COMPASS & TAPE

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Survey and Cartography Section - 1991

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Cover: Drawing by Linda Heslop of Dale Pate Sketching in Sistema Purificacion, based on a photo by Dave Bunnell

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CLIPBOARD SURVEYING

by Tom Kaye

INTRODUCTION

When I first heard of it, I assumed that surveying with a clipboard was a ridiculously overdone technique without any real benefit. The thought of using a protractor while drawing in an ordinary sketchbook was interesting enough to try, however. We were beginning to survey in a small mazey area in a cave were working on at the time, and it seemed like it would be a good way to get a little more accuracy.

Revelation! The cave passage began to appear in our sketchbook. The drawing wasn't really that much better than usual, but there was something about the way it looked there on the page that spoke more of the cave's appearance than the usual freehand sketching would have done. We were hooked, and gradually we all began to regularly use a clipboard for sketching.

The usefulness in maze situations was immediately apparent. Loops of passages fit together very well and intersections were much easier to draw. Even in simple trunk passages, we noticed a significant increase in our attention to detail in the drawing and knew that it was attributable to the angle and distance measurements which afforded a greater ease in including it.

ADVANTAGES

Intersections, breakdown, and other features can be better drawn and placed in the passage drawing if it is all done to scale and with accurate angular control. Since you are measuring as you go, you know the size of detail that your final map scale will allow. Also, passage areas that are relatively lacking in detail are readily apparent when you know just how big they are. Vertical control is done using foreshortening calculations while drawing. This is important for the later map drafting stage. The sketcher in the cave is constrained to draw a sketch that is accurately tied to the level plane. Again, the level of detail is accurate in this controlled situation.

A lighter advantage of clipboard surveying is that it looks good in process. Surveyors on the trip get instant feedback on how much the product of their work "looks like the cave".

Error correction is afforded by the technique since the drawing is no longer semi- independent of the data taken in the cave. Shot reversals, problems with lengths, and even angular errors are caught by the sketcher while using the data to make the sketch. Also, the accuracy of the sketch is good enough, and at times successful, for use in error correction at home if the computer shows that there are data problems.

For the drafting stage, clipboard sketches are convenient to use. The sketches are much closer to the finished product and fit together well. There is also much less difference between sketches made by different people. There are few if any scale problems to be worked out at home. Between trips, tie -ins from one trip to the next are easier to find, since the sketches are more like completed maps and are on larger sheets than those in the usual sketchbook.

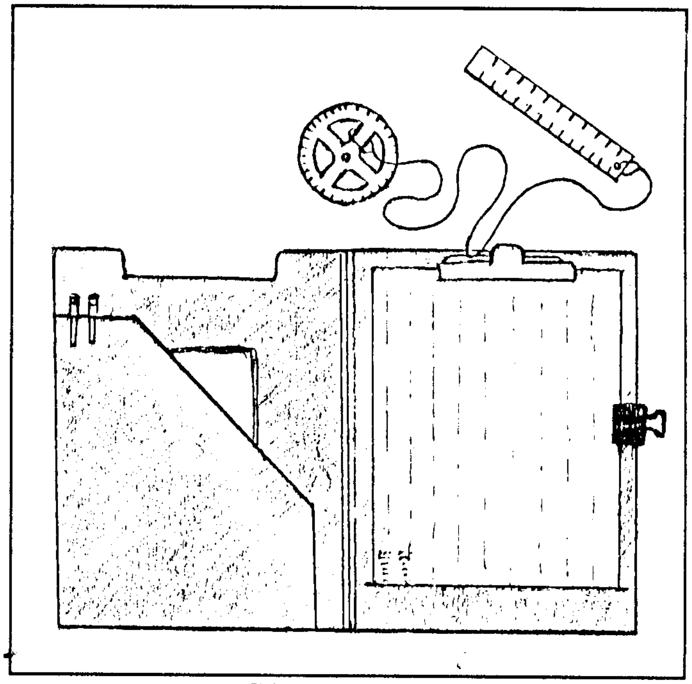
One somewhat surprising thing is that clipboard sketching is easier for a new sketcher to learn than ordinary sketching. The angle and distance measurements make it much more difficult to draw a distorted (and disappointing) view of the cave passage. There are few scale problems, even between stations, since the measurements force accurate spatial relationships.

MATERIALS

Probably several kinds of clipboards have been used in cave surveying. I have found that the cheap plastic over cardboard type found in office supply stores to be good for dry caves. The aluminum kinds are of course waterproof, but they aren't so flexible and could be slightly dangerous to carry. There are many different brands of office type clipboards, but one simple variation should be noted; only some have a slit in the plastic near the bottom into which the working sheet can be tucked. The clipboards that do not have this slit could probably be sliced open for tucking in the bottom of the working sheet.

An essential addition to the clipboard is the white backing (not needed for an aluminum clipboard). The white backing provides contrast for drawing on translucent mylar. I have found two kinds of material for this. One is the vinyl report folders also found in office supply stores. White is about the only good color, but it is not common. The plastic should be fairly thick and hard to provide a good writing surface. The plastic over cardboard structure of the clipboard itself is unsuitable, besides being brown or black. The other source of white plastic backing is the plastic "for sale", etc. signs found in hardware stores. The better varieties are opaque enough that you aren't bothered by the lettering while using the back of the sign.

The white plastic backing should be ruled with lengthwise lines about one inch (or one ruler width) apart. These will serve for orienting the protractor without distracting you in the drawing process. Rule the backing with a ballpoint pen that has reasonably indelible ink.



Clipboard Set Up
for Cave Surveying

Use the colorless translucent mylar found in art supply stores for your sketches. The kind with frosting on only one side is best, since dirt won't stick so easily on the back side. Although you may be tempted to buy mylar that is conveniently lined with some grid, you will find that plain mylar is less distracting while drawing in the cave. The grid lines aren't like cave passage walls and never seem to be oriented in the right direction! They are also not conducive to passage detailing. The simple vertical ruling on the plastic backing as described above is a good compromise. Be sure to cut the mylar sheets to size so that they will fit in the clipboard and fit into the tucking slit in the bottom of the clipboard.

Of course, you will want to use a 0.5mm or even a 0.3mm mechanical pencil for your sketching. Be sure to use the polymer type of "lead" in the pencil, especially if you are going to be sketching in a wet cave. A sketch done with the polymer lead can be washed off with water to get any mud off without danger of ruining the drawing if you don't rub it too hard. Erasing is not as easy as with regular lead, but it works fine if you lick your eraser first.

A small protractor or orienteering compass is a necessary part of the equipment. These are two rather different instruments for accomplishing the same end. The advantages of the protractor are its extreme cheapness and the ease with which it can be carried in the clipboard. The advantage of the orienteering compass is that it doubles as a ruler and thus provides the advantage of a one- step process in locating the next station.

The protractor should be small so that its center can be placed anywhere within a large area on the working sheet. It should also be numbered clockwise! Most are not. A few are numbered both ways. If you get one that is marked both ways, be sure to scratch out the numbers that you don't want to use. I prefer the whole circle type since I hate to add and subtract. Calculating angle reflections also defeats the shot reversal catching feature of the system. A good one to get is made by the Sterling company.

If you choose to use the orienteering compass method, be sure the scale along its edge is the one you want. I like the ones marked in tenths of an inch, but they are rare; most are ruled in eighths of an inch. You will want one with vertical lines that parallel north. Beware of those whose vertical lines are not fixed. The rotating part that has the angular measurements should also have a set of parallel lines for map matching. The parallel line part should be fixed to the part marked in degrees so that they rotate together. The Brunton orienteering compass is not made that way and it would have to be glued or otherwise fixed for use in clipboard surveying.

If you use a protractor, you will also need a small plastic ruler. Be sure the scale is the one you want. I prefer tenths of an inch with a slightly larger mark at the half inch intervals. A neat trick which works for a sketching scale of 25 feet per inch is to use a metric scale. It is close enough (5" off in 10') and the scale is essentially marked in feet of cave.

We have found that the protractor and ruler should be connected to the clipboard with string. This actually amounts to another advantage of the protractor and ruler choice over the orienteering compass; they can be tied to the clipboard. Vertical equipment sewing thread works very well. I tie a bowline loop to one of the cross- arms of the protractor, thread the string through the clip hinge and make another loop go through a small hole in the ruler. A good length of string is such that both the ruler and protractor can be tucked into the slit at the bottom of the clipboard for carrying. Of course you don't want to tie the string through the orienting hole in the center of the protractor.

Another useful minor addition to the clipboard is an ordinary spring binder clip found in any office supply store. This can be used to hold the clipboard together while traveling through the cave and can be used to help hold the mylar in place while drawing.

I add a small vertical foreshortening table to the clipboard. This table can be written with a pen on the white vertical backing in a corner.

Degrees	Subtract or Factor
11.5	-1/50
13	-1/40
15	-1/30
18	-1/20
25	-1/10
35	-1/5
40	-1/4
50	-1/3
60	1/2
70	1/3
75	1/4
80	1/5
85	1/10

Vertical Foreshortenting Table

THE PROCESS

The clipboard needs a little extra setup effort when starting the survey. First, draw match lines on the mylar over a couple of the inked lines on the white backing plastic. Although the binder clip and the clipboard's clamp will usually prevent movement, this will provide insurance against a possible rotating cave problem during the survey. Also, you will want to use some estimation of which way most of the upcoming survey will go when you establish your start point on the sketch.

If you use a protractor, always orient it parallel to the inked lines on the plastic backing. One part or another of the protractor will be near enough to one of the inked lines so that you can orient it parallel to the line. The top of the clipboard is usually considered North, although it could of course be any direction you choose. Just so you keep it consistent! (Actually, if you use a protractor, the top of the clipboard could be just about any azimuth; with an orienteering compass, only North or South are really usable.)

If you use an orienteering compass, you "dial in" the azimuth, matching it on the mark at the top of the compass. The movable dial part is the one that has (if you bought the right kind) the parallel lines. After setting the azimuth on the instrument, place it on the page so that its lines are parallel to those on the white plastic backing. Then draw the shot line along the edge of the compass that has the proper scale (or just place a dot on the next station if you prefer). In order to not make the mistake of using the wrong scale of a two- scale compass, rub one out with sandpaper or something.

Remember to use the vertical foreshortening table if an inclination is 18 degrees or more.

Using mylar instead of paper, it is easy to transfer a part of a sketch or a cross section to another piece by tracing it a couple of times. You can also do a nicer job of going from one sheet to another, tracing an overlapping area onto the next sheet.

DISADVANTAGES

The clipboard method of course adds to the equipment you carry through the cave. We have found that some sketchers prefer not be burdened with writing down the data in the notebook, leaving that job to one of the other persons on the team. This may or may not be a disadvantage; there is a person dedicated full time to the sketch, a critical part of cave surveying. The clipboard method definitely takes a little extra time, depending on the sketcher's dexterity with the protractor and ruler. There is often some extra communication between the note taker and the sketcher for reviewing data if the sketcher does not write notes while the compass and tape readings are made.

CONCLUSION

Clipboard sketching has been very satisfactory for most of those who have tried it. One person did not like it, complaining chiefly that he prefers to use a varying scale while sketching in the cave. The end user of the sketches is of course the person who draws the final map. They like clipboard sketching a lot! Locally, clipboard sketching has become sort of a standard mode. It was also a requirement in a maze cave that we just recently finished; all surveys in the cave were done using clipboards. The only way to <u>really</u> see the difference is to try it yourself!

TILT ERROR IN SUUNTO COMPASSES SIGHTED WITH THE GLASS ROD CYLINDRICAL LENS

by Roger V. Bartholomew NSS 9349

This study presents the tilt error which occurs when the Suunto Compass is sighted with the glass rod cylindrical lens mounted on the case for survey sightings having inclination angles from +24.2 to +76.9 deg.

It was observed that when the compass was rolled to the left, the silver of light observed in the glass rod was seen to move to the right and upward; therefore the compass had to be pointed to the right to a false bearing to realign the compass cursor line with the silver of light observed in the glass rod (figure 1).

For the first series of experiments a light was supported at the ceiling with a white string hanging straight down from it to a lead weight (figure 2). The Suunto compass was mounted on a device which enabled the compass to be tilted on the horizonal axis ET-ET' which extends through the eyepiece lens to the vertical string. Also, the compass was able to be rotated on the vertical axis CA-CA' through the compass drum axis (figure 3) so that the cursor could be directed to the false position of the sliver of light caused by the tilt error. The zero tilt was determined with a 1-3/8" bubble level placed directly on the clear top of the Suunto compass. The bubble shift between opposite inner edges of the inner ring is 0.1 deg. The glass rod was stuck on the Suunto case with its center about 1 inch beyond the compass pivot axis with 1/16" thick foam strip with double sided adhesive. The angle position indicator enabled setting the tilt angles to the nearest 0.1 deg.

Readings of the compass bearings were taken for various tilt angles for each of four different inclination angles. The errors added to the correct reading versus the degree of tilt were graphed (figure 4). The slopes of the four straight lines produced were calculated by a linear regression program on a TI 55-III and are listed below and graphed in figure 5.

Inclination Angle (deg.)	Azimuth Error (deg.) per Degree of Tilt
+24.2	+0.27
+45.1	+0.83
+63.4	+1.79
+76.9	+3.99

These values point out the rapid rise of the azimuth error due to tilt of the glass rod at large magnitude inclination angle sightings. The glass rod is used on the Suunto case to help point the Suunto compass at the target light for high inclination angles that the glass rod must be held level more precisely to avoid greater tilt errors which point the Suunto away from the target station!

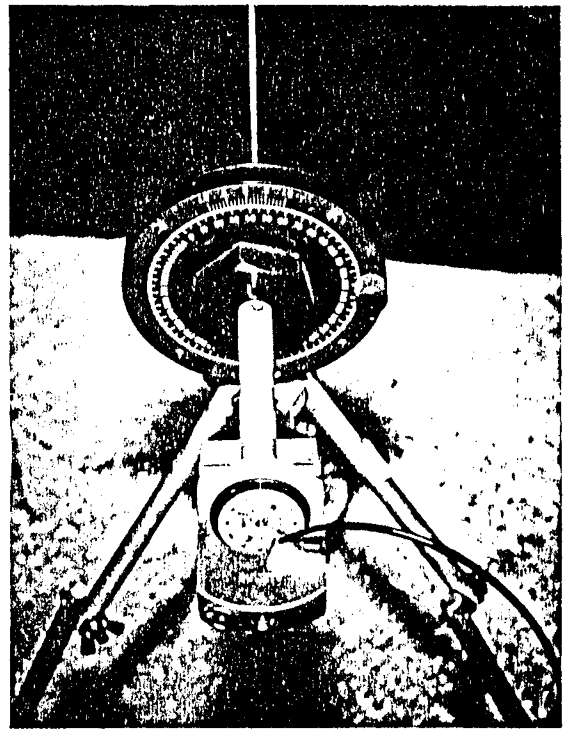


Figure 3

It has been suggested that the compass drum of the Suunto can be used to keep tilt error to a minimum by tilting the Suunto until the tip and bottom edges of the compass drum appear to be parallel with the top and bottom edges of the Suunto case as seen in the eyepiece. The following data were taken with a tripod mounted Suunto to compare a drum leveled azimuth with the azimuth of the vertical string as a standard.

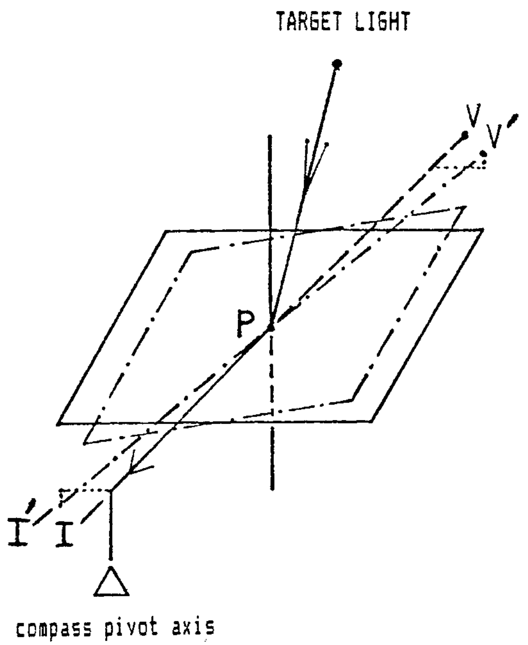
Inclination Angle (degrees)	Azimuth of Vertical String	Azimuth with Drum Leveling	Difference
+24.2	249.4	250.2	+0.8
+45.1	242.2	242.7	+0.5
+63.4	242.5	245.7	+3.2
+66.0	245.6	245.8	+1.2
+76.9	238.3	244.8	+6.5

The experiment was rudimentary, but the data indicate that drum leveling causes a variability in the errors and is not a good control on tilt error. A situation in which the compass drum is not balanced of local magnetic dip will cause the drum itself to be out of level for east/west readings. Some type of leveling device must be added to the Suunto compass especially for hand held readings, which can be seen along with the sliver of light in the glass rod or seen in the Suunto eyepiece along with the cursor line and compass drum.

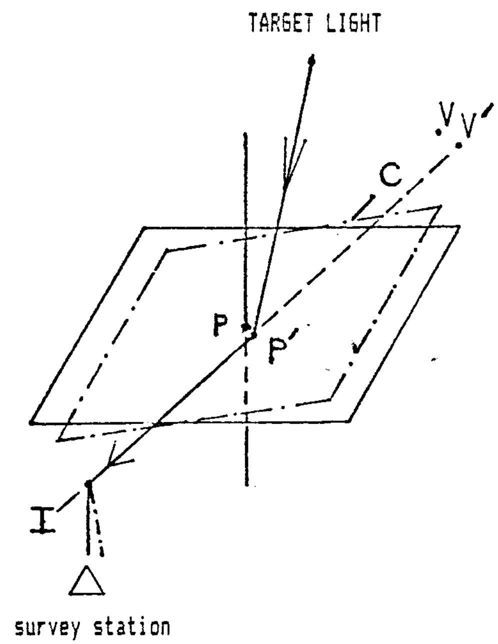
It is important for every surveyor, who is using the glass rod sight on the Suunto, to get a feel for the great magnitude of the tilt generated errors. The best way is to set up a light with a white string hanging down directly under the filament as in different sightings with various inclination angles and tilts using the white string as the correct aiming point.

FIGURE 1

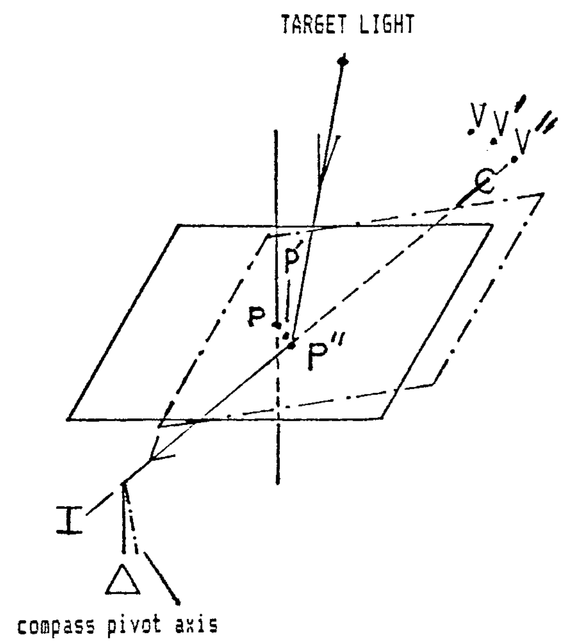
STAGES IN THE PRODUCTION OF TILT ERROR IN THE SUUNTO COMPASS SIGHTED WITH THE GLASS ROD.



Stage 1 - The part of the glass rod which reflects the target light into the eye is like the plane mirror drawn with a solid line above. When the glass rod rolls left (ccw) to the orientation drawn with dots/dashes above, the light striking the glass rod at point P is reflected to point I'. During the ccw roll, the observer sees the sliver of light in the glass rod, the virtual image V, move right and up to V'.

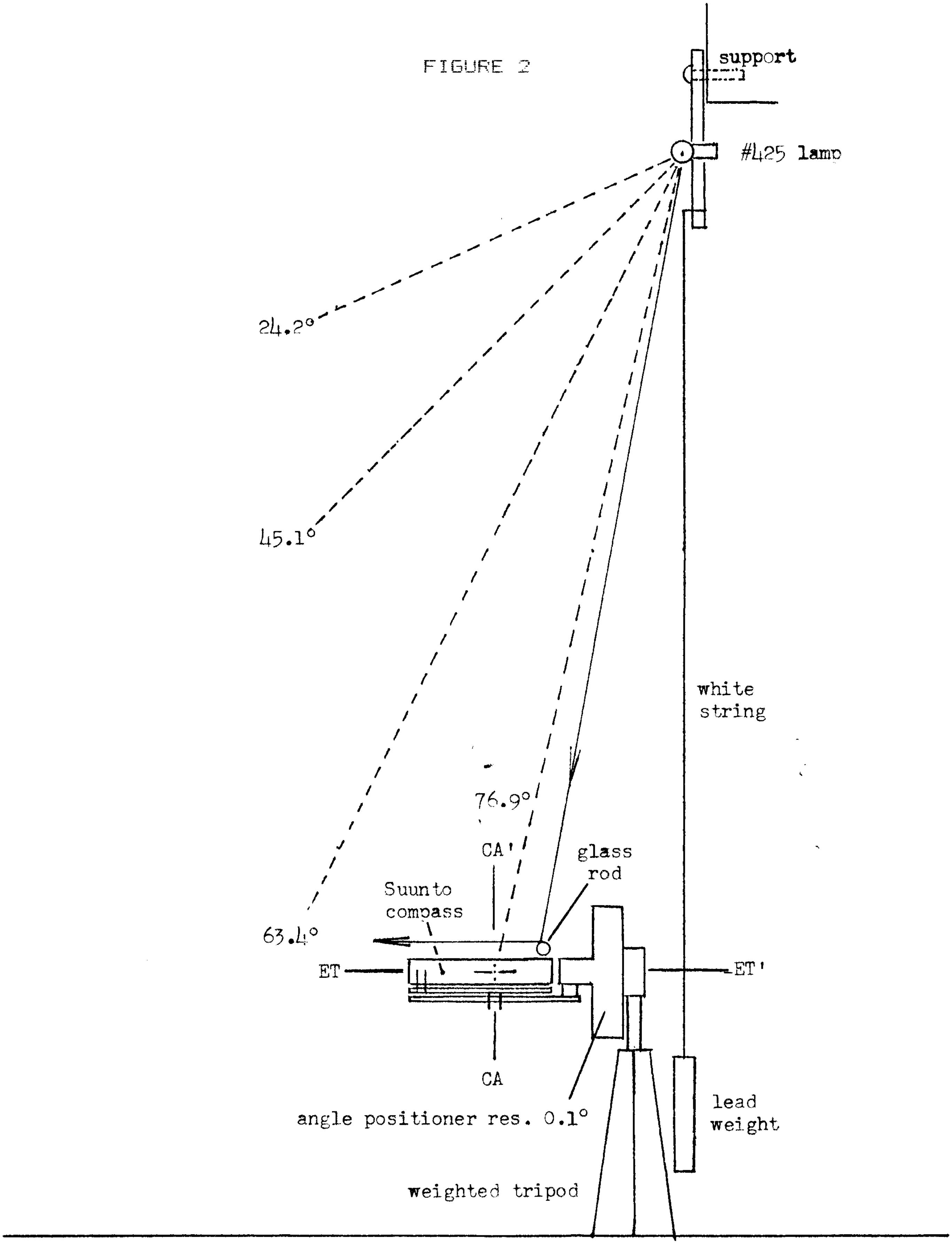


Stage 2 - In following the movement of V' to the right and up, the surveyor's eye ends up looking through I, the compass pivot axis, which is fixed over the survey station, and through a point P' higher and to the right of point P. However, the compass cursor C is still on line IPCV and so the Suunto compass cursor line appears to be located to the left of the sliver of light seen in the tilted glass rod.



Stage 3 - To line up the Suunto compass cursor C with V' on line IV', the glass rod is rotated on the dot/dashed plane on the compass drum axis I. This introduces another deviation of V' to point V''. And the surveyor ends up looking through a new point P'' on the glass rod on line IV''. Thus a ccw roll or tilt to the left makes the Suunto point more to the right of the correct target and the azimuth reading is greater than what it should be.

FIGURE 2


support
#425 lamp
24.2°
45.1°
white string
76.9°
CA'
glass rod
Suunto compass
63.4°
ET
ET'
CA
lead weight
angle positioner res. 0.1°
weighted tripod

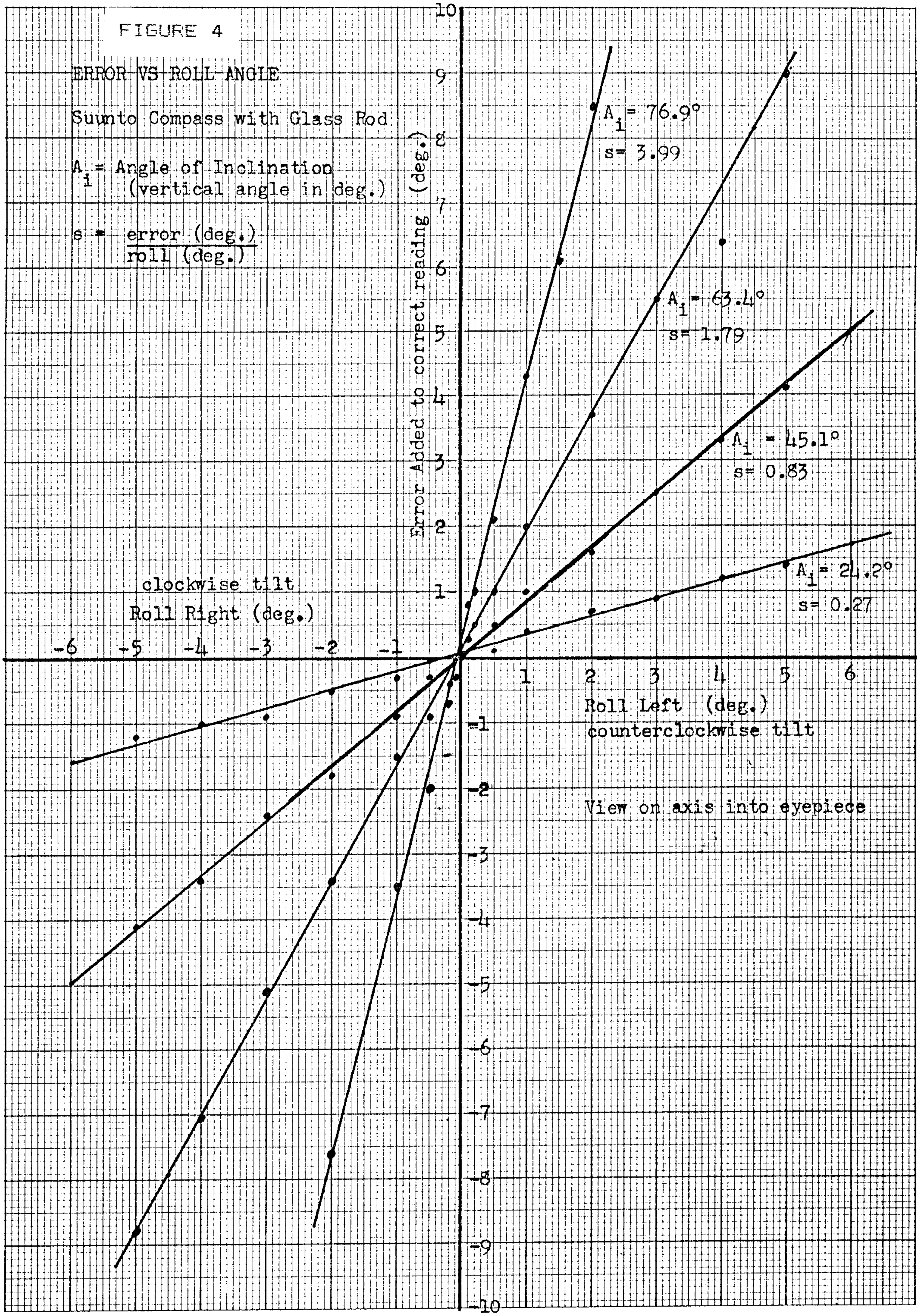
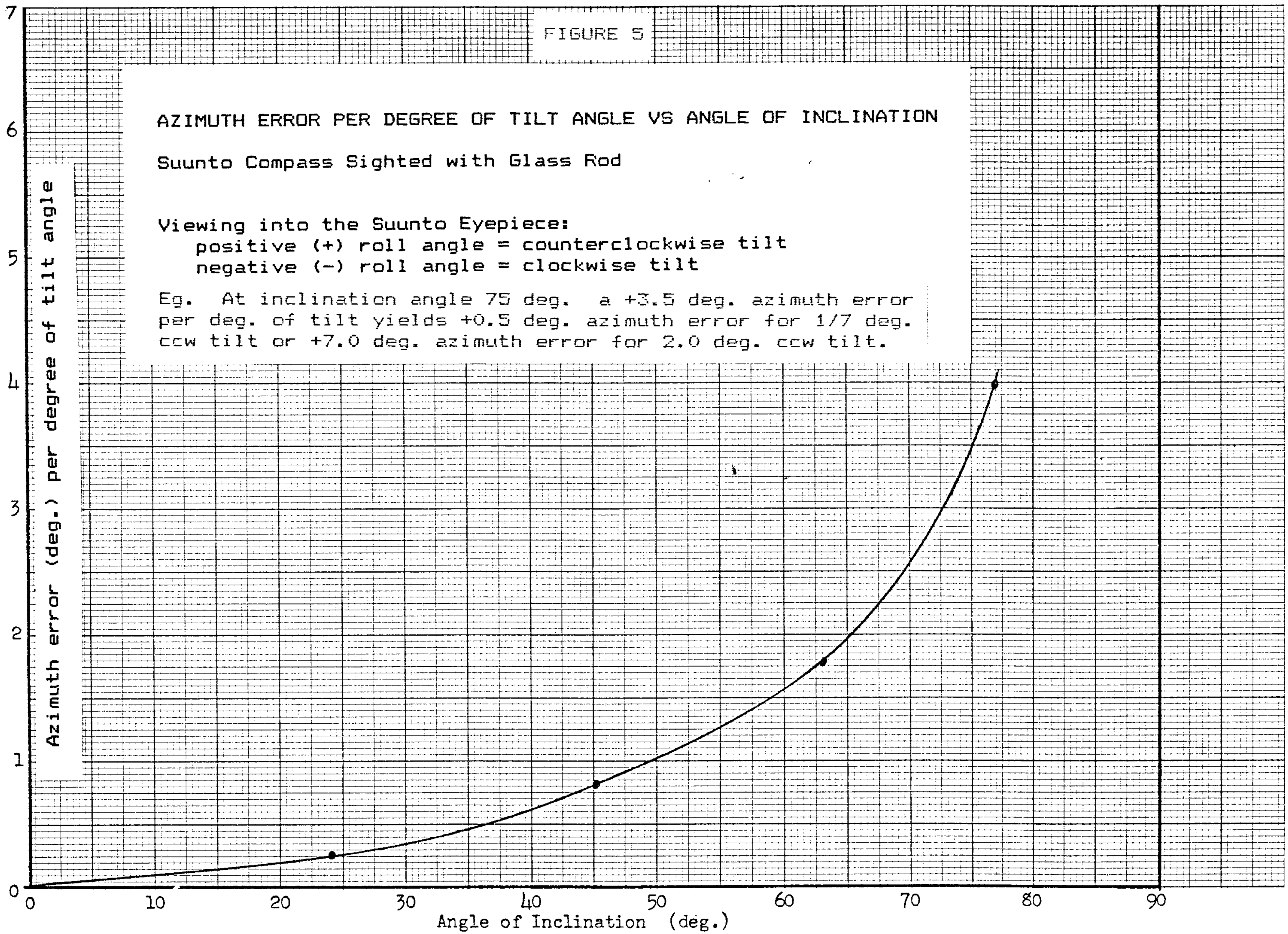


FIGURE 4
ERROR VS ROLL ANGLE
Suunto Compass with Glass Rod
A_i = Angle of Inclination (vertical angle in deg.)
s = error (deg.) / roll (deg.)
Error Added to correct reading (deg.)
clockwise tilt
Roll Right (deg.)
Roll Left (deg.)
counterclockwise tilt
View on axis into eyepiece
A_i = 76.9°
s= 3.99
A_i = 63.4°
s= 1.79
A_i = 45.1°
s= 0.83
A_i = 24.2°
s= 0.27

FIGURE 5


AZIMUTH ERROR PER DEGREE OF TILT ANGLE VS ANGLE OF INCLINATION
Suunto Compass Sighted with Glass Rod
Viewing into the Suunto Eyepiece:
positive (+) roll angle = counterclockwise tilt
negative (-) roll angle = clockwise tilt
Eg. At inclination angle 75 deg. a +3.5 deg. azimuth error per deg. of tilt yields +0.5 deg. azimuth error for 1/7 deg. ccw tilt or +7.0 deg. azimuth error for 2.0 deg. ccw tilt.
Azimuth error (deg.) per degree of tilt angle
Angle of Inclination (deg.)
0
1
2
3
4
5
6
7
10
20
30
40
50
60
70
80
90

THE TOPO DIGITIZING PROGRAM
OR
USING A DIGITIZING TABLET TO GET CAVE COORDINATES

by Robert Thrun

We have begun using a digitizing tablet, connected to a computer, to get cave coordinates from topographic maps. The digitizing tablet is a Summagraphics MM 1201 or a Summasketch II, which is a newer model, but virtually the same. The tablet is about 16 inches square with an active area over 11 inches square. It can read points with a resolution of 1000 points per inch. There are many other tablets on the market. Most tablets in this size range emulate the MM series. The tablet can be found for as low as $350. We read coordinates by putting the crosshairs of a cursor on a point and hitting a button. The absolute tablet coordinates can be converted to anything we want by a computer.

The program is simple to use. You tape a map to the tablet and click on the corners of a 2.5 minute section that is marked on all USGS 7.5 minute topo maps. Give the North latitude and West longitude of the lower right hand corner of the section. Then click on a point and type a description of the point at the computer keyboard for as many points as you want on that section. The program gives both the latitude-longitude and Universal Transverse Mercator coordinates.

The coordinates are repeatable to within .1 or .2 arc seconds, which is better than most persons can read with a draftsmans scale. When I compare the digitized coordinates with the marked UTM ticks on the map, I get a constant bias as much as 7 meters, but the deviation from the mean error is only about 1 or 2 meters. The bias seems to be due to registration problems in printing different colors on the map.

After having used the tablet and program, I think the method is both faster and more accurate than the old way of gridding and measuring maps. I am willing to give the program to any caver with a tablet and a need to read map coordinates.

INDEX FOR THE COMPASS AND TAPE

george dasher
June 1991

MAP SYMBOLS:

CUMULATIVE INDEX
FOR THE COMPUTER APPLICATIONS SECTION NEWSLETTER

Bob Hoke

The Computer Applications Section of the NSS published a total of 15 newsletters between 1980 and 1985. The following is a bibliography of material in the 15 issues of the CAS Newsletter, sorted by general subject. Each article only appears under a single subject. In front of each entry is the volume in which it appeared (v01-v15). The CAS Newsletter is out of print, but copies of individual articles are available for the cost of copying and postage from Bob Hoke (6304 Kaybro St., Laurel MD 20707).

Publication dates for the CAS Newsletters were:

v01 December 1980	v06 March 1982	v11 June 1983
v02 March 1981	v07 June 1982	v12 September 1983
v03 June 1981	v08 September 1982	v13 December 1983
v04 September 1981	v09 December 1982	v14 February 1985
v05 December 1981	v10 March 1983	v15 July 1985

SOFTWARE & PROGRAMMING:

v02 Thrun, Bob	"Connectivity of Cave Surveys" (1-pg article)
v05 Hoke, Bob	"Drawing Lines on a Dot Marrix Printer" (3-pg article)
v06 Hoke, Bob	"Line Drawing Revisited" (2-pg article)
v07 Halleck, John	"An improved dot matrix line drawing algorithm (1-pg article)
v07 Hill, Paul	"The Convex Boundary Problem" (7-pg article)
v08 Hoke, Bob	"A 'Real Cave' Adventure Game" (3-pg article)
v09 Smith, Neil	"Simultaneous Multiple Loop Closure ... Program" (13-pg article)
v10 Dotson, Doug	"An Algorithm for Drawing Lines on a Dot Matrix Printer (4-pg article)
v11 Halleck, John	"Reply to Asst. Prof. Dotson" (1-pg letter)
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v12 Halleck, John	Using shading to show cave passages (4-page article)
v13 Halleck, John	"Shading Notes" (refering to his v12 article) (1.5-pg article)
v13 Hoke, Bob	"A review of Doug Dotson's SMAPS Survey Processing Program" (5-pg article)
v14 Heaton, Timothy	"Cave Mapping with the Hewlett-Packard 15C Calculator" (2-pg article)
v14 Hoke, Bob	"Current status of Doug Dotson's SMAPS Mapping Program" (.3-pg article)
v14 Judge, Brian	"Things to do on the Way to the Cave" (1-pg article)
v15 editor	"Map Coordinate Conversion Programs" (.5-pg article)
v15 Judge, Brian	Comments on use of "pigdin-BASIC" (sic) (1-pg letter)
v15 Nieuwenhuis, Luurt	"Survey Transform" (BASIC program) (3.5-pg article)

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v14 editor	"Doug Dotson Designs an In-cave Data Acquisition System" (.5-page article)

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v01 editor	Summary of member's primary areas of interest (note)
v06 editor	Results of CAS Membership Survey (2-pg article)
v14 editor	Results of the 1984 membership questionnaire (1-pg article)
v15 editor	"What CAS Members are Doing" (1.5-pg article)

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v07 Mixon, Bill	"Designing the Longest Cave" (3-pg article)
v10 Dreybrodt, Wolfgang	"Computer Simulation of the Growth of Stalagmites" (5-pg article)
v12 editor	"Cavers Use National Unix Network" (.3-pg article)
v13 editor	"Word Processing Help Needed (by the NSS)" (.2-pg article)
v14 editor	"Cave Oriented Bulletin Boards" (.3-pg article)
v15 editor	"A Rescue Data Base for the [NSS] Office Computer" (.5-pg article)
v15 editor	Review of "An Introduction to Cave Mapping" by the MSS (.3-pg review)
v15 Moore, Roger	Statistical Analysis of Cave Rank/Size Relationships" (6-page article)

COMPASS & TAPE

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