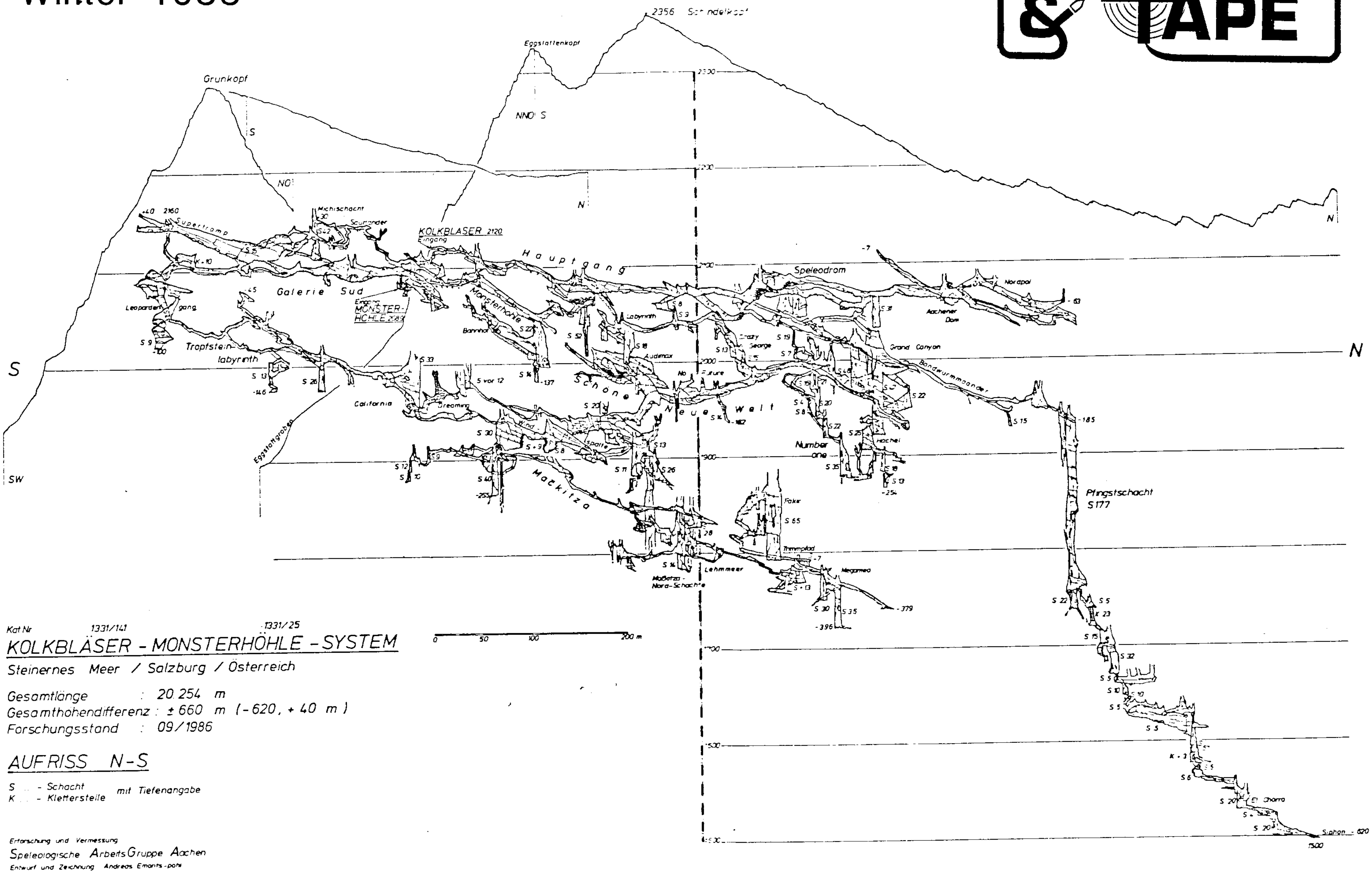
Winter 1988

COMPASS & TAPE



COMPASS & TAPE

Volume 5 Number 3 Winter 1988

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Survey & Cartography Section - 1987/1988

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COVER: Kolkblaser-Monsterhohle System, Austria. Drawn by Andreas Emonts-pohl.

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Surveying German-Style in the Austrian Alps

by Carol Vesely ***
Monrovia, California

After the International Convention in Barcelona Spain, Bill Farr and I were invited by two German friends, Michael Denneborg and Andreas Emonts-Pohl to help explore and survey in their club's project cave, Monster Hole. In addition to the excitement of exploring virgin cave I was also looking forward to the opportunity to learn something about European survey techniques. I do not know whether our friend's survey techniques are common throughout Europe but I do know they differ somewhat from ours. The purpose of this article is to share my experience surveying in Austria and my opinion of the advantages and disadvantages of their techniques compared to ours.

BACKGROUND

Kolkblaser-Monsterhohlen (Monster Cave) is located in the Austrian Alps and is currently over 640 meters deep and 20 kilometers long. Michael and Andrew's club, Speleologische Arbeits Gruppe Aachen (SAGA), has been exploring and mapping Monster Cave for about 5 years now. According to Michael and Andrew, there are few cave serious explorers or surveyors in Germany because most of the nearby caves are small and have been known for hundreds of years. Our friends claim that most German cavers are more interested in cave history and club politics (all of them want to be "chief") than in exploring virgin cave. Thus we were lucky to meet such "gung-ho" German cavers. While there is very little cave to be found in Germany the same cannot be said for Austria, where kilometers of unexplored karst abound. This is not too surprising since it snows there most of the year, making the caves very cold (1-degree C) and the caving season short. Also there aren't a lot of Austrian cavers and the government tries to regulate the number of foreign expeditions by requiring cavers to file for a permit. We all joked about the possibility of some government bureaucrat descending 600 meters deep into Monster Cave to check the group's permit. Nevertheless, the permit system supposedly keeps out the riff-raff assuring that foreign groups will actually survey the caves and produce a quality map, not just "scoop booty". I was quite impressed with the quality of the Monster Cave map. Both the plan and profile are well drawn and the map is updated every year. No matter how much clothing I wore I found it difficult to stay warm while surveying in a 1-degree C cave. Luckily most of Monster Cave is dry. However, constant freezing and thawing has shattered the rock, even inside the cave. Loose rocks abound and large handholds and footholds frequently break at the slightest touch. Vertical development is extensive with many drops and climbdowns, made all the more interesting by the loose rock. The cave is generally breakdown-floored and devoid of speleothems.

SURVEYING TECHNIQUES AND EQUIPMENT

Fortunately, SAGA has instituted a policy of surveying as they explore. Survey teams usually consist of only two or occasionally three people, but almost never more. Larger parties are generally avoided to limit the opportunity for hypothermia while waiting for others to ascend drops. There are no "designated" sketchers for the project. This is advantageous since it is not uncommon for the first sketcher's hands to get too cold to continue and then another person can simply take over the book. A profile is included as well as plan and cross sections. The sketching I witnessed was excellent: neat, highly detailed and to scale. On a typical survey trip, our group of three consisted of a book-keeper, instrument reader and point person. When a series of drops is encountered the lead person sets bolts and rigs ropes while the other two follow behind surveying as they go. Since all the Germans wear the Petzl carbide lamps typical in Europe they cannot easily mark stations by putting small carbide dots on the walls. Instead the lead person carries a small container similar to a nail polish bottle on a string around his neck. A small (1 centimeter) red dot is painted at each station and only very rarely accompanied with a station number. I found the tiny red marks to be unobtrusive enough not to spoil the look of the cave and about as easy to find as carbide dots when necessary.

THE TOPOFIL

The Germans, like many Europeans, use a topofil for surveying. This rugged little metal box serves as a compass, clinometer and tape in one (Figure 1). On each shot the lead person must carefully wrap a delicate thread around his fingers (to keep from accidentally dropping it) and pull it from the box until it is stretched tight between stations. A continuous counter measures the thread as it leaves the spool inside the topofil. It is impossible to retract the thread once it has been pulled out so the lead person must be careful not to go too far. To mitigate against this possibility the experienced instrument reader will typically hold the topofil slightly in front of the station while the lead person searches for the next point. That way the lead person can backtrack about a meter without causing problems. The cumulative numbers listed on the counter are recorded in the book and the subtraction necessary to determine the actual length of the shot is done later. To determine the azimuth the instrument reader places the topofil behind, above or beneath the station and reads the angle of the string. Then he rotates the topofil 90 degrees, places it beside the station, loops the thread around a small hook positioned at the center and reads the inclination of the thread on the degree scale on the back of the box. Care must be taken not to pull any additional thread from the box while positioning it. If the thread breaks in the middle of a shot the lead person must return to the topofil to start again. The note taker must also record new numbers since thread length is cumulative. After each shot the thread is deliberately broken, rolled into a little ball and disposed of. At first I was stashing the used thread in my pocket but the Germans typically just tossed it under a convenient rock. They claim it is made of thin cotton and decays quickly. I guess when it's common practice to dump your carbide in the cave a few pieces of thread don't seem like much. (Actually, our concern about dumping carbide in the cave had a positive influence on our German friends. They recently decided to discontinue this practice and haul their spent carbide out, even from the bottom of the Pfingstschacht at -620 meters).

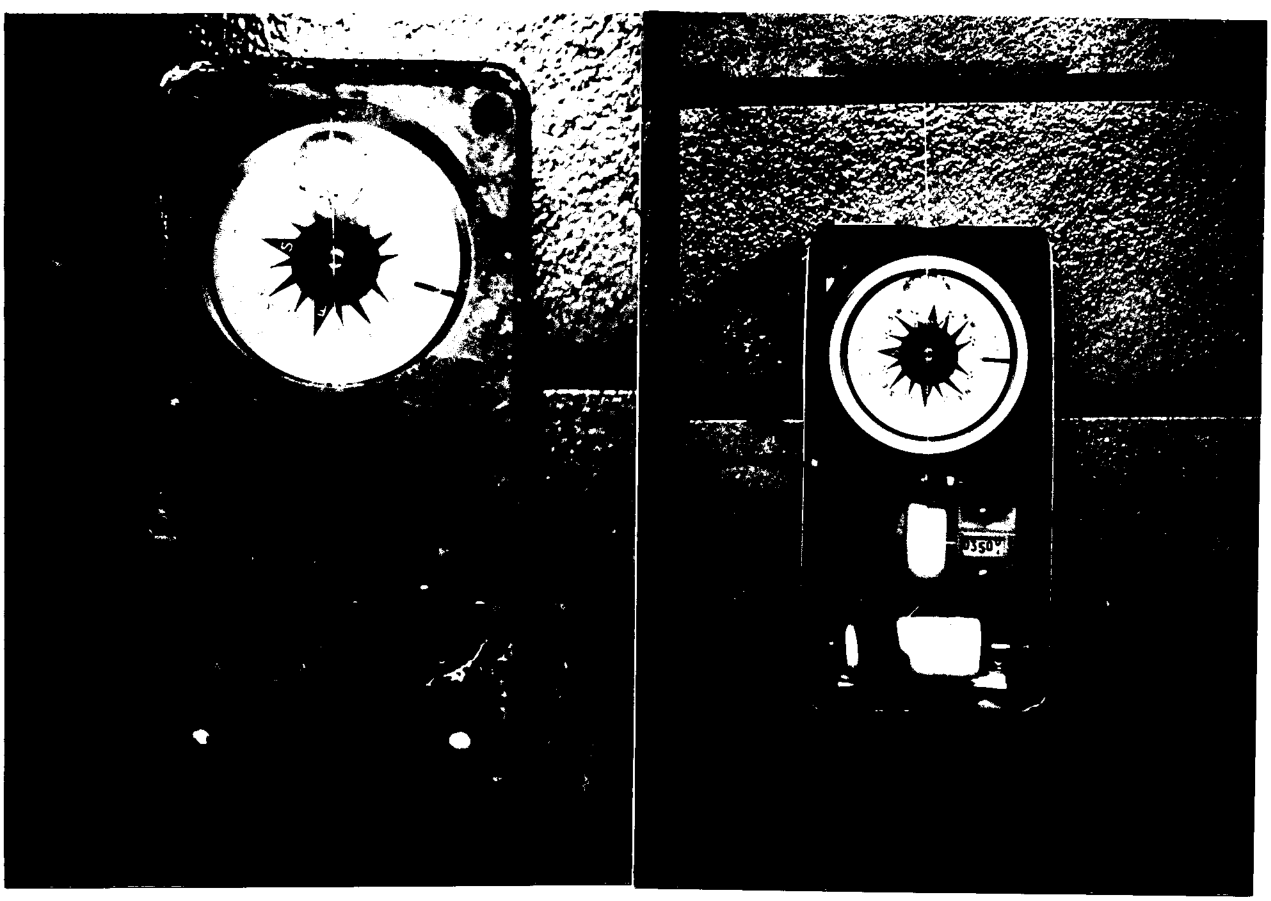

FIGURE 1: The Topofil.

ADVANTAGES AND DISADVANTAGES

As with other survey instruments the topofil has its advantages and disadvantages. On the positive side the topofil is relatively easy to learn to use and the readings can be taken quickly without fumbling around with multiple instruments. The fact that the topofil serves the purpose of three instruments makes it smaller and more compact than carrying a compass, clinometer and tape. The box appeared relatively sturdy and not easily destroyed by mud and water. Due to its simple construction it would probably not be too difficult to fix if something did go wrong. When taking a reading it is only necessary to have the box itself at the station. The instrument person's eye, head and body can assume a more comfortable position making it somewhat easier to take readings in awkward places. Meanwhile, the point person does not need to hold his light on the station for the shot. This is particularly an advantage in survey parties of only two people since the bookkeeper can hook the string on a projection and be free to use his light and hands for the time-consuming job of sketching. One last advantage of the topofil is that it seems particularly well-suited for high angle shots in steeply dipping but not entirely vertical passages. There are many disadvantages to the topofil, as well. Perhaps the most annoying problem is when the string breaks. This frustrating experience is fairly common and quite time-consuming. The lead person must return to the topofil and get a new piece of string and a new set of numbers must be recorded in the book. Because the string is so delicate it is also easy for the end of it to slip from your grasp. With gloves on the lead person may not even notice that he has dropped it. In addition it can be particularly difficult to keep the string intact when rappelling. If it breaks or is lost on a drop, a rock is usually tied to the end of the new piece and the end is lowered down the pit (a real drag). Fortunately, with practice the frequency of mishaps decreases. While the topofil may be small compared to a compass, tape and clinometer combined it is still too big to stick inside your pocket to protect from mud, etc. When it does become muddy a large window area must be wiped or licked (yech!) clean much the same as when a compass or tape gets muddy. The constant wiping of the grit and mud tends to leave small scratches on the plexiglass window eventually giving it a frosted appearance difficult to read through. Choosing a station using a topofil requires careful consideration since it is impossible to retract the string. Also after each shot the lead person must meet the instrument person to obtain a new piece of string. It is not possible for the lead person to simply mark the station and move on ahead. The little pieces of string used on each shot must be either left behind in the cave or packed out. Finally, I am not convinced that this method is as accurate as Suuntos or Brunton. Michael sent me a chart showing the percentage error on loop closures in Monster Cave. (See Figure 2).

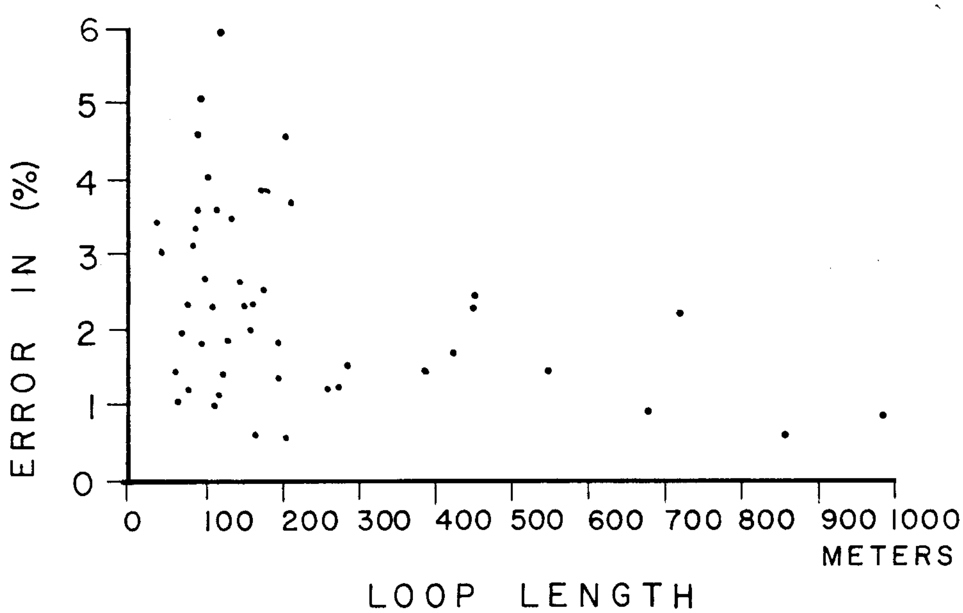

FIGURE 2: Percent Error vs. Loop Length in meters for 47 Loops surveyed with Topofil.

The average error of the 47 loops surveyed is 2.25 %. I do not know what errors may have been the result of data recording mistakes or other problems. Unfortunately, I have never had the opportunity to compile the data for any cave of similar length so I have no way to make a direct comparison with my own surveys. However, a 2.25% loop closure error seems a bit high to me. Most cavers I know seem satisfied only if their errors are less than 2% or sometimes 1%. I do not know if the German's plan to resurvey the loops with the large closure errors or not. Perhaps in a cave as remote and cold as Monster Cave it is just not worth the effort.

CONCLUSIONS

The survey techniques the Germans use in Monster Cave seem well-adapted to the cold and somewhat hostile nature of the environment. They need a survey system that is fast, easy to use with two people and appropriate for steeply dipping passages. However, very few caves in America have conditions similar to those in Austria. Nevertheless, it was interesting learning about their survey techniques and if I ever have an occasion to do a two-person survey of a long, cold, vertical cave I would consider using their methods. All in all, I'm glad the nearest cave country to California is Mexico and not Austria.

*** Many thanks to Michael Denneborg and Andreas Emonts-Pohl for the graphs, map and photos that accompany this article.

Mental Calculation of Reciprocal Bearings

by Frank Reid
Bloomington, Indiana

When I go cave-mapping, I like to operate the compass. I used to map with a lady who always knew instantly when my backsights disagreed with the foresights. A few years later, I studied instrument flying and learned the simple trick for adding or subtracting 180 degrees from a compass bearing:

Angle <180: Add 200, then subtract 20.
Angle >180: Subtract 200, then add 20.

Examples:

Reciprocal of 057 deg:	57 + 200 = 257,	-20	= 237
" " 323 "	323 - 200 = 123,	+20	= 143

Thread-Measuring Devices: A Review

by John Ganter
State College, Pennsylvania

In the US we have traditionally surveyed caves in a crude imitation of land surveys. We carry a 'system' into the cave consisting of bits and pieces manufactured and marketed for other uses: a compass, a clinometer and a tape measure. This equipment, intentionally designed for general use, becomes a limiting factor in the design and practice of ergonomic and efficient survey procedures. Modifications like taping Suunto instruments back-toback, quick-opening cases, and tethered tape reels are partial (but effective) fixes applied late in the game. These modifications and skilled surveyors result in the job getting done, but undoubtedly a detailed analysis would reveal a surprising amount of wasted motion and time-- and for all practical purposes compass and tape requires at least two cavers.

In Europe, colder caves in particular have encouraged the development of customized cave surveying equipment. The objectives are speed and efficiency: to get the job done with minimal sitting around and waiting. In particular the inefficiency of unreeling and reeling tapes has been eliminated by the use of what is essentially a 'disposable' tape: a piece of thread. Thus the Topofil was invented, presumably by some French caver. (I haven't been able to trace the history of the idea.) Further gains in efficiency and ergonomics were attempted by integrating the compass and clinometer into the Topofil unit.

Thread-Measurers Compared

The evolution of these devices is unclear, and at present there are at least two 'Topofils,' one of which does not include instruments; a custom-built 'Survey Box,' which does; and two other simple thread-only devices in the literature and/or for sale. In this discussion I'll refer to them all as 'ThreadMeasuring Devices' (TMDs), describe each one, and relate my impressions from limited use of a couple of them.

Topofil Vulcain

According to Steve Foster (1987) the device generally known as 'the Topofil', and described in this issue by Carol Vesely, is made by the Groupe Vulcain, of Lyon, France. Just how you obtain one is unclear: none of the Anglophone speleodealers seem to sell them, eg. Inner Mountain Outfitters (Virginia), Caving Supplies, Ltd. (Derbyshire, UK) or Inglesport (Lancashire, UK). Foster reports a 60 PSterling price (of which half was for the compass) in 1981. Compensating roughly for both a devalued Pound and exchange rates, I would guesstimate that today a Topofil Vulcain would set us back over $100, if we could get one.

Anyway, the device (Figure 1) feeds thread from a 500 or 1000 meter spool through a cumulative centimeter counter. When the thread is stretched between stations, it runs over a large-dial compass with a magnifier lens. Inclination of the thread is determined by hooking it at the center of a large protractor on the back of the device, which is then leveled using a small bubble-level.

Francois Saussure, a Belgian caver who I met in Mexico recently, demonstrated the Topofil Vulcain for me; I was impressed by the construction quality. The compass in Francois' was graduated in Grads: there are 400 grads in a circle. Backazimuths are a snap: you simply subtract 200 rather than 180. Apparently the newer Topofil Vulcains have some problems with excessive bulk and possibly even ferrous materials-- since Francois only speaks three languages I was not able to understand the details.

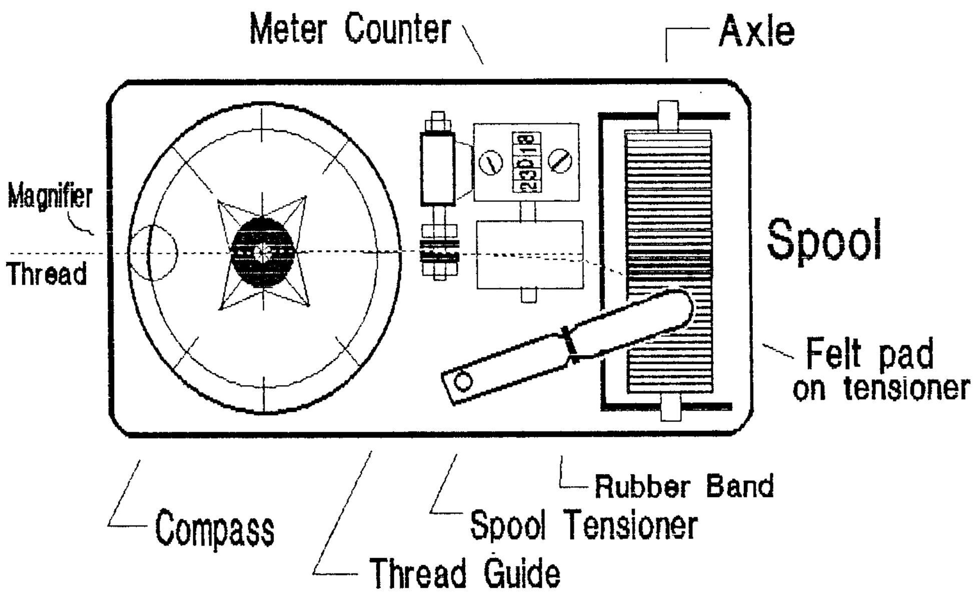

Fig. 1: The Topofil Vulcain.
(Based on photos from Vesely (1988), and drawing in Foster 1987.)

The Survey Box

Paul Griffiths (1979) was exposed to a Topofil while caving in Italy during the mid-1970s. Cavers were few at home on Vancouver Island (Canada), but they were finding lots of new caves, many of which they did not fancy returning to. Thus Griffiths designed and built a single unit which incorporated a string measurer, Suunto compass and clinometer, and writing surface for solo surveying.

The Box (Figure 2) is assembled from quarter-inch Plexiglas glued with contact cement. The instruments, main and spare spools of thread, and revolution counter are mounted inside, and the (presumably hinged) lid serves as the note-taking surface. Griffiths (1979) suggests that a revolution counter can be obtained from "scientific supply houses," and cautions that it (and everything else in the Box) must be non-ferrous, but gives no details on making or calibrating the counter wheel that the thread turns.

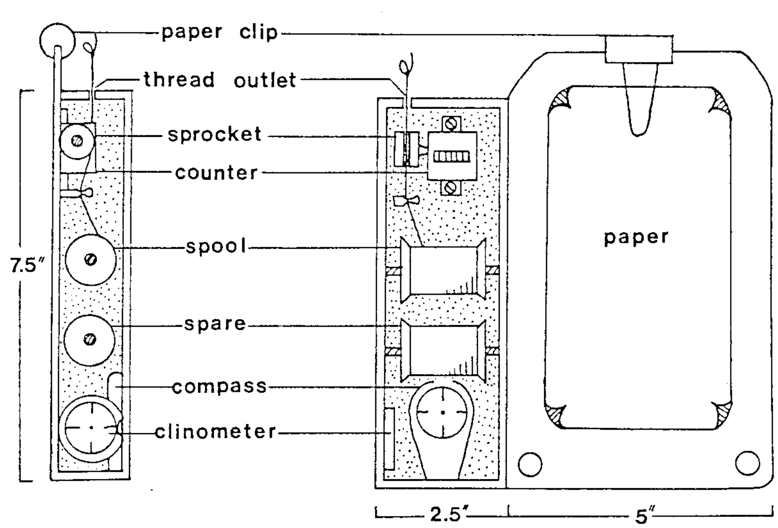

FIGURE 2: The Survey Box, by Paul Griffiths (1979).

It appears from Figure 2 that there is some parallax between the instruments and thread, but apparently one can compensate for this by careful sighting. Griffiths concluded that he has had little trouble finding stations to tie the thread to, always cleans up the thread as he surveys, and "wouldn't go back to tape and compass for anything."

Topofil TSA

The Topofil TSA is a simple TMD which lacks compass and clinometer. It is made by TSA, a French caving equipment company run by Georges Marbach. Caving Supplies Ltd. (19 London Rd., Buxton, Derbyshire SK17 9PA, UK) carries the TSA for about 30 PSterling including shipping, which will come to over US$50 at present. I bought one sight-unseen when I was having trouble finding cave surveyors, and decided to stop recruiting and start getting things done.

The device (Figure 3) is made out of a plastic storage box, secured with a nylon strap and buckle. Inside are various bits and pieces of hardware which are probably worth about one-fifth what the thing costs. A rubber band holds the thread spools to a Plexiglas bracket, with a window in the cover allowing one to monitor the thread supply. The thread then passes through a couple of foam disks on a machine screw, around the counter wheel, through more foam and finally exits the case through a grommet.

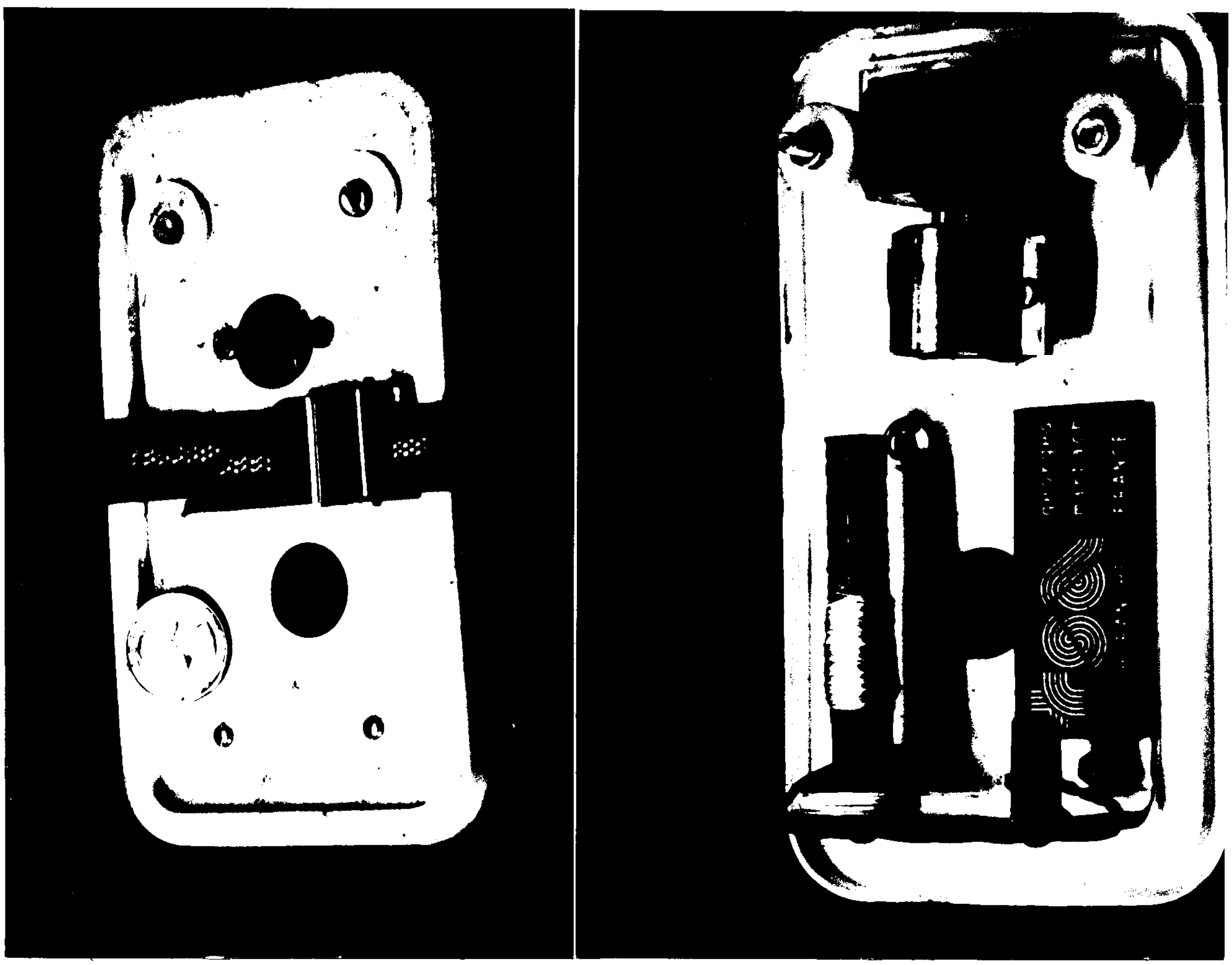

FIGURE 3: The Topofil TSA, closed and open.

The case is by no means waterproof, but the insides will stay reasonably dry if the case is kept right-side-up and not submerged. Regardless, drying things out after use should keep the rather-simple works functioning.

The stock spool holds over 2000 feet of thread. Unfortunately, when this runs out you will find that the TSA only accepts "Au Croissant" thread which naturally is not available in this hemisphere. I had to modify the TSA to accept American-style 400 to 450-yard spools, which cost under $1.00 each. I used a long machine screw and a trimmed-down wingnut to hold the spool in place.

The 100% cotton thread which I got was "Sanforized," which apparently involves optical brightener treatment because it was blazing white compared to the dull "Au Croissant." The end of the spool which the thread runs over must be sanded smooth or the thread will hang up.

I put the Topofil TSA on a lanyard around my neck, with Suuntos (taped together) similarly attached and my book stuck under the piece of inner-tube on my helmet, as usual. My procedure was to back down the passage, carefully paying out the thread, and back-sighting to my last station. Like clean SRT rigging, one has to find and utilize features of the environment to serve as stations. My note-taking form is different from what others have recommended: I record both starting and ending counter readings, so that I can use extra thread to wrap around the stations and thus get a secure anchor. I then subtract the two readings in my head and record the difference alongside for use in the sketch, and later computer entry.

I've done quite a bit of surface surveying in this manner and a few hundred feet in caves. I find the technique more demanding than having a team and suspect that accuracy is reduced, but the bottom line is that cave is going onto paper.

The Hip-Chain

Like the Topofil TSA, the Hip-Chain lacks instruments; it is also a strange collection of off-the-shelf hardware (Figure 4). The case is a fishing tackle-box, with a spray-can cap, a rubber stopper, apiece of Bakelite, a toggle-nut, a wire crimp-connector, a piece of Velcro and a digital counter inside. The price ? A mere $95 to $130 depending on whether the measurement is in feet, yards or meters ! You can get one from Forestry Suppliers Inc., PO Box 8397, Jackson MS 39204-0397. I once used a Hip-Chain for some cave and surface surveying, and liked the fact that you can reset the counter at any time by twisting the knob sticking out of the case. It also holds a lot of thread: 9000 feet per spool.

Conclusions

Thread-measuring devices, with or without other incorporated instruments, are an alternate approach to surveying. Those cavers with special requirements (particularly lack of personnel or need for speed) may want to at least try them.

Accuracy appears to be compromised (Vesely, this issue): more study needs to be done to quantify this drawback. Also, I wonder how TMD techniques compare to compass-and-pace, and also 'AirStation' surveys (Worthington 1987). In the latter technique, used often in the Canadian Rockies where caves are around freezing temperature, the compass and tape team does not set or mark stations, but simply shoots 'nose-to-nose' in the approximate center of the passage. Worthington presents data that suggest results are surprisingly close to surveys with fixed stations (Worthington 1987, p.58).

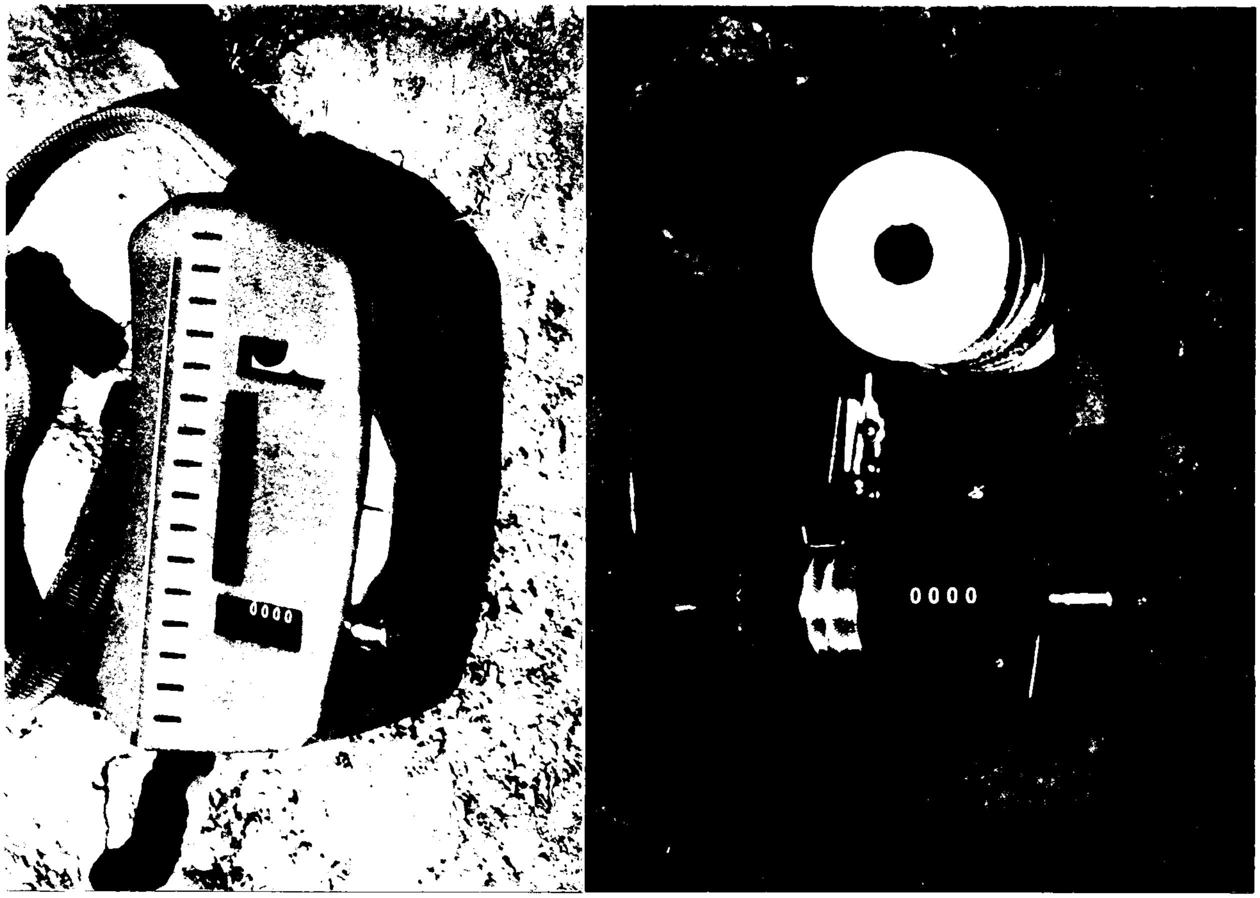

FIGURE 4: The Hip-Chain.

Anyone interested in owning a TMD is advised to consider building one if at all possible. 'Clones' of the Topofil TSA and Hip-Chain could be built for a fraction of their cost and relatively little work. With more effort, the Survey Box could be evolved further. A variety of gasketed 'Sushi boxes' are available, and Ira Sasowsky (pers. comm.) has pointed out that revolution counters are widely available as bicycle odometers. Ultimately, thread will go the way of steel chain when scaled-down and inexpensive Electronic Distance Measurement (EDM) devices are marketed for home and manual trade use.

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A Trigonometric Analysis of Suunto Sighting Error

by Brad Neff
Lebanon, Tennessee

A number of cavers have noticed that when using Suunto compasses they get different readings when sighting with both eyes (as recommended by Suunto) and with one eye. Roger Bartholomew (Ganter 1985) presented a paper at the '85 Convention which suggested, on the basis of some experiments he did using a tripod, that sighting with one eye is better, and it seems that most cavers do this.

Is the two-eye method a significant source of error? Basically, the problem is that our eyes see the world from slightly different perspectives. Rangefinder camera sighting systems suffer from a similar 'defect,' called Parallax (lack of parallax is one of the advantages of a single-lens reflex camera over a rangefinder camera).

Figure 1 is a trigonometric analysis of the situation. In the diagram, the points all lie on a north-south line. When sighting with two eyes, the compass should actually indicate the direction of the object-viewing eye to the point. Now, only the left eye can see the actual front point. This results in an error angle theta, whose tangent is equal to the ratio of the opposite side to the adjacent. Here, the error angle is found by taking the inverse tangent of the distance between the compass user's pupils divided by the horizontal distance of the given shot. Table 1 lists the error in degrees for several distances, using my 2.5-inch pupilto-pupil distance (0.21 feet).

Note from Figure 1 that the error angle also occurs on the back sight, and both are clockwise errors. ***They do not cancel out!*** Two-eye sighting error, then, is NOT a (relatively) benign random error, but cumulative. Each and every shot will contain the error, and it is in the same relative direction each time.

What Does It All Mean And How Significant Is It?

Cumulative errors can be serious, because they do not tend to average out. Using an unmodified two-eye sighting system results in an error of about 2.5-inches on each shot, regardless of the distance (from Figure 1). If one surveyed a straight-line passage 5,000 feet long in 40 foot shots, there would be:

5,000 feet / 40 feet/shot = 125 shots

This would result in a location error at the end station of:

0.21 feet/shot x 125 shots = 26.3 feet (to the right)

In general, it appears that two-eye errors may not be particularly significant, being 0.53% in the example above. (In actual practice, the situation is trigonometrically more complicated, but the above should be a good first-order approximation of the true error). Using a single eye eliminates the error, but it is sometimes difficult for certain types of shots.

Another approach can be taken. Use two eyes, but position the ***sighting eye,*** not the compass, over the point. This should eliminate the two-eye error.

Why does Suunto recommend the two-eye method? Table 1 indicates that, for distances past 75 feet, the error introduced is less than the stated (1/6-degree) precision of the compass. In "normal" long sighting distances, the error is infinitesimal.

Finally, note that the above trigonometric discussion relies on the compass eye tracking the sighting eye. This is a simplifying assumption and may not be entirely accurate. However, the above analysis of error should be worse-case for normal binocular vision.

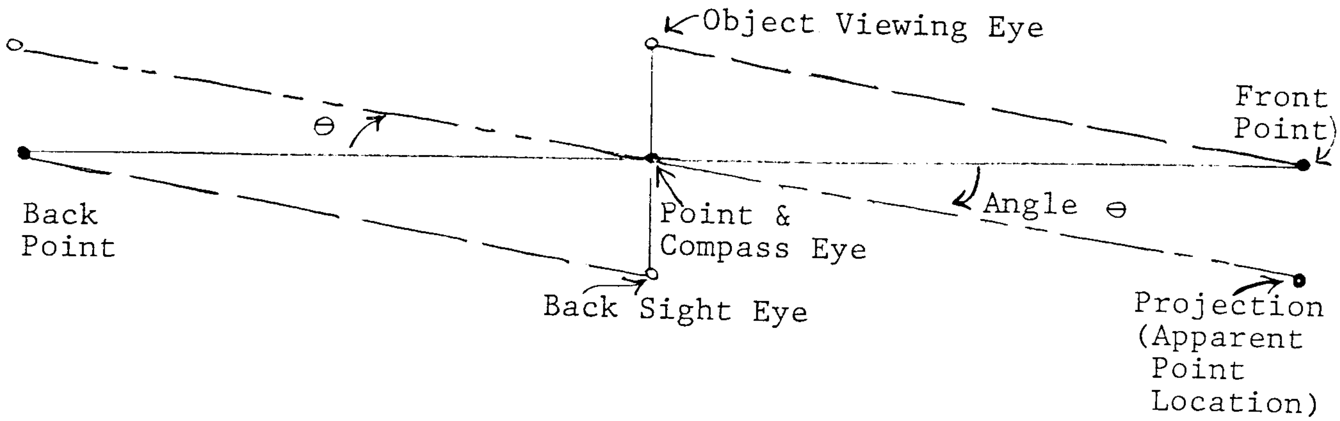

Figure 1:

Trig Analysis
(Vertically Exaggerated)

TABLE 1

SUUNTO SIGHTING ERROR

True Horizontal Distance (Feet)	Error Angle (Degrees)
2	6.0
5	2.4
10	1.2
25	0.48
50	0.24
100	0.12

Table 1 lists the error in degrees for several distances, using my 2.5" pupil-to-pupil distance (0.21 feet).

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Ganter, John. 1985. SACS Activities at Convention 1985. ***Compass & Tape*** 3:1, Summer 1985, p. 12-14.

[Adapted from the February 1986 ***Speleonews*** 30:1 (Nashville/Chattanooga Grottoes), p.3 - 5.]

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Suunto Instrument Availability

During Summer 1987, Bob & Bob Inc. stopped carrying Suunto instruments. In May, Suuntos went up from the long-time price of $49.50, to $63.00. The June pricelist had no Suuntos; Bob had switched to the (apparently) new competitor, Sisteco, at introductory pricing of $45.00 for the compass and $48.00 for the clinometer. By August, they were at $60.00 each.

The Sistecos are Suunto clones, but have a couple of interesting features. You can buy a 'Survey Master' unit which combines compass and clinometer end-to-end in one unit. Also, there is an illumination option available for $6.00 extra on each unit. The switch, an O-ring sealed 'button' on the side, is the tiny lithium cell which powers the light inside the instrument.

Unfortunately, the Sistecos don't seem to be very good clones. Corners have been cut, with a plastic insert replacing the finely-milled viewing tube of the Suunto, sloppy numbers on the card, and lanyards running through holes in the body rather than brass fittings. Whether the ruggedness of the instruments has been compromised is unknown: we hope to have more details on Sisteco instruments later when cavers have used them more. Please contact the editor if you have any experience with these instruments which you would like to share (302 Walker, Geography Dept., University Park, PA 16802). Meanwhile, it is suggested that anyone buying instruments compare, side-by-side, samples of each brand that they are considering.

Happily, for those who would rather stick with old faithfuls, Suuntos are still available, and... ***they are cheaper than Sistecos!*** Forestry Suppliers (PO Box 8397, Jackson MS 39204-0397. Toll-Free line: 1-800-647-5368) has a wide variety of Suuntos, plus many other things for the surveyor (like plastic binder-style Rite-inthe-Rain books and paper to fill them). The Suunto KB-14 compass is $55.50, available either in azimuth or the 'Nautical' model which has smaller back-azimuth numbers above the azimuth numbers. The Suunto PM5/360PC clinometer is $59.95.

Rebuild Service

Forestry Suppliers also offers a rebuild service for Suuntos. The instruments are restored to good order, usually involving complete replacement of the capsule and viewing lens, for a flat fee: compasses ($29.50) and clinometers ($28.50). <--- J. Ganter