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NRL Report 4234

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# INSTRUCTION BOOK FOR ELECTRONIC EQUIPMENT AND TOWED BODY OF LOW-FREQUENCY TOWED SONAR (XHA)

Sonar Systems Branch  
Sound Division

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**INSTRUCTION BOOK  
FOR ELECTRONIC EQUIPMENT AND  
TOWED BODY OF LOW-FREQUENCY  
TOWED SONAR (XHA)**



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INSTRUCTION BOOK  
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TOWED SONAR (XNA)



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**PREFACE**

The Low-Frequency Towed Sonar (XHA) is an experimental variable-depth sonar equipment. It was assembled by marrying the transducer and electronic equipment of the NRL 10-kc Long-Range-Search (LRS) Sonar System, as installed on a submarine (USS GUAVINA), to a hoist and an articulated towline. This new equipment should provide a surface-ship platform for obtaining additional information about 10-kc echo-ranging and, in addition, permit a choice of operating depth premised on prevailing thermal conditions.

Several Navy activities cooperated in this recombination. NRL designed and constructed a towed body containing the transducer and suitable training gear and modified its electronic equipment as necessary. This instruction book contains the design, operation, and maintenance information for only the equipment provided by the Laboratory.

This book was written by the members of the Sonar Systems Branch of the Sound Division who participated in the design, construction, and testing of the XHA equipment. The individuals who contributed to the work are: James L. Bradford, S. Joseph Campanella, Isidore Cook, Albert L. Gotthardt, Ralph M. Gran, Thomas G. Hall, Richard H. Houston, John B. Humphrey, Donald B. Sill, Harry J. Tucker, Jr., and James S. West.

**PROBLEM STATUS**

This is an interim report; work on the problem is continuing.

**AUTHORIZATION**

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## CHAPTER 1 SYSTEM INFORMATION

### 1. BACKGROUND

The Low-Frequency Towed Sonar (XHA) is an echo-ranging equipment operating at a frequency of 10 kc. It has been assembled by combining the Naval Research Laboratory's 10-kc Long-Range Search Sonar with an over-the-side hoist, an articulated towline, and a towed body. The streamlined towed body or "fish" houses an ADP crystal transducer and the Transducer Training Mechanism.

The 10-kc Long-Range Search Sonar was originally installed on the submarine USS GUAVINA, and the transducer was housed in a fixed cylindrical dome topside on the vessel. The electronics have been changed only slightly for this equipment, and the transducer, with a new training gear, has been housed in a fish.

Only the electronic equipment and the transducer with a towed body have been the responsibility of the Naval Research Laboratory, and it is about these that the information contained herein is concerned.

The electronic gear is considered to be divided into:

- (a) Display Equipment—located principally in Rack I,
- (b) Reception Equipment—located principally in Rack II,
- (c) Generation Equipment—located principally in Racks III and IV and in the High-Voltage Power-Supply Unit, and
- (d) Control Equipment—located principally in Rack I, the Train Amplifier, and the towed body.

In the installation aboard the USS F. M. ROBINSON (EDE 220), the equipment was assigned to two major spaces:

- (a) Clipping Room—this compartment on the main deck contains Rack IV, the High-Voltage Power Supply, the Transfer Relay Box, the Train Amplifier, and several switch and junction boxes.
- (b) RCM Room—this compartment on the superstructure deck contains Racks I, II, III, and the Chemical Range Recorder.

Location of the various parts of the system and identification of the interconnecting cabling is shown in Figure 1.1.

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## 2. PHYSICAL ARRANGEMENT AND DESIGNATIONS

### Rack Construction and Assembly

The major portion of the XHA electronic units are panel-mounted on equipment racks which were designed in the Sound Division of NRL and adopted as a standard for all Laboratory sonar installations. Each rack is a weldment of four sections of steel channel (6 inches  $\times$  8.2 lb/ft), and the over-all rack dimensions are 60 inches high  $\times$  21-1/2 inches wide  $\times$  6 inches deep. Matching columns of No. 10-32NF tapped holes, located along the left and right sides of both faces of these racks, are utilized in securing notched (slotted) panels to the racks. An additional set of tapped holes along the left side of the front face of each rack provides a means for securing the male half of a hinge set, and the mating portion is mounted on the panel to be hinge-mounted.

This type of construction has several advantages:

- (a) Ease of maintenance is permitted by hinge-mounting of panels,
- (b) Quick replacement of panels having faulty components can be made, thus permitting the defective panel to be repaired on the work bench,
- (c) The rack itself acts as a natural chimney for cooling the components. (Electron tubes and other heat-dissipating elements are mounted on the inside of the panel whenever feasible), and
- (d) The racks permit the use of covers that can be neatly stacked one upon the other when the equipment is being serviced. This permits maximum utilization of crowded compartments.

### Rack Nomenclature

Most of the electronic units in the XHA system are mounted on four racks of this type. These racks are identified by the Roman numerals I to IV inclusive. The panels on individual racks are identified from top to bottom by the capital letters A, B, C, - - - L (as determined by the number of panels mounted on each rack). Terminal strips of each panel are identified (from top to bottom and left to right) by the capital letters P, Q, R, - - - - - Z. Individual terminal points of a strip are signified by the Arabic numerals 1, 2, 3, 4, etc. Thus the designation II B indicates the second panel (Panel B) of Rack II, and the identification II BP-4 indicates terminal P-4 of this particular panel.

The prefix "M" has been used for identifying special interrack terminal strips. The "M-board" numbers are common throughout the system, i.e., M-board terminals on one rack are electrically connected to corresponding terminal numbers on each of the other racks. On the other hand, the counterpart "N-boards" of the system are coaxial terminations that do not necessarily have common interrack connections, and therefore (for complete identification) they must be prefixed by a rack number.

Figure 1.2 shows the M-board and N-board connections to the various racks of the system. In addition to this information, the diagram shows the terminations of the individual conductors of the electrical cables shown in Figure 1.1.

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### Component Nomenclature

Generally, the component designation system employed in the XHA also follows a rack-panel basis. For example, resistors on Panel A (the top panel of any rack) would be labeled R101, R102, R103, etc. Similarly, capacitors are prefixed by "C," inductors by "L," relays by "K," vacuum tubes by "V," etc., and the prefix is followed by a three-digit designation which indicates the panel upon which the component is mounted and also the component number of the particular series.

### System Cabling

As shown in Figures 1.1 and 1.2 most of the XHA equipment is located in the RCM Room and the 40-mm Clipping Room. Signal and control leads from the Clipping Room connect to the transducer tow cable via a deck-mounted, 20-wire junction box and the hoist slip rings.

In general, the system is operated from the RCM Room since the equipment racks containing the receivers and displays are located there. The Driver and Servo Amplifier, situated in the 40-mm Clipping Room, can be operated remotely. Although remote operation of these units is possible, all system power is controlled from the Clipping Room.

System power is obtained from the ship's 3-phase 440-volt 60-cycle main power line. Power for the High-Voltage Power Supply is obtained directly from this line. A 440-volt/115-volt transformer connected across one leg of the 3-phase 440-volt line supplies power to other units of the system.

## 3. PROCEDURE FOR ENERGIZING XHA SYSTEM

- (a) TURN ON "XHA POWER SWITCH" LOCATED ON DISTRIBUTION PANEL IN MACHINE SHOP. The XHA POWER SWITCH applies power to the XHA system via fuses and power switches located in the Clipping Room.
- (b) TURN ON 115-VOLT AC SYSTEM POWER SWITCH AND 440-VOLT 3-PHASE SWITCH, BOTH OF WHICH ARE LOCATED IN THE CLIPPING ROOM. The 115-volt switch energizes the M-boards of the XHA system, and the 440-volt 3-phase switch applies power to the High-Voltage Power Supply. (Three-phase power is applied via a relay, the coil of which must be actuated by the Driver before the plate circuit of the High-Voltage Power Supply is energized.)
- (c) TURN SERVO AMPLIFIER ON-OFF SWITCH TO "ON" POSITION. THE SERVO AMPLIFIER IS LOCATED IN THE CLIPPING ROOM. This switch energizes the low-voltage power-supply circuits of the Servo Amplifier and the green pilot light of the unit. The high-voltage circuits are turned on automatically after a three minute delay; this is indicated by the illumination of a red pilot light. After the delay interval, the Servo Amplifier is in operating condition, i.e., it will respond to "train orders" from the Program Control Unit.
- (d) TURN DRIVER (RACK IV) SAFETY SWITCH "ON." THE DRIVER IS ALSO LOCATED IN THE CLIPPING ROOM. This switch is in series with the Keyer Unit (Panel III-C) ON-OFF switch, and both of these switches must be closed before the Driver can be energized.\*

\*See step (h) of this series for further explanation.

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- (e) THE FOLLOWING OPERATIONS TAKE PLACE IN THE RCM ROOM. MAKE SURE THAT THE KEYING SWITCH OF THE PROGRAM CONTROL UNIT (PANEL I-A) IS IN THE "OFF" POSITION AND THAT THE "AUTO-MANUAL" SWITCH IS IN THE "MANUAL" POSITION. NOW TURN PROGRAM UNIT ON-OFF SWITCH (LOCATED ON THE LEFT SIDE OF PANEL I-A) TO THE "ON" POSITION. The Program Unit supplies train information to the Servo Amplifier, sweep voltage to the crt displays, range-sweep initiating action to the Range Recorder, and keying initiating action to the Keyer Unit (Panel III-C). The latter function is governed by the Keying Switch mentioned in this step.
- (f) TURN ON THE FOLLOWING RACK II SWITCHES: (1) THE ON-OFF SWITCH OF THE COMBINING UNIT (PANEL II-B) AND (2) THE ON-OFF SWITCH OF THE POWER SUPPLY UNIT (PANEL II-F). These switches energize the Reception Equipment (Narrow-Band and SSI Receivers). However, the Time Varied Control circuit will not function properly until the Keyer Unit (Panel III-C) is energized.
- (g) TURN ON-OFF SWITCH OF DISPLAY CONSOLE (RACK I) TO "ON" POSITION. This switch energizes the Rack I display circuits. As sweep information is generated by the Program Unit, it is important that the Program Unit be energized first (see step e) in order to prevent damage to the crt screens. Signal inputs to the displays are provided by the receivers on Rack II.
- (h) TURN "GAIN" CONTROL SETTING OF THE SIGNAL UNIT (PANEL III-B) TO A MINIMUM, AND TURN KEYER UNIT (PANEL III-C) ON-OFF SWITCH TO "ON" POSITION. The Keyer ON-OFF switch energizes the Signal Unit (Panel III-B) and the Keyer Unit (Panel III-C). When keyed, the latter operates the T/R Relay, the TVG circuit, and supplies the input pulse to the Driver. Due to interconnected switches, the Keyer Unit must be "ON" before the Driver (Rack IV) can be energized. Thus the Keyer Unit switch acts as a remote control for the Driver.
- (i) WHEN THE KEYER UNIT "DRIVER POWER" PILOT LIGHT COMES ON (APPROXIMATELY ONE MINUTE AFTER COMPLETING STEP (h) OF THIS PROCEDURE), THE SYSTEM IS READY FOR ECHO-RANGING. THE PROGRAM-UNIT KEYING SWITCH (SEE STEP (c)) CAN NOW BE TURNED TO THE AUTOMATIC (AUTO) OR MANUAL (THE MOMENTARY "SINGLE PING") POSITION, AND THE "GAIN" SETTING OF THE SIGNAL UNIT CAN BE ADJUSTED FOR THE DESIRED INPUT LEVEL TO THE DRIVER. Driver meter settings given in Chapter 4 should serve as a reference for proper operation of the Driver. Care should be taken not to overdrive this unit.
- (j) DISPLAY AND RECEIVER ADJUSTMENTS SHOULD BE MADE IN ACCORDANCE WITH INFORMATION APPEARING IN CHAPTERS 2 AND 3, RESPECTIVELY. THE PROGRAM UNIT CAN BE SET UP FOR THE DESIRED SEARCH PROGRAM AS OUTLINED IN CHAPTER 5.

#### 4. PROCEDURE FOR DE-ENERGIZING XHA SYSTEM

The following method should be used except in case of equipment failure or other emergency.

- (a) TURN PROGRAM-UNIT KEYING SWITCH TO "OFF" POSITION AND SET THE AUTO-MANUAL CONTROL ON "MANUAL."
- (b) TURN OFF KEYER UNIT (PANEL III-C). THIS DE-ENERGIZES RACK III AND THE DRIVER, RACK IV.
- (c) DE-ENERGIZE THE FOLLOWING RACKS LOCATED IN THE RCM ROOM:  

RACK I (ON-OFF SWITCHES LOCATED ON PROGRAM UNIT AND DISPLAY CONSOLE)

RACK II (ON-OFF SWITCHES LOCATED ON COMBINING UNIT, PANEL B, AND POWER SUPPLY, PANEL F).
- (d) TURN OFF DRIVER SAFETY SWITCH AND SERVO AMPLIFIER ON-OFF SWITCH, BOTH OF WHICH ARE LOCATED IN THE CLIPPING ROOM.
- (e) TURN OFF 115-VOLT POWER SWITCH AND 440-VOLT 3-PHASE POWER SWITCH, BOTH OF WHICH ARE LOCATED IN THE CLIPPING ROOM.
- (f) TURN OFF XHA POWER SWITCH (SYSTEM MAIN POWER) LOCATED IN MACHINE SHOP.

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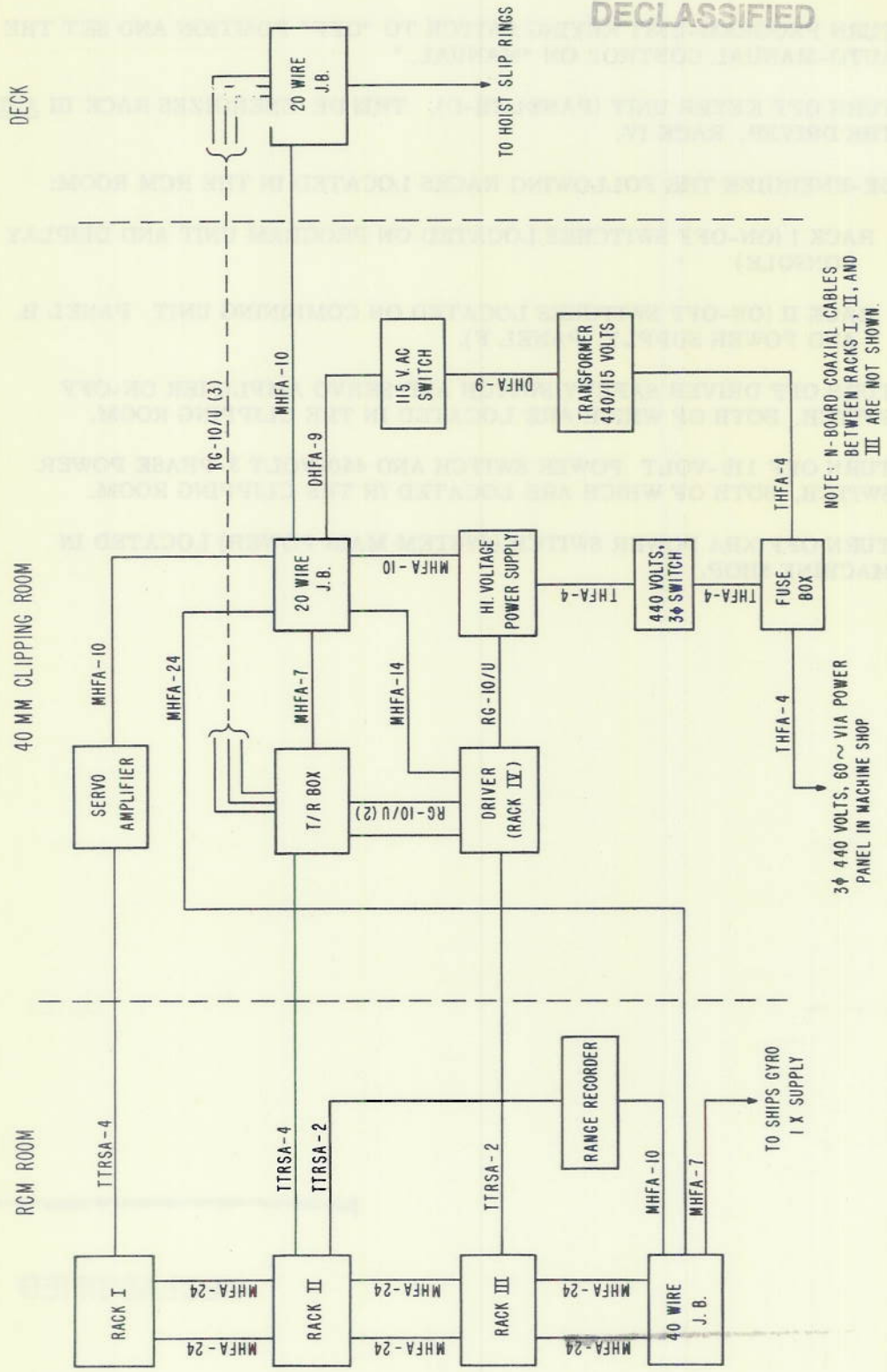


Fig. 1.1 - Cabling Diagram of XHA System

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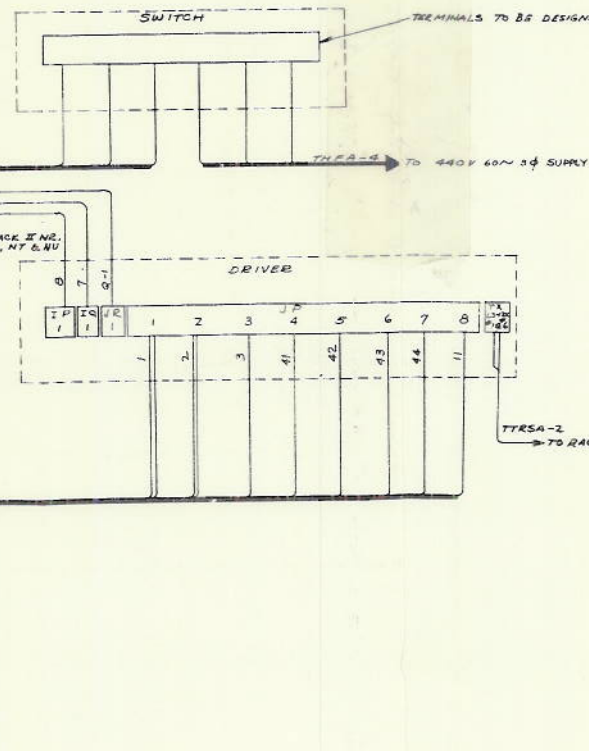
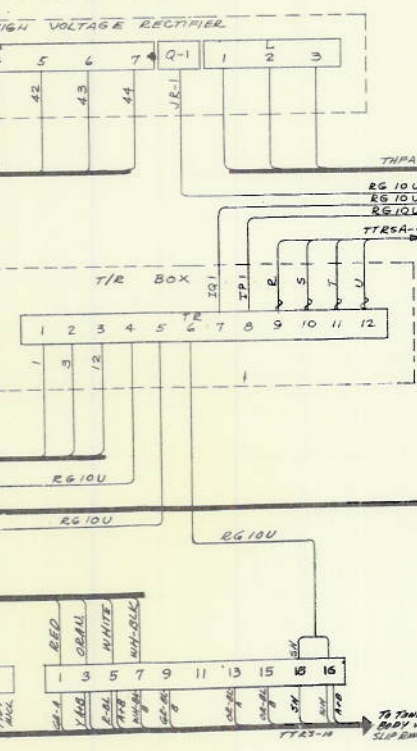
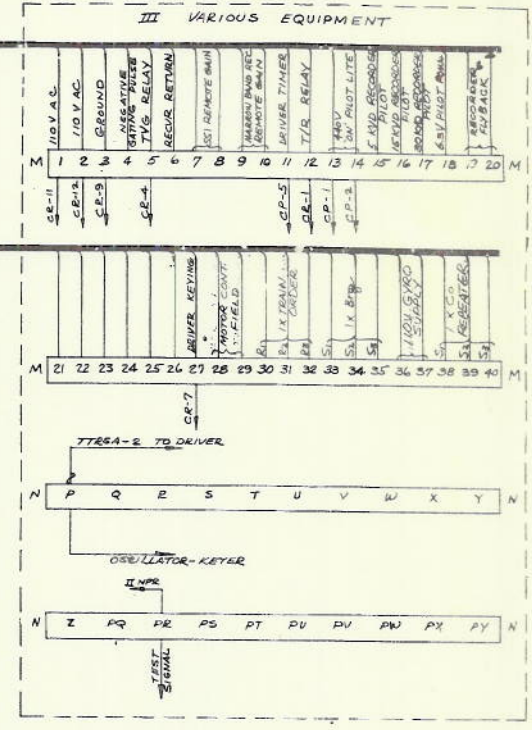
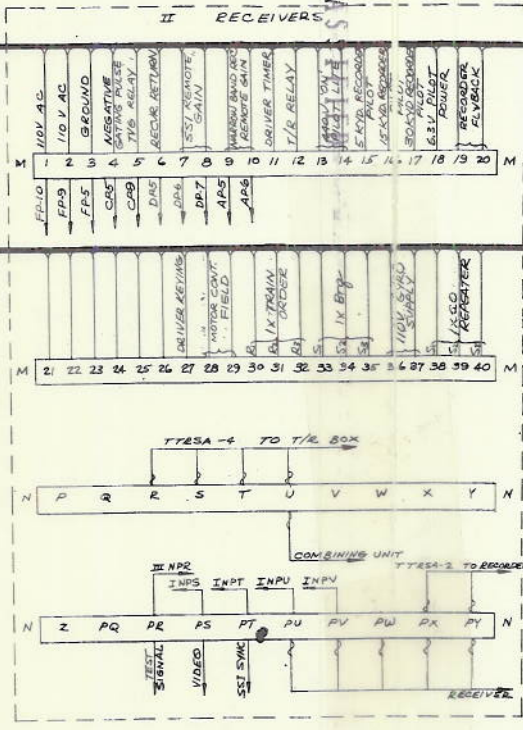
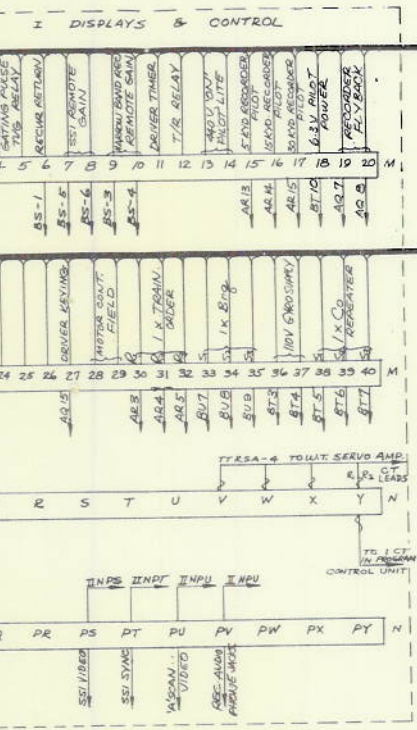


Diagram Showing Individual Cable Terminations

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## CHAPTER 2 DISPLAY EQUIPMENT

### 1. INTRODUCTION

The primary function of the XHA Display Equipment is to provide visual presentation of acoustical information received by the XHA transducer. The Display Equipment is mounted in Rack I (Figures 2.1 and 2.2) and incorporates the following lettered panels: (B) Display Console, (C) A-Scan Vertical Deflection and SSI Marking Amplifiers, (D) A-Scan and SSI Range Amplifiers, (E) SSI Horizontal Sweep Generator, (F) Low-Voltage Power Supplies, and (G) High-Voltage Power Supply. These units are interconnected as shown in the block diagram of the Display Equipment (Figure 2.3) and in the Interpanel Wiring Diagram (Figure 2.4). A complete schematic of the Display System is shown in Figure 2.5.

Two separate displays, each using a type 5FP7-A cathode-ray tube, are used in this equipment. The first, an A-Scan Display, has a horizontal range sweep with vertical signal deflection; and the second, an SSI (Sector Scan Indicator) Display, is essentially a B-Scan with a vertical range sweep and spot brightening for signal presentation.

Individual Range Sweep Amplifiers for the A-Scan and SSI use the sweep potentiometer output (of the Mechanical Program Control Unit, Panel I-A) as an input signal. Outputs of the two Range Sweep Amplifiers are applied to the horizontal deflection coil in the A-Scan, and to the vertical deflection coil in the SSI, respectively.

A 2-kc synchronizing signal, taken from the SSI Receiver (Panel II-A), is used to actuate the SSI Horizontal Sweep Generator. The output of this latter unit is applied to the SSI horizontal deflection coil.

The Narrow-Band Receiver output is amplified and integrated by the A-Scan Vertical Deflection Amplifier and then applied to the vertical deflection coil of the A-Scan. The signal from the SSI Receiver is amplified in the SSI Marking Amplifier and applied to the control grid of the SSI cathode-ray tube.

### 2. RANGE SWEEP POTENTIOMETER

#### Circuitry and Operation

To obtain the range sweeps, a negative voltage (300 volts dc) is applied through an attenuation network to a motor-driven potentiometer. The rotor of the potentiometer supplies a linear driving voltage to the A-Scan and the SSI Range Amplifiers. Both the network and potentiometer are located in the Program Control Unit; a schematic diagram of this unit (Figure 5.4) will be found in Chapter 5. Range settings are varied by controls in the Program Control Unit. The range is variable on both the SHORT RANGE (2,500 to 15,000 yards) and the LONG RANGE (5,000 to 30,000 yards) positions. The attenuator network provides increments of 1,250 yards on "short range" and of 2,500 yards on

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"long range." A RANGE SWEEP switch, located on the front of the Program Control Unit, allows the use of a "expanded" sweep on any range setting. However, the crt range indications would then have no meaning.

### Servicing

The major difficulties arising in this unit will be no range sweep, a partial range sweep, or a nonlinear or jumpy range sweep. In the absence of range-sweep voltage, check the circuit for a sweep output (which should be a gradually increasing negative voltage) on terminal AR-11. Then check for a minus 300 volts on terminal AR-12, and determine whether or not the rotor arm of the potentiometer is turning. If none of these checks reveals the trouble, examine the attenuation network. A jumpy sweep may be caused by bad spots in the motor-driven potentiometer or poor regulation of the power supplies. A spare potentiometer, already installed in the unit, can be utilized if damage occurs to the one in use.

## 3. RANGE SWEEP AMPLIFIERS

### Circuitry and Operation

The A-Scan and SSI use identical Range Sweep Amplifiers (Figure 2.6). Both amplifiers are mounted on the same 3-1/2 x 19 x 1/8 inch dural panel (Panel I-D), and the unit weighs approximately two pounds. Panel power requirements are 6.3 volts ac at 1.8 amperes, plus 300 volts at 40 milliamperes, and minus 300 volts at 35 milliamperes.

The Range Sweep Amplifiers take the output of the sweep potentiometer, amplify it, and apply the amplified output to the appropriate deflection coils. The negative sweep output of the Program Control Unit (terminal AR-11) is connected via the rack wiring harness to terminal DP-6 of the Range Sweep Amplifier.

As shown in Figure 2.7 each amplifier employs a bridge circuit which has a 6L6 tube and a 15,000-ohm cathode resistor as two of the legs; the other two legs are the positive and negative power supplies. The range-length resistance and the deflection coil are tied across the bridge. When variations occur in tube bias, the 6L6 acts as a varying resistance. If the bias is such that the tube represents a 15,000-ohm resistance, the bridge is balanced and no current flows in the deflection coil. When a positive increase (bias change) from the balanced condition occurs, the tube resistance decreases, the cathode becomes positive with respect to ground, and current flows in the deflection coil. The deflection is in the opposite direction when a negative change in tube bias from the balanced condition occurs. The tube is biased by adjusting R401, the CENTERING control. During the range sweep, the signal voltage is increasing in a negative direction.

### Servicing and Aligning

To adjust the Range Sweep Amplifiers, apply the negative signal to the input. Adjust R401 to center the sweep and R406 to give the proper sweep length. Any great nonlinearity in the sweep should be apparent, but if it is desirable to check the linearity, decrease the intensity and apply evenly spaced pips to the grids of the cathode-ray tubes.

Little difficulty should arise in this circuit, and aside from improper shielding, any irregularities in the sweep would probably be due to trouble in the power supply or range sweep potentiometer.

The range sweeps are aligned by the following procedure:

- (a) Set the RANGE SELECTOR to 15,000 yards (short-range scale) and the RANGE SWEEP switch to NORMAL,
- (b) If the sweep start is incorrect, adjust the Range Amplifier CENTERING control,
- (c) If the sweep length is incorrect, adjust the Range Amplifier RANGE control, and
- (d) Switch to the next shorter range and adjust its length with the appropriate RANGE CALIBRATE potentiometer in the sweep attenuation network, located in the Program Control Unit.

#### 4. SSI HORIZONTAL SWEEP GENERATOR

##### Circuitry and Operation

The SSI Horizontal Sweep Generator (Figure 2.8) develops the sweep for the SSI display in the horizontal axis. The unit, a schematic diagram of which is shown in Figure 2.9, is mounted on a 19 x 5-1/8 x 1/8 inch dural panel and weighs approximately 3-1/2 pounds. It requires 6.3 volts ac at 1.5 amperes and 300 volts dc at 30 milliamperes. The plate current of the push-pull 6V6 output tubes is 70 milliamperes at 300 volts; plate voltage is applied to the 6V6's via the deflection coil.

The input signal is the sine-wave difference frequency of the SSI Receiver local oscillators and enters the unit on EP-5 from terminal NPT. The sine-wave voltage applied to the unit is clipped by the cathode-coupled limiter, V501. The square-wave output is differentiated by the network of C503 and R505. The resultant negative spike is used to trigger the one-shot multivibrator, V502, and the output of the multivibrator keys the discharge circuit composed of V503, R513, and C506. This circuit provides a linear sawtooth output which is amplified by V504A; V504B is a phase inverter whose outputs drive the push-pull tubes V505 and V506. Tubes V505 and V506 derive their plate voltage from the center-tapped deflection coil.

##### Adjusting and Servicing

With a 2-kc sine-wave input applied, adjust R526, the CENTERING control, and R517, the GAIN control, to give the proper sweep position and width. The SYNC control, R509, should be adjusted so that the sweep is synchronized. This will be apparent when the left and right edges of the sweep pattern are smooth and not jagged. With an oscilloscope connected to the grid of V504B, the SHAPING control, R513, should be adjusted for the best waveform, while of course, holding synchronization. It will probably be necessary to readjust the GAIN and CENTERING controls. If a view of the output waveform is desired, the best means of accomplishing this is to insert a small resistor in series with one of the plate circuits and to apply the voltage across this resistor to a cathode-ray oscilloscope. The waveform across the resistor should be trapezoidal in shape.

On the plate of V501B the waveform should be a square wave, which is differentiated and clipped to produce a negative spike at the grid of V502A. These waveforms, together

with the sawtooth at the grid of V504B, indicate that the sweep-generation portions of the circuit are operating properly.

The loss of synchronization (apparent by jagged edges on the sweep), a free-running condition, or nonlinearity are the greatest causes of trouble in the circuit. If readjusting the SYNC and SHAPING controls do not correct synchronization loss, replace V501 and V502 with new tubes. If the trouble is still uncorrected, vary the time constant of the differentiation network. When the multivibrator is free-running, an abrupt change occurs in horizontal size and jagged edges again appear. This effect is probably due to a loss of the 2-kc input signal, so check EP-5 for the sine-wave input of approximately 2-volts magnitude. If a nonlinear waveform appears, check R527, the GAIN control, the SHAPING control, and the SYNC control.

## 5. A-SCAN VERTICAL DEFLECTION AND SSI MARKING AMPLIFIERS

### Functions

The A-Scan Vertical Deflection and SSI Marking Amplifiers (Figure 2.10) weigh approximately two pounds and are mounted on the same 19 x 3-1/2 x 1/8 inch dural panel (Panel I-D). The two amplifiers require 6.3 volts ac at 0.9 ampere and 300 volts dc at approximately 35 milliamperes.

These units provide the signal amplification for the displays. The A-Scan Vertical Deflection Amplifier receives input signals from the Narrow-Band Receiver, amplifies and integrates them, and applies them to the vertical deflection coil of the A-Scan display. The SSI Marking Amplifier receives the output-signal pips from the SSI Receiver, amplifies them, and applies them to the grid of the SSI display tube. Both of these units have external gain controls which are electrically located in the input grid circuits. A schematic of the two units is shown in Figure 2.11.

### A-Scan Vertical Deflection Amplifier

Circuitry—The A-Scan Vertical Deflection Amplifier receives its signal on terminal CP-5 from terminal NPU via terminal BS-8, a 500K potentiometer (R211), and terminal BS-7. After passing the remote GAIN control, R211, the A-Scan signal is amplified by V301 and rectified by a 1N58A germanium diode. The rectified signal goes from terminal CP-10 to console terminal BP-11 and then to the integration network. This network has four time constants: 0, 0.05, 0.25, and 0.5 second. The optimum time constant for the integration network should be selected in accordance with the receiving conditions encountered. The signal leaves the integration network on terminal BP-12 and re-enters the amplifier unit at CP-11. A cathode-coupled self-phase-inverting push-pull amplifier is used in the output circuit.

Adjusting and Servicing—With a pulsed signal (not cw) applied to the unit, adjust R211 for the desired gain and R309 to center the vertical sweep. The integration time should be set as required.

The two main difficulties encountered in using this amplifier are improper integration time and the absence of vertical deflection. To correct for improper integration time, test the various integration switch positions and the 1N58A diode. If there is no vertical deflection, check the GAIN control, R211, as well as the receiver remote and local GAIN controls.

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## SSI Marking Amplifier

Circuitry—The SSI Marking Amplifier receives its signal on CP-6 from NPS via BS-9, R212, and BS-10. The circuit, one of the conventional resistance-coupled type, has a greatly extended range on the low-frequency end to accommodate the slow scanning rates of the receivers. The external GAIN control, a potentiometer (R212) mounted in the Console, is electrically connected in the grid circuit of the input stage. The output is capacitively coupled to the grid of the SSI display tube for intensity modulation.

Servicing—If no signal appears on the SSI display, check the external GAIN control, R212, as well as the SSI local and remote GAIN controls.

## 6. DISPLAY CONSOLE

The Console, a circuit diagram of which appears in Figure 2.12, contains the cathode-ray tubes and associated controls, the external controls for reception and display circuits, and the audio output jacks. This unit also contains the Handwheel Assembly of the Train Control Mechanism; however, that device is discussed in Chapter 5 of this information manual.

The unit is built on a standard console rack and weighs approximately 40 pounds. The tubes require 6.3 volts ac at 1.2 amperes and 300 volts at 10 milliamperes exclusive of the plate current for the output tubes of the SSI Horizontal Sweep Generator.

The Console receives the signal inputs on terminal boards P, R, and S. Terminal board Q is for intra-unit connections of the cathode-ray-tube deflection and focus coils. The Console contains such controls as FOCUS and INTENSITY, both of which are necessary for operation of the cathode-ray tubes. It also contains the GAIN controls for the A-Scan Vertical Deflection and SSI Marking Amplifiers and the A-Scan INTEGRATION control. The power for all the units except the Program Control Unit is controlled by the ON-OFF switch in the Console. Remote gain controls are provided for the Narrow-Band and SSI Receivers, and phone jacks are supplied for the Narrow-Band Receiver.

## 7. DISPLAY POWER UNITS

## Low-Voltage Supply

The Low-Voltage Power Supply (Figure 2.13) is mounted on a 19 x 12-1/2 x 3/16 dural panel and provides plus 300 and minus 300 volts dc (regulated) for operation of the display equipment. The supplies require 110 volts ac at approximately 4 amperes.

The outputs of the unit are 6.3 volts ac at 10 amperes, regulated plus 300 volts at 200 milliamperes, and regulated minus 300 volts at 200 milliamperes. The regulator circuits of both 300-volt supplies are identical. As shown in Figure 2.14, each circuit employs a two-stage voltage amplifier to provide a correcting voltage to the grids of the 6AS7 tube which is used as a variable impedance element. An 0A2 regulator tube provides a stable reference voltage. A potentiometer adjustment varies the output voltage. Both the input and output of the positive and negative supplies are independently fused.

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## High-Voltage Supply

The High-Voltage Power Supply, a model PS-5 unit manufactured by the Condenser Products Company, furnishes an unregulated high voltage for the cathode-ray tubes. The unit is mounted on a bracket which is located within the rack and behind the console; it supplies 5000 volts at 5 milliamperes to the anodes of the cathode-ray tubes. Terminal GP-5 provides a test point for the High-Voltage Supply and should be approximately 400 volts above ground potential.

If the cathode-ray tubes do not produce brightening, check the INTENSITY control and the high-voltage connection on the tubes. If there is no test voltage at GP-5, check the fuse in the circuit and the 110-volt ac input. Should failure occur in this supply, use the spare unit which is available for replacement.

## 8. RANGE RECORDER

## Description

The Chemical Range Recorder (Figures 2.15 and 2.16) used with the XHA equipment is a standard Sangamo type which has been modified both electronically and mechanically to allow for ranges of 5,000, 15,000, and 37,500 yards. Since standard Sangamo recorder paper dries out too rapidly at the slow range rates, a special paper developed at the Naval Research Laboratory is used and recommended. This paper remains moist for the required length of time and uses the standard Sangamo stylus with a platinum-iridium tip.

## Modifications

Electrical—In the electronic modifications of the Sangamo Chemical Range Recorder\* (Figure 2.17), a change in the clutch circuit allows it to be "slaved" to the XHA Program Control Unit. The 2050 tube was removed from the Recorder and a 2500-ohm 25-watt resistor inserted in its place. The circuit was also interconnected with a microswitch (located in the Program Control Unit) in order to allow the Recorder to be synchronized with the range sweeps. Under certain conditions, the single 6SN7-GT did not furnish sufficient gain. As a result, it was necessary to construct a plug-in adapter which would allow optional use of two 12AU7's instead of the original 6SN7-GT.

Mechanical—The mechanical modifications of the Recorder include the insertion of a 10:1 reduction-gear box between the driving motor and the gear-shifting unit. This latter unit has also been modified by the insertion of an extra gear ratio which makes three range scales (0-5,000, 0-15,000, and 0-37,500 yards) possible. Geared to the control knob of the gear-shifting unit is a wafer switch which controls a system of range-scale indicating lights on the Recorder cover.

The lights to the right of the Recorder window indicate the Recorder range-scale setting, and the lights to the left of the window denote the range-scale setting of the Program Control Unit. Each range scale is identified by a different color; red, white, and green indicate 0-5,000, 0-15,000, and 0-37,500 yards, respectively. By matching the colors of the lights on the two panels, the operator of the Recorder automatically selects the proper recording speed. Any change of range scale by the Program Control Unit operator is immediately reflected to the Recorder.

\*See instruction book on the Chemical Range Recorder, Model CAN-55134, manufactured by the Sangamo Electric Company.

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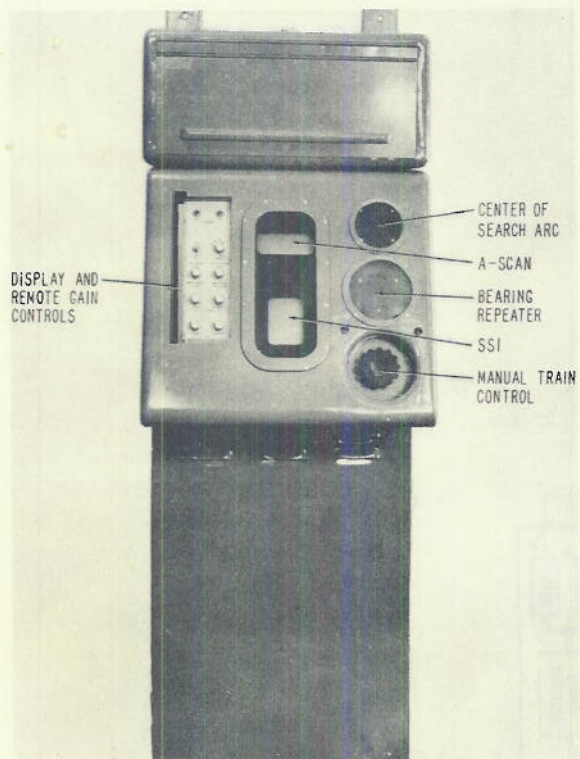
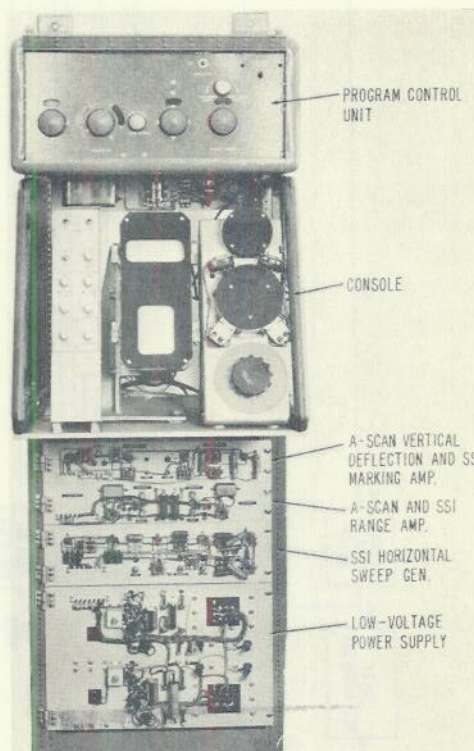


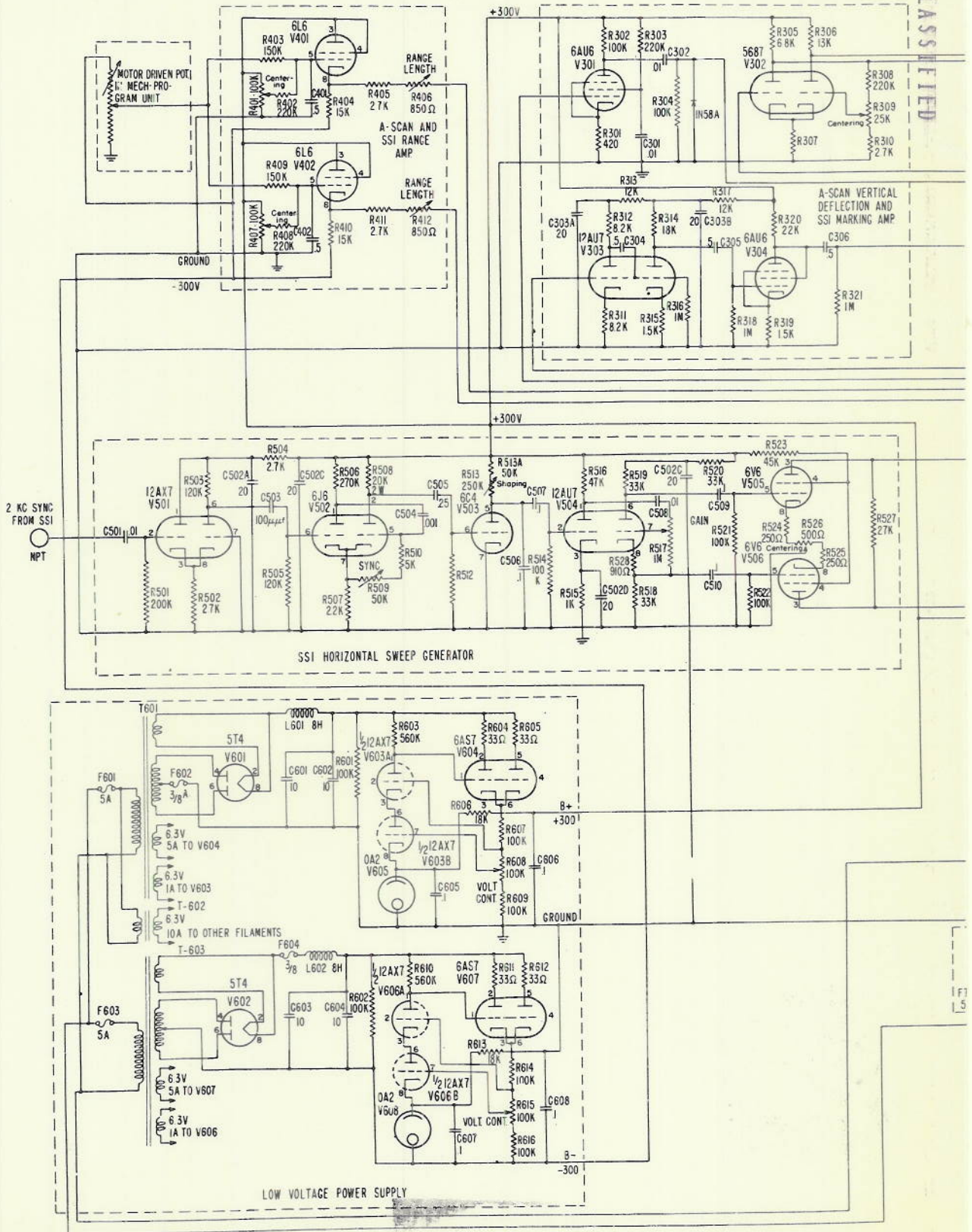
Fig. 2.1 - Front View of Rack I with Cover On

Fig. 2.2 - Front View of Rack I with Cover Off



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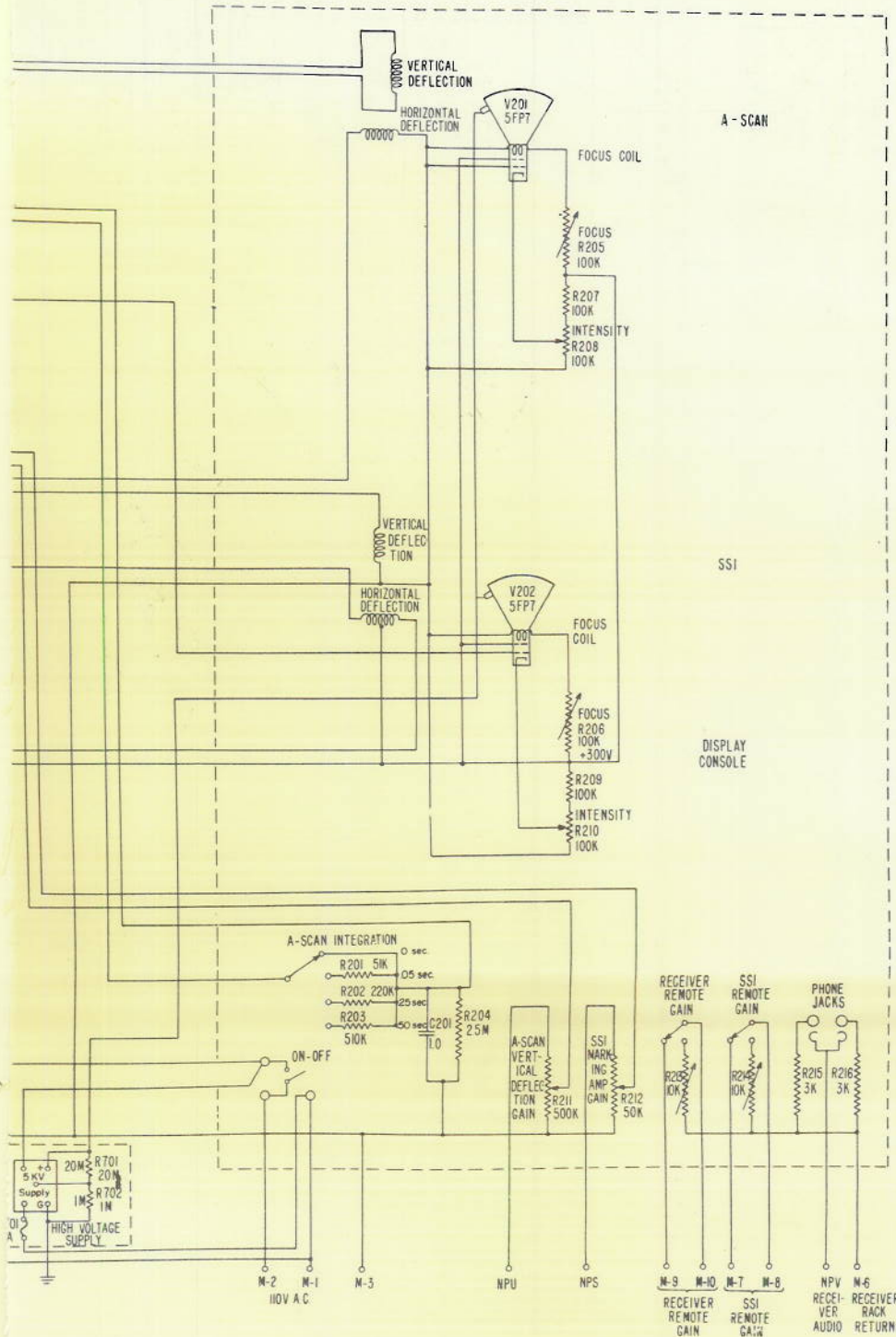
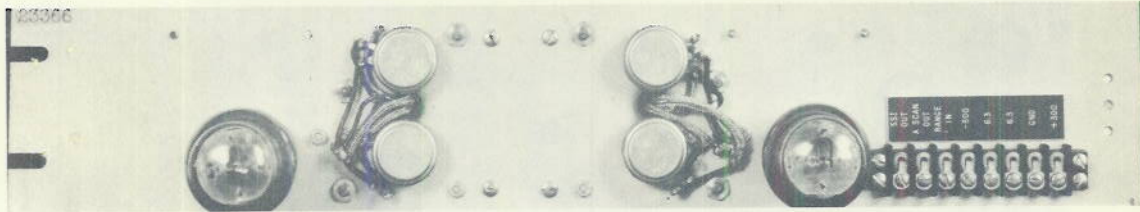
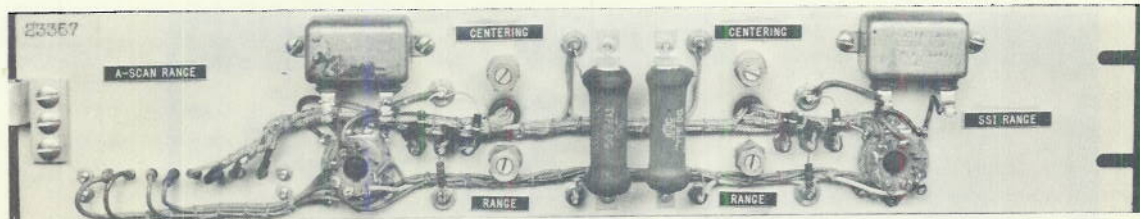


Fig. 2.5 - Schematic Diagram of Display System



(a) Front view



(b) Rear view

Fig. 2.6 - A-Scan and SSI Range Sweep Amplifiers

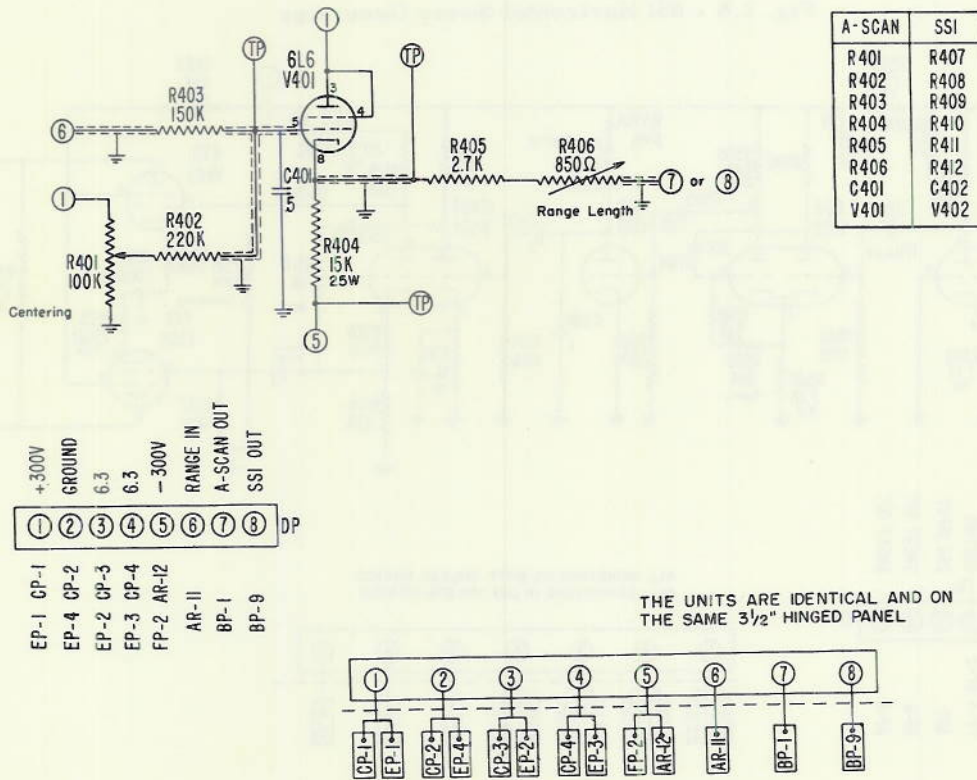
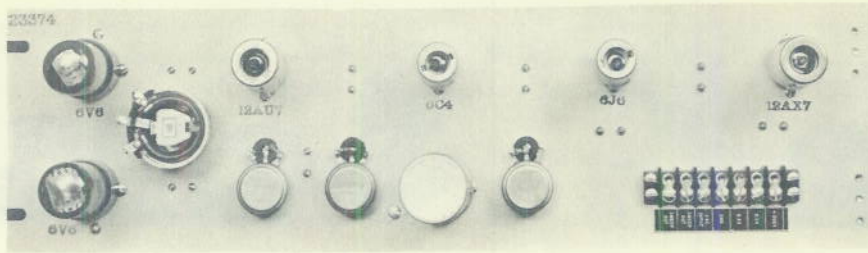
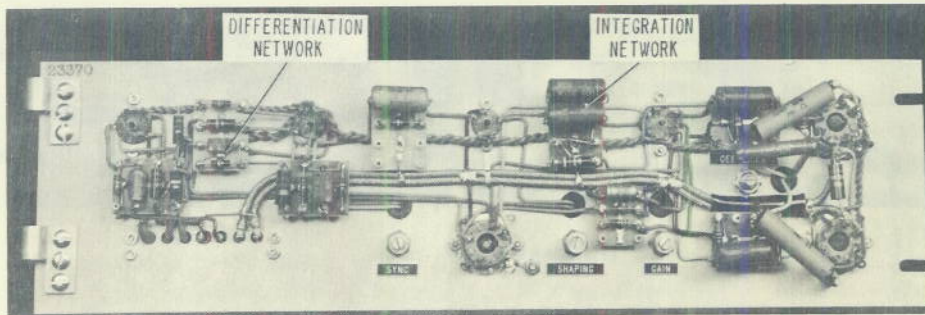


Fig. 2.7 - Schematic Diagram of A-Scan and SSI Range Sweep Amplifiers



(a) Front view



(b) Rear view

Fig. 2.8 - SSI Horizontal Sweep Generator

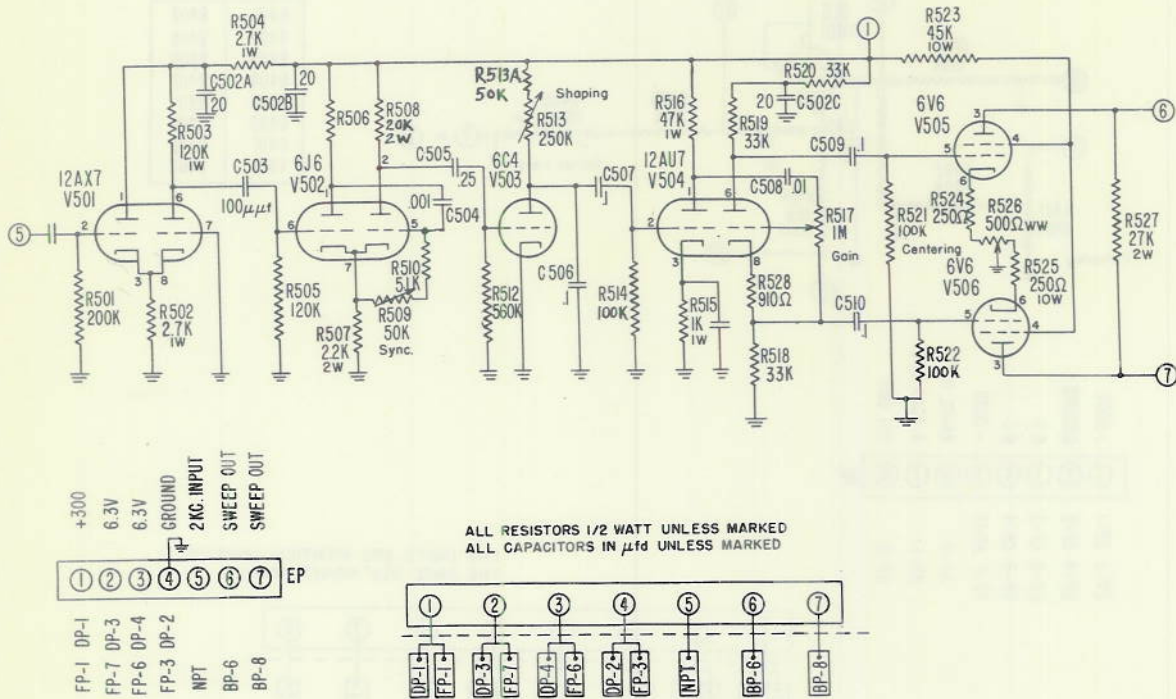


Fig. 2.9 - Schematic Diagram of SSI Horizontal Sweep Generator

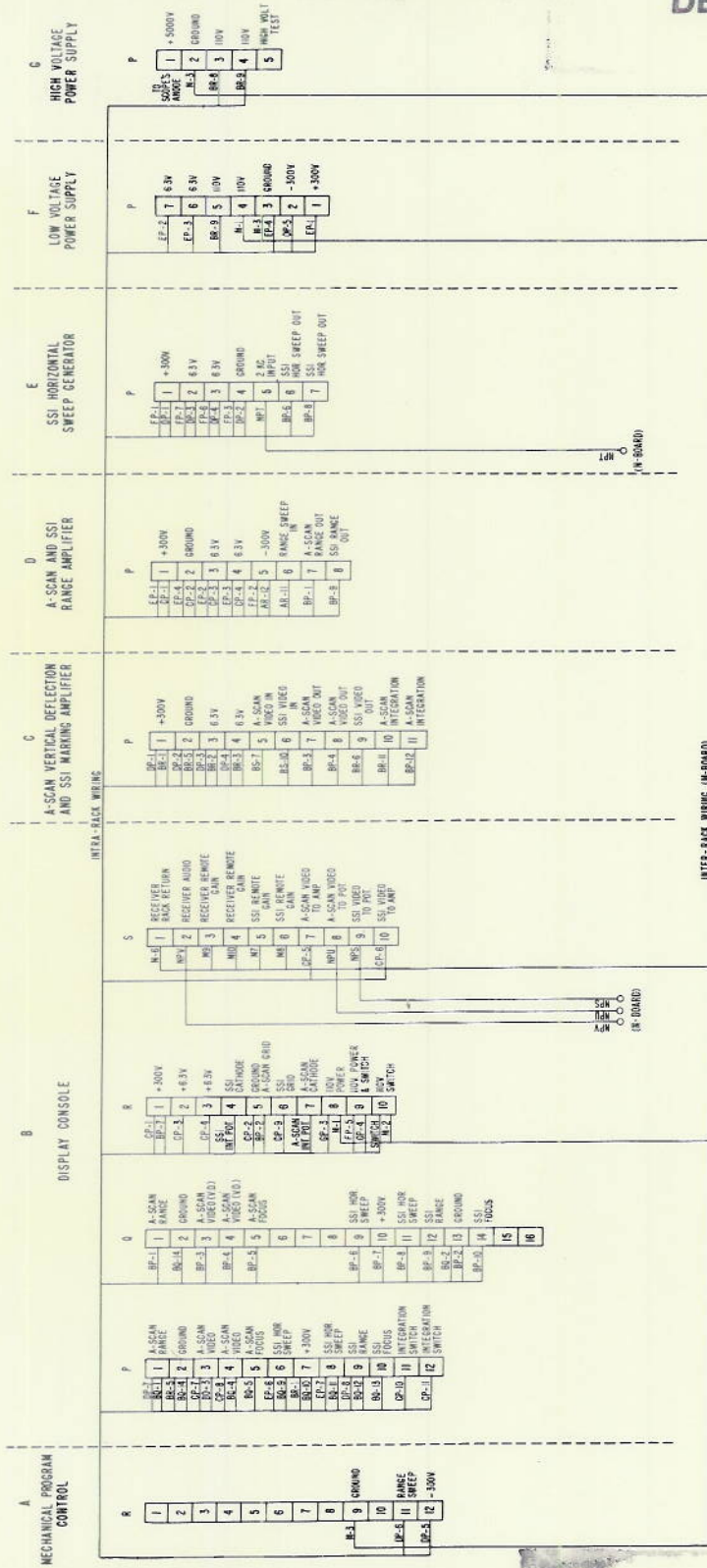
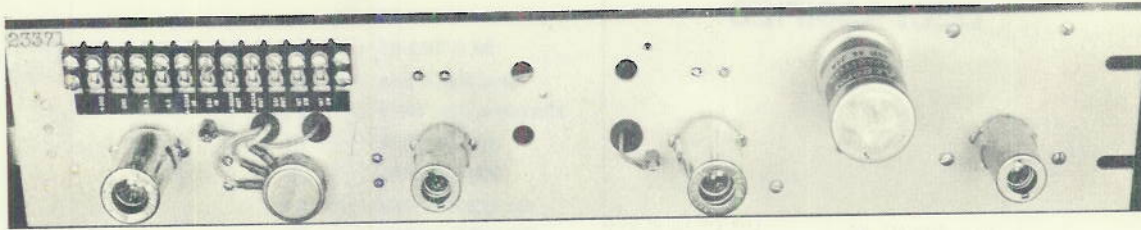
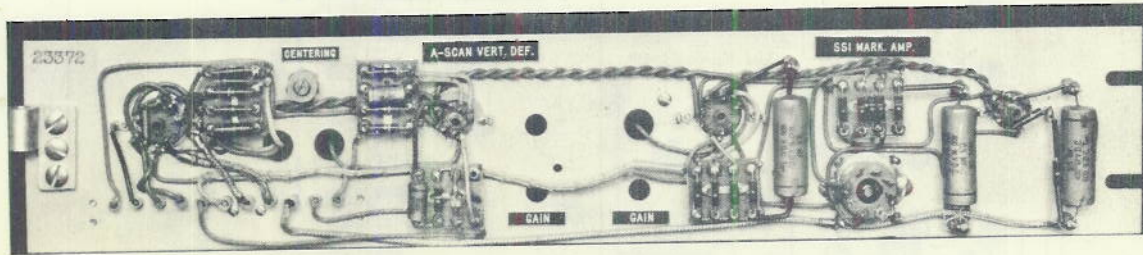


Fig. 2.4 - Interpanel Wiring Diagram of Display System





(a) Front view



(b) Rear view

Fig. 2.10 - A-Scan Vertical Deflection and SSI Marking Amplifiers

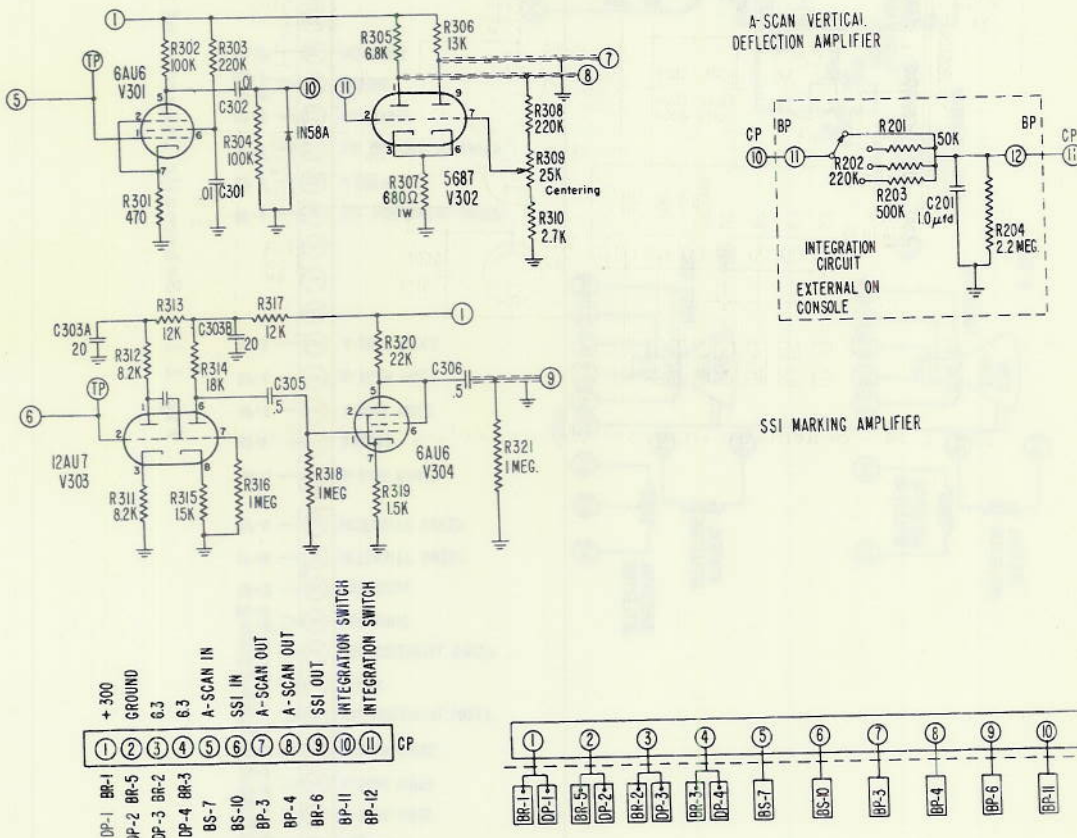


Fig. 2.11 - Schematic Diagram of A-Scan Vertical Deflection and SSI Marking Amplifier

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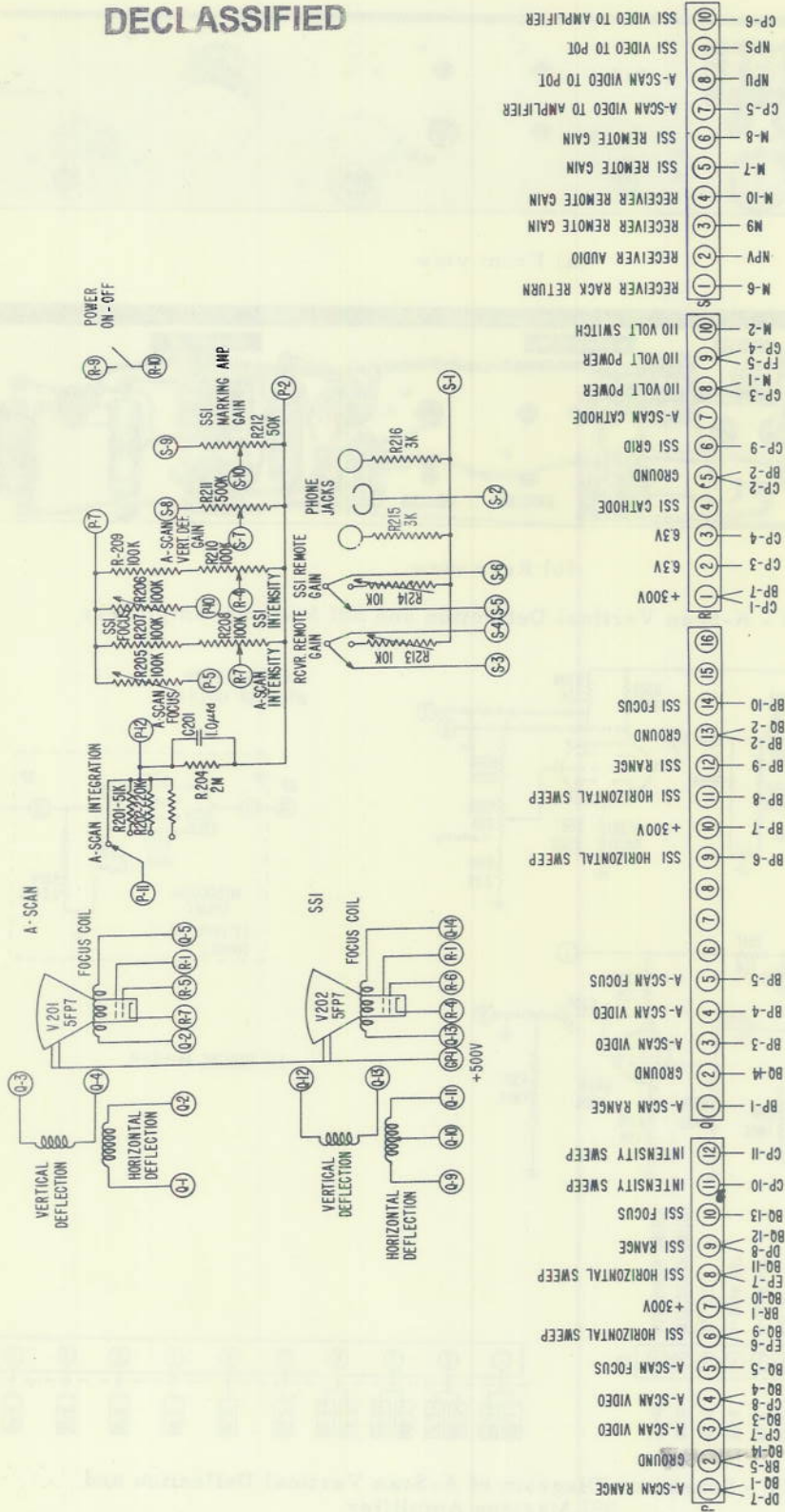
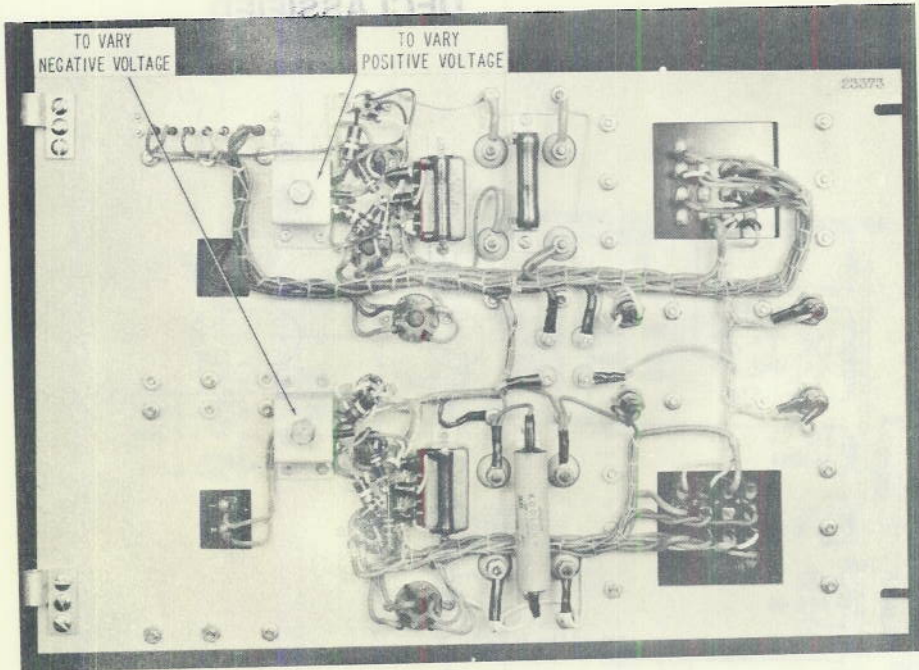
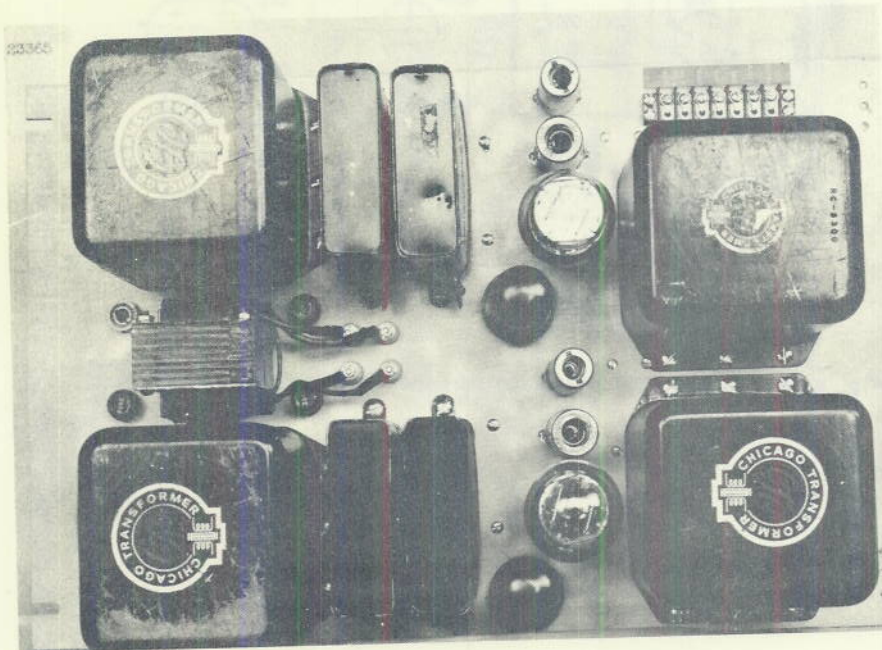


Fig. 2.12 - Schematic Diagram of Display Console



(a) Front view



(b) Rear view

Fig. 2.13 - Low-Voltage Power Supply



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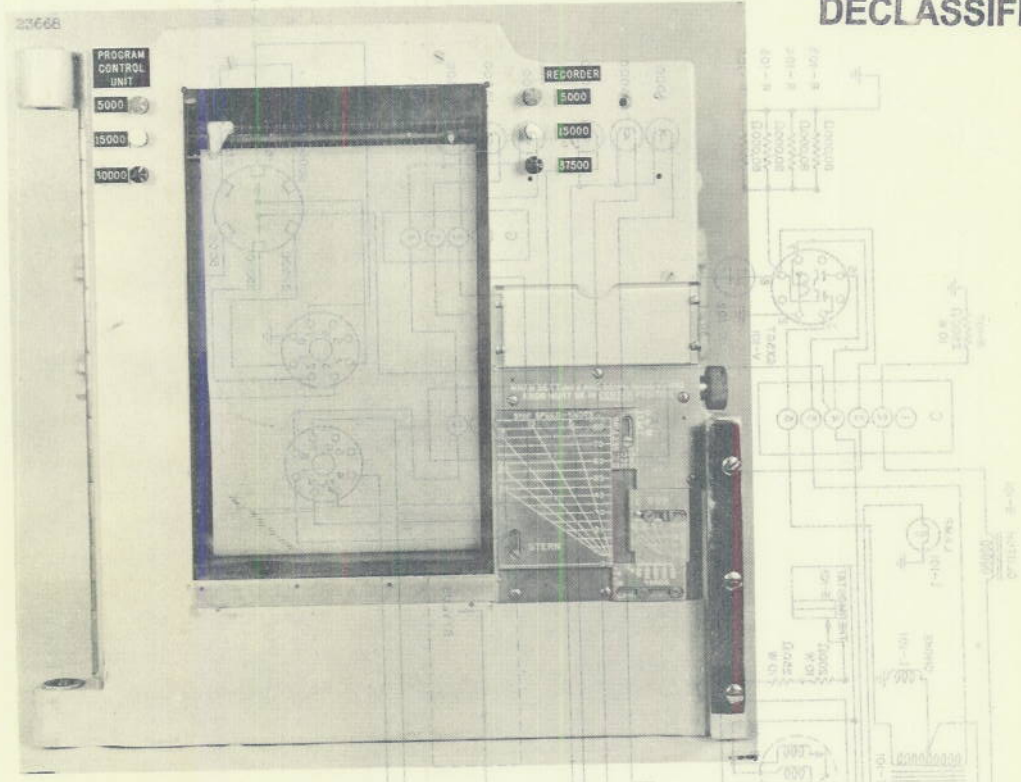


Fig. 2.15 - Front View of Range Recorder

Fig. 2.15 - Schematic Diagram of Range Recorder

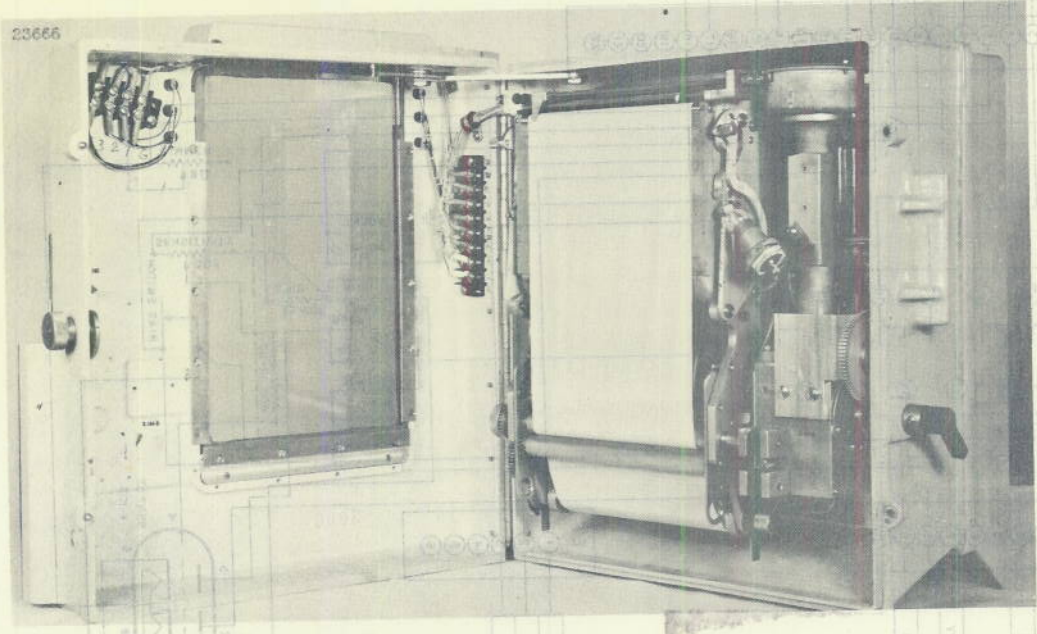


Fig. 2.16 - Interior View of Range Recorder

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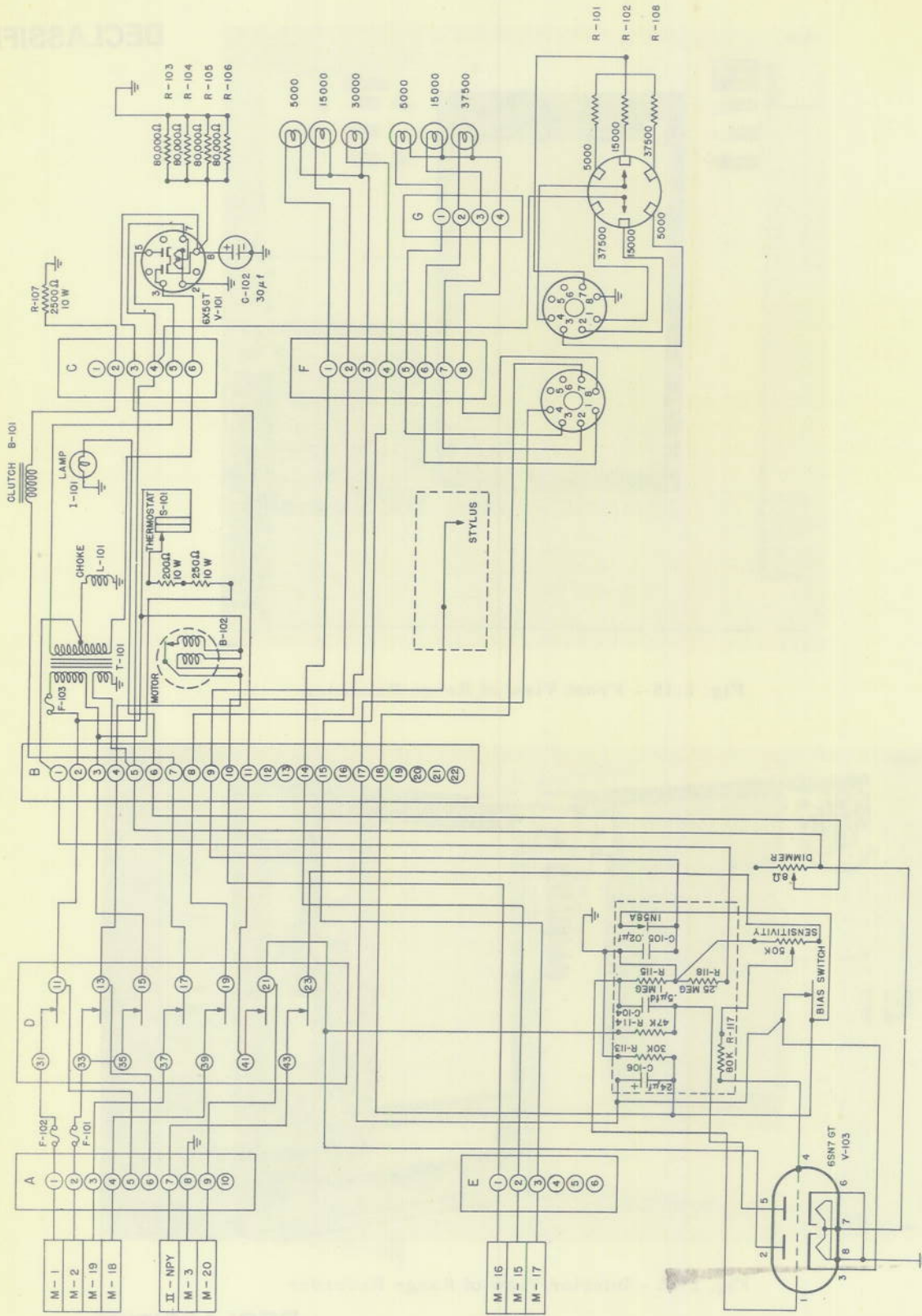


Fig. 2.17 - Schematic Diagram of Range Recorder

## CHAPTER 3 RECEPTION EQUIPMENT

### I. INTRODUCTION

#### Function

The reception equipment provides information for both visual and aural detection of noise generated within the target and detection of echoes produced by sonifying the target in a sound beam. Essentially, the reception system consists of two receivers centered at 10 kc: (a) a Narrow-Band Receiver which provides aural and A-scan display information and (b) a Sector Scan Indicator (SSI) Receiver which provides target azimuth information to a B-scan display.

A functional diagram of the reception equipment is shown in Figure 3.1. Signal voltages induced in the transducer are applied to the receivers through the Combining Unit which (a) amplifies the two signals from the split transducer and applies the two individual outputs to an SSI Receiver, and (b) combines these signals and feeds the resultant to a Narrow-Band Receiver. The two receivers process their respective inputs and supply information to the Display Console (Rack I) for aural and visual presentation.

A Time Varied Gain Control (TVG) Unit renders the receivers inoperative during pulse transmission and then restores the Narrow-Band-Receiver gain at a predetermined rate.

A test signal, applied to the receiver through the Combining Unit and a calibrated attenuator, is used for testing and aligning the receivers.

#### Arrangement of Units

The reception equipment for the XHA Sonar System consists of six units mounted in Rack II. Front views of the units are shown in Figure 3.2 and rear views, except that of the Power Supply, are shown in Figure 3.3. The units are arranged in the rack from top to bottom as follows:

Panel II-A	Narrow-Band Receiver
Panel II-B	Combining Unit
Panel II-C	Time Varied Gain Control
Panel II-D	SSI Receiver
Panel II-E	Test-Signal Attenuator
Panel II-F	Power Supply.

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### Interpanel Wiring

The interpanel wiring used in the reception rack consists of two distinct systems (Figure 3.4). One system, a wiring harness located in the left side of the rack, provides all control and power connections from panel to panel and to the M-board. The other system consists of shielded leads which provide all signal connections from panel to panel and to the N-board.

### Power Requirements

The entire reception equipment requires 1.5 amperes at 115 volts, 60 cycles.

## 2. NARROW-BAND RECEIVER

### Description

The Narrow-Band Receiver (Figure 3.5), weighing nine pounds and constructed on a 7 x 19 inch panel, is a tuned-frequency unit which operates over a bandwidth of 50 cycles on any one of five frequencies — 9.90, 9.95, 10.00, 10.05, or 10.10 kilocycles. In addition, bandwidths of 100 and 200 cycles are provided; these, however, should be used only in the 10.00-kc position. The receiver provides audio output to a speaker and two headsets, and video output to the A-Scan Amplifier.

The audio output from the receiver is obtained by mixing the band of frequencies passing through the signal-frequency stages with a local oscillator frequency of 9.2 kc and then selecting only the difference-frequency components. Thus, for a 10.00-kc signal input to the receiver, the audio output is 800 cycles. Any variation of the input frequency is reflected directly as a change in the output frequency which thereby permits aural detection of doppler present in the received signal.

### Circuitry

The signal-frequency stages of the receiver circuit (Figure 3.6) consist of two cascaded tuned-frequency variable-gain amplifiers which are shock-mounted. The input transformer T101 operates from a 100-ohm source impedance provided at the output of the Combining Unit. The transformer is untuned and has an impedance step-up of 100 to the grid of the initial amplifier V101. This stage is impedance-coupled by the secondary inductance of transformer T103 to the tuned transformer T102 through coupling capacitor C104. The secondary of T102 has an unloaded Q of 200 at 10 kc and thus provides the 50-cycle bandwidth at this frequency. The bandwidths of 100 and 200 cycles are obtained by the loading resistors R106 and R105, respectively; these resistors are paralleled with the secondary of T102 by switch S101. In order to tune the receiver to the frequencies of 9.90, 9.95, 10.00, and 10.05 kc, capacitors C108, C109, C110, and C111 are paralleled with the secondary by switch S102. In the 10.1-kc position of switch S102, it should be noted that no capacity is used since this is the frequency to which capacitors C106 and C107 tune the secondary. The following amplifier stage, V102, is transformer-coupled to the grids of V103, a push-pull-connected balanced mixer. The secondary of the coupling transformer T104, is tuned to 10 kc and resistor-loaded to provide a 250-cycle bandwidth.

The 9.2-kc local oscillator, V104, is coupled to the balanced mixer by virtue of the common cathode resistor of V103 and the cathode-follower half of V104. The 800-cycle output

of the push-pull mixer is transformer-connected through T105 to the output-amplifier stage. The primary and secondary of this transformer are shunted with capacity, and the result is a circuit which is broadly tuned to 800 cycles.

The output amplifier consists of two 6AQ5 tubes driven push-pull by transformer T105. These tubes, used in conjunction with output transformer T106, provide an audio power output of 8 watts at an impedance of 500 ohms.

The gain of the receiver with no Time Varied Gain (TVG) voltage applied is adjusted by control of the voltage to which the cathodes of the signal-frequency amplifiers V101 and V102 are returned. This control is obtained locally by potentiometer R120, or remotely by a similar potentiometer, R121, connected as shown on the schematic. The control transfer switch S103, located on the rear of the remote-control potentiometer, is actuated at the extreme counterclockwise position of this control. The switch transfers the gain control from the remote position to the local position.

During pulse operation of the system, the gain of the receiver is controlled by the TVG voltage derived in the TVG Unit (Panel II-C) and applied to the grids of the signal-frequency amplifiers through decoupling networks. At the instant of keying, this voltage is highly negative and cuts off the two signal-frequency amplifier stages. The TVG voltage then decreases at a controlled rate and gradually permits the receiver to recover its gain as the level of reverberation drops. Finally, at a predetermined time, the receiver recovers the gain as determined by the setting of the remote or local gain control. In general, the gain control is adjusted to permit a satisfactory noise-level output after reverberations have subsided. Proper adjustment of the TVG control is considered in the description of the TVG Unit.

Circuit Adjustments

Alignment of Signal-Frequency Stages and Output Frequencies—In order to align the signal-frequency stages of the receiver, a standard 10-kc test signal is fed from jack P of the Attenuator Unit (Panel II-E) into jack U (labeled TEST-SIGNAL INPUT) of the Combining Unit,

The receiver output may be monitored at jack Q, which is located on the N-board in the rear of the rack. With the receiver gain at maximum, the bandwidth switch S101 in the 50-cycle position, and the tuned frequency switch S102 in the 10-kc position, the attenuator on Panel II-E should be adjusted to produce a receiver output of approximately 1 volt. Trimmer capacitors C107 and C115 are then adjusted for a maximum output. If at any time during the trimmer adjustment the output exceeds 50 volts rms, the signal input should be reduced 10 db and the procedure continued. Adjustment of the trimmer capacitors in this manner automatically brings all other tuned frequencies of S102 into alignment.

To adjust the output frequency to 800 cycles, an external audio oscillator must be used in conjunction with an oscilloscope. The external oscillator is applied to the X-axis amplifier of the oscilloscope and the receiver output to the Y-axis amplifier. The external audio oscillator is set to 800 cycles. By adjusting C117, the local oscillator is then brought to 9.2 kc, and proper capacitor setting is indicated by a circular Lissajous pattern on the oscilloscope.

Balanced-Mixer Adjustment—To adjust the balanced mixer, the receiver gain is set to a minimum and potentiometer R117 and capacitor C121 are alternately adjusted until the

receiver output is a minimum. When proper adjustment has been achieved, the leakage of the local oscillator should not be greater than 0.05 volts measured across a 500-ohm load.

Electrical Specifications

(a) Tuned Frequencies (in the 50-cycle bandwidth position of S101 only):

9.90 kilocycles

9.95 kilocycles

10.00 kilocycles

10.05 kilocycles

10.10 kilocycles

(b) Bandwidths:

50 cycles in all frequency positions

100 cycles in 10.00-kc position only

200 cycles in 10.00-kc position only

(c) Input Signal from 100-Ohm Source to Produce an Output Signal-to-Noise Ratio of 20 db.

Bandwidth	Input Signal
50 cycles	0.22 microvolt
100 cycles	0.52 microvolt
200 cycles	1.20 microvolt

(d) Oscillator Leakage with Minimum Gain is 5 Microwatt (i.e., 0.05 volt across a 500-ohm load)

(e) Dynamic Range (maximum undistorted output from minimum detectable input):

Bandwidth	Dynamic Range
50 cycles	61.6 db
100 cycles	63.0 db
200 cycles	64.4 db

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(f) Sensitivity (input in microvolts to provide 1-watt output):

Bandwidth	Sensitivity
50 cycles	9 microvolts
100 cycles	21 microvolts
200 cycles	51 microvolts

(g) Power Requirements:

40 ma at 100 v dc
60 ma at 250 v dc
2.2 amperes at 6.3 v ac

### 3. COMBINING UNIT

#### Function

The Combining Unit (Figure 3.7) is an isolation amplifier designed (a) to distribute the signal energy from the transducer to the receiving devices and (b) to minimize any coupling effect between their inputs. The receiving devices used with this equipment are the SSI and Narrow-Band Listening Receivers.

#### Circuitry

General Description—The Combining Unit, a circuit diagram of which is shown in Figure 3.8, consists of two identical isolation amplifier channels; each is completely isolated and electrostatically shielded from each other and from surrounding equipment. The input to each channel is made through individual Amphenol connectors; the input to transformers T201 and T202 is therefore isolated from the chassis. A test-signal input provided through connector U (J-206) makes it possible to introduce a 10-kc correlated signal into the Combining Unit through individual 100-kilohm isolation resistors. Outputs, which include a single output from each channel to the SSI and a combined output from both channels to the listening receiver, are obtained from cathode followers.

The unit includes its own power supply which requires an input of 0.5 ampere at 110 volts, 60 cycles.

#### Electronic Characteristics

Input Impedance	50 ohms
Output Impedance	100 ohms
Maximum Gain at 10 kc	
Channel I	15.6 db
Channel II	16.7 db

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Cross Talk	-64 db at 10 kc between outputs and measured with 50-ohm input terminations and with 10-db gain setting in each channel.
S/N Ratio	The noise level at the single outputs is 0.075 microvolts, and about 3 db higher, or 0.106 microvolts at the combined output. A 0.17-microvolts input signal is necessary to give an S/N ratio of 20 db at the output*
Frequency Response	With a gain setting of 10 db at 10 kc, the frequency response is flat within 1 db from 4 to 40 kc

Gain Adjustments—To make the only necessary gain adjustment, the gain-control potentiometers should be set to give a 10-db over-all gain through each channel of the unit.

#### Mechanical Description

The unit, which is mounted on a 19 x 7 x 1/8 inch anodized aluminum panel, weighs 12-1/2 pounds and has a maximum depth of 7-1/2 inches. The panel cover is divided into three compartments in order to provide shielding between each amplifier channel and the power supply. To permit access to the circuitry, compartment cover plates may be removed independently without interrupting the shielding between the other sections.

#### TIME VARIED GAIN CONTROL

##### Function

The TVG Unit (Figure 3.9), designed to provide a gain controlling voltage for the receiving equipment, blanks the receivers during the transmitted pulse and then restores their gain at a predetermined rate which depends upon the estimated rate of reverberation-level decay.

##### Circuitry

General Description—Basically, the circuitry of the TVG Unit (Figure 3.10) consists of a relay-controlled RC charging network. Relay K301 is energized by a pulse from the Keyer Unit of the Driver system. The pulse is initiated approximately 100 milliseconds before the transmitted pulse and terminated approximately 100 milliseconds thereafter. With the relay in the de-energized position, capacitors C301 and C302 are charged to about minus 80 volts by the negative power supply of the unit. When the controlling pulse energizes the relay, capacitor C301 supplies a negative impulse to the RCG circuit of the SSI, while capacitor C302 charges capacitor C303 to some negative level determined by the position of the TVG START selector S301. The voltage across C303 is applied to the grids of the listening receiver, thereby reducing the gain of the receiver to a very low level and effectively cutting it off. The gain of the receiver is gradually restored as the charge on capacitor C303 decays toward some positive voltage determined by the TVG SLOPE selector, S302. The rate of gain recovery is therefore equal

\* These measurements were made in a 50-cycle band, with 50-ohm terminations at the inputs, and 10-db gain settings in each channel.

to the rate of decay of the charge on C303, which in turn is dependent upon the settings of the selector switches. However, regardless of the voltage level to which C303 is recharging, the clamping diode begins to conduct and the capacitor is maintained at zero potential as soon as the charge on the capacitor reaches zero.

By proper positioning of the selector switches S301, S302, and S303, the characteristic of the gain-rise curve set up by the TVG Unit can be made to correspond to the rate of reverberation-level decay so that the signal level at the output of the listening receiver is always within  $\pm 10$  db.

TVG Start—The selector switch S301 provides a choice of five starting-voltage levels, i.e., 0, -10, -20, -30, and -40 volts. These values correspond respectively to switch markings of 1, 2, 3, 4, and 5. Figure 3.11a indicates that the receiver gain-rise behavior for the five TVG start positions of this selector should depend upon the range at which the equipment is to operate. Assuming operation ranges of 5, 10, 15, 20, and 25 kiloyards, position 1 on the TVG START selector corresponds to minimum range, and position 2 to the next lowest range, etc.

Time Constant—The selector switch S302 provides a choice of five time constants (6.25, 12.5, 18.75, 25, or 31.25 seconds) which determine the time rate of gain recovery for the receiver. Figure 3.11b indicates the effect of various time constants on the character of the gain-rise curve for a particular TVG START and TVG SLOPE settings. The positioning of this selector, in conjunction with the TVG SLOPE selector, should be determined by the operating conditions encountered in the field, i.e., ocean depth, bottom characteristics, etc.

TVG Slope—The TVG SLOPE selector switch S303 provides ten voltage levels (from 10 to 100 volts) toward which the capacitor C303 may charge. This charging level determines the slope linearity of the gain-rise curve as shown in Figure 3.11c. The positioning of the TVG SLOPE and TIME-CONSTANT selectors should depend upon sea conditions; optimum settings are largely determined by experience.

#### Power Requirements

Filament	1.3 amp, 6.3 volts ac
Plate Supply	0.3 ma, 100 volts dc

#### Mechanical Description

The TVG Unit is constructed on a 1/8-inch anodized aluminum panel which is equipped with hinges for mounting on a standard NRL rack. The selector switches are mounted on the front of the panel, and the larger circuit components project from the rear of the panel. Mechanical specifications are as follows:

Weight	6-1/2 pounds
Panel Size	19 x 5-1/5 x 1/8 inches
Maximum Depth Behind Panel	4 inches
Maximum Depth in Front of Panel	4 inches.

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## 5. SSI RECEIVER

## Function

The SSI Receiver (Figure 3.12) is a dual-channel phase-sensitive receiver in which the input signal for each channel is obtained from one-half of a split-type transducer. The receiver processes the information and provides outputs to the Display Console for visual presentation.

## Theory of Operation

A block diagram (Figure 3.13) will aid in the following explanation of the SSI operation theory.

A sound wave of frequency  $f_0$  will induce a signal in each half of the split transducer. The two signals will have the same frequency but a difference in phase dependent upon the angle of arrival of the signal. Each of the two signals is amplified and then mixed with the outputs of two local oscillators, which have frequencies of  $G_1$  and  $G_2$ . Because the i-f amplifiers accept only the lower sidebands from mixer No. 1 and mixer No. 2, new frequencies of  $(G_1 - f_0)$  and  $(G_2 - f_0)$  result. These two frequencies are combined in mixer No. 3, and a filter network accepts only the lower sideband of the mixer output. This results in a new frequency  $(G_1 - G_2)$ , which is independent of the frequency of the input signal and equal to the difference of the frequencies of the oscillator signals. Differentiating circuits convert the signal to pips which are amplified and used for spot brightening on the cathode-ray tube of the Display Console.

A reference frequency is obtained by mixing the two local oscillator frequencies ( $G_1$  and  $G_2$ ) in mixer No. 4. The following circuit accepts only the lower sideband, and this action results in a new frequency  $-G_1 - G_2$ . This signal is used to synchronize the horizontal sweep of the cathode-ray tube in the Display Console.

The filtered outputs of mixers No. 3 and 4 are identical in frequency but differ in phase by an amount equal to the phase difference between the two input signals derived from the split transducer. This phase relationship can be shown by mathematical analysis.

To correlate the position of the spot on the cathode-ray tube with the position of the target in the transducer beam, a phase shifter is introduced into the synchronizing circuit. The phase of the reference frequency is adjusted so that the brightened spot will appear at the center of the sweep when there is no phase difference between the input signals. The vertical sweep for range indication is furnished by a circuit in Rack I. Under operating conditions, the position of the spot indicates the bearing deviation and range of the target.

## Circuitry

From the circuit diagram of the SSI (Figure 3.14), it can be seen that each of the two channels consists of a signal-frequency amplifier, a balanced converter, and an intermediate-frequency amplifier. The first stage amplifies all incoming signals. The input to the converter is tuned to 10.0 kc, and the converter mixes this signal with its associated oscillator signal. As a result, an intermediate frequency of 29 kc is developed in Channel I and 31 kc in Channel II. The converter maintains oscillator leakage at a minimum by means of the balance adjustment R445 or R446. Such adjustment may be necessary to

compensate for small differences in converter tube characteristics when new tubes are inserted.

The outputs of the channels are then combined in the output mixer V414 and fed to a narrow-band Q-multiplier which is tuned to the 2-kc scanning frequency. The Q-multiplier output is clipped to produce a square wave having a fast rise time. The resulting square wave is differentiated to produce pips by the RC network R493 and C487. Since the amplitude of the square wave is fixed, the amplitude and duration of the pips appearing at the grid of the output stage are dependent only on the rise time of the square wave. The output stage is biased well below cutoff by the positive voltage on its cathode. This causes the output stage to amplify only the positive portion of the pips that are above the cutoff voltage. Thus the signal appearing at the plate of the output stage consists of negative pips of approximately 10-microsecond duration.

The oscillator section consists of two crystal oscillators operating at frequencies of 39 and 41 kilocycles, respectively. In each there is a small variable condenser connected from ground to one side of the crystal, and capacitor is adjusted to provide undistorted output from each oscillator. This output is usually of the order of 4 volts rms measured at jacks R or Q. A crystal varistor is used to mix the two oscillator frequencies and thus obtain the difference frequency which is the reference frequency. The reference voltage is RC filtered, amplified, and passed through a variable phase-shift network used to center the B-scan spot brightening for axial beam signals. The reference voltage is amplified again and fed to output jack X.

During pulse operation of the system, the SSI gain is controlled by the Reverberation-Controllable-Gain (RCG) circuit. At the beginning of the transmit interval, a negative charge from the TVG Unit is applied to a 1-microfarad condenser, C471. The voltage across this condenser is applied to the grids of the channel amplifiers and converters through RC decoupling networks and is sufficient to drive all these stages into cutoff. At the end of the transmit interval, the negative charge on the condenser is permitted to decay at a rate proportional to the level of the reverberation at any instant. Thus, as the reverberation level from the sonified region diminishes, the gain of the receiver increases at a rate that keeps the output level relatively constant. After the reverberations have completely diminished and the condenser charge is fully dissipated, the gain of the receiver reverts to the level set by the remote or local gain control. The RCG circuit operates by amplifying and rectifying the output of Channel II and using this negative voltage to control the discharge rate of C471 through one half of the dual diode V413.

The INPUT REVERSE switch is used as an aid in zeroing the transducer on the target. As the INPUT REVERSE button is alternately pressed and released, the spot on the display cathode-ray tube alternately moves from side to side of zero calibration unless the target is centered in the transducer beam.

#### Electronic Characteristics

Operating Frequency	10 kilocycles
Frequency Response	Each channel is 3 db down at 10 kc ± 100 cycles
Q-Multiplier Bandwidth	10 cycles

Sensitivity	1 microvolt to give signal-to-noise ratio at output of 20 db
Dynamic Range	At maximum useful gain* and using pulses of 250 milliseconds or longer, the indication on the B-scan will vary no more than $\pm 2.5$ percent of the total sweep width for variation in input level from 1 microvolt to 0.01 volt, a dynamic range of 80 db.
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B-Scan Indication Versus Gain-Control Setting	The indication will vary no more than $\pm 2.5$ percent of sweep width for variation in gain-control setting
B-Scan Indication Versus Frequency	The indication will vary no more than $\pm 1$ percent of sweep width for frequency changes of $\pm 150$ cycles from 10 kilocycles
Coupling Between S-F I-F Channels	Crosstalk, or coupling between channels is less than -26 db measured at i-f outputs
B-Scan Indication Intensity Versus Input Level	A change in the input level of 6 to 10 db is sufficient to change the video output from an unstable pip having an average amplitude of 20 percent of maximum output to a stable pip having an amplitude more than 90-percent maximum output
Signal-Input Impedance	Each input is designed to operate from a 100-ohm source
Reference-Voltage Output (Jack X)	
Frequency	2-kilocycle sine wave
Amplitude	Approximately 5 volts rms
Impedance	11,000 ohms in series with 0.1-microfarad condenser

#### Circuit Adjustments

Signal-Frequency and Intermediate-Frequency Amplifiers—The test signal is applied through the Test-Signal Attenuator to the test input of the Combining Unit and adjusted in amplitude until voltage measured at the Q-multiplier cathode of V415 is 0.5 volts with full gain. The tuning condensers of all stages in each channel are adjusted for maximum output. If necessary, the signal is attenuated so that the measured output does not exceed 2 volts.

Balanced Converters—Remove test signal and de-energize the Combining Unit. Then adjust the balance-converter potentiometers R445 and R446 for a minimum output measured at the cathode of the Q-multiplier section of V415.

\* Approximately +4 volts on all cathodes of gain control tubes

Output Clipping Level—Apply the test signal as described in Paragraph 1 of "Circuit Adjustments." Adjust clipping level (R497) until only a negative pip appears at jack V. The plug V should be removed for this adjustment.

Q-Multiplier Tuning—Apply test signal as described in Paragraph 1 of "Circuit Adjustments." Adjust C475 for maximum signal output measured at the Q-multiplier section of V415. If the signal output should exceed 1 volt during this adjustment, reduce the level to 0.1 volt and continue adjustment. The bandwidth should be set to 10 cycles by adjusting feed-back resistor R477.

Phase Centering—Apply test signal as described in Paragraph 1 of "Circuit Adjustments." Adjust R424 until the spot brightening on the B-scan is centered.

#### Power Requirements

The SSI requires an input power of 4.8 amperes at 6.3 v ac and 110 milliamperes at 100 v dc. Power is furnished by the Power Supply (Panel II-F).

#### Mechanical Description

The SSI is constructed on a 19 x 14 x 1/8 inch anodized aluminum panel and equipped with hinges for mounting in a standard NRL rack. Most of the electronic circuit components are mounted on the front side of the panel with the tubes projecting from the rear side to keep the generated heat away from the circuit components. Maximum projection behind the panel is 2-1/4 inches; maximum projection in front of panel is 5-1/8 inches. The unit weighs 19 pounds.

The circuit is divided into five sections and each is built on a separate subchassis which is mounted to the main panel. Most interconnections are made with Amphenol microphone-type connectors. The plate and filament supply wires, however, are permanently wired on the back of the panel to ceramic feed-throughs which project through clearance holes in the subchassis. Plate and filament supply wires on each subchassis are soldered to the feed-throughs. The subchassis are as follows: 1 video, 1 RCG, 1 Oscillator and Reference Voltage, and 2 S-F I-F. The gain-control potentiometer, input reverse switch, and input reverse relay are mounted on the main panel.

## 6. TEST-SIGNAL ATTENUATOR

#### Function

The Attenuator Unit (Figure 3.15) provides a 10-kc test-signal output that is calibrated in 1-db steps. The input and output impedances of the unit are 600 ohms, and the signal-level output at zero db is 10,000 microvolts.

#### Circuitry

General Description—The circuit schematic of the unit is shown in Figure 3.16. The 10-kc signal is obtained from a crystal-controlled oscillator located on Panel III-B; and it is fed to the attenuator unit through jack J-501.

When the ON-OFF switch is in the OFF position, it shorts the signal and unit input leads to ground to prevent any signal-leakage pickup during system operation. The switch is in the ON position for testing only. Testing procedure for the two receivers, has been given under "Circuit Adjustments" in each instance.

By adjusting the LEVEL control R501, the desired initial output can be obtained at jack J-502. The output can be varied in 1-db increments by the dual-section attenuator which is calibrated in 1-db steps.

Adjustments—With the test signal applied and the attenuator set in the zero db position, the LEVEL control R-501, is adjusted for a 10,000-microvolt signal output at jack J-502.

#### Electronic Specifications—

Output Impedance	600 ohms
Signal Output at 0 db	10,000 microvolts
Attenuator Range	0 - 110 db
Power Requirements	None

#### Mechanical Description

The Attenuator Unit is constructed on a 5-1/4 x 19 x 1/8 inch aluminum anodized panel and weighs three pounds.

### 7. POWER SUPPLY

#### Function

The Power Supply (Figure 3.17) furnishes the filament power and various B+ voltages necessary for the operation of the other units in the reception rack.

#### Circuitry

The unit, a circuit diagram of which is shown in Figure 3.18, is protected by two 2-ampere line fuses and is equipped with an ON-OFF switch which permits the reception rack to be serviced in safety. A neon lamp indicates the application of panel power. The 110-volt duplex convenience outlet on the panel is fused for 10 amperes and is not de-energized by the ON-OFF switch.

Under rated load the unit requires an input of approximately 275 watts at 110 volts, 60 cycles. Output voltages with maximum current ratings are available on the terminal board as follows:

+100 v, 250 ma

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+300 v, 65 ma

+200 v, 15 ma

+250 v, 50 ma

Ground (B-, common filament)

6.3 v, ac

6.3 v, ac

6.3 v, ac

} 24 amperes

The +200-v output is electronically regulated by a conventional circuit. Interaction between outputs due to load variation is negligible.

#### Mechanical Description

The Power Supply is constructed on an anodized aluminum panel equipped for hinge mounting on a standard rack.

To facilitate heat dissipation, all tubes, selenium rectifiers, power resistors, transformers, and chokes are mounted on the back of the panel. Other components are mounted on the front.

The physical specifications of the unit are:

Panel Size	19 x 17-1/2 x 1/8 inch
Maximum Depth Behind Panel	5-1/4 inches
Maximum Depth in Front of Panel	2-3/4 inches
Weight	48.2 pounds.

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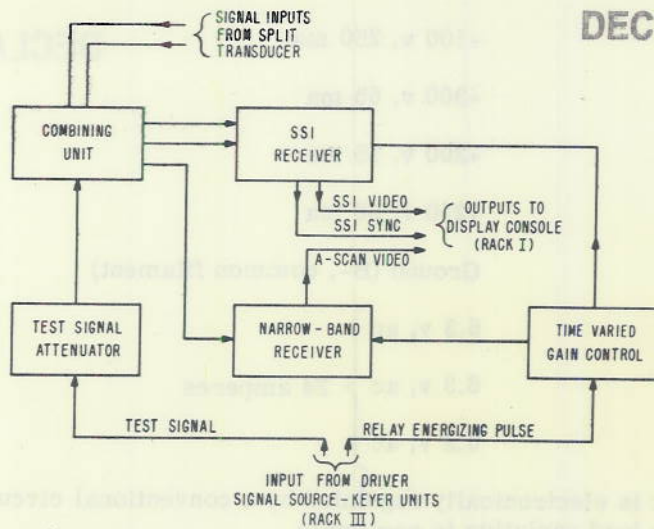


Fig. 3.1 - Functional Diagram of Reception Equipment

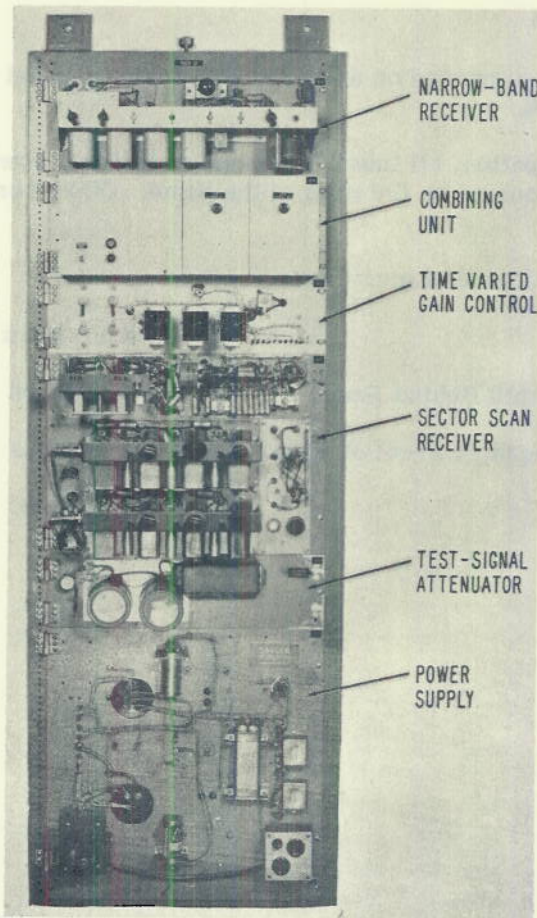
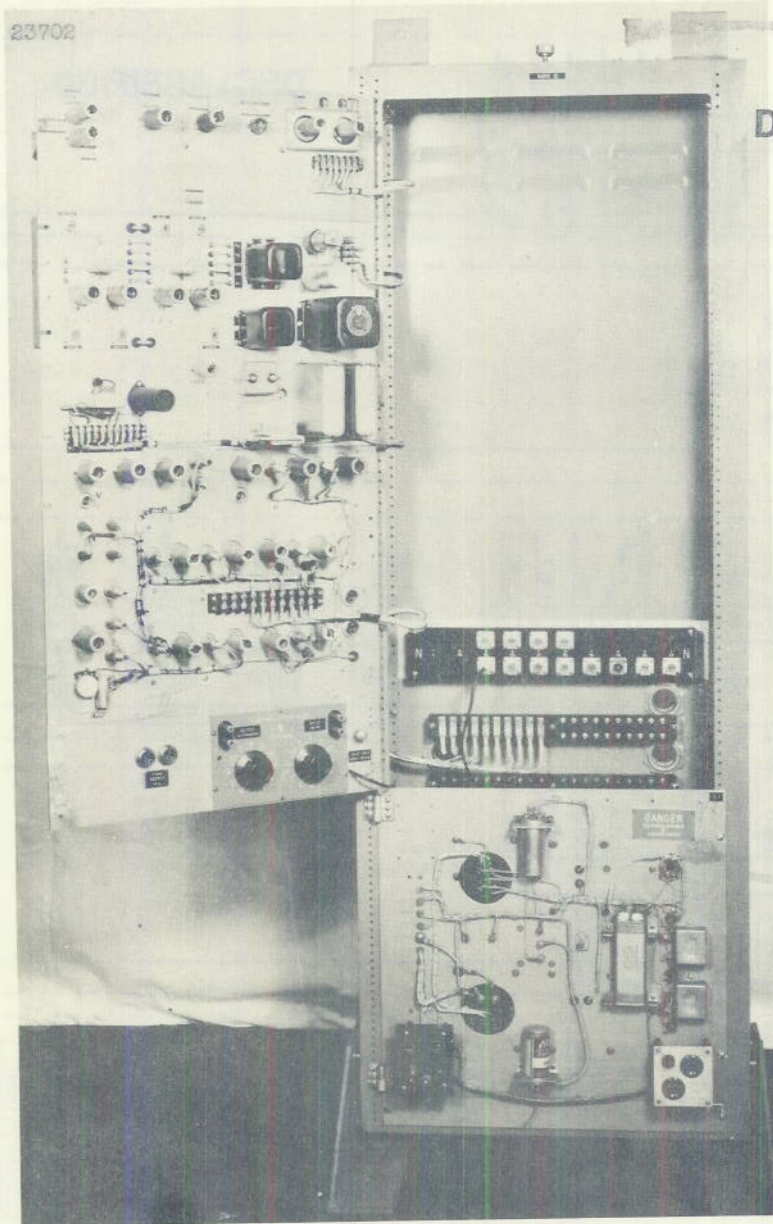


Fig. 3.2 - Front View of Reception Units in Rack II



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Fig. 3.3 - Interior View of Reception Units in Rack II

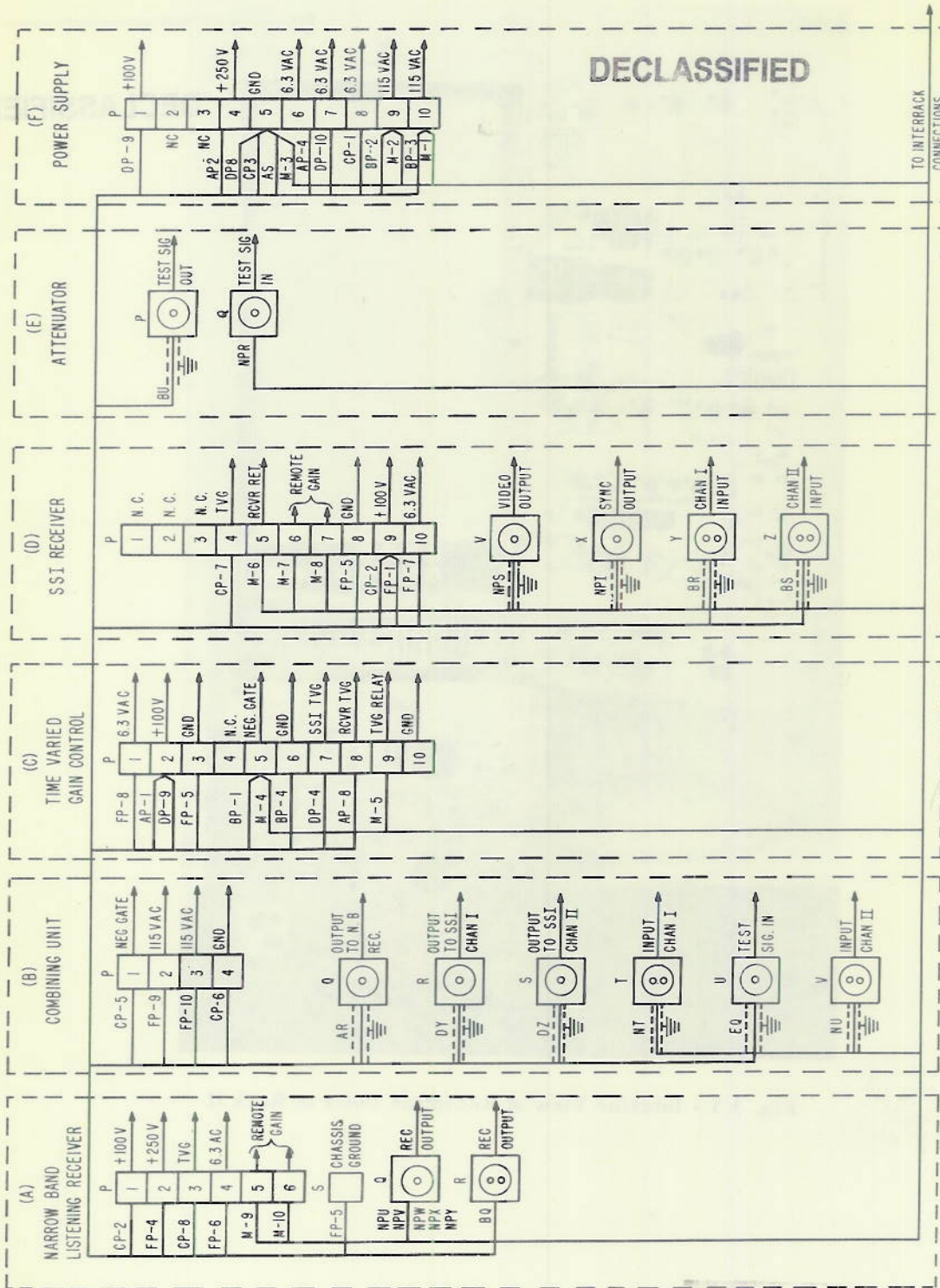
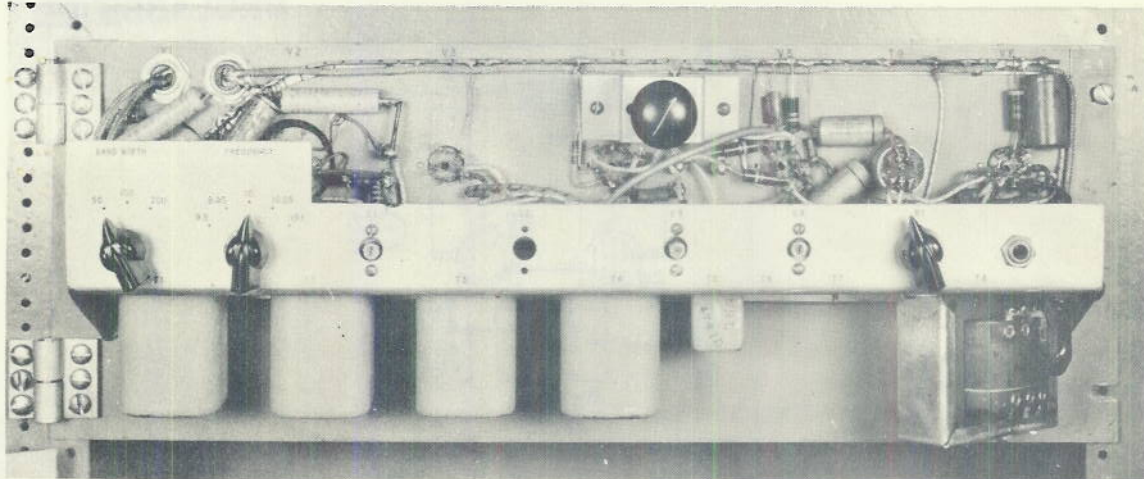
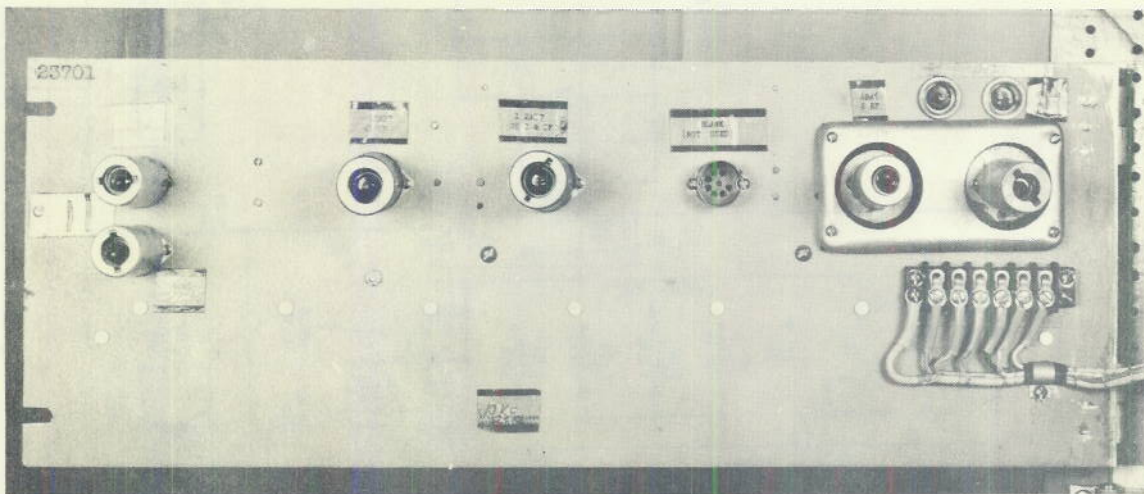


Fig. 3.4 - Interpanel Wiring Diagram of Rack II



(a) Front view



(b) Rear view

Fig. 3.5 - Narrow-Band Receiver

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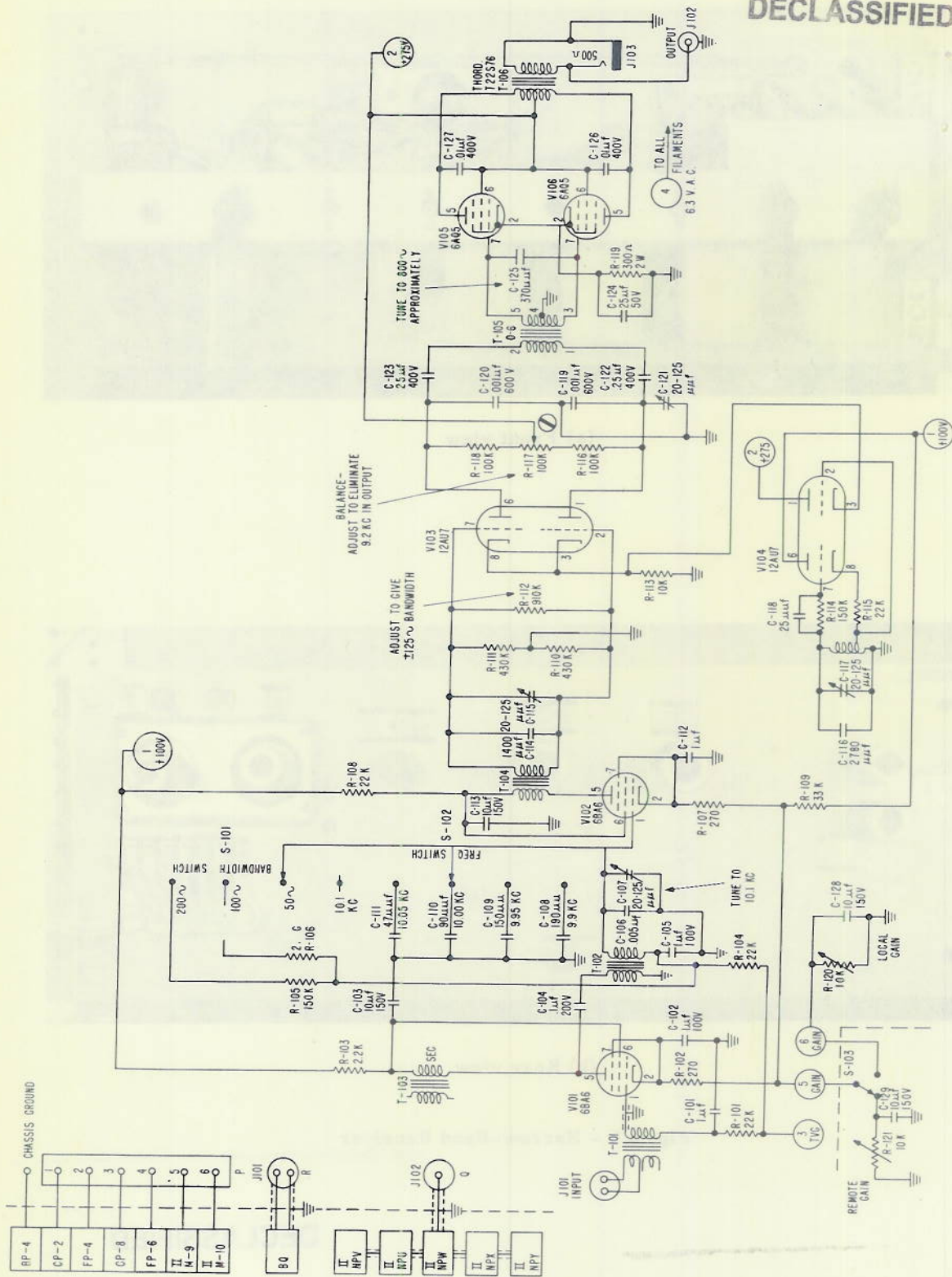
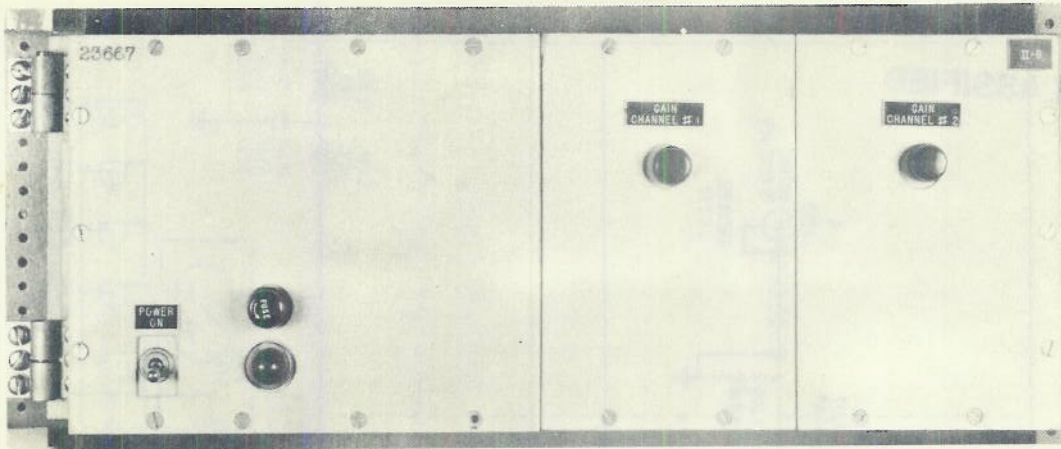
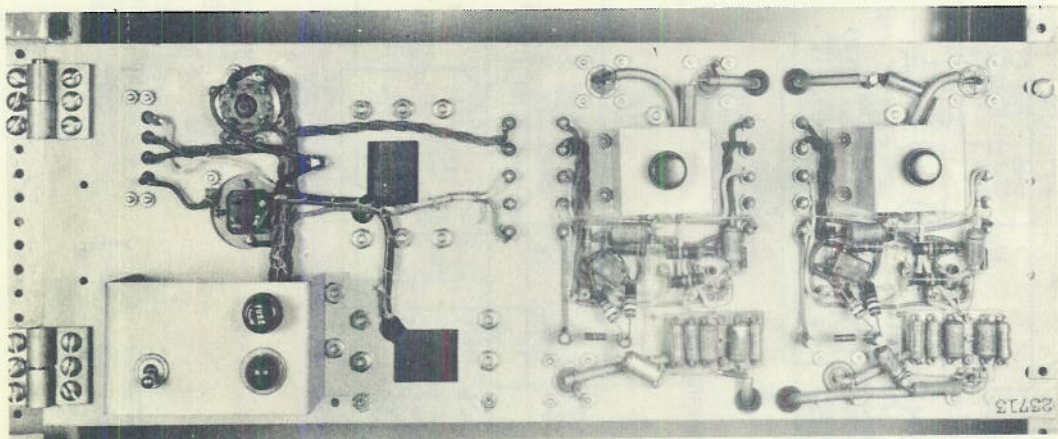


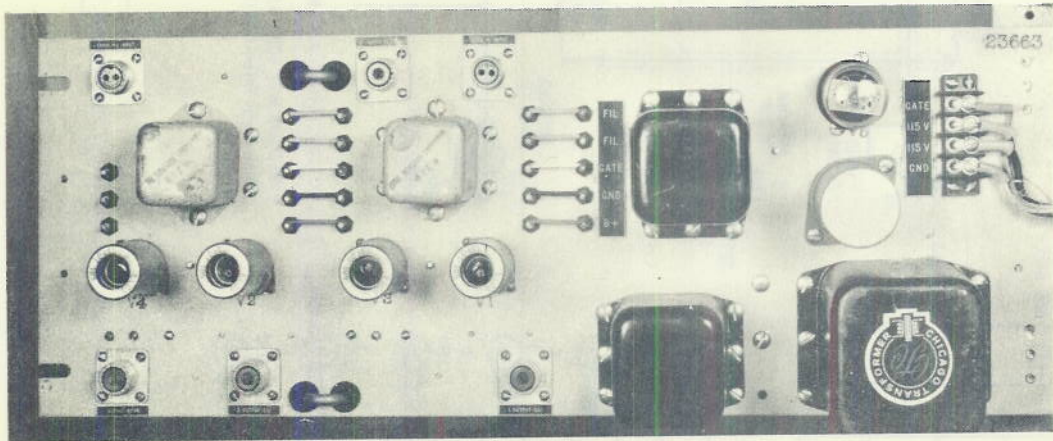
Fig. 3.6 - Schematic Diagram of Narrow-Band Receiver



(a) Front view with cover on



(b) Front view with cover off



(c) Rear view

Fig. 3.7 - Combining Unit

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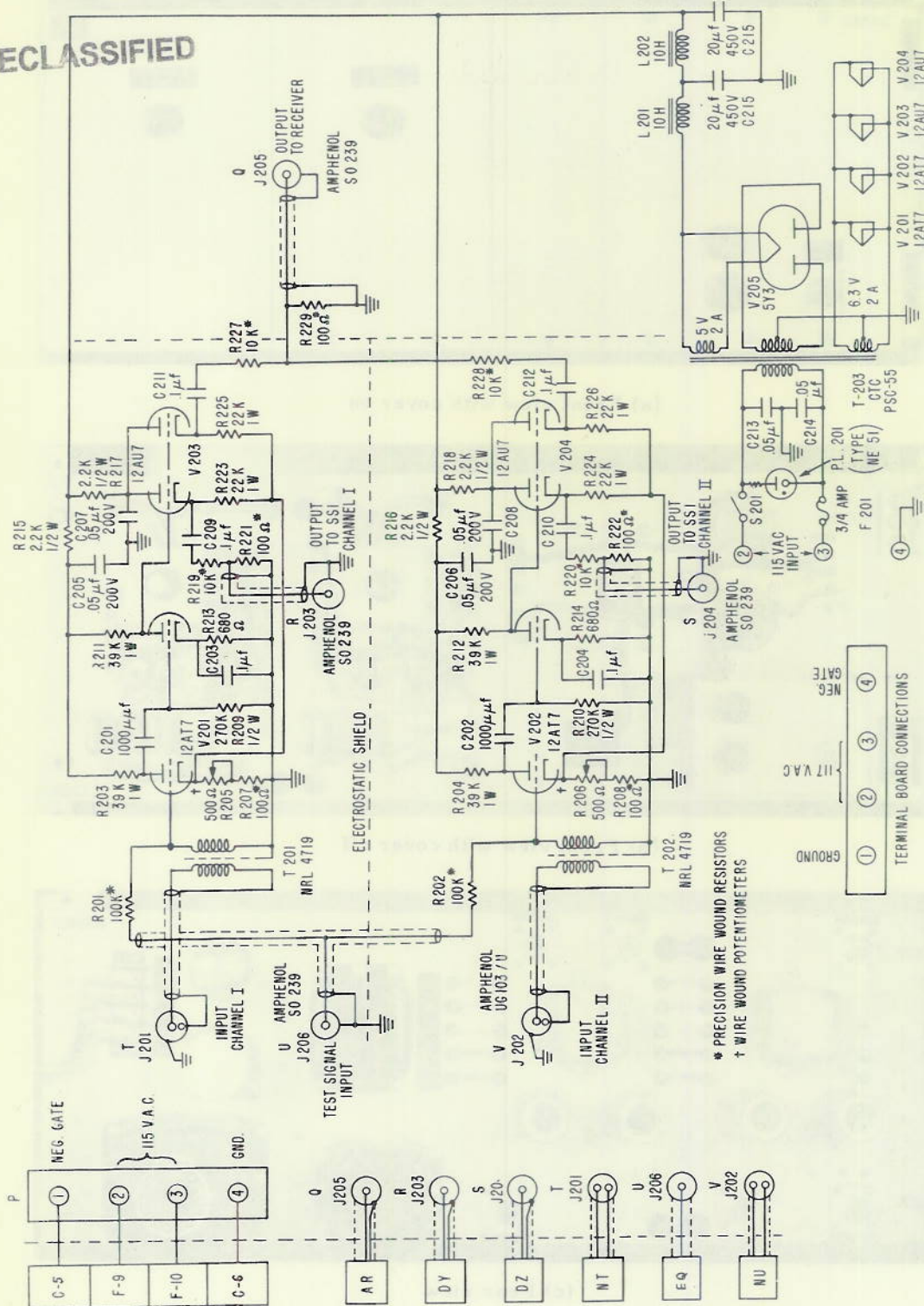
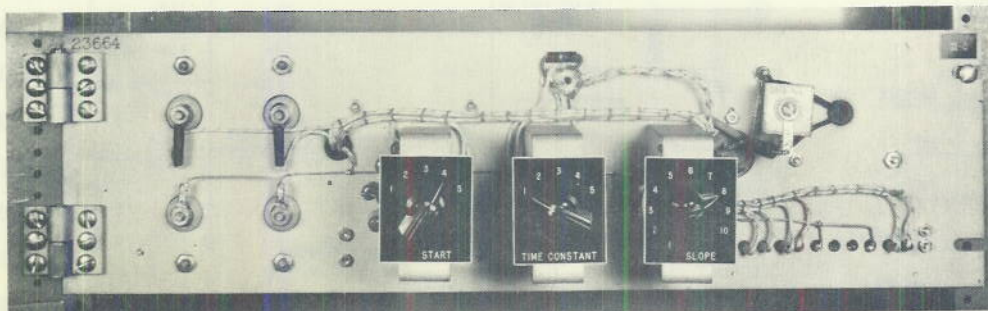
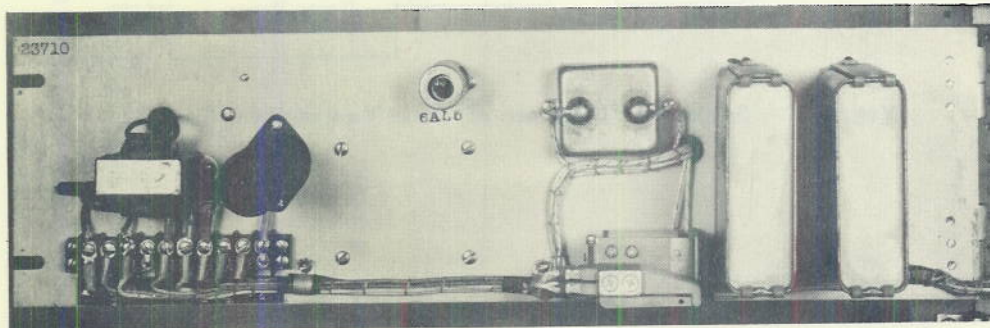


Fig. 3.8 - Schematic Diagram of Combining Unit

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(a) Front view



(b) Rear view

Fig. 3.9 - Time Varied Gain Control

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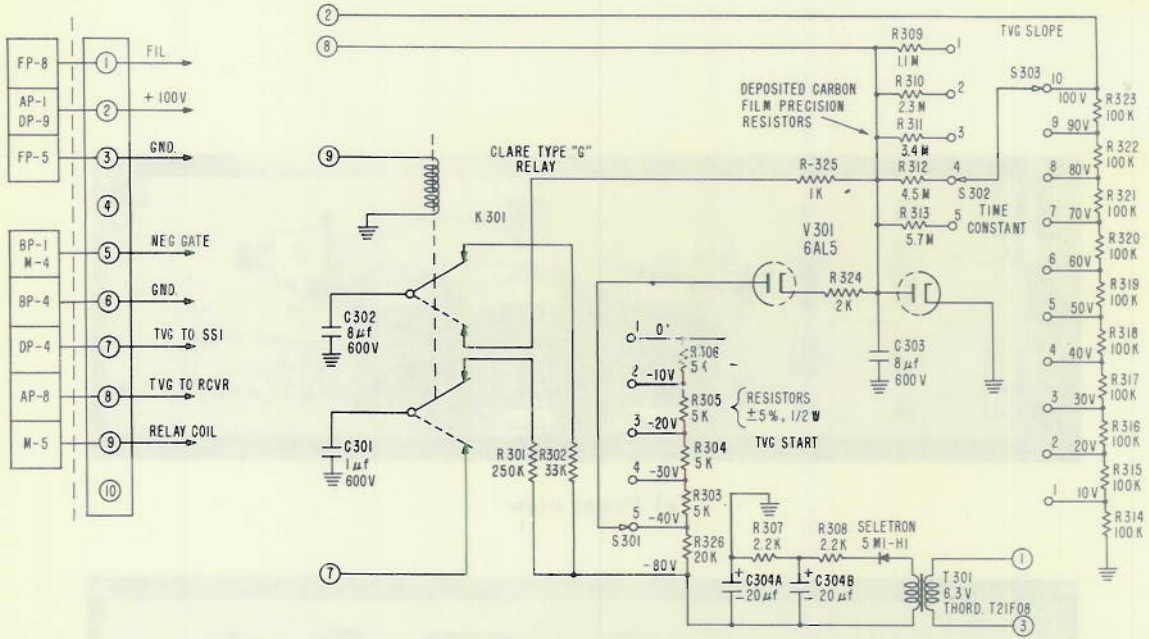


Fig. 3.10 - Schematic Diagram of Time Varied Gain Control

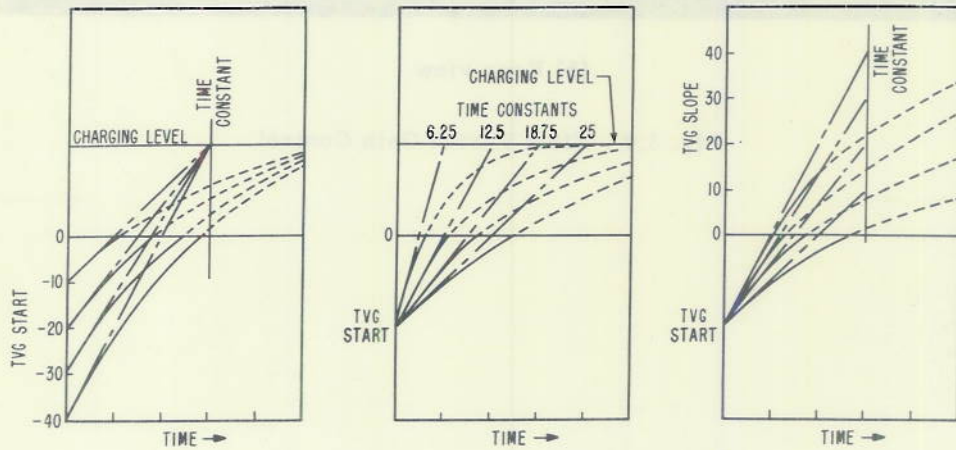
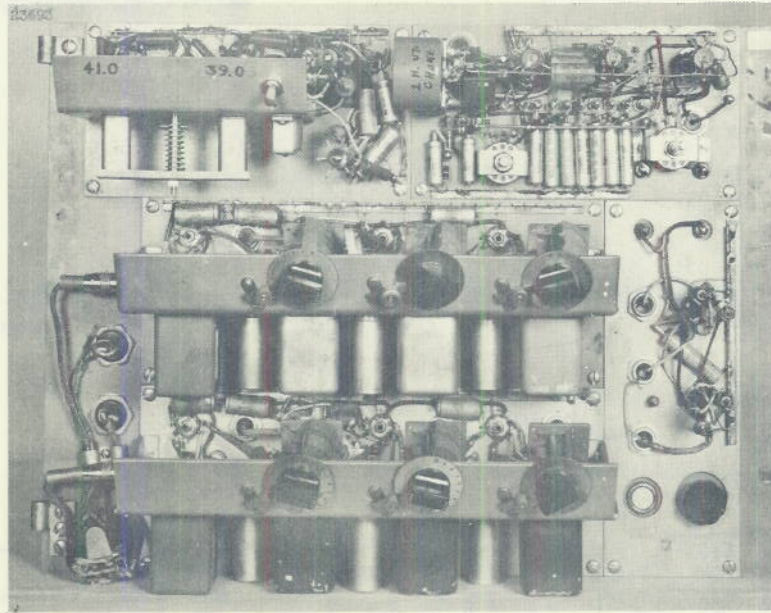


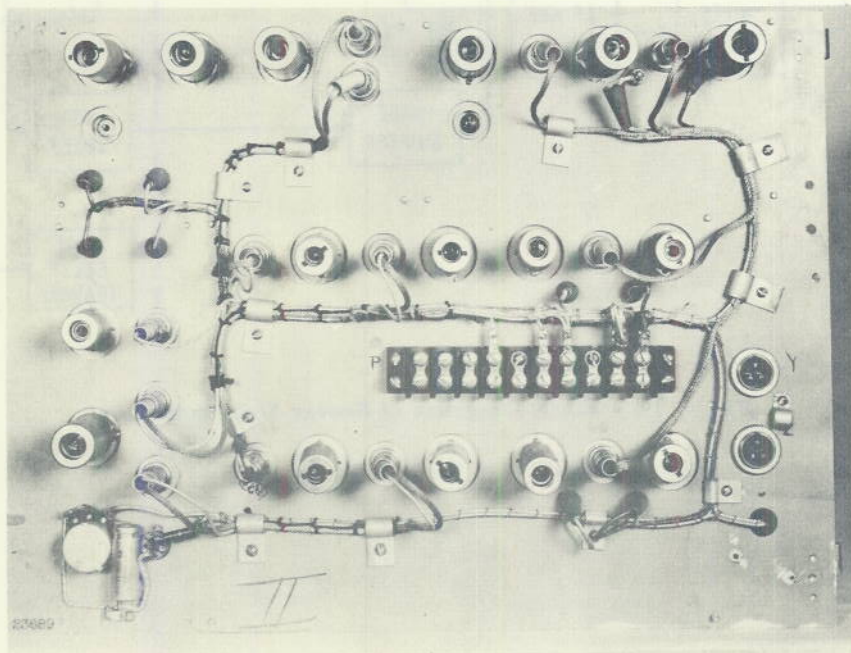
Fig. 3.11 - Performance Curves of Time Varied Gain Control

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(a) Front view



(b) Rear View

Fig. 3.12 - SSI Receiver

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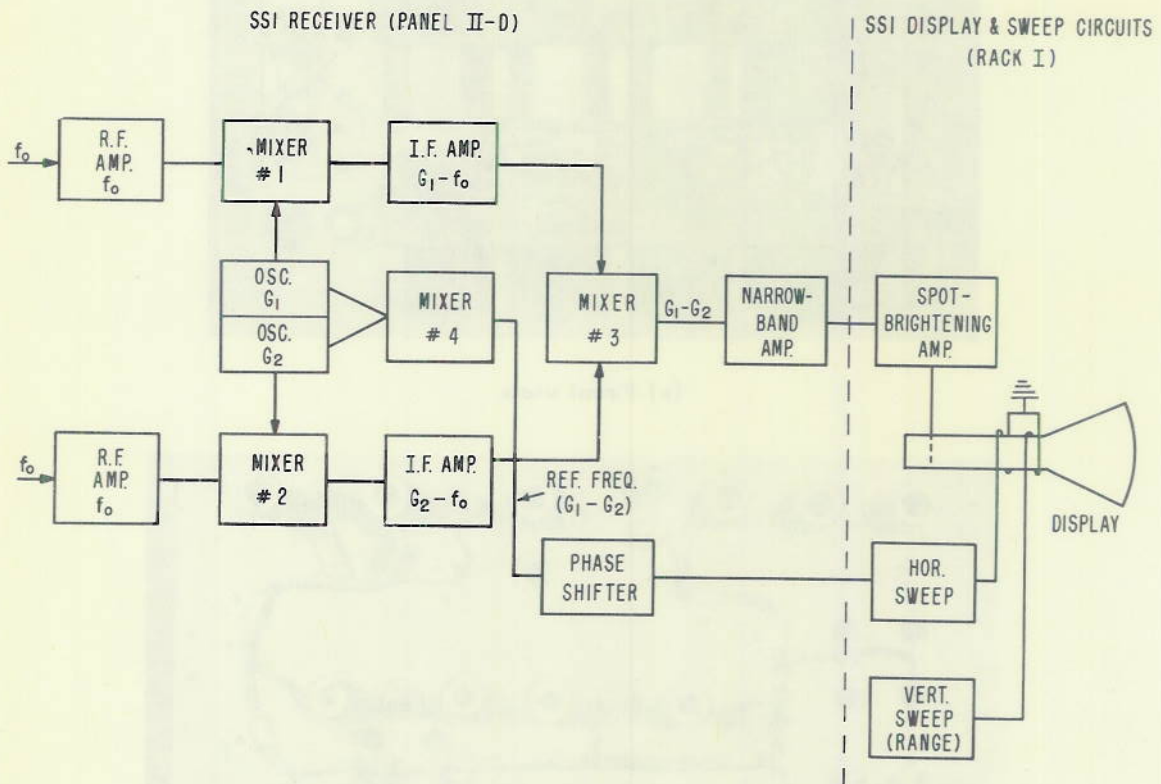
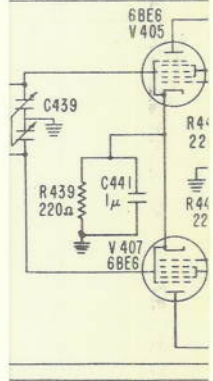
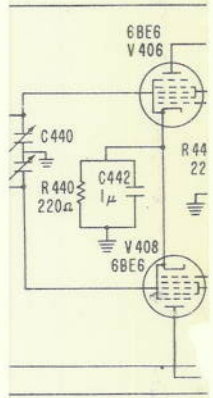
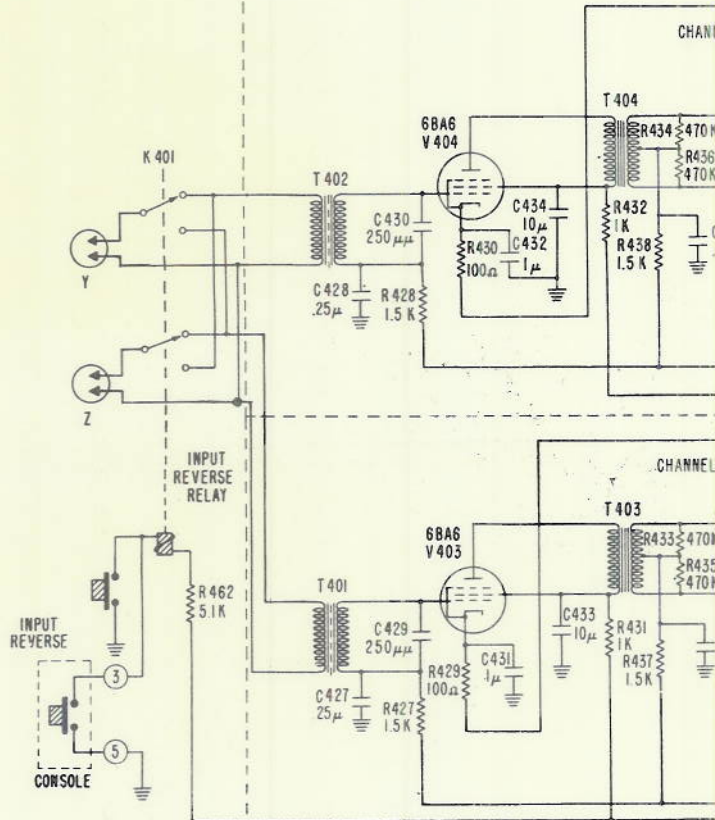
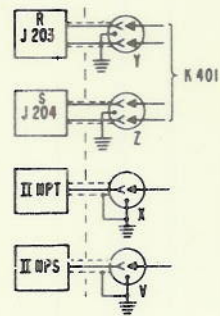
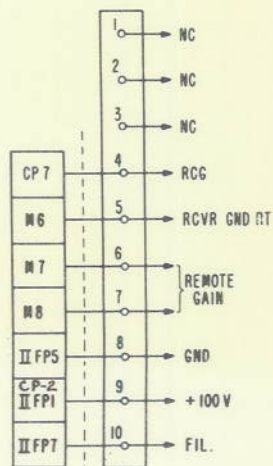
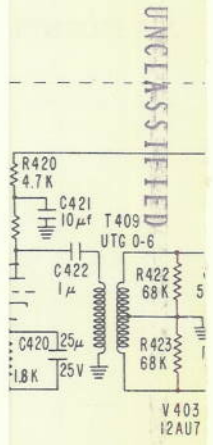
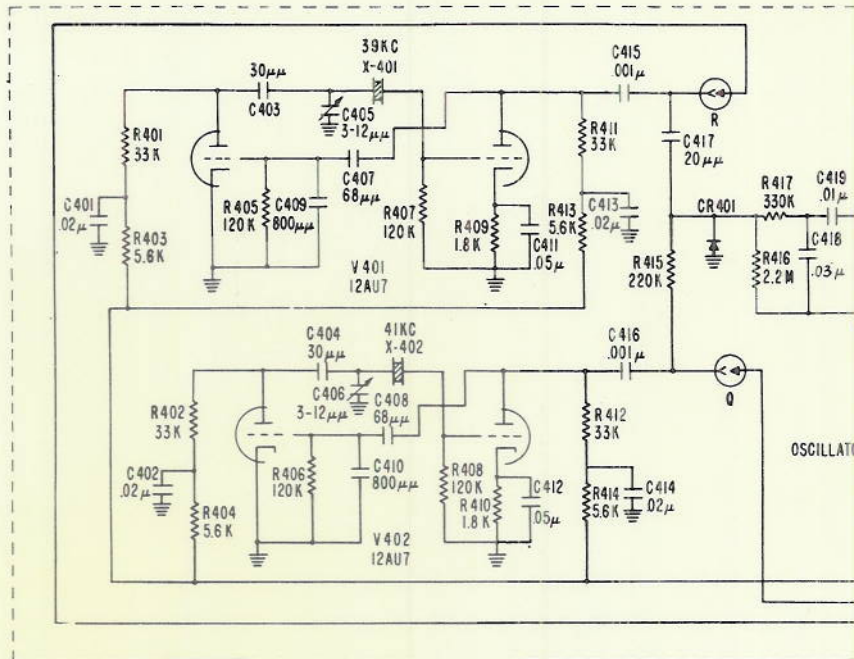


Fig. 3.13 - Block Diagram of Sector Scan Indicator

RECEPTION EQUIPMENT



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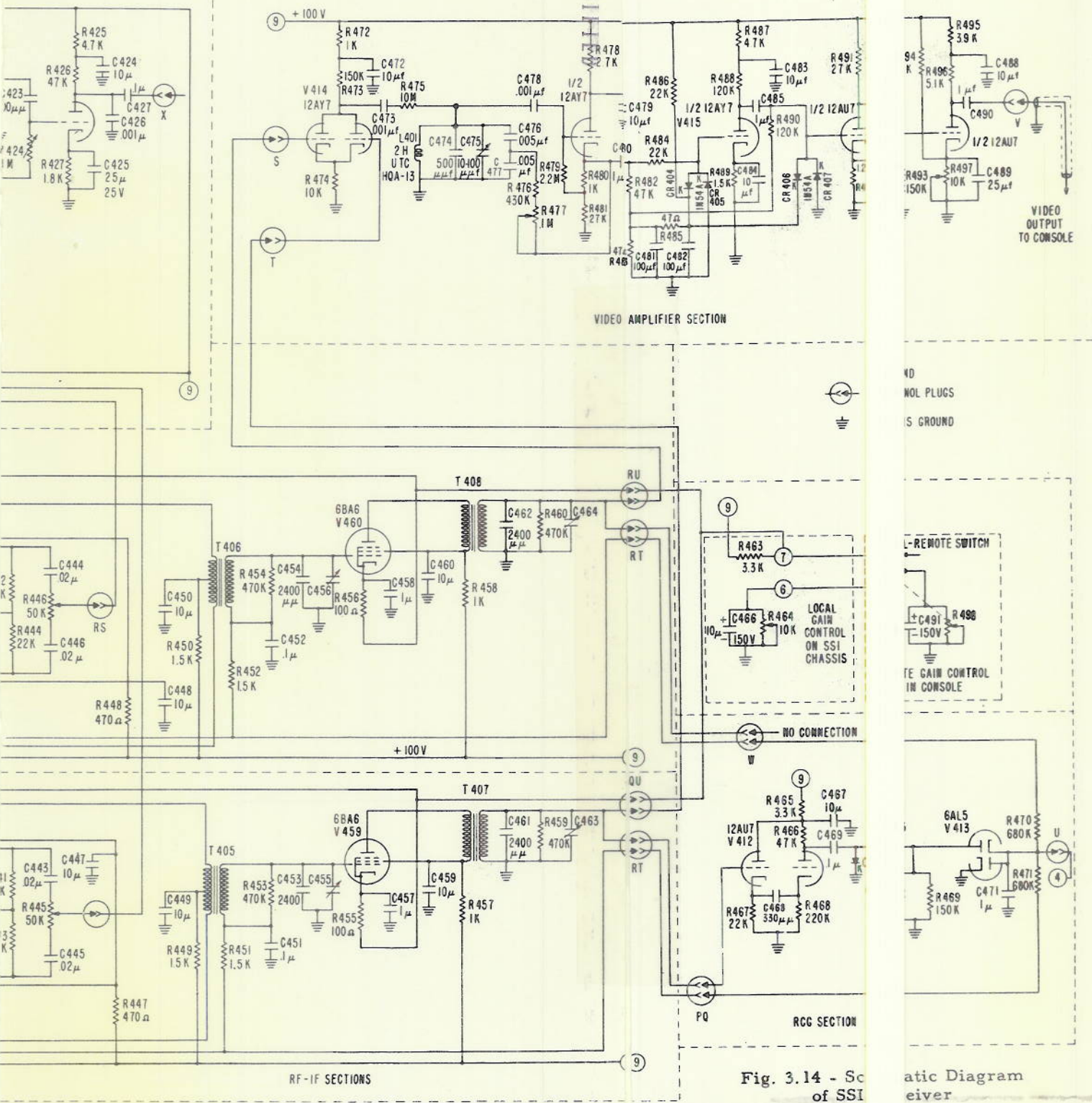
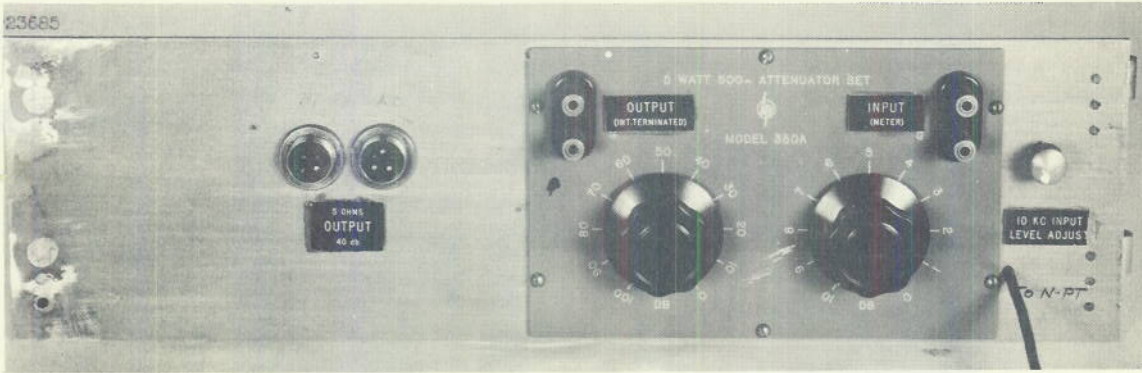
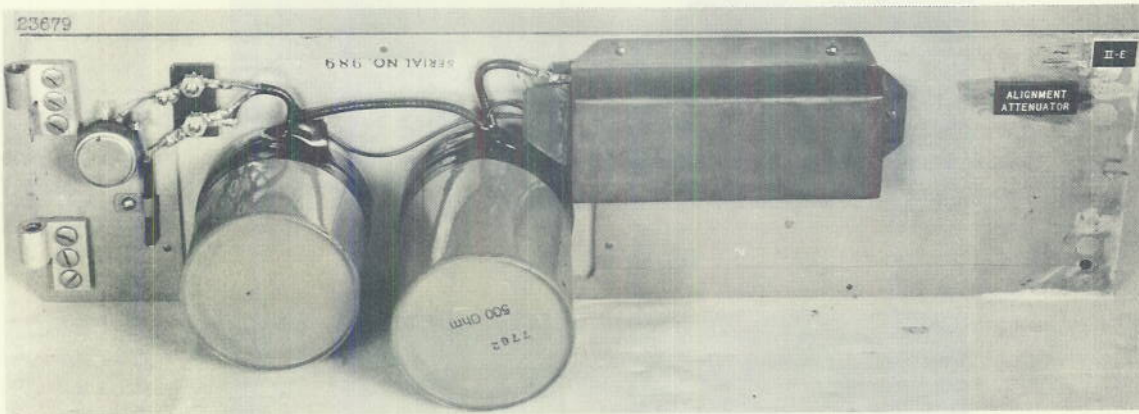


Fig. 3.14 - Schematic Diagram of SSI Receiver

Schematic Diagram of SSI Receiver



(a) Front view



(b) Rear view

Fig. 3.15 - Test-Signal Attenuator

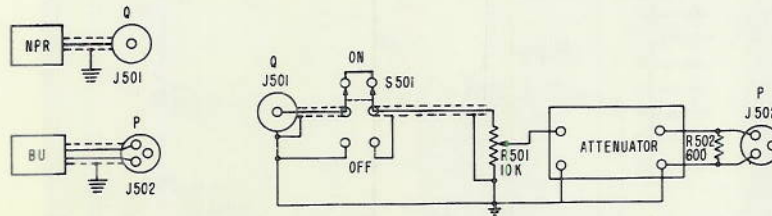
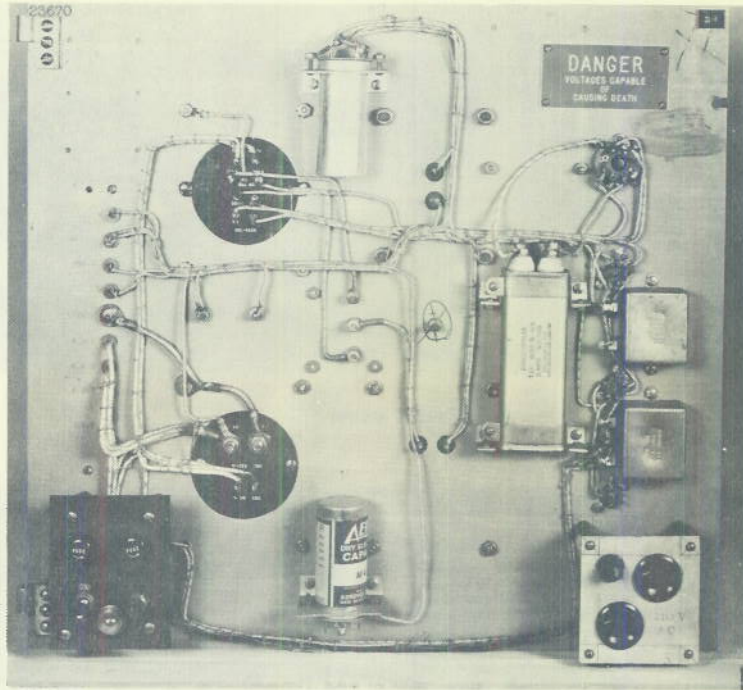
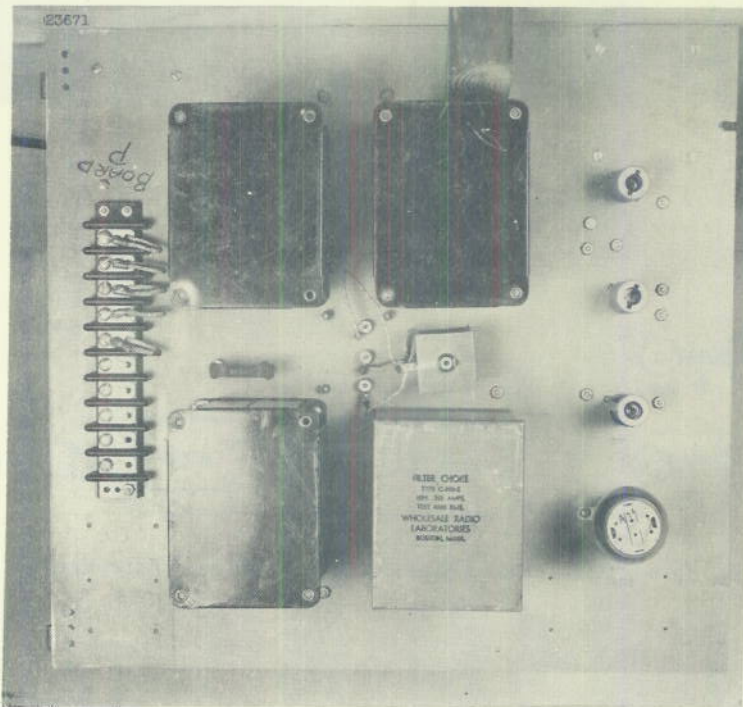


Fig. 3.16 - Schematic Diagram of Test-Signal Attenuator

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(a) Front view



(b) Rear view

Fig. 3.17 - Receiver Power Supply

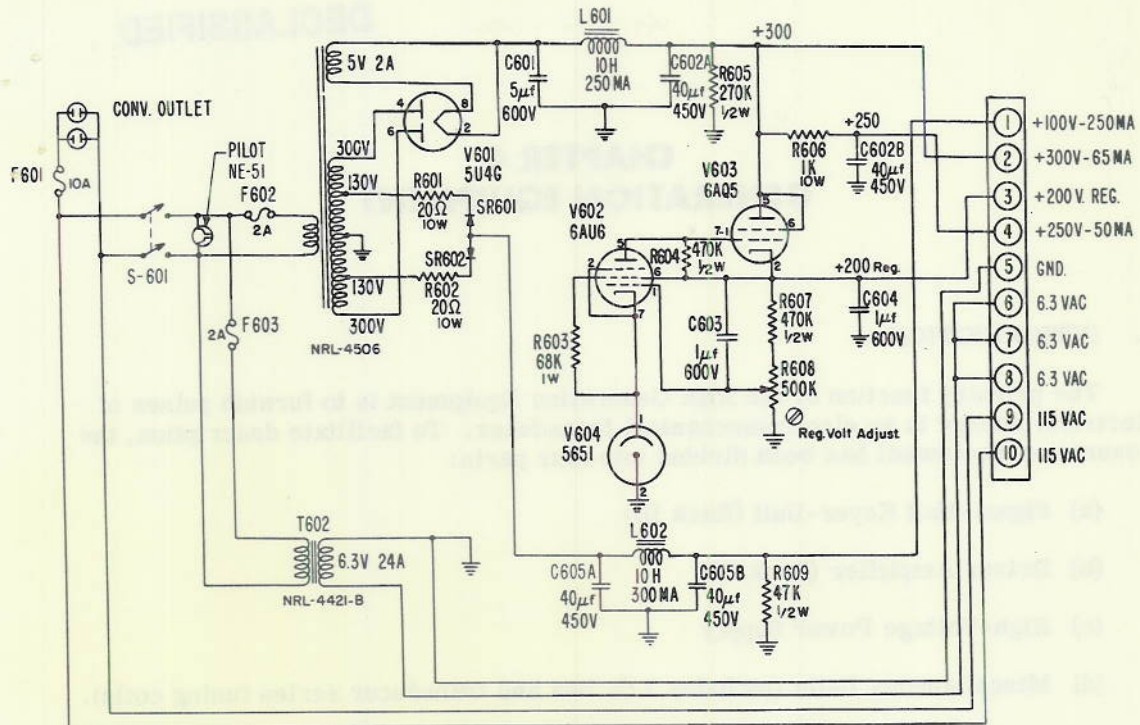


Fig. 3.18 - Schematic Diagram of Receiver Power Supply

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## CHAPTER 4 GENERATION EQUIPMENT

### 1. INTRODUCTION

The primary function of the XHA Generation Equipment is to furnish pulses of electrical energy to an electromechanical transducer. To facilitate description, the Generation Equipment has been divided into four parts:

- (a) Signal-Unit Keyer-Unit (Rack III)
- (b) Driver Amplifier (Rack IV)
- (c) High-Voltage Power Supply
- (d) Miscellaneous Units (includes T/R Box and transducer series tuning coils).

The Driver signal source of the XHA system is a 10-kc crystal-controlled oscillator located in the Signal Unit (Panel III-B). The output of the Signal Unit is gated by the Keyer Unit (Panel III-C), which also controls the application of receiver TVG voltage, governs the operation of the transducer transfer relay, and performs other internal functions. Provisions have been made in this unit for hand keying (i.e., code keying) of the Driver. The operation cycle of the Keyer Unit for automatic and single-ping operation is initiated by the Program Control Unit (Panel I-A).

The pulse output from Rack III is supplied by means of a shielded cable connected to the input stage of the Driver Amplifier. After amplification, this signal is applied to the XHA transducer via the Transfer Relay (T/R) Box. Two series tuning coils (one for each half-section of the transducer) are interposed between the T/R Box and the transducer proper. These tuning coils are located in the towed body.

The Driver Amplifier, including all power supplies except the High-Voltage Power Supply which furnishes 5000 volts of dc plate voltage to the amplifier, is mounted on Rack IV. Unlike the Signal-Unit Keyer-Unit and the Driver Amplifier, which are both mounted on standard racks with 19-inch panels, the High-Voltage Power Supply is mounted in a specially designed unit consisting of three separate sections bolted one on top of another. Rack III is located in the same compartment as the XHA display and receiver racks (Racks I and II, respectively). Other units of the system are remotely located with respect to these three.

The entire Signal-Unit Keyer-Unit Driver system is energized through the Keyer Unit ON-OFF switch, and 115-volt ac power is supplied via this switch to the units mounted on Rack III proper. The switch also controls a system of relays and timing motors incorporated in Rack IV for governing the application of power to the Driver Amplifier and the High-Voltage Power Supply. This same 115-volt ac source provides all input power to the Driver

Amplifier and its associated power supplies except a 440-volt 3-phase requirement by the plate transformers of the High-Voltage Power Supply. A pilot light mounted on the Keyer Unit serves to indicate the application of final amplifier plate power and the readiness of the system for pulsing.

## 2. SIGNAL-UNIT KEYER-UNIT

### Introduction

The 10-kc signal for the XHA Sonar System is generated by a crystal-controlled oscillator which is followed by a phase splitter, a balanced gated amplifier, and a cathode-follower output stage. The balanced amplifier is controlled by the XHA Keyer, which supplies pulse lengths of 10, 30, 100, 300, and 1,000 milliseconds.

Reference to the block diagram of the XHA Signal and Keyer Units (Figure 4.1) will facilitate the description of these units which are located in Rack III (Figure 4.2 and 4.3). A keying impulse, produced when a cam-controlled microswitch\* or a momentary-action toggle switch\* grounds terminal R-7 of the Keyer, triggers the first delay multivibrator and at the same time closes the keyer relay and readies the system for transmission. After a delay of approximately 100 milliseconds, the pulse-length multivibrator is triggered, the cutoff voltage is removed from the balanced gated amplifier on Panel B, and the signal is transmitted to the Driver input (Rack IV) via the keyer relay contacts. At the end of the period of the pulse-length multivibrator, cutoff voltage is again applied to the gated amplifier and the second delay multivibrator is triggered. After a delay of approximately 100 milliseconds, the keyer relay is opened and the system is ready for reception. The initial 100-millisecond delay is necessary to allow sufficient time for the keyer relay and the T/R relay to close before the pulse envelope is formed. The final 100-millisecond delay is provided so that the T/R relay will not interrupt the transmitted pulse.

The foregoing discussion applied when the KEYING SELECTOR switch of the Keyer is in the AUTOMATIC-SINGLE PING position. In the HAND KEY position, signal characters may be transmitted (at reduced power) for communication purposes. In addition to being satisfactory for direct transmission, reduced power is necessary to keep the average heat dissipation of the transducer tuning coils within allowable limits.

### Signal Unit

**Function**—The Signal Unit (Panel III-B) provides a pulse of 10-kc energy to the Driver. The length of this pulse is determined by the Keyer and is adjustable for 10, 30, 100, 300, or 1,000 milliseconds in either the automatic or single-ping position. For hand-key operation (at reduced power) the pulse length is determined solely by the "key-down" time.

**Description**—The Signal Unit is mounted on a 19 x 5-1/4 x 1/8-inch dural panel. Filament and plate power are furnished by the Oscillator-Keyer Power Supply (Panel III-D). The Signal Unit, Keyer Unit, and Power Supply are interconnected as shown in Figure 4.4.

Functionally, the Signal Unit consists of four parts: (a) a 10-kc crystal-controlled oscillator, (b) a phase splitter to provide the required phase relationship for push-pull

\*Both switches are located in the Program Control Unit

operation, (c) a balanced gated push-pull amplifier (controlled by the Keyer Unit), and (d) a cathode-follower output stage.

As shown in the circuit diagram (Figure 4.5), the 10-kc signal, generated by a crystal-controlled oscillator using a Western Electric low-frequency crystal (type 20JB), is applied to a phase splitter, V202. The outputs of V202 are applied to a pair of 6AH6's (V203 and V204), connected in push-pull. The 6AH6's are gated by a voltage developed in the gating circuit of the Keyer Unit and their outputs are transformer-coupled to a cathode-follower (V205). The output pulse from V205 is then transmitted via the Keyer Unit to the Driver.

**Circuit Operation**—The crystal is used in a standard low-frequency oscillator circuit with an amplitude limiter (308A varistor) and frequency adjustment (C204). Since this oscillator is sensitive to loading, the oscillator load (i.e., the resistive combination of R205, R206, R207, R208, and R209) should remain constant.

The oscillator signal is fed to V202 where two equal voltages separated 180 degrees in phase are developed. These voltages are coupled to the grids of a balanced push-pull gating circuit. A 10-kc tank circuit is connected between the grids to insure a sinusoidal input wave. The push-pull stage employs two 6AH6's, sharp cutoff pentodes, and is gated by a negative cathode pulse. For normal operation, i.e., using automatic or single-ping keying, the 750-ohm cathode resistance of V308 of the Keyer is also connected as a cathode return for the 6AH6 push-pull stage. As this resistor normally has 10 volts across it, the push-pull stage is normally cut off. However, when the cutoff voltage is removed during the Keyer pulse time, the 750-ohm resistor acts as a conventional cathode-biasing resistor and the 6AH6's amplify the input signal. When the KEYING SELECTOR switch is in the HAND KEY position, the hand key grounds pin 5 of V306A on the Keyer and allows V307 to conduct, thus removing cutoff voltage from the 6AH6's. This condition permits manually controlled pulse lengths to be formed (at reduced power) for communication purposes.

The output of the 6AH6 pentodes, V203 and V204, is balanced by adjusting the relative screen voltages of these tubes. Actually, V203 has a fixed screen potential of approximately 135 volts, and the screen voltage of V204 is adjusted by means of potentiometer R220.

The keyed signal from V203 and V204 is transformer-coupled to cathode follower V205, a 6C4 triode. The output of this latter stage is adjustable from 0 to approximately 2.7 volts by means of a potentiometer GAIN control, R223. The signal output of V205 is applied to the input stage of the Driver (Panel IV-B) via the contacts of the Keyer relay on Panel III-C. Since these relay contacts complete the signal path during normal keying procedure, no signal energy can be applied to the Driver while the transducer is in the receive position.

A 10-kc continuous receiver test signal supplied by the Signal Unit is obtained from the grid of V203 and transmitted to the receiver via connectors BR-1 and NPR.

**Frequency Adjustment**—The frequency of the 10-kc oscillator is adjusted by means of a ceramic trimmer capacitor, C204, located on Panel III-B. Since the amplitude of the oscillator output varies with the setting of C204, the voltage across R209 is proportional to the frequency of the oscillator. To adjust the oscillator frequency, turn the unit on by throwing the power switch\* on Panel III-C to the ON position. Allow the oscillator to

\*This switch also energizes the Driver, which in turn energizes the High-Voltage Rectifier. If the Driver is not to be used, the safety switch located on Panel IV-B should be turned off.

warm up for approximately 15 minutes. Attach a high-impedance r-f voltmeter across R209 and rotate C204 until the voltage reads 0.58 volt rms. The oscillator frequency should now be 10 kilocycles.

Balance Adjustment—The outputs of the two 6AH6 push-pull-connected pentodes are balanced by adjusting the screen voltage on one of these tubes, i.e., adjusting the screen voltage of V204 while the voltage of V203 remains fixed. This adjustment is made by positioning the rotor of R220, which is a 50K potentiometer forming part of a balanced resistor network connected between 270 volts (regulated) and ground. Adjustment of R220 should be made in accordance with the following procedure:

- (a) Make sure the XHA Driver is not energized by turning off the safety switch on Panel IV-B.
- (b) Connect an oscilloscope between terminal Q-1 (Panel III-B) and ground. Now set the Signal Unit GAIN control to approximately one-half gain.
- (c) Set the KEYING SELECTOR switch to the AUTOMATIC-SINGLE PING position and set the PULSE LENGTH selector to the 10-millisecond position.
- (d) Initiate the Keyer sequence by depressing the keying switch of the Program Control Unit to the SINGLE PING (momentary) position. Examine the Signal Unit's output waveform on the oscilloscope screen. The presence of a nonlinear pulse envelope is indicative of unbalanced 6AH6's. Positive or negative spikes (transients) near the leading and trailing edges of the pulse envelope are characteristic of this condition. If adjustment seems advisable, loosen the lock nut on the balancing potentiometer R220 and position the potentiometer rotor so a linear pulse envelope will be produced.
- (e) After adjustment of R220, tighten the lock nut on the rotor shaft and re-examine the output waveform at Q-1 on the oscilloscope. If the waveform is satisfactory, the balancing procedure has been completed; if not, repeat the instructions given in steps (d) and (e).

#### Keyer Unit

Function—The Keyer Unit (Panel III-C) furnishes the gating pulse for the XHA Signal Unit, which in turn supplies the Driver input signal. The length of this pulse is adjustable for either 10, 30, 100, 300, or 1000 milliseconds.

The gating pulse is preceded and followed by fixed protective delay intervals, and the Keyer's relay remains closed for the sum of the delay and gating intervals. The delay intervals are necessary to insure that the receiver circuits are effectively blanked while the Driver is being keyed. The entire delay-pulse-delay sequence is normally initiated by the closing of a set of cam-controlled microswitch contacts in the XHA Program Control Unit. Provision has been made to perform this same initiating action by depressing the keying switch of the Program Control Unit to the SINGLE PING (momentary) position. Closing of the Keyer relay contacts (a) energizes the transfer relay, which switches the transducer between the transmit and receive positions, (b) furnishes a relay energizing pulse to the receiver TVG circuit, and (c) completes the signal path to the Driver input

circuit (i.e., the 829-B). It can be seen from (c) that de-energizing the keyer relay breaks the signal input circuit to the Driver and thus insures that signal energy is not being coupled to this stage during the receive time.

Provision has been made for hand keying at reduced power for communication purposes.

Description—The Keyer is mounted on a 19 x 8-3/4 x 1/8-inch dural panel and the unit's operating controls are placed on a small subpanel. Filament and plate power for the unit are furnished by a regulated power supply mounted on the panel, and bias voltage is supplied by the 115-volt unregulated negative power supply located on Panel III-D.

Functionally, the Keyer is composed of three parts: (a) a group of three cascaded one-shot multivibrator circuits, (b) a relay control circuit, and (c) a gating circuit. These are interconnected as shown in the block diagram (Figure 4.1). A circuit schematic appears in Figure 4.6.

When keying automatically, a complete sequence of operation is initiated by closing a set of cam-controlled microswitch contacts on the Program Control Unit. If single-ping operation is desired, a complete sequence of operation is begun by depressing the keying switch on the Program Control Unit to its momentary position. Either action serves to ground terminal R-7 of the Keyer, thereby triggering the first one-shot multivibrator (MV-1) and also energizing the keyer relay. The trailing edge of the negative pulse from MV-1 triggers MV-2, and the trailing edge of this second multivibrator pulse triggers MV-3. To complete the cycle, the trailing edge of the pulse from MV-3 de-energizes the keying relay. The gating circuit operates during the MV-2 pulse time. Thus the gating time is preceded and followed by fixed protective delay intervals, and the Keyer Unit relay remains closed for the sum of the delay and gating intervals.

For hand-key operation, the keying switch on the Program Control Unit is turned to the OFF position and the KEYING SELECTOR switch of the Keyer is turned to the HAND KEY position. The latter switch holds the keyer relay in the energized position and inserts an attenuator in the signal lead to limit the power level. The oscillator is then gated by depressing a hand key. (The HAND KEY jack is located on the Keyer subpanel.)

Multivibrator Circuits—Except for time-constant considerations, MV-1, MV-2, and MV-3, the three cathode-coupled one-shot multivibrators, are identical; each is a 12AU7 dual triode and the individual tubes are identified in the schematic diagram as V302, V303, and V305, respectively. To insure stable operation, each has a decoupling filter connected in the plate circuit of its normally nonconducting half-section. In addition, each multivibrator receives its triggering impulse via separate 1/2-12AU7 triode sections which are connected as cathode followers. These isolating triodes are normally nonconducting since they are biased considerably beyond cutoff and conduct only when a high positive input voltage is applied to them. This latter event occurs in the initial isolating triode (V301A) when terminal R-7 is grounded, and in the remaining triodes (V301B and V304A) when the negative pulse from the preceding multivibrator stage is differentiated. A fourth isolating triode (V304B) amplifies and inverts the differentiated positive pulse from the final multivibrator. In turn, the positive pip from V304B is coupled into the relay control circuit where it serves as the triggering pulse which de-energizes the keyer relay.

Relay Control Circuit—The relay control circuit employs two 2D21 thyratrons, V309 and V310. Normally, both of these tubes are nonconducting, V309 because of the high

negative voltage (i.e., -58 volts) on its control grid, and V310 because of an open cathode circuit. In addition, the grid of V310 is held at approximately -28 volts - well within the nonconducting region. When the Program Control Unit's microswitch contacts are closed or when its keying switch is depressed to the SINGLE PING position, C316 is grounded, and a positive potential of 58 volts is instantaneously placed on the control grid of V309. Therefore V309 now conducts and energizes K301, a 10,000-ohms dc relay in its cathode circuit. Although the cathode-to-ground return of V310 is now complete, this tube remains deionized owing to the -28 volt potential on its grid.

When this set of events was initiated, the first of the three cascaded multivibrators was also triggered. At the conclusion of the multivibrator timing sequence, a positive pip is applied to the control grid of thyatron V310, which now ionizes and effectively "shorts out" thyatron V309. The cathode voltage\* of V309 cannot change instantaneously because C317, a 1.5-microfarad capacitor, shunts the cathode relay. As a result, the plate of V309 becomes negative with respect to its cathode; this causes deionization of V309 and restoration of grid control to the tube. Under these conditions, K301 is de-energized and consequently the cathode circuit of V310 is opened and the deionization of this tube occurs.

When hand-key operation is used, one section of the KEYING SELECTOR switch disconnects the plate of V310 from B+ and shorts the plate of V309 to its cathode. The Keyer relay remains energized in this position. When the KEYING SELECTOR switch is turned to the AUTOMATIC-SINGLE PING position, the 2D21's regain control of the relay circuit.

Gating Circuit—The gating circuit consists of a diode, V306A, and two triode-connected pentodes, V307 and V308. The diode is directly coupled by means of a resistance network to MV-2, the pulse-time multivibrator. Normally, the diode transmits a negative potential of approximately 20 volts to the control grid of V307, the pulse-inverter pentode, thereby cutting off this tube. When MV-2 is triggered, the cathode of the diode rises to a positive potential; as a result, its plate-to-ground potential is reduced and V307 is permitted to conduct. Normally conducting V308 is now cut off, and its cathode is reduced from approximately 10 volts to ground potential. The negative cathode pulse gates the push-pull 6AH6's in the XHA signal circuit (Panel III-B) since the 750-ohm cathode resistance of V308 is also connected as a cathode return in this stage.

Power Circuits—The ac power for Rack III (Keyer, Oscillator, and Power Supply) and the control relays K301 and K302 which are located in the Sequence Timing Unit on Panel IV-C, is supplied via the power ON-OFF switch mounted on the Keyer control panel. Bias voltage for the Keyer is provided by the negative supply on Panel III-D. Filament and plate voltages are furnished by a separate power supply on the Keyer panel. The plate potential of 300 volts is regulated by means of two series-connected 0A2 voltage-regulator tubes.

#### Power Supply

The Keyer-Oscillator Power Supply (Panel III-D) provides a regulated output of +270 volts to the Signal Unit, an unregulated output of -115 volts to the Keyer, and a filament voltage of 6.3 ac to the Signal Unit.

\*The voltage drop across cathode relay K301 is normally about 75 volts.

Functionally, the Power Supply consists of a positive electronically regulated source and a negative unregulated supply. A circuit schematic is shown in Figure 4.7. The electronically regulated supply employs a conventional circuit using V401 (a 5Y3) as the rectifier tube with V402 (a 6L6-G) as the series regulator tube controlled by the dc amplifiers V404 and V405 (both 6SF5's). Since the cathodes of V404 and V405 are held at a fixed potential with respect to the positive output terminal, any change in the output voltage will appear between ground and the cathodes of the dc amplifiers. However, a smaller portion of the change (as determined by voltage-divider action) appears as cathode-to-grid voltage of V405. For example, an increase in the voltage across the output terminals results in a smaller, though proportionate, decrease in the grid-to-cathode voltage of V405. This latter change is amplified by V405 and V404 and results in a more negative voltage being applied to the control grid of the 6L6-G regulator tube. As a result, the voltage drop across V402, the 6L6-G, is increased and the voltage across the output terminals is reduced.

The negative 115-volt unregulated supply contains a conventional half-wave rectifier circuit which uses V407, a 6X5 rectifier tube, and a resistance-capacitance filter. The ac input voltage for this supply is obtained from terminal No. 4 of T401.

### 3. DRIVER

#### Amplifier

Rack IV (Figures 4.8, 4.9, and 4.10) contains the entire Driver Amplifier including all power supplies except the High-Voltage Supply (4-1000 A plate supply), which is housed in a separate unit. A wiring diagram of Rack IV appears in Figure 4.11. The front panels of the rack are hinged to permit access to components mounted within the six-inch channel. This alleviates the necessity for hinging the rear panels. Whenever practical, tubes and other heat-producing elements are placed within the channel. A high-pressure blower mounted on the rear of Panel B exhausts directly into the air chamber located beneath the 4-1000A power output tubes and assures adequate air flow to the various seals of these tubes.

The normal input level required by the XHA Driver (Figure 4.12) is approximately 1.8 volts rms at 500 ohms. Two push-pull transformer-coupled stages are utilized in the Driver. The first, an 829-B, drives the pair of 4-1000A's employed in the final amplifier. The amplifier is designed to deliver a maximum output power of approximately 5 kilowatts at an impedance of 28 ohms. The load (transducer) is resonated at the signal frequency of 10 kilocycles by means of two series tuning coils (one for each half-section of the transducer) located in the fish. A T/R Box connects the Driver to the transducer.

Power for all Driver units is controlled from the Sequence Time Delay (Panel IV-C). This unit is made operative when 115-volt ac power is applied to the XHA system and the Keyer's ON-OFF switch is closed, provided the safety switch on the Driver meter panel is also closed. The three pilot lights on the meter panel indicate respectively the application of (a) RACK POWER, (b) FILAMENT POWER, and (c) plate power to the Driver (SEQUENCE COMPLETE). All Driver 115-volt ac power is applied directly through the Sequence Time Delay, and the 440-volt 3-phase power to the plate transformers of the High-Voltage Power Supply is applied via a relay controlled by the Sequence Time Delay.

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Typical meter panel readings are in Table 4.1.

TABLE 4.1

Meter	Zero Signal Reading	Reading at Rated Output (5 kw)
4-1000A grid current	0 ma	85 ma
4-1000A cathode current	0.2 amp	1.8 amp
4-1000A plate voltage	5.5 kv	5.2 kv

For rated output (corresponding to an input voltage of 1.8 volts rms), grid-to-grid signal voltages of the Driver push-pull stages are found in Table 4.2.

TABLE 4.2

Stage	Class of Operation	Grid-to-Grid Voltage
829-B	AB <sub>1</sub>	33
4-1000A	B <sub>2</sub>	280

An output-current (i.e., transducer-current) meter is located in the T/R Box. Several readings\* of output power versus transducer current are given in Table 4.3.

TABLE 4.3

Power (kw)	Current (amp)
5.0	13.3
4.0	11.9
3.0	10.3
2.0	8.4
1.0	5.95
0.5	4.2
0.1	1.88

Sequence Time Delay

The function of the Sequence Time Delay (Panel IV-C) is to serve as a 115-volt 60-cycle power-distribution panel for all Driver stages. The sequence in which power is applied to the various Driver stages, as well as the time delays between them, is controlled by the group of timing motors and relays which comprise the unit. In addition,

\*The figures given are based on a tuned-transducer resistive load of 28.5 ohms. Cable losses have not been taken into consideration.

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Chapter 4

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GENERATION EQUIPMENT

the Rack IV blower motor, which cools the final amplifier tubes, is energized when filament power is applied to the driver racks and de-energized five minutes after filament power is removed. A schematic diagram of the Sequence Time Delay is shown in Figure 4.13.

Pilot light No. 201 (of the panel B meter subpanel) indicates when the XHA 115-volt ac main power switch is closed, i.e., when ac power is available at terminals P-1 and P-2 of Panel IV-C. If rack power is on, the operating sequence of Panel C can be initiated by closing the coil circuit of the relay K301. This is accomplished by closing the ON-OFF switch on the Keyer and the safety switch on the meter subpanel. This latter switch is normally left in the ON position. Initiating action is indicated by a second pilot light (P.L. No. 202) labeled "FILAMENT POWER" on the meter subpanel. Completion of the normal timing sequence is shown by a pilot light (P.L. No. 203) marked "SEQUENCE COMPLETE" on this same panel.

As shown on the circuit diagram of the Sequence Time Delay, closing the two fore-mentioned series switches energizes K301, which in turn closes K301A and energizes K302. Contact K302A now "seals" around K301A through  $S_m-301$ . Also, contact K302C closes, and as a result, K303 is energized and ac is applied to K304, K305, and the timing motor M302. After a 40-second delay, the contact  $S_m-302$  of the timing motor M302 closes and energizes the relay K306. The contacts of the relay K304 energize the Bias Supply, the 829-B Screen Supply, and the blower and filament circuits of Rack IV; those of K305 energize the High-Voltage Power Supply's blower motor and filament transformers; and those of K306 energize the plate transformer of the Plate-Screen Power Supply and the relay\* in the High-Voltage Power Supply.

After the timing sequence has been completed, all motors and relays of the unit are energized except the motor M301. When either one of the switches in series with K301 is opened, all these relays except K302 are de-energized. However, de-energizing K301 closes K301C and thereby shunts M301 across K302. Thus, both K302 and M301 remain energized until their ac circuit is broken by the opening of contact  $S_m-301$  at the end of the 5-minute timing interval set by M301. AC power to the Rack IV blower motor is available as long as K302 is energized.

#### Screen Supply

The 829-B regulated screen voltage (200 volts) is furnished by an electronically controlled power supply which is mounted on Panel IV-D, a 19 x 5-1/4 x 1/8 inch hinged, dural panel. Electrically, the regulator (Figure 4.14) is similar to the one employed in Panel III-D. The Screen Supply is energized by the closing of relay K304 which is located in the Sequence Time Delay panel.

#### Bias Supply

The Bias Supply (Panel IV-F) is mounted on a 19 x 8-3/4 x 1/8 inch dural panel which is located on the top rear portion of Rack IV and therefore adjacent to T101, the 4-1000A filament transformer. As a result, the placement of components on the panel has been dictated largely by restricted space limitations. The unit is energized when relay K304 of the Sequence Time Delay panel is closed.

\*Three-phase plate power is applied to the High-Voltage Power Supply via the contacts of this relay.

Output ratings of the Bias Supply are as follows:

Voltage Ranges	-80 to -115 volts regulated (normal setting is -90 volts)
	-18 to -30 volts regulated (normal setting is -23 volts)
Fixed Load Resistances	625 ohms (approximate)
Voltage Regulation	2 percent (between 0 and 135 ma at the -90 volt output point).

The bias supply is electronically regulated and its output is variable from -80 to -115 volts. Normally, the unit's voltage-adjustment potentiometer is set for a -90 volt output (4-1000A bias). Fixed output-current drain at this point is approximately 135 milliamperes. Voltage regulation between no load and full load (135 ma) is approximately 2 percent. An additional potentiometer sets the bias point of the 829-B (normally -23 volts) and adjusts the voltage from about -18 to -30 volts. It should be noted that this low-voltage circuit is shunted across the higher-voltage circuit and its output voltage is therefore partially dependent upon the setting of the previously mentioned potentiometer. The output voltage of the -23 volt circuit is regulated, provided the 829-B draws no grid current.

As shown in the schematic diagram (Figure 4.15), two rectifier circuits are connected across the high-voltage winding of transformer T401. The first, a full-wave rectifier using a 5U4G, supplies unregulated high voltage for the regulator-tube output load circuit; the second, a 5Y3-GT half-wave rectifier, supplies regulated reference voltages for the 6AC7 dc amplifier. These reference voltages are established by a group of three VR tubes. They are connected so as to place the cathode of the dc amplifier at -180 volts with respect to the C- output terminal, P-2, and the screen voltage of the 6AC7 is fixed at 75 volts with reference to its cathode. Therefore, the potential between the ground terminal P-3 and the cathode of V604 (the 6AC7) is equal to 180 volts plus the output voltage.

Any change in the output voltage produces a proportionate, though smaller, change in the control grid voltage of V604. An increase in the output voltage results in the application of a less negative voltage to the control grid of the dc amplifier. This voltage change is amplified, inverted, and then applied to the grids of the 6AS7 twin-triode regulator tube connected in series with the load. As the 6AS7 grids are driven more negative, the voltage drop across this tube increases and therefore compensates for the voltage change in the original load.

#### Plate-Screen Power Supply

The Plate-Screen Power Supply (Panel IV-H) is mounted on a 19 x 14 x 3/16 inch dural panel. The unit is designed to provide a regulated dc voltage for the screens of the 4-1000A final amplifier tubes and also for the plates of the 829-B power pentode. Rated output current of the supply is 500 milliamperes.

All filament transformers on the panel are energized through relay K304 (Panel IV-C), i.e., when Rack IV filament power is applied. Primary voltage to the plate transformer is applied through relay K306 of the Sequence Time Delay after the supply's mercury-vapor rectifier tubes have been heated to operating temperature.

As seen from the schematic drawing, (Figure 4.16) most of the larger components of the supply are mounted on the panel proper, and the electronic regulator circuit is located on a small subpanel. This arrangement facilitates servicing the unit because the entire regulator circuit can be replaced easily with a spare subpanel without detaching Panel H from its rack.

The regulator circuit uses three paralleled 6AS7 twin triodes in series with the output terminals. The grid voltage of these regulator tubes is controlled by a dc amplifier circuit which employs a single 12AX7 twin-triode in conjunction with two VR voltage-reference tubes.

Any change in the output voltage will appear between the cathodes of the dc amplifier V807 and ground. That portion of the change which appears between the rotor of the voltage-control potentiometer R818 and the high-voltage terminal is applied directly to the grid of V807B. Since the cathode of V807B is held at a fixed potential with reference to the positive output terminal, a positive change will result in a more negative grid-to-cathode voltage. After two stages of amplification, a positive change in the output voltage results in a more negative regulator-tube grid voltage; consequently, the voltage drop across the 6AS7 regulators is increased and compensation for the change in output voltage is attained.

#### 4. HIGH-VOLTAGE POWER SUPPLY

The High-Voltage Power Supply (Figures 4.17 and 4.18) furnishes final amplifier plate voltage to the XHA Driver. The rated output of the unit is 5000 volts at 2 amperes.

Single-phase power (115 volts, 60 cycles) for rectifier filaments and blower operation is obtained when relay K305 in the Sequence Time Delay (Panel IV-C) is closed. Fuses for the filament and blower circuits are located on Panel IV-J. After a preset delay, K306 of Panel IV-C closes and energizes a 3-pole relay in the High-Voltage Power Supply; this relay applies 440-volt 60-cycle three-phase power to the three plate transformers of the rectifier. Three-phase power is supplied to the unit via an external switch box. The application of plate power is indicated by a pilot light (mounted on the Keyer, Panel III-C) which is operated from T-6, a 440-volt to 110-volt isolation transformer located in the Power Supply (Figure 4.19).

The Power Supply itself consists of the three plate transformers connected "delta-wye," six 872-A mercury-vapor tubes connected as a three-phase full-wave rectifier, filament transformers for the 872-A's, a blower motor for cooling the unit, a filter, and a bleeder. The plate transformers step up the line-to-line voltage to approximately 3800 volts rms. Rectifier output of approximately 5000 volts is applied to an L-type filter consisting of two 5-henry series-connected input chokes, two 20-mfd 4000-volt series-connected filter capacitors, and a 35,000-ohm bleeder.

Physically, the unit is built in three sections, and one bolts on top of another to form a "stack." The lower section houses the filter capacitors and chokes, the middle section the plate transformers, and the top section the remaining components. Louvered covers enclose the stack, and the front covers are fabricated in a manner to afford easy accessibility to all components.

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## 5. MISCELLANEOUS UNITS

The XHA Transducer is tuned by two coils which have mutually perpendicular axes; they are electrically connected to the Driver through cables in the fish towing links, a Deck Junction Box, and the Transfer Relay (T/R) Box. These connections are illustrated in Figure 4.20.

## Transfer Relay Box

The T/R Box (Figure 4.21) contains four vacuum switches (type 1S21) which connect the transducer to the Driver during transmission and to the receivers during reception. As shown in the schematic (Figure 4.22), the vacuum switches are actuated simultaneously in order to give 4-pole double-throw action. Two 115-volt ac relay-type coils, which are energized by the Keyer (Panel III-C), are incorporated in the actuating mechanism.

All cables are brought into the T/R Box through terminal tubes. The transducer return lead is grounded at the T/R Box, and this is the sole ground point in the receiver-input Driver-output system. To protect the XHA receiver circuits, the receiver input leads are fused at the T/R Box. A lucite cover plate is placed over the T/R Box to facilitate inspection of the unit and permit reading of the Driver output current meter mounted in the unit.

## Tuning Coils

Since two separately tuned sections of the transducer are required for SSI operation (Chapter 3), two identical tuning coils are necessary. These coils use No. 60 x 38 Litz wire which is layer-wound in a recessed section of a cylindrical bakelite form. One end of the bakelite form is hollow and contains a copper slug used for tuning. The coil has an inductance of approximately 3.6 millihenrys and a maximum Q of 100. These figures were obtained at a signal frequency of 10 kilocycles with the slug at maximum spacing from the coil.

The coils, which are mounted with their axes mutually perpendicular, are attached to a bakelite bracket located within the lower watertight compartment of the towed body or fish (See Chapter 5, Figure 5.2). Restricted compartment size has necessitated the use of physically small tuning coils. They are suitable at rated power (5 kw) for echo-range operations but should be used at reduced power when a comparatively long duty cycle (such as in hand keying) is encountered.

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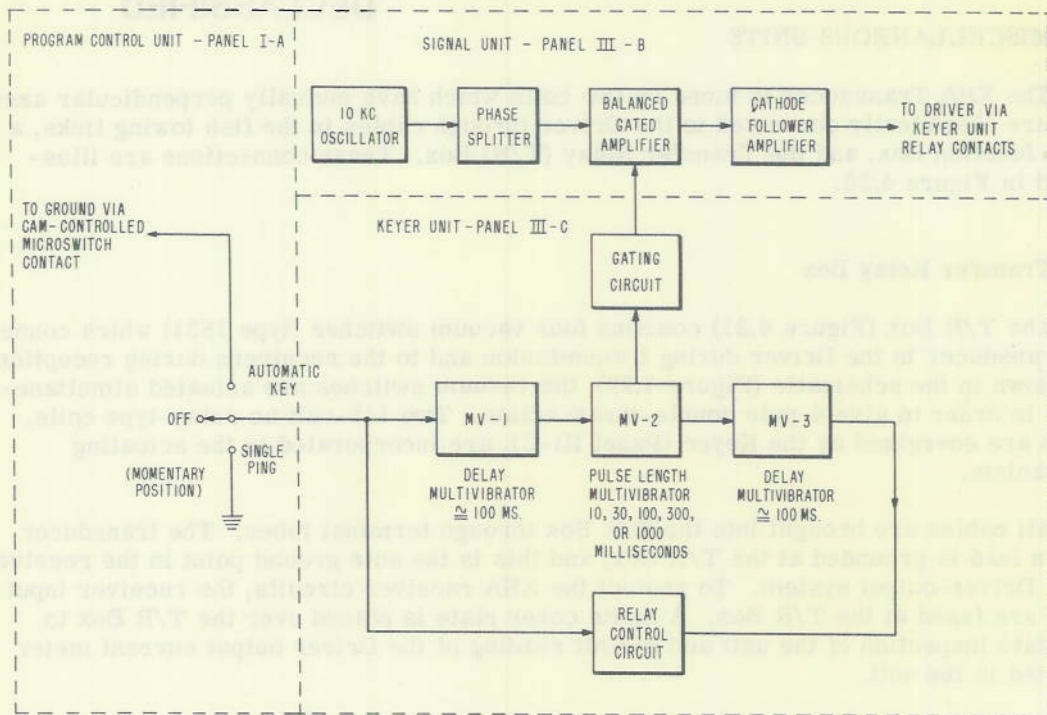


Fig. 4.1 - Block Diagram of Signal-Unit Keyer-Unit

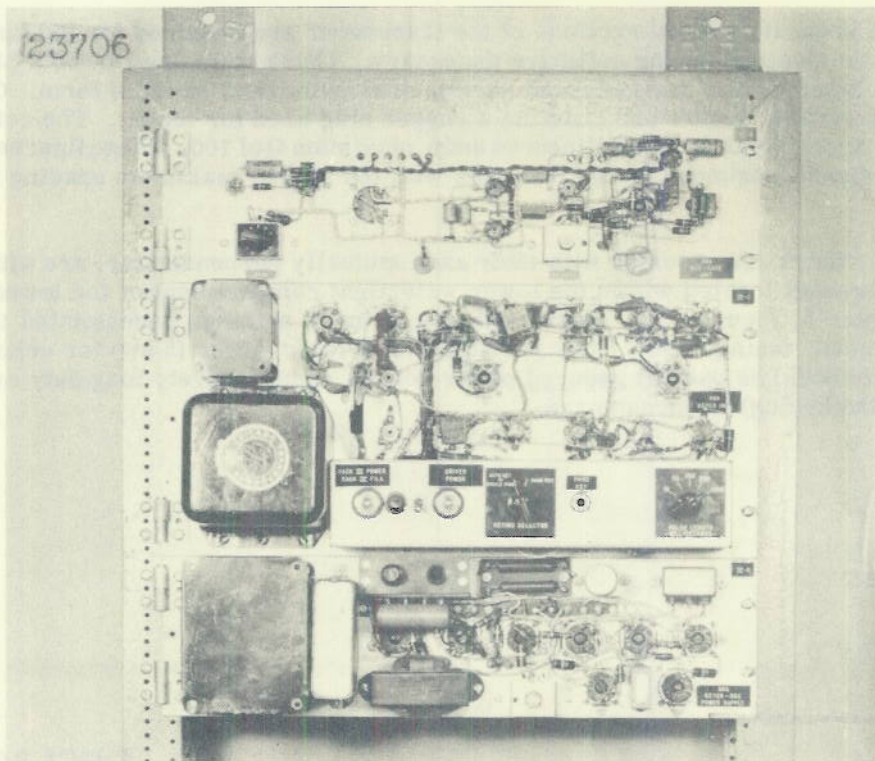


Fig. 4.2 - Front View of Signal-Unit Keyer-Unit

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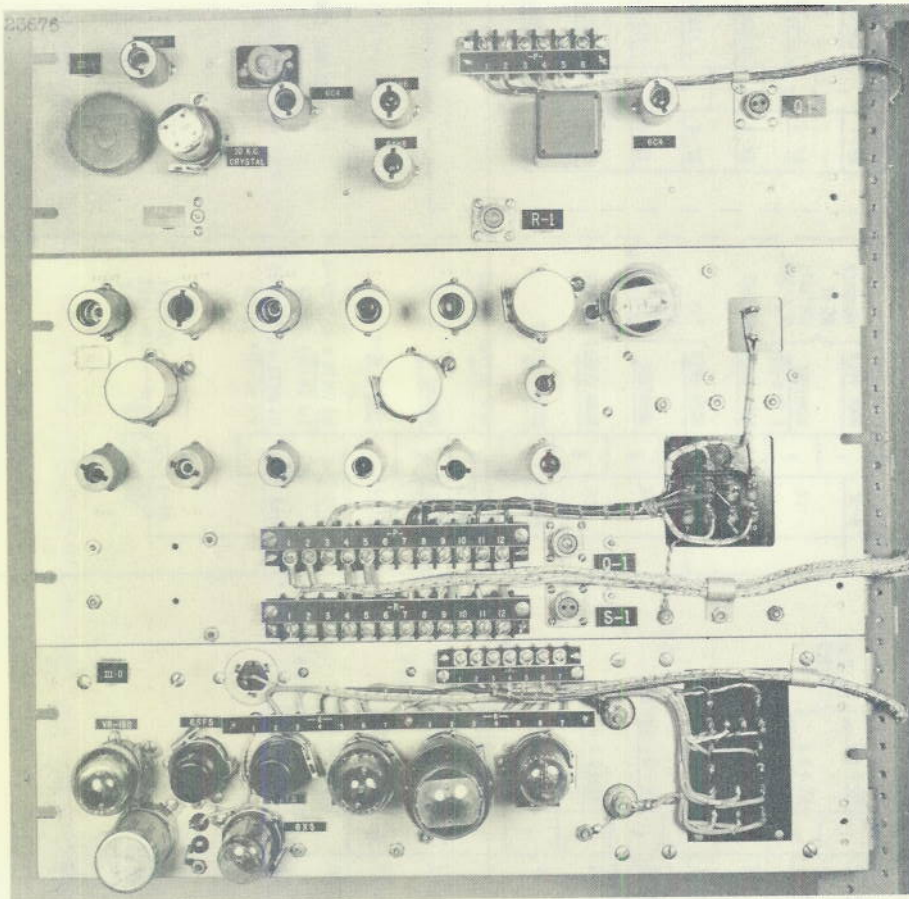
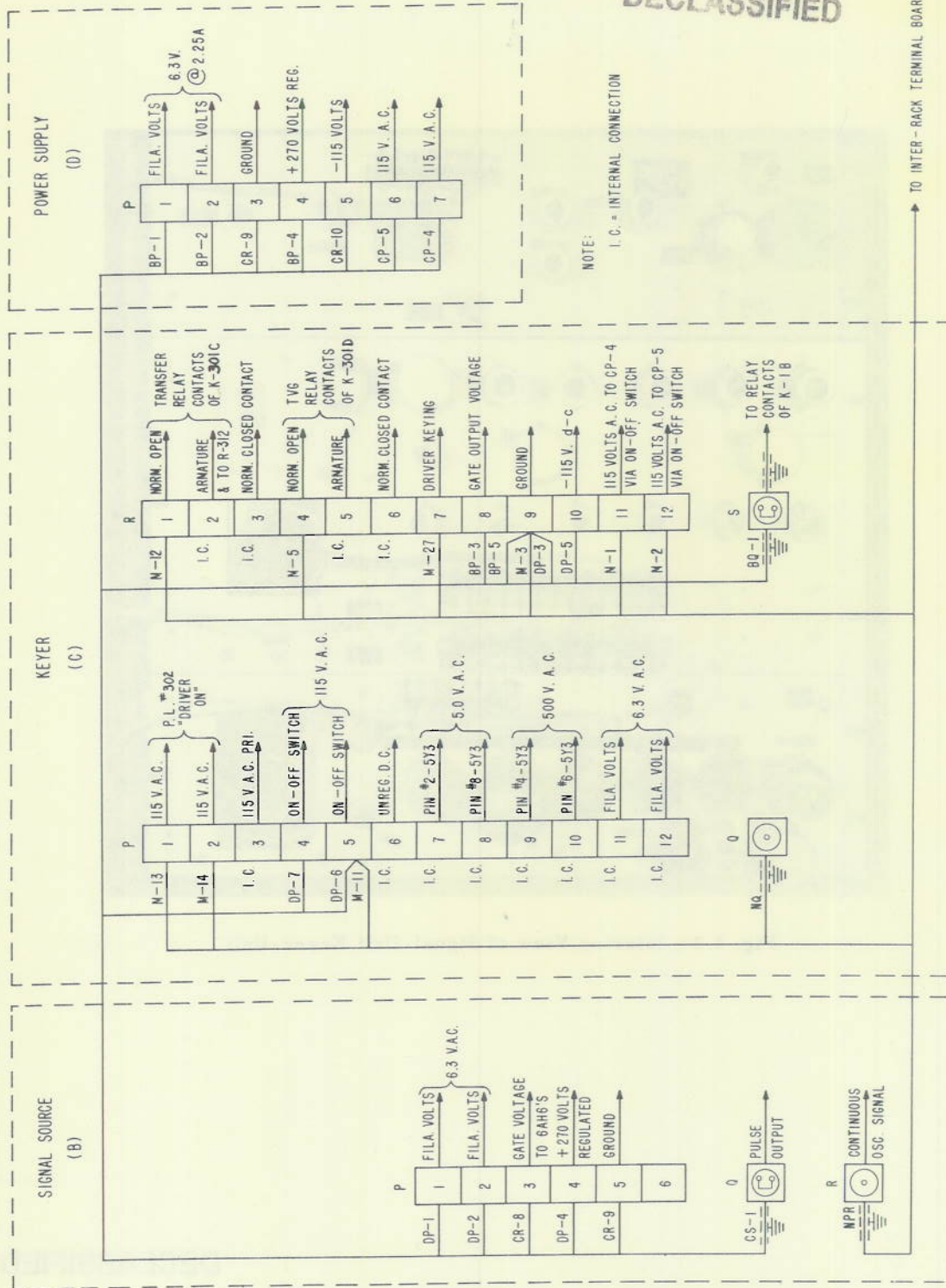


Fig. 4.3 - Interior View of Signal-Unit Keyer-Unit

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Fig. 4.4 - Wiring Diagram of Signal-Unit Keyer-Unit

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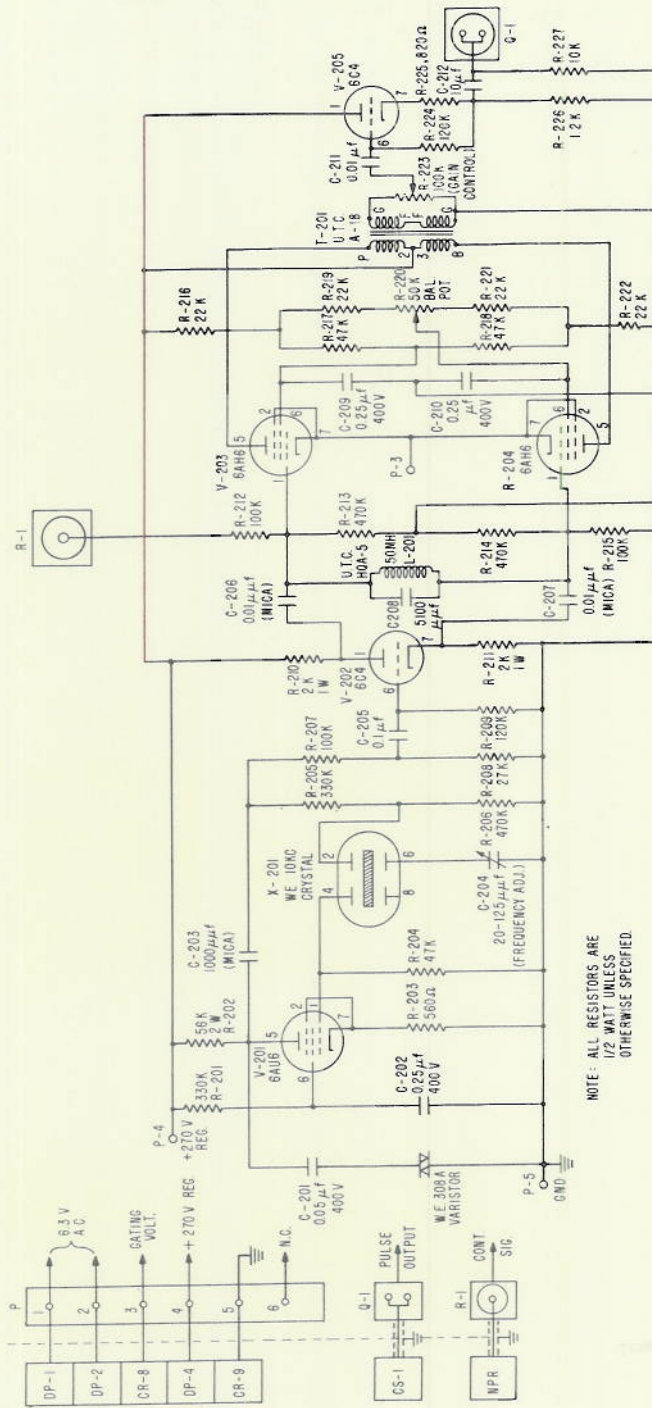


Fig. 4.5 - Schematic Diagram of Signal Unit

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and length to output standard 1.8 GHz



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GENERATION EQUIPMENT

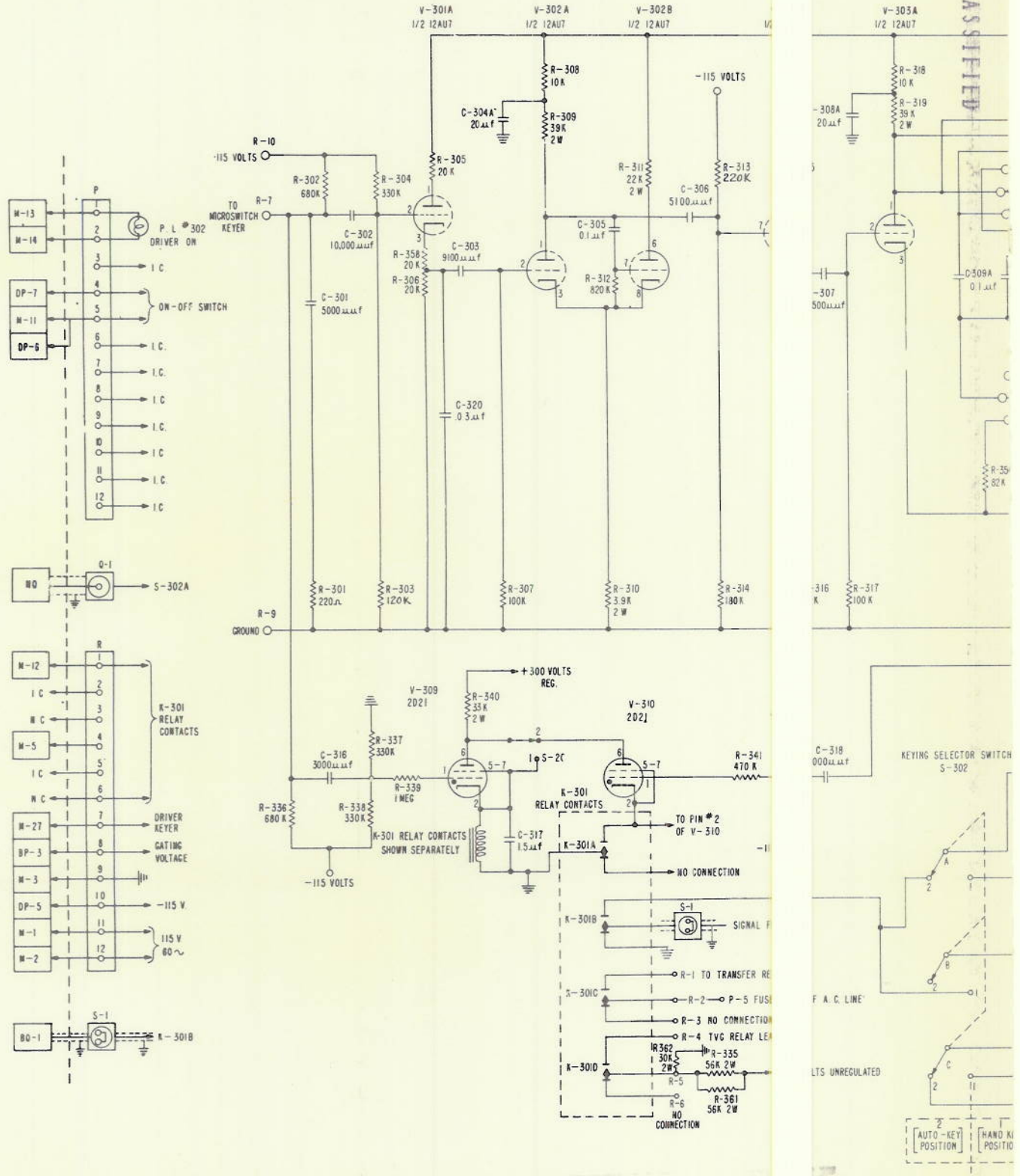
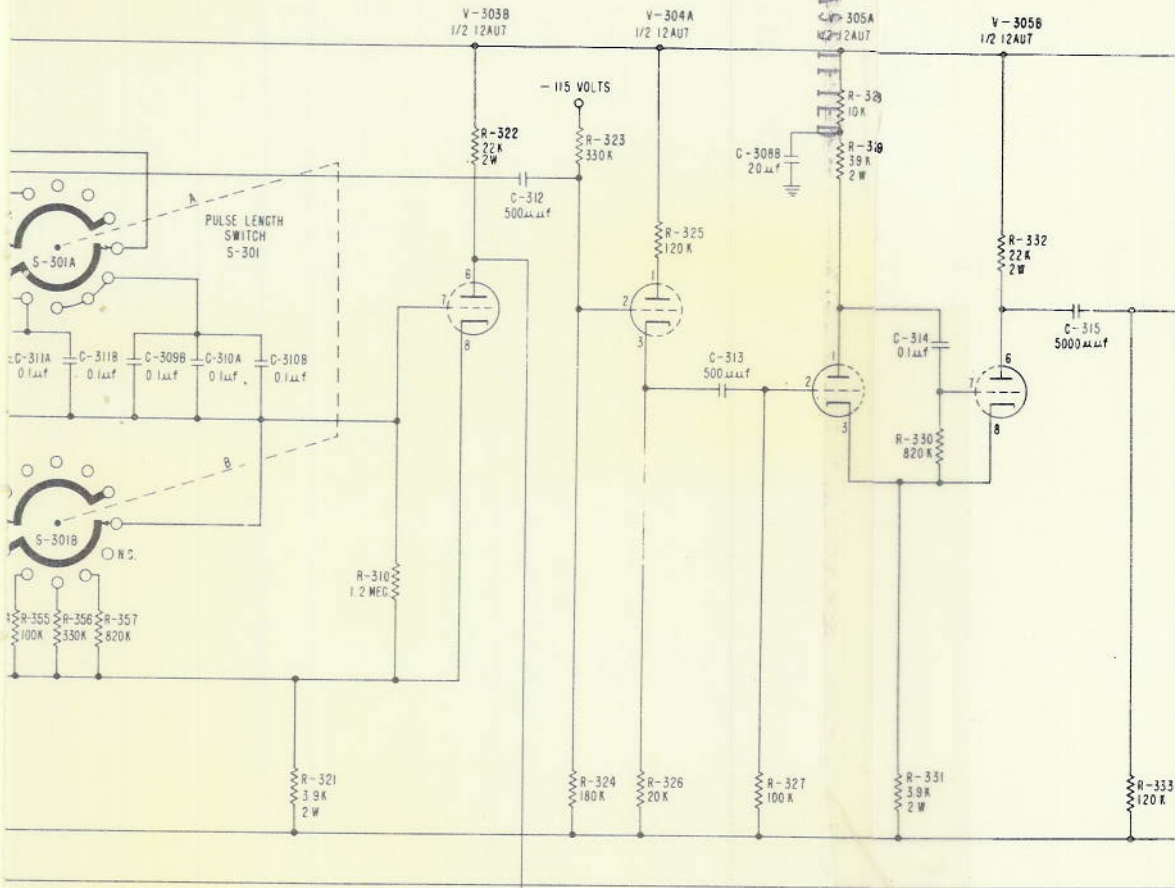


Fig. 4.6 - Scher

75

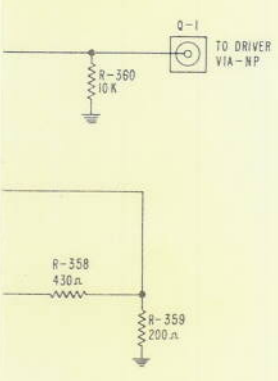
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104B  
AUT  
→ +300 VOLTS (REG)

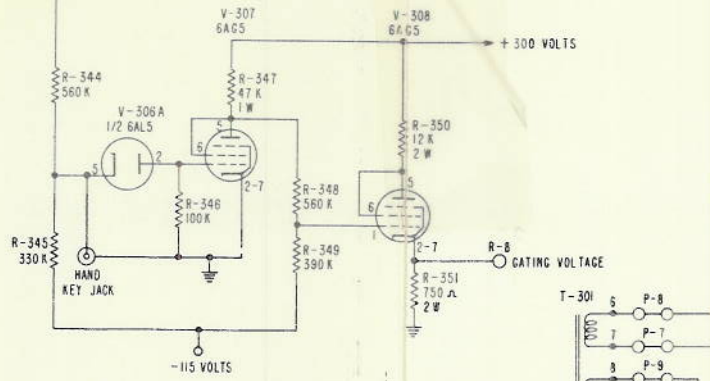
-334  
7K  
W



→ TO PIN #6 OF V-303

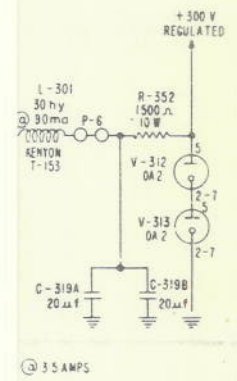
→ TO PIN #2 OF V-305

→ TO PIN #6 OF V-310



115 V 60~

NOTE  
TWIN CIRCLES ○○  
INDICATE TERMINALS  
EMPLOYED AS "FEED-THROUGHS"



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Schematic Diagram of Keyer Unit

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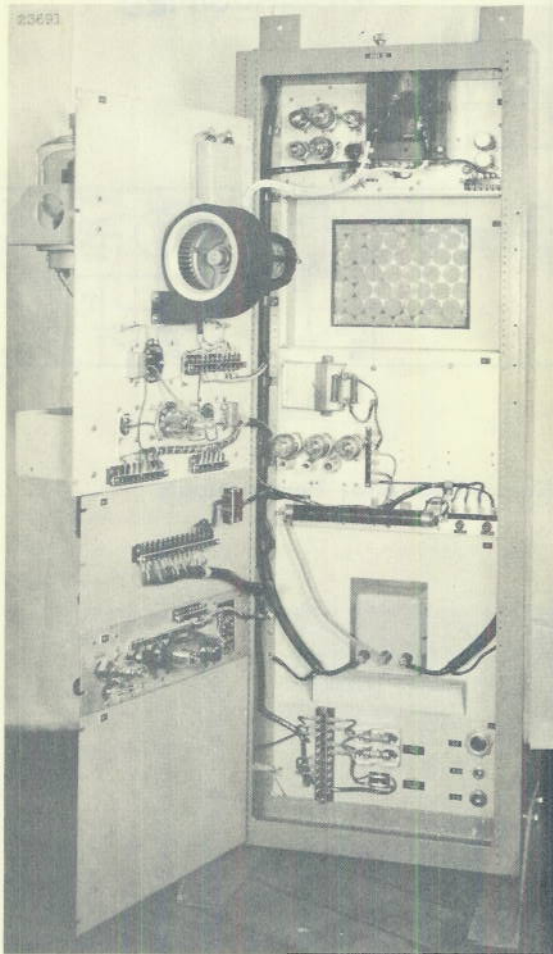
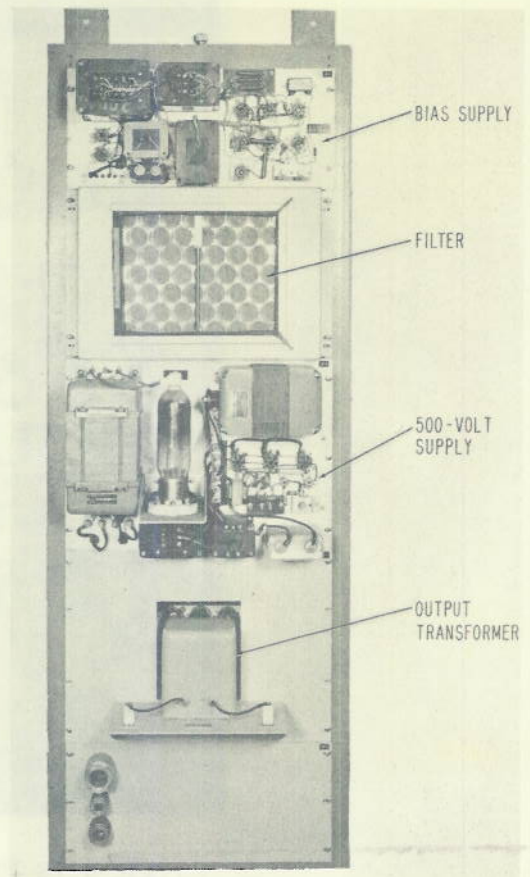


Fig. 4.9 - Interior View of Rack IV

Fig. 4.10 - Rear View of Rack IV



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SEQUENCE TIME DELAY UNIT

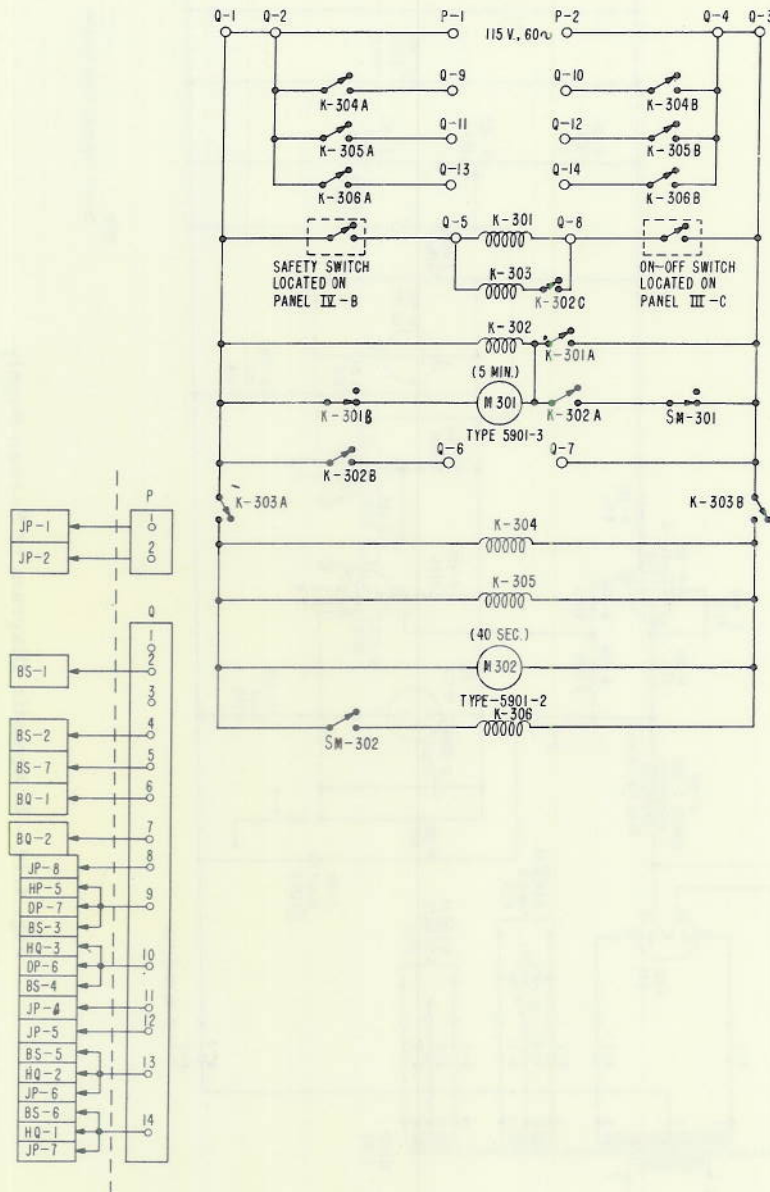
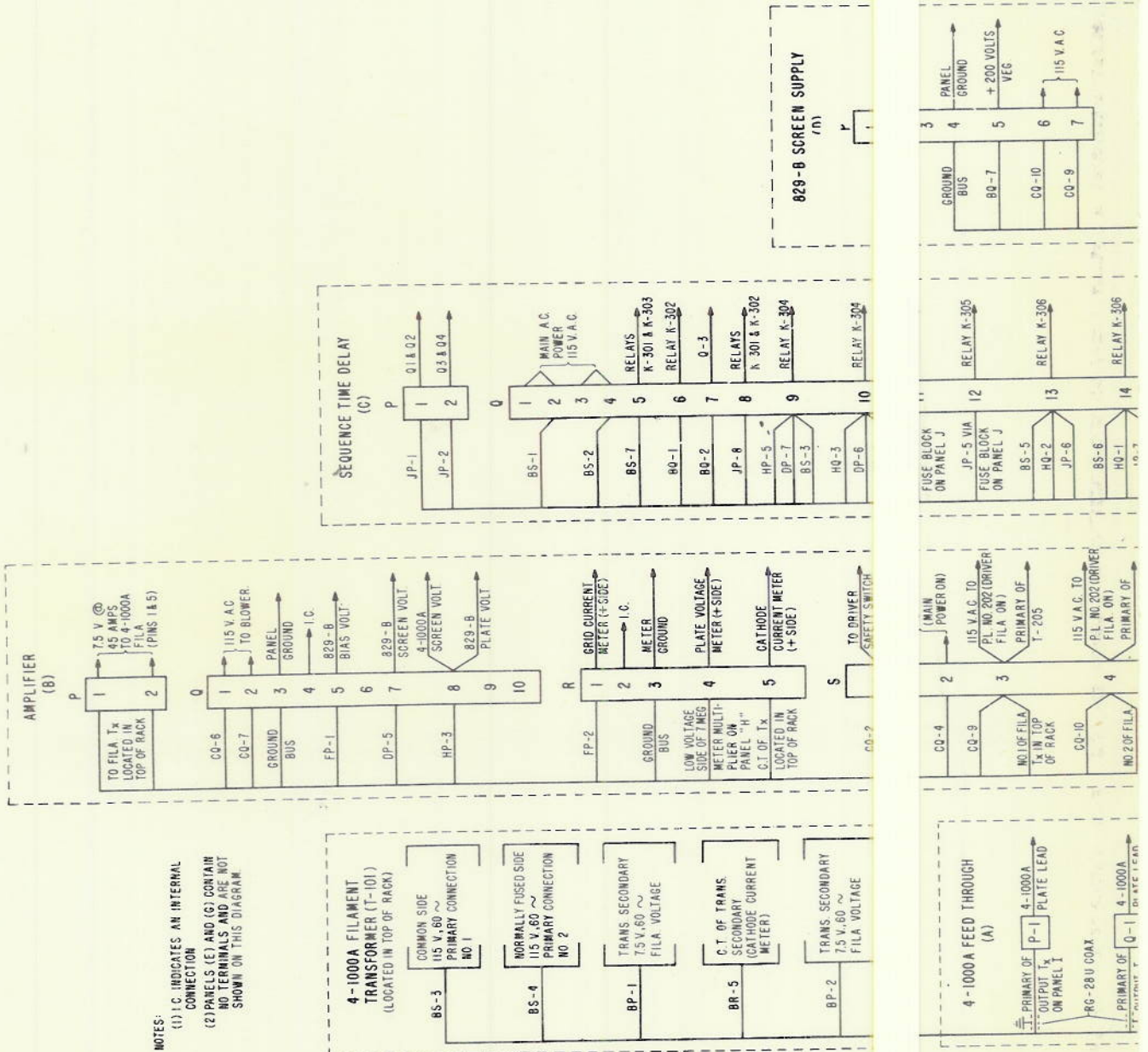


Fig. 4.13 - Schematic Diagram of Sequence Time Delay

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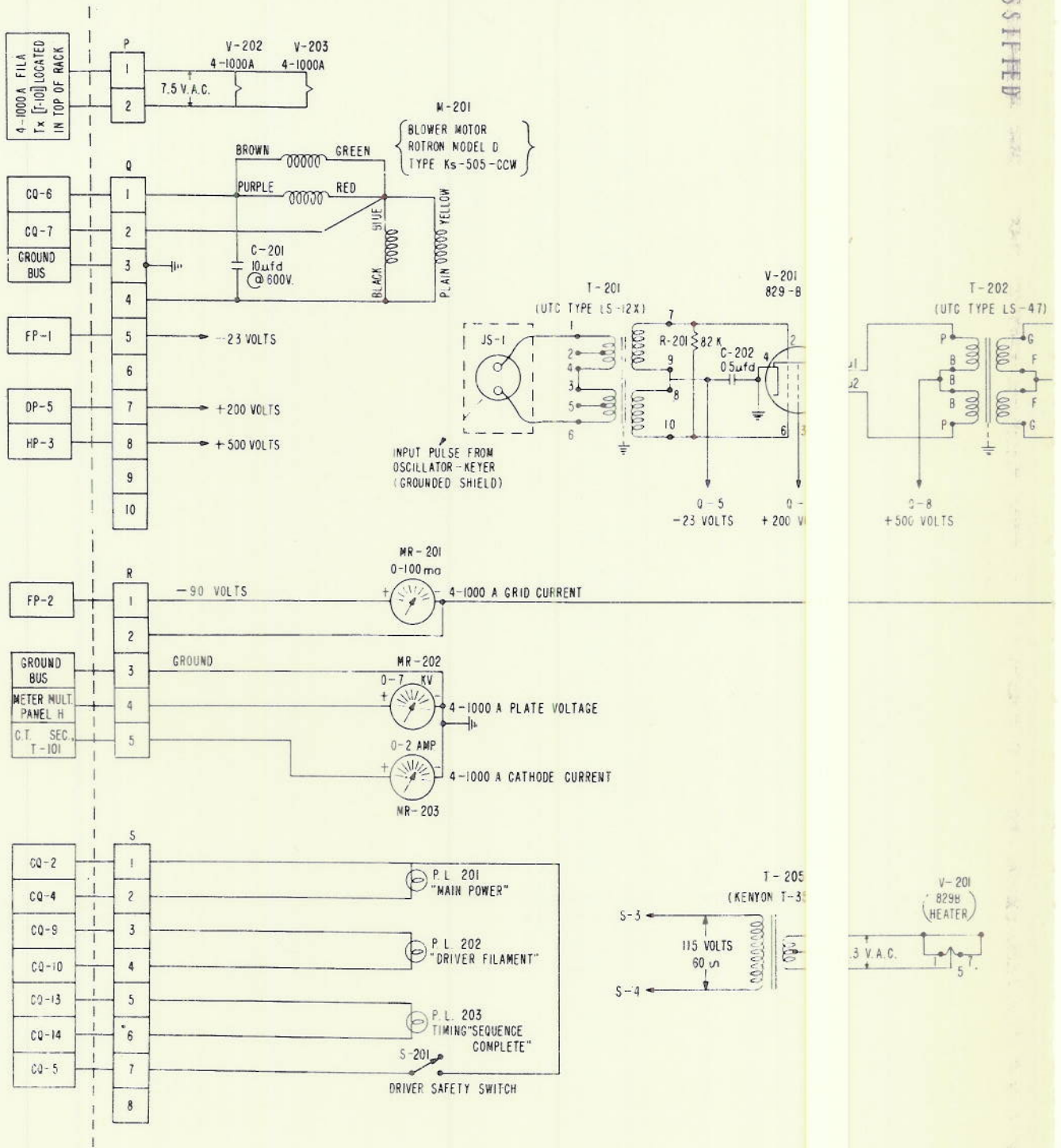
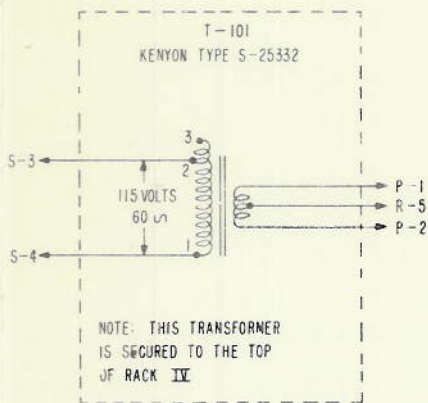
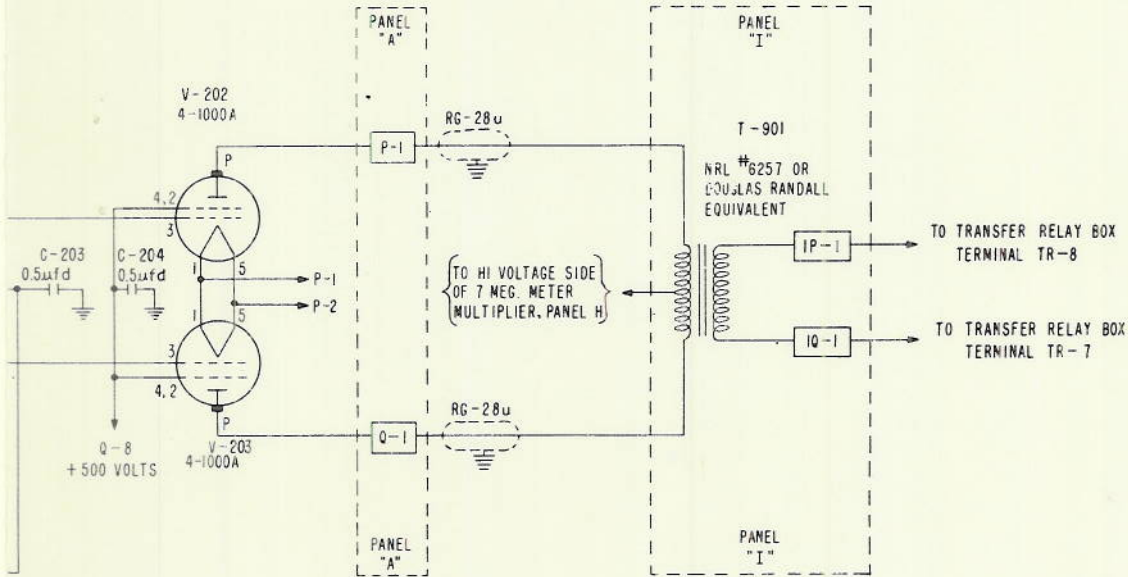


Fig. 4 - Schematic Diagram

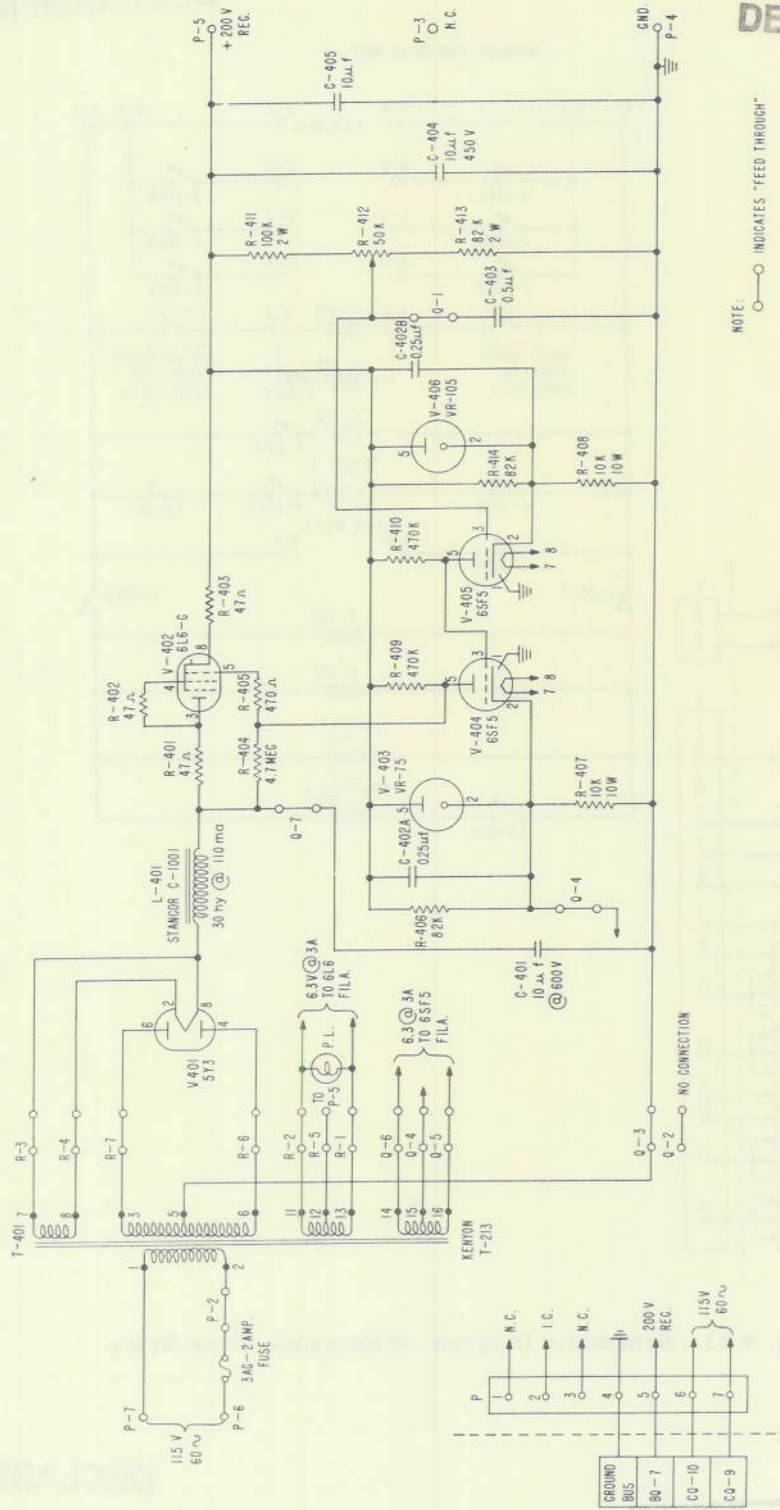
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of Amplifier

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Fig. 4.14 - Schematic Diagram of Screen Supply



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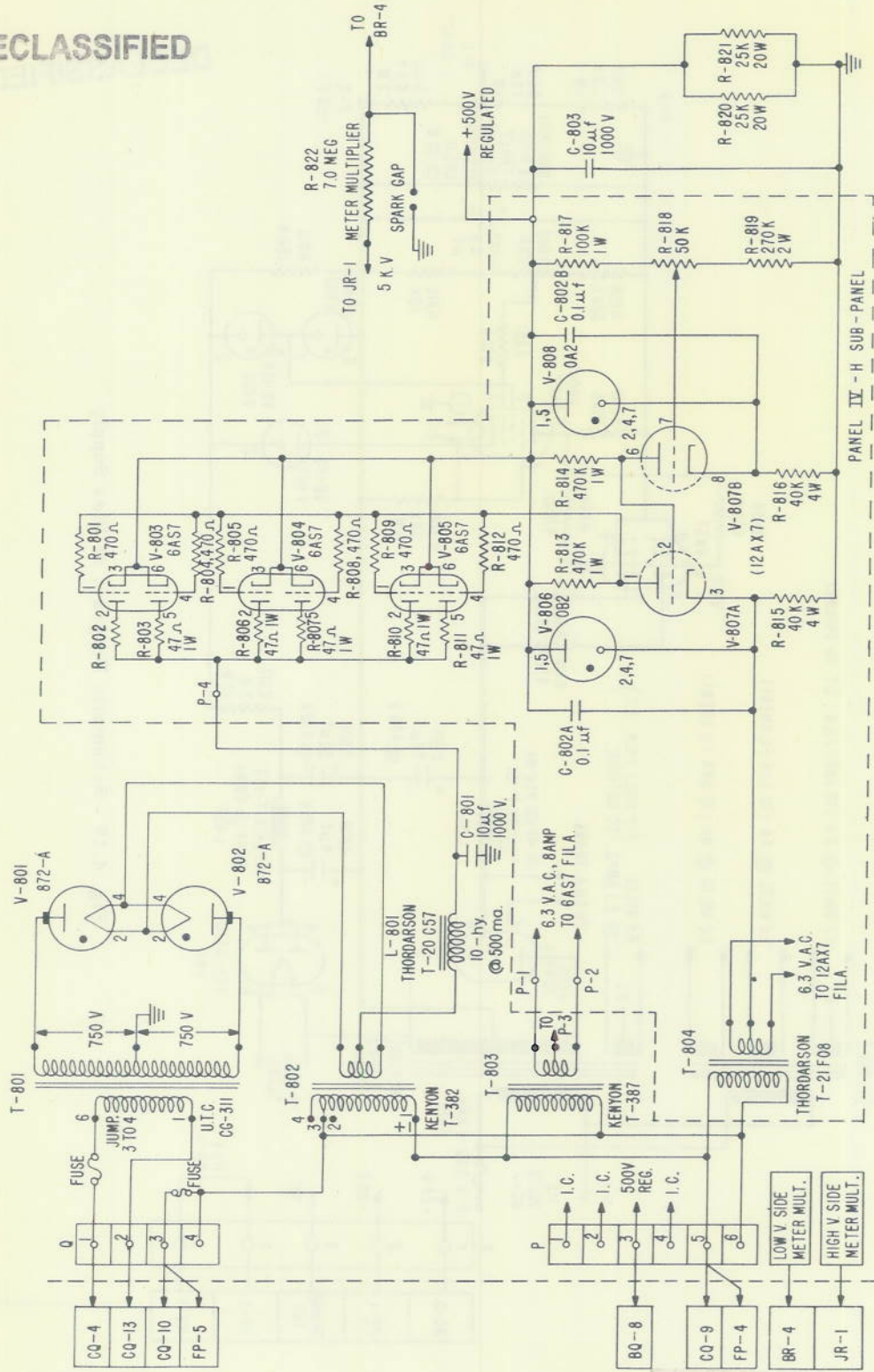


Fig. 4.16 - Schematic Diagram of Plate-Screen Power Supply

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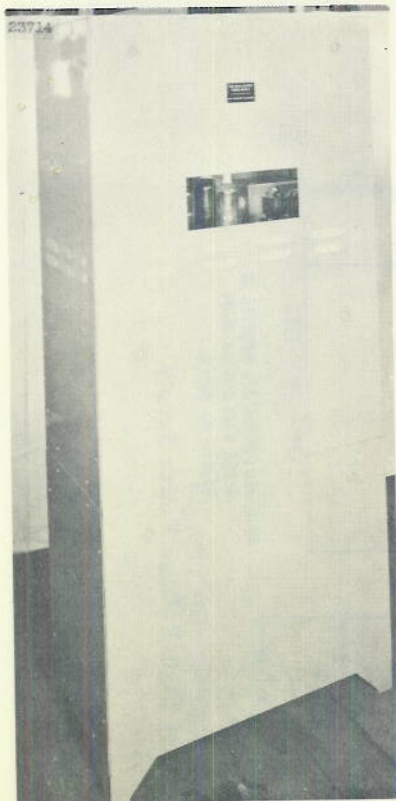


Fig. 4.17 - High-Voltage Power Supply with Cover On

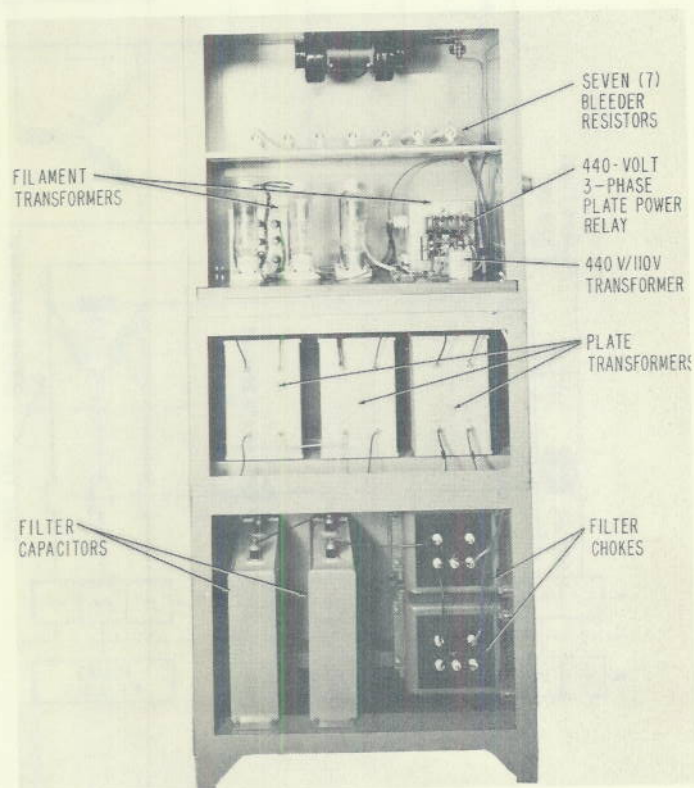


Fig. 4.18 - High-Voltage Power Supply with Cover Off

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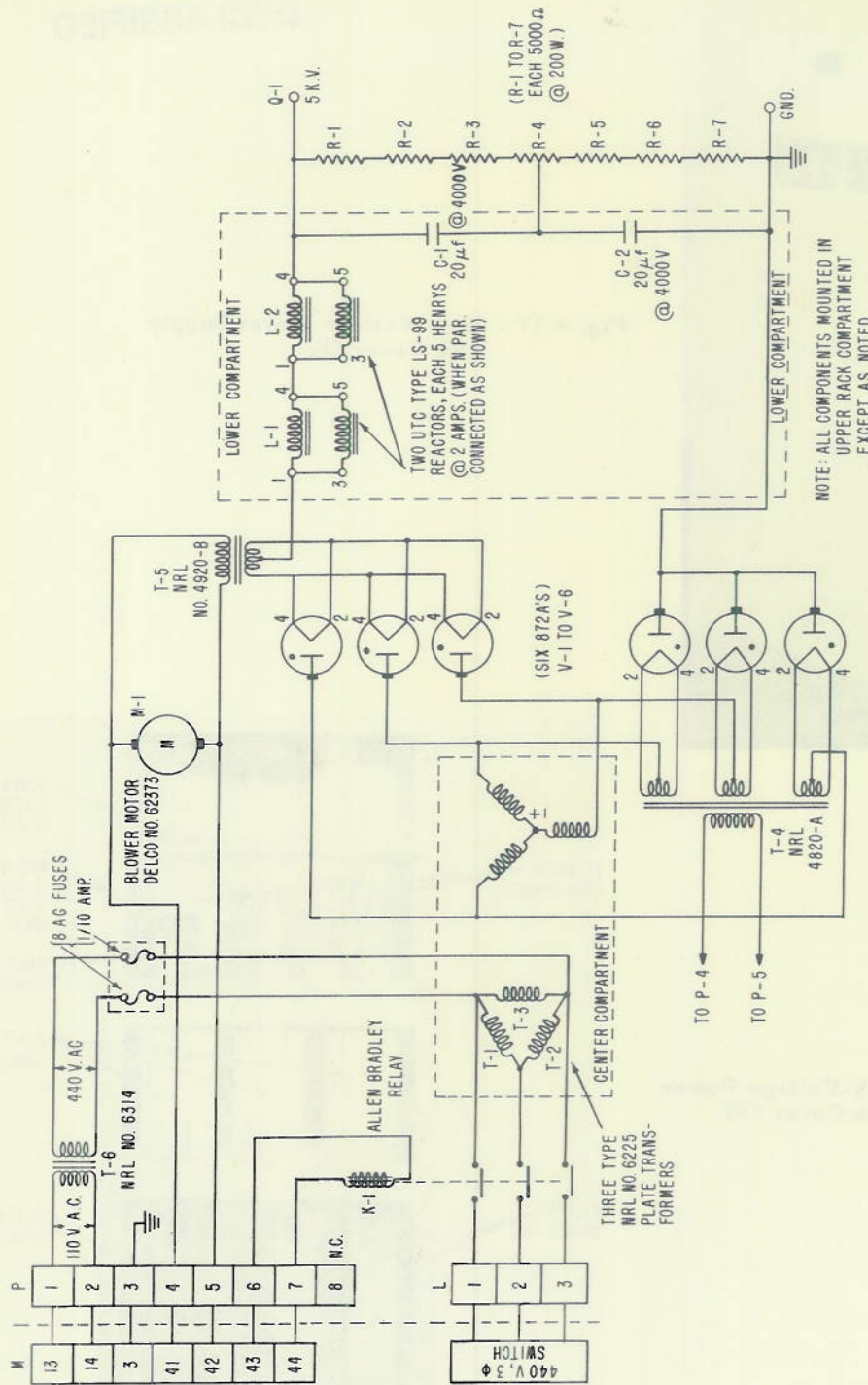


Fig. 4.19 - Schematic Diagram of High-Voltage Power Supply

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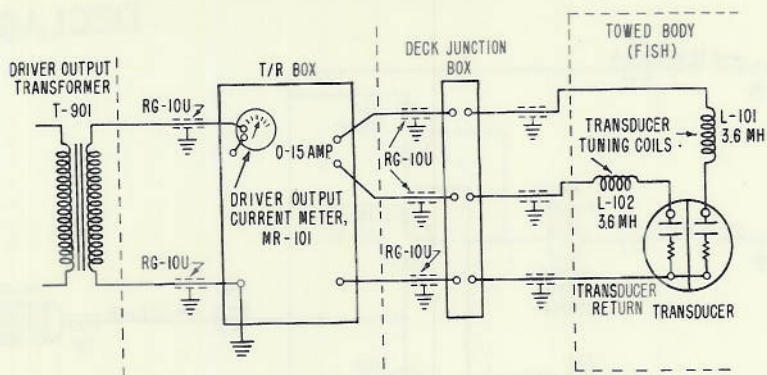


Fig. 4.20 - Block Diagram of Transfer Relay Box, Deck Junction Box, and Transducer Tuning Coils

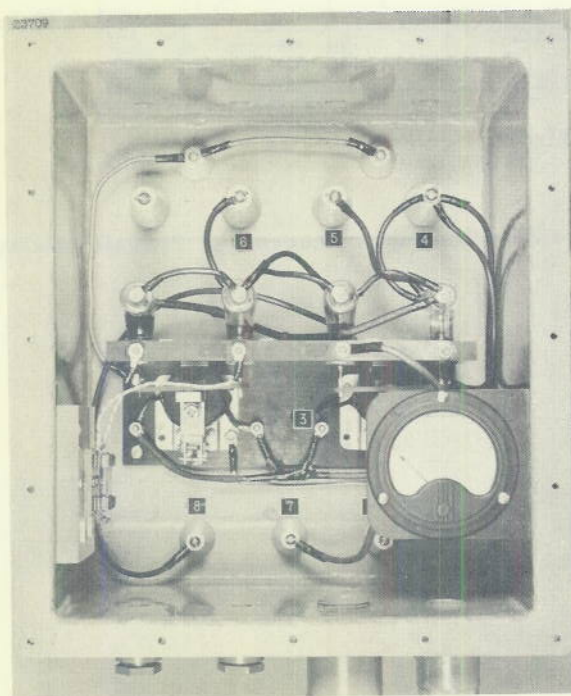


Fig. 4.21 - Front View of Transfer Relay Box

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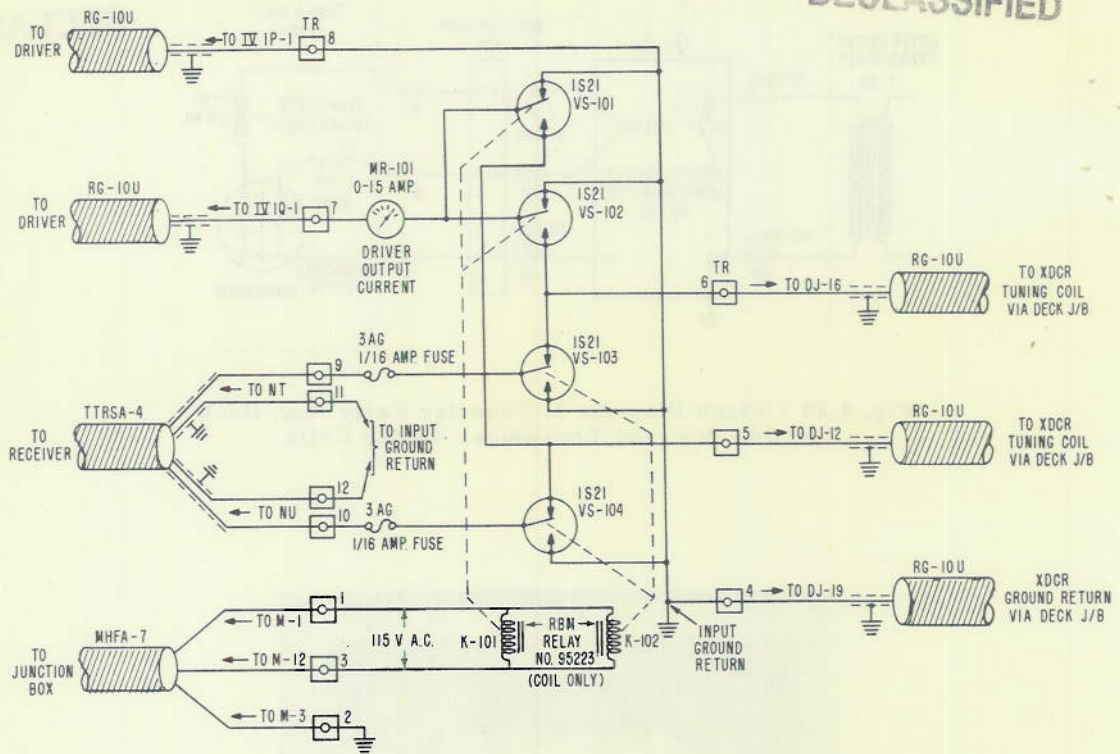


Fig. 4.22 - Schematic Diagram of Transfer Relay Box

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## CHAPTER 5 CONTROL EQUIPMENT

### 1. INTRODUCTION

The main function of the XHA control equipment is to provide a closed loop servo for training the transducer. The control equipment of the XHA Sonar consists of four units:

- (a) Program Control Unit, located in the upper compartment of Rack I, (Figures 2. 1 and 2. 2),
- (b) Servo Training Amplifier,
- (c) Transducer Training Mechanism, and
- (d) Handwheel Assembly, located in the second compartment of Rack I to the right of the display tubes.

When a mechanical input is automatically fed to the shaft of B101\* (Figure 5. 1), a signal from its "R" leads will be applied to the Servo Training Amplifier. Here it will be amplified and fed to the control field of the training motor, M301, where it will cause the motor to train the transducer through a 600:1 gear reduction. A repeat-back 5G synchro, B301, is geared 1:1 with the transducer. Three-wire "S-lead" information from this synchro is fed back to B101 through a 5DG synchro, B201, located in the Handwheel Assembly. Thus, the train loop is completed, and the signal voltage of the 1CT, B101, continuously nullified. Train order may also be introduced manually by turning the shaft of the 5DG, B201, in the Handwheel Assembly.

The Program Control Unit also contains a 1G synchro, B102, which is geared 1:1 with the train order 1CT, B101. A 1DM, B202, in the Handwheel Assembly drives a dial card which indicates the heading of the CENTER OF SEARCH ARC; B202 receives its electrical inputs from the 1G synchro, B102, in the Program Control Unit and from the repeat-back 5G, B301. This CENTER OF SEARCH ARC may be varied from a relative heading of 270 to 090 degrees by means of the handwheel. However, it must be remembered that when the SEARCH ARC called for by the Program Control Unit is 180 degrees, the CENTER OF SEARCH ARC must be set on 000, otherwise the transducer will be trained into the electrical limit stops. Also, when the SEARCH ARC is 90 degrees, the CENTER OF SEARCH ARC must never go below 315 degrees or above 045 degrees for the same reason. Therefore, the handwheel must be trained judiciously by the operator whenever automatic training is used. More detailed information on search arc, center of search arc, and electrical and mechanical limit stops will be found in the description of the individual units.

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\*The 1CT synchro in the Program Control Unit.

A 5F synchro, B203, in the Handwheel Assembly also receives the three-wire information from the repeat-back 5G, B301, and drives a circular dial card which shows transducer heading. On the outside of this card is a fixed card on which relative target bearing may be read. Inside the card showing transducer heading is another dial card driven by a 1F synchro, B204, which receives its information from the ship's gyro.

The XHA control equipment has other functions besides that of training the transducer. These take the form of synchronizing and timing certain actions and will be taken up as the individual units are discussed.

## 2. PROGRAM CONTROL UNIT

**Functions**

The Program Control Unit (Figures 5.2 and 5.3) governs:

- (a) The SEARCH ARC or the angle through which the transducer may be trained automatically. It is variable in 10-degree increments from an included angle of 90 degrees (45 degrees each side of the CENTER OF SEARCH ARC) to an included angle of 180 degrees (90 degrees each side of the CENTER OF SEARCH ARC).
- (b) The PING ARC or angle through which the transducer is trained automatically during a range interval. The PING ARC, sometimes called "degrees per ping," is variable from 3 to 9 degrees per range interval in 1-degree increments.
- (c) The RANGE which is variable on the SHORT RANGE from 2,500 to 15,000 yards in 1,250-yard increments, and on LONG RANGE from 5,000 to 30,000 yards in 2,500-yard increments. Based on the fact that the speed of sound in sea water is approximately 5,000 feet per second, the range interval for 2,500 yards will be 3 seconds.
- (d) The synchronizing contact for initiating the keying pulse in the Driver Keying Unit.
- (e) The synchronizing contact for controlling the Chemical Range Recorder.
- (f) The automatic training cutout.
- (g) The automatic keying cutout.
- (h) The NORMAL or EXPANDED range sweeps of the display tubes.

Certain factors about the first three controls are worthy of specific mention.

- (a) Adjustment of the RANGE control changes the transducer train rate inversely, but the PING ARC remains unchanged.
- (b) Changes in the PING-ARC control do not affect the range interval.
- (c) Changes in the SEARCH-ARC control do not affect either the range interval or the PING ARC.
- (d) Adjustment in magnitude of these controls may be made independently, and adjustments put into the system become fixed.

## Description and Operation

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Power Drive—The basic power drive of the Program Control Unit is an 1800-rpm synchronous motor, M101. When the search-arc limits are reached, the direction of the motor is reversed by the Search-Arc Mechanism and associated circuitry. Figure 5.4 is an over-all wiring diagram of the XHA control system, and Figure 5.5 is a diagram of the reversing circuit and limit cutoff. The relay panel associated with this circuit is shown in Figure 5.6. As indicated in Figure 5.5, relay K101 is de-energized in the position shown, and the contact from K101D to K101F is closed. In this position one side of the 115-volt ac line is applied to the right side of a 6- $\mu$ f capacitor, C101, and as a result, the motor turns the cams of the Search-Arc Mechanism in a clockwise direction. When the end of the search arc is reached, MS101 is momentarily actuated, and MS101A is closed to MS101C. Then K101 is energized, and the contact from K101D to K101E is closed. This applies the line voltage to the opposite side of the 6- $\mu$ f capacitor, and the rotation of the motor and cams is reversed. Since K101A is now closed to K101B (a holding contact), this direction will be maintained until the other end of the search arc is reached and MS102 is momentarily actuated. This action breaks the line to the holding contacts, and relay K101 is again de-energized. As long as voltage is applied to the Program Control Unit, this cycle will continuously repeat itself.

Doubler Box—The output of the motor, M101, is fed directly into a gear box containing a 50:1 gear reduction. A further reduction of the speed may be had by the selective positioning of a sliding cluster gear. The first position indicated on the panel as LONG RANGE, gives a speed ratio of 1:1 so that the output of the first gear box (B of Figure 5.3) is 36 rpm. In the other position, indicated as SHORT RANGE, the ratio becomes 2:1 and the output speed 72 rpm. This box is called a Doubler Box and can be seen in Figure 5.7. Its output of either 36 or 72 rpm is transmitted through spur gears of 1:1 ratio to the input of the Gear Ratio Box (Figure 5.8 and C of Figure 5.3).

Gear Ratio Box—The input shaft of the Gear Ratio Box carries a sliding gear, and the shaft is parallel to one side of a cone formed by eleven gears whose pitch diameters vary from one-half inch to three inches. These gears are fixed to a shaft so that the spacing between each is equal to the face width. The sliding gear is actuated linearly by a yoke moving on a quadruple-threaded screw that is driven by the knob on the panel marked RANGE. The screw lead is proportioned so that one revolution of the screw will impart a linear movement to the sliding gear sufficient to move it out of full mesh with one of the gears in the cone and into full mesh with the next gear in line on either side. The direction of yoke motion depends upon the direction of rotation of the screw, and an increase or decrease in the speed of the cone-gear assembly is obtained by the selective mating of the sliding gear with one of the gears on the cone-gear assembly.

Main Drive Shaft—Power from the Gear Ratio Box is transmitted to the Main Drive Shaft which is located parallel to the control panel. This shaft transmits power at one end through a pair of helical gears to the Same Direction Mechanism (Figure 5.9 and D of Figure 5.3) and through spur gears on the other end to the Clutch Mechanism (Figure 5.10 and F of Figure 5.3). It should be noted that the speed of this shaft is always proportional to the speed required for the range interval selected by the setting of the two range knobs.

Same Direction Mechanism—The Same Direction Mechanism is designed with an output shaft on which two over-running clutches are mounted. These clutches are designed to drive in one direction only and are free to coast in the other. The drive to these clutches is made through gears pressed on their outer housings, and the gears are driven

by mating gears on the input shaft. The gear drive to one clutch is direct. In the drive to the second clutch, an idler is introduced to reverse the direction of rotation. When the Main Drive Shaft is running in a clockwise direction, the clutch driven by the direct gearing drives the output shaft counterclockwise while the clutch driven by the idler coasts clockwise. When the Main-Drive-Shaft rotation is reversed, the clutch driven by the direct gearing coasts clockwise while the clutch driven by the idler drives the output shaft counterclockwise. The result of this mechanism is that the output-shaft rotation is always in the same direction regardless of the direction of the input-shaft rotation. This is necessary because the keying cams and continuously rotating potentiometers (E of Figure 5.3) for the electronic display sweep circuits, which are driven by the Same Direction Mechanism, must always rotate in the same direction. (Note that the drive motor, A of Figure 5.3, is used for obtaining the range interval selections as well as the train orders. Also note that when training automatically the direction of train must be reversed at the ends of the search arc in order to remain within the limits of this arc.)

Keying Cam Mechanism—The Keying Cam Mechanism (Figure 5.11 and E of Figure 5.3) consists of a shaft with a differential on one end; the shaft supports a drum carrying three cylindrical cams. Each is adjustable, within fixed limits, by means of annular slots and locking screws located on the periphery of the drums. The actuation of the microswitches is made by means of a linear groove milled in the face of each cam.

The Keying Cam Assembly also contains an infinitely variable adjustable cam. Here the drum and cam are free to rotate about the shaft, but are fixed to one side of a differential. The opposite side of the differential is geared to a control knob on the panel. By means of this gearing, plus friction, this side of the differential is held stationary until the control knob is turned. As long as the differential is stationary, the relative position of its cam with respect to the other cams remains fixed but turns with them since the spider of the differential is pinned to the driving shaft. The relative position of this cam with respect to the others may be changed at will, but once changed it remains fixed until another change is made by the operator. THIS CAM IS NOT USED IN THE XHA EQUIPMENT, AND ITS CONTROL KNOB SHOULD BE NEGLECTED IN ALL OPERATING PROCEDURES.

The first of the fixed cams actuating MS103 is used as a spare, but the second closes a microswitch, MS104, which serves to initiate the keying pulse in the Driver Keyer. Leads from this microswitch are connected to Q-5 and Q-6 (Figure 5.4), and its circuitry feeds through the AUTO KEY—OFF—SINGLE PING switch as shown in Figure 5.12. The theory of operation for the keying circuits is described more fully in Chapter 4. However, it should be noted that the timing between keying pulses (i.e., range interval) is accomplished in the Program Control Unit.

The third fixed cam is used to actuate a microswitch, MS105, that breaks the magnetic clutch circuit of the Chemical Range Recorder and slaves or synchronizes the recorder to the range interval. The leads of this microswitch are brought out to terminals Q-7, Q-8, and Q-9 of the Program Control Unit. The fourth cam, actuating MS106, is the infinitely variable cam previously mentioned; it is not used, however.

Range Sweep Potentiometers—The output shaft of the Keying Cam Mechanism drives two continuously rotating potentiometers at the range interval speed (1:1 with the keying cams). These potentiometers are used in the sweep circuits of the electronic displays; one acts as a spare in the event of failure of the other. In addition to the sweep-circuit potentiometer, the Program Control Unit contains a NORMAL—EXPAND switch and a group of attenuator potentiometers (one for each range interval).\* Part of the circuitry

\*The operation theory, circuitry, and alignment of all these controls was discussed in Chapter 2 of this manual.

is shown in Figure 5.4. The spare sweep potentiometer previously mentioned should be kept uncoupled until it is absolutely necessary to put it to use. If it is essential to adjust the alignment of these potentiometers, great care must be taken not to have the tightening screw of the coupling too loose or too tight. The tightening screw must be turned so that the split arms of the coupling just touch the pin between them. If they are too loose, backlash will cause difficulty when the start of the trace is aligned. If the arms are too tight, the potentiometer will be damaged after a few revolutions.

Clutch Mechanism—The mechanisms discussed thus far have had the generation of range interval as their function; hence, this portion of the Program Control Unit is called the "range branch." The second portion, or "training branch," begins at the end of the main drive shaft feeding the Clutch Mechanism (Figure 5.10). The purpose of the Clutch Mechanism is to uncouple the training branch from the drive motor, M101, when the knob on the panel is turned from AUTO to MANUAL Train. It will be noted that this action does not affect the range branch, nor does it prevent manual training by the handwheel.

Ball Integrator—When engaged, the Clutch Mechanism transmits power to a Ball Integrator (G of Figure 5.3). The output speed of this unit determines the ping arc, which may be varied from 3 to 9 degrees per range interval. The integrator is the usual ball-and-disc type in which linear motion of the control shaft determines the output-shaft speed. Linear movement of the control shaft which carries the balls in a yoke is obtained from a threaded screw fixed to the shaft. A nut, restrained in linear motion but free to rotate about the screw, is geared to a shaft attached to a knob on the panel. Rotation of the control knob turns the nut about the screw and moves the control shaft of the integrator linearly. This movement carries the balls across the face of the disc and varies the speed of the output shaft. When the balls are moved to the exact center of the disc, the output speed is zero. Before the zero point is reached, however, the control shaft encounters a stop; at this time the ping arc will be 3 degrees per range interval. The other extreme position of the control shaft brings it against another stop, at which time the ping arc will be 9 degrees per range interval.

Search Arc Mechanism—The output of the integrator is fed to the drive shaft of the Search Arc Mechanism (I-I, J-J, and H of Figures 5.3 and Figure 5.13) through a spur-gear reduction and a worm and wheel. The worm wheel, fixed to the drive shaft, carries two drums, I-I. Cam rings similar to those in the Keying Cam Mechanism are fixed to these drums. Located between the drums is a modified bevel-gear differential, H. The modification of the differential, in effect, locks the spider block in a fixed position. The spider gear is coupled to a shaft which is connected to a panel knob marked SEARCH ARC. When the knob is turned, the shaft rotates the spider gear which in turn rotates two side gears of the modified differential in opposite directions. Fixed to each side gear is an arm on which a microswitch (MS101 or MS102 of Figures 5.4 and 5.5) is mounted; the arm is adjusted so that the actuating roller of the microswitch rides on the surface of the cam ring. Movement of the control knob in a clockwise direction decreases the arc (angle) between the actuating rollers, and movement in a counterclockwise direction increases the arc. It should be noted that the cam rings and drums are fixed to the shaft, which is continuously rotating. The actuation of one microswitch causes the main drive motor, M101, to rotate the cam drums clockwise, and the actuation of the other microswitch causes M101 to rotate the cam drums counterclockwise. Electrical operation is discussed in the initial section of the "Program Control Unit."

Train Order Synchro—The worm shaft that drives the Search Arc Mechanism is extended and fitted with a second and similar worm which drives a worm wheel fixed to the shaft of a 1CT synchro, B101. This is the Train Order Synchro of the Program Control Unit, and it rotates at the called-for train speed, i.e., at the same speed as the transducer. Refer to the Introduction of Chapter 5 for additional details.

Search Arc Synchro—The shaft that drives the cam drums of the Search Arc Mechanism is extended and fitted with a pair of 1:1 ratio helical gears. One of these gears is fixed to the shaft of a 1G synchro, B102, which is also driven at one speed (1X) with the transducer. A 1DM synchro, B202, which is located in the Handwheel Assembly, carries the CENTER OF SEARCH ARC dial card; the search-arc information to B202 is supplied by synchro B102. (For a more complete discussion of the servo circuits, reference should be made to the "Introduction" of Chapter 5). It should be noted that B102, the 1G synchro in the Program Control Unit, is not "cognizant" of the heading of the CENTER OF SEARCH ARC, since the heading is dependent upon the position of the handwheel.

Power and Lighting Circuits—Located above the ball integrator is a 6.3-volt filament transformer which supplies voltage to a number of light bulbs which illuminate the dial cards on the front panel of the Program Control Unit. One side of the transformer secondary is grounded to the Program Control Unit chassis and tied to terminal M-3, the system ground. The filament transformer also furnishes voltage to the bulbs lighting the raster of the display tubes. The ungrounded side of the transformer secondary is brought out on terminal Q-14 to M-18 and then to the bulbs. The other side of these bulbs is grounded to M-3. Voltage from the transformer is applied to the warning-light system in the Handwheel Assembly via terminal M-18. The warning-light system will be described under the "Handwheel Assembly."

The main 115-volt ac power is taken from terminals M-1 and M-2 via P-12 and P-13 and applied through an ON-OFF switch. A 2-ampere fuse is connected in series with this switch. Both the ON-OFF switch and the fuse are located on the left-hand bracket supporting the panel of the Program Control Unit. BEFORE PUTTING THE ON-OFF SWITCH IN THE "OFF" POSITION, THE INTENSITY OF BOTH DISPLAY TUBES MUST BE TURNED DOWN TO PREVENT BURNING THE CATHODE-RAY-TUBE SCREENS WHEN THE SWEEP CIRCUITS ARE DE-ENERGIZED.

Position-Identification Devices—Fixed to the control shaft of the Ping Arc Mechanism is a translucent dial card upon which the numbers 3 through 9 are engraved. The number appearing in the center of the panel viewing window indicates the PING ARC setting of the Program Control Unit; this number is illuminated by a fixed bulb.

Each of two arms geared to the control shaft of the Search Arc Mechanism carries a hooded bulb; the bulbs illuminate identical numbers on both panel viewing windows of the Search Arc Mechanism. When the SEARCH ARC is increased, the arms will spread and illuminate a new number, thereby indicating the new search arc. For every 10-degree increment between 90 and 180 degrees, a spring-loaded plunger will drop into an indented disc fixed to the control shaft. This will give a positive "feel" for each new SEARCH ARC position.

The position of the Clutch Mechanism is governed by the TRAIN CONTROL switch located on the front panel. As indicated by the engraving on the panel, two switch positions, AUTO and MANUAL, are available.

The RANGE knob carries a translucent dial card and is fixed to a shaft that extends to the Gear Ratio Box. The card is engraved with two concentric rings of numbers which indicate SHORT RANGE readings on the inner ring and LONG RANGE readings on the outer ring. Behind this card is a masking card fixed to the SHORT RANGE-LONG RANGE knob shaft. A light bulb is mounted behind the masking card. Therefore, with the knob set on the SHORT RANGE position, only one number of the inner ring of numbers will be lighted and appear in the range window of the panel. When the knob is set to LONG RANGE, only one number on outer ring will be lighted and appear in the viewing window. Each revolution of the RANGE knob changes the Gear Ratio Box one step and causes a new number to appear in the viewing window. Geared to the shaft of the RANGE knob is an eleven-position three-wafer switch. The first wafer switches the range attenuator potentiometers in accordance with the called-for range (Figure 5.4). The second and third wafers, in conjunction with a microswitch operated from the SHORT RANGE-LONG RANGE knob, control three lights located on the Chemical Range Recorder. These lights indicate the particular section of the Range scale in which the Program Control Unit is operating. Leads from these wafers are brought out on terminals R-13, R-14, and R-15.

### 3. SERVO CONTROL AMPLIFIER

The amplifier stack (Figure 5.14) consists of a preamplifier, a power amplifier, and a power supply.

As shown on the circuit diagram (Figure 5.15), the 1X train-control order from the Program Control Unit enters the preamplifier through Connector J-104. The preamplifier (Figures 5.16 and 5.17) consists of an input stage, a phase inverter, and a push-pull output stage which uses 6L6 tubes. This unit has its own power supply which employs a 5U4-G rectifier tube. An error meter (M101) located on the front panel is used to indicate the lag in the follow-up system. The button switch, S105, must be depressed to obtain expanded scale readings on the meter. FOR BEST OPERATION, SWITCHES S101 AND S103 SHOULD NOT BE MOVED FROM THE PARALLEL-T POSITION. THEREFORE, IT IS NEVER NECESSARY TO CHANGE THE POSITION OF PHASE-REVERSAL SWITCH S104.

The output of the preamplifier at T103 connects to T201, the input of the final amplifier (Figure 5.18). Here the signal is amplified to obtain sufficient power for the control field of the train motor in the towed body. The final amplifier employs a pair of 250 TH tubes connected in push-pull. Meters M201 and M202 indicate output voltage and plate current, respectively.

Plate voltage for the final amplifier is supplied by the High-Voltage Power Supply (Figure 5.19).

A ladder diagram in Figure 5.20 presents a simplified schematic of 115-volt 60-cycle power distribution in the Servo Amplifier.

### 4. TRANSDUCER TRAINING MECHANISM

#### Functions

The XHA Training Mechanism (Figure 5.21) provides both a mount for the 40-inch diameter ADP crystal transducer and a means for training it within an arc of plus or

minus 100 degrees with respect to the articulated linkage. It also provides the means by which the transducer mount and the fish body are joined to the articulated linkage. It is designed to allow the fish body to swivel about the articulated linkage without disturbing the training of the transducer with respect to this linkage. Suitable vibration isolation mounts, effective above 12 cycles per second, are used to isolate the training mechanism from the fish, the transducer from the training mechanism, and the training mechanism from the articulated linkage.

### Electrical Circuitry

The electrical cable from the hoist slip-ring assembly passes through the articulated strut and enters the Train Gear Box of the Transducer Training Mechanism through a stuffing tube. This cable, Navy type TTRS-10, contains ten (10) separately shielded, twisted pairs housed in an impervious sheath. The fabric covering of each shielded pair is color coded and the individual conductors of a pair are identified by use of clear and black synthetic insulation. Figure 5.22 shows the electrical connections of the cable to the fish. Five of the shielded pairs connect to the "A" strip of the gear box, and provide the electrical connections for the train motor and the repeat-back 5G synchro, B301. Two pairs tie to a terminal strip mounted on the inspection plate of the Transducer Coil Box. Also mounted on this plate is a depth gauge and a pitch and roll sensing device for use in determining the swimming characteristics of the fish. These inspection-plate-mounted components comprise the Pitch, Roll, and Depth (PRD) Indicator. When the PRD Indicator is not being used, the coil box cover-plate containing the PRD components may be replaced by a plain plate. Under these conditions the PRD leads are tied off as spares.

The three remaining shielded pairs are transducer signal leads. In order to reduce the electrical resistance of the signal path, the two conductors of each pair are paralleled. Two of the resultant shielded cables connect to the right and left halves of the transducer via series tuning coils mounted on the bakelite bracket of the coil box. The third cable serves as a common transducer return. Care should be observed in properly grounding the shielding of these leads.

### Mechanical Description

Figures 5.23 through 5.27 are construction drawings used in describing the Transducer Training Mechanism.\* The part numbers referred to in the discussion are used in these drawings.

Transducer Mount—As shown in Figure 5.23, the 1250-pound transducer, part No. 301, is fixed to its mount by six studs, part No. 153. These studs are isolated by rubber washers, 147, 148, 149, 150, and 151, and secured by stainless steel washers and nuts, 152, 381, and 390. Two vibration mounts, 326, are used to isolate the lower feet of the transducer from the mounting plate, 131, which is a weldment of 3/4 inch stainless steel.

The lower portion of the transducer has been machined to form a trunnion which fits into a thrust bearing, part No. 317 of Figure 5.23. The bearing is housed and supported by a stainless steel casting, 161, which is grooved for an O-ring, 324. This O-ring seals off the bearing pocket against salt water. The bearing support casting, 161, is isolated by three vibration mounts, 326, which are bolted to a stainless steel plate, 162, fastened

\*The training mechanism was constructed from NRL Drawings No. RA 10J 1217. Figures 5.23 through 5.27 are excerpts from this series

to the lower transverse ribs of the center section of the fish body. The bottom of the bearing support casting, 161, is fitted with a pipe plug which replaces a pipe assembly, 344, 345, 346, 347, and 348, shown in the drawing.

Bolted to the top of the transducer mounting plate is a step trunnion, part No. 50 of Figure 5.24, supported by two radial ball bearings, 319 and 320. The lower step of the trunnion is grooved for an O-ring, 312, which seals the bearing pocket of the torsional coupling casting, 11, against salt water.

Torsional Coupling Assembly—Bolted to the lower end of the torsional coupling casting is a stainless steel bull gear (part No. 21 of Figure 5.24) that is fixed, by virtue of the torsional coupling, with respect to the articulated linkage. The transducer and transducer mounting assembly are trained around this gear. During a reassembly, the fixed relative position of the bull gear with respect to that of the torsional coupling casting is insured by the offset of one of the holes through which a bolt, 353, is screwed. The upper end of the torsional coupling casting, 11, contains a rubber piece, 33, fixed to it by means of six pins, 44, pressed into the casting. One of these pins is offset to prevent changing the relative angular position of the torsional coupling casting and the articulated linkage during reassembly. It will be noted that fastening the rubber piece by this method fixes the training mechanism (transducer, transducer mounting plate, gear box, etc.) to the articulated linkage torsionally, but allows for independent axial movement of each. The rubber piece, 33, is sandwiched between the linkage flange, 43, and a retaining ring, 41, by screws, 368. When these pieces are disassembled, the relative angular position of the rubber piece and the linkage flange should be carefully indexed. When the linkage flange is screwed up onto the last link, 302, the Swivel-Link Assembly is locked into place.

Swivel-Link Assembly—This assembly consists of three radial-thrust ball bearings, part Nos. 316 and 318 of Figure 5.24, the fish-support casting, 61, and a sleeve, 31. The linkage flange is keyed to the last link by a straight key, 396, which is retained by a ring, 32, screwed to the flange. Three O-rings, 314, 308, and 310, seal the swivel bearings against salt water. Four vibration isolation mounts, part No. 327 of Figure 5.23, are bolted to the fish-support casting, part No. 6 of Figure 5.24, and the top center section of the fish body. The fish load is carried by these rubber mounts and transmitted to the articulated linkage through the Swivel-Link Assembly. Around the upper portion of the torsional coupling casting, 11, is a support assembly for use in holding the upper end of the training mechanism when the Swivel-Link Assembly and top center section of the fish are removed. This assembly consists of a rubber piece, 34, fitted into a stainless steel ring, 26, tied to the fish by four rods, 45. By loosening lock nuts on the ends of the rods and screwing the rods in or out, the center of the support assembly may be made to coincide exactly with the axis of train. The tie rods should be removed when the Swivel-Link Assembly and top center section of the fish are in place. The electrical cable passing through the articulated linkage comes out through a hole in the torsional coupling casting to a stuffing tube mounted on the gear box. The preferred method of removing the Swivel-Link Assembly is to disconnect the electrical cable at the hoist slip rings and to feed the cable through the articulated linkage as the assembly is removed. An alternate method would be to disconnect the cable from the gear box before removing the Swivel-Link Assembly and the top center section of the fish body.

Pipe plugs, part Nos. 375 and 376 of Figure 5.24, have been provided for draining and greasing the bearing pockets of the Swivel-Link Assembly.

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Gear and Tuning Coil Boxes—The upper gear box and the lower tuning coil box are welded to a main plate. Two runners, welded to the main plate, mate with two other runners welded to the back of the transducer mounting plate. Shims inserted between these runners permit adjustment of the mesh of the main pinion gear, part Nos. 98 and 396 of Figure 5.25, to the bull gear, part No. 21 of Figure 5.24. Bolts, part No. 350 of Figure 5.23, extending through the runners secure the gear and coil box assembly to the transducer mounting plate.

A 2-inch pipe connecting each box permits the passage of electrical conductors between the two compartments. Both boxes are provided with a number of inspection plates, part No. 106 of Figure 5.23, which are sealed by O-rings, part Nos. 107 and 108 of Figure 5.25, to maintain the water tightness of the boxes. At the bottom of each box is a 1/4-inch pipe plug, part No. 375 of Figure 5.23, removal of which permits draining in the event of salt-water seepage.

The lower box of the assembly houses the tuning coils of the transducer. The function of the coils and their electrical circuitry are discussed in Chapter 4 of this instruction manual. Electrical conductors are fed through a flexible rubber hose, part No. 330 of Figure 5.23, from the coil box to the transducer junction box located on the back of the transducer. The hose is fastened by clamps at each end to nipples, 331, which are pipe-threaded into the transducer junction-box cover, 146, and into the coil box. Large clearance holes in the main plate of the gear and coil box assembly and the transducer mounting plate permit the removal of the transducer junction-box cover. This cover is sealed by 1/4-inch-square neoprene gaskets.

The gear box (Figure 5.25), the upper box of the assembly, contains a 200-watt servo motor, 304, which is mounted on an eccentric ring by means of screws, 367. This type of mounting permits the motor and ring to be rotated; the operation is necessary to adjust the mesh of the main pinion, 400, 372, and 78, and the first cluster gear, 87 and 399. Once adjusted, the eccentric ring is locked in place by drawing up the clamp ring, 77, with screws, 367. The first cluster gear is keyed to a shaft, 121, that rides in ball bearings, 323, of an eccentric sleeve, 120. This arrangement permits the first cluster gear to be properly meshed with the second cluster gear, 86 and 398, and once the gears are correctly meshed, the eccentric sleeve, 120, may be locked in place by drawing up the clamp ring, 110, with screws, 370. Since the second cluster gear, 86 and 309, is mounted in a similar manner, its adjustment to the third cluster gear, 96 and 397, which is mounted on the main shaft, is made the same way.

A 5G synchro, part No. 305 of Figure 5.25, is mounted on an eccentric ring, 79, by screws, 369. Rotation of the ring adjusts the synchro gear, 97, to the third cluster gear, 96 and 397. The adjustment is locked by drawing down on the clamp ring, 81, with screws, 369. It will be noted that all gear mesh adjustments start from, and are made with respect to, the third cluster gear. The main shaft, which carries the third cluster gear on one end and the main pinion on the other, rides in two ball bearings, 321. Because the shaft passes through one of the top inspection plates, 108, it is grooved for an O-ring. This plate is doweled in place and should be removed only when the entire assembly is torn down. The O-ring acts as a watertight seal between the rotating main shaft and the inspection plate. The main pinion, 98 and 396, which is a stainless steel gear with a 1-2/3 inch pitch diameter, is keyed to the main shaft and meshes with the bull gear.

The hat, part No. 154 of Figure 5.25, permits removal of the servo motor during assembly.

**Mechanical Stops**—Welded to the top of the gear box are two ears (Figure 5.26)\* that act as mechanical train stops. They are spaced to permit the transducer a train arc of plus or minus 100 degrees with respect to a zero reference that is determined by the articulated linkage. Before the plungers (Figure 5.27) mounted on the bull gear make full contact with these ears, the electrical limits will disable the automatic train. The plunger assembly is bolted to the bull gear in a particular position, and this position must be carefully indexed when the assembly is removed.

A stainless-steel sheet-metal shelf has been provided above the main pinion and bull gear to prevent the electrical cable from being damaged by the gear teeth.

#### Maintenance

Access is gained to the Transducer Training Mechanism by the removal of the three back covers of the fish body. The Swivel-Link Assembly may be removed by disconnecting the electrical cable from the hoist slip rings and the articulated linkage from the hoist drum. The electrical cable should then be fed through the linkage as the Swivel-Link Assembly and the top center section of the fish are lifted off. During this operation the Swivel-Link Assembly will break free at the torsional coupling.

If it is desired to remove the rest of the mechanism from the fish at this time, rig a crane to the transducer mounting plate. Remove the support assembly by disconnecting the tie rods from the fish body and then lift the transducer assembly through the opening. Before removing the transducer assembly, it is necessary to rotate it 90 degrees from a zero position with respect to the bow of the fish.

Before installing the fish for its first towing test, the swiveling action of the fish should be checked, and this test should be repeated every month thereafter. It should require no more than 75 foot-pounds of torque to rotate the fish about the linkage.

After the first towing test, and every two weeks thereafter, the gear and coil boxes should be checked for salt-water leakage by removing their main inspection plates. If water is present, the transducer junction box should also be checked and the leaks found and sealed. Whenever a watertight seal is broken for any purpose, a vacuum test should be performed after resealing. This is done by sealing off the electrical cable at the hoist and drawing a vacuum on the system at the gear box. The gage reading of this vacuum should hold constant for at least 24 hours.

All bearing pockets must be checked every month and if necessary regreased. In addition, a monthly inspection should be made for excessively corroded parts.

## 5. HANDWHEEL ASSEMBLY

### Description

The Handwheel Assembly, which provides the means for manually training the transducer, is located in the center section of Rack I to the right of the display tubes. It consists primarily of an aluminum-alloy casting on which is mounted a 5DG synchro, B201; a 1DG synchro, B202; a 5G synchro, B203; and a 1F synchro, B204.

\*Figure 5.26 represents section X-X of the train assembly shown in Figure 5.23

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### Manual Train Orders

A bakelite handwheel is connected to the 5DG synchro, B201, through a 300:1 ratio gear box. It is the function of this synchro to provide "manual train orders" to the training servo loop as discussed in the "Introduction" of Chapter 5 (Figure 5. 1).

### Center of Search Arc

The synchro mounted in the uppermost portion of the casting is a 1DG, B202. Search-arc and transducer-heading information are fed to it electrically and combine to give the output shaft a displacement that represents the center of search arc. When no manual train orders are fed to the servo training loop from B201, the transducer heading follows the "automatic train orders" generated by B101, the 1CT in the Program Control Unit. Since B102, the 1G in the Program Control Unit, is geared 1:1 with B101, the search arc information it supplies to the 1DG in the Handwheel Assembly, B202, corresponds exactly with transducer heading. Under these conditions there will be no displacement of the output shaft of B202, and the center of search arc will remain constant.

The output shaft of B202 carries a translucent dial card on which the numbers 315, 0, and 45 are engraved in white. Outside the range of 315 to 45, red dotted lines are engraved every 22-1/2 degrees. A metal hood with a slot cut in its face is placed over the dial, and a view of the numbers engraved on the card can be obtained through the slot. A light bulb located behind the card illuminates the numbers in the viewing slot. WHEN THE XHA EQUIPMENT IS OPERATED ON AUTOMATIC TRAIN, CARE SHOULD BE TAKEN SO THAT THE RED DOTTED LINES DO NOT COME PAST THE CENTER OF THE VIEWING SLOT. WHEN THE CENTER OF SEARCH ARC IS SET ON EITHER 315 OR 45, CARE MUST BE TAKEN SO THAT THE SEARCH ARC IS NO GREATER THAN 90 DEGREES.

### Target Bearing

The 5G synchro, B203, receives transducer-heading information from the 5G synchro in the fish, B301. This information is transmitted to a card by an extension coupled to the shaft of B203; the extended shaft is geared 1:1 with the card assembly. The card is engraved with a double-headed arrow so that its outer head may be read against a fixed dial card calibrated every 10 degrees from 0 through 350. This will give a reading of relative target bearing.

The 1F synchro, B204, receives own ship's course information from the ship's gyro and drives a dial card engraved every 10 degrees from 0 through 350. This card turns inside the one driven by B203, and when read against the inner arrow head gives an indication of true target bearing.

### Dial Card Illumination

Beneath and around the dial cards is an aluminum ring which holds a number of light bulbs used to illuminate the numbers engraved on them. The 6.3 volts ac used to operate these and all other light bulbs of the Handwheel Assembly comes from the filament transformer in the Program Control Unit through terminals M-18 and BT-10 (Figure 5. 4). The ground side of all bulbs is returned to the casting and then through BU-10 to the system ground, M-3.

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## Train Limits

Screwed to the front and back side of the gear on the extended shaft of B203 are two aluminum pieces that form cam surfaces. Two microswitches are mounted so that their actuating arms ride these surfaces. The microswitches are adjusted so that one will be actuated when the 5G synchro, B203, indicates a relative target bearing of 090, and the other when it indicates 270. **THIS IS A CRITICAL ADJUSTMENT, AND THE SETTINGS OF THE MICROSWITCHES MUST NOT BE ALTERED.** These microswitches are the electrical train limits. The circuitry shown in Figures 5.4 and 5.5 is designed so that when either microswitch is actuated relay K102 on the Relay Panel will be energized and will break the 115-volt ac line to the Program Control Unit drive motor, M101. This will immediately stop the automatic training, but will not affect the manual training.

The circuitry is also designed so that when the dial card of B203 indicates a relative target bearing of 090 the microswitch that is actuated will also turn on a red warning light located above and to the right of the handwheel. The color red indicates that the handwheel is to be trained to port so that the transducer can be brought out of the electrical limit. Rotation of the handwheel in this direction is to be maintained until the red warning light goes out and stays out. When the dial card of B203 indicates 270, the microswitch that is actuated will turn on a green warning light, located to the left and above the handwheel. The color green indicates that the handwheel is to be trained to starboard so that the transducer can be brought out of the electrical limit. Rotation of the handwheel in this direction is to be maintained until the green warning light goes out and stays out.

If the transducer is trained manually past the electrical limits, it will be forced against the mechanical stops described under "Transducer Training Mechanism" of this chapter. This occurrence will be indicated by a large error on the servo-amplifier error meter and by the failure of the dial card of B203 to follow the handwheel movement. Care should be taken that this condition arises as infrequently as possible. The best rule to follow is to maintain constant vigil of the bearing and center-of-search-arc dials whenever the handwheel is in use.

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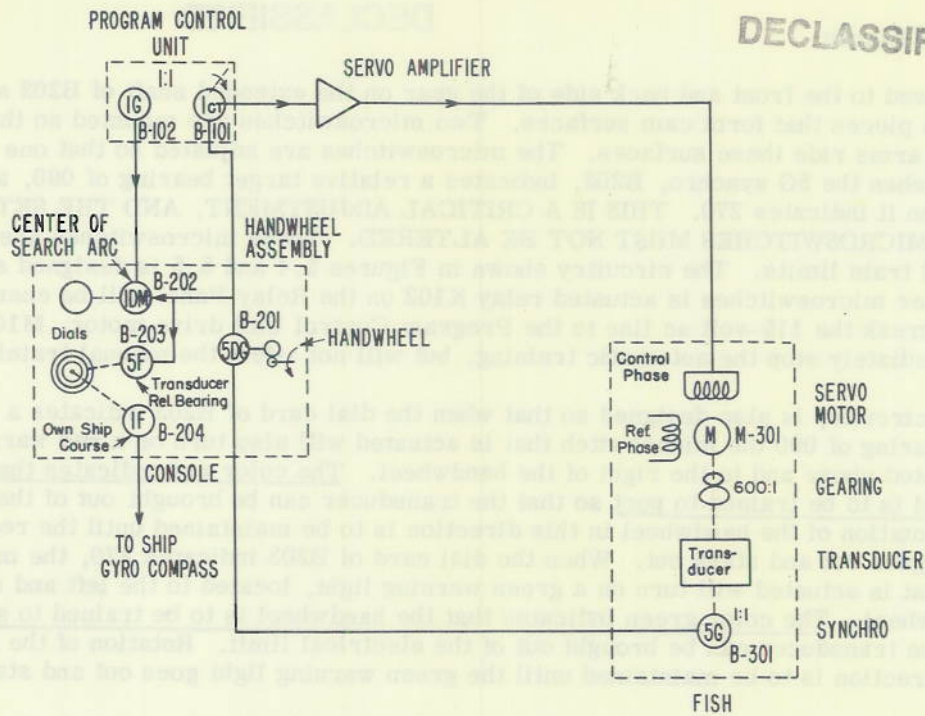


Fig. 5.1 - Functional Diagram of XHA Servo Control

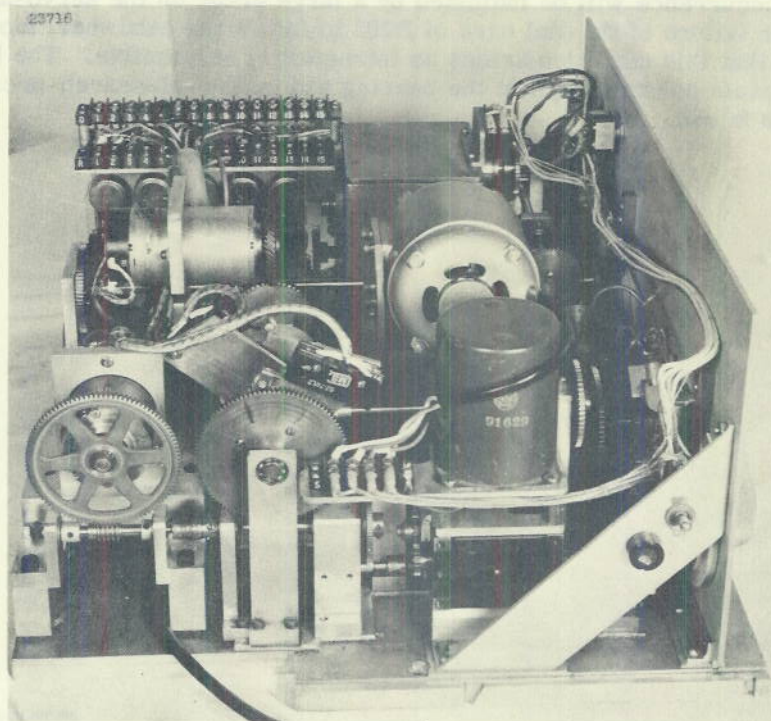
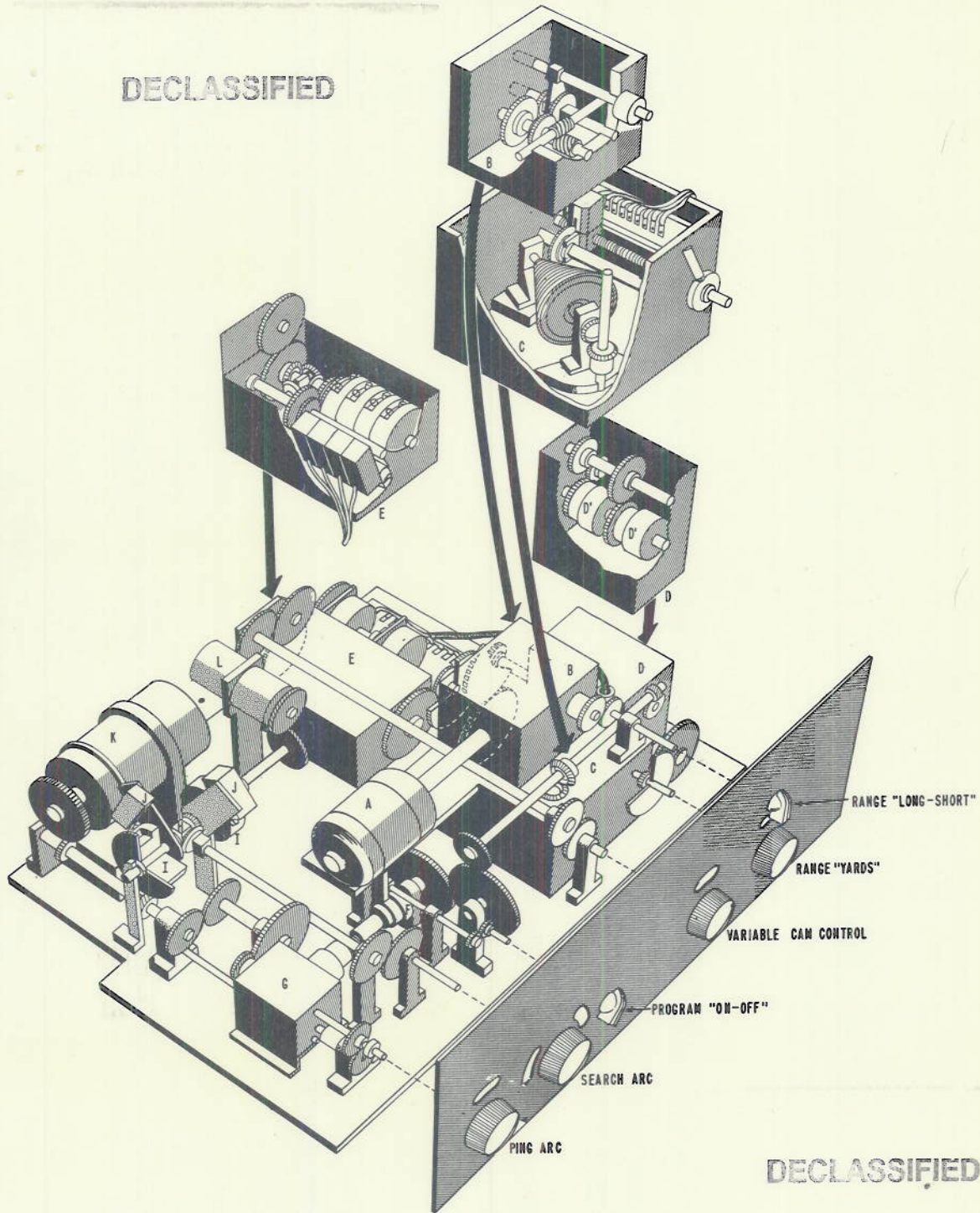


Fig. 5.2 - Left Side View of Program Control Unit

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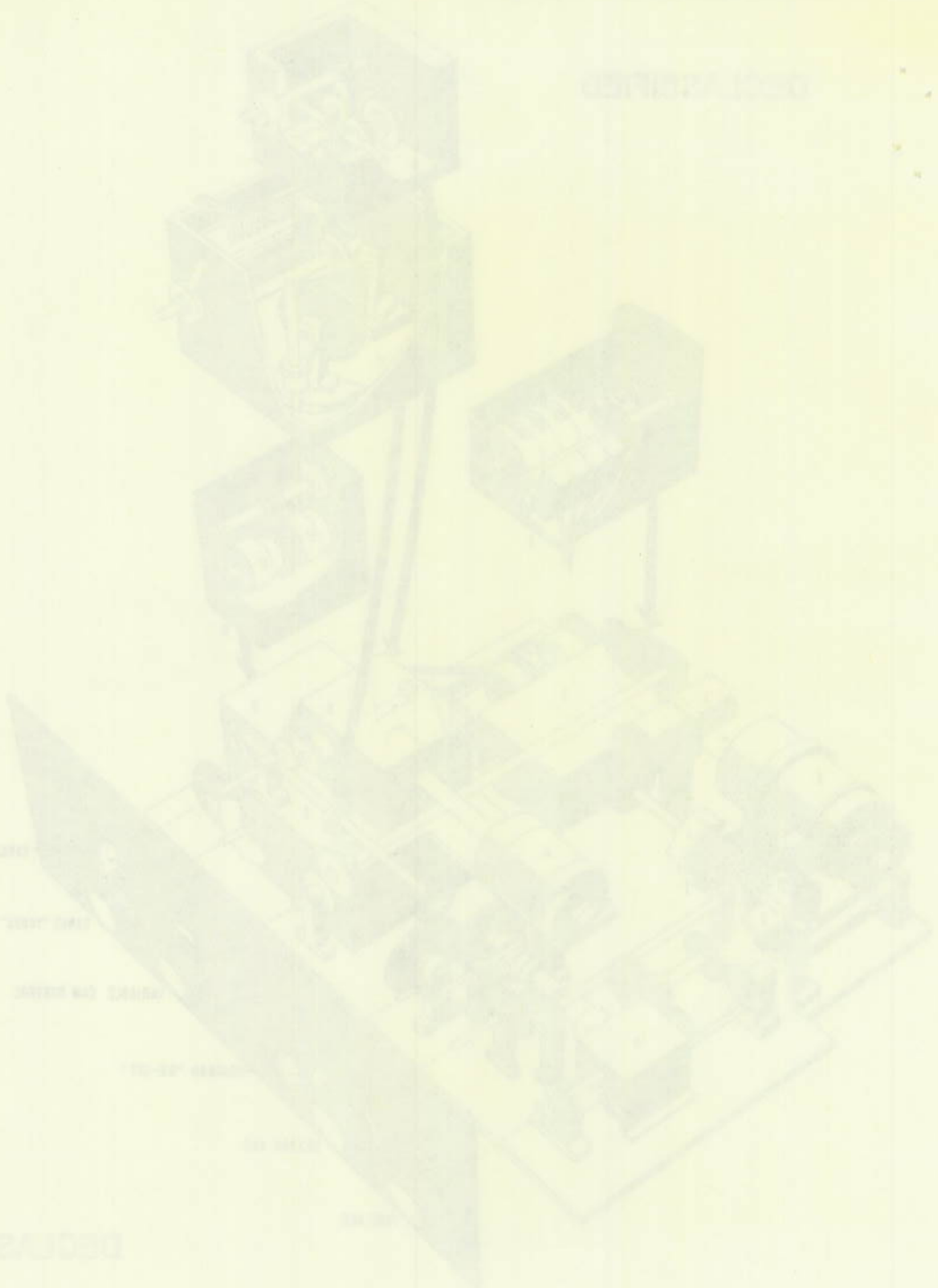


MECHANICAL PROGRAM CONTROL UNIT

Fig. 5.3 - Artist's Conception of Program Control Unit



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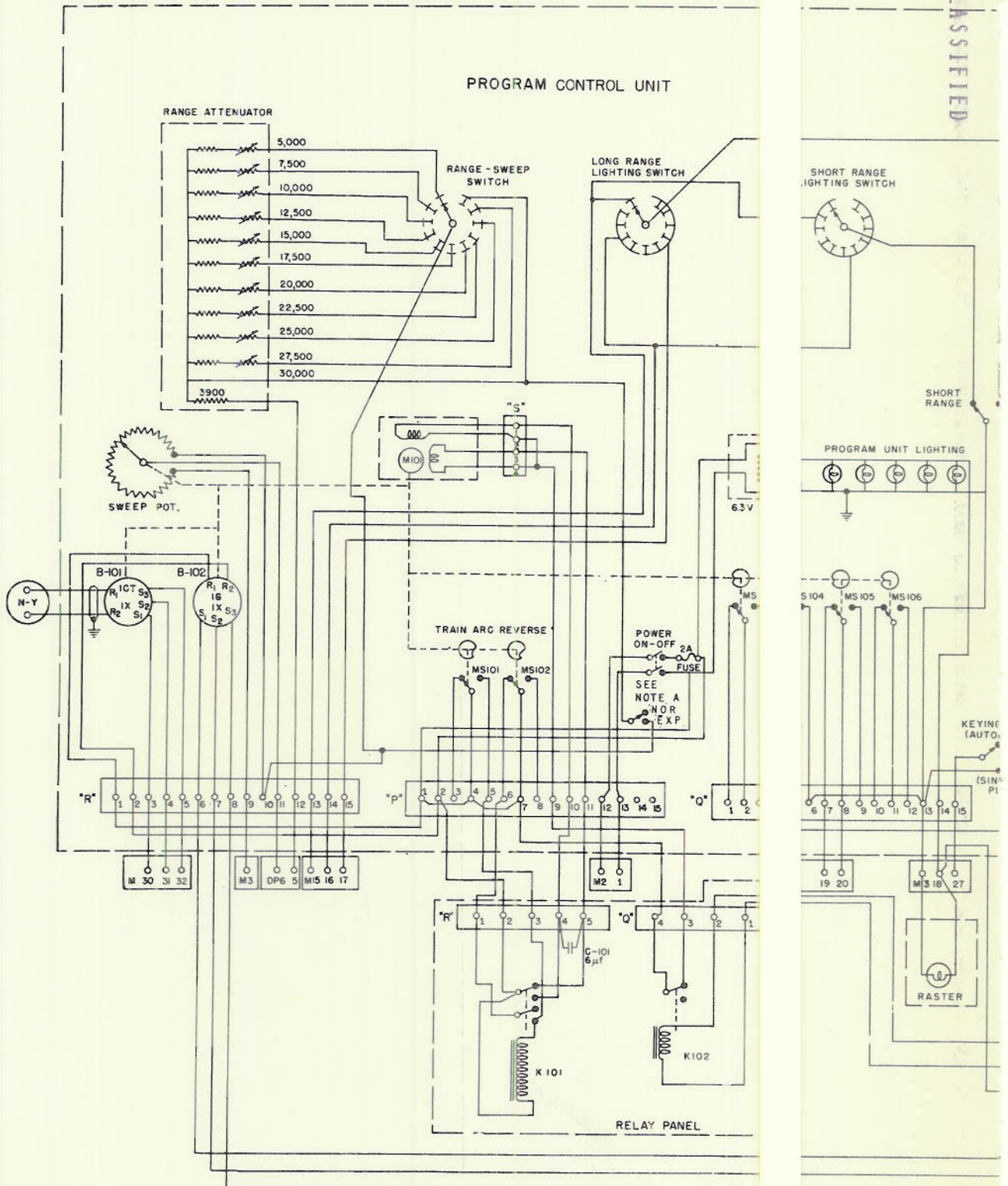
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Fig. 2-1. Control Panel Assembly



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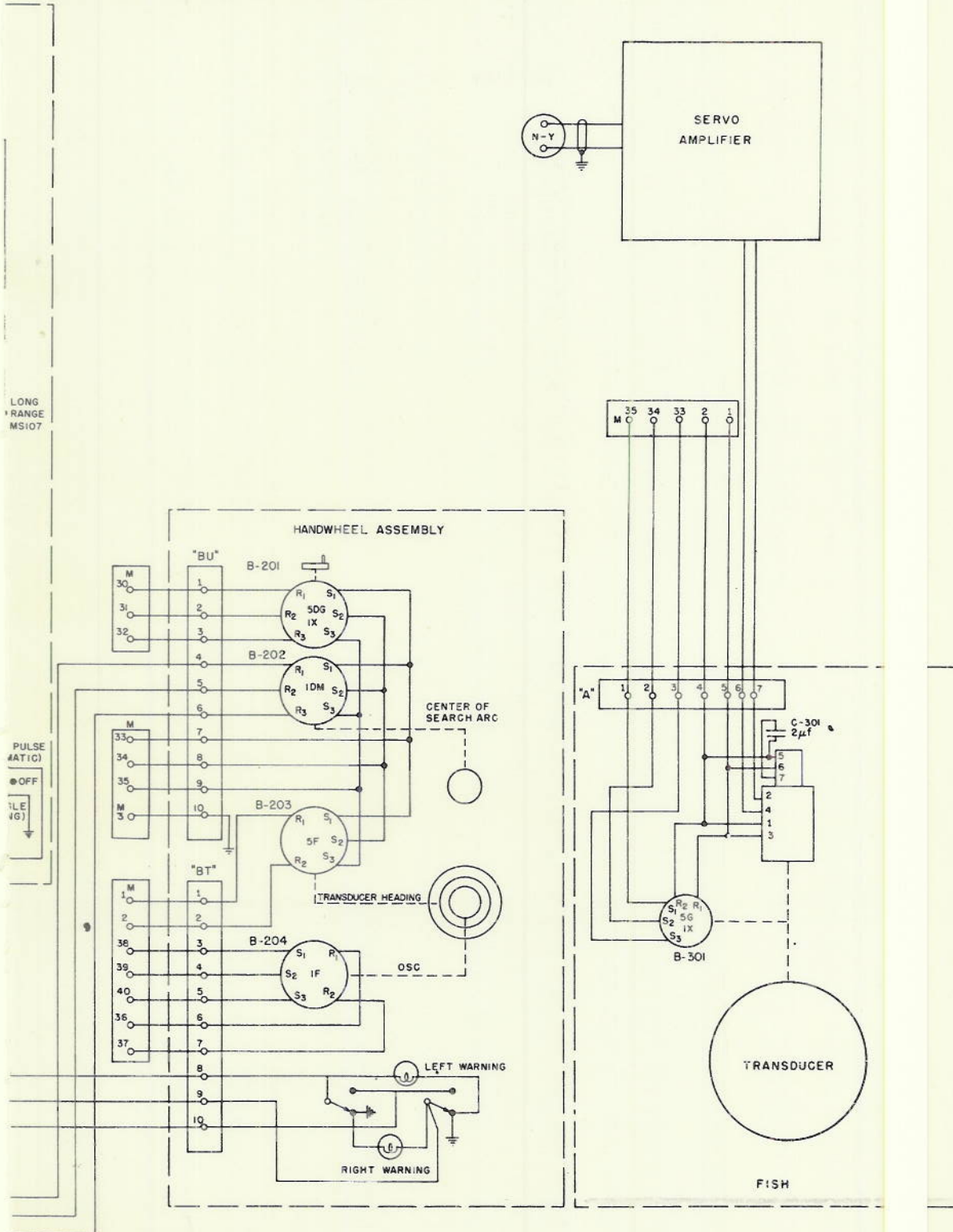
NOTE A: RANGE SWEEP, "NORMAL" (NOR), "EXPANDED" (EXP)

Fig.

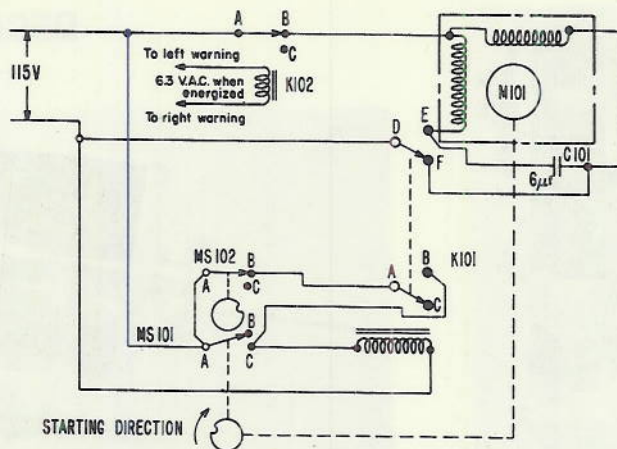
Wiring Diagram of

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XHA Control System



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Fig. 5.5 - Diagram of Motor Reversing Circuit and Limit Cutoff

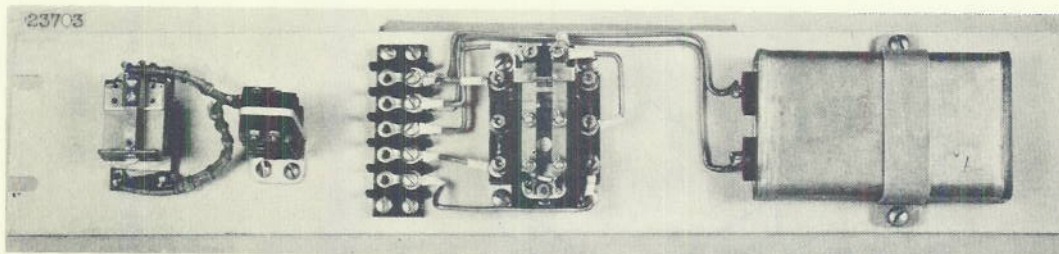


Fig. 5.6 - Relay Panel

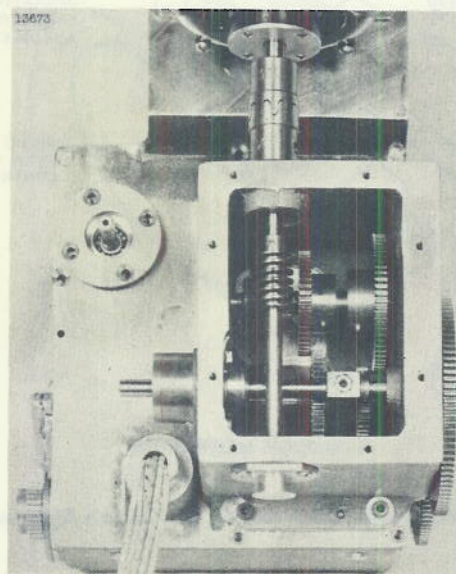


Fig. 5.7 - Doubler Box

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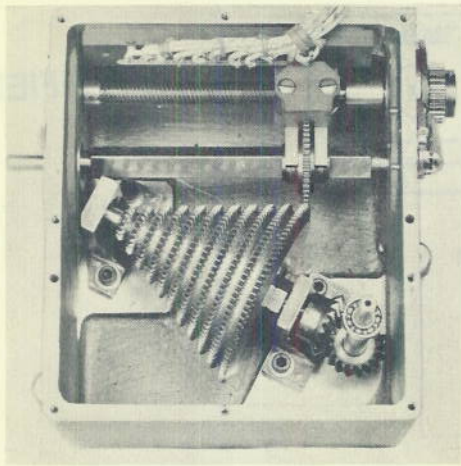


Fig. 5.8 - Gear Ratio Box

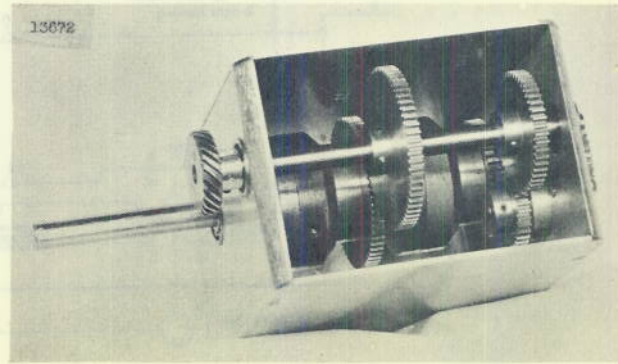


Fig. 5.9 - Same Direction Mechanism

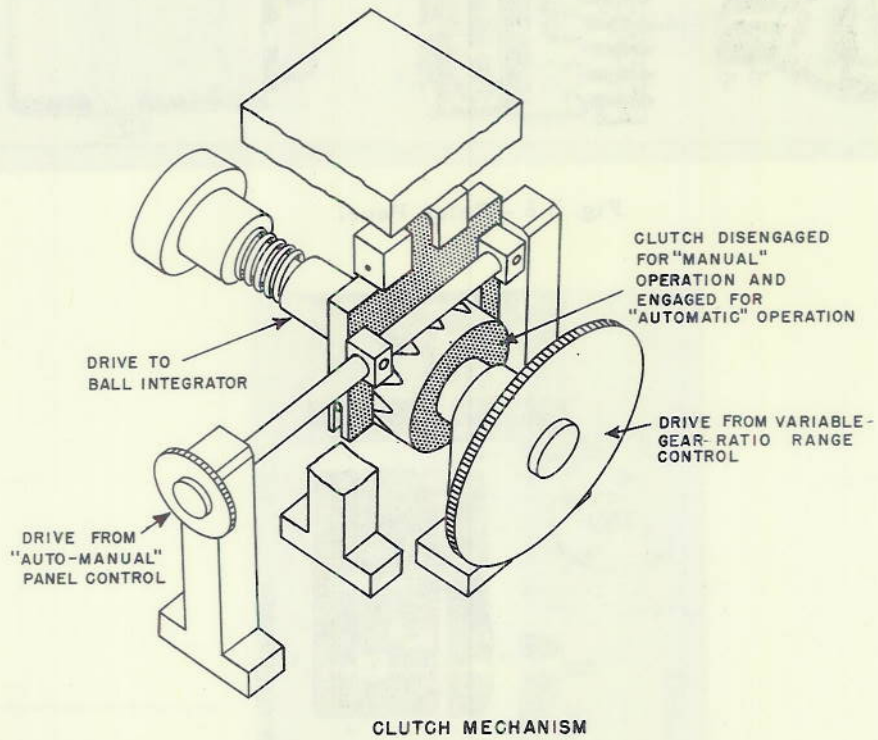


Fig. 5.10 - Artist's Conception of Clutch Mechanism

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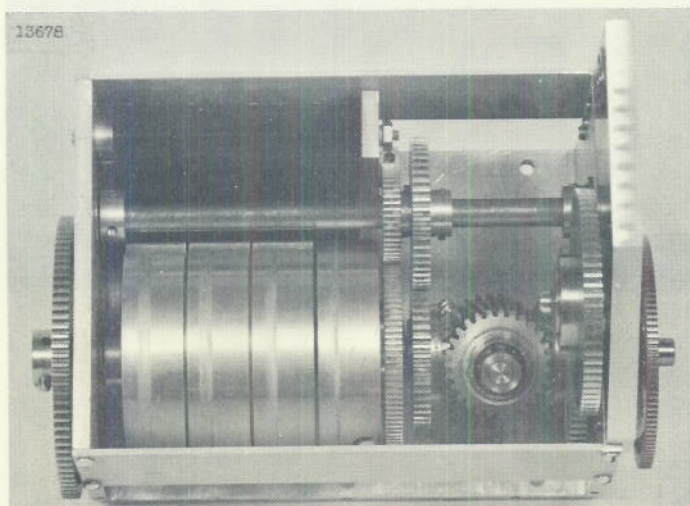


Fig. 5.11 - Keying Cam Mechanism

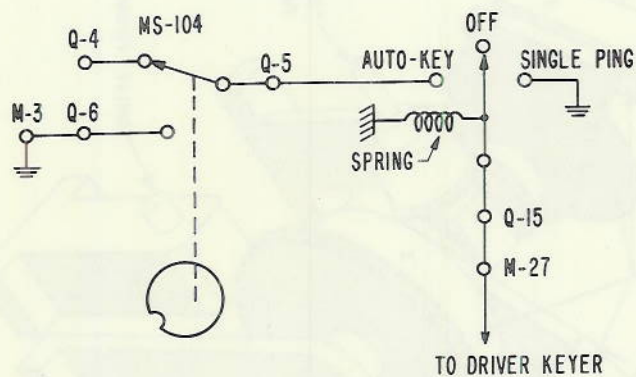


Fig. 5.12 - Diagram of Microswitch Keying Circuit

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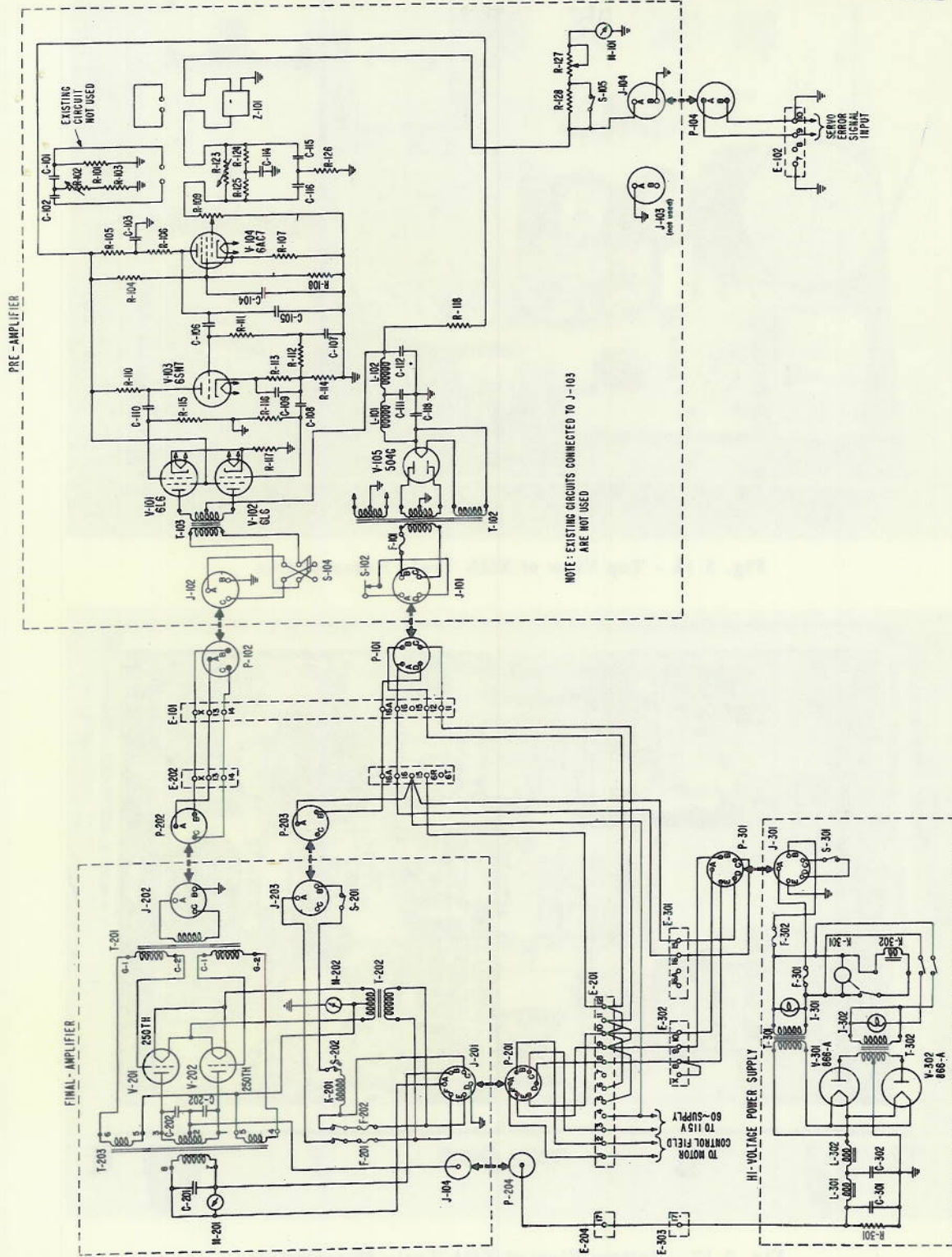


Fig. 5.15 - Schematic Diagram of Servo Control Amplifier

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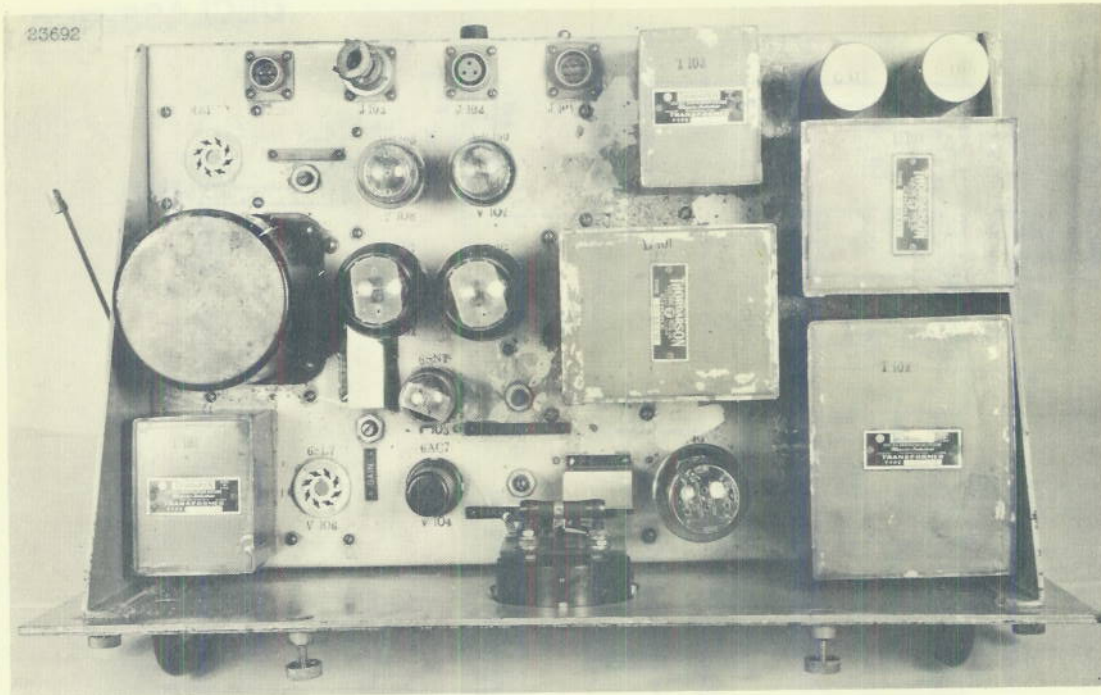


Fig. 5.16 - Top View of XHA Train Preamplifier

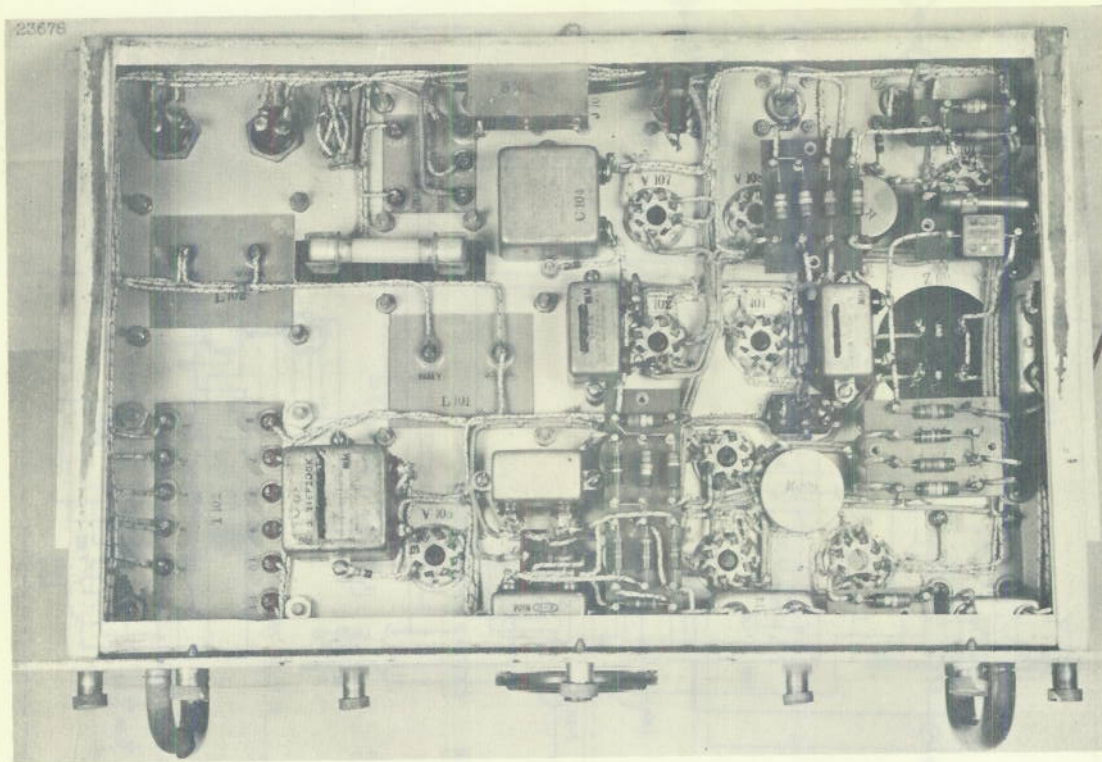


Fig. 5.17 - Bottom View of XHA Train Preamplifier

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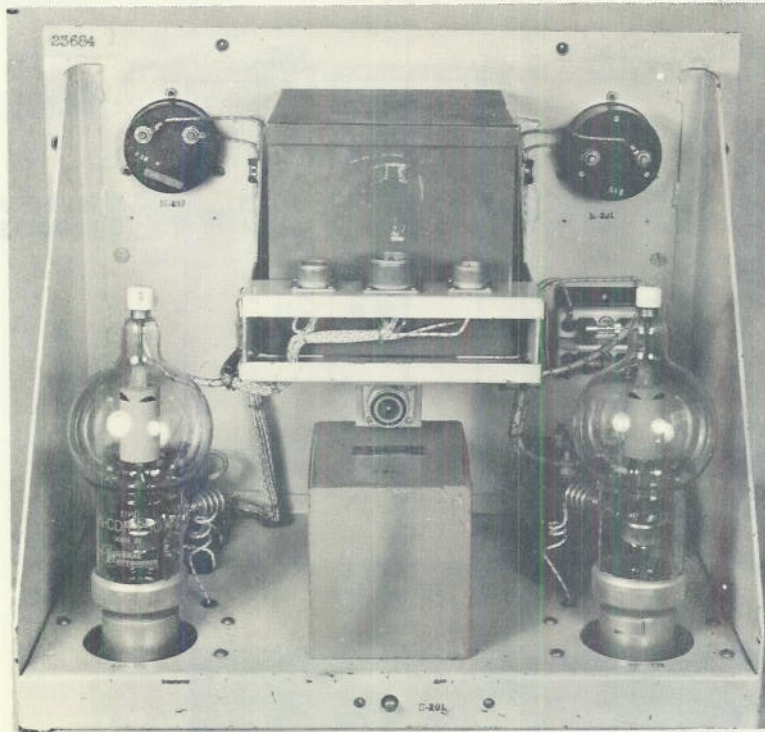


Fig. 5.18 - XHA Train Power Amplifier

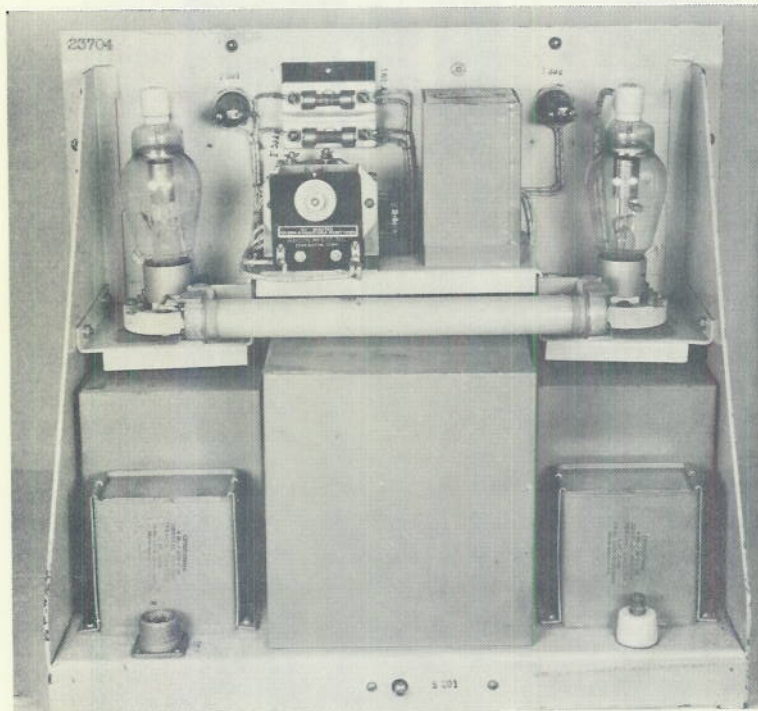


Fig. 5.19 - XHA Train Power Supply

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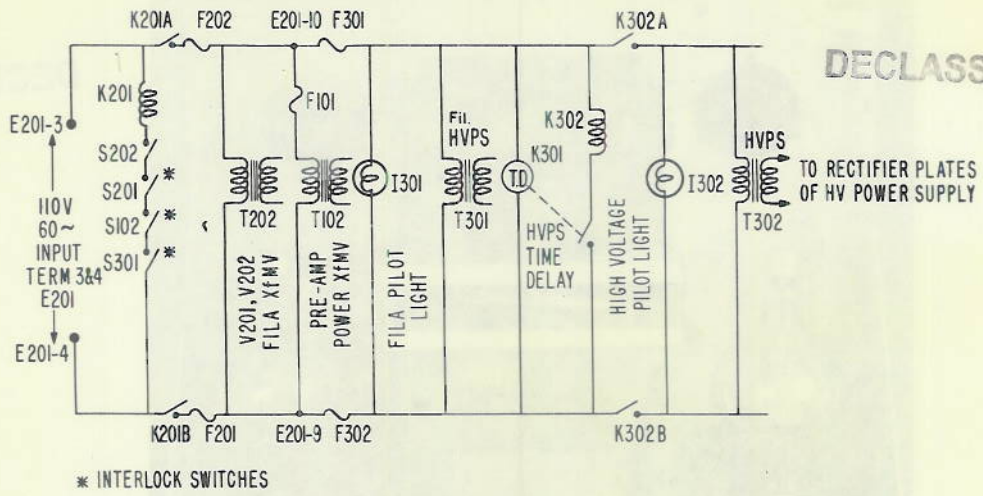


Fig. 5.20 - Schematic Diagram of Power Distribution for Servo Amplifier

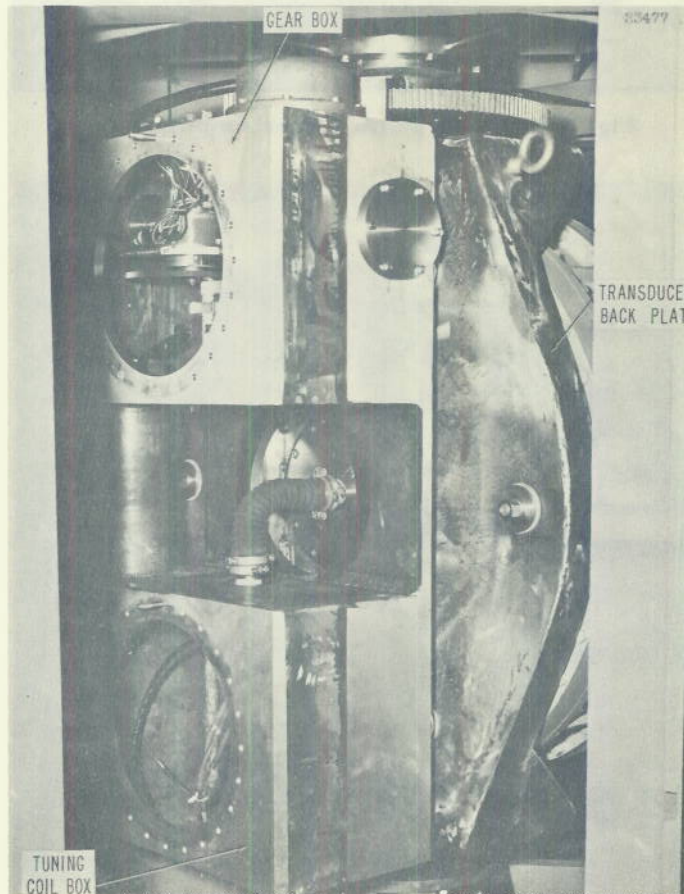


Fig. 5.21 - Rear Left-Quarter View of Transducer Training Mechanism

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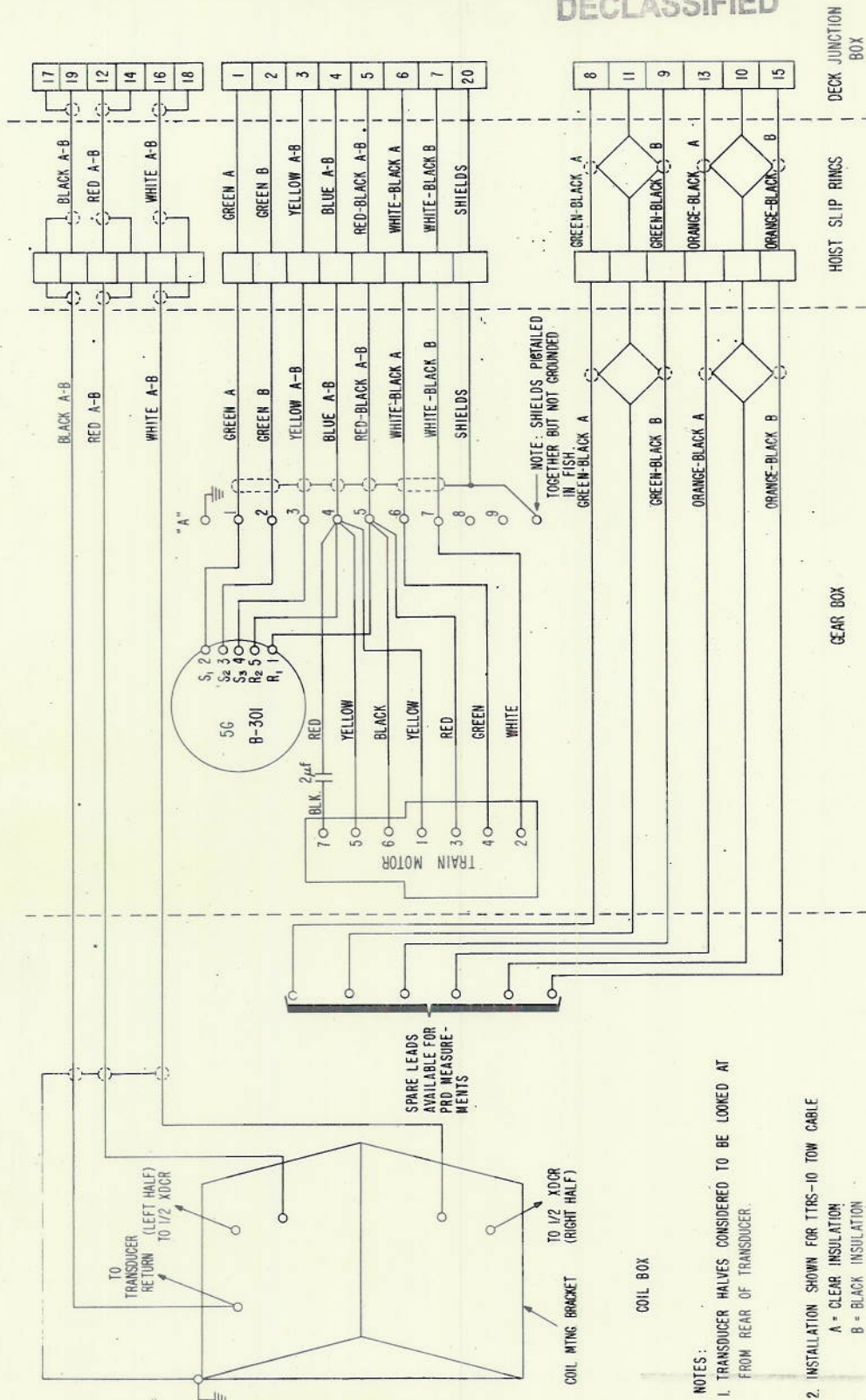


Fig. 5.22 - Wiring Diagram of XHA Fish

- NOTES:
1. TRANSUDCER HALVES CONSIDERED TO BE LOOKED AT FROM REAR OF TRANSUDCER.
  2. INSTALLATION SHOWN FOR TTRS-10 TOW CABLE  
A - CLEAR INSULATION  
B - BLACK INSULATION

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Wiring diagram of control equipment - see page 1



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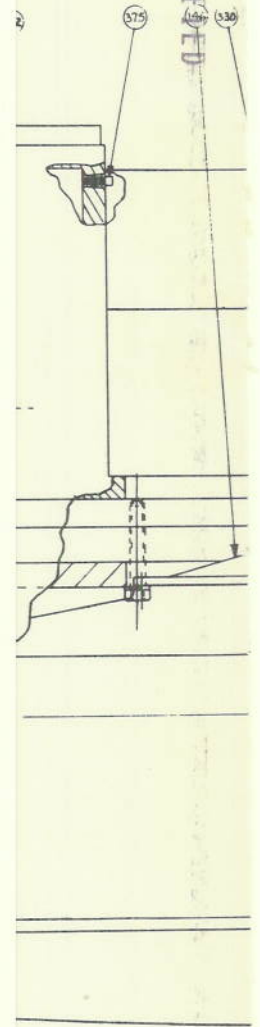
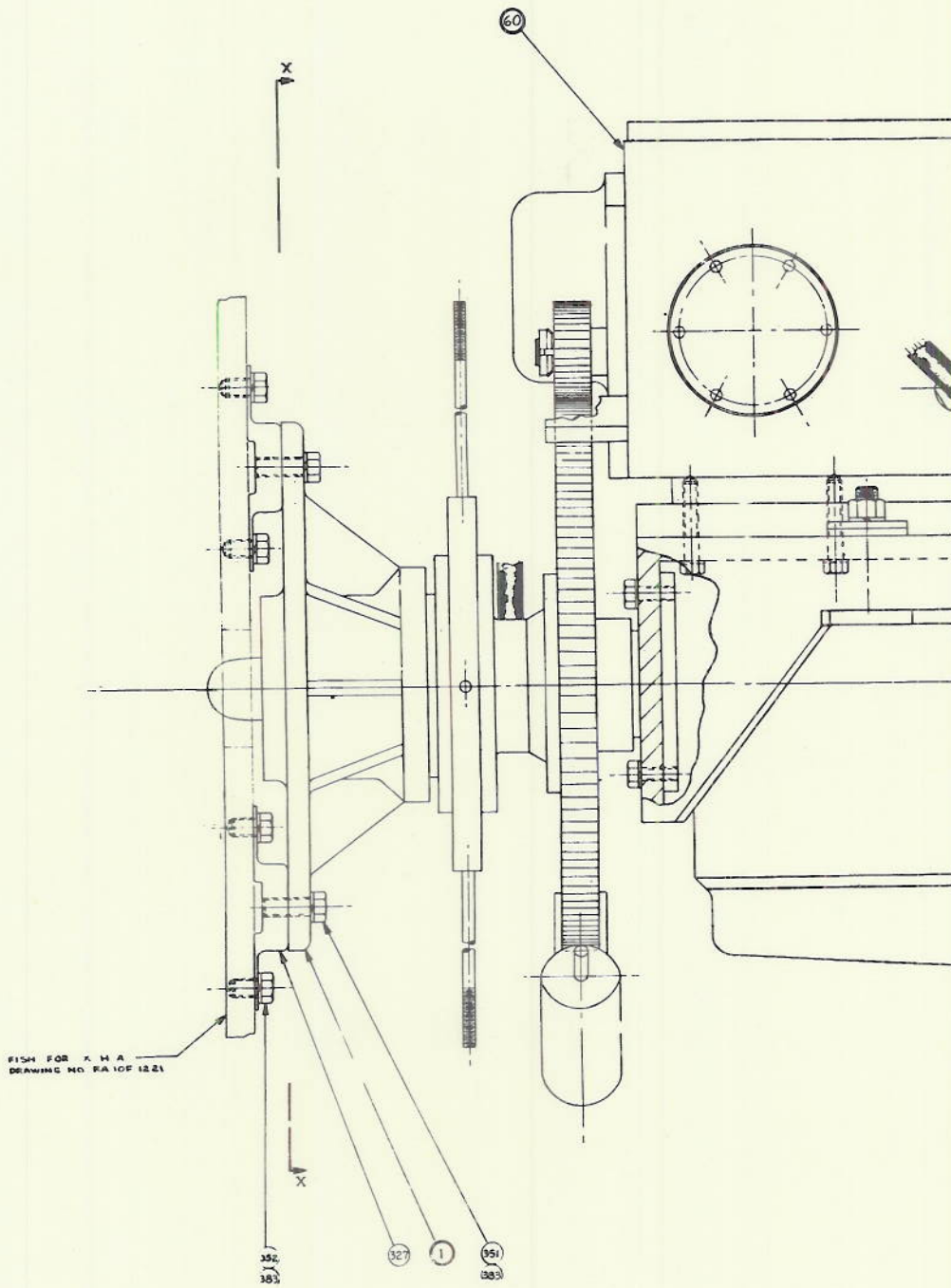


Fig 3 - Side View of T

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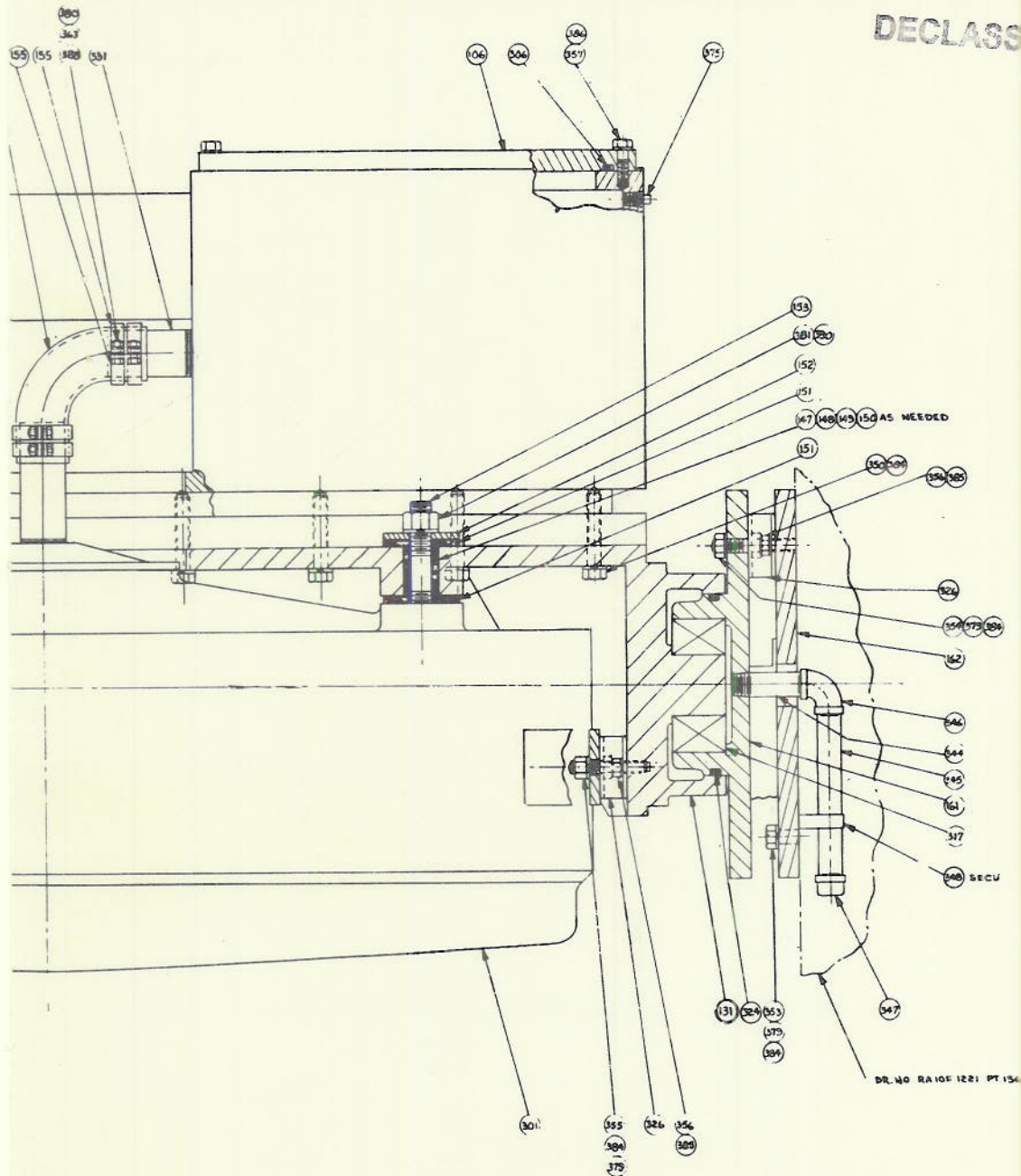
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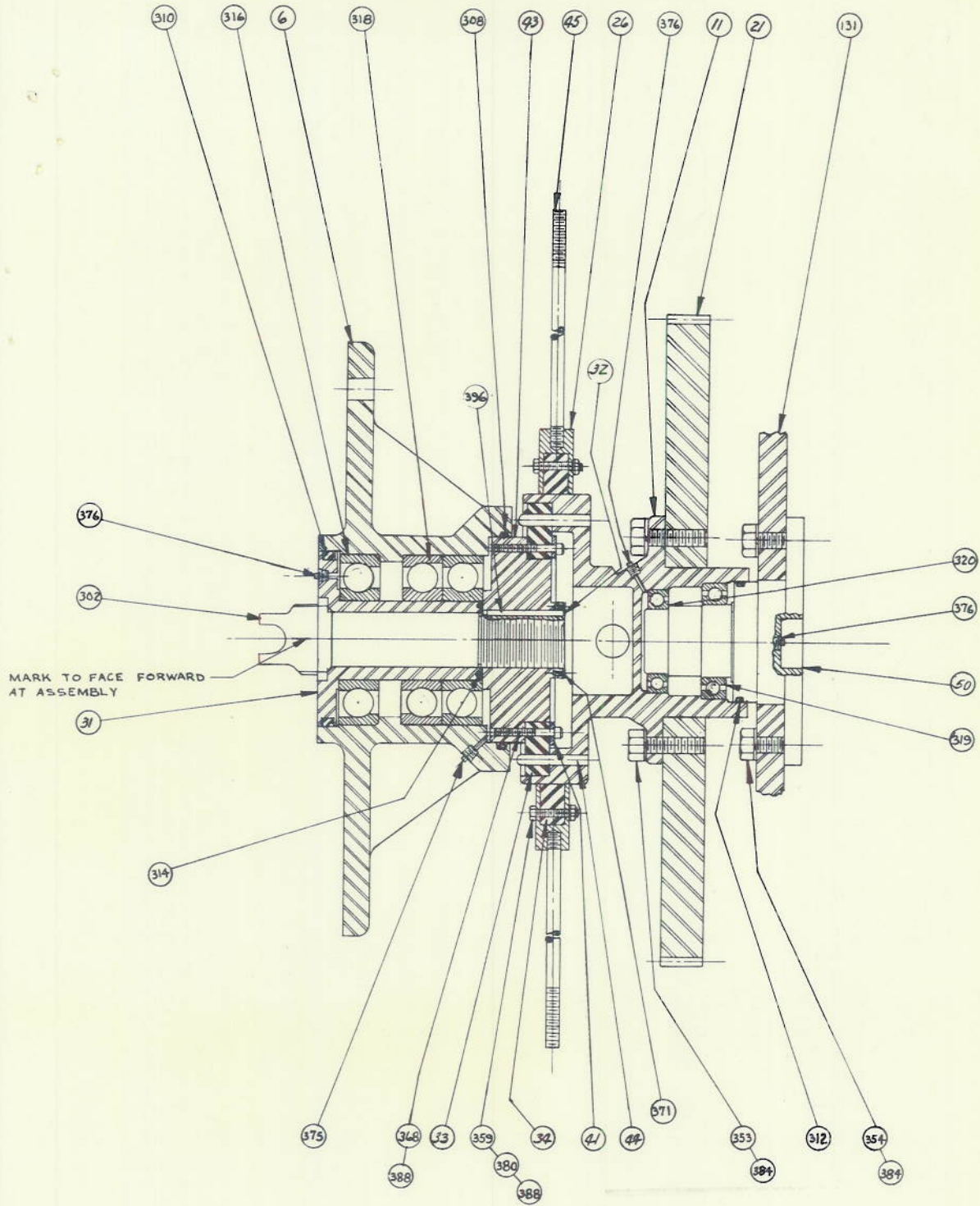


Fig. 5.24 - Swivel-Link Assembly

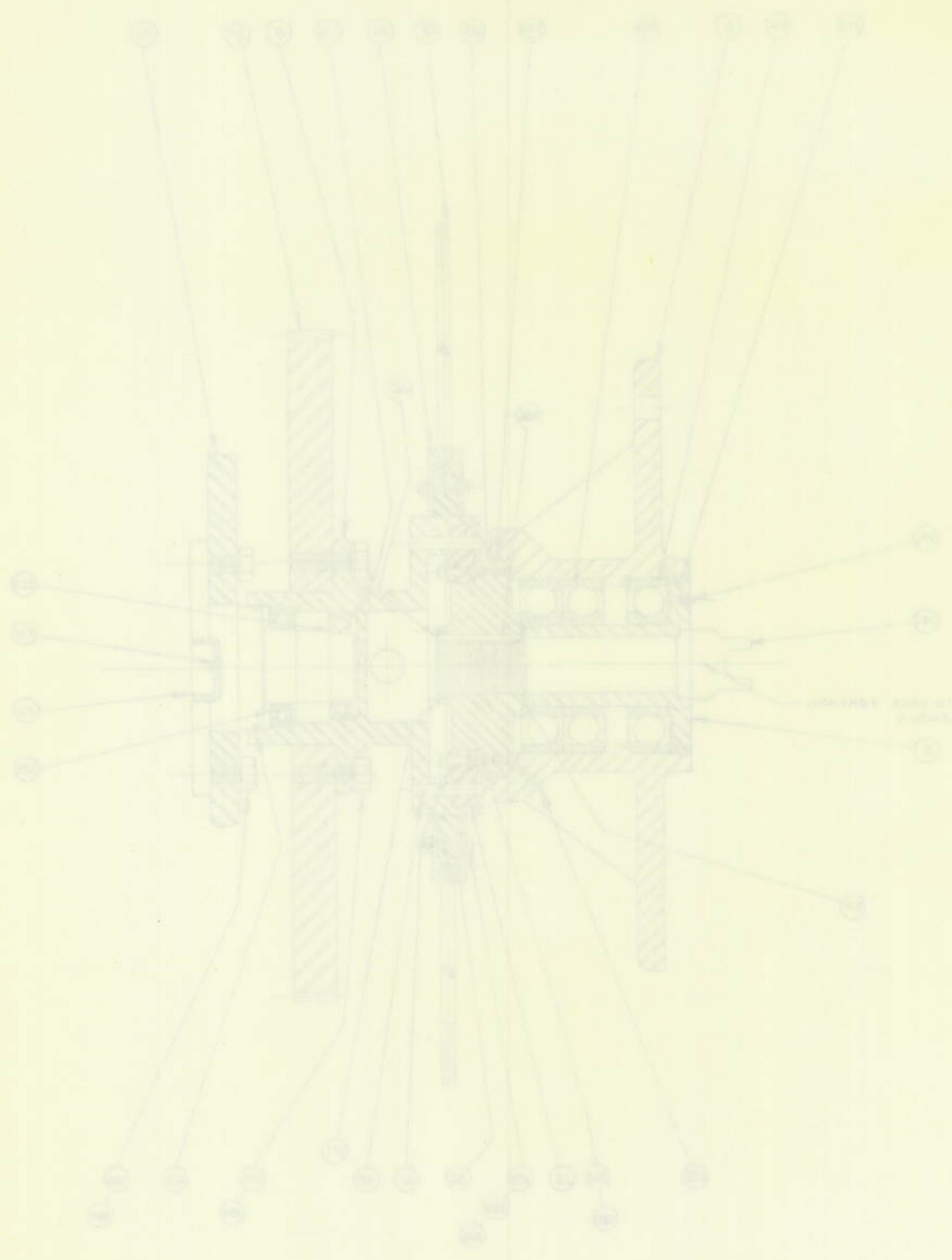
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Figure 1



INDICATE END OF SHAFT  
WELD TO CASE

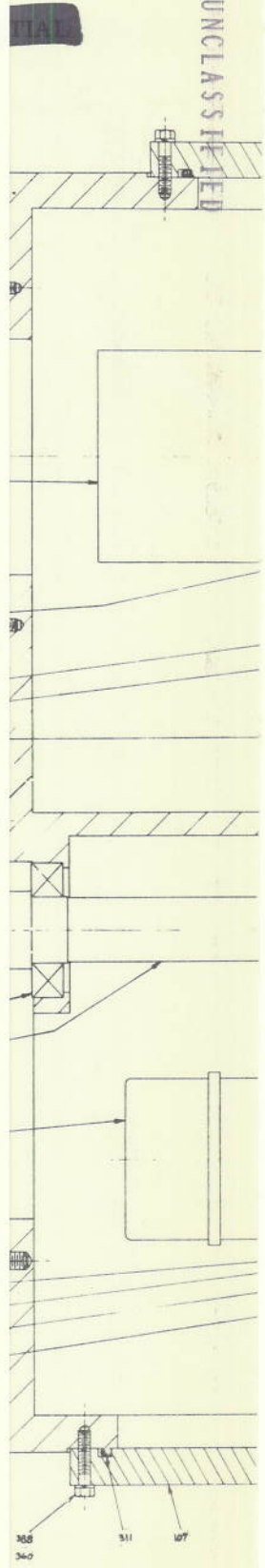
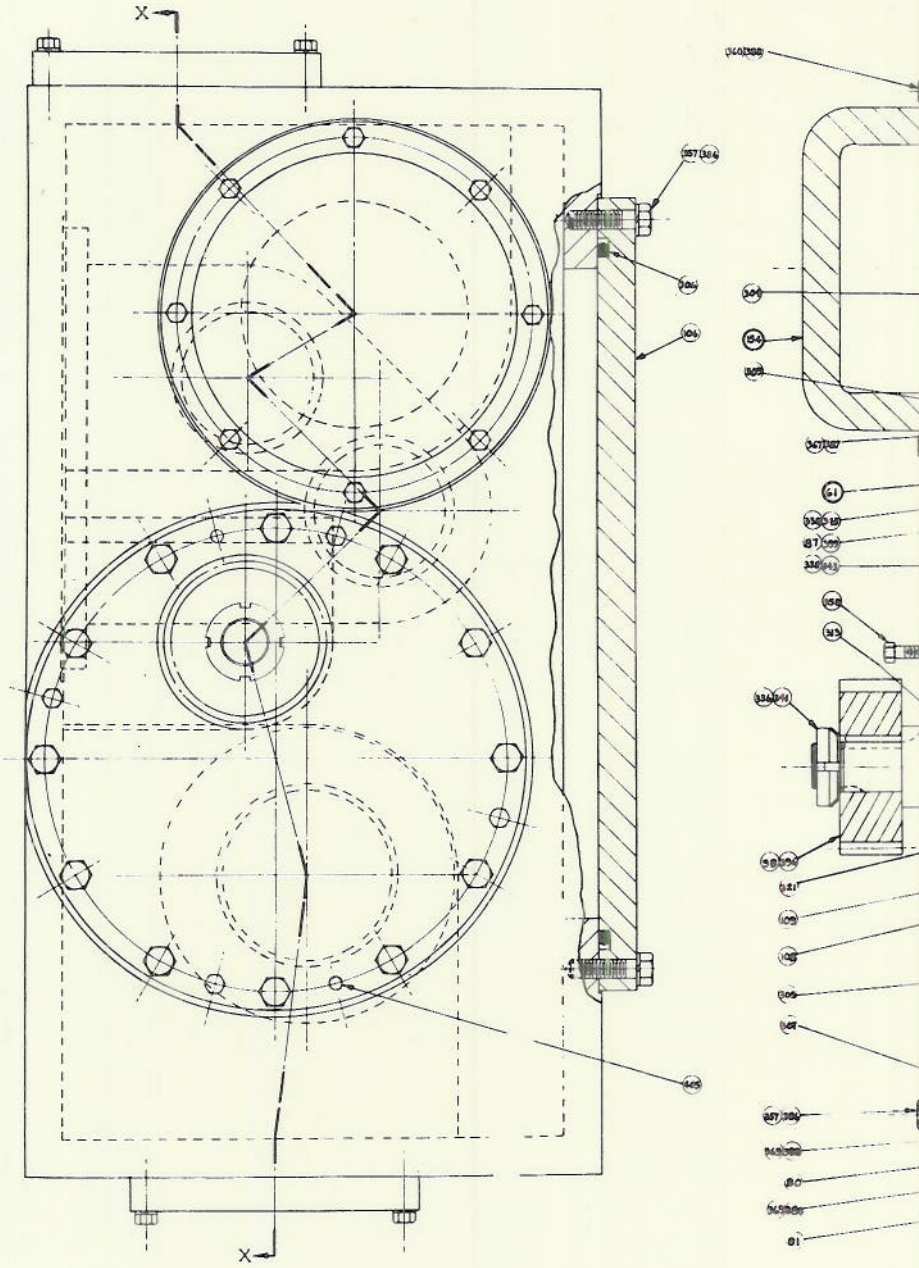
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Fig. 1 - Detail of Turbine Assembly

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Fig. 5.25 - Gear Box Assembly

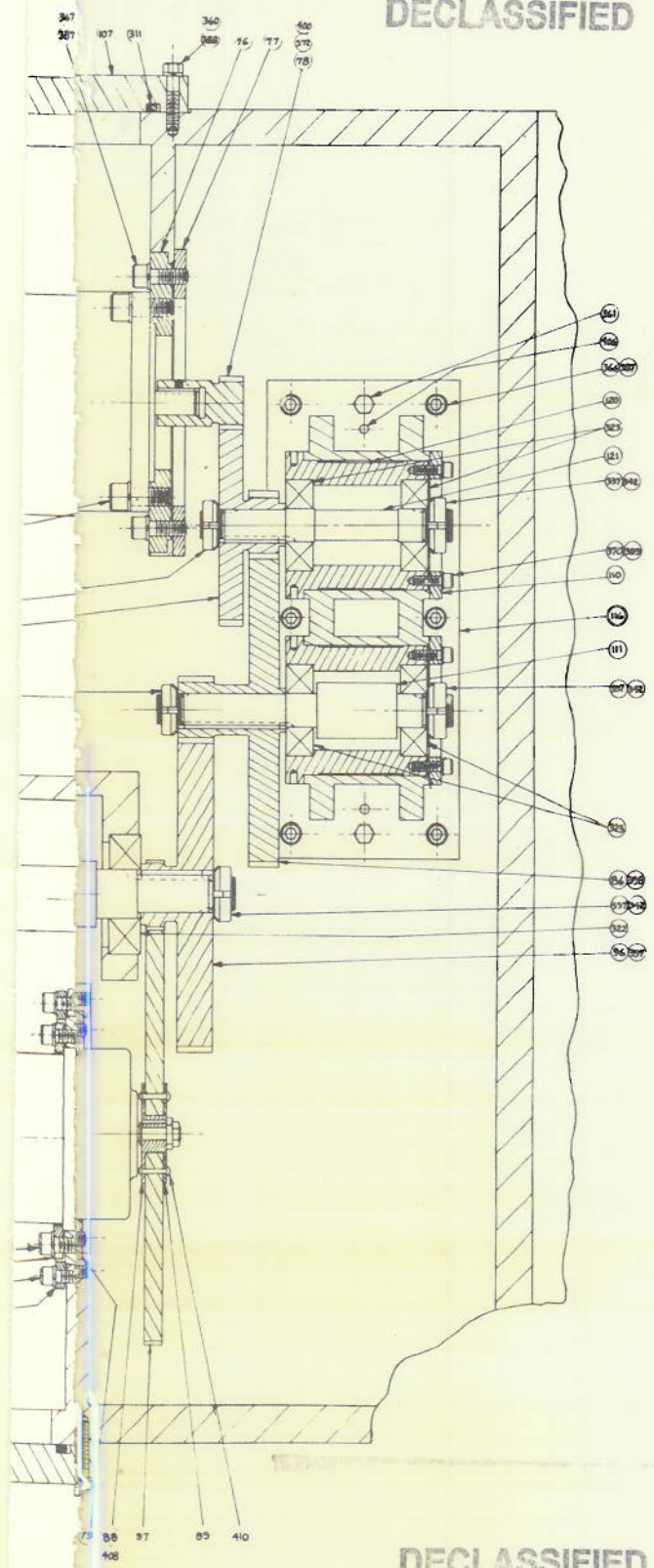
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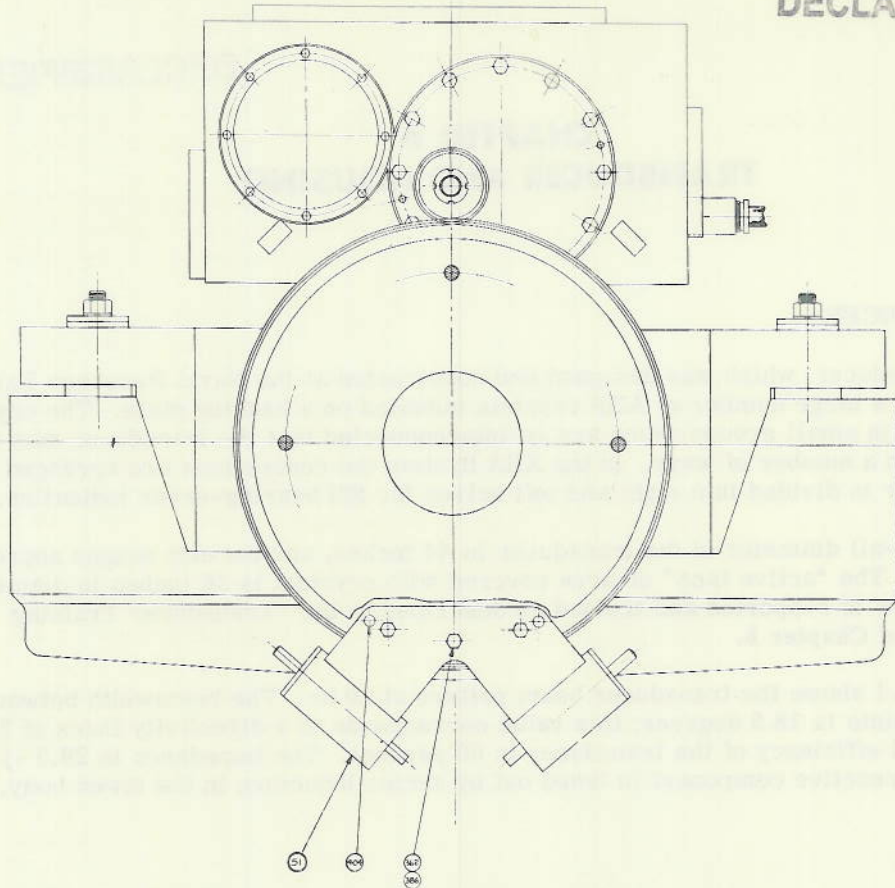


Fig. 5.26 - Top View of Train Assembly

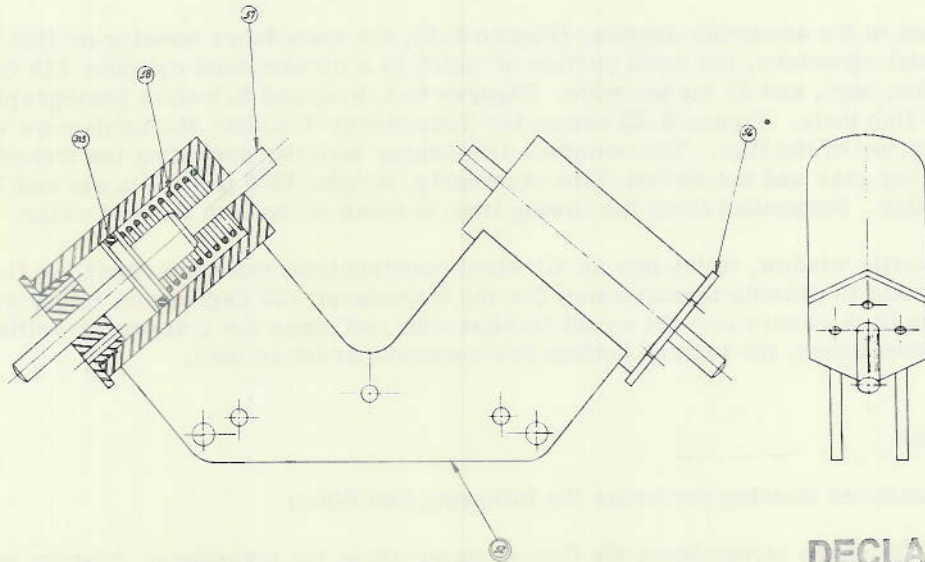


Fig. 5.27 - Plunger-Stop Assembly

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## CHAPTER 6 TRANSDUCER AND HOUSING

### 1. TRANSDUCER

The transducer, which was designed and constructed at the Naval Research Laboratory, is made up of a large number of ADP crystals mounted on a backing plate. The crystals are arranged in small groups which are so interconnected that the transducer may be "split" electrically in a number of ways. In the XHA System the connections are arranged so that the transducer is divided into right and left halves for SSI bearing-error indication.

The over-all diameter of the transducer is 44 inches, and the unit weighs approximately 1700 pounds. The "active face" or area covered with crystals is 36 inches in diameter. The transducer is supported and trained as described in the "Transducer Training Mechanism" of Chapter 5.

Figure 6.1 shows the transducer beam pattern at 10 kc. The beamwidth between the 10 db down points is 18.5 degrees; this value corresponds to a directivity index of 25 db. The electrical efficiency of the transducer is 60 percent. The impedance is  $28.5 - j 110$  ohms, however, the reactive component is tuned out by series inductors in the towed body.

### 2. HOUSING

#### Description

As shown in the assembly drawing (Figure 6.2), the transducer housing or fish body is an all-metal structure, the main portion of which is a streamlined cylinder 115 inches long, 72 inches high, and 46 inches wide. Figures 6.3, 6.4, and 6.5 show photographic views of the fish body. Figure 5.22 shows the Transducer Training Mechanism as viewed from the interior of the fish. The complete transducer housing, including the transducer and its training gear and the Swivel-Link-Assembly, weighs 9200 pounds in air and 7800 pounds in water. Suspended from the towing link, it balances in both air and water.

The acoustic window, which has an all-steel construction, extends around the fish body sufficiently to provide transparency for the transducer 120 degrees on either side of the bow. The back covers are not sound transparent, and since the transducer neither elevates or depresses, the top and bottom are nontransparent as well.

#### Functions

The transducer housing performs the following functions:

- (a) Its shape streamlines the flow of water about the transducer, thereby reducing water noises due to cavitation and eddying,

- (b) It provides mechanical protection for the transducer and supports the weight of the transducer and its training gear,
- (c) Being free-flooding, it provides a body of still water immediately adjacent to the transducer.

The towed body free-floods upon immersion and evacuates upon removal from the water. This is accomplished by gravity flow; the water passes through a vertical series of 2-inch-diameter holes located in the back covers of the body.

#### Hydrodynamic Characteristics

The horizontal longitudinal contours of the fish body conform to the EPH (Ellipse, Parabola, Hyperbola) shape which was developed by the David Taylor Model Basin (DTMB) to take advantage of the high cavitating speed of the ellipse and the low resistance and reduced eddying of a streamlined form. Within the towing speeds designated by the Bureau of Ships for the operation of this equipment, hydrodynamic noises are expected to be negligible.

The size of the stabilizing (tail) surfaces of the fish body and their location in relation to the tow point were established by towing tests conducted on a one-quarter scale model in the towing basin of DTMB. Satisfactory stability in tow should be realized over a speed range of 0 to 20 knots. It was also estimated by DTMB that the towed body, when operating with an articulate towline,\* will tow no higher at 15 knots than the AN/SQS-6(XN-1) body will tow at 22 knots.

#### Construction

To facilitate maintenance and repair work, the fish body<sup>†</sup> was assembled from several subassemblies, and the transducer and its training gear were integrally housed in the streamlined cylinder which constitutes the basic unit. Each of the other units of the fish body can be removed from the basic unit without affecting the integrity of the training system.

The streamlined cylinder is the load-bearing portion of the fish body. It consists of a framework of truss structures welded to each other and to flanges at both top and bottom. To form the sound-transparent window, a stainless steel sheet, 0.040-inch thick, is spot welded to a 0.125-inch-thick plate which has been perforated with 2-inch-square holes. This window is welded to the trusses. Completing the cylinder are three back access doors fastened to the body by machine screws.

The bottom cover of the cylinder is a one-piece steel weldment which is bolted to the cylinder at four points.

The top cover of the cylinder is made in three parts—each a steel weldment. The fore and aft covers are secured to the cylinder with only two bolts each. However, the middle cover is made part of the Swivel-Link Assembly and, in addition, carries the full load of the complete fish body. It is fastened to the cylinder by a number of bolts sufficient to withstand the calculated loads.

\*Developed at the Woods Hole Oceanographic Institute, Woods Hole, Massachusetts

<sup>†</sup>The fish body was manufactured in accordance with NRL Drawing No. RA 10F 1221, "XHA FISH." The details of the construction can be obtained from these drawings

The stabilizing surfaces of the fish body are all-aluminum weldments of bars shaped to the airfoil section and covered with a 1/16-inch aluminum sheet which is riveted to the bars. Pipe of the same metal extends to meet the steel pipe of the cylinder, and the two are held together by a stainless steel coupling. The ends of the aluminum pipe are "Hardcoated" to prevent contact corrosion with the steel.

### Maintenance

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Since the sound-transparent window of the fish body is made of stainless steel sheet, all repairs to it should be made in accordance with the instructions for repair of stainless steel domes as given in the Sonar Bulletin.

The fish body is completely covered, both inside and outside, with a new vinyl anti-fouling paint. If it is necessary to repaint all or any portion of the fish body, the following material should be obtained:

Item No.	Nomenclature	Specification No.
1	Pretreatment Coating	Mil - C - 15328A
2	Vinyl Zinc Chromate Primer	Mil - P - 15930 (Ships)
3	Vinyl Red Antifouling Paint	Mil - P - 15931A
4	Ethyl or Isopropyl Alcohol	
5	Methyl Isobutyl Ketone	

The metal surfaces to be painted should first be cleaned by sandblasting. (The pressure used in this operation should be low so that the sheet metal of the window or the stabilizing surfaces will not be distorted).

Prior to use, stir one part of diluent into four parts of Pretreatment Coating. This diluent is not a thinner; if it is necessary to thin the coating, add item 4. Now apply one very thin coat (approximately 0.3 mil thick) of item 1 to the prepared surface.

Apply two coats of item 2. The total thickness of the two coats should be approximately 5 mils.

Apply two coats of item 3. The total thickness of the two coats should be approximately 5 mils.

The thinner for items 2 and 3, if required, is item 5. The drying time between coats is 30 minutes.

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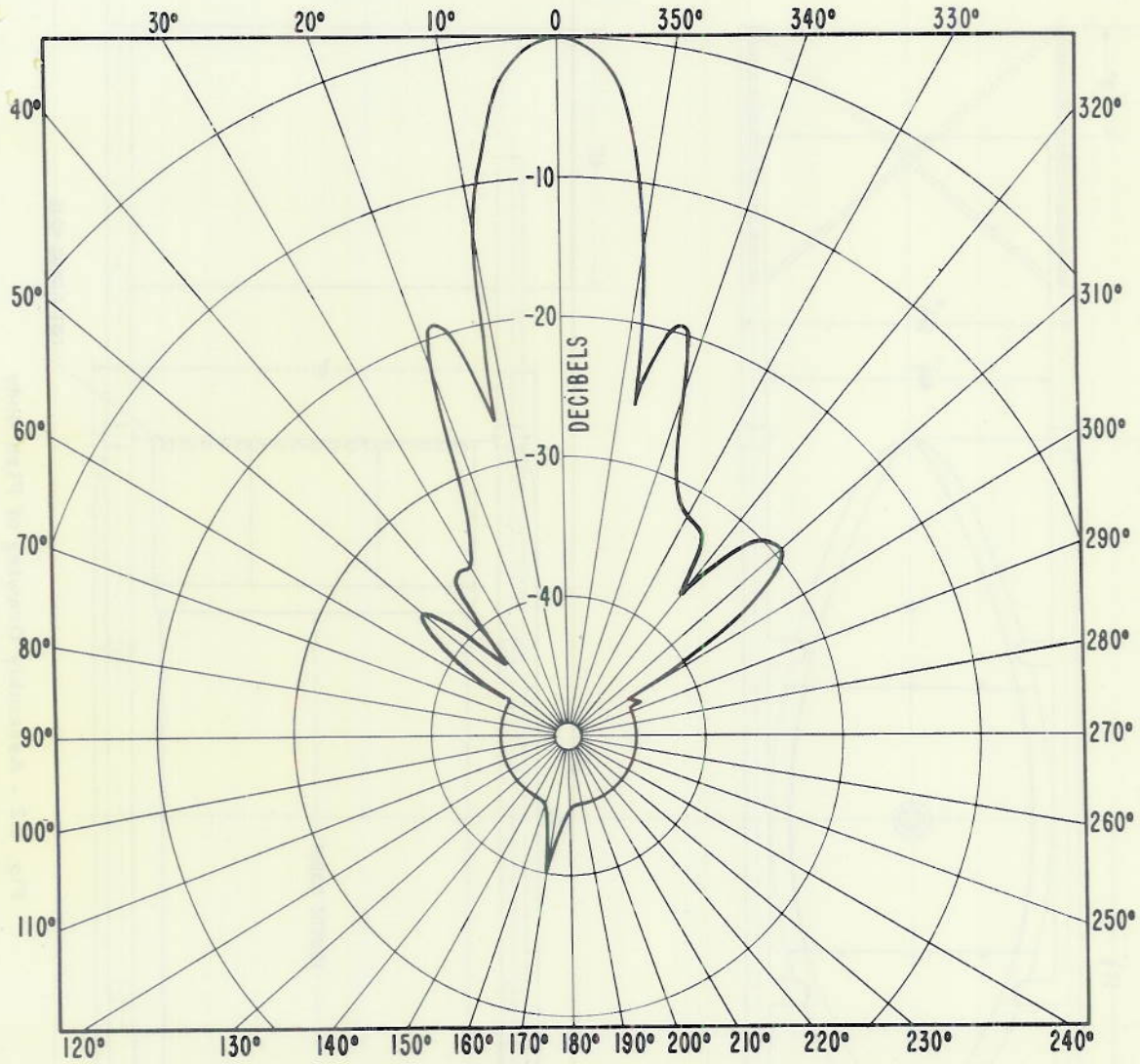


Fig. 6.1 - Transducer Beam Pattern with All Sections Paralleled

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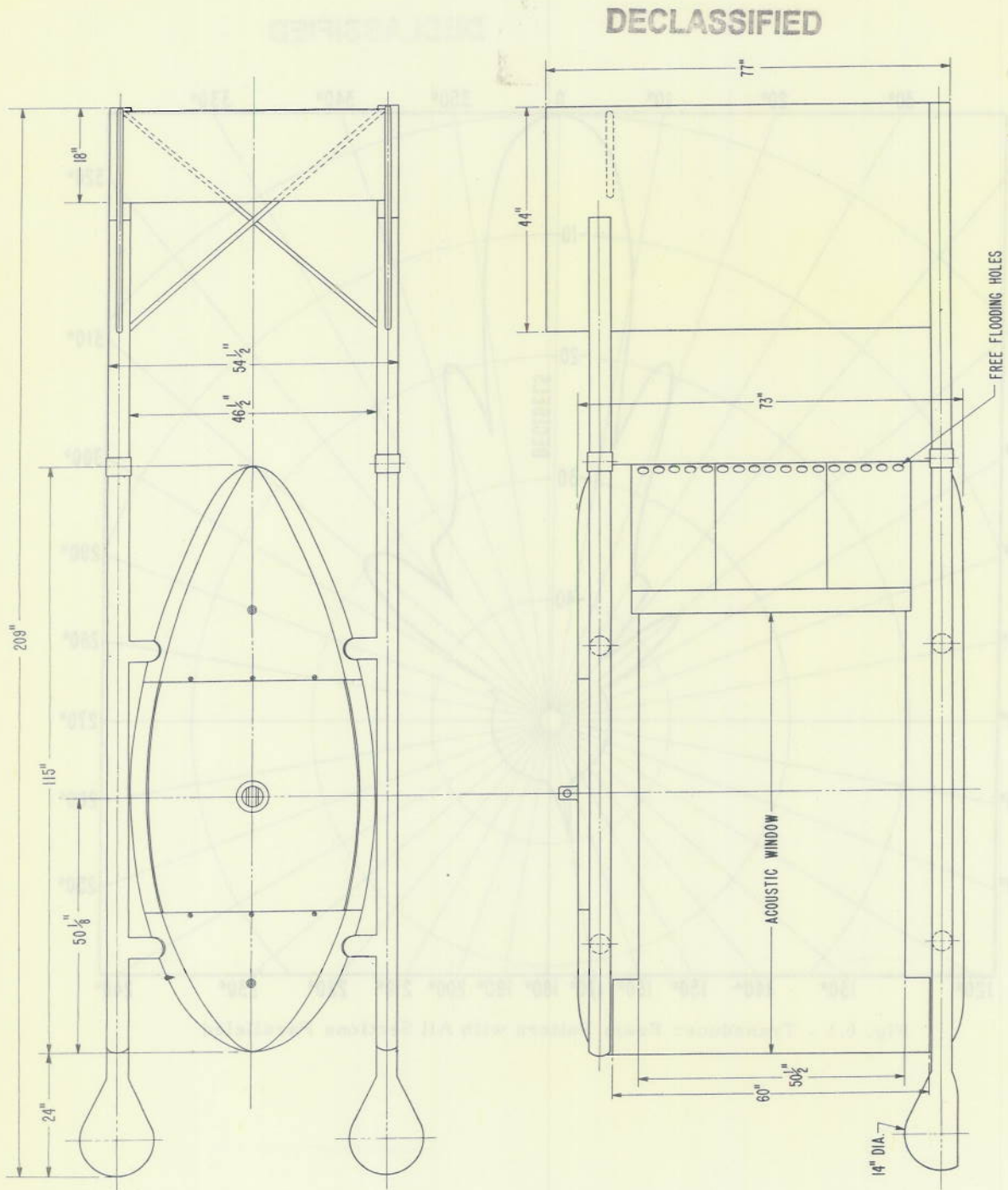


Fig. 6.2 - Assembly Drawing of Fish Body

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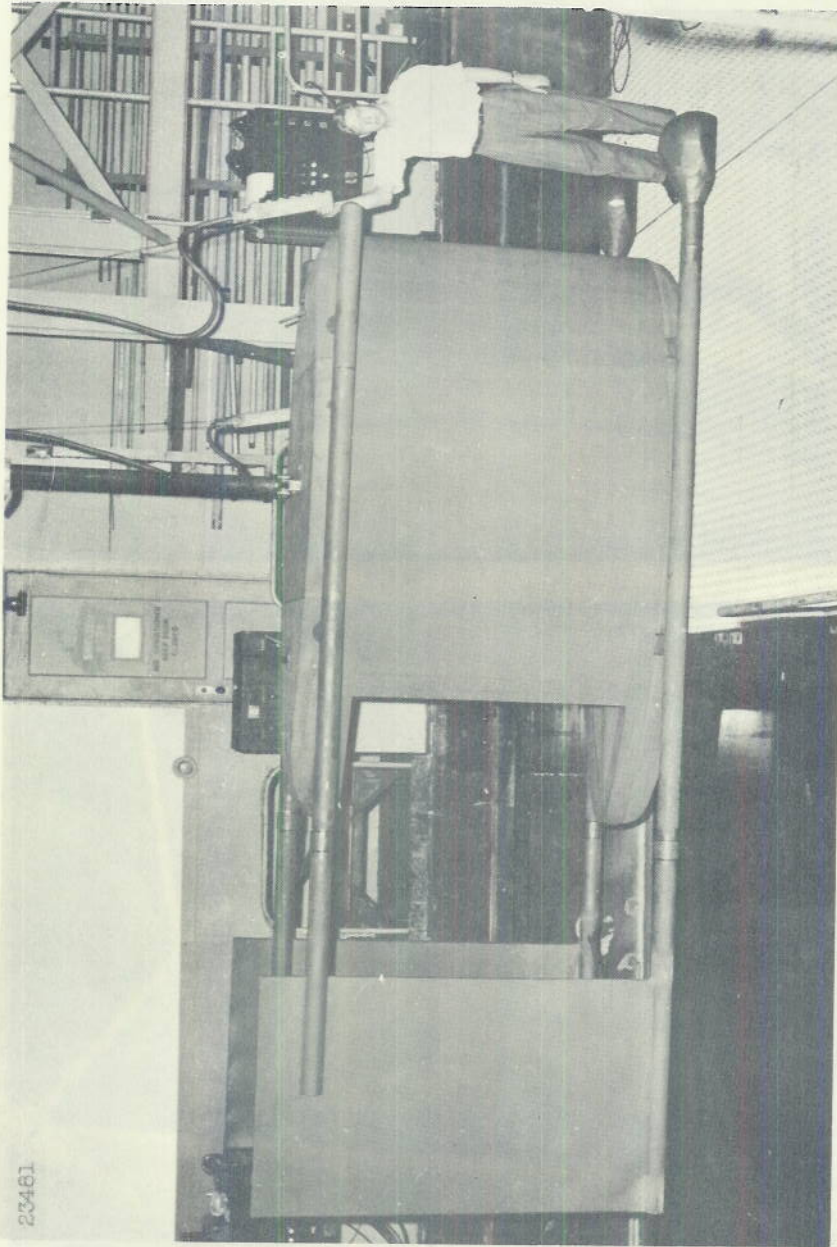


Fig. 6.3 - Side View of Fish Body with Access Covers Removed

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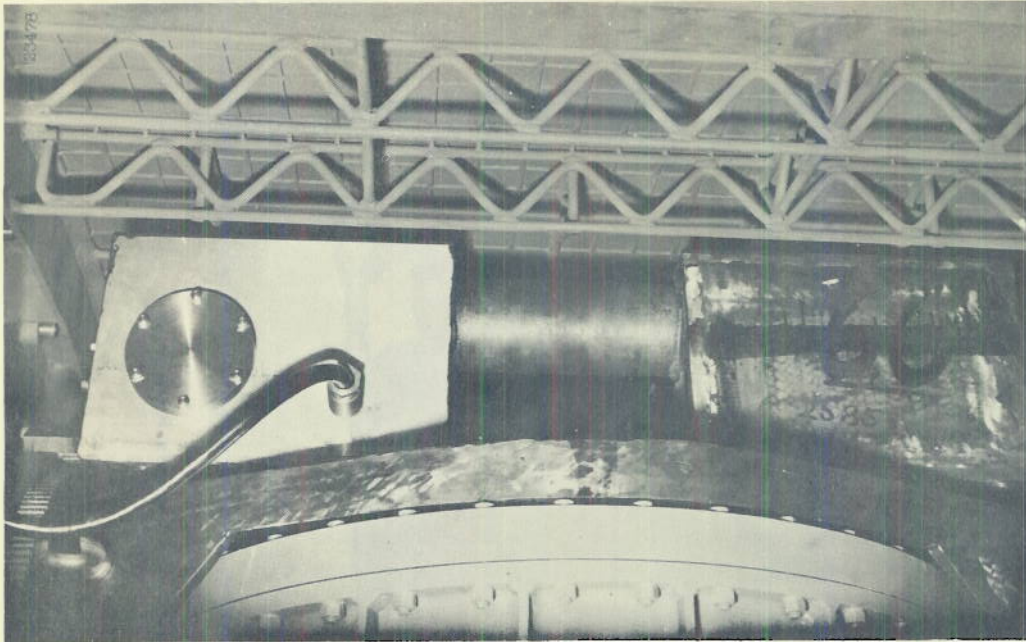


Fig. 6.5 - Fish Interior View Showing Truss Structure and Side of Transducer

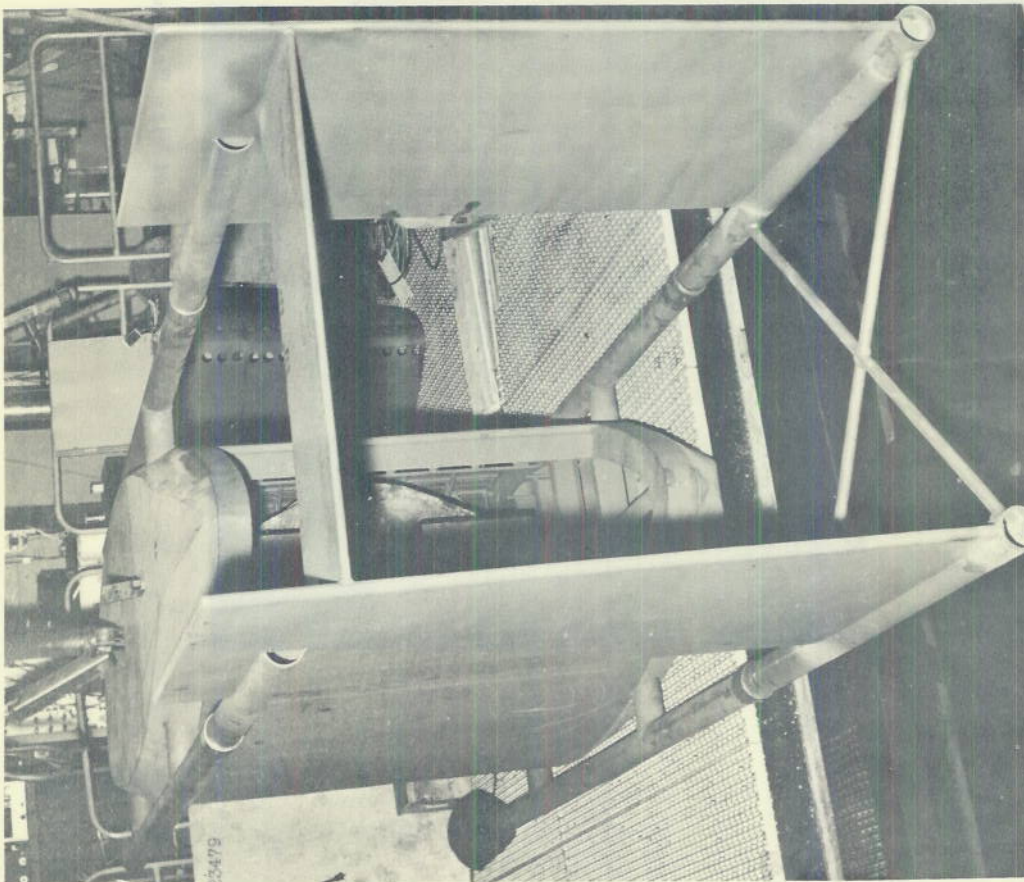


Fig. 6.4 - Rear Quarter View of Fish Body with Access Covers Removed