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FORT TRUMBULL, NEW LONDON, CONNECTICUT

MAINTENANCE MANUAL FOR THE EXPERIMENTAL
LONG DISTANCE SOUND RANGING EQUIPMENT (SOFAR)

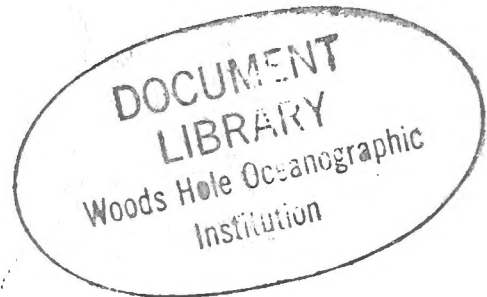
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by

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ABSTRACT

This report, to be used in conjunction with USL Report No. 55 "Long Distance Sound Ranging Equipment (SOFAR) - Installation and Operating Notes," provides complete instructions for maintenance work and performance tests on the SOFAR equipment. The initial alignment, self noise measurements, gain and output calibration, and servicing of the amplifiers are described; the adjustment and operation of the automatic switching unit, graphic level and magnetic tape recorders, chronometer and code switch, and shot arrival time evaluator are explained in detail; and general maintenance instructions are presented.

AUTHORIZATION

U. S. Navy Underwater Sound Laboratory Project D74, authorized under BuShips Problem P-17.1.

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MAINTENANCE MANUAL FOR THE EXPERIMENTAL
LONG DISTANCE SOUND RANGING EQUIPMENT (SOFAR)

SCOPE

1. This report provides detailed instructions for performance tests and maintenance work on the receiving, recording, and timing equipment of a station in an Air-Sea Rescue network. It supplements USL Report No. 55, "Experimental Long Distance Sound Ranging Equipment (SOFAR) - Installation and Operating Notes." In addition, it provides technical data on the station components.

INITIAL ALIGNMENT

2. Before the SOFAR equipment will operate reliably a number of performance tests must be made (see USL Report No. 55, paragraphs 26 and 27). These tests are described in the following sections, each one of which also provides the technical and maintenance data required for its part of the equipment. It may be necessary to repeat these tests during daily operation when servicing of the station components is required or when a defective unit is replaced. The Maintenance Manual, together with electronic test equipment, should therefore be available to station personnel at all times.

3. Before undertaking the preliminary alignment, operating personnel should study Figs. 50 and 38 to familiarise themselves with the location and function of the station components. They should carefully note the system layout and the path of an incoming signal through the receiver-amplifier to the recording and timing equipment.

AMPLIFIER CHANNELS

Description

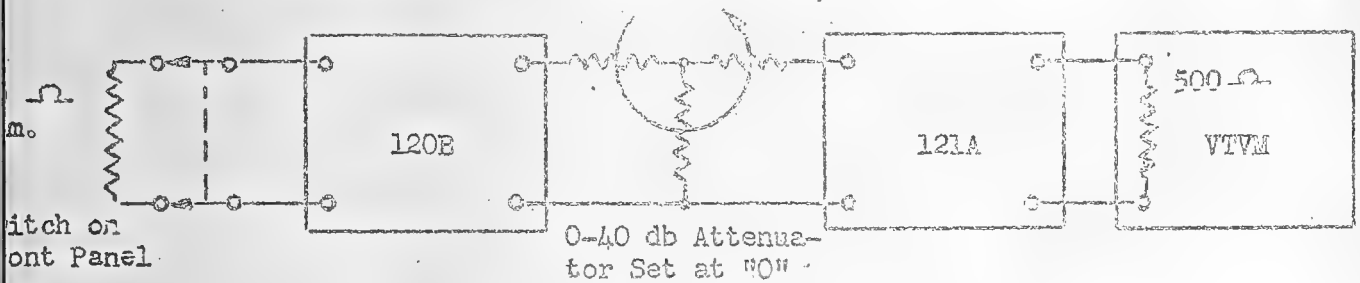
4. Amplifier channels numbers 1 and 2 are located on the two upper shelves of Rack 1 (Fig. 2). They are identical and each consists of a W.E. 120B preamplifier (Fig. 39) working into a 40-db attenuator. The attenuators are controlled by knobs on the left sides of the two upper front panels, one knob labeled CHANNEL NO. 1 VOLUME and the other labeled CHANNEL NO. 2 VOLUME. Each attenuator is followed by a W.E. 121A line amplifier (Fig. 40). The amplifiers are shock-mounted and should float freely. In operation, one of the channels amplifies the signal from the hydrophone before it is applied to the recorders and the other channel is in stand-by.

5. The top panel of Rack 1 contains five male Cannon receptacles labeled HYDROPHONE NO. 1, HYDROPHONE NO. 2, etc. Five hydrophone circuits are permanently connected to these receptacles by the hydrophone terminal strip located on the upper right-hand side of Rack 1 (Fig. 2). A protective cover which acts as a magnetic shield is provided for this terminal strip. On the front panel below the male Cannon receptacles are two female Cannon receptacles labeled CHANNEL NO. 1 and CHANNEL NO. 2. Jumpers connect these receptacles to the hydrophones, making it possible to connect any one of the five hydrophones to either channel.

6. Between the male and the female Cannon receptacles are two lever-action switches, one for each channel. These switches are spring-loaded to return automatically to their central positions. When centered, each switch connects the female Cannon receptacle below it to its channel; when pushed up, it lifts the hydrophone from the channel input and replaces it with a 600-ohm terminating resistor which is used for self-noise measurements; and when pushed down it again lifts the hydrophone and connects the channel input to a set of binding post terminals on the panel labeled SIG. GEN. IN. Since these switches automatically return to the center position, a hydrophone is always connected to each channel unless one of the switches is actuated.

Self-noise Measurements

7. Since self-noise, generated within the amplifier channel, may alter the signal characteristic or mask the signal and prevent clear reception, it is necessary to measure each channel to determine that self-noise is at a minimum. This should be done as part of the initial alignment and should be repeated each day. Sketch 1 illustrates the circuit to be used for the first step in this test. Remove the Cannon output plug from the 121A



Sketch 1 - First Step in Self-Noise Measurement

amplifier (marked OUTPUT and NO. 1 CHANNEL 121 at the back of Rack 1, top panel, or OUTPUT and NO. 2 CHANNEL 121 at the back of panel 2 from the top). In its place connect a vacuum tube voltmeter terminated in 500 ohms and adjust the channel volume control to 0. Push the channel input switch for

the channel under test to 500 Ω TWM. The voltmeter should then read at least .056 volts, or 25 db below 1 volt. If this value is not obtained noise is either being generated within the channel amplifier or is being picked up from some external source.

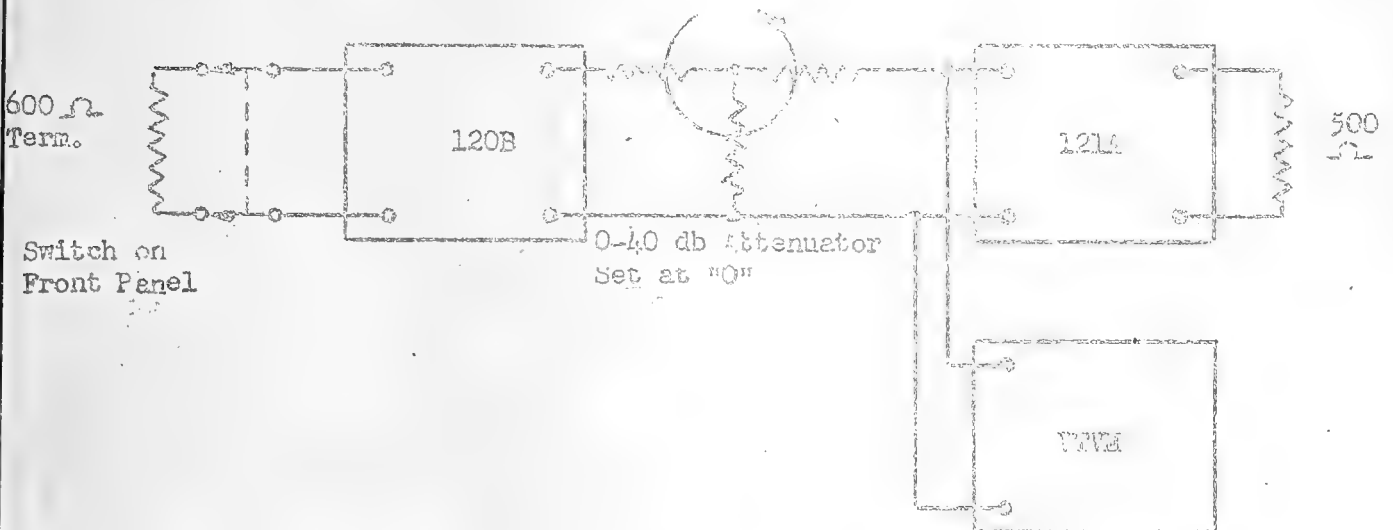
8. If noise is present remove the rear end plate from the 121A amplifier chassis of the channel under test and disconnect the input connections, which are the right-hand red and blue leads. Bridge a 500-ohm resistor across the input terminals, as shown in Sketch 2. The voltmeter should be



Sketch 2 - Second Step in Self-Noise Measurement

left connected as in Sketch 1. The meter will now read the noise level of the 121A amplifier alone. This should be at least .006 volts, or 42 db below 1 volt.

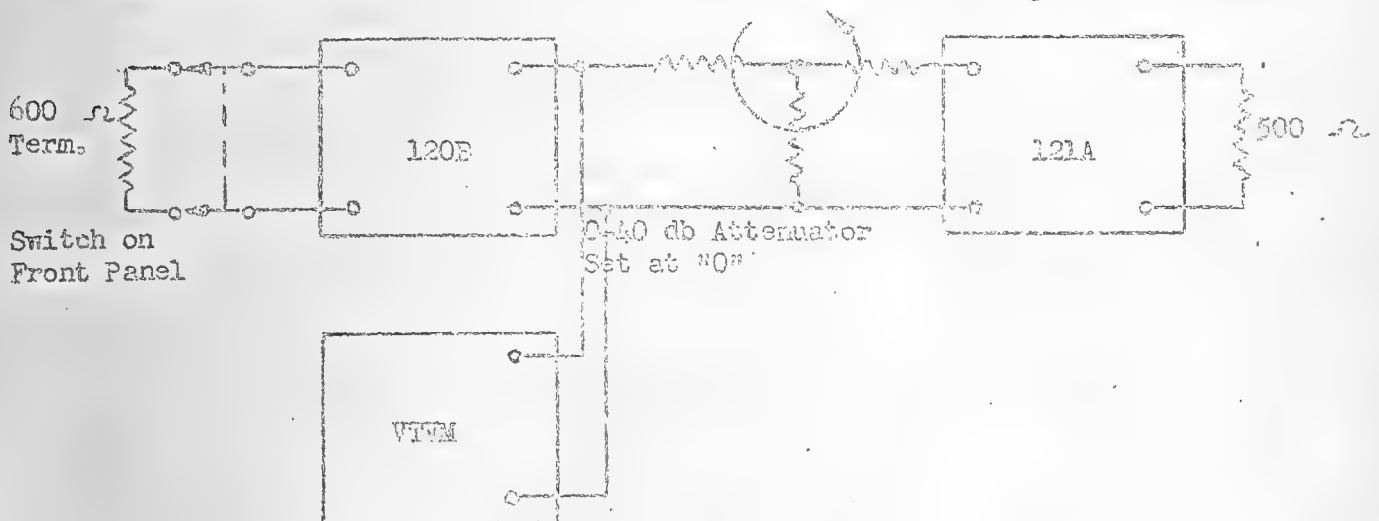
9. If the 121A amplifier is not the source of the noise the 120B preamplifier and the 40-db Daven potentiometer should be checked. Sketch 3 illustrates



Sketch 3 - Third Step in Self-Noise Measurement

the circuit to be used. Reconnect the 121A input leads after removing the 500-ohm resistor and remove the voltmeter from the 121A output, replacing it with 500 ohms. Connect the voltmeter across the input leads to the 121A amplifier, thus bridging the system. Push the proper channel input switch up into the 121A position. With the channel volume control at the 0 position the voltmeter should read at least .00008 volts or 82 db below 1 volt.

10. The next step, in case the noise has not been located, is to eliminate the Daven 40-db attenuator as shown in Sketch 4 by removing the rear end



Sketch 4 - Fourth Step in Self-Noise Measurement

plate of the 120B amplifier and disconnecting the output leads (left-hand red and blue leads). When the unterminated vacuum tube voltmeter is now connected across the output of the 120B preamplifier it should read .00008 volts as before, or 82 db below 1 volt.

120B Amplifier

11. If noise is present in the channel amplifiers its source will usually be in the 120B preamplifier, the input stage of which is very susceptible to hum pickup. Care should be exercised in grounding this amplifier, carrying the cable shields to ground if necessary. It may also be necessary to run a ground wire from Rack 1 to a good external ground to obtain minimum noise. This will ground all three racks. Note (Fig. 39) that an R.F. filter has been provided to suppress radio-frequency interference and that a 618B W.E. input transformer (T-101) has been used to obtain maximum low-frequency response. The normal over-all gain of this amplifier is 35 db and the normal undistorted output is approximately 5 volts.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that this is crucial for ensuring transparency and accountability in the organization's operations.

2. The second part of the document outlines the various methods and tools used to collect and analyze data. It highlights the need for consistent and reliable data collection processes to support informed decision-making.

3. The third part of the document focuses on the role of technology in data management and analysis. It discusses how modern software solutions can streamline data collection, storage, and reporting, thereby improving efficiency and accuracy.

4. The fourth part of the document addresses the challenges associated with data security and privacy. It provides guidelines for implementing robust security measures to protect sensitive information from unauthorized access and breaches.

5. The fifth part of the document discusses the importance of data quality and integrity. It outlines strategies for identifying and addressing data errors, ensuring that the information used for analysis is accurate and reliable.

6. The sixth part of the document explores the various applications of data analysis in different business contexts. It provides examples of how data insights can be used to optimize operations, improve customer service, and drive strategic growth.

7. The seventh part of the document concludes by summarizing the key findings and recommendations. It emphasizes the ongoing nature of data management and the need for continuous improvement and adaptation to changing business requirements.

12. Fig. 30 shows the frequency response of the 120B amplifier. Its tube complement is as follows:

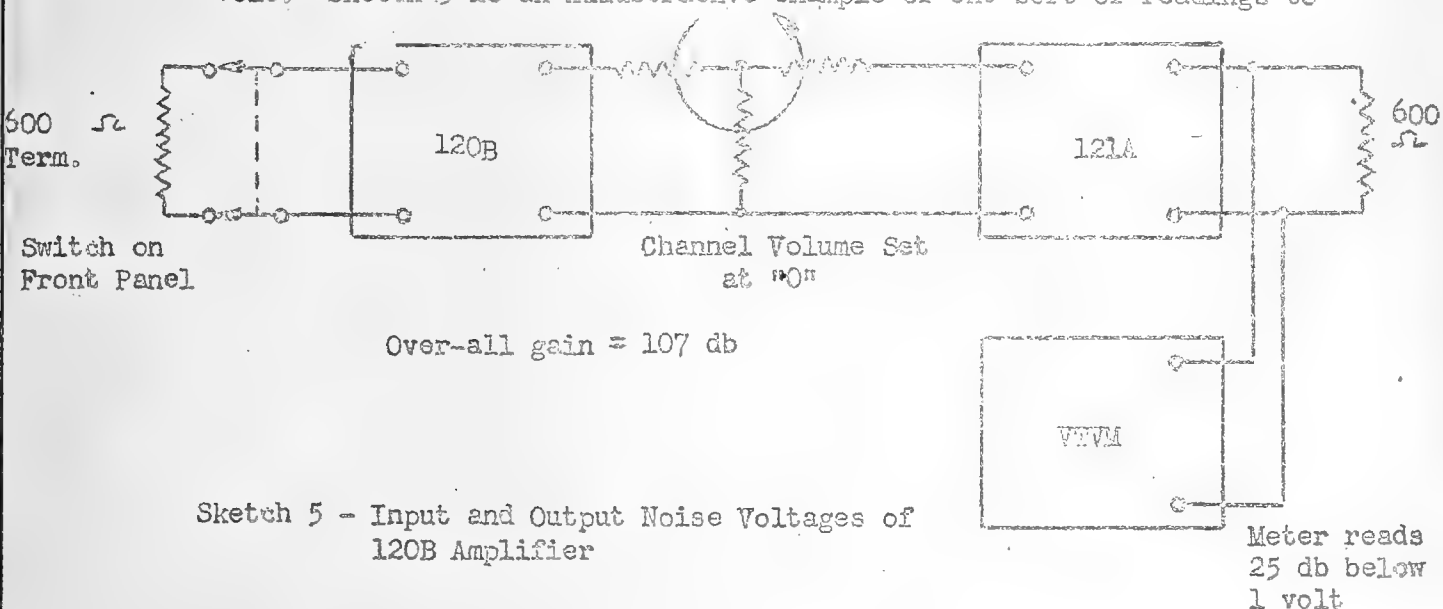
120B Amplifier: One 6C6, replaceable with type 1603 or 77

: One 1620, replaceable with type 6J7 or W.E. type 348A

Input and Output Noise Voltages of 120B Amplifier

13. To determine the input and output noise voltages of the 120B pre-amplifier using a 121A amplifier and a vacuum tube voltmeter, apply the following procedure:

- (a) Set channel volume control at 0.
- (b) Connect a Ballantine or Hewlett-Packard vacuum tube voltmeter across the output socket of the 121A amplifier and place a 600-ohm terminating resistor across the meter terminals.
- (c) Determine the over-all gain of the 120B and the 121A amplifiers together. This should be between 106 and 108 db.
- (d) Throw the channel input switch to 600 Ω TERM and observe the voltmeter reading across the 121A output. Evaluate this reading, using one volt as the reference point.
- (e) To determine the input noise to the 120B amplifier add the voltmeter reading to the actual gain of the system referred to one volt.
- (f) To determine the output noise of the 120B amplifier, subtract the voltmeter reading from the gain of the system referred to one volt. Sketch 5 is an illustrative example of the sort of readings to



Sketch 5 - Input and Output Noise Voltages of 120B Amplifier

be expected. In this case, the input noise = 107 db + 25 db = 132 db down, and the output noise = 107 db - 25 db = 82 db down.

121A Amplifier

14. The 121A amplifiers are provided with 500-cycle low-pass filters to improve their signal-to-noise ratios. A 1500-cycle and a 200-cycle filter are included in the spare parts and may be substituted for the 500-cycle filter if operating conditions require a change. The installed filter is located on the right rear corner of each 121A amplifier. Its pass-band is stamped on the top, as 500 C₅₀ L.P.F., etc. Figs. 29, 36 and 37 are response curves of the three filters.

15. The normal over-all gain for the 121A amplifier is 75 db and the normal undistorted output is approximately 20 volts. The tube complement is as follows:

121A amplifier : Two 1620's

: One 6F6, replaceable with W.E. type 349A.

Servicing

16. Extra precaution should be observed if the input tube of the 120B preamplifier (type 1603 or 6C6) requires replacement. It has been found that considerable variation in inherent noise level can be caused by tubes picked at random from stock. When replacing this tube, try several stock tubes, using the one giving the lowest noise reading. Use the test circuit of Sketch 1, watching the output meter for the lowest possible reading. Exercise care in replacing all other tubes as well.

17. If further servicing is necessary remove the cables connected to the amplifier (either the 120B or the 121A). All cables except the filament leads can be reached by removing the rear end plate; the filament leads are reached by removing the front panel of the rack cabinet. Then take the entire chassis out of the Rack by removing the four nuts holding the chassis and the Lord Mounts to the tray. The nuts are located under the tray. When the amplifier has been serviced and is replaced make certain that the cables do not interfere with the shock mounting and that the amplifier floats freely.

Gain and Undistorted Output Measurements

18. At least once each week each channel should be checked for over-all gain and maximum undistorted voltage output. To do this a signal generator should be connected to the terminals on the top panel of Rack 1 marked SIG. GEN. IN. Pushing the proper channel control switch down will place the signal generator across the input of the channel under test. The signal

generator should be terminated with 600 ohms and a shielded cable should be used between the generator and Rack 1. A constant signal voltage at least as low as .0001 volts should be fed into the channel for frequencies between 30 cps and 500 cps.

19. The wave shape of each frequency should be observed on an oscilloscope connected across the system bus at any convenient point, such as the signal input terminal strip to the automatic switching unit, the signal input to either graphic level recorder, etc. For clear measurement both the channel volume control and the BUS VOLUME control should be set at 0. The over-all gain for each channel should then be at least 105 db above the input voltage and no distortion should be evident.

Channel Amplifier Power Supplies

20. Each channel has its own plate and filament supply. The AC mains for these supplies are separately fused on the fifth panel from the top of Rack 1. All the fuses on this panel except those labeled 7 VOLT DC NO. 1 and TIME TONE SUPPLY are 3-ampere Little Fuses. The AC to Racks 2 and 3 is supplied through the 7 VOLT DC NO. 1 and the TIME TONE SUPPLY fuses. These fuses are therefore 5-ampere Little Fuses.

21. The channel power supplies are identified from the back by the labels 18A #1 CHANNEL, 18A #2 CHANNEL, 7-VOLT DC #1 CHANNEL, and 7-VOLT DC #2 CHANNEL. The Western Electric 18A power supply (Fig. 41) is the plate supply, designed to furnish 250 volts DC to both amplifiers of one channel. The plate supply terminal strip is behind the chassis end plate while the 110-volt AC input is located at the front end of the 18A power supply. The 18A uses a 274A rectifier which can be replaced by a type 80 tube. Note that the 18A amplifier is shock-mounted. The negative (B-) side of the high voltage supply should be grounded at the 120B and the 121A terminal strips.

22. The 6.3 volt AC filament supply from the 18A is not used, and instead a 7-volt DC power supply (Fig. 42) supplies the 120B and 121A filaments. This power supply uses a selenium rectifier. An "on-off" switch is mounted on the rear end plate of each of the 7-volt chassis so that the supply which is not in use may be turned off, prolonging the life of the rectifier. If constant use over a long period of time considerably decreases the output of the rectifier it can be increased by changing the 110-volt AC connection from tap 4 to tap 3 on the rear terminal strip. With the AC connected to tap 4 the normal filament voltage is 6.3 volts under load; if this voltage is slightly high it can be reduced by adjusting the variable resistor in the heater supply, mounted on the rear terminal strip. This resistor normally has a value of one ohm. The negative terminal of each 7-volt supply is grounded to the chassis. Note, in later units the one ohm resistor is located on the under side of the chassis.

23. If the selenium rectifier develops mechanical noise as a result of

loosening of the rectifier plates the noise can be remedied by tightening the bolt holding the plates together.

CAUTION! Condensers having a total capacity of 12,000 microfarads are connected across the output of the 7-volt DC supply. Although these are low-voltage condensers, they nevertheless store considerable energy over a long period of operation. Therefore handle filament leads with care, even after the unit has been turned off for some time.

TIME TONE AMPLIFIER

Description

24. The time tone amplifier (Fig. 43) is the distribution center for the entire SOFAR receiving system, as can be seen in Figs. 3 and 12. It is located on the third shelf from the top of Rack 1. The output of whichever channel is in use is fed through the BUS VOLUME control to this amplifier and is then distributed from the system bus to the various recorder units by means of selective switching.

25. The time tone amplifier contains:

(a) A headphone monitor amplifier for monitoring the signal on the bus or the signal played back from the magnetic tape recorder. A low-frequency rise equalizer counters the falling off of the headphone response at low frequencies. A jack on the front of the third panel from the top of Rack 1 is fed from the monitor amplifier.

(b) A 3-kc oscillator, the output of which is controlled by the Hamilton break-circuit chronometer, to time index the magnetic tape recorders.

(c) A 2.5-kc to 3.5-kc band-pass filter used to separate the 3-kc time-tone index from the recorded signal when the magnetic tape recorder is played back onto the high-speed graphic level recorder.

(d) A time-tone amplifier and rectifier which amplifies the 3-kc tone separated by the band-pass filter and converts it into DC. A volume control for this amplifier is located on the right rear corner of the chassis and is adjusted to provide good time indexing on the high-speed graphic level recorder when the magnetic tape recorder is played back.

(e) A time-tick pulse amplifier which operates the time indexing relays on the sound level recorders whenever a pulse is initiated by the break-circuit chronometer. The second stage of this amplifier

(V-102 on Fig. 43) operates the index relay of the slow-speed recorder when switch S-101 TO RECORDER is in either the BUS or the MIRROR position. The first stage (V-101 on Fig. 43) is energized by the chronometer when switch S-101 TO RECORDER is in the BUS position, and by the rectified 3-kc pulse from the magnetic tape recorder when S-101 is in the MIRROR position.

(f) A 1.5-kc low-pass filter which passes only the signal being played back from the magnetic tape recorder, allowing it to be recorded on the high-speed graphic level recorder.

Servicing

26. Normally, the only servicing required by the time tone amplifier will be occasional tube replacement. If more extensive servicing is necessary the amplifier can be taken from the rack by removing the four screws holding it to the tray. The control knobs must be removed from the front, but it is unnecessary to remove the front panel. The time tone amplifier employs three 6J5 tubes, two 6SJ7 tubes, two 6V6 tubes, and one 6X5 tube.

27. The chronometer time control and phone monitor power supply (Fig. 44) furnishes all operating voltages to the units described in paragraph 24. It is located on the left side of the second shelf from the bottom of Rack 1. It employs a two-section filter with condenser input and supplies a 260-volt DC plate voltage and a 6.3-volt AC filament voltage. Negative bias voltage is available between terminals 16 and 17 and is controlled by the break-circuit chronometer to obtain time indexing on the original tapes of the sound level recorders. Bias voltage is varied by means of R-202, located on the under side of the power supply.

28. The 110-volt AC input to this power supply is fused at 5 amperes on the front panel of Rack 1 by the center fuse labeled TIME TONE SUPPLY. This fuse also controls the 110-volt AC for Rack 2. To remove the power supply for servicing, disconnect the cables to it (all are at the rear of the chassis) and remove the four screws located under the tray beneath the four corners of the chassis. This power supply uses a single 5U4 tube.

MONITOR AMPLIFIER AND LOUD-SPEAKER

29. The 124A monitor amplifier, used only to drive the monitoring loud-speaker, is located on the bottom shelf of Rack 1. Its input comes from the Cannon receptacle marked MONITOR on the rear of the Time Tone amplifier chassis. A SPEAKER VOLUME control to regulate the output level from the speaker is located on the bottom front panel of Rack 1.

30. The 110-volt AC input to the monitor amplifier is fused at the rear of the amplifier chassis (Fig. 3). In case of power failure in the amplifier, check this fusing. The chassis is bolted to the tray by four bolts at the four corners on the top of the chassis. These bolts pass through the chassis and screw into the tray.

31. Fig. 45 is the circuit schematic of the 124A amplifier. A low-frequency rise equalizer compensates for the falling off of the monitor speaker response at low frequencies. The amplifier's normal over-all gain is 50 db; its maximum undistorted power output is approximately 12 watts; and its output noise level should be about 35 db below one milliwatt.

32. The 124A amplifier uses the following tubes:

- 2 type 6J7 (replaceable with Western Electric type 348A)
- 2 type 6L6 (replaceable with Western Electric type 350B)
- 1 type 5U4 (replaceable with type 5T4 or Western Electric type 274B)

33. The monitor speaker, a 15-inch Altec Lansing permanent magnet speaker housed in a bass reflex cabinet (Fig. 28), should be located to suit the convenience of the station operator. The output of the 124A amplifier, available at the rear of Rack 1 at the right-hand side of the amplifier chassis (Fig. 3), is connected to the speaker by a cable furnished with the speaker. The monitor provides an excellent and rapid means of checking for channel noise, since any change in the background noise characteristic of the channel being used will be immediately heard by the operator.

AUTOMATIC SWITCHING UNIT

Operation

34. When a signal arrives the automatic switching unit (Figs. 17 and 18), located at the top of Rack 2 (Fig. 6), automatically alerts the station operator and switches on the motors and time index control relays of the two graphic level recorders. Fig. 46 is a schematic diagram of the Automatic Switching Unit. The unit employs two stages of amplification, the second of which works into a tuned circuit that is resonant at 175 cycles. This circuit controls the grid of a type 2050 thyatron tube. Normally, the DC grid voltage on the thyatron, which can be varied from -32 volts to 0 volts by means of a control marked ~~SENSITIVITY~~ on the front panel (Fig. 17), is set at such a value that about -1 to -2 volts DC are on the grid. This voltage just suffices to block the tube and keep it from firing.

35. When a signal containing energy building up to 175 cycles is received it is amplified and passes through the tuned circuit to the grid of the thyatron. As soon as the magnitude of the amplified signal exceeds the predetermined voltage, the thyatron fires and plate current flows, energizing



a relay coil. The relay completes the 110-volt AC circuit to a female receptacle located on the rear of the switching unit chassis and marked

36. The relay also completes the 110-volt AC circuit to a cord which is plugged into the strip at the rear of the sound level recorder directly below the automatic switching unit. This receptacle supplies power to the sound level recorder motor and to the AC relay controlling the transfer of power to the time indexing system. A second cable bridges across the twist-lock receptacle cable at the rear of the sound level recorder and carries the AC current to the motor and AC control relay of the graphic level recorder in Rack 3.

37. Another cable at the back of the switching unit chassis (P-601 in Fig. 18) supplies 110 volts AC to the automatic switching unit which has a self-contained power supply built on its chassis. The power switch (S-602) is on the front panel (Fig. 17). A voltage regulator tube prevents fluctuations in voltage from firing the unit.

38. The signal input comes from the system bus and is led in through a terminal strip marked INPUT on the right rear corner of the chassis (Fig. 18). A VOLUME control, located on the left of the front panel (Fig. 17), controls the level of the signal input into the unit. Normally, this control is placed close to its maximum setting.

Sensitivity Adjustment

39. The sensitivity of the Automatic Switching Unit is adjusted as follows. After a 15-minute warm-up period, the SENSITIVITY control (Fig. 17) is rotated clockwise until the thyatron fires. It is then turned back very slightly and the unit is reset. The maximum sensitivity will be just below the point where self-noise fires the thyatron and at the point where the operator can reset the unit without reducing the sensitivity further. The sensitivity will probably be close to 9 on the scale when this adjustment is achieved.

Resetting

40. To reset the unit after it has fired, push in the PUSH TO RESET button on the front panel (Fig. 17) and hold it in for about five seconds to deionize the 2050 tube. If the tube fires again when the reset button is released, reduce the sensitivity setting slightly and repeat the resetting.

Servicing

41. The automatic switching unit is bolted to the front panel and can be

removed for servicing by removing the front panel retaining screws. The unit contains two 6J5 tubes, one 2050 tube, one VR150 tube, and one 5Y3 tube.

GRAPHIC LEVEL RECORDERS

Description

42. The two Power Level graphic level recorders are located in the center sections of Racks 2 and 3 (Figs. 7 and 10). Fig. 47 is a schematic diagram of a recorder circuit. These recorders provide a visual or graphic recording, on waxed-paper tape, of the shot arrival as received at the hydrophone and amplified through either channel. The tapes are time indexed along the right-hand edge by the amplified time impulses from the break-circuit chronometer.

43. Both recorders are mounted on extension tracks so that they may be pulled out beyond the normal cabinet panel face (Fig. 8). The upper half of each recorder panel folds back on the lower half, concealing the hinge and exposing the controls of the recorder. Two knobs at the front of the chassis facilitate sliding the recorders out until the latches on the sliding tracks drop into stops. To return the recorders to the cabinet press down on the latch handles on the moving slides and push easily on the whole unit until it moves back into the cabinet.

44. The graphic level recorder in Rack 2 is normally referred to as the "slow-speed" recorder and normally operates at a paper speed of five mm. per second. The graphic level recorder in Rack 3 is normally referred to as the "high-speed" recorder and operates at ten mm. per second, providing a time base twice the length of that of the "slow-speed" recorder. The "high-speed" recorder is used to record the play-back of either of the two magnetic tape recorders.

45. When the signal strength of a shot arrival rises above the background noise the automatic switching unit will fire, turning on the motors of both graphic level recorders and actuating the time indexing stylus. If the "high-speed" recorder has its AMP control switch turned off, however, and its motor switch on MAN., its motor will not be started.

Explanation of Operation

46. A careful analysis of the circuit connections will explain the operation of the "slow-" and "high-speed" graphic level recorders. The two switches on the right front corner of each recorder chassis marked AMP and MOTOR control the recorder operation (Fig. 23). When the MOTOR switch is in the MAN. position the drive for the recorder paper and scribe will not function unless the AMP switch is ON, thus providing 115 volt 60 cycle AC to the recorder amplifier and the recorder motor. When the AMP switch is off, no power will be supplied to either the amplifier or motor and the recorder will not respond when the automatic switching unit fires.

47. When the **STOP** switch is in the **STOP** position, the motor power supply is controlled by the automatic switching unit which will energize the motor even if the **STOP** switch is off. This will cause paper to be fed through the recorder, even though no record will be made on it. In the **STOP** position, however, the jewelled pilot lamp will glow, the tubes will be heated, and the recorder will operate either manually or by the action of the automatic switching unit.

48. A study of Fig. 38 will show that the input to the "slow-speed" graphic level recorder is permanently bridged across the system bus and that except for the reception of broadcast time signals, it cannot be energized from any other source. The "high-speed" recorder, on the other hand, can be energized from the system bus or from either magnetic tape recorder, and may also be used to record broadcast time signals. The selection of **RECORD** or **MIRROPHONE** (microphone) and of **MIRROPHONE NO. 1** or **MIRROPHONE NO. 2** is controlled by **RECORD** and **MIRROPHONE** on the front of the third panel from the top of Rack 1 (Fig. 2), the time tone amplifier chassis.

Speed Controls

49. Located to the left and slightly back of the power control switches is a gear box with two indicator knobs on its top (Fig. 23). The left knob is labeled **WRITING** and controls the speed with which the scribe moves across the tape. In the center or 0 position it disengages the scribe; turned to the left it gives **FAST** operation and to the right **SLOW** operation. The right knob is labeled **PAPER** and also has a center or neutral position, a left position of $\frac{5}{10}$, and a right position of $\frac{50}{10}$.

50. With these two knobs paper-tape delivery speeds of 1, 5, 10, and 50 mm. per second can be obtained. The normal position for the "slow-speed" graphic level recorder in Rack 2 is with the **WRITING** control on **FAST** and the **PAPER** speed control on $\frac{5}{10}$. This combination gives a resulting paper tape speed of

5 mm per second. The "high-speed" graphic level recorder in Rack 3 is normally used with its **WRITING** control on **SLOW** and its **PAPER** speed control on $\frac{50}{10}$.

This combination gives a resulting paper tape speed of 10 mm per second.

51. Although it is possible to use the **WRITING** control to start and stop the paper feed, the controls should in general be set as described above before the recorder is turned on. If the **WRITING** control is used for starting and stopping, the time indexing space interval should be measured to see that it remains at 5 or 10 mm per second; if the interval changes the time evaluation will be impaired. Too much force exerted on the control knob to effect clutch engagement may introduce a slight bind in the paper tape feed and affect the spacing of the time indexes. This difficulty is not so likely to occur with the 10 mm per second speed setting as with the

5 mm speed. The shot arrival time evaluator (see paragraphs 108 through 114 below) should be used to check the time index interval for both speeds. Do not disengage the PAPER speed selector while the machine is operating or damage to the gear train may result.

Inserting Paper Tape

52. Just to the left of the clutch control system is the index relay and writing stylus carriage assembly (Fig. 23). Normally, the carriage is latched into place, the latch control lever being just to the right of the relay coil. When it becomes necessary to insert a new roll of paper, the carriage assembly must be unlatched by gently pulling the latch control lever to the left and at the same time raising the assembly which is pivoted at the left-hand side. To prevent the writing pen from dropping from its guide, with possible injury to its sapphire writing tip, it must be set at 20 on the writing scale before the carriage is lifted. Place a new roll of paper on the spindle behind the carriage, being sure that the holes along the paper edge are properly lined up over the drive sprockets located in front of the carriage assembly. When the paper is in place, gently lower the carriage assembly and make certain that it latches properly. It will be noted that along the lower side of this carriage assembly is a row of short, pointed pins which are spring loaded (Fig. 24). These pins engrave equally spaced db division lines along the length of the paper, so that the level of the signal with respect to background, etc., can be determined.

Protective Relay

53. Mounted on the upright metal strip which shields the tubes from the paper-drive system just described is another relay. This relay operates on 115 volts AC and controls the indexing relay on the carriage assembly. Its coil is connected across the recorder motor and it is thus activated by the MOTOR switch. It was installed to prevent the indexing relay from operating when paper is not being fed through the machine, causing the indexing stylus to dig into the stationary paper and stopping the paper from feeding freely at the arrival of a shot. Make certain that the cables to this relay do not impair the paper tape feed.

Changing the Signal Input Potentiometer

54. To the left of the carriage assembly is a box with two small knurled knobs and two binding posts at one end. This is the signal input potentiometer, across which the signal from the bus is applied. The potentiometer can be removed by unscrewing the two knurled fastening knobs and lifting up. Pins are located on the bottom of the potentiometer to facilitate replacement. When changing the potentiometer do not screw the knurled knobs too tightly or the sliding arm will bind.

55. The recorders are shipped with 0-75 db potentiometers installed. This means that the db lines inscribed on the recording paper are 7 1/2 db apart, giving a total of 75 db for the writing width of the paper. A 0-50 db potentiometer is included in the spare parts for each station. This should be used only when very weak signals are being received. When the 0-50 db potentiometer is used the lines on the recording paper represent steps of 5 db each, or a total of 50 db for the writing width of the paper. Care should be taken when handling the potentiometer to see that the contact train, located on the underside, is not damaged in any way. The slider arm contact moves across this train to vary the potentiometer resistance. Each week both contact train surface and slider arm surface should be cleaned with carbon tetrachloride to keep contact resistance at a minimum.

Switch Box and Amplifier

56. Directly in front of the signal-input potentiometer is a grey box with two phone jacks and a switch. The left jack receptacle labeled EDS MONITOR is connected across the output of the channel in use, and is for monitoring purposes. Only crystal headphones should be used here. The other jack receptacle labeled RADIO TIME allows the output of a radio receiver to be fed to the recorder for recording radio time signals from the Bureau of Standards standard frequency station WWV on the recorder tapes when making a chronometer correction. While this is being done, the spring-loaded switch between the jacks must be held in the RADIO TIME position. This eliminates all signal except that from the radio receiver, which may then be read against the break-circuit chronometer time ticks.

57. Across the rear of the chassis behind the shield supporting the 115-volt AC relay are the recorder-amplifier tubes, with the exception of two which are located under the chassis.

Sensitivity Adjustment

58. On the top of the chassis between the DC Milliammeter and the AC power plug is a screw-driver adjustment labeled SENSITIVITY. This controls the sensitivity of the writing pen, and normally is turned fully clockwise for maximum sensitivity.

Checking for Erratic Behavior

59. The meter, a DC Milliammeter (10-0-10), is a signal-indicating device in the writing circuit. If the mechanical operation of the recorder is correct the meter will read about 0 when a steady signal is applied. With the motor turned off and the intensity of the input signal varied, the meter should deflect to both sides of the center position approximately equally. This indicates that the amplifier circuit of the recorder is functioning normally.

60. If this check or erratic operation indicates that the sound level recorder is not functioning properly and the cause is not obvious (i.e., a defective tube, defective condenser, etc.), the solenoid-wound, magnetic clutch coils should be tested for continuity. Reference to Fig. 47 will show their circuit function and give their DC resistance as approximately 2200 ohms. Their physical location in the recorder is on the under side of the chassis, just above the selective clutch box. They are terminated near the 6H6 diode rectifier sub panel and are accessible for continuity checks.

61. At the rear of each shelf containing a graphic level recorder is a metal strip on which terminals are mounted. To these are brought the cables containing the signal, the time index pulses, and the 115 v AC supply controlled by the automatic switching unit.

Maintenance

62. Keep paper feed sprocket and guide rails free from accumulation of wax and paper perforation chips. Clean them after use each day or the wax will harden and interfere with the paper feed on restarting the machine. Oil holes are indicated for lubrication of the motor and clutch assembly. Use oil sparingly.

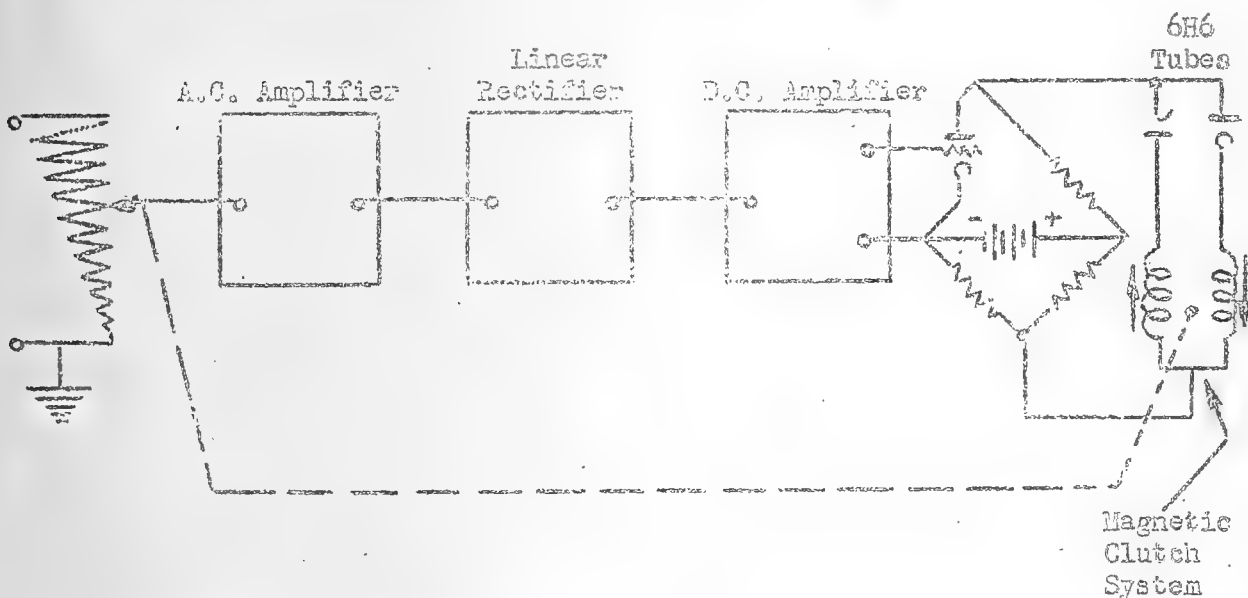
63. If it is desired to remove a graphic level recorder from its shelf this must be done from the rear. The front panel must be removed at the hinge mounting fastened just inside the slide track on each side, the rear-terminal strip panel must be detached, and the unit must be pushed out through the back, while the latches located in each side of the sliding track are held up.

Basic Construction and Operation

64. A brief description of the basic construction of the Power Level graphic level recorder made by the Sound Apparatus Co. may be of assistance in maintaining this instrument in proper operating condition. It has three major parts:

1. Input Potentiometer. This is the measuring device; it determines the db. per division scale, and the dynamic range of the instrument.
2. Automatic Operating Mechanism. This consists of the AC amplifier, the linear rectifier, and the DC amplifier which controls a pair of motor-driven magnetic clutches operating the input potentiometer slider and the writing scribe.
3. Recording Mechanism. This consists of the selective feed paper tape drive system, and a clutch system to control the writing speed of the writing scribe.

65. Sketch 6 shows schematically the relationship of these major parts.



Sketch 6 - Schematic - P.L. Graphic Level Recorder

The function of the recorder is as follows. When a signal voltage is impressed across the input potentiometer it is amplified by the AC amplifier and converted to pulsating DC by the linear rectifier. This variable DC voltage, after being further amplified by the DC amplifier, is impressed across a bridge circuit which controls the current in the solenoids of the magnetic clutch and energizes a train having the input potentiometer slider at one end and the writing scribe at the other. The input potentiometer functions to maintain the bridge in balance, thus causing the writing scribe to follow signal input variations. The scribe engraves a record of its movement across a waxed-paper tape.

66. Each Power Level graphic recorder uses the following tubes: 2 type 6SF5, 1 type 6R7, 2 type 6N7, 2 type 6H6, 1 type 6X5.

TIME INDEXING MECHANISM

67. The time indexing mechanism which is a part of each graphic level recorder is so important to the successful operation of the monitor station that the following section is devoted to its operation and adjustment.

Recorder as Received

68. Fig. 22 is a general plan view of the recorder as received. It is especially to be noted that the gauge plate on the left has no stop, thus allowing the writing scribe to operate to the 0 position.

Altered Recorder

69. Fig. 23 shows an altered recorder with the time indexing mechanism in place. Here a stop plate for the writing scribe has been added. The stop plate must be adjusted so that the writing scribe clears the timing stylus shank. The shank must operate between the 0 db trace and the perforated holes in the tape.

Timing Stylus Mechanism

70. Fig. 24 is a front view of the timing stylus mechanism mounted on the main writing scribe bracket. The spring adjustment for the magnet bar at the top of the relay solenoid is clearly shown at the upper right. The spring tension must be sufficiently light to allow the solenoid to pull the magnet bar freely, and yet return it to the off position without sticking.

71. The position of the magnet bar in relation to the horizontal holding plate is important because the guiding hinge slots in the magnet bar must be free to move in the horizontal plate, and yet must not allow the magnet bar to become disengaged.

72. Fig. 24 also shows the timing stylus shank at the right of the latch lever. This shank makes possible a vertical adjustment for the timing stylus. For this adjustment the lock nut is loosened and the shank is screwed either up or down to permit legible time indexes without tearing the paper. It is very important that the timing stylus be perpendicular to the paper tape. If necessary, the spring on the timing stylus slide bar can be bent to meet this requirement. The tension of the timing stylus slide bar spring against the paper tape is important, but this spring cannot be finally adjusted until all other adjustments are completed.

73. Fig. 24 clearly shows the marking pins below the writing scribe bracket which impress the db lines on the waxed-paper tape. Spring tension on the individual marking pins must be enough to permit legible marking but not enough to tear the paper. Accumulation of wax residue must not be permitted.

Bottom View

74. Fig. 25 is a view of the bottom of the writing scribe bracket with the timing stylus mechanism attached. The upper part of the photograph shows the two terminal screws on which the index relay feed wires terminate. Directly below the terminal screws are the two screws for the horizontal

adjustment of the relay solenoid. By moving the solenoid longitudinally by the use of these screws the tension of the spring extension from the magnet bar can be adjusted to locate the timing stylus shank so that it operates freely in the clearance hole. The ideal position of the armature from the magnet bar is with the gap as small as possible with the sliding bar at the rest position. At the end of the stroke of the sliding bar the timing stylus shank sleeve should just clear the opening in the plate in which it operates. Too much tension either front or back will cause the mechanism to bind.

75. In the lower part of Fig. 25 are shown the two adjusting screws which hold the guide plates for the timing stylus slide bar. The adjustment here allows a crosswise movement of these plates so that both the timing stylus shank and the magnet bar spring can be adjusted centrally with the sliding bar and the writing scribe.

End View

76. Fig. 26, an end view of the relay solenoid, shows the magnet bar with its spring, and the stylus shank with the stylus projecting. It is to be noted that the magnet bar spring just barely clears the side of the main stylus bracket and is also above the slot for the writing scribe guide pin. The end of the magnet bar spring which fits the slide bar must be clear of the slot in which the guide pin of the writing scribe operates.

MAGNETIC TAPE RECORDERS

Location, Use, and Connections

77. The magnetic tape recorders are located in the lower sections of Rack 2 (Fig. 7) and Rack 3 (Fig. 10). Their schematics are shown in Figs. 48 and 49, and on panel and chassis insignia they are referred to as MIRRROPHONES. They consist of an amplifier and a vic alloy-tape magazine.

78. Normally, one recorder is in constant operation. The other is turned on by the station operator to maintain continuous station monitoring after the operating recorder has been switched to HOLD to preserve a shot arrival. The magnetic tape recorder in use and switched to RECORD is constantly recording and erasing; it therefore records the signal in its entirety. Simultaneously, it records the 3-kc pulses from the chronometer time control unit.

79. The signal input lead to each Mirrophone is from the receptacle on the rear of the chronometer time control and phone monitor chassis labeled 2-TO MIRRROP. 1st. STA.-1. It is plugged into the jack receptacle marked SIGNAL INPUT on the front panel of the proper Rack (either Rack 2 or Rack 3, Fig. 6 or 9), and the signal is applied directly to the input of the tape

recorder amplifier. The 3-kc tone pulses are applied to the final stage of the amplifier, the 3-kc input leads being terminated on the two left-hand binding posts of the terminal strip on the rear of the tape magazine. The 3-kc signal lead comes from the receptacle on the rear of the time tone amplifier chassis marked 2-TO MIRROR, 2nd. STA.-1. The two right-hand terminals on the strip mounted on the rear of the tape unit are the magnetic tape recorder output leads. These terminals are connected by cable to the receptacle marked 2-FROM MIRROR.-1 on the rear of the time tone amplifier.

80. During playback, both the signal and the 3-kc indexing as recorded on the tape recorder are fed to the time tone amplifier. Here the shot-arrival signal is separated from the 3-kc signal by a low-pass filter and applied to the input of the high-speed sound level recorder when the switch on the front of the time tone amplifier TO RECORDER is switched to the MIRROR position. The 3-kc tone is filtered out, amplified, then rectified, and finally applied to the time-indexing relay on the high-speed sound level recorder, causing its pulses to reproduce on the paper tape, in its identical relation to the shot signal as recorded originally on the magnetic tape recorder.

Distinction Between Mirrophone and Galtron

81. It is desirable at this point to explain clearly the term "Mirrophone". Actually, "Mirrophone" (Fig. 48) is the Western Electric Company's trade name for their model of the magnetic tape recorder. When construction of the SOFAR station was begun, these were the only types of magnetic tape recorders known to be available; hence, all name plates and references concerning the tape recorders were marked "Mirrophone". However, it was discovered that not enough Mirrophones were available; consequently another type of magnetic tape recorder was obtained bearing the trade name of "Galtron" (Fig. 48).

82. Basically, the "Mirrophone" and the "Galtron" are identical. The tape magazines are alike with these two exceptions:

a. The tape on the "Galtron" is a little longer than that on the "Mirrophone".

b. The recording head on the "Galtron" contains a hum-bucking coil in series with the record-playback coil.

83. The major difference between the "Mirrophone" and the "Galtron" is in the amplifier. The "Mirrophone" has a two-stage audio amplifier, and utilizes DC for erasing purposes. The "Galtron" has a three-stage amplifier, and employs a 25-kc oscillator to furnish AC erase. The added stage in the "Galtron" necessitates the insertion of a 40-db fixed attenuator at the input to the amplifier to prevent overloading and distorting of the signal.

84. In both "Mirrophone" and "Galtron" units, erasing is accomplished only during the recording process. The tape passes through the erase head just before it reaches the recording head (facing the tape unit from the rear,

the erase head is on the left). Thus the wire is magnetically clean before any signal is recorded on it. During playback, the erase circuit is inoperative.

85. For simplicity, the magnetic tape recorder will hereafter be referred to as "Mirrophone." Where any great difference exists between operation of the "Mirrophone" and the "Caltron", direct reference will be made to the individual unit. In any case, each installation will contain either two "Caltrons," or two "Mirrophones."

Operation

86. On the front of the Mirrophone are its operating controls. Two volume controls are available, one for the signal labeled SIG. V.C. (normally set at about "7") and one for the 3-kc labeled 3 K.C. V.C. (normally set at maximum). On the Caltron the power control switch is on the signal volume control; on the Mirrophone it is on the 3-kc signal control. This switch turns on the power to both the magnetic recorder amplifier and tape unit motor.

87. The large indicator knob on the front panel labeled TIME is connected to a 2.5 r.p.m. clock by a slipping sleeve engagement which permits it to be moved by hand without damage to the clock itself. When recording is started on the Mirrophone, this indicator is set at zero, and is then used as an indication of recording time available. The indicator makes one revolution in two minutes and thirty seconds. Maximum recording time available on the magnetic tape recorder is two minutes and twenty-two seconds. After this time, the first part of the signal recorded will be erased. Since switching will consume some time, it is necessary to consider two minutes and fifteen seconds as maximum recording time, determined as approximately $\frac{3}{4}$ of a complete revolution from any starting position of the time indicator knob.

88. The control switch labeled SELECTOR has three positions marked RECORD, HOLD, and PLAYBACK. When the SELECTOR is switched to RECORD, the unit is ready to record the signal and 3-kc time tone pulses applied to it. When the SELECTOR is in the HOLD position, the magnetic tape recorder is neither recording nor reproducing although the motor is operating. It is in a stand-by condition and the previously recorded signal is preserved on the tape until the operator desires to play it back. In the PLAYBACK position the amplifier output is switched from the recording head to the time tone amplifier, and the recording on the tape is made available for the re-recording operation on the high-speed sound level recorder. During playback the 3 K.C. V.C. control must be turned back to 1 or off position for this control, but not for the switch which is part of it.

89. On the panel directly above the magnetic tape recorder panel a tuning-eye tube visual indicator is located (Figs. 6 and 9). This eye affords a

means of checking the level applied to the recording head of the Microphone. In the case of the Caltron recorder, the eye sensitivity can be adjusted. Access to this adjustment is obtained by removing the front panel of the amplifier section. The sensitivity control for the eye will be found directly beneath the 3-kc tone. For best indication the eye should just close at the peak of a signal -- regardless of the possibility that the 3-kc tone pulse may cause the eye to overlap. In the case of the 3-kc tone pulse, quantity not quality is the determinant. Note that on the W. E. Microphone there is no eye sensitivity adjustment.

90. On the same panel with the tuning-eye indicator, just beneath the tube, a jack receptacle will be found marked VIVM ONLY. This jack is across the grid circuit of the output tube of the magnetic tape recorder amplifier to make signal level measurements possible at this point. Only a high impedance instrument should be plugged into this jack; if a low impedance instrument is used the Microphone will fail to record properly.

91. Continuous operation of the magnetic tape recorders will cause the pole pieces in the recording head to become dull as a result of constant friction against the tape. If they become extremely dull, the tape signal-to-noise ratio as well as the high-frequency response will be considerably decreased. For this reason, the second Microphone is not put into operation until a signal arrives.

92. When the station is first installed, the operator should record progressive frequencies at intervals between 20 cycles and 5,000 cycles on the tape by connecting an audio signal generator into the Microphone input, maintaining the same recording level for each frequency, and keeping a log of all control settings. This test is important. After recording these frequencies, connect an output meter across the Microphone output, switch the Microphone to PLAYBACK, and note on the output meter the level for each frequency. These values can be plotted against frequency on logarithmic graph paper if desired, and the curve retained for future reference.

93. This response test should be repeated every two weeks, using the same levels as in the original test. Compare the values obtained with the original values. They will probably be somewhat lower than the original, giving an indication of the condition of the pole pieces. If the response at 3-kc has dropped at least 10 db, the pole pieces are dull and should be replaced. The U. S. Navy Underwater Sound Laboratory at New London, Connecticut, should be notified, whereupon a new recording head will be shipped. Upon receipt of this, remove the head containing the dull pole pieces and return it to USN USL. The pole pieces will appear flat. They are however ground to a small critical angle, which the pole piece makes with the tape.

Tape Repair and Upkeep

94. The most vulnerable part of the magnetic tape recorder is the tape

itself. If the tape should break during operation, it will probably be kinked so that nothing can be done to repair it. The tape unit must be removed and shipped to USN USL for the installation of a new tape. If it is accidentally broken when the unit is not in operation, it may be temporarily repaired by soldering the broken ends together. This is only a temporary measure, however, because the joint will tend to throw the pole pieces away from the tape as the tape passes between them. Since these pole pieces are under spring tension, they may again shear the tape as they spring back into place. Normally, the tape ends are welded and the joint dressed down until smooth. If it is in any way possible to do so, the tape unit should be returned to USN USL for repair.

95. To prevent rusting, the tape is oiled by an automatic reservoir in which oil is filtered, stored, and distributed constantly while the machine is operating. This oil supply will require replenishing every two to three months. Do this with the machine inoperative. Remove any dirt or debris which may have collected in the oil pan located directly below the pole pieces and drop 20 to 25 drops of fine grade machine oil (such as sewing machine oil) into the pan.

Servicing the Amplifier and Recorder

96. With the exception of occasional tube replacement the amplifier should require little servicing. It is located directly in front of the tape unit with which it is connected by three cables. One cable is the power cable from the motor, terminating in a plug which fits into a socket on the amplifier chassis. The second cable goes from the amplifier to the recording head on the tape unit and may be disengaged at the recording head end. The third cable goes from the amplifier to the terminal strip on the back of the tape unit. Before the tape unit or the amplifier can be removed, these cables must be disconnected.

97. The tape unit can be removed from the rear of the rack by removing the five screws which bolt it to the tray. These are located below the tray at the four corners and rear center of the tape unit. The amplifier unit may be removed from either the front or back by removing the control knobs at the front and the four screws which bolt it to the tray. These are under the tray at the four corners of the amplifier. When the amplifier is removed from the front it is necessary to remove the front panel. The recording-eye indicator tube is connected permanently to the amplifier unit by a cable; when the amplifier is removed this eye indicator tube must be slipped from the bracket which holds it to the panel and the V.T.V.M. jack receptacle must be unscrewed.

98. The tape unit motor is connected to a speed reducing pulley by means of a belt. The pulley in turn is connected to the main drive pulley by another belt. This drive mechanism is located on the side of the tape unit nearest the amplifier. Tension on the drive belt is adjusted by moving the motor on its sliding base when long use has caused the belt to loosen.



99. The tube complement of the amplifiers for each type of magnetic recorder is as follows:

<u>MICROPHONE</u>	<u>CALTRON</u>
One 6E8	One 6S57
One 6V6	One 6SQ7
One 6E5	Two 6V6
One 6X5	One 6E5
	One 6X5

CHRONOMETER AND CODE SWITCH

100. A Hamilton break-circuit marine Chronometer (Fig. 11), housed in a shielded compartment, is located on the sliding tray at the top of Rack 3. Two stop positions on the extension tracks permit the chronometer to be slid out for the convenience of the operator, both for operating ease, and for rewinding. In addition, a hold-down screw on the front right side permits the slide tracks to be secured at an intermediate position and prevents accidental jar or movement to the sliding tray.

101. The break-circuit Chronometer is mounted in its normal wood box receptacle. The cover has been removed, however, as the sliding cover to the shielded compartment provides ample security for the chronometer and at the same time makes it completely accessible for operation and facilitates rewinding.

102. The function of the break-circuit chronometer is to interrupt the negative bias applied to the tubes of the time tick pulse amplifier (time tick DC), allowing the tubes to conduct once each second, except the 59th, in each minute. This energizes the time index relay and initiates the travel of the time indexing styli on the graphic level recorders.

103. At the same time the relay in the output circuit of the 3-kc oscillator in the time tone amplifier is actuated, and 3-kc pulses, in synchronism with the Chronometer, are recorded onto whichever magnetic tape recorder is operating. Therefore, as the signal is recorded on the tape, 3-kc tone signals are simultaneously recorded at one-second intervals.

104. A normally closed switch is located in the right-front corner of the Chronometer box. This is the shot signal arrival coding switch. Pressing this switch opens the bias control circuit manually and applies a secondary time index to the graphic level recorder tapes and a secondary 3-kc tone signal to the operating magnetic tape recorder. The code mark assists the station operator in determining the exact time at which the signal arrived by identifying its position with respect to the adjacent one-second indexes from the break-circuit Chronometer.

105. At the right rear of the chronometer shelf a terminal strip for the time control cable is mounted. Another terminal strip is mounted on the inside bottom of the chronometer box; the chronometer circuit terminates on this strip.

106. The Chronometer supplied as station equipment is a standard Navy type Hamilton 12-hour Marine chronometer, designed to run a maximum of 56 hours on a full winding. It should be placed into operating service only by qualified personnel. Navy procedure for handling, winding, and setting a chronometer should be carefully adhered to. A description of this procedure lies outside the scope of this Maintenance Manual.

107. The following three rules must be strictly followed by station personnel:

1. Never let the chronometer run down; always wind it at regular intervals, preferably once each day.
2. Never touch or interfere with the second hand. Never move the hour and minute hands counterclockwise.
3. Never remove the chronometer from its case except for winding.

Further details concerning this type of marine Chronometer can be obtained from the booklet entitled "Care and Handling of the Hamilton Marine Chronometer," published by the Hamilton Watch Company at Lancaster, Pennsylvania, U.S.A. This booklet is available from the manufacturer on request.

SHOT ARRIVAL TIME EVALUATOR

108. The accuracy with which the source of an explosion signal in a given area of triangulation can be determined depends upon the SOFAR station operator's ability to time the arrival of the peak of each shot. The shot arrival time evaluator (Fig. 27) is designed to enable the operator to do this timing accurately to one tenth of a second.

109. The shot arrival time evaluator resembles a slide rule. It has a body of wood with gates on each end to clamp the paper tape from the graphic level recorder tightly in place. The sliding indicator is of lucite. It has two scales engraved upon it -- one for use with 5 mm./sec. tape speed, and the other for use with 10 mm./sec. tape speed. Two small metal posts are located at one end of the body. These are designed to fit into the sprocket holes on each edge of the waxed-paper tape, and thus eliminate error due to improper positioning of the tape in the evaluator.

110. One of the engraved scales on the cursor is labeled PAPER SPEED 5 MM 1 SEC. This scale is used when analyzing tapes from the "slow-speed" graphic level



recorder in Rack 2. The other scale, labeled PAPER SPEED 10 MM 1 SEC., is for use when analyzing tapes from the "high-speed" graphic level recorder in Rack 3. This will be the graphic level tape recording of the magnetic tape recorder playback. On one scale the second marks are 5 mm. apart, and on the other scale these marks are 10 mm. apart.

111. To use the evaluator, the operator should let the graphic level recorders run for a sufficient length of time after the recording of the shot to include the next break-second and to insure adequate length of tape for the evaluating device. The tape containing the recording of the shot should be at least 12 inches in length.

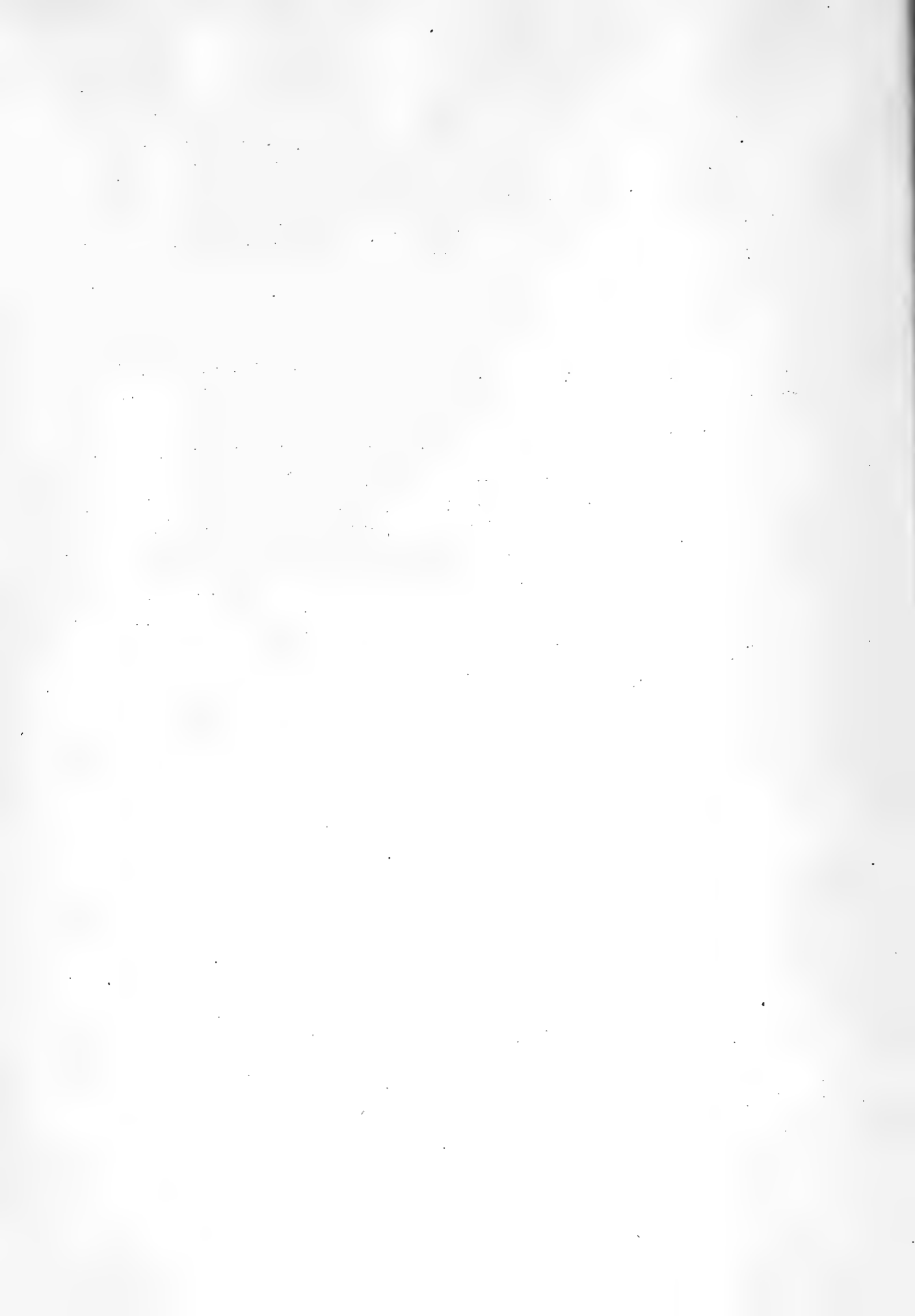
112. To insert the tape into the rule, first determine the speed at which the tape was recorded (either 5 mm/sec or 10 mm/sec), and then slide the tape under the indicator so that the index marks along the right edge of the tape appear just below the corresponding speed scale. Lift up on the handles located at each end of the body and lift the end gates out of the way. Fit the sprocket holes at one end of the tape over the small posts. Close the end gate nearest these posts, being certain it pulls the tape firmly in place without tearing the sprocket holes. At the other end of the body, again pull the tape firmly, avoiding any tearing of the sprocket holes, and close the end gate. The tape is now ready for evaluation.

113. It will be noted that on either scale on the indicator there are four different lengths of index lines. The long line is for locating the indicator with respect to the peak amplitude of the shot recording on the graphic level recorder tape. The next largest markings represent the 1-second intervals; the next indicate the 1/2-second intervals, and finally the smallest lines are the 1/10-second intervals.

114. When the graphic level recorder tape containing the recording of the shot has been properly located in the evaluator, move the indicator until the longest line coincides with the exact point on the tape where the abrupt fall-off in signal energy commences (see Fig. 27). Referring to the scale, count back the number of small divisions from the long line to the nearest previous second mark on the tape. The number of small divisions will represent the number of tenths of seconds which must be added to the total time determined for the shot.

OPERATOR'S MAINTENANCE

115. In addition to the actual operation of the station as described in USL Report No. 55, "Long Distance Sound Ranging Equipment (SOFAR) - Installation and Operating Notes," it is the operator's duty to see that the station is in good condition and at all times ready to function for air-sea rescue. The operator should promptly report defects in the equipment which are beyond his responsibility to repair.



116. The station operator should normally perform the following maintenance duties:

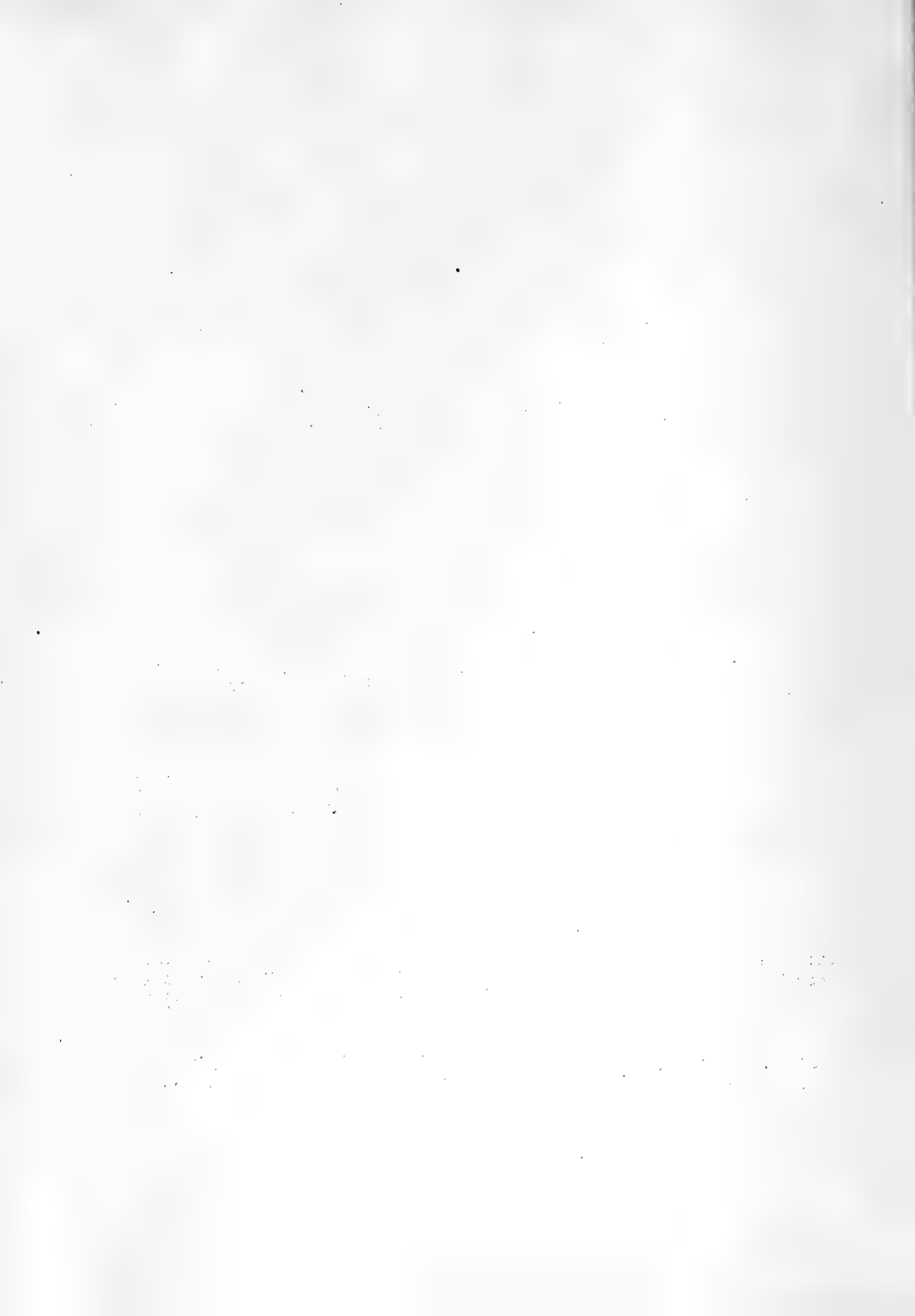
1. Keep the SOFAR station log completely posted at all times.
2. Rotate the input channel and components in an established duty cycle.
3. Replace fuses when necessary. This requires a knowledge of fuse size and location. All fuses with the exception of that for the 124A Monitor Amplifier are accessible from the front panel of Rack 1. The fuse for the 124A amplifier is located at the rear of the amplifier chassis, adjacent to the AC input receptacle. Note that the original fuse (a Buss Fusestat) has been replaced with the "Little-Fuse" type.
4. Remove the accumulation of wax and paper residue daily from the graphic level recorder paper tape feed drive.
5. Although it may be desirable to delegate the care of the break-circuit chronometer to one responsible individual, each operator should note the condition of the wind of this instrument during his watch.
6. Measurement of self-noise generated in each channel can be readily made once measuring equipment is set up for this purpose. This may be established as a daily duty performed by the station operator.

117. As the station operator becomes familiar with the theory and operation of long distance sound ranging equipment, additional duties in the maintenance of the station may be expected of him. These, however, should not be of such a nature as to conflict with the prime necessity of determining the time of a shot signal arrival with maximum accuracy.

PREVENTIVE MAINTENANCE

118. Preventive maintenance, involving performance checks on the various components of a SOFAR station unit at specified intervals, will not eliminate the possibility of electronic and mechanical breakdown, but will tend to minimize such occurrences.

119. The following suggested schedule of preventive maintenance and the intervals at which each test should be made are subject to revision as dictated by actual operating experience with SOFAR station equipment:



A. Daily Tests

1. Operation of monitor amplifier and loud-speaker to obtain a noise check on each channel.
2. Adjustment of sensitivity control on automatic switching unit.
3. Operation of graphic level recorders to check writing response and time indexing on both manual and automatic motor switch positions.
4. Operation of each magnetic tape recorder on record, playback, and time indexing.
5. Operation of break circuit chronometer to check time indexing and operation of code switch.
6. Check of headphone monitor position in Rack 1.
7. During dual channel operation, monitoring check at each graphic level recorder, using crystal headphones.

B. Weekly

1. Over-all gain check on each channel. (Paragraph 17)
2. Cleaning of slider arm on graphic level recorder potentiometers with carbon tetrachloride. (Paragraph 54)

C. Biveekly

1. Response test of the magnetic tape recorders. (Paragraphs 91 and 92)
2. Replenishment of oil supply in magnetic tape recorder oil reservoir.

120. Each test should be logged when performed for subsequent comparison and reference. The performances of the tests should follow the procedure for each component as outlined in the manual.

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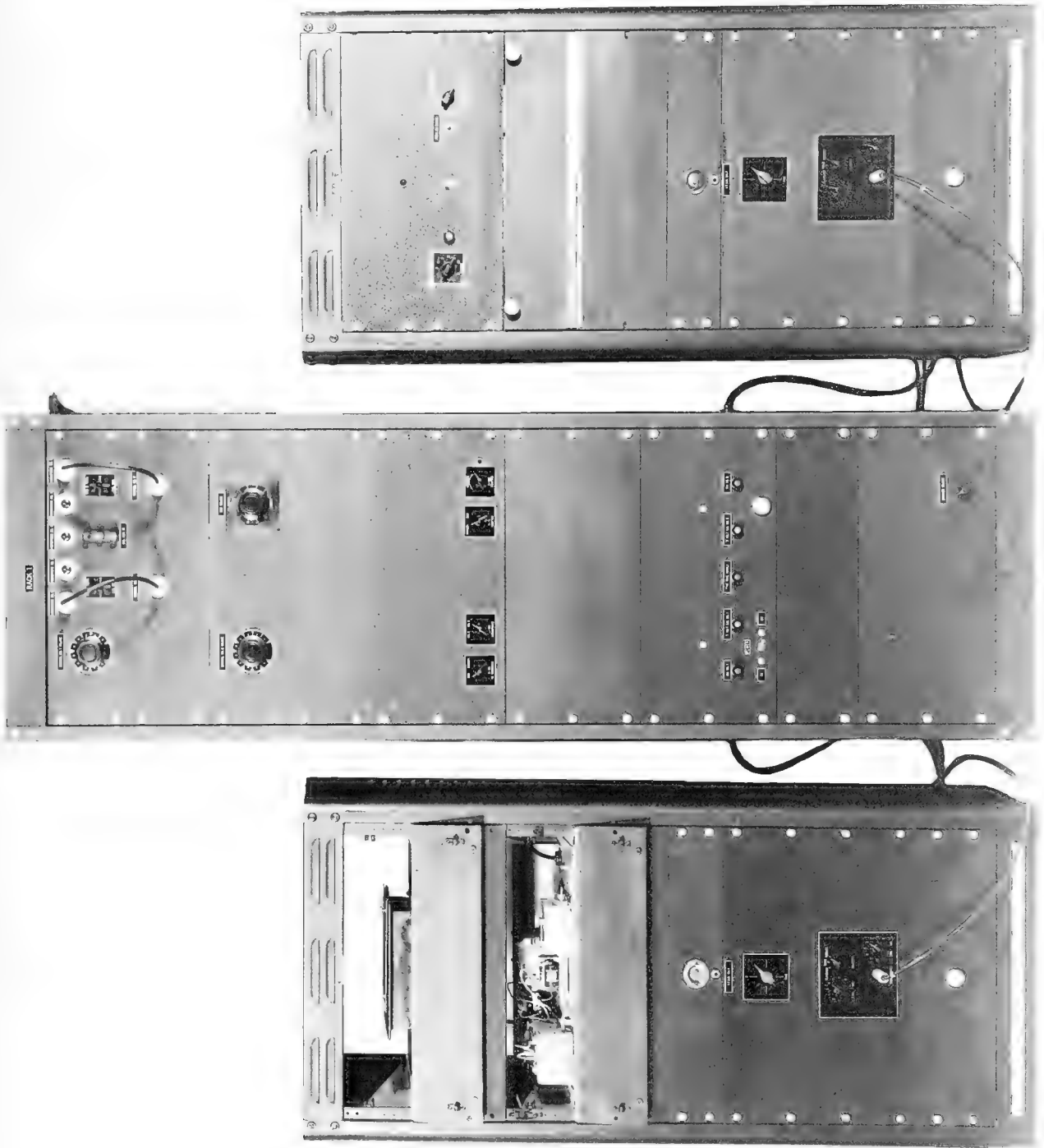
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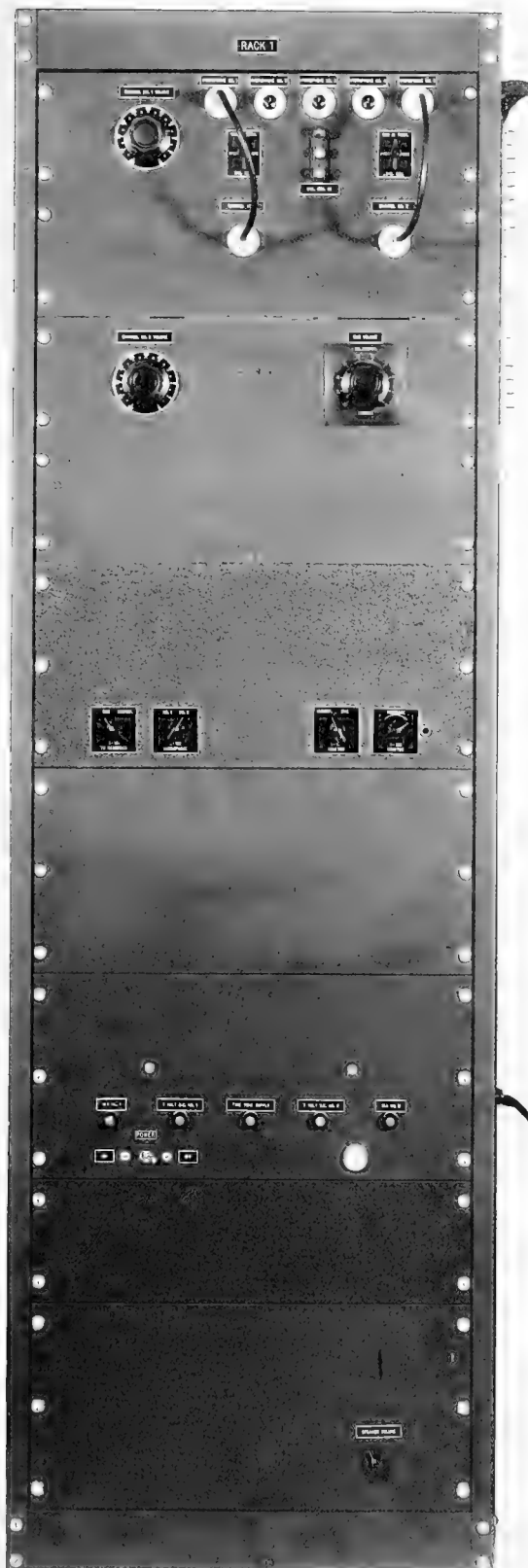


FIG. 2 - Rack One, Front View



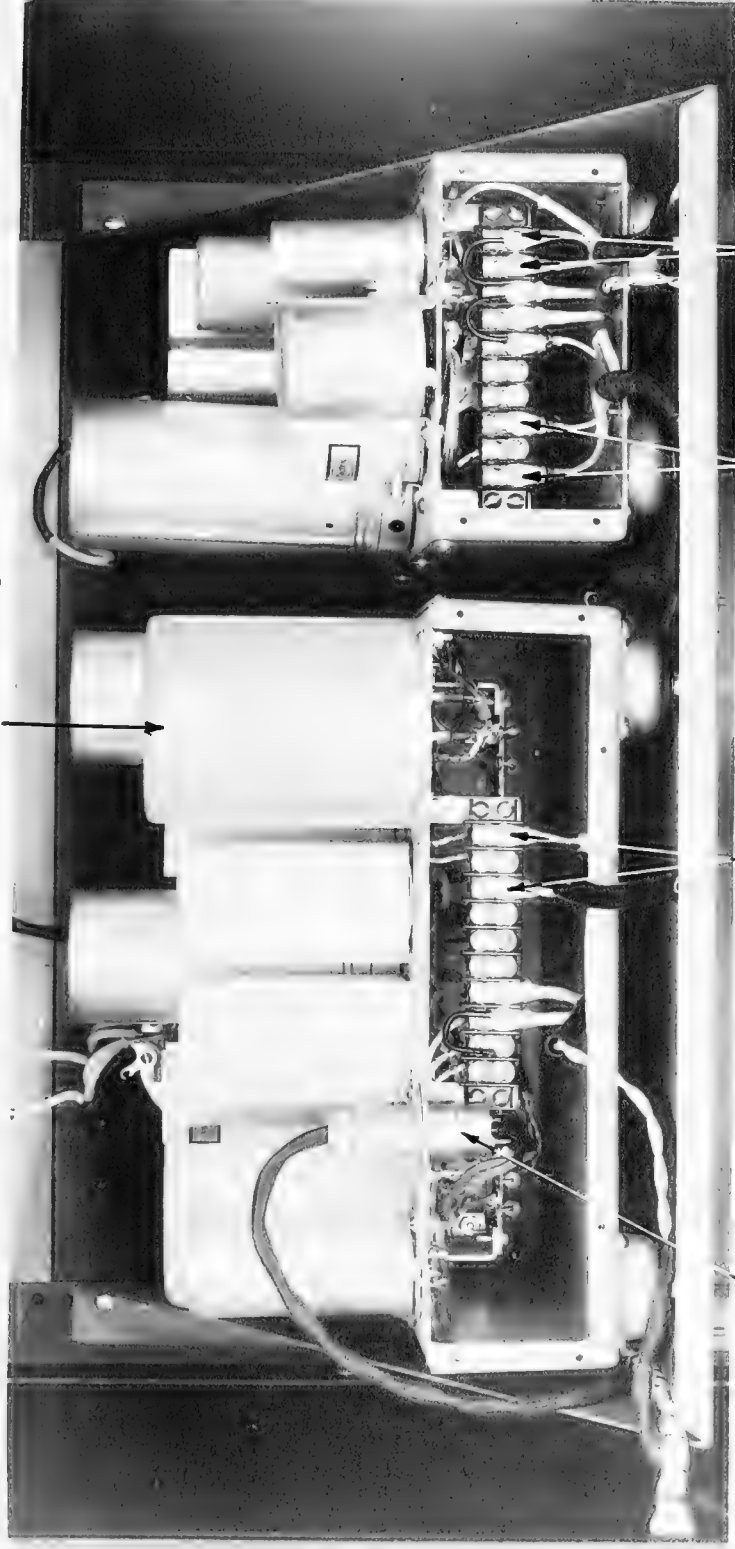


FIG. 3 - Rack One, Rear View

121A AMPL.

120B AMPL.

500~ LOW PASS FILTER



121A OUTPUT RECEPTACLE

121A INPUT

120B INPUT

120B OUTPUT

FIG. 4 - Rack One, Shelf Two

N-4911

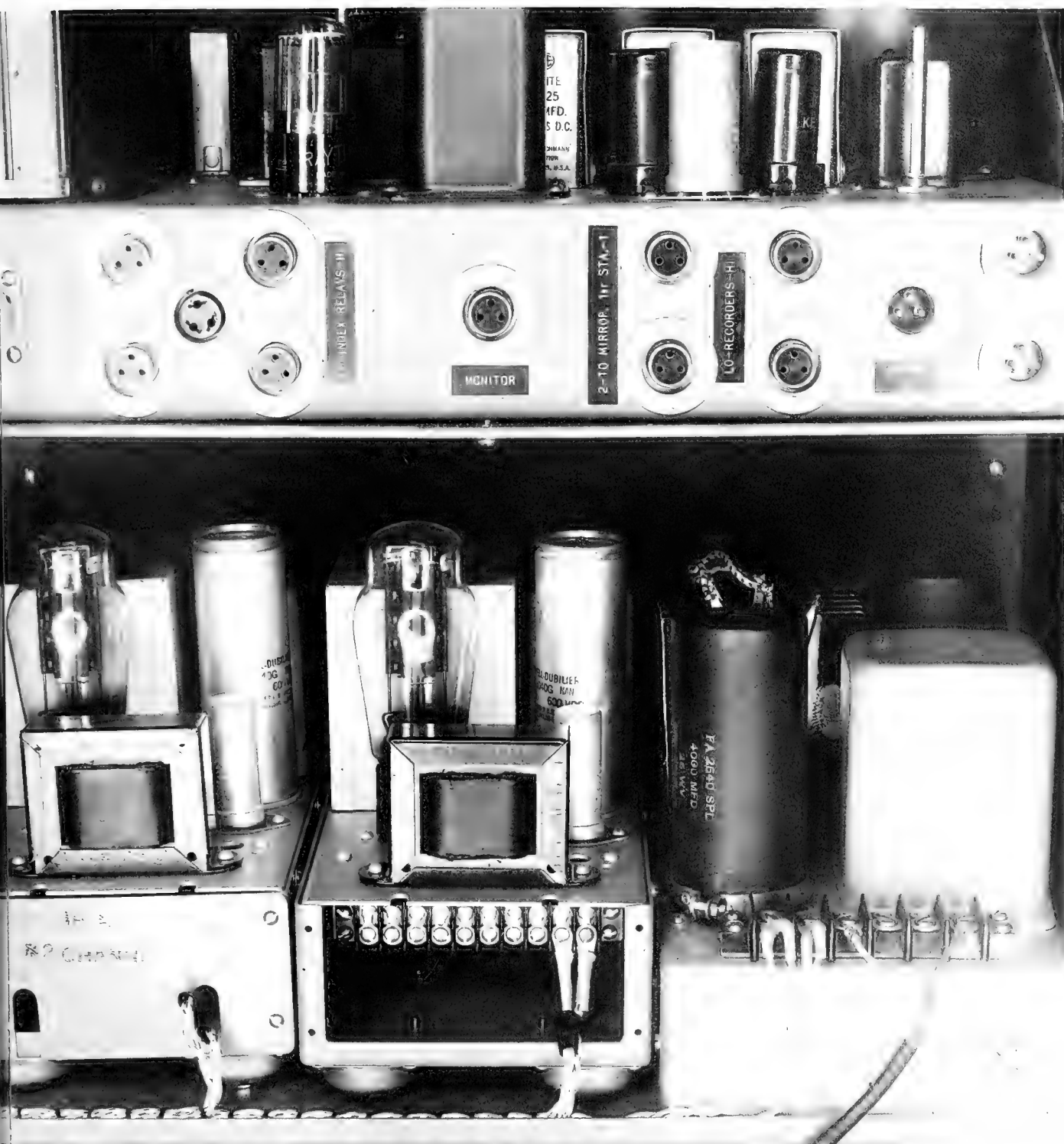




FIG. 6 - Rack Two, Front View



FIG. 7 - Rack Two, Rear View

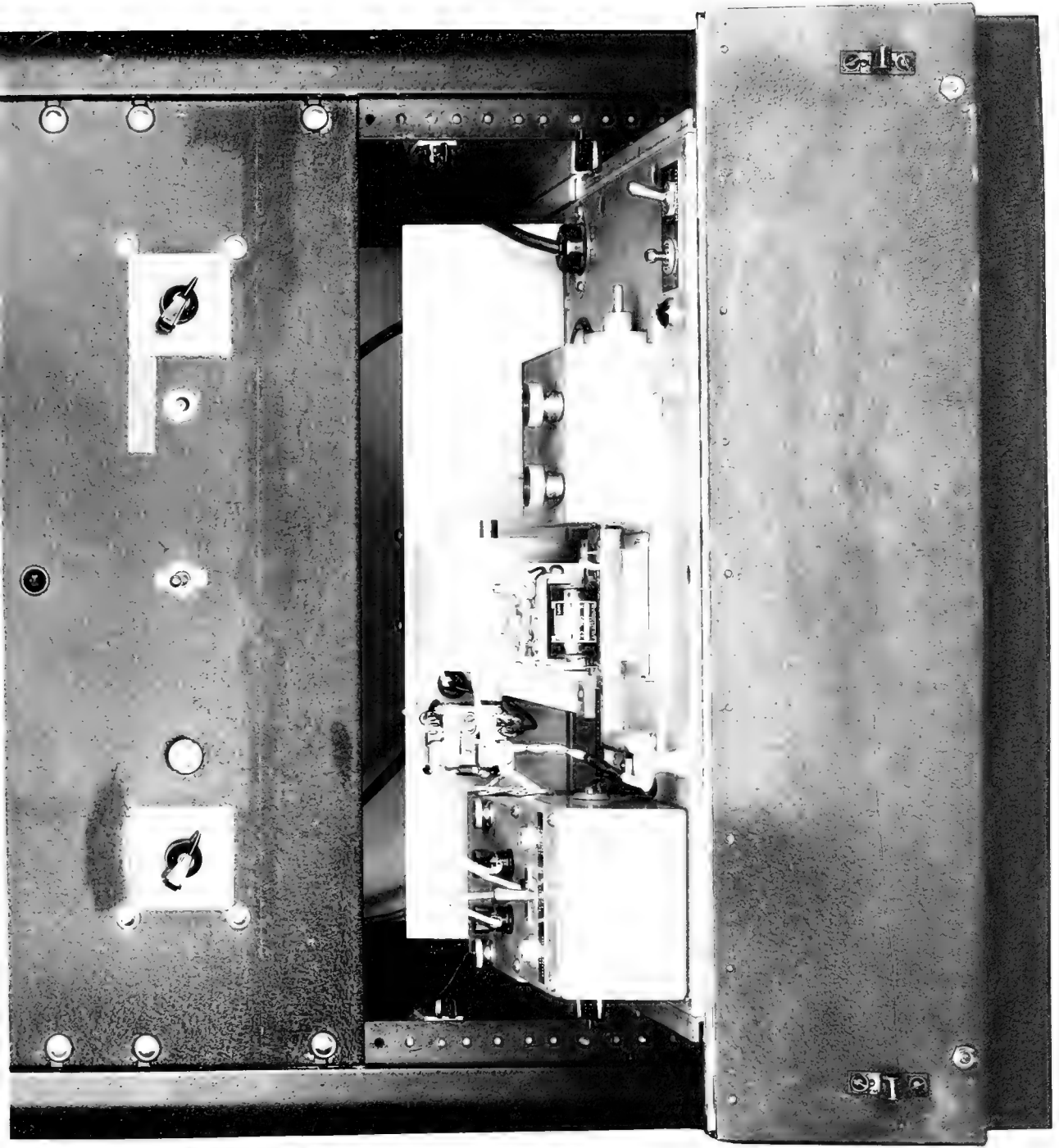


FIG. 8 - Rack Two, Automatic Switching Unit and Slow-Speed Sound Level Recorder



FIG. 9 - Rack Three, Front View

N-4856

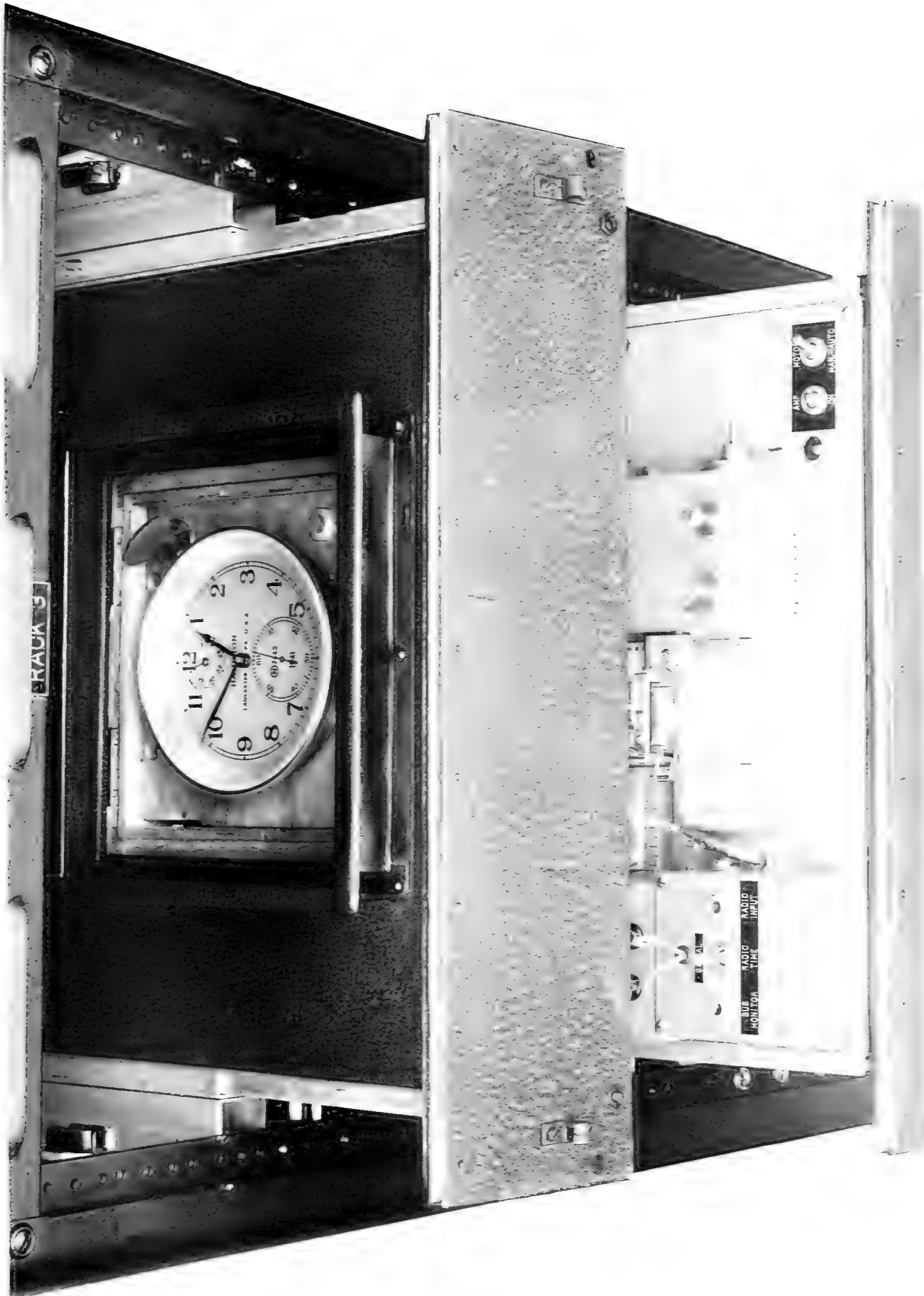
USL Report No. 61



N-4861

FIG. 10 - Rack Three, Rear View

USL Report No. 61



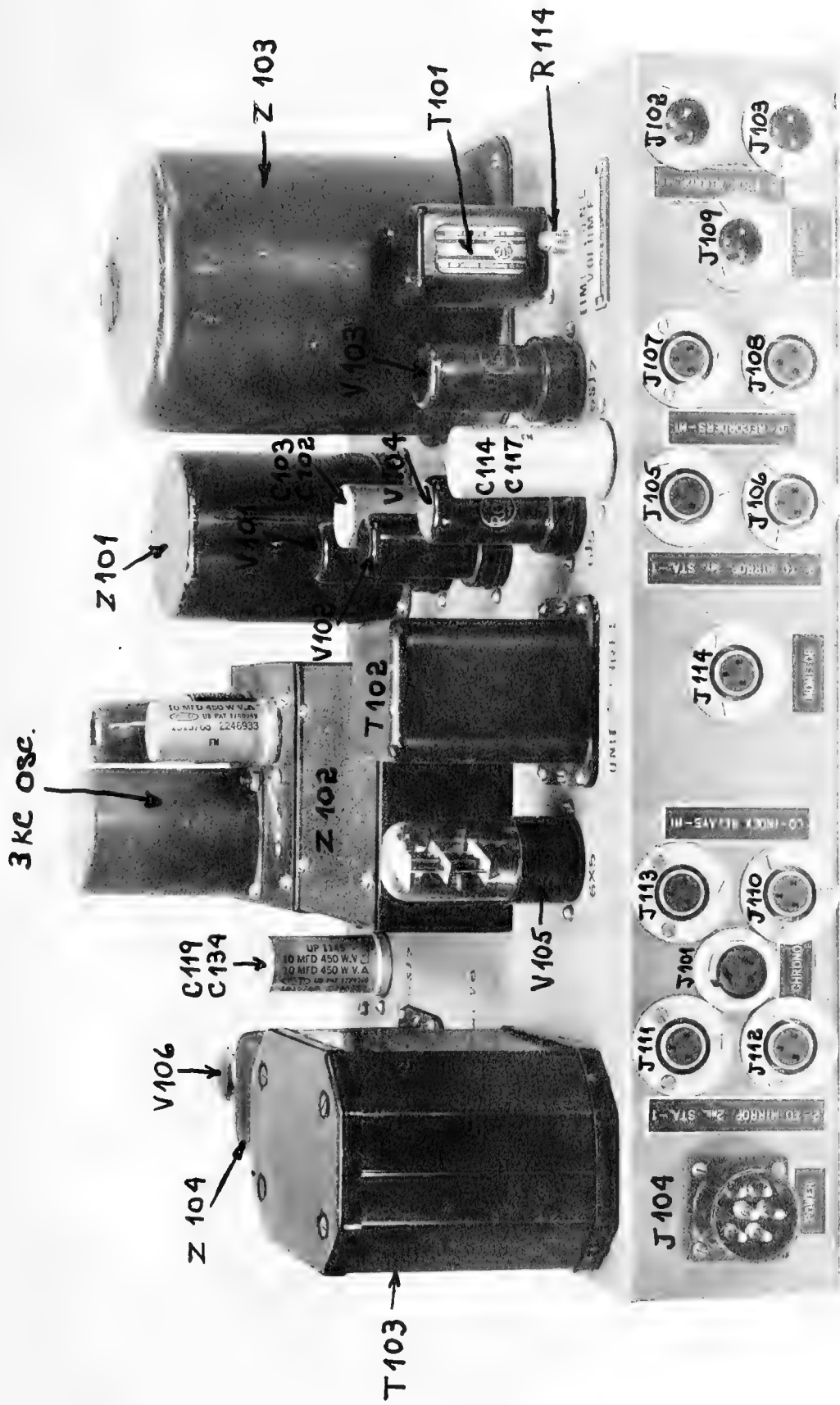


FIG. 12 - Rear View, Time Tone Amplifier

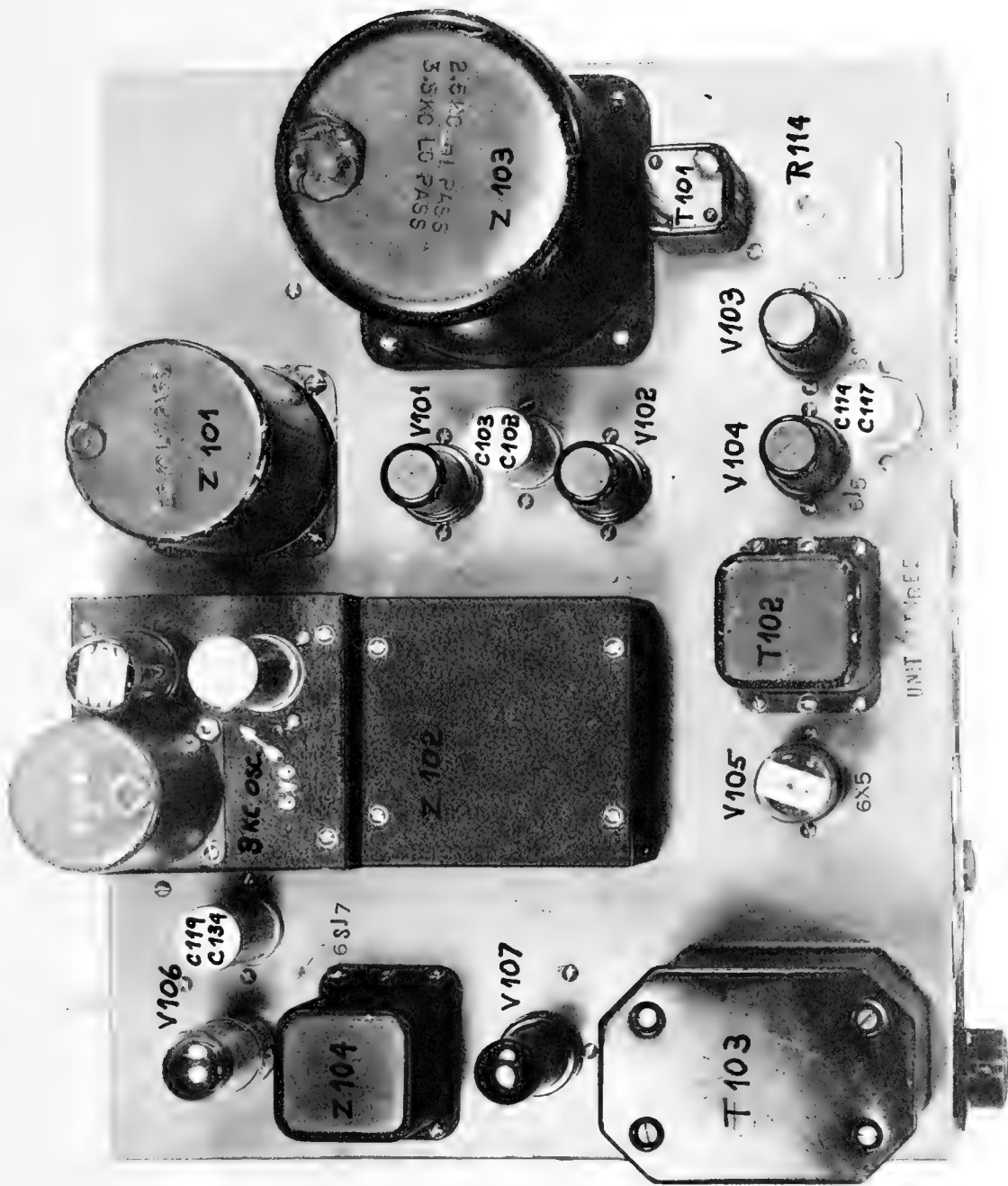


FIG. 13 - Top View, Time Tone Amplifier

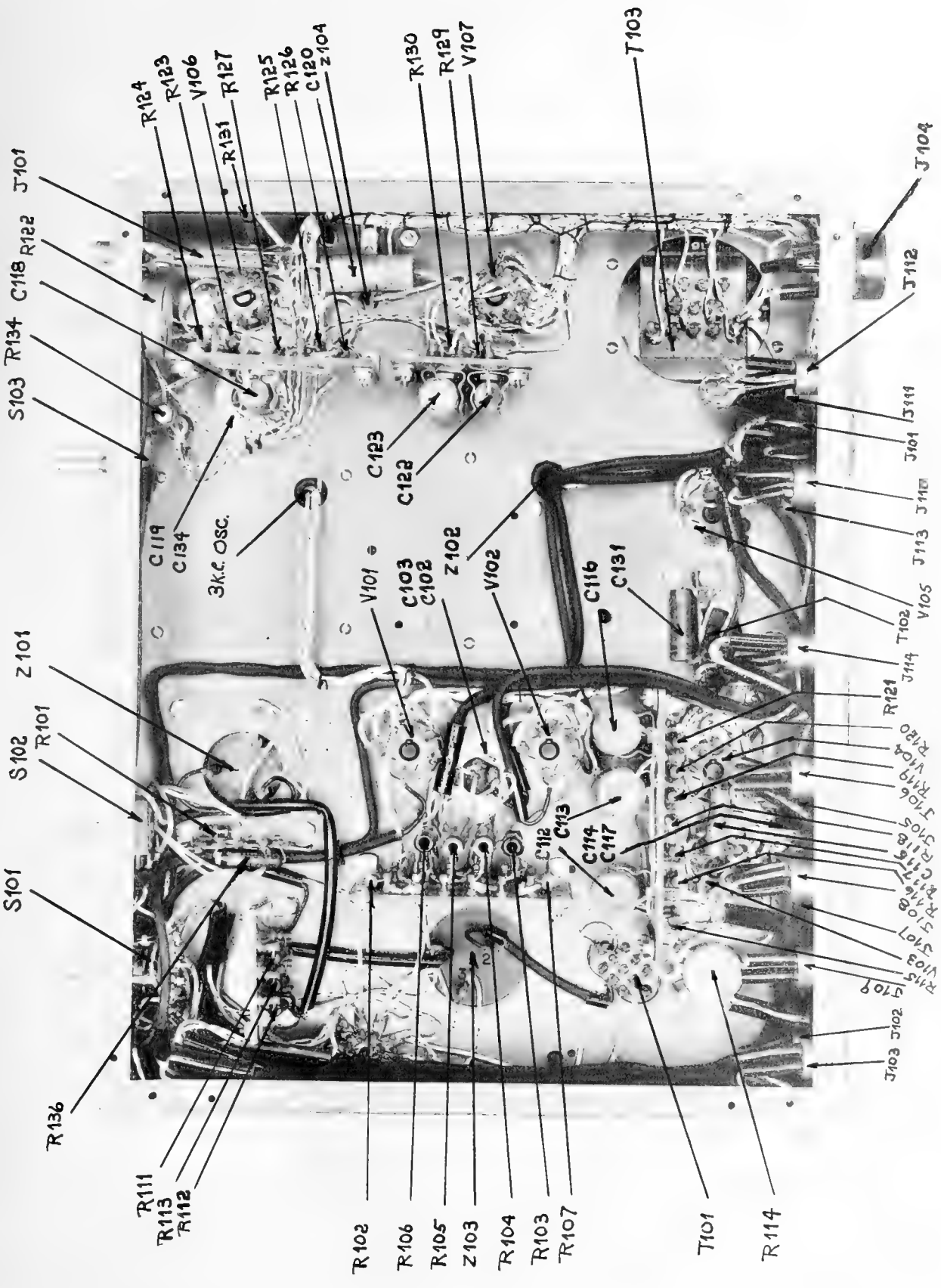


FIG. 14 - Bottom View, Time Tone Amplifier

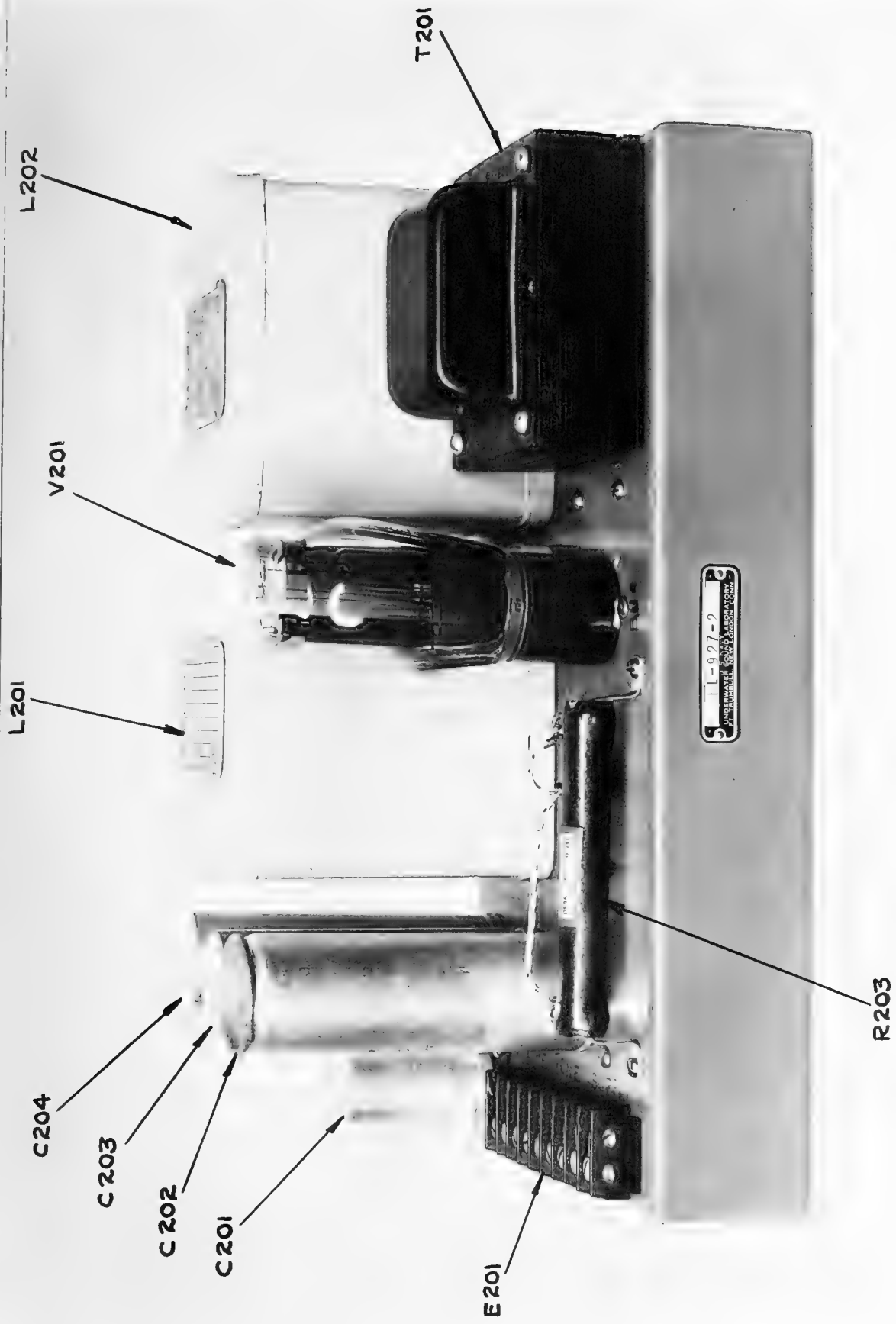
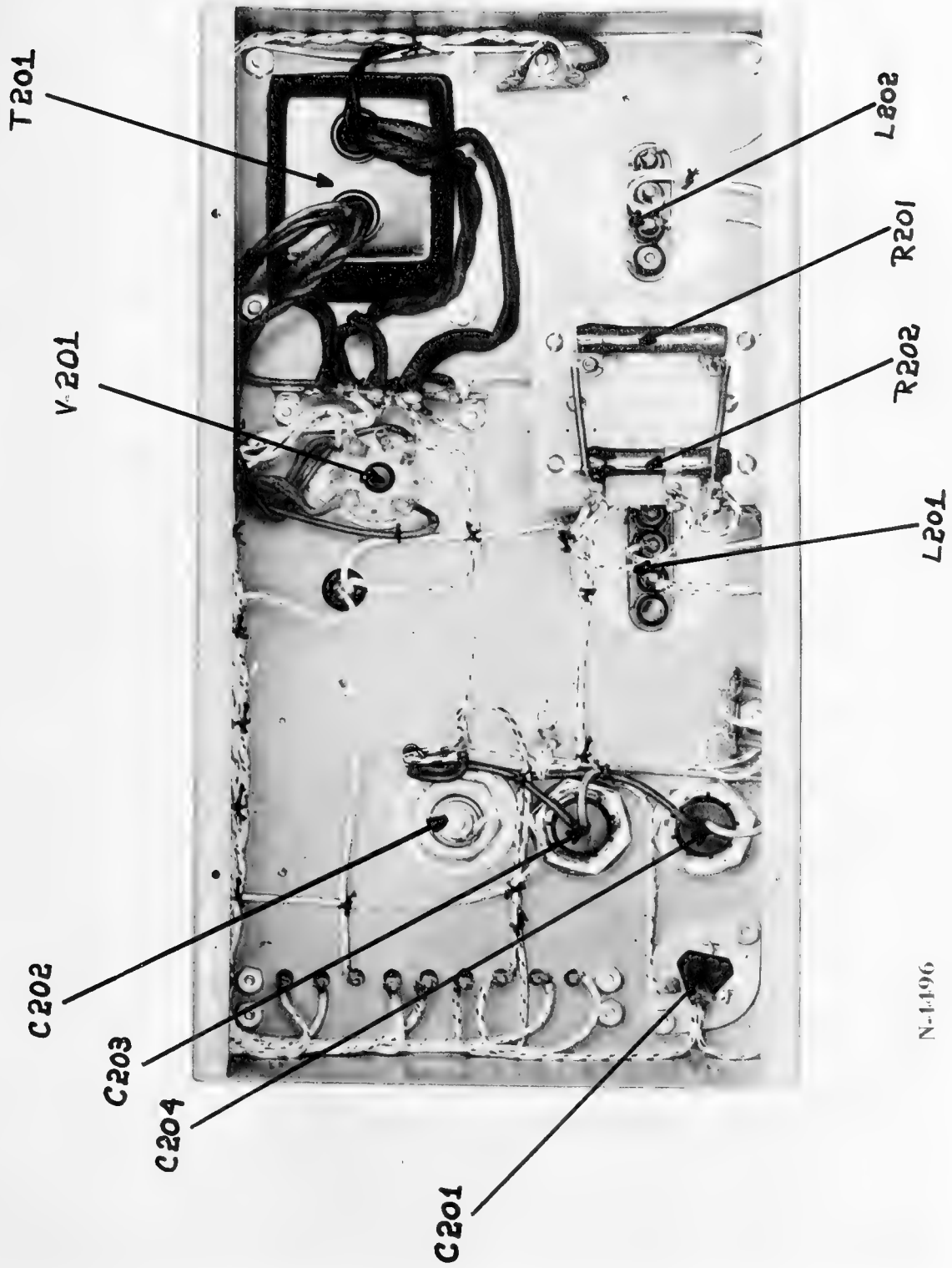
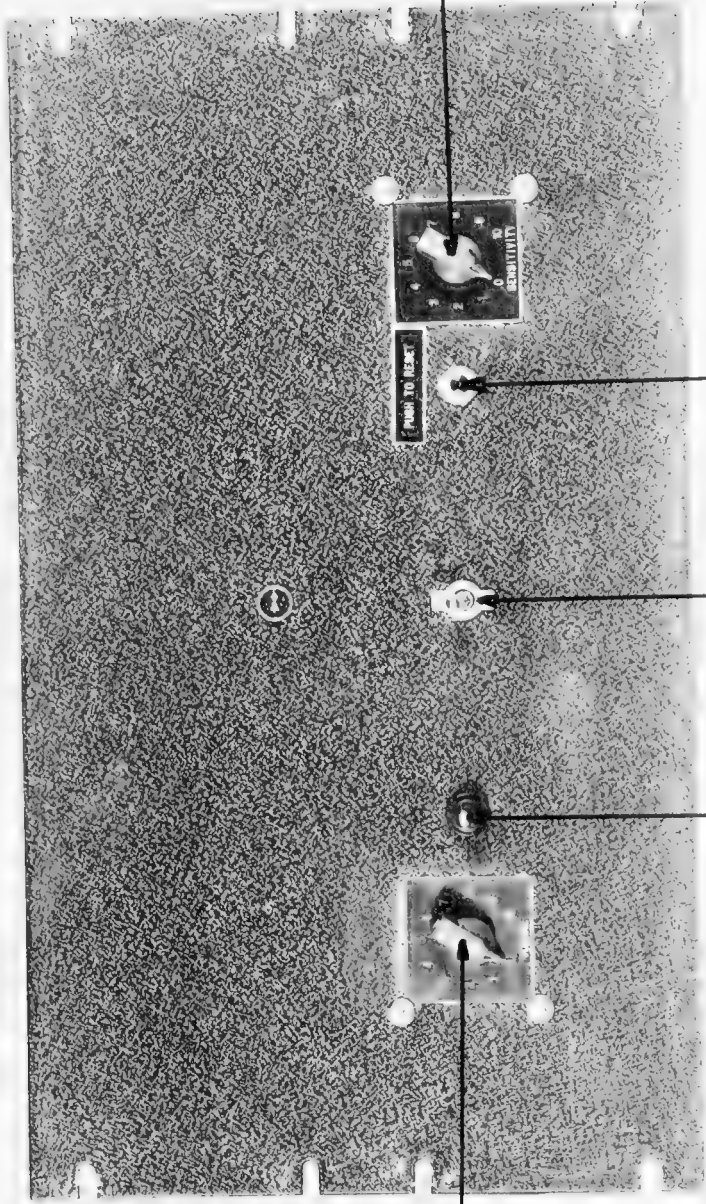


FIG. 15 - Time Tone Amplifier Power Supply



N-1496

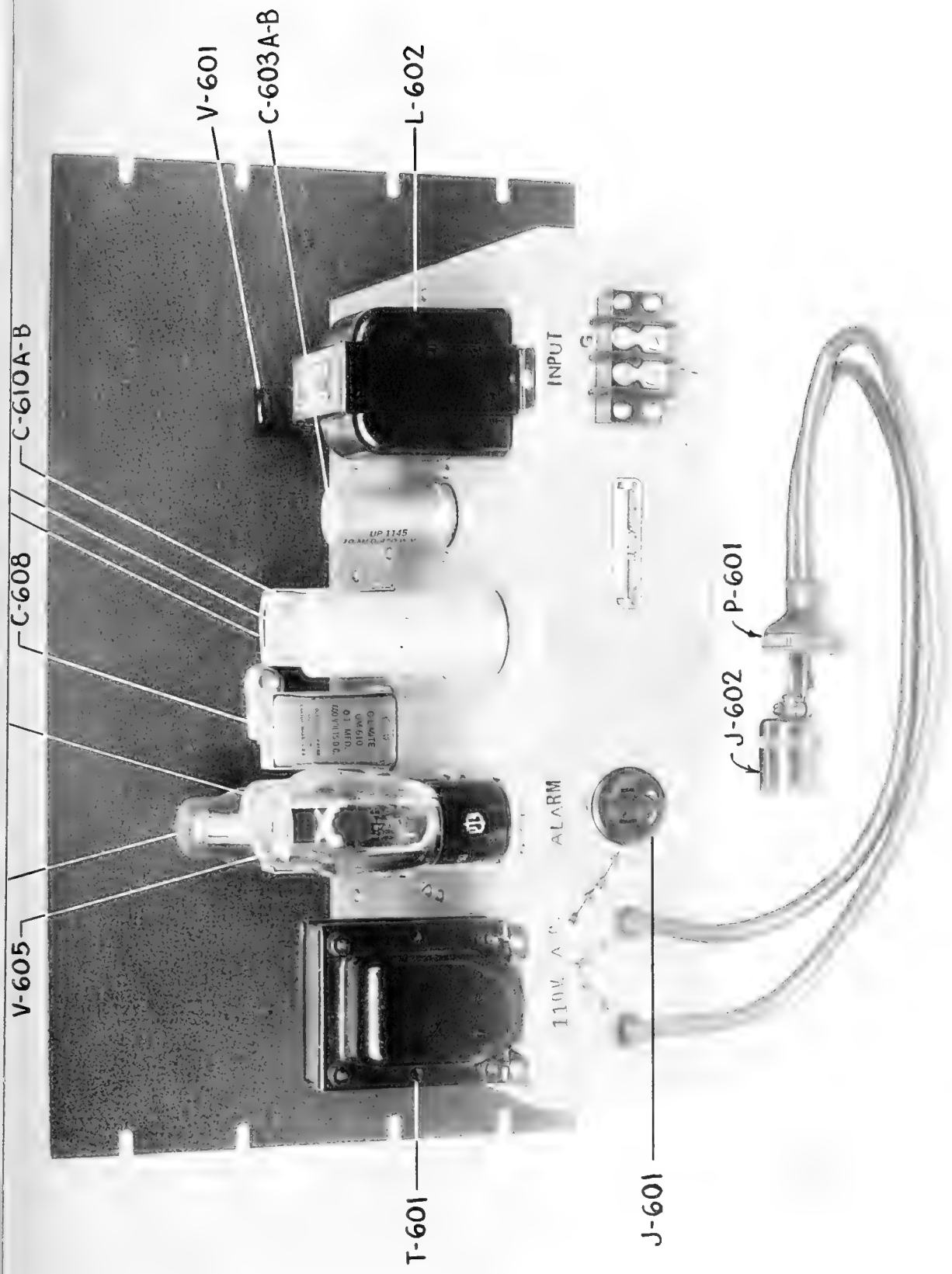
FIG. 16 - Bottom View, Time Tone Amplifier Power Supply



N-4489

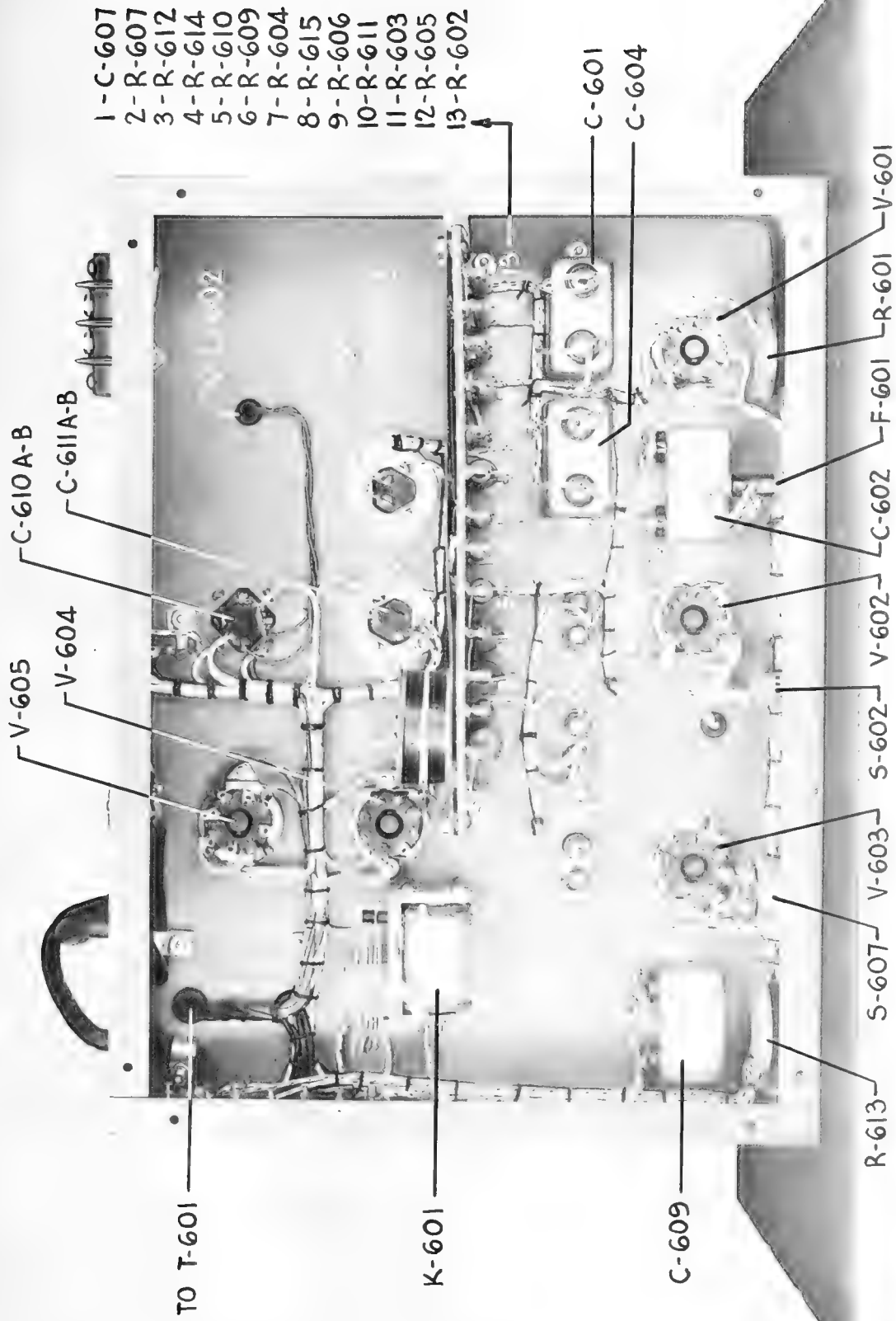
USL Report No. 61

FIG. 17 - Automatic Switching Unit



N-4908

FIG. 18 - Rear View, Automatic Switching Unit



N-4909

USL Report No. 61

FIG. 19 - Bottom View, Automatic Switching Unit

IT+T
7B441

C 101B

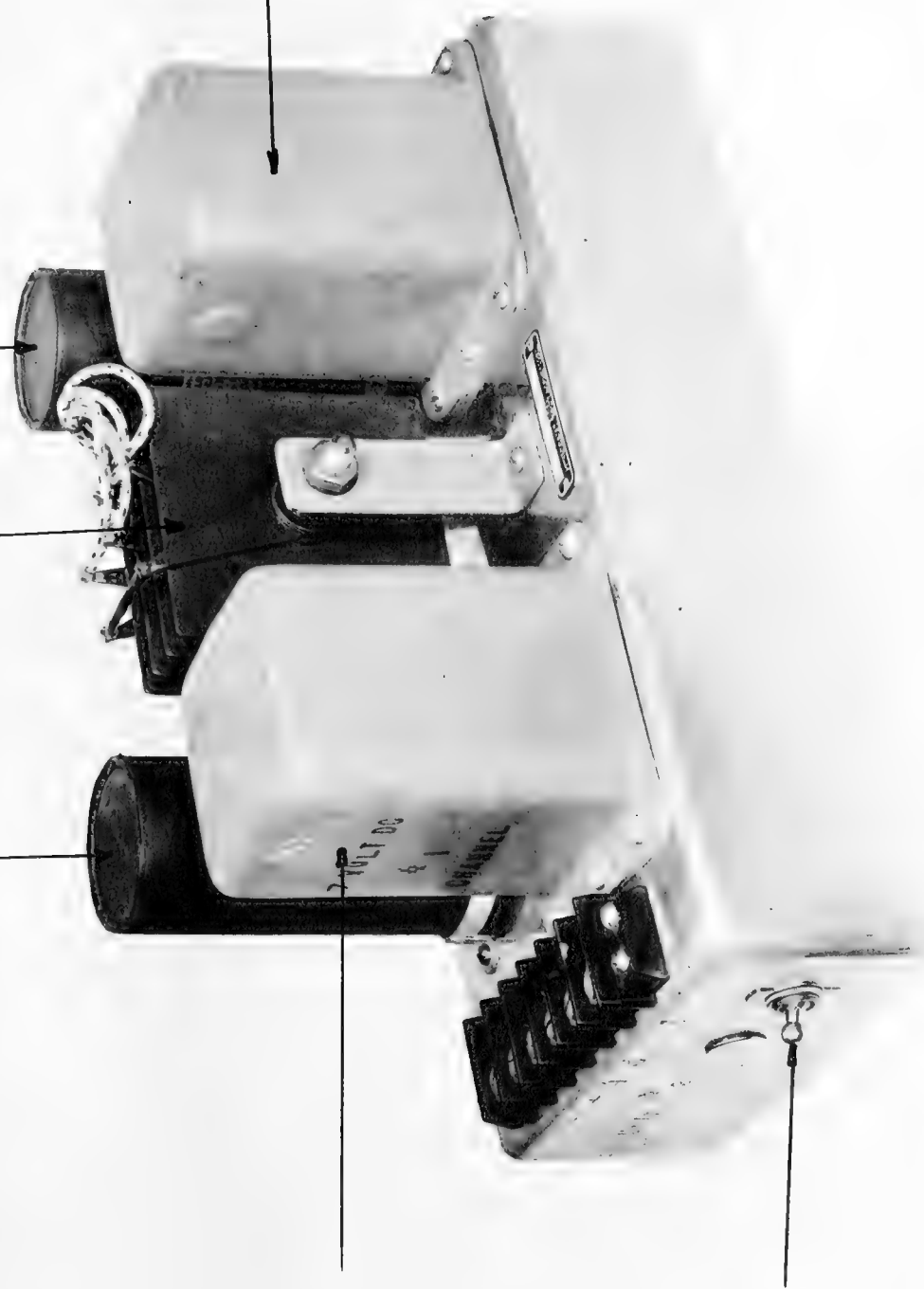
L 101

C 101A

T 101

S 101

FIG. 20 - 7 v. DC Power Supply



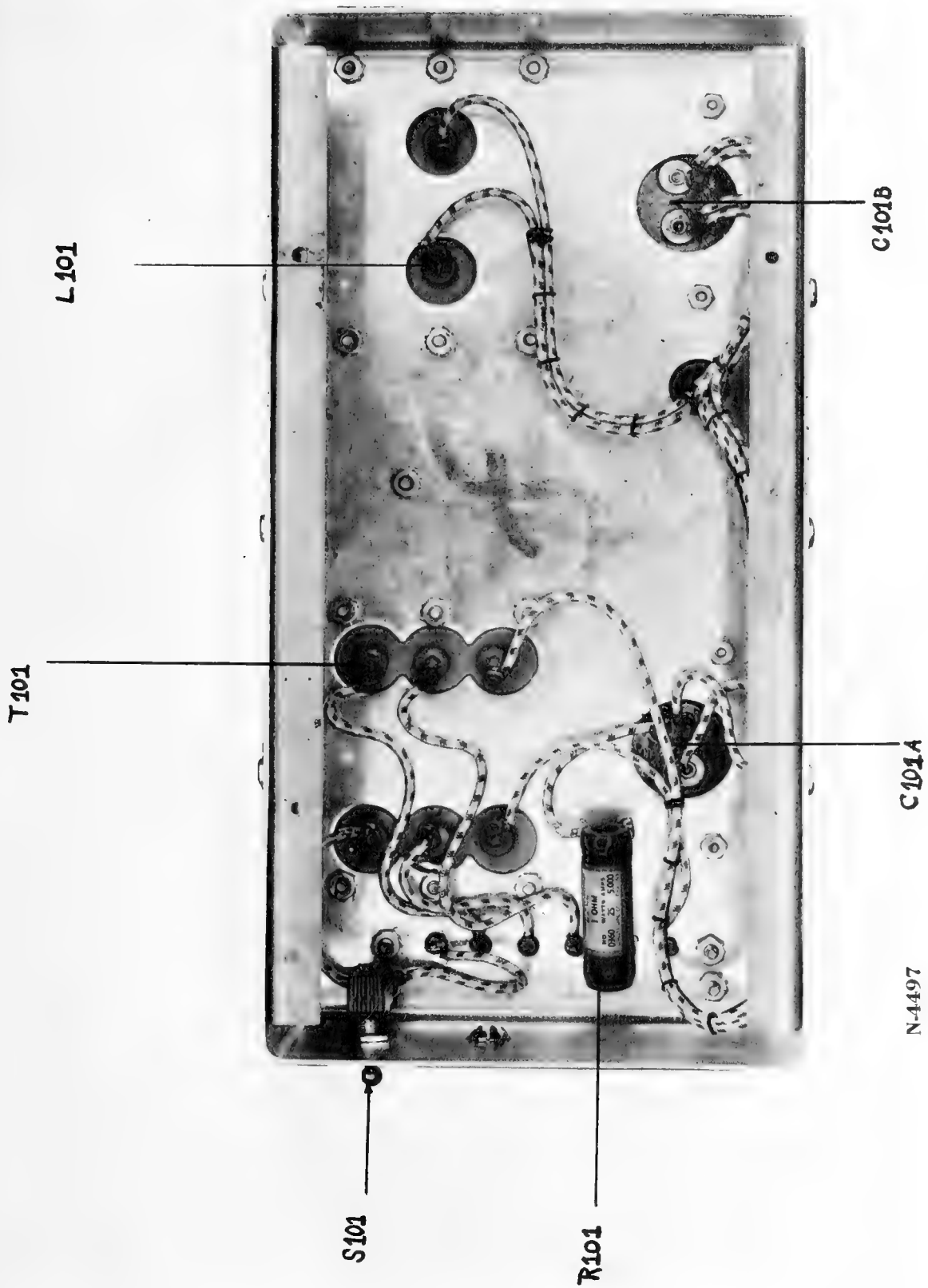


FIG. 21 - Bottom View, 7 v. DC Power Supply

GAUGE PLATE

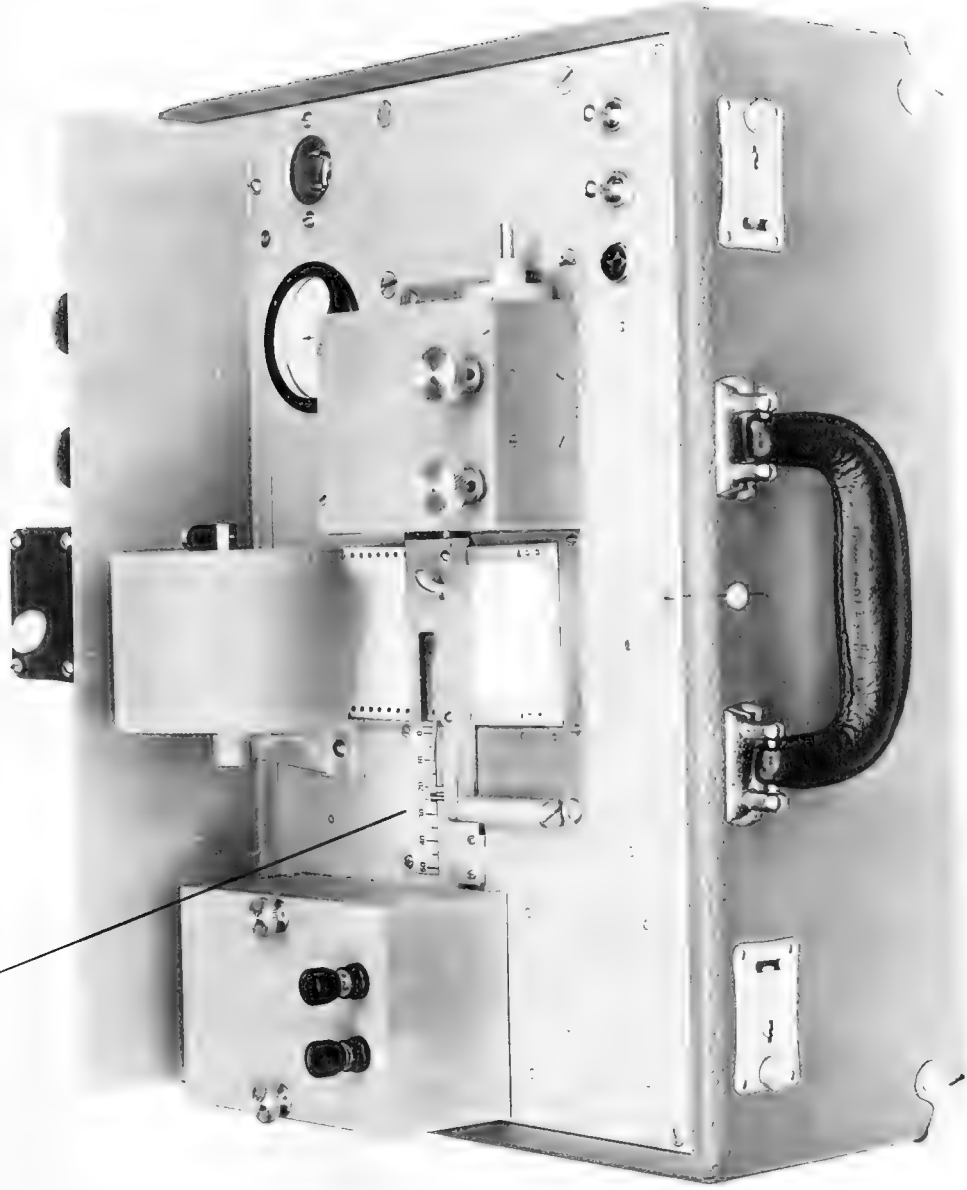
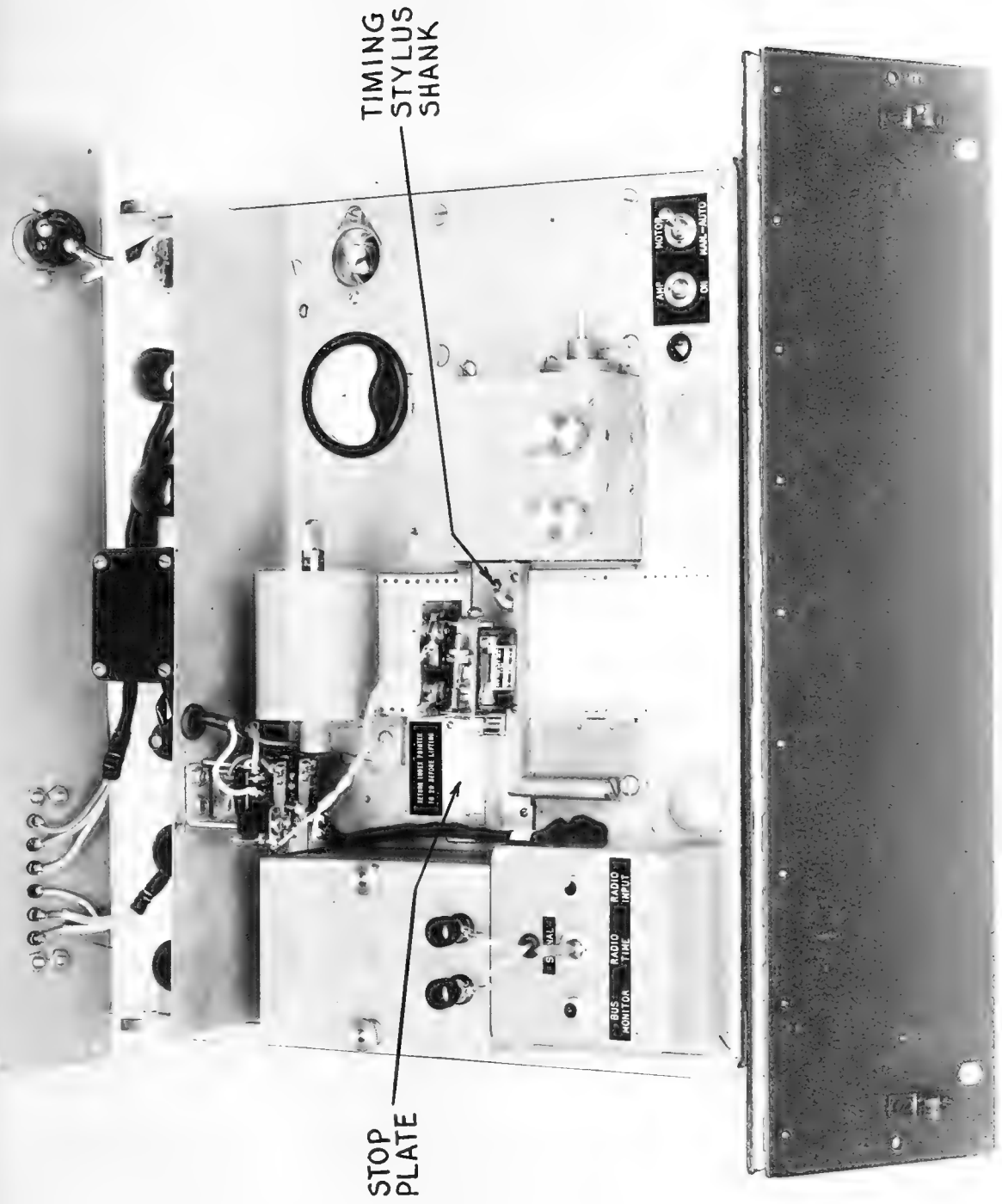


FIG. 22

GRAPHIC LEVEL RECORDER AS DELIVERED USL Report No. 61

N-4354 A



STOP
PLATE

TIMING
STYLUS
SHANK

FIG. 23

Recorder with Timing Stylus in Place

SPRING ADJUSTMENT

MAGNET BAR

HORIZONTAL
HOLDING PLATE

TIMING STYLUS SHANK

LOCK NUT

MARKING PINS

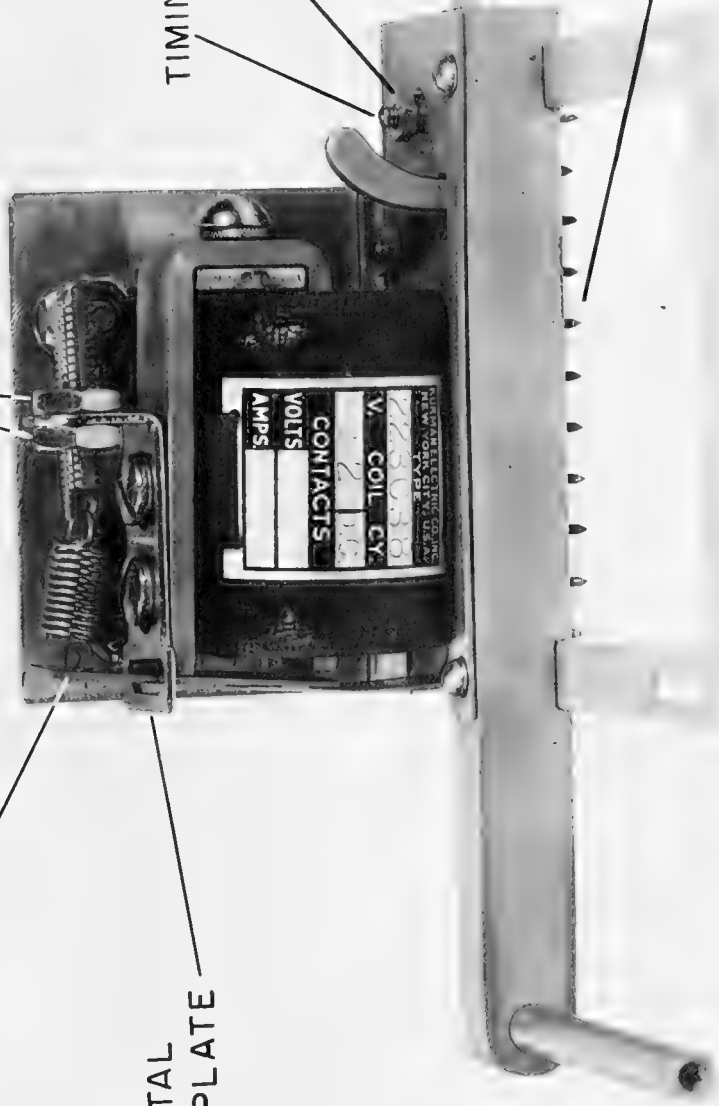


FIG. 24

FRONT VIEW OF
TIMING STYLUS MECHANISM

N-4357 A

USL Report No. 61

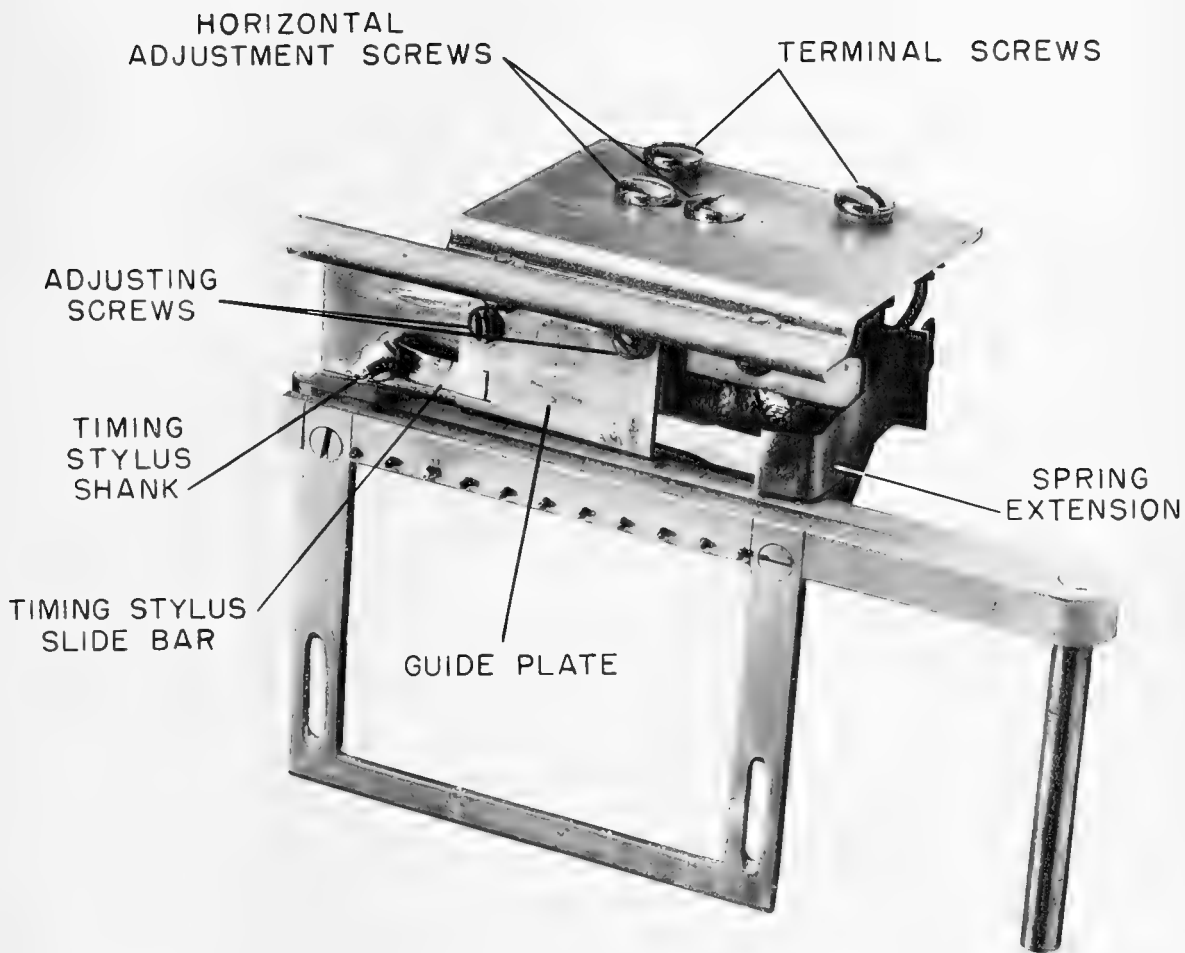


FIG. 25
BOTTOM VIEW OF
TIMING STYLUS MECHANISM

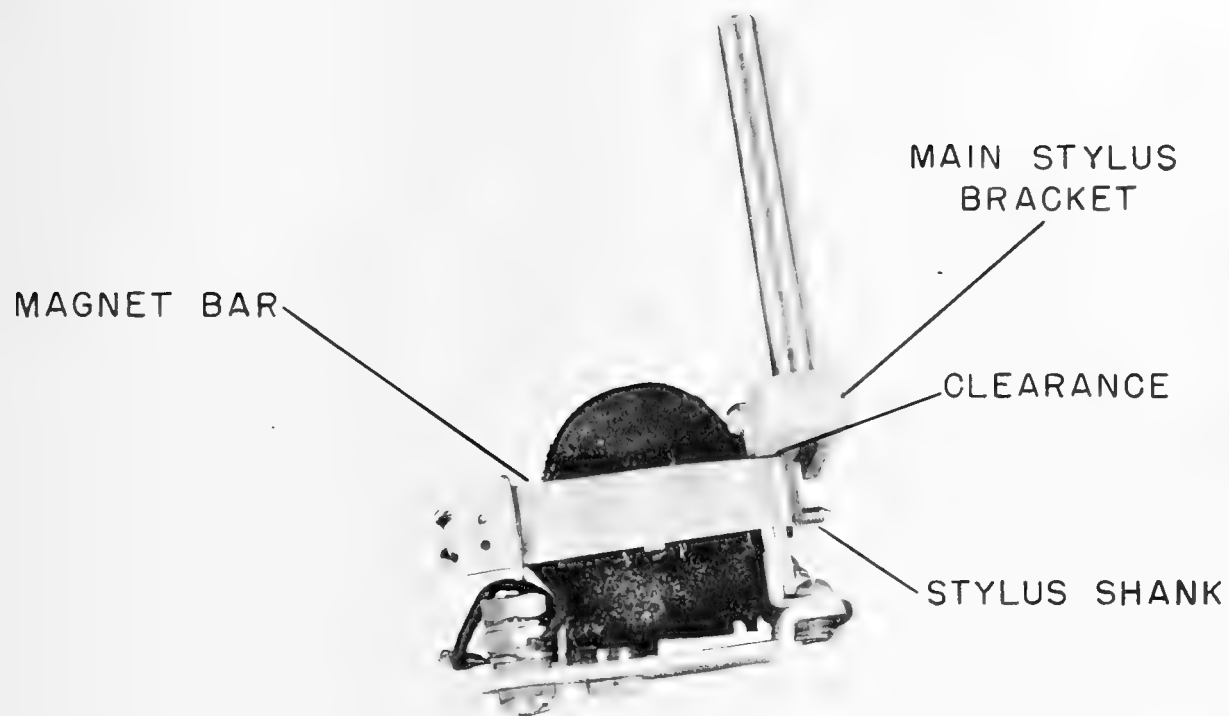
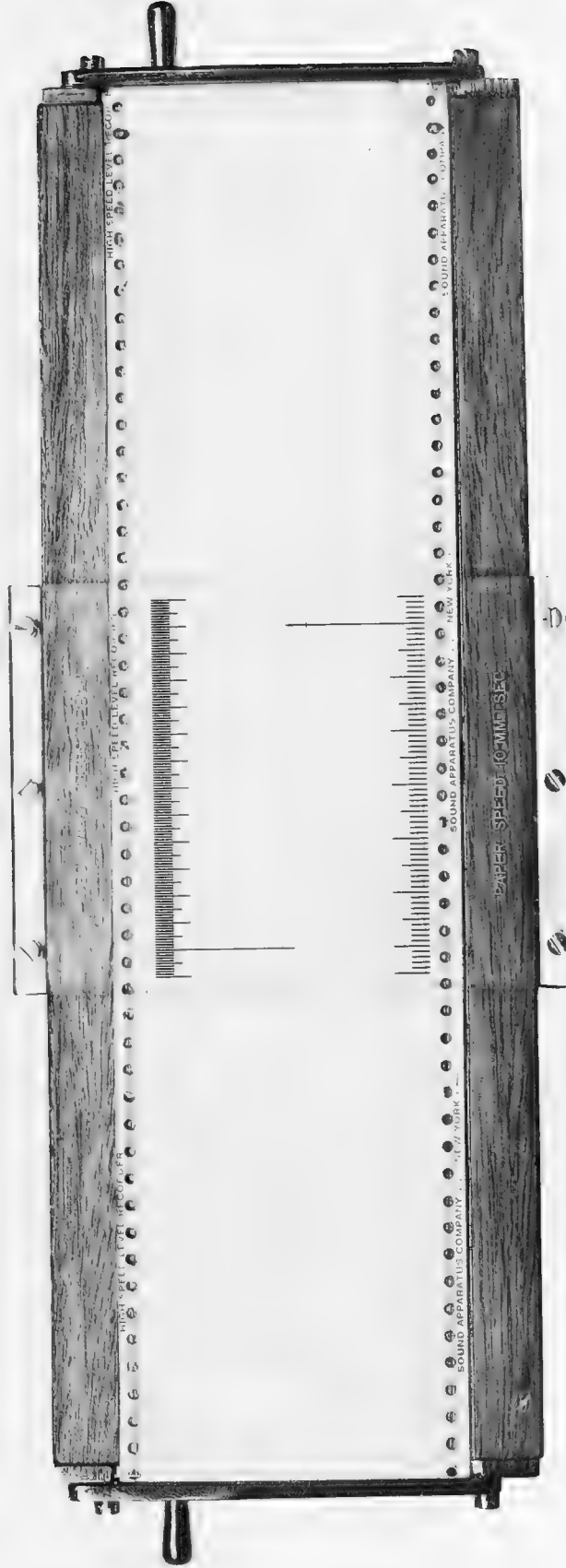


FIG. 26
END VIEW OF TIMING STYLUS MECHANISM

N-4355 A

USL Report No. 61



USL Report No. 61

FIG. 27 - Shot Arrival Time Evaluator

N-4983

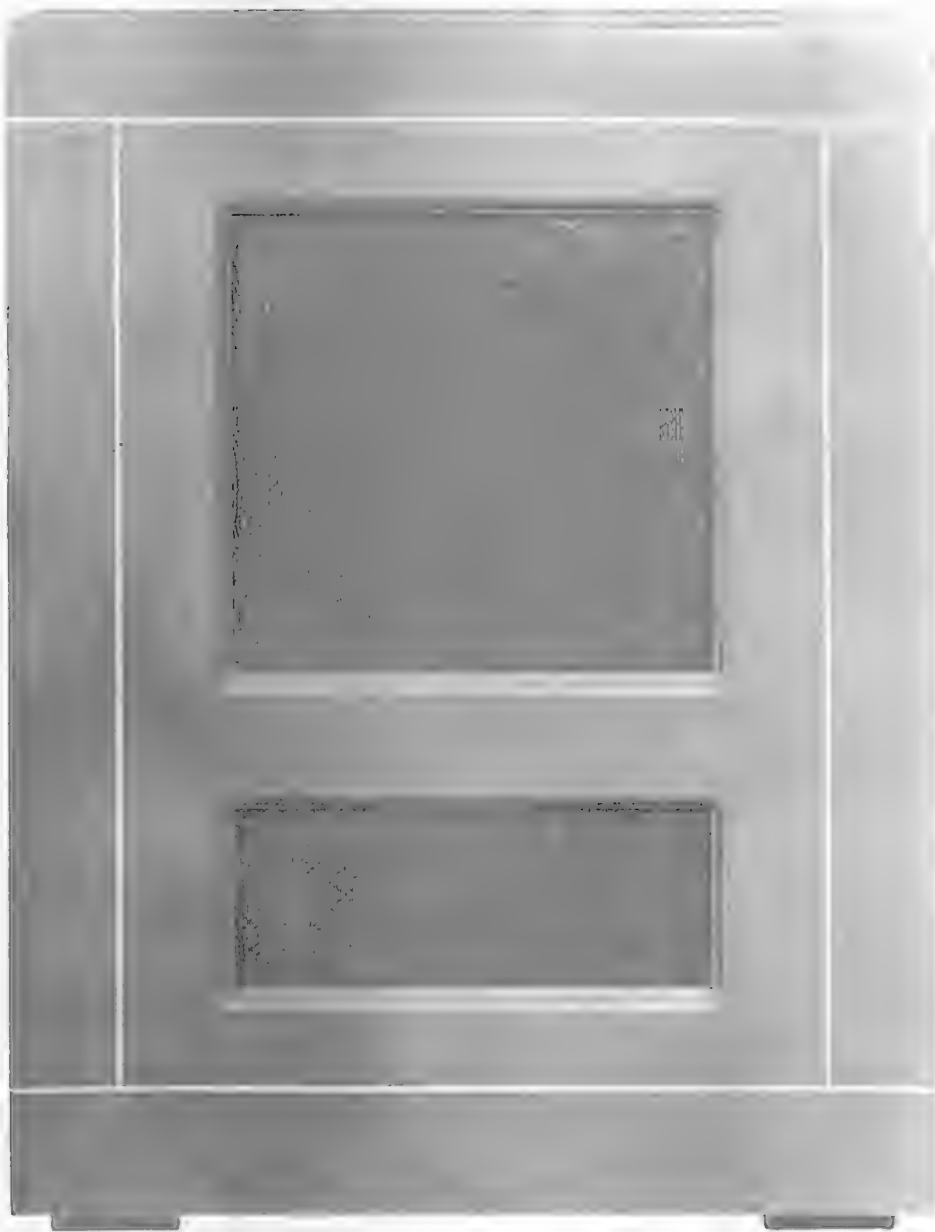


FIG. 28

MONITOR SPEAKER IN CABINET

N-4451-A

USL Report No. 61

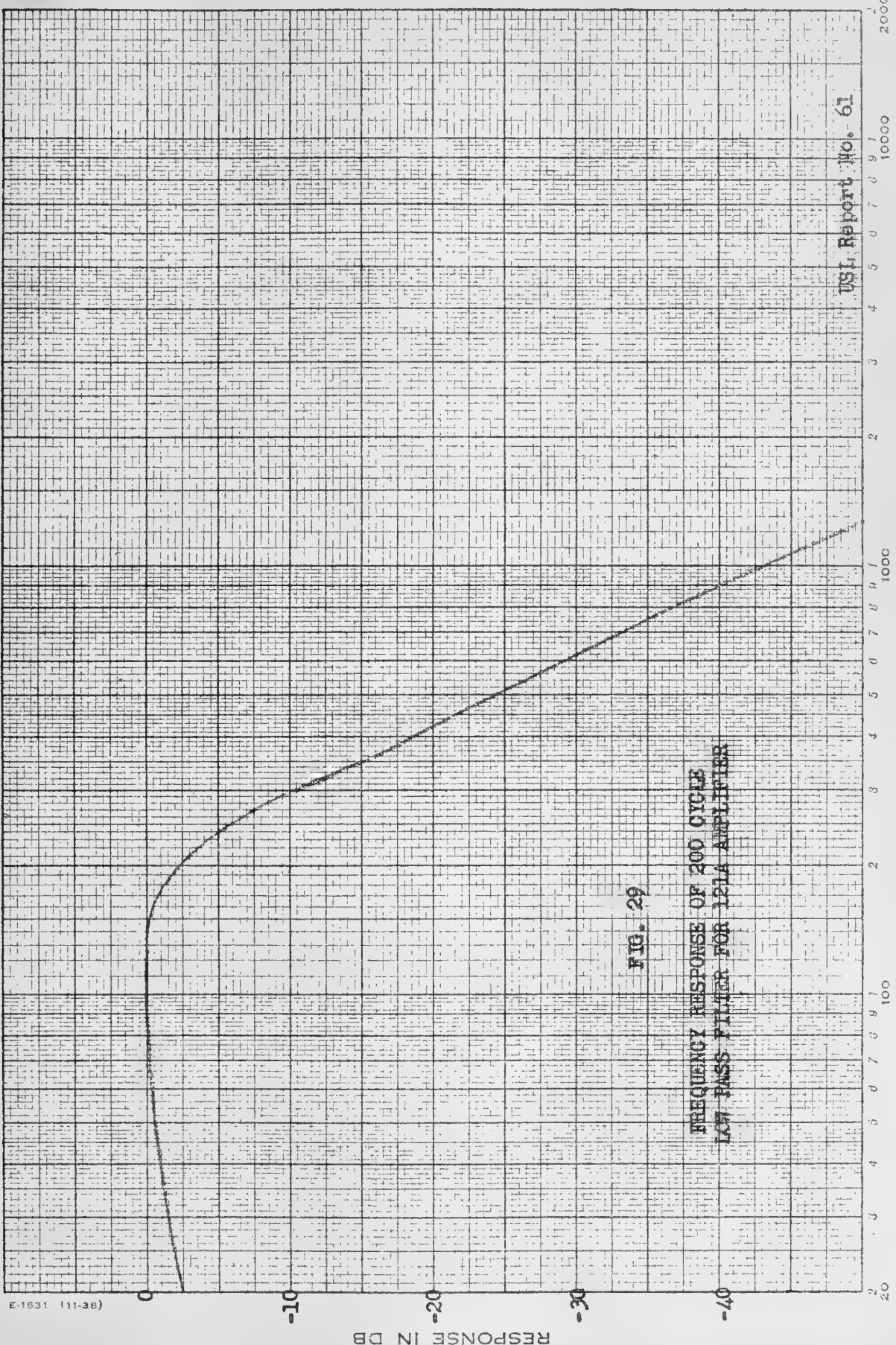


FIG. 29

FREQUENCY RESPONSE OF 200 CYCLE
LOW PASS FILTER FOR 121A AMPLIFIER

USI Report No. 61

(9e-11) 1391-3

(8e-11) 1E91-3

RESPONSE IN DB

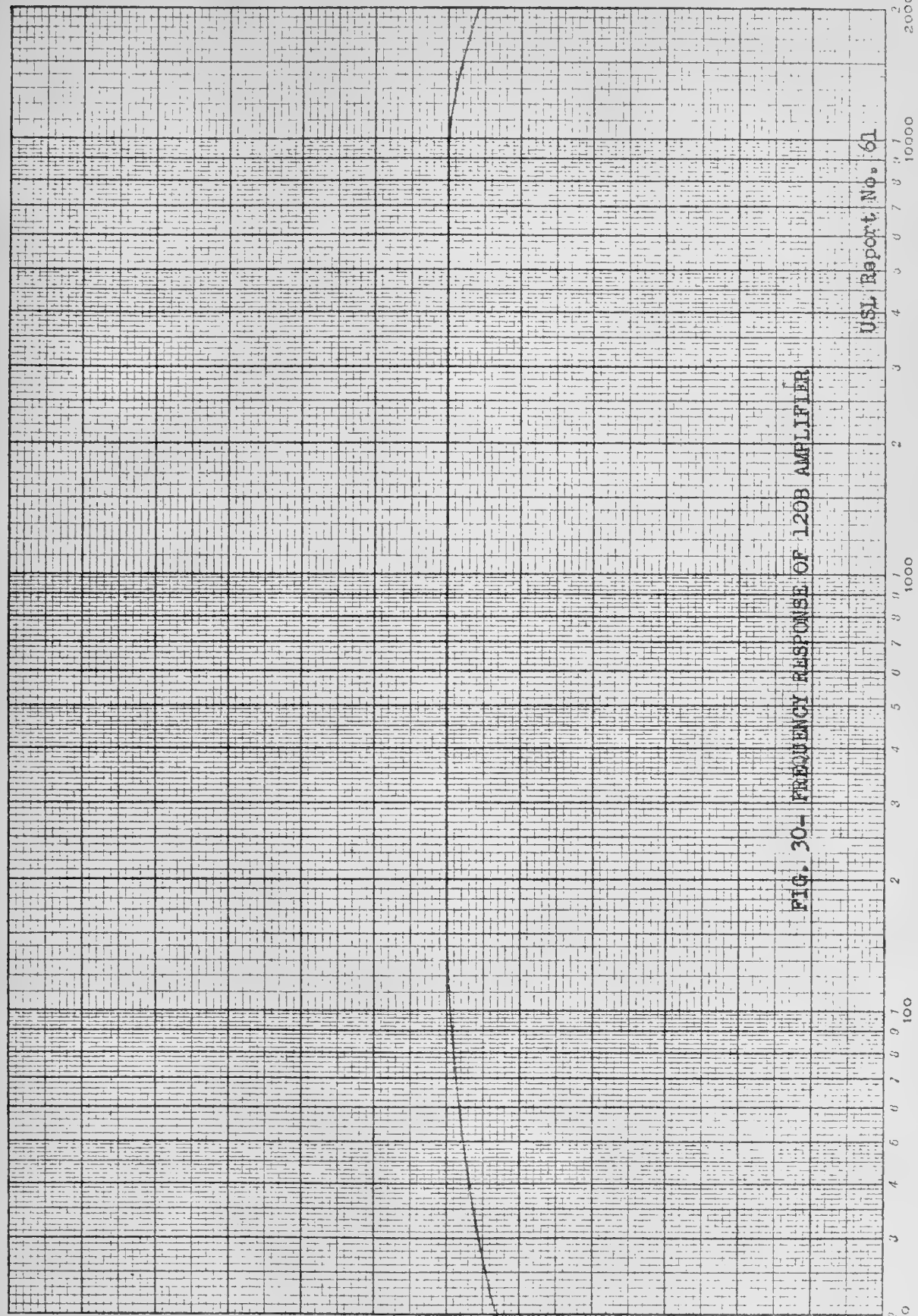


FIG. 30- FREQUENCY RESPONSE OF 120B AMPLIFIER

USL Report No. 61

FREQUENCY IN CYCLES PER SECOND

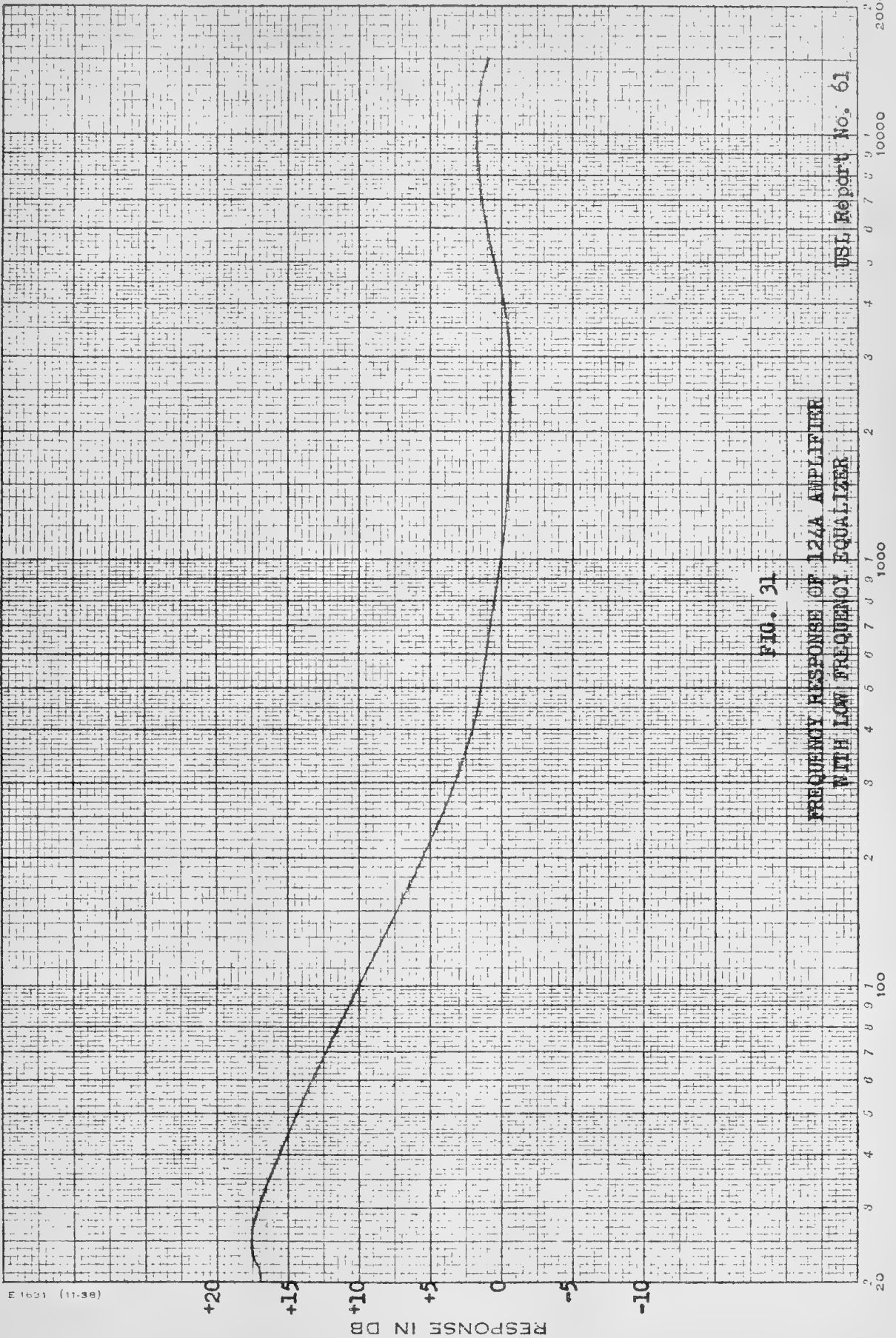


FIG. 31

FREQUENCY RESPONSE OF 127A AMPLIFIER
WITH LOW FREQUENCY EQUALIZER

USL Report No. 61

FREQUENCY IN CYCLES PER SECOND

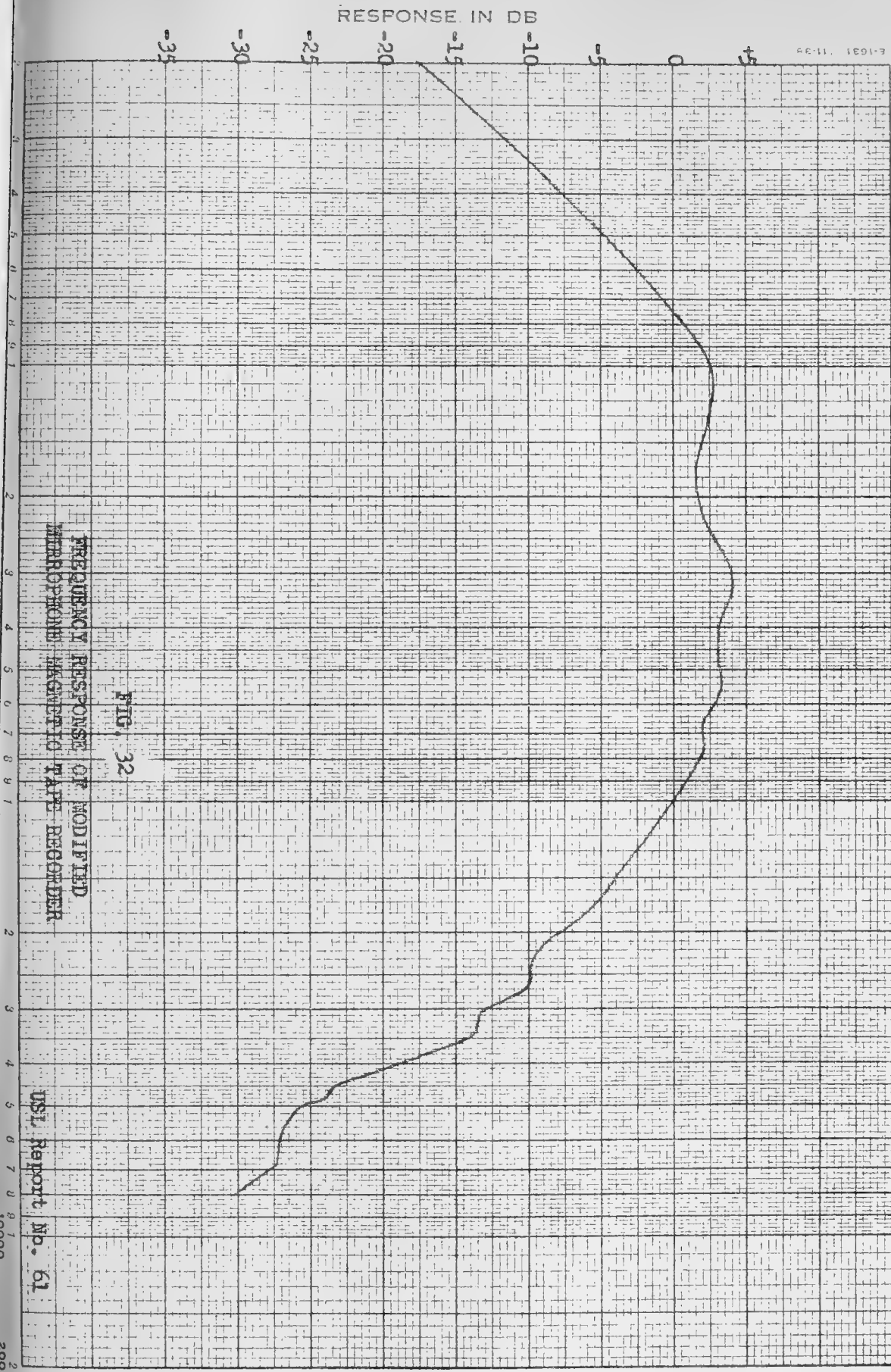


FIG. 32

FREQUENCY RESPONSE OF MODIFIED
MICROPHONE AMPLIFIER TYPE RECORDER

USI Report No. 61

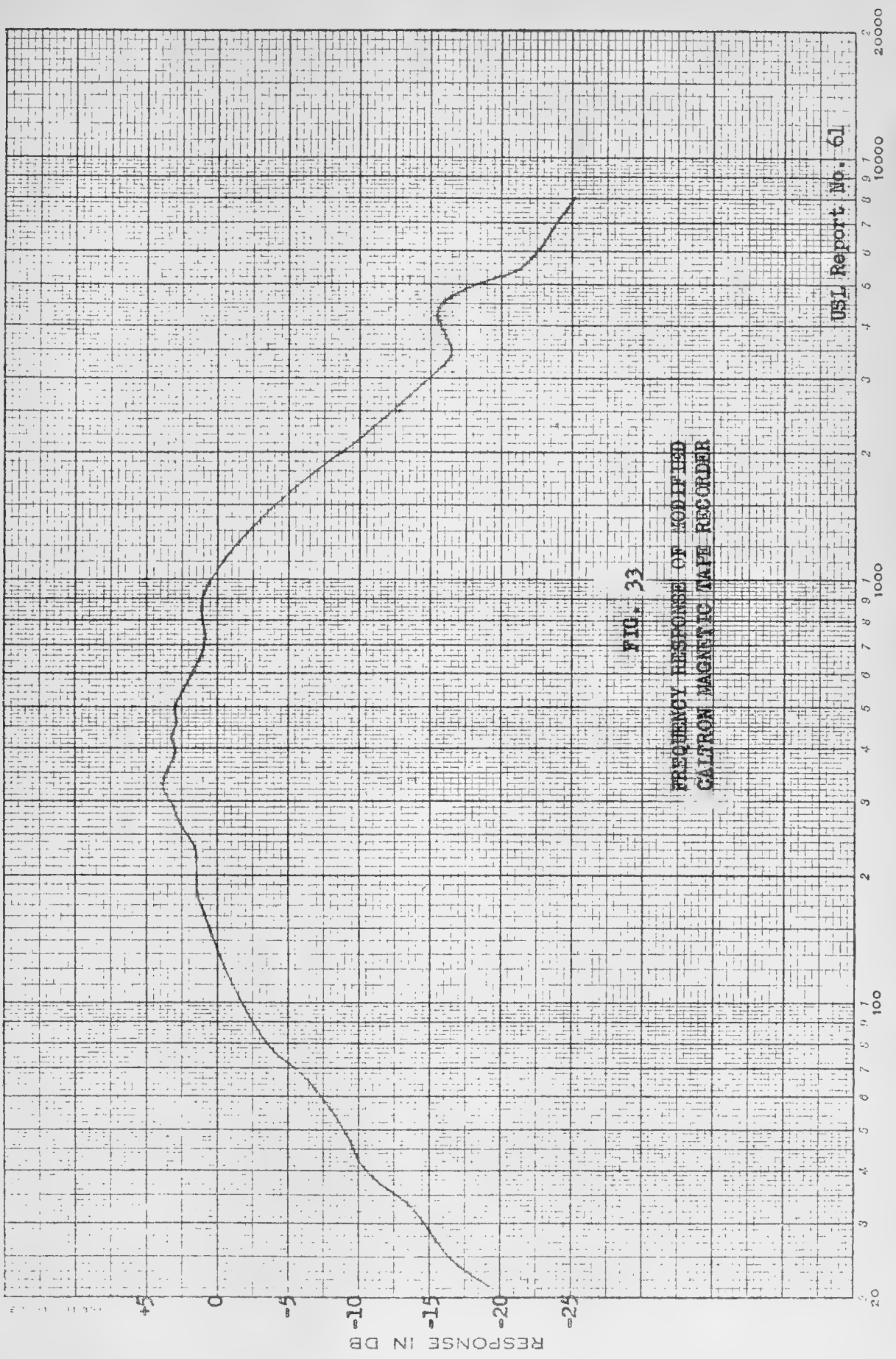


FIG. 33

FREQUENCY RESPONSE OF MODIFIED
GALTRON MAGNETIC TAPE RECORDER

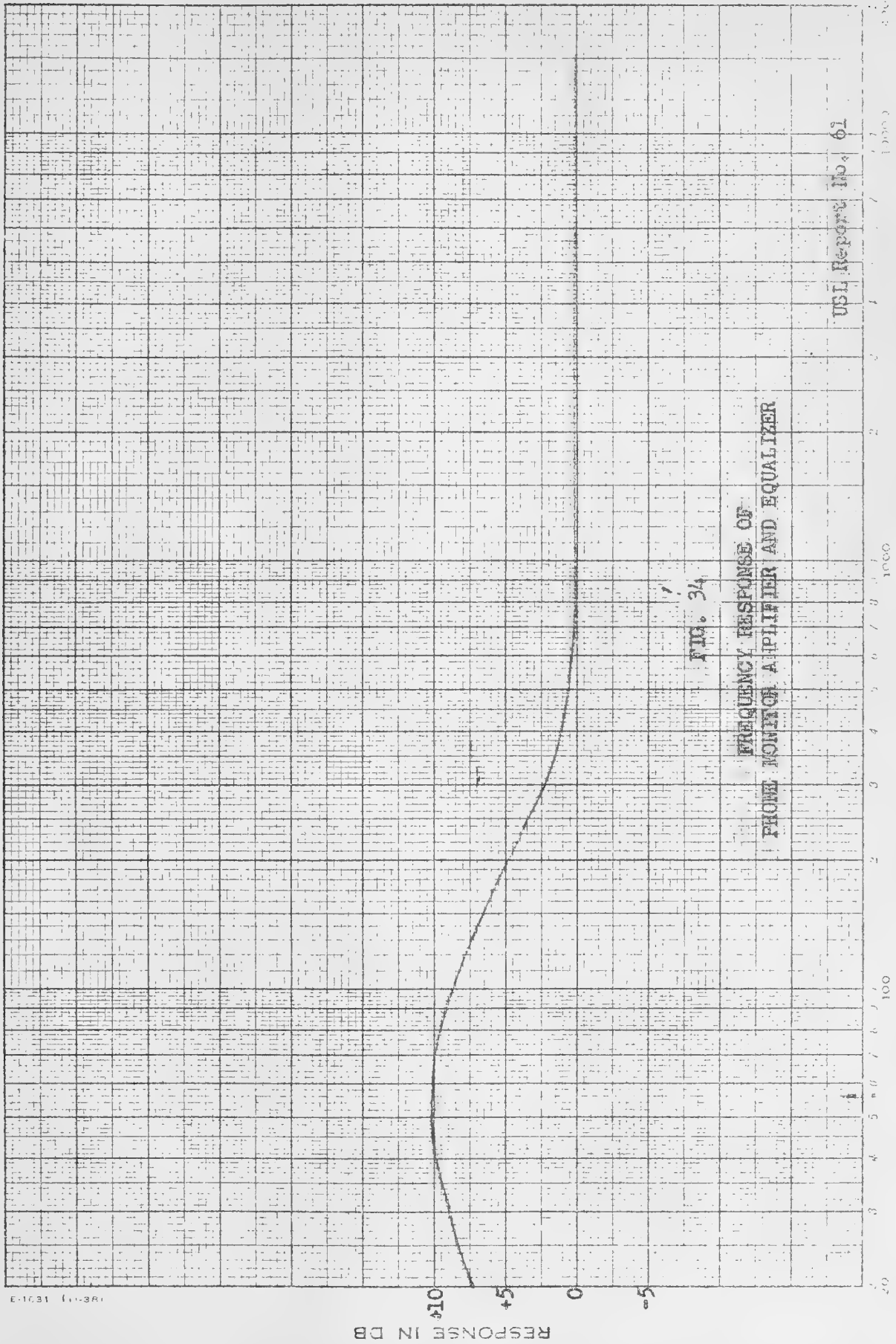


FIG. 34

FREQUENCY RESPONSE OF
PHONE MONITOR AMPLIFIER AND EQUALIZER

USL Report No. 61

FREQUENCY IN CYCLES PER SECOND

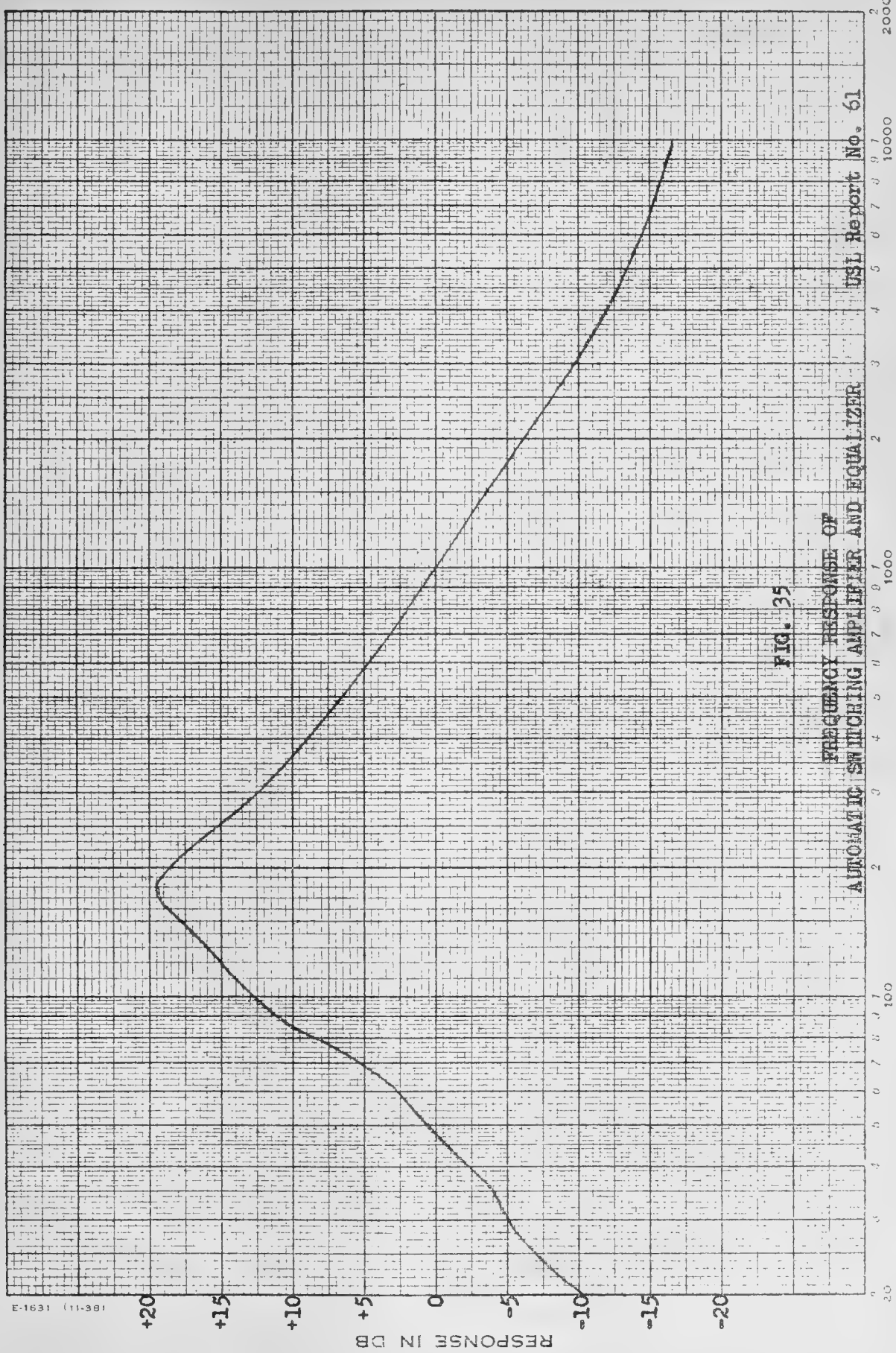


FIG. 25

FREQUENCY RESPONSE OF
AUTOMATIC SWITCHING AMPLIFIER AND EQUALIZER

USI Report No. 61

FREQUENCY IN CYCLES PER SECOND

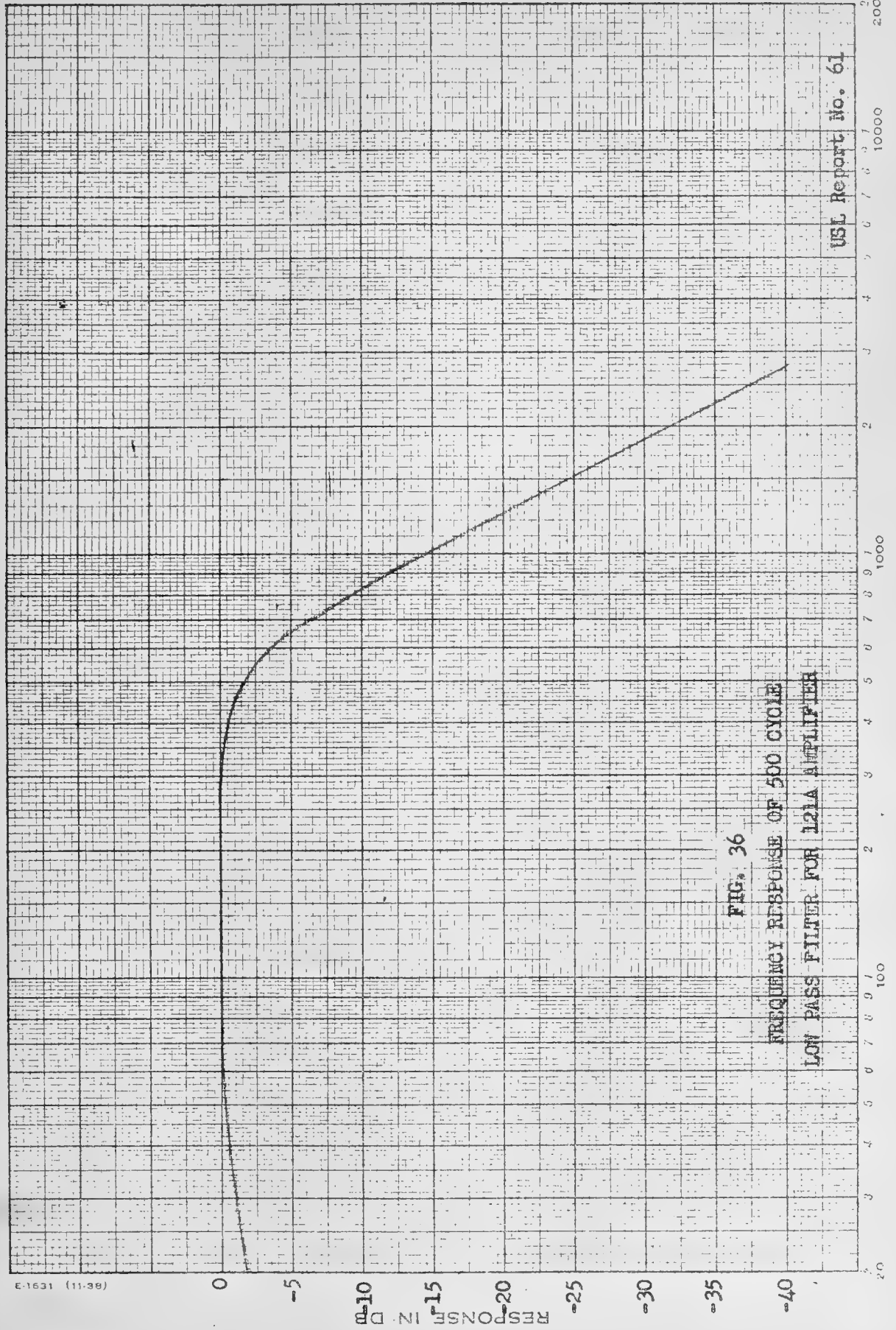


FIG. 36

FREQUENCY RESPONSE OF 500 CYCLE
LOW PASS FILTER FOR 121A AMPLIFIER

USL Report No. 61

FREQUENCY IN CYCLES PER SECOND

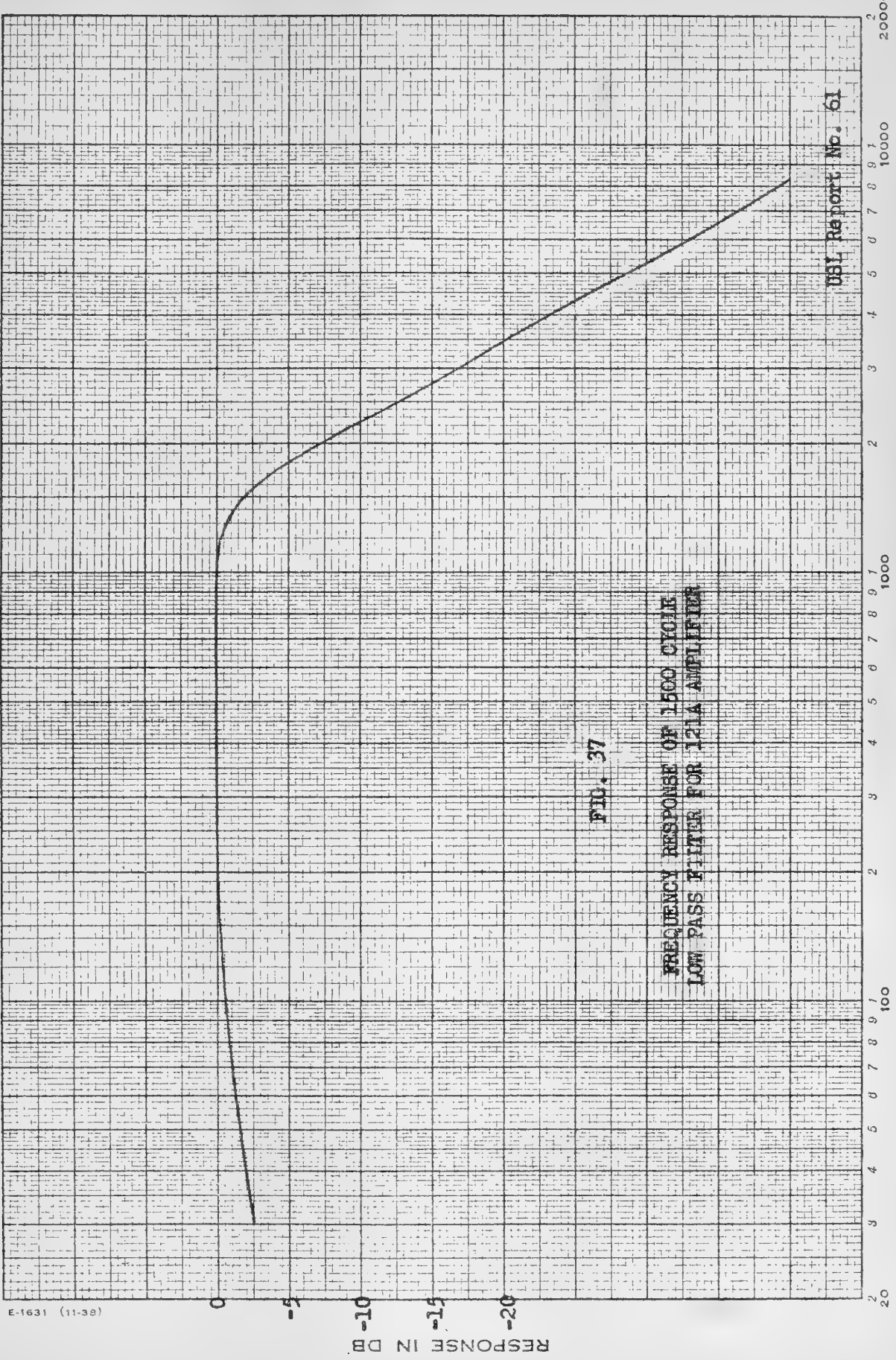


FIG. 37

FREQUENCY RESPONSE OF 1500 CYCLE
LOW PASS FILTER FOR 121A AMPLIFIER

USL Report No. 61

(6-11) 1691-3

Eleuthera Sofar
Monitoring Equipment

FIG. 1

As of June 16, 1945

BLOCK DIAGRAM WHOI

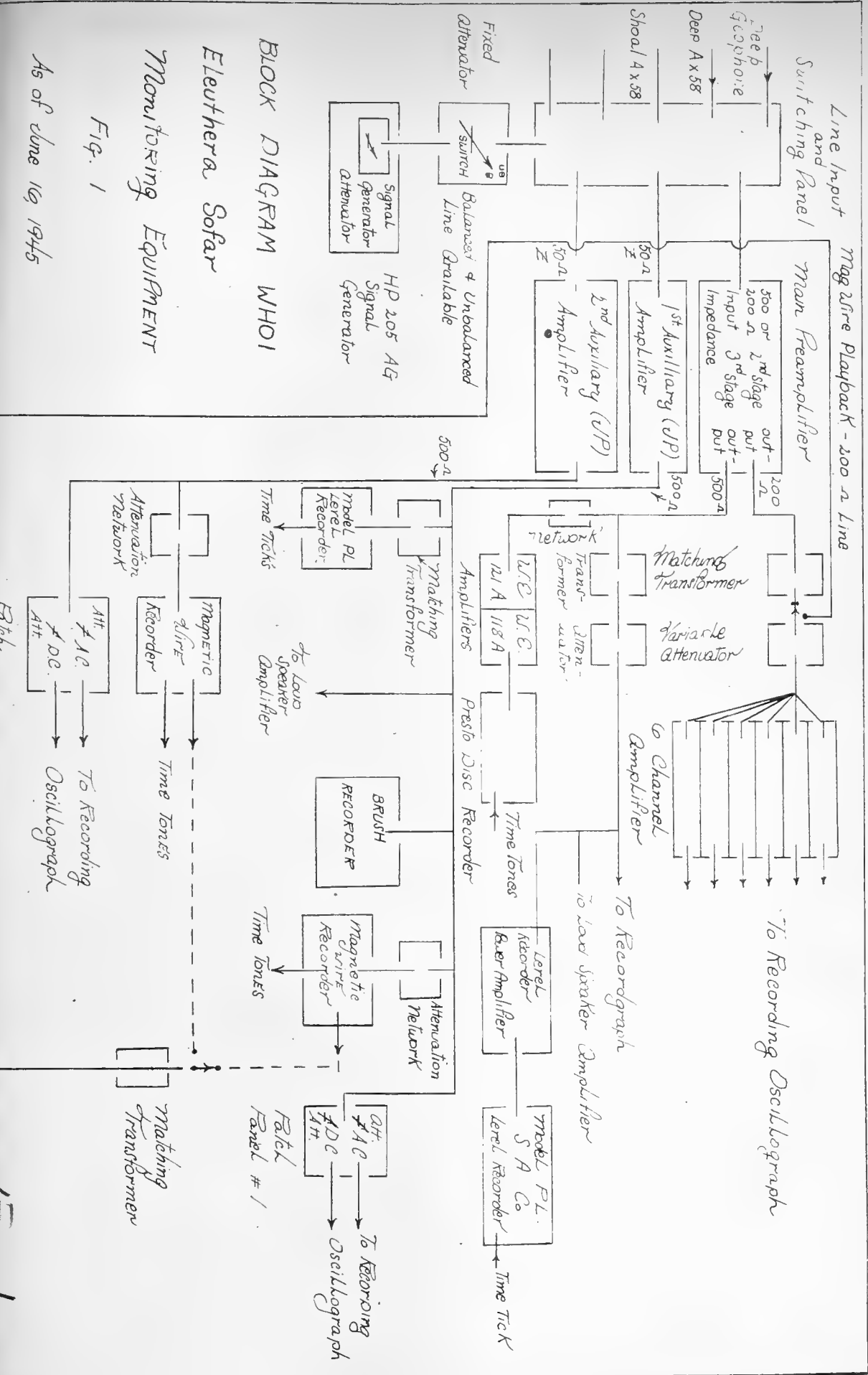


FIG 1

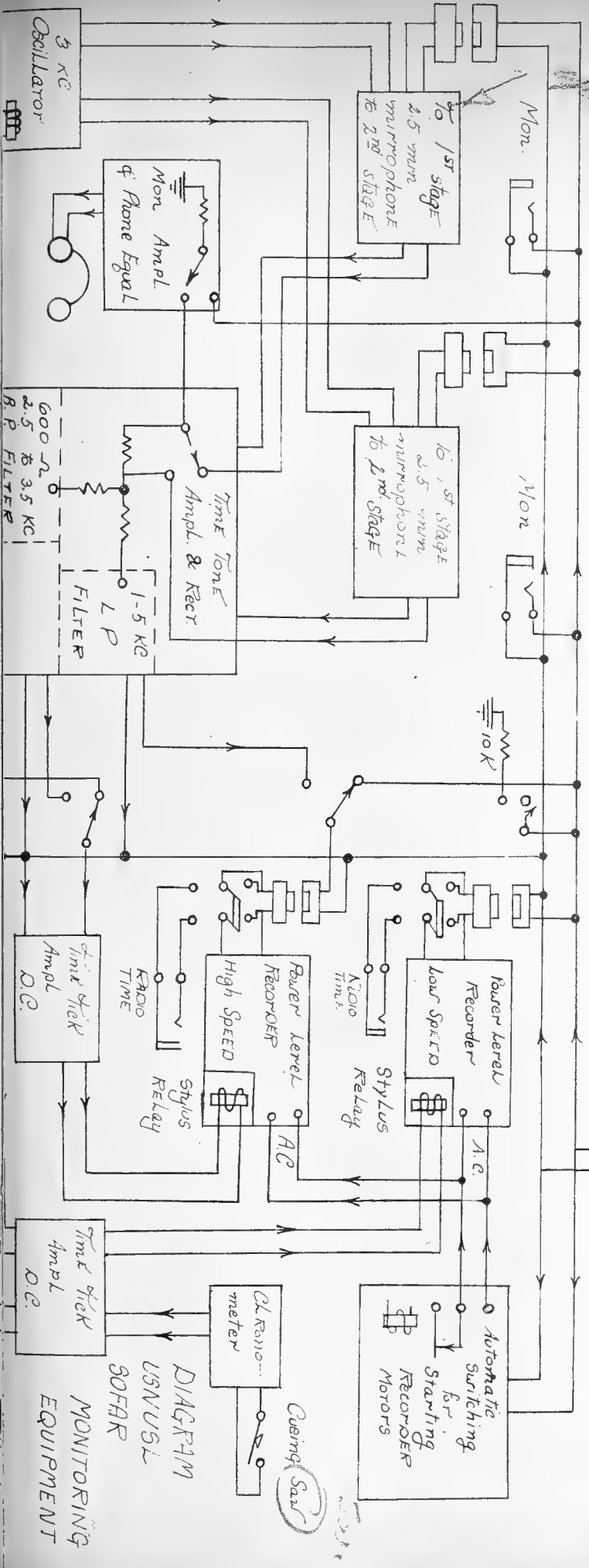
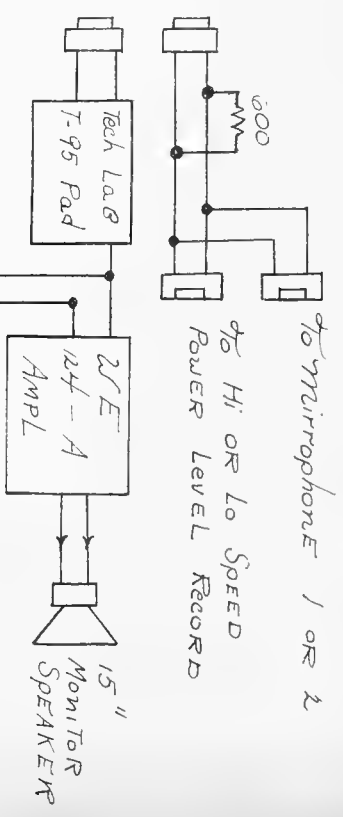
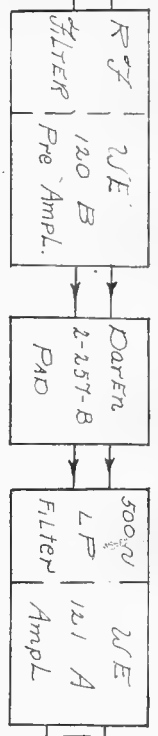
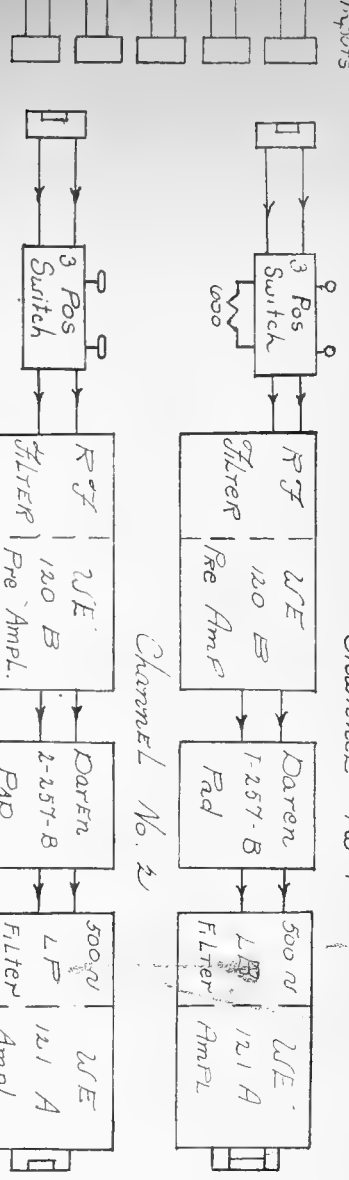
Hyphone
Inputs
For Sig Gen.

Channel No 1

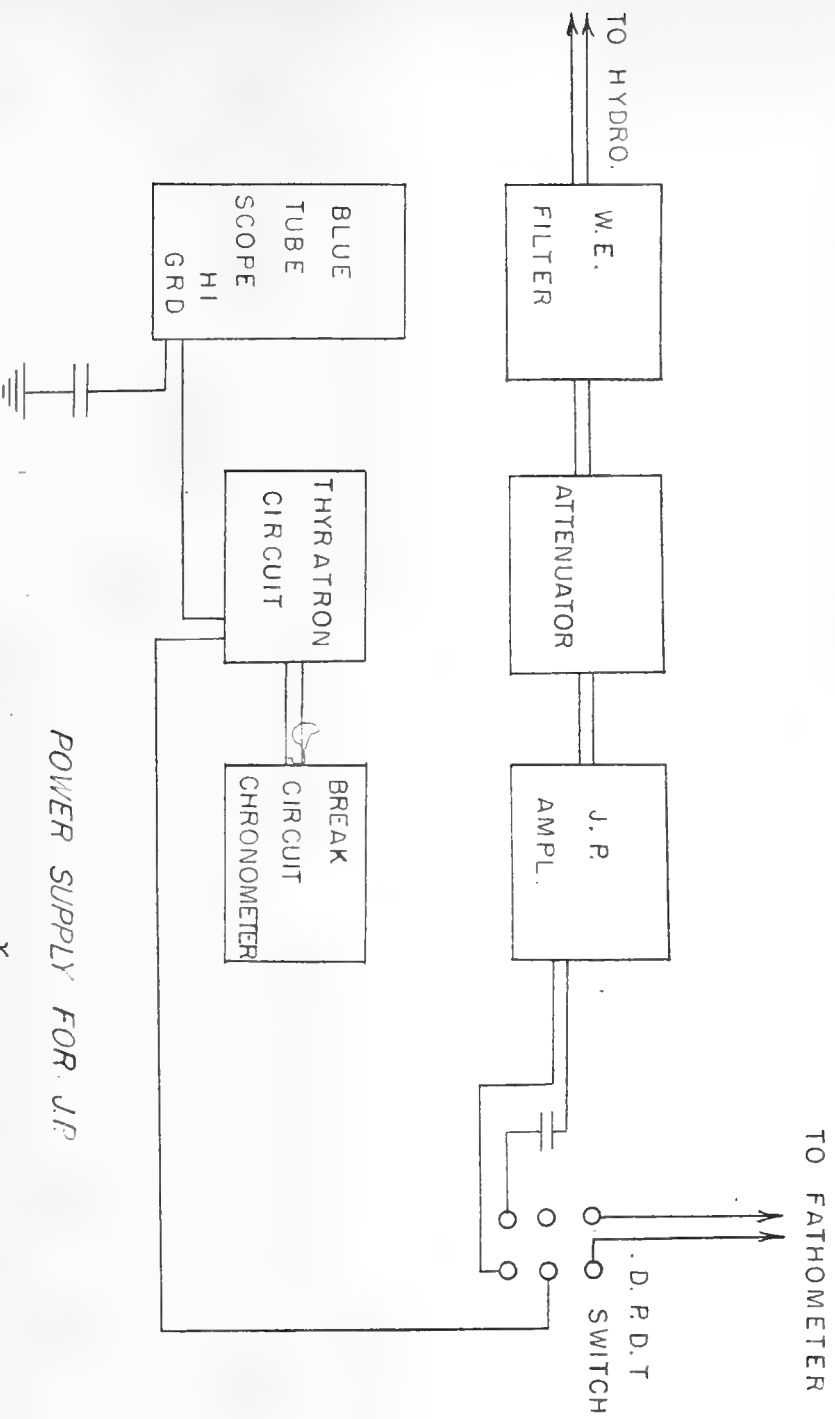
For Dual Channel
Operation

To Microphone 1 OR 2

To Hi OR Lo SPEED
POWER LEVEL RECORD



BLOCK DIAGRAM OF ATLANTIS GEAR FOR RECORDING ACOUSTIC ENERGY



ALL GROUNDS TO SCOPE EXCEPT W.E. FILTER

"FIL" 12^x dev

FIG. 3

NO. DATE



U S NAVY UNDERWATER SOUND LABORATORY
FORT TRUMBULL, NEW LONDON, CONN.

DRAWG NO. 0-4-4 SHEET OF SHEETS
DRAWN BY JH DATE 1/24/46 INSPECTED BY WCL DATE 2/27/46
TRACED BY DATE APPROVED BY WCL DATE 6/4/46
SCALE REPRODUCTION OF FINAL PLANS MADE
PLAN EXAMINED & FOUND SATISFACTORY

BU. SHIPS PROJECT OFFICER COMMANDING OFFICER

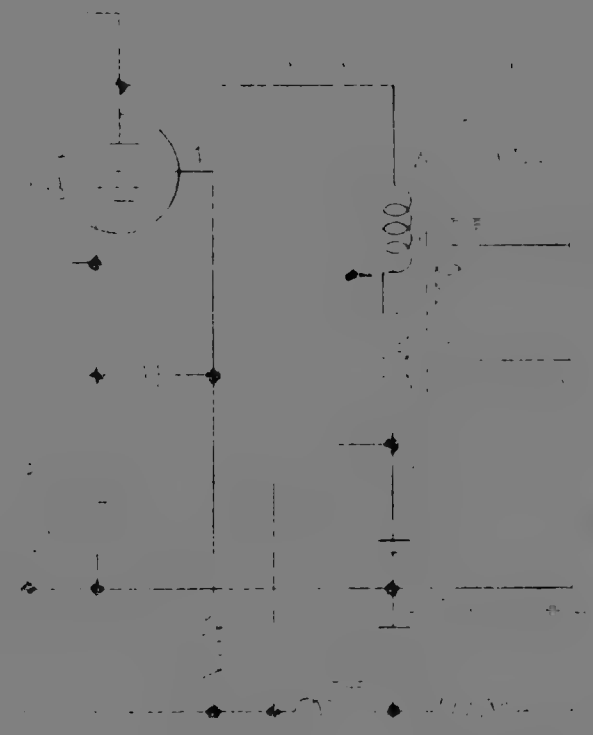
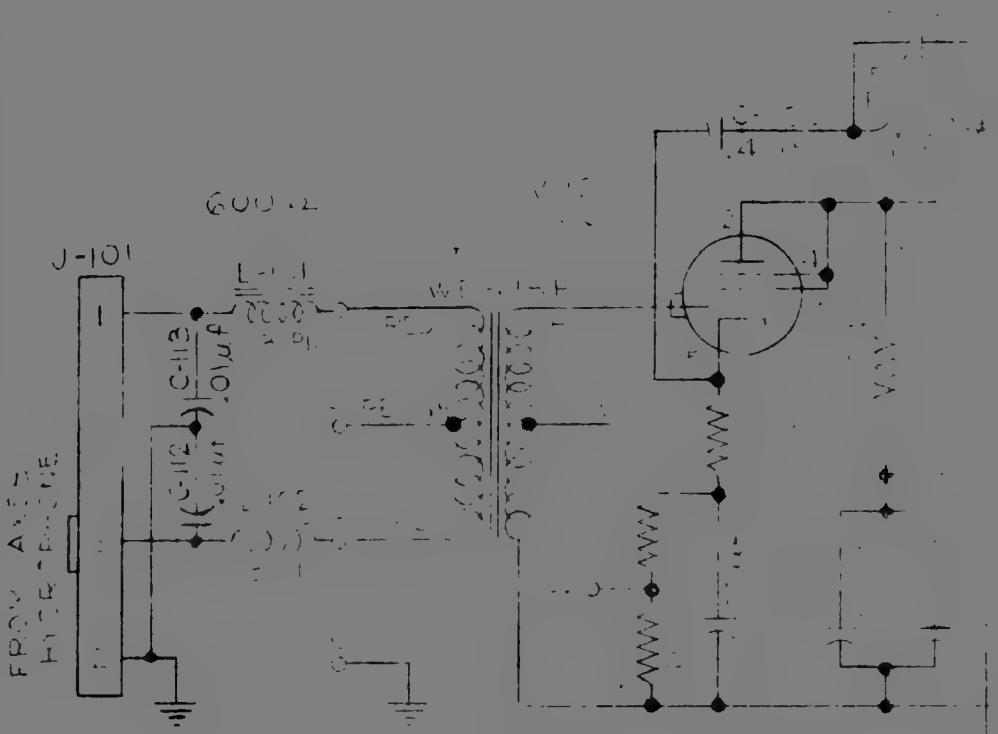
CONTRACT NO. 50-1
FURNISHING MATERIALS
FOR UNDERWATER SOUNDING SYS.
A PART OF
SOPAC EQUIPMENT

BUREAU OF SHIPS PLAN NUMBER

USL REPORT NO. 61

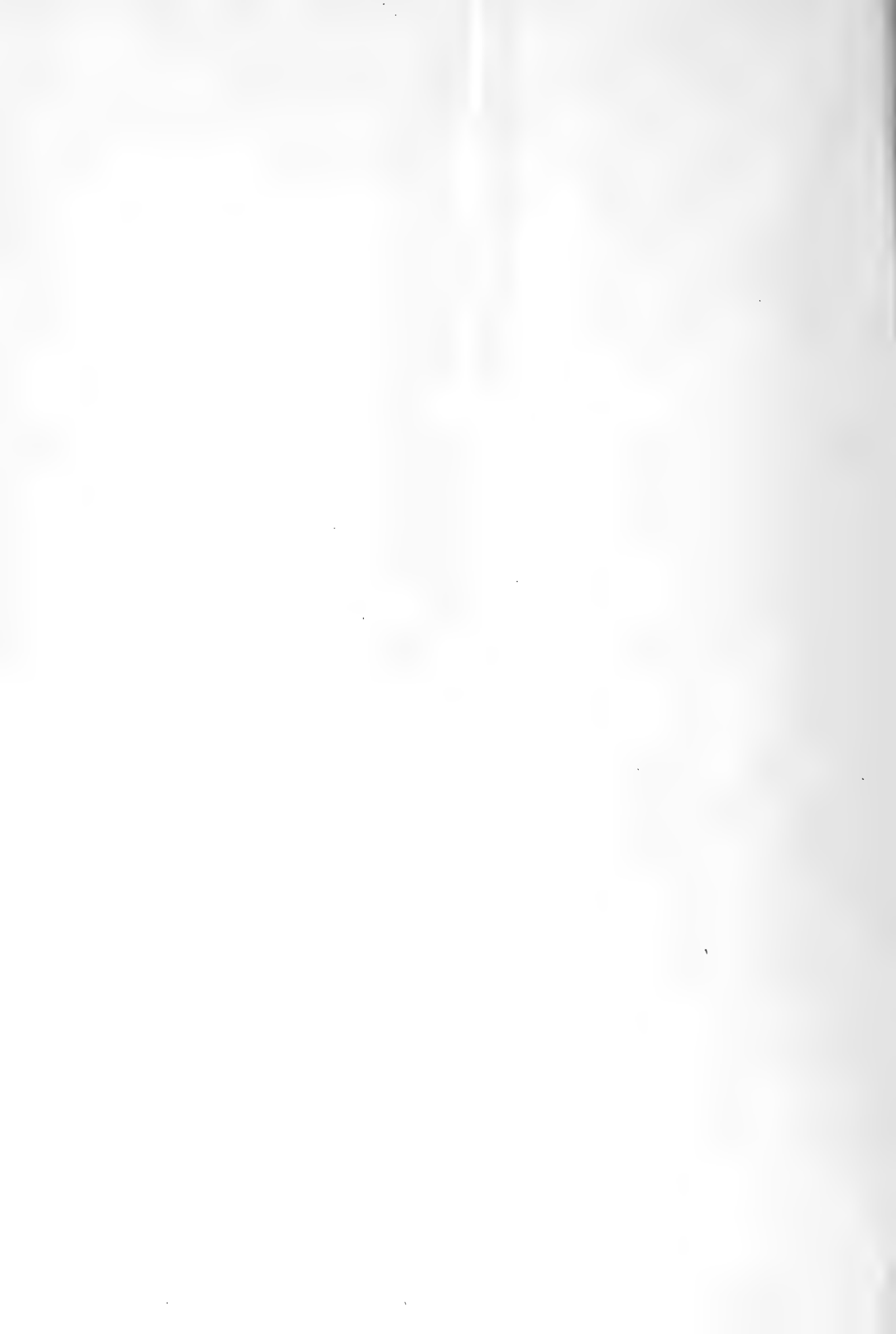
Fig. 35

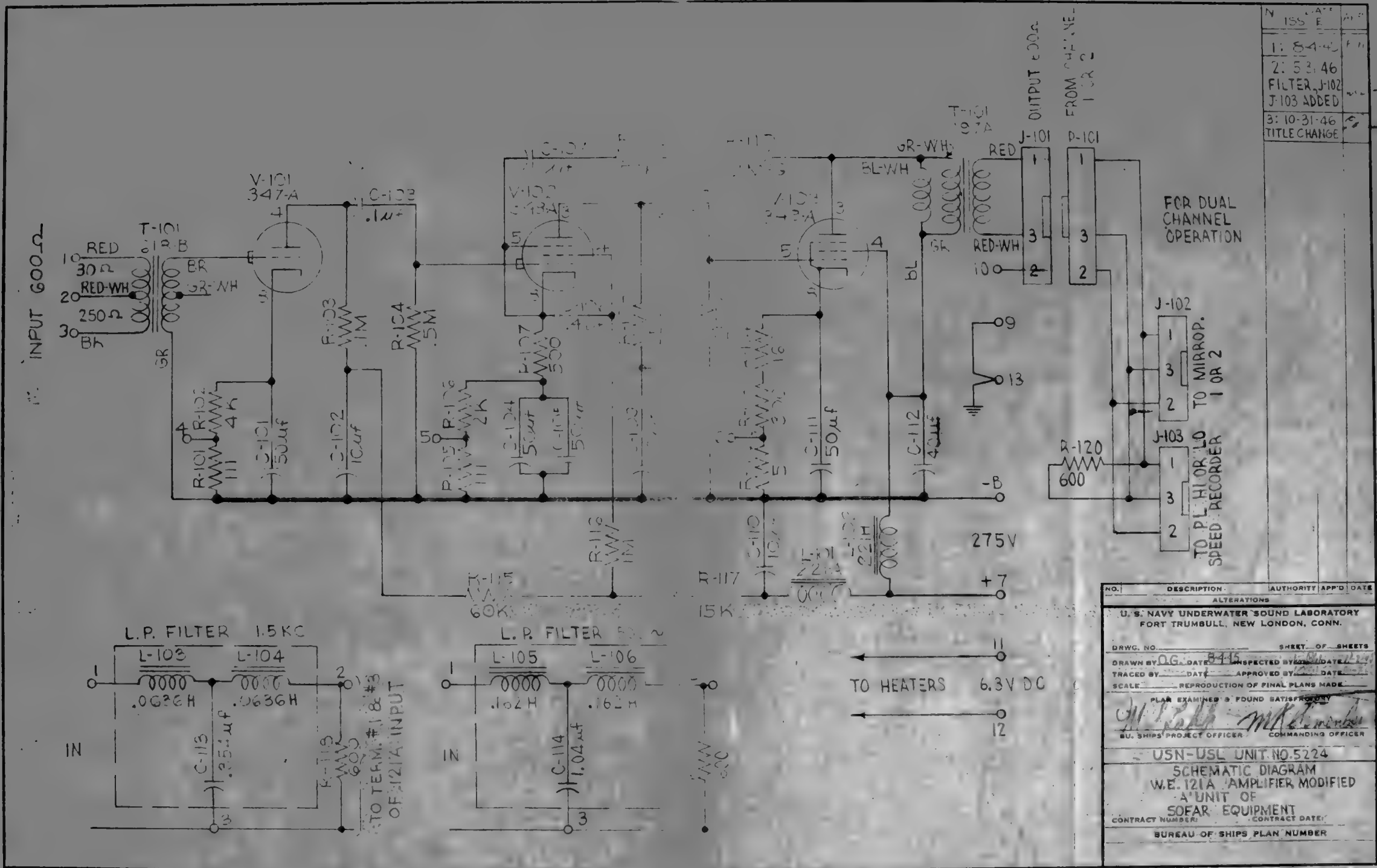
SHEET E-22296-AA



ISSUE
NO. LATE A-10

DATE: _____ BY: _____





N	155	E	
1:	8-4-46		
2:	5-3-46		
	J-103 ADDED		
3:	10-31-46		
	TITLE CHANGE		

FOR DUAL CHANNEL OPERATION

TO PLH OR LO TO MIRROR. SPEED RECORDER 1 OR 2

NO.	DESCRIPTION	AUTHORITY	APP'D	DATE
ALTERATIONS				
U. S. NAVY UNDERWATER SOUND LABORATORY FORT TRUMBULL, NEW LONDON, CONN.				
DRWG. NO.	OG-8445	SHEET	OF	SHEETS
DRAWN BY	DATE	INSPECTED BY	DATE	
TRACED BY	DATE	APPROVED BY	DATE	
SCALE	REPRODUCTION OF FINAL PLANS MADE			
PLAN EXAMINED & FOUND SATISFACTORY				
BU. SHIPS PROJECT OFFICER		COMMANDING OFFICER		
USN-USL UNIT NO. 5224				
SCHEMATIC DIAGRAM W.E. 121A AMPLIFIER MODIFIED A UNIT OF SOFAR EQUIPMENT				
CONTRACT NUMBER	CONTRACT DATE			
BUREAU OF SHIPS PLAN NUMBER				

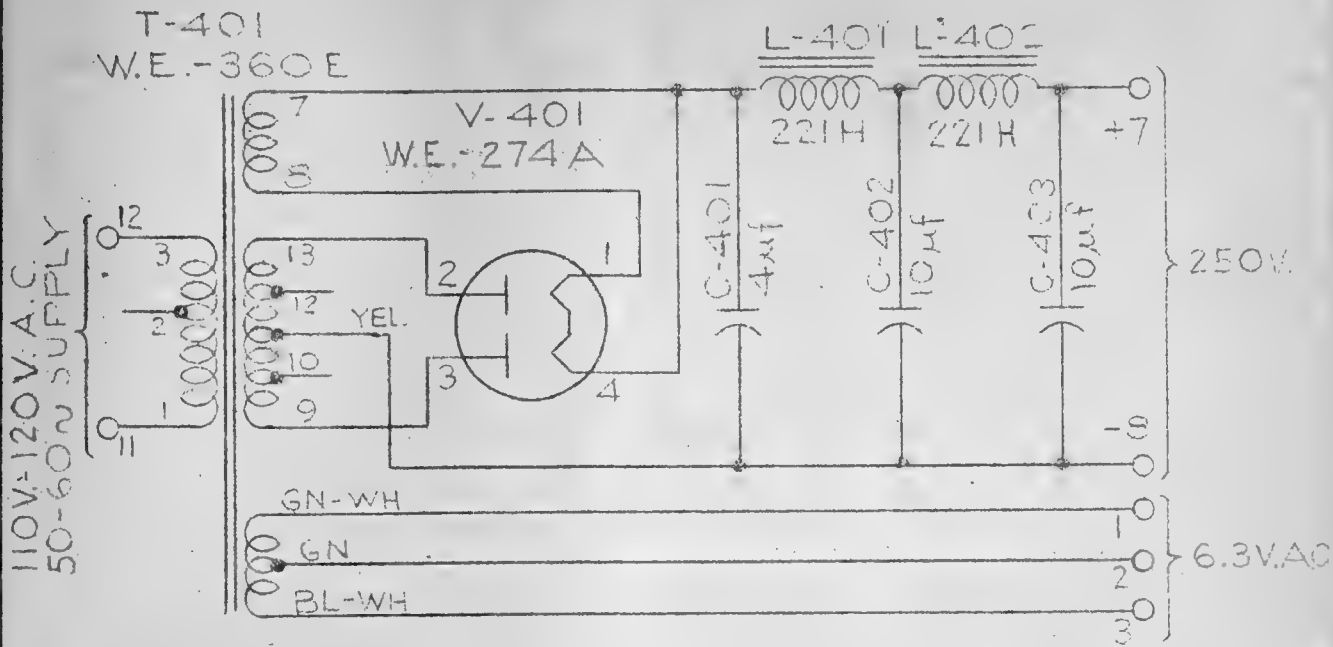
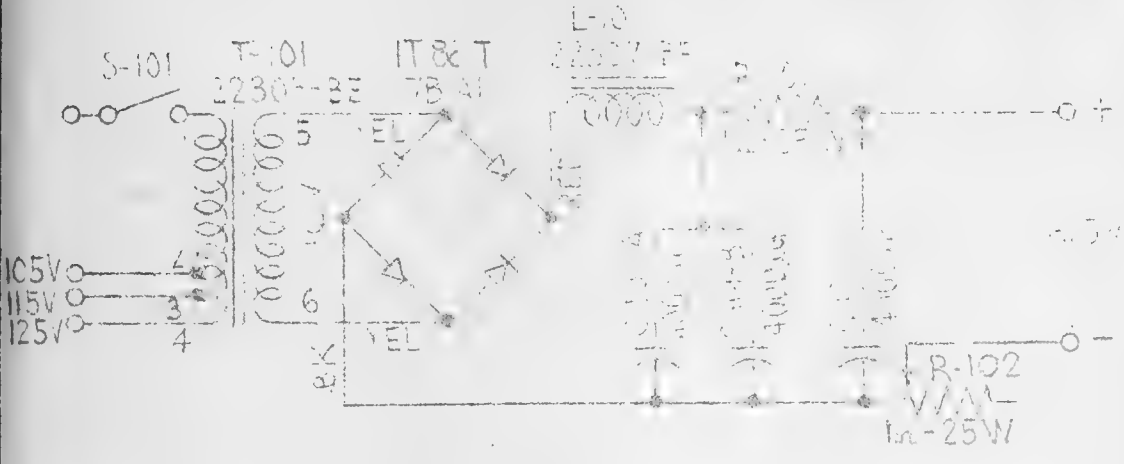


FIG. 41

ISSUE		
NO	DATE	APP
1	8-15-46	AA
2	10-31-46	922
TITLE CHANGE		

NO.	DESCRIPTION	AUTHORITY	APP'D	DATE
ALTERATIONS				
U. S. NAVY UNDERWATER SOUND LABORATORY FORT TRUMBULL, NEW LONDON, CONN.				
DRWG. NO. _____		SHEET OF SHEETS _____		
DRAWN BY <u>H.S.</u> DATE <u>8-25-46</u>		INSPECTED BY <u>[Signature]</u> DATE <u>11-27-46</u>		
TRACED BY _____ DATE _____		APPROVED BY <u>[Signature]</u> DATE <u>11-27-46</u>		
SCALE <u>NONE</u> REPRODUCTION OF FINAL PLANS MADE _____				
PLAN EXAMINED & FOUND SATISFACTORY				
[Signature]		[Signature]		
BU. SHIPS PROJECT OFFICER		COMMANDING OFFICER		
USN-USL UNIT NO. 5228				
SCHEMATIC DIAGRAM				
18A POWER SUPPLY MODIFIED				
A UNIT OF				
SOFAR EQUIPMENT.				
CONTRACT NUMBER: _____		CONTRACT DATE: _____		
BUREAU OF SHIPS PLAN NUMBER _____				

ISSUE NO.	DATE	APP.
-----------	------	------



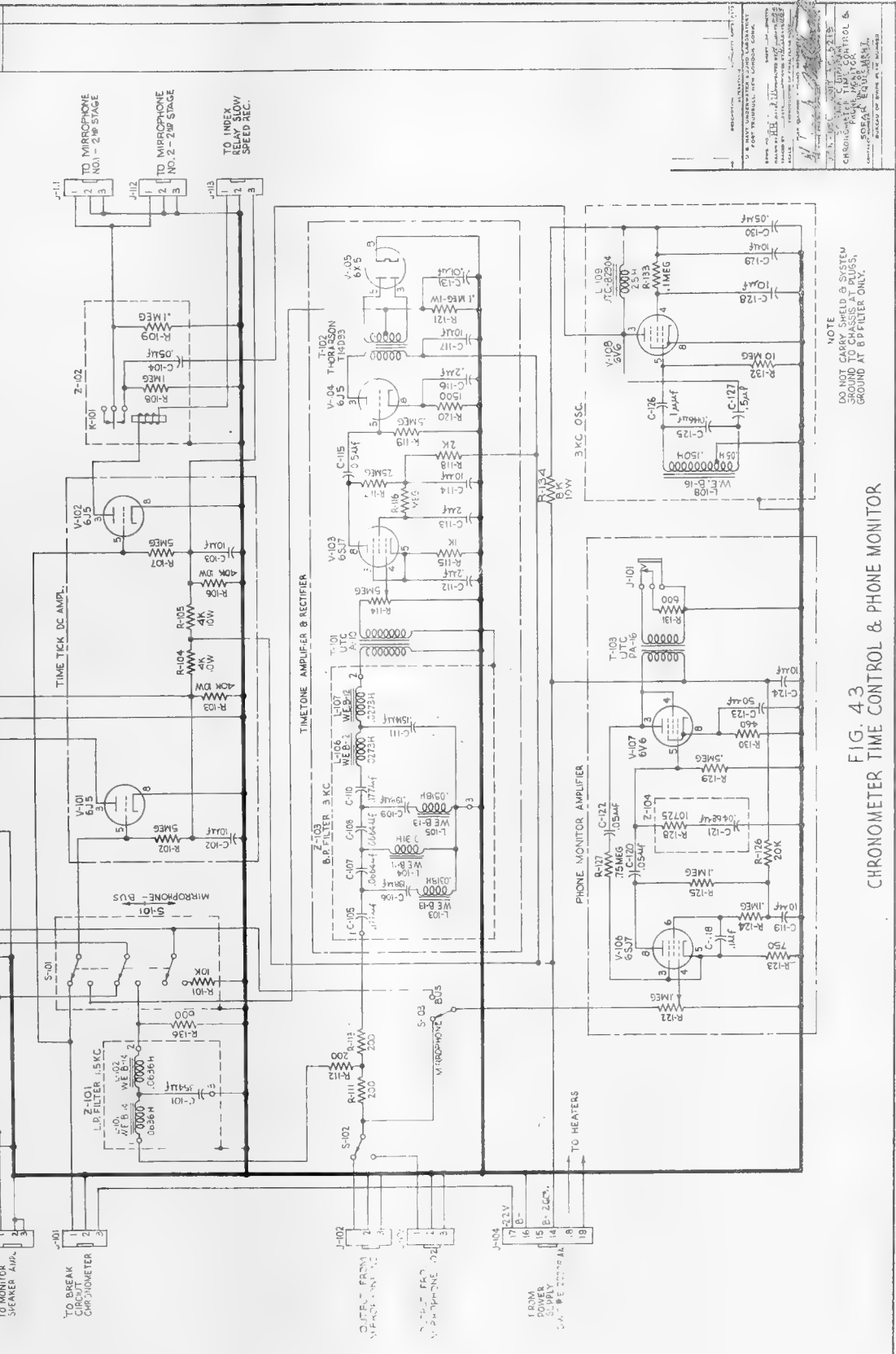
NOTES

- 1- IF OUTPUT VOLTAGE UNDER LOAD IS TOO HIGH, MOVE TAP ON R-102.
- 2- IF OUTPUT VOLTAGE UNDER LOAD IS TOO LOW, CHANGE PRIMARY CONNECTION FROM TAP 4 TO TAP 3.

FIG. 42

NO.	DESCRIPTION	AUTHORITY	APP'D	DATE
ALTERATIONS				
U. S. NAVY UNDERWATER SOUND LABORATORY FORT TRUMBULL, NEW LONDON, CONN.				
DRAWG. NO. <u>USN-22317-J</u> SHEET <u>1</u> OF <u>1</u> SHEETS				
DRAWN BY <u>DW</u> DATE <u>6-3-46</u> INSPECTED BY <u>WGL</u> DATE <u>6-1</u>				
TRACED BY _____ DATE _____ APPROVED BY <u>WGL</u> DATE <u>6-3-46</u>				
SCALE _____ REPRODUCTION OF FINAL PLANS MADE _____				
PLAN EXAMINED & FOUND SATISFACTORY				
BU. SHIPS PROJECT OFFICER		COMMANDING OFFICER		
USN-USL UNIT NO 5227				
SCHEMATIC DIAGRAM				
7 VOLT D.C. POWER SUPPLY				
A UNIT OF				
SOFAR EQUIPMENT				
CONTRACT NUMBER:		CONTRACT DATE:		
BUREAU OF SHIPS PLAN NUMBER				

NO.	DATE	APP.
1.	11-04-51	RM
2.	1-5-54	RM
MINOR COR.		
3.	7-17-54	RM
C-111 C-112 C-113 C-114 C-115 C-116 C-117 C-118 C-119 C-120 C-121 C-122 C-123 C-124 C-125 C-126 C-127 C-128 C-129 C-130 C-131 C-132 C-133 C-134 C-135 C-136 C-137 C-138 C-139 C-140 C-141 C-142 C-143 C-144 C-145 C-146 C-147 C-148 C-149 C-150 C-151 C-152 C-153 C-154 C-155 C-156 C-157 C-158 C-159 C-160 C-161 C-162 C-163 C-164 C-165 C-166 C-167 C-168 C-169 C-170 C-171 C-172 C-173 C-174 C-175 C-176 C-177 C-178 C-179 C-180 C-181 C-182 C-183 C-184 C-185 C-186 C-187 C-188 C-189 C-190 C-191 C-192 C-193 C-194 C-195 C-196 C-197 C-198 C-199 C-200		
A-1022644 FILE CHANGED		



NOTE
DO NOT CARRY SHIELD & SYSTEM
GROUND TO CHASSIS AT PLUGS,
GROUND AT 8 PLETER ONLY.

FIG. 4-3
CHRONOMETER TIME CONTROL & PHONE MONITOR

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U.S. NATIONAL BUREAU OF STANDARDS
431 RICHMOND STREET
WASHINGTON, D.C. 20535

DATE: 11-04-51
BY: RM
CHECKED BY: RM
APPROVED BY: RM
TITLE: CHRONOMETER TIME CONTROL & PHONE MONITOR
FILE NO: A-1022644

ISSUE

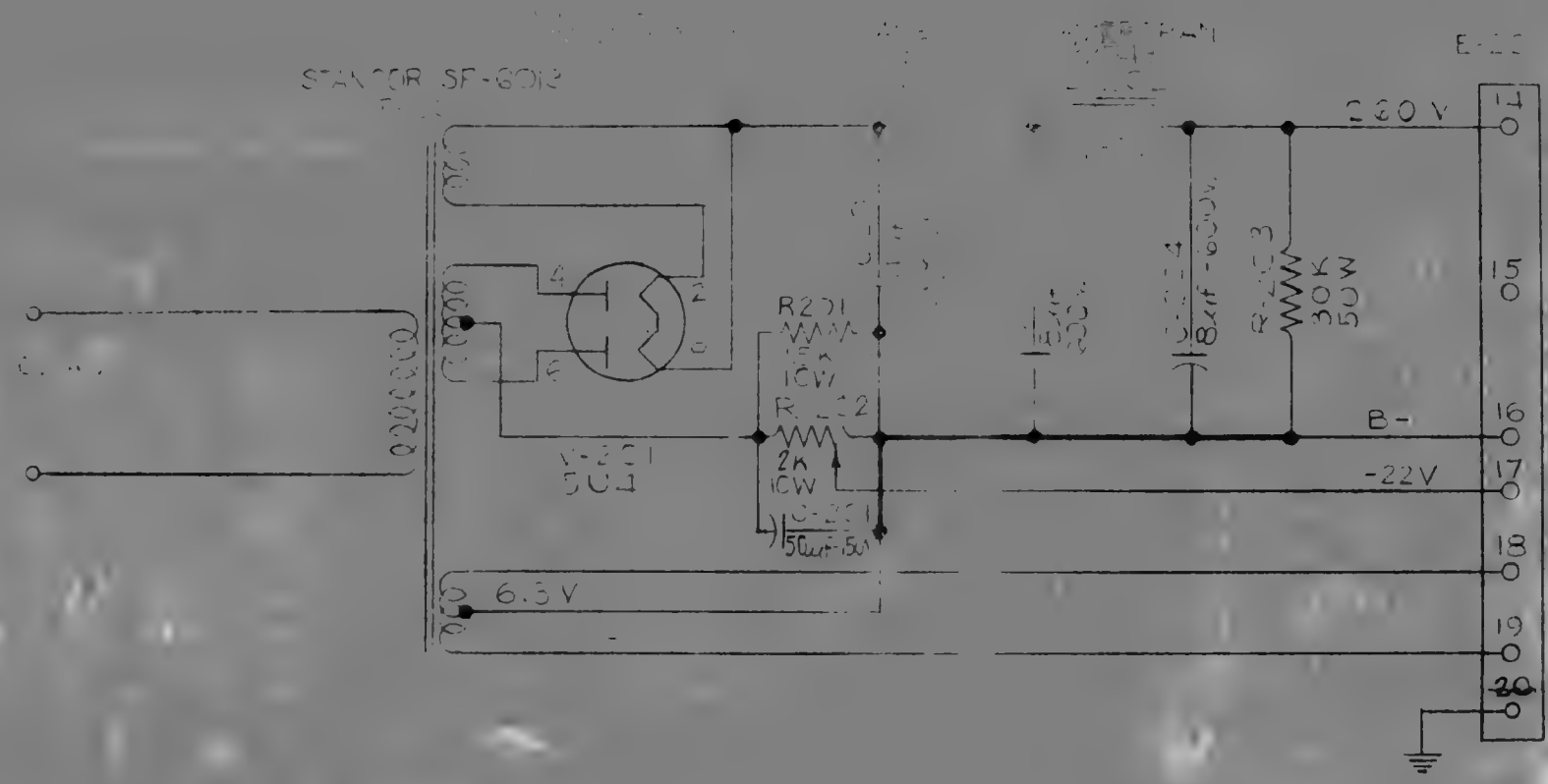
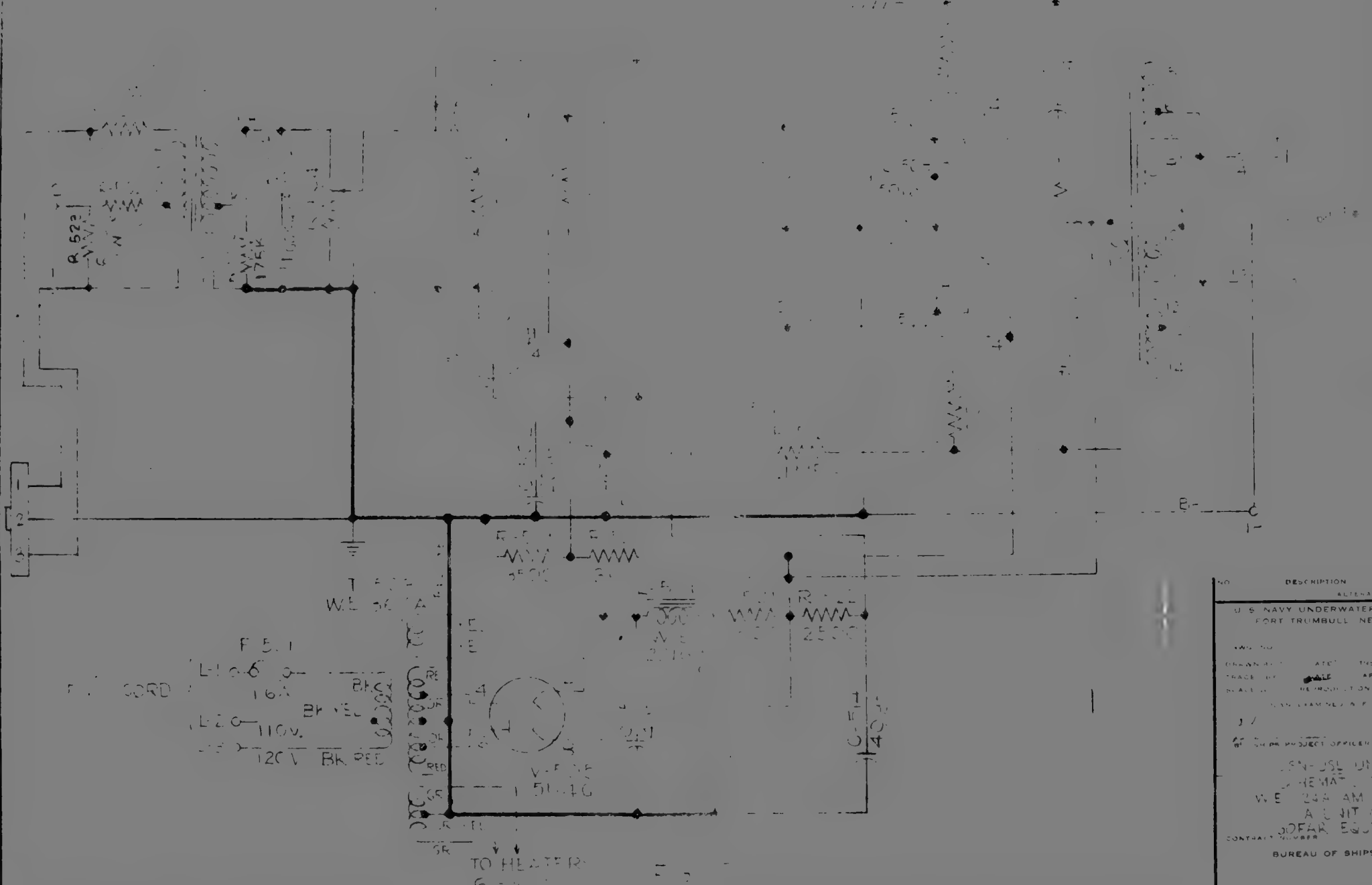


FIG. 44

NO.	DESCRIPTION	AUTHORITY	APP'D	DATE
ALTERATIONS				
U. S. NAVY UNDERWATER SOUND LABORATORY FORT TRUMBULL, NEW LONDON, CONN.				
DRWG. NO.	SHEET OF SHEETS			
DRAWN BY: H.S.	DATE: 7-25-47	INSPECTED BY: [Signature]	DATE: 7-25-47	
TRACED BY: [Signature]	DATE: [Signature]	APPROVED BY: [Signature]	DATE: 7-25-47	
SCALE: 1/2" = 1"	REPRODUCTION OF FINAL PLANS MADE			
PLAN EXAMINED & FOUND SATISFACTORY				
[Signature]	[Signature]			
BU. SHIPS PROJECT OFFICER		COMMANDING OFFICER		
USN-USL UNIT NO. 5220				
SCHEMATIC DIAGRAM POWER SUPPLY A UNIT OF SOFAR EQUIPMENT				
CONTRACT NUMBER:	CONTRACT DATE:			
BUREAU OF SHIPS PLAN NUMBER				



NO.	DESCRIPTION	AUTHORITY APP'D.	DATE
ALTERNATIONS			
U.S. NAVY UNDERWATER SOUND LABORATORY FORT TRUMBULL, NEW LONDON, CONN.			
NO. 50	SHEET OF SHEETS		
DRAWN BY	DATE	INSPECTED BY	DATE
TRACE BY	DATE	APPROVED BY	DATE
SCALE OF THE PRODUCTION OF FINAL PLANS MADE			
PLAN CHECKED BY & DATE SATISFACTORY			
PROJECT OFFICER		COMMANDING OFFICER	
USN-USL UNIT NO. 5226 SCHEMATIC DIAGRAM WE 50 VA AMPLIFIER MODIFIED A UNIT OF SOFAR EQUIPMENT			
CONTRACT NUMBER	CONTRACT DATE		
BUREAU OF SHIPS PLAN NUMBER			

CHANGED
3910 31-4
TITLE CHANGE

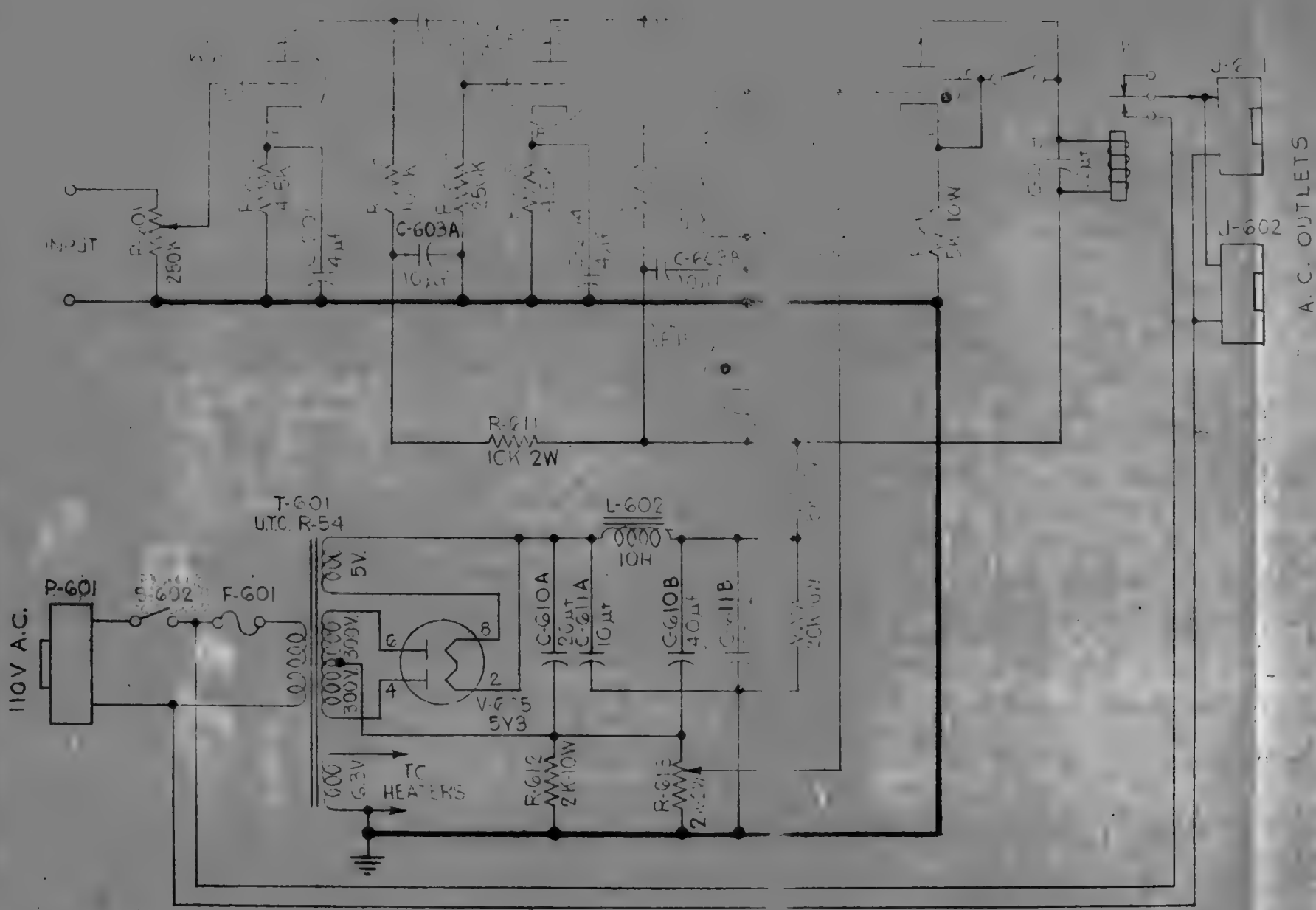
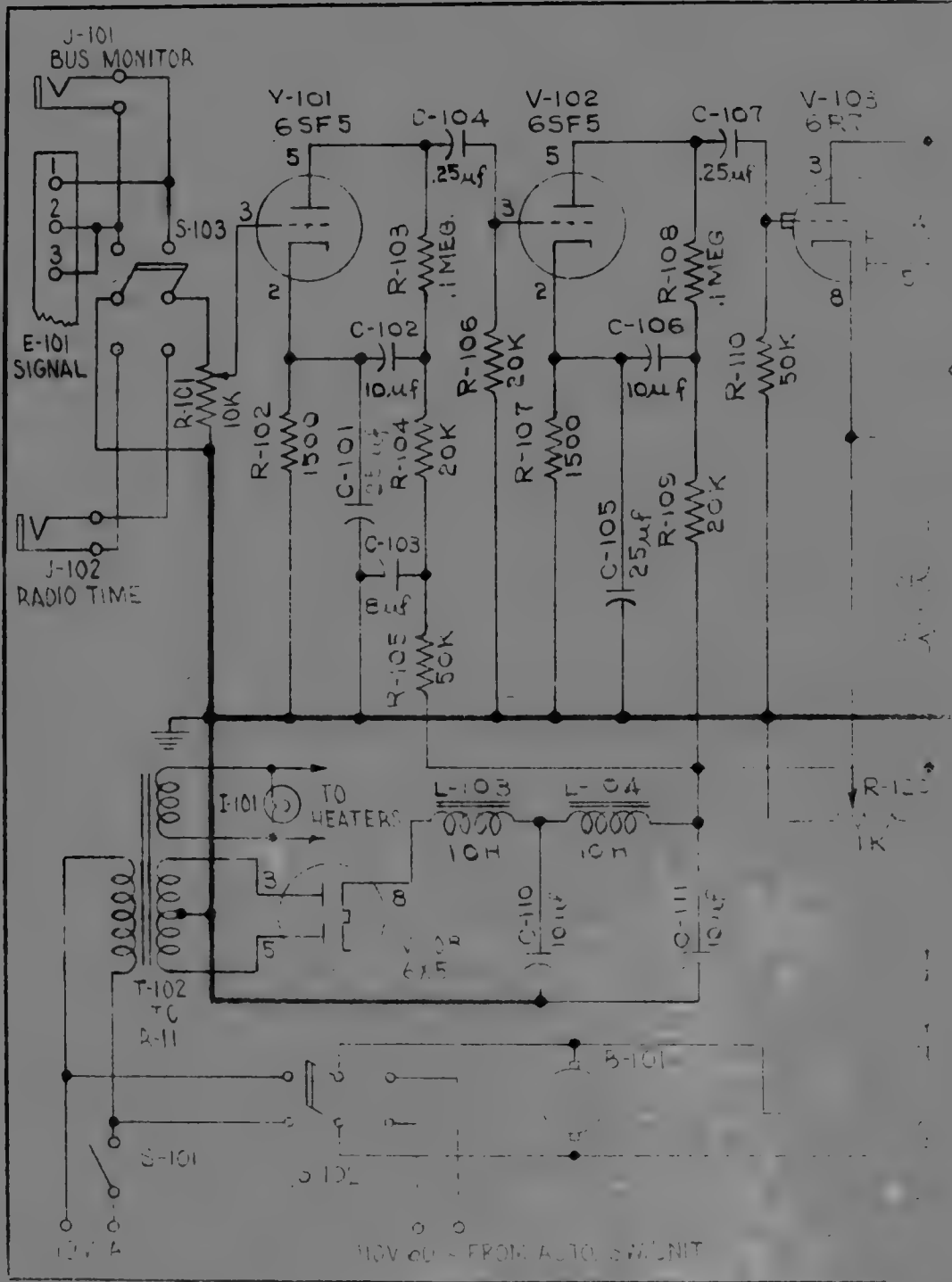


FIG. 46

NO.	DESCRIPTION	ALTERATIONS	AUTHORITY	APP'D.	DATE
	U. S. NAVY UNDERWATER SOUND LABORATORY FORT TRUMBULL, NEW LONDON, CONN.				
DRWG NO.	SHEET OF SHEETS		DRAWN BY	DATE	INSPECTED BY
TRACED BY	DATE	APPROVED BY	DATE	SCALE	
REPRODUCTION OF FINAL PLANS MADE					
PLAN EXAMINED & FOUND SATISFACTORY					
BU. SHIPS PROJECT OFFICER			COMMANDING OFFICER		
USN-USL UNIT NO. 5251					
SCHEMATIC DIAGRAM					
AUTOMATIC SWITCHING & SIGNALING UNIT					
A UNIT OF					
SOFAR EQUIPMENT					
CONTRACT NUMBER	CONTRACT DATE		BUREAU OF SHIPS PLAN NUMBER		

A. C. OUTLETS



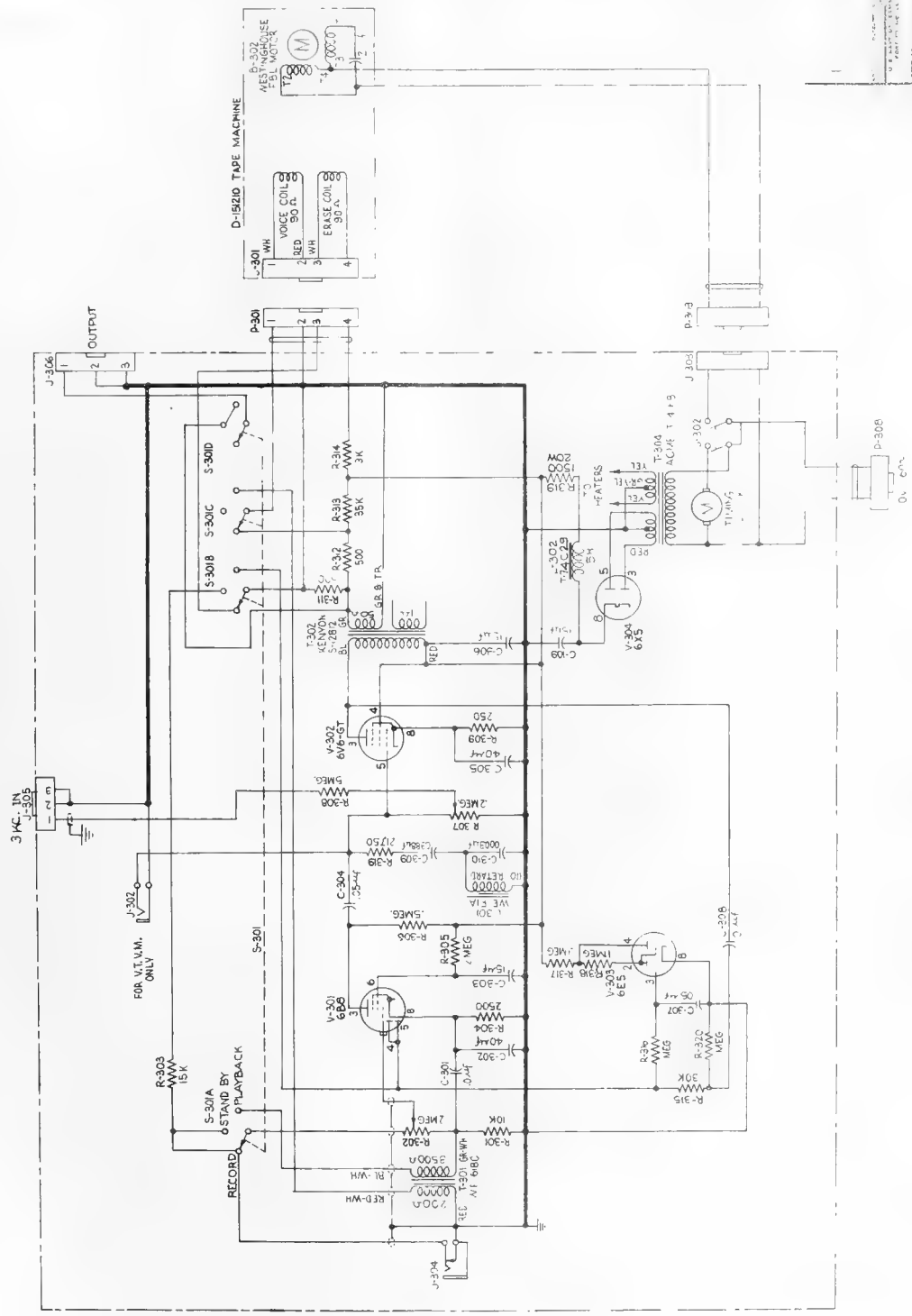


ISSUE		
NO	DATE	APP
1	11-8-45	EPN
2	4-7-46	
3	2-1-46	
4	MOTCH	
5	1-5-46	
6	1-3-46	
7	1-3-46	
8	1-10-46	
9	1-10-46	
10	1-10-46	
11	1-10-46	
12	1-10-46	
13	1-10-46	
14	1-10-46	
15	1-10-46	
16	1-10-46	
17	1-10-46	
18	1-10-46	
19	1-10-46	
20	1-10-46	
21	1-10-46	
22	1-10-46	
23	1-10-46	
24	1-10-46	
25	1-10-46	
26	1-10-46	
27	1-10-46	
28	1-10-46	
29	1-10-46	
30	1-10-46	

DRAWN BY: A.N. GATECOCK
 CHECKED BY: J. G. GATECOCK
 APPROVED BY: J. G. GATECOCK
 SCALE: NONE. REPRODUCTION OF FINAL PLANS MADE.
 PLAN EXAMINER'S FOUND SATISFACTORY.
 BU. SHIP PROJECT OFFICER: [Signature]
 COMMANDING OFFICER: [Signature]
 SCHEMATIC DIAGRAM
 P.L. SOUND LEVEL RECORDER
 PART OF
 SOFAR EQUIPMENT
 BUREAU OF SHIPBOARD EQUIPMENT

E-22314-AA

NO	DATE	APP
ISSUE		
1	11-8-45	JHM
2	5-21-46	
3	2-22-47	
4	7-15-48	
5	2-20-49	
6	7-22-50	
7	1-22-51	
8	1-22-51	
9	1-22-51	
10	1-22-51	

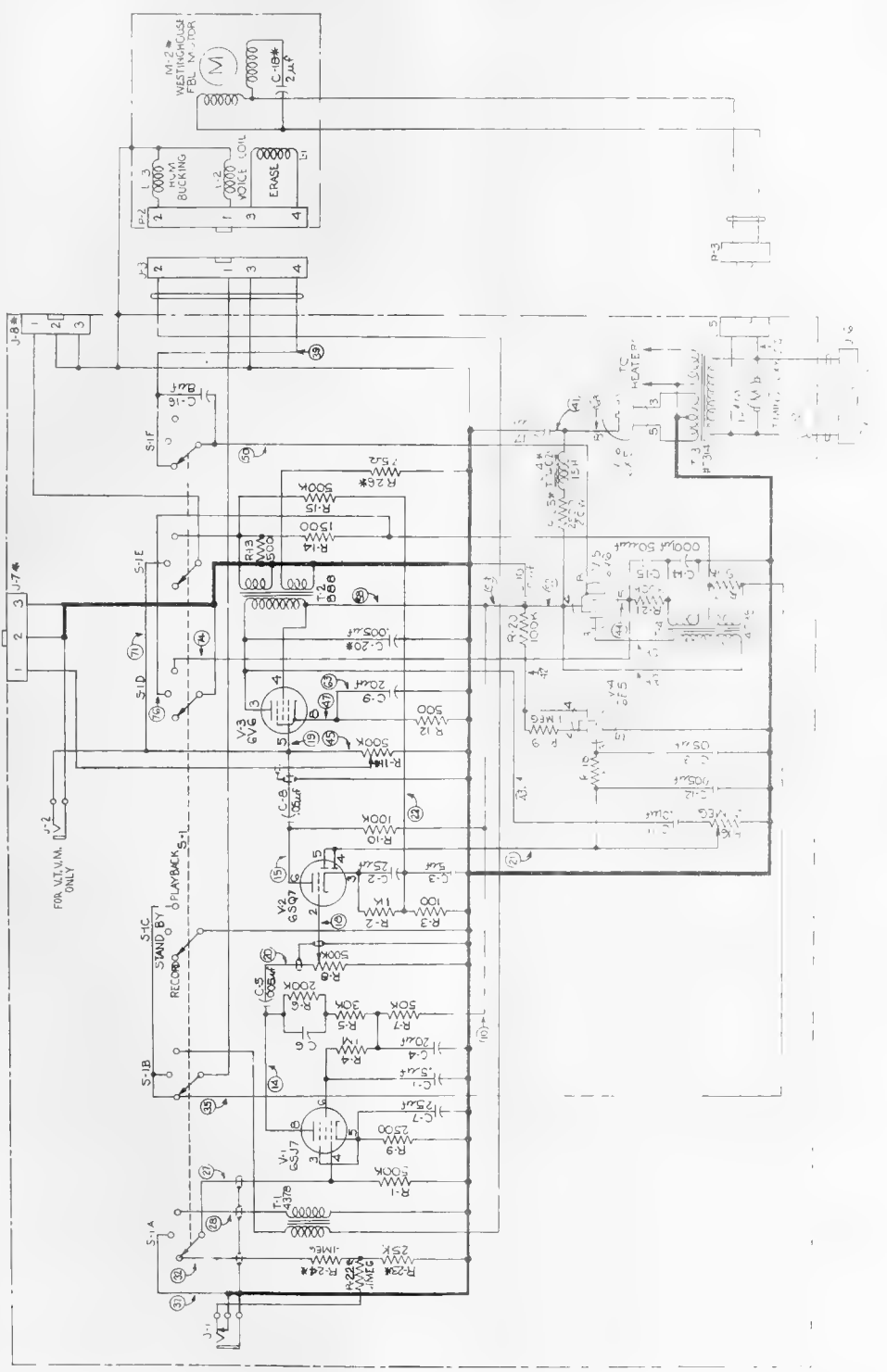


NOTE: ① INDICATES CONTACTS ON PLUG OF INTERCONNECTING CABLE WHICH CONNECTS EXISTING EQPT. TO ADDED EQPT.

FIG. 48
2.5 MIN. MIRRORPHONE

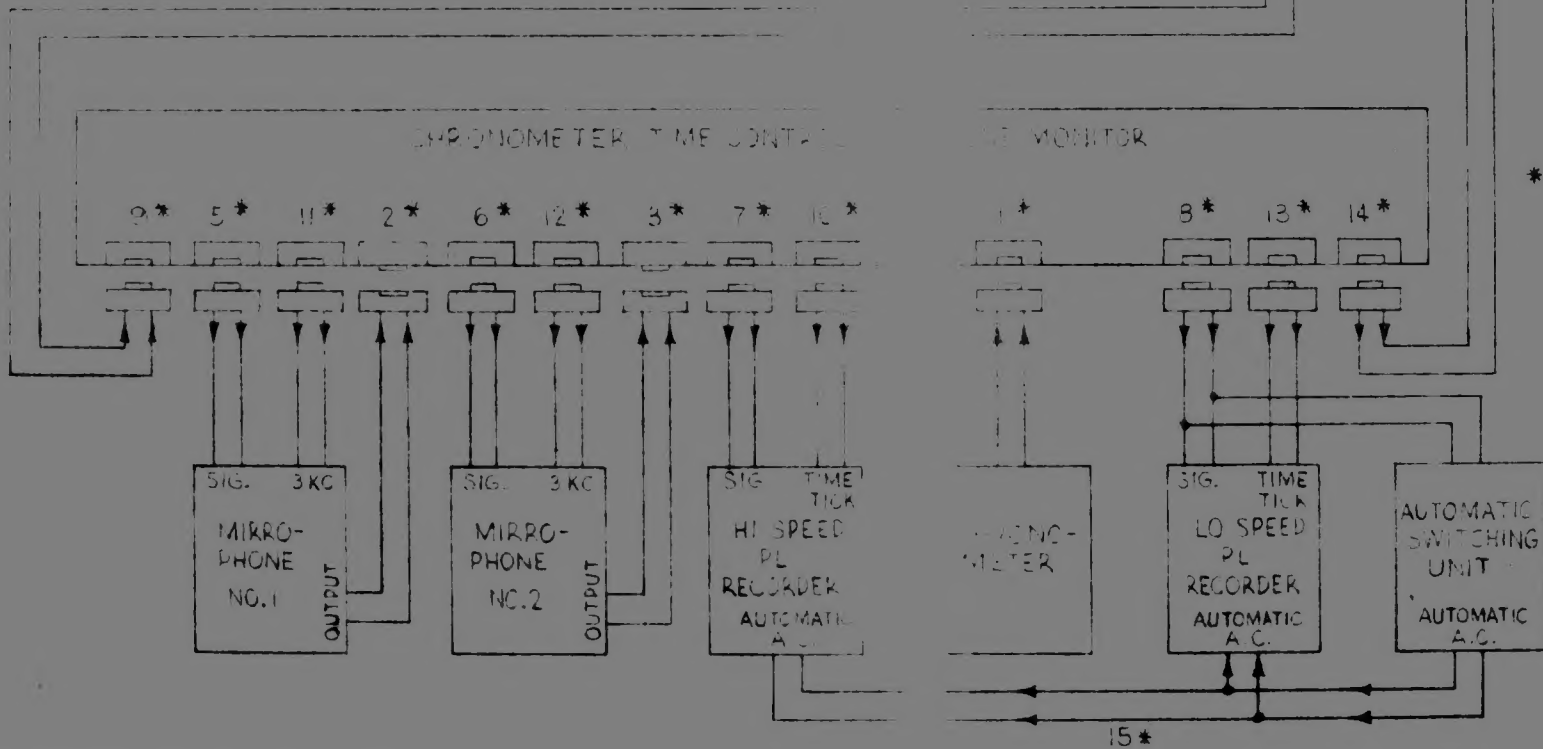
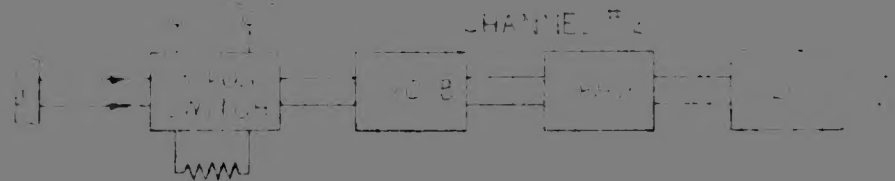
NO	ISSUE	DATE	APP
1	0315-45	FIN	
2	0331-46	WED	
3	0707-46	MON	
4	0722-46	WED	

R-75 REMOVED
 R-75 REMOVED
 R-75 REMOVED
 R-75 REMOVED



NOTE
 ASTERISK FOLLOWING PART DESIGNATIONS
 INDICATES COMPONENTS ADDED TO THE
 ORIGINAL DESIGN

FIG. 49
 CALTRON MAGNETIC TAPE RECORDER



-KEY-
* - REFERS TO CABLE IDENTIFYING NUMBERS

U. S. NAVY UNDERWATER SOUND LABORATORY FORT TRUMBULL, NEW LONDON, CONN.	
DRWG. NO. _____	SHEET OF SHEETS _____
DRAWN BY: HH DATE: 7-31-46	INSPECTED BY: WSL DATE: 8-7-46
TRACED BY: _____ DATE: _____	APPROVED BY: WSL DATE: 8-24-46
SCALE: _____ REPRODUCTION OF FINAL PLANS MADE _____	
PLAN EXAMINED & FOUND SATISFACTORY	
<i>M. J. ...</i>	<i>M. K. ...</i>
BU. SHIPS PROJECT OFFICER	COMMANDING OFFICER
USN USL UNIT NO. 5214	
BLOCK DIAGRAM STATION ASSEMBLY A UNIT OF SOFAR EQUIPMENT	
CONTRACT NUMBER: _____	CONTRACT DATE: _____
BUREAU OF SHIPS PLAN NUMBER _____	

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