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THE AN/UQS-2(XG-1) SHIP-HELICOPTER MINE DETECTING SONAR.(U)
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Research and Development Report

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THE AN/UQS-2(XG-1) SHIP-HELICOPTER MINE DETECTING SONAR (U)

J. W. Behrendt [redacted] J. W. Sampsell

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U. S. NAVY ELECTRONICS LABORATORY, SAN DIEGO, CALIFORNIA
A Bureau of Ships Laboratory

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THE PROBLEM

Develop a combined ship-helicopter sonar equipment utilizing CTFM techniques and using the helicopter as a maneuverable and stable platform to carry the primary target acquisition portions of the system.

RESULTS

1. After several modifications in the design approach, an equipment was developed and sent to U. S. Navy Mine Defense Laboratory, Panama City, Florida, for technical evaluation tests. The results of these tests will be desscribed in a report from USNMDL.

2. The advantages of helicopter mobility and associated variable-depth transducer arrangement were demonstrated; however these were partially offset by difficulties in keeping the helicopter positioned above the transducers during a search operation.

RECOMMENDATIONS

Defer any decision regarding further development or use of the AN/UQS-2(XG-1) in minehunting operations until the USNMDL evaluation report is available for further guidance.

ADMINISTRATIVE INFORMATION

Work was done under AS 14101, NE 051456-846.6, TED-NEL-AR-44101 (NEL E4-3), jointly sponsored by the Bureau of Ships and the Bureau of Aeronautics. BuShips authorization was set forth in their confidential letter to NEL, serial 846-09, of 15 January 1954. The report

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covers work from 1 March 1954 through 30 June 1959 and was approved for publication 9 December 1960.

For administrative purposes the work program was divided into three parts: I, sponsored by the Bureau of Aeronautics, covered the airborne equipment; II, sponsored by the Bureau of Ships, covered the ship-or-shore equipment; and III, sponsored by the Bureau of Aeronautics, comprised, during the experimental phase, a limited system study; and, during the developmental phase, a study of the stabilized soundhead. (The latter study was terminated by lack of funds.)

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INTRODUCTION

The objective of this equipment development program was to enhance the mine-hunting capabilities of the U. S. Navy. An improvement of any one of the factors present in today's mine-hunting techniques should result in some increase in effectiveness; the cumulative effect of several simultaneously improved factors should result in a very marked over-all improvement.

The use of a helicopter as a primary sonar platform, proceeding in a planned and orderly fashion, from spot to spot in an area of interest and then hovering and "dipping," would appear to contribute the following benefits over a surface vessel: (1) rapid maneuverability for increased area coverage vs. time, (2) increased platform stability, (3) facility of variable-depth sonar operation, (4) reduction of water flow turbulence in the vicinity of the soundhead, (5) no generation of masking wakes in the area, and (6) less vulnerability to a detonated mine. When working with a shore station instead of a ship, there would be fewer personnel involved in the operation, and the installation and maintenance problems are reduced.

The actual design and development of the AN/UQS-2(XG-1) combined ship-helicopter sonar equipment was completed in May 1957. Effort on the project during fiscal year 1958 was chiefly related to assistance in the preliminary operational evaluation conducted by the U. S. Navy Mine Defense Laboratory, Panama City, Florida, and to modifications in the equipment which were found desirable following this evaluation. Minor effort was still applied to the project during fiscal year 1959, and was associated with the technical evaluation which was conducted at the U. S. Navy Mine Defense Laboratory; this evaluation was completed in May 1959. A final MDL-NEL meeting concerning the equipment was held at Panama City, Florida, on 27-28 May 1959.

DESCRIPTION OF EQUIPMENT

Physically, the AN/UQS-2(XG-1) (fig. 1) differs from the other mine-hunting sonar systems in that (1) the soundhead and the electroacoustic transmitting and receiving portions are located in the helicopter; and (2) it incorporates vhf radio

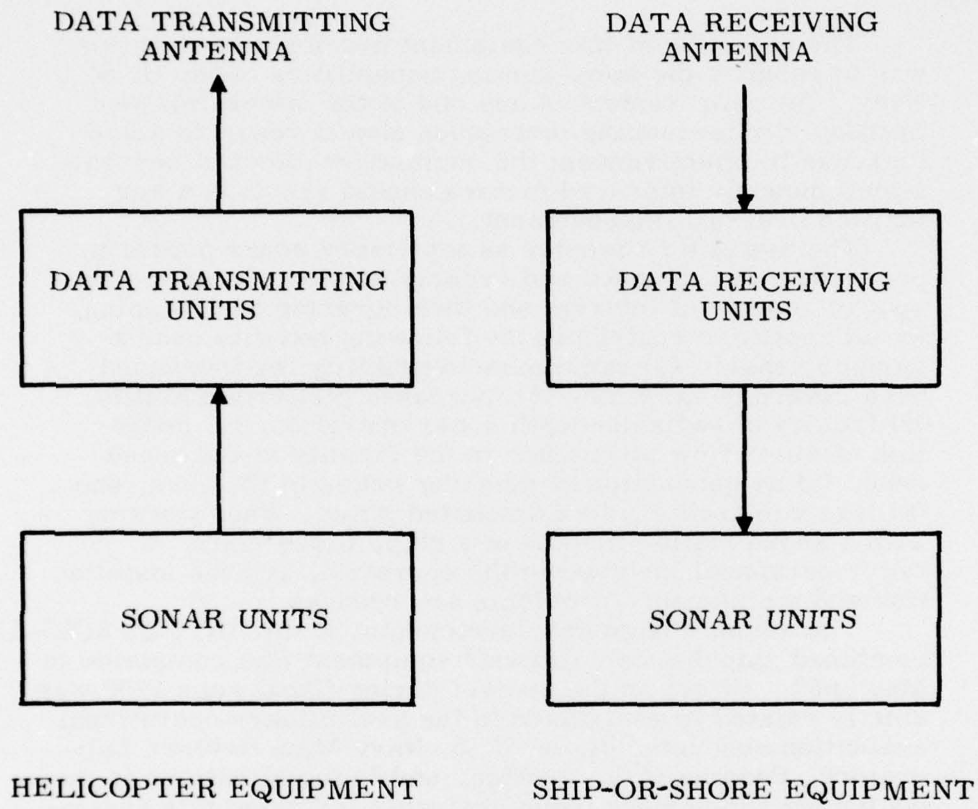

Figure 1. Block diagram of AN/UQS-2(XG-1) mine detecting set.

link, by which raw sonar data are telemetered to a ship or shore unit where the remainder of the sonar system analyzes and displays the information for the operator's interpretation.

In the helicopter, the sonar transmitter generates a continuous-transmission, frequency-modulated (CTFM) electrical signal which sweeps from 65 kc/s to 52 kc/s, in a linear fashion. This signal is fed through a multiconductor cable, mounted on a reel, to the soundhead, which is caused to rotate through 360° in azimuth. The signal energizes the projector and is converted to acoustic energy which is radiated into the water. Portions of this energy, upon impinging on a target, are reflected to the hydrophone where they are converted back into electrical signals and fed via the signal cable to the sonar receiver. Here, the received signal is heterodyned with the signal being generated and transmitted at that moment. Due to the elapsed time of sonar signal travel to and from the target (and to the fact that the generated signal is sweeping in frequency), the result of the heterodyning action will be a difference frequency (Δf). This Δf is in the audible range, and the exact frequency, for a given range scale, is a function of target range. This arrangement can handle simultaneously as many tones as there are targets in the hydrophone beam. These tones are fed to the telemeter transmitter and are radiated as modulation on a radio frequency carrier. In addition, four subcarriers are used in the telemeter transmitter. One is used for range scale information; two more are used to transmit the directional reference and hydrophone azimuthal information; and the remaining subcarrier is used to monitor the helicopter intercom and sonar operator's commentary. Maneuvering requests are passed to the helicopter pilot over a separate radio circuit which is also connected to the intercom. A pilot's indicator unit provides such information as soundhead cable angle and soundhead depth to assist in maintaining the proper hovering position.

The telemetered information is received at the ship or shore installation, where the sonar information is fed directly from the telemeter receiver to a 300-channel analyzer and loudspeaker-headphone arrangement. Two subcarrier discriminators with 22-kc/s and 30-kc/s plug-in filter/tuning units are used for demodulation of the shaft position data. One discriminator with a 14.5-kc/s filter/tuning unit is used for recovery of "range scale in use" information. One discriminator with a 70-kc/s filter/tuning unit is used to recover the operator's voice. The soundhead azimuthal information and the frequency-analyzed sonar information are combined to form the plan position display on the 16-inch CRT indicator. Unique electromechanical aids are provided for the operator at the display console. One of these is an electronic "hook" type of cursor. Another is automatic readout which quickly and accurately provides the sonar operator with the range and bearing of the target. These outputs are also available as servo inputs for computers or plotters when these are used.

Illustrations of the developmental units of the AN/UQS-2 equipment, including special test and calibration units, and schematics and block diagrams of the electronic portions of the equipment, are furnished in the Appendix, page 26.

WORK PROGRAM

The work program was divided into two phases, as summarized briefly below and described more fully in the following sections:

The Experimental Phase, which included:

1. The design study of the airborne and ship-or-shore portions of the equipment; a paper study of underwater television for classification; and construction and tests of the experimental equipments.
2. A limited feasibility study of the operational system.

The Developmental Phase, which included:

1. Construction and tests of the developmental equipments (airborne and ship-or-shore).
2. Study of the stabilized soundhead.
3. Assistance to the U. S. Navy Mine Defense Laboratory during evaluation.

EXPERIMENTAL PHASE

The first year was spent in the design and construction of the experimental equipment, which was tested in the San Diego area during the period February-April 1955. The airborne components were adapted for mounting aboard a picket boat, with the soundhead being suspended from a platform over the bow. The ship-or-shore portions of the equipment were installed in a portable test hut located on land, near the operating area. (See table 1 and fig. 2 to 6.)

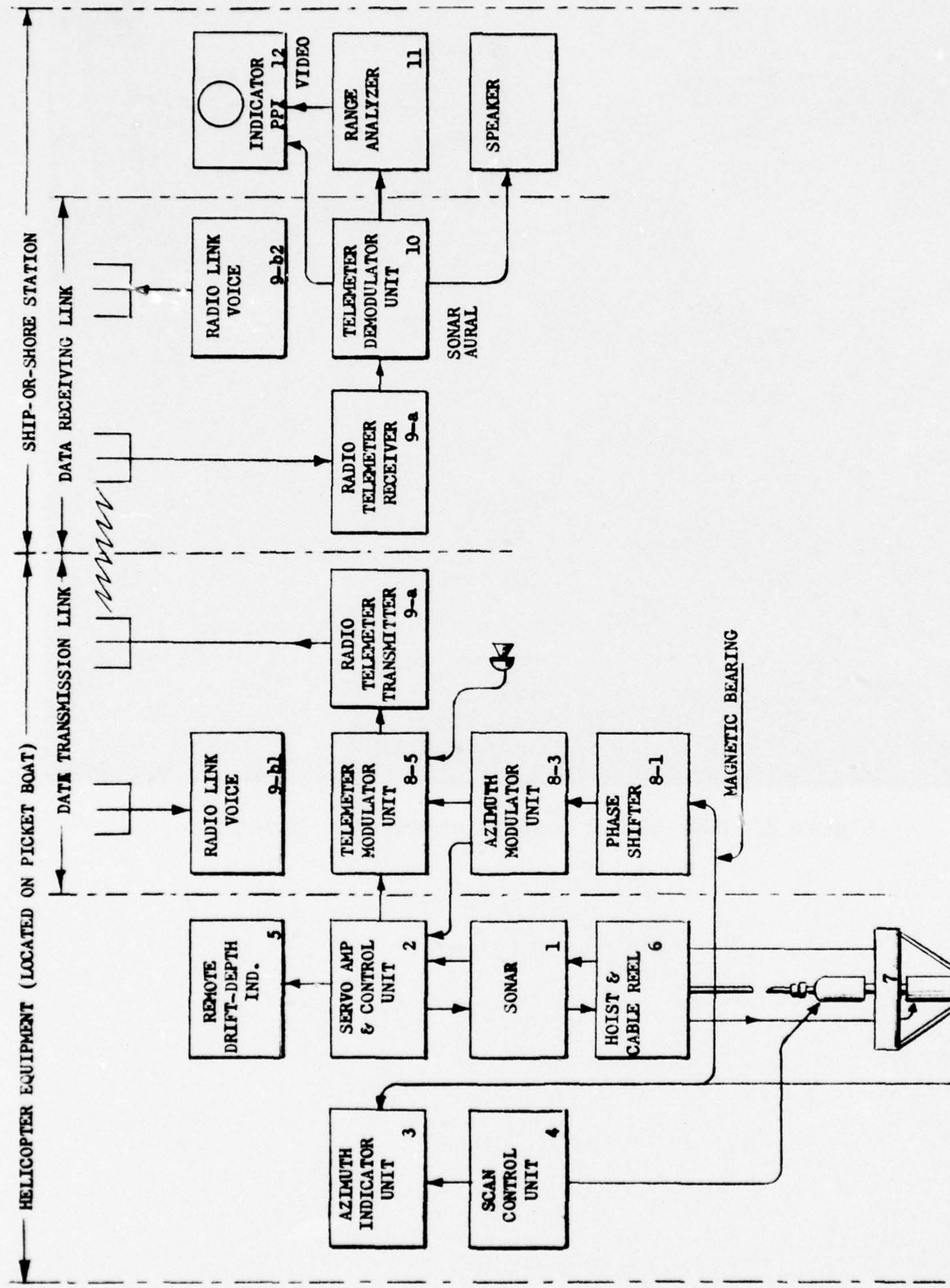

Figure 2. Block diagram of ship-helicopter experimental sonar equipment.

Figure 3. NEL picket boat (experimental platform).

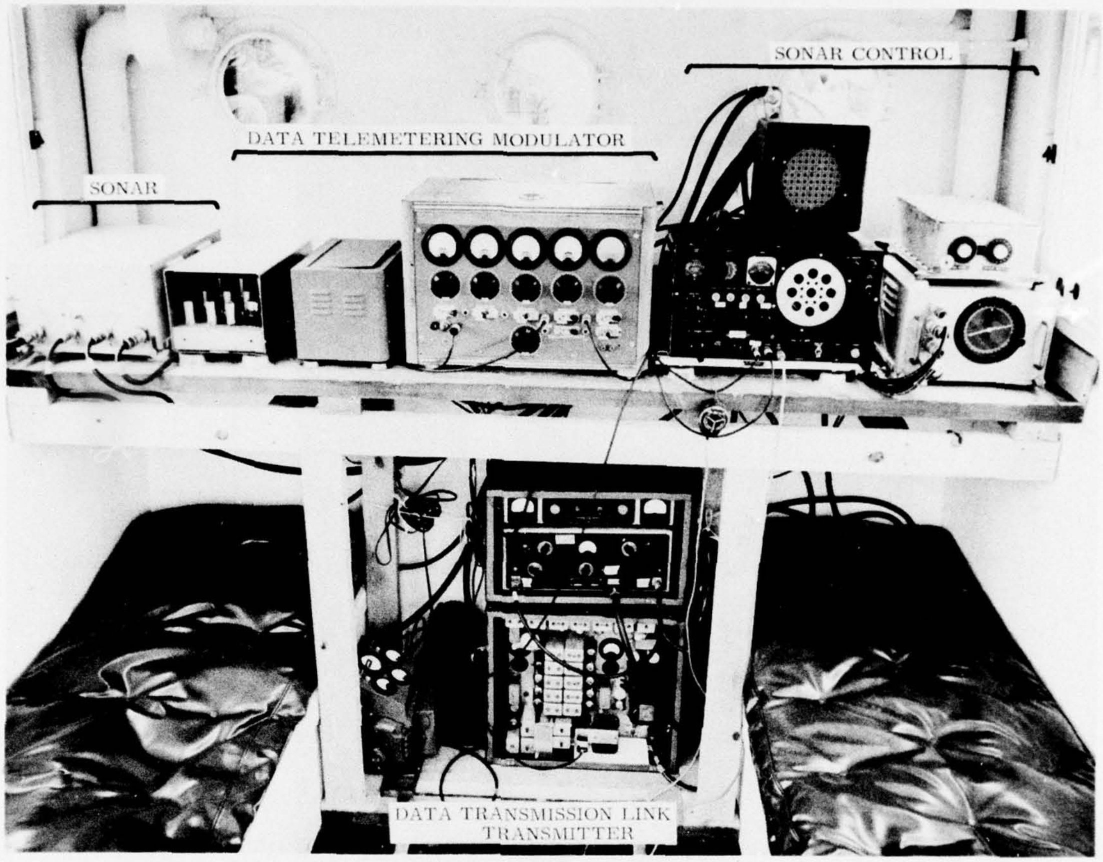

Figure 4. Interior view of picket boat installation.

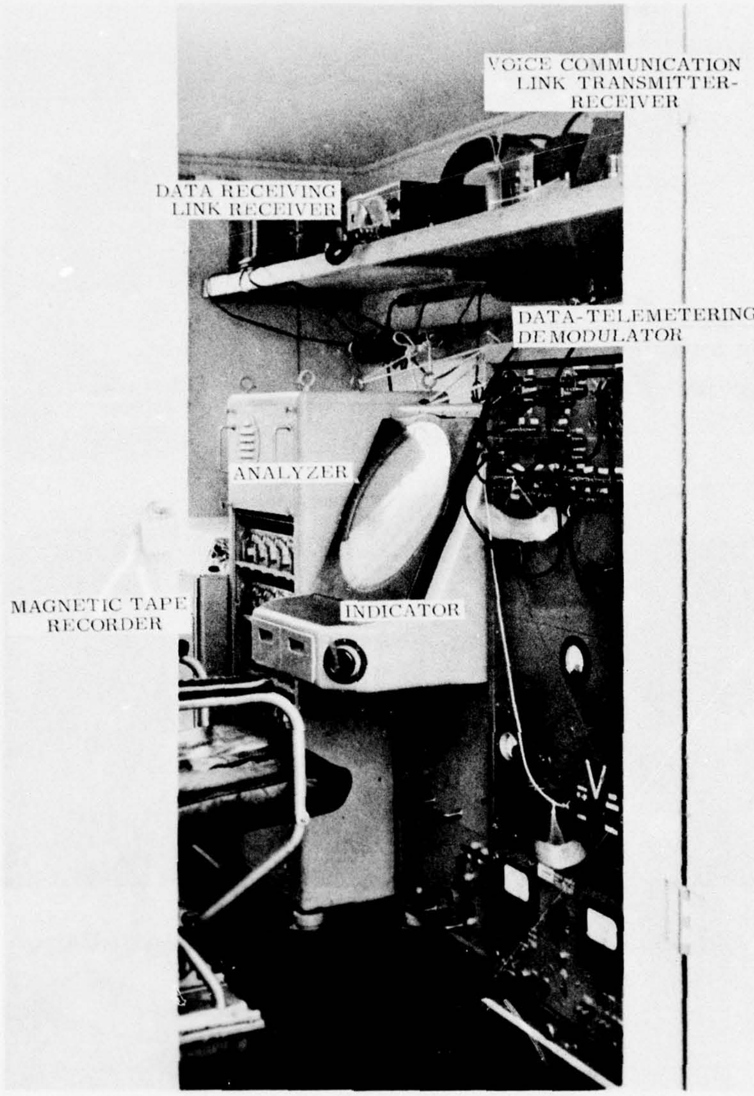

Figure 5. Interior view of portable test hut installation.

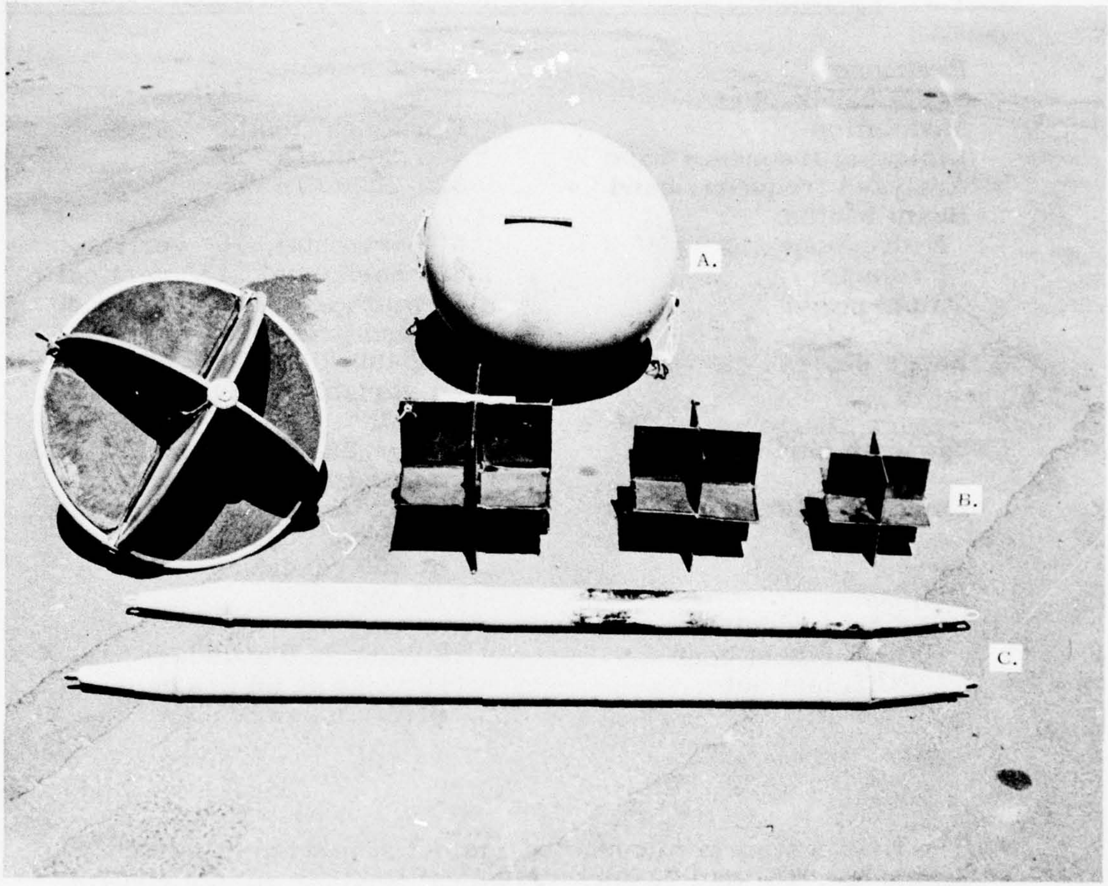

Figure 6. Experimental equipment used in sea tests: A, 2-foot free-flooding sphere; B, 24-, 12-, 10-, and 8-inch triplanes; C, floats.

Table 1. Principal Parameters of the Experimental Sonar Equipment

Frequency	52-65 kc/s
Swept bandwidth	13 kc/s
Modulation	Linear sawtooth
Listening frequency band	400-3000 c/s
Analyzed frequency band	500-2000 c/s
Beam widths:	
Hydrophone	5° horizontal, 15° vertical
Projector	30° horizontal, 15° vertical
Output power	10 watts electrical for 92 db sound pressure
Range scales	800, 400, 200, 100 yards and a variable scale 100 to 10 yards
Sawtooth period	6.5, 3.25, 1.625, and 0.8125 seconds, respectively
Range resolution	Approximately 0.25% of max. range of scale (i.e., 1 yd at 400 yards)
Display	PPI and aural
Primary power:	
USNEL picket boat	28 volts dc (batteries)
USNEL test hut	110 volts ac 60 c/s gas-electric power plant

The first tests were conducted against simulated moored mines (8-, 10- and 12-inch triplanes) to allow simple control of the tests and to develop operational techniques. Later tests were conducted against actual, bottomed mines (fig. 7).

The results of these preliminary tests were encouraging and, briefly were as follows.

The variable-depth capability inherent in the equipment made it possible to obtain and maintain sonar contacts which would otherwise have been lost due to varying sonar conditions. Bottomed mine targets were detected repeatedly to ranges of 300 yards and occasionally 400 yards in water depths in the regions of 50 to 100 feet. The time required to position (vector) an assisting helicopter averaged less than 3 minutes.

Figure 8 is a photograph of the cathode ray tube at the operator's console (ship-or-shore station).

The difficulties encountered in the experimental tests were the need for (1) greater stability of the soundhead, (2) better lock-up of azimuth data, and (3) reduction of interference in the soundhead cable.

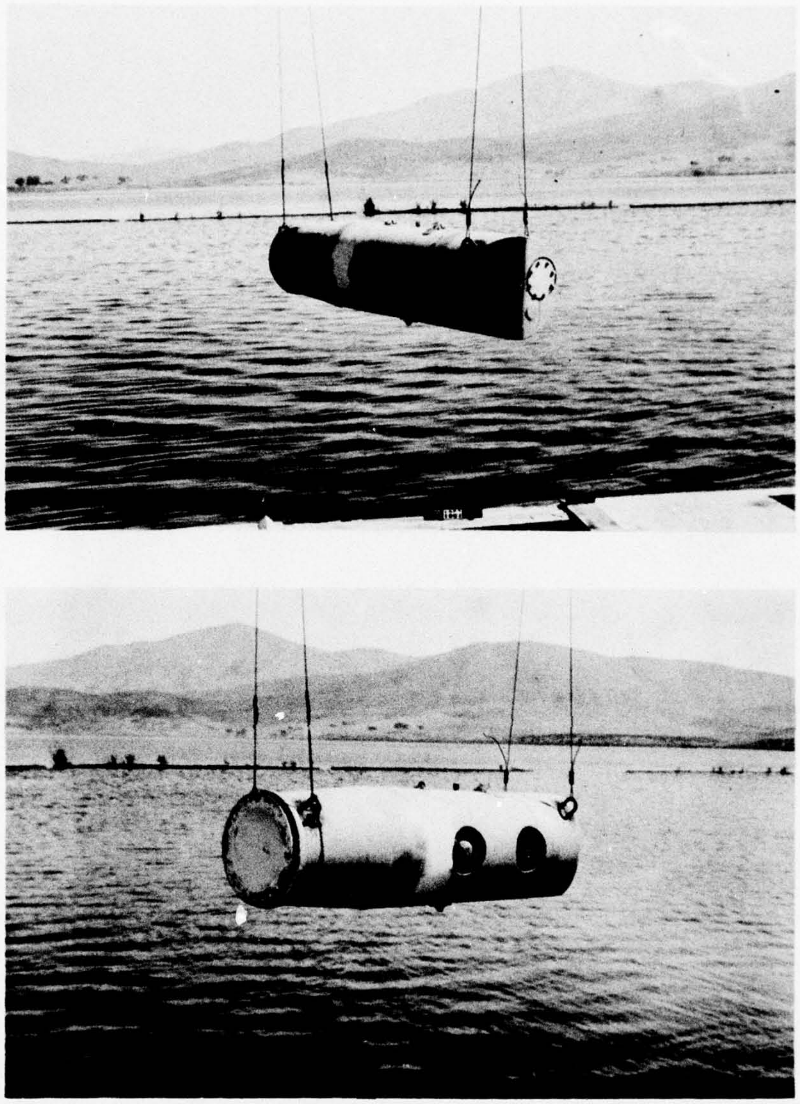

Figure 7. Mk 36 mine case of type used in sea tests against planted mine fields.

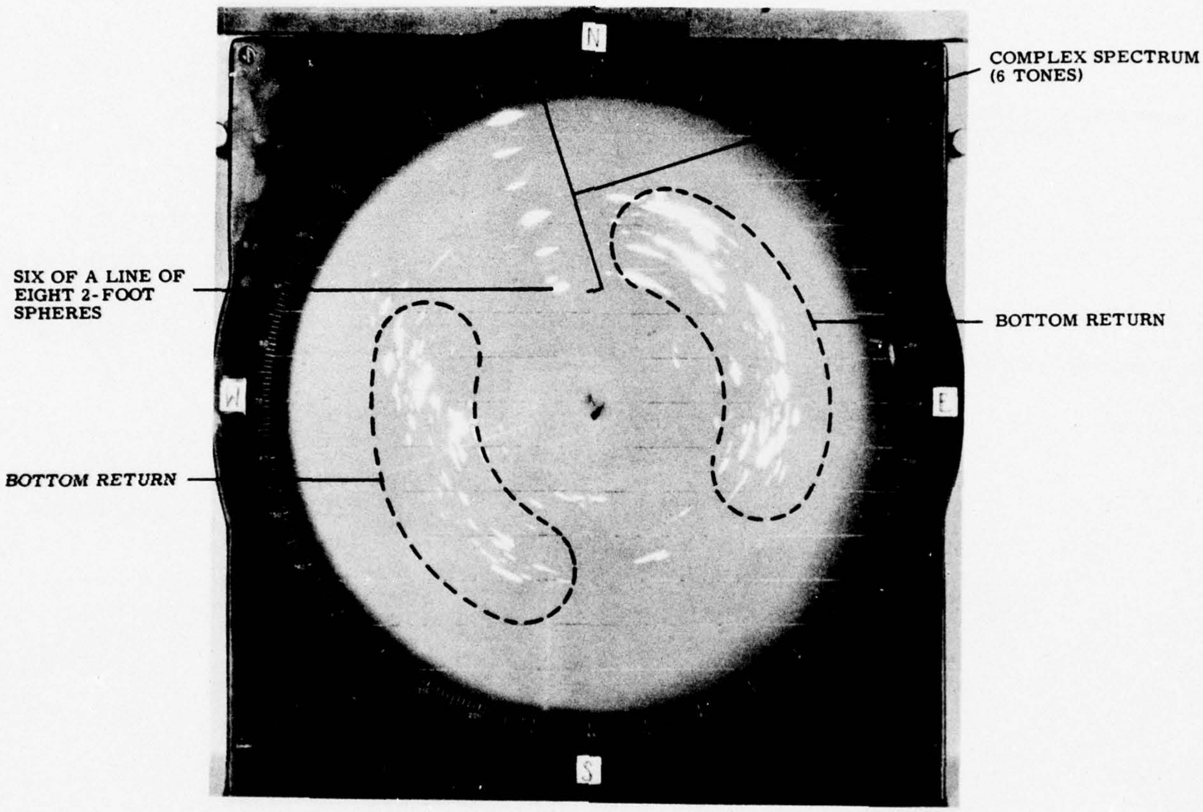

Figure 8. Operator's display on experimental equipment, showing target acquisition under good echo-ranging conditions.

When compared to the advantages obtained with the variable-depth transducers and system mobility, the significance of these problems was quite small, and the program continued into the developmental phase.

DEVELOPMENTAL PHASE

Based on the information acquired during the experimental tests, the parameters and composition of the developmental model were established.

A typical modification in the approach was the election to use the style of packaging already existing in the AN/AQS-4 equipment. This decision was made to minimize installation difficulties and delays, since most of the helicopters which were considered for installation of the ship-helicopter equipment already had AN/AQS-4 equipment aboard.

Another modification in concept was to procure standard telemetering equipment for use in the developmental model, rather than evolve an improved design of the experimental telemetering equipment. It was anticipated that such a plan would provide an economy in design and procurement, while insuring dependable telemetry performance, and at the same time simplify maintenance. This proved to be a serious error in approach, since essentially none of the expected advantages occurred. Actually, the late arrival of the "off the shelf" items, and those modified by the manufacturer, delayed test and evaluation of the developmental model. Their cost was high, the packaging of the shore units was bulky, and a large proportion of maintenance problems with the developmental equipment were associated with the components of the telemetering link.

Several modifications were necessary in the equipment design to obtain suitable operation for test: (1) The Fathometer constructed for continuous operation interfered with the sonar to the extent that recourse to alternate or time-sharing operation became necessary. This not only reduced the sonar time for each function, but rendered the integrating meter indicator on the Fathometer ineffective because of the stabilization time required. (2) The 400-c/s training motor contained in the soundhead was another source of interference which was eliminated by modifying the drive to use a dc motor.

Engineering sea tests were conducted during September and October 1956, with helicopter assistance being provided by HELISRON-TWO of Ream Field; San Diego.

These tests were not complete, but allowed recognition of several equipment deficiencies when operating from a helicopter. One of the more serious difficulties was the microphonic characteristics of the low signal level amplifier in the sonar unit.

After correction of recognized deficiencies, tests were continued beginning later in March 1957, which was the earliest that helicopter assistance could be obtained. At this time, one of the Mine Defense Laboratory personnel who was to be responsible for guiding the subsequent evaluation at Panama City, Florida, participated in the test operation to familarize himself with the equipment. The Commanding Officer of the helicopter activity in Panama City, Florida, also participated in these tests at San Diego to familiarize himself with the requirements peculiar to the installation, and with operation of the helicopter as a sonar platform. Meanwhile, information and dimensional details on the airborne components were forwarded to BuAer, BuShips, MDL, and others.

Performance of the equipment during these tests was consistently better. Although the helicopter offered a much better platform than the picket boat insofar as vertical stability was concerned, the need for greater soundhead stability was still apparent. Horizontal drift and currents were such that it was difficult at times to maintain a vertical cable axis at the soundhead for the period necessary to make an effective search.

During the latter phase of these sea tests, sufficient motion picture footage was taken, with related sound recordings, to allow preparation of a technical film report on the problem.

Following the sea tests, the entire equipment was shipped to the Mine Defense Laboratory for the preliminary phase of project "AIRVISH," and technical assistance was provided by NEL. Tests were conducted during July 1957, with an HSL type helicopter (fig. 9) assigned to carry the AN/UQS-2 airborne equipment. This craft proved to be especially unsuited for the job. However, the over-all performance of the AN/UQS-2 was such that at the conclusion of the tests the Mine Defense Laboratory personnel believed the status of the equipment justified a complete technical evaluation.

Minor breakdowns and malfunctioning were suffered by the airborne equipment during this preliminary evaluation at MDL. These malfunctions proved to be, for the most part, a combination of environmental conditions (heat and humidity) and the excessive vibration of the HSL type helicopter. It was stated in a subsequent report to BuAer that the HSL was unsuitable for an operation of this type and recommended that, in the interest of operational and environmental

Figure 9. HSL helicopter used in preliminary tests at MDL.

compatibility, certain minor modifications including the addition of test units and calibration aids should be incorporated in the equipment before further evaluation at MDL.

The AN/USQ-2 equipment was returned to NEL, following acceptance of the request for additional work by BuAer. The sonar equipment modifications and design and construction of test and calibration units were undertaken at NEL, while the malfunctioning units of the telemetering equipment were shipped to the manufacturer for factory reconditioning and recalibration.

One such modification was the transistorizing of the low-level voltage amplifiers of the sonar receivers to correct the microphonics, which still persisted, and which had been aggravated by the intense vibration encountered in the HSL helicopter.

Another modification was the conversion of the ac azimuth training drive in the soundhead to a dc drive (mentioned earlier) to increase the available torque as well as reduce the interference from the ac power in the soundhead cable.

While this work was in progress, the test hut containing the analyzing and display portions of the AN/UQS-2 equipment was shipped to the Defense Research Laboratory, Austin, Texas, to allow analysis of the magnetic tapes recorded by their people during the preliminary evaluation (July 1957). The results of these analyses and certain observations of equipment behavior are contained in a DRL report.[1]

A summary of the content of the DRL report is contained in this quote from the report abstract:

> "Tapes were available for two range scales, 400 and 800 yards; two scan rates, three and six rpm; and three hover positions in the mine field. For the 400-yard, 3-rpm runs a detection percentage of 57.1 per cent was obtained; for the 400-yard, 6-rpm a detection percentage of 57.7 per cent was obtained. For the 800-yard, 3-rpm runs the detection percentage was 16.6 per cent; and for the 800-yard, 6-rpm runs the detection percentage was 9.1 per cent."

Preliminary bench checks were conducted on the modified and reconditioned equipment and final adjustments and

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[1] Texas University Defense Research Laboratory Report DRL-A-135, The Performance of the AN/UQS-2 in a Ground Mine Field, by C. L. Wood and others, CONFIDENTIAL, 10 April 1958.

corrections made. The complete equipment was then re-assembled at NEL, following the return of the equipment loaned to DRL, and given a thorough checkout. Considerable use was made of the newly constructed "self test" and calibration aids during this time.

Tentative scheduling by the Mine Defense Laboratory indicated the complete technical evaluation of the AN/UQS equipment would be in August 1958. At the request of NEL a conference involving cognizant representatives of BUAER, BUSHIPS, MDL, and NEL was arranged to be held in Washington, D. C. on 27 May 1958. Scheduling, planning, instrumentation, and vehicular and funding requirements were discussed and for the most part satisfactorily resolved.

A status report on the work accomplished on Part III of the basic problem was issued to cognizant Bureaus during this period.

MDL requested that the evaluation scheduled for August be delayed and rescheduled for November 1958. The complete equipment was shipped to MDL in mid-October and NEL personnel arrived on 3 November 1958 to assist in the installation. Table 2 and figures 10-13 illustrate this installation. Due to delay in availability of certain necessary mounting fixtures for the airborne equipment, the indoctrination flights did not start until late November. The resulting compression in available time worked a hardship on all concerned. The first phase of the evaluation was completed during the month of December and involved NEL assisting personnel until the middle of that month. MDL personnel continued the evaluation following the Christmas holidays and during the week of 16 March 1959 the NEL representatives visited MDL to observe the last phase of the evaluation. However, due to weather, equipment, and vehicular difficulties, operations were restricted and subsequently the evaluation was not completed as expected. Assistance was given at this time to the MDL personnel in eliminating a persistent noise problem caused by contaminated slip rings in the cable reel. Except for this difficulty, it was observed the equipment was operating in a satisfactory manner and the enlisted personnel assigned to operate the equipment, airborne and shore portion, were very competent considering the short amount of time devoted to their indoctrination with the equipment.

The results of the technical evaluation of the AN/UQS-2 equipment, it is assumed, will be reported on separately by the Mine Defense Laboratory.

The cognizant BuAer representative (Code AV-211) was visiting MDL during the week of 16 March 1959 and he requested that NEL assume responsibility for the equipment, pending

Table 2. Sizes and Weights of Main Units of AN/UQS-2(XG-1) Airborne Equipment

Quantity to be Furnished	Designation		Over-All Dimensions (in.)			Weight
	Name	Unit No.	Length	Width	Height	⊕
1	Sonar O	1	18 1/2	9	7	21
1	Sonar control O	2	11 1/2	17 1/2	10 1/4	44
1	Soundhead assembly †	3	19 1/4	(dia)	35	65 1/2
1	Bottom indicator O	4	11	7 3/4	5 1/2	10 1/2
1	*Cable reel assembly & cable	5	23 1/2	20 1/4	24	150
1	Pilot indicator O	6	5	6	11	3 1/2
1	* Dynamotor assembly O	7	16	9 1/4	7	34
1	Telemeter transmitter assembly O	8, 9, 10, 11	7	9 5/8	13 1/2	18
1	Power supply (telemeter transmitter)	12	12 1/4	11	5 1/2	38
1	Transmitting antenna (telemeter)	13	16	6 3/4	4 3/4	5

O Dimensions do not include shock-mounted base } {Shock mounts & bases furnished}
⊕ Weight includes shock-mounted base
† 19 1/4" dia is the dimension of the seating fixture (see fig. 5)
* AN/AQS-4 equipment modified as furnished
Note - Miscellaneous spares will be furnished

	Weight (lbs)
AN/UQS-2(XG-1) Airborne equipment units 1-13	389 1/2
Interconnect cables	28
Total weight	417 1/2

the time when the final system evaluation would be scheduled at MDL. No commitment was made, but willingness was expressed to comment on the type and magnitude of such support if and when requested bu BuAer.

The equipment was subsequently returned to NEL for storage.

Figure 10. HSS helicopter.

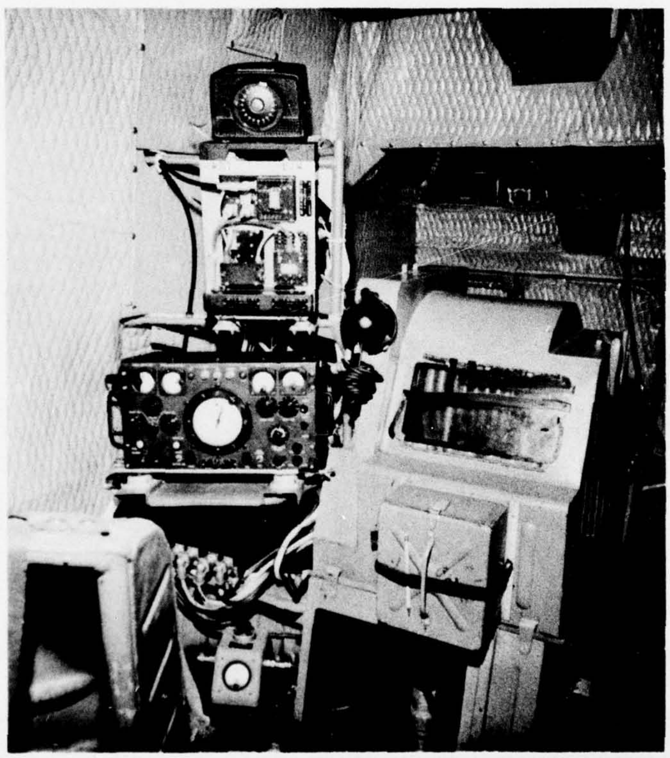

Figure 11. Interior of HSS helicopter, showing airborne AN/UQS-2 installation.

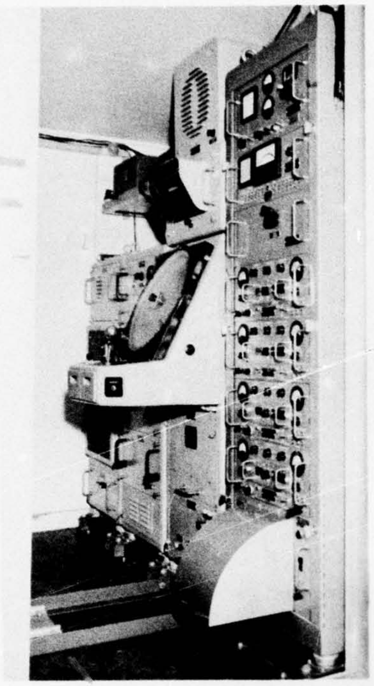

Figure 12. Interior of test hut, showing AN/UQS-2 ship-or-shore installation.

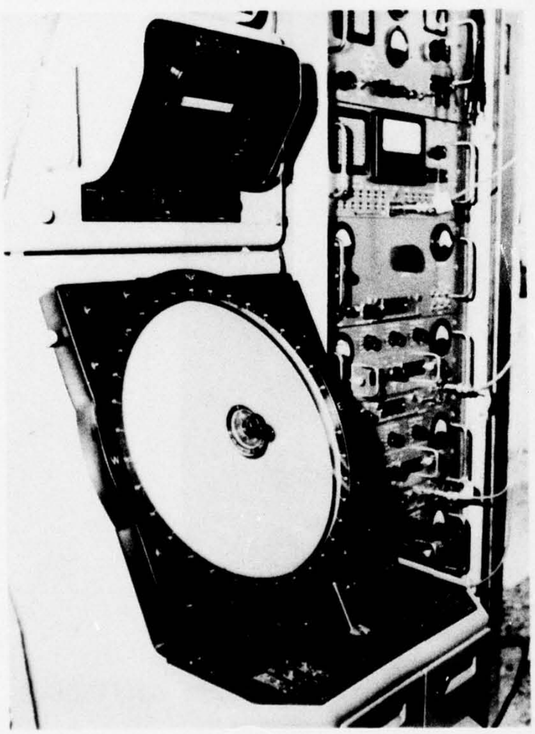

Figure 13. Close-up view of AN/UQS-2 ship-or-shore indicator in test hut.

CONCLUSIONS

1. The advantages of helicopter mobility and the associated variable-depth transducer arrangement were demonstrated.

2. The advantages were partially offset by difficulties in keeping the helicopter positioned above the transducers during a search operation.

3. Certain types of helicopters, notably the HSL, are not suitable for this application; however the H SS type was used successfully.

4. The "hook" method of encircling the target for range and bearing readout is operationally useful.

5. The use of "off the shelf" items (such as the telemetering equipment) does not necessarily provide the expected saving in laboratory man-time or procurement dollars.

RECOMMENDATIONS

1. Consideration should be given to means for maintaining the position of the helicopter above the transducers, and/or stabilization of the soundhead during the search operation.

2. Any decision regarding further development or use of such an equipment in mine hunting operations should be deferred until the USN Mine Defense Laboratory's evaluation report is available for further guidance.

APPENDIX: ILLUSTRATIONS OF DEVELOPMENTAL UNITS OF AN/UQS-2 EQUIPMENT

AIRBORNE EQUIPMENT

Figure A-35 (p. 50) is a block diagram of the airborne portion of the AN/UQS-2(XG-1) equipment, consisting of 13 units. The sonar components are contained in units 1 through 7, and the telemetering data-transmitting components in units 8 through 13. These units are shown in the following photographs, with brief descriptions.

DATA TRANSMITTING UNITS NOS. 8 THROUGH 13

These units make up the transmitter for the telemetering equipment and were supplied by the Bendix Corporation.

The sonar signal and four subcarriers are combined to frequency-modulate the transmitter carrier. One of the subcarriers (14.5 kc/s) carries the "range scale in use" signal; two others (22 and 30 kc/s) handle the azimuth data; while the fourth (70 kc/s) is used for the operator's voice.

The units are described in a Bendix report.[2]

SHIP-OR-SHORE EQUIPMENT

Figure A-36 (p. 51) is a block diagram of the ship-or-shore station portion of the AN/UQS-2(XG-1) equipment,

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[2] Bendix Aviation Corporation Pacific Division Report RDP-149, Proposal For The Use of FM/FM Equipment to Transmit Sonar Data, 10 October 1955

consisting of 26 units (Nos. 14 through 40). These units are shown in the following photographs, with brief descriptions.

DATA RECEIVING UNITS

Data receiving units Nos. 14 through 16 and 18 through 26 make up the data receiving station. They were supplied by the Bendix Corporation and are described in a Bendix Report.[3]

SONAR UNITS NOS. 27 - 40

Sonar units Nos. 27 through 40 make up the ship-or-shore portion of the sonar equipment where the sonar data are presented to the operator both aurally and visually, along with read-out equipment to aid in determining range and bearing of sonar targets by matching an electronic hook to the target position.

SPECIAL TEST & CALIBRATION UNITS

Although several test units were included with the original developmental equipment, it was found during the preliminary tests at USNMDL that additional test and calibration units were required to assure proper equipment adjustment and operation in the field, prior to evaluation runs.

A total of eight test units were provided for use during the final technical evaluation at USNMDL. These are arranged to plug in, in place of interconnecting cables or into special test sockets on the various chassis. The circuit to be tested is then selected by means of a switch on the panel of the test unit.

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[3]Bendix Aviation Corporation Pacific Division Report 4-1599, Instruction Book for Maintenance and Operation of 4-Channel FM/FM Telemetering Receiving Station, 5 October 1956

Where practical the panel meters are calibrated to indicate per cent of normal values with 100 per cent at center scale.

These units are shown in the following photographs, with brief descriptions.

LIST OF AVAILABLE SCHEMATICS AND BLOCK DIAGRAMS

Complete sets of schematics and block diagrams for both the airborne and the ship-or-shore portions of the AN/UQS-2(XG-1) equipment, as listed below, are available upon request. Please note that either complete set, or both, may be ordered, but not individual drawings. Address requests to: U. S. Navy Electronics Laboratory, San Diego 52, California, attention Code 2624.

Set 1: Airborne Equipment

Cabling diagram of helicopter equipment.
Sonar block diagram, unit No. 1.
Sonar schematic, unit No. 1.
Sonar receiver, Part "A" of unit No. 1.
Sonar voltage regulator, Part "B" of unit No. 1.
Sonar frequency-modulated oscillator and power amplifier, Part "C" of unit No. 1.
Resistor board data, unit No. 1.
Printed circuit boards, unit No. 1.
Sonar control block diagram, unit No. 2.
Shaft position servo (sonar control), Part "A" of unit No. 2.
Intercom switching and amplifier, Part "B" of unit No. 2.
Scan speed and bottom controls, Parts "C" and "D" of unit No. 2.
Cable length, height and depth, Part "E" of unit No. 2.
Sonar gain control and range switch, Parts "F" and "G" of unit No. 2.
Power and control switches; indicator lights; Part "G" of unit No. 2.
Cursor generator and leakage indicator, Part "I" of unit No. 2.
Block diagram of soundhead assembly, unit No. 3.
Soundhead wiring diagram, unit No. 3.
Simplified soundhead circuits, unit No. 3.
Bottom indicator schematic, unit No. 4.
Cable reel wiring diagram, unit No. 5.
Wiring diagram of pilot's indicator, unit No. 5.

Dynamotor assembly, unit No. 7.
PM transmitter (part of data transmitter), unit No. 8.
Data transmitter wiring diagram.
Power supply, part of data transmitter, unit No. 12.
Test unit No. 1 for AN/UQS-2 unit No. 7.
Test unit No. 2 for AN/UQS-2 unit No. 12.
Test unit No. 3 for AN/UQS-2 unit No. 1.
Test unit No. 4 for AN/UQS-2 unit No. 3.
Test unit No. 5 for AN/UQS-2 unit No. 2.

Set 2: Ship-or-Shore Equipment

Ship-or-shore equipment cabling diagram.
Shaft position servo schematic, data receiving units, unit No. 17.
Shaft position servo terminal boards, data receiving units, part of unit No. 17.
Power supply schematic (sonar units), unit No. 27.
12-channel drawer, part of unit No. 28.
Modulator schematic, unit No. 29.
Cabinet wiring diagram (sonar units), units Nos. 27, 28, 29.
Computer amplifier schematic, unit No. 30.
Computer amplifier wiring diagram, unit No. 30.
Reference supply schematic, unit No. 31.
Power supply schematic, unit No. 32.
Cabinet wiring diagram, target position and sonar amplifier, units Nos. 30, 31, 32, and 40.
Target position indicator block diagram, unit No. 33.
Circuit diagram of target position indicator, unit No. 33.
Block diagram of sonar indicator, unit No. 34.
Schematic diagram of sonar indicator, unit No. 34.
Wiring diagram of PPI cabinet and control panel, unit No. 35.
Block diagram of sweep generator, unit No. 36.
Schematic diagram of sweep generator, unit No. 36.
Power supply schematic, unit No. 37.
Circuit diagram of loudspeaker amplifier, unit No. 40.
Circuit diagram of analyzer test unit.

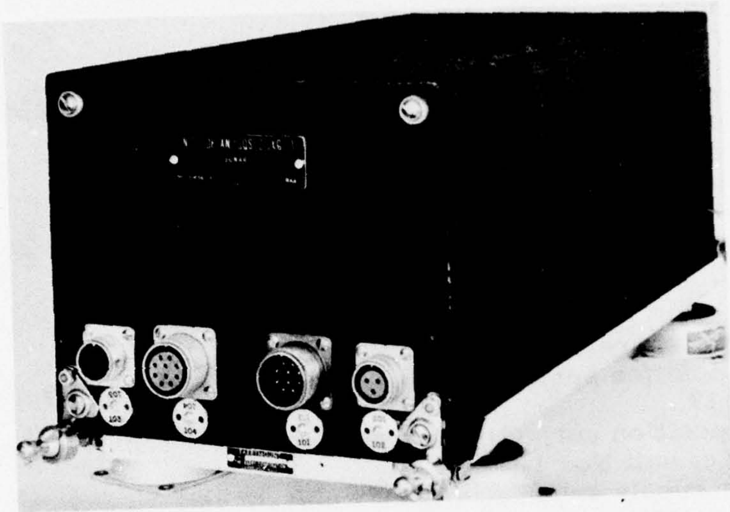

Figure A-1. Sonar unit No. 1. This unit, developed at NEL, contains the continuous-transmission sonar signal generating and receiving circuits. Power is supplied from the dynamotor assembly unit No. 7 via the control unit No. 2. The transducers located in unit No. 3 are connected via the cable reel unit No. 5.

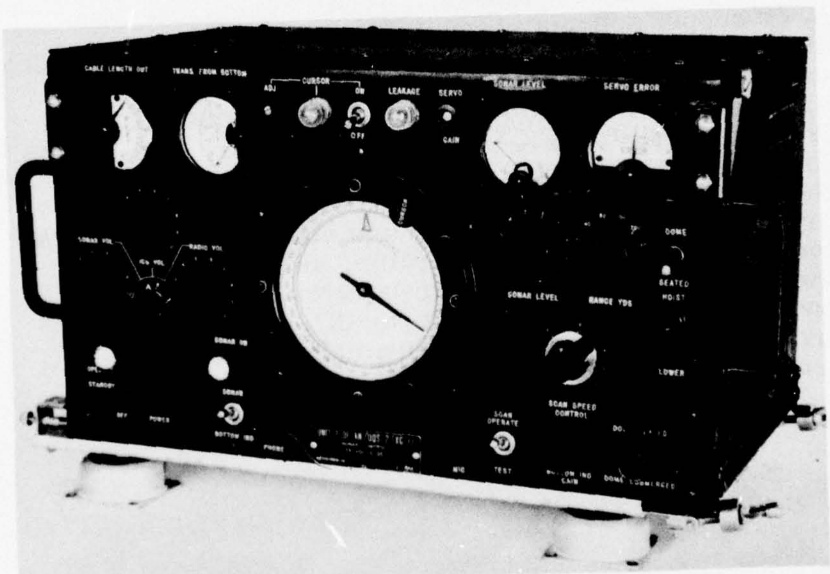

Figure A-2. Sonar control unit No. 2. Controls for not only the sonar unit but for all functions of the AN/UQS-2 mounted in the helicopter are contained in the sonar control unit. This is the central unit of the sonar operator's station and indications of soundhead azimuth, depth, cable length, etc., are displayed on the panel. Interconnection to the aircraft intercom system is also provided in this unit.

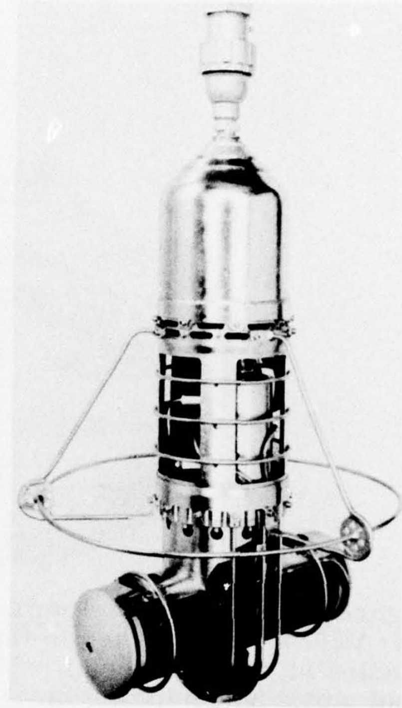

Figure A-3. Sonar head unit No. 3. In addition to its primary function of housing the hydrophone and projector and the azimuth training motor and slip rings assembly, this unit includes the flux-gate compass sensor element, the bottom-sounder transducer, and the depth-sensing pressure element.

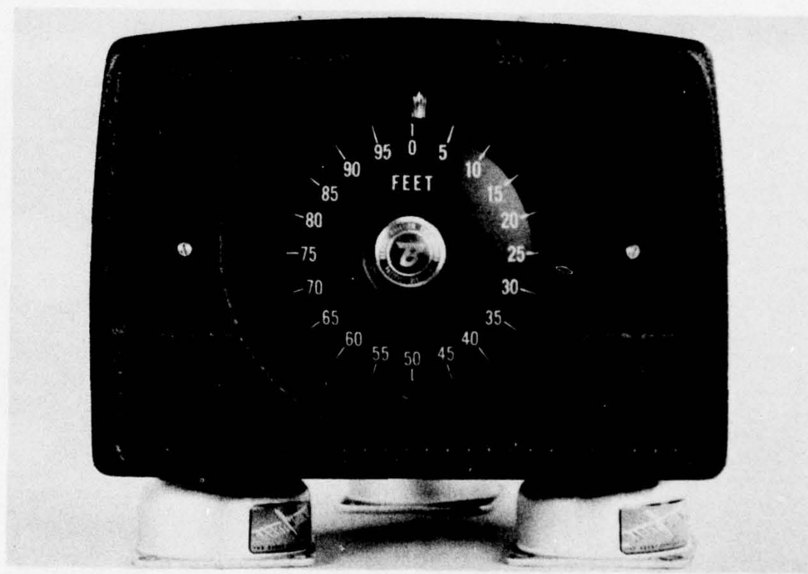

Figure A-4. Bottom indicator unit No. 4. This Bendix Fathometer with its transducer, located in the soundhead unit No. 3, connected via the cable reel unit No. 5, and having its controls on the panel of the sonar control Unit No. 2, makes use of a rotating indicator with a flasher on its front panel to indicate the clearance between the sea bottom and the soundhead.

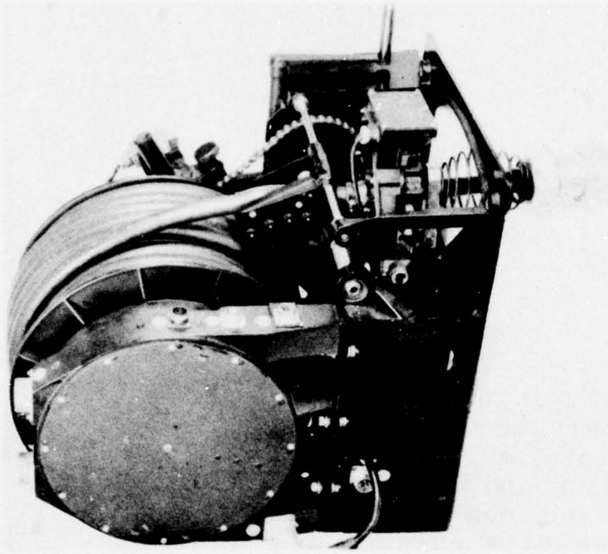

Figure A-5. Cable reel unit No. 5. The cable reel is an adaption of an AN/AQS-4 unit modified to function with the AN/UQS-2 equipment. It handles 90 feet of special cable and is the only connection to the soundhead unit. The hoisting motor, slip ring assembly and "cable length in use" sensing potentiometer, as well as the device which measures the angle of the cable leaving the aircraft, are contained in this unit.

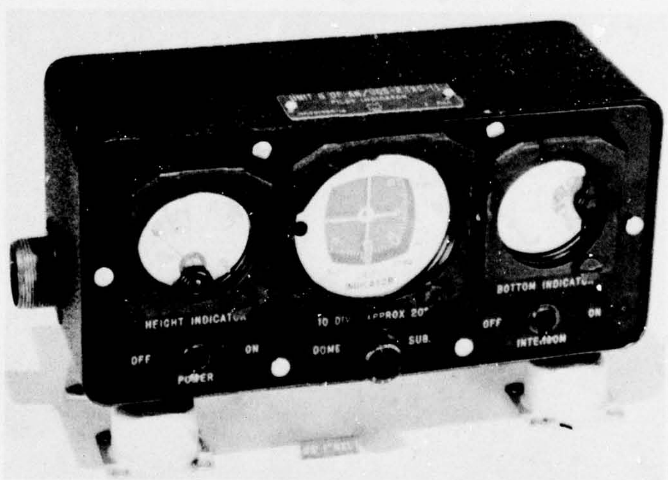

Figure A-6. Pilot's indicator unit No. 6. The pilot's indicator is a remote unit which presents meter indication of height of aircraft above water, angle of cable leaving the aircraft, and length of cable in use, plus a light which shows when the soundhead is in the water. Switches are also provided for emergency override of system power and intercom use.

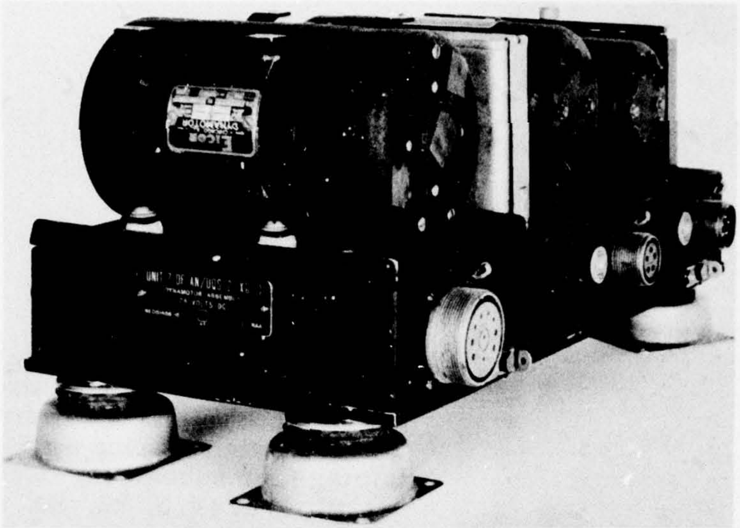

Figure A-7. Dynamotor assembly unit No. 7. Three dynamotors make up this assembly to provide power to the airborne sonar equipment. They deliver 250 volts dc,425 volts dc, 115 volts, 400 c/s ac from the 28-volt primary power of the aircraft.

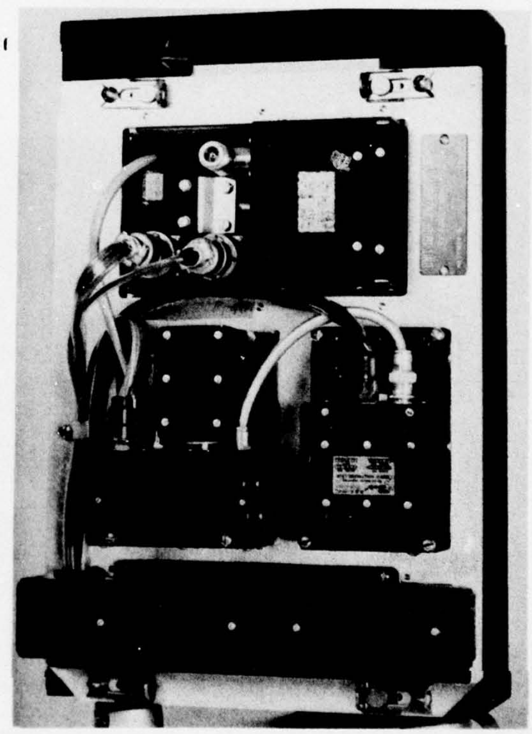

Figure A-8. Data transmitting units Nos. 8, 9, and 10. PM unit No. 8 is a Bendix type TXV-13 crystal-controlled, phase-modulated transmitter with two modulation inputs: one accepts the sonar signal for FM modulation of the transmitter; the other, the inputs from four subcarrier oscillators for PM modulation of the transmitter. Rf unit No. 9 is a Bendix type TAV-4 amplifier operating in the frequency band of 215-235 Mc/s. It serves as a buffer amplifier to couple the output of unit No. 8 to the input of the rf power amplifier unit No. 10 which is a Bendix type TAV rf power amplifier operating in the frequency band of 215-235 Mc/s and is capable of delivering 100 watts of rf power to the transmitting antenna when driven by the output of the type TAV-4 amplifier (unit No. 9).

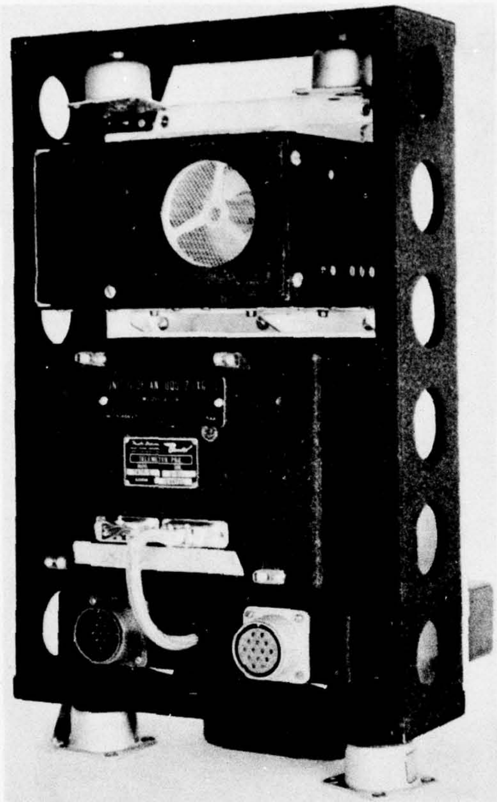

Figure A-9. Modulator unit No. 11 (rear view of equipment shown in fig. A-8). This is a Bendix type TATP-5 telemetering package containing four subcarrier oscillators operating at 14.5, 22, 30, and 70 kc/s, as well as a sonar signal amplifier and limiter. Together these form the modulator unit for the telemeter transmitter.

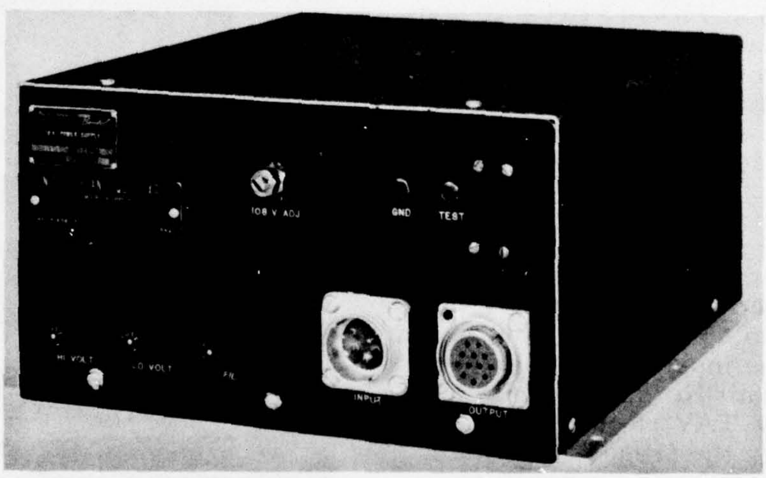

Figure A-10. Power supply unit No. 12. The power supply is a Bendix type TPP-7 dynamotor type unit capable of providing power for the entire telemeter transmitter. The input power requirement is 550 watts at 26 volts.

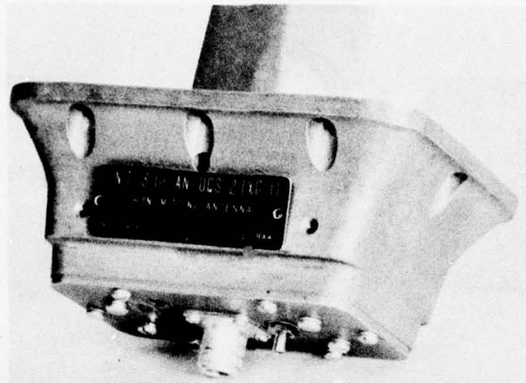

Figure A-11. Transmitting antenna unit No. 13. The antenna is a Bendix type TNA-11 quarter-wave stub design for aircraft use in the frequency band 215 to 235 Mc/s. It is tuned for minimum VSWR at the operating frequency.

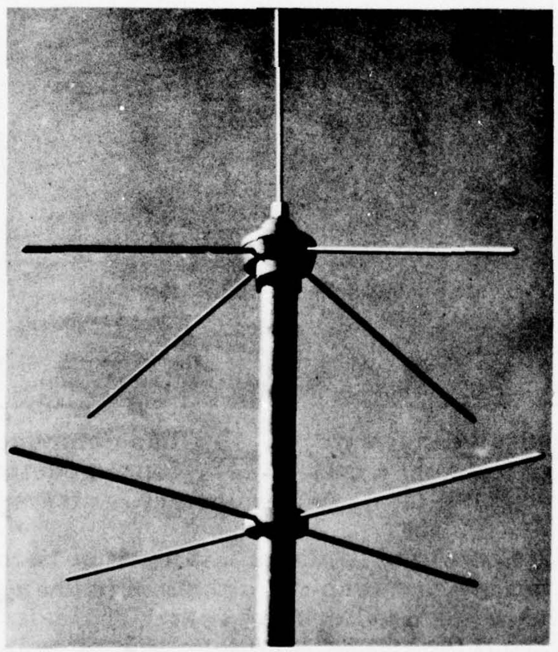

Figure A-12. Data receiving antenna unit No. 14. A Motorola model P-8351, modified and supplied by Bendix Corp. This antenna is a vertical modified ground plane and is essentially nondirectional in the 215- and 235-Mc/s band.

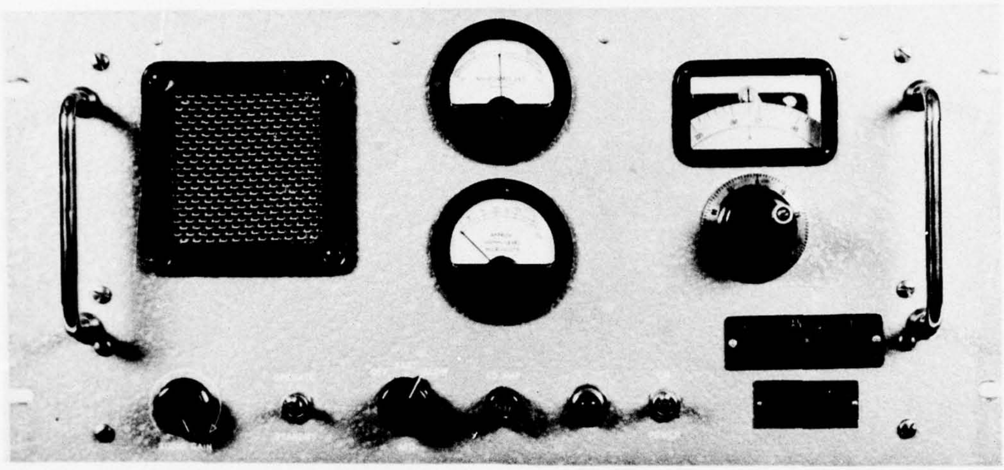

Figure A-13. Data receiver unit No. 15. This unit is a special-purpose fm receiver, Nems Clarke model 1670-E, supplied by Bendix Corp. It is described in the applicable instruction book.[4]

[4]Nems Clarke, Incorporated, Instruction Book for Model 1670 Special Purpose Receivers, n.d.

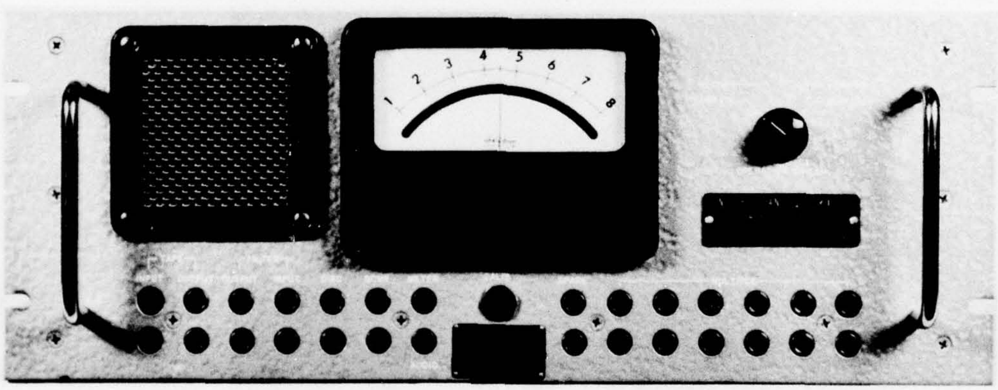

Figure A-14. Monitor panel unit No. 16. The demodulated telemeter carrier, containing the sonar data and the four modulated subcarriers, is connected to the inputs of all four subcarrier discriminators via the monitor panel.

A low-pass filter located in the monitor panel recovers the sonar data by rejecting the subcarriers from the sonar channel.

A meter on the panel monitors the range-scale-in-use information which is obtained from the output of discriminator unit No. 18, while a small loudspeaker also mounted on this panel monitors the voice channel obtained at the output of discriminator unit No. 21.

A row of patch connectors are located on this panel for connection of the data recorder and test instruments.

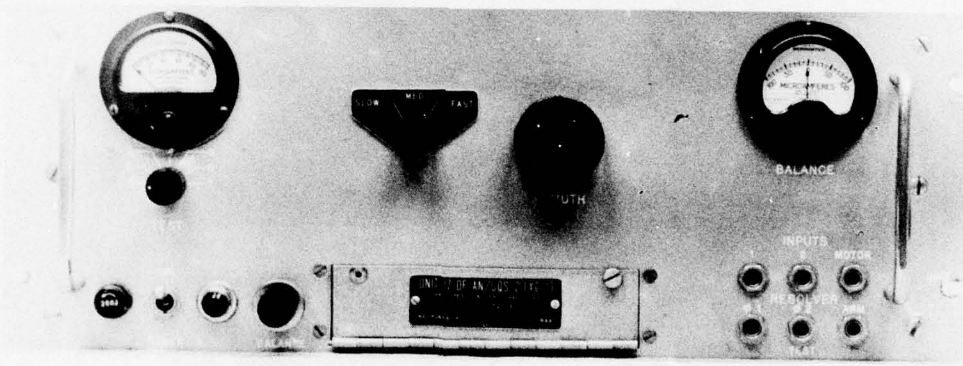

Figure A-15. Shaft position servo-amplifier unit No. 17. The shaft position servo-amplifer unit is a phase-sensitive servo system developed by NEL for the purpose of converting the azimuth data obtained at the output of units Nos. 19 and 20 into sweep direction for the sonar plan position indicator unit No. 34.

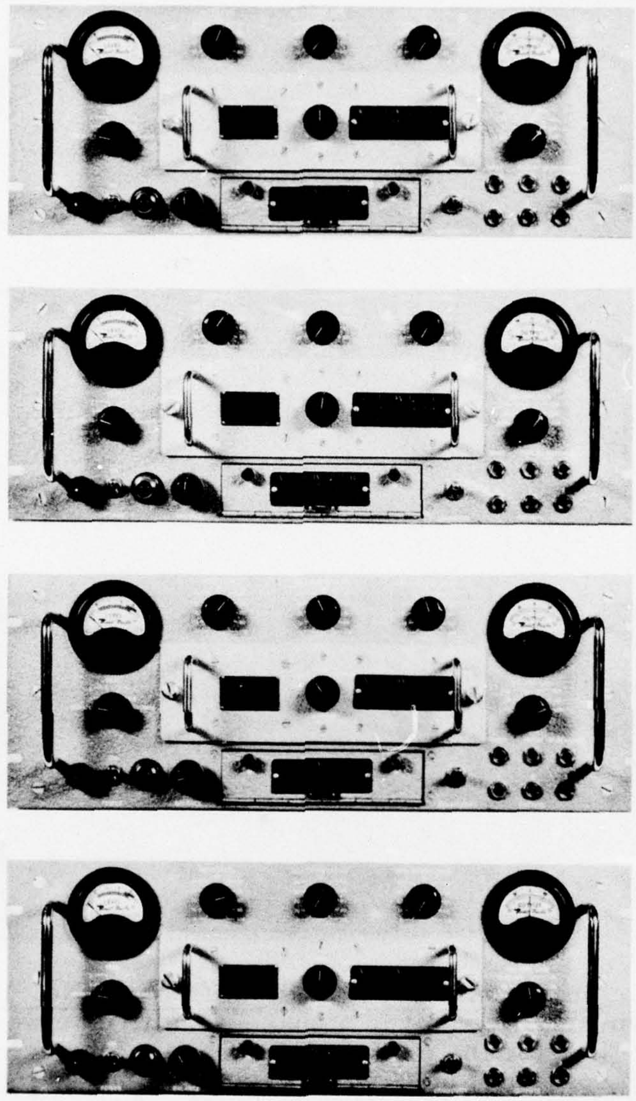

Figure A-16. **Discriminator and filter tuning units. The four subcarrier** discriminator units (Nos. 18-21) are identical except for their plug-in tuning units and the data which they handle.

The four subcarrier filter tuning units (Nos. 22-25) plug into the subcarrier discriminators for the purpose of selecting the proper subcarrier and filtering the demodulated signals.

Units Nos. 18 through 25 are described in detail in a Bendix report.[5]

[5]Bendix Aviation Corporation Pacific Division Report 4-1369, Manual for Operation and Maintenance of TDA-9 Subcarrier Discriminator, 30 July 1956

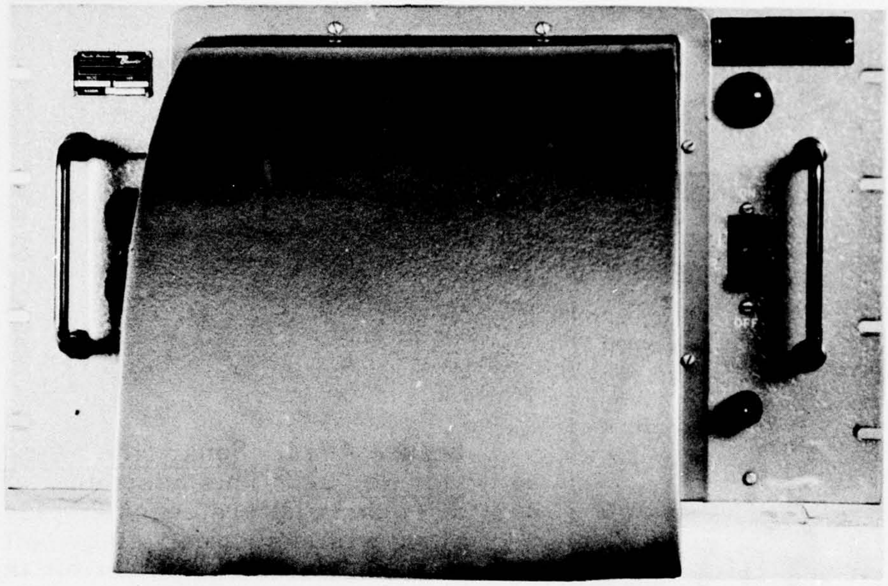

Figure A-17. Dual blower unit No. 26. This unit serves to maintain the operating temperature of the data-receiving equipment below maximum values, ventilating the cabinet through ducts which control the distribution of the forced air.

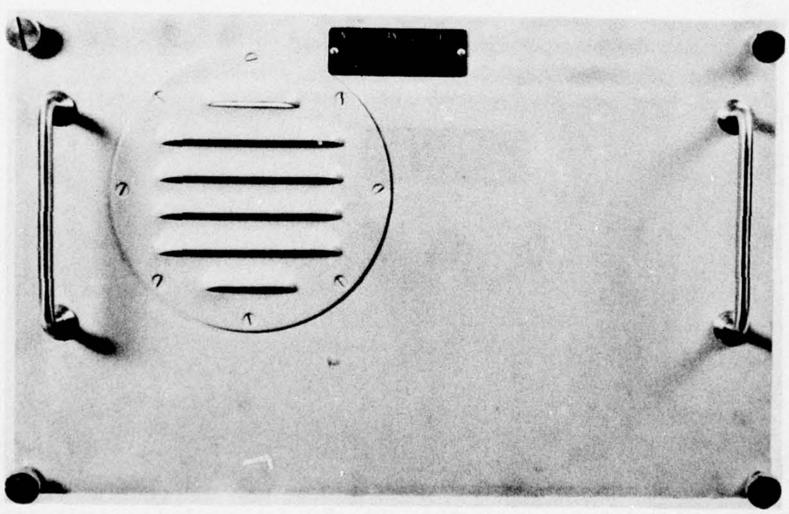

Figure A-18. **Power supply unit No. 27. This unit supplies power to** the sonar filter assembly for the operation of the pulse generators and associated circuits in each of the 25 module drawers.

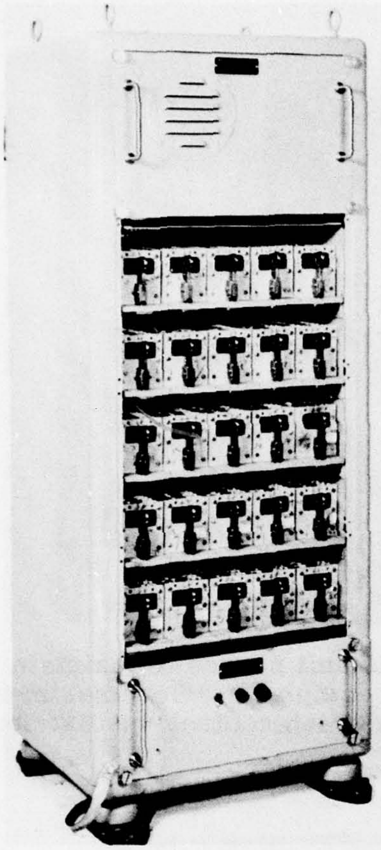

Figure A-19. Sonar filter assembly unit No. 28. This assembly contains 300 quartz filters, each 5 cycles wide, along with detectors, electronic switch, and associated equipment for the purpose of analyzing the sonar range spectrum and converting it to video signals suitable for presentation on the PPI.

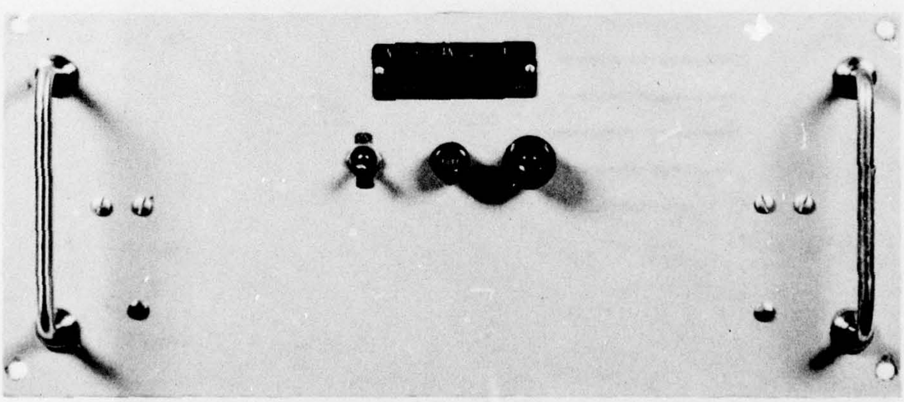

Figure A-20. Modulator unit No. 29. The modulator unit contains the equipment to convert the sonar range spectrum, 1/2 - 2 kc/s, to the frequency band of the sonar filter assembly, i.e. 32.5 kc/s through 34 kc/s.

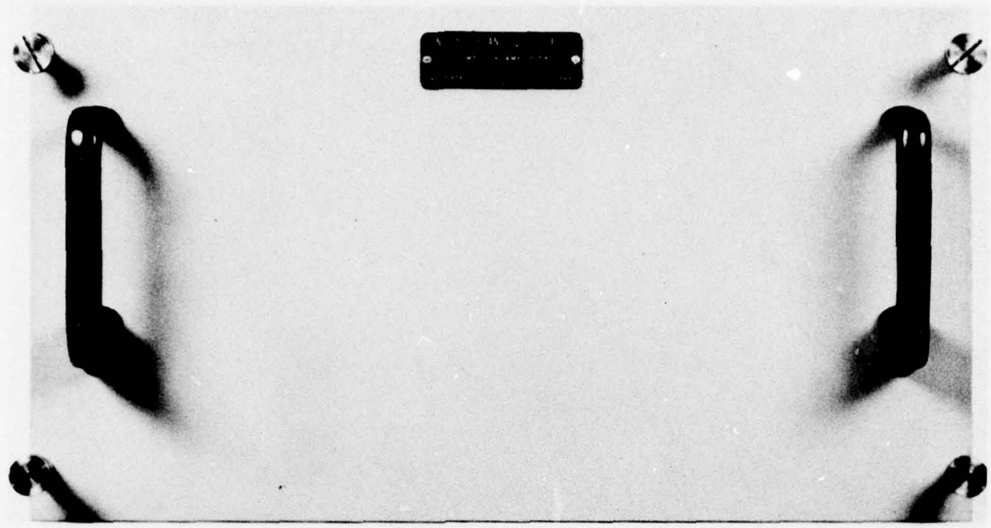

Figure A-21. Computer amplifier unit No. 30. This unit contains a two-channel amplifier having extremely low distortion and high stability both as to amplitude and phase; the amplifier forms a part of the computer which converts the position of a target on the PPI into analog data for use by the target position indicator.

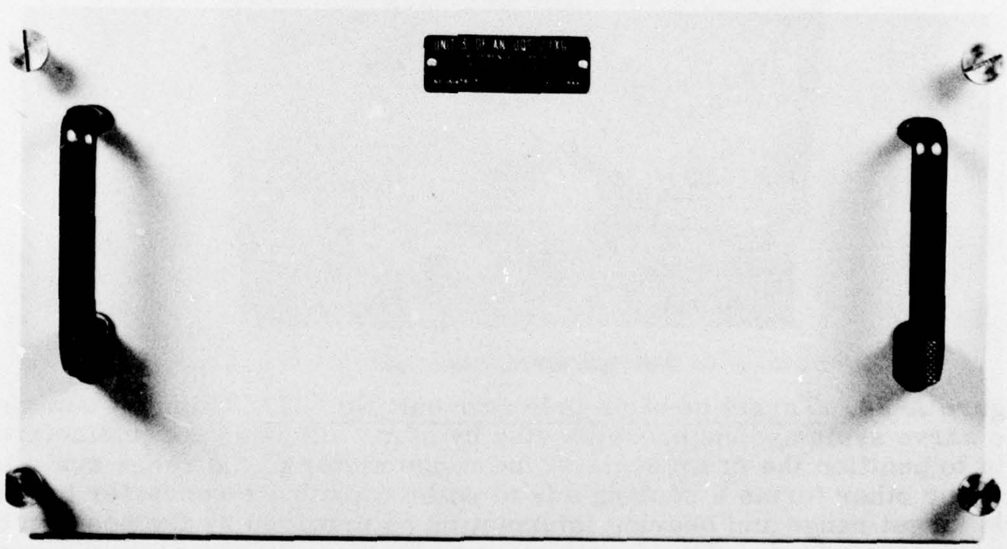

Figure A-22. Reference supply unit No. 31. This unit serves as a source of the stabilized voltages necessary for proper function of the servo system located in the target position indicator.

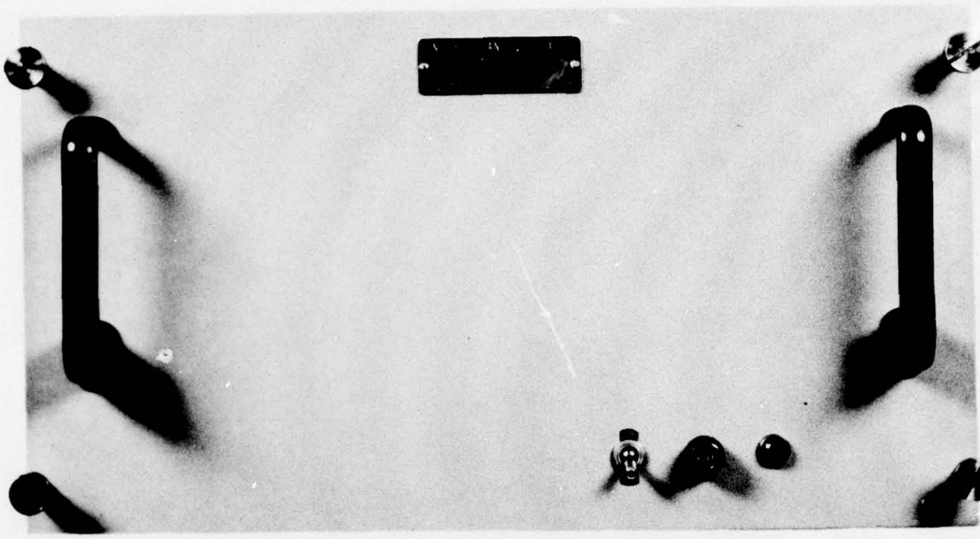

Figure A-23. Power supply unit No. 32. This unit supplies power to the computer amplifiers in unit 30 (fig. A-21).

Figure A-24. Target position indicator unit No. 33. This unit contains two servo systems: one operates step by step, following the telemetered data to position the drum scale of the range meter to the range scale in use; the other forms a rectangular to polar coordinate converter to provide target range and bearing information as provided by the position of the electronic hook. This information is not only presented on the range meter and bearing counter on the front panel of the unit, but is made available for remote connection as servo inputs to computer or plotters from plugs located on the back.

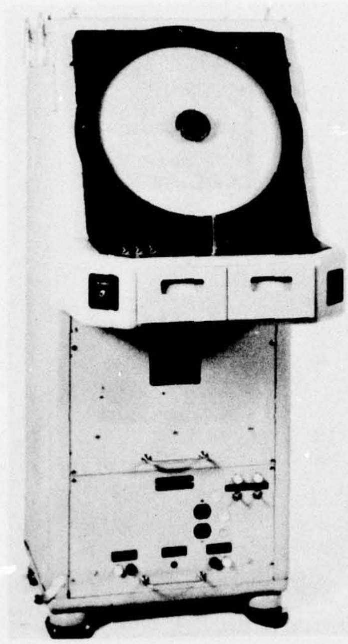

Figure A-25. Sonar indicator unit No. 34 and control panel unit No. 35. The sonar indicator provides the operator with a 16-inch plan position display of sonar targets and an electronic hook. The sweeps for both the sonar display and the electronic hook are generated in unit no. 36. Azimuth direction is given to the radial sweep of unit no. 17 while position is given to the electronic hook by the control stick on unit no. 35. Sonar targets appear as video signals at the output of unit no. 28 and are synchronized to appear at the proper range on the radial sweep. The control panel is in the form of a shelf below the sonar indicator screen. The following controls are located on this shelf directly in front of the operator. The joystick which controls the position of the electronic hook on the PPI screen is centrally located in the top surface of this shelf and permits rapid positioning of the hook to encircle any target which appears on the indicator screen. Three communication switches are located convenient to the operator's left hand for the purpose of connecting the operator's headset to radio, sonar signals, or voice channel of the data receiving equipment.

Master level controls are provided for headphones, microphones, and sonar signals to the analyzer as well as adjustment for the indicator and its lights.

The controls which are least often used (set-up controls) are located under hinged covers to lessen the number of controls presented to the operator during operation. A three-channel headphone mixer unit is mounted near the side of the control panel and serves to balance the relative signal levels when more than one communication channel must be monitored at the same time.

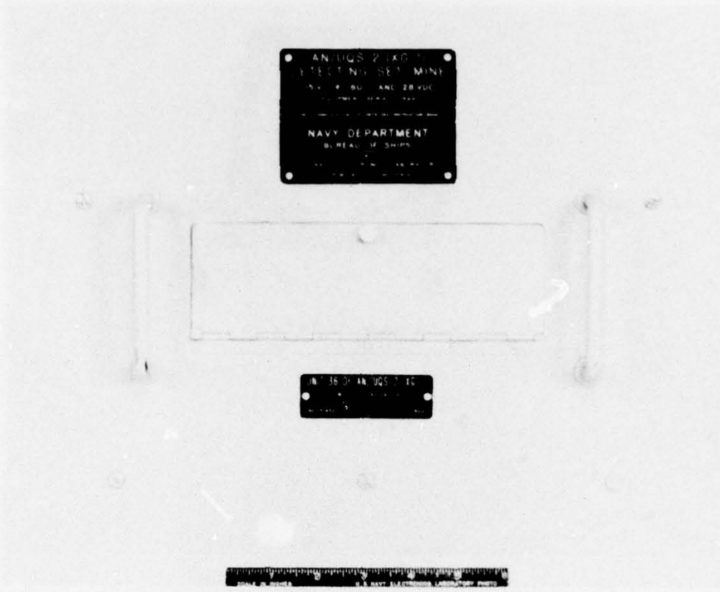

Figure A-26. Sweep generator unit No. 36. Two sweeps for the sonar indicator are generated alternately in this unit. One is the radial sweep for the PPI of the sonar data; the other is the sweep for the electronic hook. A pulse for the purpose of synchronizing the sonar video data generated in unit No. 28 (fig. A-19) is also produced.

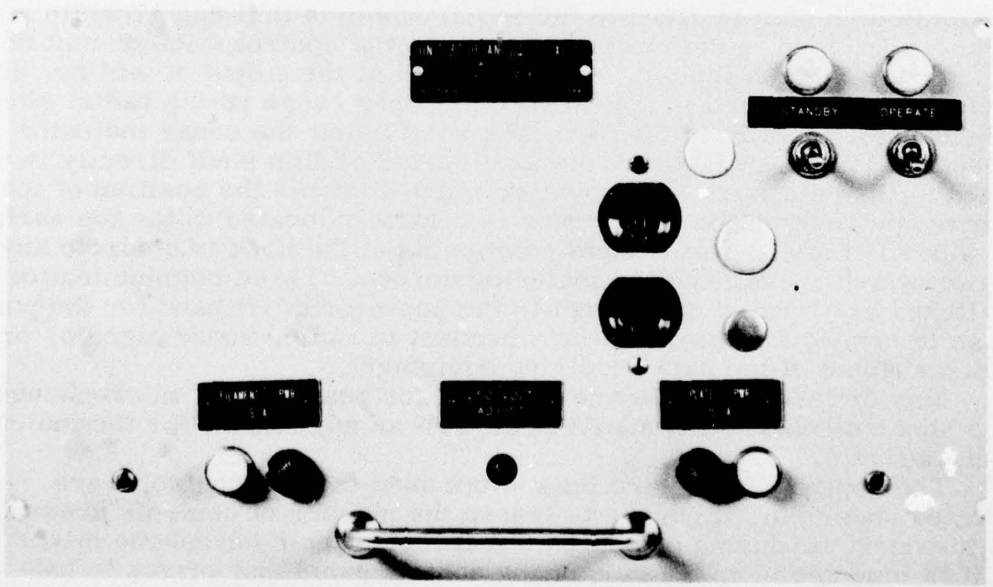

Figure A-27. Power supply unit No. 37. Power for the operation of the sonar indicator is supplied by this unit.

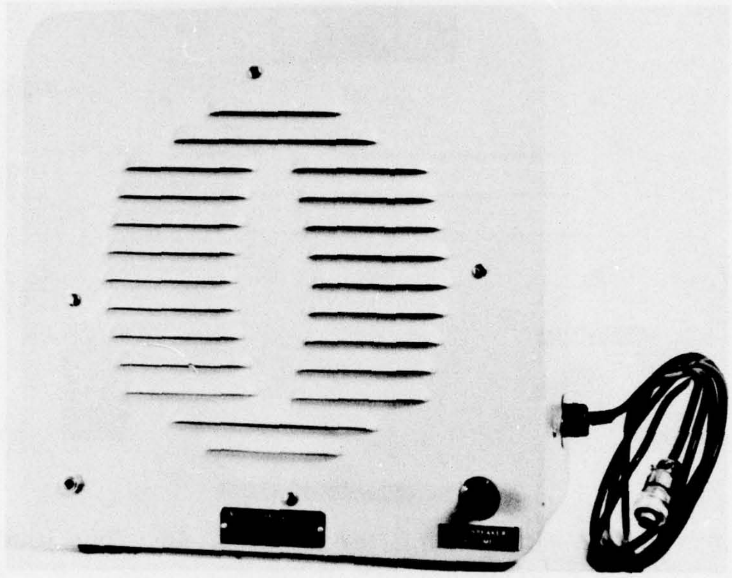

Figure A-28. Loudspeaker unit No. 38. The loudspeaker is mounted above the sonar indicator to provide aural sonar signals to personnel other than the operator as they evaluate visual sonar targets on the sonar indicator.

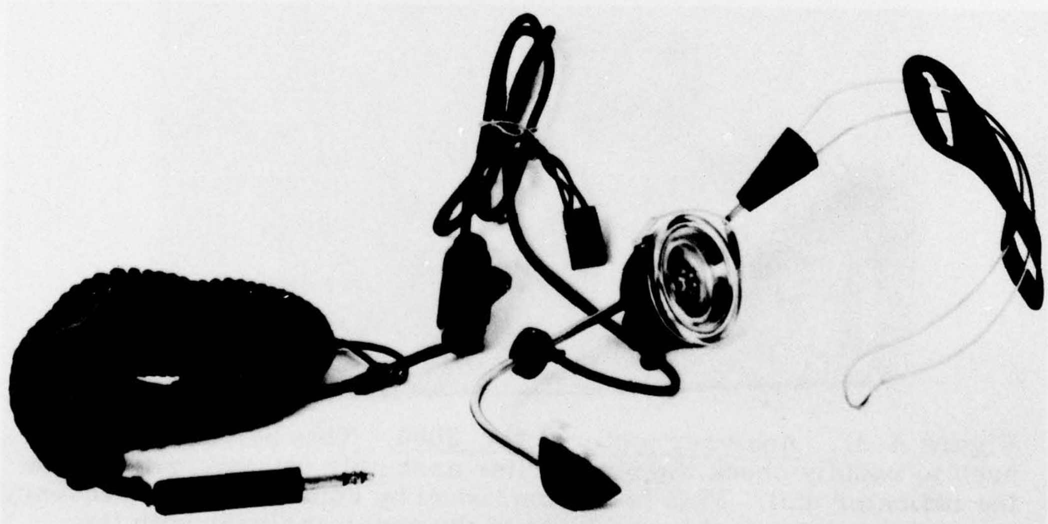

Figure A-29. Operator's headset unit No. 39. The headset provides the operator with aural sonar signals as well as radio and telemeter communication signals. A microphone to transmit the operator's voice is a part of this assembly.

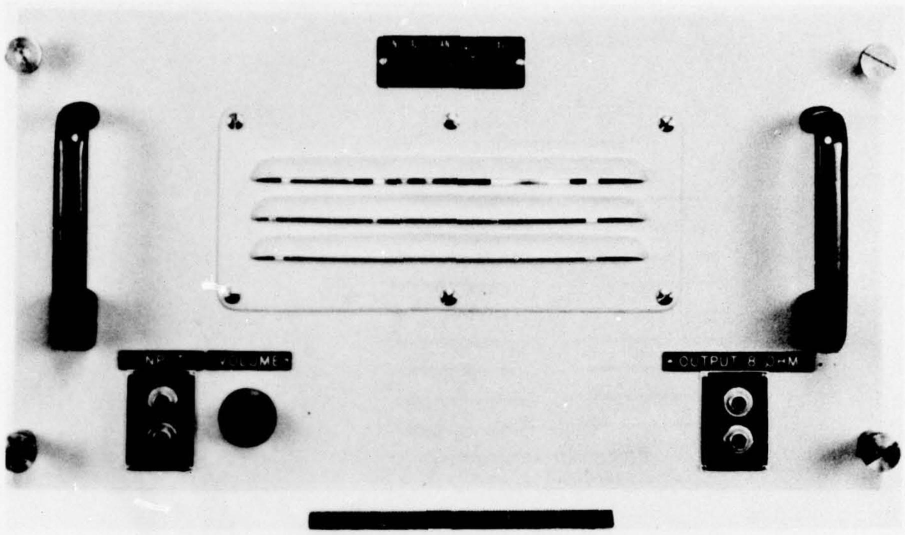

Figure A-30. Loudspeaker amplifier unit No. 40. The loudspeaker amplifier supplies the sonar signals to the loudspeaker and signals of a lower level for one of the headphone channels.

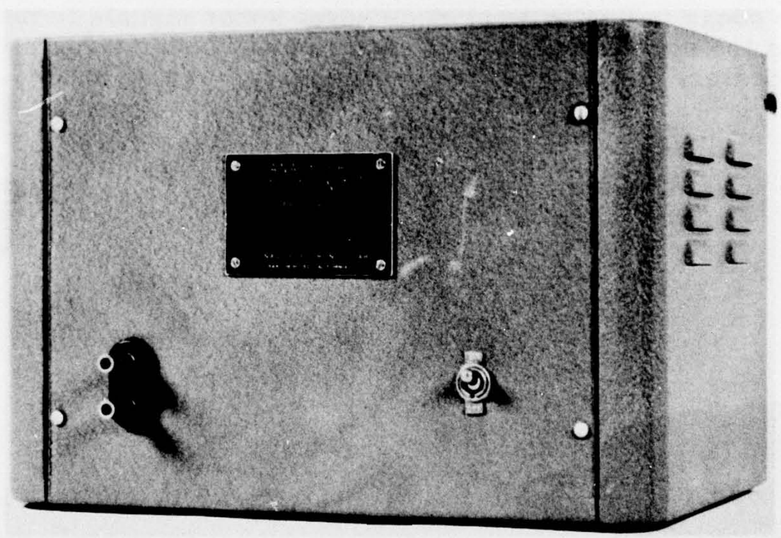

Figure A-31. Analyzer test unit No. 2000. This unit is a device used to rapidly check the sonar filter assembly in combination with the indicator unit. This is accomplished by connecting the frequency sweep from its output to the input of the sonar analyzer with the indicator in operation. As the frequency sweeps past each of the sonar range filters it draws a spiral on the PPI of the indicator. Defective filter channels will cause discontinuities in brightness of the test spiral.

Figure A-32. Data transmitter and output power test unit. A power monitor, which may be connected in the transmission line to the data-transmitting antenna gives meter indications of the output power from the data transmitter. It may also be used to detect reflected power from the antenna due to mismatch.

The unit is a standard device. The one used with this equipment was manufactured by Sierra Electronics Corp.

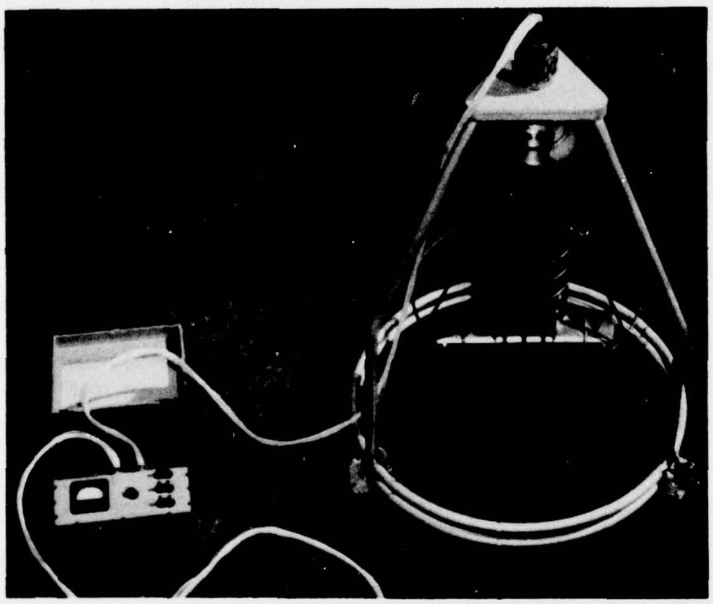

Figure A-33. Soundhead test unit and stand. The soundhead test unit plugs into the disconnect socket at the top of the soundhead, and a socket on the test unit receives the cable normally plugged into the soundhead. Power to the training motor, projector, and flux valve compass element is selected and measured by means of a switch and meter located on the test unit.

The three-phase sense signal from the compass element is brought out to the front panel of the test unit on GR terminals for external tests.

A test stand, in the form of a roller-mounted aluminum tripod, provides both support for the soundhead unit during tests and calibration of the compass.

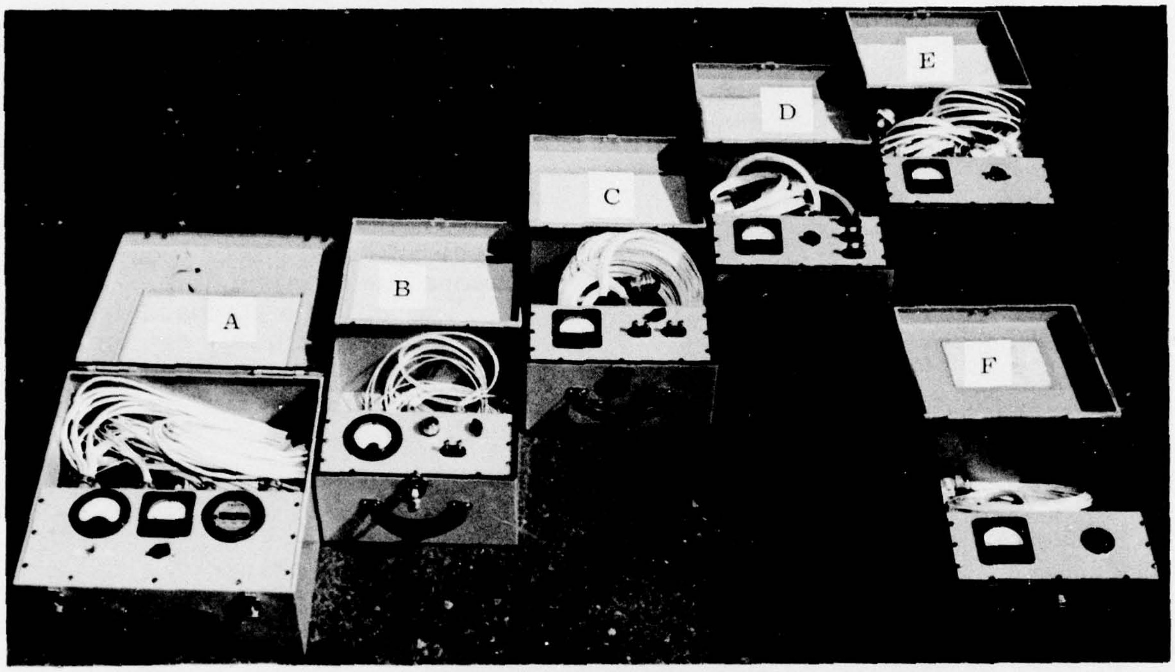

Figure A-34. Test units for helicopter and ship-or-shore equipments.

A. Test unit for helicopter equipment: This unit when interconnected with the sonar generator set (unit No. 7) measures the voltages and currents of input and output of the two dc generators and the voltage of the ac generator. A chart in the cover of the test unit lists the tests to be made and correlates them with the selector switch position. These values are indicated in terms of per cent of normal by one of three meters on the panel of this unit. A second meter (thermo-ampmeter), indicates the ac generator load current, while a third (reed type frequency meter) indicates the frequency of the ac generator.

B. Test unit for helicopter equipment: This unit when connected to the sonar unit No. 1 measures the current to the projector by means of a thermo-ampmeter located on its panel. Switching is provided to transfer the projector power to a dummy load located in the test unit. This allows testing of the sonar power amplifier independent of the projector and aids in locating malfunction. GR terminals are provided on the test unit for connection of an oscilloscope to examine the waveform of this signal.

C. Test unit for helicopter equipment: This unit, when interconnected with sonar control unit No. 2, measures the modulation signals and control voltages, which are all either generated in or pass through the sonar control unit.

A chart in the cover lists the tests to be made and correlates them with the selector switch position. These values are indicated in per cent on the panel meter.

The azimuth signals are brought out to GR terminals on the front panel for external tests of phase and waveform.

D. (See fig. A-33)

E. Test unit for helicopter equipment. This unit when interconnected with the data transmitter generator (unit No. 12) measures the voltage and currents of inputs and outputs of the two dc generators and the output of the stabilized filament supply.

A chart in the cover lists the tests to be made and correlates them with the switch position. These values are indicated in per cent of normal on the panel meter. Division of the power for the separate stages in the data transmitter takes place in the generator unit, permitting separate current readings for these circuits.

F. Test unit for ship-or-shore equipment. The ship-or-shore equipment has test sockets located on the front panels of the chassis to facilitate tests by this unit.

A chart in the cover of the test unit lists the tests to be made and correlates them with the switch positions. The meter reads in terms of per cent of proper values of voltage, currents, and signals.

The shunts to read current, multipliers to read voltage, and rectifiers to indicate signals are located in the chassis to be tested, to simplify the testing of several chassis with the same test unit.

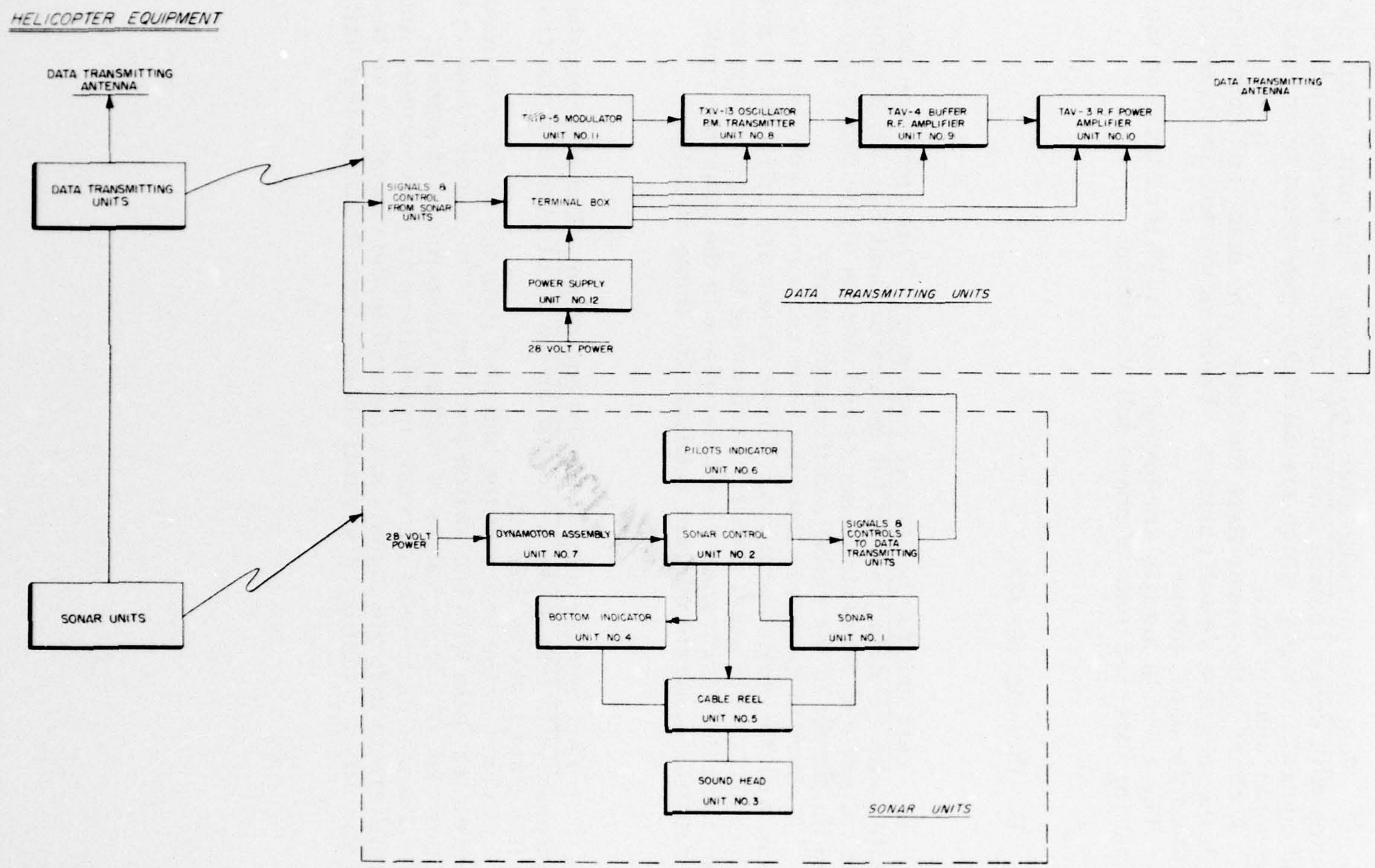

Figure A-35. Block diagram of airborne portion of the AN/UQS-2(XG-1) equipment.

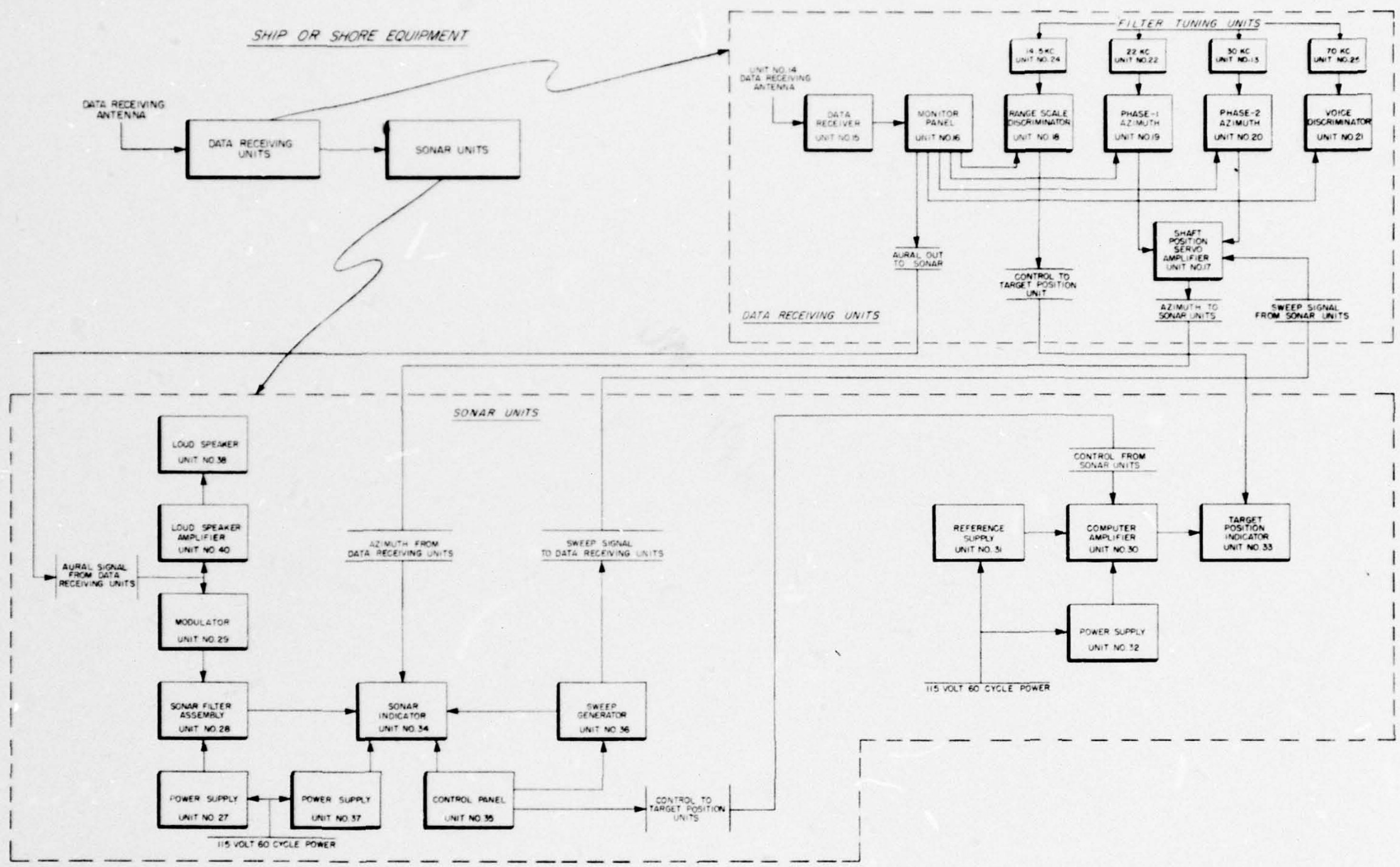

Figure A-36. Block diagram of ship-or-shore station portion of AN/UQS-2(XG-1) equipment.

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CONFIDENTIAL

A combined ship-helicopter sonar equipment was developed utilizing CTFM techniques and using the helicopter as a maneuverable and stable platform to carry the primary target acquisition portions of the system. Raw sonar data are transmitted to a ship or shore station containing the analyzer and display units. Preliminary tests indicated several advantages of the system. Technical evaluation was conducted at the Navy Mine Defense Laboratory, Panama City, Florida, and will be reported separately by that activity.

1. CTFM Sonar
2. Helicopter sonar - Development
3. Model AN/UQS-2(XG-1)
4. Sonar systems - Development

I. Behrendt, J. W.
II. Sampsell, J. W.

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THE AN/UQS-2(XG-1) SHIP-HELICOPTER MINE DETECTING SONAR (C), by J. W. Behrendt and J. W. Sampsell. 51p., 9 December 1960.

CONFIDENTIAL

A combined ship-helicopter sonar equipment was developed utilizing CTFM techniques and using the helicopter as a maneuverable and stable platform to carry the primary target acquisition portions of the system. Raw sonar data are transmitted to a ship or shore station containing the analyzer and display units. Preliminary tests indicated several advantages of the system. Technical evaluation was conducted at the Navy Mine Defense Laboratory, Panama City, Florida, and will be reported separately by that activity.

1. CTFM Sonar
2. Helicopter sonar - Development
3. Model AN/UQS-2(XG-1)
4. Sonar systems - Development

I. Behrendt, J. W.
II. Sampsell, J. W.

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