CANADIAN HYDROGRAPHIC SERVICE
CENTRAL REGION and
N.O.A.A. - N.O.S.
LAKE SURVEY CENTRE - DETROIT, MICHIGAN
ATLANTIC MARINE CENTRE - NORFOLK, VIR.

STAFF EXCHANGE - 1975
JULY TO OCTOBER

CANADIAN HYDROGRAPHIC SERVICE

CENTRAL REGION

AND

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL OCEAN SURVEY

LAKE SURVEY CENTRE - DETROIT, MICHIGAN

ATLANTIC MARINE CENTRE - NORFOLK, VIRGINIA

STAFF EXCHANGE

1975

(JULY TO OCTOBER)

B. EIDSFORTH
HYDROGRAPHER

SUMMARY

The 1975 field season saw a continuation of the technical exchange program between the National Ocean Survey (N.O.S.) of the National Oceanic and Atmospheric Administration (N.O.A.A.), U.S. Department of Commerce and the Canadian Hydrographic Service of Environment Canada.

Survey office operations of Lake Survey Centre, Detroit, Michigan and Atlantic Marine Centre, Norfolk, Virginia were both observed.

Mr. R. Stachon of L.S.C. was the participant from N.O.A.A. in the exchange.

I found the exchange program to be worthwhile and informative and should be continued.

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INTRODUCTION

In 1970, the National Oceanic and Atmospheric Administration (NOAA) was formed and placed under the responsibility of the U.S. Department of Commerce.

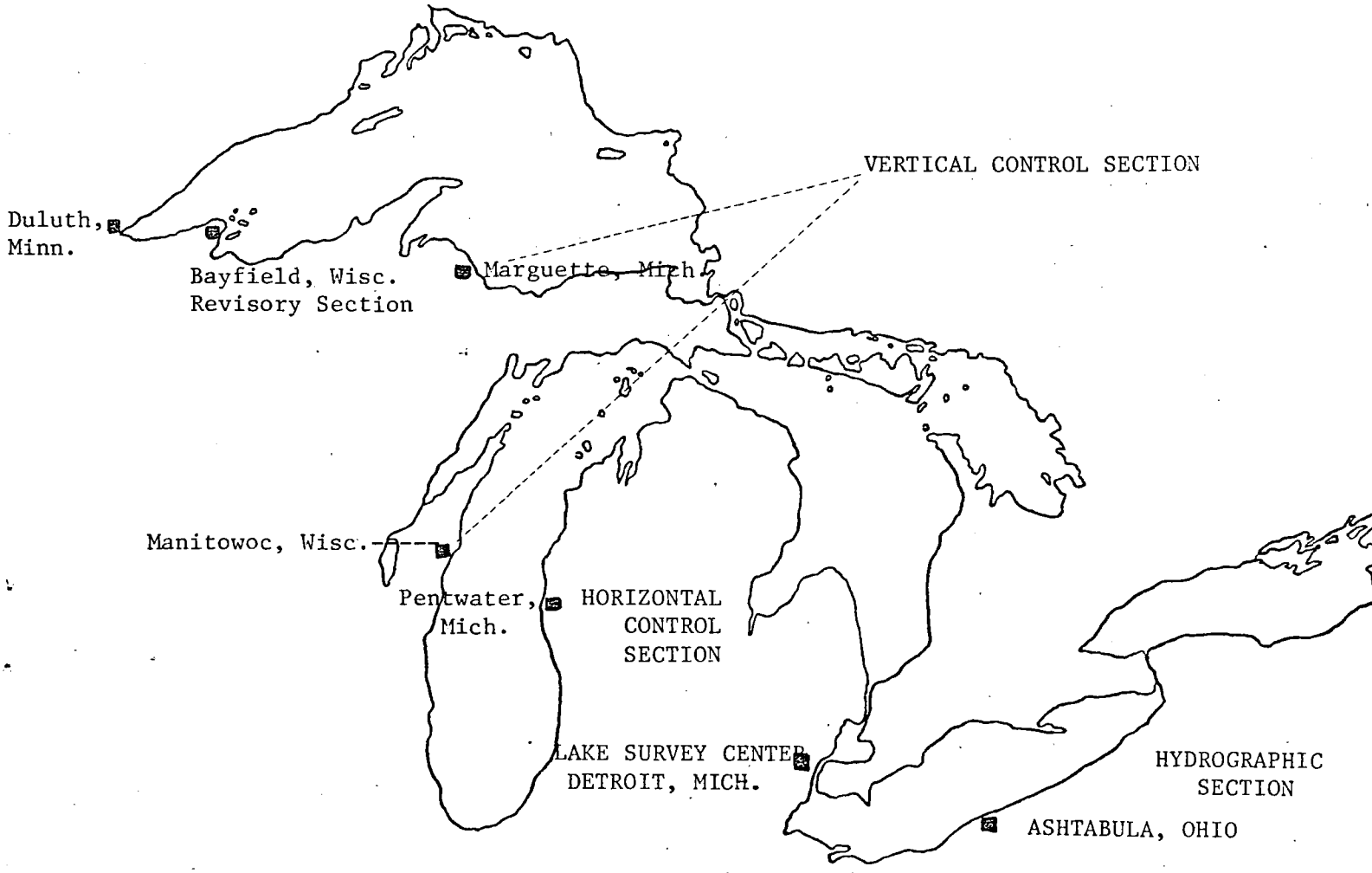
The National Ocean Survey (NOS) is a part of NOAA and presently houses the offices of the National Geodetic Survey (NGS), the Atlantic Marine Center (AMC), the Pacific Marine Center (PMC) and Lake Survey Center (LSC).

This report covers a three and one-half month technical exchange between the National Ocean Survey and the Canadian Hydrographic Service.

ITINERARY

Lake Survey Center

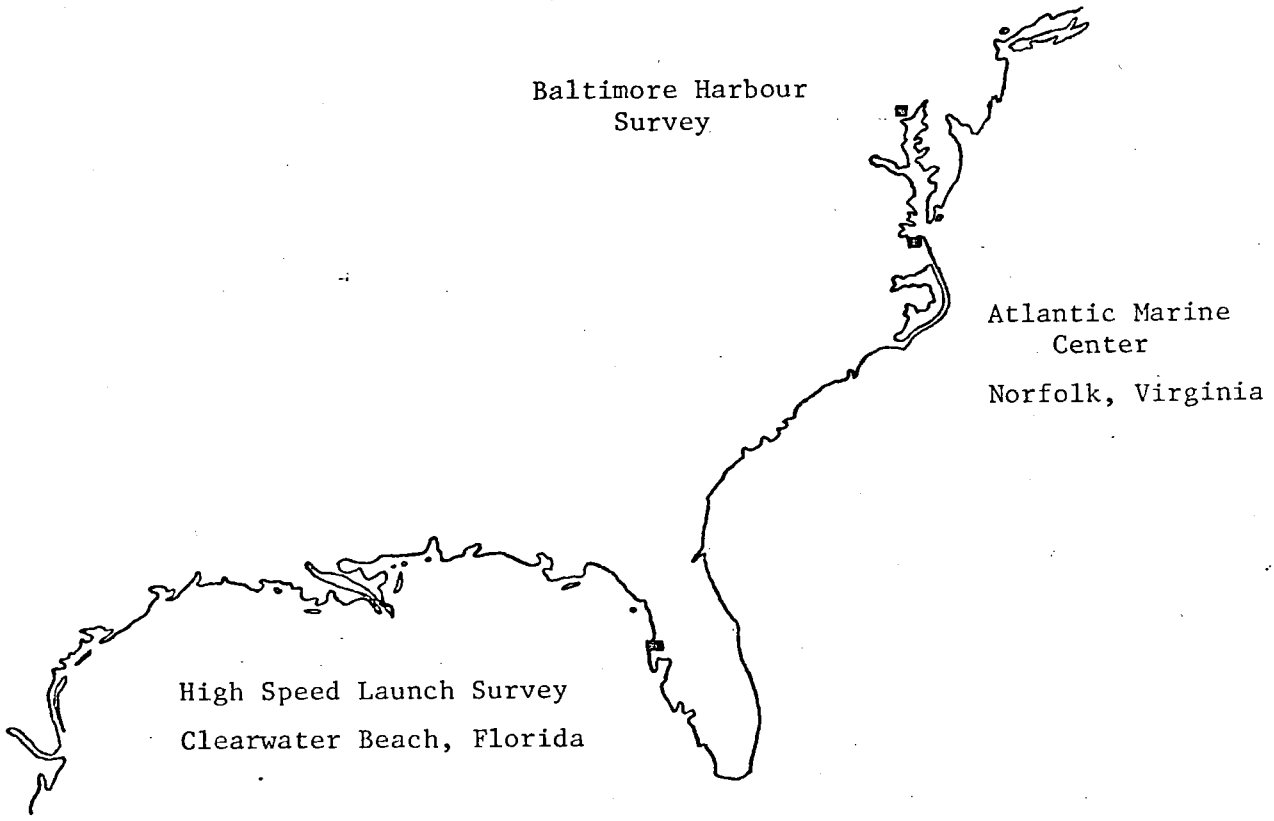
Lake Survey Center Offices (Detroit, Michigan)	July 2, 3 (2 days)
Revisory Section (Duluth, Minn. & Bayfield, Wisconsin)	July 7-18 (2 weeks)
Vertical Control Section (Marquette, Mich. & Manitowoc, Wisc.)	July 21 - August 1 (2 weeks)
Horizontal Control Section (Pentwater, Michigan)	August 5 - 9 (1 week)
Hydrographic Section (Ashtabula, Ohio)	August 11 - Sept. 5 (4 weeks)



ITINERARY

Atlantic Marine Center

A.M.C. Offices (Norfolk, Virginia)	September 8, 9 (2 days)
Baltimore Harbour Survey Launch No. 1207	September 10-12 (3 days)
High Speed Launch Survey Launches No. 1255 & 1257 Clearwater Beach, Florida	September 15-26 (2 weeks)
Baltimore Harbour Survey Launch No. 1270 (Baltimore, Maryland)	September 29 - October 9 (2 weeks)



EXCHANGE PERIOD

At Lake Survey Center, Detroit

L.S.C. Offices	2 days or 2.7%
Revisory Section	2 wks. or 13.5%
Vertical Control Section	2 wks. or 13.5%
Horizontal Control Section	1 wk. or 6.8%
Hydrographic Section	4 wks. or 27.0%
TOTAL	47 days or 65.5%

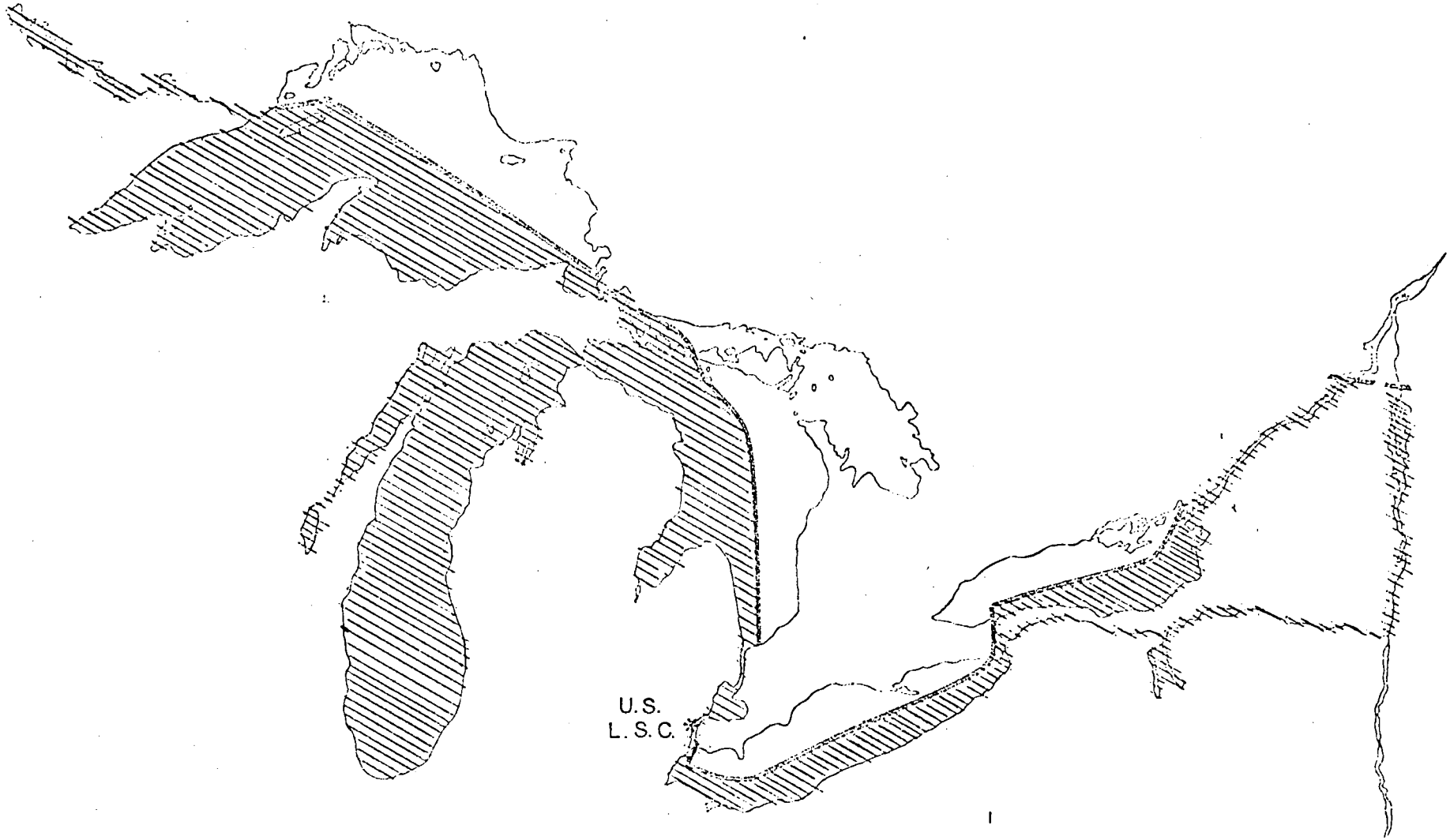
At Atlantic Marine Center, Norfolk

A.M.C. Offices	2 days or 2.7%
High Speed Launch Survey	2 wks. or 13.5%
Baltimore Harbour Survey	11 days or 14.9%
TOTAL	23 days or 31.1%
Miscellaneous travel time	4 days or 5.4%
TOTAL EXCHANGE PERIOD	74 days or 100%

U.S./CANADIAN NOMENCLATURE COMPARISON

CONTINUED FROM J. KEAN, 1974

U.S.	Canadian
Junction	F.S. overlap
T-Sheet	Shoreline sheet
Marigram	Tide gauge graph
"Football" or "Banana"	Accuracy lobe for range/range positioning systems
Hub	Point from which azimuth cuts are made to sounding launch
"Future Field"	Maintenance copy of chart



U.S. GREAT LAKES SURVEY CENTER RESPONSIBILITY

LAKE SURVEY CENTER - DETROIT, MICHIGAN
MARINE MAPPING AND CHARTING DIVISION

1. SURVEYS BRANCH

1.1. L.S.C. Offices

The Detroit office of the Lake Survey Centre underwent a major shuffle in 1974. The Marine Mapping and Charting and Administrative Divisions are all that remain in the L.S.C. office.

While in Detroit, I was given a tour of the three remaining Branches of the Marine Mapping and Charting Division plus the Fleet Services Branch in Monroe, Michigan.

a. *Photogrammetry Section* (Surveys Branch)

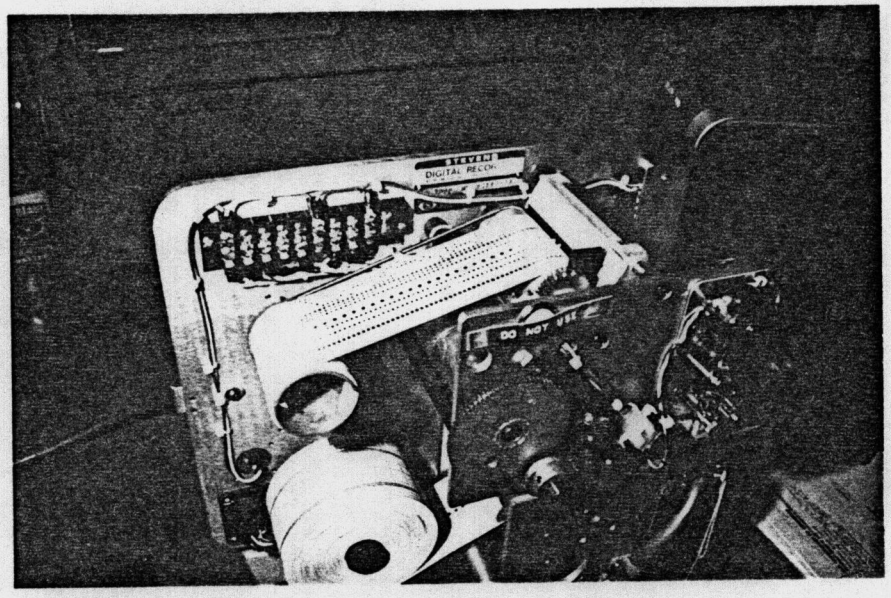
Equipped with a BELFORT Stereoplotter and 3 KELSH plotters, this section provides accurate planimetry for the Lake Survey Center, primarily for the harbour charts and the hydrographic survey on Lake Erie.

They also work closely with the Revisory Section's three year cycle in the maintenance and updating of the charts.

Analytical aerotriangulation is used for bridging in photo mosaics as well as positioning aids to navigation and landmarks.

b. *Chart Section* (Compilation Branch)

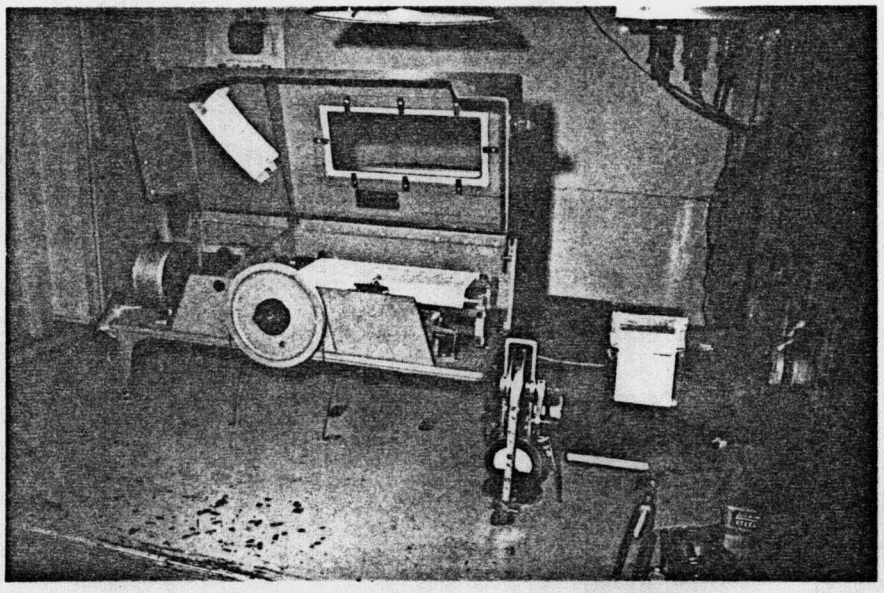
This section works closely with the Revisory Section. Information obtained by Revisory Section is recorded on the "Future Field" copy of the revised chart. This is then sent to the Chart Section where all recorded information is verified and checked for correct format. The "Future Field" copy is then sent on to Rockville, Maryland where it is again checked before a new edition of the chart is published.



Tide Gauges in Use With

Lake Survey Centre,

Detroit, Michigan



Before any construction can be started on the shoreline or in a body of water, permission must first be obtained from the U.S. Corps of Engineers. Copies of the permits are sent to the Revisory Section, L.S.C., where they are kept on file until the Revisory cycle reaches the area. Each permit is then taken into the field and checked to see if work has been completed. These permits are among the "Pre-Survey Items" that are detailed on the "Future Field" copy of each chart to be revised.

c. *Gauging Section (Water Levels Branch)*

The Water Levels Branch is responsible for approximately 70 permanent gauges distributed throughout Lake Survey Center's area of responsibility. Of those, eight (8) are telemetry while the remaining are either Fischer and Porter with punch paper tape outputs or Stevens A-35 analog recorders.

They also process the tide graphs obtained from the temporary gauges installed by the Revisory Section each summer.

d. *Fleet Services Branch (Monroe, Michigan)*

The Fleet Services Branch provides winter storage for the equipment of Lake Survey Center. Maintenance required on vehicles and boats is provided by this Branch. Electronic equipment is overhauled by the electronic technicians that are stationed there.

1.2. Revisory Section

Introduction

Lake Survey Center has divided their area of responsibility (Figure #1) into the three sections as shown in Figure #1.

In 1975, the charts of the Northern Section were due for revision in preparation for new chart editions in 1976.

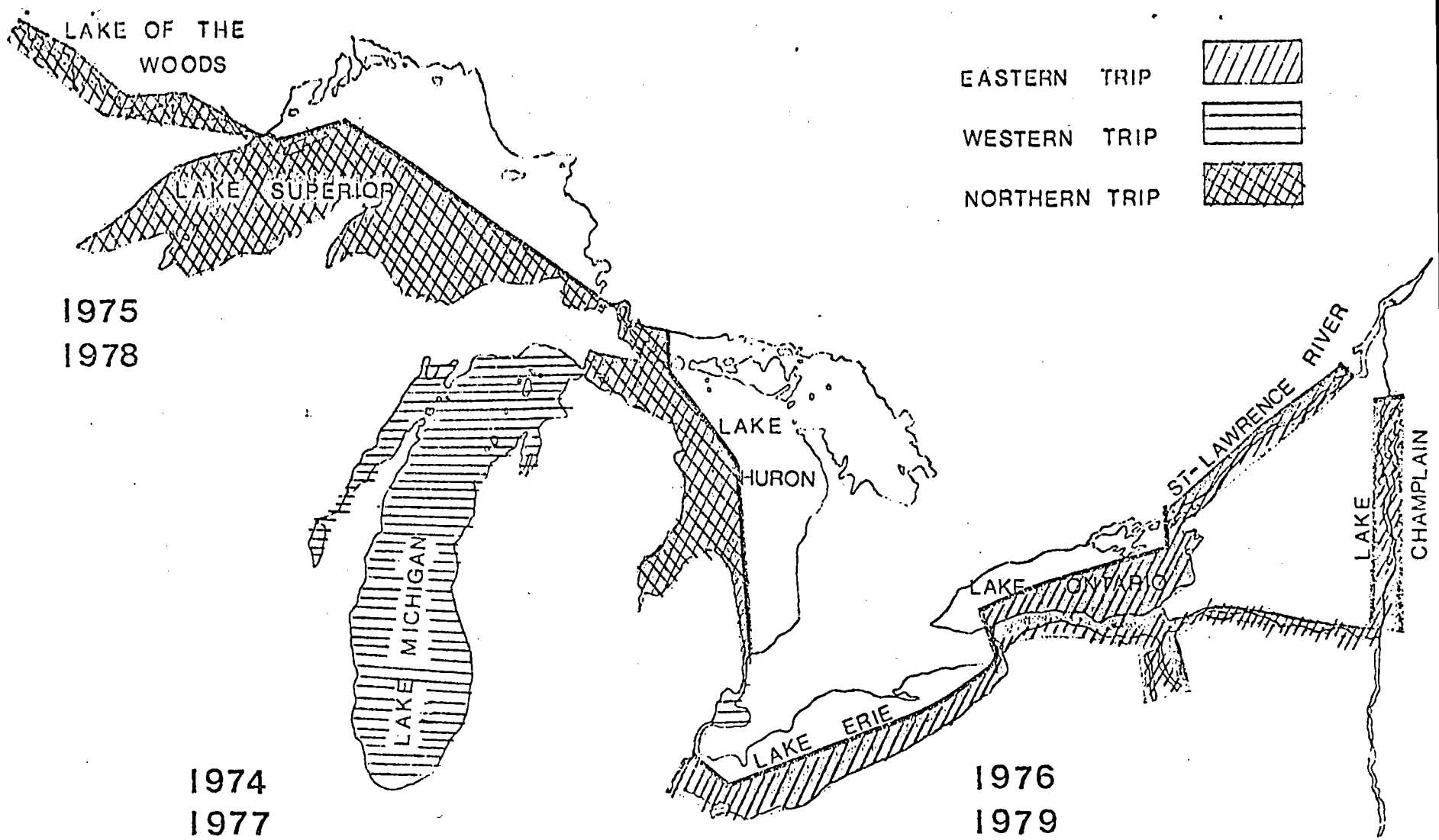


FIGURE #1

REVISORY TRIENNIAL CYCLE

Major Equipment

1 19' "Maritime" launch w/2 - 50 H.P. Evinrudes
1 21' "Mon Ark" launch - diesel
1 35' "Holiday" Rambler office trailer
3 vehicles
2 Wild T-1 theodolites
1 Wild T-2 theodolite
1 K&E transit
2 "Bludworth" fathometers
1 HP 65 calculator
1 HP 45 calculator
1 drafting machine w/portable table
2 Zeiss Ni 2 automatic levels

Operations

On my arrival at the Revisory Survey field headquarters in Duluth, Minn., 17 harbours and 16 charts had already been revised.

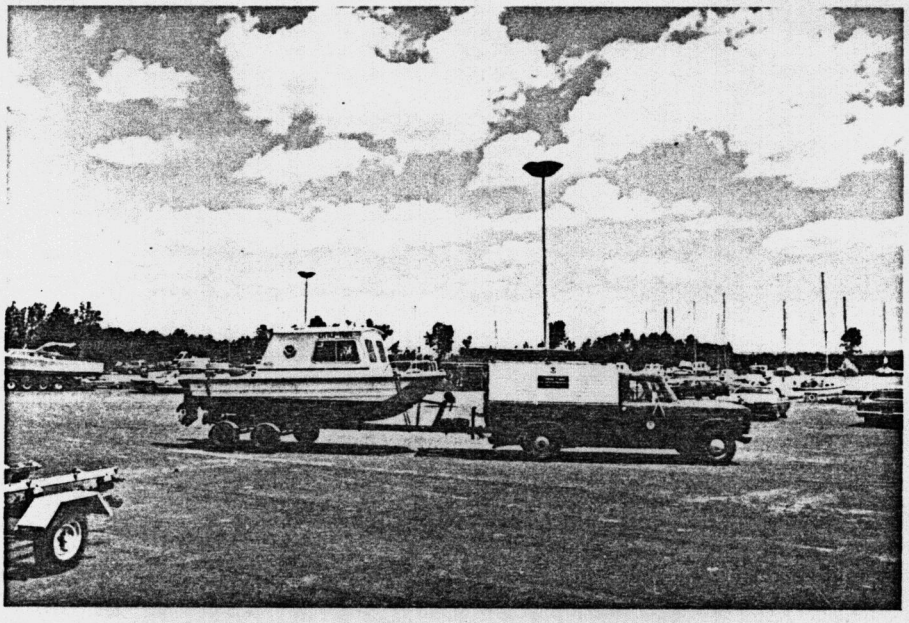
From their base in Dulth, the revision of harbours in Silver Bay, Two Harbours, Knife River, Duluth-Superior, Port Wing and Cornucopia, Wisconsin was to be completed.

The primary field operations of the Revisory Survey are:

(a) sounding in lake area,
(b) sounding in harbours,
(c) water front reconnaissance (launch check),
(d) inland reconnaissance and name verification (truck check),
(e) topographic or planimetric surveys,
(f) reduction of data,
(g) chart history and future work book.

For launch sounding, the Revisory Party still positions their launch by azimuth cuts. This method was described in J. Kean's Exchange Report, 1974.

A launch check and truck check are the methods used by Revisory to verify pre-survey items on the "Future Field" chart copy. The truck check is required to verify place and street names, landmarks and wharf names.



Vehicle and Launch of Revisory Survey

A major part of Revisory's work load was the installation and maintenance of temporary tide gauges in their work area. This included running level lines between all the Bench Marks in the immediate area of the temporary gauge. New Bench Marks would have to be established if any were destroyed. Twenty-three temporary and thirty permanent gauges were Revisory's responsibility in 1975.

The original instructions for Revisory Party included a major survey of the Duluth-Superior Harbour. P. Richards, C.H.S., on his exchange in 1972, helped put in the horizontal control for the photogrammetric plot that was to be used as the new chart base. Due to a budget cut, the sounding operation was postponed to a future date. The photogrammetric plot checked well during the launch sounding of harbour entrances.

The "Standard Operation Procedures for Revisory Surveys" can be found in the Appendix of this report.

1.3. *Vertical Control Section*

Introduction

The 1975 Vertical Control Project consisted of running first order level lines in 3 areas.

They were:

(a) gauge site at Port Inland, Mich. to tie National Geodetic Survey level line along U.S. Highway 2,

(b) Escanaba (Kipling), Mich., to gauge site at Marguette, Mich. (62 miles),

(c) Manitowoc, Wisc., to gauge site at Sturgeon Bay Canal Entrance (60 miles).

Major Equipment

1 30' office trailer
3 vehicles
3 Kern's telescopic rod sets
4 Zeiss Ni 2 automatic levels
2 Plane-parallel plate micrometers
1 H.P. desk top calculator

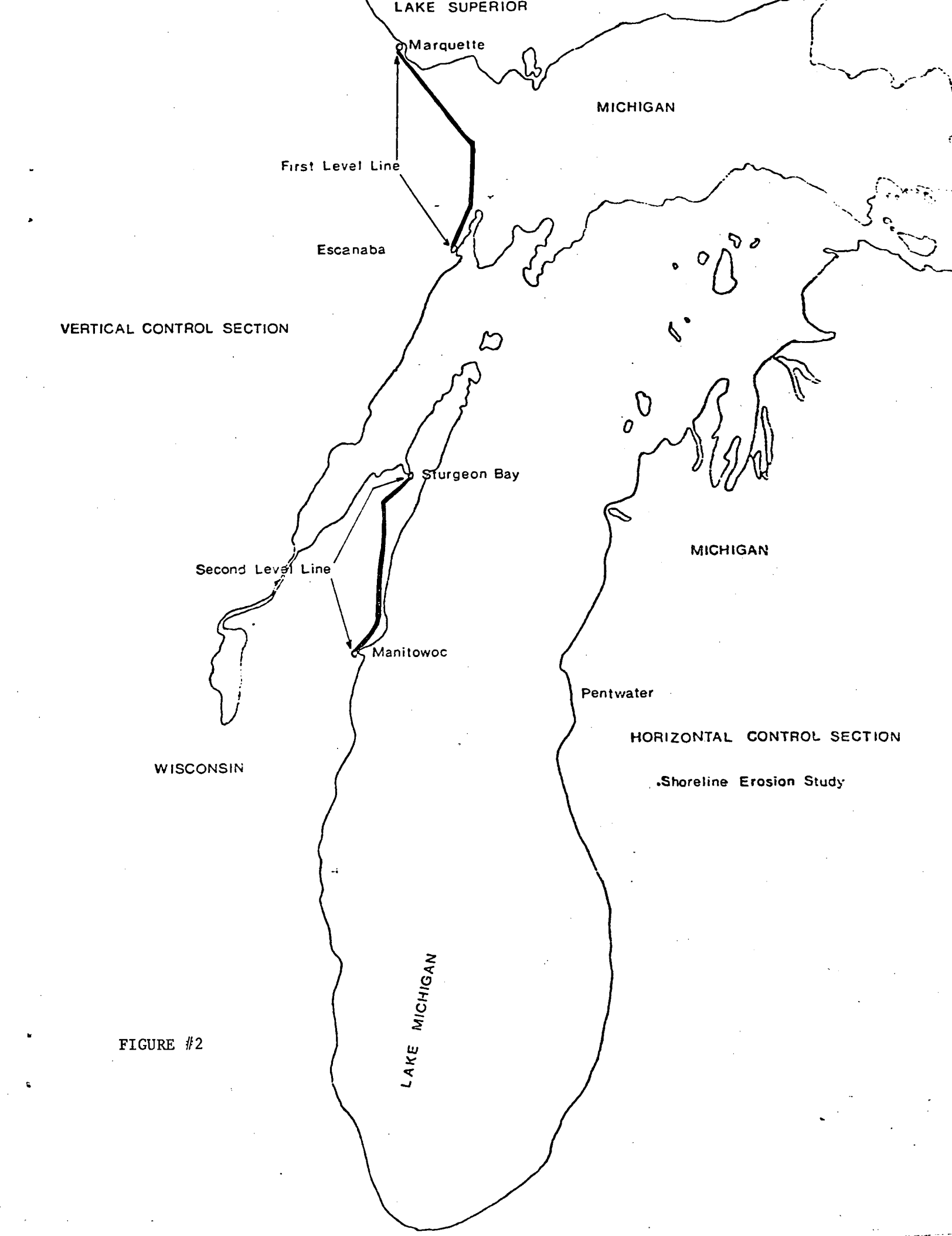

LAKE SUPERIOR
Marquette
MICHIGAN
First Level Line
Escanaba
VERTICAL CONTROL SECTION
Sturgeon Bay
MICHIGAN
Second Level Line
Manitowoc
Pentwater
HORIZONTAL CONTROL SECTION
WISCONSIN
Shoreline Erosion Study
LAKE MICHIGAN

FIGURE #2

Personnel

The vertical control party consisted of 7 people: a party chief, four-man levelling crew, and two people to set bench marks, write descriptions, assist party chief in checking field computations and rotate with the levelling crew.

Operations

The procedures and techniques used by the Vertical Control Party are outlined in "LEVELS WITH AUTOMATIC INSTRUMENTS" by Elmer F. Kulp. This article is included in the Appendix of this report.

The Vertical Control Party has developed an automated system for levelling. Due to wear on Hewlett-Packard desk top computer from daily installation in the truck and faulty power supply, the automated system was not functional for my two week stay. However, the automated system is described in P. Richards' Exchange Report, 1972 and J. Kean's Exchange Report, 1974.

With the failure of the computer, notes were hand recorded. Figure #3 is a sample of the level notes.

The sequence of rod readings and operations by the note keeper are:

1 level reading on main scale
2 first three digits of level reading transferred to thread interval column as bottom stadia reading
3 upper stadia line is read
4 sight distance computed
5 level reading on check scale
6 while this reading is being made, recorder adds 59250 to level reading of main scale (59250 - difference between main scale and check scale - constant built into rod)
7 check is made on sight distance - units counted on check scale intercepted between level and upper stadia lines

1

T SCHOCHTERT
T #68990
M BREITKREITZ
H.R. OWASKO # 129481
R.R. PREBUS # 129486

SPIRIT LEVELING

Date June 16, 1975
Sun Partly Cloudy

From T.B.M. "NO" To T.B.M. "END"
Wind 0 - 5 mph Time PM

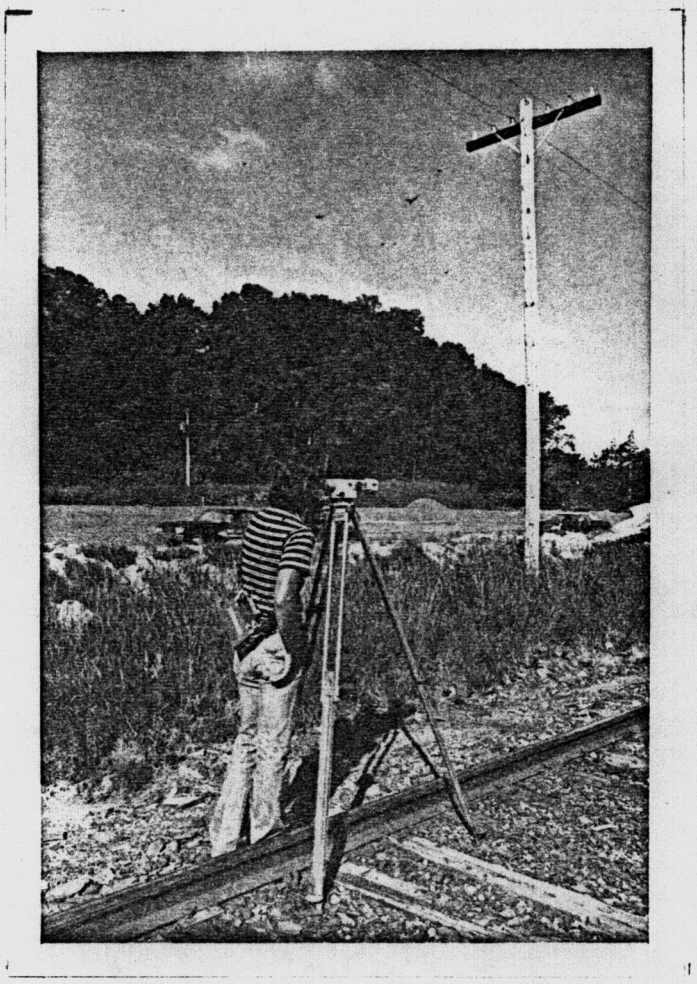
No. of Station	Thread Reading Backsight	Rod Reading Left	Rod Reading Right	Thread Interval	Sum of Intervals	Rod and Temp.
TBM "NO"		25155		3028		
		59250		251		
	-2	84405	84403	518	51.8	
		32108		3708		
	-2	59250		321	49.8	✓
	-1	91358	91357	498	101.6	
		28362		3318		
	-3	59250		283	48.8	
	+1	87612	87613	488	150.4	
	#1 ←	30928	#3 ←	3558		
	-2	59250	#2 ←	309	46.8	→ #7
	+1	90178	90179 #4	468	197.2	
	#6 →	32038	↓	3669		
	-1	59250	#5	320	46.9	
	-2	91288	91286	469	244.1	
		33962		3858		
	-3	59250		339	46.8	
	-1	93212	93211	468	290.9	
		30368		3478		
	-4	59250		303	44.8	
	0	89618	89618	448	335.7	
		41022		4520		
	-4	59250		410	42.0	
	+3	100272	100275	420	377.7	
		727943•	727942•			
	-1	~~59250~~				
		685642	685640			
		4.2301•	4.2302•			
		59250				
			4.23015			
		59250	2			

LEVELING 2

Thread Reading Foresight	Rod Reading Left	Rod Reading Right	Thread Interval	Sum of Intervals	Remarks
	31480		3641		
	59250		314	50.1	
0	90730	90730	50.1	50.1	
	27240		3221		
0	59250		272	50.1	
-1	86490	86489	50.1	100.2	
	32088		3690		
-1	59250		320	49.0	
+2	91338	91340	490	149.2	
	31295		3600		
+1	59250		312	48.0	
0	90545	90545	480	197.2	
	26863		3147		
+1	59250		268	46.7	
+1	86113	86114	467	243.9	
	30070		3471		
+2	59250		300	47.1	
-2	89320	89318	471	291.0	
	28838		3327		
0	59250		288	44.7	
-1	88088	88087	447	335.7	
	03768		0791		
-1	59250		037	42.1	TBM
-1	63018	63017	421	377.8	"END"
	685642•	685640•			
-2	59250				+ 2.11508•
	59250				
	59250				

Figure #3 Sample Readings for First Order Levelling

Sequence of rod readings outlined on Page #11



Instrumentman Transmitting Observations to Notekeeper in Vehicle

With the completion of the day's levelling, the differences in B.S. and F.S., and the total sight distance between bench marks are recorded on a schematic diagram (Figure #4) of the level line. The values are then checked for maximum allowable error on a two-way level run which is 2.0 mm $\sqrt{K}$, where K is the distance in kilometres. If any errors are discovered, that section of line is re-run.

As the level values are being checked and confirmed, a table of elevations is being drawn up. This table (Figure #5) compares 1975 elevations with previous values.

After level data has been checked and re-checked, information is forwarded to the National Geodetic Surveys for inclusion in the national files.

1975 ESCANABA (KIPLING) TO MARQUETTE (2)

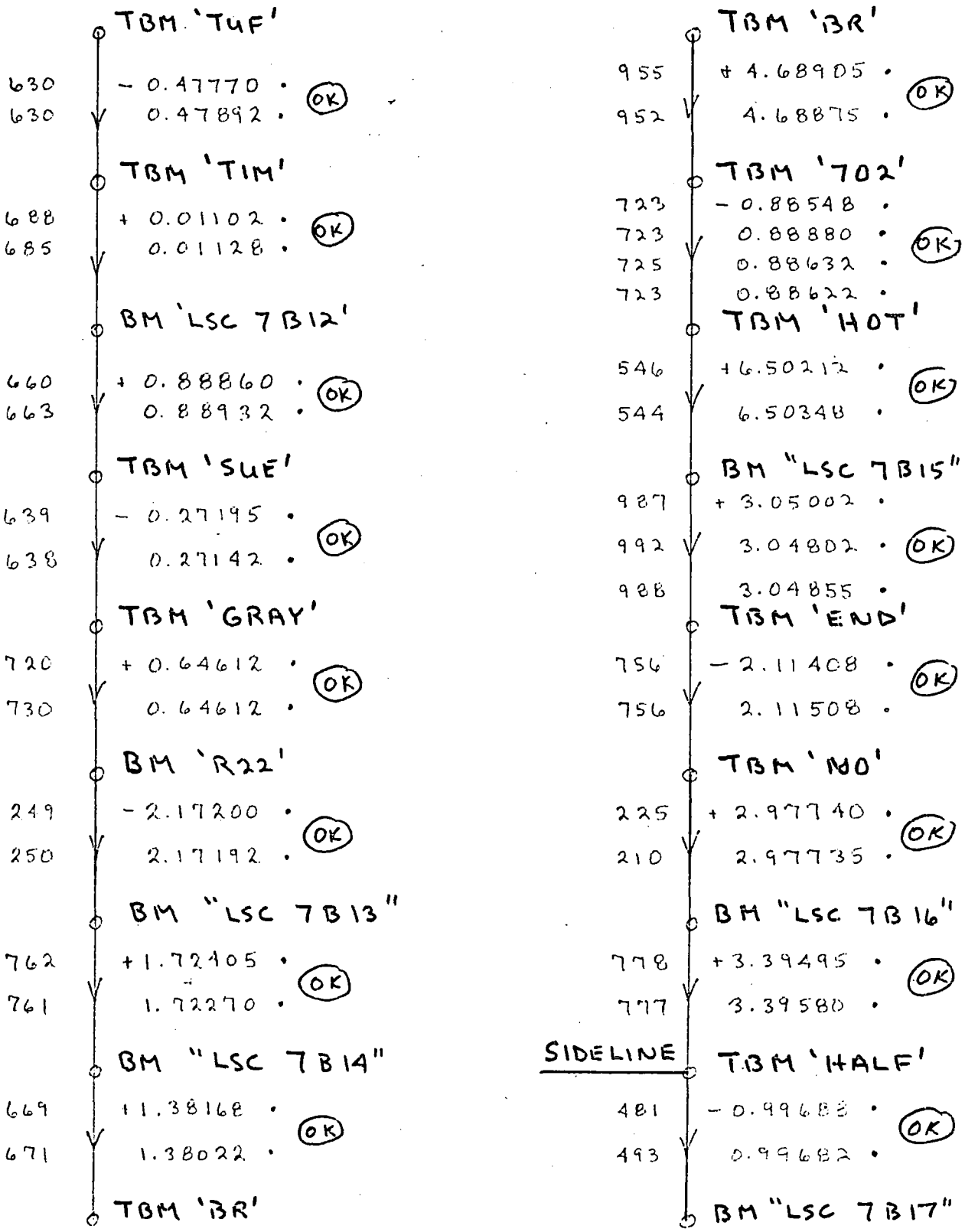


FIGURE #4
SCHEMATIC OF LEVEL LINE

1975 MAINLINE ELEVATION TAB ESCANABA(KIPLING) TO MARQUETTE

BENCHMARK	DIFF. METERS	ELEVATION METERS	ELEVATION FEET 1975	ELEVATION FEET 1955 IGLD	DIFF 1955 – 1975	ELEVATION FEET N.G.S. (U.S.G.S
B.M. TANK		177.89940	583.663	583.666	-0.003	
BM RUINS	+1.73936	179.63876	589.366	589.366	0.000	
BM IRON	-0.56719	179.07157	587.505	587.504	+0.001	
BM K205	+0.19264	179.26421	588.137	588.143	-0.006	589.177 N.G. 1.03
TBM BERG	-0.74967	178.51454	585.678			
BM J205	+1.24782	179.76236	589.772	589.778	-0.006	590.812 N.G.
BM H205	+1.62314	181.38550	595.097	595.106	-0.009	596.140 N.G
TBM VEW	+7.85684	189.24234				
TBM LOU	+25.62420	214.86654				
DM LSC 7B8	+6.65706	221.52360	726.783			
TBM D8	-1.37680	220.14680				
BM LSC 7B9	+0.04359	220.19039				
TBM DUP	-0.38813	219.80226				
BM LSC 7B10	+2.43756	222.23982				
TBM BOX	+1.19644	223.43626				
BM LSC 7B11	-0.20469	223.23157				
TBM TUF	+2.23373	225.46530				
TBM TIM	-0.47831	224.98699				
BM LSC 7B12	+0.01115	224.99814				
TBM SUE	+0.88896	225.88710				(1903) 1.67
TBM GRAY	-0.27168	225.61542				
BM R22 (RESET)	+0.64612	226.26154	742.328	742.187	+0.141	744.060
BM LSC 7B13	-2.17196	224.08958				
BM LSC 7B14	+1.72338	225.81296				
TBM BR	+1.38095	227.19391				
TBM 702	+4.68890	231.88281				
TBM HOT	-0.88670	230.99611				
BM LSC 7B15	+6.50280	237.49891				
TBM END	+3.04915	240.54806				
TBM NO	-2.11458	238.43348				
BM LSC 7B16	+2.99738	241.41086				
TBM HALF	+3.39538	244.80624				
BM LSC 7B17	-0.99685	243.80939				
TBM RAIN	+0.77998	244.58937				
TBM BLU	+3.10267	247.69204				
BM LSC 7B18	+1.32158	249.01362				
TBM JOKE	+2.83728	251.85090				
BM LSC 7B19	+4.74526	256.59616	841.851			
TBM JUNK	+0.18488	256.78104				
BM LSC 7B20	+3.68403	260.46507				
BM LSC 7B21	+4.11080	264.57587				
TBM PIPE	+0.31392	264.88979				
BM LSC 7B22	-1.07096	263.81883				
TBM BUG	+0.75775	264.57658				
BM LSC 7B23	+8.26006	272.83664				

FIGURE # 5 – TABLE OF ELEVATIONS

1.4. *Horizontal Control Section*

Introduction

The Horizontal Control Section planned to complete second and third order horizontal control surveys started in 1974 between Conneaut, Ohio and Buffalo, New York. By the beginning of August, the major part of their program was completed. The Horizontal Party was then divided into two groups:

1. positioning floating aids in and around Ashtabula, Ohio plus supplying any control required by the Ashtabula Hydrographic Party,

2. provide positioning support to Ed Hands, Coastal Engineering Research Centre (CERC), Washington, D.C., in Pentwater, Michigan.

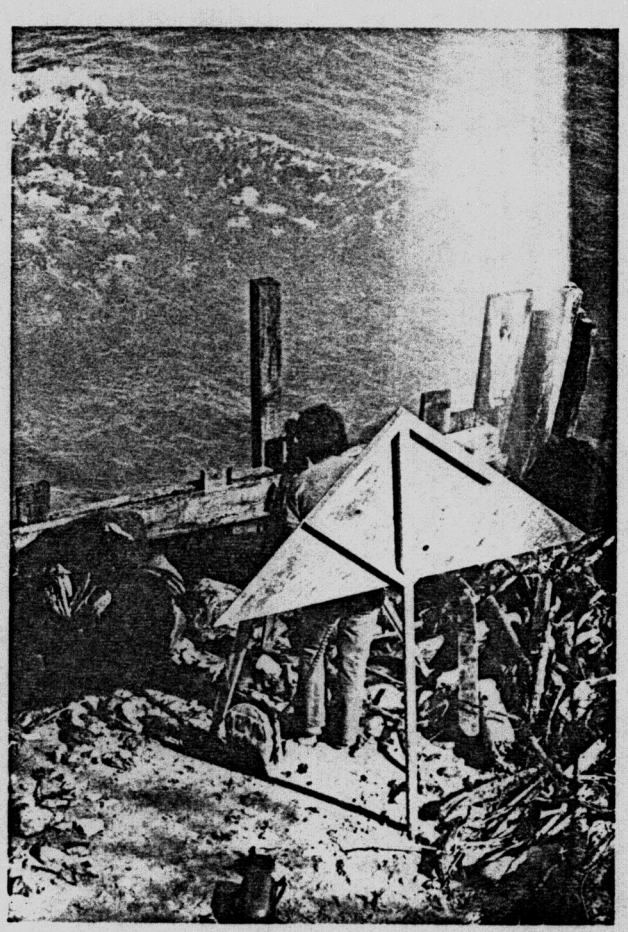
Near the end of July, it was decided that my exchange period with Horizontal Control would be spent with the group in Pentwater, Michigan.

Major Equipment

3 vehicles
1 17' office trailer
1 17' Maritime launch - twin 40 H.P. outboards
2 Wild T-2 theodolites
2 Wild T-1 theodolite
1 Zeiss Ni 2 automatic level
1 "Del Norte" Trisponder 202A positioning system
2 "Bludworth" echo sounders
4 Motorola VHF radios



17' MARITIME SOUNDING LAUNCH



KEEPING SOUNDING LAUNCH ON RANGE LINE.

Operations

Pentwater, Michigan is located in a 20-30 mile long stretch of sand shoreline extending inshore in places several thousand feet. This area has been subjected to severe erosion over the last 20 years.

In 1966, a traverse was completed along the east shore of Lake Michigan around Pentwater. Sounding ranges at approximately 1,000 foot intervals were set up on shore and monumented for future use. Small metal markers attached to steel fence posts were driven into the sand to aid in the recovery of the ranges.

Sounding lines were run perpendicular to shore from the 40 foot depth contour to the shore. Level lines were run from 4 feet of water to about 300 feet inland from waters edge.

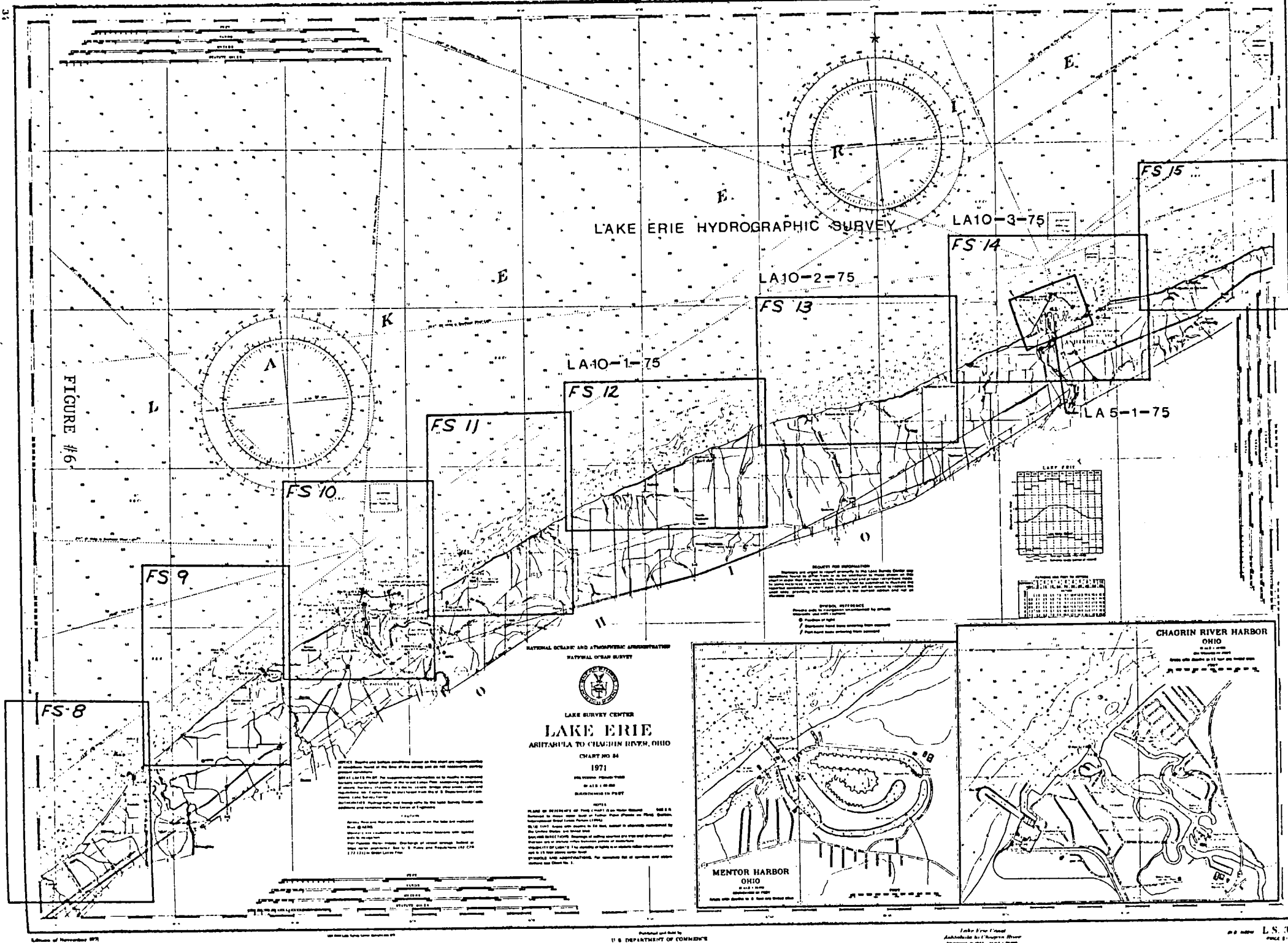
A 17' Maritime launch, positioned by a 'Del Norte' system was used for the sounding. Operating in the range/range mode, an azimuth cut was made to the launch to ensure the required accuracy was maintained when inside the accuracy lobe. A Wild T-1 theodolite was set up on the front range of each line to keep the launch on line.

1.5. *Hydrographic Section*

Introduction

The Lake Erie inshore hydrographic survey continued in 1975. The area of work stretched from a point 7 miles east of Fairport Harbour, Ohio to Conneaut, Ohio. This area consisted of 5 field sheets at a scale of 1:10,000 and 2 harbour sheets at 1:5,000.

Data obtained between the land/water interface and the 40 foot depth contour will provide a new data base for proposed recreational craft charts of the near shore waters along the southerly shore of Lake Erie.


LAKE ERIE HYDROGRAPHIC SURVEY
LA10-3-75
LA10-2-75
LA10-1-75
LA 5-1-75
FS 15
FS 14
FS 13
FS 12
FS 11
FS 10
FS 9
FS 8
FIGURE #6
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SURVEY
LAKE SURVEY CENTER
LAKE ERIE
ARITABIA TO CHAGRIN RIVER, OHIO
CHART NO. 84
1971
MENTOR HARBOR
OHIO
CHAGRIN RIVER HARBOR
OHIO

Due to problems in the hardware of the PDP-8 computer and the Del Norte positioning system, progress was slow for about one month. This resulted in only 3 field sheets of 1:10,000 and 1 harbour sheet being completed by season's end on September 6th.

Major Equipment

Major equipment used on this survey consisted of:

1 54' launch S/V LAIDLY outfitted for hydroplot/hydrolog
1 24' diesel Mon Ark launch outfitted for range/azimuth positioning
2 Del Norte Trisponder 202A positioning systems
1 30' office trailer outfitted with Hydroplot/Hydrolog processing unit
1 12' storage trailer (equipped to charge batteries)
3 vehicles
1 set of Geodimeters (borrowed from Horizontal Control Section)
4 transits
1 Wild T-2 theodolite
2 Wild T-1 theodolites
1 portable drafting machine
1 12' aluminum dingy and 10 h.p. outboard

Operations

The field personnel consisted of 13 people; three permanent L.S.C. staff, one boat operator and 9 summer students.

S/V LAIDLY outfitted with the Hydroplot/Hydrolog system used 'Del Norte' in the range/range mode. Calibration of the system was by azimuth intersection from three known points on shore. Four or five calibration points were computed on board the LAIDLY with the mean being applied to the Hydroplot Controller. Thereafter, ranges were adjusted as they were recorded on paper tape. Figure #7 is an example of a calibration point.

```
OBSERVED READINGS(1,2)=892,384

HEADING =130

METHOD(A/R)? R


STATIONS(L,R)=034,035
RANGES(L,R)=234/35/00,313/58/18

CHECK FIX(Y/N)? Y


STATIONS(L,R)=035,037
RANGES(L,R)=313/58/18,106/41/30

FIX                  890.35       385.77   041/54/57.90   080/47/33.21

CHECK FIX            890.37       385.88   041/54/57.90   080/47/33.21

INVERSE DISTANCE   =      0.11

MEAN FIX             890.36       385.83   041/54/57.90   080/47/33.21

OBSERVED RDNGS       892.00       384.00

CORRECTION            -1.64         1.83
```

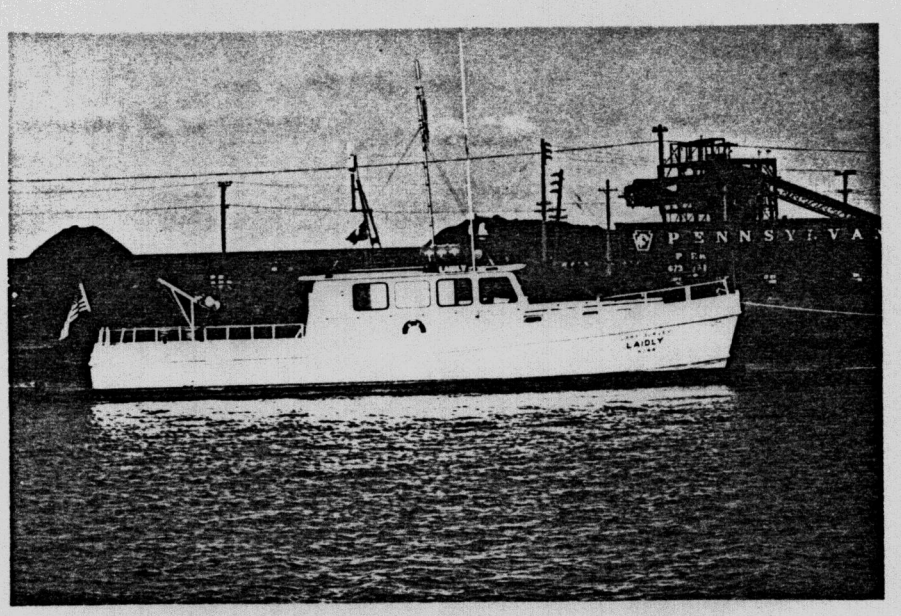
FIGURE #7

CALIBRATION OF DEL NORTE POSITIONING SYSTEM

The LAIDLY sounded on a compass course, perpendicular to shore, from outside the 40 foot depth contour to approximately 10 feet of water.

The MONARK launch sounded in the range/azimuth mode, filling in the "football" areas between the DEL NORTE transponder sites. Equipped with a Raytheon 723D digitized sounder and a teletype, range, depth and time data were recorded on paper tape. Angle information recorded at the transponder site was later merged on paper tape. Sounding lines, run on range arcs, were later plotted up in the office trailer.

The echo sounder used on the LAIDLY and MON ARK was a Raytheon 723D model. The sounder was barchecked once a day on the form illustrated in Figure #8. The bar used in the calibration had a CHS innovation developed at the Atlantic Oceanographic Laboratories. Information on the bar was brought back from the 1975 CHS conference in Halifax. The innovation was a sealed pipe attached to the back of the bar check giving a better returning signal to the sounder.



S/V LAIDLY

FIGURE #8 - BAR CHECK FOR S/V "LAIDLY"

DIRECT COMPARISON LOG

BAR CHECK ✓ VERTICAL CAST _____

LAIDLY VESSEL ID NO. 1264 JUL. DATE 246 TIME GMT 1545 - 1600

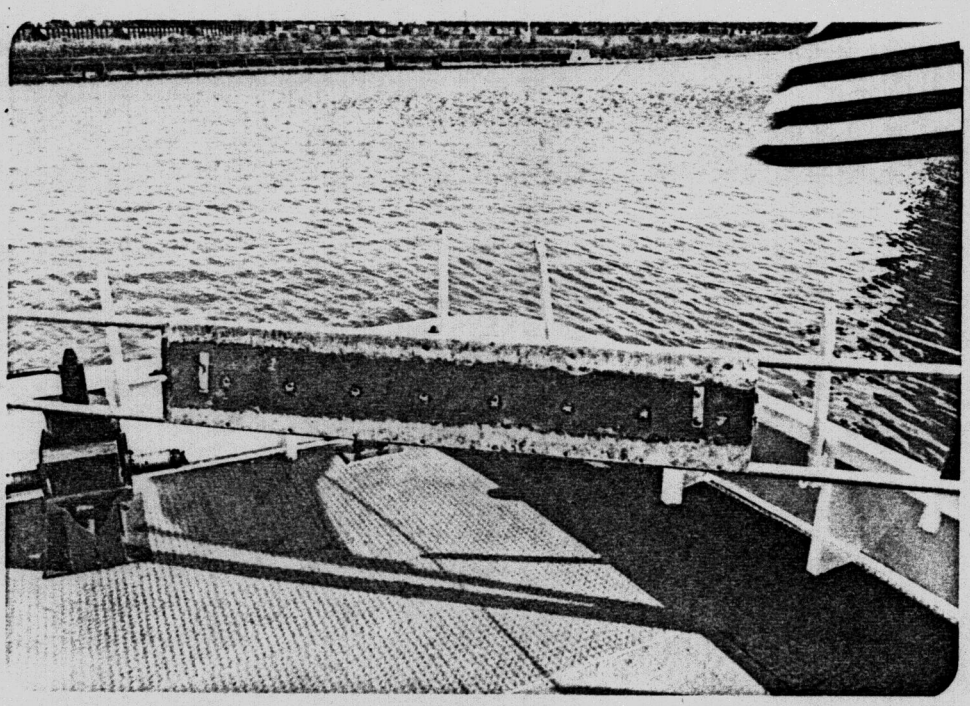
WIND _____ SEA 0 DEPTH UNITS Feet DRAFT 2.5

INSTRUMENT 723D RECORDER SERIAL NO. 2928 LATITUDE _____ LONGITUDE _____

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(P)	(Q)
				Analog Instrument Depth						Digital Instrument Depth					
Line Depth	Line Corr.	True Depth	Gain	Scale	Down	Up	Mean	Mean + Draft	Corr. (C-I)	Down	Up	Mean	Mean + Draft	Corr. (C-N)	Instrument Error (J-P)
		10	3.3	A	7.4	7.4	7.4	9.9	+ .1	7.4	7.5	7.4	9.9	0	0
		15			12.3	12.3	12.3	14.8	.2	12.4	12.4	12.4	14.9	+ .1	+ .1
		20			17.0	17.05	17.0	19.5	.5	17.2	17.3	17.2	19.7	.3	.2
		25			21.95	21.95	22.0	24.5	.5	22.15	22.15	22.2	24.7	.3	.2
		30			26.80	26.75	26.8	29.3	.7	27.05	27.05	27.0	29.5	.5	.2
		35			31.65	31.65	31.6	34.1	.9	32.0	32.0	32.0	34.5	.5	.4
		40			36.45	36.45	36.4	38.9	1.1	36.85	36.85	36.8	39.3	.7	.4

DRAFT 2.55 ft @ 10 ft bar check





BAR CHECK USED ON SURVEY LAUNCH "LAIDLY"

2. ATLANTIC MARINE CENTRE

2.1. A.M.C. Offices

The headquarters for the Eastern Region of N.O.A.A., N.O.S. is located at A.M.C. in Norfolk, Virginia. Their responsibility includes the east coast of the United States plus the Gulf of Mexico, Puerto Rico and the Virgin Islands, an area covering two and one-half million square miles.

While at A.M.C., I was able to observe the following sections:

(a) Photogrammetric Bathymetry Section,
(b) Compilation Section,
(c) Verification Branch, and
(d) Electronic Data Processing Branch.

(a) *Photogrammetric Bathymetry Section*

The photobathymetry survey around the Virgin Islands continued in 1975. By using colour aerial photography and precise stereometric techniques accurate contouring up to twenty feet was obtained. This photogrammetric development was found to reduce sounding launch damage substantially and effect a time saving with only a few check lines by launch required.

This section is also involved in the construction of airport 'Obstruction Charts' and 'Tidal Current Charts'. The photogrammetry section recently began using orthophotography on airport obstruction charts. This extends the use of the chart to include:

1) airport development studies,
2) noise abatement studies,
3) pilot briefings, and
4) negotiations with property owners for obstacle clearance.

Orthophotography is being experimented for use in small craft charts. The advantage being a reduction in chart construction time and accelerating chart revision. Figure #9 shows a section of a chart using orthophotography.

A 'Tidal Current Chart' shows a series of arrows and figures for each hour of the tidal cycle. To obtain the current measurements, one pound water soluble bags of aluminum powder are dropped by launch or low flying plane in the required area. Black and white photography is then flown at full tide and at 1, 2, and 3 hours before and after full tide. The movement of the aluminum powder can be tracked thus giving direction and distance travelled over a time lapse interval. The aluminum powder eventually settles on the bottom in its natural form.

(b) *Compilation Section*

This section produces the shoreline plots that are used for the smooth sheets.

Shoreline is updated from any recently acquired photography on plastic overlays at chart scale. A field edit party then takes the overlay into the field and verifies changes as correct or surveys in any further corrections.

As the field edit team verifies the overlays as correct, they are sent on to Rockville, Maryland for appropriate chart changes.

(c) *Verification Branch*

The main purpose of this Branch is to verify that all information shown on the smooth sheet is correct and complete.

To do this, they obtain the original horizontal control and sounding notes. From the notes, they print up four plots to use:

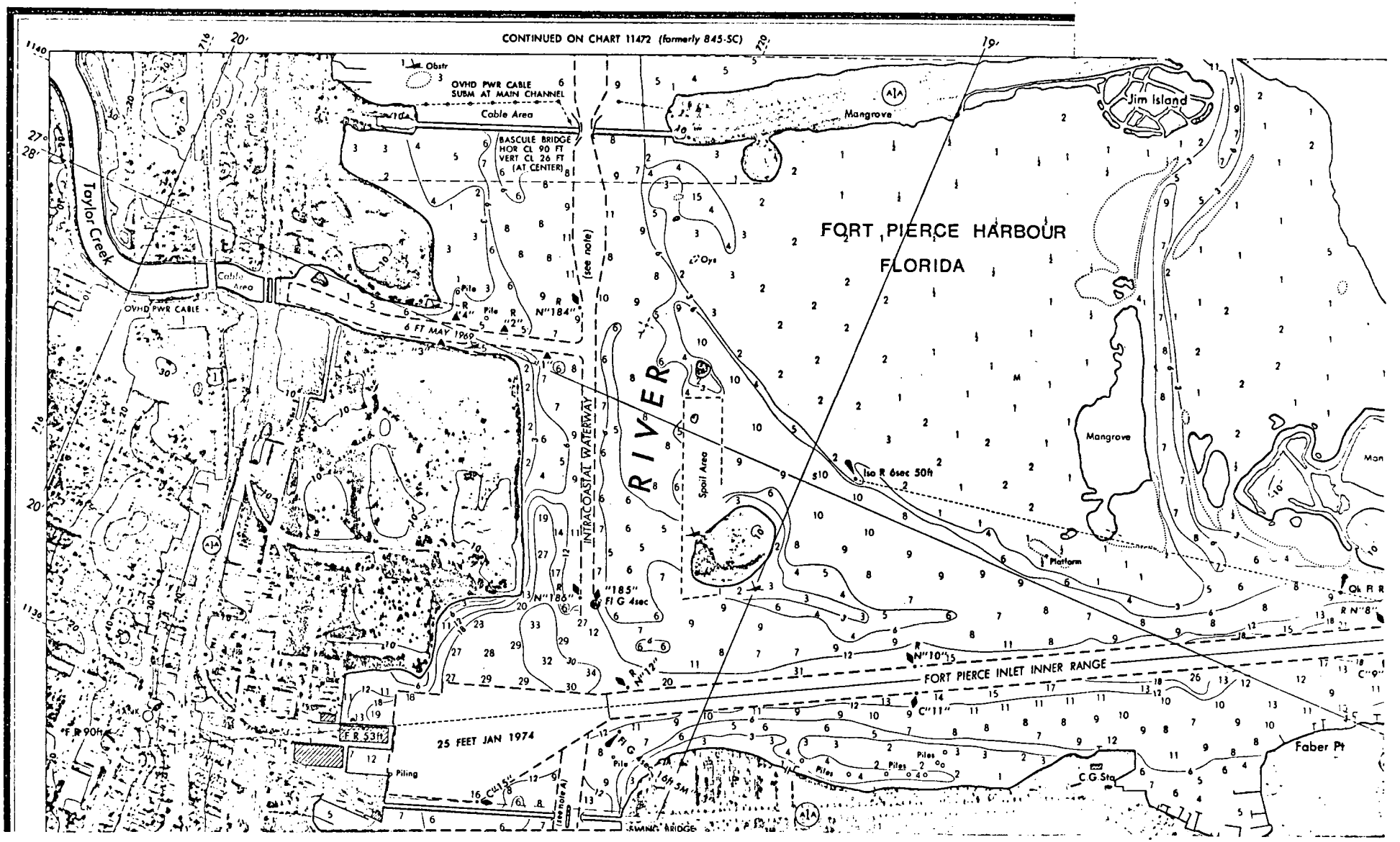
TOPOGRAPHY

Land areas on this chart are reproductions of rectified aerial photographs. Only symbolized land features should be used for accurate positioning. User comments are requested. Address comments to: National Ocean Survey, Marine Chart Division (C32), Rockville, Maryland 20852.

Wreck, rock, obstruction, or shoal swept clear to the depth indicated.
Rocks that cover and uncover, with heights in feet above datum of soundings.

AERO aeronautical R. Bn radiobeacon C.G. Coast Guard station
Bn. daybeacon R. TR. radio tower D.F.S. distance finding station
AUTH. authorized; Obstr. obstruction; P.A. position approximate; E.D. existence doubtful.

CONTINUED ON CHART 11472 (formerly 845-SC)



11475 (formerly C&GS 582)

FIGURE #9

(a) position of horizontal control stations,
(b) positions of all sounding fixes,
(c) smooth sheet,
(d) excess sounding sheet - all soundings that overplot are re-plotted on a separate sheet. This sheet is then placed beneath the smooth sheet to determine if any of them need be included on the smooth sheet.

The Verification Branch also checks:

(a) smooth tide currectors,
(b) accuracy of shoreline, and
(c) new data as opposed to existing data for discrepancies and deletions.

With the verification processes complete, the smooth sheet is sent on to Rockville, Maryland for chart production.

(d) *Electronic Data Processing Branch*

This Branch provides the plots used by the Verification Branch in checking smooth sheets. In the production of check field sheets, colour coded pens are used for soundings.

e.g.	blue	0-6
	red	7-12
	black	13-18
	green	19-31

The coloured soundings aid in the contouring and also show up obvious errors that can be made by hand scaling sounding rolls and by bad position data.

2.2. *High Speed Launch Survey - Clearwater Beach, Florida*

Introduction

In 1972, an inshore survey of the northwest coast of Florida was started near Tampa. This survey was halted in 1974 when the launches, numbers 1255 and 1257, were required on the northeastern coast of Florida to help complete Project SCOPE. In 1975, the west coast Florida survey was continued.

This area was originally surveyed in 1880 - 1884.

Major Equipment

2 59' launches capable of 22 knots±
2 Hydroplot/Hydrolog systems
1 Raydist chain in range/range mode
1 travelall

Operations

This party consisted of eight personnel: 3 commissioned officers, one ensign from N.O.A.A., and 4 survey technicians.

On my arrival, the survey party was just finishing the last sounding lines in the area between Dunedin Pass and Chassahowitzka Point. Over 4900 nautical miles of sounding covering 466 sq. miles and 6 field sheets were completed from their base in Clearwater Beach. The field sheets were at a scale of 1:20,000 with sounding lines run parallel to shore at 200 metre intervals.

The high speed launches worked into 10 feet of water. The remaining bottom profile will be surveyed by an inshore party at a later date.

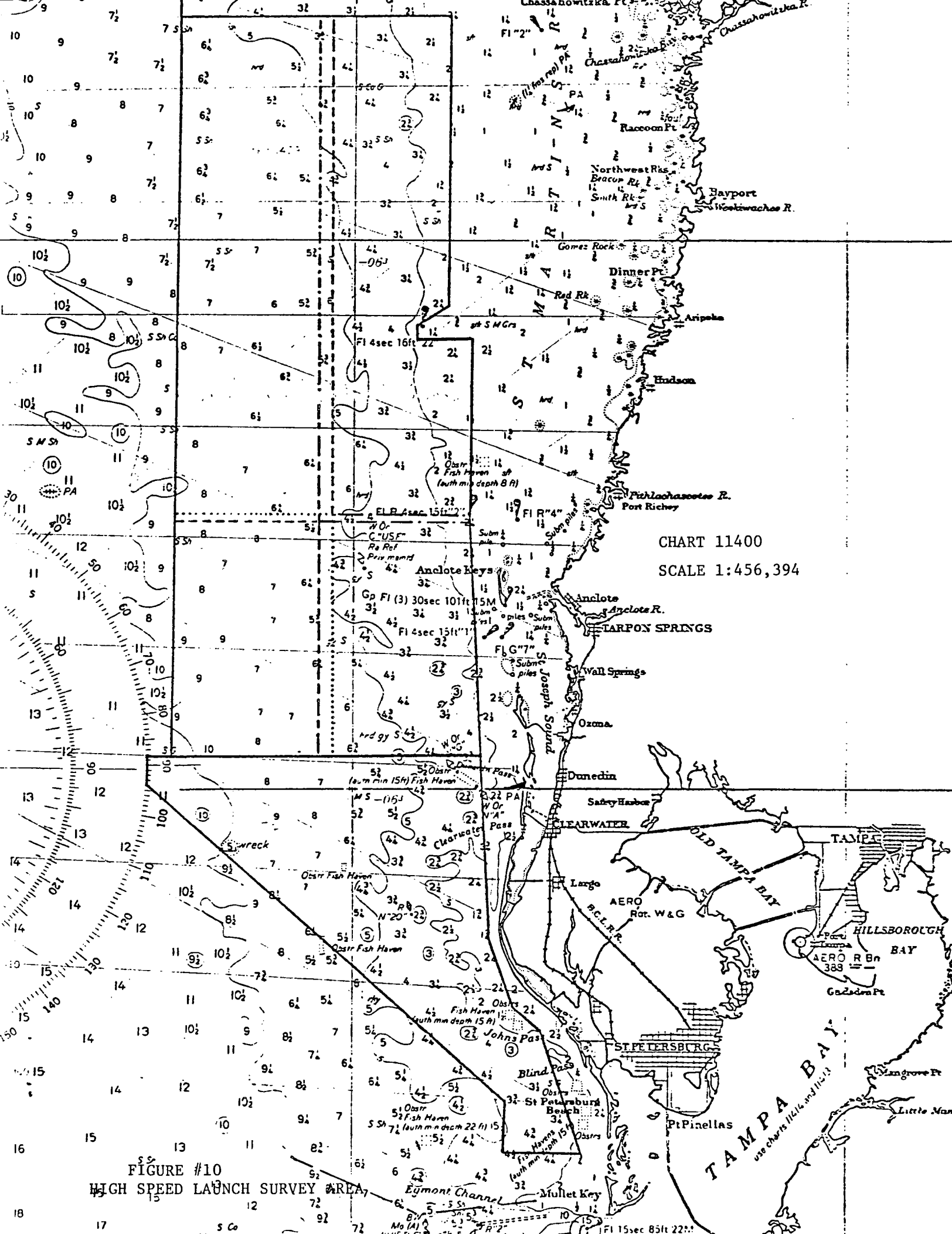
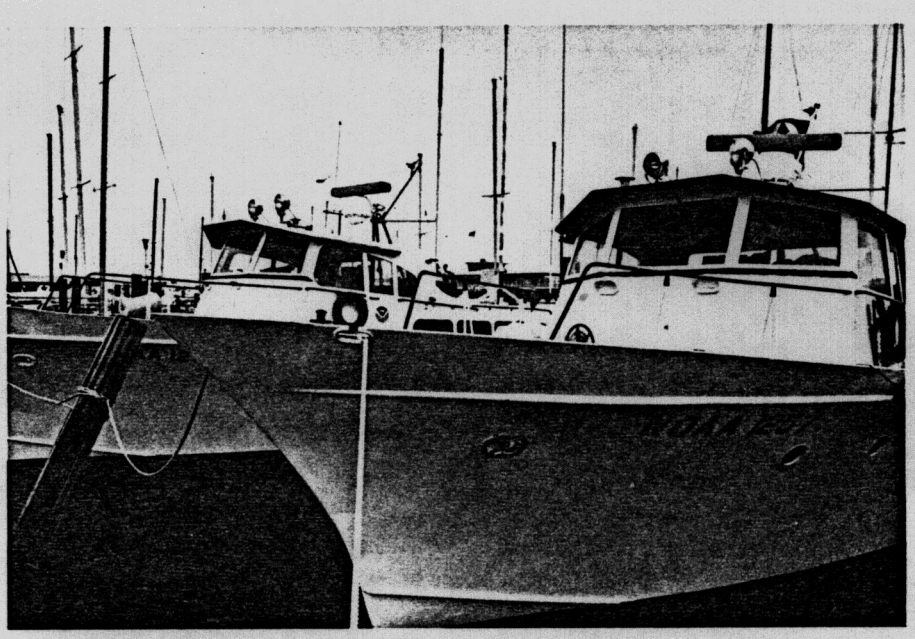
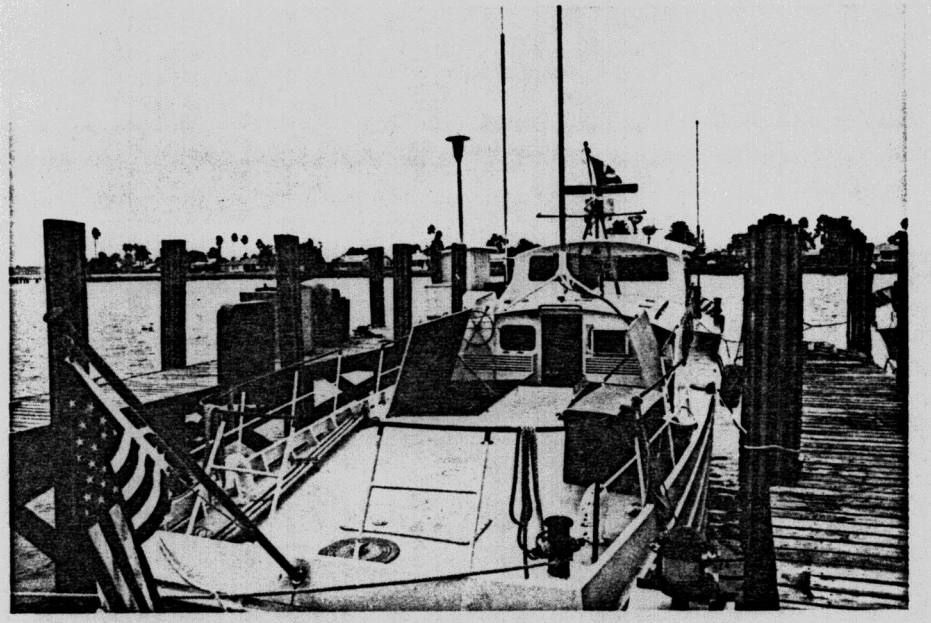


FIGURE #10
HIGH SPEED LAUNCH SURVEY AREA



HIGH SPEED LAUNCHES

CLEARWATER BEACH, FLORIDA



Sextant Calibration of Raydist Positioning System

High Speed Launch Survey Clearwater Beach, Florida

```
HDGTS =1,0

HEADING =300

METHOD(A/R)? A          A= Angles        R=Range-Range


SIGNALS(L,C,R)=200,150,160      Stations used for calibration
ANGLES(L,R)=80/25/30,60/44/00

CHECK FIX(Y/N)? Y


SIGNALS(L,C,R)=141,7        Left station changes
ANGLES(L,R)=33/03/00,S
```

	Pattern I	Pattern II		
FIX	1339.65	291.62	027/59/28.92	032/52/12.45
CHECK FIX	1339.63	291.58	027/59/28.94	032/52/12.38
INVERSE DISTANCE =	1.90			
MEAN FIX	1339.64	291.60	027/59/28.93	032/52/12.41
OBSERVED BLNGS	1339.64	290.93		
CORRECTION	0.00	0.67		

FIGURE #11

Each launch operates with a crew of four: one N.O.A.A. officer, one hydroplot operator, and two survey technicians. The survey technicians act as mechanics, scan sounding rolls, and rotate with the other personnel on the launch.

Operating with a minimum of personnel, the Raydist positioning chain was calibrated by sextant. The mean of 4 or 5 position fixes are required before sounding operations begin. Figure #11 shows the form used for sextant calibration of the Raydist chain.

2.3. *Baltimore Harbour, Maryland*

Introduction

On August 1, 1975, the Atlantic Hydrographic Party launches began a basic hydrographic survey of the entire Patapsco River area, including Bear Creek, Curtis Creek, and other Patapsco River tributaries, to the head of navigation. The survey area covers 26 square nautical miles and information obtained will be used to update nautical charts based on a 1934-37 survey.

Major Equipment

1 24 ft. "Penn Yan" tunnel drive, diesel engine
1 26 ft. "Plastic Pig" outfitted with Hydroplot/Hydrolog
1 29 ft. "Mon Ark" with jet outdrive, Hydroplot/Hydrolog
3 Del Norte trisponder 202A positioning systems
2 Teledyne-Gurly Digital Sextants

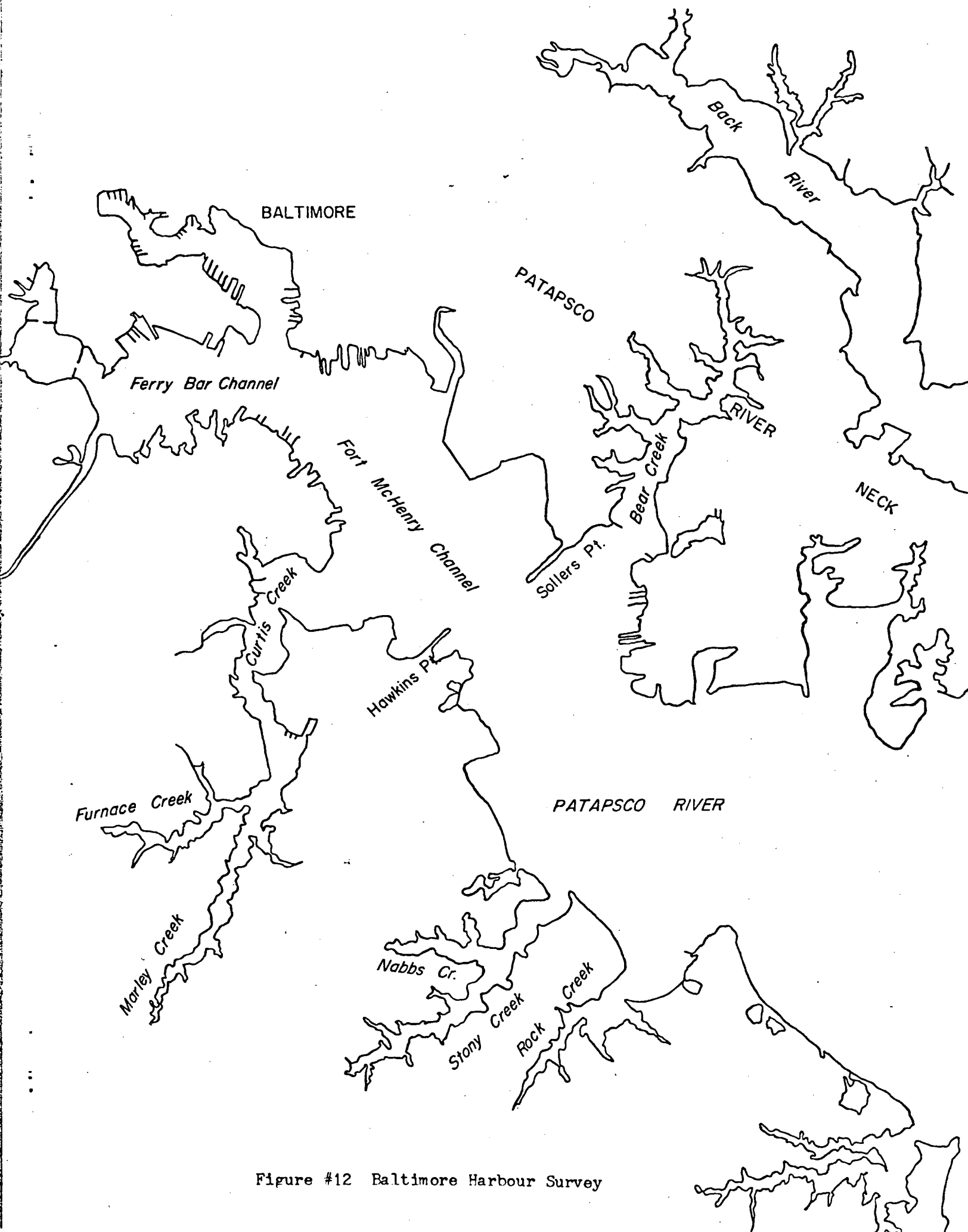


Figure #12 Baltimore Harbour Survey

Operations

The "Penn Yan", using "Del Norte" in the range/azimuth mode sounded the narrow tributaries of the Patapsco River. A portable plotting table was installed over the engine cover, fixes were plotted up with protractor and scale as sounding progressed. This section of the survey was all done by hand.

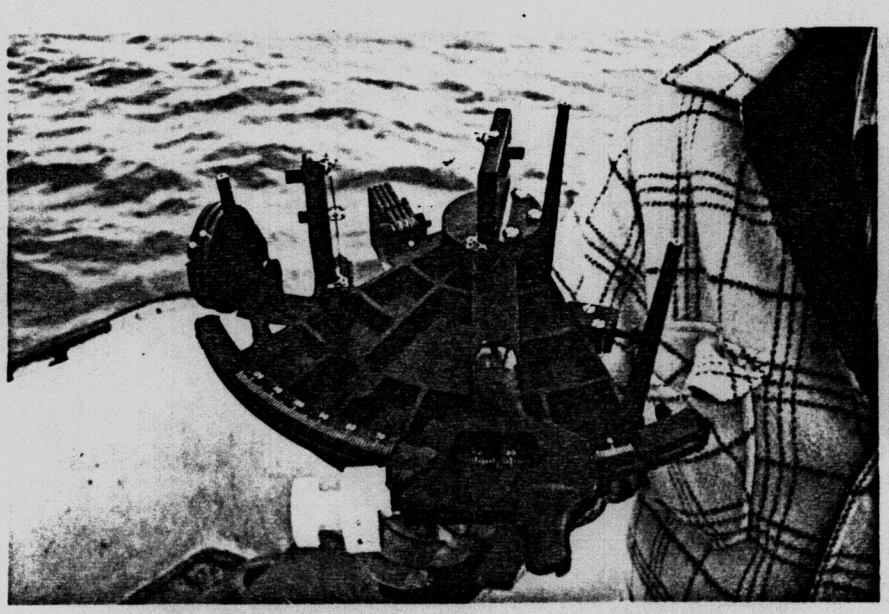
The "Mon Ark", using 'Del Norte' in the range/range mode, sounded the area of Patapsco River, southeast of the Hawkins Point-Sollers Point Bridge. The section was fully automated with the Hydroplot/Hydrolog system and no serious problems were encountered.

The 'Plastic Pic' outfitted with Hydroplot/Hydrolog used 'Del Norte' in the range/range mode. Sounding in the Fort McHenry and Ferry Bar Channels, a large number of erroneous readings were picked up by the automated system. These erroneous readings were attributed to the large steel structures and heavy ship traffic in the confined area. After several attempts to alleviate the problem, it was decided to use a pair of newly developed digital sextants to sound that area.

The digital sextant is very similar to the ordinary sextant. A curved glass scale takes the place of the conventional graduated arc, an electro-optical reading head replaces the operator's eye, and electronic interpolation replaces the drum vernier. As an angle is being measured, the electro-optical encoder head attached to the radial arm, moves along the scale and measures the angle of rotation. Further information on the sextant can be found in the report on Electronic Digital Sextant in the Hydrographic Data Centre.

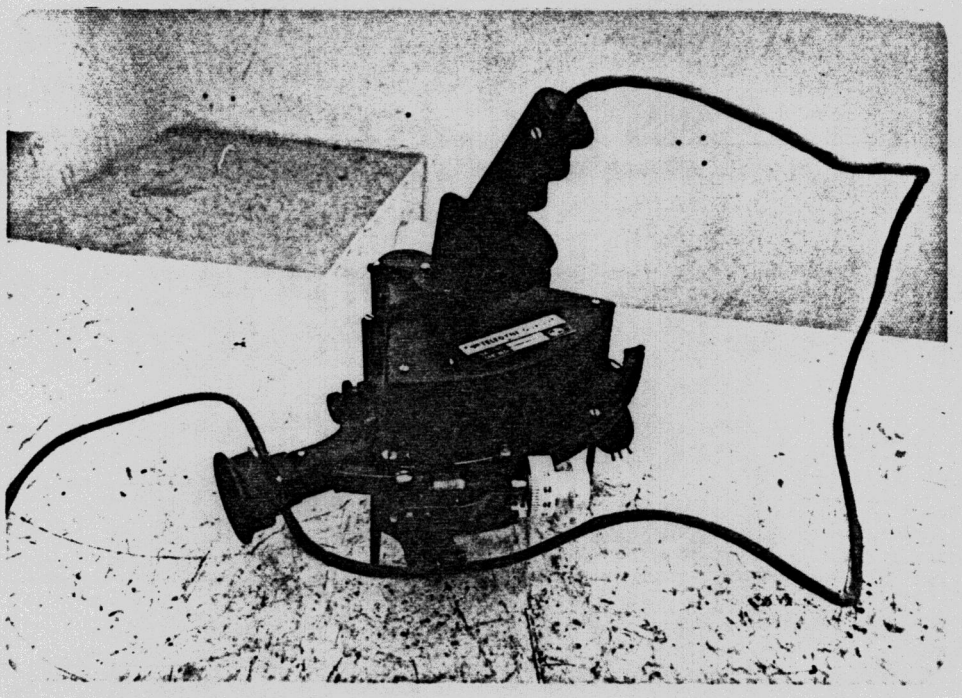
The program used for digital sextant sounding is also outlined in the Appendix. The main features of the program are listed below:

(a) the digital sextants are calibrated by sighting on the horizon. The detached position switch on the Hydroplot Controller is then pushed. All succeeding angles will then be adjusted by the correct amount.



TELEDYNE GURLEY

ELECTRONIC DIGITAL SEXTANT



(b) sounding line is started by depressing Mark interrupt button. Standby bell is rung immediately.

(c) a bell ringing twice is sounded 10 seconds before fix.

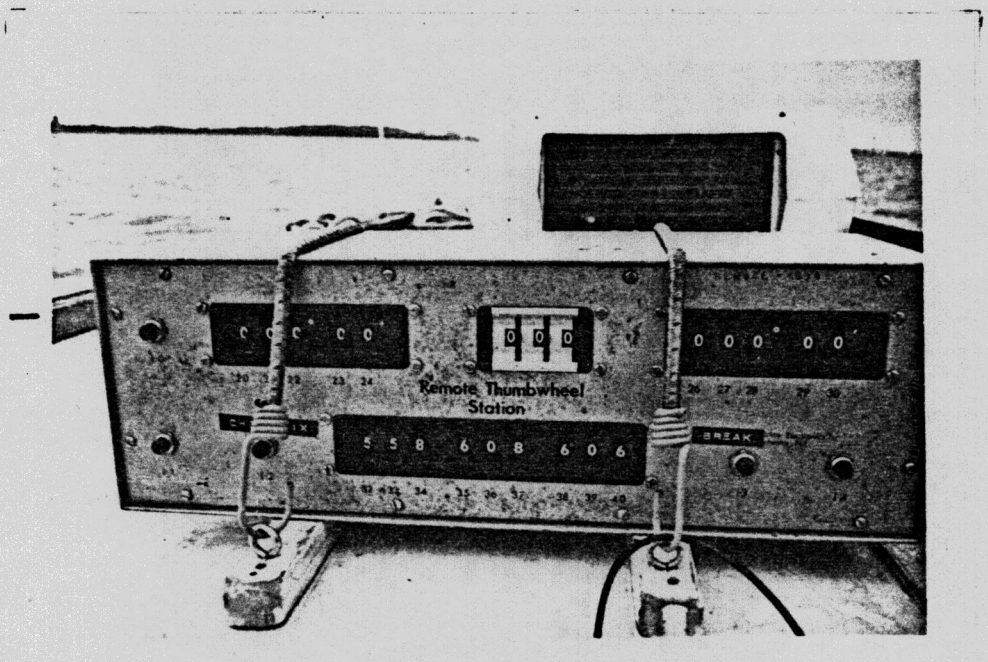
(d) fix is taken on single ring of bell - fix updates left/right indicator.

(e) check fix updates left/right indicator but does not appear on master printout.

(f) hydrographer can cancel fix up to 6 seconds after taken by pressing button on sextant handle. Standby bell then rung. Soundings will not be printed up until the Reject Interval has passed.

(g) if a fix is cancelled or missed, computer will retain only 12 soundings before computer bombs out program. Sextants must be recalibrated.

(h) sounding station numbers are entered into computer memory bank on signal tape. Incorrect station number entered on Thumbwheel Remote Station will result in 'Bad Fix' printed on printout.



REMOTE THUMBWHEEL STATION

(i) while computer waits for hydrographer reject interval to pass, it computes position from observed angles. Changing angles by 1 minute, position is recomputed. If position changes by more than 8 metres, 'BAD FIX' is printed on printout.

(j) weight of digital sextants is $4\frac{1}{2}$ lbs.

Examples of the printout from both the teletypes used in the Hydroplot/Hydrolog system are found in Figures #13 and #14.

N.O.A.A. personnel, for the last few years, have been using a different type of tide gauge. Instead of the traditional floats or diaphragm, dry nitrogen gas is used as the pressure sensing agent.

A pressure sensor is placed at chart datum. A constant flow of gas (60-80 bubbles/min.) is set up in the pressure hose. With a change in height of water over the pressure sensor, a resulting change will take place on the gas in the hose. This change in pressure will cause the pen linked to the pressure regulator to fluctuate accordingly.

Advantages of the Bristol Bubbler Tide Gauge are:

1) pressure sensor can be set up a few thousand feet away from the gauge,
2) bottle of dry nitrogen gas will last for 4 months, then only pen has to be checked for ink,
3) gauge can be hooked up to telemetering system.

A report on the Bristol Bubbler Tide Gauge can be found in the Appendix.

PRINTOUT FROM TTY-I FOR DIGITAL SEXTANT SOUNDING

```
CHECK FIX

X=    13711
Y=    13864
D=       54 ——Distance launch off line
KTS=     1.19

CHECK FIX

X=    13693 ——> Sextant angles converted
Y=    13813 ——> to X-Y coordinates
D=        0
KTS=     0.86

FIX     5377 ——Start of line

X=    13661
Y=    13812
D=        2
KTS=     1.71

CHECK FIX ——Update left/right
                indicator

FIX     5378

X=    13466
Y=    13812
D=        2
KTS=     7.75—Launch Speed

CHECK FIX


FIX     5379

X=    13272
Y=    13834
D=       -6
KTS=     7.42

FIX     5383

X=    13077
Y=    13838
D=       -2
KTS=     7.73

CHECK FIX


FIX     5331

X=     9878
Y=    13813
D=        3
KTS=     8.32

CHECK FIX
```

FIGURE #13

```
FIX     5382

X=     9681
Y=    18811
D=        1
KTS=     7.84

CHECK FIX


FIX     5383

X=     9484
Y=    18837
D=       -3
KTS=     7.89

REJECT—Angleman rejects Fix

FIX     5383

X=     9427
Y=    18838
D=       -2
KTS=     7.93

CHECK FIX


FIX     5384

X=     9234
Y=    18815
D=        5
KTS=     7.75

CHECK FIX


FIX     5385

X=     9033
Y=    18811   New heading ——— HDNG=      90
D=        1   Turn 45 Metres to
KTS=     7.56 port ——— TURN=     -45

Approaching next line—CHECK FIX

CHECK FIX


FIX     5386

X=     8834
Y=    18812
D=
KTS=     7.83

CHECK FIX


FIX     5387

X=     8637
Y=    18812
D=        2
KTS=     7.54
```

```
CHECK FIX

FIX     5388

X=     8445
Y=    18807
D=       -3
KTS=     7.86

CHECK FIX

FIX     5389

X=     8251
Y=    18833
D=       -7
KTS=     7.63

CHECK FIX

FIX     5390

X=     8048
Y=    18836
D=       -4
KTS=     7.34
3

FIX     5391

X=     7832
Y=    18831
D=       -9
KTS=     7.93
End of line

X=    18088
Y=    18855
HDNG=      90
TURN=     -45

CHECK FIX

X=     7696
Y=    18824
D=       31
KTS=     8.78

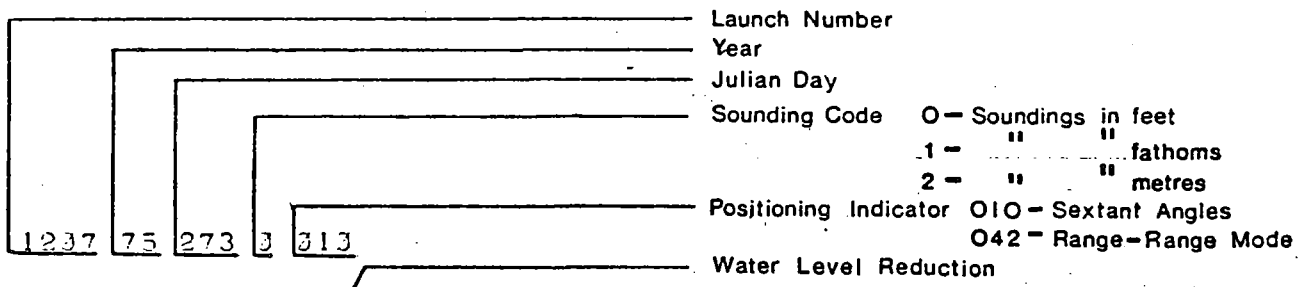
CHECK FIX

X=     7696
Y=    18669
D=      -14
KTS=     1.41

CHECK FIX

X=     7731
Y=    18877
D=      -22
KTS=     8.69
```

MASTER DATA PRINTOUT
DIGITAL SEXTANTS




```
135137 1336 3313 333333 333 333 333

135137 33366 36258 333245 373255 534 633 593

135144 33333 3

135151 33357 3

135158 33354 3

135205 33367 3

135212 33357 3

135219 33352 3

135226 33355 36259 377445 376253 534 633 593

135233 33342 3

135240 33354 3

135247 33363 3

135254 33373 3

135301 33362 3

135308 33364 3

135315 33368 36263 374333 379393 534 633 593

135322 33375 3

135329 33365 3

135333 33364 36
```

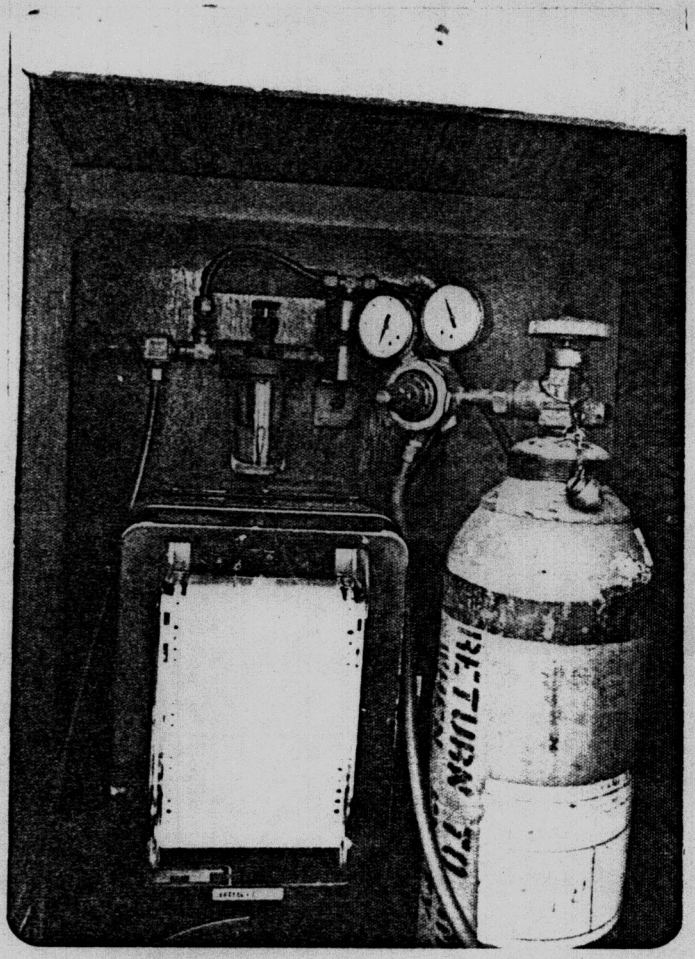
Time GMT	Depth	Fix Number	Left Angle	Right Angle	Left Station	Centre Station	Right Station

FIGURE #14 - PRINTOUT FROM TTY-2

BRISTOL

BUBBLER

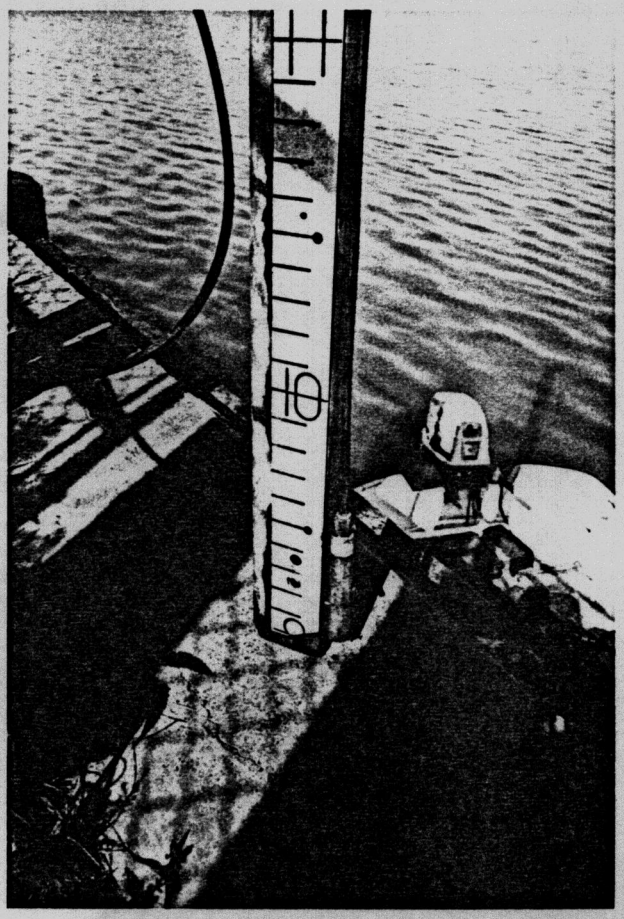
TIDE GAUGE



PRESSURE

SENSING

UNIT



3. *OBSERVATIONS - General*

1) Neither a gas engineer nor an electronic technician were assigned to any of the survey parties I visited. Lake Erie hydrographic party lost two weeks of good sounding weather waiting for an electronic technician to correct a hardware problem in the Hydroplot system.

2) The prime difference between N.O.A.A. and C.H.S. is that horizontal and vertical control are separate parties whereas ours are combined.

3) Fathometer bar checks are taken once a day.

4) All surveys are sounded in feet. Vertical control was done in metres but converted to feet.

5) Hydroplot/Hydrolog system produces a plotted sounding track as the launch is underway. Only soundings taken on a specific interval are recorded on tape and the smooth sheet. Therefore, all sounding rolls must be hand scaled afterwards for shoals. Program should be adjusted to plot shoal soundings between the sounding interval.

6) On their Revisory Survey, instead of positioning the sounding launch by azimuth intersections, I think sextants or 'Del Norte' in range-azimuth could be used just as effectively.

7) When sounding in the range/azimuth mode, sounding positions are hand plotted on the launch. A lattice drawn to survey scale of range arcs and rays of intersection would help in the plotting.

8) The amount of inshore detail (i.e., street names, building names, etc.) should be decreased. Time spent by photogrammetrists compiling the information and by Revisory Survey checking the information could be well spent on other duties.

4. CONCLUSIONS AND RECOMMENDATIONS

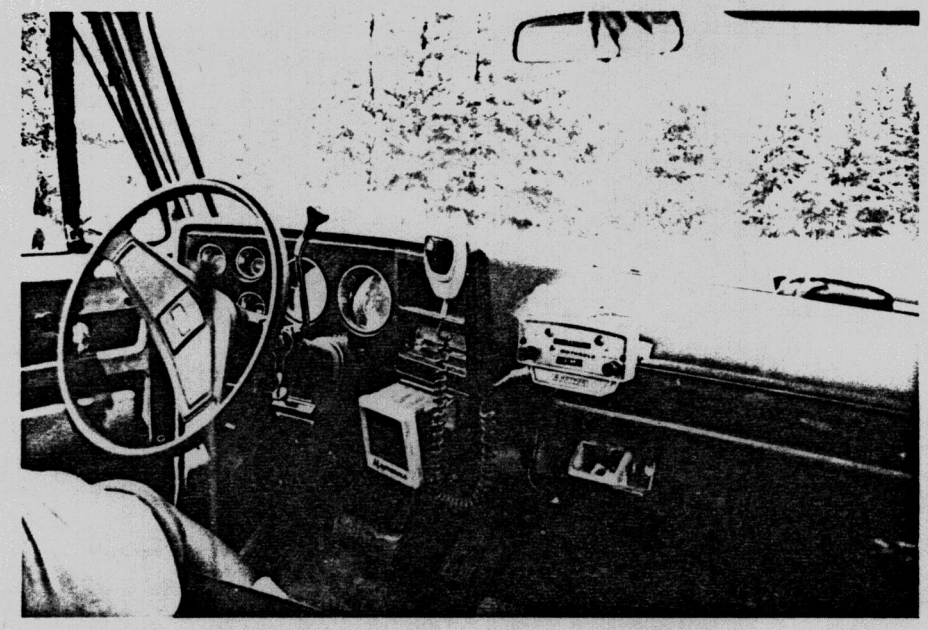
I found my U.S. Exchange Program to be a rewarding experience. It was interesting to meet fellow hydrographic personnel and watch them deal with problems similar to ours.

During my exchange with N.O.A.A., I observed three procedures that are worth consideration by C.H.S. Central Region. They are:

1) A specific schedule for the revision and publication of new chart editions. Central Region should be divided into three or four areas and new chart editions be published every third or fourth year. Charts in each area being revised the year before publication of new editions.

2) A central body - probably the Federal Ministry of Transport and Communications or the Department of Public Works should issue permits for any work to be done in Canadian waters and shoreline.

3) Lake Survey Center use Motorola "Motrac" portable radios in all their vehicles. Mounted on the dashboard, they provide good communication to launch and office even while the vehicle is underway.



Truck-mounted Motorola "Motrac" Portable Radio

I think the exchange program for 1976 should be altered slightly. Beginning in the middle of June, the schedule should be:

two days - Lake Survey offices, Detroit, Michigan
two weeks - Hydrographic Party, L.S.C.
two weeks - Horizontal Control Party, L.S.C.
one week - Vertical Control Party, L.S.C.
two weeks - Revisiry Section, L.S.C.
two days - A.M.C. offices, Norfolk, Virginia
two weeks - High Speed Launches, A.M.C.
two weeks - River or inshore survey, A.M.C.
one week - Revisory field party, A.M.C.
one week - Photogrammetry field party, A.M.C.
one week - Wire sweep party, A.M.C.

TOTAL 15 weeks

In conclusion, I would like to thank the staff at Lake Survey Center, especially Messrs. W. Monteith, R. Watts, Chung-Yun Chiang, A. Christenson, W. Bergen, and T. Kuchciak. My thanks also go to the Atlantic Marine Center staff and to Lt. Cdr. J. Rolland, Lt. Cdr. D. Wilson, Lt. R. Floyd, Lt. D. Drake, Lt. (j.g.) B. Otto, V. Serena and W. Johns.

APPENDIX A

- STANDARD OPERATING PROCEDURES FOR REVISORY SURVEYS -

STANDARD OPERATING PROCEDURES

FOR

REVISORY SURVEYS

Revisory surveys are designed and performed to obtain, and provide on a timely basis, hydrographic and correlated cartographic data required to update the existing published charts and produce new chart editions on a regular schedule. While hydrographic and cartographic survey procedures should conform to specifications and requirements detailed in the Hydrographic Manual (SP 20-2), deviations from these standards are necessary since revisory operations involve on-site field verification of the charted detail, and real-time processing of revision information acquired therefrom. With limited exceptions, data shown on each large scale harbor chart, river chart, and small craft chart of the Great Lakes area are verified and/or revised triennially.

Other operations performed in conjunction with revisory field surveys, and which are described herein, include: (1) verification and revision of data published in the Great Lakes Pilot; (2) maintenance of horizontal and vertical control at sites on the Great Lakes and along the connecting rivers; (3) assisting in the inspection and maintenance of water level gages comprising the Lake Survey Center gaging network; (4) obtaining information on the adequacy of chart scales, overlap, limits, format, and content through interviews of chart users; (5) chart sales agency inspections; and (6) special assignments.

Lake Survey Center survey operations are normally performed in the months of May through October when weather conditions prevalent in the Great Lakes are most favorable. Operations during the remainder of the year by field personnel, principally completing the reduction of data acquired in prior surveys, verifying the reduction, and preparing for future surveys, are performed at the Center.

Revisory survey operations follow this seasonal pattern to field inspect and obtain verified revision data for each chart on a recurring three year schedule. This work is accomplished prior to the compilation and production of new chart editions in accordance with Project Instructions. As required, coordination of operations is conducted with the Marine Chart Division (C32) to better effect a viable printing schedule of new chart editions consistent with the supportive field surveys program. Because of the extent of territory to be surveyed and the limited time available, it is necessary to restrict surveys in general areas critical to navigation and where significant changes have been reported or may be expected to occur. Such selective surveys require thorough planning and preparation and good judgement in implementation.

The following sections cover the Plans and Preparations, and the General Specifications and Requirements for revisory surveys and other related operations.

I. Planning and Preparation for Field Season. Emphasis must be placed on proper planning and preparation for revisory survey field operations. Whether

or not the section is able to complete the field assignment properly, efficiently, and in the allotted time depends to a large extent on the adequacy of the preparation accomplished prior to going into the field. This effort, as discussed in the following paragraphs, relates to work to be performed in chart revision, horizontal control, and vertical control surveys; gage inspections; Great Lakes Pilot information verification; special assignments; fitting out; and scheduling operations. Additional supplementary field operations often involve programs associated with the promoting of public relations, determining chart adequacy, or the inspections of authorized chart sales agents. Overall plans for each field season will be provided in Project Instructions. However, for effective operations, coordination with other units of LSC and NOS headquarters is necessary.

(1) Chart Revision. The original and prime objective of the Revisory Section is to revise the planimetric topographic and hydrographic features of Lake Survey charts in such a manner that new editions are as near up-to-date and as accurate as possible at the time of printing. In order to accomplish the required work effectively and efficiently, it is necessary to take certain charts and drawings into the field and to have certain other pertinent data available for consideration.

a. Current Edition of Charts. Copies of the latest edition of all charts being revised shall be taken into the field. On the average, three copies of each chart will suffice; however, it is advisable to include one or two extra copies where the chart covers and includes insets of several harbors or one large harbor, like Buffalo or Duluth. Two of the charts should be regular paper copies with all colors while the third should be black and white only and preferably on plastic. If the harbor or river chart, or inset scale is 1:15,000 or smaller, a 2X photo enlargement should be made of all or portions thereof where considerable detail is shown. Two prints, one on plastic and one on paper, should be made of the enlargement for field use.

b. Past Work Charts. Copies of the chart which contain revisory survey field notes from the most recent two field inspections shall be taken into the field for reference use.

c. Field Sheets. Prints of all smooth sheets showing the latest surveys in the area under revision should be taken into the field. These prints are used primarily for reference. However, in the case of new surveys of harbors which have been made and drafted since the last revisory inspection, it is intended that a careful field check of these prints will be performed as part of the routine revisory work.

d. Name Authorities. Authorities for commercial names charted in the harbors being revised should be sorted into alphabetical order for each chart or inset. These authorities are taken into the field for use in the planimetric or topographic reconnaissance and name verification portion of the field work.

e. Future Field Work Charts. Future field work charts maintained by the LSC, or chart standards maintained by NOS headquarters, are copies of

the current chart edition on which notes are made indicating items requiring field investigation. Location and depiction or description of proposed or completed construction authorized by permit, changes recommended in Cooperative Charting or Chart Updating reports, or other pertinent information from chart letters, are noted on these charts. Where the anticipated revision in the chart resulting from the construction is of a simple nature such as increasing depths in slips, adding a submarine cable symbol, adding short docks or jetties, etc., the proposed construction can be roughly depicted on this chart along with the file number of the report or permit. In the case of larger construction where the anticipated chart revision is more complex, a brief note on the type and extent of construction authorized by the permit and its file number should be entered on the future field chart. All additions or changes noted on proof copies of the chart, and not previously field checked, should also be noted on the future field copy of the chart, especially those additions or changes which were not incorporated in the new edition of the chart. These charts will be taken into the field for reference use. The notes can be transferred to another work chart for subsequent field use as required. The action taken to revise the charts or to be taken in the office or on future surveys, must be recorded on the future field work chart as each item is investigated or verified.

f. Chart Letters. All permits and completion reports issued by the Corps of Engineers for construction in the area being inspected, Cooperative Charting, Chart Updating and other reports which require field verification will be provided. As noted in the preceding paragraph, the effect of each report will be noted on a copy of the current edition of each chart designated as the future field work chart. Notes should be added to these permits or reports while in the field to help clarify any changes to be made on the charts.

g. Engineer Prints. Corps of Engineers prints showing the latest soundings, latest topography (planimetry), and latest Corps' horizontal and vertical control will be provided to the field section.

h. Photogrammetric Data. As discussed in succeeding paragraphs, the charted depiction of planimetry, including shore line, prominent buildings, landmarks and aids to navigation, will be verified prior to field inspection through use of projectors and stereo plotters. Changes found necessary will be made on a plastic copy of the latest chart edition and provided to the field party for appropriate on-site review and verification. In cases where insufficient photogrammetric control is available, or where photo-interpretation is in question, a specific request for supplemental field surveys or investigation will be made. Necessary photo prints will be provided.

i. Revisory Section Notes. A work notebook is maintained by the Revisory Section which contains a summary of work done on each chart, including notations regarding future work needed to complete current surveys or future work anticipated because of ongoing or proposed construction. Adequate notes will be made on the proper charts so that as the field work progresses, the recommendations contained in this book will not be overlooked.

j. Horizontal Control Data. Descriptions, positions, and contemporary recovery notes of all NGS and LSC horizontal control located along the contiguous lake, river, or canal areas shall be assembled and taken into the field for use in locating landmarks and other critical features at or between the harbors. Control in these areas established by other agencies, such as the Corps of Engineers or U.S. Geological Survey, should also be assembled for possible use. All control in the area of the revision surveys should be recovered with pertinent recovery notes transmitted following prescribed NGS or LSC procedures.

(2) Vertical Control. The Lake Survey Center is charged with the responsibility of establishing and maintaining adequate bench marks at or near each Corps of Engineers District project within the Great Lakes System. Reliable marks are also required at various other sites in the Great Lakes area for National Ocean Survey use. In coordination with the Vertical Control Section, Water Levels Branch, it is the responsibility of the Revisory Section, Surveys Branch, to maintain all existing bench mark sites and to establish additional ones as needed. This work is carried out in conjunction with the normal triennial revisory surveys. To provide high quality and dependable control, it is of paramount importance that certain preparatory work on vertical control be accomplished prior to going into the field.

a. Bench Mark Descriptions. A complete set of prints of bench mark descriptions for the area to be surveyed, giving elevations on International Great Lakes Datum (1955), must be assembled and taken into the field. Draft copies of bench mark descriptions for all new marks which have been established since the bench mark file was last revised should also be taken into the field and verified. Occasionally, under special vertical control instructions, it is necessary to take descriptions of bench marks which are not currently tabulated in the bench mark file. These will be obtained from other field data, such as notebooks, reports, etc.

b. Bench Mark Histories. Working copies of tabulations showing the dates bench marks were established and recovered shall also be included.

c. Difference and Elevation Tabulations. Tabulations showing the differences in elevations between bench marks, and the elevations of bench marks and water level reference gages, as determined from previous leveling, are needed in the field as a guide in determining relative stability of the existing bench marks.

d. Review of Recent Work by Other Sections and Agencies. Vertical control work performed by other sections and/or agencies, which has been accomplished since the last revisory visit to the bench mark site, should be reviewed to assure that all required data discussed in the preceding paragraphs are assembled. These data include differences in elevations between bench marks and water level reference gages, notes regarding bench mark recovery, and descriptions of new bench marks and gages.

e. Proposed Work. Notes from the Revisory and Vertical Control Sections regarding the status of each bench mark site, including recommendations

from various sources on proposed work at each location, should also be reviewed. The discussions of previous work and statements regarding bench mark stability contained in the Vertical Control Histories for each site should also be reviewed at this time. Based on these reviews, a tabulation showing all desirable vertical control work for the current field season must be prepared. In coordination with the Vertical Control Section, the priorities of work at each site will be established in one of three categories:

1. Work which must be accomplished.

2. Work which is very desirable and should be accomplished, if possible.

3. Work which should be done, as time is available, without delaying other work of higher priority.

(3) Gage Inspections. In conjunction with the triennial revisory surveys, the Revisory Section is also responsible for inspecting and maintaining any National Ocean Survey water level gage installation in or near its working area. During spring and fall trips, to and from seasonal working areas, other active gage installations are inspected as required, depending on conditions such as men and time available, time of year, condition of gage, etc. Planning of such work must be coordinated with the Water Levels Gaging Section, Water Levels Branch, which has basic responsibility for these gages. In order to accomplish this work properly, it is necessary to assemble reference data and perform other preparatory work before going into the field.

a. Latest Gage Inspection Data. A copy of the latest "gage inspection record" should be obtained from the Water Levels Gaging Section and taken into the field as a reference in the forthcoming inspection. Instructions and recommendations on necessary and desirable maintenance work will also be obtained from that Section.

b. Data on Observer. It is very important to have a record of the name and address of the gage observer, as well as information regarding salary, length of service, and any other pertinent notes that might be of value in the field.

c. Description of Gage and All Reference Gages. The latest description of each gage and of all reference gages at each site should be obtained, including dates of establishment if known.

d. Special Work Required. The Water Levels Branch will provide instructions and recommendations on necessary and desirable maintenance work for each field season. These must be obtained prior to going into the field in order that special gage work can be assigned proper priorities. In cases where the requested special work might delay the operations of the Revisory Section, the requests must be referred to the Chief of the Charting Operations Division for decision on its priority.

(4) Great Lakes Pilot. Numerous agencies furnish revisory material for the Great Lakes Pilot and in many instances the information furnished requires field investigation for clarification. A detailed field check of points in question and a general inspection of all other items in the Pilot must be accomplished in conjunction with the triennial revisory surveys. Such work must be planned and performed in coordination with the Marine Information Specialist responsible for editing this publication. The following preparatory actions are paramount in importance.

a. Copies of Current Edition. Four copies of the current edition of the Pilot should be obtained for field use. One copy is for navigation uses and use as a working copy for the launch party, one copy for a reference copy and use as a working copy by the shore party, with the other two in loose-leaf form (one sheet per page) being reserved for the final revisory notes which will be furnished, as completed, to the Processing Branch, Charting Operations Division. These revisions will be provided in accordance with a revision format established through coordination with the Marine Information Specialist (Processing Branch).

b. Special Items to be Investigated. The Processing Branch will furnish a list of all features or items in need of clarification in the field. This list usually will be prepared in advance of the field season but may be augmented from time to time during the season as additional questions arise.

(5) Special Assignments. On occasion, special work over and above previously discussed operations is assigned in conjunction with revisory surveys. Specifications for such projects as soundings in commercial dredging areas, investigation of groundings, soundings over dumping grounds, field edit of photogrammetric compilations, and establishment of water level gages at special control points, will be provided in Project Instructions. Preparation necessary for such special assignments will vary with the project. However, three items probably would be necessary in all cases.

a. Charts. In most special assignments, it will be necessary to obtain additional charts covering the area in question.

b. Smooth Sheets. Where necessary, prints of smooth sheets will have to be obtained in advance of the work.

c. Station Descriptions. In order to recover the necessary horizontal and vertical control points, descriptions should be obtained for the required bench marks, triangulation stations, and boundary reference marks or traverse stations.

(6) Supplementary Field Operations.

a. Public Relations and Chart Adequacy Surveys. Information on active or proposed survey programs will be provided to the Reports and Information Section, Processing Branch, for dissemination to newspapers in the area of the field operations. Information on names and addresses of Cooperative Charting and Chart Updating Officers, and other individuals and organizations supplying chart revision data should be obtained from the Processing Branch prior to departure for the field.

b. Chart Agency Inspections. The Distribution Division (C44) must be advised of the area to be visited in the next season's revisory surveys and be requested to provide a list of authorized chart sales agents to be inspected in that area.

(7) Fitting Out. While "Fitting Out" is of necessity, the last step in field work preparation, it is by no means of minor importance. The section will be operating many miles from the home station over a period of from five to six months and improper or inadequate "fitting out" will definitely interfere with efficient field operation.

a. Winter Repairs. In order to be sure that the survey vessel will be ready for use when it is needed, it will be necessary to advise the Engineering Division (CLS3) well in advance of the field season, the date equipment is required and specific desired repairs and replacements thereto. Also, it will be necessary to confer periodically with CLS3 so that any problems concerning the winter repairs can be overcome with a minimum of delay. Should it be impossible for the Engineering Division to accomplish all desired repairs before the date the equipment is needed, or if it becomes necessary to advance the field season starting date, the winter repair work priority will be amended, as necessary.

b. Seasonal Help. Early in the planning stage for the field season it is important to determine the number of additional temporary help which will be required. The normal complement in the field to accomplish the work both effectively and efficiently is ten men, six of whom are temporary or seasonal on the average. Well in advance of the date they will be needed, requests should be made through channels to the Charting Operations Division for recruiting the seasonal employees that will be required. The Section Chief will interview all applicants for the positions and pass on their qualifications before they are hired.

c. Supplies. Requisitions for the supplies which will be required by the section for the field season should be prepared early in the winter. The list should be comprehensive and the quantities requisitioned should be such that field purchases and excess supplies returned at the end of the season will be held to a minimum. Necessary follow-up should be made to see that these supplies are in stock about 2 months prior to fitting out. These supplies shall be loaded into the office trailer, trucks and surveyboat just prior to sailing. A similar procedure must be followed to obtain office supplies from the Lake Survey Center stockroom. Items not stocked must be requisitioned.

d. Property. A detailed list of all property that will be required in the field should be made well in advance of the "fitting out" period. This property will be moved into the office trailer and trucks, or aboard the survey vessel just prior to departure. The remaining items which are on the property books of the section and are not taken into the field should be properly cared for and/or stored before leaving the office. Annotations should be made in the property book indicating the location of each item of property.

(8) Schedule for Field Season. A chronological schedule for field season operations is a necessity for the revisory survey work. Each season there is a definite number of charts that must be inspected and, the time available for field work is limited by funds and weather. Therefore, it is very important that time to be spent in each charted area in a season be carefully apportioned. Prolonging the field work late into the fall may result in loss of time due to the adverse weather. As a guide in preparing a realistic schedule, the following procedure should be followed:

a. Chart Priority. The Marine Chart Division (C32) must be consulted to determine whether certain chart data is required early.

b. Past Schedules. Past schedules should be reviewed and weighed to ascertain the effect of any special work accomplished over and above routine revisory surveys. From these schedules the average time required for work at each harbor can be estimated.

c. Estimate of Routine Work. By reviewing anticipated operations as noted under previous paragraphs on preparation, estimates can now be made of the number of man-hours required at each harbor to be visited. Convert the man-hours into days and tabulate for the harbors the order in which they will be visited. The number of working days for a harbor will be augmented by sufficient time allowance for moving the party from harbor to harbor. The next step is to include two additional days after every fifth working day, for weekends, giving a preliminary estimate of the total number of days for the proposed trip. By basing the schedule on a five day work week, delays caused by bad weather, plant breakdown, etc., can be offset by working overtime on Saturdays and the estimated schedule can be maintained. If the total number of days estimated for the trip is not within a few days of the total available time, reductions will have to be made in the time allowed at various harbors where the priority of the workload will permit. After the adjustments have been made and the total estimated days required to accomplish the work falls within a reasonable allowance of the days available, a realistic working schedule can be developed.

d. Special Assignments. A fairly reasonable estimate of time required to accomplish special assignments will have to be made and inserted in their proper places in the field season schedule. If the time required for the special assignments is more than a few days, it will have to be given consideration prior to the final development of the schedule in paragraph c. above.

e. Printed Schedule. The schedule must be typed and about 40 copies reproduced. Information under the following headings should be included: Harbor (to be listed in order reached), Miles (from previous harbor), Arrival Date (schedule), Chart No. (opposite proper harbor), and Send In Date (for chart data). Copies of the schedule will be provided to the Chief, Surveys Branch, for distribution.

II. General Specifications and Requirements. The specifications and requirements for revisory surveys, for field operations performed as a coordinated effort with these surveys, and for the reduction and disposition of data acquired in these operations are outlined in this section. Reference is also made to the Hydrographic, Topographic, Photogrammetric, Nautical Chart, and other NOS Manuals and Operating Instructions which afford more detailed specifications.

Overall plans for each seasons operations are contained in Project Instructions. It is important that these specifications, requirements and instructions be followed in performing and planning day to day field operations. These operations include Chart Revision Surveys, Pilot Inspection, Vertical and Horizontal Control Surveys, and Water Level Gage Maintenance. Supplementary operations on chart adequacy (user) surveys, chart agent inspections, equipment maintenance, and proper safety and security procedures are also discussed.

(1) Chart Revision Surveys. These are the primary field operations of the Revisory Section and their scheduling establishes a time frame within which other operations are performed. It is very important that significant changes in a charted area be identified and that appropriate revision data be provided to the Marine Chart Division on a timely basis as required to meet chart production schedules. In general, revisory surveys are made of each critical charted area in the Great Lakes at three year intervals. The day to day operations must be planned, as necessary, to take advantage of good weather.

Revisory surveys consist of field inspections or reconnaissance surveys to verify or note changes in charted features such as landmarks and critical hydrography, located soundings over approaches to harbors, soundings along docks, in slips and over other critical areas, and investigation of changes authorized by permit or reported from other various sources. It is also important that the location of aids to navigation and landmarks used to position buoys be verified. Consistent with the NOS program of reconstructing charts, and/or constructing new charts, revisory surveys may include verification of photogrammetric compilations; establishing horizontal control to support photogrammetric compilations or a program of aerial triangulation; or complete hydrographic surveys of harbors or other selected areas as may be required. Specifications for this work have been identified in other NOS or NGS Manuals or Operations Instructions. Adherence to these instructions are considered standard procedure for conducting revisory surveys.

The basic operations of revisory surveys are discussed in the following paragraphs.

a. Sounding in Lake Areas. Ranking second only to safety, sounding in lake areas in and around entrances to harbors are the most important field operation. Being most vulnerable to adverse weather, hydrography rates first priority on the schedule of operations at each harbor. Specifications for hydrographic surveys, detailed in the Hydrographic Manual, must be followed.

Instrumentally located soundings shall be taken in lake areas immediately adjacent to all harbor entrances and shall cover all areas of approach. Where the entrance channel is not maintained by the Corps of Engineers, it shall be included in the area covered. Otherwise, inclusion of entrance channels in the sounding areas should only be done where a routine line crosses the channel. In general, entrance soundings will be considered to be reconnaissance soundings. However, when the soundings show that a definite change has taken place, requiring densification or a more complete hydrographic survey, it is accomplished immediately. Even though only a limited number of soundings are added to the revised chart, the complete sounding overlay is forwarded to the Marine Chart Division (with the revised chart) for additional review of the survey.

Location of the reconnaissance lake soundings by means of simultaneous (real-time) manual plotting of the data is preferred, but not mandatory. If other methods are used, field plotting should be accomplished as soon as practicable after the completion of the reconnaissance soundings. The length and spacing of the sounding lines should conform to specifications in the Hydrographic Manual, while the area covered may be varied from harbor to harbor, depending on conditions, such as chart scale and type of bottom. However, a sufficient number of soundings shall always be taken to determine whether or not the charted depths immediately adjacent to and in all avenues of approach beyond the maintained channel, as well as in the entrance channel itself when it is not maintained, are correct. In most cases open lake soundings will be considered to be verified if the reconnaissance soundings agree within plus or minus one foot of the charted depth. In critical areas such as over bars or shoals in or immediately adjacent to avenues of approach, verification will be assumed only when charted depths are not decreased. Except in special cases, it shall be considered adequate if soundings are taken over an area extending out to a depth one contour interval deeper than the controlling depth in the harbor.

If it is found that charted depths are not correct, sufficient additional instrumentally located soundings shall be taken until adequate data are obtained to depict the correct depths. Necessary revisions will be made in blue ink on the plastic copy of the chart which will be forwarded, with the sounding record, overlay plot, positional data and stage correction used, to the Processing Branch for verification and subsequent transmittal to the Marine Chart Division for an additional review.

b. Sounding in Harbors. Inner harbor soundings are given lower priority of effort to open lake soundings only because of the weather consideration. However, they are equally important if not more so. Sufficient reconnaissance soundings shall be taken in all active slips and along all dock faces until it has been shown that the charted depths and contours are correct or until adequate data has been recorded for correcting the soundings shown. Spacing of soundings with respect to dock faces shall be governed by the general size of boats which moor thereto. One sounding line should be run approximately where the keel of the using vessel will travel in approaching and mooring to the dock. In no case will soundings be taken so close to the dock that false echoes from the dock structure itself will be recorded as

bottom depths. Reconnaissance soundings shall also be taken in other portions of the inner harbor outside of regularly maintained project areas to verify the depths shown. Additional soundings shall be taken, instrumentally located if possible, to correct any discrepancies found. Statements in the Great Lakes Pilot regarding area sounded must be verified or revised.

c. Waterfront Reconnaissance. In planning the inspection of a chart, the future field work copy of the chart must be reviewed and reports and permits requiring verification extracted from the files. Suitable assignment of items to be verified should be made to boat and shore parties and areas where the boat and shore work must be coordinated should be identified. The waterfront topography as depicted on the chart shall be compared with the actual topography item by item in sufficient detail to determine wherein the chart does not present a true picture of the charted area. Cartographic factors such as the scale of the chart must be given due consideration. For example, features that can and should be shown on a scale of one to five thousand may not be desirable on one to twenty thousand or smaller.

When discrepancies are discovered, necessary topographic or planimetric surveys shall be made to remedy the situation. The method used will be determined by the size of the area to be surveyed, weather conditions and time available. Such surveys must meet NOS accuracy requirements for topographic surveys. Where possible, surveys should be limited to provide sufficient control for photogrammetric compilation and planimetry. Corps of Engineers surveys, construction drawings, private surveys, and city or county maps shall be utilized wherever possible to eliminate duplication of effort. However, when prints of other organizations are used, verification of information shown must be obtained to insure that the resulting correction of the chart will be correct and adequate.

In most cases the waterfront reconnaissance will be carried out in conjunction or concurrent with the sounding work discussed under "Sounding in Harbors." It will also be advantageous to coordinate shore operations on topography and name verification and Pilot revisions discussed in subsequent paragraphs with this work to assure investigation of features back from shore and avoid duplication of effort.

d. Inland Reconnaissance and Name Verification. All charted features back from the immediate waterfront will not be inspected as a routine procedure by a shore party. As discussed under, "Waterfront Reconnaissance," this party will be assigned reports and permits which it can verify. Landmarks which are visible from the lake shall also be verified. A lookout for uncharted landmarks will be maintained from the launch while working or traveling on the open lake. When such objects are noted, the information will be transmitted to the shore party whose responsibility it will be to secure sufficient data by instrumental survey to position the landmark accurately.

A printed authority of one form or another, such as letterheads or invoices, shall be retained on file for all names shown on National

Ocean Survey charts. Each name shall be verified, revised, or deleted, as the case may be, by personal contact, questioning a person who is in a position to know if the company still is operating, has changed owners or name, etc. Verification will be noted on the existing authority showing the date and the initials of the person making the contact. When changes are found, the change will be noted on the old authority, and a new authority will be obtained and properly annotated. If possible, the date of the change and the reason for the change should be noted on the authority. Deletions will likewise be noted on the existing authority, giving the date, initials of the person who determined that the name should be removed and the reason for deletion. While the section is working around the waterfront and especially during the name verification and waterfront reconnaissance work, a sharp lookout will be kept for new names which should be added to the chart. A printed authority will be obtained for all new names. The person obtaining the authority will show the date obtained, the chart on which it is to be added, the reason for adding it, and his initials.

Names shown on Lake Survey charts fall into three categories. First, individuals, companies or corporations that are using the waterfront for shipping in or out. Names in this category are a must and have first priority for available space. Second, names of individuals, companies or corporations that offer a service to mariners such as marine hardware, marine supplies, marine repair, fuel, lumber, etc. Names in this category have second choice for available space and will be shown if possible. The third category for available space and least important of the three, are those names of companies, corporations, or in some cases individuals whose property serves as landmarks, such as large waterfront installations, inland factories with prominent tanks or stacks, especially where the company name is shown on the stack or tank. Names in the third category will be shown when space is available without crowding the topographic features. Names of public buildings such as courthouses, post offices, libraries, etc., will also be shown when the building referred to is charted.

Roads between harbors and streets in towns which are shown on the coast charts will be inspected only insofar as they are traveled by the shore unit of the section while enroute from harbor to harbor. Whenever this inspection or information from other sources indicates that new roads have been built or that old ones have been relocated, sufficient field data will be obtained to properly revise the chart. Particular care must be taken to assure that accurate geographic positions are obtained for structures which serve as landmarks. Statements in the Great Lakes Pilot regarding the area covered must be verified or corrected.

e. Topographic or Planimetric Surveys. When it is found necessary to make extensive topographic or planimetric surveys, standard survey practices shall be followed. Adequate control will be recovered or established and properly utilized in the survey or provided for subsequent photogrammetic compilation. Sufficient sketches will be made to permit proper development of the notes into an accurate drawing. Annotations will be made on the chart being revised to insure that the survey will not be overlooked

and as a guide to the compiler in using the plotted survey or photogrammetric compilation to revise the working drawing of the chart.

f. Reduction of Data. All inspection notes will be inked on the chart under consideration as the work progresses. Notes indicating the removal of the features shown will be made in green. Notes indicating a change or an addition to charted features based on visual comparison will be shown in red and those based on instrumental survey in blue. Verification notes or those made to give information only will be made in violet. From the Hydrographic Manual (Chapter 4.5.7.4.), the standard color code for depth contours to be used is as follows: 0 foot (Low Water Datum) - orange; 6 foot - green; 12 foot - red; 18 foot - blue; 24 foot - orange; and 30 foot - red.

Wherever possible, such as in small harbors, all inspection notes should be inked on one chart for transmittal to the Marine Chart Division. In other cases the notes will be inked on as many charts as necessary to accomplish the desired end result in the most efficient manner. When more than one chart is used in the revision, adequate indexes and cross-references shall be made on the charts to insure that the compiler in the Marine Chart Division will be able to revise the working drawing (office copy) of the chart correctly with a minimum effort. As soon as practicable after the field work has been completed at each harbor, the chart or charts containing the revisory notes will be checked for clarity and completeness and, after a summary of work done is entered in future work book, forwarded to the Chief, Surveys Branch. If extensive instrumental surveys have been made, it will be necessary to plot the surveys in the field on stable plastic sheets, chronaflex or mylar, for transmission with the chart to the office. A list, in duplicate, of all revisory data forwarded shall be made and the original sent in with the data. Any special work required of the Processing Branch or the Marine Chart Division, such as questions to be addressed to the Coast Guard on lights or buoys or the Engineer District on dredging or construction, should be noted on this list, as well as on the appropriate chart.

g. Chart History and Future Work Book. The Revisory Section shall be expected to maintain a file, preferably in a small notebook (about 4x7 inch record type) of notes summarizing changes found, survey methods employed and identifying work to be accomplished in future revisory surveys. One work book is used for each field season and prior to sending revision data to the office, a summary of work done and work anticipated is entered for each revised chart. A copy of these notes should be forwarded with the chart.

(2) Pilot Inspection. The Revisory Section is responsible for field checking and rewriting the Great Lakes Pilot insofar as it concerns the area being covered by the revisory survey. Verification shall be obtained in the field for all statements in the Great Lakes Pilot that are not the direct responsibility of other government organizations. The excepted features are Corps of Engineers' District project descriptions, navigation light characteristics, etc. Detailed instructions will be furnished by the Processing Branch for all special work required in connection with the Great Lakes Pilot.

(3) Horizontal and Vertical Control Surveys. Horizontal and vertical reference or datum planes are identified for each chart of the Great Lakes area published by the National Ocean Survey. Consequently, proper cognizance of these datums must be maintained when processing the various planimetric, topographic, or hydrographic data collected under the LSC chart revision surveys program.

a. Horizontal Control Surveys. Horizontal control surveys provide essential support to the LSC chart revision surveys program in the control of investigative hydrographic surveys, the positioning of new landmarks, the location of significant shore line changes, the expansion of existing chart coverages, and in support of associated photogrammetric programs. The latest Hydrographic Manual (1975 Provisional Copy) defines the standards to which all NOS chart data collection efforts should be designed in order to acquire data consistent with the needs of NOS nautical chart production. In general, chart revision surveys will require supportive horizontal control surveys to Third-order, Class I accuracy standards (see Hydrographic Manual, Chapter 3.1.2.). Third-order control stations shall be described, monumented and marked with standard National Ocean Survey discs in accordance with prescribed NOS procedures (see Hydrographic Manual, Chapter 3.1.2.1.2.). Horizontal control surveys in conjunction with, or in support of LSC revisory surveys should be performed in accordance with the standards and procedures defined in the Hydrographic Manual. In particular, the following procedures must be followed:

1. A full station description shall be written at the time the mark is set; not left for another visit.

2. A full description implies complete compliance with pages 115-123 of SP 247; without exception.

3. Brief or terse descriptions are not acceptable; regardless of the order of accuracy.

4. A minimum of three distances shall be taped between natural references and the various station marks; including Reference Marks and Azimuth Mark.

5. Descriptions and sketches shall be recorded (hand written) in a bound notebook; not on looseleaf or tabular paper. The Hor Ob Book is preferred.

6. Before leaving a station (or it's vicinity) the description shall have been written in sufficient detail such that no return visit will be required and the final typed version may be transcribed directly from the field notebook with minimum effort or confusion.

7. The narrative portion of the description shall follow the standard format as specified in SP 247 - explicitly.

8. Descriptions shall be typed in final format on the prescribed forms within a reasonable length of time after initial establishment; a reasonable length of time being one week.

9. All block data and distance/direction data shall be entered on the station description as soon as it becomes available - it is critical that the directions to objects visible from the ground be contained on each description if the control is to have any value whatsoever.

10. Note the SP 247 procedures for identifying older control (with dates), current project control; and the prescribed procedure for naming intersect stations; note and follow this exactly.

11. The designated name for any station or intersect object shall not differ in either the Observing Book, Abstracts, Lists of Directions, Field Geographic Lists, Descriptions, and/or on computation forms - it is imperative that the exact name for each station or intersect object be ascertained in advance of any field work and that all subsequent data forms carry the correct name without change or abbreviation.

12. All Observation Books shall be indexed on site.

13. The full station name, and a description of the target and/or intersect point, shall be shown on the first position of observations; again, without abbreviation. Stations may be abbreviated during subsequent positions.

14. All feild recording forms, books, or computation sheets shall contain (1) date of observation/computation, (2) name(s) of observer/ recorder/computer, and (3) cross-index reference code, without fail.

15. Geodetic computations shall be performed on the prescribed forms; regardless of the fact that an automatic computing device was utilized for most of the computation.

16. When recovering a published NGS station, a full recovery note shall be prepared; this includes taping distances to Reference Marks and rewriting the original description if required. It is unlikely that the singular statement "recovered as described" will ever suffice for any existing control on the Great Lakes. Two T2 positions should be observed to all reference marks.

Submittal of the above data will be specified in individual Project Instructions.

b. Vertical Control Surveys. In conjunction with the triennial chart revision survey program, the Revisory Section performs required maintenance services and vertical control surveys at any LSC water level gaging station located in the survey area. This work is coordinated with the Chief, Water Levels Branch, who provides a listing of work required for inclusion in the Project Instructions prepared for the revisory surveys. In general, the work consists of the following activities:

1. Bench Mark Recovery. Bench marks on the Great Lakes fall into two subdivisions: (1) marks at gage sites and (2) bench marks along first-order level lines which follow the rivers between the lakes and between certain harbors on the lakes. Bench marks in the first category, that is, those at gage sites, are recovered once every three years at the time of the revisory survey. Bench marks in the second category, known as first-order line bench marks, are recovered on the average of one every nine years. Wherever possible, all bench marks at each gage site in the harbors being visited shall be recovered and their descriptions checked in detail and revised, if necessary, once every three years. A schedule of recovery for the first-order line bench marks shall be set up so that, insofar as possible, all first-order line bench marks will be recovered and redescribed if necessary once every nine years.

Descriptions of new bench marks, that is those marks which have not previously been recovered by the Revisory Section, shall be given a thorough check when recovered for the first time. In revising bench mark descriptions, the standard format shall be followed in all cases. All revisions to gage site bench mark descriptions must be noted in level notebooks.

2. Bench Mark Replacement and Establishment. Whenever bench marks are found to have been destroyed or made valueless by local movement, consideration should be given to the replacement of the mark. It will be mandatory to replace such marks when only two reliable marks remain. The need for replacement will diminish as the number of existing stable marks increases.

Before establishing bench marks, careful consideration should be given to soil conditions and topographic features. Wherever possible, gage site bench marks should be established approximately four to six level set-ups apart, in a relatively straight line leading away from the waterfront, and progressing to more stable ground. The exact location of the mark should be chosen to afford as much protection as possible against destruction and to insure that recovery will not be difficult. It is also advisable to give some thought as to how the mark will be described and reached by levels before it is set.

The names of all known bench marks in the immediate vicinity, as shown in the bench mark history, should be reviewed so that the new name will not be similar, even though the old mark has been destroyed or dropped from the files. If possible the name should be descriptive.

Careful consideration should also be given to the choosing of the type of mark to be set. If local conditions permit, it is advisable to have a variety of types of marks rather than several alike. The use of monuments in locations subject to frost heaving should be avoided. Each new bench mark must be described in the field at the time it is established and an independent check made of the description.

3. Levels. It is necessary to run instrumental levels between bench marks to prove or disprove their relative stability. Levels may be run to new marks anytime after they have been established except in the case of bars or pipes driven into the ground, pre-cast monuments, or marks cast in place. It is advisable to allow several days or a week, if possible, between the driving of a bar or pipe and the establishing of its elevation. Pre-cast monuments, which are set into the ground, should be established as much as two to four weeks before levels are run to them. Monuments or marks which are cast in place require only the necessary time for the concrete to set before levels should be run to them.

Levels will be run between bench marks as often as necessary to determine elevations and relative stability. When three or more sets of levels over a period of eight to twelve years have indicated stability and the recovery inspection discloses no obvious reason for suspecting movement, it will not be necessary to run instrumental levels between the marks oftener than once every six to nine years. Instrumental levels shall follow standard engineering practices and procedures as modified by Lake Survey Center requirements. On lines of one kilometer or more, closure of lines should be within the limit of a $\pm$ 3 mm x Distance in Kilometers; or $\pm$ 0.002 ft $\sqrt{n}$, where n is the number of setups in the line. The allowable closure between lines shall never exceed 0.010 foot.

4. Water Level Transfers. The Revisory Section is responsible for making water level transfers wherever necessary to maintain or establish adequate vertical control. Water level transfers fall into two classes: (1) Short period transfers where all work is accomplished by the Revisory Section in the field during a period of 1 to 3 days, and (2) Long period transfers where gage observers are hired to make tri-daily prescribed water level gage observations and the computation work is accomplished in the office. Only water level transfers in the first category will be dealt with here.

Existing gages shall be used wherever possible in making water transfers. However, in practically all cases, at least one gage will have to be installed for the operation. After the temporary gage or gages have been installed and levels run from nearby bench marks to the gage zeros, personnel shall be assigned to make and record observations on the gages and the transfer will start. Observations should be made on all gages simultaneously insofar as possible. The closer together the gages are, the more important it is that the observations be simultaneous. All gages shall be read at regular intervals, the time interval between the observations varying with the distance between the gages. Readings every minute are desirable when the gages are very close together such as when a float gage is used to determine the zero of a recording gage. The interval of observation will increase to two minutes, five minutes, and even as much as ten to fifteen minutes as the distance between the gages becomes greater.

When water level gage locations are widely separated, it is essential that water level transfers be made during periods of fair weather, especially during periods of light winds, and should follow one or two days

of similar weather. No short term transfer will be made if there is evidence of a possible slope in the water surface between gages. A tabulation shall be prepared showing the two simultaneous gage readings and the difference between the readings, as soon as practicable after they are made. Theoretically, the differences between two simultaneous observations of any pair of gages should always be the same. A careful analysis of the tabulated differences in readings will enable the person making the transfer to determine the relative value of the transfer. By computing the means of five consecutive differences, the range in variation should be reduced considerably. If the inspection of the means of consecutive five differences shows that successive means consistently increase or decrease over a period of time, the water surface in the area of the transfer is tilting and the result of the transfer will be of no value. For additional discussion see LSC Standard Operating Procedures for Water Transfers.

(4) Water Level Gage Maintenance. Gage work is normally accomplished for the Water Levels Branch and shall meet the specifications for such work as established by that Branch. On occasions, in connection with the establishment or reevaluation of elevations and with crustal movement studies, water level gages will be installed, inspected, and maintained by the Revisory Section. Gages in the latter category usually are set in rather large numbers, from 10 to 40 per year, and constitute a special assignment of the Revisory Section.

a. Inspection and Installation. Existing gages shall be inspected in accordance with specifications and instructions furnished by the Water Levels Branch. In general, the work shall be thorough and efficient. The gage shall be left in first-class operating condition. The elevation at the gage zero and of all reference gages shall be verified or determined.

When gage installations are made directly for the Water Levels Branch, specifications for the installation will be furnished by that Branch and shall be followed as rigidly as field conditions will permit. Such gage installation specifications shall also be used as a guide in installing other gages. In selecting the gage site, it is very important to avoid locations where surrounding conditions might effect the record. If the gage records are to be of any value, true lake levels must be recorded. Secondly, the gage should be installed in a sheltered area where it will be protected against damage and from over activity by exposure to open lake waves. Accurate levels must be run to the gage, and routine inspections must be made if the gage is to be operated satisfactorily, therefore, it is also important that the gage be installed in a readily accessible location.

b. Maintenance and Improvements. The Revisory Section is responsible for maintaining as many as possible of the principal gage installations of the Water Levels Branch during their routine triennial revisory surveys. All gage houses shall be carefully inspected and any needed repairs shall be accomplished. Roofing material should be checked for leaks and repaired or replaced if necessary. Broken glass in windows or doors shall be replaced as well as loose or missing putty around the windows. The building shall be

given a thorough cleaning inside and out and painted if and where necessary. All hardware shall be inspected and repaired or replaced where necessary. If electricity is available in the gage house, all wiring and electrical apparatus shall be carefully inspected and repaired or replaced if necessary.

The gage observer should be contacted while the party is in the vicinity and should be questioned as to any problems which might exist and asked to make an inspection of the gage in the presence of a member of the Revisory Section. In the case of experienced observers, the demonstration inspection may be omitted. When the observers are relatively new at the job or when it is necessary to hire observers in the field, detailed instructions shall be given on the operation and maintenance of the gage.

Major improvements are made to gage installation at the direct request of the Water Levels Branch. Such improvements are made insofar as possible, in accordance with specifications furnished. However, whenever it becomes obvious in the field that improvements to any gage installation are desirable, the Revisory Section is responsible for taking the initiative to accomplish the improvements. Such improvements might consist of building walkways during periods of high lake levels, adding handrails and guard rails around existing structures as a safety measure, etc.

APPENDIX B

- LEVELS WITH AUTOMATIC INSTRUMENTS -

BY ELMER F. KULP

Journal of the
SURVEYING AND MAPPING DIVISION
Proceedings of the American Society of Civil Engineers

LEVELS WITH AUTOMATIC INSTRUMENTS[a]

By Elmer F. Kulp[1]

INTRODUCTION

The Lake Survey, a district of the North Central Division, Corps of Engineers, has the sole responsibility for all the surveys and compilations necessary to produce and maintain the navigation charts of the Great Lakes. Another important mission includes studies of the water level and flows in these waters for engineering purposes such as necessary regulatory measures, for maintenance of channel depths, diversion of water for power generation, and operation of numerous locks.

In connection with these operations, the Lake Survey is responsible for establishing and maintaining the first-order levels throughout the Great Lakes for use of not only the many Corps of Engineers Districts involved but also for private industry and individuals who use this vast inland coast line.

During the past two years, the Lake Survey has been involved in updating its leveling procedures in order to obtain a significant increase in accuracy. This has resulted in adoption of certain new or modified equipment and techniques which permit this upgraded accuracy without a corresponding reduction in production.

The Lake Survey has used the Zeiss Ni 2 automatic level for all its first- and second-order leveling for the last 10 yr. Not desiring to make a reduction in production rates, it was decided to continue to use the Zeiss level. The Ni 2 level has been in widespread use throughout the United States and most surveyors are familiar with its operation. To the Zeiss was added an accessory plane-parallel-plate micrometer (Figure 14). This device has not had very wide use in the United States although it has been available from European manufacturers for some 30 yr. It provides a means for determining

Note.—Discussion open until February 1, 1971. To extend the closing date one month, a written request must be filed with the Executive Director, ASCE. This paper is part of the copyrighted Journal of the Surveying and Mapping Division, Proceedings of the American Society of Civil Engineers, Vol. 96, No. SU2, September, 1970. Manuscript was submitted for review for possible publication on February 10, 1970.

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the subdivision of the rod graduation-interval with more precision than is possible by estimation.

PLANE-PARALLEL-PLATE MICROMETER

The parallel-plate micrometer depends on the principle that a ray of light incident obliquely on a plane air-glass surface is bent by refraction toward the perpendicular to the surface, and, after traversing a finite thickness of glass, on passing through a glass-air surface parallel to the original, is bent again by refraction through the same angle but in the opposite direction. It

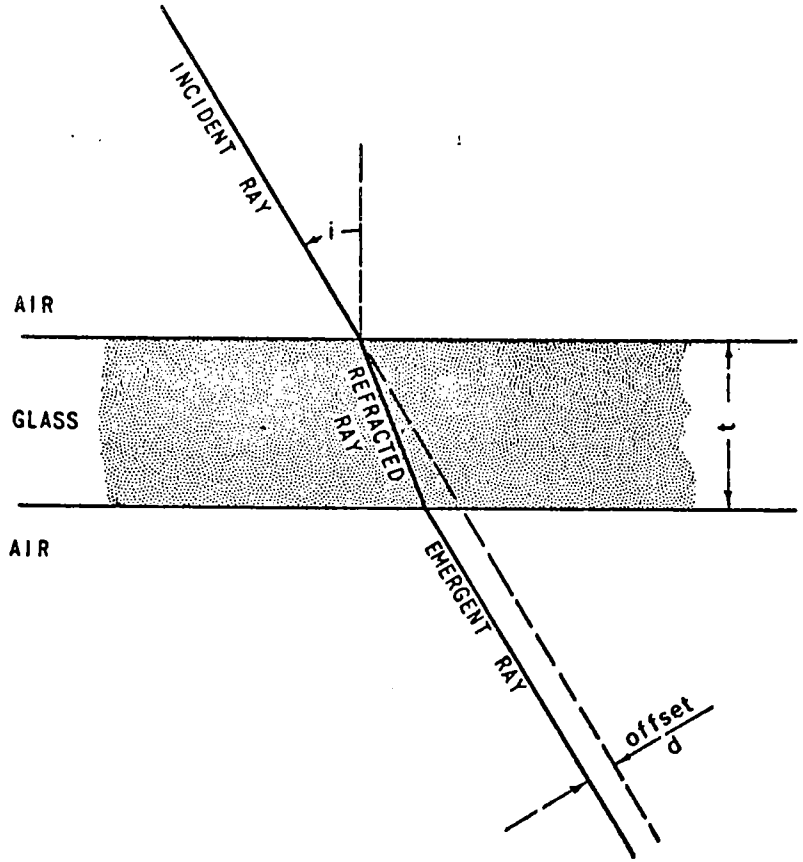


FIG. 1.—RAY PATH THROUGH GLASS PLATE



FIG. 2.—UNDEFLECTED LINE OF SIGHT THROUGH TELESCOPE

thus emerges parallel to its original direction but offset from it by a predictable distance, as shown in Fig. 1.

It can be shown to be a sufficient approximation (3) for incident angles within the required range that:

$$d = t \tan i\left(\frac{n - 1}{n}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

in which d = perpendicular offset between incident and emergent rays; t = thickness of glass plate with plane parallel surfaces; i = angle between incident ray and the perpendicular to the glass surface; and n = index of refraction of glass, relative to air.

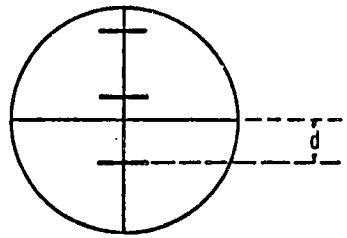


FIG. 3.—LEVEL LINE OF RETICLE NOT COINCIDENT WITH GRADUATION



FIG. 4.—LINE OF SIGHT DEFLECTED BY PARALLEL PLATE MICROMETER

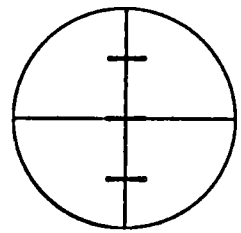


FIG. 5.—LEVEL LINE OF RETICLE COINCIDENT WITH ROD GRADUATION

In the application of this principle, a plane-parallel glass plate is mounted in front of the objective lens of the telescope of the level, and provided, through a linkage, with a means of rotating it about a horizontal axis, as shown in Fig. 2.

In the usual situation, the line of sight will intercept the level rod at some interval between two graduations, as shown in Fig. 3.

It is necessary to determine accurately the interval d between the level intercept of the reticle (with the plane-parallel plate untitled) and the rod

graduation below it. This is accomplished by rotating the plane-parallel plate about its horizontal rotational axis (as shown in Fig. 4) introducing a vertical shift of the line of sight (in accordance with the principle illustrated in Fig. 1). This produces an apparent vertical shift of the field of view until a graduation on the level-rod appears to be placed precisely in coincidence with the level line of the reticle with the view of the rod graduations appearing as seen in Fig. 5. The interval, indicated as d in Fig. 3, between the undeflected line of sight (Fig. 2) and the rod graduation, is measured by the amount of rotation of the plane-parallel plate required to effect coincidence of the image of the graduation with the "level" line of the reticle. As shown by Eq. 1, the vertical shift effected varies with the tangent of the angle of tilt of the plane-parallel plate. A mechanical linkage connects the tilting knob with the plane-parallel plate and is so designed that uniform rotation of the knob generates a tangent function of tilting of the plate. A simple drum scale, attached to the tilting knob, permits reading of the amount of rotation of the tilting knob, indicated in units of vertical shift of the line of sight. The rod reading then is simply the reading of the drum scale of the micrometer added to the value of the rod graduation on which the level line of the instrument is set. With the rod graduation pattern currently in use (1/2-cm graduations), the unit of the micrometer scale is 0.5 mm, with tenths of units (0.05 mm = 0.00016 ft) being readily estimated. Present practice is to require the observer to make the setting twice, with spread not to exceed 0.2 unit.

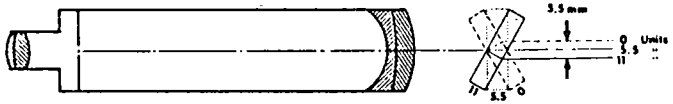


FIG. 6.—NUMERICAL RANGE OF PARALLEL PLATE MICROMETER

The tilting range of the micrometer plate includes 11 micrometer units, or one unit more than the range required exactly to span the interval between two consecutive rod graduations. This relieves the observer from having a decision problem if the untilted position of the micrometer plate happens to place the line of sight almost precisely midway between two rod graduations. He can than make a coincidence with either graduation and have a scale reading available for either setting.

In order not to exceed the limits imposed by the approximations involved in Eq. 1, the tilting range provided for the micrometer plate consists of a motion of equal displacement on each side of the vertical (untilted) position of the plate. A rotation such that the upper edge of the plate is displaced toward the eyepiece causes an apparent raising of the line of sight (lowering of the field of view), while rotation that displaces the upper edge of the plate away from the eyepiece causes an apparent lowering of the line of sight (raising of the field of view).

For convenience in field observing and computation, the micrometer units are numbered from 0 with the line of sight at its maximum upward displacement to 11 at its maximum downward displacement, the reading then being 5.5 units when the plate is at its vertical (untilted) position. The geometry of this system of numbering is shown in Fig. 6.

The advantages of this system of numbering are:

1. All micrometer readings are positive and are always added to the value of the rod graduation on which the level line is set by rotating the tilting knob.
2. All rod readings thus derived are 5.5 micrometer units (2.75 mm) too large; that is, in effect, rod readings are referred to the upper maximum displaced position of the line of sight.
3. Since all readings are too large by a constant amount, any difference of elevation obtained by differences of foresights and backsights is mathematically correct.
4. It is not necessary to set the tilting plate to any specific initial setting. It is merely necessary to set the line of sight in coincidence with a rod graduation and then read the drum scale of the micrometer.

PRECISE LEVELING ROD

Precise leveling rods used in conjunction with the plane-parallel plate micrometer method of leveling are of the "line graduation" type. The rods

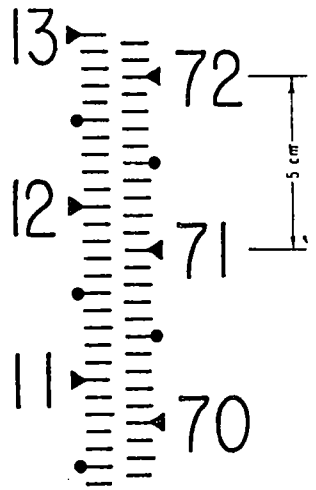


FIG. 7.—GRADUATION PATTERN DOUBLE SCALE PRECISE LEVEL ROD—5 MILLIMETER INTERVAL

used were graduated at 1/2-cm intervals, with every tenth graduation numbered. Needless to say, the rods themselves must be precise and meet the following specifications:

1. Graduations on a single continuous (not collapsible or folding) metal scale, usually of invar.
2. Scale supported on a staff of wood or light extruded metal, but permanently attached to the staff only at the foot, and freely supported under tension by a spring-loaded clamp at the top. The scale is free of longitudinal restraint between the foot and the top. The staff is thus free to change length in response to changes in ambient humidity and/or temperature without affecting the length of the graduated scale.

3. Attached circular level to permit holding of rod vertical within acceptable limits.

There are two vertical rows of graduations. The left-hand scale (or the main scale) is numbered with zero at the foot of the rod as is done with the usual single-scaled rods. The right-hand scale (or the "check scale") has its graduations offset precisely 2.5 half-centimeters below corresponding units of the parallel main scale with the 5-cm unit graduations (Fig. 7) numbered with a higher series of numbers, the first one appearing above the foot of the rod being 60. By this arrangement, a reading from the same level set-up, made on the check scale should be precisely 59.250 units higher than the reading made on the main scale. In operation, both scales are read on every

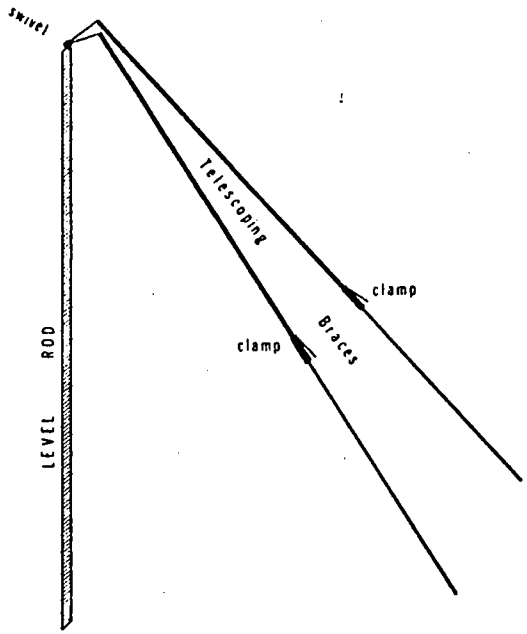


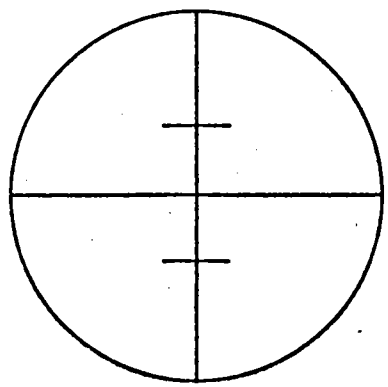
FIG. 8.—SCHEMATIC OF PRECISE LEVEL ROD BRACES

point (both backsight and foresight) and the check is made immediately that the main scale reading plus 59.250 equals the check scale reading within about two units in the third decimal place. Since completely different numbers must be read on the two scales, this constitutes an almost perfect check against numerical blunders in reading. It serves the same purpose as the upper interval vs. lower interval and the front scale (in meters) versus rear scale (in feet) in checks in the three-wire system. It also comprises an additional independent reading, which provides a redundancy at each reading, contributing to the overall precision of the line of levels.

The staff which supports the invar strip with the double graduation is made of light-metal, extruded in a T-section, which provides superior strength and rigidity with lighter weight than the traditional wood staff. Another innovation consists of a pair of metal tubular telescoping braces (Fig. 8) attached by swivel joints to the top of the rod and shod with points on the free ends. The points are stuck into the ground on each side of, and slightly behind the rodman, and the brace lengths adjusted, through a sliding motion, so that the rod is vertical, based on the use of a carefully-adjusted permanently attached bulls-eye level for guidance of the rodman in plumbing the rod, when held on a turning pin or B.M. disc. Once the braces are set, the rod is maintained free from tilt or sway by only minimum maintaining action from the rodman, although, since the rod is vertical, the set-up is not free-standing, and the rodman must hold it continually to keep the rod from falling over with a gust of wind or air pressure wave from passing traffic. The braces fold against the edges of the staff for carrying between points. Error due to sway or careless plumbing of the rod is negligible under systems where readings are estimated to millimeters but with the optical micrometer an appreciable error is introduced if the top of the rod (3 m) is more than about 1-1/2 cm out of plumb. The use of the braces will absolutely eliminate sway of this magnitude, but are ineffective against the errors of a careless rodman. Thus, use of the braces introduces a valuable element of stability in the rod setup, but the foregoing caution against the careless rodman has implications that need no further elaboration. The rods are also equipped with attached thermometers, but these have not been used because the Lake Survey levels involve small differences of elevation to which temperature corrections to the invar scale would be quite insignificant. This practice should be carefully reviewed in any application of the system to more rolling or rugged terrain.

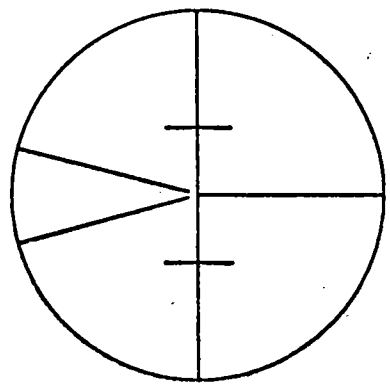
RETICLE DESIGN

The design of the array of lines in the reticle must be carefully considered. The Zeiss Ni 2 level comes equipped with the standard pattern used for leveling which includes a single horizontal level line and a pair of suitably-spaced "stadia" lines (ratio 1:100) as shown in Fig. 9.



STANDARD RETICLE

FIG. 9.—STANDARD RETICLE



WEDGE RETICLE

FIG. 10.—WEDGE RETICLE

This array is not completely compatible with the requirements for making a coincidence setting, because it requires the exercise of some judgement by the observer in setting the single line in the center of the line graduation. A more practical solution to the problem involves the use of the "wedge reticle."

In the wedge reticle, the left half of the horizontal "level" line of Fig. 9 is replaced with a divergent pair of lines, as shown in Fig. 10. The divergent lines provide a sensitive indicator for setting precisely on a definite graduation of finite, but varying, width (the apparent width of a line graduation varies with sight-distance). Rather than to attempt to set the point of the wedge figure on the center of the graduation, the object is to set the wedge so that the upper and lower diverging lines cross the edges of the graduation in the same vertical distribution.

As indicated in Fig. 11(*a*), if the graduation is not centered, the position where the upper reticle line crosses the upper edge of the graduation will be horizontally displaced from the point where the lower reticle line crosses the lower edge of the graduation. Fig. 11(*b*) shows the appearance of the centered

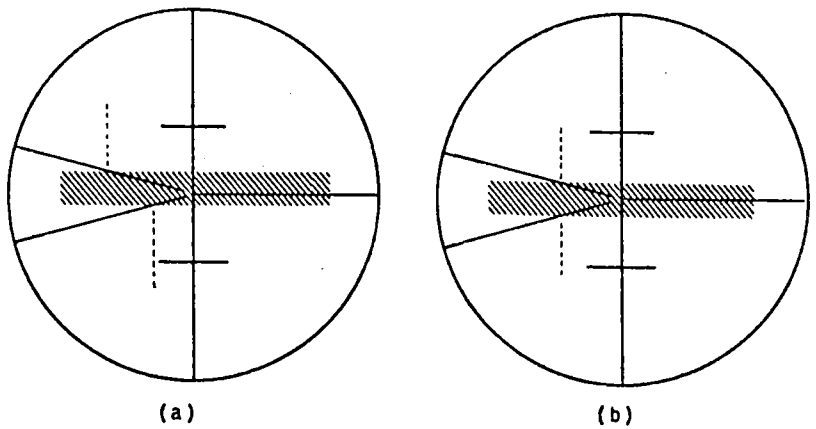


FIG. 11.—WEDGE RETICLE ROD GRADUATION: (*a*) NOT CENTERED; (*b*) CENTERED

graduation; the upper and lower crossings of the wedge lines are precisely in vertical alignment. This setting can be made with considerably more precision than in the bisection of the line graduation with a single level reticle line.

TURNING PINS

The last equipment item is the turning pin. There has been considerable debate of these over the years and no two surveyors will agree on any one design. The Lake Survey has been using a version of this pin, Fig. 12, for many years. This is made from 3-in. bar stock and is about 10 in. long. The upper part of the top is flanged to accommodate a driving cap that is set on top while the pin is driven into place. The highest point, the actual turning point, is provided by a steel hemisphere of appropriate diameter to fit a

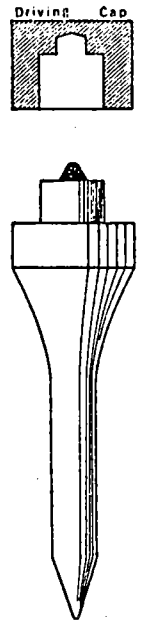


FIG. 12.—TURNING PIN FOR PRECISE LEVEL ROD

receptacle in the base cover plate on the foot of the rod. The driving cap is attached to the turning pin by a short length of chain which serves the dual purpose of preventing loss and providing a ready means of carrying the two parts with one hand. In certain terrain a turning plate, or "turtle" is used, a type which is regularly supplied with European precise level rods.

FIELD PROCEDURES

Personnel requirements vary somewhat from job to job but a basic unit generally consists of a party chief, four-man observing unit and a sixth person who has the capability to assume any position on the observing unit, and also to set bench marks, write descriptions, and assist the party chief in checking field computations.

The field observations must be reduced to an efficient routine if satisfactory progress is to be maintained. Following is an outline of the basic steps followed, with brief explanations as deemed necessary:

1. Designation of the two rodmen (and their rods) as A and B. This is to permit ready compliance with the requirements of steps 9*a* and 9*b*, following.
2. Rodman A holds his rod on the starting bench mark and is observed first at the initial set-up.
3. Rodman B paces (number of steps) from A to the instrument set-up, and paces the same count to the point where he sets his turning pin for the turning point. For high precision, serious effort should be devoted to maintaining sights balanced at every set-up (within two m) rather than simply

maintaining a balance of the sum of backsights and foresights within a section. Pacing is usually adequate for maintaining the balance of sight-distances, but they are checked by stadia readings made on the rod at the time of observations. Pacing must, of course, be calibrated so that the maximum permissible sight distance (50 m) is not exceeded.

4. Rodman B is observed.
5. Instrument is moved to new set-up.
6. Rodman A proceeds to set new turning point, pacing distances to maintain balance of sight distances.
7. Rodman A is observed.
8. Rodman B is observed.
9. Procedure continues:

a. Always observing Rodman A first at each set-up, to permit partial compensation of any systematic settling of instrument such as in soft or frozen ground. To minimize stand-by time interval, when B is foresight, A should not be read until B is in position.

b. As noted by Karren (2), if the circular bubble is not in perfect adjustment (which it never is), the value of the collimation error will change with azimuth. To compensate for this effect, at each set-up, while the instrument is leveled with the circular bubble, the telescope must be pointed in the direction of Rodman A. With this procedure, the instrument will be alternately pointed backward and forward along the level line, as it is leveled.

10. Leveling of a section is concluded by observation on a bench mark. Care must be taken by the observer, at the last set-up, to set the instrument so that the sight distances of backsight and foresight are equal.

The actual readings are simple but must be made in systematic order, to maintain progress and avoid blunders. As noted previously, the rod has two scales, the main scale and the check scale, which provide checks against blunders and double reading for increased precision. Sight distance is observed on each scale, using only the upper stadia line (1:100) provided in the reticle. This reading is combined with the level reading to obtain a half-intercept which, since the rod is graduated in half-centimeter units, gives the sight distance directly in meters. This avoids using the lower stadia line (except when the upper line is "off the rod") which may be close to the ground and anomalously refracted. Level readings of less than 10 (i.e. 1/2 m above ground) are to be avoided.

Sequence of readings on rod, both backsight and foresight, is:

1. Level reading on main scale is made. The micrometer is set twice with spread not more than 0.2 micrometer unit.
2. With level setting of micrometer unchanged, reading of upper stadia line is made, estimating to single micrometer unit. Recorder computes and records sight distance. For this purpose, the level reading is taken as the integral value of the rod graduation on which the level line is set (micrometer reading is ignored but the micrometer plate setting is left unchanged). The integral level reading subtracted from the upper stadia reading gives the sight distance in meters.
3. Level reading on check scale is made. While this reading is being made, recorder adds 59.250 to level reading of main scale. As soon as check scale reading is made, it is compared with main scale plus 59.250. If it does not agree within 0.2 micrometer unit (2 in third decimal place of rod units) both main scale and check scale readings are repeated.
4. Check is made on sight distance. Using the check scale, and with the micrometer still unchanged from coincidence, the observer counts units on the check scale intercepted between level and the upper stadia line. This gives a second determination of sight distance. In the first determination, the recorder computes the intercept from the readings; whereas in the check determination, the observer actually counts the intercepted units. Hence, the distance is determined twice, with different numbers used, and by two independent persons.

It is realized that the position of the anallactic point is displaced when stadia intercepts are observed through a tilted parallel-plate micrometer, but if the tilt of the plate is not changed between making the level and upper intercept readings, approximate calculations indicate that the error in the sight distance will not exceed about 3 cm.

As is usual with precise levels, lines are run in sections of 1 km to 2 km, with a bench mark at end of every section. Each section must be run twice, in opposite directions, preferably on different days, one run in the morning and the other in the afternoon. The elevation difference as determined by the two runs of a section must not differ by more than 1.5 mm times the square root of the section length in kilometers.

A collimation check is made by the standard "peg" method at the beginning of each day. Adjustment of the line of collimation is made if a correction of 0.1 mm in 10 m is indicated. The difference between the sum of foresights and sum of backsights in a section must never exceed 5 m and is not expected on the average to exceed 2 m. Under these tolerances, no correction for collimation is required.

BENCH MARKS

The main objective of the first-order leveling program is to provide elevations not only for Lake Survey and other Corps of Engineers Districts use but also for other government agencies, private surveyors, etc. The elevations derived are only as good as the permanent bench marks that are established. No one type of mark is best suited in all cases. Over the years many bench marks of the precast type, cast in place, discs in building foundations, on bridge piers, large culverts, etc., have been used. In recent years satisfactory results have been obtained with use of a 5/8-in. "copperweld" rod. These rods are driven by manual or power hammers to refusal, in successive coupled sections and left with the top 2 in. to 6 in. below the ground surface. No identifying disc is placed on the top of the rod. This tends to eliminate tampering by souvenir seekers and also leaves minimum surface for frost action. Being thus below the ground and out of sight, very few of this type mark have been lost. Of course, a complete description with good dimensions must be written so that the mark can be recovered in the future.

During the summer of 1968, it was decided to experiment with a new type of deep bench mark originally designed by the National Research Council of Canada (1) for use in studies of building settlement in permafrost areas. The application of this design to geodetic bench marks was instituted in 1967 by

the Geodetic Survey of Canada. The techniques and equipment used in setting these marks were demonstrated to Lake Survey personnel in that year. Lake Survey design and techniques are essentially identical except for minor deviations to take advantage of existing equipment available for the purpose.

The fundamental novelty in the design is the use of two concentric galvanized steel pipes; an inner 3/8-in. pipe, with a special steel driving foot screwed on the lower end and with a stainless steel stud screwed on the top to serve as the actual bench mark, surrounded by a 1-in. pipe which fits onto the driving foot.

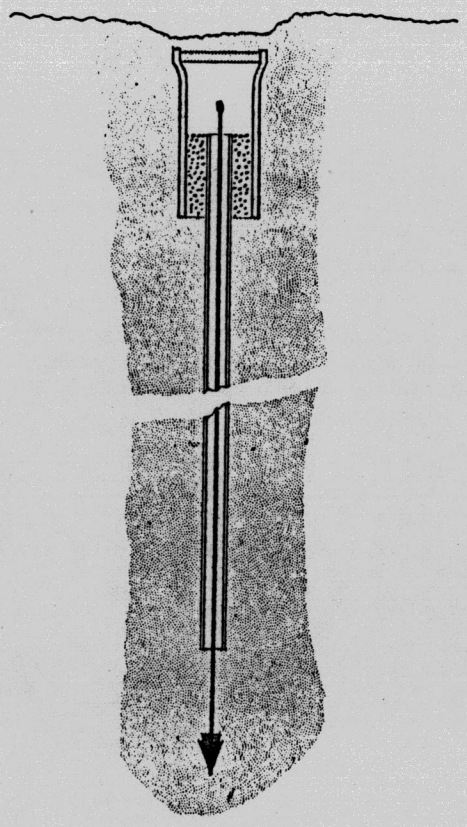


FIG. 13.—DEEP BENCH MARK

Driving is accomplished by a large truck-mounted soil-sampling rig with a motor-driven hydraulic tower-mounted jack which, acting through a chuck, drives the outer pipe which, as stated above, bears on the driving foot and thus pulls the inner pipe with it, although there is no other firm attachment between the two pipes. The rig is capable of exerting a simple vertical thrust of about 15,000 lb. The pipe is driven to refusal, additional sections of both inner and outer pipe being screwed on as required. The outer pipe is withdrawn about a half meter. At the top, the outer pipe is cut off about 30 cm

below the ground and the inner pipe about 10 cm above this.

The top of the inner pipe is threaded and a high-pressure grease pump is attached. Grease is pumped under pressure into the top of the inner pipe, from where it goes down and escapes through holes drilled near the bottom of the inner pipe but above the level to which the bottom of the outer pipe was withdrawn after driving. Escaping through the holes in the inner pipe, the grease works its way into the annular space between the inner and outer pipes. Pumping continues until the grease appears at the surface, at which time it is assumed that the annular space is essentially filled with grease from top to bottom. The grease pump is removed and the top steel stud screwed in place for the reference point of the bench mark. A single section of 6-in. concrete pipe is placed around the bench mark at the top, with its top 5 cm to 10 cm below ground. The inside of the concrete pipe from its lower end to the top of the outer pipe is filled with loose crushed rock (Fig. 13). The job is completed by placing a special concrete disc cover in the top of the concrete pipe and backfilling. No surface mark is visible and the bench mark can only be found by using the descriptive data and reference measurements.

It is presumed that the earth displaced by the outer pipe when it was driven to its deepest position will fill back into the space below the withdrawn bottom end of the outer pipe and eventually provide a secure anchorage around the driving foot. To permit this to take place, the bench marks are placed at least a month before the levels are run. If at least five meters of penetration is not achieved, the location is rejected and an alternative site selected. In some locations, penetrations of about 30 m are obtained.

Deep bench marks are comparatively expensive and, at this time, no attempt is being made to use them to the exclusion of other types. In the first season, they were put in sets of three at all locations of permanent water level gages and singly along the level line about 15 km apart. Since their usefulness will depend on availability for future large-scale releveling at 10-yr to 20-yr intervals, serious efforts were devoted to placing them in locations with some expectancy of permanence. Attempts were made to place them in city parks or on federal reservations, such as Coast Guard stations or post office grounds. The sets of three were distributed so that, hopefully, all would not be destroyed by a single construction operation.

AUTOMATION EXPERIMENTS

Preliminary experiments are being tried to extend the possibilities of remote terminal computer operation to a field survey situation. At present, a teletype unit is used in the field party to transcribe each day's field notes to a punched-paper tape which, through a portable acoustic coupler, is transmitted over commercial voice-grade long distance telephone, as input data to a central computer in the Detroit area. The results of the day's work are received back through the field teletype unit in a minute or two with the elevation differences, divergences, section misclosures, etc., completely tabulated. This stage has been accomplished with complete satisfaction, but the necessity still remains for manual recording all day in the field notebook, with transcription to a tape at the end of the day. Equipment is now being

procured which, hopefully, will permit mounting the teletype unit in a truck which will be kept alongside the field unit all day. It is expected that all field notes will be entered directly, in the field, onto punched-paper tape with complete elimination of the field notebook. This will permit immediate transmission of the data to the computer at the end of the day without the intermediate time-consuming effort of transcription from the manual field notes.

CONCLUSIONS

Studies were undertaken to examine the feasibility of using the Zeiss Ni 2 level (Fig. 14) for levels of high precision, with the addition of the plane-

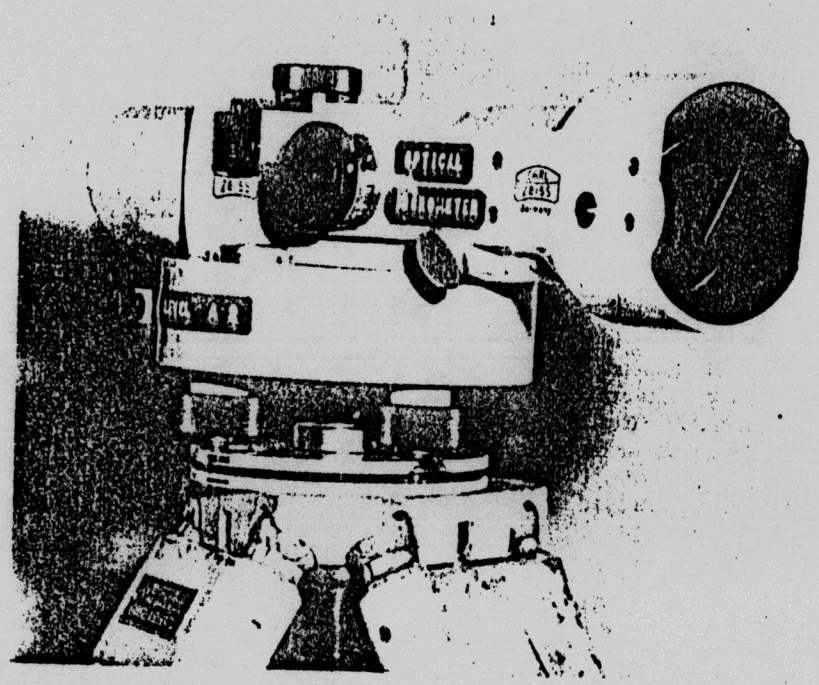


FIG. 14.—ZEISS NI 2 LEVEL WITH PLANE-PARALLEL MICROMETER ATTACHMENTS

parallel plate micrometer. Standard techniques were devised for accomplishing this with satisfaction. Allowable closures were to be 1.5 mm $\sqrt{K}$ where K = length of the section in kilometers. Results so far using these methods have been gratifying. After the first season, closures were computed and checked and the average of all sections leveled was found to be 0.58 mm $\sqrt{K}$.

Methods outlined herein have been adopted as standard procedures for all Lake Survey first-order level lines.

APPENDIX.—REFERENCES

1. Bozozuk, M., Johnston, C. H., and Hamilton, J. J., "Deep Bench Marks in Clay and Permafrost Areas," Paper 86-C, National Research Council, Ottawa, Canada, 1962.
2. Karren, Robert J., "Recent Studies of Leveling Instrumentation and Adjustment," *Surveying and Mapping*, Vol. XXIV, No. 3, 1964, pp. 383 et seq.
3. Warchalowski, Edward, "Geometrical Leveling," U.S. Department of Commerce, Office of Technical Services, (TT61-11319), translated from Polish, Warsaw, Poland, 1965.

APPENDIX C

- PROJECT INSTRUCTIONS FOR ATLANTIC HYDROGRAPHIC PARTY, FLORIDA -

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SURVEY
Rockville, Md. 20852

Date: AUG 20 1974

Reply to Attn of: C3x4

Subject: PROJECT INSTRUCTIONS: OPR-508-AHP-74, Northwest Coast of Florida

To: Director, Atlantic Marine Center

Subject Instructions are forwarded for issuance to the Chief, Atlantic Hydrographic Party.

The copies required for distribution by this Office have been retained.

for Donald R. Tibbitt
Robert C. Munson
Associate Director
Office of Marine Surveys
and Maps

Attachment

August 26, 1974

1ST ENDORSEMENT

TO: Chief, Atlantic Hydrographic Party

Forwarded for your compliance.

Alfred C. Holmes
Director, Atlantic Marine Center

cc: CAM02
CAM101, CAM102
CAM3
CAM5
CAM6, 4, XO

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SURVEY
Rockville, Md. 20852

C3x4

AUG 2 0 1974

Chief
Atlantic Hydrographic Party

PROJECT INSTRUCTIONS: OPR-508-AHP-74, Northwest Coast of Florida

1.0. GENERAL

1.1. The purpose of this survey is to provide hydrographic data needed to respond to expressed user requirements for improved charting.

1.2. Work on this project is scheduled to resume in early November 1974. Hydrography shall begin at a junction with the 1973 surveys and proceed systematically north and northwest, remaining within Area I. Area II is scheduled for completion by other field elements and/or by photobathymetry.

1.3. The Special Investigation of the approaches to Tampa Bay, as outlined in Section 5.0, shall be completed prior to the resumption of basic hydrography on OPR-508.

2.0. GEODETIC CONTROL

2.1. Geodetic control data and required support will be furnished by the Atlantic Marine Center.

3.0. HYDROGRAPHY

3.1. A project limit sketch has been furnished.

3.2. Hydrography shall be basic and in accordance with the Hydrographic and AMC Manuals.

3.3. Hydrography will be controlled by electronic methods.

3.4. Depth Unit: Soundings shall be recorded in feet.

3.5. Junctions: Satisfactory junctions shall be made with all contemporary surveys. Copies of the sheets H-9390 (746-20-2-73) and H-9391 (746-20-3-73) will be furnished by AMC.

3.6. Inshore Limit: Hydrography should be run as close to shore as conditions permit but not so far as to reduce the effectiveness of the operation. The inshore limit of Area I should be, if possible, in an area with a regular bottom to facilitate junctioning when the inshore hydrography in Area II is accomplished.

3.7. Scales: The basic scale for the project area will be 1:20,000. Larger scales are authorized where considered necessary.

3.8. Line Spacing: Sounding line spacing shall not exceed 200 meters in Area I. Line spacing shall be reduced as necessary to develop shoals and to show bottom configuration adequately.

3.9. Presurvey Review: The Presurvey Review dated September 26, 1972, has been examined and no additional items have been found. The Presurvey Review is now considered to be updated to July 30, 1974.

3.10. Crosslines: Hydrography shall be verified by crosslines to the extent of 8-10 percent of the principal system of sounding lines, exclusive of development.

4.0. TIDES

4.1. It is the responsibility of the Officer-in-Charge to see that proper field monitoring of all tide gages in support of this project is carried out. A line of communication must be established between the party and any contract observer to ensure prompt notification of gage malfunctions or changes in the staff-gage relationship. Breaks or invalid tide records from any gage in excess of three continuous days cannot be interpolated. This might result in a loss of tide control to the extent that a resurvey of the area involved would be required. Time and staff comparisons are required whenever a gage is checked.

4.2. St. Marks and St. Petersburg, Florida, will serve as the reference stations for predictions. The tide stations operating at Clearwater Beach, Cedar Key, and Shell Point will provide additional basic control, and will also be used for datum determination in smooth reduction of soundings in the vicinity. Copies of the latest NOAA Form 77-12 (Report - Tide Station) will be furnished by the Rockville Office. Servicing of these tide gages is not required.

4.3. As field work progresses, tide gages shall be installed and operated during the entire period of hydrography in the vicinity. In addition to this requirement, the gage at St. George Island (d.) should be operated for a minimum of 30 days.

	Station	Approx. Lat. (N)	Approx. Long. (W)
a.	Indian Rocks Beach	27°52.4'	82°51.1'
b.	Anclote Lighthouse, Anclote Keys	28°09.9'	82°50.6'

	Station	Approx. Lat. (N)	Long. (W)
*c.	Lighthouse Point	29°55.0'	84°20.0'
d.	St. George Island, East End	29°41.2'	84°47.2'
*e.	Dog Island, East End	29°49.0'	84°35.0'
f.	Sand Island, West Pass	29°37.6'	85°05.6'

*No tidal bench mark data are available.

4.4. Servicing and proper operation of these gages must be assured by the hydrographic party.

4.5. Levels will be required to a minimum of five permanent bench marks (standard disks), for all 30-day stations and three permanent bench marks for stations operating for less than 30 days. Three additional bench marks shall be established at Anclote Lighthouse and Anclote Keys. Previously established bench marks were destroyed.

4.6. For each tide gage location, a NOAA Form 77-12 (C&GS 681) shall be submitted. In addition, a nautical chart section indicating the location of the tide gage, staff, and bench marks shall be provided for each location. A description of each new bench mark established shall be included in NOAA Form 76-77 (C&GS 258).

4:7. All tidal work shall be in accordance with the Hydrographic Manual, AMC Manual, and the Manual of Tide Observations.

4.8. Geographic limits of each tide zone, tide gage used, and any time and range corrections shall be included in the Tide Note of the Descriptive Report. A copy of the Tide Note shall be sent to the Oceanographic Division, C331. Assistance with tidal zoning will be provided by the Oceanographic Division, C331, upon request.

5.0. SPECIAL INVESTIGATION

5.1. Reports have been received concerning shoaling in the approaches to Egmont Channel at the entrance to Tampa Bay. Shoaling to a depth of 30 feet has been reported in the "Safety Fairway" approaches to this channel where the general charted depths range from 40 to 60 feet.

5.2. Because of these potentially serious discrepancies, a basic survey of this area shall be conducted before regular progression resumes on

OPR-508. Surveys shall begin at the entrance to the channel marked by buoys "1" and R"2" and proceed westward, while remaining within the "Safety Fairway," to the 11-fathom curve or until depths are encountered that corroborate those portrayed on the chart. Should this occur, inshore of the 11-fathom curve, reconnaissance hydrography should then be run over the remaining area.

If extensive changes are found within the Fairway west of Egmont Channel buoys "1" and R"2," basic survey work should be expanded to a larger area, bounded by the following limits:

Limits: 27°30'N to 27°40'N
82°50'W to the 11-fathom depth curve

5.3. Hydrography shall be basic and in accordance with the specifications of the Hydrographic and AMC Manuals.

5.4. Hydrography shall be controlled by electronic methods.

5.5. Scale: The scale of this Special Investigation shall be 1:20,000.

5.6. Line Spacing: Sounding line spacing shall not exceed 200 meters in the areas of basic hydrography. Line spacing shall be reduced as necessary to develop shoals and to show bottom configuration adequately.

5.7. Tides: St. Petersburg, Florida, will serve as the reference station for predictions. Corrections for the approaches to Egmont Channel (Tampa Bay) will be from Table 2, No. 3074 Egmont Key, Egmont Channel, of the East Coast Tide Table.

5.8. A tide gage shall be installed at Egmont Key and shall be operated during the period of the survey. Bench mark descriptions and a sketch showing their location are provided.

5.9. If serious shoaling is discovered, appropriate Notice to Mariners action should be initiated and pertinent field records forwarded to headquarters through AMC at once.

6.0. MISCELLANEOUS

6.1. Reports shall be submitted in accordance with Sections 2-36 through 2-44 of the Hydrographic Manual.

6.2. The Coast Pilot description of the project area shall be carefully reviewed and a special report submitted in accordance with the Hydrographic Manual and Section 9 of the Coast Pilot Manual, Third (1969) Edition.

6.3. Accomplishments shall be reported on NOAA Form 12-8b under Work Identification Code 0132050 (Hydrographic Surveys).

6.4. Monthly progress sketches shall be submitted to AMC at the scale of chart C&GS 1114. Progress sketches shall include the sheet layout and the assigned field and registry numbers.

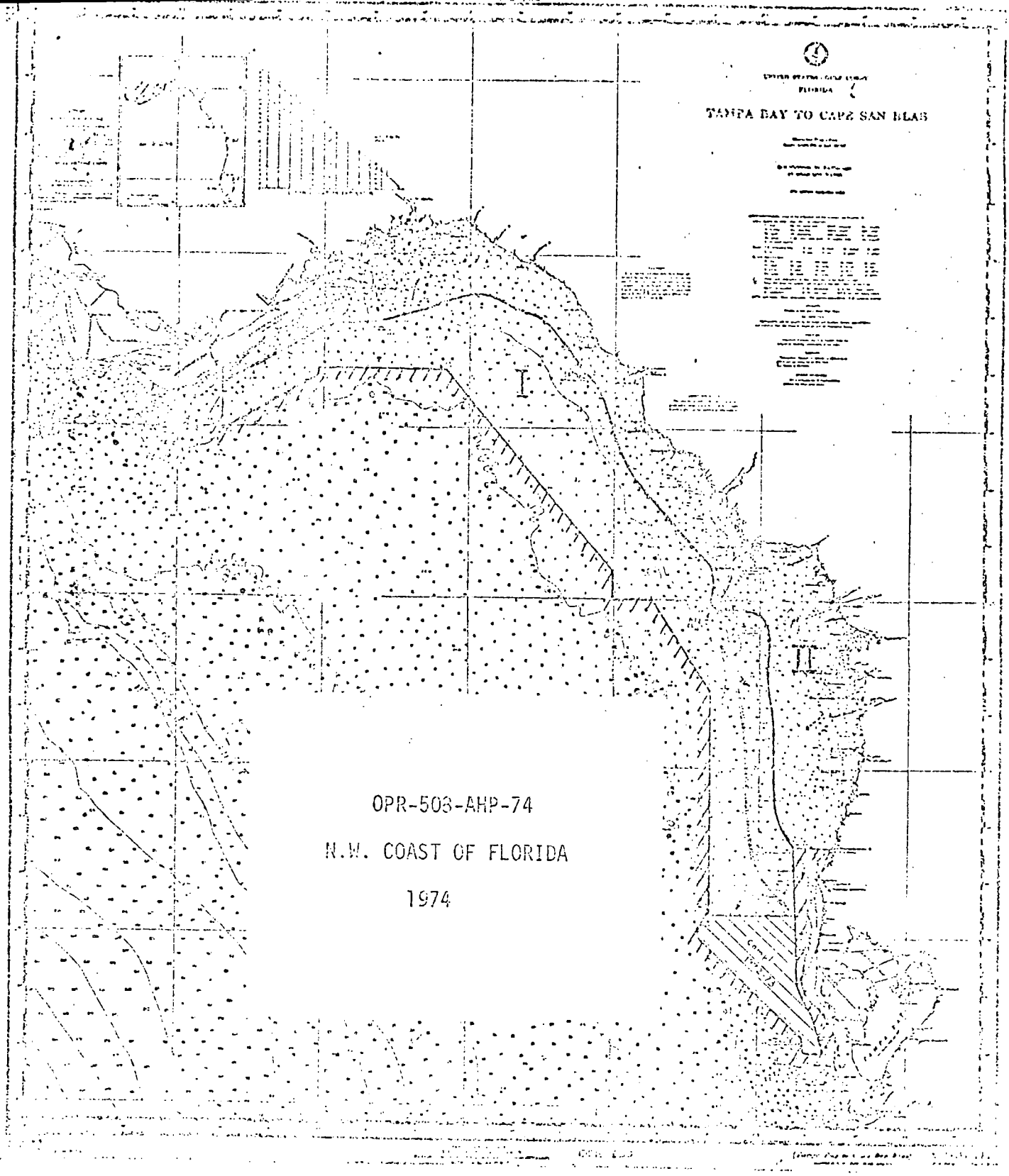
6.5. Responsive public service requires that every reasonable effort be made to keep the public aware of NOS activities and the results. Upon completion of your project, contact shall be made with the NOS Public Affairs Officer (PA11), phone (301) 496-8708, to report newsworthy accomplishments.

6.6. Submit recommendations if it appears advisable to amend these instructions.

6.7. Receipt of these instructions shall be acknowledged.

Donald R. Tibbet

Robert C. Munson
Associate Director
Office of Marine Surveys
and Maps



OPR-503-AHP-74

N.W. COAST OF FLORIDA

1974

3/12/71

FLORIDA III - 35

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SURVEY

TIDAL BENCH MARKS

Egmont Key, Tampa Bay
Lat. 27°36'.0; Long. 82°45'.6

BENCH MARK 1 (1858) is a chiseled mark about 2½ inches in diameter, ½-inch deep, on threshold of entrance to Egmont Key Lighthouse. It is about 1 foot from right-hand edge of door as one enters. Elevation: 9.00 feet above mean low water.

BENCH MARK 4 (1937) is a standard disk, stamped "NO 4", set in southwest corner of concrete platform on rear of warehouse building on lighthouse dock. It is about 2½ feet above ground, ½ foot from south face of platform and ½-foot east of west face of platform. Elevation: 8.78 feet above mean low water.

BENCH MARK 5 (1937) is a standard disk, stamped "NO V", set in concrete base on east side of flag pole in front of old lightkeeper's house. Elevation: 5.83 feet above mean low water.

BENCH MARK 6 (1937) is a standard disk, stamped "NO VI", set in southwest corner of remains of base of old radio tower at head of dock, 5 feet south of dock and 10 feet west of walk leading to lightkeeper's house. Elevation: 5.82 feet above mean low water.

BENCH MARK 7 (1951) is a standard disk, stamped "B. M. 7 1951", set approximately 4 feet from southwest corner of old dock, on 6-inch by 22-inch concrete floor beam. This beam is one nearest to shoreline and approximately parallel to it. Elevation: 6.12 feet above mean low water.

Mean low water at Egmont Key is based on 21 months of records, January 1925 - September 1926, reduced to mean values. Elevations of other tide planes referred to this datum are as follows:

(OVER)

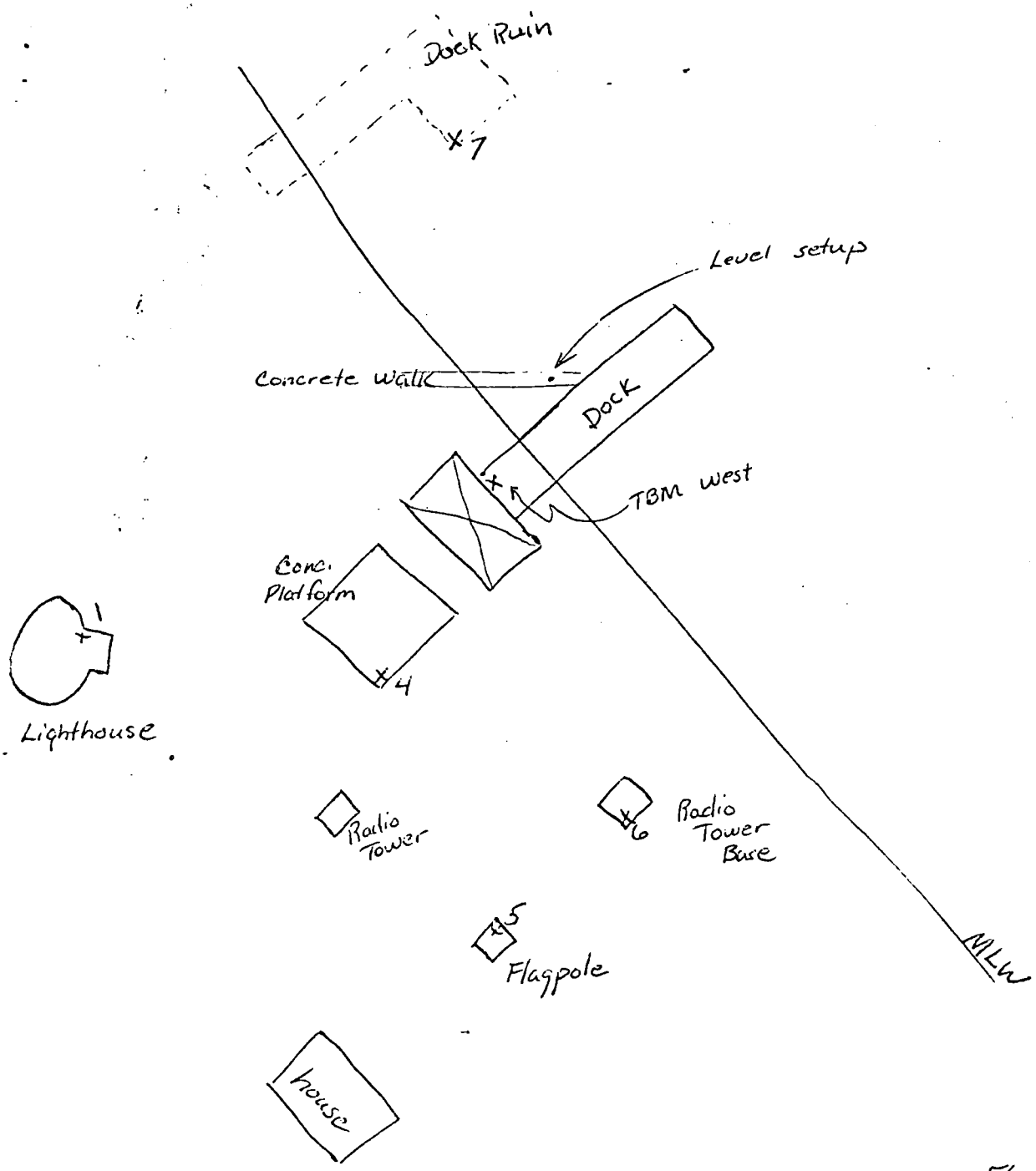
Egmont Key, Tamp Bay - (Cont'd.)

	Feet
Mean high water	2.10
Mean tide level	1.05
Mean low water	0.00

The estimated highest water level to the nearest half foot is 5 feet above mean low water. The estimated lowest water level to the nearest half foot is 2½ feet below mean low water.

NOTE: The tides are chiefly diurnal at this locality.

Egmont Key Side



Egmont Key, Fla.
1/22 - 2/1/57

5/5/64

FLORIDA - III - 52A

U. S. DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY

TIDAL BENCH MARKS

Indian Rocks Beach, Gulf of Mexico
Lat. 27° 52'.4; Long. 82° 51'.1

BENCH MARK 4 (1937) is a standard disk, stamped "NO 4" set in northwest corner of concrete post of sea wall of apartment house. Post marks outer end of property line between bathhouse and apartment house. Bench mark is 200 feet west of center line of road, and 6/10 mile south of intersection of State Highways 694 and 699. Elevation: 10.56 feet above mean low water.

BENCH MARK 5 RESET (1954) is a standard disk, stamped "NO 5 RESET 1954", set in top of a concrete post flush with ground about 110 yards south-southwest of Indian Rocks swing bridge, 24 feet west of center line of new road, 1½ feet north of a concrete fence 5½ feet high and at the southeast corner of the Indian Rocks Beach parking area. Elevation: 8.48 feet above mean low water.

BENCH MARK 6 (1963) is a standard disk, stamped "TBM 6 1963" set flush in top of concrete seawall at 30 Gulf Boulevard owned by Louis Snelling. It is 1 foot south of concrete wall between properties located at 30 and 34 Gulf Boulevard. Elevation: 9.94 feet above mean low water.

Mean low water at Indian Rocks Beach, Gulf of Mexico is based on 2 months of records, January-February 1964, reduced to mean values. Elevations of other tide planes referred to this datum are as follows:

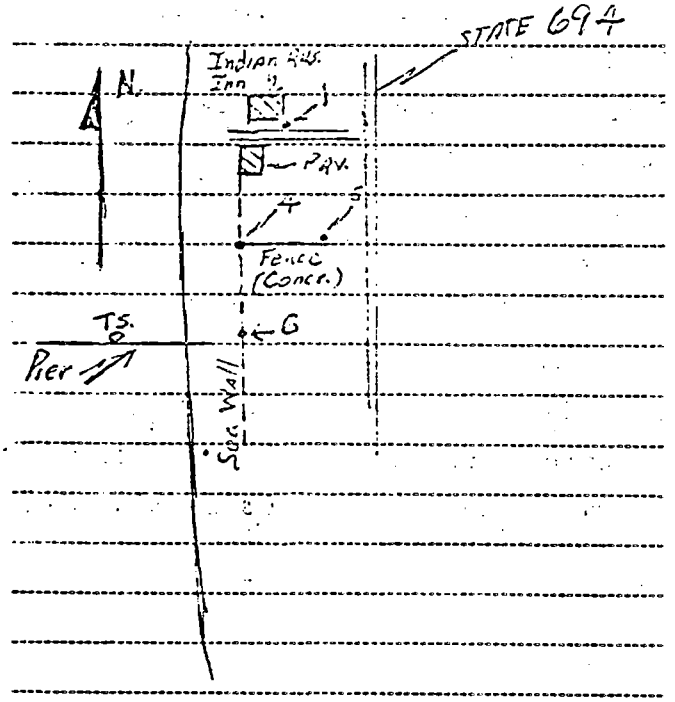
	Feet
Mean high water	2.70
Mean tide level	1.35
Mean low water	0.00

The estimated highest water level to the nearest half foot is 5 feet above mean low water. The estimated lowest water level to the nearest half foot is 3 feet below mean low water.

NOTE: The tides are considered as chiefly diurnal at this locality.

USCOMM-C&GS-DC

8 SKETCH SHOWING LOCATIONS OF TIDE STATION AND BENCH MARKS



Indian Rocks Beach Florida

V.I. Sobrinos

October 1915

16—21453-3

REMARKS 9

16—21453-2

8/17/62

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U. S. DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY

TIDAL BENCH MARKS

Anclote Lighthouse, Anclote Keys
Lat. 28° 09'.9; Long. 82° 50'.6

BENCH MARK 1 (1925) is a standard disk, stamped "BM 1 1925," set flush with concrete base of lighthouse, on south end of Anclote Key, 429 feet northwest of high water line at inshore end of dock, about 4 feet east from center of lighthouse, 3 feet from metal door of entrance to lighthouse and 1½ feet from face of lighthouse. Bench mark is 125 feet northeast of high water line on west side of key. Elevation: 6.17 feet above mean low water.

BENCH MARK 3 (1925) is a standard disk, stamped "BM 3 1925," set in center and top of concrete sidewalk, on south end of Anclote Key, 480 feet northwest from high water line at inshore end of dock, 8 feet southeast of southeast corner of west house, 29 feet southwest of southwest corner of east house, 47 feet northwest of center of Anclote Keys Lighthouse and 2 feet southwest from center of sidewalk corner. Bench mark is 110 feet northeast of high water line on west side of key. Elevation: 4.92 feet above mean low water.

DESTROYED DESTROYED UNRECOVERED

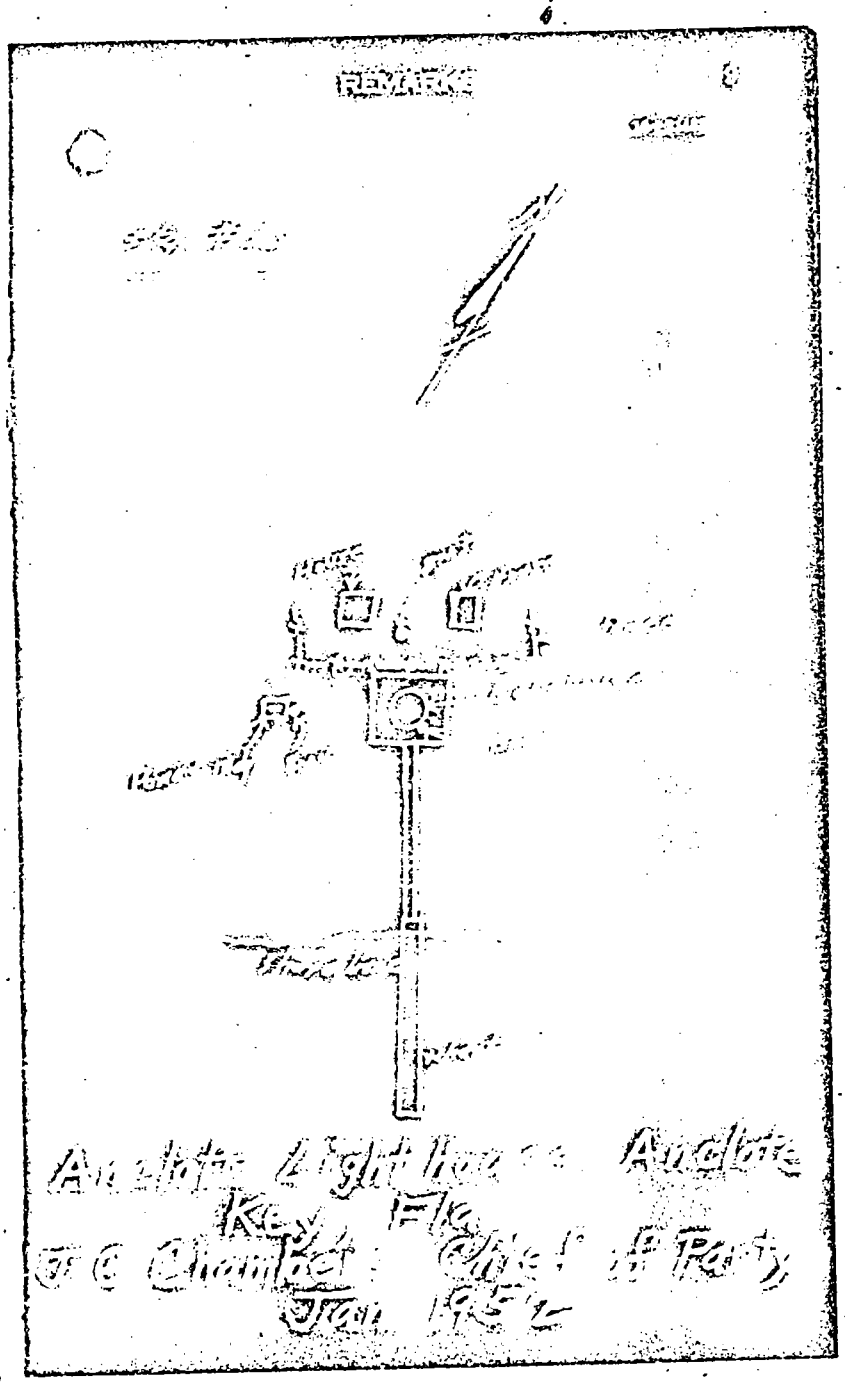
BENCH MARK 4 (1950) is a standard disk, stamped "NO 4 1950," set in granite door sill of brick power house (11½ feet by 14 feet), 68 feet west of center of lighthouse, 48½ feet south-southwest of southwest corner of west house, 60 feet east of high water line on west side of key. It is set in lower step of granite block flush with level of sidewalk leading west from lighthouse. Elevation: 4.69 feet above mean low water.

Mean low water at Anclote Lighthouse, Anclote Keys, is based on 6 months of records, October - November, 1950, and February - May, 1951, reduced to mean values. Elevations of other tide planes referred to this datum are as follows:

	Feet
Mean higher high water	2.50
Mean high water	2.10
Mean tide level	1.05
Mean low water	0.00
Mean lower low water	-0.50

The estimated highest water level to the nearest half foot is 5½ feet above mean low water. The estimated lowest water level to the nearest half foot is 3½ feet below mean low water.

USCOMM-CGS-DC


REMARKS

9/19/73

FLORIDA III

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SURVEY
TIDAL BENCH MARKS

St. George Island, East End, Gulf of Mexico
Lat. 29°41.2'N; Long. 84°47.2'.W

BENCH MARK 1 (1972) is a standard disk stamped "NO 1 1972," set flush in the top of a concrete post, along a shell road, north of its junction with Florida State Road 300. The mark is 65 feet east of the most inshore piling of an old abandoned pier, at the northeast corner of a parking lot, 52 feet west of the last post in an abandoned east-west barbed wire fence, 49 feet south of a large leaf pine tree in a small sand hollow and 3 feet east of a concrete post. Elevation: [redacted] feet above mean low water ([redacted] feet above mean high water).

BENCH MARK 2 (1972) is a standard disk, stamped "NO 2 1972," set flush in the top of a concrete post, approximately 507 feet south of the centerline of an old abandoned pier, 36 feet east of the centerline of the local road, and 2.3 feet east of a concrete post. Elevation: [redacted] feet above mean low water ([redacted] feet above mean high water).

BENCH MARK 3 (1972) is a standard disk, stamped "NO 3 1972," set flush in the top of a concrete post, northeast of the first turn to the west of the road leading from SR 300 to the abandoned pier, 740 feet north of the centerline of SR 300, and 5 feet west of a concrete post. Elevation: [redacted] feet above mean low water ([redacted] feet above mean high water).

BENCH MARK 4 (1972) is a standard disk, stamped "NO 4 1972," set flush in the top of a concrete post, 470 feet north of the centerline of SR 300, 15 feet west of the centerline of the road leading from SR 300 to the abandoned pier, and 3.2 feet west of a concrete post. Elevation: [redacted] feet above mean low water ([redacted] feet above mean high water).

BENCH MARK 5 (1972) is a standard disk, stamped "NO 5 1972," set flush in the top of a concrete post, 175 feet north of the centerline of SR 300, 20 feet west of the centerline of the road leading from SR 300 to the abandoned pier, and 3 feet west of a concrete post. Elevation: [redacted] feet above mean low water ([redacted] feet above mean high high water).

(OVER)

St. George Island, East End, Gulf of Mexico

BENCH MARK 6 (1972) is a standard disk, stamped, "NO 6 1972," set flush in the top of a concrete post, 54 feet south of the centerline of SR 300, 25 feet east of the centerline of a sand road leading from SR 300 to the gulf beach, and 2.8 feet east of a concrete post. Elevation: [redacted] feet above mean low water ([redacted] feet above mean high water) [redacted]

Mean low water at St. George Island, East End, is based on 2 months of record, September and October, reduced to mean values. Elevations of other tide planes referred to this datum are as follows:

	Feet
Mean high water	~~2.00~~
Mean tide level	~~1.00~~
Mean low water	~~0.00~~

The estimated highest water level to the nearest half foot is [redacted] above mean low water. The estimated lowest water level to the nearest half foot is ~~2~~ feet <u>below</u> mean low water.

~~NOTE: The tides are considered as chiefly diurnal at this locality.~~

St George Island

4 SKETCH SHOWING LOCATIONS OF TIDE STATION AND BENCH MARKS

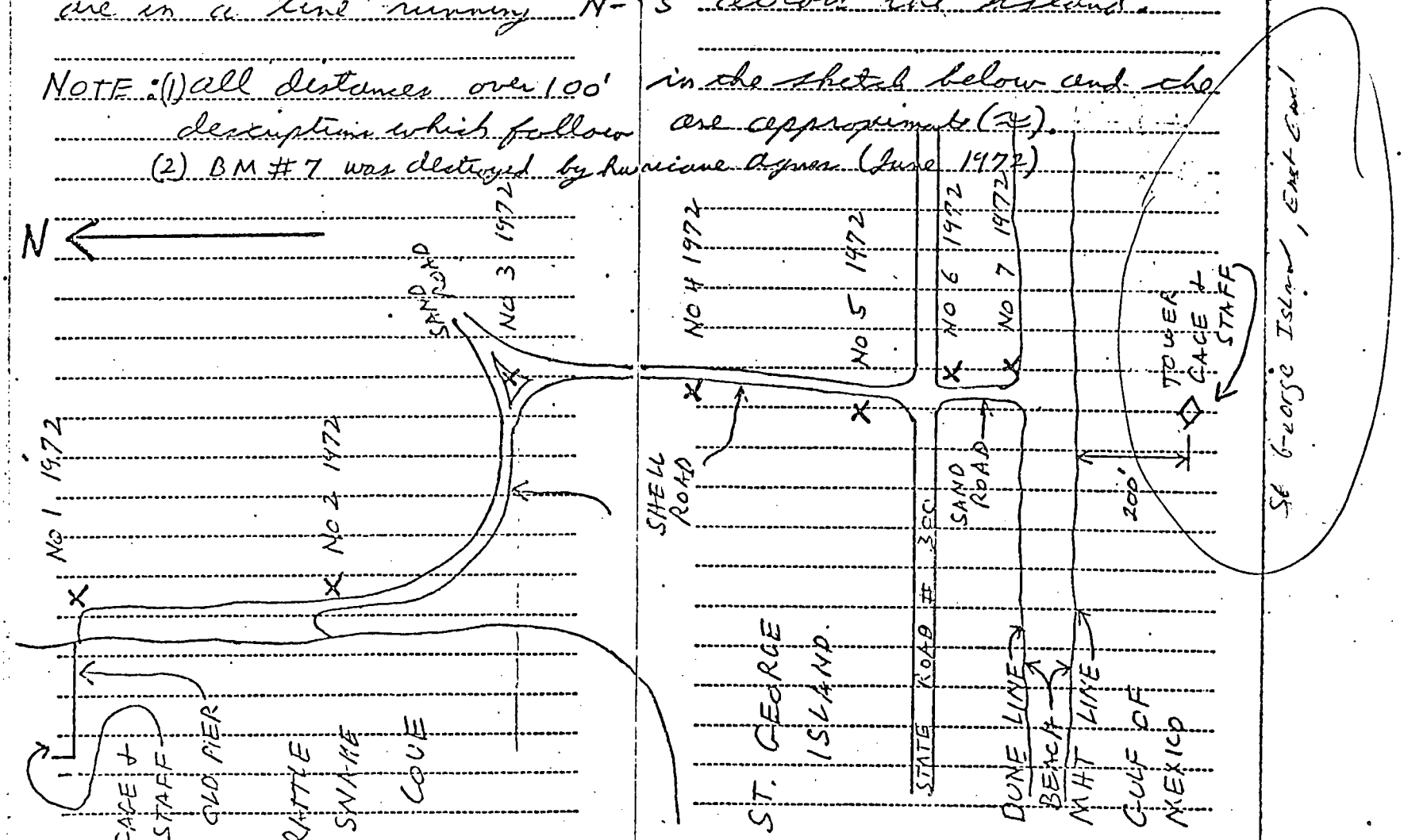
REMARKS Florida 5

5/28/72

Both gages - Rattlesnake Cove tied into the same level line are in a line running N-S across the island and East Gulf of Mexico, are (7) B.M. disks. These disks are shown in the sketch below and the distances are approximate (≈).

NOTE: (1) all distances over 100' are approximate (≈).

(2) BM #7 was destroyed by Hurricane Agnes (June 1972)



9/14/62

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U. S. DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY

TIDAL BENCH MARKS

Sand Island, West Pass to Apalachicola Bay
Lat. 29° 37'.6; Long. 85° 05'.6

BENCH MARK 3 (1909) is triangulation station WEST PASS 2 and is center of concrete-filled 4-inch tile embedded in block of concrete 6 inches square and 2 inches below surface of ground, on northwest end of Sand Island, at inshore base of sand ridge which is about 165 feet from high water line. Bench mark is in low ground to east and north of sand dunes, about 105 yards from twin pine trees in azimuth 141 degrees 45 minutes about on range with largest pine tree on point, a palmetto tree near headstone (Lewis Island), and another lone palmetto tree about 3/4 mile southeastward. Elevation: 5.70 feet above mean low water.

BENCH MARK 4 (1909) is reference mark No. 1 (1909) for triangulation station WEST PASS 2 and is top of 1-inch galvanized iron pipe, 6 feet long, projecting 1 foot above surface of ground. It is set in 10-inch square concrete block, on line between Bench Mark 3 and twin pine trees, distant 108 feet and 210 feet respectively and about 110 feet from Bench Mark 3 in azimuth 321 degrees 45 minutes. Elevation: 6.13 feet above mean low water.

BENCH MARK 5 (1909) is reference mark No. 1 (1934) for triangulation station WEST PASS 2 and is top of 1½-inch galvanized iron pipe, 6 feet long, projecting 1 foot above surface of ground, in 10-inch square concrete block, about 130 feet east-northeasterly from Bench Mark 3. Elevation: 5.59 feet above mean low water.

BENCH MARK 6 (1942) is reference mark No. 2 (1934) for triangulation station WEST PASS 2 and is a standard reference mark disk, stamped "WEST PASS 2 NO 2 1934," set in concrete post, flush with ground surface, in hard marsh ground, on line with Bench Marks 3 and 5, 287 feet from Bench Mark 2 and 257 feet from Bench Mark 4. Elevation: 2.74 feet above mean low water.

(OVER)

USCOMM-CGS-DC

Mean low water at Sand Island, West Pass to Apalachicola Bay, is based on 4 months of records, November 1942 - February 1943, reduced to mean values. Elevations of other tide planes referred to this datum are as follows:

	Feet
Mean high water	1.40
Mean tide level	0.70
Mean low water	0.00

The estimated highest water level to the nearest half foot is 5½ feet above mean low water. The estimated lowest water level to the nearest half foot is 2 feet below mean low water.

NOTE: The tides are considered as chiefly diurnal at this locality.

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

REPORT - TIDE STATION

Station St. Petersburg, Florida Lat. 27 46.0 N
Established Long. 82 37.0 W Time Mer. 75° W
Inspected by Bud Gilden Date 6/26/72

Wharf - Name and location* Municipal Pier, foot of 2nd Ave. N.

Owner and arrangements for maintaining station Co-op station with city of St. Petersburg, permission from city.

Tide Observer - Name, address and telephone No. John Lights, 474 32nd Ave. N., St. Petersburg, Florida Home Phone: 896-8886 Office-890-8924
33713

Business address and telephone No.

Tide House - Size and brief description 9x7x6 ft. concrete block bldg. located on SW landing of Municipal Pier.

Tide Staff - Portable or fixed ElecTape Date of installation { Staff support / Fixed staff
Limits of graduations Hinged? Vitrified scale ?
Scale graduation corresponding to stop ft. Is staff support sheathed with copper?
Method of securing staff and support in place and remarks Typical elec. tape installation, 50 ft. end of tape has weight attached to it.

Type of Gage ADR Date of installation 6/26/72 ✓
NOS No. * Scale 1 - 24 Scale 0-99
Float, size 8½ in.; weight 4½ lb. Counterpoise lb. Tension weight X lb.
Remarks

Float Well - Material Fiberglass Date of installation 10/68
Length, top to intake 11.0 ft. Inside diameter 12 in. Size and position of intake 1½ in.

Construction, installation, and remarks Fiberglass well, cemented into the concrete deck and bolted to floor joists with brass bolts.

*7106A1974M6

*A section of chart showing location should accompany this report.

(Use reverse side of form for additional information)

NOAA FORM 77-12 (3-71)

Measurements - Referred to wharf or unless otherwise indicated. Negative (to be used when point is above wharf floor.

			(Automatic gage)		(Tape gage)	
Top of staff support	ft.	Top of float well	-1.0	ft.	-3.6	ft.
Zero of tide staff	ft.	Intake to well	10.0	ft.	9.0	ft.
Harbor bottom at staff	ft.	Harbor bottom at well	14.6	ft.	15.1	ft.

Bench Marks - Date of levels to tide staff 3/27/72 Number of marks connected 3

Number of new marks established _____ Number of old marks recovered 3

(Complete descriptions of bench marks must accompany leveling record)

Inventory of Instruments:

2 water therm. 950216

1 jar

1 water sampler W/thermometer (Q22535)

1 resistance tide gage

Additional Information: 877-1677 Tampa W/B Phone: 813-228-7366-MIC Mr. Dye

Needs New tape & Weight for tape gage. Needs New Roof on Tide House. Deck needs to be fastened to concrete wall with Ramset Gun. Windows need replacing with concrete except for one small pane. Old float well entry in side of wall needs to be closed up. Standard Tide-Gage was washed out by hurricane Agnus and was Replaced by an ADR; (only gage on hand).

Recommendations: Tide gage be moved a higher elevation

Note - This form being designed both for the establishment and an inspection of a tide station, questions not pertinent to the work at hand may be omitted; but at the time of an inspection it is desirable that the depth of water and such other information as can be conveniently obtained should be entered in the form in order that any changes since the previous inspection may be detected.

NOAA FORM 77-12 (3-71)

U.S. GOVERNMENT PRINTING OFFICE 1971-760-237

REPORT - TIDE STATION

Station CLEARWATER BEACH Lat. 27° 58.6' N
Established Long 82° 49.9' W Time Mer. 75th
~~Inspected~~ by J. E. Guth Date 4/19/73
Wharf - Name and location* Big Pier 60 Clearwater Beach, Florida
Owner and arrangements for maintaining station City permission (City Engr. Mr. BaHle and Asst Engr. Mr. Henderson) - Private Pier extension leased by Mr. Jim Mead
Tide Observer - Name, address and telephone No. Mr. Jim Mead 1035 Nolan Dr Largo, Florida 33540 (813) 584-3696
Business address and telephone No. Big Pier 60, Clearwater Beach (813) 446-0060
Tide House - Size and brief description None

Tide Staff - Portable or fixed Fixed Date of installation { Staff support / Fixed staff 4/17/73
Limits of graduations 0'-6'' Hinged? No Vitrified scale ? Yes
Scale graduation corresponding to stop 6.0 ft. Is staff support sheathed with copper? No
Method of securing staff and support in place and remarks Vitrified scale fastened to a treated 7' x 2" x 4", which is secured to the pipe well by three iron clamps near the 0', 3', and 6' marks.

Type of Gage Fisher Porter ADR Date of installation 4/19/73
NOS No. 8909A424 IMI AC Timer Scale Scale
Float, size 3 in.; weight 3½ lb. Counterpoise ____ lb. Tension weight ____ lb.
Remarks

Float Well - Material 4" galvanized steel Date of installation 4/18/73
Length, top to intake 16½ ft. Inside diameter 4 in. Size and position of intake ½ in.
intake coupling 16½' below base of gage
Construction, installation, and remarks The 31' pipe well was water jetted about 11' into the sand bottom, with one iron clamp lag screwed into the 4" thick concrete pier deck, and another 3½' below the pier deck into the end of a 3'X3' concrete horizontal cross beam. * See Additional Information

*A section of chart showing location should accompany this report.

(Use reverse side of form for additional information)

NOAA FORM 77-12 (3-71)

	(Automatic gage)	(Tape gage)	
Top of staff support 5.5 ft.	Top of float well	-3.5 ft.	ft.
Zero of tide staff 11.5 ft.	Intake to well	12.5 ft.	ft.
Harbor bottom at staff 16.5 ft.	Harbor bottom at well	16.5 ft.	ft.

Bench Marks - Date of levels to tide staff 4/20/73 Number of marks connected 6

Number of new marks established 1 Number of old marks recovered 5

(Complete descriptions of bench marks must accompany leveling record)

Inventory of Instruments:

Additional Information: Mr Mead, who leases the private pier, stated that a sand bar shifts in and out parallel the beach. The depth at the gage location varies from about 6' to 14' below the mean water level. Therefore the pipe well was water jetted to a depth of about 20' below mean water level. The intake orfice was placed 5' below the mean water level to keep it low enough to record the extream lows and high enough to prevent it from clogging with sand.

Recommendations:

Note - This form being designed both for the establishment and an inspection of a tide station, questions not pertinent to the work at hand may be omitted; but at the time of an inspection it is desirable that the depth of water and such other information as can be conveniently obtained should be entered in the form in order that any changes since the previous inspection may be detected.

NOAA FORM 77-12 (3-71)

U.S. GOVERNMENT PRINTING OFFICE 1971-760-237

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

REPORT - TIDE STATION

Station Cedar Key, Florida Lat. 29 08.0 N
Long. 83 01.9 W Time Mer. 75 W
Inspected by William L. Outalw Date 3/21/73
Wharf - Name and location* County Dock at end of "C" Street.
Owner and arrangements for maintaining station Permission from county commissioner.

Tide Observer - Name, address and telephone No. Gene Hodges, P. O. Box 1022, Cedar Key, Fl. 32625

Business address and telephone No. 904-5439
Tide House - Size and brief description 8x8x8 ft. frame house, one window, NOS sign, louver on west side, house painted white.

Tide Staff - Portable or fixed Portable Date of installation { Staff support 3/9/70
Limits of graduations 0-12 ft. Hinged? Yes Vitrified scale ? No
Scale graduation corresponding to stop 12.000 ft. Is staff support sheathed with copper? No
Method of securing staff and support in place and remarks Fiberglas support secured to a creosoted piling with brass lag screws, rack arrangement for raising and lowering the staff, spare staff at the station.

Type of Gage ADR Date of installation 1973
NOS No. 7206A266448 Scale 1-24 Scale
Float, size 8½ in.; weight 4½ lb. Counterpoise lb. Tension weight lb.
Remarks Solid state timer, 4v motor, 7½v battery.

Float Well - Material Fiberglas Date of installation 1967
Length, top to intake 16.0 ft. Inside diameter 12 in. Size and position of intake 1 in.
Std. intake.
Construction, installation, and remarks Fiberglas well secured at the tide house floor and braced between two concrete pilings with 6 inch "I" beam and 1 inch bolts.

*A section of chart showing location should accompany this report.

(Use reverse side of form for additional information)

NOAA FORM 77-12 (3-71)

wharf floor.

	(Automatic gage)	(Tape gage)	
Top of staff support 0.8 ft.	Top of float well	-1.3 ft.	ft.
Zero of tide staff 12.8 ft.	Intake to well	16.0 ft.	ft.
Harbor bottom at staff 23.8 ft.	Harbor bottom at well	23.9 ft.	ft.

Bench Marks - Date of levels to tide staff 3/22/73 Number of marks connected 4

Number of new marks established None Number of old marks recovered 4

(Complete descriptions of bench marks must accompany leveling record)

Inventory of Instruments: Temperature and Density

1 air therm. 2 jars

2 water therm. 697534 697563 1 water sampler

2 med. hyd. T-4687 7726

2 hvy. hyd. T- 4730 T-63292

1 lt. hyd. T-1222

Additional Information: Repaired staff hanger, painted house outside.

Recommendations:

Note - This form being designed both for the establishment and an inspection of a tide station, questions not pertinent to the work at hand may be omitted; but at the time of an inspection it is desirable that the depth of water and such other information as can be conveniently obtained should be entered in the form in order that any changes since the previous inspection may be detected.

NOAA FORM 77-12 (3-71)

U.S. GOVERNMENT PRINTING OFFICE 1971-760-237

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

REPORT - TIDE STATION

Station St. Marks, Florida ~~Established~~ Lat. 30 04.5 N Long. 84 10.9 W Time Mer. 75 W

Inspected by William L. Outlaw Date 3/11/74

Wharf - Name and location* Small boat dock ½ mile NW of light house.

Owner and arrangements for maintaining station Permissinn from Fish & Wildlife, Atlanta, Ga. Permit #RLTY-19 3/25/65

Tide Observer - Name, address and telephone No. H. B. Barron, St. Marks, Fl. 32355 Phone; 952-9191

Business address and telephone No.

Tide House - Size and brief description 6x6x7 ft. frame building, galv. steel roof and siding. Window in door, NOS sign on door.

Tide Staff - Portable or fixed Portable Date of installation { Staff support ~~Bracket~~ 1965

Limits of graduations 0-9 ft. Hinged? Yes Vitrified scale ? No

Scale graduation corresponding to stop 9.000 ft. Is staff support sheathed with copper? Yes

Method of securing staff and support in place and remarks Staff support secured on offshore side of dock to a creosoted piling with brass lag screws.

Type of Gage ADR Date of installation 3/8/74

NOS No. 7206A2664M11 Scale 1-24 Scale

Float, size 8½ in.; weight 4½ lb. Counterpoise lb. Tension weight lb.

Remarks Solid state timer, 4v motor, 7½v battery.

Float Well - Material Fiberglass Date of installation 1965

Length, top to intake 8.0 ft. Inside diameter 12 in. Size and position of intake 1 in. Cone in end of pipe.

Construction, installation, and remarks Fiberglass well secured at the tide house floor and at HWL with a wood collar secured to two creosoted pilings.

*A section of chart showing location should accompany this report.

(Use reverse side of form for additional information)

NOAA FORM 77-12 (3-71)

Measurements - Referred to wharf floor unless otherwise indicated. Negative sign to be used when point is above wharf floor.

			(Automatic gage)		(Tape gage)	
Top of staff support	0.2 ft.	Top of float well	-0.5	ft.		ft.
Zero of tide staff	8.7 ft.	Intake to well	8.0	ft.		ft.
Harbor bottom at staff	8.3 ft.	Harbor bottom at well	9.2	ft.		ft.

Bench Marks - Date of levels to tide staff 3/11/74 Number of marks connected 3

Number of new marks established None Number of old marks recovered 3

(Complete descriptions of bench marks must accompany leveling record)

Inventory of Instruments:

Additional Information: Gage set 10.0 ft. above staff reading.

Recommendations:

Field Elev. in Feet

No.6 7.844

No.7 11.593

No.9 9.435

Note - This form being designed both for the establishment and an inspection of a tide station, questions not pertinent to the work at hand may be omitted; but at the time of an inspection it is desirable that the depth of water and such other information as can be conveniently obtained should be entered in the form in order that any changes since the previous inspection may be detected.

* U.S. G.P.O. 1972-769-563/449 REG. #6

DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

REPORT - TIDE STATION

cit

Station Shell Point, Florida Lat. _____ Long. _____ Time Mer. 75 W

Inspected by William L. Outlaw Date 3/1/74

Wharf - Name and location* Shell Point Marina, Shell Point, Florida

Owner and arrangements for maintaining station Permission from A. B. Taff and Sons, Inc., George S. Taff, President

Tide Observer - Name, address and telephone No. Pauline Bradshaw, Rt. 2 Box 380, Crawfordville, Fl. 32327 Phone: 904-926-3963

Business address and telephone No. _____

Tide House - Size and brief description 6x8x7 ft. frame building, white aluminum siding, asphault shingles on roof, NOS sigh over door, house elevated 6 ft. above bulkhead on ½x6 inch angle iron supports.

Tide Staff - Portable or fixed Portable Date of installation { Staff support 4/27/73

Limits of graduations 0-9 ft. Hinged? Yes Vitrified scale ? No

Scale graduation corresponding to stop 9.000 ft. Is staff support sheathed with copper? No

Method of securing staff and support in place and remarks Fiberglass staff support is lag screwed to two 4x4 blocks bolted to angle iron supports at two elevations.

Type of Gage ADR Date of installation 4/30/73

NOS No 7206A2664N20 Scale 1-24 Scale _____

Float, size 8½ in.; weight 4½ lb. Counterpoise _____ lb. Tension weight _____ lb.

Remarks Solid state timer, 4v motor, 7½v battery.

Float Well - Material Fiberglass Date of installation 4/18/73

Length, top to intake 18.0 ft. Inside diameter 12 in. Size and position of intake 1 in. Cone in end of pipe.

Construction, installation, and remarks Fiberglass well rest on tide house floor and clamped with steel band bolted to tide house support.

*A section of chart showing location should accompany this report.

(Use reverse side of form for additional information)

NOAA FORM 77-12 (3-71)

Measurements - Referred to wharf floor unless otherwise indicated. Negative sign to be used when point is above wharf floor.

		(Automatic gage)	(Tape gage)
Top of staff support	-1.4 ft.	Top of float well	-7.4 ft.	ft.
Zero of tide staff	7.6 ft.	Intake to well	18.0 ft.	ft.
Harbor bottom at staff	8.8 ft.	Harbor bottom at well	11.8 ft.	ft.

Bench Marks - Date of levels to tide staff 3/1/74 Number of marks connected 5

Number of new marks established None Number of old marks recovered 5

(Complete descriptions of bench marks must accompany leveling record)

Inventory of Instruments:

1 bristol metameter S/N 71A4925

Additional Information:

Recommendations:

Field Elev. in Feet

No.1	7.709
No.2	7.945
No.3	8.087
No.4	6.730
No.5	5.185

Note - This form being designed both for the establishment and an inspection of a tide station, questions not pertinent to the work at hand may be omitted; but at the time of an inspection it is desirable that the depth of water and such other information as can be conveniently obtained should be entered in the form in order that any changes since the previous inspection may be detected.

NOAA FORM 77-12 (3-71)

U.S. GOVERNMENT PRINTING OFFICE 1971-760-237

APPENDIX D

- HYDROPLOT/HYDROLOG PROGRAM RK 211 -

HYDROPLOT/HYDROLOG PROGRAM RK 175

A. Introduction

This program, written in assembly languages, provides for a real-time acquisition of positions and soundings, without the aid of a plotter (Hydrolog).

Three-point sextant fixes are used for positions control. The angle input is by thumbwheel (remote or on the Hydroplot Controller) or by Digital Sextant. The computation parameters, signal locations and digital sextant correction tables (optional) are stored in memory by program RK 171, which must be used in conjunction with RK 175.

Depth input may be either manual or automatic. Draft corrections are entered through the Hydroplot Controller.

The program uses the Modified Traverse Mercator projection as a base for X-Y co-ordinate computations. The program uses parameters which will operate only in north latitudes and west longitudes.

Predicted tides, punched in binary tape format, are retained in this system for easier off-line processing. The predicted tides are real using the High-Speed Reader while system control commands are entered through TTY-1. If predicted tides are desired but there is no tide tape in the High-Speed Reader at initialization time, then a zero tide correction will be applied throughout.

Output consists of a hard copy print out of the Visual Master Tape on TTY-2, a Visual Master Tape punched in ASC II (even parity) code on the High-Speed Printer, left/right steering indicator updated at every fix, X-Y co-ordinates of fixes typed on TTY-1 at every fix, buzzers at standby and fix times, and event marks on the fathogram.

Each fix is checked for strength of fix and validity of signal numbers. If the fix is weak or the signal numbers invalid, the fix will be rejected unless the hydrographer has requested an end of line fix. In

this case, the fix is logged and the message "BAD FIX" is typed on TTY-2.

A weak fix is determined in the following manner. The two angles used for a fix computation are changed by one minute and the fix is recomputed. If the position has moved by more than 8 meters, the fix is determined to be weak.

Fixes may also be rejected by the angleman or the program operator if they desire. There are specified time intervals after a fix in which buttons may be pushed to reject or accept a fix after it is taken, but before it is punched on paper tape or typed. For this reason, the program operates with a delayed reaction. Fixes and soundings are taken and stored until they have been accepted or rejected, and then they are punched.

A standby is given 10 seconds before almost all fixes. The few exceptions are noted in the following sections.

B. *Methodology*

1. *Program Modes*

RK 175 functions in two basic modes, LINE and IDLE, after initialization has been completed. Due to limitations on the number of interrupt buttons available, some of them have different functions in the two different modes.

The IDLE mode is entered immediately after program initialization or after ending a line in any of several ways. In this mode, check fixes to determine the vessel's location can be taken but not recorded, detached positions can be taken and recorded and the X-Y co-ordinates of a line can be entered.

The LINE mode is entered by depressing the MARK button (remote or HYDROPLOT CONTROLLER). In this mode, sounding and fix data is analyzed and recorded at specified intervals. A maximum of nine soundings may be recorded between fixes.

2. Acceptance and Rejection Intervals

In either mode, there are two intervals to be considered dealing with rejecting or accepting a fix.

The first one is called the Angleman's Interval. During the Angleman's Interval, the fix can be rejected by depressing the Reject button or accepted by depressing the Data Ready button. Signal numbers (and angles, if not using digital sextant) must be thumbed into the Remote Thumbwheel Station or into the HYDROPLOT CONTROLLER before the Data Ready button is depressed. The length of this interval is the length of the fix interval minus the length of one sounding interval. The interval starts at the time of the fix and terminates when the Data Ready or Reject button is depressed or when the time has. If the interval time elapses before either the Reject or the Data Ready button is pressed, the data is automatically accepted (this is protection against losing sounding data even if position data is in error.).

Upon Angleman's acceptance of the fix data (automatic or push botton), computed X-Y values of the fix and a speed between fixes (if it is not the first fix) will be typed on TTY-1. This allows the hydrographer inside the boat to quickly examine this data and determine any obvious errors and reject the fix if necessary during the Hydrographer's Interval. To reject a fix during this interval, the "R" key on TTY-1 must be struck. The only way of accepting during this interval is to let the interval run down. The length of this interval is one-half the length of the sounding interval if the sounding interval is 14 seconds or longer, or the length of the sounding interval minus one second if it is 13 seconds or less. The Hydrographer's Interval starts immediately after the Data Ready button is depressed or the Angleman's Interval has run down.

During these intervals, soundings are stored in a buffer at the specified intervals. Once final acceptance has been allowed by letting the Hydrographer's Interval run down, the fix data and all sounding data from that fix to the final acceptance time will be logged. After that, all soundings will be logged immediately at each sounding interval until the next fix when they will again be stored awaiting fix data.

3. *Fix Rejection*

A fix can be rejected in 3 ways: Angleman's Reject button; "R" on TTY-1; or, a computed bad fix. If the fix is rejected, a sounding instead of a fix will be logged for that time, all soundings until the rejection occured will be logged, and the next sounding at least 10 seconds away will be a fix. Standby bells will be rung as usual (see Section 3). The word "REJECT" will by typed on TTY-1. The only time a rejected fix will be recorded as a fix is if it is the last fix on a line. In this case, the words "BAD FIX" are typed on TTY-2 below that fix.

4. *Manual Depth Input Interval*

A third interval to be considered is the manual depth input interval. This interval is the length of one sounding interval less one second and starts at the sounding time. If the depth rotary switch is in the Manual position, the Enter Manual Depth interrupt (I-11) must be depressed after each sounding prior to the time of the next sounding, otherwise a missed depth will be recorded and "MD" will be typed on TTY-1.

5. *Starting a Line*

A line is started by depressing the Mark interrupt button (I-4 or I-9). Standby bells are sounded immediately and 10 seconds later a fix is taken and the LINE mode is entered.

A line cannot be started on a rejected fix. If the initial fix on a line is rejected in any of the three ways discussed above, the program will immediately give standby bells and 10 seconds later a fix will be taken and the line started at that time. Any soundings stored prior to fix rejection, will not be recorded, however, the events marks on the fathogram cannot be erased, therefore, special care should be taken to properly annotate the fathogram (this is also true for rejected fixes in the middle of a line - e.g., the fix mark as differentiated from a sounding mark will still exist on the fathogram even though there is a regular sounding logged at that time).

6. *Breaking a Line*

There are four ways to break a line.

1. Break interrupt button (I-3 or I-10) will cause the line to be broken one second later. It may be pressed at any time (this is the only interrupt command accepted during the Angleman's and Hydrographer's Intervals). No standby is sounded since this is designed to be the panic button for breaking a line when approaching a hazard without the standby delay. If this button is pressed during the Angleman's or Hydrographer's Intervals, the previous fix is rejected since there was not enough time to accept it. "REJECT" will be typed on TTY-1 and the stored soundings will be recorded just as for a normal rejected sounding. The steering indicator is updated to the next line when this interrupt is used to Break the line.

2. "B" on TTY-1 will make the next sounding, at least 10 seconds away, a fix, break the line and update left/right steering indicator to the next line. A standby will be sounded.

3. "G" on TTY-1 is similar to "B" except the steering indicator is not updated to next line.

4. "A" on TTY-1 aborts the line immediately, no end of line fix is taken. The steering indicator is not updated to a new line.

It must be remembered that any end of line commands, with the exception of the Interrupt buttons (I-3 and I-10) are not valid until the previous fix has been rejected or accepted. In other words, the TTY-1 break command cannot be issued before the Hydrographer's Interval has run down.

7. Miscellaneous

It must be noted that the sounding and fix interval thumbwheels on the HYDROPLOT CONTROLLER have significance even in the IDLE mode because they are used to determine acceptance and rejection intervals for detached positions.

It should also be pointed out that aside from starting and breaking the lines and thumbing in angles and signal numbers, the hydrographer may elect to push no interrupt buttons since this program will accept and reject fixes as it thinks necessary by simply allowing intervals to run down. If such a method is used, the user is cautioned that at the time of one fix, the previous fix may be being logged, thus creating possible confusion.

Any interrupt may be depressed at any time without bombing the program. If an interrupt is pressed at an "illegal" time, the message "IPB" will be typed on TTY-1. In some cases, the interrupt will simply be ignored, if it is "legal" but not meaningful (i.e. if Data Ready is depressed twice for one fix).

Illegal commands on TTY-1 will be followed by a question mark and carriage return.

The most common illegal commands are commands issued during the Angleman's or Hydrographer's Intervals. No commands except Data Ready (I-1 or I-8), Reject (I-2 or I-5), or Break (I-3 or I-10) on the Controller and thumbwheels and "R" on TTY-1 are valid during these intervals.

III Input Specifications

Input consists of the following:

A. Binary Tide Tape (optional)
B. Digital Sextant (optional)
C. Remote Thumbwheel Station (optional)
D. HYDROPLOT CONTROLLER
E. TTY-1 Keyboard Commands

A. *Binary Tide Tape*

Each item of the tide corrector (i.e., Day, Time and Correction) is punched in 3-word floating point binary format (6 channels of data).

The tape has leader-trailer codes at both ends, and at least 2 frames between each corrector. The last corrector is followed by a day of "999".

The binary tide tape is generated from AM500 or AM504. The units are assumed to be the same as indicated by thumbwheel switch (49) on the Hydroplot Controller.

B. *Digital Sextant*

Angle input from the digital sextant is automatically sampled at fix time. It is relayed through the navigation interface and displayed there. Since the interface is basically an up/down counter, the display is in total half minutes, not degrees, minutes and seconds. The function switch on the interface must be in the ENCODER position.

The one interrupt button on the digital sextant has the same function as (I-2) on the Remote Thumbwheel Switch (I-5) on the Controller.

C. *Remote Thumbwheel Station*

Refer to the attached diagram for the following explanation of the Remote Thumbwheel Station. The numbers in parenthesis are the actual numbered labels on the Remote Thumbwheel Station. The thumbwheel (but not the interrupt) numbers also correspond to thumbwheel numbers on the Hydroplot Controller.

1. Thumbwheels

(20-22) Left angle, degrees

(23-24) Left angle, minutes

(26-28) Right angle, degrees

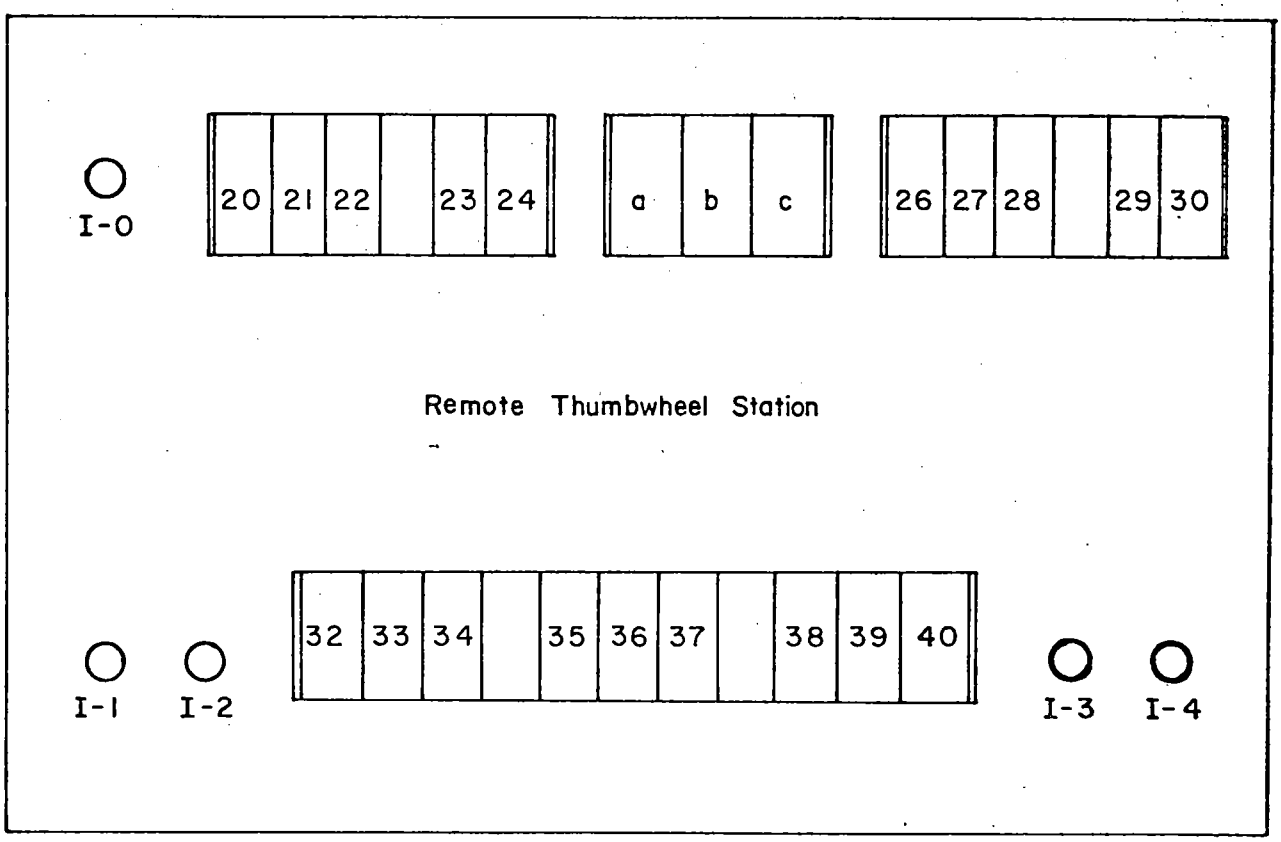
(29-30) Right angle, minutes

(32-34) Left object

(35-37) Centre object

(38-40) Right object

a, b, c - not used



The thumbwheels mentioned above are logically ORed with those of the same number on the Hydroplot Controller. Therefore, the thumbwheels on the Station or those on the Controller must be set to zero when the other unit is being used.

2. Interrupt Buttons

(I-0) not used.

(I-1) Data Ready - this button is used in either mode to notify the computer that the fix data is in the thumbwheels.

(I-2) LINE mode: REJECT - The previous fix will be rejected if this button is pressed during the Angleman's or Hydrographer's Intervals.

IDLE mode: CHECK FIX - Compute a check fix with the data in the thumbwheels, type X-Y position on TTY-1 and update steering needle. No standby is given and DATA READY need not be pressed.

(I-3) LINE mode: BREAK - The line will break one second later. No standby is given. If pressed during the Angleman's or Hydrographer's Interval, the previous fix will be rejected.

IDLE mode: DETACHED POSITION - Take one fix with a sounding immediately. No standby is given, but the acceptance and rejection processes apply.

(I-4) LINE mode: MARK - The next sounding at least 10 seconds away will be a fix. The sounding interval and number of inbetweens in the HYDROPLOT Controller thumbwheels (7-9) and (11) will be read and applied. A standby will be given.

IDLE mode: MARK - Immediate standby; ten seconds later start a line with a fix and enter LINE mode.

D. HYDROPLOT Controller

There are presently 2 models of the HYDROPLOT Controller in use aboard NOAA vessels. The one associated with the PDP/8-I is referred to as the Prototype, all the others on the PDP-8/E's are the Model 1.

1. General

(a) Model 1 Controller

All thumbwheels on the Model 1 Controller are numbered from 1 to 49. The 2 position pushbutton switches are located along the top edge of the Controller and are numbered from 0 to 11 (less 5 + 8) under the label "Control Word". The Manual Interrupts (pushbuttons) are found on the left side and in the 2nd row (right side). The Manual Interrupts are labelled "I-7", "I-11", and "Manual Interrupts" 10, 9, 8, 5, 6. The Automatic Interrupts 0 - 4 are on the back panel of the Controller.

In this documentation, characters enclosed in parenthesis "( )" refer to labels which actually appear on the face of the Model 1 HYDROPLOT CONTROLLER. A drawing of the front panel is included to aid in the identification of the various thumbwheels and buttons.

In describing the dual functions of the two position pushbuttons, the terms lower half (LH) and upper half (UH) are used. When a switch is in the lower half position, the lower right is lit (the bit is set to 0) and appears white. When the same switch is in the upper half position, the upper light is lit (the bit is set to 1) and should appear as an amber color.

(b) Prototype Controller

None of the thumbwheels on the Prototype Controller were labelled by number when the unit was originally manufactured.

Since that time it is possible that stick on numbers have been added which correspond to the numbers on the Model 1 Controller.

The 2 position switches referred to in 1(a) above are found in the middle row (right side). They are rocker type switches and are labelled 0 to 11. When the documentation refers to the switch as being in the "UH" position, the top portion of the switch should be pressed in and when in the "LH" position, the lower portion should be in.

The manual interrupts are located in the upper right hand corner under the label "MANUAL INTERRUPTS". They are spring loaded rocker switches and need only to be pressed in to be activated.

The Prototype Controller does not have the additional words 30_8 - 37_8 nor does it have manual interrupt 5 or automatic interrupts I-0 thru I-4. Therefore, the Remote Thumbwheel Station cannot be used with the Prototype.

In this documentation, characters enclosed in parenthesis "( )" refer to labels which actually appear on the face of the Model 1 Hydroplot Controller. A drawing is included which shows the corresponding numbers on the Prototype front panel. Functions shown by a darkened area are not used in this program.

2. *Control Word - Two Position Switches*

These switches are activated once the time has been synchronized and from that time on are read and decoded automatically once per second.

(a) *Switch 0 - IDLE PLOTTER*

not used in this program.

(b) *Switch 1 - Tide INPUT (Real or Predicted)*

not used in this program.

(c) *Switch 2 - Depth UNIT (Fathoms or Feet)*

UH - soundings are entered and recorded in fathoms.
LH - soundings are entered and recorded in feet.

(d) *Switch 3 - DEPTH DIGITS (Nearest tenth or nearest unit)*

UH - soundings are entered to nearest tenth.
LH - soundings are entered to nearest unit.

(e) *Switch 4 - ACTIVATE LANE JUMP SUBROUTINE*

not used in this program.

(f) *Switch 6 - Type of Depth Recorder*

UH - a Ross depth recorder is being used with the special feature that draws a 2 inch line below the digitized depth.
LH - any other digital depth recorder is being used (including a Ross without the special feature).

(g) *Switch 7 - ACTIVATE STEERING METER*

UH - shut the steering indicator off and indicate same by setting the meter to the mid-scale (straight up) position.
LH - update the steering indicator at each fix if the "L" type-in command has been activated.

(h) *Switch 9 - ANGLE INPUT*

UH - angle input will come from thumbwheels (Remote or Hydroplot Controller) after the fix time.
LH - angle input will be read from Digital Sextant at fix time. This switch is read only once, when the time is synched and cannot be changed without restarting the program.

(i) *Switches 10, 11*

not used in this program.

NOTE: From a programming standpoint, thumbwheel 16 (the + - in TRA) and the Depth Rotary Switch (Man-Shoal) perform as Control Word switches 8 and 5 respectively.

3. *Manual Interrupts*

These switches are recognized once the interrupt has been turned on or, specifically, when the Day = step has been accomplished.

(a) *Manual Interrupt (5) - Same as (I-2) on Remote Thumbwheel Station*

LINE mode: REJECT - The previous fix will be rejected if this button is pressed during the Angleman's or Hydrographer's Intervals.

IDLE mode: CHECK-FIX - Compute a check-fix with the data in the thumbwheels, type X-Y position on TTY-1 and update steering needle. No standby is given and Data Ready need not be pressed.

(b) *Manual Interrupt (6) - Print Correctors*

This switch causes the program to update the current values of TRA and Meter Sensitivity as indicated in thumbwheels (16-19) and (41-46). This switch may be pressed as many times as possible within a sounding interval but only the last TRA corrector in the thumbwheels is punched at the time of the next sounding. The steering meter sensitivity is not applied until the next fix.

(c) *Manual Interrupt (I-7) - Synchronize the time*

The switch causes the program to read the time that is entered in thumbwheels (1-6) and use it as the basis for computing the real

time. Once pressed, this switch is disabled and becomes an invalid pushbutton if pressed again. (Pressing it a second time has no effect on system).

(d) *Manual Interrupt (8) - Same Function as (I-1) on Remote Thumbwheel Station*

Data Ready - This button is used in either mode to notify the computer that the fix data is in the thumbwheels.

(e) *Manual Interrupt (9) - Same Function as (I-4) on Remote Thumbwheel Station*

LINE mode: Mark - The next sounding at least 10 seconds away will be a fix. The sounding interval and number of inbetweens in the Hydroplot Controller thumbwheels (7-9) and (11) will be read and applied. A standby will be given.

IDLE mode: Mark - Immediately standby; ten seconds later start a line with a fix and enter LINE mode.

(f) *Manual Interrupt (10) - Same Function as (I-3) on Remote Thumbwheel Station*

LINE mode: BREAK - The line will break one second later. No standby is given. If pressed during the Angleman's or Hydrographer's Interval, the previous fix will be rejected.

IDLE mode: DETACHED POSITION - Take one fix with a sounding immediately. No standby is given, but the acceptance and rejection processes apply.

(g) *Manual Interrupt (I-11) - ENTER MANUAL DEPTH*

This switch is used to enter a manual depth from thumbwheels (12-15) when the depth select rotary switch is in the MAN position. The operator has the sounding interval, less one second, to enter the

depth. If the button is pressed more than once per sounding interval, the interrupts are ignored and the message "IPB" is printed. If the button is pushed when the rotary switch is in the SHOAL or DEEP positions, it is ignored; no "IPB" message is typed.

4. *Automatic Interrupts*

(a) I-00

This interrupt is used with the special feature of the Ross Recorder.

(b) I-1 thru I-4

The interrupt buttons of the Remote Thumbwheel Station are connected to these automatic interrupts, thus making them remoted manual interrupts.

5. *Thumbwheel Switches*

(a) *TIME (1-6)*

This is the time that is used to initially synchronize the system. Set hours in (1-2), minutes in (3-4) and seconds in (5-6). These switches are read by the computer the first time TIME SYNCH is pressed.

(b) *Sounding Interval (7-9)*

Switch (7) is set to units of minutes of the sounding interval. Switches (8, 9) are set to seconds of the sounding interval. These switches are read whenever the "MARK" Manual Interrupt (9) or (4) is pressed.

(c) *Numbers of Inbetween (11)*

This is the number of soundings that will be recorded between positions. If set to zero, this thumbwheel will cause a fix to be taken at every sounding.

The switch is read whenever the "MARK" Manual Interrupt (9) or (4) is pressed.

(d) *Manual Depth (12-15)*

These switches are used to enter the Manual Depth. Note that only 4 switches are available so that attention must be paid to the position of the decimals; in other words, if Control Word Switch (3) indicates tenths, then (12-15) must be set to the nearest tenth. If Control Word Switch (3) indicates units, then (12-15) must be set to the nearest unit.

The depth is transferred from the thumbwheels into the computer when the Manual Depth Interrupt (I-11) is pressed (once per sounding interval).

These switches may be remoted from another location in which case the remote switches and these switches will be logically ORed.

(e) *DRAFT or TRA (16-19)*

The DRAFT or TRA is entered in these switches. A water level corrector (lake stage) may also be entered by algebraically adding it to the TRA.

The sign of the correction (+ or -) is entered in (16). The remainder of the field (17, 18, 19) is for the TRA correction. The correction is <u>always</u> entered to tenths and in the same units (feet, fathoms, or metres) as indicated by thumbwheel switch (49). These switches are read and applied when the PRINT CORRECTORS Manual Interrupt (6) is pressed.

(f) *LEFT and RIGHT ANGLE (20-25 and 26-31)*

These switches are logically ORed with switches (20-24) and (26-30) on the Remote Thumbwheel Station. Switches (25) and (31) are ORed with zero. Therefore, if the Remote Thumbwheel Station is connected to the Controller, either the thumbwheels on the Controller or on the Remote Station should be set to zero.

(20-22)	Left Angle degrees
(23-25)	Left Angle minutes to tenths
(26-28)	Right Angle degrees
(29-31)	Right Angle minutes to tenths

(g) *Signal Numbers (32-40)*

These switches are logically ORed with switches (32-40) on the Remote Thumbwheel Station. Therefore, if the Remote Thumbwheel Station is connected to the Controller either the thumbwheels on the Controller or on the Remote Box should be set to zero.

32-34	Signal number of left object
35-37	Signal number of centre object
38-40	Signal number of right object

(h) *Meter Sensitivity (41-46)*

These thumbwheel switches determine the sensitivity of the steering meter. Set the desired half-scale deflection for the steering meter in thumbwheel switches (41-46). The number is read as positive whole meters and must never be zero. These switches are read any time the PRINT CORRECTORS Manual Interrupt (6) is pressed. They are applied at the next fix, check fix or detached position.

(i) *TRA and TIDE CORRECTION UNITS (47-49)*

Thumbwheel switches (47) + (48) should always be set to zero.

Thumbwheel (49) indicates the units in which the TRA correction, thumbwheel (16-19) and tide corrections (from the tide tape) are entered. It should be set as follows:

0 - if the TRA and TIDE corrections are entered in feet
1 - if the TRA and TIDE corrections are entered in fathoms
2 - if the TRA and TIDE corrections are entered in metres

This switch should not be changed during operation of the program. If it is, the program assumes the units have changed and applies the change, but no indication is given except that the TRA and TIDE corrections will change.

6. *Rotary Switches*

(a) *Depth*

This rotary switch determines where the sounding input comes from. If it is set to MAN, the input will be from thumbwheel switches (12-15) and the program will wait for the ENTER MANUAL DEPTH (I-11) interrupt button to be pressed before reading the sounding value in the switches.

If it is set to SHOAL, the sounding will be taken automatically from the digitized echo sounder.

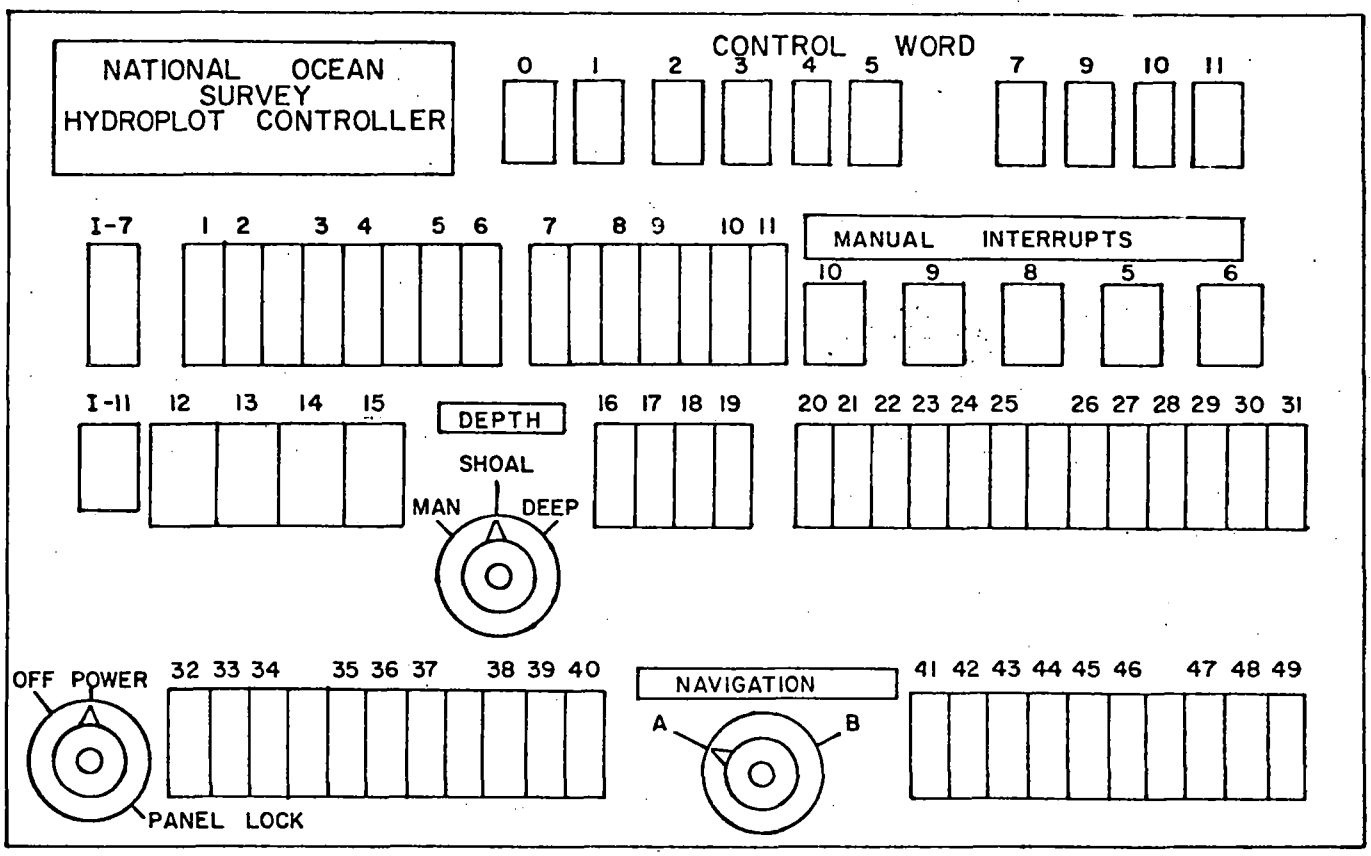
The DEEP position should be used in conjunction with a deep-water digitizer.

This switch may be moved at anytime while the program is running and the method of sounding input will be changed accordingly.

(b) *NAVIGATION*

This rotary switch is designed to allow electronic control (navigation) input from more than one system without moving cables.

If digital sextants are being used, this switch must be set in the A position.



E. TTY-1 KEYBOARD COMMANDS

The program constantly checks for single characters which, when typed on TTY-1, cause some specified action to be taken. All TTY-1 commands except "R" are invald during the Angleman's and Hydrographer's Intervals. The characters currently recognized are:

1. "A" - Abort the line; stop running present line. All soundings since the last fix will be lost.

2. "B" - On the next depth interval, at least ten seconds away, take a fix and break the current line. Update the steering indicator to next line.

3. "G" - Same as "b' except don't update the steering indicator to the next line.

4. "L" - Enter Line Parameters. Define the family of lines to be run by typing the X-Y co-ordinate of a point on the first (next) line, the heading of the first (next) line, and the interline spacing of the adjacent lines.

5. "R" - Reject the fix just computed. "R" must be struck during the Hydrographer's Interval.

IV Output Specifications

There are presently four types of output:

A. Left-Right Steering Meter
B. X-Y co-ordinates, Speed and Fix Number
C. Warning and Event Marks
D. Hydroplot Master Tape and Printout

A. *Left-Right Steering Meter*

The program considers the ship to be a point, and the theoretical path the ship is to follow as a line (with a known direction). With respect to the meter, the program considers mid-scale on the meter as the centre of the line and the needle as the vessel. For each fix the program computes the distance from the ship (a point) to the line and updates the meter accordingly. If the needle is to the left of mid-scale, it means the ship is to the left of the imaginary line (similarly for the right). At no time does the computer consider the true course of the ship; and, as a result, left and right on the meter are not necessarily indicative of rudder command, particularly in this program since the meter is not updated each second as in electronic control programs.

Meter sensitivity, in terms of half-scale deflection in metres, may be varied by setting thumbwheels (41-46) on the HYDROPLOT Controller. The system is then notified by depressing the Print Correctors Manual Interrupt (I-6).

B. *X-Y Co-ordinates, Speed and Fix Number*

At the instant of a fix, its fix number is typed on TTY-1. After the fix data has been input to the computer for a fix, the X-Y co-ordinates, distance to the line and average speed travelled since the previous fix (no speed is computed for the first fix) will be typed on TTY-1.

C. *Warning and Event Marks*

At specified times, Relay 1 of the HYDROPLOT Controller will be closed, with the intent that a bell or buzzer of some sort is wired into Relay 1.

1. Standby Bells - Before each fix (except as noted previously), Relay 1 will be closed twice (10 seconds before and nine seconds before) as a standby warning.

2. Fix Bell - At the instant of each fix, Relay 1 will be closed once to signify a fix.

At the time of each fix, Relay 2 will also be closed for marking of the fathogram.

At the time of each sounding, Relay 3 (and 4 if the Depth Rotary switch is in the SHOAL or DEEP position) will be closed for marking the fathogram.

APPENDIX E

- BRISTON BUBBLER TIDE GAUGE -

BRISTOL PRESSURE RECORDING TIDE GAUGE SYSTEM

A. Introduction

The bubbler gauge provides a continuous strip chart recording of tide height. Output can be made available for telemetering tide information. Relatively simple installation and operation procedures are required. The bubbler gauge can make measurements in a situation in which the tide sensor is located up to a few thousand feed from the recorder.

Pressure in a body of water varies with the depth; the pressure is about one-half pound per square inch for every foot of depth. So, with a pressure sensor at a fixed horizontal level, the water level (tide) above the sensor is measured by observing the pressure at the sensor.

The orifice (sensor) is a short metal chamber attached to the end of the small bore plastic tubing. The orifice volume, which is sizeable compared to the supply line volume, desensitizes the system to errors caused by wave action.

Water pressure at the sensor is detected by keeping the orifice full of nitrogen gas and detecting the pressure in the gas. The water above the orifice keeps the gas compressed to a pressure equal to the water pressure where the air and water meet in the orifice. In order to keep the orifice full of gas, a regulated flow of nitrogen is fed to the orifice through the orifice supply line. The gas pressure in the supply line, which is the same as the pressure at the bottom of the orifice, is detected by a set of temperature-compensated bellows which is linked to a recording pen. A diagram of the complete system is shown in Figure #1.

Variation in atmospheric pressure does not affect the recording because the pressure on the surface of the body of water is the same as the pressure on the outside of the bellows.

B. *Application Considerations*

In operation, dry nitrogen is constantly being purged from the open orifice at a regulated rate. To provide good regulation of the bubble rate, a constant pressure differential regulator (Figure #2) is located between the gas supply and the needle valve. This regulator provides a constant pressure difference of about three pounds per square inch between the pressure reducer output on the nitrogen bottle and the water at the bottom of the orifice.

The gas supply rates normally used can be measured by counting the bubbles passing through the oil. The required rate of supply (bubble rate) is determined by the maximum rate of tide height increase and the volume of the system, including orifice, supply lines, and bellows. The volume of the plastic supply line used is about 15 cubic inches per 100 feet of length; the bellows volume is about 2 cubic inches. Orifices are available with a volume of either 3 or 5 cubic inches. Figures #3 and #4 provide a means to estimate the required bubble rate. Figure #5 shows the relationship of gas consumption to cylinder pressure and temperature.

The effect of wave action on the gauge is lessened by a relatively large orifice volume. Figure #6 shows a drawing of sensors with and without a large volume orifice tip. When the water level is as shown in Group A, both gauges read the proper depth. With a wave over the sensors as in Group B, there is an error in both systems due to the compression of the gas. However, because the volume of the large orifice is comparable to the supply line volume, the error using the large orifice is small compared to the error using only the open plastic tubing. Also, with a large orifice, sea water can be prevented from reaching the small bore plastic tubing. If salt water is allowed to continually wash inside the plastic supply line, the dry nitrogen can, over a period of time, evaporate the water and leave salt deposits which may plug the line.

The curves in Figure 8 relate the amount of orifice back-filling to the wave height and relative volumes of the supply line and the orifice volume. Figure #7 pictorally describes the quantities used in calculating the curves for Figure #8.

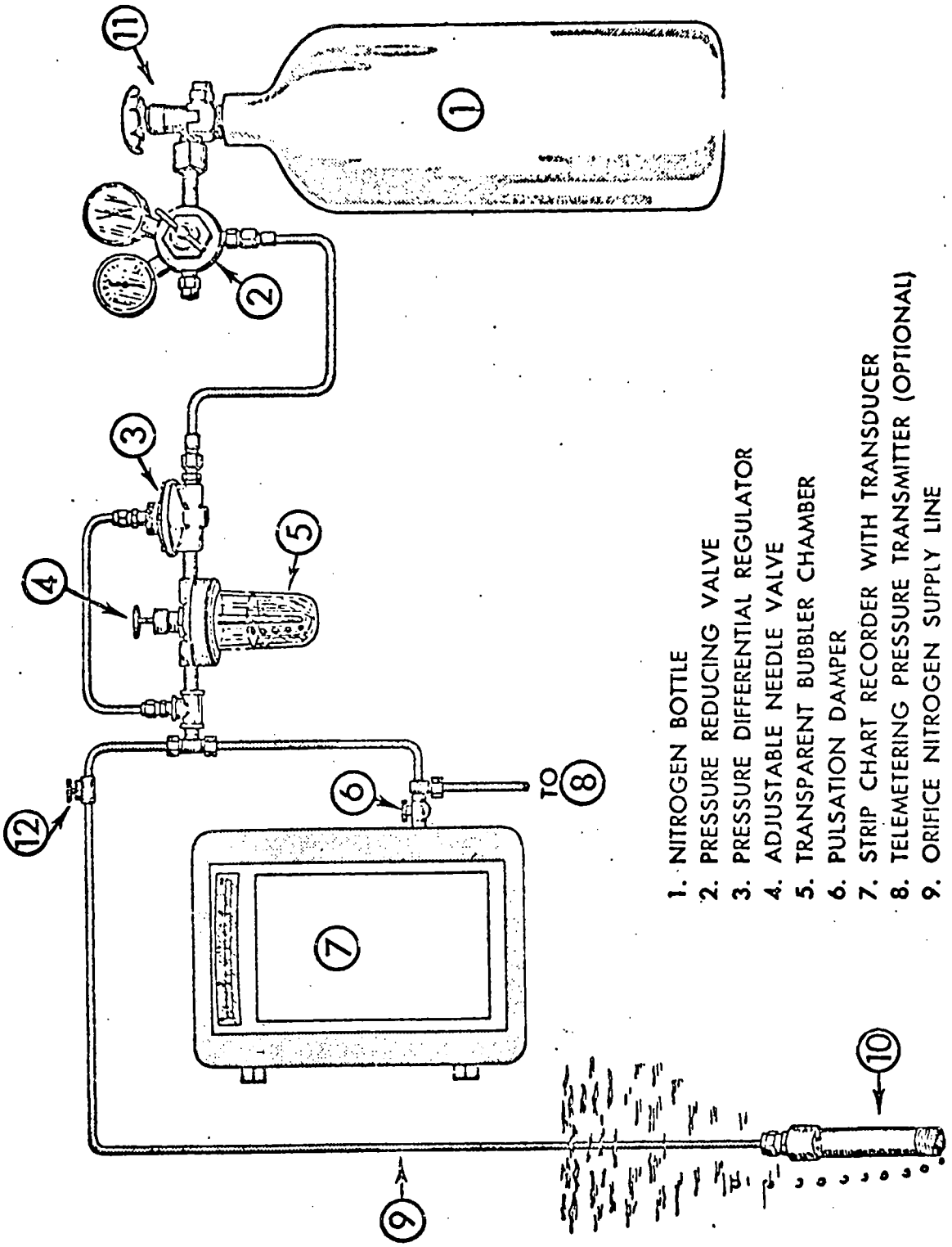
For line lengths of a few thousand feet, the friction of the flowing nitrogen in the supply line begins to create a measurable pressure difference between the orifice and the bellows. A 1/8" inside diameter feed line 2500 ft. long carrying a flow rate of 60 bubbles per minute has a depth error of about 0.1 ft. due to friction. For practical tide measurements, this error can be tolerated. In lines of greater length, variations due to friction can be offset by using two lines to the orifice, one to supply gas and the other to transmit pressure to the recorder.

Errors due to the water changing density because of temperature changes are not measurable. Errors due to variations in salinity may, in the worst cases, be measurable, but are so small that they may be ignored.

There is a maximum error in the indicated pressure of 1% of the full scale value because of the way that the bellows - pen linkage is designed.

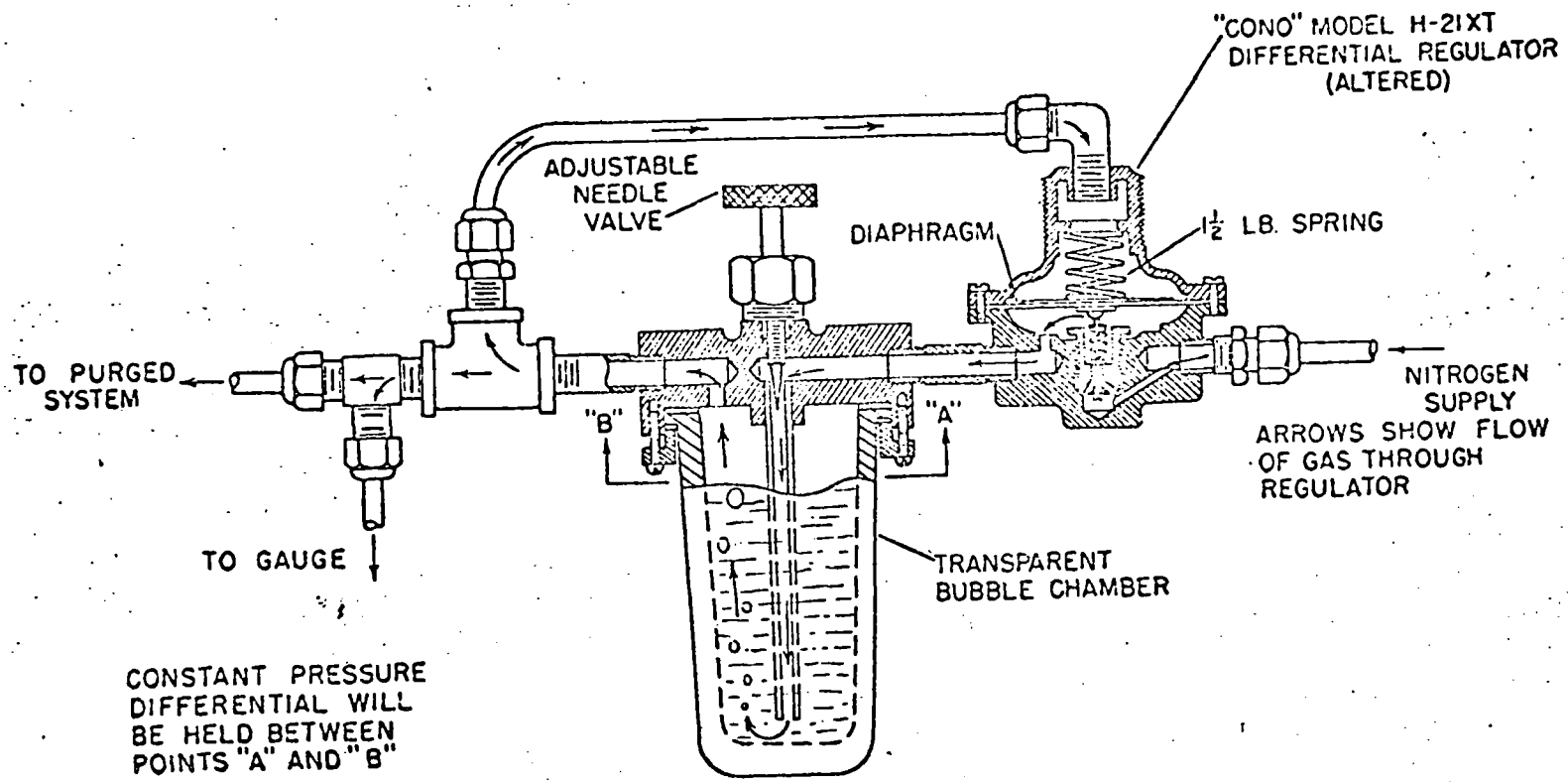
The pressure line connecting the recorder bellows to the rest of the system has a needle valve in it to restrict air flow to the bellows. Pressure variations due to wave motion can be damped out by adjusting the needle valve. Thus, it is possible to obtain a smooth recording of the tide height without a superimposed wave variation.

The 80 cuft gas bottles supplied should each last from 4 to 9 months in normal use.



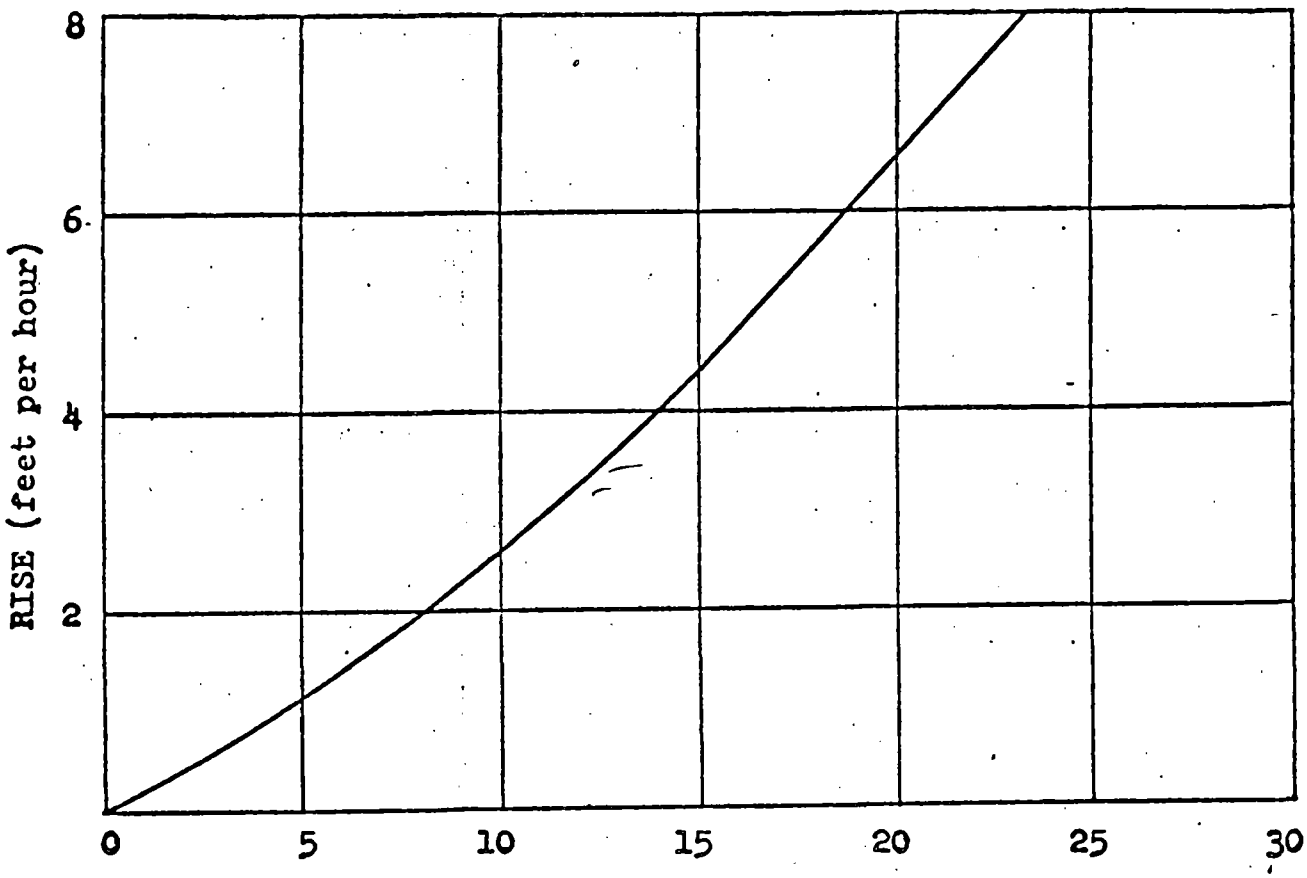
Drawing of Bubbler Gage

FIGURE I



COMBINATION MERIAM BUBBLER – NEEDLE VALVE
WITH CONSTANT DIFFERENTIAL REGULATOR
FOR NITROGEN SERVICE

FIGURE 2



(minimum bubble rate for any installation is 30 bpm)

FIGURE 3

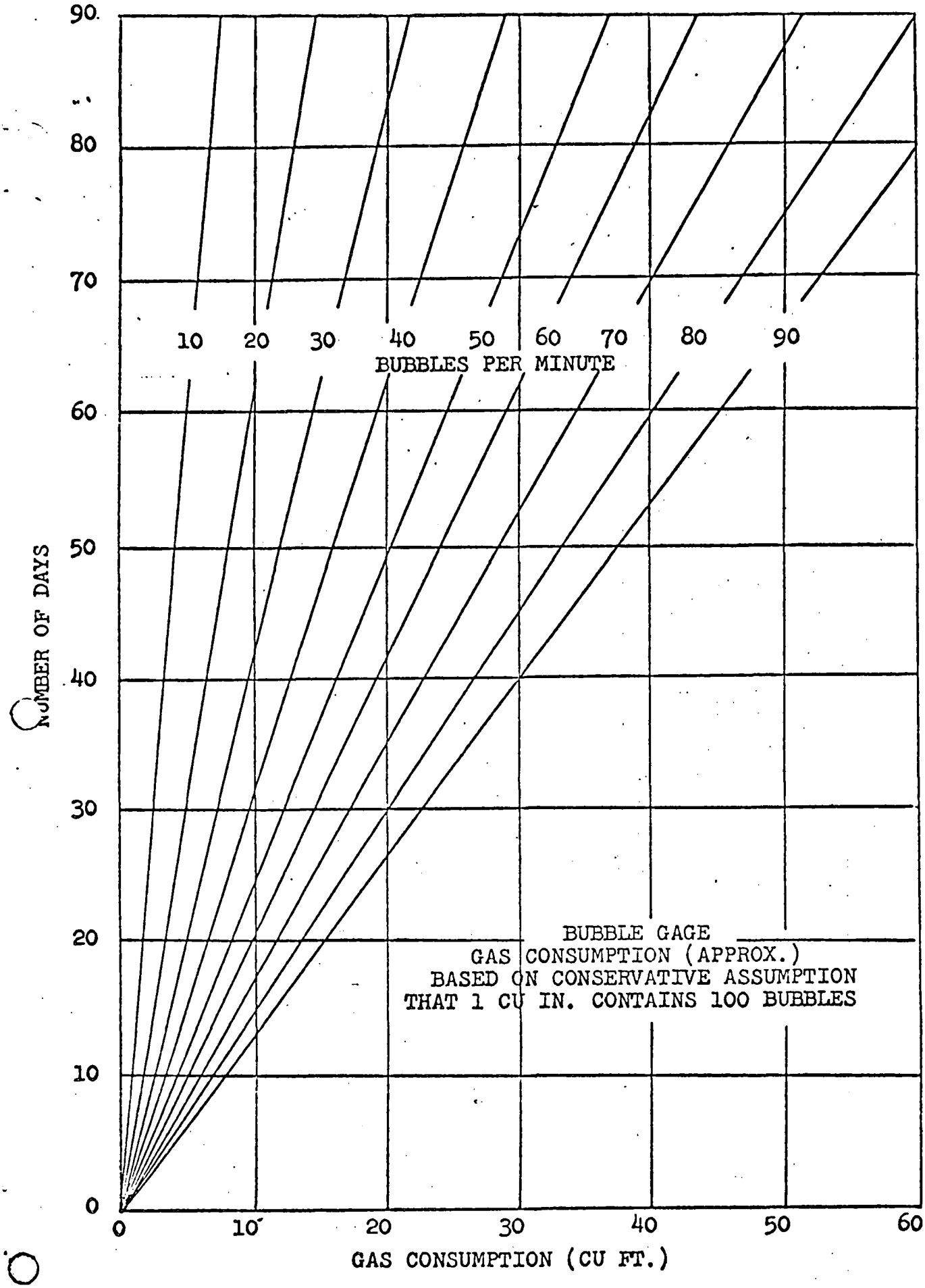

90
80
70
60
50
40
30
20
10
0
NUMBER OF DAYS
10 20 30 40 50 60 70 80 90
BUBBLES PER MINUTE
BUBBLE GAGE
GAS CONSUMPTION (APPROX.)
BASED ON CONSERVATIVE ASSUMPTION
THAT 1 CU IN. CONTAINS 100 BUBBLES
0 10 20 30 40 50 60
GAS CONSUMPTION (CU FT.)

FIGURE 4

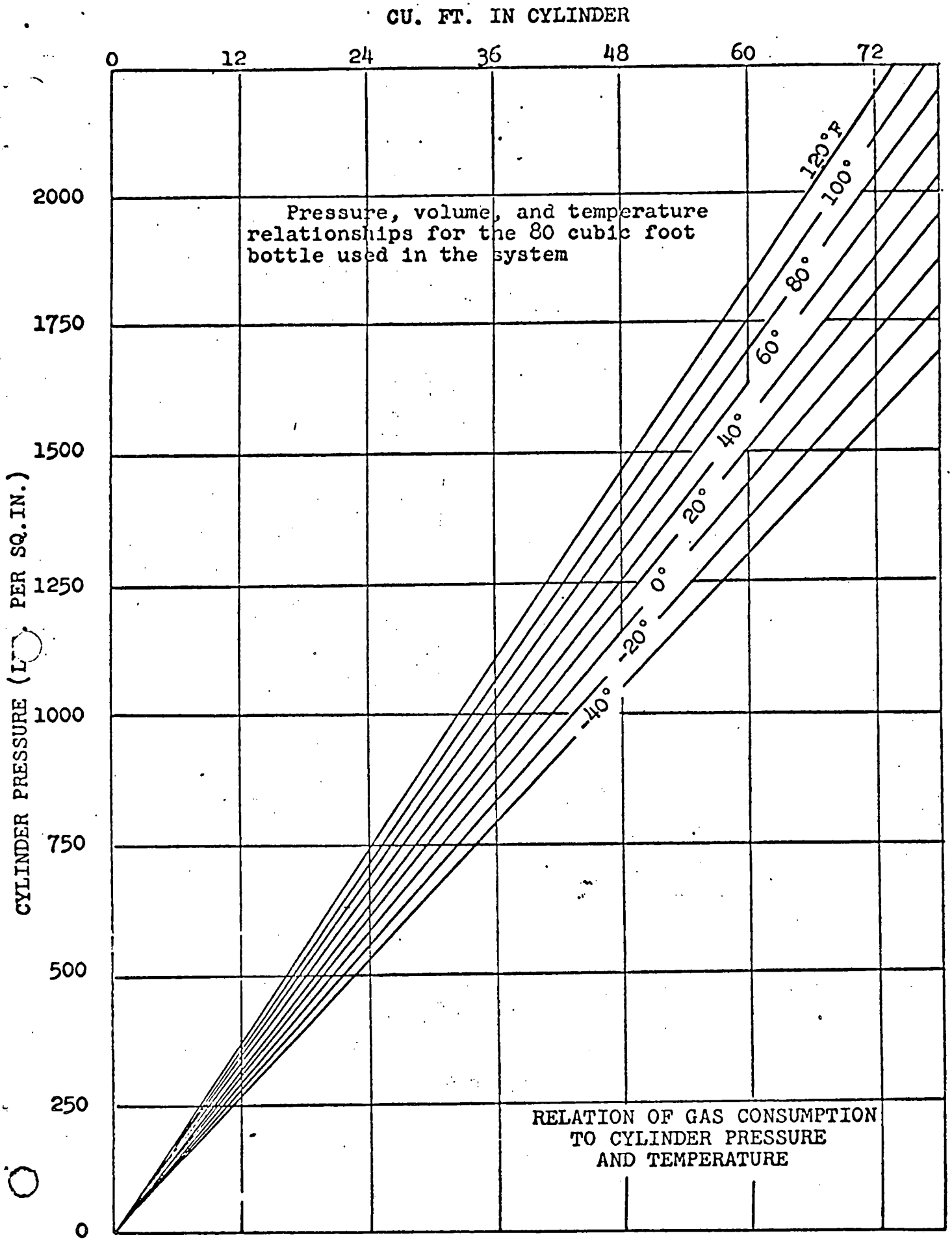

CU. FT. IN CYLINDER
0
12
24
36
48
60
72
2000
1750
1500
1250
1000
750
500
250
0
CYLINDER PRESSURE (LBS. PER SQ.IN.)
120°F
100°
80°
60°
40°
20°
0°
-20°
-40°
Pressure, volume, and temperature relationships for the 80 cubic foot bottle used in the system
RELATION OF GAS CONSUMPTION TO CYLINDER PRESSURE AND TEMPERATURE

FIGURE 5

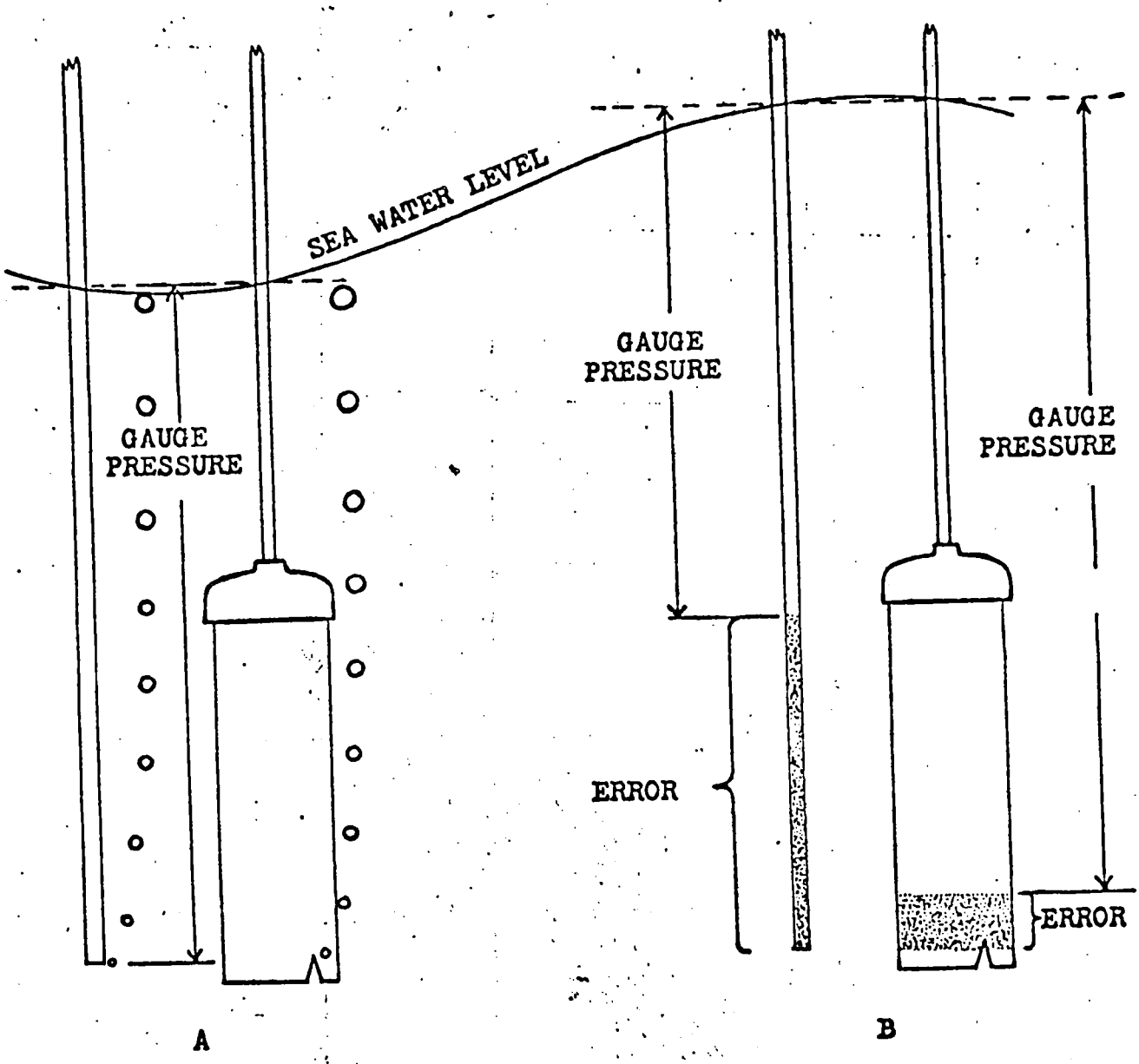
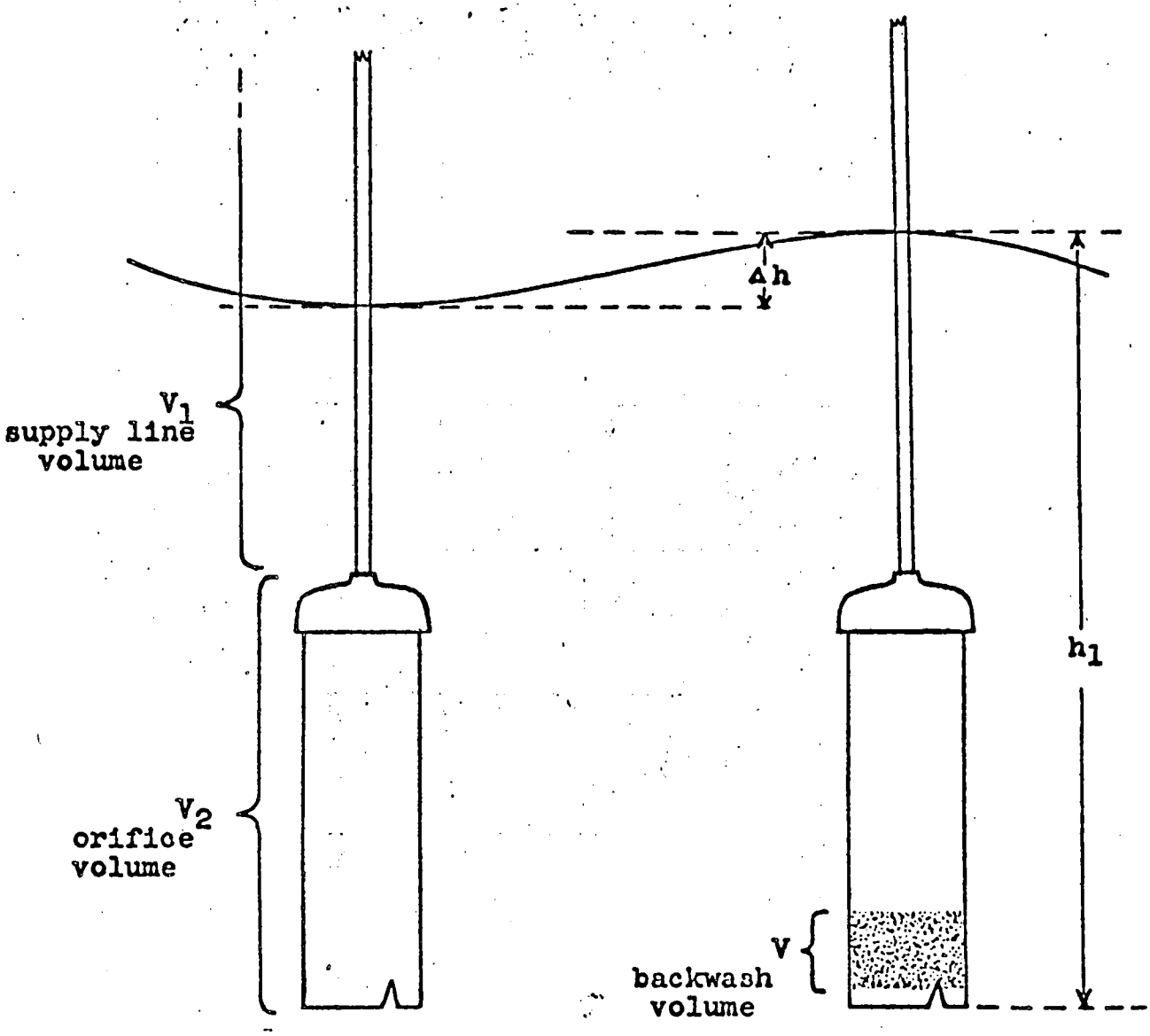
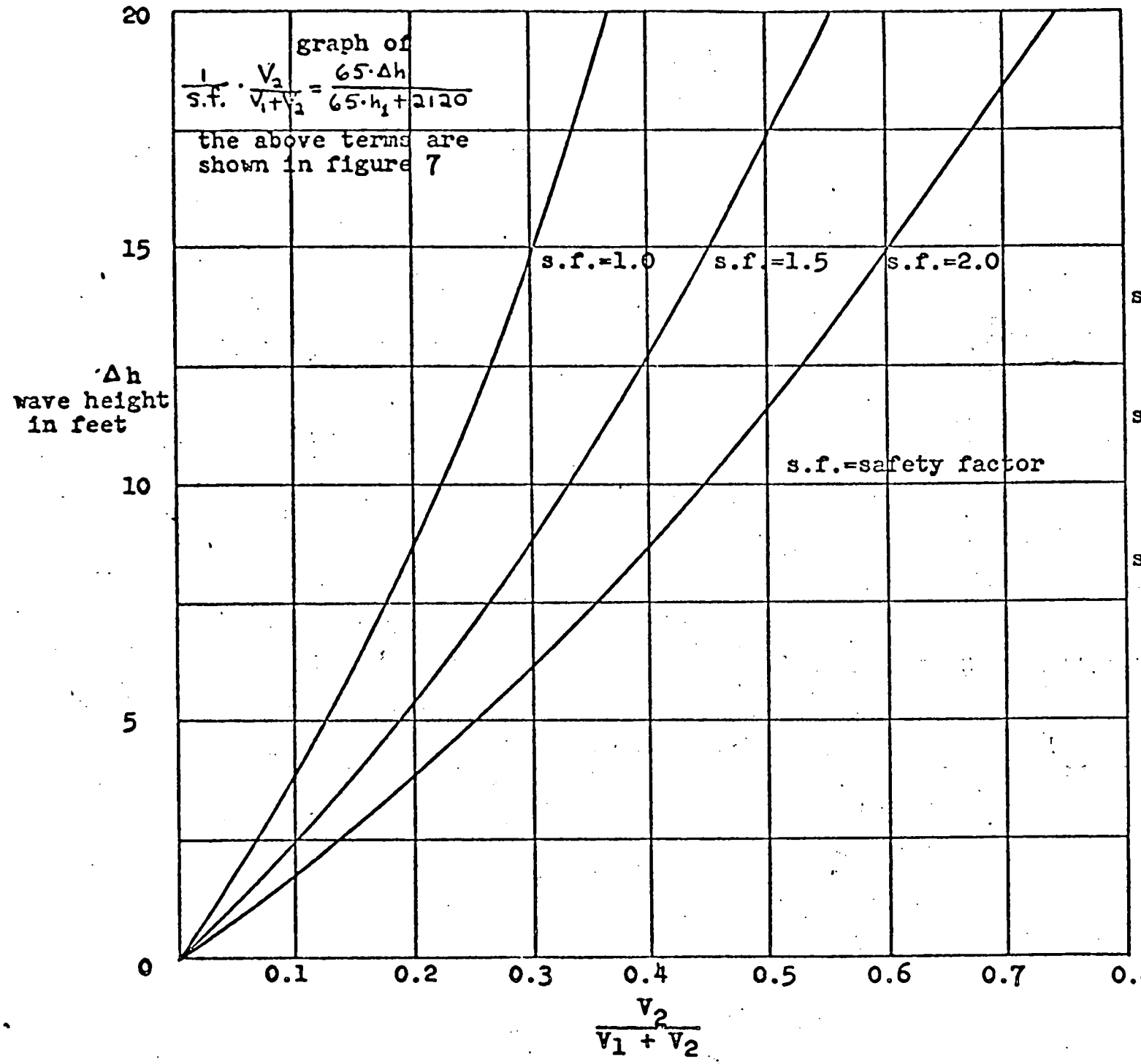

SEA WATER LEVEL
GAUGE PRESSURE
GAUGE PRESSURE
ERROR
GAUGE PRESSURE
ERROR
A
B

FIGURE 6



Quantities used for calculating amount of backwash due to wave action

FIGURE 7



s.f.=1 means that the orifice is full of water when there is a wave over the orifice

s.f.=1.5 means the orifice is two thirds full of water when there is a wave over the orifice

s.f.=2 means the orifice is half full of water with a wave over the orifice

The calculations which give these curves assume that the orifice is 2 feet below the shallow of the wave.

FIGURE 8