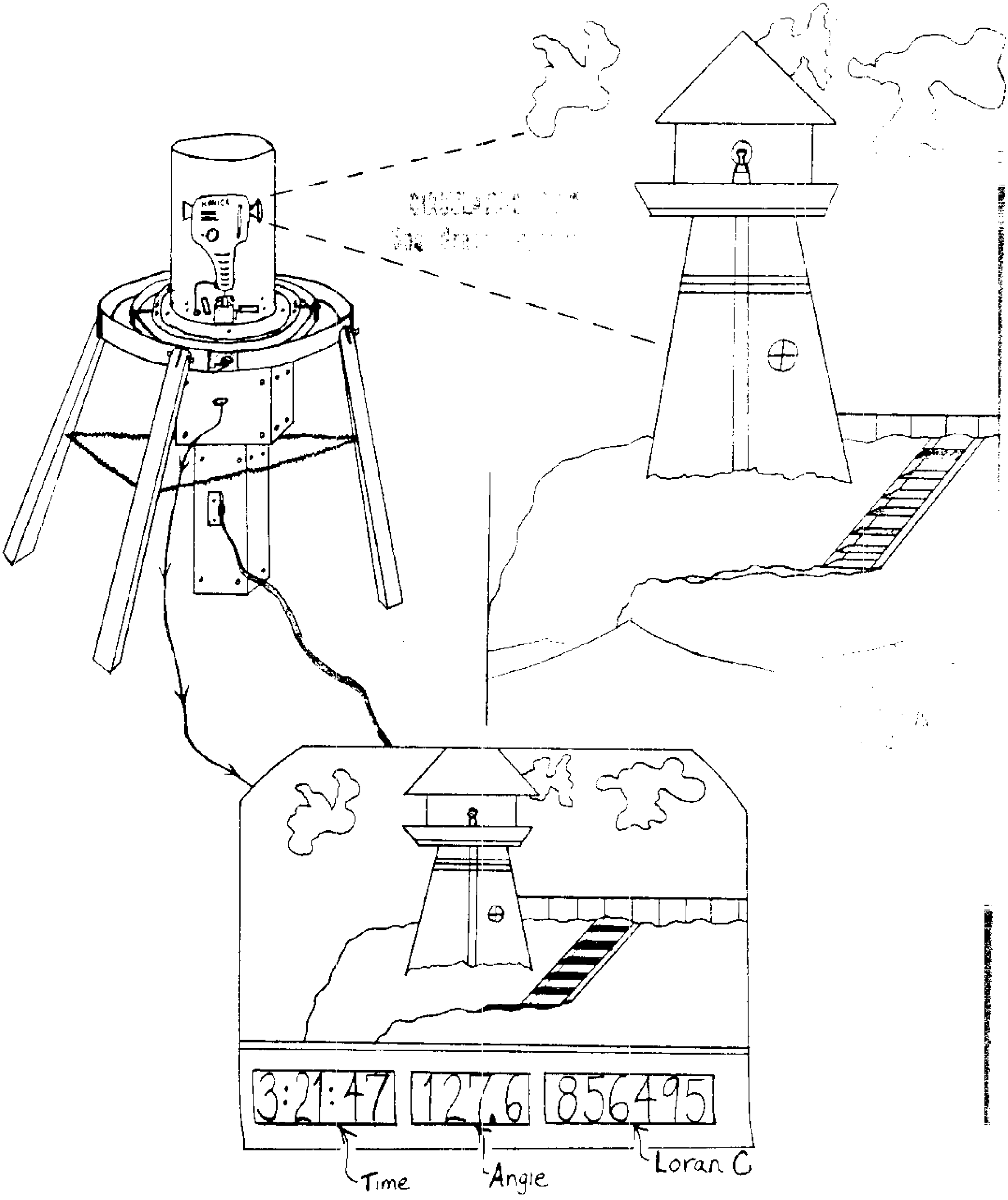
NHU-T-86-005 C2

VIDEO THEODOLITE



VIDEO THEODOLITE

OCEAN PROJECTS

SEA GRANT
1985-1986

UNIVERSITY of NEW HAMPSHIRE

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AKNOWLEDGEMENTS

We would like to thank Dr. Albert Frost, who provided us with invaluable help and guidence during this project.

We would also like to thank:

-Wasco Products Inc. and Dr. Joe Murdoch for providing the plexiglass dome

-Eastern Air Devices for the stepper motor and drive circuit card.

-Bob Blake and Bob Doucette from the UNH machine shop for their skill and expertise.

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-Dr. and Mrs. Savage for their help and criticism.

-Antronics Inc. for the video mixer.

-The Coast Guard for the computer programs and data.

-The Electrical Engineering department for the use of the assorted power supplies that were needed.

ABSTRACT

The Video Theodolite is the first step in the automation of surveying. It will prove to be very useful on ships where speed in surveying is a must, since a boat on the water is always moving and time is of the essence.

The Video Theodolite consists of: a video camera and VCR, the actual theodolite in this apparatus; a stepper motor, which will turn the camera on one end and a resolver on the other; a resolver, with an interpretor will give us relative angle locations of points of reference; gimbals, on which the camera, stepper motor, and the resolver are mounted to keep them level on the boat.

By obtaining the angle measurment between 3 known points from one location the position of that location can be determined in reference to the known points. Our data(the actual video recording of points of reference, angles between them and time) will be stored on video tape. The video tape can then be played back to retrieve data and calculate the position of the boat at a particular time. The video tape also provides a permanant record for future reference.

We have hope that this device will be of great help to those wishing to map inland waterways.

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INTRODUCTION

The ability to give accurate postion is very benificial in many marine applications. Whether it be to give a position of a newly set bouy or an object set on the ocean floor, accuracy of position and the consistancy of which that position can be determined play an important role. In the case of the bouy it is important to put the bouy as close as possible to the position in which it was intended. Bouys set to indicate shallow areas or hazards are not much good if they are set in the wrong place. For an object on the bottom of the ocean, unless you know that you are just above the object it will be extremely hard to find. Once again finding an accurate position proves to be important.

Determining accurate position on water is not an easy task. The problem here being one of drifting while trying to take accurate surveying data as well as trying to keep a theodolite fixed on the horizon. The goal of this project is to build a device that is capable of collecting data, needed to determine position, fast enough to minimize error due to drifting and minimize time wasted because of the motion of the boat.

Our device is the Video Theodolite. By using this device the data is taken quickly and stored on video tape which can then be taken to the lab where position will be calculated with the help of a computer. In the future the small computer will be on board so that position can be determined immediatly.

Another application for future use of our surveying device can be to correct values given by navigational devices such as Loran-C. The Loran-C reciever has become a very widely used navigational device. Its application has grown tremendously since its inception 15 years ago. This is mainly due to constant improvements being made to the system. At present most of the applications are for use on the open ocean. Recently there has been an expressed interest in using Loran-C for use in inland waterways. Although the accuracy to which the Loran-C reciever gives position is plenty accurate for navigational purposes on the open ocean, the error is too great to possibly navigate in narrow waters. With the use of our device, values for Loran-C in localized areas within inland waterways can be corrected to give a greatly decreased error in that area. Thus making safe navigation possible.

DESIGN

The Video Theodolite apparatus can be broken down into three main parts; video,electronics and structure. The integration of these three systems is the essence of this project.

VIDEO

The video part of this apparatus consists mainly of two video cameras, a portable VCR, a TV/monitor and a video mixer.

The video camera to be used as the actual theodolite needed to possess the following characteristics; weigh less than 5lbs.(the lighter the better), small in size (to minimize cost of the rest of the apparatus and to make the moment of inertia about its center small), easily mounted without modification and would have a field of view in the vicinity of 10-20 degrees. Finally our budget would only allow a us to spend a maximum of 500.00 for the camera.

The camera that we chose was the Konica CV 301. This camera weighs 1.54lbs., well under the maximum allowable. This camera is also configurated so that it is taller that it is wide (See fig.1), contrary to the design of most cameras, giving it a smaller moment of inertia about the vertical axis. These last two features allowed us to make many things smaller than originally planned. This made our apparutus both lighter and less expensive. The final feature important to this project was the field of view. The zoom capability of this camera allows us to set our field anywhere from 10 to 30 degrees, ideal for this application. (Consult table 1 for specifications on this camera.)

The requirements for the VCR we needed were these; It needs to be

FIGURE 1

Nomenclature

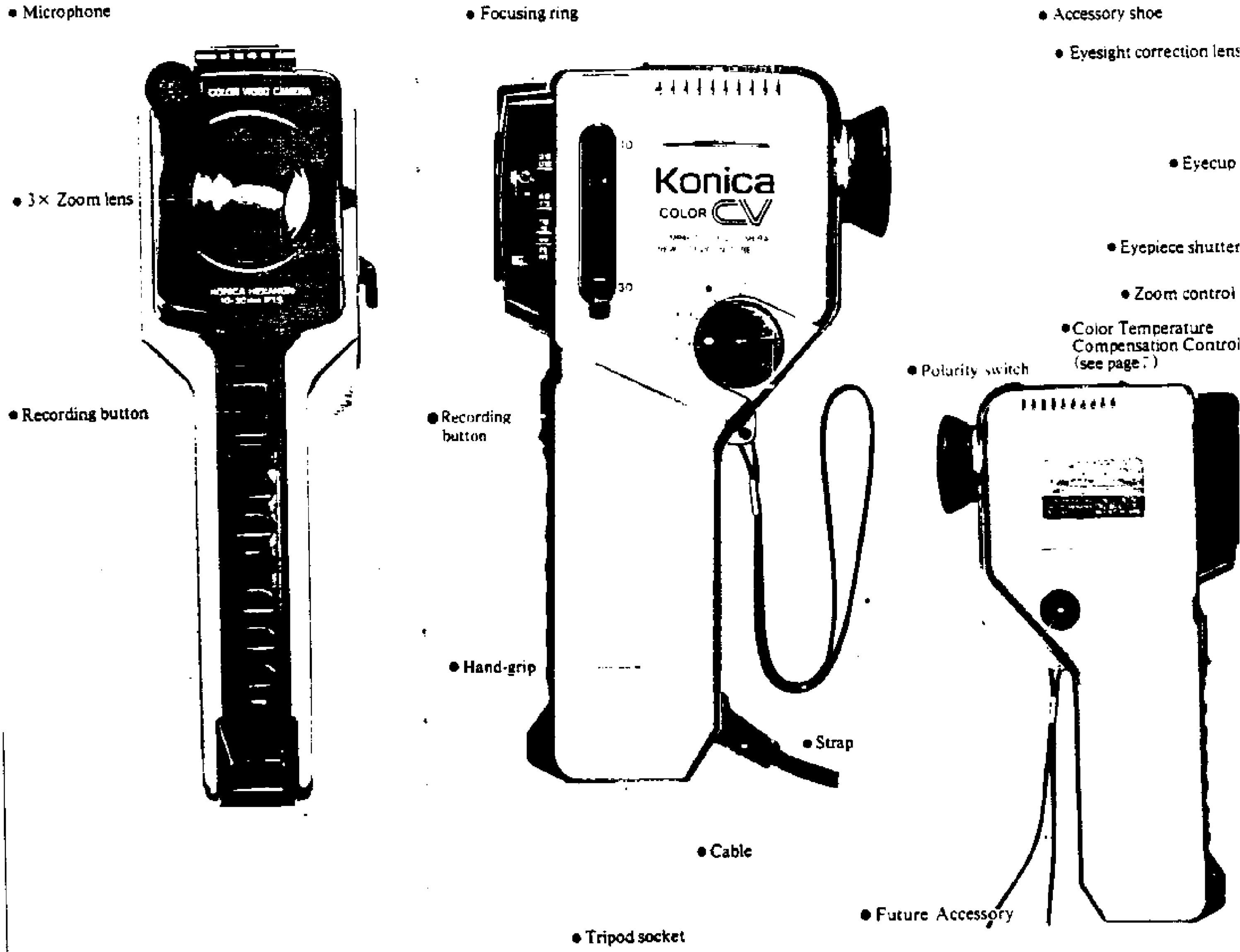


TABLE 1

Specifications

Television system	Single carrier frequency separation system (NTSC Standard)
Pickup tube	1 2"S-M New Cosvicon™
Video output signal	1.0Vp-p 75ohms
Scanning system	525/60 fields/sec 2:1 interlace
Horizontal resolution	270lines plus
Image s/n ratio	45dB plus
Minimum required luminance	35 lux
Microphone	Unidirectional electret condenser microphone
Audio output level	−20dB (1kΩ)
Lens	f 1.5 3× manual zoom 10−30mm focal length 43mm filter diameter automatic iris
Minimum focusing distance	0.8 meter
Viewfinder	Through-the-lens optical viewfinder:in-finder LED signals indicate "recording," low light and power warnings
Color temperature compensation control	4 position control, color temperature range 3200° − 7000°K Cloudy 7000°K Sunny 5500°K Fluorescent light 4500°K Incandescent light 3200°K
Power requirement	12V DC
Power consumption	approx. 3.5W
Temperature range for operation	0°C to 40°C (32°F to 104°F)
Size	66mm × 225mm × 122mm (W × H × D) (2.6" × 8.9" × 4.8")
Weight	720grams (including 1.5m cable)

compatable with the camera mentioned above, easy to use and have a clear and steady freeze-frame and be portable. The cost of a VCR with these capabilities was out of the scope of our budget, so for now we are renting one. The price of these machines are going down so it is not unrealistic that one could be purchased at a later date. As for now, we have no problem renting what we need. We found that the minimum stipulation for VCR specifications are that it be one with 4 videoheads and have a 10 pin connecter for our camera. This gives us a very good freeze-frame and meets the rest of the criteria as well.

The TV/monitor needed to be portable(small in size), have a large enough screen to distinguish features(good resolution as well), and be purchased so that we can use the same one every time. This is important since different TVs have different screen angles. We have to put a calibrated grid on the screen, which when used in conjunction with the angle measurement given by the shaft resolver gives us actual angular difference. Therefore we don't want to have to change the grid everytime we use our apparatus. The TV that we purchased was an RCA model AXR120Y. It is black and white (less expensive than color and there is no problem using our color camera with it) and has a 12 inch screen. This meets the project requirements for a viewing monitor.

The RCA TC1470A Screen Splitter is used to mix the theodolite picture with that of our second camera. The criteria here is that it can be made compatable with our two cameras and allow us to place the second cameras picture in a desirable part of the first picture. The second camera had to be able to syncronize with the first camera. We are borrowing this camera from the EE dept.

ELECTRONICS

The electronics part of our project consists of two major pieces, a stepper motor and a shaft resolver.

Our choice for a stepper motor was Eastern Air Devices' model LA34ADK-4, which steps 1.8 degrees per pulse and is bidirectional. Eastern Air has had a close relationship with UNH over the years and offered the motor and drive circuit card at no charge. This motor was chosen because it was felt that the performance data best the needs of the project. The calculated spinning torque required to spin the theodolite camera was 45 oz-in. which is well under the rated spinning torque of 100 oz-in of the motor. The axial load of the camera on the motor is 1.54 lbs. which is also well under the load rating for this heavy duty motor. A stepper motor with a rear shaft was used so that a shaft resolver could be attched to it.

The drive circuit card for the stepper motor takes three power supplies, a frequency oscillator, and a signal generator to spin the motor(see fig.2). The main power supply requirements are variable, depending on the performance needed. At higher voltages, the motor produces more spinning torque and holding torque. On this project, we have been running the main power supply at around 12 volts, which provides enough torque to spin the camera. The signal generator in conjunction with the frequency oscillator, provides the actual electrical pulses to spin the motor. At the present, the direction that the stepper motor spins is controlled manually (see fig.3) by holding down the forward or reverse direction button. An automatic spinning scheme is proposed for the future. A cam has been designed and built which is to be mounted on the camera shaft. Two micro-switches(normally open) have

FIGURE 2

DRIVER CARD.

3000 EXTERNAL WIRING AND DIMENSIONS

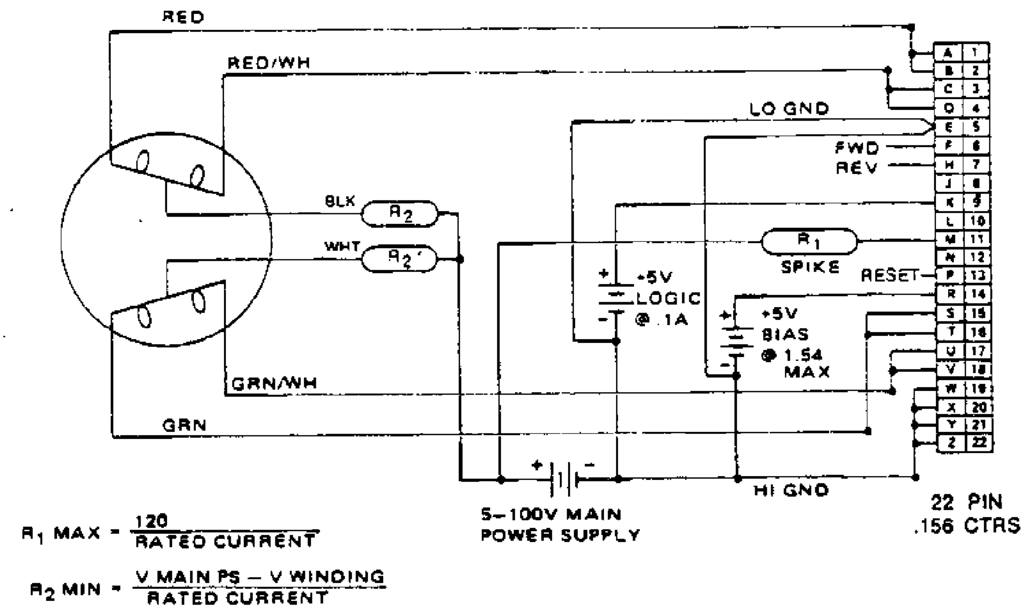


FIGURE 2 DRIVE CIRCUIT BOX

(TOP VIEW)

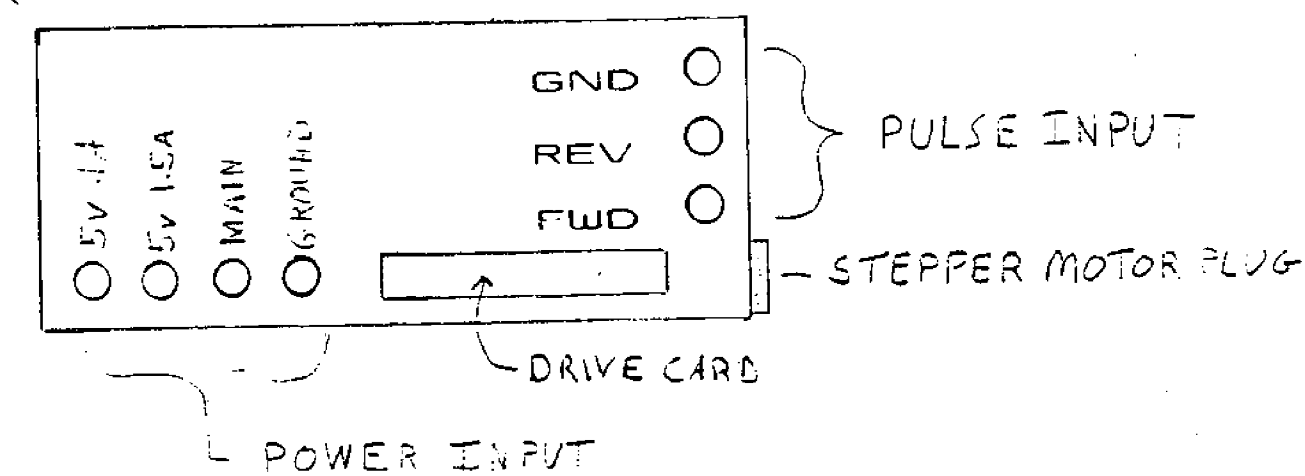


FIGURE 3

Switcher Circuit Diagram

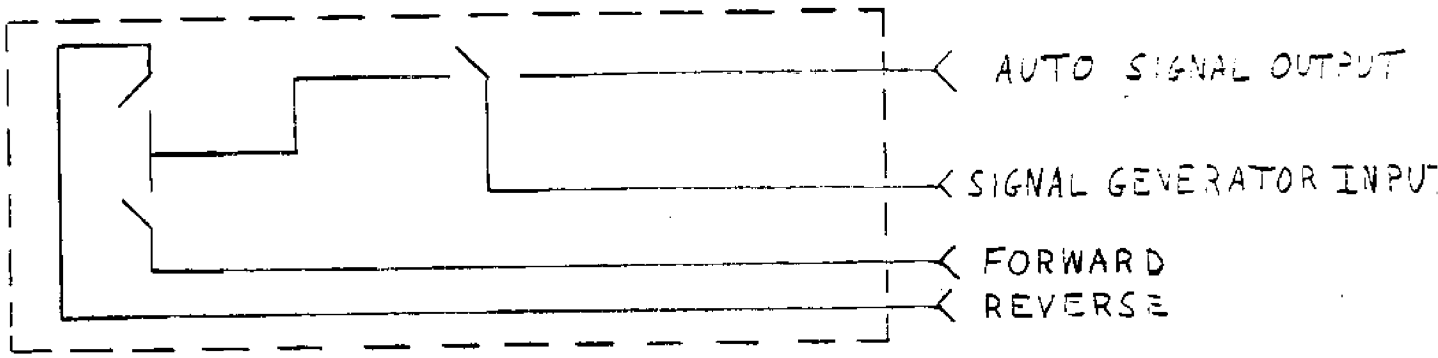
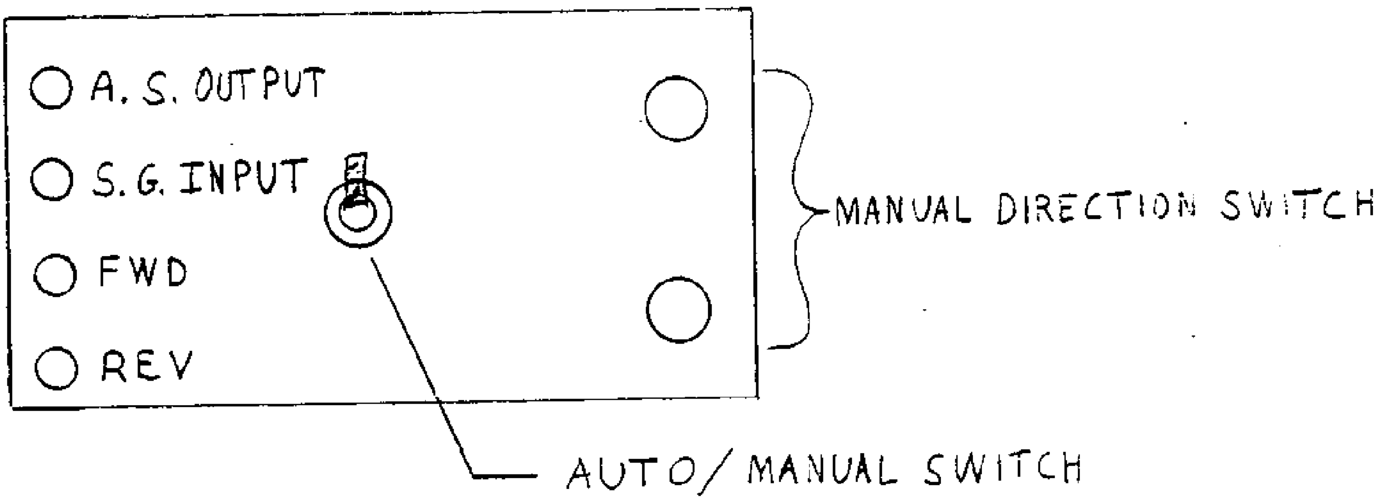


FIGURE 3

Switcher Box



been mounted on the gimble plate to be activated by the cam. The algorithim for hte automatic operation is as follows:

1) Start motor spinning clockwise.

2) When microswitch #1 is closed, a set of relays and a time delay circuit change the direction of the motor to counterclockwise.

3) When micro-switch #2 is closed, a set of relays and a time delay circuit change the direction of the motor back to clockwise.

4) The system repeats itself until the circuit is shut off.

Another aspect of the automatic operation scheme involves the signal generator. The signal generator would be set up so that 5 or 10 electrical pulses would be sent to the motor, the signal generator would wait another 5 or 10 pulses before sending another set of pulses to the motor. The wait of 5 to 10 pulses is require

to allow the video camera

and motor to settle down to get a clear 'shot' before moving on. The number of pulses sent to the motor depends on how many degrees wide the monitor screen is, if 10 electrical pulses were sent to the motor, the camera would turn 18 degrees.

The second major part of the electronics is a shaft resolver that we salvaged from an unused piece of electrical equipment. The resolver is an optical type absolute encoder. An absolute resolver is neccesary for this project. Because it gives a relative angle measurment from the devices zero point and is bidirectional. An incremental encoder is a unidirectional device which could not be used. An optical encoder is superior to the resistive potentiometer. The optical encoder is more reliable and has a longer lifespan due to using non-moving photo sensors and is the more sensitive of the two.

A constant amplitude sinusoidal waveform is inputed into the shaft resolver and a phase shifted wave form with the same amplitude is outputed. The input and output waveforms are compared by a phase meter (See fig.4), which computes and displays the phase shifted angle in degrees (-180 to 0 to +180). The phase meter also outputs a DC voltage that is proportional to the angle in degrees. A DC voltmeter can be connected to this output to get an LED readout of the angle.

STRUCTURE

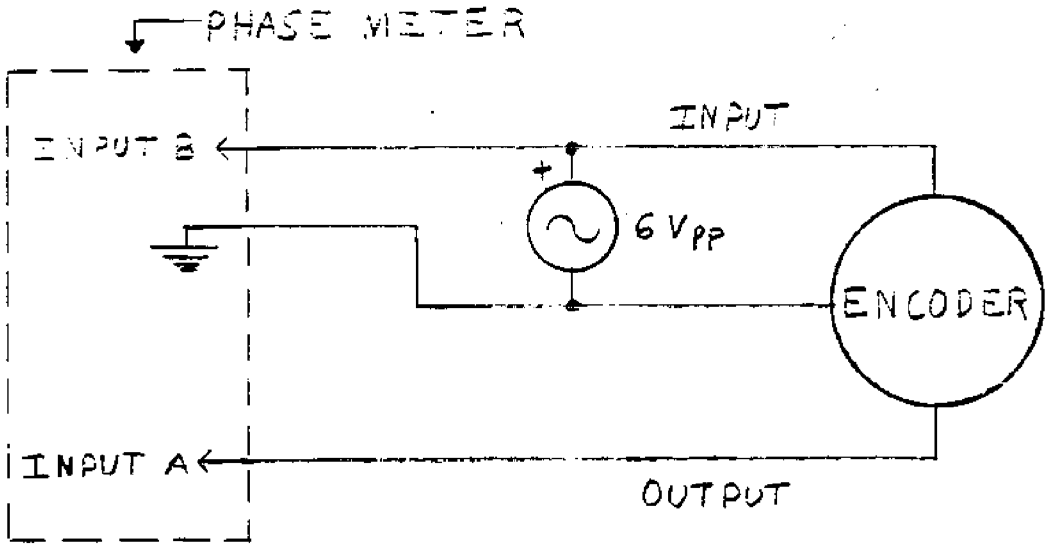
The structure part of this project is basically what holds it all together.(See fig.5)

There were 3 main objectives sought to be met by the structure. The first objective was to keep moisture out of and away from the video camera and the rest of the electronics incorporated with it. Secondly the structure would need to hold the theodolite camera in such a way that the field of view remains fixed on the horizon. Lastly we wanted a design that would stand the test of time.

The video theodolite will constantly be exposed to sea mist and sometimes rain. Since our theodolite is actually a camera which is very susceptible to moisture damage, it is important that it remain in a dry enviroment. But because of the very nature of this project it is also very important to maintain a 360 degree view. Our solution to this problem was to try and aquire a glass or plexiglass dome that would completly cover our delicate camera. With the help of Professor Dr. Joseph Murdoch we were able to find a company willing to make us what we needed at no charge. Wasco Products Inc. of Sanford, Maine put together a plexiglass cylinder with a clear top and a flange on the bottom to mount it to the rest of our structure(See fig.6). We are grateful to

FIGURE 4

Shaft encoder wiring diagram.



Shaft encoder wiring scheme.

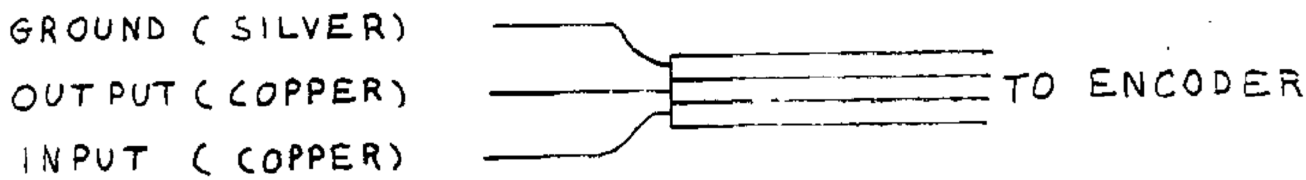


FIGURE 5

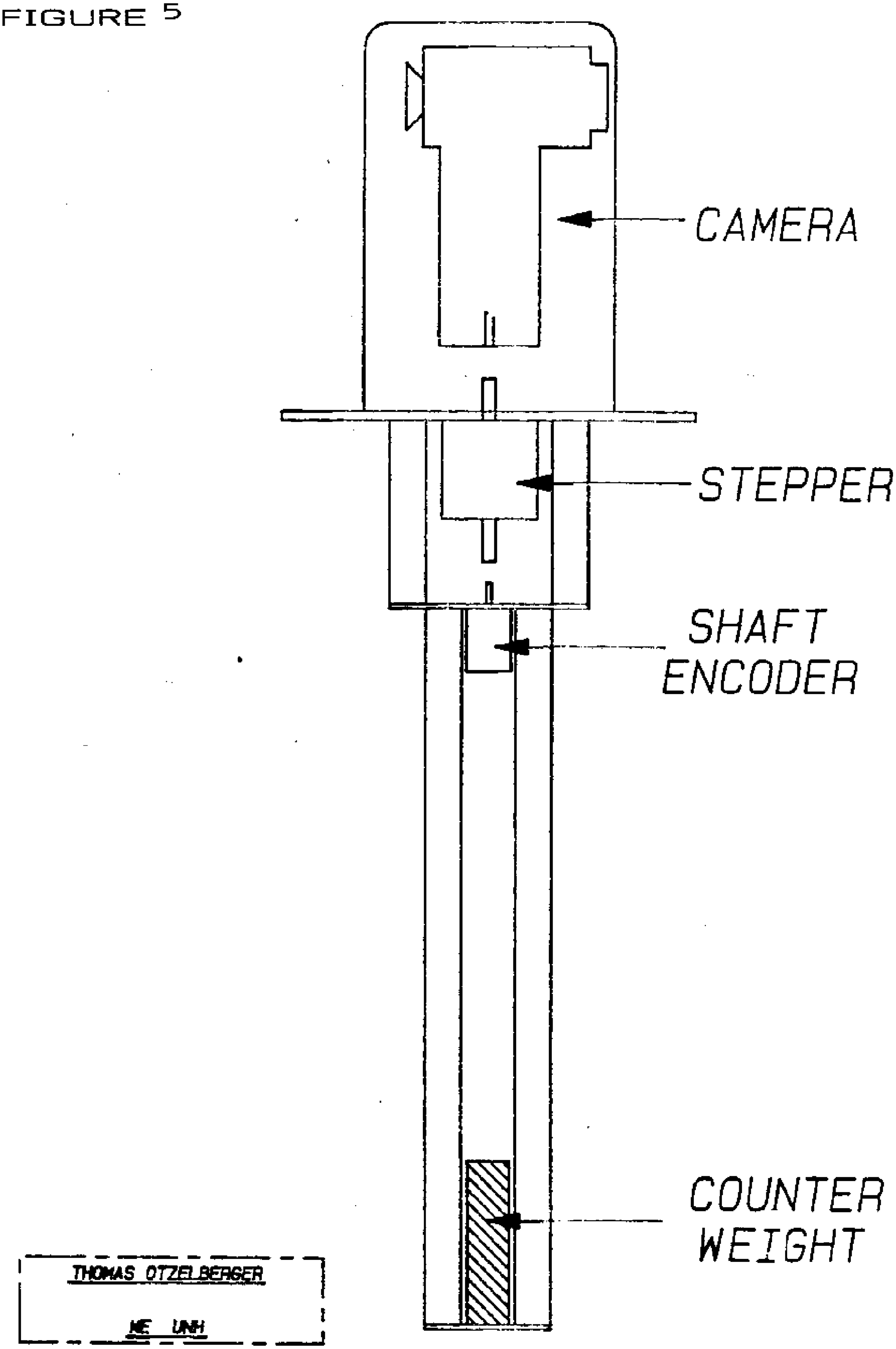
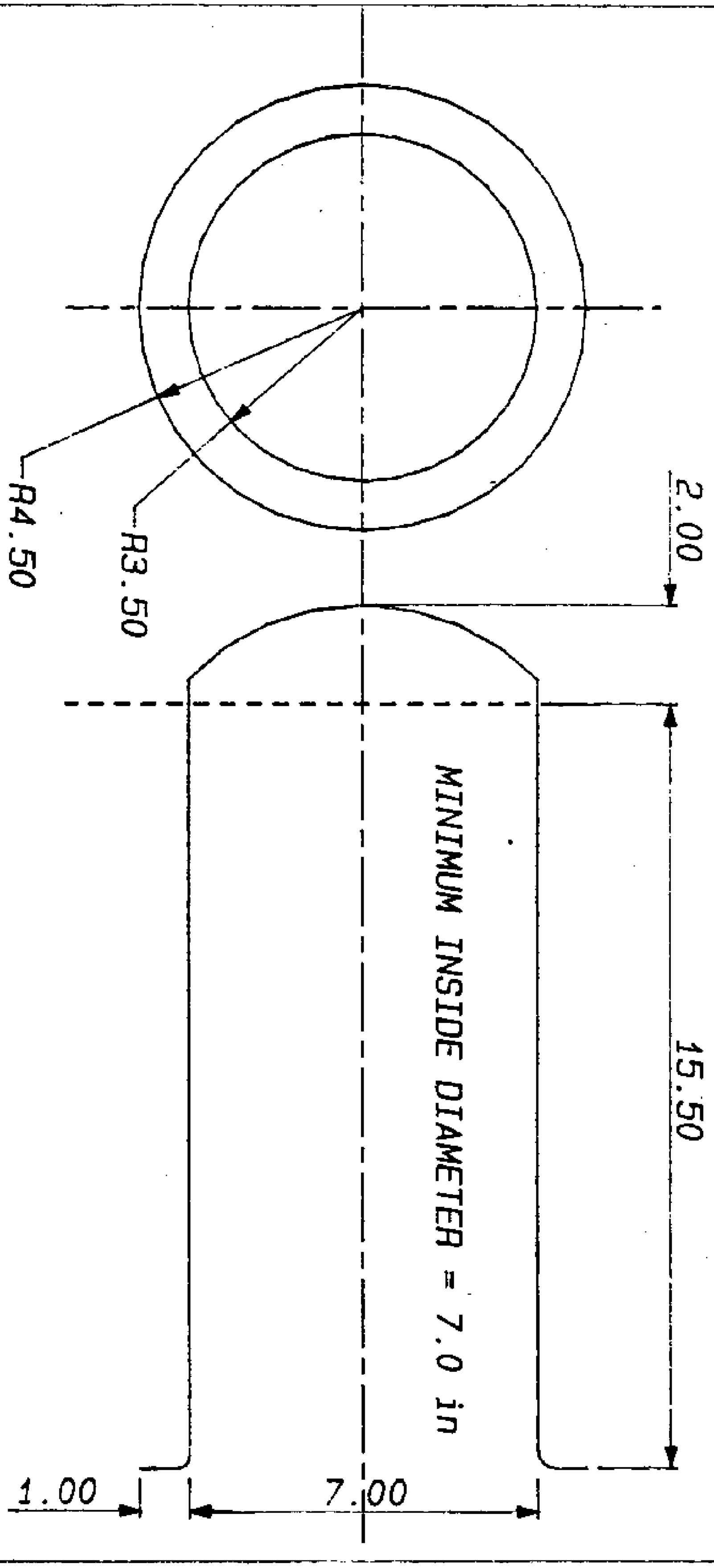

CAMERA
STEPPER
SHAFT
ENCODER
COUNTER
WEIGHT
THOMAS OTZELBERGER
ME UNH

FIGURE 6

DOME



THOMAS OTZELBERGER

ME UNH

Wasco Products Inc. and Dr. Murdoch for helping us out. This dome has worked out well so far. It keeps out the moisture and it doesn't obstruct the theodolite's view.

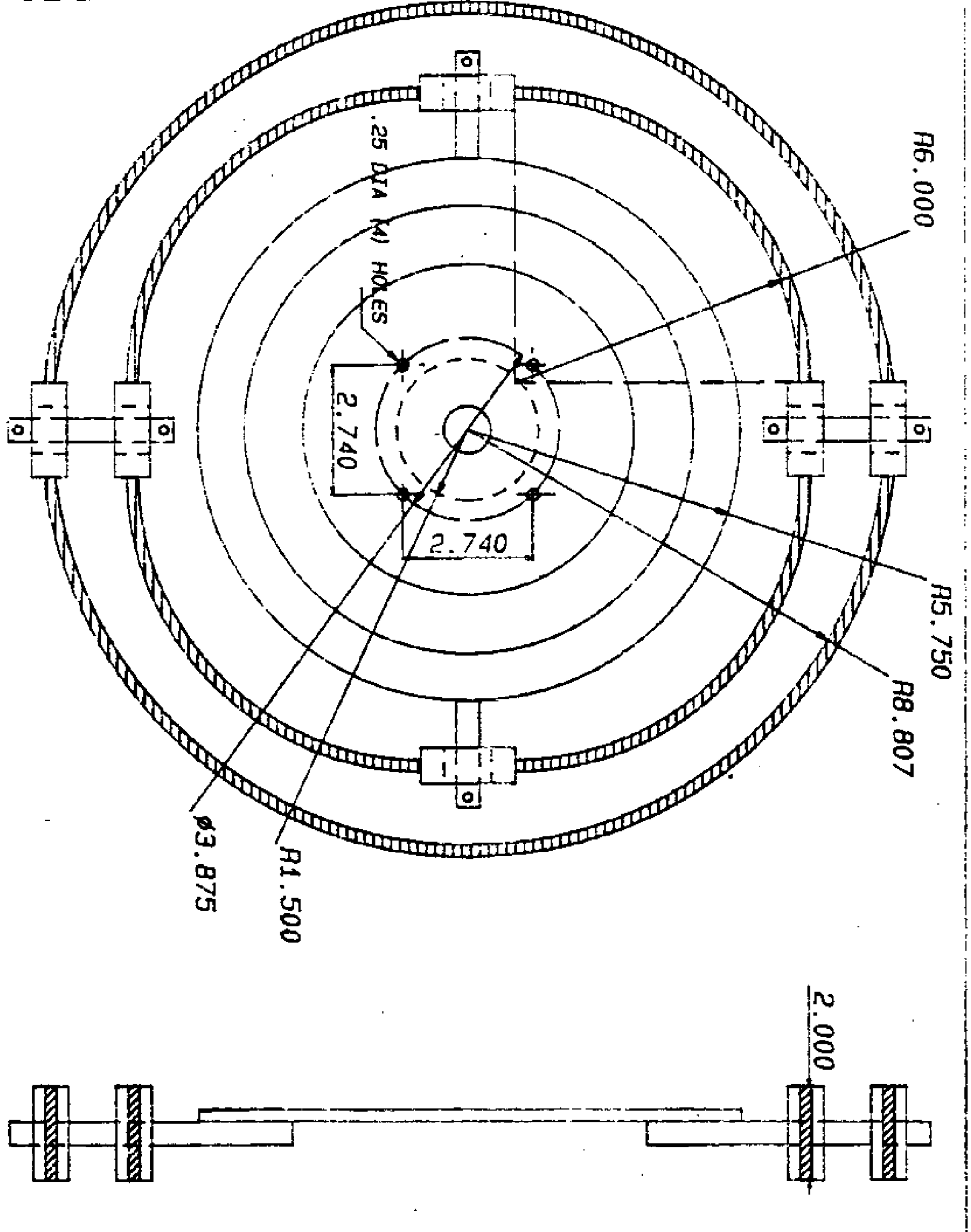
The rest of the structure is enclosed by 1/4" pieces of plywood to keep the weather from reaching the stepper motor and the shaft resolver.

In order to keep the theodolite camera fixed on the horizon it was nessasary to build a set of gimbals (See fig.7). Gimbals are a device that supports an apparatus on rings and bearings and has a counterweight to keep it plum regardless of how the boats sits or moves in the water. With a sufficiently heavy counterweight to offset the weight of the camera and the use of cintered bronze bearings at the pivot points, the gimbals do a sufficient job of keeping the camera's view horizontally paralell to the horizon.

Nearly the entire structure was made of either stainless steel or of hardwood. It is felt that the non-corrosive qualities of the stainless steel and the rigidity of the hardwood (Oak) will help our device last with a minimum amount of maintnance. The gimbals were made entirely of stainless steel except for the cintered bronze bearings. These bearings are used both for their lubricating quality (Cintered means, that powdered metal is heated and pressed into shape. The small particles act as a lubricant) and for their electronegitivly inert relationship with the stainless steel that the bearings are pressed into.

The entire structure is supported at the gimbals by 5 ft. oak legs. The oak legs should be durable and rigid enough to last a long while and are easily replaced. We made them 5ft. high so that the theodolite would be sufficiently above all obstruction on the top of the boat.

FIGURE 7



THOMAS OTZELBERGER

ME UNH

CADAG CENTER
UNIVERSITY OF NEW HAMPSHIRE

GIMBELS

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etg

HOW DOES IT WORK

As mentioned in the design section, the actual theodolite is our Konica video camera. This camera is mounted on the stepping motor to one end of the motor's shaft. The resolver is connected to the other end of the shaft. The stepper motor is in turn mounted on the center plate of the gimbals.

By mounting the camera and connecting the resolver to the same shaft, the output of the resolver will directly reflect the angle in which the camera is turned by the stepper. The gimbals keep everything level and the field of the theodolites view on the horizon.

The other video camera is fixed on the LED readouts of: angle measurement as given by the resolver(via DC volt meter), Time and if we are working with a navagation system, its readout as well. By using the video mixer the desirable parts of both video outputs are stored on the video tape and displayed simultaneously on our monitor.

In our field of view we seek to find known points of reference (at least 3) on the horizon. We can then determine the angle between them by using the resolver output and the calibrated screen on the monitor which are both easily visible. The two angles put us on 2 lines of postion which must intersect, giving us our position with respect to the known points (to be explained in greater detail in the next section). The time gives us some reference as to what points go together when we play the tape back in the lab.

SURVEYING PROCESS

How do we get results? Position computation assumes that the map position of the several selected target points are known (See fig.8 ,for our illustration we have 4 known points) as well as the angle seperation between selected pairs at the postion sought.

Two computational programs are used on our computor to get results (See appendix for more information on the computor and the programs). To start the process we must first make an initial first order estimate of our actual position (See fig.9). Program A (for which there are several versions depending on the relative geometry of he targets and the observer) computes the loci of points in th vicinity of the estimated position at which a selected target pair (T_1) and (T_2) have an angular seperation of θ (See fig.10). The user inputs the target positions in map coordinates, the angle θ and starts the solution at a map position slightly to the left(west) and below(south) of the estimated observer position. The program procedes to compute, printout and store the coordinates of the path (See fig.11).

This is then repeated with a second target pair and angle. This second locus is stored in a designated record area(See figs.12 & 13)

Program B examines these data sets and estimates their intersection. The intersection search is initiated from a coordinate slightly to the left(west) of the intersection as estimated from examination of printer output of A.Intersection is output in map coordinates (See fig.14).

Because of limitations in various parts of the apparatus, there is a small amount of error is introduced into our final position coordinates. In order that our results don't reflect an accuracy beyond the video theodolites capabilities, a tolerance of +/- 1 degree was set. Two new sets of lines of position result, each one is calculated as +/- 1 degree from the original lines of position. This gives us a position somewhere within the paralellagram formed by the outside lines of position.(See figs.15 & 16)

UNH SEA GRANT 1986 PROJECT: VIDEO SURVEYOR

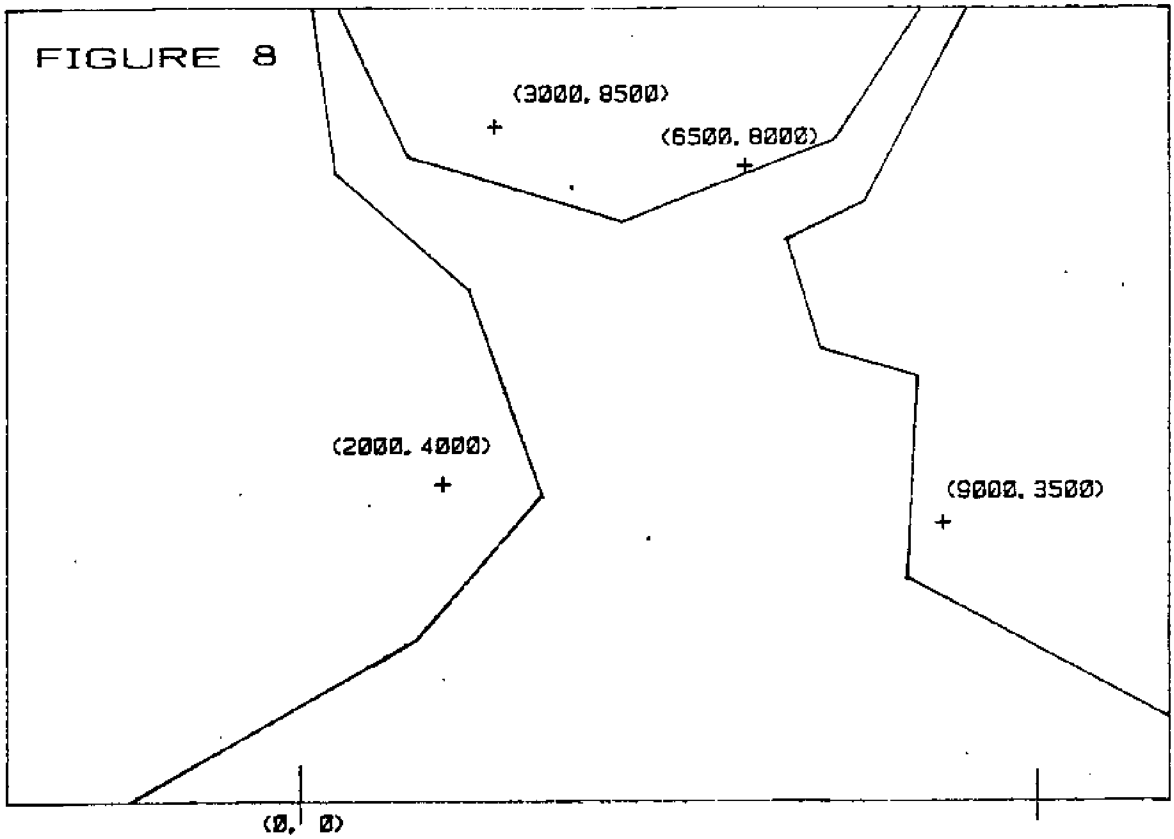


FIGURE 8

UNH SEA GRANT 1986 PROJECT: VIDEO SURVEYOR

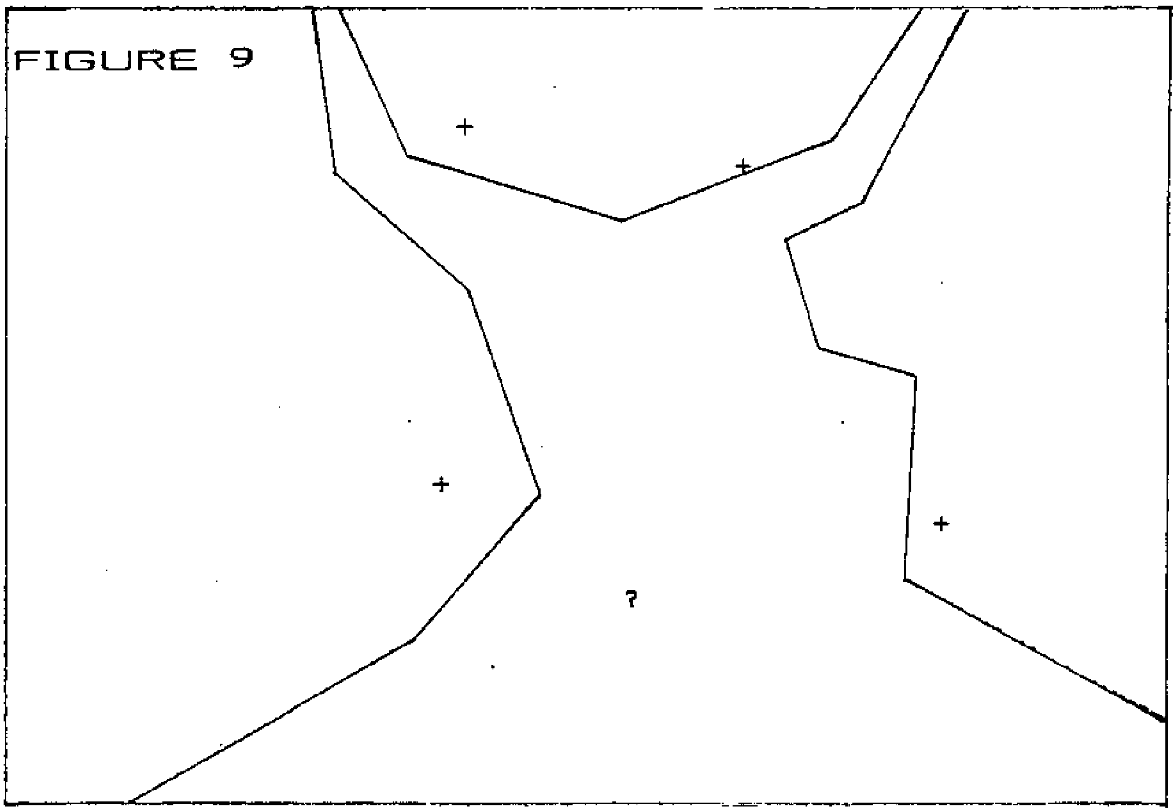


FIGURE 9

UNH SEA GRANT 1986 PROJECT: VIDEO SURVEYOR

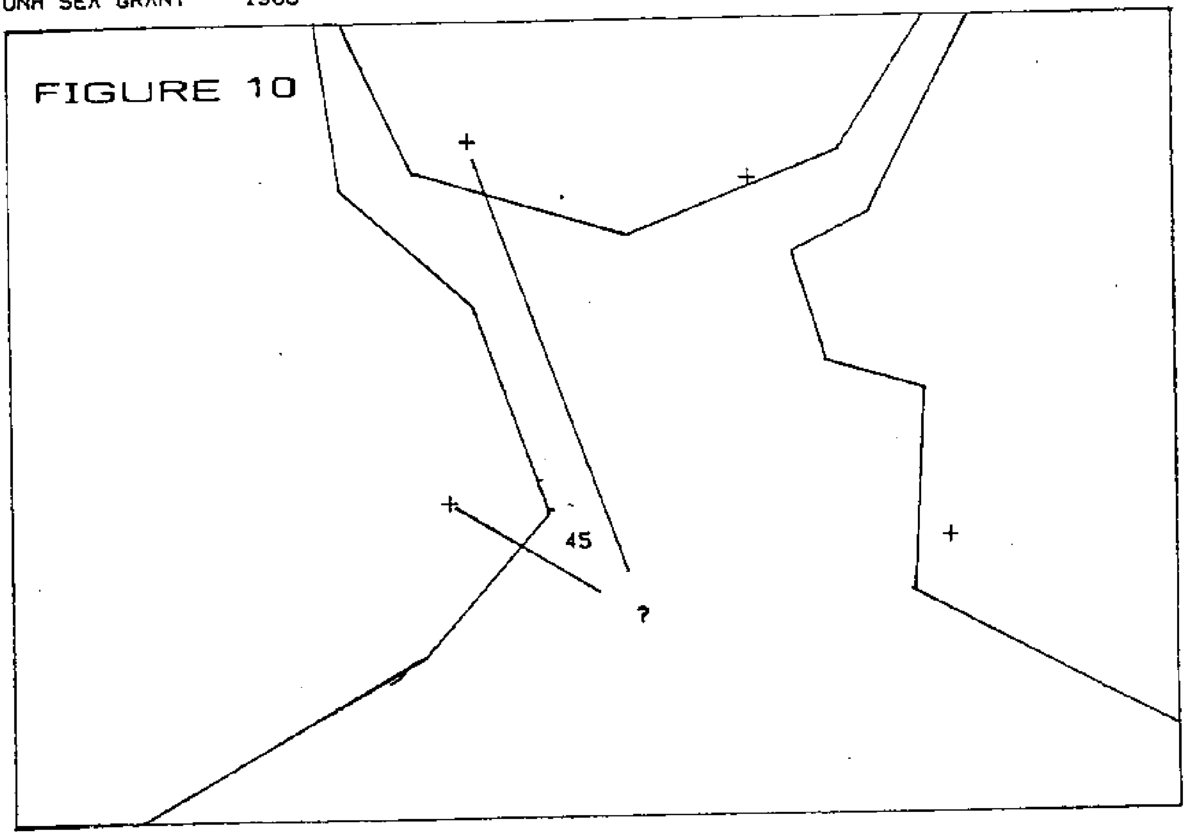


FIGURE 10

UNH SEA GRANT 1986 PROJECT: VIDEO SURVEYOR

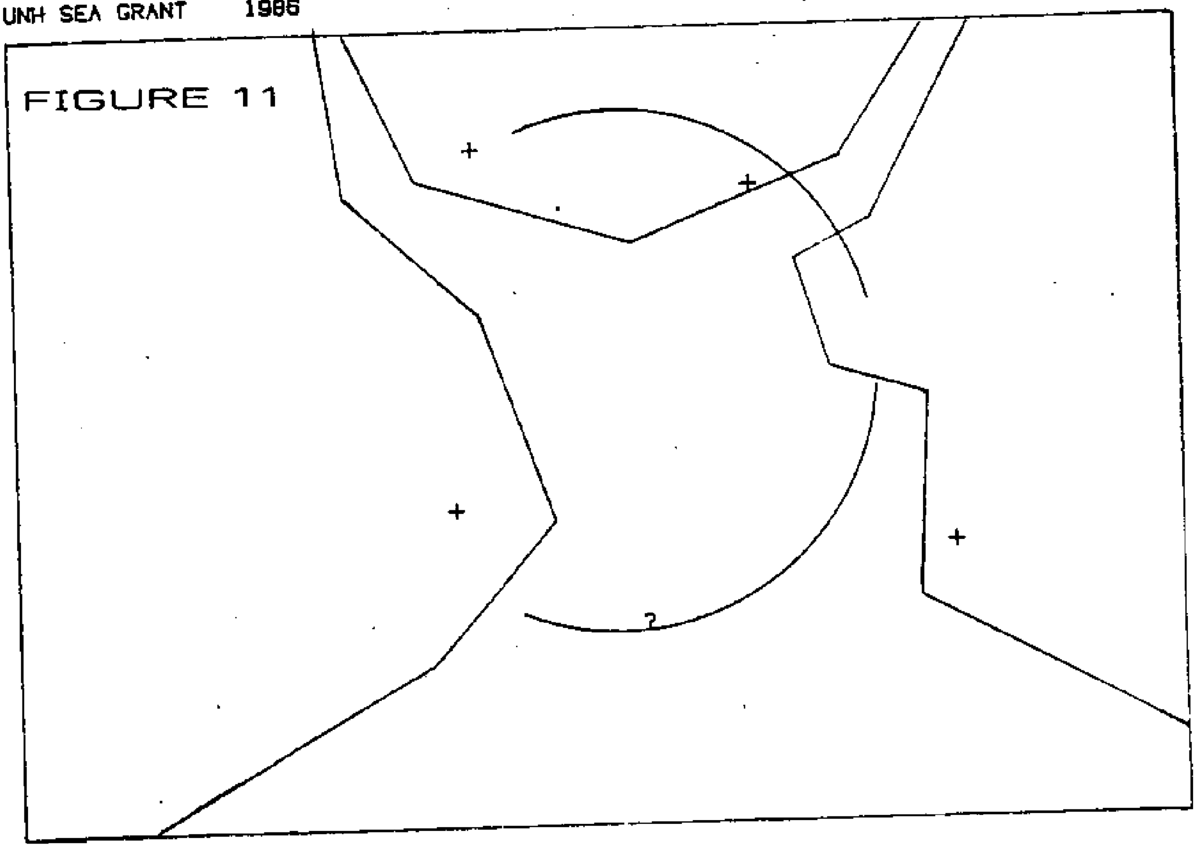


FIGURE 11

UNH SEA GRANT 1986 PROJECT: VIDEO SURVEYOR

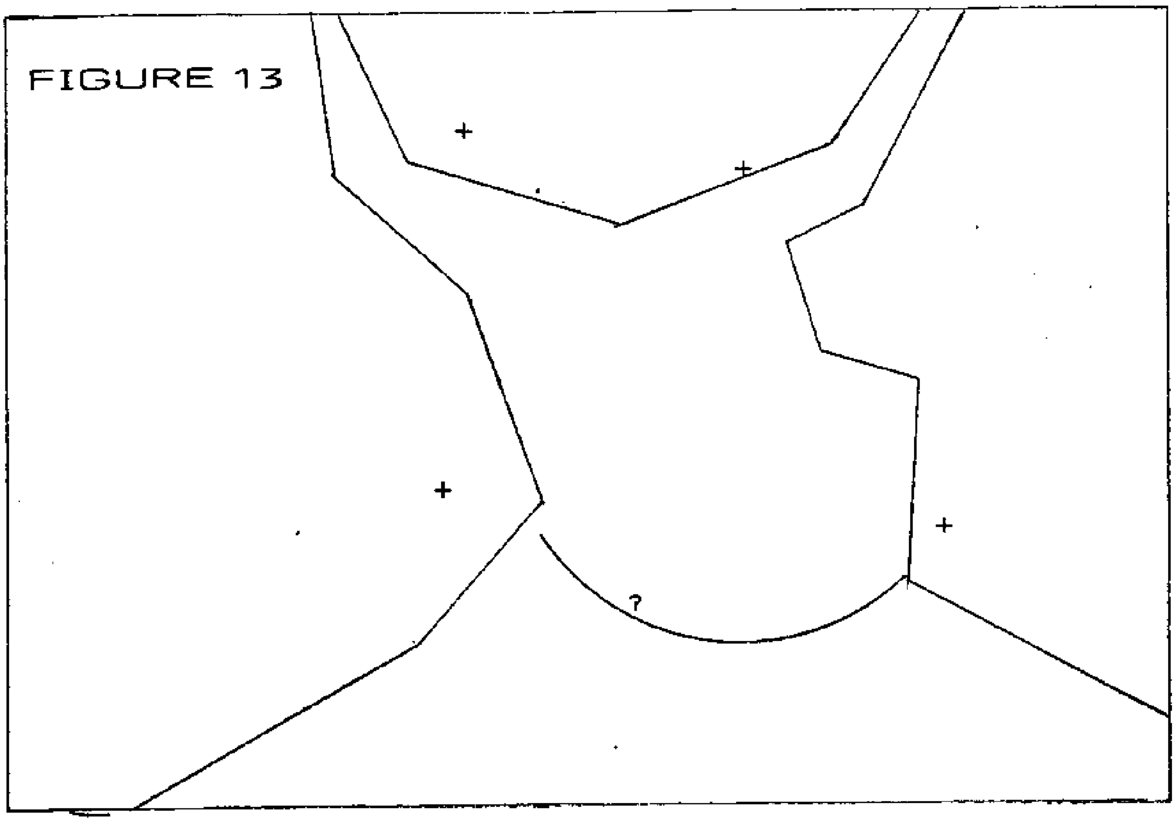


FIGURE 13

UNH SEA GRANT 1986 PROJECT: VIDEO SURVEYOR

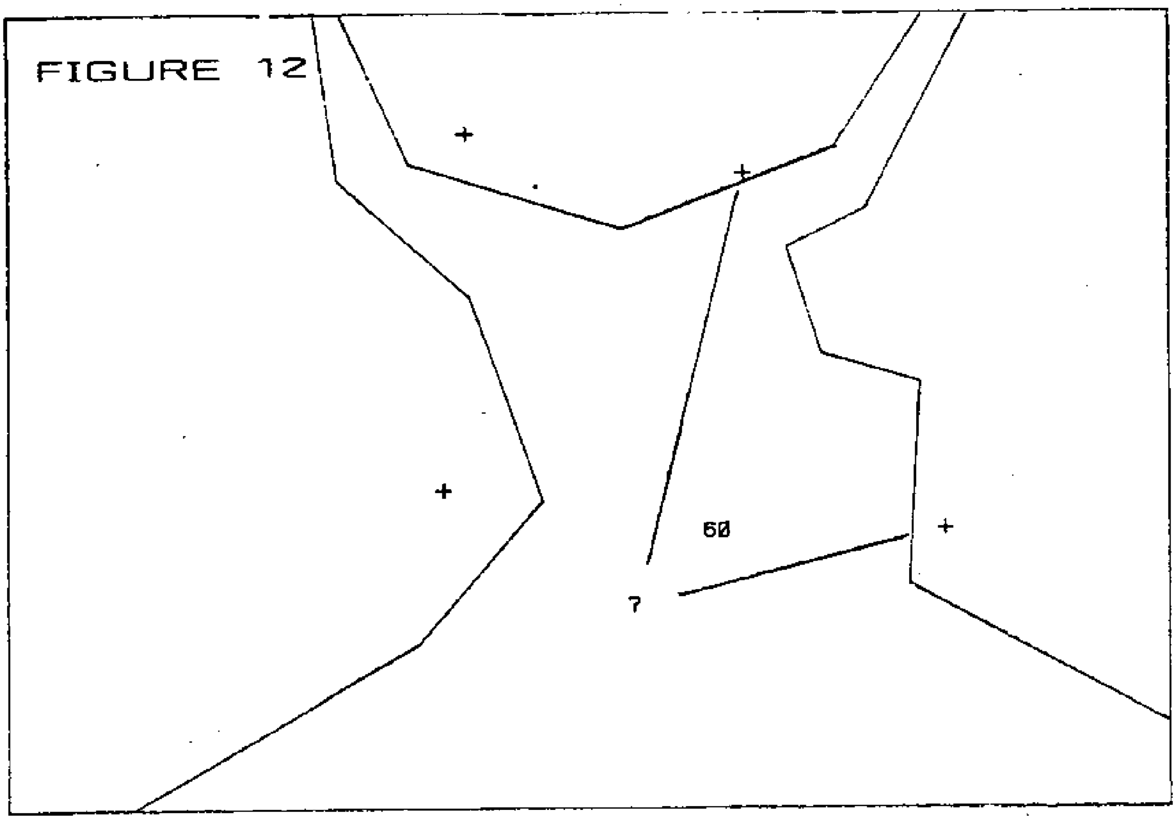
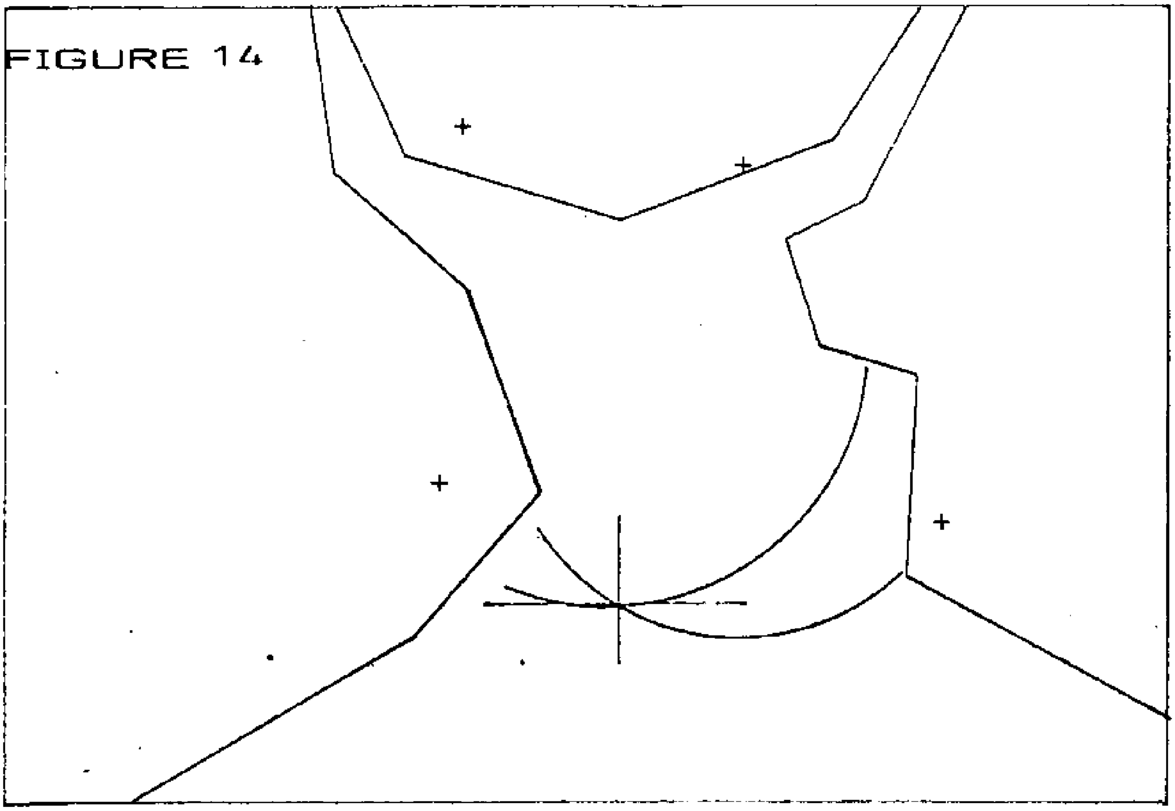


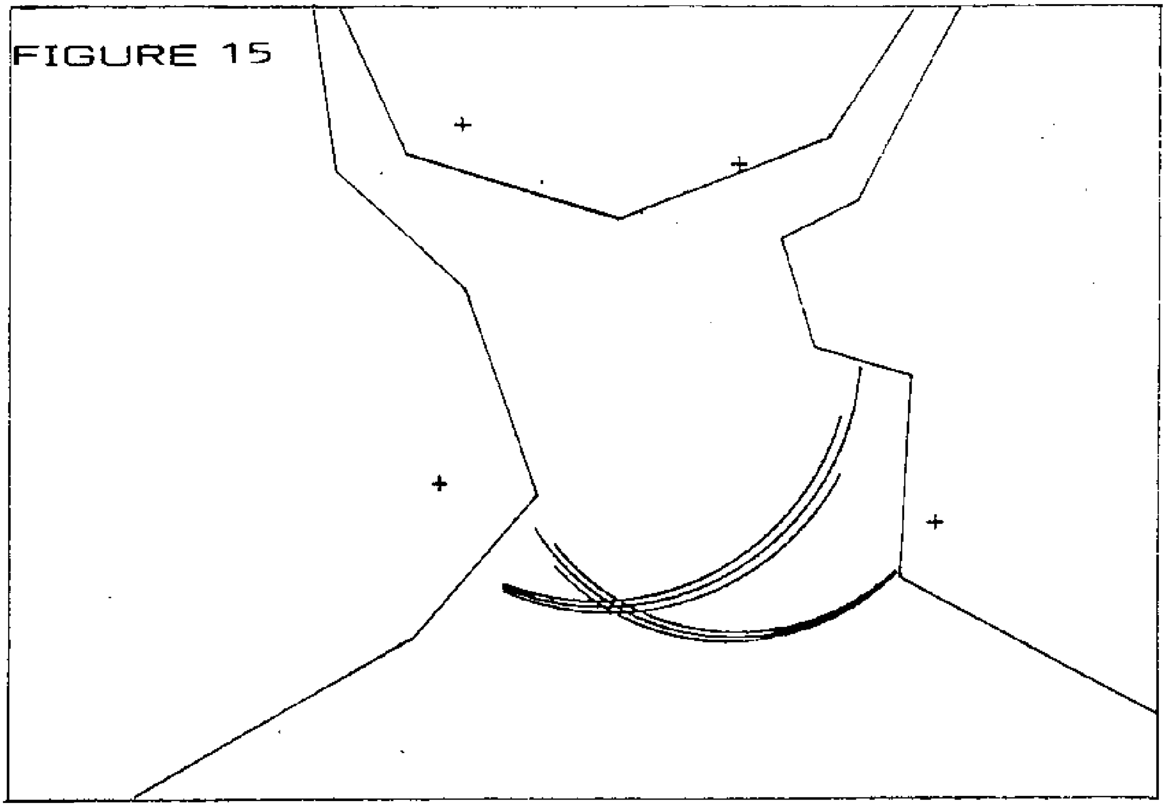
FIGURE 12

UNH SEA GRANT 1986 PROJECT: VIDEO SURVEYOR



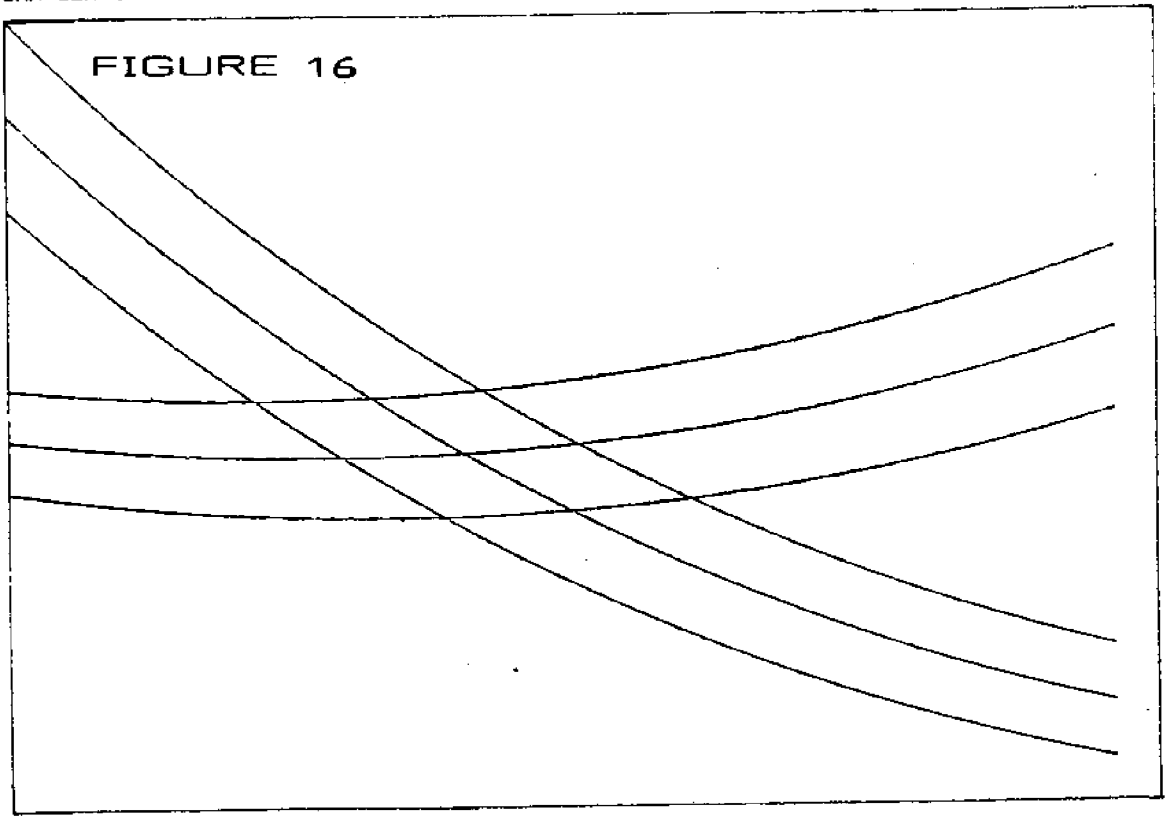
UNH SEA GRANT 1986 PROJECT. VIDEO SURVEYOR

FIGURE 15



UNH SEA GRANT 1986 PROJECT. VIDEO SURVEYOR

FIGURE 16



Testing and Calibration

Dry land testing and calibration was performed in a large indoor room. A transit was used to divide the room up into 10 degree increments which was used to calibrate the monitor screen. It was decided to make the screen 10 degrees wide for use while the camera is stepped around manually. For automatic operation, a 20 degree wide screen would be more suitable. This would allow for an increase in the rotation speed of the camera.

The stepper motor performed well at the slow speeds (about 10 steps/second) that we are running it at without gaining or losing steps. The shaft resolver is far more accurate than is needed with the 1.8 degree stepper motor.

The first test on board the Jere Chase ended prematurly due to equipment failure. The shaft resolver failed to give accurate data after we got underway on the Piscatiqua river. The day was damp and drizzily, with the humidity at 100 percent. It seems failure cam be attributed to the amount of moisture in th air on that day. The next day the shaft resolver was bench tested and it worked properly, giving accurate results. This may mean that the resolver may have to be better protected from the weather while on the boat.

On the positive side, the set of gimbals kept the video camera plumb so that it had a good view of the horizon. The video camera gives a sharp clear picture through the plexiglass dome which protects the camera from the elements. During the test, the video mixer was not operational yet to so we were unable to put the shaft resolver data and time on the video tape. Further testing is planned with the apparatus in complete working condition. Unfortunatly this will be beyond the due date of this report.

CONCLUSION

In conclusion we feel that the video theodolite project was a success. Although we had alot of doubts along the way everything pulled together in the end. Equipment that we needed always seem to show up in the nick of time.

Our project is really the integration of the three systems mentioned in our report. It all seemed much simpler in the beginning. Probally the biggest obstacle that we faced was trying to put output from the resolver on the video tape. Our original idea was to just place the LED readout of angle measure and time in an unused portion of the cameras field of view. The problem that occured with this idea was that of focusing on things at two differences. We then thought of an idea to to place the information on the audio side of the video tape. Although this may be feasible at some date there was a problem forseen in the syncrinization of resolver information and what was being seen on our screeen. The idea that we take two video signals and mix them seemed far fetched as well. Not because it wouldn't work, but because alot of people, knowledgable in the video area, pointed us in the direction of equipment that was beyond our budget. Fortunatly we were able to aquire what we needed to complete it. Miracles never cease.

APPENDIX A

Position finding program with example of searches.

```
10 PRINT " UNH SEA GRANT                              PROJECT: VIDEO SURVEYOR "
11 PRINT
20      DEG
30 PRINT
40 PRINT " PROGRAM  A      COMPUTATION OF LINE OF POSITION  (CASE I) "
50 PRINT
60 DISP " INPUT COORDINATES OF POINT S1 :   LOWER LEFT      "
70 RB=-5 @ RA=RB
80 M=200
90   ASSIGN# 1 TO  "mapX"
100 DISP "  X1 =  ?"
110 INPUT X1
120 DISP "  Y1 =  ?"
130 INPUT Y1
140 DISP " INPUT COORDINATES OF POINT    :   UPPER  LEFT    "
150 DISP " X2  =     ?"
160 INPUT X2
170 DISP " Y2  =     ?"
180 INPUT Y2
190 PRINT "   TARGET #1 X = ";X1;"  Y =  ";Y1
200 PRINT
210 PRINT "   TARGET #2 X = ";X2;"  Y =  ";Y2
220 PRINT
230 DISP " CASE I    X0 > X1 OR X2     Y0  < GREATER  Y VALUE  "
240 DISP " INPUT THE ANGLE ( DEGREES) BETWEEN  S1 AND S2  "
250 INPUT A
260 PRINT
270 PRINT "   ANGLE BETWEEN  T1   AND T2   ";A;" degrees "
280 PRINT
281 PRINT "........................................"
282 PRINT
290 PRINT "    RECORD#      X         Y    "
300 PRINT
310  R=0
320 DISP " INPUT INITIAL X VALUE FOR SEARCH  "
330 INPUT XS
340 DISP " INPUT INITIAL Y VALUE FOR SEARCH "
350 INPUT YT@ YS=YT
360  SA=YS-Y1 @ SA=SA/(XS-X1) @ T1=ATN (SA) @ T1=ABS (T1)
370  SB=YS-Y2 @ SB=SB/(XS-X2) @ T2=ATN (SB) @ T2=ABS (T2)
380 R=T2-T1-A
390 DISP XS,YS,R
400 IF SGN (RA)<> SGN (R) THEN 460
410 GOTO 430
420  Z=1
430 YS=YS+50
440 RT=R
450 GOTO 360
460 XS=XS+50
470 RA=RB
480 Z1=ABS (R)+ABS (RT)
490 Z2=ABS (RT)/Z1
500 YY=YS-1+Z2*50
510 PRINT USING 520 : M,XS,YY
520 IMAGE 5X,3D,5X,5D.1D,5X,5D.2D
530 YS=YT
540 PRINT# 1,M : XS,YY,R
550 M=M+1
560 GOTO 360
570 END
```

UNH SEA GRANT PROJECT: VIDEO SURVEYOR

PROGRAM A COMPUTATION OF LINE OF POSITION (CASE I)

TARGET #1 X = 2000 Y = 4000

TARGET #2 X = 3000 Y = 8500

ANGLE BETWEEN T1 AND T2 45 degrees

....

RECORD#	X	Y
200	3550.0	2788.46
201	3600.0	2768.13
202	3650.0	2749.00
203	3700.0	2730.44
204	3750.0	2713.00
205	3800.0	2696.55
206	3850.0	2680.75
207	3900.0	2665.96
208	3950.0	2652.14
209	4000.0	2639.00
210	4050.0	2626.71
211	4100.0	2615.32
212	4150.0	2604.81
213	4200.0	2595.06
214	4250.0	2586.03
215	4300.0	2577.85
216	4350.0	2570.49
217	4400.0	2563.93
218	4450.0	2558.17
219	4500.0	2553.20
220	4550.0	2549.00
221	4600.0	2545.51
222	4650.0	2542.81
223	4700.0	2540.88
224	4750.0	2539.72
225	4800.0	2539.34
226	4850.0	2539.73
227	4900.0	2540.88
228	4950.0	2542.81
229	5000.0	2545.52
230	5050.0	2549.00
231	5100.0	2553.21
232	5150.0	2558.20
233	5200.0	2563.97
234	5250.0	2570.54
235	5300.0	2577.91
236	5350.0	2586.09
237	5400.0	2595.08
238	5450.0	2604.84
239	5500.0	2615.40
240	5550.0	2626.80
241	5600.0	2639.06
242	5650.0	2652.16
243	5700.0	2666.07
244	5750.0	2680.87

UNH SEA GRANT PROJECT: VIDEO SURVEYOR

PROGRAM A COMPUTATION OF LINE OF POSITION (CASE II)

TARGET #1 X = 9000 Y = 3500

TARGET #2 X = 6500 Y = 8000

ANGLE BETWEEN T1 AND T2 60 degrees

....

RECORD#	X	Y
300	4050.0	3396.22
301	4100.0	3325.61
302	4150.0	3259.02
303	4200.0	3196.12
304	4250.0	3136.60
305	4300.0	3080.08
306	4350.0	3026.32
307	4400.0	2975.13
308	4450.0	2926.31
309	4500.0	2879.72
310	4550.0	2835.21
311	4600.0	2792.65
312	4650.0	2751.96
313	4700.0	2713.02
314	4750.0	2675.75
315	4800.0	2640.08
316	4850.0	2605.94
317	4900.0	2573.25
318	4950.0	2541.98
319	5000.0	2512.06
320	5050.0	2483.45
321	5100.0	2456.11
322	5150.0	2429.98
323	5200.0	2405.07
324	5250.0	2381.28
325	5300.0	2358.65
326	5350.0	2337.10
327	5400.0	2316.62
328	5450.0	2297.23
329	5500.0	2278.80
330	5550.0	2261.42
331	5600.0	2245.05
332	5650.0	2229.59
333	5700.0	2215.13
334	5750.0	2201.65
335	5800.0	2189.02
336	5850.0	2177.32
337	5900.0	2166.55
338	5950.0	2156.70
339	6000.0	2147.74
340	6050.0	2139.58
341	6100.0	2132.32
342	6150.0	2125.93
343	6200.0	2120.41
344	6250.0	2115.75