

Columbia University  
in the City of New York

LAMONT GEOLOGICAL OBSERVATORY  
PALISADES, NEW YORK

Technical Report No. 4  
CU-57-1-N ONR 266-37-Geol.

RESULTS OF THE OCEANOGRAPHIC  
SURVEY AT ENIWETOK

February 1958



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AT ENIWETOK

SEPTEMBER - OCTOBER 1957

BY

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ST. DAVIDS, BERMUDA.

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FEBRUARY 1958

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## A B S T R A C T

AN OCEANOGRAPHIC SURVEY WAS CONDUCTED AT ENIWETOK DURING OCTOBER 1957. THIS REPORT PRESENTS THE GENERAL ORGANIZATION OF THE SURVEY AND THE RESULTS OF THE BATHYMETRIC AND OFFSHORE OCEAN CURRENT PHASES. CHARTS COVERING RESULTS OF BOTH PHASES ARE INCLUDED. THE OFFSHORE BATHYMETRIC WORK ON THE SOUTHWEST SEAWARD SIDE OF THE ATOLL REEF SHOWED A SMOOTH, STEEPLY SLOPING BOTTOM. THE LAGOON BATHYMETRIC WORK SHOWED MANY CORAL HEADS ON A GENERALLY FLAT BOTTOM. THE OCEAN CURRENT SURVEY REVEALED A VERY COMPLICATED FLOW PATTERN ON THE LEE SIDE OF ENIWETOK ATOLL.

RESULTS OF THE SEISMIC AND OCEANOGRAPHIC WORK WILL BE PUBLISHED SEPARATELY BY THE MINE DEFENSE LABORATORY AND THE PACIFIC OCEANIC FISHERY INVESTIGATIONS RESPECTIVELY.

## INTRODUCTION

DURING THE MONTH OF SEPTEMBER AND OCTOBER 1957 AN OCEANOGRAPHIC SURVEY WAS CONDUCTED IN THE VICINITY OF THE ENIWETOK ATOLL IN THE MARSHALL ISLANDS. THE GENERAL OUTLINE OF THE ENIWETOK AREA IS SHOWN ON CHART 7.

THE MAIN TASKS OF THIS SURVEY, IN ORDER OF THEIR PRIORITY WERE:

I. BATHYMETRIC SURVEYS:

- A. A SURVEY OF AN AREA ON THE SOUTHWESTERN SEAWARD SLOPE OF THE ATOLL.
- B. A DETAILED SURVEY OF A SMALL AREA INSIDE THE LAGOON.
- C. EXPLORATORY LINES IN A GENERAL NORTH-EASTERLY DIRECTION ACROSS THE LAGOON FROM THE LAGOON AREA.

2. A SEISMIC SURVEY TO MEASURE BOTTOM REFLECTION COEFFICIENTS AND REFRACTION VELOCITIES.
3. AN OFFSHORE CURRENT SURVEY TO STUDY THE DEEP OCEAN CURRENTS SOUTHWEST OF THE ATOLL.
4. COLLECTION OF STANDARD PHYSICAL OCEANOGRAPHIC AND MARINE BIOLOGICAL DATA IN THE AREAS OF INTEREST.

THE GENERAL DIRECTION AND ORGANIZATION OF THE EXPEDITION WAS THE RESPONSIBILITY OF THE COLUMBIA UNIVERSITY GEOPHYSICAL FIELD STATION AS WERE TASKS I AND 3.

TASK 2 WAS THE RESPONSIBILITY OF THE USN MINE DEFENSE LABORATORY, PANAMA CITY, FLORIDA. THE WORK WAS CARRIED OUT BY GEORGE B. DOWLING AND EDWARD G. MCLEROY WHO WILL ISSUE A SEPARATE REPORT COVERING THE PHASE.

TASK 4 WAS CONDUCTED BY THE PACIFIC OCEANIC FISHERY INVESTIGATIONS OF THE U.S. FISH AND WILD LIFE SERVICE. THIS WORK WAS CARRIED OUT BY HERBERT H. SHIPPEN AND ROBERT T. B. IVERSEN WHO WILL REPORT THIS PHASE SEPARATELY.

MR. J. W. WINCHESTER, ASSISTED BY ENS. T. S. SCOTT BOTH OF THE OFFICE OF NAVAL RESEARCH (CODE 418) WERE IN CHARGE OF THE ADMINISTRATIVE ARRANGEMENTS FOR THE SURVEY AS WELL AS BEING MEMBERS OF THE SCIENTIFIC PARTY. MR. A. W. ANDERSON OF THE USN HYDROGRAPHIC OFFICE TOOK PART IN THE SURVEY GIVING MUCH ASSISTANCE AND ADVICE.

THE RESEARCH SHIP M/V HUGH M. SMITH WAS CHARTERED FROM THE PACIFIC OCEANIC FISHERY INVESTIGATIONS FOR THE SURVEY. THIS SHIP WAS A VERY FORTUNATE CHOICE WITH MANY

ADVANTAGES. FOREMOST OF THESE WAS THE ENERGY AND INTELLIGENCE OF THE SHIP'S COMPANY. HER MASTER, CAPT. B. COLLINSON, HER OFFICERS AND HER CREW WERE OF INESTIMABLE ASSISTANCE DURING THE SURVEY, AND WERE AMONG THE BEST EVER ENCOUNTERED BY THE WRITERS IN THE FIELD OF MARINE RESEARCH. THE SHIP HAS DISADVANTAGES WHICH SHOULD BE NOTED. THE LACK OF A GYRO COMPASS WITH BRIDGE REPEATERS AND THE LACK OF AN ACCURATE RADAR MAKE OFFSHORE POSITIONING FOR THE DEEP OCEAN CURRENT WORK LESS PRECISE THAN DESIRABLE. THE SHIP'S DEEP WATER ECHO SOUNDER IS NOISY WHEN RUNNING UPWIND AND WILL NOT THEN RECORD IN DEPTHS OVER 1500 FATHOMS.

ESSENTIAL EQUIPMENT FOR EACH PHASE OF THE SURVEY WAS SHIPPED FROM THE HOME BASES OF THE ORGANIZATIONS CONCERNED. MUCH EQUIPMENT WAS ALSO PROCURED FROM THE U.S. NAVAL SUPPLY DEPOT AND NAVAL SHIPYARD AT PEARL HARBOR, AND FROM POFI IN HONOLULU. THE GOOD ASSISTANCE OF THESE ORGANIZATIONS WAS MOST HELPFUL.

THE AEC BRANCH OFFICE AT ENIWETOK AND THEIR CONTRACTORS, HOLMES AND NARVER INC, PROVIDED SERVICES IN THAT AREA SUCH AS HOUSING PERSONNEL, TRANSPORTATION WITHIN THE ATOLL, MANUFACTURE OF SPECIAL EQUIPMENT, REPAIRING ELECTRONIC EQUIPMENT AND PROVIDING A SMALL



SHIP TO FIRE THE SEISMIC CHARGES. THE ATOLL COMMANDER PROVIDED ASSISTANCE IN COMMUNICATIONS, WEATHER DATA AND A HELICOPTER FOR TRANSPORT OF PERSONNEL. ALL THESE ORGANIZATIONS FUNCTIONED SMOOTHLY AND EFFICIENTLY, HANDLING ALL THE SURVEY'S NEEDS EXCELLENTLY.

THE AZIMUTH STATIONS WERE ERECTED PRIOR TO THE SMITH'S ARRIVAL IN THE ENIWETOK AREA ON SEPTEMBER 28TH. THE SMITH DEPARTED THAT AREA ON OCTOBER 19TH. A LARGE AMOUNT OF DATA WAS COLLECTED IN THIS TIME DUE TO THE ENTHUSIASTIC COOPERATION OF ALL THE SCIENTISTS AND SHIP'S PERSONNEL.

#### BATHYMETRY TECHNIQUES:

THE PRIMARY TASK OF THE SURVEY WAS TO MAKE BATHYMETRIC CHARTS OF TWO AREAS NEAR THE SOUTHWEST PORTION OF THE ATOLL. THESE WERE CLOSE TO THE ISLANDS OF GIRIINIEN AND MUI, AS SHOWN ON CHART 7. THESE AREAS WERE SURVEYED DURING THE FIRST WEEK THE PARTY WAS IN THE AREA. THIS DATA WAS REPLOTTED AND CHARTS PREPARED AT ENIWETOK AND TURNED OVER TO THE ONR REPRESENTATIVES PRIOR TO THEIR DEPARTURE FROM ENIWETOK.

IN GENERAL THE TECHNIQUES EMPLOYED FOR BOTH AREAS WERE SIMILAR. SHIP POSITIONING WAS DONE FROM THE ISLANDS

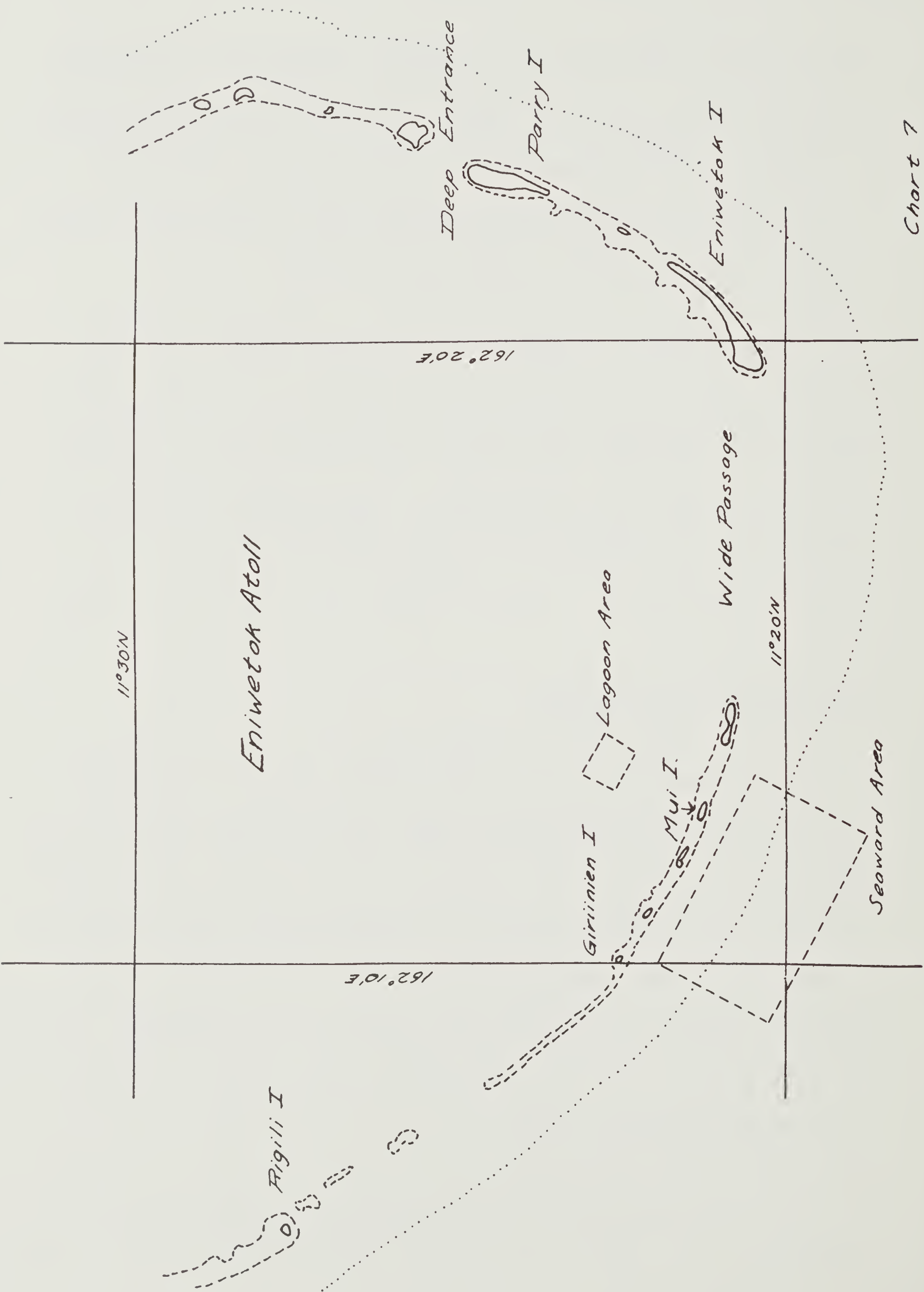


Chart 7

OF MUI AND GIRIINIEN, USING AZIMUTH INSTRUMENTS (SEE REFERENCE I) LOCATED OVER THE SECOND ORDER TRIANGULATION STATIONS HENRY (MUI IS.) AND KEITH (GIRIINIEN IS.).

THE FOLLOWING POSITIONS OF THESE STATIONS WERE GIVEN BY THE HOLMES AND NARVER ENGINEERING DEPARTMENT:

HENRY:         $11^{\circ}21'20.942''N$          $162^{\circ}12'17.478''E$

KEITH:         $11^{\circ}22'34.240''N$          $162^{\circ}10'02.755''E$

THIS GAVE AN ACCURATE BASE LENGTH OF ABOUT 3 MILES FOR THE SHIP POSITIONING. TCS RADIOS WERE INSTALLED AT THE BASE OF THESE TOWERS WITH REMOTE UNITS LOCATED AT THE TOP OF THE TOWERS ADJACENT TO THE AZIMUTH INSTRUMENTS. ADAPTERS WERE MADE UP TO PLACE THE AZIMUTH INSTRUMENTS DIRECTLY ON THE INNER BILBY TOWER. THESE AZIMUTH INSTRUMENTS READ DIRECTLY TO  $0.01^{\circ}$ . THEY HAVE BEEN TESTED AGAINST THEODOLITE MEASURED ANGLES IN BERMUDA. THEY ARE ACCURATE TO WITHIN  $\pm 0.01^{\circ}$  THROUGHOUT THE ENTIRE CIRCLE. IN THE ACTUAL SURVEYED AREAS THE WORST LINEAR ERROR OF A LINE OF POSITION IS APPROXIMATELY  $\pm 6$  FT.

A PRECISION DEPTH RECORDER MK-5 OR PDR WAS USED AS THE RECORDER FOR THE SMITH'S AN/UQN-1B DEEP WATER ECHO SOUNDER. THIS ECHO SOUNDER IS MANUFACTURED BY THE EDO CORPORATION. THESE EQUIPMENTS ARE DESCRIBED IN REFERENCES 2 AND 3. THE PDR KEYED THE EDO TRANSMITTER AND RECORDED

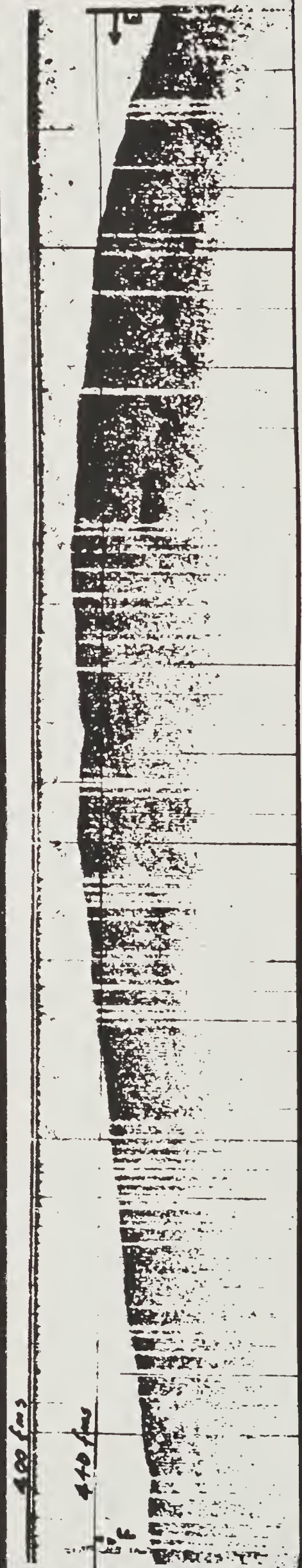
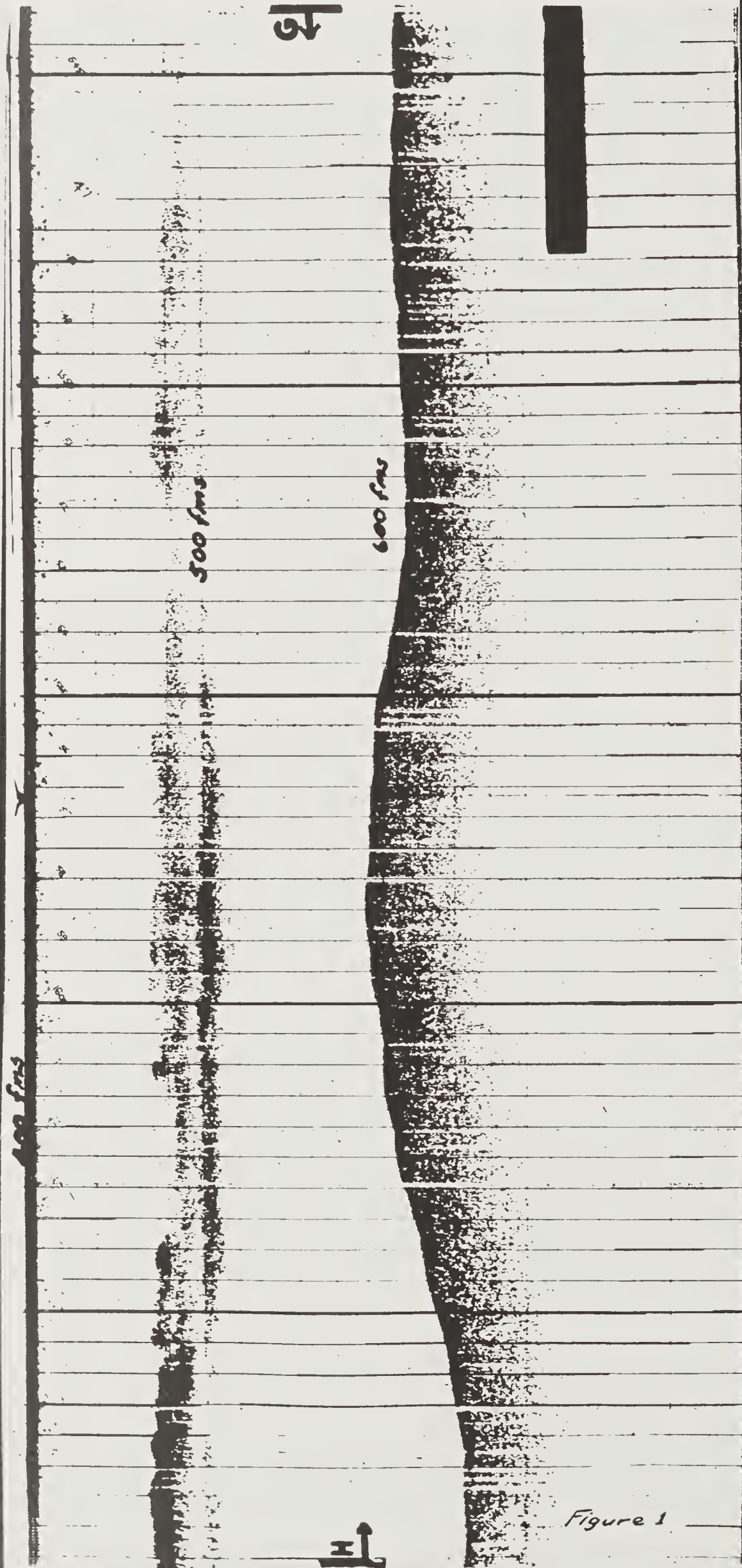
THE RETURN ECHOES FROM THE EDO RECEIVER. A SHORT, 3 MILLISECOND TRANSMITTER PING WAS USED TO PERMIT RESOLUTION OF TOPOGRAPHIC HIGHLIGHTS OR CRESCENTS (4). A PING REPETITION RATE OF ONCE PER SECOND WAS USED FOR ALL DEPTHS. THIS LIMITED THE RECORDING ON THE PDR TO 400 FATHOMS AND SUPERIMPOSED ALL ADDITIVE 400 FATHOM DEPTHS, I.E. 122 FATHOMS, 522 FATHOMS, 922 FATHOMS, ETC., ALL RECORDED AT THE SAME PLACE ON THE PDR RECORD. THIS EFFECT IS WELL SHOWN ON FIGURE 2. IF ONE WAS UNCERTAIN ABOUT THE ACTUAL DEPTH IT COULD BE CHECKED BY SWITCHING THE ECHO SOUNDER BACK TO STANDARD EDO OPERATION. THE PDR CHART RECORD SPEED OF 96" PER HOUR WAS USED. THIS COMBINED WITH THE ONE SECOND PULSE RATE GAVE EXCELLENT RECORDS ON EVEN THE STEEPEST SLOPING BOTTOMS. THE VERTICAL EXAGGERATION OF THE BOTTOM SLOPE ON THE PDR CHART RECORD VARIED FROM 3.4:1 TO 5:1 DEPENDING ON SHIPS SPEED. THE PDR RECORD WAS INDEXED ON EACH POSITION "MARK" - NORMALLY EVERY 30 SECONDS, AND ANNOTATED ON EVERY "TIME CHECK MARK" NORMALLY MADE EVERY 3 OR 5 MINUTES. THE TWO OBSERVING STATIONS TOOK BEARINGS ON "MARKS" BROADCAST BY THE SMITH'S RADIO, RECORDED THEM AND IMMEDIATELY TRANSMITTED THE BEARINGS TO THE SMITH. A RUNNING PLOT WAS MAINTAINED ON BOARD THE SMITH MAKING IT POSSIBLE TO IMMEDIATELY ADJUST THE SHIPS COURSE TO APPROXIMATE THE DESIRED SOUNDING



LINES. THE RUNNING PLOT WAS MADE ON PREVIOUSLY PREPARED CHARTS ON WHICH AZIMUTHS FROM EACH STATION WERE DRAWN. THE SMITH HOLDS COURSE WELL AND HAS A GOOD AUTOMATIC STEERING SYSTEM. THIS MADE IT POSSIBLE TO RUN PLANNED SOUNDING LINES WITH ONLY VERY MINOR COURSE ADJUSTMENTS AFTER SET AND DRIFT HAD BEEN PREVIOUSLY ESTIMATED. ALSO OF ADVANTAGE FOR THE SHALLOW WATER SOUNDING WORK WERE THE FULL WHEELHOUSE ENGINE ROOM CONTROLS WHICH RESULTED IN A WILLINGNESS ON THE PART OF THE SMITH'S SKIPPER TO EASE INTO UNKNOWN WATER.

SEAWARD BATHYMETRIC SURVEY:

IN THE SEAWARD AREA WHERE DEPTHS RANGED FROM 100 TO 800 FATHOMS A BATHYMETRIC MAP WAS REQUIRED FROM WHICH THE ACTUAL BOTTOM TOPOGRAPHY COULD BE COMPUTED. SOUNDING LINES WERE RUN IN THIS AREA ON 500' CENTERS WITHOUT DIFFICULTY. CROSS CHECK LINES WERE RUN ON 2400' CENTERS. THIS DATA WAS REPLOTTED ON CHART I SHOWING INDICATED BOTTOM CONTOURS EVERY 20 FATHOMS. A TABLE OF DEPTH CORRECTIONS IS INCLUDED IN THIS CHART. THESE CORRECTIONS INCLUDE TRANSDUCER DEPTH ( 2 FATHOMS), SEA WATER SOUND VELOCITY CORRECTION OBTAINED FROM REFERENCE 5 AND A CORRECTION FOR THE SLOPING BOTTOM. THE LATTER CORRECTION WAS COMPUTED GRAPHICALLY USING THE METHODS DESCRIBED IN REFERENCES 6 AND 7. FIGURE I SHOWS THE SOUNDING RECORD





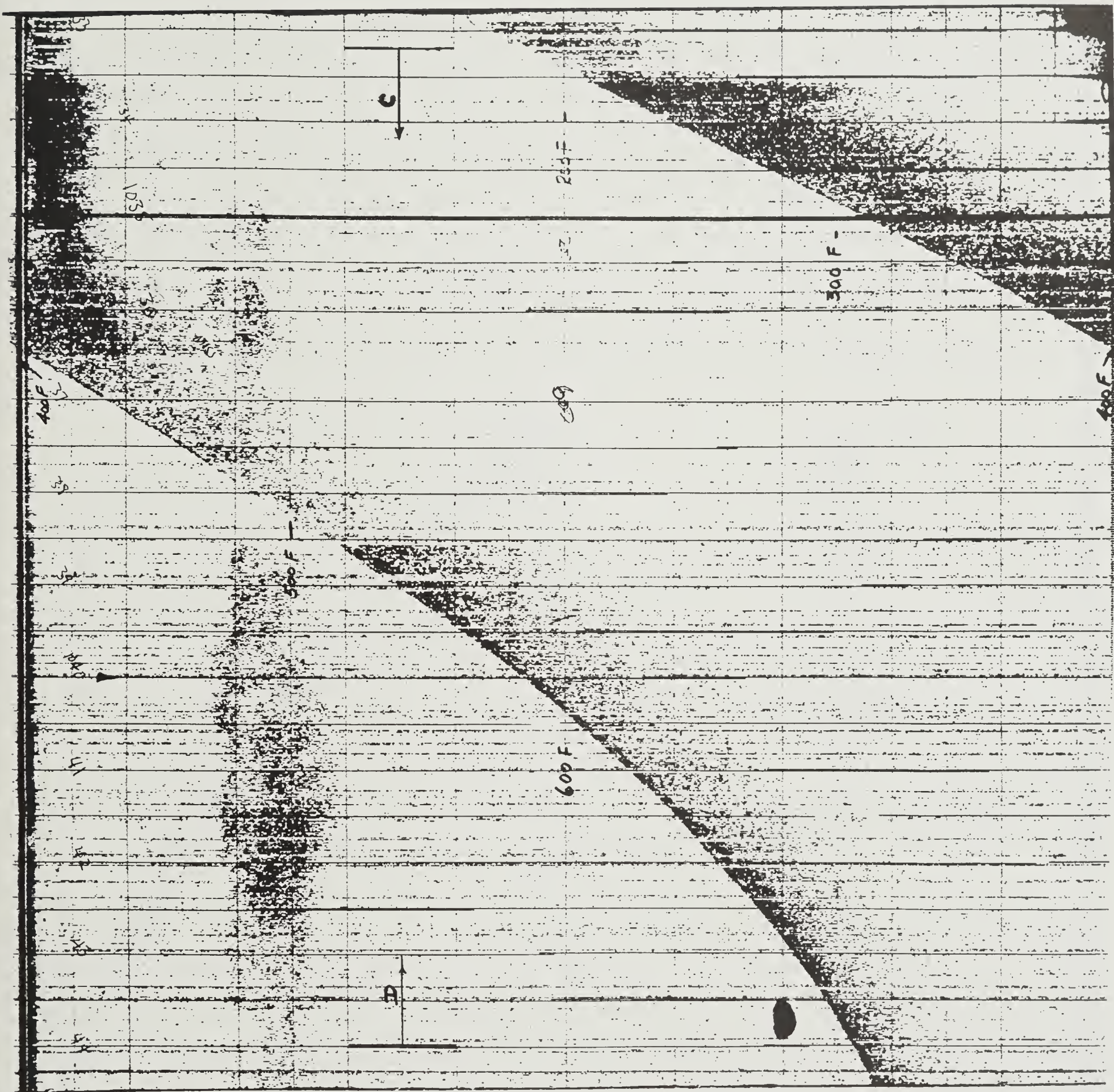


Figure 2



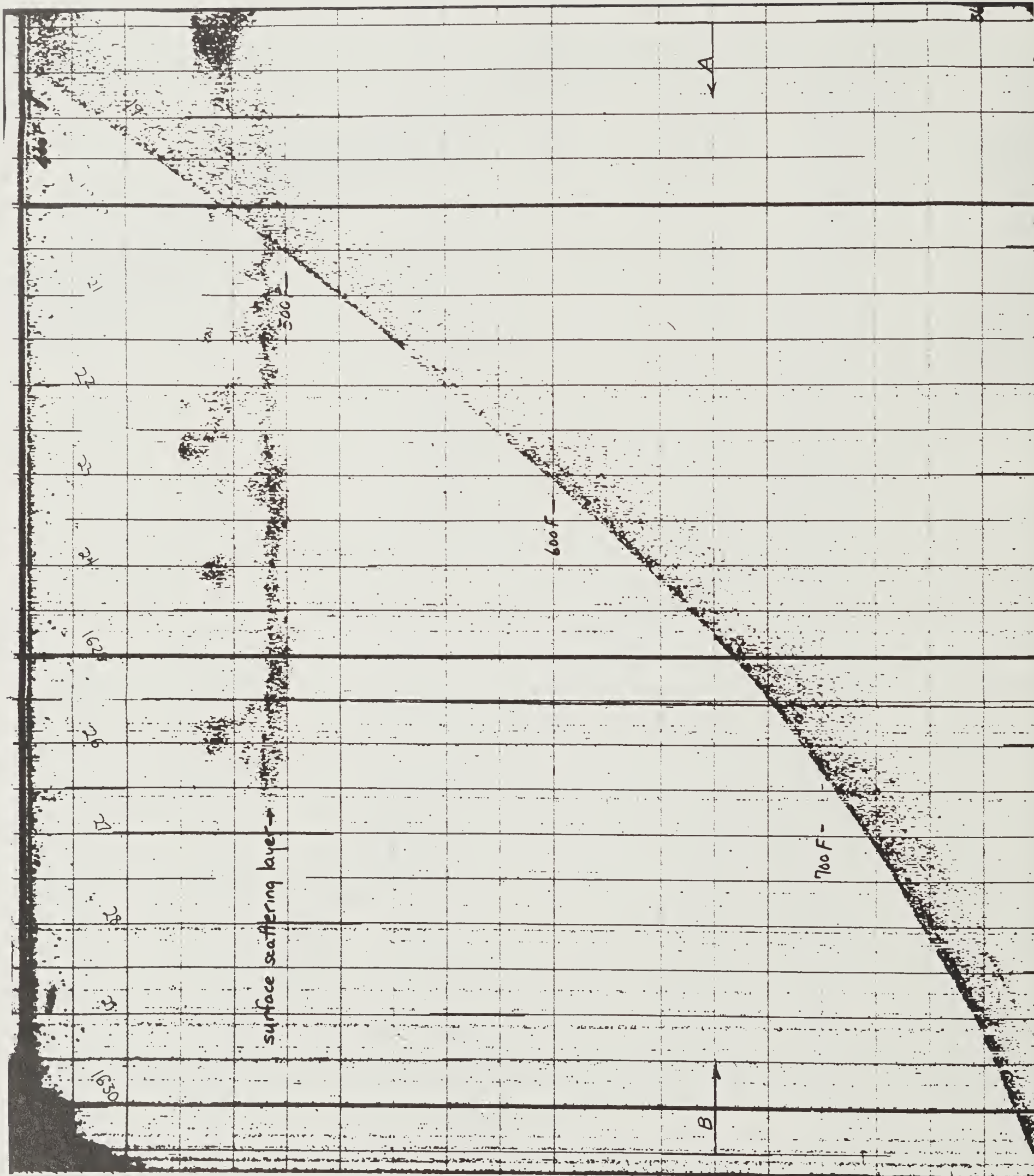


Figure 3



FROM TWO OF THESE SOUNDING LINES. THE REFERENCE LETTERS HAVE BEEN MARKED ON CHART I. FIGURES 2 AND 3 SHOW THE SOUNDING RECORDS ON TWO OF THE CROSS CHECK LINES. IN ALL THREE OF THESE FIGURES A SURFACE SCATTERING LAYER WAS RECORDED, LOCATED AT ABOUT 100 FATHOMS. THE SMOOTHNESS OF THE BOTTOM IS INDICATED BY THE LACK OF HIGHLIGHT ECHOES, I.E. ONLY THE FIRST RETURN IS SHARP. FINER DETAIL OF SUCH SMOOTH SLOPING BOTTOM TOPOGRAPHY COULD ONLY BE OBTAINED WITH A SUBMERGED TRANSDUCER.

LAGOON BATHYMETRIC SURVEY:

THE LAGOON AREA HAS AN AVERAGE WATER DEPTH OF SLIGHTLY OVER 20 FATHOMS WITH NUMEROUS CORAL HEADS RISING TO LESSER DEPTHS. REASONABLE COVERAGE OF THE DETAILED BATHYMETRY OF THIS AREA WAS REQUIRED. TO GET THIS COVERAGE SOUNDING LINES WERE RUN ON 100' SPACINGS. THIS SPACING PROVED TO BE DIFFICULT TO MAINTAIN. 'HOLIDAYS' (DEFINED AS AREAS WHERE THE SEPARATION BETWEEN ACTUAL SOUNDING LINES RUN WAS GREATER THAN 1.5 TIMES THE PLANNED SEPARATION) WERE ELIMINATED BY DECREASING THE SHIP FIX INTERVAL TO 15 SECONDS AND COMMENCING THE 'HOLIDAY' LINES A GOOD DISTANCE OUTSIDE THE AREA. SEVERAL EXTRA LINES ON NORTHEASTERLY AND SOUTHWESTERLY HEADINGS WERE RUN ON ABOUT 400' CENTERS OUTSIDE THE AREA. SEVERAL CROSS CHECK LINES WERE ALSO RUN.



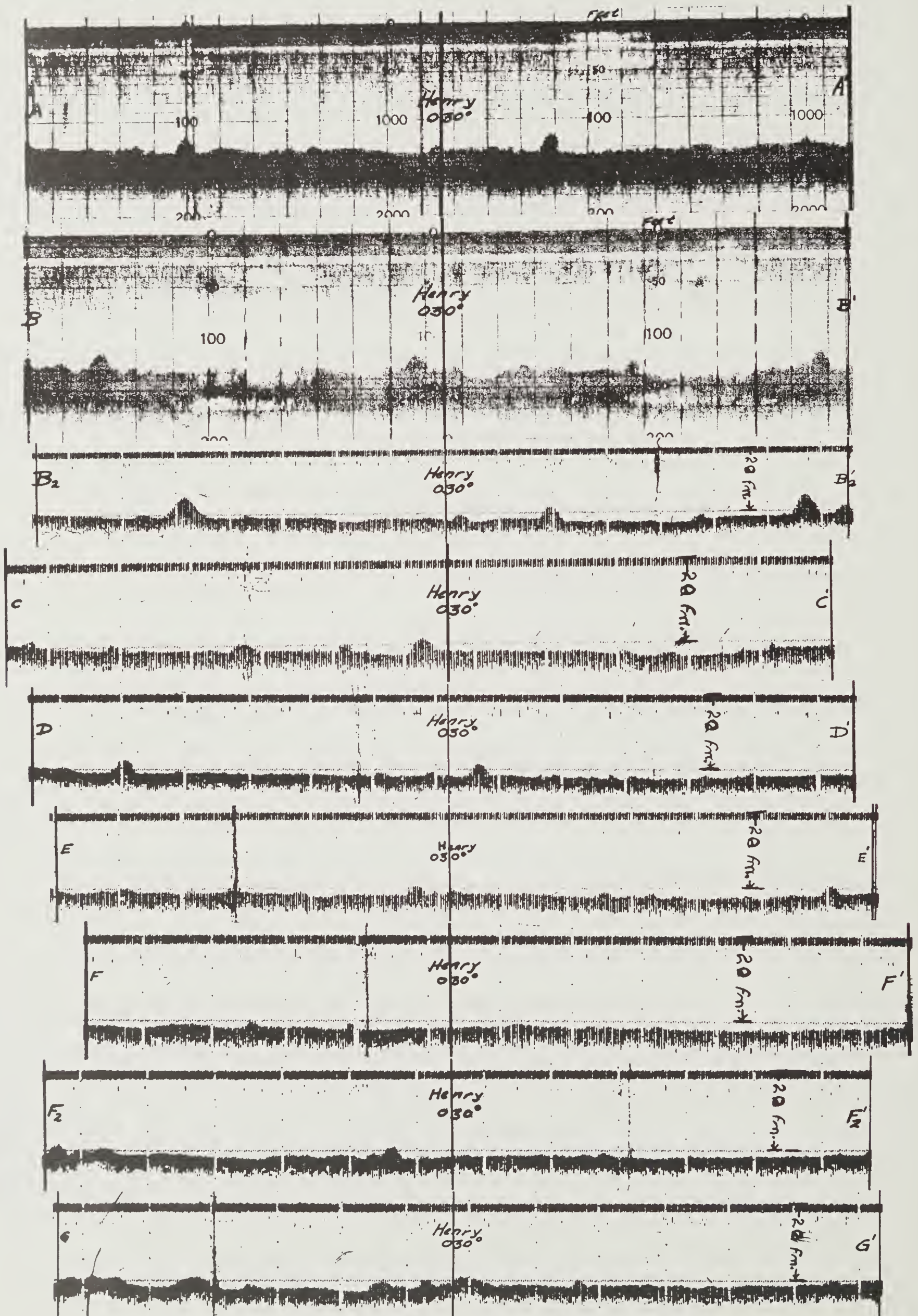


Figure 4



THE LAGOON SOUNDING DATA SHOWN ON CHART 2 WAS CORRECTED TO MEAN LOW WATER AND FOR TRANSDUCER DEPTH. CHART 3 WAS PREPARED TO SHOW THE LOCATION OF THE LARGER CORAL HEADS. THE SOUNDING LINES REPRODUCED IN FIGURE 4 ARE APPROXIMATELY 20% OF THE TOTAL RUN. THIS LAGOON SOUNDING WORK WAS COMMENCED ON THE EDO RECORDER BUT CHANGED TO THE PDR WHEN IT WAS DEMONSTRATED THAT THE PDR RECORD GAVE CLEARER DATA. IN FIGURE 4 THE SOUNDING RECORDS SHOWN ARE ARRANGED WITH THE MOST NORTHEASTERLY LINES AT THE TOP.

EXPLORATORY LINES:

EXPLORATORY LINES WERE RUN FROM THE CENTER OF THE LAGOON AREA ON A COURSE OF ABOUT  $068^{\circ}$  FOR 6 MILES. THE PURPOSE OF THESE LINES WAS TO GIVE A GENERAL PICTURE OF THE BOTTOM ALONG THIS BEARING. IN ORDER TO DETERMINE THE COMPLETE BOTTOM CONFIGURATION OF THIS AREA A MUCH MORE INVOLVED AND LENGTHY SURVEY WOULD BE REQUIRED.

SHIP POSITION CONTROL FOR THESE EXPLORATORY LINES WAS BY HORIZONTAL SEXTANT ANGLES USING THE APPROPRIATE 3 OF 5 PERMANENTLY INSTALLED OBJECTS ON THE BEACH AS TARGETS (8). THEIR SECOND ORDER SURVEY LOCATIONS WERE GIVEN BY THE HOLMES AND NARVER ENGINEERING DEPARTMENT AS FOLLOWS:

<u>NAME:</u>	<u>ISLAND LOCATION</u>	<u>DEG.</u>	<u>MIN.</u>	<u>SEC.</u>	<u>DESCRIPTION.</u>
RADAR	ENIWETOK Is.	11 <sup>o</sup>	20'	29.0"N	ORANGE RED RADAR TOWER
		162 <sup>o</sup>	19'	48.9"E	
TOWER	PARRY Is.	11 <sup>o</sup>	24'	41.4"N	125' SILVER COLORED OBSERVATION TOWER.
		162 <sup>o</sup>	22'	43.9"E	
GLEN	IGURIN Is.	11 <sup>o</sup>	20'	54.2"N	50 FT. BILBY TOWER
		162 <sup>o</sup>	13'	50.7"E	
HENRY	MUI Is.	11 <sup>o</sup>	21'	20.9"N	50 FT. BILBY TOWER
		162 <sup>o</sup>	12'	17.5"E	
WATER	ENIWETOK Is.	11 <sup>o</sup>	21'	24.3"N	BLACK WATER TANKS.
		162 <sup>o</sup>	20'	56.4"E	



18 October 1957

0920  
Radar Glenn - Henry  
106°35' 32°46'

Time  
Targets  
-SC Angle Right Angle  
Total Angle

0924  
No Fix

0926  
Radar - Glenn - Henry  
82°26' 29°06'  
109°33'

18 October 1957

0923  
No Fix

20 fathoms

0937  
No Fix

0934  
Water - Glenn - Henry  
99°40' 17°51'  
119°36'

0932  
No Fix

0929  
No Fix

20 fathoms

0940  
No Fix

0940  
No Fix

0937  
No Fix

COURSE  
CHANGE  
110°

0951  
Water - Radar  
58°48' 18°02'  
78°47'

0948  
Tower - Water Radar  
54°37' 18°45'  
73°21'

18 October 1957

0946  
No Fix

0944  
No Fix

20f

COURSE  
CHANGE  
156°

0957  
Tower - Water - Radar  
62°N' 14°58'  
77°12'

0954  
Tower - Water - Radar  
62°11' 16°48'  
78°58'

0951  
Tower - Water - Radar  
58°48' 18°02'  
78°47'

Figure 5

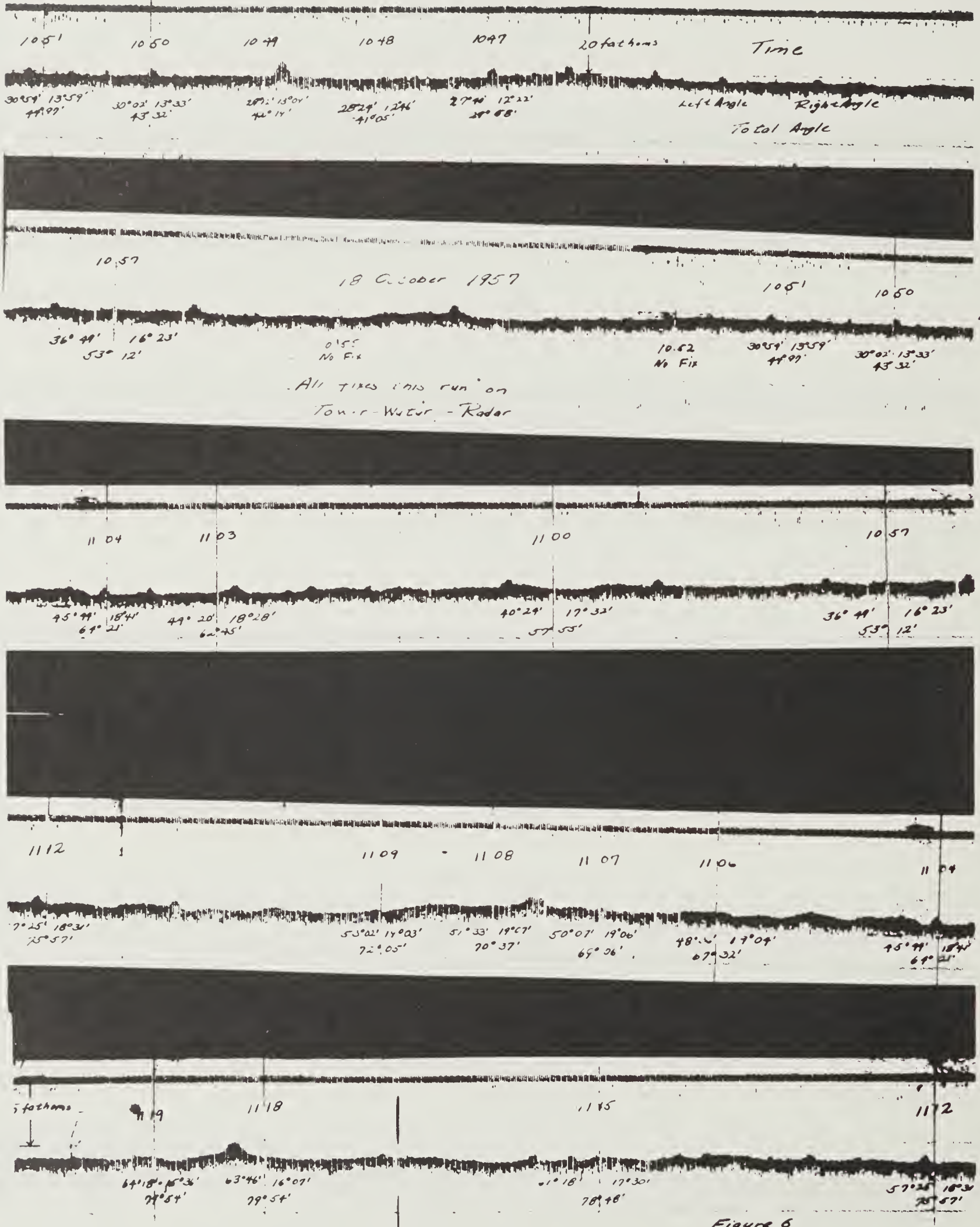


Figure 6



DUE TO THE LACK OF TIME AND THE INEXPERIENCE OF THE PERSONNEL WITH THE HORIZONTAL SEXTANT ANGLE TECHNIQUES USED, ONLY TWO OF THE LINES RUN HAD ACCEPTABLE SHIP POSITION FIXES.

AN ATTEMPT WAS MADE TO RUN THESE LINES ON A STRAIGHT COURSE, BUT WATER DISCOLORATIONS AND INDICATIONS OF CORAL HEADS ON THE BOTTOM MADE IT PRUDENT AT TIMES TO DEVIATE FROM THE STRAIGHT LINES. IN ADDITION TO THE TWO SEXTANT ANGLES REQUIRED FOR EACH FIX A THIRD SEXTANT ANGLE, THE TOTAL ANGLE FROM THE LEFT TO THE RIGHT OBJECT, WAS TAKEN AND RECORDED TO TEST THE ACCURACY OF THE TWO STANDARD SEXTANT ANGLES. ON THE TWO LINES SHOWN ON CHART 4 THIS ERROR SELDOM EXCEEDED 4 MINUTES OF ARC.

FIGURES 5 AND 6 ARE REPRODUCTIONS OF THE SOUNDING RECORDS OF THESE TWO EXPLORATORY LINES. EACH SHIP FIX IS PLOTTED ON CHART 4. ANNOTATED ON THE SOUNDING RECORDS AT EACH FIX ARE THE LEFT, RIGHT AND TOTAL ANGLES AS WELL AS THE TIME OF FIX. THE RECORDS IN FIGURES 5 AND 6 MAY THUS BE CORRELATED WITH THE SHIP TRACKS ON CHART 4. THE HORIZONTAL LINES ON THE RECORDS OF FIGURES 5 AND 6 ARE 20 FATHOM MARKERS. THE SOUNDINGS ARE UNCORRECTED IN THESE FIGURES. THE INTEREST IN THESE LINES WAS BOTTOM CONFIGURATION RATHER THAN EXACT TOTAL DEPTH. THE OTHER LINES

RUN IN THIS GENERAL AREA GAVE SIMILAR SOUNDING RECORDS TO THOSE SHOWN IN FIGURES 5 AND 6. IN THE OPINION OF THE WRITERS, INFLUENCED BY VISUAL OBSERVATIONS FROM HELICOPTERS, IT WOULD BE VERY DIFFICULT TO LAY DOWN A STRAIGHT COURSE ON ANY AZIMUTH FROM THE SURVEYED LAGOON AREA WHICH WOULD NOT GIVE THE SAME SORT OF BOTTOM.



OFFSHORE CURRENT SURVEY:

THE OFFSHORE CURRENT SURVEY WAS MADE TO EVALUATE THE GROSS WATER MOVEMENT SOUTHWEST OF THE ATOLL.

OVER-AGE STANDARD AIRCRAFT PERSONNEL PARACHUTES WERE USED AS DROGUES (9 AND 10) TO STUDY THE WATER MOVEMENT AT VARIOUS DEPTHS. SUSPENSIONS OF 20', 200' 400' AND ABOUT 2000' WERE USED TO PLACE THE WEIGHTED PARACHUTES NEAR THE WATER SURFACE, IN THE MIXED LAYER, BELOW THE MIXED LAYER AND IN DEEP WATER. A DETAILED DESCRIPTION OF THE DROGUE IS GIVEN IN TABLE I. REQUIREMENTS FOR EASE OF SETTING THE DROGUE AND DROGUE RELIABILITY DURING THE SHORT AVAILABILITY OF THE SMITH AT ENIWETOK NECESSITATED USE OF MANILA SIX THREAD FOR THE SUSPENSION BETWEEN PARACHUTE AND SURFACE FLOAT. THE ONE EXCEPTION WAS DEEP DROGUE 2 USING A 3/32" WIRE ROPE SUSPENSION. OIL DRUMS WERE USED FOR THE SURFACE FLOATS. EXCEPT FOR THE TWO DEEP DROGUES C AND H WITH SIX THREAD SUSPENSIONS, THE ERROR IN THE SUB-SURFACE CURRENT VELOCITY AS INDICATED BY THE SURFACE FLOAT, DUE TO THE DRAG OF THE UPPER WATER LAYERS ON THE SUSPENSION AND ON THE SURFACE FLOAT, WAS BELOW 10% (10).

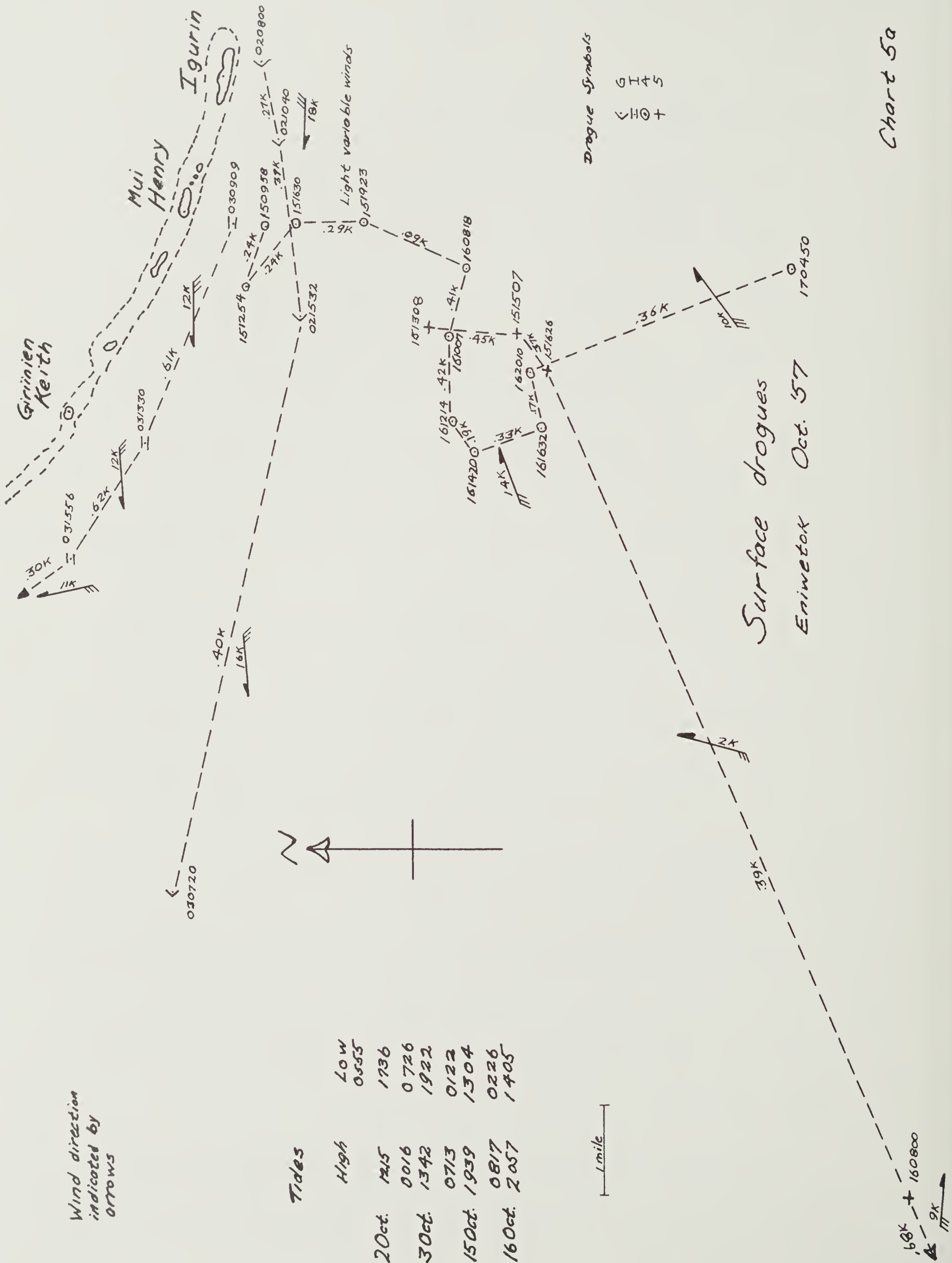
DROGUE TRACK PLOTS ARE SHOWN IN CHARTS 5, 5A-5G AND 6. AZIMUTH STATION TRACKING OF DROGUES WAS POSSIBLE WHEN

Wind direction indicated by arrows

Tides

	High	Low
20 Oct.	1215	0555
30 Oct.	0016	1736
15 Oct.	1342	0726
16 Oct.	0713	1922
	1939	0122
	0817	1304
	2057	0226
		1405

1 mile

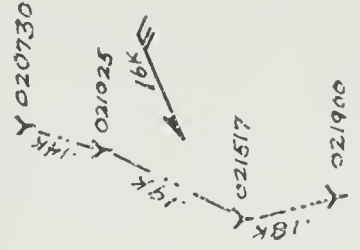




200' Drogues

Eniwetok

Sept. 29 - 90, Oct. '57



Drogue Symbols  
 ▽ BEJ 36  
 △

400' drogues  
Eniwetok

Sept 29-30, Oct. '57

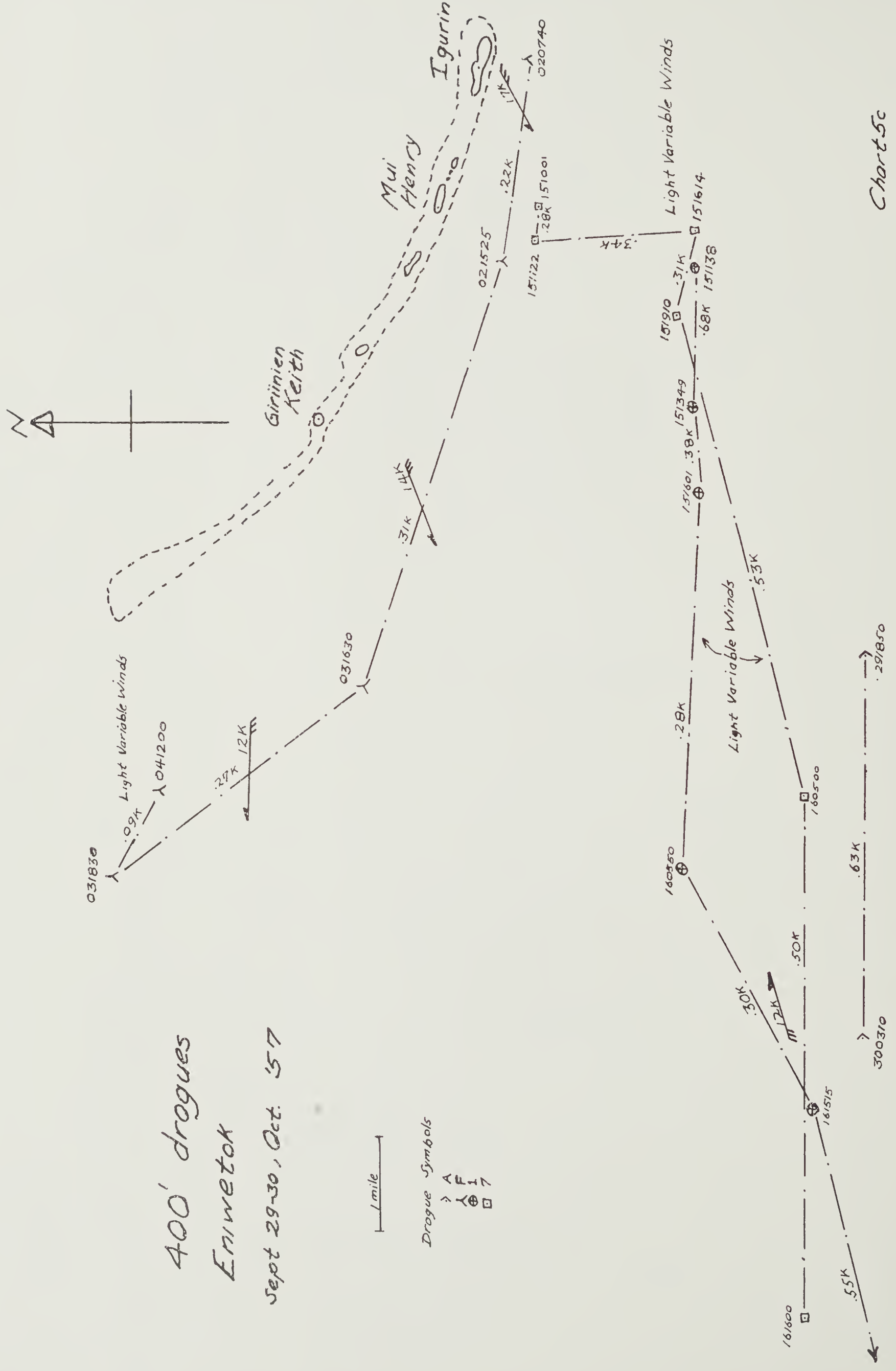


Chart 5c



Deep drogues

Eniwetok

Sep. 29-30, Oct. 57

- 2400' C
- x 2400' H
- ⊙ 2000' 2

1 mile

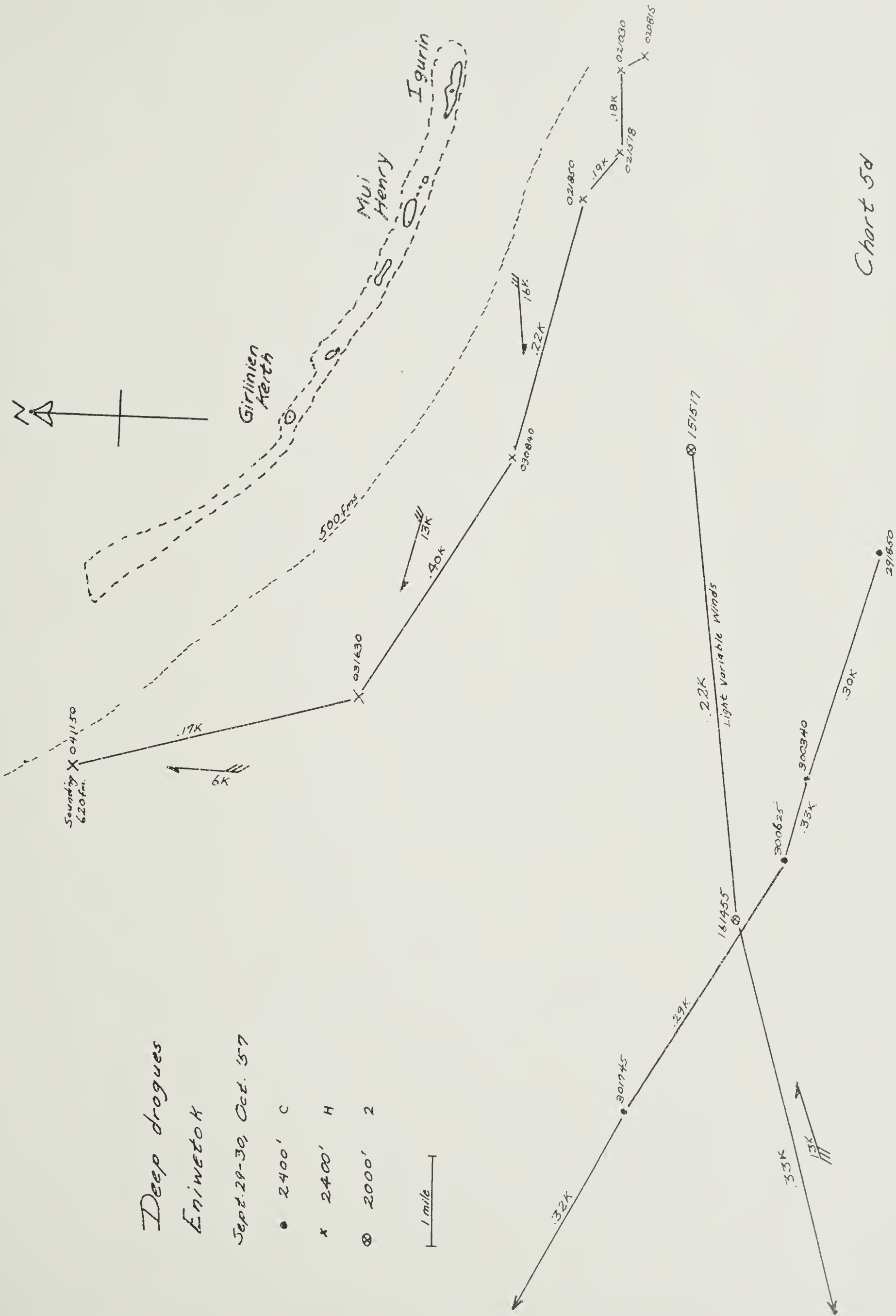


Chart 5d

*Drogues*  
*Sept. 29 - Oct. 1*

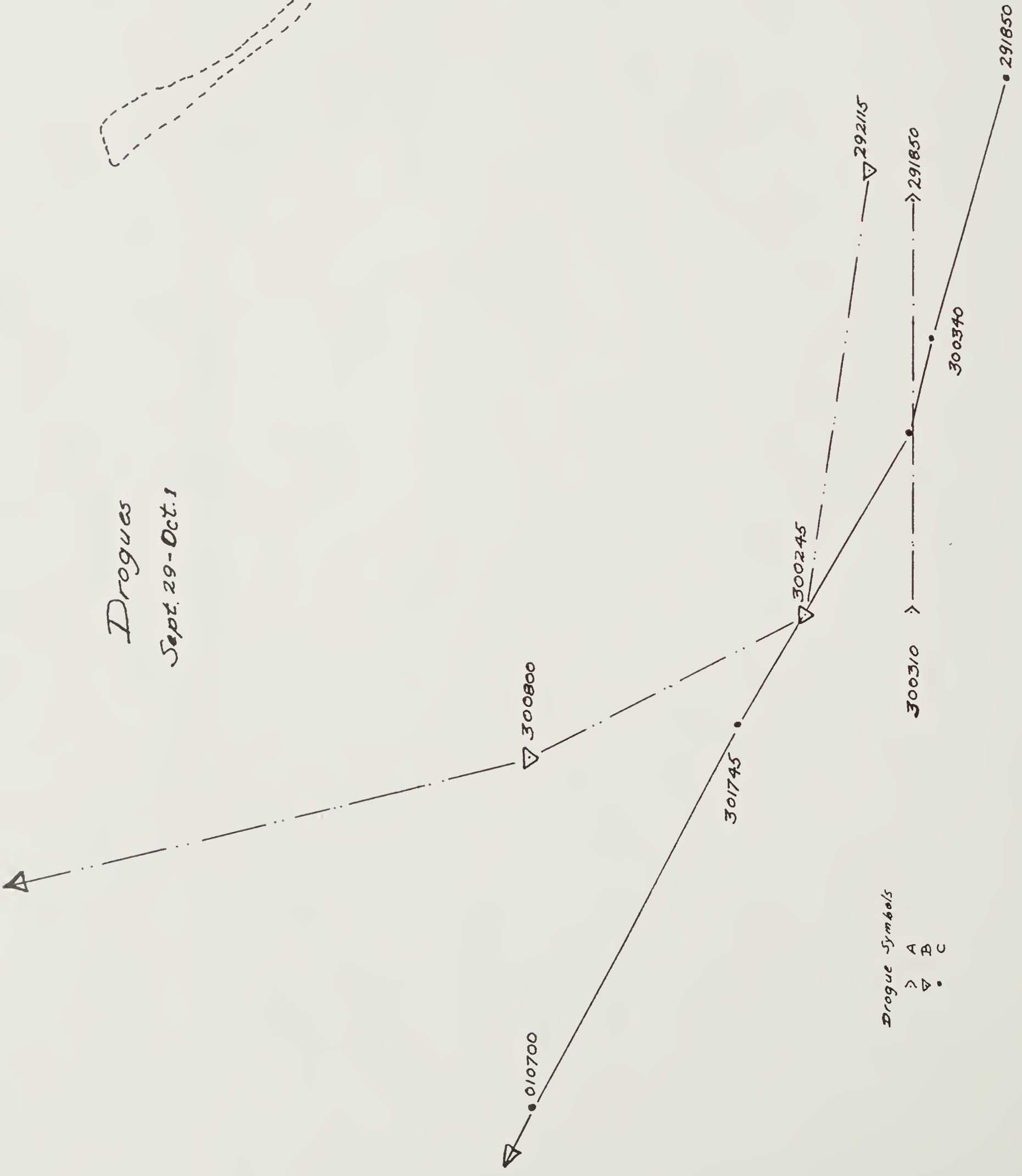
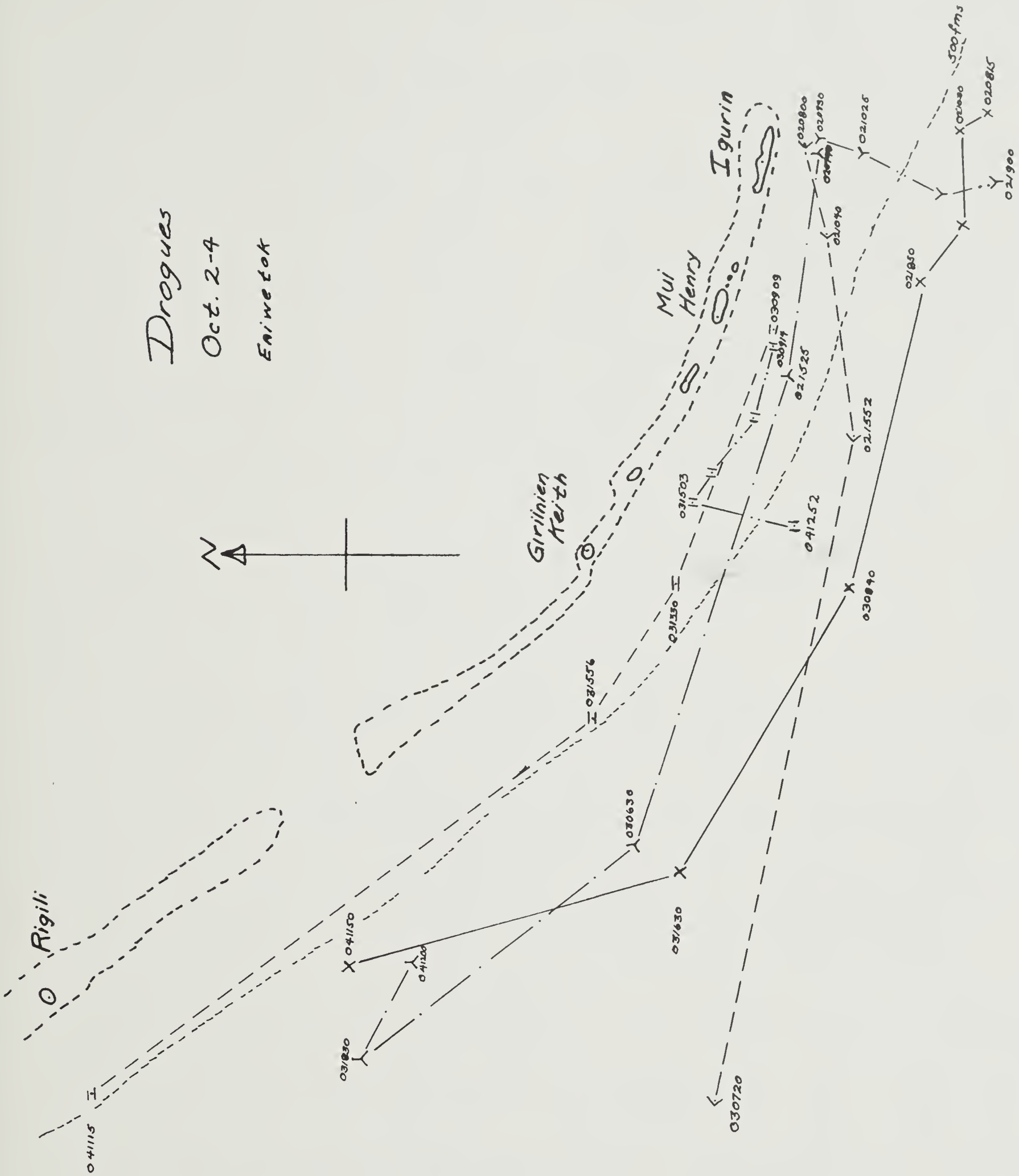


Chart 5e

Drogues

Oct. 2-4

Eniwetok



Drogue Symbols

F  
G  
H  
I  
J

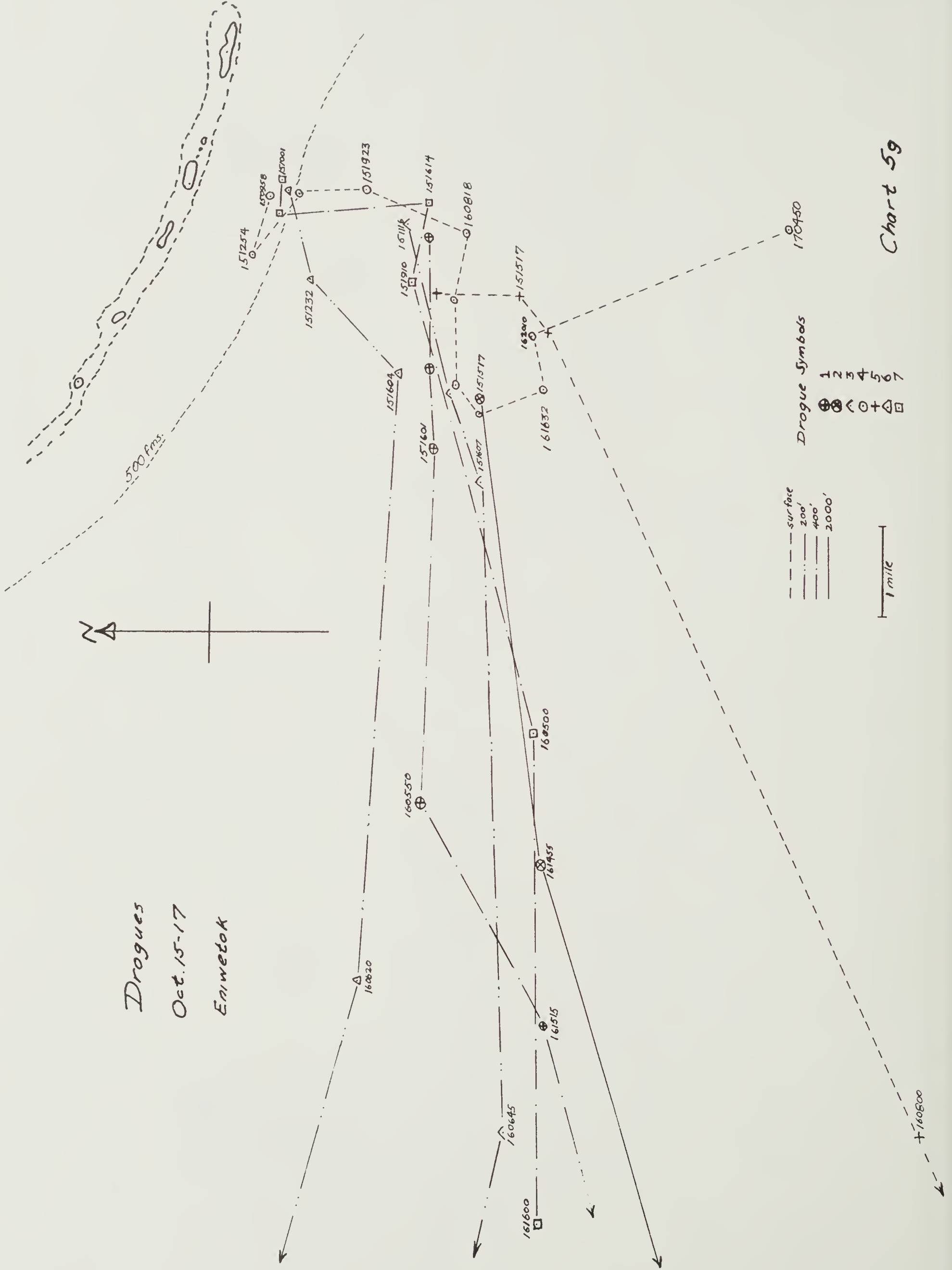
--- surface  
 - - - 200'  
 . . . 400'  
 - - - 2400'

1 mile

Chart 57



Drogues  
Oct. 15-17  
Eniwetok



--- surface  
--- 200'  
--- 400'  
--- 2000'

Drogue Symbols

- 1 ⊕
- 2 ⊗
- 3 ⊙
- 4 ⊕
- 5 △
- 6 □

1 mile

Chart 59

THESE STATIONS WERE MANNED BETWEEN THE HOURS 0800 TO 1600 AS DETERMINED BY THE HELICOPTER PERSONNEL TRANSPORTATION SCHEDULES. THE HIGH ACCURACY OF THE AZIMUTH STATION BEARINGS PROVIDED THE PRECISE SIMULTANEOUS DROGUE TRACKS SHOWN ON CHART 6. OFFSHORE DROGUE POSITIONS AND ALL DROGUE POSITIONS WHEN THE AZIMUTH STATIONS WERE NOT MANNED WERE DETERMINED BY THE SMITH'S NAVIGATION RELATIVE TO THE ATOLL. MAGNETIC COMPASS BEARINGS ACCURATE TO PERHAPS  $1\frac{1}{2}^{\circ}$  AND RADAR RANGES ACCURATE TO  $\frac{1}{4}$  MILE WITHIN 8 MILES OF THE ATOLL AND TO 1 MILE AT GREATER RANGES WERE USED.

WHILE THE DROGUE TRACKS CONFIRM THE GENERAL WESTERLY CURRENT FOUND BY REFERENCE 9 THE CURRENT STRUCTURE CLOSE TO THE ATOLL WAS CONFUSED AND IN MANY CASES CONTRADICTORY. THE DATA SEEMS TO INDICATE THE PRESENCE OF LARGE VARIABLE BACK EDDIES. THESE VARIATIONS COULD NOT BE CORRELATED WITH WEATHER OR TIDES. IN SEVERAL CASES DROGUES WHICH WERE LAUNCHED IN THE SEAWARD AREA OF DIRECT INTEREST WERE STILL IN THE SAME GENERAL AREA A DAY LATER.

THE SURFACE DROGUE "I" AND THE 200 FOOT DROGUE "J" LAUNCHED SIMULTANEOUSLY ON 3 OCTOBER IN THE SEAWARD AREA ARE OF PARTICULAR INTEREST. THEIR TRACKS IN DETAIL ARE SHOWN ON CHART 6. THE SURFACE DROGUE "I" MOVED NORTHWESTERLY ALONG THE REEF OF THE ATOLL, SEE ALSO CHART 5F.

THE 200 FOOT DROGUE "J" HOWEVER, AFTER STARTING IN A SIMILAR DIRECTION AT A LOWER VELOCITY TURNED SOUTH.

THE SURFACE DROGUE "4", 200' DROGUE "6", AND THE 400' DROGUE "7" LAUNCHED CLOSE TOGETHER ON THE MORNING OF THE 15TH OF OCTOBER IN THE SEAWARD AREA PRESENT A SIMILAR CONFUSED PICTURE AS SHOWN ON CHART 6. THE 200' DROGUE "6" MOVED IN A GENERAL SOUTHWESTERLY DIRECTION THROUGHOUT THE 15TH. THIS SOUTHWESTERLY MOVEMENT WAS PARALLELED BY THE 200' DROGUE "3" SET FURTHER OFFSHORE A FEW HOURS LATER, SEE CHART 5B. THE SURFACE DROGUE "4" AFTER STARTING TO THE NORTHWEST REVERSED AND MOVED SOUTHEAST DURING THE AFTERNOON, THEN THROUGHOUT THE NIGHT MOVED IN A SOUTHERLY DIRECTION. DURING THE DAY OF THE 16TH SURFACE "4" GENERALLY REPEATED THIS REVERSAL AND SOUTHERLY MOVEMENT. SURFACE DROGUE "5" SET FURTHER OFFSHORE ON THE AFTERNOON OF THE 15TH SHOWED FIRST A SOUTHERLY MOTION AND THEN MOVED SOUTHWESTERLY THROUGH THE SAME AREA IN WHICH SURFACE DROGUE "4" MOVED NORTHEASTERLY THE NEXT AFTERNOON. THE 400' DROGUES OF THIS SET, "I" AND "7", MOVED GENERALLY SOUTHWESTERLY EXCEPT THAT THE CLOSE INSHORE DROGUE "7" MOVED SOUTHERLY OFFSHORE FOR A FEW HOURS AND THEN TURNED SOUTHWESTERLY AGAIN.



A STUDY OF CHARTS 5A-5G AND 6 SHOWS THE COMPLICATED CURRENT PATTERN NEAR THE ATOLL. THE TIDAL DATA IS SHOWN ON CHART 5A. THE WIND DATA IS SHOWN ADJACENT TO EACH DROGUE TRACK AND ON TABLE 2. THERE IS NO OBVIOUS CORRELATION OF DROGUE MOVEMENT TO WIND OR TIDAL DATA. BATHY-THERMOGRAPHS TAKEN ON THE 12TH, 13TH, 16TH AND 17TH SHOW NO SIGNIFICANT DIFFERENCE.

IN SUMMARY IT APPEARS THAT THERE EXISTS TO THE LEE SIDE OF ENIWETOK A SERIES OF LARGE VARIABLE EDDIES FOR WHICH NO PRECISE PREDICTIONS MAY BE MADE WITHOUT FURTHER STUDY. IN SOME CASES WATER MAY BE EXPECTED TO STAY IN THE AREA FOR PERIODS EXCEEDING A DAY BEFORE MOVING INTO THE GENERAL WESTERLY CIRCULATION.

THE COLUMBIA UNIVERSITY GEOPHYSICAL FIELD STATION, ST. DAVID'S, BERMUDA, PLAN TO CARRY OUT FURTHER DROGUE CURRENT MEASUREMENTS AT BERMUDA DURING 1958 TO STUDY THIS EDDY EFFECT AROUND AN ISLAND. A 20 MILE LINE OF 20 IDENTICAL DROGUES WILL BE SET "UP STREAM" FROM BERMUDA AND THEN TRACKED IN DETAIL AS THEY MOVE DOWN TOWARD AND PAST THE ISLAND.

LIST OF FIGURES

FIGURE No:

1. TWO SOUNDING LINES IN THE SEAWARD AREA. LINE H-G IS 17,300 FEET LONG, WATER DEPTH IS ABOUT 600 FATHOMS AND THE VERTICAL EXAGGERATION IS 3.4:1. THE RETURN INDICATED AT 500 FATHOMS IS ACTUALLY A SCATTERING LAYER AT 100 FATHOMS. LINE F-E IS 18,500' LONG, WATER DEPTH IS ABOUT 440 FATHOMS AND THE VERTICAL EXAGGERATION IS 4:1.
2. CROSS CHECK SOUNDING LINE DC IN THE SEAWARD AREA IS 11,000 FEET LONG WITH A VERTICAL EXAGGERATION OF 5:1. NOTE THE ALMOST COMPLETE ABSENCE OF HIGHLIGHTS INDICATING A SMOOTH BOTTOM.
3. CROSS CHECK SOUNDING LINE B-A IN THE SEAWARD AREA IS 11,500 FEET LONG WITH A VERTICAL EXAGGERATION OF 4.5:1.
4. LAGOON AREA SOUNDING LINES. THESE WERE RUN ON SE OR NW HEADINGS. THE TOP TWO ARE EDO SOUNDINGS WITH A VERTICAL EXAGGERATION OF 5.5:1. THE REMAINDER ARE PDR SOUNDINGS WITH A VERTICAL EXAGGERATION OF 3.75:1. THE LOCATION OF THE LINES IS SHOWN ON CHART 3. THE LINE DRAWN THROUGH THE CENTER OF ALL THE TRACES INDICATED THE PLACE WHERE THE SMITH WAS 030° TRUE FROM STATION HENRY.
5. - 6. REPRODUCTIONS OF SOUNDING RECORDS OF TWO EXPLORATORY SOUNDING LINES.

LIST OF CHARTS

CHART No:

1. ECHO SOUNDING CHART SOUTHWEST SLOPE  
ENIWETOK ATOLL - INDICATING SOUNDING  
LINES SHOWN ON FIGURES 1, 2 AND 3.
2. ECHO SOUNDING CHART - ENIWETOK LAGOON AREA.
3. CORAL HEAD CHART ENIWETOK LAGOON AREA -  
INDICATING SOUNDING LINES SHOWN ON  
FIGURE 4.
4. EXPLORATORY SOUNDING LINES ENIWETOK ATOLL.
5. COMPOSITE OF DROGUE TRACKS  
5A SURFACE DROGUE TRACKS - INCLUDING TIDE DATA.  
5B 200' DROGUE TRACKS  
5C 400' DROGUE TRACKS  
5D DEEP DROGUE TRACKS  
5E DROGUE TRACKS - SEPTEMBER 29 - OCTOBER 1.  
5F DROGUE TRACKS - OCTOBER 2-4.  
5G DROGUE TRACKS - OCTOBER 15-17.
6. PRECISION INSHORE DROGUE TRACKS.
7. GENERAL OUTLINE ENIWETOK ATOLL - SHOWING  
SOUNDING AREAS.

NOTE: Charts 1 through 6 in separate envelope



TABLE I.

## DROGUE DESCRIPTIONS

DROGUE DESIGNATION	DESCRIBED DEPTH.	SUSPENSION				PARACHUTE WEIGHT.	
A	▷	400'	400'M	50'C	3'8	3 - 15D	75 LB.
B	▽	200'	200'M		3'B	3 - 15D	75 LB.
C	•	2400'	2400'M	50'C	3'BO	55D	75 LB.
E	Y	200'	200'M	50'C		55D	50 LB.
F	人	400'	400'M	50'C		55D	50 LB.
G	◀	SURFACE	6 FATHOM OF FISH NET 1 FATHOM WIDE WITH SMALL FLOATS AND WEIGHTS ALONG TOP AND BOTTOM EDGES.				
H	×	2400'	2400'M	50'C	3'B	55D	75 LB.
I	≡	SURFACE		20'C		15D	50 LB.
J	·	200'	200'M	50'C		55D	75 LB.
I.	⊕	400'	400'M	50'C		55D	75 LB.
2.	⊗	2000'	100'M	60'C		55D	100 LB.
			2000'	3/32"	BT WIRE ROPE.		
3.	^	200'	200'M	50'C		55D	75 LB.
4.	⊙	SURFACE		20'C		15D	25 LB.
5.	+	SURFACE		20'C		15D	25 LB.
6.	△	200'	200'M	50'C		55D	50 LB.
7.	□	400'	400'M	50'C		55D	50 LB.

M - 1/4" MANILA LINE, SIX THREAD.

C - 1/4" GALVD. CHAIN WEIGHING 3/4<sup>LB</sup>/FT.

3'B - 3' DIAMETER WOODEN BAFFLE AT DEPTH 50 FEET.

3'BO - " " " " WITH 90<sup>LB</sup>.

BUOYANT OXYGEN TANK.

3-15D THREE 15 GALLON OIL DRUMS.

55D 55 GALLON OIL DRUM.

15D 15 GALLON OIL DRUM.

TABLE 2

TRUE SURFACE WIND VELOCITY AND DIRECTION FOR  
ENIWETOK ATOLL, M.I. ABSTRACTED FROM REF: II.

	<u>SEPT. 28/57</u>		<u>SEPT. 29/57</u>		<u>SEPT. 30/57</u>		<u>OCT. 1/57</u>		<u>OCT. 2/57</u>		<u>OCT. 3/57</u>	
	DIREC- TION	SPEED (KNOTS)	DIR.	SPEED	DIR.	SPEED	DIR.	SPEED	DIR.	SPEED	DIR.	SPEED
0055	E	8	SE	10	ENE	10	080	14	080	20	080	13
0255	ENE	6	ESE	10	NE	12	020	10	090	19	080	15
0455	E	5	ESE	7	NNE	9	080	19	060	16	070	13
0655	E	4	E	10	ENE	12	080	16	060	18	060	14
0855	ENE	7	E	9	NE	17	070	16	070	18	060	18
1055	ENE	11	ENE	9	NE	10	060	15	060	16	100	13
1255	NE	10	ENE	9	E	18	050	16	070	20	090	10
1455	ENE	16	ENE	19	ENE	14	070	15	070	17	080	13
1655	ENE	14	NE	12	E	16	050	15	060	16	140	11
1855	E	13	ENE	12	ENE	16	080	13	070	14	130	11
2055	E	13	ENE	12	E	13	070	12	080	19	130	10
2255	ESE	12	ENE	13	E	12	070	18	070	17	150	14
<hr/>												
	<u>OCT. 4/57</u>		<u>OCT. 13/57</u>		<u>OCT. 14/57</u>		<u>OCT. 15/57</u>		<u>OCT. 16/57</u>			
0055	110	08	080	16	100	16	350	12	150	03		
0255	160	06	090	12	110	16	050	04	240	01		
0455	190	12	110	12	140	10	150	04	220	01		
0655	190	10	110	12	110	08	100	10	190	08		
0855	250	04	110	09	100	12	110	04	220	08		
1055	260	04	110	10	100	10	100	04	260	10		
1255	110	06	110	14	110	12	020	04	250	12		
1455	120	04	110	10	110	06	020	07	250	12		
1655	110	03	110	12	110	08	020	04	250	12		
1855	130	04	090	12	250	12	CALM		230	12		
2055	150	04	090	16	300	04	180	04	260	12		
2255	130	02	090	16	050	02	190	02	230	12		

R E F E R E N C E S.

- I. WAR DEPARTMENT T.M.9-1675. AZIMUTH INSTRUMENTS M I910 AND M I910AI (DEGREES). SEPTEMBER-1941
2. LUSKIN B, AND ISRAEL H.G. PRECISION DEPTH RECORDER MK-V, LAMONT GEOLOGICAL OBSERVATORY, TECHNICAL REPORT No: 15, JANUARY 1956.
3. NAVSHIPS 91420 INSTRUCTION BOOK FOR SONAR SOUNDING SET AN/UQN-IB, EDO CORPORATION, 21 MAY 1951.
4. LUSKIN B, NAFF J.E., AND EWING M. THE USE OF TOPOGRAPHIC HIGHLIGHTS FOR THE MEASUREMENT OF SHIPS GROUND SPEED, LAMONT GEOLOGICAL OBSERVATORY TECH. REPORT No: 15. MARCH 1957.
5. MATTHEWS D.J. TABLES OF THE VELOCITY OF SOUND IN PURE WATER AND SEA WATER, HYDROGRAPHIC DEPARTMENT ADMIRALTY 1939.
6. ELMENDORF C.H. AND HEEZEN B.C. OCEANOGRAPHIC INFORMATION FOR ENGINEERING SUBMARINE CABLE SYSTEMS; LAMONT GEOLOGICAL OBSERVATORY CONTRIBUTION No: 251, BELL SYSTEMS TECH. JOUR. V XXXVI, 1047-1093, 1957.
7. NORTHROP J, BLAIK M, FROSSETTO R, A SLOPE MIGRATION TECHNIQUE APPLIED TO BATHYMETRY, HUDSON LABORATORIES CONTRIBUTION No: 25. ADVANCE COPY TO AUTHORS.
8. HYDROGRAPHIC MANUAL, USC&GS SPECIAL PUBLICATION #143, ARTICLE 333.
9. FAUGHN, J.L., ET AL, RESULTS OF OCEANOGRAPHIC SURVEY AT ENIWETOK, NOVEMBER-DECEMBER 1956, SCRIPPS INST. OF OCEANOGRAPHY, 15 AUGUST, 1957.
10. VOLKMAN G, KNAUSS J, AND VINE A. THE USE OF PARACHUTE DROGUES IN THE MEASUREMENT OF SUB-SURFACE OCEAN CURRENTS, TRANS. A. GEOL. VOL.37, No: 5 573-577.
- II. ENIWETOK WEATHER RECORDS - U.S.A.F. 15TH WEATHER SQUADRON, DETACHMENT 25, ENIWETOK, M.I.













350

000

010

162°12'10"E



11°23'N

12°30'

035

090

035

090

11°22'34.20"N  
162°12'17.47"E







010

020

075

050



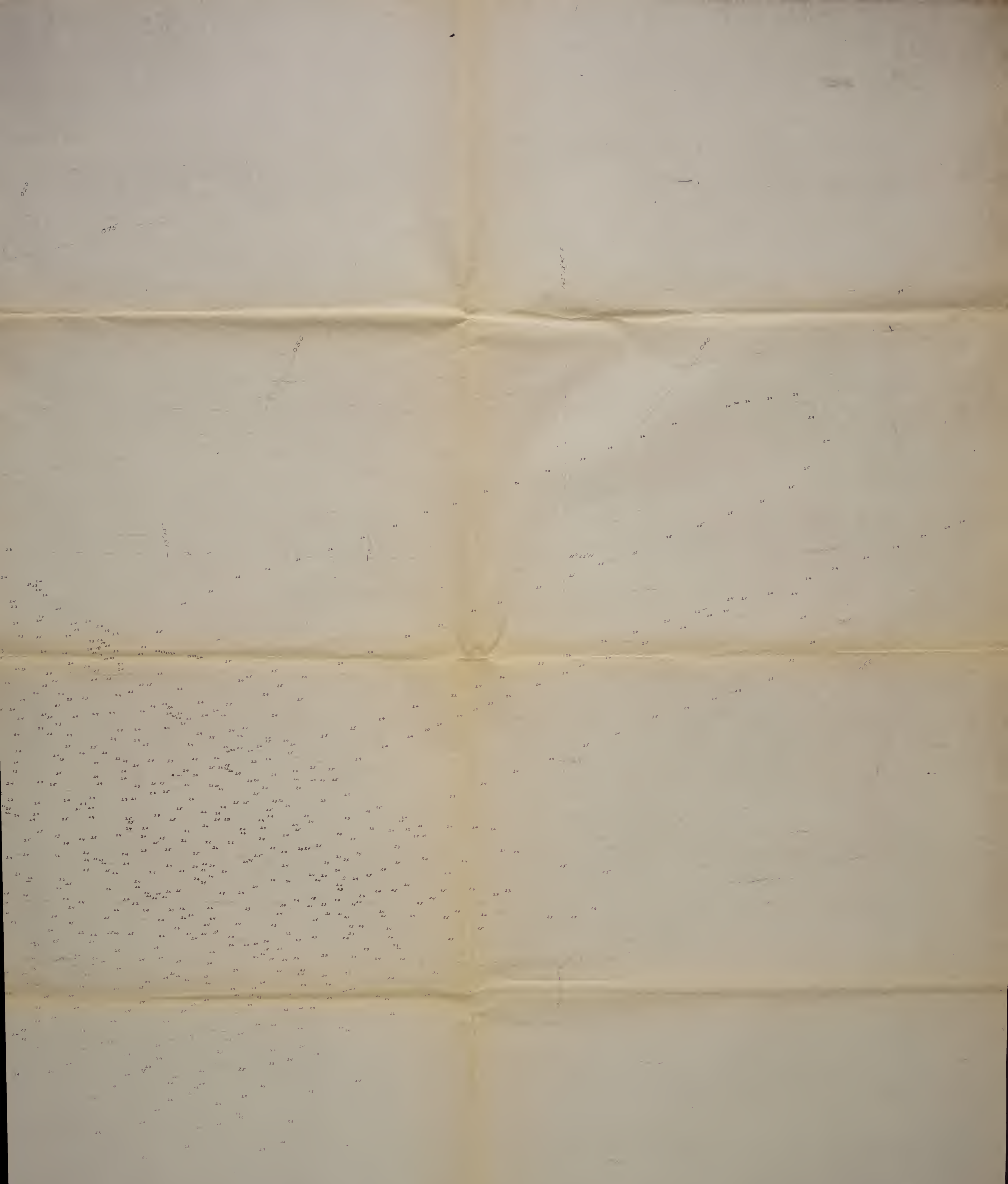
Echo Sounding On  
 Eniwetok Lagoon  
 October 1957  
 Soundings in fathoms  
 corrected to mean low water  
 Scale 1" = 300'

010

010

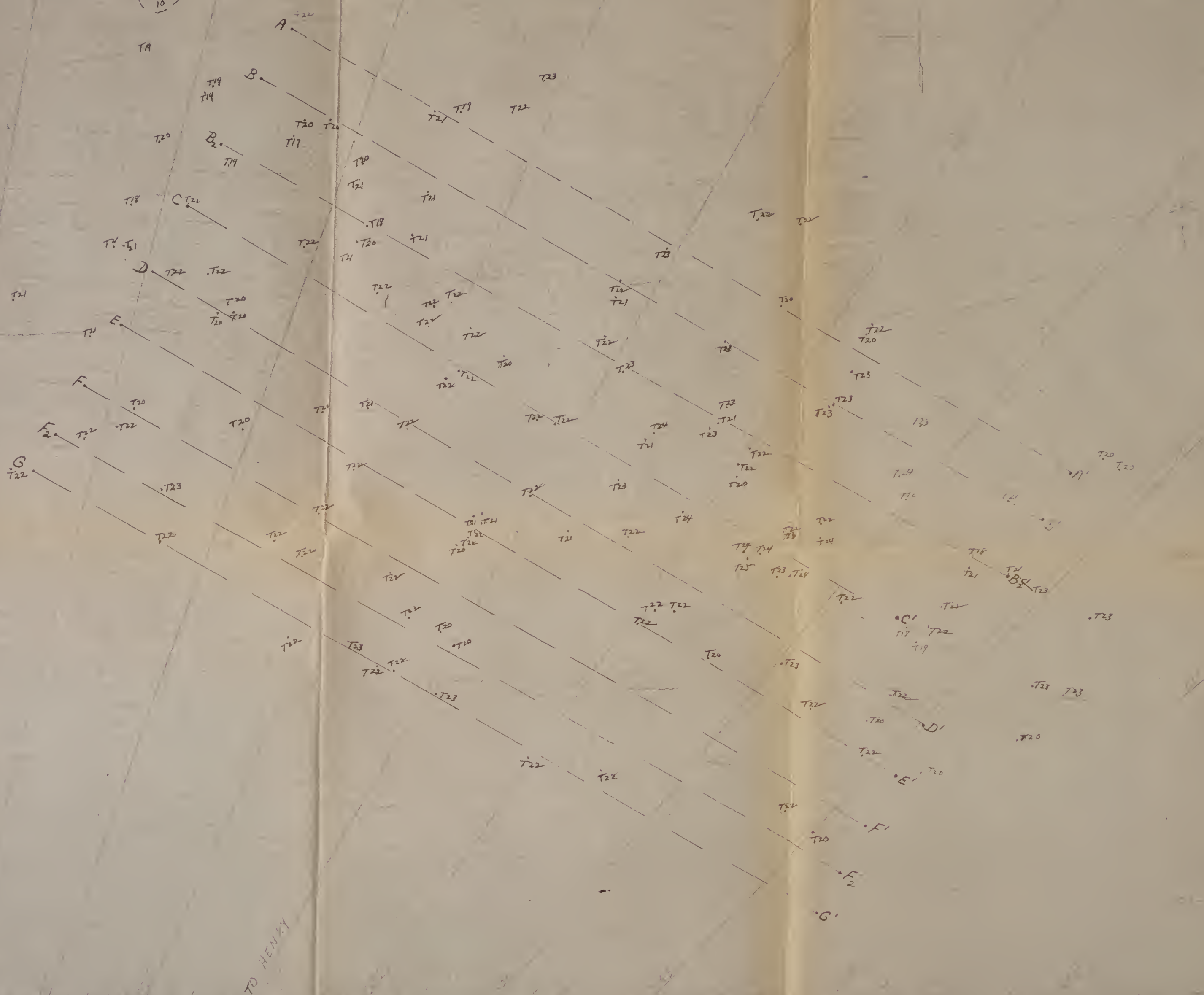
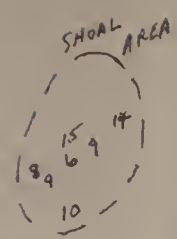
010





Echo Sounding Chart  
Eniwetok Lagoon  
October 1957  
Soundings in fathoms  
corrected to mean low water  
Scale 1" = 300'





KEITH  
 $11^{\circ} 22' 34.24'' N$   
 $152^{\circ} 11' 02.15'' E$

HENRY  
 $11^{\circ} 21' 20.142'' N$   
 $152^{\circ} 11' 17.972'' E$

Eniwetok Lagoon

contour lines indicated by 'T' and  
 minimum sounding in fathoms  
 reference lines for location of recorder readings  
 see figure 4

Scale 1" = 30'

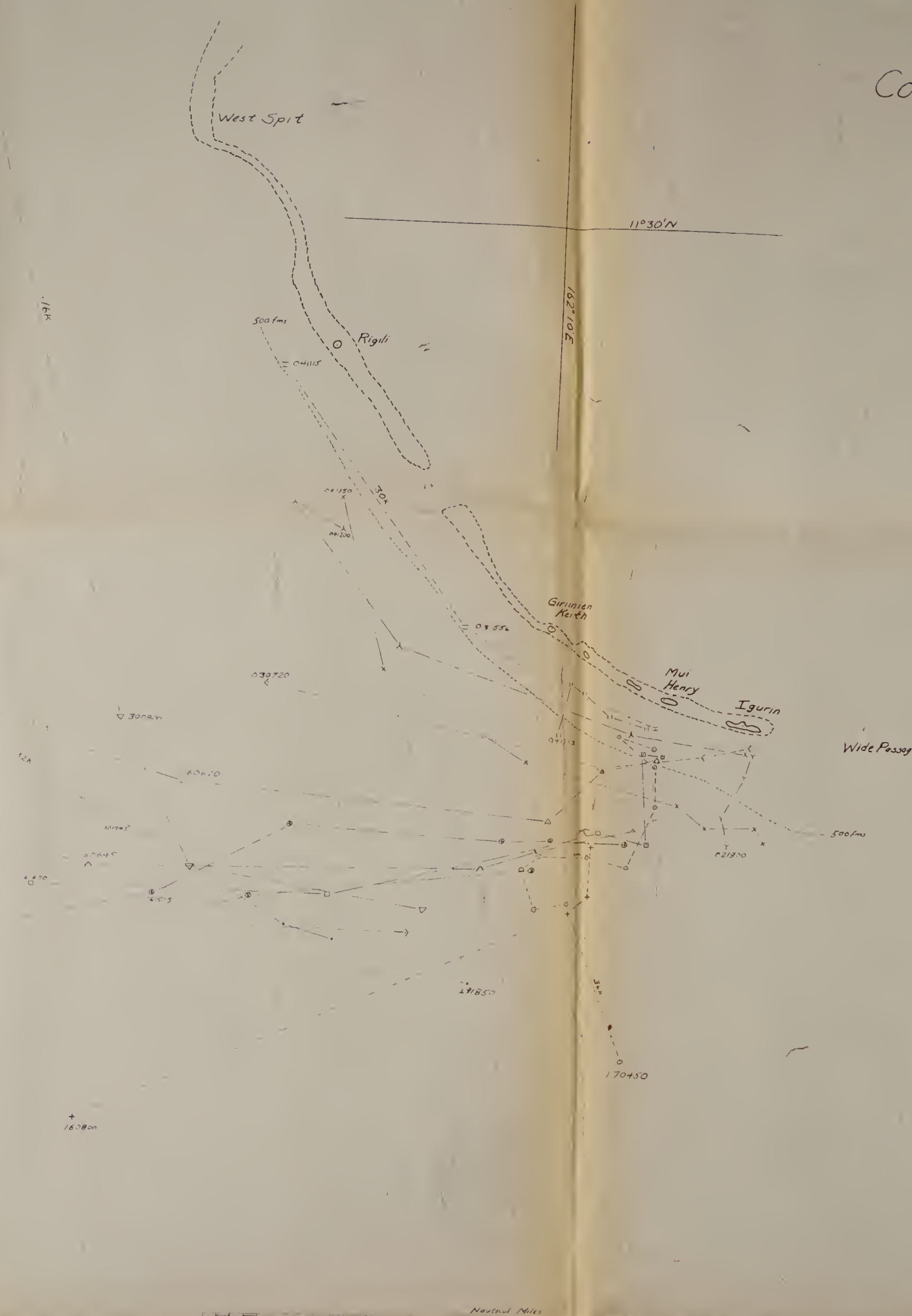
U.S. Navy Hydrographic Office  
 Hydrographic Survey  
 Eniwetok Lagoon  
 S.S. 157



# Composite of Drogue Tracks

Eniwetok

1957



## Drogue Data

Number	Symbol	Depth	First Fix Date Time	Last Fix Date Time
C	•	2400'	Sept. 29 1850	Oct. 01 1835
B	▽	200'	29 2115	04 1000
A	>	400'	29 2050	Sept. 30 0310
E	Y	200'	Oct. 02 0730	Oct. 02 1900
F	λ	400'	02 0740	04 1200
G	<	Surface	02 0800	03 0720
H	X	2400'	02 0815	04 1150
I	≡	Surface	03 0909	04 1115
J	≡	200'	03 0914	04 1252
L	⊕	400'	16 1138	17 1703
2	⊗	2000'	15 1517	17 1815
3	^	200'	15 1116	16 1850
4	○	Surface	15 0958	17 0450
5	+	Surface	15 1308	16 1812
6	△	200'	15 1003	16 1626
7	□	400'	15 1001	16 1600

For detailed data see Charts 5a-5g, and 6

Surface  
200'  
400'  
Deep



Surface  
200'  
400'  
Deep

Chart 5

11°30' N

162°05' E

Exploratory Sounding Lines  
Eniwetok Atoll  
October 1957

162°15' E

163°20' E

162°25' E

o Is. position  
- DR position



11°15' N

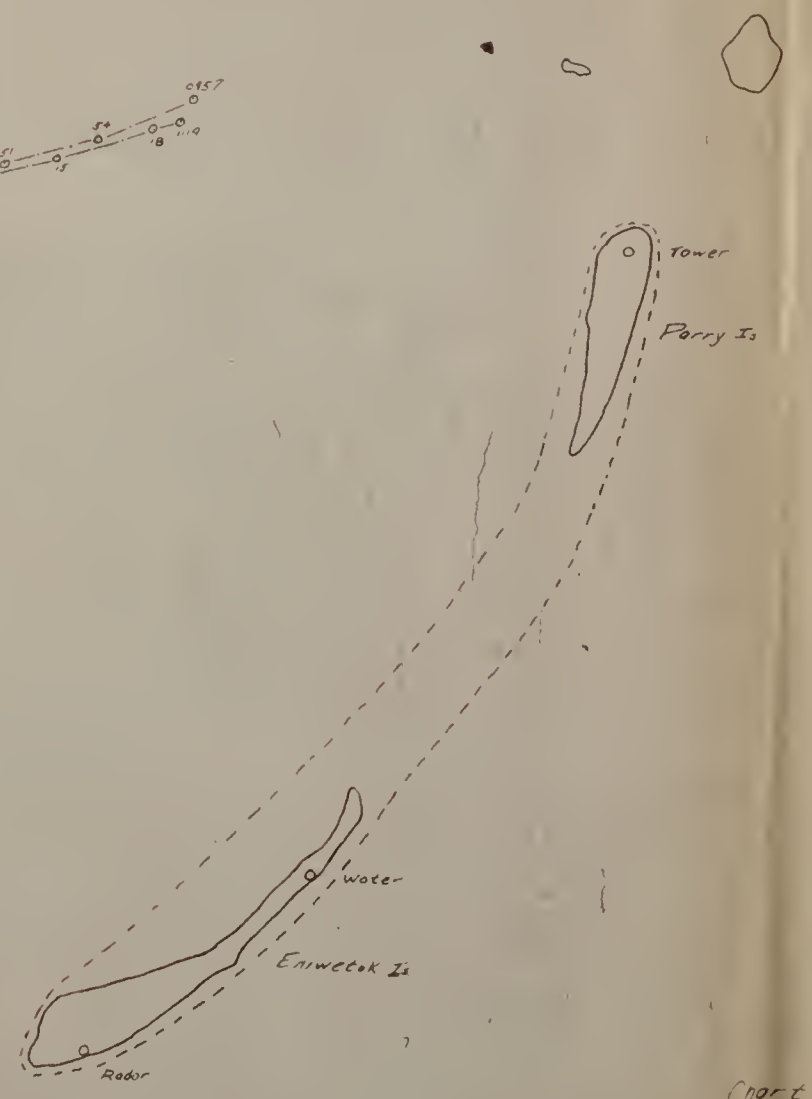
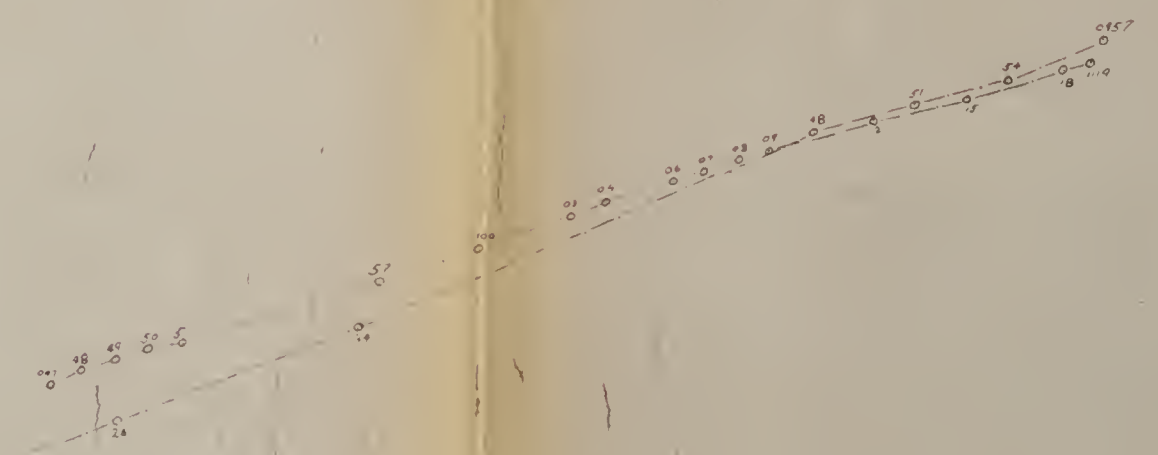
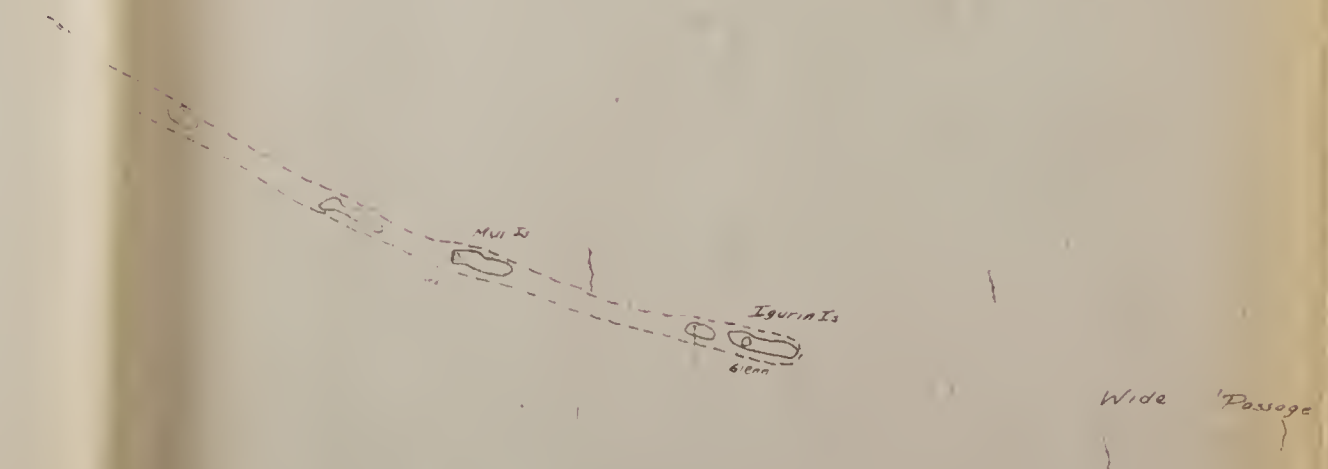
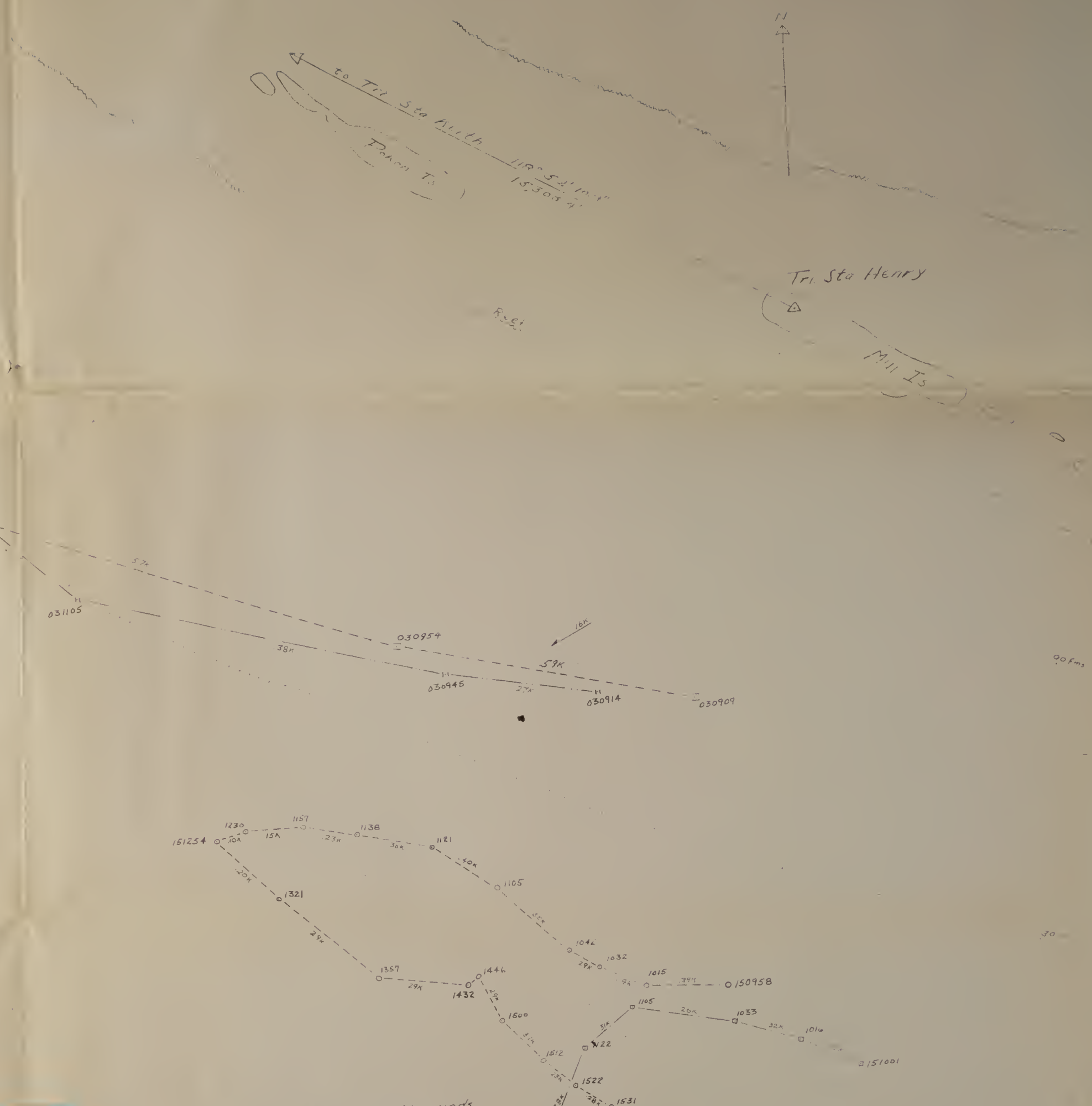
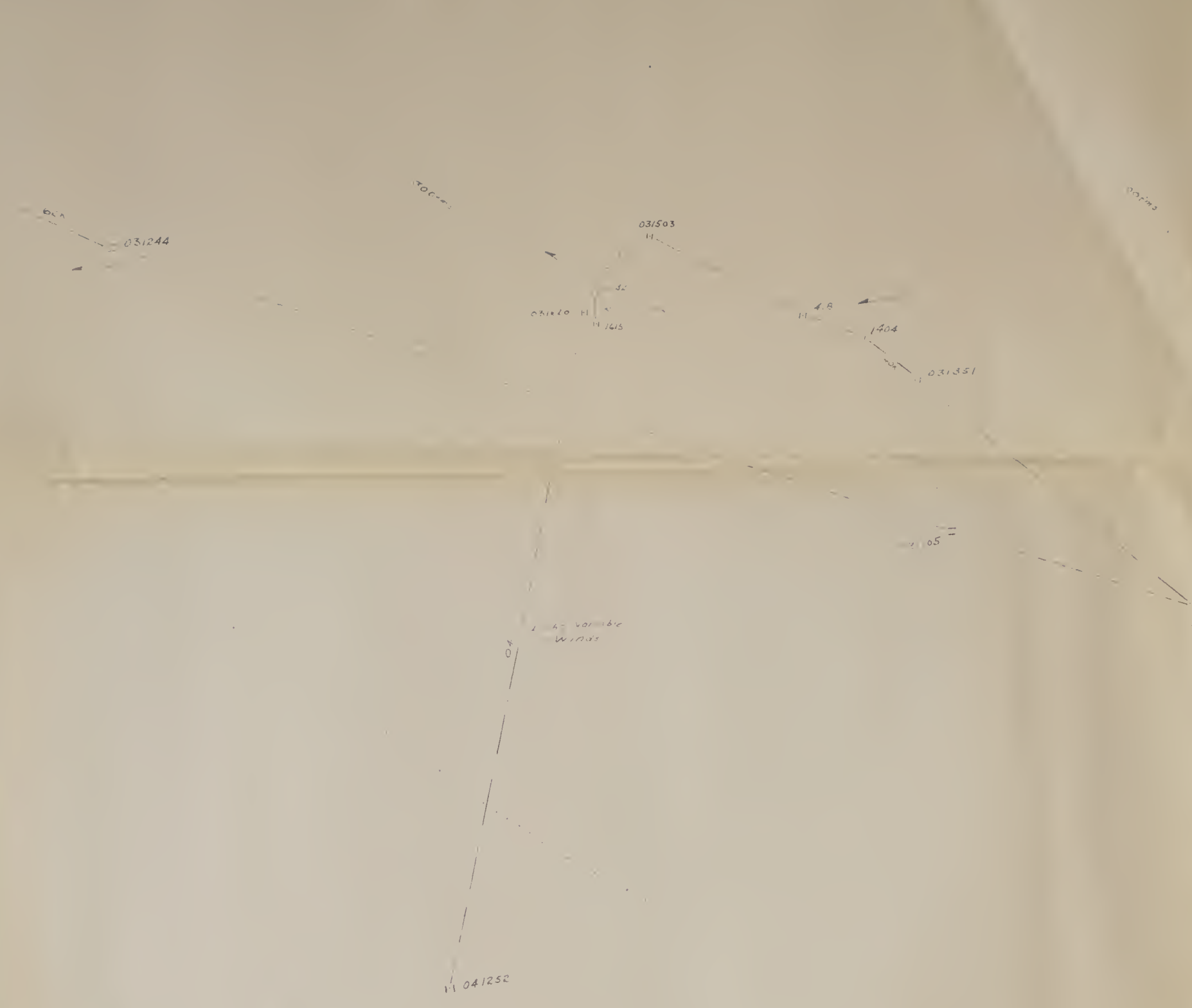
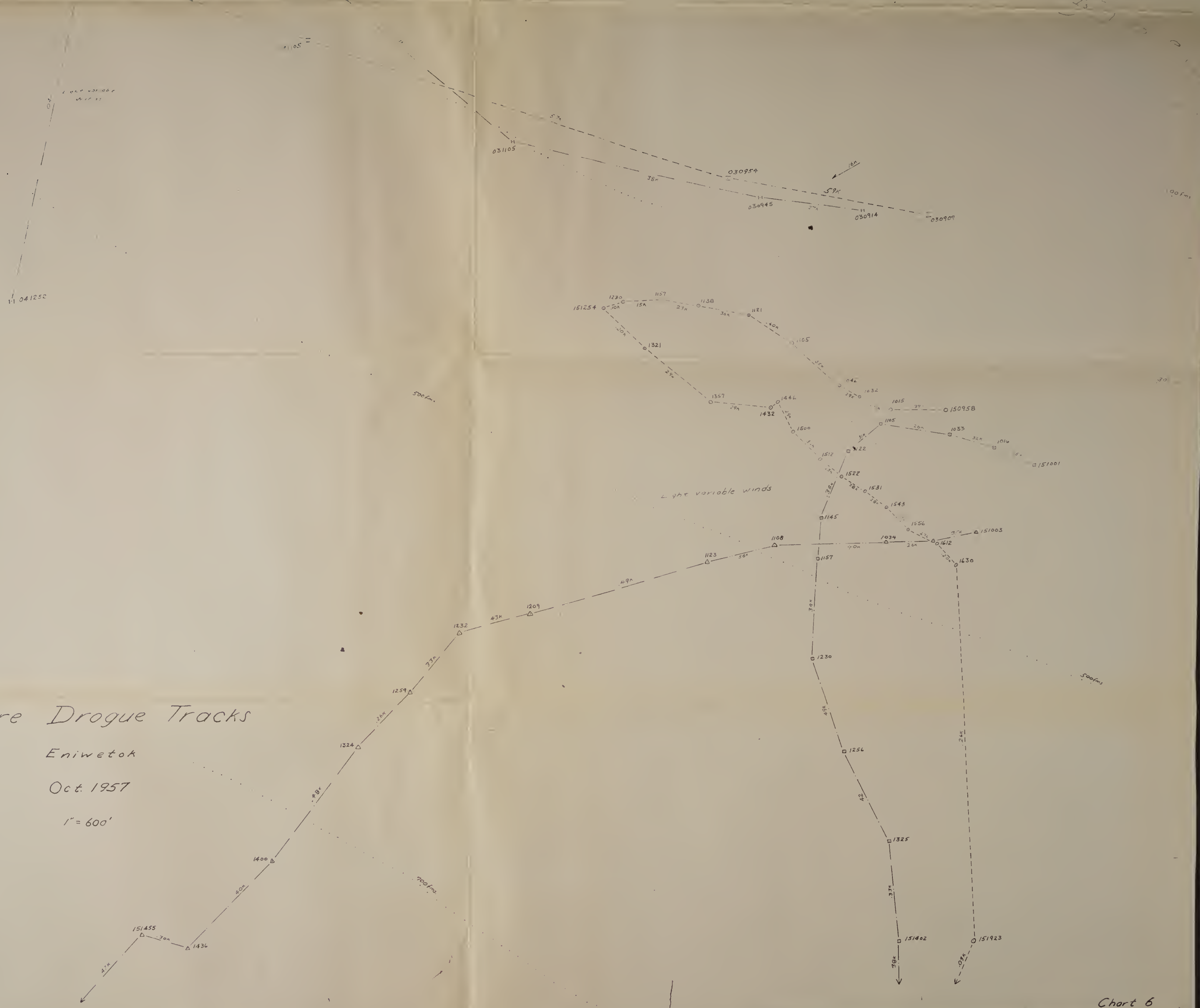


Chart 4





# Inshore Drogue Tracks

Eniwetok

Oct. 1957

1" = 600'

Track Code

Surface ————

200' ————

400' ————

Drogue Symbols

□ I

○ J

○ 4

□ 7

△ 6