Report No. NA-68-7
(DS-68-9)

FINAL REPORT

Project No. 530-003-07X

UNDERWATER LOCATOR BEACON DETECTION RANGES FOR FUSELAGE ENCAPSULATED RECORDERS

JULY 1968

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
National Aviation Facilities Experimental Center
Atlantic City, New Jersey 08405

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AIRCRAFT DEVELOPMENT SERVICE

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ABSTRACT

An acoustic locator beacon was developed and tested in an underwater environment simulating the conditions that might exist when an aircraft crashes into water. The beacons were self-contained, battery-powered, and produced a 10- to 20-millisecond pulse of 35 to 40 kHz at a rate of 1 to 4 pulses per second. The locator beacons were designed to be attached to airborne flight data recorders to assist in the recovery of the recorder records for use in aircraft accident investigations following a crash.

The crash environmental tests were conducted using a section of an aircraft fuselage that still contained the cabin pressure bulkhead. The beacons tested were placed in two different representative locations; (1) inside the cabin pressure area, and (2) aft of the pressure bulkhead in the unpressurized area. The fuselage section was lowered into sea water at depths of 50, 100, and 200 feet off the coast of the Florida Keys. Search runs were made using a motor powered craft equipped with an acoustic locator receiver. The results indicate that the signals of a fuselage encapsulated locator beacon can be detected at reasonable surface distances (up to 3000 yards) and at depths as low as 200 feet.

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INTRODUCTION

Purpose

The purpose of this project was to investigate the feasibility of utilizing a sonar concept, in the form of an acoustic locator beacon, to locate encapsulated flight data recorders in a water crash environment, and to evaluate the operational characteristics of these beacons.

Background

Certain types of commercial transport aircraft are required by regulation to carry airborne flight data recorders for accident investigation purposes. A number of airborne recorders and their records were never located following a crash, especially after an aircraft crashed into water. The CAB requested the FAA to conduct a study for possible solutions to aid in locating the recorders and/or the recorded records from submerged aircraft. Following a crash in 1965 in which a flight recorder and its record were lost in water and never recovered, the CAB formally requested the FAA to require commercial carriers to install acoustic-type locating beacons on all flight data recorders that are carried for crash investigation purposes.

Description of Underwater Locator Beacon: The underwater acoustic locator beacons (commonly referred to as "pingers," Figure 1) used for these tests were developed under contract for the FAA by the Dukane Corporation of St. Charles, Illinois. The technical characteristics and physical requirements of the contract specifications are listed in Table I. The beacons are relatively small, 2 1/8" x 2 1/8" x 1 3/8" and weigh only 4 3/4 ounces. They can be attached to any flat surface by screws through the four holes provided in the base, or to a curved or uneven surface by bracketing or shimming.

No external connections or wiring are required for operation as the beacons are completely self-contained. The dome, or top of the beacon housing, acts as the acoustic radiating surface-antenna and Figure 2 shows the sound pressure pattern measured and recorded for Beacon-Serial No. 8, as viewed in the horizontal plane. The beacons start transmitting immediately when submerged in water. The wet switch, activated by either fresh or salt water, completes the power circuit and energizes the transmitter. The pulsed signal is then transmitted through the dome of the beacon.

Power is supplied by a 7.0-volt mercury battery that fits into a recessed cavity in the center of the beacon. The electrical components and wiring of the beacon are potted in a plastic compound around the battery cavity, filling the remaining internal space in the beacon. Batteries can be changed by separating the two halves of the beacon

FIG. 1 UNDERWATER ACOUSTIC LOCATOR BEACON

TABLE I

FAA CONTRACT
SPECIFICATIONS
UNDERWATER LOCATOR BEACONS

Operating Characteristics

Acoustic Output:	1000 dynes/cm^2 at 1 meter
Frequency:	35-40 kHz
Pulse Duration:	10-20 milliseconds
Pulse Repetition Rate:	1-4 per second
Operating Life:	Output not less than 700 dynes/cm^2 at 1 meter after 48 hours operation
Power Source:	Replaceable self-contained battery
Activation:	Water switch (fresh and salt water)
Operating Temperature:	28^o to 100^o
Detection Range:	500-1000 yards
Depth of Water:	200 feet
Radiation Pattern:	Approaches a hemisphere (or, "nearly hemispheric")

Physical Requirements

Overall Height:	1 3/8" maximum
Body Diameter:	2 1/8" maximum
Mounting Plate:	2 1/8" X 2 1/8" maximum
Weight:	6 ounces maximum

Environmental Requirements

Shall be demonstrated to meet the environmental requirements for Type I recorders in TSO-C51 dated June 12, 1958, with the exception of Fire Protection in Section 7.8.3 of the TSO.

The mounting plate of the beacon shall be designed to withstand the physical loads that would be imposed upon it if it were mounted on a recorder undergoing tests under TSO-C51. A time increment of 15 milliseconds shall apply to the 100_g impact in Section 7.8.2 of the TSO.

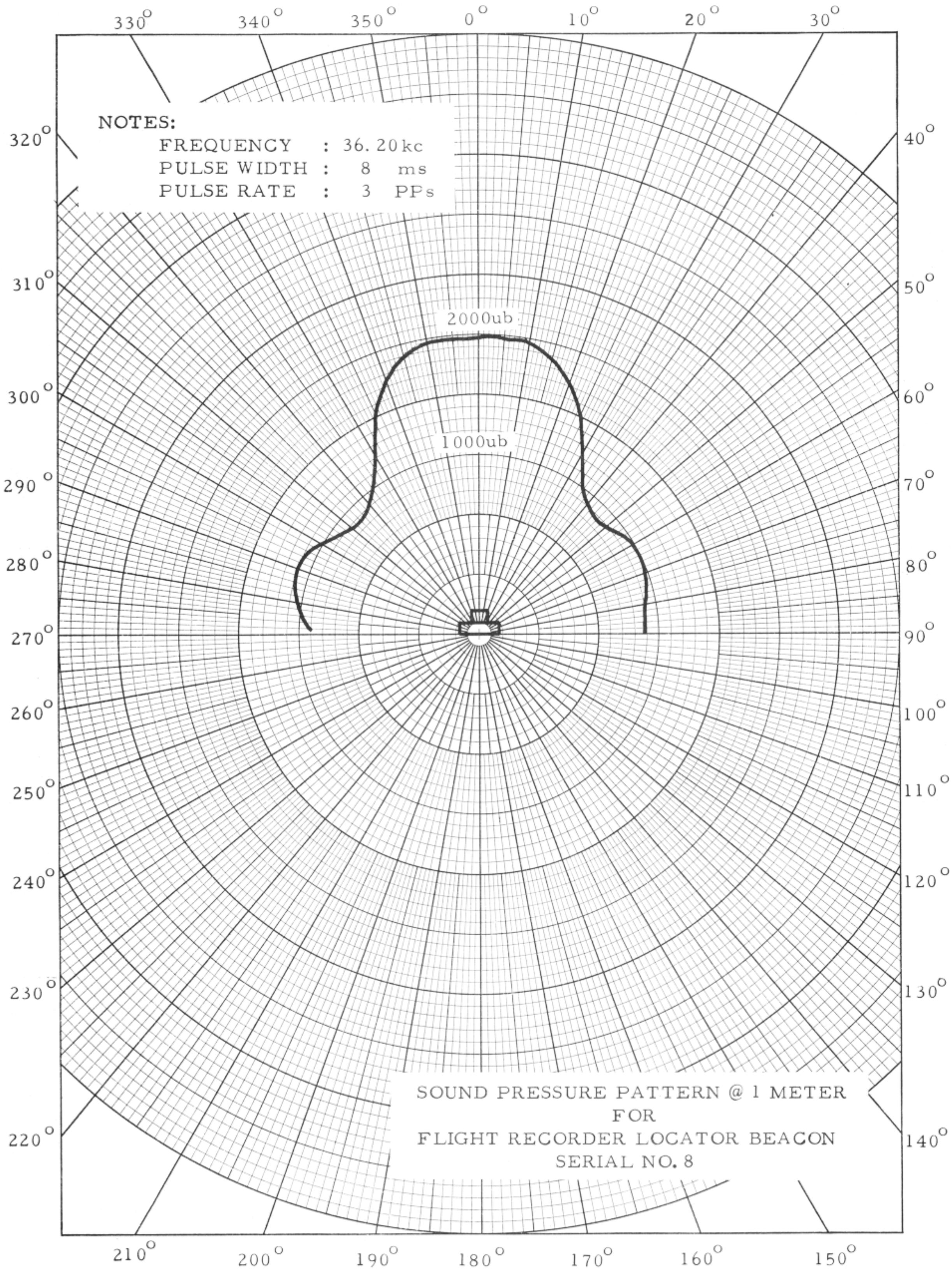


FIG. 2 LOCATOR BEACON SOUND PRESSURE PATTERN

TABLE II

SPECIFICATIONS
LOCATOR RECEIVER

Frequency Range:	Continuously tunable from 30 to 45 kHz
Receiver Gain:	130 dB minimum at 37.5 kHz
Receiver Noise Level:	.3 microvolt rms equivalent at the receiver input
Receiving Band Width:	Response down a minimum of 10 dB at $\pm$500 cycles with 5uv signal input
Audio Output:	250 mw minimum at peak response between 1000 and 3000 Hz
Hydrophone:	Not less than -85 dB from 30 to 45 kHz
Receiver Directivity:	Acoustic response down at least 10 dB at $\pm 30^{\circ}$ to a maximum at 38 kHz
Power Source:	Mercury battery providing in excess of 50 hours of normal operation
Operating Temperature:	0° to $+140^{\circ}$F
Storage Temperature:	-65 to $+140^{\circ}$F
Size:	4.5 inches in diameter X 9 inches in length
Weight:	4 pounds 8 ounces

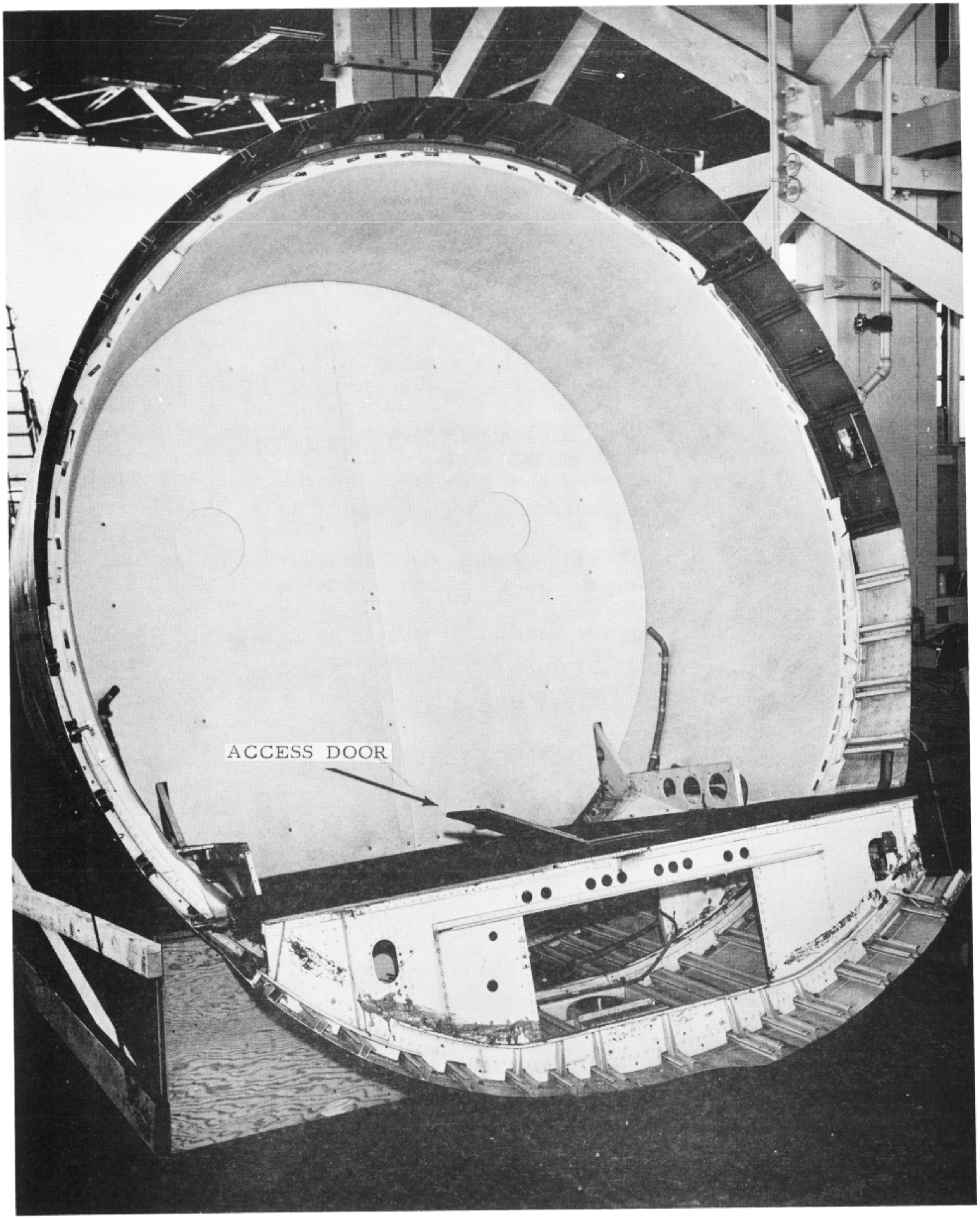


FIG. 4 TEST BED AFTER REFITTING SHOWING DECK PANEL ACCESS DOOR

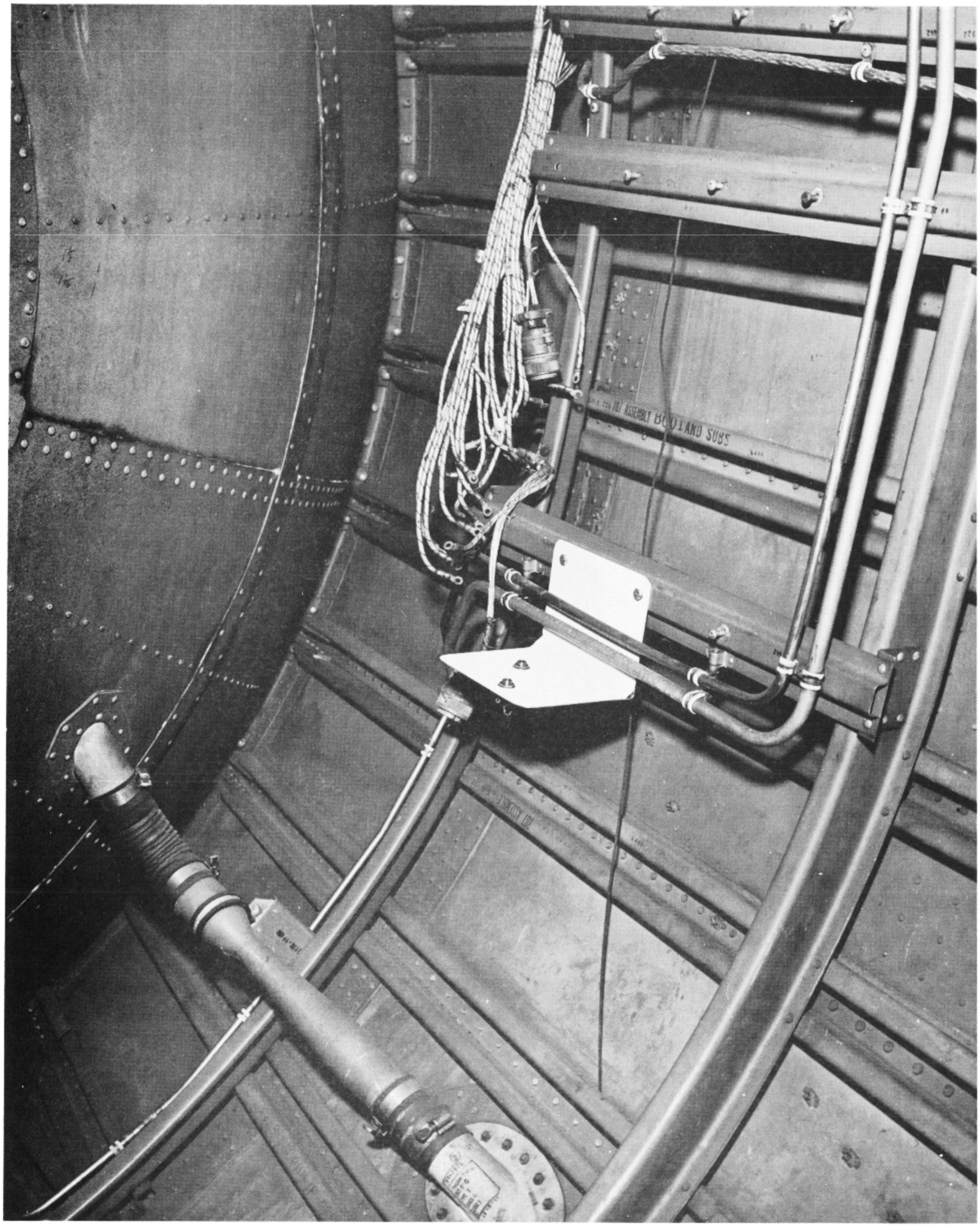


FIG. 5 LOCATOR BEACON ATTACHMENT IN AFT POSITION

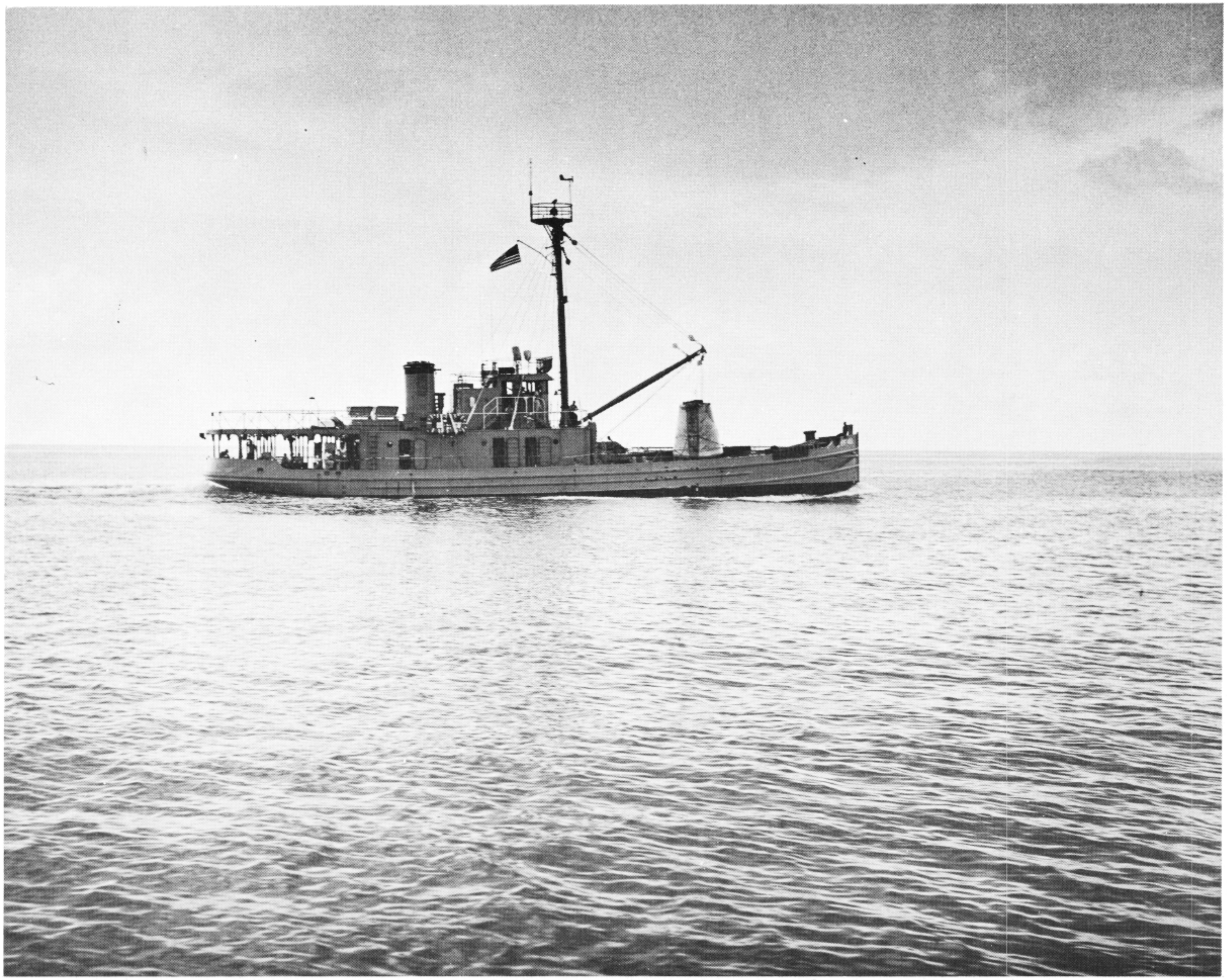


FIG. 6 NAVY YF-411 USED AS THE TENDER CRAFT

The ship's 30-foot boom and 10,000-pound winch were used to lower the test section into the water and to raise it for recovery to the ship's deck. All steady lines had to be handled manually by the crew. Steering, headings, and bearings were derived from a Sperry Gyro Compass, (Mark XVIII Model I), with three repeater compasses (Mark XV Model O), two of which were fitted with BUSHIPS Model MK-III Alidades for bearing measurements. The ship's radar, Type AN/BPS-9, was housed on the Bridge level. The radar unit had a maximum range of 8000 yards; however, a smaller range scale was used for these tests with the scale units displayed in 10-yard increments. The radar scope could be read to 1/2 increment accuracy, thus giving ± 15 feet readout. The radar unit was calibrated to ± 10 feet accuracy at 2200 feet using Coast and Geodetic Survey measurements. A Fathometer, made by EDO Corporation, Model 185 AN/UQN-1C, was located in the Wheelhouse and was used to check the water depth at the selected anchor site against that shown on the navigation charts. A Bathythermograph (BT), Figure 7, Model OC-2C/S, manufactured by Wallace and Tiernan Products, Incorporated, was carried on board the ship and was used to record the water temperature at the various levels of testing. The BT produced an oscillographic record on a chemically smoked glass slide.

Two different search craft were used during the testing to prevent schedule delays as much as possible. One craft, the 6ND125, Figure 8, was a speedboat with four Diesel engines powering two screws; it could maintain about 20 knots cruising speed. The second search craft, Figure 9, 6ND129, was a modified Navy Launch with a single Diesel engine and one screw. It could cruise at about 10 knots. However, speed for both craft during test runs for signal search was 5 to 7 knots. A Shick, Incorporated, manufactured Stadimeter, S/N 2878, was carried on board the search craft and used as a backup and a verification of the detection ranges recorded by radar.

Test Methods and Procedures

The ETB (test section) was carried on board the Control Ship to the test site for each test and lowered into place on the ocean floor in the particular position required. The locator beacon was placed in the ETB prior to lifting it from the deck. Following the lowering, divers would descend to verify the ETB position on the bottom, the rotation with respect to the Control Ship's heading, and make a second depth check with a wrist-held depth gauge.

Following the determination that the ETB was in the position desired for the ensuing test, the search craft, starting beyond detection range, would be given a bearing to the Control Ship and thereafter maintained that course by change in heading determined by the Alidade operator and relayed to the search craft by the Control Ship Skipper. All communications between the two craft were transmitted by VHF radio. The Officer in Command of the Control Ship was in charge of, and directed, all sea operations. When the signal had been recognized by the locator

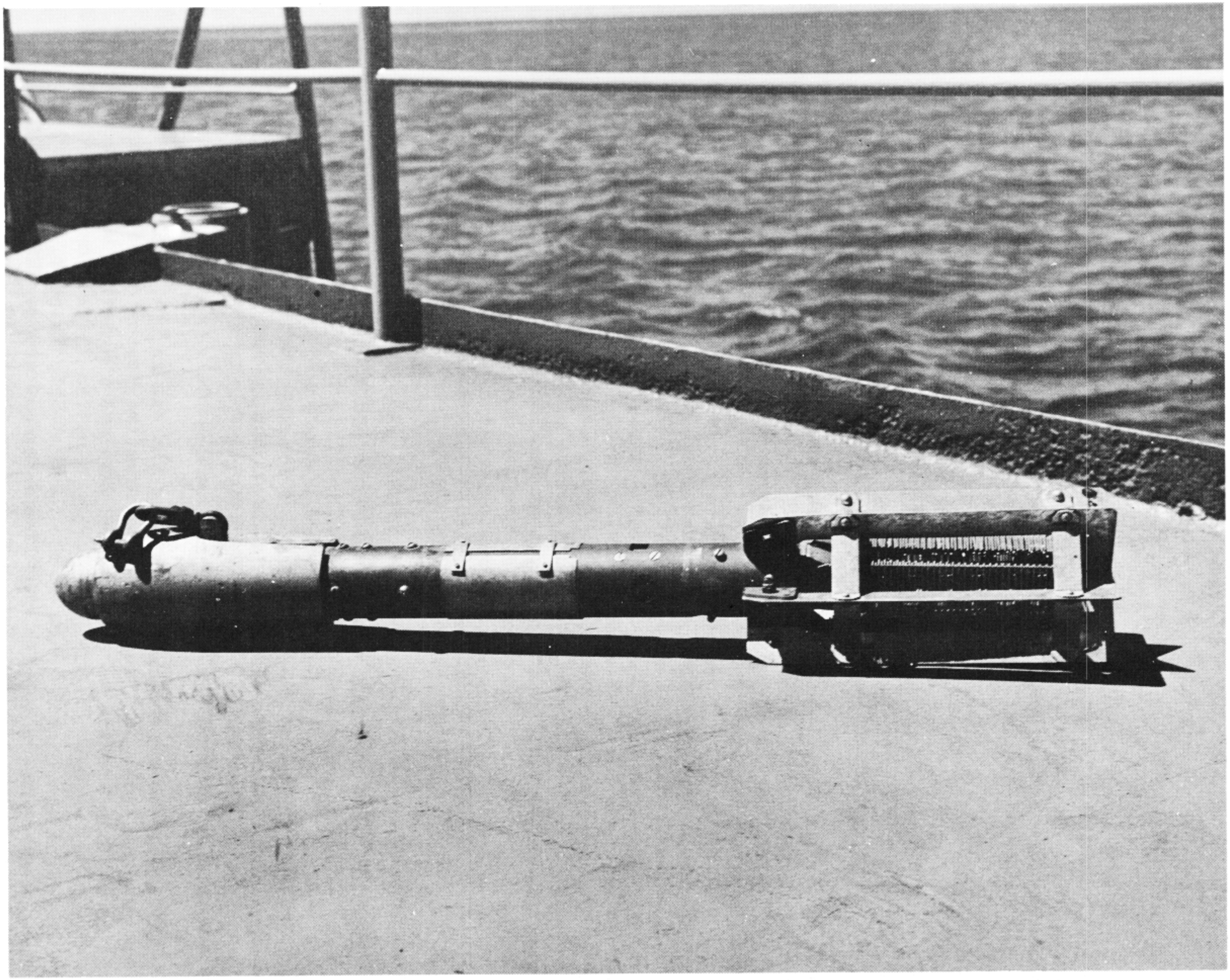


FIG. 7 BATHYTHERMOGRAPH MODEL OC-2C/S

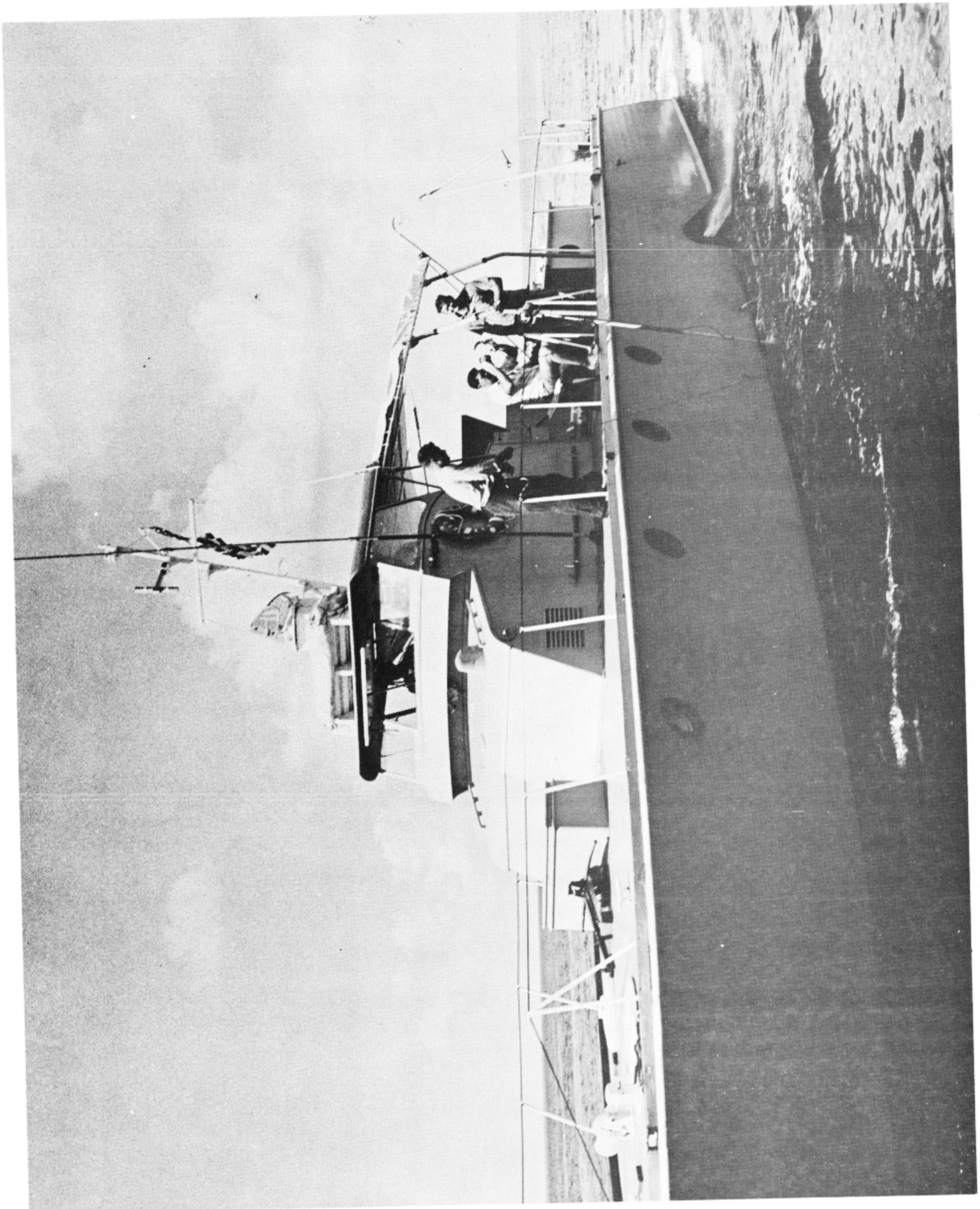


FIG. 8 NO. 1 SEARCHCRAFT 6ND125

FIG. 9 NO. 2 SEARCHCRAFT 6ND129

receiver operator, he blew a whistle which alerted the search craft Coxswain to call the word "mark" over the radio to the Control Ship Commander. At that time, the Quartermaster on the Control Ship recorded the alidade reading, the radar operator on duty recorded the radar range reading, and a Boatswain Mate on the search craft recorded the Stadimeter range reading. The search craft would then proceed outbound from the Control Ship to a point well beyond that at which the signal had just been picked up, and a new search using a different bearing would begin. This procedure was repeated for each 15° of azimuth or an average of 24 times on each complete test run.

The signal pickup search technique was also set to determine the pattern of attenuation of the beacon signal caused by the aluminum honeycomb used in aircraft construction. The transmitting beacon was positioned in the geometric center of an aluminum honeycomb box, so there would be no structural shielding of the beacon. The sides of the box were loosely fitted so the box could fill with water and there would be no voids. Five search signal pickup tries were made at 45° intervals to cover a semicircular azimuth about the submerged box.

In order to determine the range of the signal transmitted from the submerged locator beacon when there were no obstructions or screening hindrances to block the signal, other than the geographic contour and the vegetation of the ocean floor, the beacon was mounted on a water vane with only the mounting base of the beacon in contact with any structure of the vane. The vane was trailed off the stern of the Control Ship on a line so that it rode at a depth of 100 feet in 200 feet of water so there would be no reflecting surface near. Signal pickup passes were made by the search craft, again in a semicircular pattern, with search course separation of 30°.

The same locator receiver operator was used for all of the range tests. The operator was given an audio hearing test prior to the start of the beacon tests and again following completion of the test program. The operator's hearing was considered average for his age, his greatest loss from the normal, established by the American Medical Association, being 20 dBs at the low frequency of 250 Hz and a loss of only 5 dBs at the receiver response frequency.

Signal level readings were taken on each beacon at the conclusion of each test and compared to previous laboratory source level tests to insure that the signal had not deteriorated and given erroneous ranges. It was also important to determine if any change had occurred from test to test in the sensitivity of the locator receiver. To establish this, a signal of 35 kHz was projected in the water at an exact measured distance from the receiver hydrophone. The signal was generated by a Waveform #512 oscillator and projected into the water through a standard Navy CQJ-5106 onmidirectional transducer. The level of the signal into the transducer was measured at the output of the oscillator using a Ballentine 310A voltmeter as a signal monitor.

In order to have a standard or a reference level from which to work, the locator receiver was first tested with new batteries at the start of the program. The projected signal was then slowly decreased to a threshold level, that is, to a point where the receiver operator could no longer hear the signal but with a very minute increase in projected signal strength, he could again hear the signal in his headphones. This signal level was recorded as the input level to the projector, as read on the Ballentine voltmeter. Thereafter, this signal level was used as the reference level or zero dB. Any deviation in dB readings from the reference level was recorded during all subsequent tests, with the projector and receiver set up in the exact same geometric pattern as used in the initial or reference test.

SUMMARY OF RESULTS

Environmental Tests

A total of 24 runs was made to determine the ranges at which the locator beacon signals could be detected when the beacon remained encapsulated in the aircraft fuselage. A summary of all the runs and associated conditions is given in Table III. Polar graphs showing the plotted results of the ranges at which the beacon signals were first identified are shown in Appendix II. Also shown on each plot is the particular position and attitude of the ETB at rest on the ocean floor as viewed from the surface of the water. The location of the beacon within the ETB is indicated on each figure by a(+).

No attempt will be made to explain all of the excursions and indentations of the plots as too many uncontrolled variables such as hilly terrain and thermoclimes existed during testing. However, attention is called to a unique similarity of the results of Run Numbers 1, 7, 8, and 9, respectively, which have an "almost" flat, one-sided record except for one spiked protrusion. This condition was noticed following the plotting of signal pickup ranges for Run No. 1, and at the time, it was suspected that the particular pattern could have been influenced by the honeycomb aluminum panel in the deck plating. Later, the same influence could be noted in a number of the plots and a decision was made to make a cursory investigation of the effect aluminum honeycomb material might have on the radiated signals.

As previously described, a 12-inch cubed honeycomb box was constructed and a beacon was placed in the geometric center of the cube and 5 pickup searches were made with the results shown in Run 22. Again, the phenomenon of the signal radiating perpendicular to the plane of the aluminum honeycomb was evident, and there was some reduction of the signal strength as the pickup distance was reduced by 400 to 500 yards.

Run No. 21 shows the results obtained when the ETB was specifically positioned to find out if the ocean floor would directly influence

TABLE III

SEARCH RUN ASSOCIATED CONDITIONS AND INFORMATION

Run No.	Test Pos.	Beacon Loc.	Beacon No.	Bat. No.	Water Temp. (sur/sub)	Water Depth (ft)	Water Curr. (kts)	Water Cond-ion	Search Craft No.	Date	Remarks
1	C	1	1	3	87.5 87.0	50	1.5	Calm	125	9/13/66	Radar cal. +10' at 2200'
2	C	2	2	2	86.5 86.5	50	3.0	Rough	125	9/14/66	Sect. moved at 16 to A position
3	C	2	4	4L	86.1 86.3	50	2.0	Choppy	125	9/16/66	Routine
4	A	1	1	3	85.5 85.5	52	2.0	Sl. chop	125	9/19/66	Sect. rolled at no. 23 to 30^{o}
5	A	2	2	2	85.9 86.1	50	3.0	Calm	125	9/21/66	New Batt. installed in receiver
6	B	2	8	8	86.0 86.0	50	2.0	Calm	125	9/23/66	Search craft lost 2 engines
7	B	1	7	7	85.1 85.1	50	1.0	Calm	125	9/26/66	Routine
8	C	1	4	1L	85.0 82.0	99	2.0	Choppy	125	9/29/66	Bottom visible
9	C	1	1	14	85.0 78.0	105	2.5	Calm	125	9/30/66	Thermoclime at 50'
10	C	2	2	15	83.0 83.0	100	*	Calm	129	10/10/66	125 disabled by storm
11	A	2	7	7	83.0 82.0	92	*	Calm	129	10/11/66	Sect. rocks with current
12	A	1	7	7	83.0 82.0	92	*	Calm	129	10/11/66	Picked up porpoise on receiver
13	B	2	8	8	83.0 82.0	100	*	Choppy	129	10/12/66	Routine
14	B	1	8	8	83.0 82.0	100	*	Choppy	129	10/12/66	Routine
15	C	1	4	16	82.2 79.0	198	*	Calm	125	10/17/66	Water murky, 125 back
16	C	2	1	14	82.0 78.0	200	*	Large Swells	125	10/18/66	Routine
17	A	2	8	8	82.0 76.0	199	2.0	Calm	125	10/19/66	Thermoclime at 130'
18	A	1	8	8	82.7 80.2	202	1.5	Calm	125	10/24/66	Thermoclime
19	B	2	8	8	82.0 74.0	215	1.5-2.0	Calm	125	10/25/66	Divers guessed $\pm 15^{o}$ sect. pos.
20	B	1	8	8	84.0 74.0	205	1.5-2.0	Calm	125	10/25/66	Divers could see
21	D	1	8	8	81.0 72.0	201	2.0	Rough	125	10/27/66	125 disabled at no. 11, line parted
22	H	14 ft	7	7	82.0 82.0	110	2.0	Choppy	125	10/26/66	Only 5 data points
23	V	Trailing 100 ft	4	24	82.0 81.0	110	2.0	Choppy	125	10/26/66	Beacon and vane test
24	V	Trailing 100 ft	4	24	82.0 81.0	110	2.0	Choppy	129	10/26/66	Quiet search also

* No record
L Low voltage battery

Test Position A - Horizontal, B - Vertical (small end down), C - Vertical (small end up), D - Vertical (small end up 30^{o} tilt)
Beacon Location 1 - Forward Pressurized Bulkhead, 2 - Aft Pressurized Bulkhead

reflected signals so that the detection distance would be significantly greater. The measurements recorded did not indicate any improvement over any of the other ETB positions tested.

A water vane was used to place a locator beacon in an unobstructed position so that a determination could be made of any effect that the different noise levels of the two search craft might have on the signal pickup ranges. Also evaluated was the difference between a low noise search craft such as anchored craft, rowboat, raft, etc., and the noise levels that the powered craft established. The differences for both conditions mentioned, as well as the maximum range at which the signal was detected during the entire operation, are shown by Run No. 24. The minimum difference between the low noise level pickup distance and the higher noise level search craft pickup ranges, approximately 200 yards, could be very significant during an accident search under certain conditions.

The worst condition that existed, or the poorest response by detection, is shown by Run No. 18. However, even under the conditions encountered during these tests, the probability of missing a detection on the pass or search is about one in three, depending on the type of search pattern in use.

Laboratory Tests

Prior to going on location for the aforementioned underwater tests, the acoustic locator beacons were given source level and operating life tests by the Pennsylvania State University Ordnance Research Laboratory at their Black Moshannon Calibration Station, Black Moshannon, Pennsylvania. The results of these tests are included in Appendix III.

A test was conducted in the laboratory to determine if condensation during an aircraft descent from high altitude into very humid atmospheric conditions would falsely energize the locator beacon.

A simulated flight profile of a transport-type aircraft descending from 30,000 feet altitude with an outside air temperature of -30°F to land at an airport where the temperature was 90°F and the relative humidity was 98 percent was made. The descent time was 15 minutes which is within the spread of actual descent times for traffic patterns at three major domestic terminals which range from 13 to 21 minutes. The tests were conducted in an environmental weather test chamber during which temperature, humidity, and pressure were controlled. Solar radiation, gas ionization effects, etc., were not included in the tests. During the tests two signal beacons were used: one beacon tested was a used one with an uncleaned wet switch; the second beacon had a clean wet switch. The results of the tests are shown by Figure 10, and as can be seen, the beacon with the uncleaned wet switch began to transmit intermittently during the simulated descent

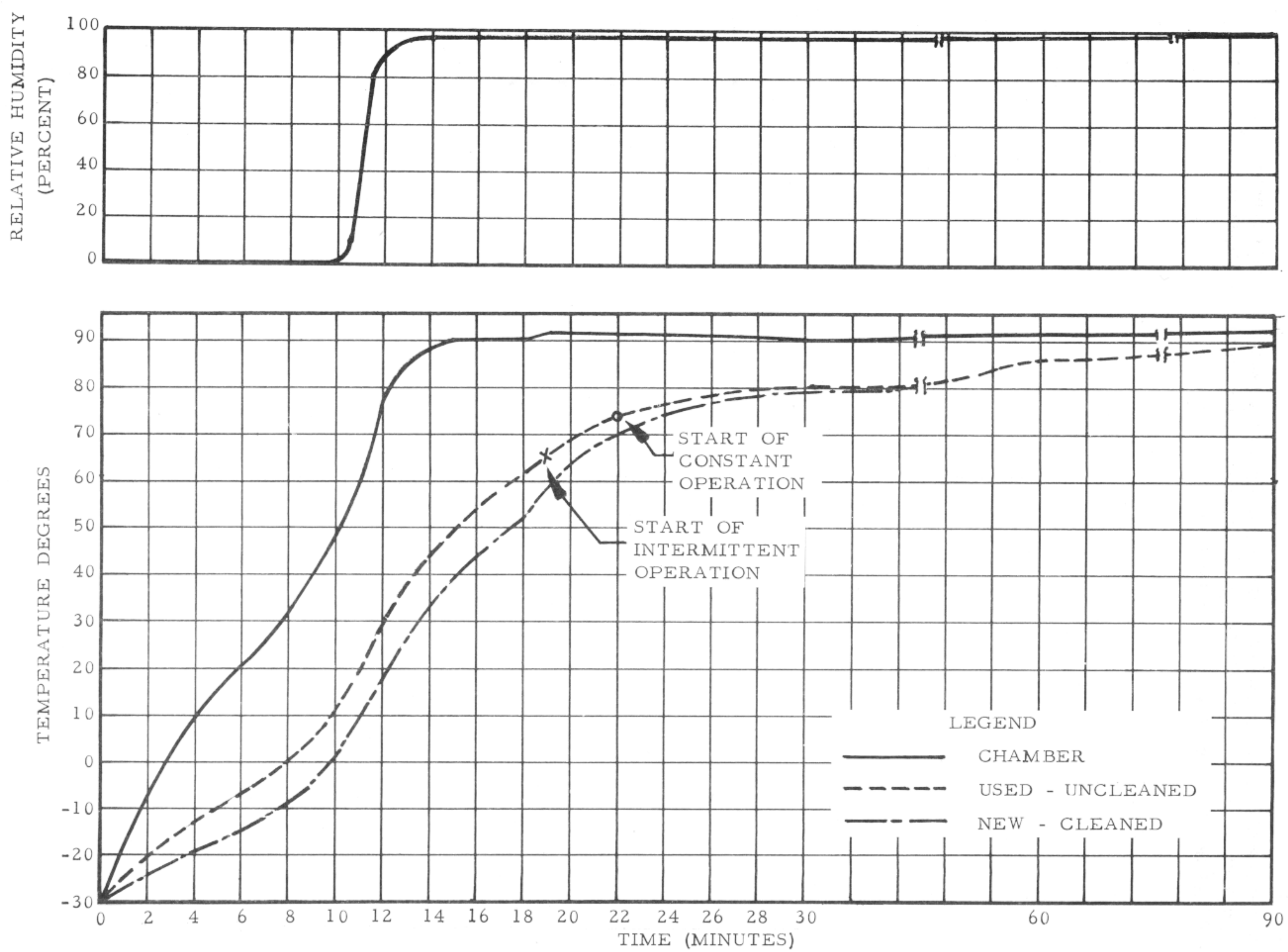


FIG. 10 WEATHER CHAMBER TEST RESULTS

when the temperature reached approximately 65°F and the relative humidity was near 98 percent. At 74°F with the same high relative humidity, the beacon began to transmit continuously.

CONCLUSIONS

Based on the results obtained from these tests, it is concluded that:

1. Acoustic locator beacons of the type used in these tests can be located by acoustic signal receivers when the locator beacon is still encapsulated in an aircraft fuselage.

2. The lower the background noise level generated during a search, the greater the distance that the signal can be detected and recognized by a receiver operator.

3. Aluminum honeycomb adversely affects the output of the locator beacons.

4. A dirty wet switch can be inadvertently activated by high humidity in the atmosphere.

RECOMMENDATIONS

It is recommended that:

1. Locator beacons of the type tested be considered for installation on aircraft recording equipment.

2. Locations of aluminum honeycomb components be carefully considered in relation to the location of the acoustic locator beacons.

3. Periodic maintenance of the wet switch be accomplished to prevent inadvertent actuation by high humidity in the atmosphere.

4. Signal attenuation effects be determined when acoustic-type locator beacons are submerged in mud, sand, silt, etc.

ACKNOWLEDGMENTS

Gratefully acknowledged is the professional assistance of Mr. James Prout and Mr. Jack Anderson of the Pennsylvania State University Ordnance Research Laboratory. Appreciation is also expressed for the cooperation and exceptional performance of the Navy personnel assigned to conduct the testing at the U.S. Naval Ordnance Unit, Naval Base, Key West, Florida.

APPENDIX I

GLOSSARY OF TERMS
AND ABBREVIATIONS

APPENDIX I

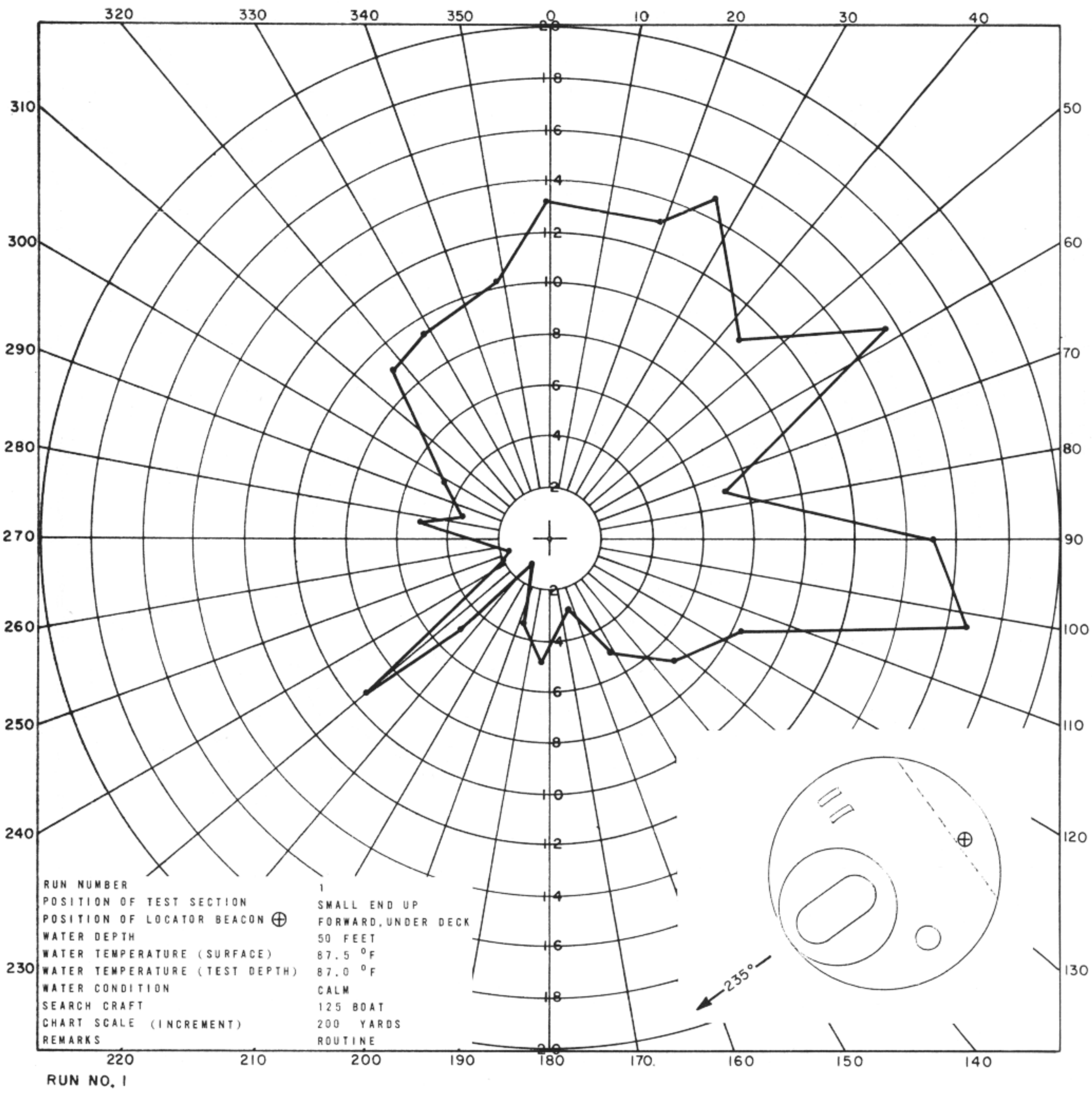
GLOSSARY OF TERMS AND ABBREVIATIONS

This Appendix is provided to define terms used in this report.

Acoustic:	Pertaining to the sense of auditory hearing, sounds, and the science of sound.
Noise:	Audible sounds perceptible to the ear that conflict with, or hide, desired sounds.
Background noise:	An audible sound level that remains fairly constant.
Thermoclime:	A temperature gradient, especially one marking a sharp change, also layers of water exhibiting this characteristic.
Alidade:	An optical measuring instrument for taking angle measurements, comprised of an indicator, verniers, telescope, etc.
cm^2:	Centimeter squared
dB:	Decibel
F:	Fahrenheit scale
ft:	Foot, feet
kHz:	Kilohertz
lb:	Pound
max:	Maximum
min:	Minimum
yd:	Yard
in:	Inch
ETB:	Environmental Test Bed (Aircraft Fuselage Section)
BT:	Bathythermograph

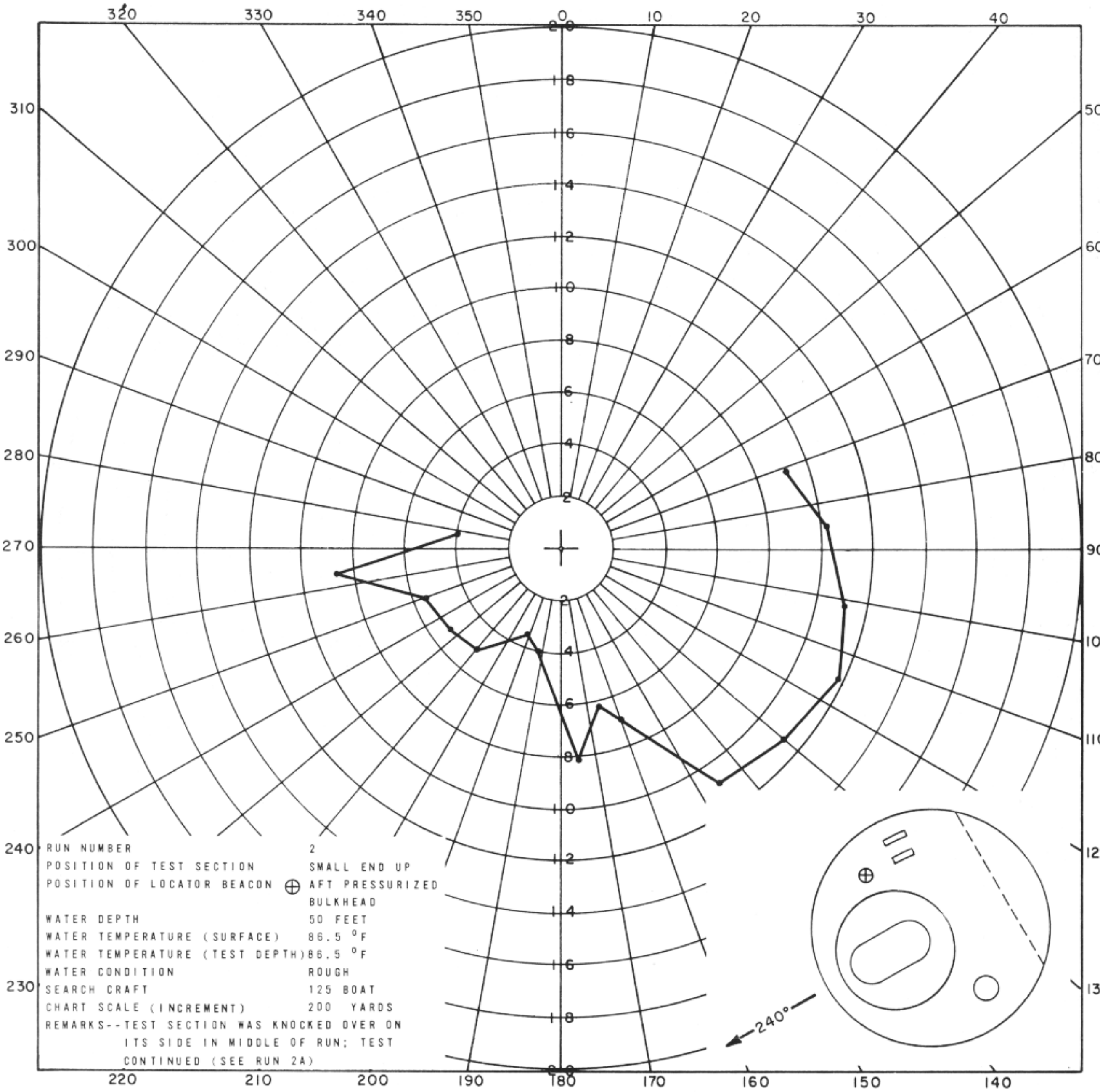
APPENDIX II

POLAR CHARTS OF RESULTS

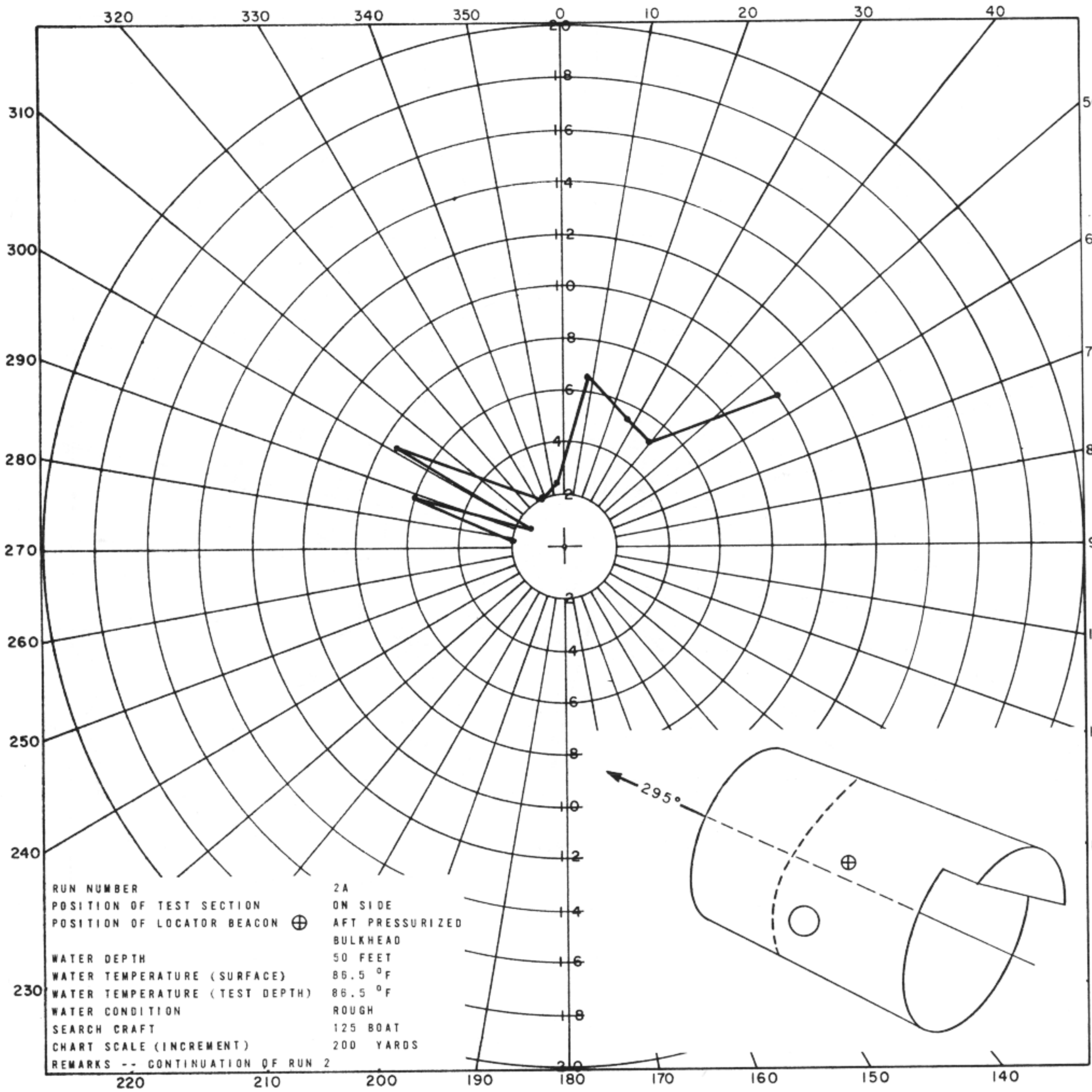


RUN NUMBER 1
POSITION OF TEST SECTION SMALL END UP
POSITION OF LOCATOR BEACON ⊕ FORWARD, UNDER DECK
WATER DEPTH 50 FEET
WATER TEMPERATURE (SURFACE) 87.5 °F
WATER TEMPERATURE (TEST DEPTH) 87.0 °F
WATER CONDITION CALM
SEARCH CRAFT 125 BOAT
CHART SCALE (INCREMENT) 200 YARDS
REMARKS ROUTINE
235°

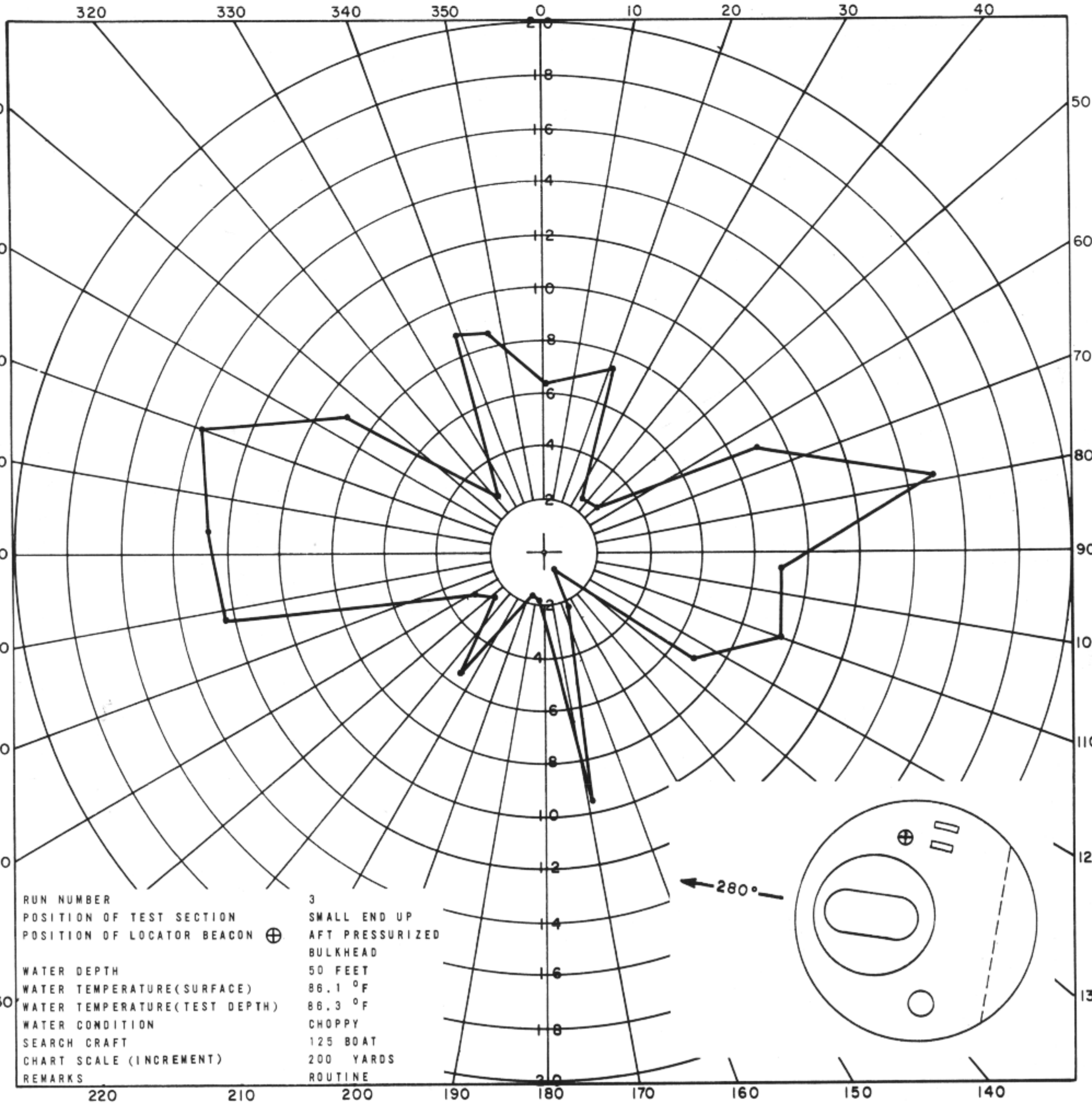
RUN NO. 1


RUN NUMBER 2
POSITION OF TEST SECTION SMALL END UP
POSITION OF LOCATOR BEACON ⊕ AFT PRESSURIZED BULKHEAD
WATER DEPTH 50 FEET
WATER TEMPERATURE (SURFACE) 86.5 °F
WATER TEMPERATURE (TEST DEPTH) 86.5 °F
WATER CONDITION ROUGH
SEARCH CRAFT 125 BOAT
CHART SCALE (INCREMENT) 200 YARDS
REMARKS--TEST SECTION WAS KNOCKED OVER ON ITS SIDE IN MIDDLE OF RUN; TEST CONTINUED (SEE RUN 2A)
240°

RUN NO. 2

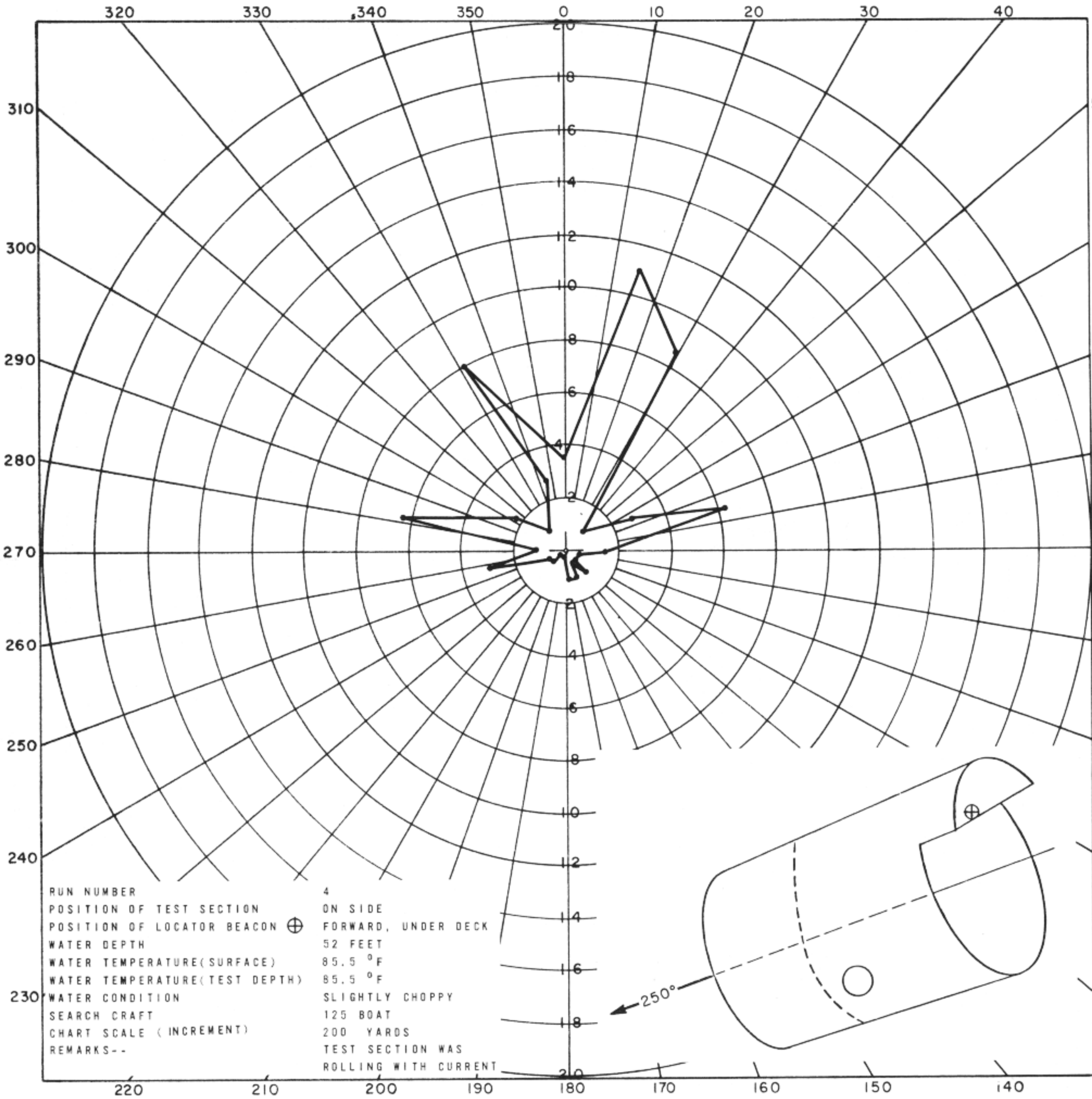

295°
RUN NUMBER 2A
POSITION OF TEST SECTION ON SIDE
POSITION OF LOCATOR BEACON ⊕ AFT PRESSURIZED BULKHEAD
WATER DEPTH 50 FEET
WATER TEMPERATURE (SURFACE) 86.5 °F
WATER TEMPERATURE (TEST DEPTH) 86.5 °F
WATER CONDITION ROUGH
SEARCH CRAFT 125 BOAT
CHART SCALE (INCREMENT) 200 YARDS
REMARKS -- CONTINUATION OF RUN 2

RUN NO. 2A



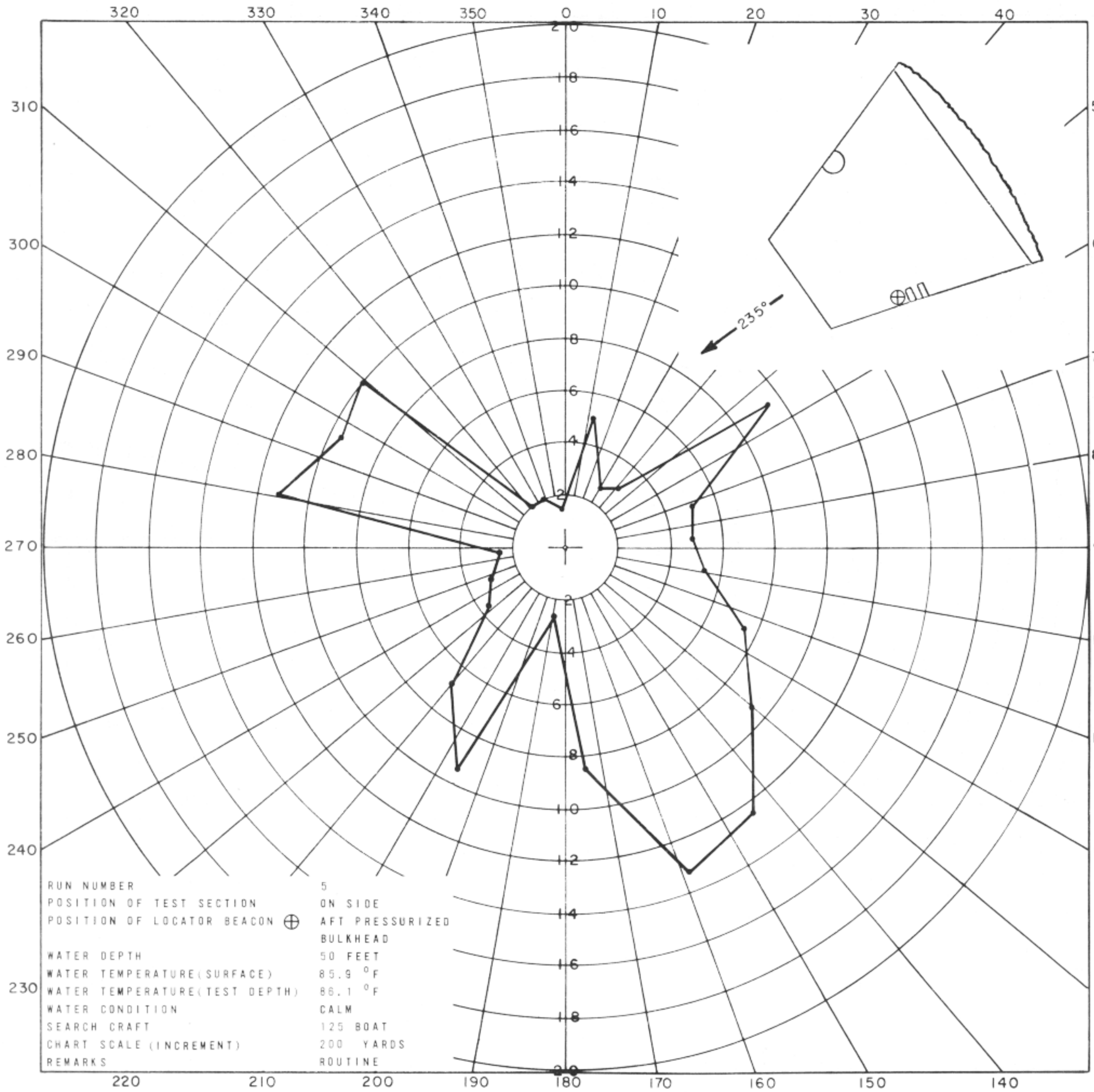
RUN NUMBER 3
POSITION OF TEST SECTION SMALL END UP
POSITION OF LOCATOR BEACON ⊕ AFT PRESSURIZED BULKHEAD
WATER DEPTH 50 FEET
WATER TEMPERATURE(SURFACE) 86.1 °F
WATER TEMPERATURE(TEST DEPTH) 86.3 °F
WATER CONDITION CHOPPY
SEARCH CRAFT 125 BOAT
CHART SCALE (INCREMENT) 200 YARDS
REMARKS ROUTINE
280°

RUN NO. 3



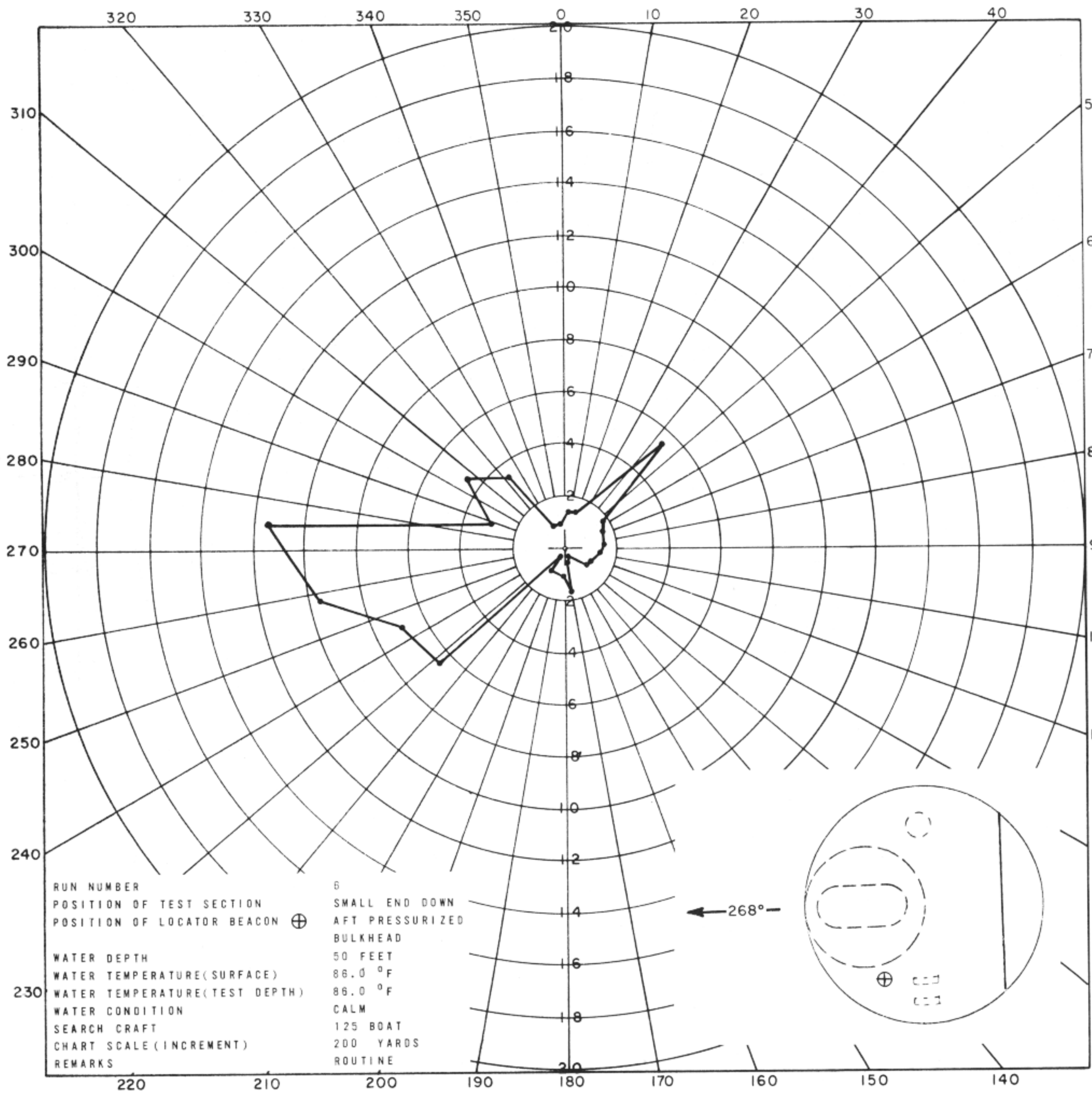
RUN NUMBER 4
POSITION OF TEST SECTION ON SIDE
POSITION OF LOCATOR BEACON ⊕ FORWARD, UNDER DECK
WATER DEPTH 52 FEET
WATER TEMPERATURE(SURFACE) 85.5 °F
WATER TEMPERATURE(TEST DEPTH) 85.5 °F
WATER CONDITION SLIGHTLY CHOPPY
SEARCH CRAFT 125 BOAT
CHART SCALE (INCREMENT) 200 YARDS
REMARKS-- TEST SECTION WAS ROLLING WITH CURRENT
250°

RUN NO. 4

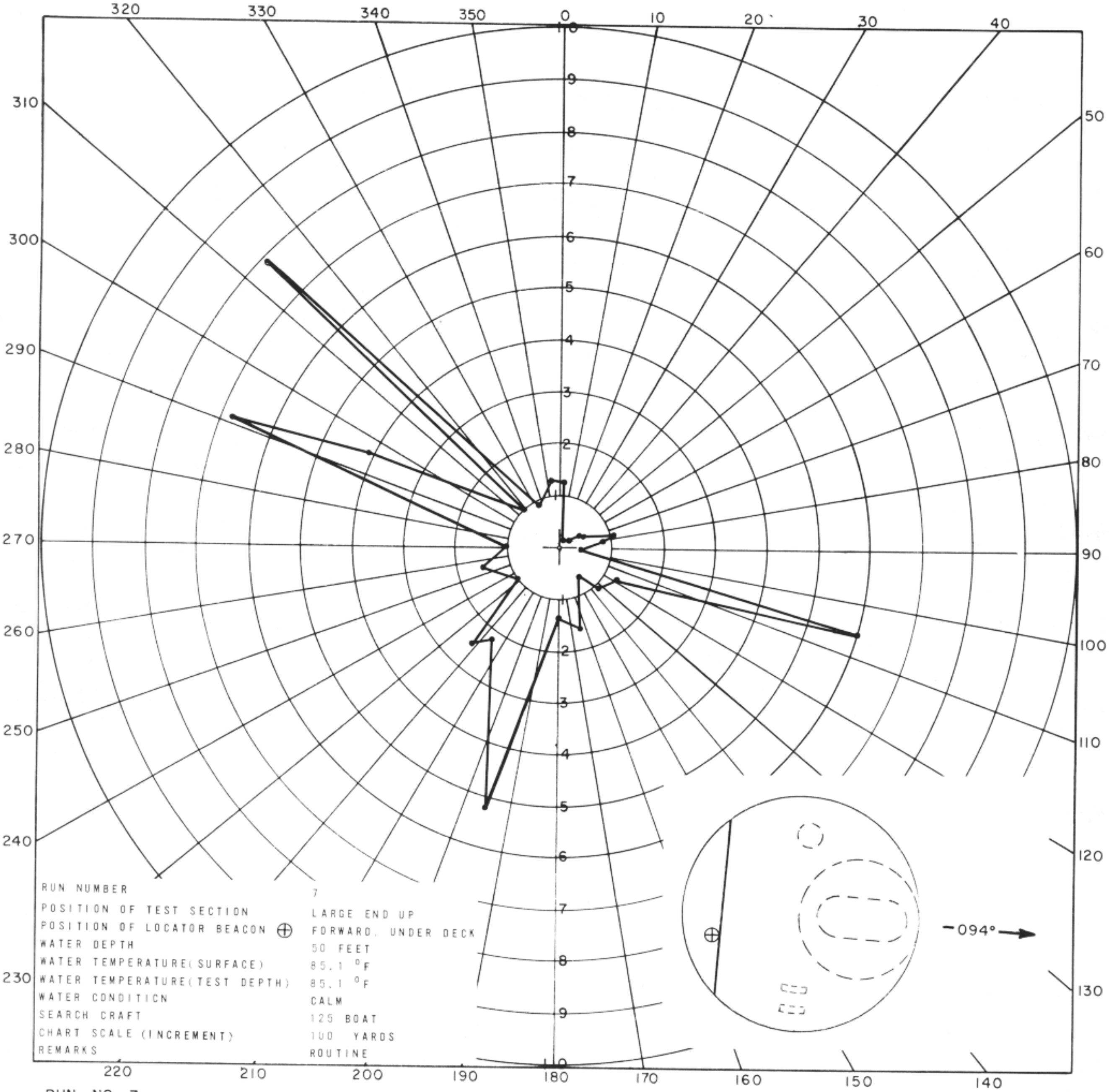


235°
RUN NUMBER 5
POSITION OF TEST SECTION ON SIDE
POSITION OF LOCATOR BEACON ⊕ AFT PRESSURIZED BULKHEAD
WATER DEPTH 50 FEET
WATER TEMPERATURE (SURFACE) 85.9 °F
WATER TEMPERATURE (TEST DEPTH) 86.1 °F
WATER CONDITION CALM
SEARCH CRAFT 125 BOAT
CHART SCALE (INCREMENT) 200 YARDS
REMARKS ROUTINE

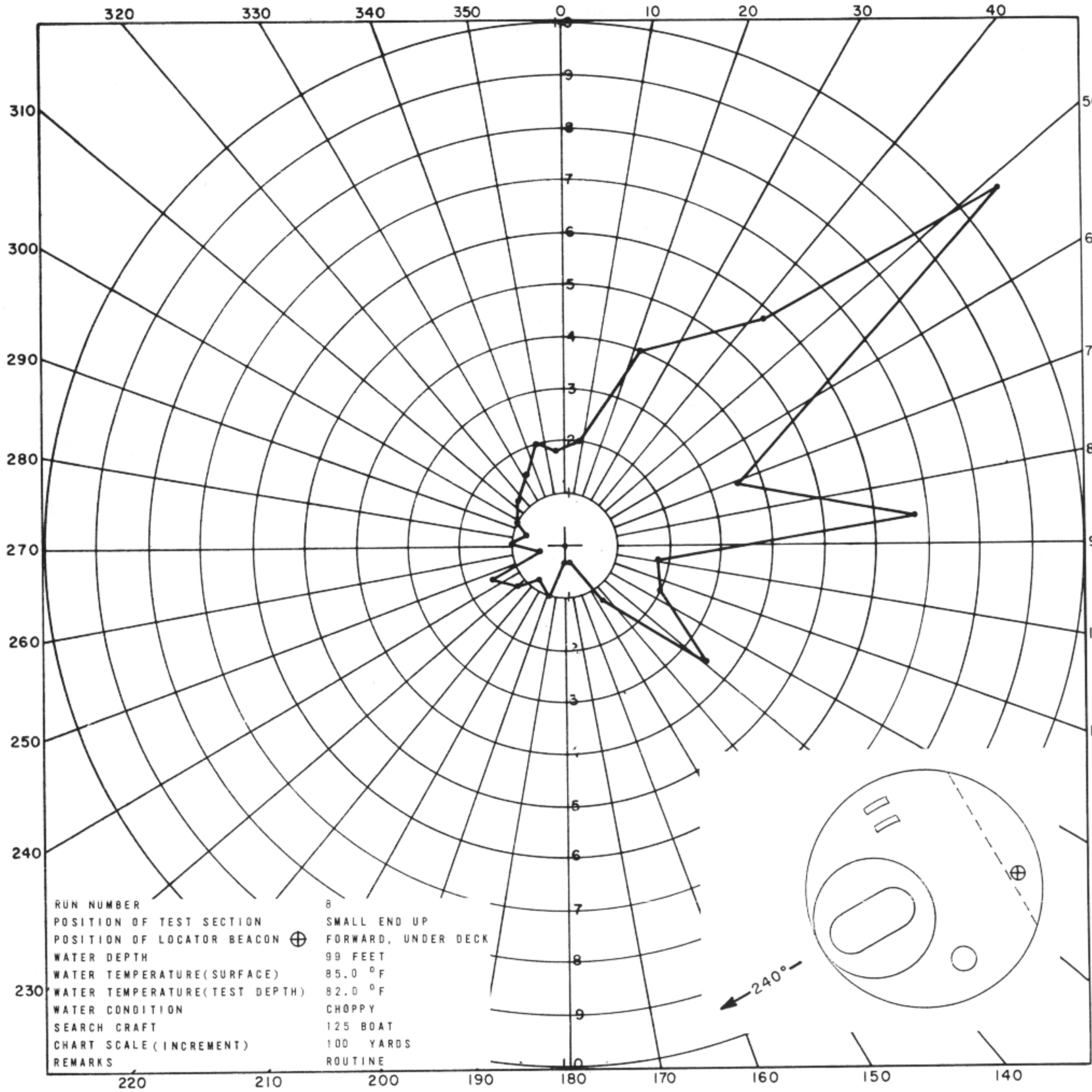
RUN NO. 5


RUN NUMBER 6
POSITION OF TEST SECTION SMALL END DOWN
POSITION OF LOCATOR BEACON ⊕ AFT PRESSURIZED BULKHEAD
WATER DEPTH 50 FEET
WATER TEMPERATURE(SURFACE) 86.0 °F
WATER TEMPERATURE(TEST DEPTH) 86.0 °F
WATER CONDITION CALM
SEARCH CRAFT 125 BOAT
CHART SCALE(INCREMENT) 200 YARDS
REMARKS ROUTINE
268°

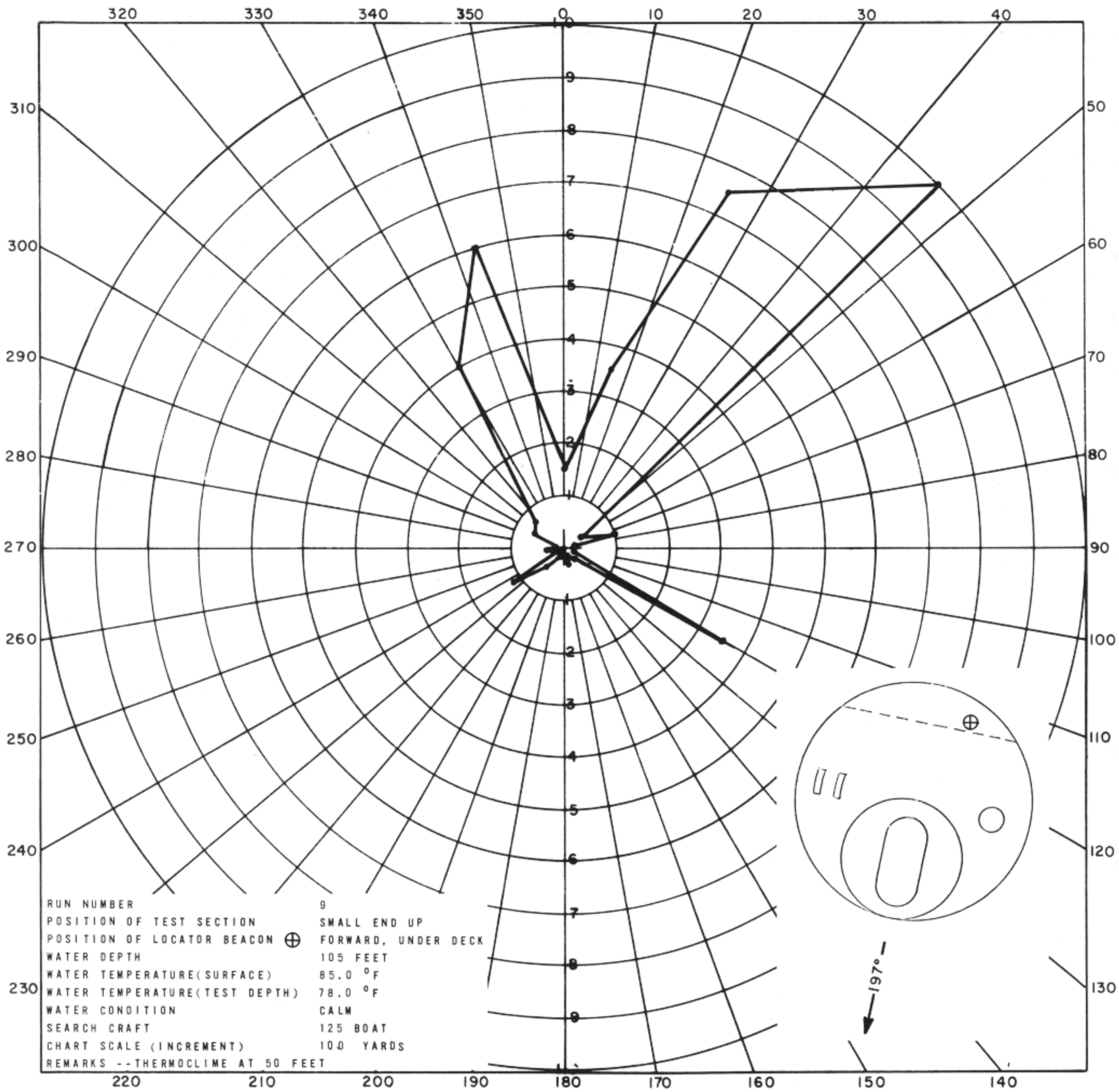
RUN NO. 6


RUN NUMBER 7
POSITION OF TEST SECTION LARGE END UP
POSITION OF LOCATOR BEACON ⊕ FORWARD, UNDER DECK
WATER DEPTH 50 FEET
WATER TEMPERATURE (SURFACE) 85.1 °F
WATER TEMPERATURE (TEST DEPTH) 85.1 °F
WATER CONDITION CALM
SEARCH CRAFT 125 BOAT
CHART SCALE (INCREMENT) 100 YARDS
REMARKS ROUTINE
094°

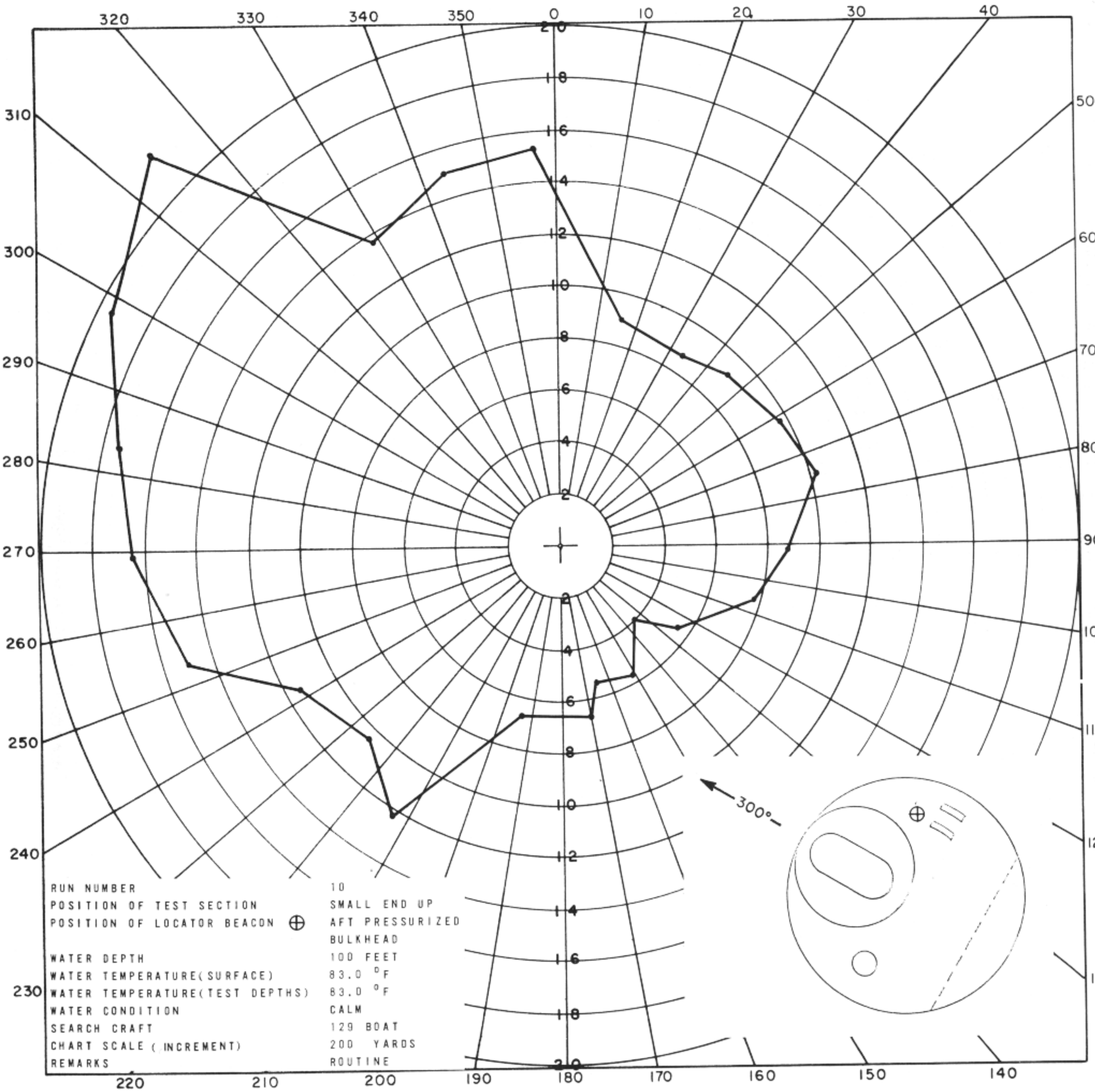
RUN NO. 7


RUN NUMBER 8
POSITION OF TEST SECTION SMALL END UP
POSITION OF LOCATOR BEACON ⊕ FORWARD, UNDER DECK
WATER DEPTH 99 FEET
WATER TEMPERATURE(SURFACE) 85.0 °F
WATER TEMPERATURE(TEST DEPTH) 82.0 °F
WATER CONDITION CHOPPY
SEARCH CRAFT 125 BOAT
CHART SCALE(INCREMENT) 100 YARDS
REMARKS ROUTINE
240°

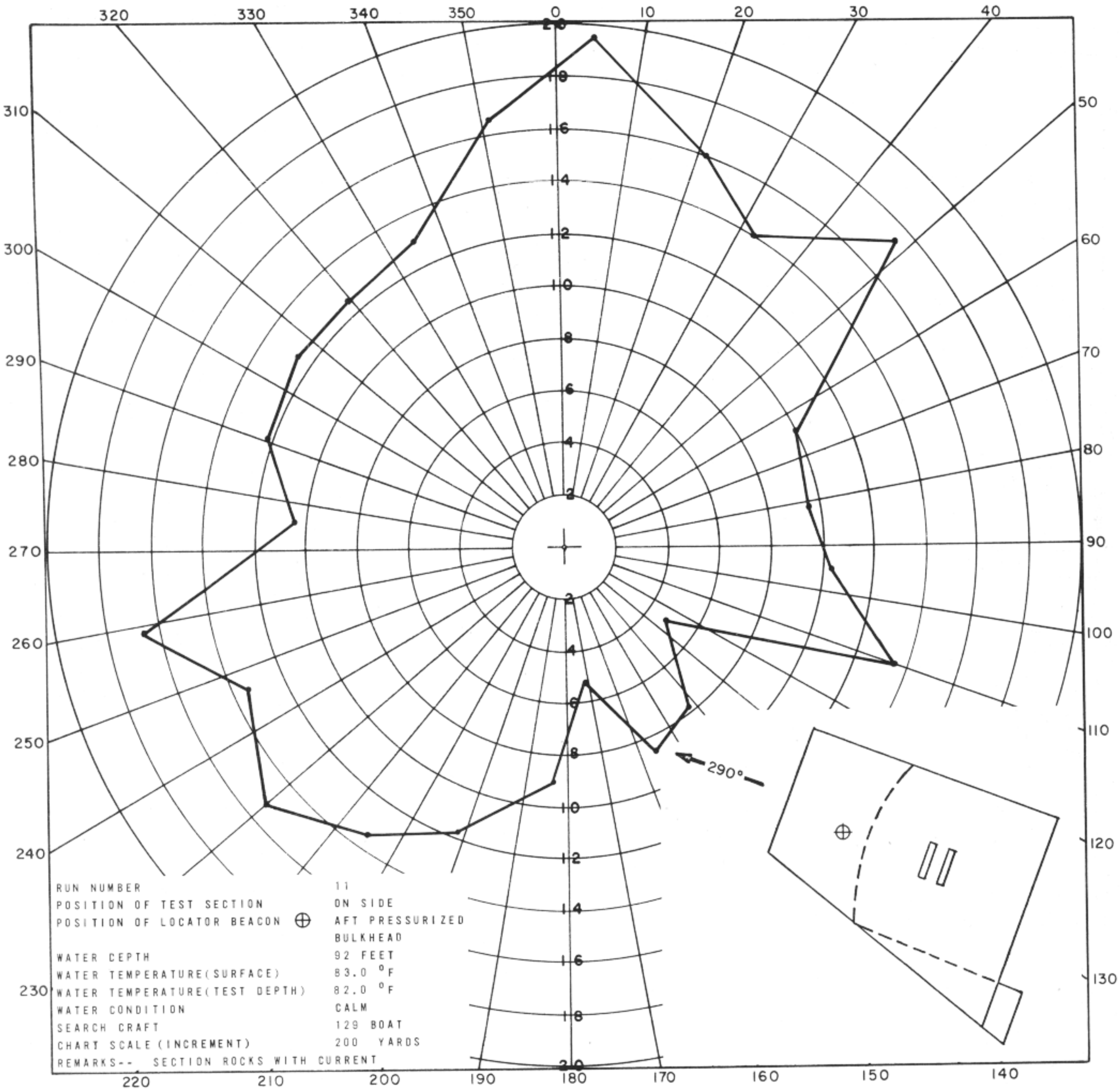
RUN NO. 8


RUN NUMBER 9
POSITION OF TEST SECTION SMALL END UP
POSITION OF LOCATOR BEACON ⊕ FORWARD, UNDER DECK
WATER DEPTH 105 FEET
WATER TEMPERATURE(SURFACE) 85.0 °F
WATER TEMPERATURE(TEST DEPTH) 78.0 °F
WATER CONDITION CALM
SEARCH CRAFT 125 BOAT
CHART SCALE (INCREMENT) 100 YARDS
REMARKS --THERMOCLIME AT 50 FEET
197°

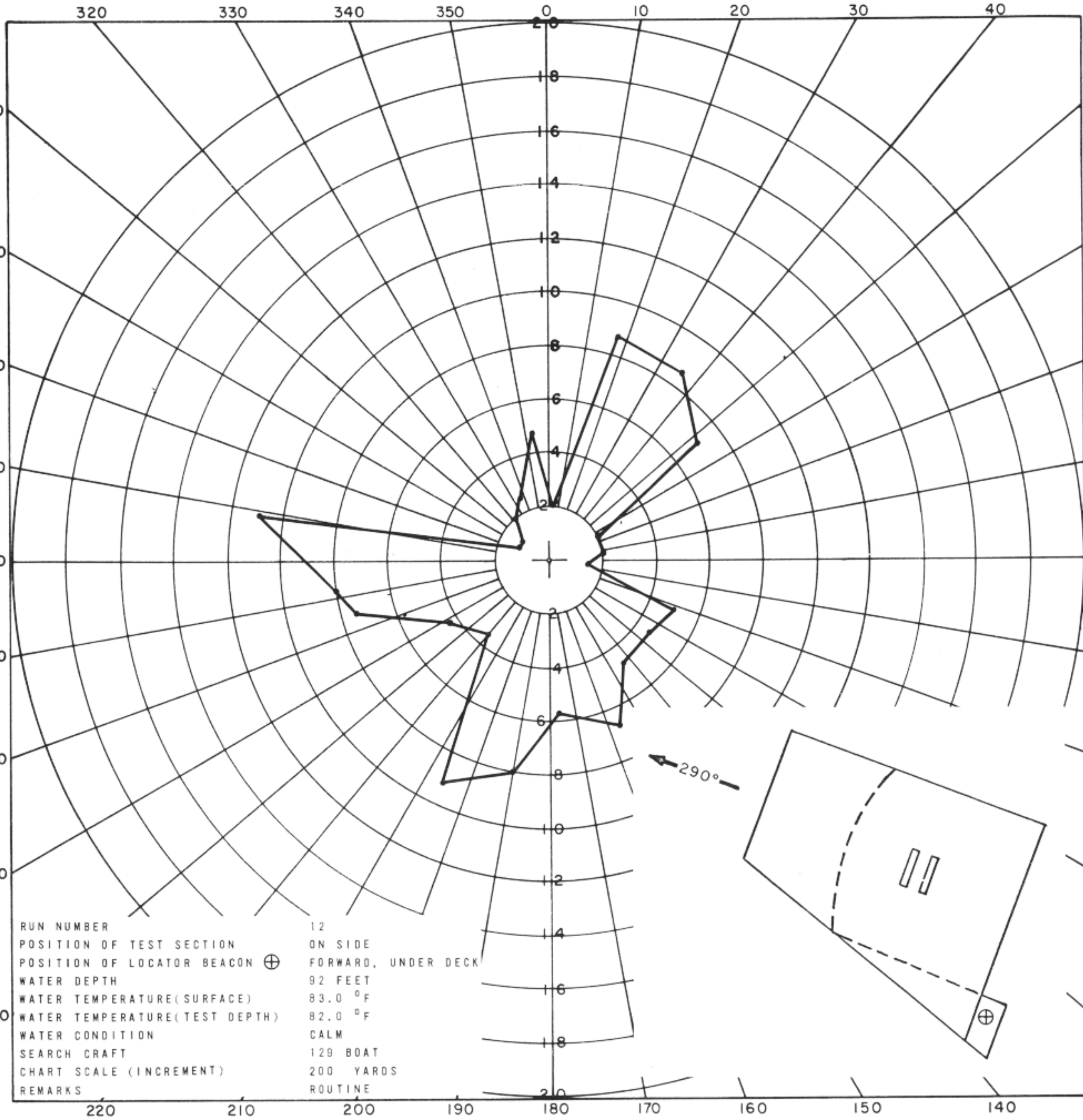
RUN NO. 9


RUN NUMBER 10
POSITION OF TEST SECTION SMALL END UP
POSITION OF LOCATOR BEACON ⊕ AFT PRESSURIZED BULKHEAD
WATER DEPTH 100 FEET
WATER TEMPERATURE(SURFACE) 83.0 °F
WATER TEMPERATURE(TEST DEPTHS) 83.0 °F
WATER CONDITION CALM
SEARCH CRAFT 129 BOAT
CHART SCALE (INCREMENT) 200 YARDS
REMARKS ROUTINE
300°
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350

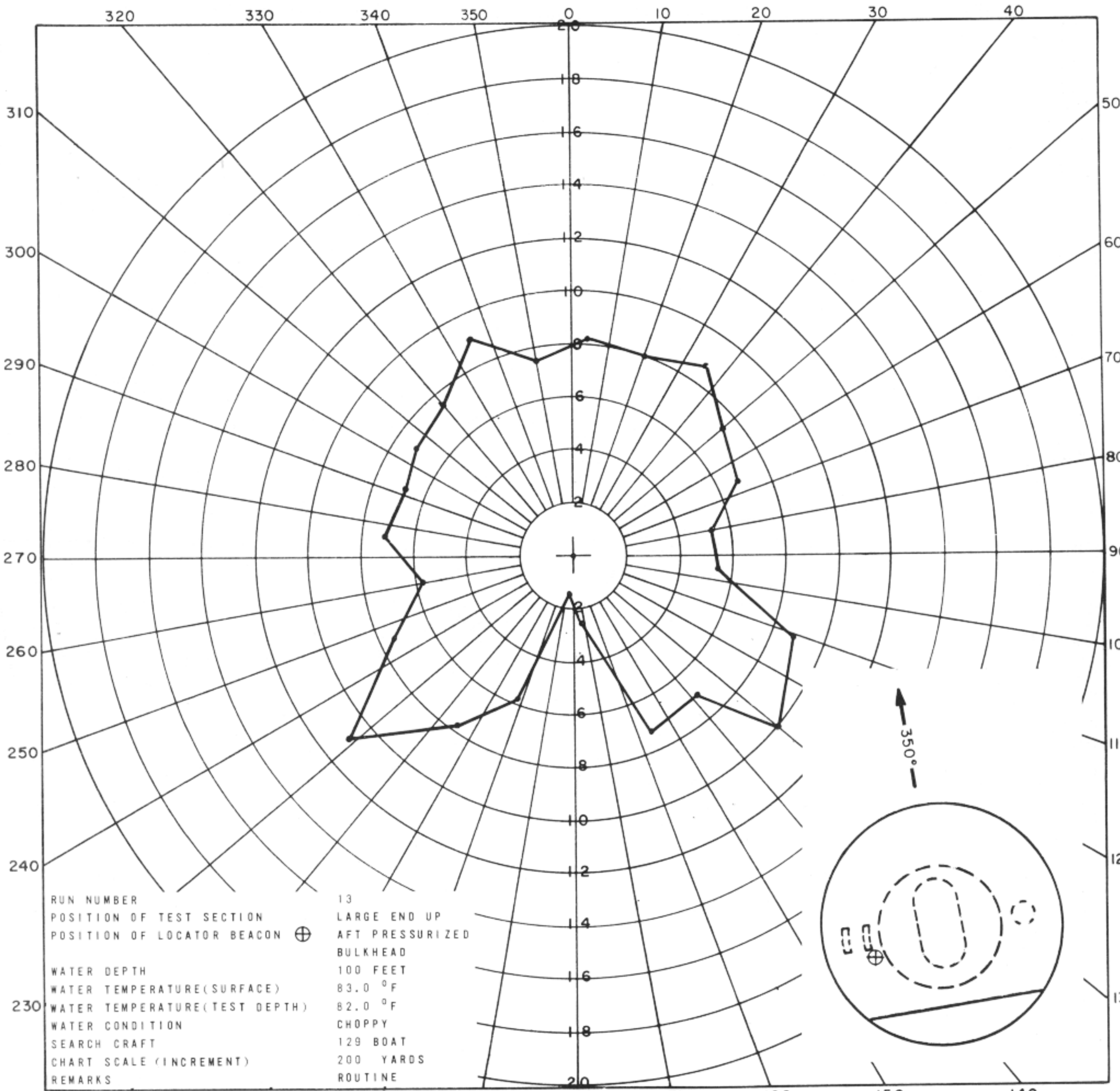
RUN NO. 10


RUN NUMBER 11
POSITION OF TEST SECTION ON SIDE
POSITION OF LOCATOR BEACON ⊕ AFT PRESSURIZED BULKHEAD
WATER DEPTH 92 FEET
WATER TEMPERATURE(SURFACE) 83.0 °F
WATER TEMPERATURE(TEST DEPTH) 82.0 °F
WATER CONDITION CALM
SEARCH CRAFT 129 BOAT
CHART SCALE (INCREMENT) 200 YARDS
REMARKS-- SECTION ROCKS WITH CURRENT
290°

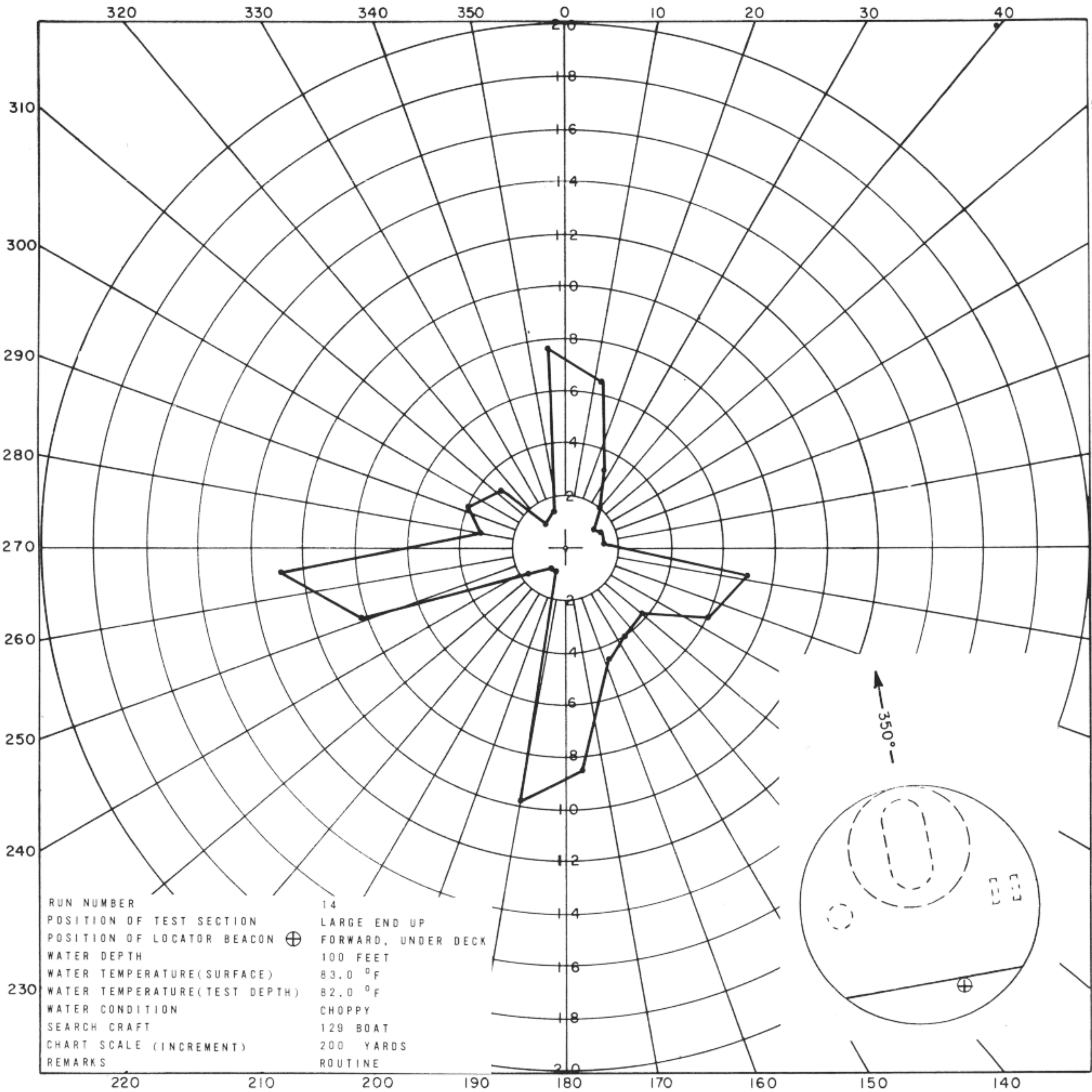
RUN NO. 11


RUN NUMBER 12
POSITION OF TEST SECTION ON SIDE
POSITION OF LOCATOR BEACON ⊕ FORWARD, UNDER DECK
WATER DEPTH 92 FEET
WATER TEMPERATURE (SURFACE) 83.0 °F
WATER TEMPERATURE (TEST DEPTH) 82.0 °F
WATER CONDITION CALM
SEARCH CRAFT 129 BOAT
CHART SCALE (INCREMENT) 200 YARDS
REMARKS ROUTINE
290°

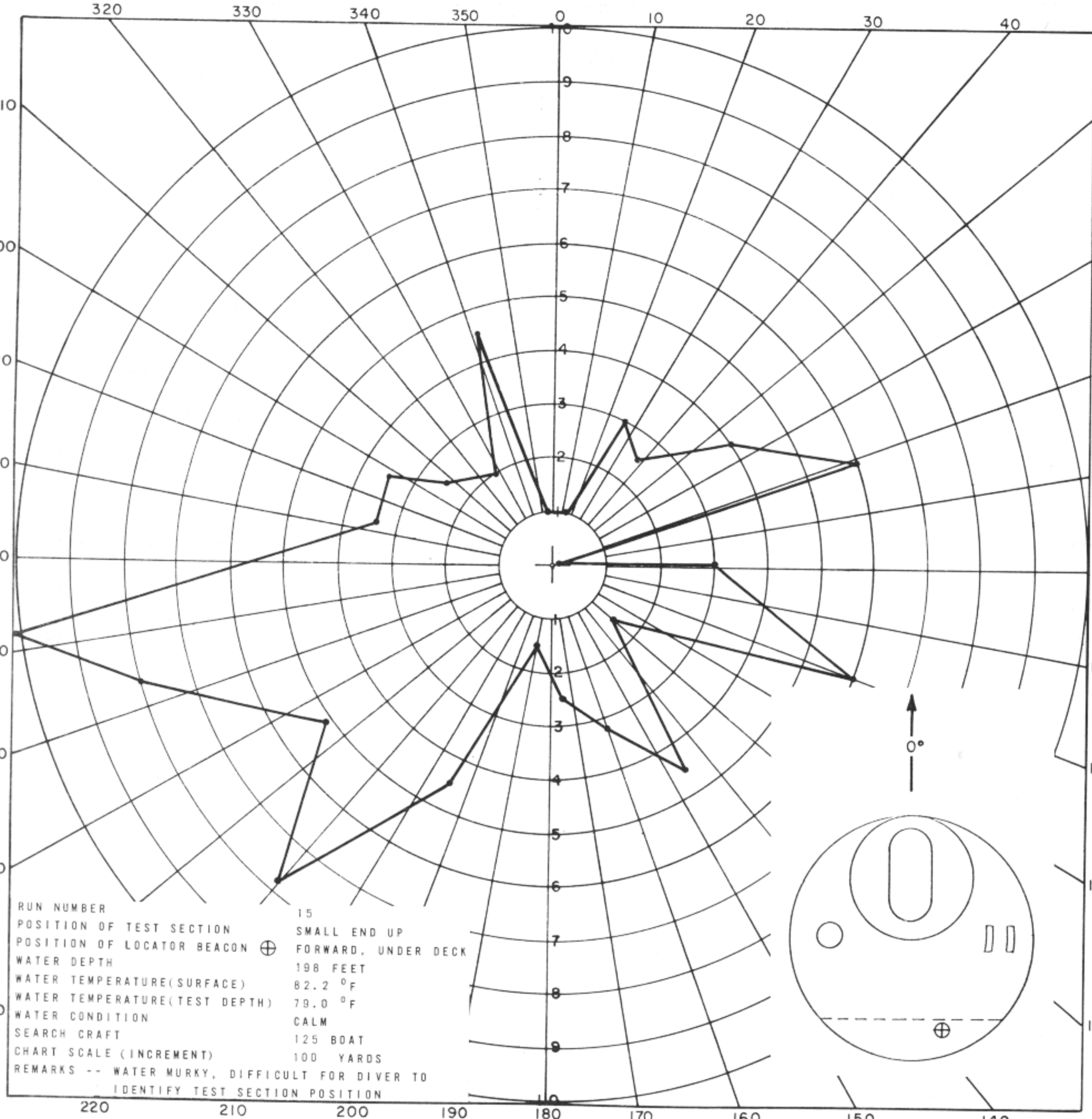
RUN NO. 12


RUN NUMBER 13
POSITION OF TEST SECTION LARGE END UP
POSITION OF LOCATOR BEACON ⊕ AFT PRESSURIZED BULKHEAD
WATER DEPTH 100 FEET
WATER TEMPERATURE(SURFACE) 83.0 °F
WATER TEMPERATURE(TEST DEPTH) 82.0 °F
WATER CONDITION CHOPPY
SEARCH CRAFT 129 BOAT
CHART SCALE (INCREMENT) 200 YARDS
REMARKS ROUTINE
350°

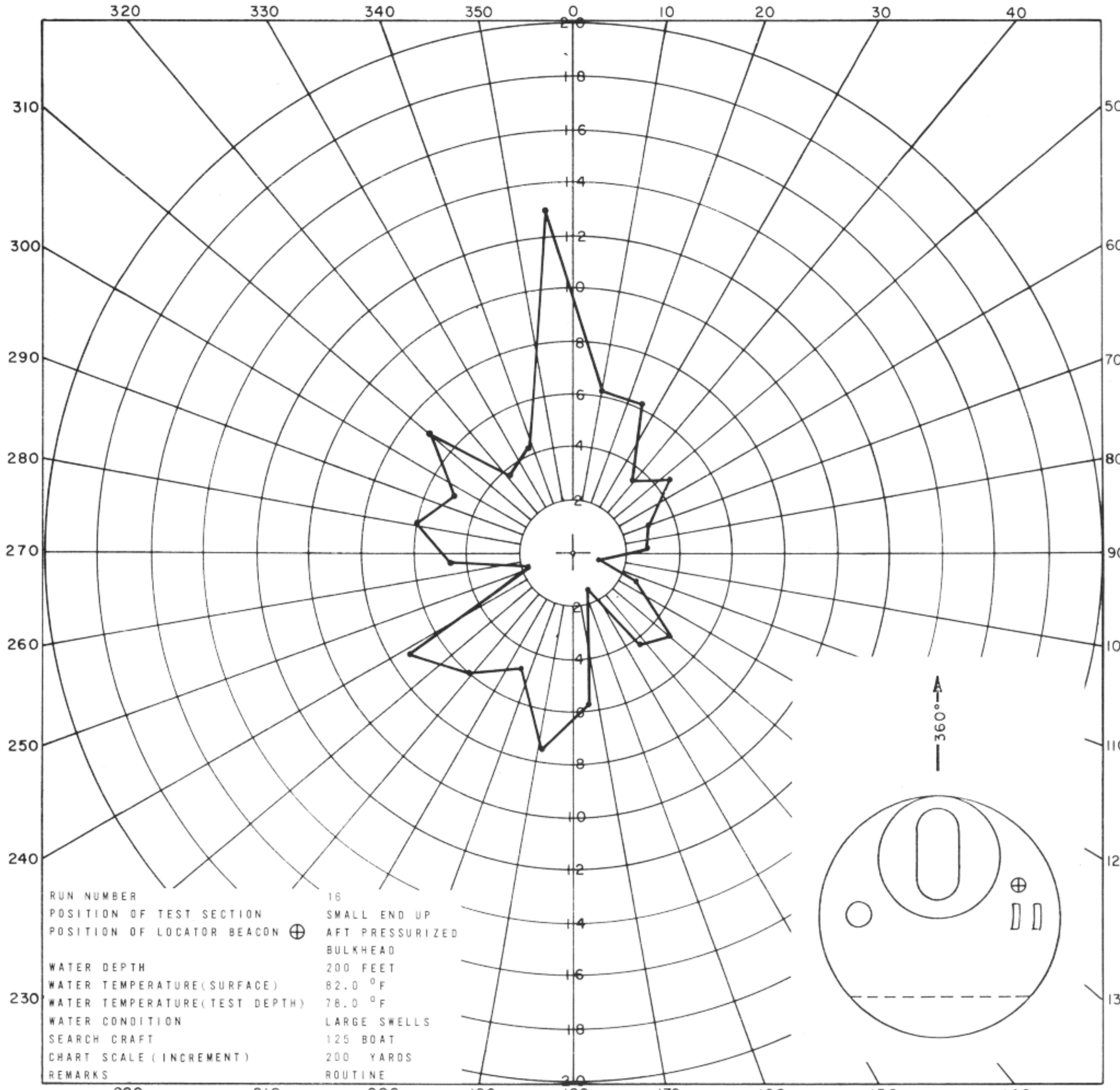
RUN NO. 13


RUN NUMBER 14
POSITION OF TEST SECTION LARGE END UP
POSITION OF LOCATOR BEACON ⊕ FORWARD, UNDER DECK
WATER DEPTH 100 FEET
WATER TEMPERATURE(SURFACE) 83.0 °F
WATER TEMPERATURE(TEST DEPTH) 82.0 °F
WATER CONDITION CHOPPY
SEARCH CRAFT 129 BOAT
CHART SCALE (INCREMENT) 200 YARDS
REMARKS ROUTINE
350°

RUN NO. 14


RUN NUMBER 15
POSITION OF TEST SECTION SMALL END UP
POSITION OF LOCATOR BEACON ⊕ FORWARD, UNDER DECK
WATER DEPTH 198 FEET
WATER TEMPERATURE(SURFACE) 82.2 °F
WATER TEMPERATURE(TEST DEPTH) 79.0 °F
WATER CONDITION CALM
SEARCH CRAFT 125 BOAT
CHART SCALE (INCREMENT) 100 YARDS
REMARKS -- WATER MURKY, DIFFICULT FOR DIVER TO IDENTIFY TEST SECTION POSITION
0°

RUN NO. 15



0
10
20
30
40
50
60
70
80
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110
120
130
140
150
160
170
180
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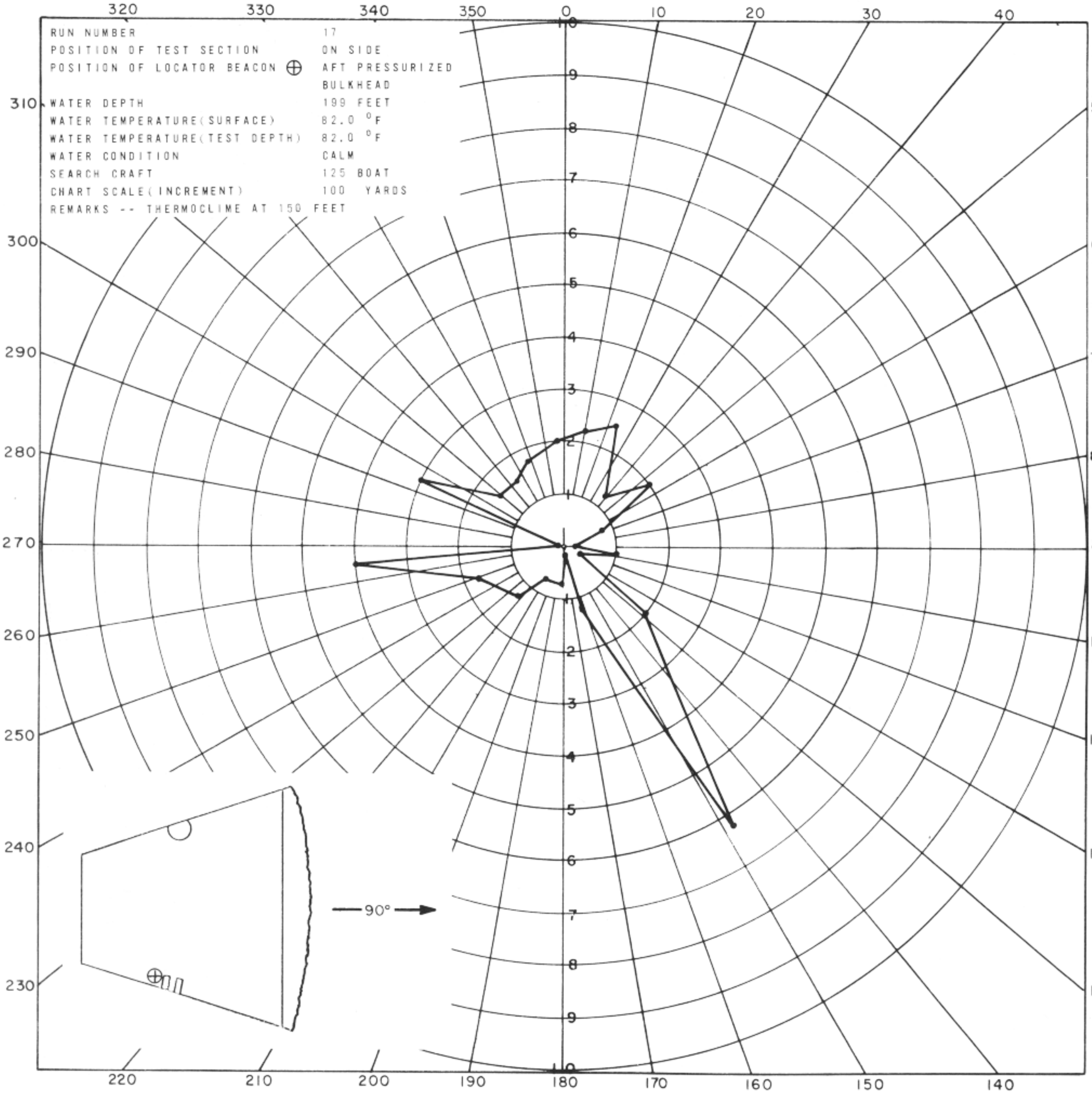
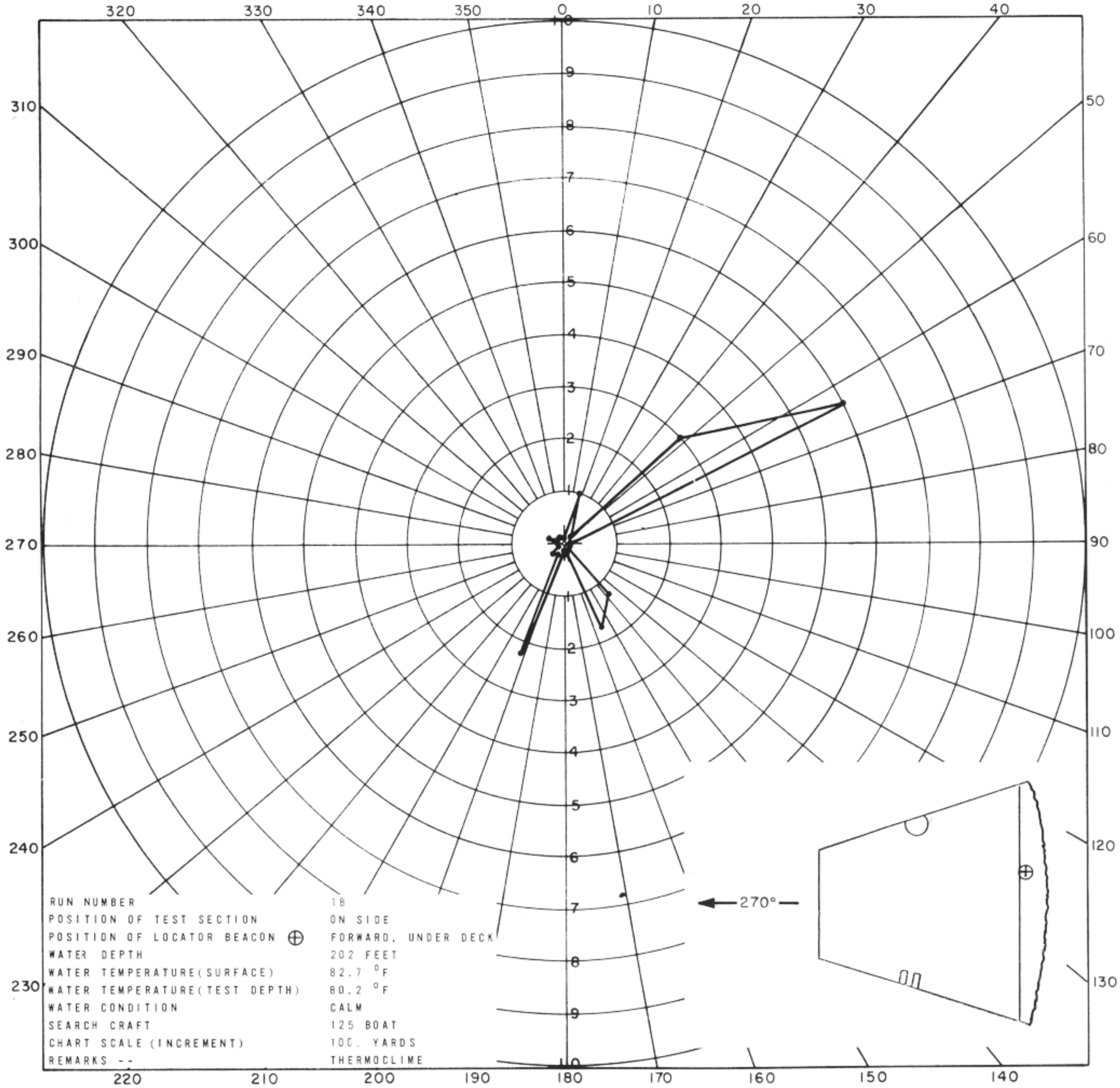
230
240
250
260
270
280
290
300
310
320
330
340
350
2
4
6
8
10
12
14
16
18
20
360°
RUN NUMBER 16
POSITION OF TEST SECTION SMALL END UP
POSITION OF LOCATOR BEACON ⊕ AFT PRESSURIZED BULKHEAD
WATER DEPTH 200 FEET
WATER TEMPERATURE (SURFACE) 82.0 °F
WATER TEMPERATURE (TEST DEPTH) 78.0 °F
WATER CONDITION LARGE SWELLS
SEARCH CRAFT 125 BOAT
CHART SCALE (INCREMENT) 200 YARDS
REMARKS ROUTINE

RUN NO. 16

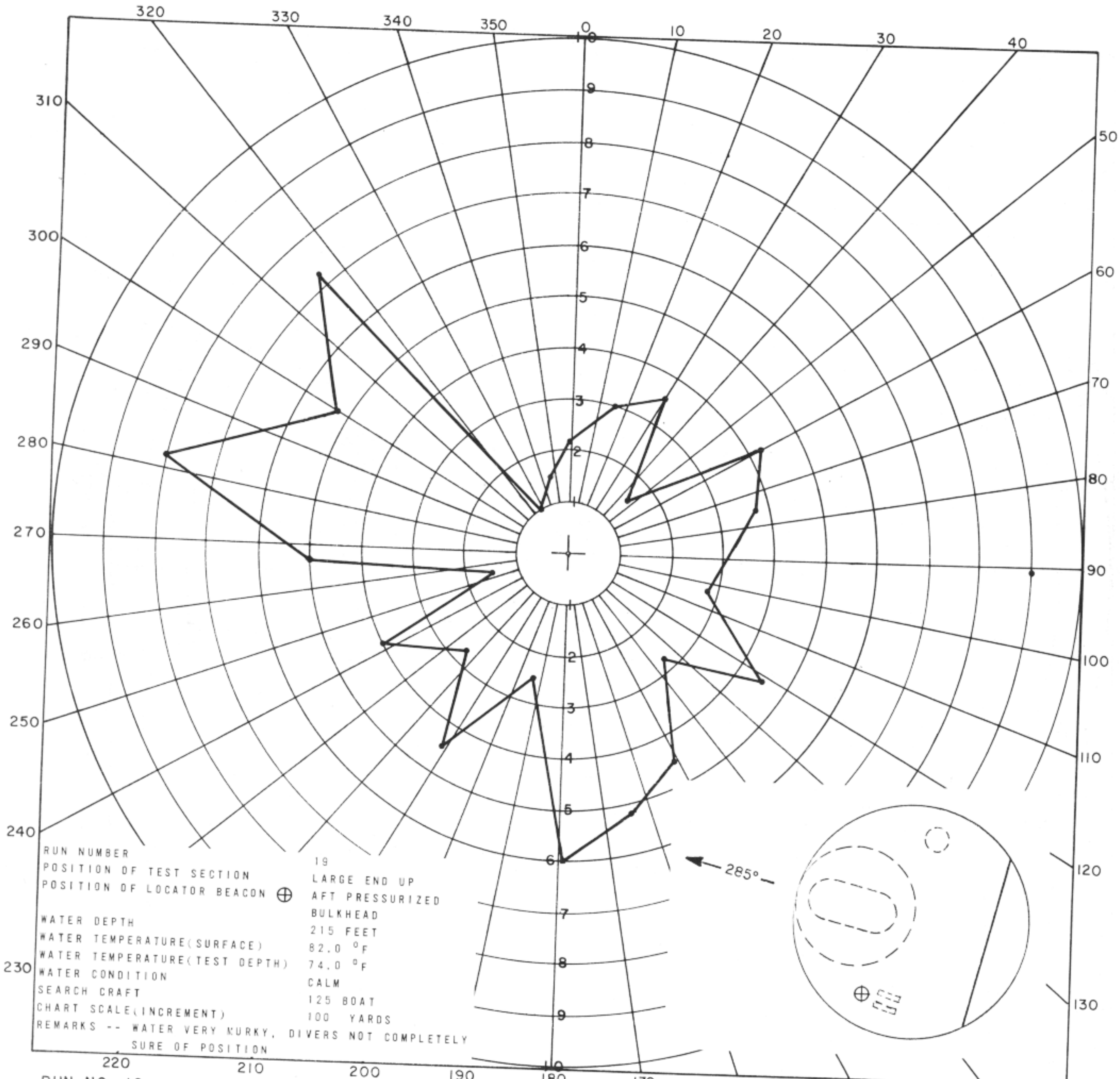


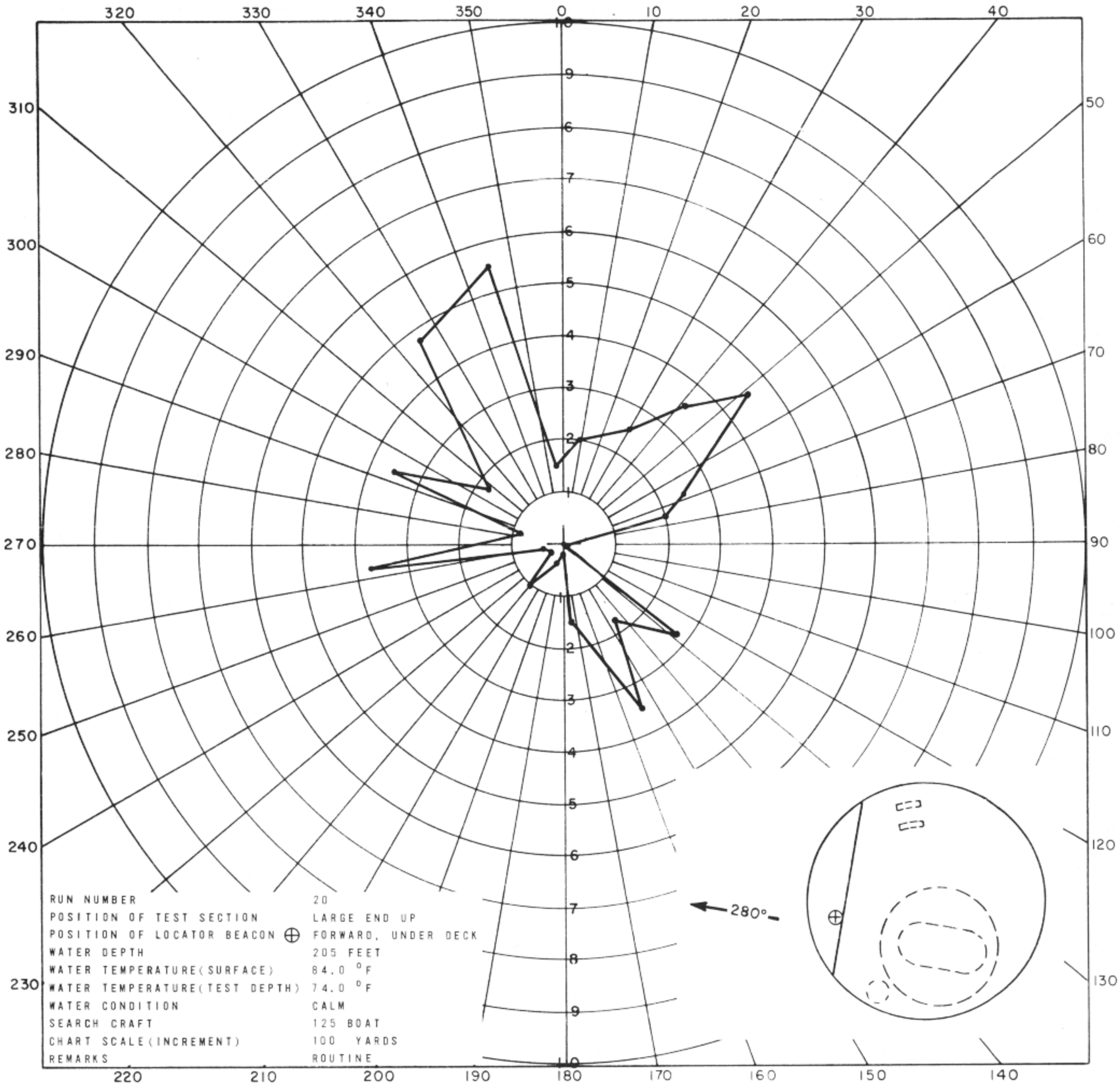
RUN NUMBER 17
POSITION OF TEST SECTION ON SIDE
POSITION OF LOCATOR BEACON ⊕ AFT PRESSURIZED BULKHEAD
WATER DEPTH 199 FEET
WATER TEMPERATURE (SURFACE) 82.0 °F
WATER TEMPERATURE (TEST DEPTH) 82.0 °F
WATER CONDITION CALM
SEARCH CRAFT 125 BOAT
CHART SCALE (INCREMENT) 100 YARDS
REMARKS -- THERMOCLIME AT 150 FEET
90°
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350

RUN NO. 17


0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
270°
RUN NUMBER 18
POSITION OF TEST SECTION ON SIDE
POSITION OF LOCATOR BEACON ⊕ FORWARD, UNDER DECK
WATER DEPTH 202 FEET
WATER TEMPERATURE(SURFACE) 82.7 °F
WATER TEMPERATURE(TEST DEPTH) 80.2 °F
WATER CONDITION CALM
SEARCH CRAFT 125 BOAT
CHART SCALE (INCREMENT) 100. YARDS
REMARKS -- THERMOCLIME

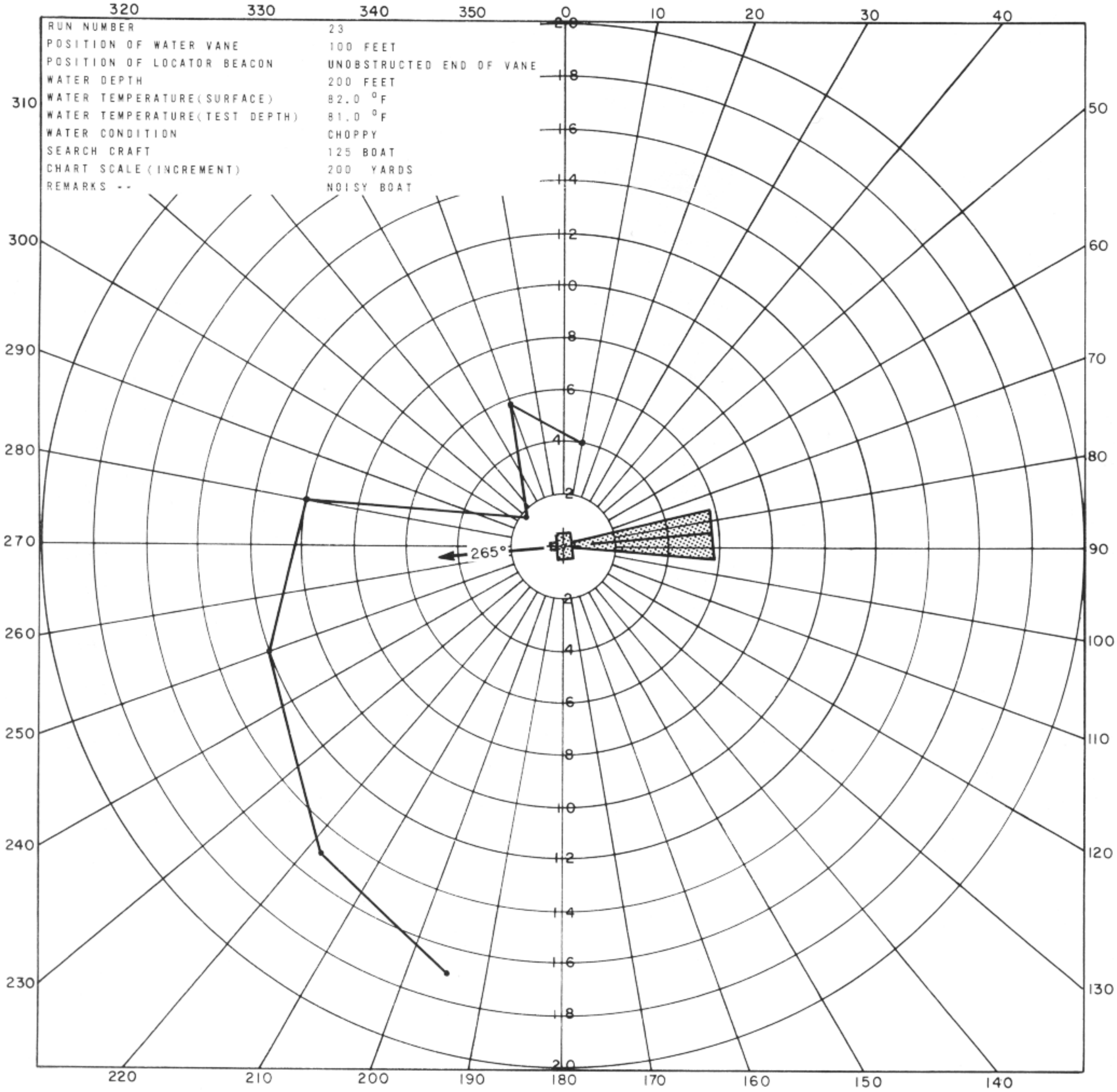
RUN NO. 18


0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
285°
RUN NUMBER 19
POSITION OF TEST SECTION LARGE END UP
POSITION OF LOCATOR BEACON ⊕ AFT PRESSURIZED BULKHEAD
WATER DEPTH 215 FEET
WATER TEMPERATURE(SURFACE) 82.0 °F
WATER TEMPERATURE(TEST DEPTH) 74.0 °F
WATER CONDITION CALM
SEARCH CRAFT 125 BOAT
CHART SCALE(INCREMENT) 100 YARDS
REMARKS -- WATER VERY MURKY, DIVERS NOT COMPLETELY SURE OF POSITION
RUN NO. 19



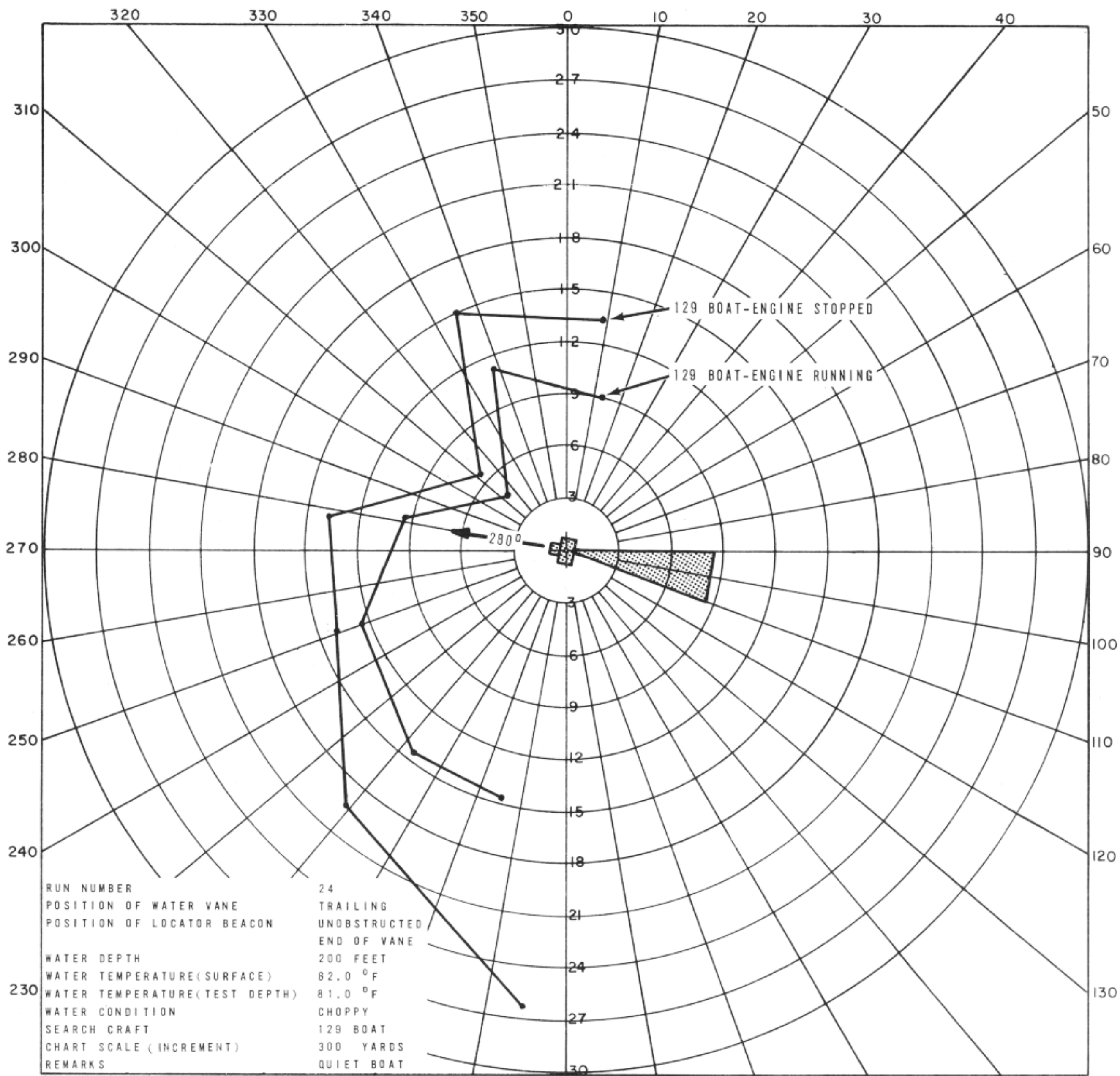
RUN NUMBER 20
POSITION OF TEST SECTION LARGE END UP
POSITION OF LOCATOR BEACON ⊕ FORWARD, UNDER DECK
WATER DEPTH 205 FEET
WATER TEMPERATURE(SURFACE) 84.0 °F
WATER TEMPERATURE(TEST DEPTH) 74.0 °F
WATER CONDITION CALM
SEARCH CRAFT 125 BOAT
CHART SCALE(INCREMENT) 100 YARDS
REMARKS ROUTINE
280°

RUN NO. 20



RUN NUMBER 23
POSITION OF WATER VANE 100 FEET
POSITION OF LOCATOR BEACON UNOBSTRUCTED END OF VANE
WATER DEPTH 200 FEET
WATER TEMPERATURE (SURFACE) 82.0 °F
WATER TEMPERATURE (TEST DEPTH) 81.0 °F
WATER CONDITION CHOPPY
SEARCH CRAFT 125 BOAT
CHART SCALE (INCREMENT) 200 YARDS
REMARKS -- NOISY BOAT
265°
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
2
4
6
8
10
12
14
16
18
20

RUN NO. 23



129 BOAT-ENGINE STOPPED
129 BOAT-ENGINE RUNNING
290°
RUN NUMBER 24
POSITION OF WATER VANE TRAILING
POSITION OF LOCATOR BEACON UNOBSTRUCTED END OF VANE
WATER DEPTH 200 FEET
WATER TEMPERATURE(SURFACE) 82.0 °F
WATER TEMPERATURE(TEST DEPTH) 81.0 °F
WATER CONDITION CHOPPY
SEARCH CRAFT 129 BOAT
CHART SCALE (INCREMENT) 300 YARDS
REMARKS QUIET BOAT

RUN NO. 24

APPENDIX III

STATUS REPORT ON FAA PINGER TESTS

THE PENNSYLVANIA STATE UNIVERSITY
INSTITUTE FOR SCIENCE AND ENGINEERING
ORDNANCE RESEARCH LABORATORY

ADDRESS REPLY TO:
ORDNANCE RESEARCH LABORATORY
P.O. BOX 30
STATE COLLEGE, PENNSYLVANIA 16801

JUN 6 1966

National Aviation Facilities
Experimental Center
Federal Aviation Agency
Atlantic City, New Jersey 08405

Attention: Mr. R. B. Fisher, Project Manager, 530-003-07X

Subject: Forwarding ORL TN

Enclosure: (1) ORL Uncl TN 301.4211-121, "Status Report on FAA Pinger Tests," by J. H. Prout, 2 June 1966, Copy Nos. 1, 2 and 3

Gentlemen:

Enclosure (1) is forwarded for your information and retention.

Very truly yours,

/Signed/ Robert F. Marboe

ROBERT F. MARBOE
Assistant Director

RFM:njt

cc: NOSC, Attn: D. C. Greene, Code 05211, Copy No. 4 of Enc. (1)
CO, NOU, Copy No. 5 of Enc. (1)

STATUS REPORT ON FAA PINGER TESTS

By J. H. Prout

Technical Note
File No. TN 301.4211-121
June 2, 1966
Contract NOw 65-0123-d
Copy No. 2

The Pennsylvania State University
Institute for Science and Engineering
ORDNANCE RESEARCH LABORATORY
University Park, Pennsylvania

NAVY DEPARTMENT · BUREAU OF NAVAL WEAPONS

Reference: (a) FAA Test Plan for Project 530-003-07X

(b) Naval Ordnance Systems Command Ltr, Ser No. ORD-0521:RAC, 18 May 1966, "Pinger Evaluation for the Federal Aviation Agency, authorization for performance of"

Abstract: Life tests were performed on two of six flight data recorder underwater location pinger units and showed the operating life to be within FAA specifications. All but one unit was found to transmit a source level of at least 1000 dynes/cm^2 at 1 yard. All five acceptable units are presently equipped with fresh batteries in preparation for tests at Key West, Florida.

* * * * *

As requested in Reference (a) and authorized by Reference (b), tests were conducted at the Black Moshannon Calibration Station to measure source level and life tests of transmitter units to be used in evaluation of an FAA underwater locating system. On May 12, 1966, with Mr. John Parsons of FAA observing, source level measurements were made on each of the six transmitter units supplied. These measurements are summarized in Table I.

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TABLE I

Transmitter Tests, 12 May 1966

Transmitter Number	Battery Number	Source Level	Pulse Length
1	1	60 dB	7.5 ms
2	2	60 dB	13 ms
3	3	54 dB	15 ms
4	4	60 dB	13.5 ms
7	7	60 dB	10 ms
8	8	60 dB	6 ms
3	13	54 dB	15 ms
3	3	54 dB*	15 ms

*Re-checked on 16 May 1966

At the time of these first tests, some difficulty was experienced with the calibration system of the source-level meter. The trouble was traced to a pinched wire in the calibration circuit and did not affect the accuracy of the source-level reading. These first readings are therefore valid.

These tests showed that all units were acceptable except number 3 which had low output. The battery number 3 in unit 3 was replaced with a new battery number 13 with the same result. Since the trouble was apparently in the unit and not the battery, the battery was removed and the unit marked not to be used for further tests. The pulse lengths shown in this table were measured after the first transmitter life test.

Transmitter unit number 1 was arbitrarily chosen for the life test. The unit was placed in the water at 11:30 a.m. on 14 May 1966. The measurements made on 16 May are presented graphically in Figure 1A. (For a discussion of the interpretation of the source-level meter readings see Appendix.) The unit was well within specifications even after 49 hours. The battery was removed and replaced with battery number 3. Source levels of each of the other transmitter units powered with used battery Number 1 were measured and reported in Table II.

TABLE II

Source level of transmitter units with expended battery number 1.

Transmitter Number	Battery Number	Source Level	Pulse Length
2	1	58 dB	16 ms
4	1	60 dB	16 ms
7	1	58 dB	10 ms
8	1	60 dB	6 ms

All units were found to be within specifications. It was during the latter tests that the variation in pulse length was noted. A pulse length measurement was made on each unit with a fresh battery with results as shown in Table I.

Because of the wide variation in pulse lengths, a second life test was conducted on transmitter unit number 4 because of its long pulse and relatively rapid pulse rate. The results of this life test is shown in Figure 1B. Again the unit was found to be well within specifications. Although the pulse length was still 13.5 milliseconds after 48 hours, the pulse rate had slowed down to a more normal rate as compared with the other units. It is interesting to note that both units appeared to get a "second wind" and return to full power after about 48 1/2 hours. Throughout both tests, the general impression was that the signal remained entirely adequate for audio-detection at all times. It appears that the units should have a useful life much greater than 48 hours--probably determined only by the battery discharge characteristics.

After the life test on unit number 4, its battery was replaced with battery number 13. The status of the 6 transmitter units on 23 May 1966 is shown in Table III.

TABLE III

Status of transmitter units for Key West Tests, 23 May 1966

Transmitter Number	Battery Number	Source Level	Pulse Length
1	3	62 dB	7.5 ms
2	2	62 dB	13 ms
3	Battery Removed		
4	13	Not Measured	
7	7	62 dB	10 ms
8	8	62 dB	6 ms

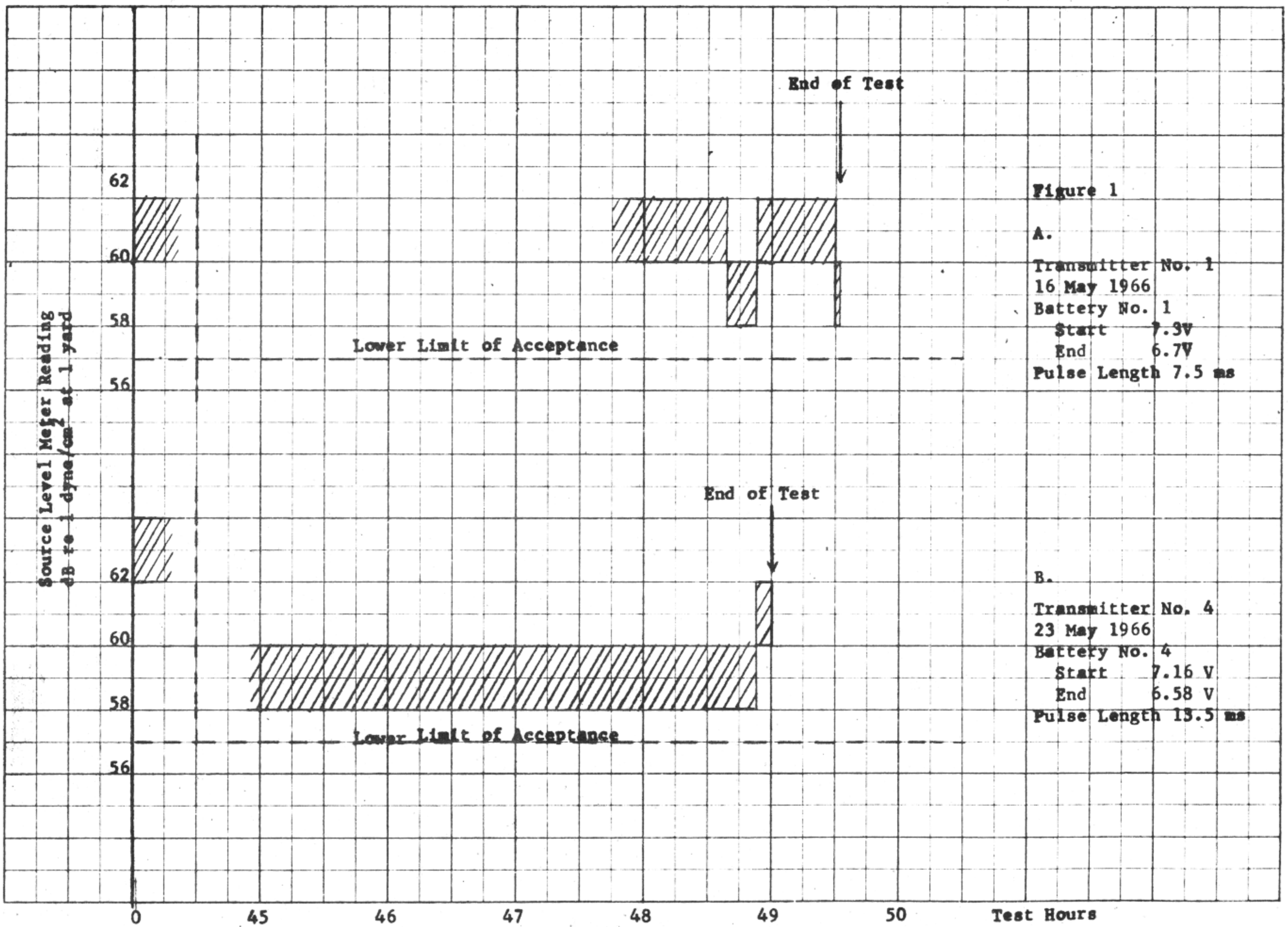
Appendix:

Interpretation of Source-Level Meter Readings

Power output of the FAA transmitter units was measured on the Ordnance Research Laboratory source-level meter. This device measures source level in dB relative to 1 dyne/cm^2 referred to a distance from the source of 1 yard. For this special purpose, an additional 40 dB amplifier was built into the SLM to extend the measurable range down to 50 dB. The FAA specification of 1000 dynes/cm^2 at 1 yard is equivalent to a source level of 60 dB. The lower limit of 700 dynes/cm^2 is equivalent to 57 dB.

Source level is read in two dB increments from a knob on the front panel of the instrument after the measuring distance has been properly set on the range dial. Signal level is detected by a fixed threshold peak detector so that a reading of 60 dB means that the signal level is at least 60 dB, but not greater than 62 dB, the next step on the source level dial. This dial has an accuracy of ± 2% or about ± .2 dB.

File No. 301.4211
June 2, 1966
JHP:kso



Department of Transportation, Federal Aviation Administration, National Aviation Facilities Experimental Center, Atlantic City, N. J.

UNDERWATER LOCATOR BEACON DETECTION RANGES FOR FUSELAGE ENCAPSULATED RECORDERS by R. Byron Fisher and Paul M. Rich, Final Report, July 1968, 22pp. incl. illus.,plus 3 appendices (Project No. 530-003-07X, Report No. NA-68-7, DS-68-9)

Unclassified Report

An acoustic locator beacon was developed and tested in an underwater environment simulating the conditions that might exist when an aircraft crashed into water. The beacons were self-contained, battery powered, and produced a 10 to 20 millisecond pulse of 35-40 kilohertz at a rate of 1 to 4 pulses per second. The locator beacons were designed to be attached to airborne flight data recorders to assist in investigations following a crash. The trash environmental tests were conducted using a section of an aircraft fuselage that still contained the cabin pressure bulkhead. The beacons tested were placed in two different representative locations; (1) inside the cabin pressure area and (2) aft of the pressure bulkhead in the unpressurized area. The fuselage section was lowered into sea water at depths of 50, 100, and (over)

UNCLASSIFIED

I. R. Byron Fisher
Paul M. Rich
II. Project No. 530-003-07X
III. Report No. NA-68-7
(DS-68-9)

Descriptors

Acoustics
Aircraft
Underwater Equipment
Underwater Tracking

UNCLASSIFIED

Department of Transportation, Federal Aviation Administration, National Aviation Facilities Experimental Center, Atlantic City, N. J.

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UNCLASSIFIED

200 feet, off the the coast of the Florida Keys. Search runs were made using a motor powered craft equipped with an acoustic locator receiver. The results indicate that the signals of a fuselage encapsulated locator beacon can be detected at reasonable surface distances (up to 3000 yards) and at depths as low as 200 feet.

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UNCLASSIFIED

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Unclassified Report

An acoustic locator beacon was developed and tested in an underwater environment simulating the conditions that might exist when an aircraft crashed into water. The beacons were self-contained, battery powered, and produced a 10 to 20 millisecond pulse of 35-40 kilohertz at a rate of 1 to 4 pulses per second. The locator beacons were designed to be attached to airborne flight data recorders to assist in investigations following a crash. The crash environmental tests were conducted using a section of an aircraft fuselage that still contained the cabin pressure bulkhead. The beacons tested were placed in two different representative locations; (1) inside the cabin pressure area and (2) aft of the pressure bulkhead in the unpressurized area. The fuselage section was lowered into sea water at depths of 50, 100, and (over)

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I. R. Byron Fisher
Paul M. Rich
II. Project No. 530-003-07X
III. Report No. NA-68-7 (DS-68-9)

Descriptors

Acoustics
Aircraft
Underwater Equipment
Underwater Tracking

UNCLASSIFIED

200 feet, off the the coast of the Florida Keys. Search runs were made using a motor powered craft equipped with an acoustic locator receiver. The results indicate that the signals of a fuselage encapsulated locator beacon can be detected at reasonable surface distances (up to 3000 yards) and at depths as low as 200 feet.

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