Broadcast Transmitter

Type 1-C

Output 1 Kilowatt

RCA Victor Company, Inc.
Camden, N. J., U. S. A.

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Broadcast Transmitter
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INSTRUCTIONS

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I. B. 5582

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TYPE 1-C BROADCAST TRANSMITTER

I. INTRODUCTION

In the RCA Victor Company's Type 1-C Broadcast Transmitter and associated apparatus, the experience of broadcast engineers, dating without interruption back to the beginning of radio broadcasting has been utilized. The research achievements of the RCA Victor Company and its Associated Manufacturing Companies, have contributed liberally to many distinctive features of design that are new. As a link in the process of broadcasting information and entertainment from its source to the listener, the Type 1-C equipment will provide outstanding service. The instructive information contained in these following pages is intended to assist the technical staff in the operation and maintenance of the radio plant.

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II. GENERAL INFORMATION

The nature of broadcast service is such that it demands that equipment be reliable and simple in operation, flexible and accessible. The 1-C transmitter has been designed with this in view.

Sufficient indicating devices are provided to assure ease of operation. All of the equipment giving access to dangerous voltages is protected by adequate interlock devices. The equipment is also protected against damage resulting from failure during operation of any power device, or through improper handling.

The proper sequence in starting and stopping is automatically fixed, a full automatic interlocked single push-button starting system being provided.

1. RATING

This Type 1-C Broadcast Transmitter has a nominal output rating of one kilowatt. It is well to observe, here, that in accordance with conventional form, when specifying this rating, no account is taken with regard to the degree of modulation. This rating of one kilowatt is the measure of unmodulated carrier wave only. When modulated 100%, however, the instantaneous peak output reaches four kilowatts. Tube capacity and circuit design are provided to permit continuous operation at full 100% modulation.

2. FREQUENCY RANGE

The Type 1-C Broadcast equipment can be adjusted for maximum performance and efficiency on any frequency within the broadcast band ranging from 1500 to 550 kilocycles. Crystals are supplied for one assigned frequency only and a change of frequency necessitates a change of crystals by the factory.

3. POWER SUPPLY

The 1-C Transmitter is designed to operate from a 220 volt, 3 phase, 3 wire, 60 cycle power supply. With regard to power supply regulation, it is advisable to operate from a well regulated power line. A supply in which the line voltage variations exceed plus or minus five percent is considered unsuitable for broadcast transmitter supply service, and requires some form of automatic regulating equipment. The use of additional voltage regulating equipment is not desirable and should be avoided in so far as possible, by proper line construction.

4. VACUUM TUBES

One set of Radiotrons for this transmitter consists of the following types and quantities:-

Quantity	Type	
2	UX-210	
4	UX-865	See Instruction Leaflet furnished with
3	UX-860	Radiotrons for data
2	UX-866	on the various types
1	UV-203-A	here listed.
1	UV-849	
2	UX-280	
1	UV-1652	

The position of these various types of vacuum tubes in the general scheme of the transmitter is as shown in Fig. 1.

5. TYPE OF CIRCUIT

Refer to circuit diagram in Appendix A, for schematic representation of circuits.

The carrier frequency is generated by a crystal controlled master oscillator, amplified by five successive stages of radio frequency power amplification, and delivered to the antenna through a transmission line. Audio frequency, i.e., the modulating frequency passes through one stage of power amplification, to the modulating circuit. Modulation takes place in the fourth radio frequency stage. The succeeding radio frequency power amplifier acts as a linear amplifier. Such a system of modulating is, by convention, called low level modulation.

The power supply for operating the radio system is primarily a fully automatic and interlocked system, but provision is made for interrupting the sequence of starting for test or adjustment purposes at several points. Some of the features of the control system are water pressure actuated device, temperature

indicators, visual control indicators, overload protection with both manual and remote electrical reset, filament and bias undervoltage interlocks, water under pressure and excessive temperature interlocks together with proper sequential starting and stopping of cooling water, filament, bias and plate voltage.

6. FREQUENCY CONTROL

The most refined practical methods of carrier frequency control known at the present time have been utilized in the Type 1-C Transmitter, which will provide exceptionally accurate carrier frequency stability. Means are provided for maintaining the mean carrier frequency of the transmitter to within plus or minus fifty cycles, of the assigned value.

There are two separate duplicate crystal controlled master oscillators, each associated with two screen grid buffer amplifiers. These are built into compact units with essential meters and controls in view and are accessible from the front of the transmitter panel. In order to insure permanent and reliable adjustment, the internal parts of the units are completely enclosed in metal shields. The tubes can be readily removed for replacement purposes by withdrawing the units from the front panel. These two units are capable of instantaneous switching from the front panel of the transmitter so that either can be used at a moment's notice.

7. METHOD OF POWER CONTROL

Power is taken from a 220 volt, 60 cycle, 3-phase source. This supply operates all control circuits, all rotating equipment including pump, filament motor-generator and plate motor-generator driving motors, and crystal oscillator supply rectifier. A 110 volt single phase lighting circuit supplies the crystal heater power. An optional battery filament supply to the speech amplifier may be used if desired.

8. PROTECTIVE DEVICES

The various devices used for safety of the operating personnel and protection of the apparatus, include the following:-

Water pressure gauge and interlock, which prevent injury because of water failure.

Water temperature or thermostatic cut-out which protects against excessive operating temperature.

Filament undervoltage relay.

Bias undervoltage relay.

Overload circuit breaker with manual and electrical reset.

Sequence interlocks which protect each successive operation in either starting or stopping.

Thermal overload relays in each motor-generator driving motor circuit.

Fuses in main and all branch circuits.

Disconnect switches in various plate supply leads.

Automatic high voltage disconnect and neutralizing changeover switch.

Switches on all doors which remove bias and plate voltages, thus protecting operating personnel from accidental contact with dangerous voltages.

Visual indicators as a guide to all important circuit conditions.

Sequence interrupting switches which provide manual control of successive stages of operation for test and adjustment purposes.

9. ANTENNA COUPLING

A two wire transmission line is used for coupling the antenna to the power amplifier. This provides an efficient coupling between the transmitter output stage and antenna when the antenna is remotely located. Remote location is quite desirable for many reasons. When properly terminated and adjusted radiation from a transmission line is negligible and the efficiency of transfer is very high. In addition through proper design, radio frequency harmonic suppression is accomplished.

10. AUDIO FREQUENCY CHARACTERISTICS

The audio frequency response curve, from audio input terminals to speech amplifier through the transmitter and into the antenna, as measured by rectified antenna current methods, is substantially flat. By substantially flat, is meant that this frequency response curve will not vary more than plus or minus 2 DB, from a straight line between 30 and 10,000 cycles, or more than plus or minus ½ DB, between 100 and 5000 cycles.

11. MODULATION

The Type 1-C Transmitter employs what is known as "low level" modulation. This is in contrast with the "high level" system used in older types of equipment in which the audio frequency power was amplified sufficient in magnitude to modulate the output R.F. amplifier by the constant current method.

In a low level modulation system, the audio circuits are simple, and with respect to main-

tenance and tube costs, quite economical compared to "high level" modulation. By this "low level" system, the radio system is modulated in one of the low power stages where 100% modulation of the transmitter output can be obtained.

A 100% modulation system has a great many advantages over the older type when only 30 to 50% modulation was obtained, by reason of the fact that the peak output in the former case reaches 400% of normal carrier output, where as, the peak output for 50% modulation, as in the latter case, would be but 225% or less of carrier output.

Thus, the average output from a 100% modulated transmitter is considerably greater than the average output of transmitters operating at lower percentages of modulation. Naturally, this increased output of power into the antenna gives a greater range of usefulness to the station, greater area of coverage, and a greater ratio of signal to interference level.

12. FILAMENT-PLATE POWER SUPPLY

Power for filament and plate circuits is derived from two motor-generator units, one of which provides filament and bias supply to all stages, the other, a high voltage motor-generator set, consists of two duplicate double commutator 3000 volt generators, each insulated for 6000 volts, connected in series. This last unit supplies plate and screen grid potentials at voltage up to 6000 volts. A 550 volt exciter machine furnished as a part of the filament motor-generator set, provides field excitation for all machines as well as bias voltage for all stages except speech amplifier and crystal oscillator units. Each of these machines is specially designed and constructed to reduce commutator ripple to a minimum, and each output circuit is provided with an adequate filter circuit. For this type of transmitter where moderately high voltages only are employed, and when reliable low maintenance cost of power supply is required, the motor-generator set is the most suitable, from an operation point of view when flexibility of voltage control and various values of voltage are required for different amplifier stages. These various voltages are obtained directly from the machine without excessive potentiometer power loss which would be the case were high voltage rectifiers to be used, and where the regulation of the power source must be considered.

13. COOLING SYSTEM

The Power Amplifier tube requires water cooling. Approximately ten gallons per minute are circulated through the system, propelled by a motor driven centrifugal water pump. This cooling water is cooled by being circulated through a highly efficient copper radiator fitted with copper cooling fins through which air is blown by means of a fan affixed to the same motor shaft which drives the pump.

When not being circulated, the water partly drains into a fifteen gallon expansion tank which reduces the level of the water in the tube jacket, thus allowing the tube to be changed easily. A visual water flow indicator is provided, the return water being forced through a jet visible through glass windows in the indicator. The top of this tank is vented to relieve trapped air which collects in any circulating hot water system, and which is a constant source of danger to tube jackets if not relieved, since a bubble of trapped air circulating past the jacket may effectively cause localized heating with consequent tube damage. The dissipation rating of this cooling system is 4 kilowatts continuously. This unit is designed with a large factor of safety and will effectively cool the transmitter even though the set be operated in the most unfavorable climatic conditions, provided that the vacuum tube cooling unit is installed where it can obtain a good air supply.

14. STATION WIRING

Circuits for the radio transmitter are shown in Appendix A diagrams, in an essentially complete form for ready reference. These diagrams include complete individual panel wiring and a schematic diagram of the entire transmitter. An interconnection wiring or installation drawing is also provided.

Under the chapter of instructions covering the individual units, the connection diagrams are given in detail.

III. LIST OF COMPONENT UNITS AND BLOCK DIAGRAM

By reference to block diagram, Fig. 1, it can be seen that the complete transmitter consists of seven component parts as listed below.

(a) Power Control Unit. Type 1-C
(b) Exciter—Modulator Unit. Type OMA-2-B
(c) Broadcast Amplifier. Type A-1-C
(d) Water Cooling Unit. Type 1-C
(e) Antenna Coupling and Tuning Unit. Type 1-C
(f) High Voltage Motor-generator Set.
(g) Filament and Bias Motor-generator Set.

These units will be considered separately in the following chapters.

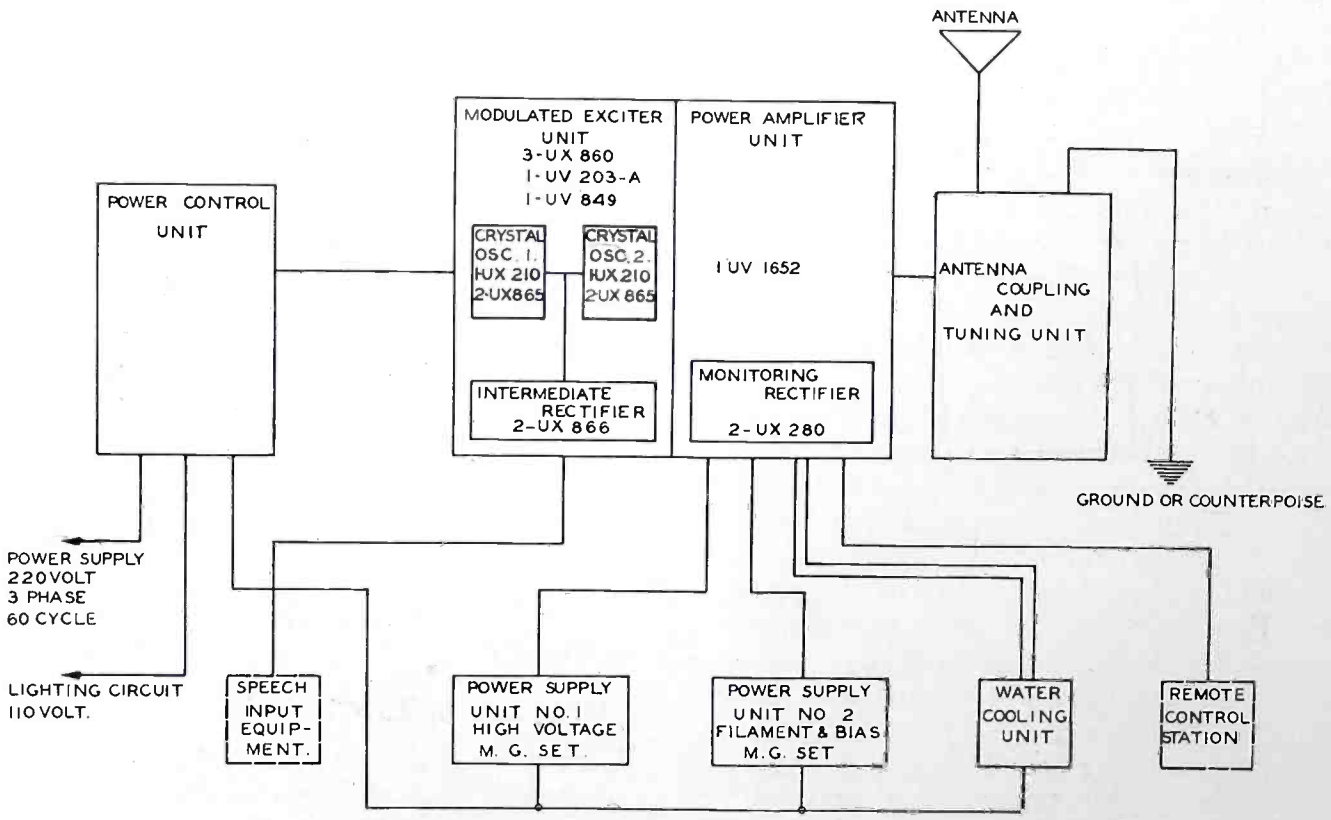


FIG. 1—BLOCK DIAGRAM SHOWING COMPONENT UNITS

IV. TYPE 1-C POWER CONTROL UNIT

This panel contains all of the relays and contactors used in the automatic interlocked starting system, together with the magnetic resistance motor-generator starting boxes. In addition, this panel serves as a distributing frame, the terminal and wire numbers originating at its terminal board. Power leads are brought to this panel and distributed therefrom to the various motor circuits and other radio panels.

Figs. 2 and 4 show a front view of the panel. All numbered parts on Fig. 4 are identified on list of parts, page 36.

Figs. 3 and 5 are rear views, showing location of starting boxes and terminal boards.

A. WIRING DIAGRAM

Fig. 6 is the wiring diagram for this panel, as seen from the rear of the unit. All parts are shown in approximately correct location and can readily be found in the assembly.

The function of the various parts may more easily be understood by reference to the schematic control diagram, Fig. 7. As may be seen, all circuits are fused, and indicating lights are provided to indicate at all times the condition of each circuit. These lights are connected on the load side of the fuses and will go out if either or both fuses open up, or if line circuit is open. Those on the filament and bias generator circuits also indicate under-

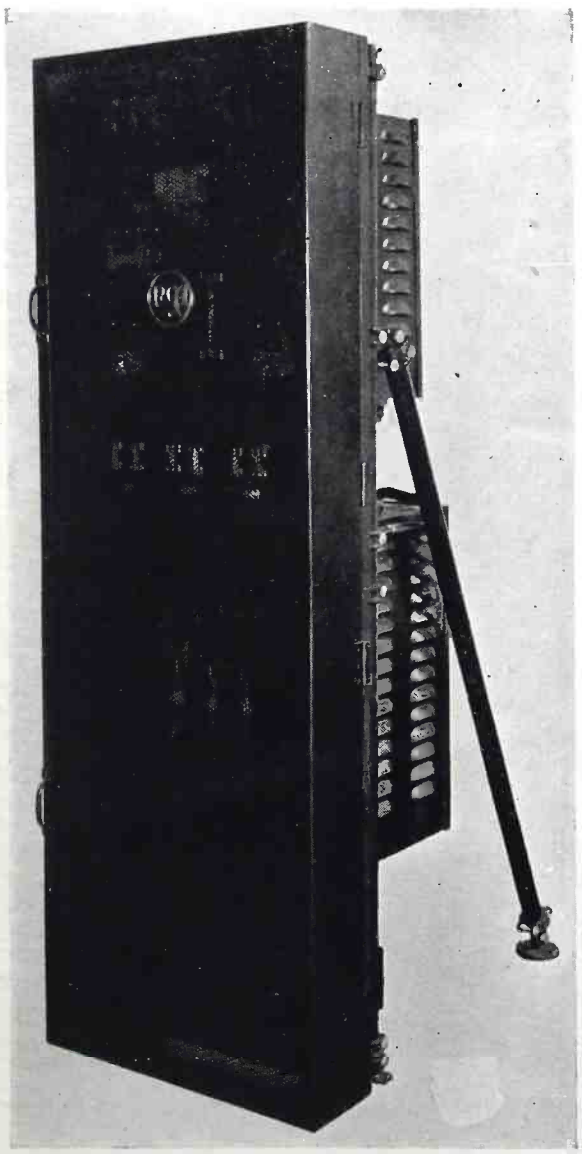


FIG. 2—POWER CONTROL PANEL

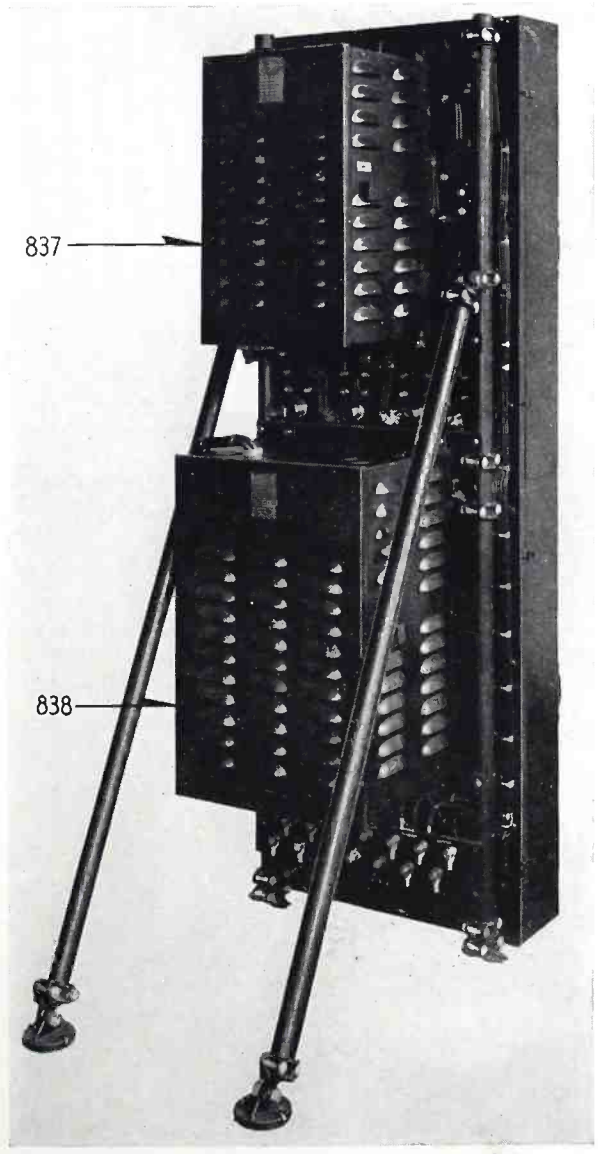


FIG. 3—RIGHT HAND REAR VIEW OF POWER CONTROL PANEL

voltage on either machine or any trouble with the circuits which cause these machines to build up voltage. These lights burn brilliantly under normal operation and come on in sequence with the automatic starting system.

Thermal overload cutouts are located within the magnetic resistance starting boxes. These overload devices may be set by hand for various percentages of full rating values as marked on cover. These magnetic resistance starting boxes permit the starting of motor-generator sets without abnormal line loading, which is an improvement over the conventional installations. In this manner, every precaution is taken to provide equipment which is not objectionable from an operating point of view to municipal power companies, since it is possible that such a power contract may contain restrictions which forbid the direct starting of induction motors on a line. The main power switch provided on the front panel, if pulled, removes all power from the transmitter except the lighting circuit which feeds the crystal ovens within the crystal oscillator units in the Modulator Exciter frame.

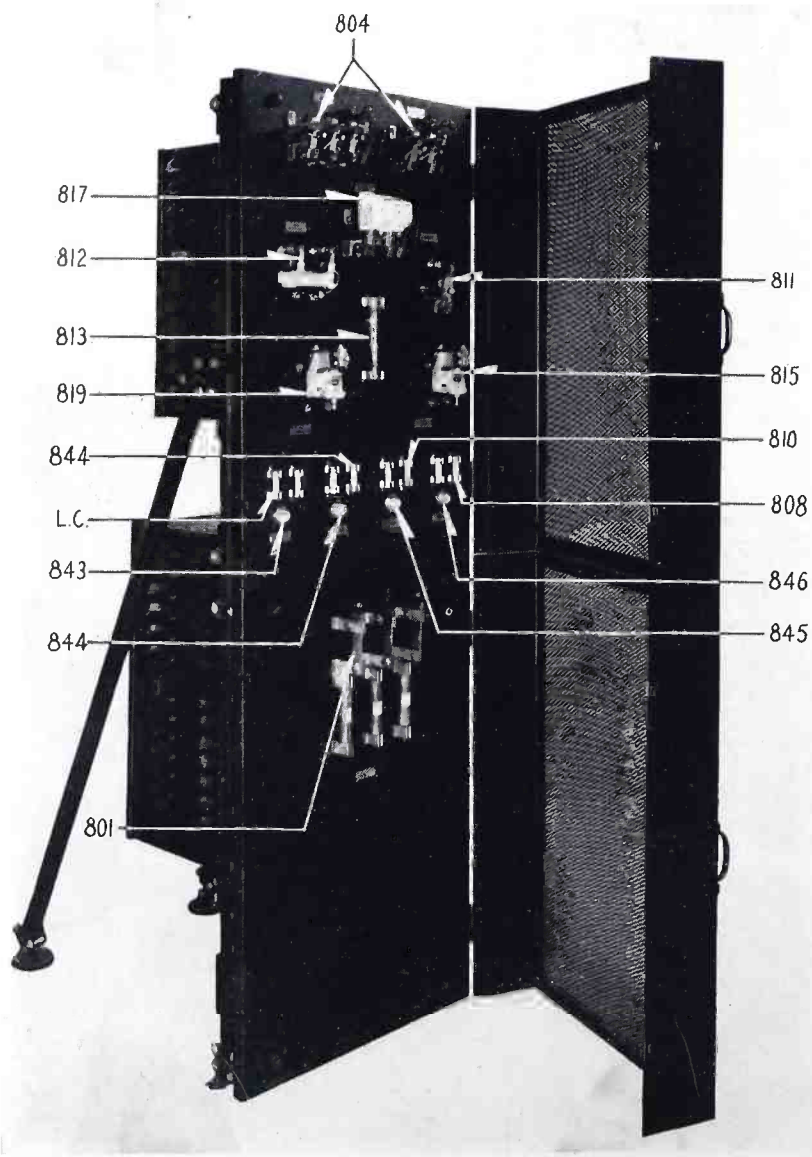


FIG. 4—FRONT VIEW POWER CONTROL PANEL
(With Door Open)

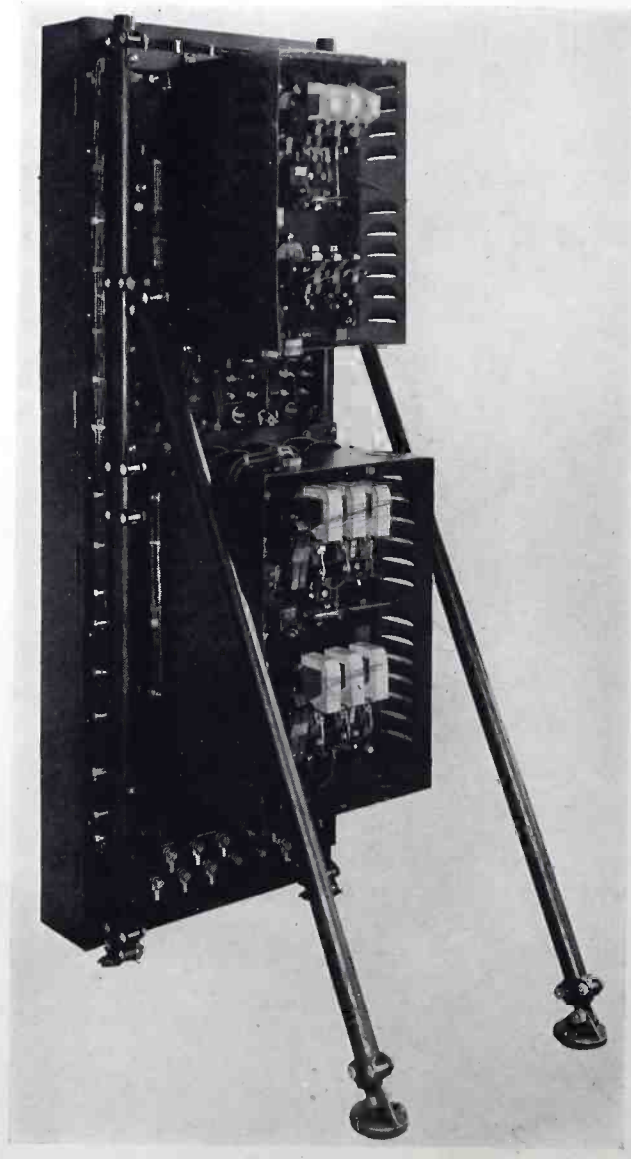


FIG. 5—REAR VIEW POWER CONTROL PANEL
(Covers Removed)

Motor Starter
11408-15
5816F27
605-222

Interlock
532477

Type 1-C Broadcast Transmitter

V. MODULATOR EXCITER UNIT

1. DESCRIPTION

This unit performs the following function:

1. Generates a constant frequency by means of a crystal controlled oscillator.
2. Amplifies this carrier frequency sufficiently to properly excite the output or Power Amplifier stage.
3. Receives the low level audio energy from line amplifier and amplifies this to a level sufficient to modulate the Radio Frequency systems one hundred per cent.

2. CRYSTAL OSCILLATOR UNIT

Two complete crystal oscillator units are mounted behind glass doors in the front panel. A crystal unit changeover switch is provided which permits the use of either unit at a moment's notice.

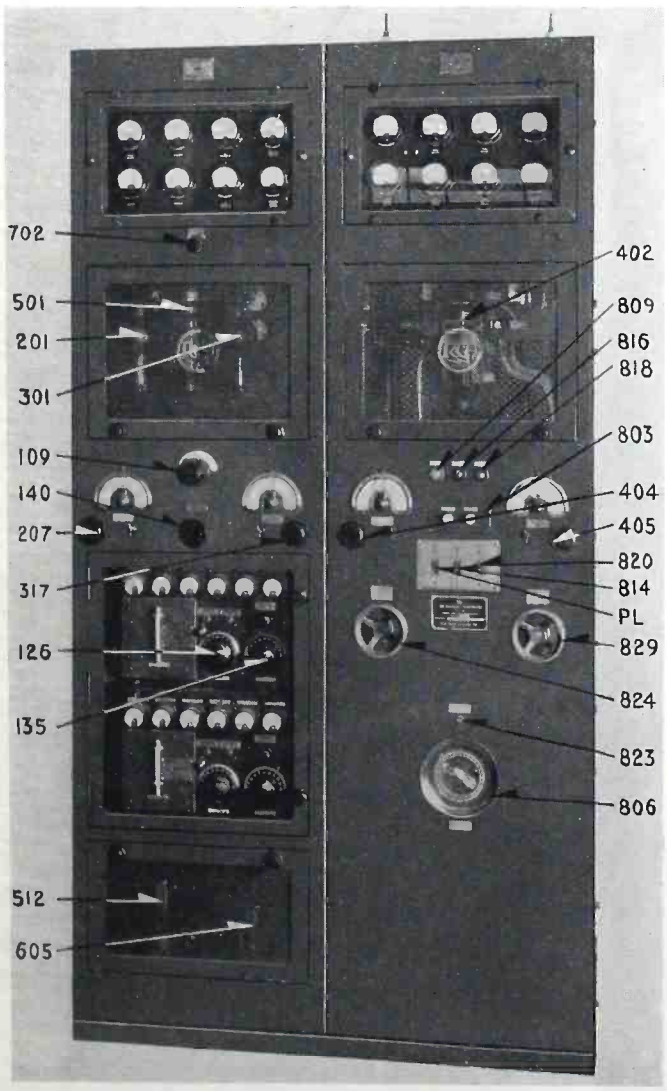


FIG. 8—TYPE 1-C BROADCAST TRANSMITTER
(Front View)

Each crystal unit is a complete, compact, self contained assembly, which is capable of being removed in its entirety from the front panel by removing connections made at the rear of each unit. It contains three stages, each thoroughly shielded from the others and from external sources of electromagnetic and electrostatic disturbances. The crystal oscillator stage employs a UX-210 Radiotron connected in a circuit with a quartz crystal, accurately ground to a specified frequency and at a specified temperature.

In order to assure sufficiently constant frequency to conform to the engineering and legal standards of the times, it is necessary to observe certain precautions in the operation as well as the design of such a circuit. It is known that, whereas the piezo-electric or quartz crystal provides the most accurate practical method of frequency control, several factors operating independently or collectively may cause frequency variations greater than the legal permissible tolerances. One of the most important factors regulating the frequency of a crystal after it is once ground to its proper physical dimensions, is the temperature at which the crystal is maintained.

3. CRYSTALS

Crystals furnished with the Type 1-C transmitter are made very carefully, of natural quartz, scientifically selected, correctly and accurately ground to within a very few cycles of any specified broadcasting frequency, at a temperature of 58° to 62°C. The crystal is mounted in a unique holder, which is carefully manufactured and is so temperature compensated that it maintains constant physical dimensions throughout a considerable range of temperature variations. The crystal holder is mounted inside of a specially designed heater compartment; and means are provided for thermostatic control so that a very nearly constant temperature is maintained inside the crystal compartment. A sensitive, mercury column thermostat is located in the vicinity of the source of heat so that it operates on comparatively small temperature changes of the heater element itself. Because of the great thermal capacity of the conducting and alternating layers of the heater cell, the resultant temperature deviation at the crystal is but a small fraction of the temperature change which causes the thermostat to operate. In this manner, a compact and convenient type of crystal heater unit is provided to maintain

essentially constant temperature of the quartz crystal and holder, and frequency variations due to temperature changes are held to within very narrow limits.

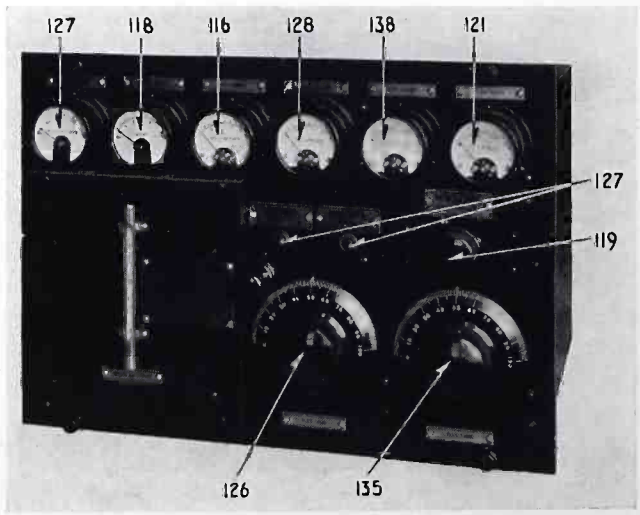
An indicating thermometer, which projects through the front panel of each unit, records the oven temperature accurately. From past experience, it has been found that any thermostat which breaks any measurable current soon gives trouble due to pitted contact faces which cause it to lose its calibration. Because of the increased accuracy of temperature control obtainable, a sensitive thermostatic regulator is supplied with each oven oscillator unit. This sensitive mercury column thermostat operates in the coil circuit of a sensitive D-C. relay which is energized by direct-current fed from a Rectox Unit. In this manner the thermostat makes and breaks an extremely small current only, which in no wise can injure the thermostat unit, thus assuring exceptionally long untroubled operating life of these sensitive instruments. For adjustment instructions of the thermostatic regulator refer to Appendix D.

The power required to maintain a given crystal oven temperature is approximately fifteen watts and provision is made for switching this heater power on or off, by means of panel board switches located on the rear panel of the set. Individual switches are used, together with individual circuit fuses, thus giving separate heater control to each unit and permitting one, or both units, to be heating constantly. Because it is the usual practice to leave the heaters more or less permanently connected, whether the transmitter is in use or not, the heater units derive power from the lighting circuit since this circuit is in most cases a reliable day and night source of power. The transmitter power circuits are so arranged that the main power switch located on the power control panel disconnects all but this crystal heater circuit, thus permitting a complete shut down of the transmitter without affecting the crystal temperature regulating equipment. The crystal oscillator filament supply can be externally adjusted by means of the rheostat located on the front panel of the modulated exciter unit.

4. AMBIENT TEMPERATURE COMPENSATION

Very great changes in room temperatures may cause a gradual change in the crystal temperature. Such change, however, must exceed plus or minus 10°C. before compensation is necessary. To compensate for ambient temperature effect, a resistance is used in series with the oven heater, and controlled by Heater Switch ✻1 and ✻2 on the panel. With both heater switches in the "OFF" position, maximum external resistance is in series with the oven heater and the heat supplied to the oven is a minimum. With both switches in the "ON" position, external resistance is short-circuited and full voltage is applied across the oven heater. With one heater switch only in the "ON" position, an intermediate condition is obtained.

To effectively regulate oven temperature changes due to ambient fluctuation, a room thermometer should be used. It is most de-



(A—Front View)

(B—Rear View)

FIG. 9—TYPE OA-1-B CRYSTAL OSCILLATOR AND AMPLIFIER UNIT

sirable to know the temperature in close proximity to the crystal units, but general changes in room temperature may be accurate enough for the changes which would require compensation. A chart compiled from observed conditions within the station, giving crystal oven uncompensated temperature plotted against ambient temperature for various periods of time would be useful.

When a drop in ambient temperature causes a drop in oven temperature of ½°C. or more, one, or both heater switches should be put in the "ON" position until the crystal oven thermometer again registers constant adjustment temperature. With ambient temperature relatively high, both heater switches will probably be in the off position.

The effect of crystal temperature on the carrier frequency is shown by the temperature-frequency chart furnished with each crystal unit. The attention paid to the foregoing depends entirely upon the choice of the station operators so long as the legal requirements are met.

Other known causes of frequency variations of a quartz crystal include change in filament or plate voltage and reactions including tuning, feedback, or inductive feedback. These have been overcome within practical limits, by calibrating the circuit with the same meters supplied with the unit, and by careful shielding. Reaction on the crystal oscillator from other parts of the radio circuit is prevented by the two screen grid buffer amplifier stages built into the crystal unit.

These two buffer stages have identical circuits and apparatus. Each uses a UX-865 screen grid Radiotron. The output from the crystal oscillator excites the first buffer amplifier directly. Its plate circuit is tuned to resonance by means of a variable condenser, adjusted from the front panel. The screen grid feature eliminates the need for neutralizing, so that reactions from tuning the buffer amplifier stage are not reflected back to the crystal oscillator to any noticeable degree. Individual shielding further reduces inductive feedback between stages. Each stage has its individual plate current meter. Plate voltage on amplifier and oscillator tubes is measured by means of a voltmeter and its transfer switch.

The vacuum tubes can be inserted or withdrawn from the unit through the top of the box. It has been found that the variations in vacuum tubes will not produce perceptible frequency changes, so that the calibration of the unit is not impaired by tube changes.

The two crystal units furnished with the modulated exciter panel are recessed so that the beveled plate glass doors which cover them are flush with the main panel. The meters and thermometers are, therefore, visible at all times although inaccessible. For adjustment, the units are accessible by opening the glass doors. It is unlikely that any troubles occurring during operation will be other than tube failures, and these can be identified immediately by observing the meters. In case of such a failure, the spare unit can be switched into service immediately, and the other unit withdrawn from the panel for inspection. These units are supplied with long flexible leads which permit withdrawal without the need for disconnecting wires.

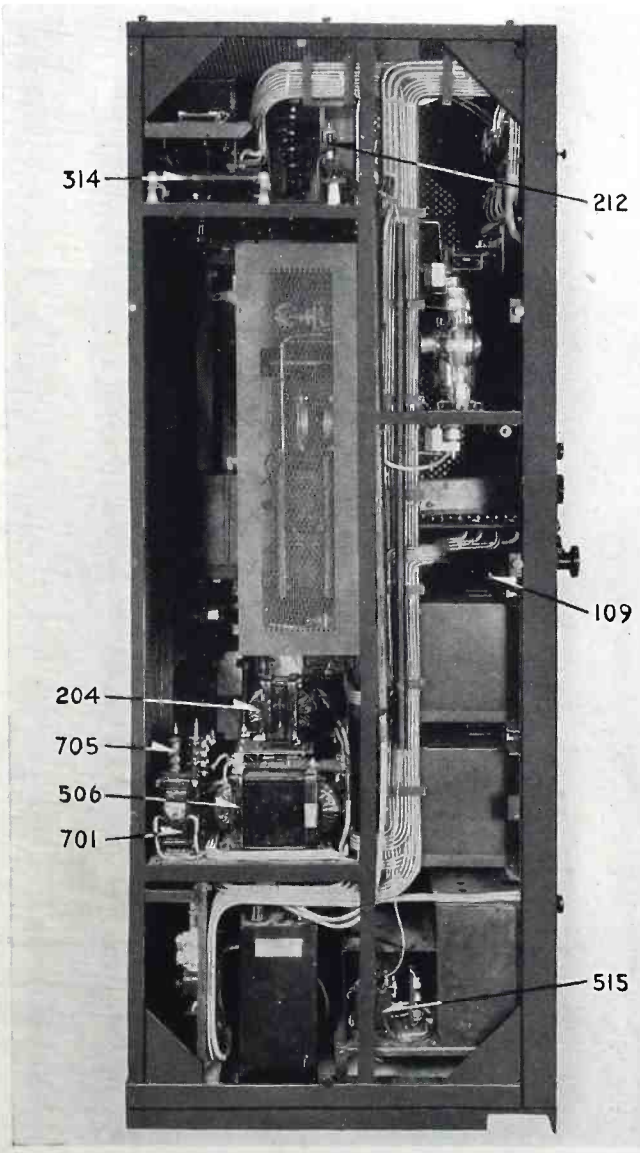


FIG. 10—MODULATOR EXCITER UNIT
(Left Side View)

5. CALIBRATION CHART

Each crystal unit, as shipped from the factory, is provided with a calibration chart showing the change in frequency of the crystal with changes in temperature. Minute frequency corrections can be made in carrier frequency of the transmitter by regulating the crystal temperature. This correction should only be made at the request of local government inspectors, etc. In general, however, the factory calibration will be satisfactory, since calibrations are made in accordance with the most refined existing standards of frequency.

To change tubes, it is merely necessary to pull the tube upward until it disengages from the UX socket. The UX-865 Radiotrons will require that the anode connection at the top be first removed.

The tuning of the buffer amplifiers is accomplished by adjusting the variable condenser in the plate circuit until resonance is indicated by a dip in plate current. Adjust for minimum plate current reading.

The complete wiring diagram for one crystal unit is as shown in Fig. 12. Careful operation of these units will insure the utmost in carrier frequency stability. It is hoped that pride on the part of the station personnel will insure, that the operation of the station will merit unsolicited approval by government inspection service with regard to the absolute carrier frequency stability of which these units are capable. When once adjusted, no controls should ever be changed unless trouble is developed within the unit.

6. INTERMEDIATE MODULATED AMPLIFIER

This modulated exciter panel contains two stages of radio frequency amplification. The first is a straight radio frequency amplifier employing a UX-860 Radiotron with a screen grid. This stage receives its excitation directly from the crystal unit and delivers its output from its tuned plate circuit into the grid circuit of two UX-860 tubes in parallel. This latter amplifier is known as the modulated stage and has a steady plate voltage of approximately 1600 to 1800 volts. This stage is modulated by the audio frequency received by it from the modulator tube and associated circuits. Its plate circuit is also tuned and its output is directly coupled to the amplifier grid circuit. Because at this point, modulation at audio frequencies is introduced into the radio system, a description of the audio amplifier stages is incorporated.

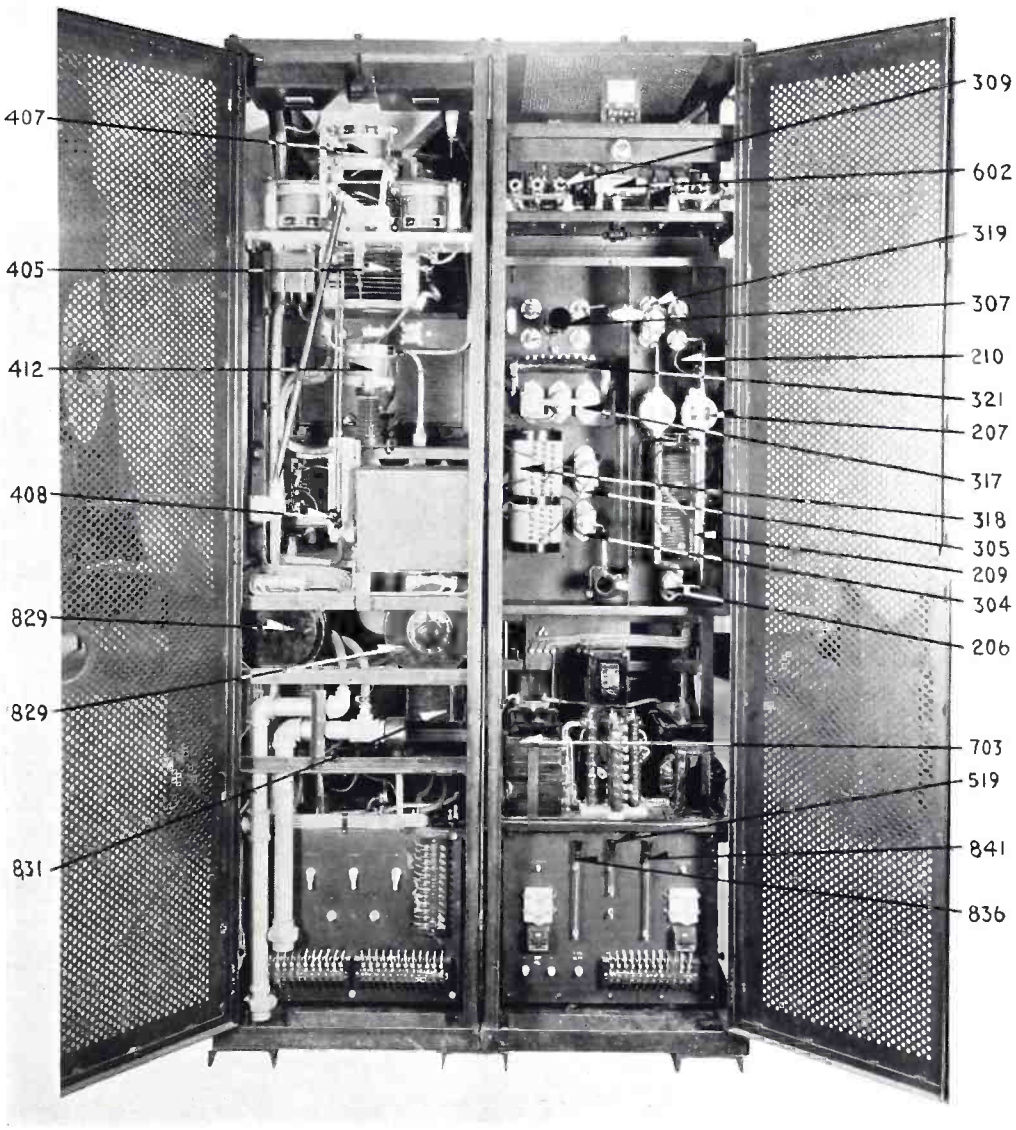
7. AUDIO INPUT

Audio frequency power received into the station from the connecting line after being amplified through the station line terminating equipment is impressed across the input terminals of a transformer coupled to the grid and filament of a UV-203-A Radiotron. This amplifier comprises the speech amplifier, which is a complete assembly, located at the lower left side of the frame, the speech amplifier tube being accessible through the lower hinged door. It contains the UV-203-A Radiotron which is resistance impedance coupled to the grid circuit of the modulator tube. Bias batteries for this stage are replaceable by removing the left side screen of the transmitter. The filament circuit of the amplifier is arranged for either battery or generator feed, a changeover switch for same being provided on rear terminal board. This speech amplifier has sufficient gain to excite one UV-849 Radiotron Modulator tube. An individual plate meter for this stage is located on the main meter panel. The normal operating value of plate current, is 50 m.a. with a plate voltage of 1000 to 1200 volts.

8. MODULATOR

A UV-849 modulator tube, accessible through tube door in front panel, receives its excitation from the speech amplifier. Its bias or grid polarizing voltage can be separately varied by means of the variable control located in the center of the panel directly over the tube door. This bias control should be so adjusted that plate current, as indicated by modulator plate current meter, is 100 m.a. with plate voltage of 3000 V., D-C. This plate voltage can be adjusted by means of the large rheostat accessible from the rear of the Power Amplifier and Control Panel. The bias supply for the modulator is derived from the exciter and bias machine, and tapped off of the potentiometer circuit contained within the modulated exciter frame. This bias supply is adequately filtered by a single stage filter system. The modulator grid circuit is directly coupled, through two coupling condensers in series, to the plate circuit of the speech amplifier.

The modulated amplifier is modulated by the so called constant current, or Heising system, with the exception of a modification which increases the usual percentage of modulation over that obtained in the common type of circuit arrangement. The plate voltage applied to the modulator is 3000 volts, and the modulator is excited sufficiently to produce a peak reactive voltage across the modulation



Power Amplifier Modulator Exciter Unit

FIG. 11—TYPE 1-C BROADCAST TRANSMITTER (Rear View)

reactor of approximately 2000 volts maximum, when the input to the speech amplifier is at its normal, or zero level. The modulated R.F. amplifier and the modulator have a common plate supply source. For 100% modulation the steady plate voltage on the radio frequency stage is reduced to 1600 volts by means of series resistance. A large condenser of low reactance at audio frequencies is shunted around this resistance. In this manner, the steady plate voltage to the radio frequency amplifier is reduced, because it must pass through the series resistor, yet the audio frequency voltage variations produced in the plate circuit of the modulator and built up across the modulation reactor, are admitted to the plate circuit of the radio frequency stage without appreciable drop through the capacity leg of this common coupling circuit. One hundred per cent modulation in the radio frequency stage can, therefore, be accomplished by delivering a peak audio voltage of the same amplitude as the applied direct voltage. The series resistor is made variable so that the direct potential applied to the amplifier can be adjusted to suit various conditions of plate current and modulator audio voltage.

9. CRYSTAL OSCILLATOR PLATE SUPPLY RECTIFIER

This unit is located to the right of the speech amplifier and consists of two mercury vapor UX-866 tubes, replaceable from the front panel through the lower hinged door. It consists of a step up transformer supplied at a potential

of 160 volts from the main 60 cycle power supply circuit. A series tapped resistor and a variable rheostat accessible from the rear of the modulated exciter unit permit the proper regulation of input potential. A rectifier filament voltmeter is provided on the front panel so calibrated that when its pointer coincides with the red mark on its scale, correct filament voltage is applied to the rectifier tubes. The plate voltage supplied from the potentiometer incorporated within this unit is also correct when this adjustment is made.

10. DIRECTIONS FOR ADJUSTING

a. Crystal Unit Mounting

Normally, both crystal units will be in position with both crystal ovens operating. When the units are once tuned, no further circuit adjustment is necessary. Unless trouble develops the tuning controls should not be changed. A record should be taken of the position of each when operating properly so that they may be returned to the same positions if accidentally moved. It is, therefore, strongly recommended that the beveled glass door on the front panel be kept closed.

b. Crystal Unit Transfer Switch

The crystal unit changeover switch is located in the center of the main panel directly below the tube door. This switch makes a complete changeover from one unit to the other. It can be thrown at a moment's notice to either position without injury to the transmitter and, without manipulating any other control.

c. Removing Crystal Units from Panel

The connections between the crystal unit terminal board and the associated terminal board on the panel are flexible and of sufficient length to permit sliding the crystal unit forward for the purpose of removal, or for changing tubes. To remove a unit from the set, either shut the transmitter off entirely or transfer power to the other unit. To remove power entirely from the crystal unit, its heating circuit switch located on the terminal panel, at the rear of the transmitter, must be thrown to the "OFF" position. The unit can now be disconnected at the rear terminal board on the crystal unit. When replacing, use great caution to put the properly marked leads back on the same terminals from which they were previously removed.

The method of changing the tubes in the crystal unit is obvious when the unit is withdrawn. Great care must be exercised that the plate connection on the top of each UX-865 tube is not overlooked. This is a beaded, flexible lead fitted with a friction cap to fit over the glass supported terminal on the tip of the tube.

11. FILAMENT SUPPLY FOR CRYSTAL MODULATOR AND LOW POWER RADIO AMPLIFIER

The filaments of all tubes except the rectifier tubes are fed from the main 14.5 volt filament bus. An exception is made in the case of the 50 watt speech amplifier tube, in that its filament circuit is arranged for optional operation from the filament generator supply, or from the station storage battery supply. A filament rheostat, located directly below the crystal unit transfer switch, provides an accurate filament voltage control for the crystal unit filaments.

The tube filaments of the other radio frequency amplifier stages and the modulator tube, are fed through individual series resistors.

12. PLATE SUPPLY

Plate supply for the crystal oscillator unit is obtained from the rectifier unit provided for this purpose. Voltages ranging from 100 to 500 are available from this unit by proper taps on the potentiometer supplied. Special precaution has been taken to give good regulation from this power source.

Plate supply for the speech amplifier tube is derived through a series resistor located in the rear of the speech amplifier compartment, from the 3000 volt generator supply with the appropriate filter system.

Plate power for the first UX-860 buffer stage is derived from the 1500 volt tap on the plate supply generators.

The modulator and modulated radio stages are fed from the 3000 volt generator source, the latter passing through series resistors which reduces the steady plate voltage to approximately 1600 volts.

13. DIRECTIONS FOR REMOVING TUBES

The crystal oscillator unit rectifier tubes are accessible through the lower hinged panel door and may be removed by pulling them upward out of their sockets, after first disconnecting the friction cap plate lead. The speech amplifier tube may be removed by twisting it counter-

clockwise to disengage it from its bayonet type socket. This tube is also available through the same lower panel door. The proper method for removal of the crystal oscillator unit tubes has been described in a previous chapter under "Crystal Oscillator Unit". The radio frequency amplifier stage tubes, UX-860's accessible through the main tube door, may be removed or replaced by first disconnecting the flexible operating grid lead (projecting from the top of the tube) and the plate lead (projecting from the center of the tube), from the terminal studs adjacent to the position of the tube leads. After disconnecting these leads the tube can be twisted counter-clockwise slightly to disengage the base from the bayonet type tube socket, after which the tube can be lifted out. The modulator tube can easily be removed by first pulling the upper or grid filament end away from the clip socket, and then lifting it upward to disengage the plate terminal located on the lower tip of the tube.

14. BIAS SUPPLY

Bias supply, or negative polarizing voltage, is obtained for the speech amplifier tubes from an individual 22½ volt battery supply located in the left side of the rear speech amplifier compartment, and available for replacement purposes from the left side of the unit by removing the side screen.

Bias potential for all other radio frequency amplifier stages and modulator tube is supplied by a 550 volt exciter and bias machine located on the same shaft with the filament generator. The proper voltage for each stage is tapped off from a voltage divider and filter unit located on the intermediate shelf accessible from the rear of the unit. A variable modulator bias control located on the front panel directly below the meter panel is provided.

15. SCREEN GRID POLARIZING VOLTAGE

The UX-865 screen grid radio frequency amplifier tubes within the crystal oscillator unit derive their screen grid polarizing voltage from the same source as the plate supply, and are fed through series resistors to provide the correct voltage value.

In a like manner the screen grid UX-860 radio frequency amplifier tubes derive their grid polarizing voltages from the same plate voltage source as that supplied to the tube in each case. This voltage is reduced to the proper value by means of adjustable series resistors located on the top shelf of the Modulated Exciter Unit.

16. ADJUSTMENT OF THE MODULATOR AMPLIFIER CIRCUIT

a. General

In tuning the circuit for the first time, one adjustment should be made at a time, progressively, starting with the crystal oscillator unit and progressing through to the output of the modulated stage.

Then, the audio circuits can be put into operation.

b. Operations

Remove modulator and speech amplifier tubes entirely from their sockets. Open the two single pole, single throw knife switches on rear terminal panel, and throw neutralizing switch on P. A. unit to neutralizing position. Place all other tubes in their respective positions. Open all of the toggle switches on the front panel of P. A. unit. Meter panel flood lights may be left on if desired. Next throw main power switch on Power Control Panel. Push "START" button on P. A. panel. Master Contactors on Power Control unit should close and water pump should start. If the water pressure does not come up as indicated on pressure gauge on P.A. panel, it may be necessary to prime the water pump by releasing trapped air in pump casing by opening relief valve located thereon. When pressure comes up to the high pressure setting on the gauge, the water interlock contactor will close on the Power Control panel and the water indicating light will light on front panel of P. A. Open either or both tube doors on Modulated Exciter and P. A. Panel. The filament stop switch located on P. A. panel (toggle switch) may now be thrown, after first making sure that the filament rheostat on the P. A. panel and the filament rheostat on the Modulated Exciter panel are on minimum voltage position, i. e., twisted in reverse arrow direction. The filament motor-generator set should start and register voltage on the filament voltmeter on the Power Amplifier meter panel. Adjust the voltage to 14.5 volts by turning, in the direction of the arrow, the filament control knob on the Power Amplifier panel. Measure filament voltage on each tube, (outside of the crystal oscillator unit), individually and check each of the values against the correct value for each tube according to the chart contained in Appendix C.

Next adjust the filament voltage to the correct value as indicated by the filament voltmeter on the crystal oscillator unit by turning in the direction of the arrow, the rheostat control

knob located on Modulated Exciter panel directly under the crystal oscillator unit selector switch.

The Modulator and speech amplifier tubes may be replaced temporarily for filament adjustments on each. After checking correct filament voltage on each, remove them again from their sockets.

c. Bias Adjustment

Place a voltmeter across the outside taps on the bias potentiometer and close all doors on each unit, after first throwing crystal oscillator selector switch to neutral position. The filament interlock relay KG-2A on the control panel should close, lighting the bias light on the Power Control Panel and the green light on the Power Amplifier panel. This KG-2A filament interlock relay on the Power Control panel should be previously adjusted to pull in at 14 volts and drop out at 13.5 volts as indicated by the filament voltmeter on the Power Amplifier meter panel.

Next adjust the KG-2A bias interlock relay to close at 550 volts approximately and fall out at 525 volts approximately as read on the voltmeter previously connected across the bias potentiometer terminals. When so adjusted, adjust bias on each tube outside of crystal oscillator unit, to correct value as specified in the table in Appendix C.

The crystal oscillator unit rectifier supply will start at the instant that all doors are closed, i.e., it will come on at the same time that bias is applied to the rest of the set.

d. Adjusting Crystal Oscillator Rectifier Supply Unit.

To adjust this unit, leave the crystal unit selector switch in a neutral position and disconnect all plate supply taps from the potentiometer or voltage divider connected across the output from this rectifier. By connecting a meter externally by running leads through screen to a meter located outside, bias voltage can be adjusted by varying the tap on this potentiometer. In a similar manner, each of the plate supply voltages to the Crystal Oscillator Unit may be fixed. Refer to the tabulated list in the Appendix for correct values.

e. Crystal Oscillator Unit Oven Adjustment.

After adjustment, close both panel board snap switches on the rear panel of the Modulated Exciter Unit thus allowing both crystal ovens to heat. The oven will reach its correct operating temperature and properly regulate approximately 24 hours after the switches are thrown. The thermometer should gradually rise to the correct value as specified for each crystal and the thermostat and vacuum tube relay unit should accurately maintain the temperature required for the correct frequency. For instructions for setting regulator refer to Appendix D.

f. Adjustment of Crystal Oscillator Unit.

Tune the two buffer amplifier controls until the plate current reading in each case is minimum.

Switch the second crystal oscillator unit into position and adjust as before for resonance. These two units should be very nearly alike in operation, i. e., plate current readings one with the other.

g. Tuning the UX-860 Buffer Stage

With the crystal oscillator unit operating properly, grid current should be indicated on the grid current meter for the buffer UX-860 stage providing its filament is lighted and the bias voltage is not excessive. Adjust the taps on the plate tank inductance until it can be tuned to resonance as indicated by a minimum plate current reading after the 1500 volt switch (single pole single throw) on the rear of the unit is thrown to the "ON" position, and the plate supply generator is started by throwing the toggle switch on the front of the Power Amplifier panel. When the high voltage generator is started a red light will appear on the front panel of the Power Amplifier Unit. Adjust the screen grid current to correct value. Next attach the excitation clip to the next stage and retune the circuit. Refer to tabulated list in Appendix C for correct meter readings.

h. Tuning the Modulated Amplifier Stage

With the correct bias and filament voltage on the two UX-860 tubes in this stage, grid current should be evidenced by a grid meter deflection for this stage. Reduce the Plate Supply voltage to approximately one-half of its correct value. Adjust the tank circuit for resonance as indicated by a minimum plate current. Adjust screen grid current to correct value. Attach the excitation clip to the Power Amplifier stage and retune for resonance. At this point, all Radio Frequency stages are approximately tuned but will probably need slight corrective adjustments when the set is finally ready for service.

NOTE—Carefully watch the Power Amplifier tank meter because the power amplifier stage is in the "NEUTRALIZING" position and not neutralized. Keep the meter on scale by turning neutralizing control until it reads zero. Use the greatest of care in doing so.

i. Adjustment of Speech Amplifier

With reduced plate voltage, adjust the bias battery voltage by removing the side screen and measuring the voltage with an externally connected voltmeter. Connect a 0-2500 voltmeter from the tube terminal to ground. With correct bias voltage on the tube as specified in Appendix C, apply plate voltage.

Plate current when voltage is as specified in Appendix C, should be approximately 40 to 50 milliamperes.

j. Adjustment of the Modulator Stage

With modulator bias control in mid position, adjust bias potentiometer tap to give 150 volts. This voltage must be read on an externally connected voltmeter by running leads through side screen. Bias control should give a variation of approximately 50 volts. With a plate voltage of 3000 as measured on an externally connected meter, the modulator plate current should be made to read 100 milliamperes by adjusting the bias values.

CAUTION—When making tap adjustments, etc., inside of the set, shut off the power before proceeding. It is possible, however, to leave the filament and bias motor-generator set running since opening a door interlock automatically removes bias voltage, and the circuit can be safely manipulated. Although high voltage plate supplies are also removed by the opening of a door, it is a safe, common sense rule to shut the plate machine down.

Although every precaution has been taken to protect the operating personnel against contact with dangerous voltages, it should be borne in mind that such contact could prove fatal.

The practice of disconnecting interlocks during adjustment periods is distinctly dangerous and should be avoided at all times.

VI. 1 KW. BROADCAST POWER AMPLIFIER AND CONTROL PANEL

The assembly of this panel and the principal parts thereof are identified in Figs. 8, 14 and 11. The diagram of connections is given in Fig. 15.

1. WATER COOLING

Water is fed to the unit by a 1¼" diameter pipe coming from the centrifugal pump. The water passes through a thermostatic control device, as shown, with a tap leading off to the pressure gauge on front panel. Cooling water then continues through an insulating hose to the plate or tube jacket of the tube, returning through another parallel rubber hose to the outlet water pipe which returns to the cooling apparatus.

2. FILAMENT SUPPLY

The filament supply comes directly from the generator source and is applied directly to the tube filament connections. The filament interlock or undervoltage device on the Control Panel is connected across this source as is also the filament voltmeter located on the meter panel. All of the other tube filament circuits fed from this generator are so arranged with series resistors to give the correct tube terminal voltage in each case when the filament voltmeter on the Power Amplifier panel reads 14.5 volts.

3. BIAS SUPPLY

Some explanation of the arrangement and adjustment of bias was given in connection with adjustment of bias on the low power radio amplifiers which are all associated with the one bias generator. The Power Amplifier tube requires the highest bias value compared with the other tubes in the set, and because of this, is connected directly across the outside terminals of the potentiometer. In this manner a low resistance grid circuit for the Power Amplifier stage is provided.

4. PLATE SUPPLY

Plate supply is taken from the two 3000 volt machines connected in series. A plate circuit disconnect switch which is an integral part of the neutralizing changeover switch, is available through the rear door of the Power Amplifier and Control Unit. The operators should take full advantage of the safety apparatus provided for their protection.

5. RADIO FREQUENCY CIRCUITS AND LINEAR AMPLIFIER

Fig. 15 shows the connections for this panel. The double pole double throw changeover switch interconnected mechanically with the plate circuit disconnect switch serves to change the tank circuit resonance device in the following manner. With this switch in the up or closed position, the plate circuit to the Power Amplifier is closed and a 20 ampere meter is in series with the tank. In the open position the P. A. plate circuit is open and a 1.5 ampere R. F. neutralizing meter is placed in the tank circuit.

Grid and plate current meters are provided for the Power Amplifier tube. The antenna ammeter is also located on this panel and wired to the thermocouple located directly in the antenna circuit.

A modulation monitoring rectifier is also provided within this panel with an adjustment meter on the meter panel. A modulation meter, here located, reads percentage modulation directly. The pickup coil actuating this monitoring rectifier is located at the top end of the main tank circuit coil.

6. ADJUSTMENT OF POWER AMPLIFIER STAGE

Assuming that all previous stages are operating properly, reduce the plate voltage by means of the rheostat located in the rear of Power Amplifier and control panel and available through the rear door.

Shut down the set and clip on the Modulated stage tank coil, the excitation and neutralizing lead to the Power Amplifier stage. Retune the tank circuit of the modulated stage if necessary and with an externally connected voltmeter, measure bias voltage at the grid and filament terminals of the tube. It should read 500 to 550 volts.

Grid current should now be observed on the grid current meter for this stage. Only a slight amount will be observed.

Detune the tank circuit of the power amplifier stage. With the neutralizing switch thrown to "NEUTRALIZING" position start up the set and gradually tune to resonance.

NOTE—See discussion on the tank tuning of the Power Amplifier stage at the end of this chapter.

This must be done very carefully. Keep the tank current meter on scale by turning the neutralizing control in the proper direction. When the tank circuit of the Power Amplifier stage is exactly in resonance as indicated by a definite peak point reading on the tank ammeter, turn the neutralizing control until the tank ammeter reads zero. It should be possible by adjusting the neutralizing control to return this tank meter to absolute zero reading. The set is now neutralized and ready for plate power on this last stage.

Before applying power to the Power Amplifier stage make sure that dummy antenna load, or that antenna coupling is made to the antenna, otherwise the tank circuit meter in Power Amplifier stage may burn out.

Throw the neutralizing switch to the normal closed position and start up the set, watching closely the plate current meter as the set starts up. This meter should not exceed 0.6 ampere

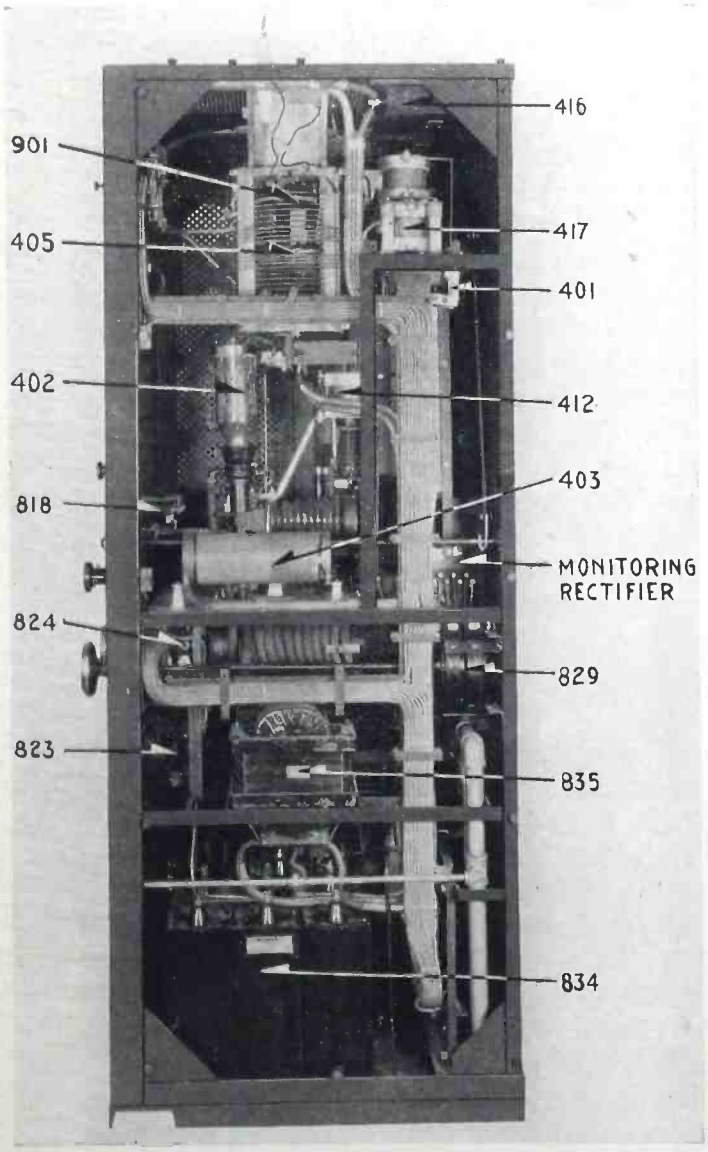


FIG. 14—POWER AMPLIFIER AND CONTROL UNIT (Right SIDE)

with the normal voltage on all stages and with the proper bias on the Power Amplifier stage, and loaded properly.

When this has been done, the coupling line to the 1 Kw. amplifier can be adjusted for resonance and proper termination impedance.

Until the coupling and tuning adjustments on the terminal end of a transmission line are correctly made, there will be a reaction on the preceding excitation amplifier. Any adjustment which upsets the plate tank tuning in the previous stage indicates incorrectness in the termination and tuning circuits.

Do not change the plate tank tuning to correct for this reaction. Rather, adjust the termination so that at resonance there is practically no reaction. A properly terminated transmission line will act on the preceding amplifier as a pure resistance load. Therefore, the full load tuning position on the tuning dial should be the same, or very nearly the same, as the no load tuning position.

When all circuits are correctly loaded, the tuning controls will apparently have considerably less tuning effect than they show at no load. This is due to apparent reflection of load resistance into the tank or plate circuit of the tube thus broadening the resonance characteristic of the circuit.

It is well at this point to go back and check each successive stage for slight correcting adjustments, after which, the set may be modulated.

With 100% sustained modulation, i.e., constant tone on the set, no appreciable change, either increase or decrease should be noticed on the plate current meter in the Power Amplifier stage. If any change is noted, it denotes a dissemetrical or distorted modulation characteristic. The tank circuit current, however, will increase 22½% over its unmodulated value.

7. ADJUSTMENT OF MODULATION INDICATING EQUIPMENT

With the set normally adjusted and with no modulation on it, increase the pick-up for the modulation indicating equipment by moving the pick-up coil more closely into inductive relationship to the Power Amplifier tank coil, until the adjustment meter on the front panel reaches the correct predetermined value as marked on the face of the meter. Whenever this meter reads the correct predetermined value during the unmodulated condition, the "per cent modulation "meter will read per cent modulation after modulation is applied to the

set. The per cent modulation reading will be correct for sustained modulation only since the meter will not follow rapidly enough the peaks of modulation under operating, or program conditions. The meter, however, will give a correct value of average modulation at all such times.

8. TUBE RECORD SHEETS

Record sheets are provided with all Radiotrons. Accurate records of tube performance, filament voltage, plate voltage, etc., should be kept at all times covering all points indicated on the record sheets. With such information, adjustment claims on tubes can more satisfactorily be considered.

9. DISCUSSION OF POWER AMPLIFIER TANK TUNING

The first step in the adjustment of the plate tank circuit for any given frequency, is to obtain the proper inductance and capacitance values. A chart provided in the Appendix, shows the approximate values in all stages for the operating frequency chosen. Such values are not made by trial and error methods, but are definitely specified by consideration of correct design.

For any operating frequency the ratio of circulating volt-amperes to watts output into the load is chosen for this particular type circuit to be 15 to 1. This means that for 1000 watts output of carrier power at 30% to 35%, efficiency, the circulating volt-amperes should be 15,000. To give 1000 watts output, the effective, or R.M.S. value of A.C. plate voltage per tube must be 1620 volts. To maintain 15,000 volt-amperes of circulating power, the effective value of tank current will be 9.25 amperes. Knowing the voltage to be built up across the tank condenser and the circulating current value, we can solve for the capacitive reactance. This gives a value of 175 ohms. Knowing the reactance of the condenser and the operating frequency, solve for the correct capacitance.

The preceding discussion is based on a "tube" carrier efficiency of approximately 30%. In actual cases, this efficiency may increase slightly which will allow some slight deviation in the values as specified. If the effective or R.M.S. value of voltage across the tank condenser is 1620 volts, for 100% modulation this value increases to 3240 volts or twice normal. In like manner the instantaneous current value will be twice normal or 18.5 amperes when modulating 100%. Because the meter in this tank circuit is an averaging device, it will indicate only 22.5% increase over normal value, or read approximately 11.33 amperes when modulating 100% sustained.

When the correct capacitance value is chosen in line with the preceding discussion, enough tank inductance should be used to bring the circuit to resonance.

10. MONITORING RECTIFIER

The monitoring rectifier unit is mounted in the Power Amplifier and Control Panel. A removable cover permits easy access. Within the unit are two UX-280 tubes, chokes, condensers, etc. The tubes are removable by removing the top cover. Filaments are fed from the main 14.5 volt bus through series resistors. Refer to Appendix A for circuit diagram. The purpose of the device is to provide a means of measuring accurately per cent modulation, and providing an aural check on the outgoing wave. In addition, whenever the Power Amplifier tank circuit is energized, a relay within this unit will close a signal lamp circuit, which lights a 110 volt lamp on the associated speech input equipment.

The small amount of power needed to operate this unit is obtained by inductive coupling to the Power Amplifier tank coil. An adjustment meter in circuit with the first rectifier tube is provided on the front panel, by means of which the correct coupling adjustment is obtained. A second meter on the front panel marked "PER CENT MODULATION" is connected in circuit with the second rectifier, and reads per cent modulation directly. A link is provided in this meter circuit which permits a second per cent modulation meter to be wired in, and located at a remote point such as the studio or audio control room, if desired.

Filtered loudspeaker and oscillograph circuits are available as shown in circuit diagram. Unless the adjustment meter pointer rests on the predetermined adjustment mark with no modulation on the set, the per cent modulation meter will not register correctly. Care should be taken to see that the circuit conditions are such that this is so. The variable feature incorporated in the untuned pick-up coil permits very close pick-up adjustment. This adjustment should be made by trial methods and, when once found, should be locked into place by tightening the mounting screws on the pick-up coil support.

VII. GENERAL INFORMATION ON LINEAR AMPLIFIER OPERATING CHARACTERISTICS

Reference should be made to any good text book on the Principles of Radio Communication such as J. H. Morecroft's, and special attention devoted to those chapters dealing with amplifier tube performance and operation. One must understand the details of performance thoroughly in order to realize the full benefit of the linear amplifier design.

The following essential points may be pointed out, and borne in mind by the installation and maintenance engineer:

(1) All of the radio frequency tubes operate either as Class B or Class C amplifiers. By this reference is meant, that all radio frequency amplifier tubes are operating at high bias or negative grid polarizing potential. Therefore, the plate current for the amplifier tube is zero, or very nearly so, when no radio frequency excitation is applied.

(2) The output power and input power (as evidenced by plate current) increases as the exciting radio frequency voltage is increased.

(3) For unmodulated carrier frequency operation the tube is running very much under-excited and the efficiency is therefore comparatively low (30 to 35%), and the power output is only one-fourth of the tube rating at the plate voltage when used.

(4) As modulation is increased to 100% no appreciable change in plate current should take place. The tank current, however, will increase. It is well to note here, however, that if 100% modulation is exceeded, the plate current will increase slightly giving evidence that some distortion is taking place in that stage.

(5) Increased carrier output can be had by merely coupling tighter to the preceding stage; however, the transmitter is not designed to modulate 100% any appreciable output greater than the specified 1000 watt carrier.

(6) With a 1 kw. carrier, when modulating 100% the transmitter is delivering 1.5 kw. continuously to the antenna.

(7) Assuming that correct excitation is being applied to the Power Amplifier stage, to increase carrier output, i.e., to load the Power Amplifier, it is merely necessary to increase the number of coupling turns connected across the transmission line. Variation of the number of these coupling turns should not affect the tuning of the Power Amplifier tank circuit if the transmission line is properly adjusted.

VIII. ANTENNA COUPLING AND TUNING UNIT

The antenna coupling and tuning unit located in an enclosed tuning house at the foot of the antenna lead-in is an assembled self contained unit as shown in Figs. 16 and 17. Circuit connections are shown in Fig. 18. Extreme care has been exercised in design to assure that simplicity of mechanical arrangement has been incorporated, and that no closed power wasting loops are formed anywhere near the current carrying coils. Within the unit are contained a transmission line terminating tank circuit, coupling coil to antenna and antenna loading and series capacitance equipment. In addition a static bleeder, or antenna drain circuit is included for protection against static charges and lightning.

Controls for tuning the transmission terminating equipment and antenna proper are located on the front panel. An antenna current meter is also located within a protective case on the front panel. A thermocouple unit which is interconnected with the Power Amplifier meter panel makes it possible to observe the antenna current from within the station as well as from within the antenna tuning house. The equipment is mounted on heavy asbestos panels which have been copper coated on the rear to provide an excellent radio frequency shielded front surface. This simple precaution assures protection to the operating staff against accidental radio frequency burns, since the panel is essentially dead front.

1. ANTENNA TRANSMISSION LINE

The output of the 1 kw. Power Amplifier is coupled to the antenna through a two wire transmission line. The antenna coupling and tuning equipment is housed in a separate building directly under the antenna, usually at some distance from the station proper.

The adjustment of a transmission line and its proper coupling to an antenna for optimum efficiency requires a knowledge of simple single phase transmission line phenomena. It is not within the scope of this instruction book to give a theoretical discussion of these phenomena.

Any infinite length transmission line has a **characteristic impedance** sometimes referred to as the **surge impedance,** which is a function of the physical size and spacing of the conductors comprising the line. It is the impedance offered by such a line as viewed from the sending end.

If a piece of an infinite line is cut off and the open end closed by an impedance equal to the characteristic impedance, it will act on the sending end driver exactly like the corresponding infinite line. At high frequencies an infinite transmission line acts to the driver like a pure resistance load, i.e., power leaves the driver into the line, never to return. Hence no reflection of power takes place. Similarly if a finite transmission line be terminated properly by closing its free end with an impedance equal to the characteristic impedance of an infinite line of equal physical dimensions with regard to diameter of wire and spacing, such a properly terminated line will act on the driver as a purely resistance load. No power reflection will take place and hence, no appreciable line loss will occur and the efficiency of transfer from driver to load will be very high.

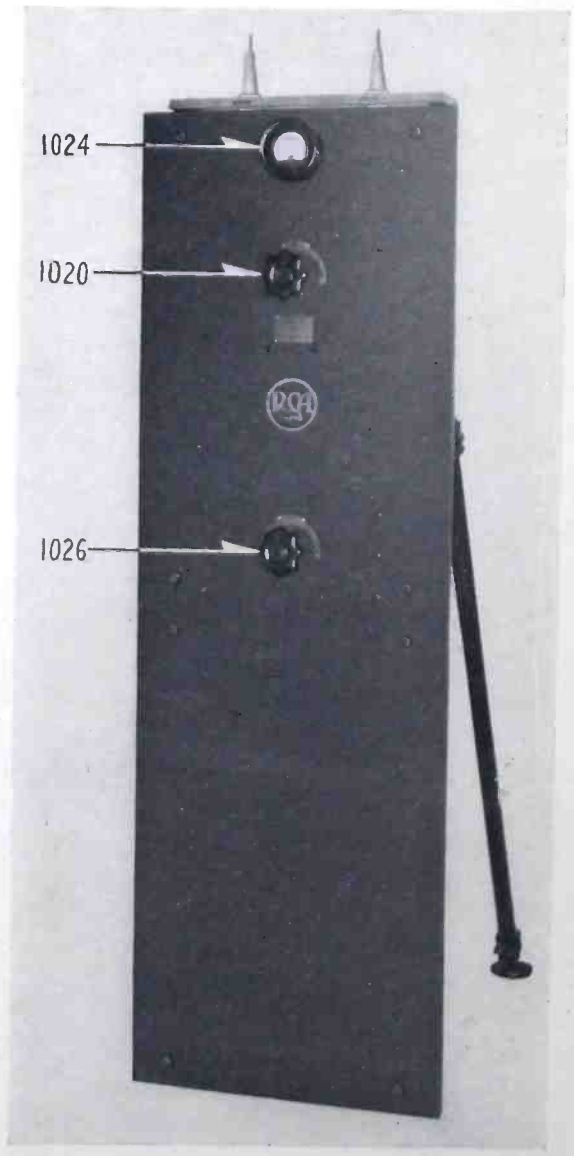


FIG. 16—ANTENNA TUNING AND COUPLING UNIT
(Front View)

A transmission line used for coupling a radio transmitter to its antenna comes under the category of an overhead open wire line operated at high electrical frequencies. Because of this, its characteristic impedance is always a simple non-inductive resistance. This can be seen by inspection of the equation for characteristic impedance in terms of the fundamental line constants:

$$Z_o = \frac{\sqrt{R + j\omega L}}{\sqrt{G + j\omega C}}$$

where R = resistance and
G = leakage per unit length.

At high frequencies the value of R is always negligible when compared to ωL, and G is negligible when compared to ωC. The equation therefore reduces to

$$Z_o = \sqrt{\frac{L}{C}}$$

Since the j component does not appear, the quantity is a pure resistance. By further consideration of the reactive characteristics of simple open wire lines it can be shown that

$$Z_o = 276 \log_{10} \frac{2D}{d}$$

as previously stated.
where D = the spacing from center to center of the conductors.
and d = the mean diameter of the wire.
Note—D >> d D and d must be measured by same unit of measurement.

The Type 1-C Transmitter is designed to operate in conjunction with a 600 ohm transmission line.

To adjust the transmission line terminating equipment and the antenna system, it becomes necessary to tune to resonance separately the tank terminating and the antenna circuit itself. This can be done by coupling each of these circuits separately to an external low power oscillator which has been previously adjusted for the required frequency. When adjusting the tank circuit, the transmission line should be disconnected at the transmitter by removing the clip leads from the pick-up coil on the Power Amplifier Unit. Resonance is indicated by connecting in series with each circuit a suitable radio frequency low reading ammeter and adjusting the circuit constants until a maximum deflection is obtained.

When adjusting the tank termination a maximum permissible amount of inductance should be used which will result in a minimum value of capacity for any particular setting. In other words, utilize insofar as possible all of the turns on this inductance coil. With both the tank termination and antenna adjusted to resonance at the operating frequency, remove the small resonance indicating meter used for this adjustment and connect the circuits for normal operation. It is now permissible to clip onto the pickup coil in the Power Amplifier and start up the set at reduced voltage on the Power Amplifier.

Recheck resonance conditions in all circuits to make sure that all are exactly in resonance by adjusting the flippers until a maximum antenna current reading is obtained. The voltage on the Power Amplifier tube may then be increased to its normal value.

Assuming that a 600 ohm transmission line is being used, insert in either or each line at the output terminals of the transmitter a 0-2.5 ampere Radio Frequency Ammeter. Increase the number of turns on the pickup coil until this meter reads 1.3 amperes with the transmitter in an unmodulated condition. The transmitter will then be delivering slightly over 1 kw. of carrier power. For any other value of transmission line impedance the correct current reading in the line can be computed by the formula listed below.

$I = \frac{E \text{ line}}{Z \text{ line}}$ when Z = the impedance of the line.

2. TESTS AND MEASUREMENTS

If it is desired to actually measure the characteristic impedance of the transmission lines, the method described in the Proc. Institute of Radio Engineers for July, 1927 pages 56 to 61 may be used.

This reference can be used to first measure the impedance of the lines and then measure the impedance of the terminating network itself. When both are adjusted to the same value, the line and termination can be connected together ready for operation.

When operating properly the following relations should hold true.

$$I_o^2 \, Z_o = I_a^2 \, R_a \qquad (2)$$

where I_o = transmission line current
Z_o = characteristic impedance of line
I_a = antenna current at base
R_a = Antenna radiation resistance or effective resistance plus conductor resistance.

If these conditions are not verified any or all of the following are true:

(a) The transmission line is not correctly terminated.
(b) The line is not correctly balanced.
(c) The antenna is not in resonance.

In general practice, transmission lines for radio frequencies will have characteristic impedance of from 500 to 800 ohms, although a 600 ohm line is generally used. This value of characteristic impedance is arbitrarily chosen, and the lines built to conform to it.

For all general purposes the characteristic impedance of an outdoor transmission line is calculated very closely by the relationship:

$$Z_o = 276 \log_{10} \frac{2D}{d} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where Z_o = characteristic impedance in ohms.
D = centerline distance between conductors.
d = diameter of one conductor (diameter of each must be the same).

Note—D and d may be measured in any units providing it is the same for each.

The termination of a transmission line is one of the most important adjustments of the entire transmitter, and will have the greatest influence on the efficiency and range of the station.

A very important point in connection with transmission line terminating is that the terminating impedance must equal the characteristic impedance of the transmission line.

If, therefore, this characteristic impedance is 600 ohms, the terminating must be a **resistance** of 600 ohms or a network with unity power factor as viewed externally and an equivalent impedance of 600 ohms when measured at the points where the transmission line is connected.

If this condition is not met, all of the power delivered by the driver will not be dissipated in the terminal network which includes the antenna. The amount of power which is not consumed in this terminal network will surge back and forth, from one end of the line to the other (reflections) until it is finally dissipated in the line itself, never getting into the antenna circuit at all.

When the line is correctly terminated, all the power delivered from the Power Amplifier will be delivered to and consumed by the load, the only loss being the I^2R loss in the conductors which is too small to consider. **Under these conditions the transmission line current is a minimum for a given power output.**

With the help of the preceding discussion it should not be difficult for the installation engineer to select a terminating tank capacity of the proper impedance, build a suitable line and then tune the terminating network thus balancing the line.

It is well to remark, here, that consideration has been made in designing the transmission line terminating network so that it acts in a manner to suppress the transfer of harmonic power to the antenna itself.

3. ANTENNA TUNING

The terminating condenser, balancing coils, loading coil and antenna series condensers, with the antenna proper, form a tuned radiating system. In the majority of cases the antenna itself will be operating approximately 30% below its fundamental wavelength.

After once tuning the antenna system to the carrier frequency, balancing, and properly terminating the transmission line, no further adjustment is necessary. To increase or decrease power output from the antenna, the only adjustment to be made is the increase or decrease of coupling coil turns. This variation of coupling turns merely increases or decreases the voltage applied to the line, as the case may be.

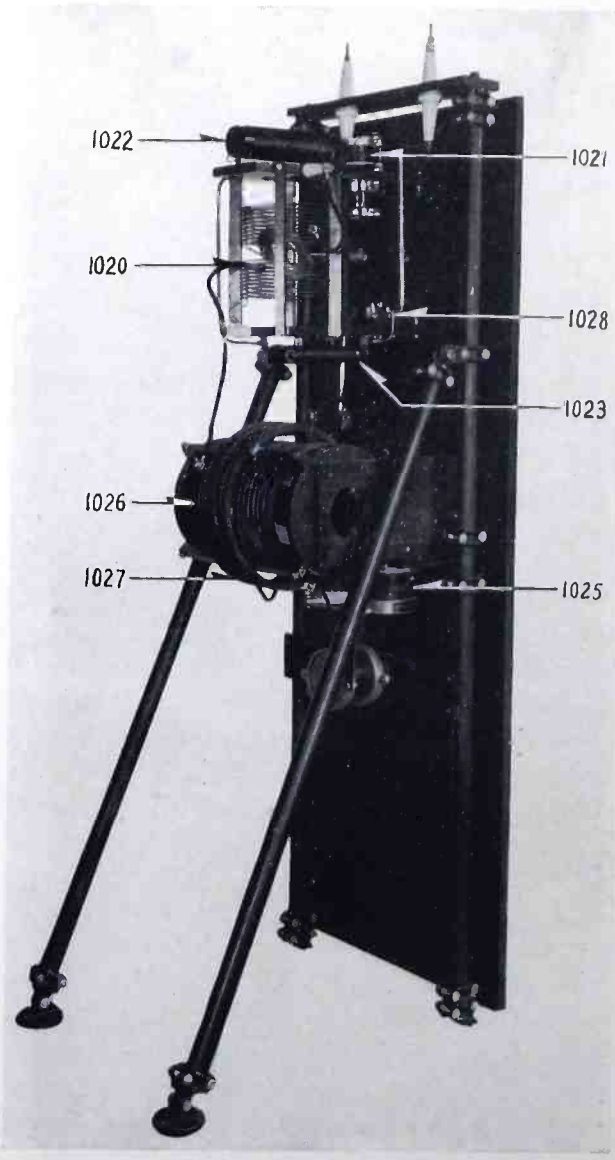


FIG. 17—ANTENNA TUNING AND COUPLING UNIT (Rear View)

IX. WATER COOLING AND CIRCULATING UNIT

1. DESCRIPTION

This interesting piece of equipment is a comparatively new application to the broadcast field and possesses some unique features.

Fig. 19 shows the assembled equipment showing copper radiator, especially built for water cooling purposes, driving motor and fan, integral water circulating pump of high efficiency, water strainer and relief or priming plug. The complete unit terminates in brass unions ready for connection to the water system.

Fig. 20 shows a fifteen gallon expansion tank with water gauge and visual, vented water flow indicator. Experience with the older types of cooling systems utilizing cumbersome cast iron radiators indicate that considerable difficulty with trapped air in the system is experienced. This trapped air appears in any type of hot water heating or cooling system and in the older types of apparatus it is necessary to relieve it at intervals, manually, by opening an escape or bleeder valve located on the radiator. The addition of the vented water flow indicator automatically releases trapped air in the system and prevents its circulation past the tube jacket in the form of bubbles, thus eliminating any chance for localized tube jacket heating and consequent breakdown of the tube jacket.

The cooling unit is rated at 4 kw. continuous dissipation and this rating is based on an ambient room temperature of 110° Fahrenheit. The maximum allowable water temperature should not exceed 156°F.anywhere in the system. The cooling system is therefore of more than ample capacity, and is adequate to cool the transmitter even if located in a tropical climate. The unit, when installed, should, of course, be located in a position where a good supply of cooling air can be obtained. Approximately 1700 cubic feet of air per minute is forced past the solid copper cooling fins.

2. DRIVING MOTOR

A four pole, 1725 r.p.m., ball bearing motor of standard design is provided. It is rated at ½ hp. and is designed for continuous reliable operation.

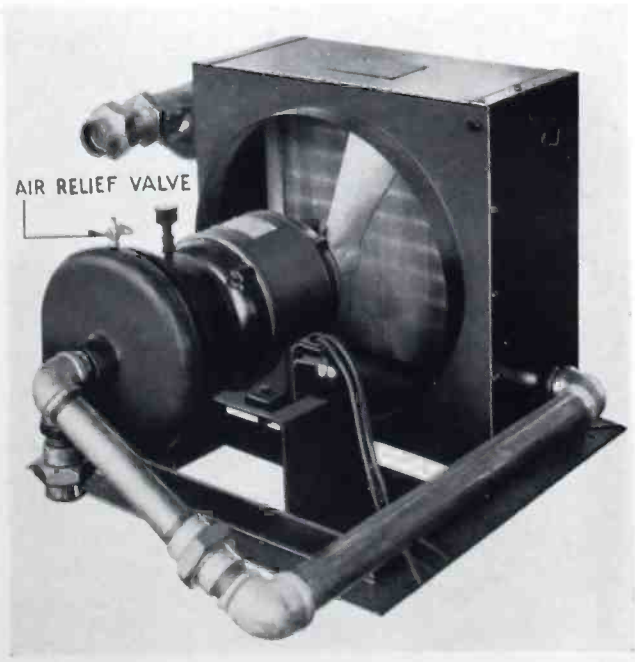


FIG. 19—WATER COOLING AND CIRCULATING UNIT

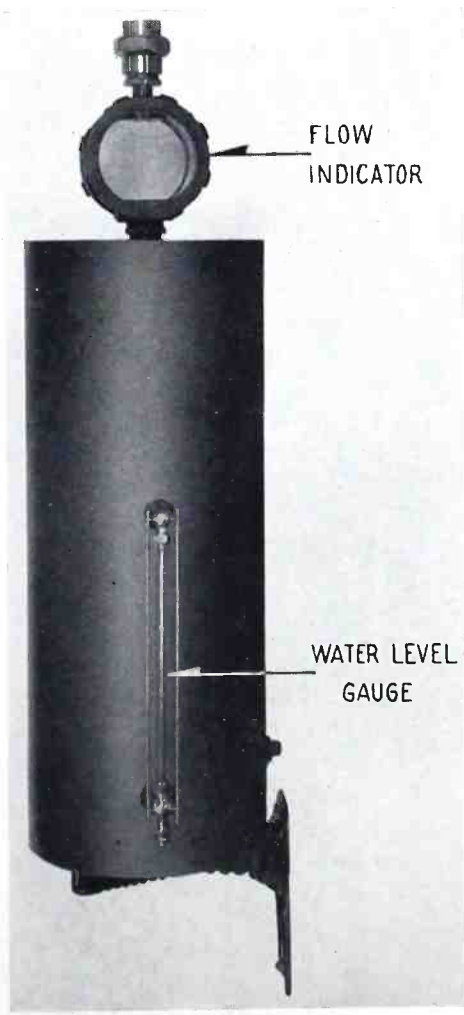


FIG. 20—EXPANSION TANK AND WATER FLOW INDICATOR

3. MAINTENANCE

Conscientious care should be exercised in the maintenance of this unit. All bearings should be oiled frequently as specified on the individual instruction sheets supplied with the equipment. Do not tighten excessively the pump bearing packing. It is possible to easily overload the driving motor by getting this bearing too tight.

On the faithful operation of this unit depends the ability of the transmitter to function, and a frozen bearing in this unit could cause a serious shutdown for replacement.

Use only **distilled** water in the cooling system, and do not fill the system so that the expansion tank is completely full. About 20 gallons of distilled water will adequately fill the system and provide an ample allowance for storage. Water may be drawn into the system by pouring it through a funnel into the filler pipe with the pump unit operating. The water pump will force the added water into the expansion tank.

Do not allow the water in the cooling system to freeze. Although the radiator is strong enough to resist any internal pressure due to freezing, there is a possibility that the pump casing may be cracked if the system is allowed to freeze solid.

Periodically drain and fill the entire system, with fresh distilled water. The tube may be removed from the jacket occasionally and wiped off with a dry rag to remove dirt which collects on the anode. The strainer may also be cleaned periodically by removing the cleaner plug and allowing the water to drain out.

X. POWER SUPPLY UNIT

The power supply unit consists of two, three unit semi-enclosed motor-generator sets.

The first of these is a filament and bias supply motor-generator which consists of a 70 ampere 19 volt generator and 550 volt .9 kw. generator driven by a 4 hp. motor. See Fig. 22. The 70 ampere 19 volt generator supplies all tube filaments except the UX-866 rectifier tubes. The 550 volt generator supplies bias supply for all tubes except those contained within the crystal oscillator unit and the speech amplifier. In addition it supplies excitation power for the filament machine as well as for the high voltage plate generator. With the exception of the 550 volt generator, all others are externally excited which is consistent with good design in that flexibility, reliability and excellent regulation of power generators is assured in this manner.

With 220 volt 60 cycle drive, this motor-generator unit rotates at 1750 r.p.m.

Special precautions have been taken in the design and construction of these generators to guarantee a remarkably low percentage of voltage ripple in their output when normally loaded. They are especially constructed for radio transmitter power supply purposes and present a very pleasing appearance.

The second unit is a three unit high voltage motor-generator set consisting of two identical 4.5 kw. 3000 volt generators driven by a 14.5 hp. motor. See Fig. 21. For operation with the Type 1-C transmitter these generators are connected in series and rated at 7½ kw. at 6000 volts. The armatures in each are interchangeable, each being insulated for maximum high voltage so that only one armature which will fit either machine need be carried for a spare. This unit also in the case of 220 volt 60 cycle supply revolves at 1750 r.p.m. These machines are especially designed and constructed to provide the most reliable kind of continuous service, and in addition are remarkably free from voltage ripple in their outputs. When wired for service with the type 1-C transmitter voltages available are 1500 volts, 3000 volts and 6000 volts. These machines are completely enclosed and protected by means of perforated metal screens. They are especially built for broadcast service and present a most pleasing appearance.

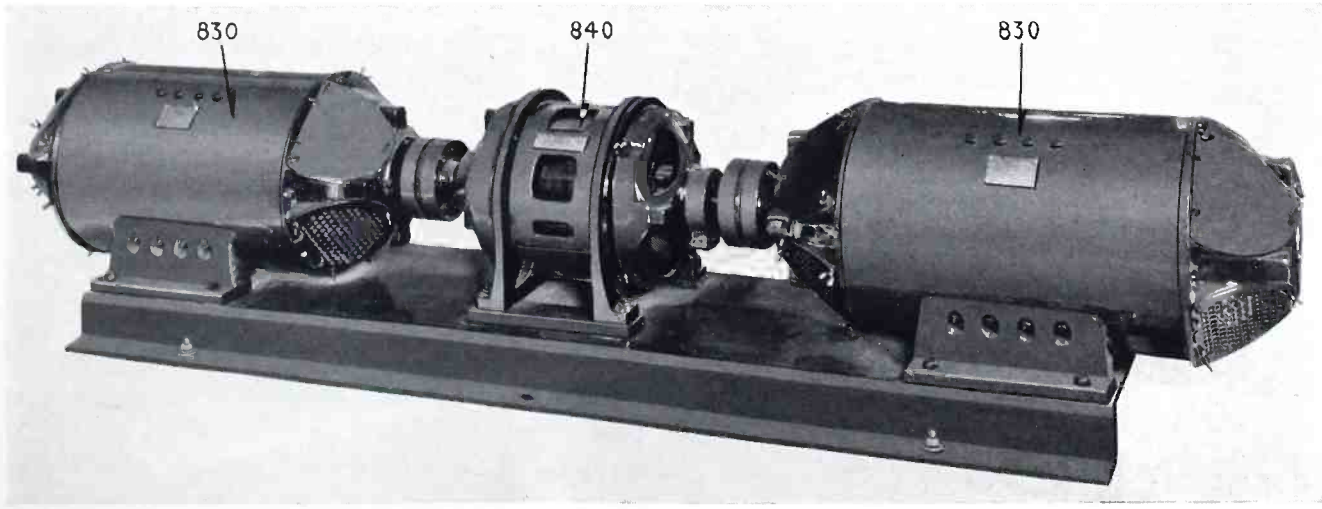


FIG. 21—HIGH VOLTAGE MOTOR-GENERATOR SET.

CIRCUIT DIAGRAM

Refer to Fig. 23 in Appendix A showing the schematic diagrams of the entire trans-transmitter, and how this power supply unit is utilized. Individual generator connections are shown in Appendix B Fig. 24.

CAUTION—Individual instruction booklets are furnished by the manufacturer with each machine. These instructions regarding the care and operation of these units should be followed explicitly to insure the long satisfactory service they are capable of giving if not abused. They concern the proper oiling and general maintenance of the units.

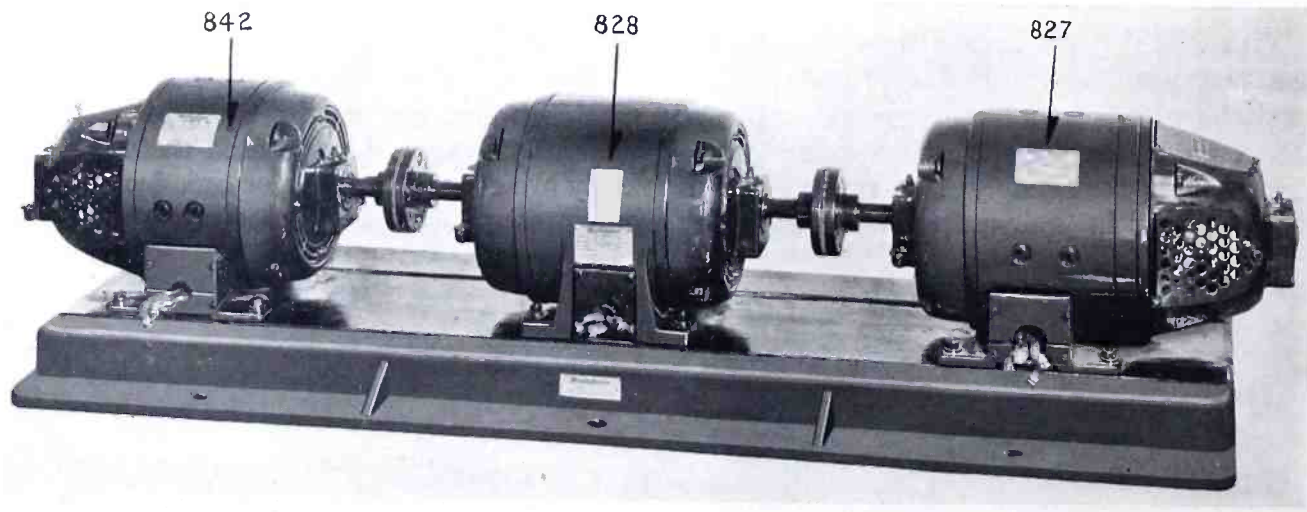


FIG. 22 – FILAMENT AND BIAS MOTOR-GENERATOR SET

XI. GENERAL OPERATING INSTRUCTIONS

When the transmitter has been adjusted ready for operation, the starting and stopping of the transmitter is a comparatively simple action on the part of the station operator. The action which takes place within the transmitting equipment, however, is quite complex. Therefore, it might be well to review the sequence of operation which is set in motion by pressing the transmitter start button.

1. TO START TRANSMITTER

First make sure that the main circuit switch on the Power Control Panel is closed and that the crystal heater switches on the rear terminal board on the modulated exciter unit are "ON". Also check to see if all high voltage disconnect switches in the rear of the modulated exciter unit are closed and that the neutralizing switch on the Power Amplifier and Control Panel is in the normal running position. When the main circuit switch is closed, the white 220 volt circuit indicator light on the Power Control panel will light.

Make sure that no one is near the antenna tuning equipment in the remotely located tuning house, that no one is working on any part of the equipment and that all doors are closed.

Turn the crystal oscillator unit selector switch to either "ON" position. Make sure that windows or doors leading to the room containing the water cooling unit are open so that a good supply of air is available.

The start button at either the Power Amplifier or the remotely located operator's desk may now be pressed. Upon doing so, **Master Contactors** on Power Control Panel will close, starting the water circulating pump and cooling fan. Water pressure will build up and begin to flow as evidenced by the **visual water flow indicator** mounted at the top of the expansion tank near the circulating pump. If the pump fails to start, the main circuit switch may be open, or fuses blown on the control panel. The **pressure indicator**, on the water pressure gauge located on the front panel of the Power Amplifier and Control unit, will increase and lie against the high pressure contact stud providing water pressure is sufficient. When the pressure indicator touches the high pressure contact stud, providing water temperature is low and that the thermostatic device is functioning properly, the contactor marked **water interlock** will close, lighting the water (white) light on the Power Amplifier panel and locking up the water pressure contact, so that the pressure indicator may touch the high pressure stud and float between low and high pressure settings without shutting down the transmitter. If the low pressure stud is touched, however, the **water interlock** relay will fall out, thus shutting down the set.

When the water interlock relay closes, the 10K contactor marked "FILAMENT M. G." will close, providing the "FILAMENT STOP SWITCH" on the front panel of the Power Amplifier and control unit is closed or in the "ON" position. The 10K contactor serves to start up the filament motor-generator set by closing the coil circuit in the 5 hp. magnetic resistance starting box located at the top rear of the Power Control Panel. This is a step type starter and will automatically bring the machine up to speed properly without even temporarily overloading the supply line.

When the 550 volt bias machine builds up so that it energizes the field of the filament generator, filament supply voltage will build up gradually as evidenced by the voltmeter reading on the Power Amplifier meter panel. The crystal oscillator unit filament voltage will also build up as indicated on its individual meter. The **white** 550 volt circuit indicator light on the control panel will light.

Bring the generator up to 14.5 volts by turning in a counter-clockwise direction the **filament rheostat** on the Power Amplifier and Control Panel. Afterwards adjust the filament voltage on the crystal oscillator unit by adjusting the rheostat provided on the front panel of the Modulated Exciter Unit.

When the filament supply voltages reaches approximately 14 volts, the **filament interlock** contactor on the Power Control Unit will go in, providing the doors are closed tight. This lights the **green** filament light on the Power Amplifier panel and also the white Filament Voltage indicator light on the Power Control Panel. At this instant also the 12-F-5 contactor marked **bias voltage** will close, the crystal oscillator unit supply rectifier will start up and supply power to this unit, and the coil circuit in the magnetic resistance starter box located in the lower rear part of the Power Control Panel will be energized. This step starter will bring the High Voltage Supply machine up to speed in a manner so as not to disturb the supply line. NOTE—Thermal overload cutouts are provided in each of these two starter boxes. They must be properly

set to insure uninterrupted normal operation. The **red** indicator light, denoting that the high voltage plate supply machine is in operation, will light providing the **Plate Stop Switch** on the Power Amplifier panel is not in the "OFF" position. If the switch is closed, the **bias interlock** on the Power Control Panel would have gone in when the 550 volt bias and excitation generator built up voltage. This serves to energize the field of the high voltage generators and apply bias so that the transmitter begins to function properly.

If the circuits are properly adjusted, the transmitter will function properly; if an overload condition exists, the **overload circuit-breaker** located behind the front panel on the Power Amplifier and Control unit will release, thus removing field excitation from the high voltage generators. The overload relay is to be operated without oil, and with the damping holes uncovered. If the overload relay does trip, it may be reset manually by pressing the "RESET" button on the front panel located directly over the water pressure gauge, or reset electrically from the remotely located operators desk by pressing the electrical reset button there.

2. TRANSMITTER WILL AUTOMATICALLY STOP ITSELF—

for any of the following reasons.

(a) Water temperature excessive.
(b) Water pressure low.
(c) Failure of water circulating system through faulty motor, pump or from loss of water because of excessive leakage.
(d) Filament voltage too low.
(e) Door open.
(f) Blown circuit fuses on Power Control Panel.
(g) Low Bias voltage because of faulty bias machine.
(h) Stopping of filament motor-generator set due to opening of thermostatic overload devices.

NOTE—Individual plate rheostats are incorporated for each high voltage generator. That for the 0 to 3000 volt unit is located in rear of Power Amplifier and Control frame, and available for adjustment purposes through the rear door. The rheostat controlling the voltage on the second machine is located on the front panel of the Power Amplifier and Control Unit.

a. The Sequence in Stopping the Transmitter is described as follows:

When the "STOP BUTTON" on the Power Amplifier panel or on the operators control desk is pushed, **master contactors** on the Control Panel fall out, breaking the field excitation on all generators except the exciter generator and stopping the water circulating pump.

The **Red** High Voltage Supply light goes **out.** At the instant that field voltage is removed from the filament machine, the **filament interlock** contactor falls out which shuts down the plate motor-generator set, removes the **green** filament light from Power Amplifier panel and cuts **off** the crystal oscillator unit rectifier supply. As water pressure falls, the filament motor-generator set stops and the water light goes out on the Power Amplifier panel.

When leaving the set for a long interval, it is well, after the set stops, to open the main primary power supply switch which shuts down the transmitter completely except for crystal heater power, which is separately fused and operated from the lighting circuit so that it may be left more or less permanently connected.

XII. STATION MAINTENANCE

SAFETY—Operators are cautioned against working on the transmitter when door interlocks are wedged. The apparatus is designed to be dead front, and so arranged that contact with dangerous circuits is impossible. Certain deliberate violations of safety provisions, such as wedging the interlocks in order to operate with doors open, cannot be guarded against in the design of the transmitter. It is well to emphasize that voltages positively dangerous to human life are being handled within these units. Caution should be observed to prevent accidents. Contact with the high voltage power supply would in all probability result in death.

An interlock is a safety device for protection against personal injury and should always be regarded as such. Station owners should insist that the rules of safety to employees include that there be no working behind closed interlocks.

Condensers in d-c. circuits are arranged so that they are automatically drained of their charges when voltage is removed from them. Always remember, however, that **it takes a few seconds for the high voltage generators to come to rest** and that their generated voltages come to zero slowly. Always notice before making circuit adjustments that these machines have come to rest before touching any part of the inside circuits.

Meter panel protective glass should never be left off during operation. Terminal board covers should also be in place when set is in operation.

Never adjust zero reading of meters with power on as in many cases the meter potentials from ground greatly exceed the insulation of the zero adjuster. It is to be noted that all plate current meters are at full plate voltage from the ground. Hence the need for strict caution regarding zero adjusting and keeping meters covered with their glass panels.

Routine operation of the 1-C Transmitter is not unlike that of any other type of transmitter. Careful maintenance which eliminates chances for breakdown at some inopportune moment is the best insurance for reliable uninterrupted program service.

Before program time, it is always good policy to put the transmitter on the air for a few minutes, to allow a check on performance and still leave time for adjustment or tube replacement before the program scheduled starts. The station can, however, in emergency be put on the air in just a few seconds after pressing the "START" button.

When changing vacuum tubes in any part of the set, a record should be kept of the period of service. Actual hours of life can be computed from the station log sheets.

Vacuum tubes of all types used in the transmitter should be mounted in a rack enclosed in a wooden structure or in any other safe place where they will be instantly available in case of need. For replacement of any air cooled tube, the set need not be off the air for more than a few seconds. Replacement of the water cooled tube has been made easy by equipping the jacket with a tilting device, by means of which, the top of the tube may be pulled forward to facilitate its removal through the front panel. The length of time required to change tubes depends to a large extent on the skill of the operator. Where possible, all new operators should be trained in the manual operations required at times when the station is not in operation.

Broadcasting stations are still a great attraction to the layman, and usually have an endless succession of visitors. The appearance of the station is, therefore, very important. All panels may be rubbed down with a thin oil dampened cloth occasionally. Brass parts, such as busses to transmission line, water piping, etc., may be polished occasionally.

MAINTENANCE SCHEDULES

(A) Daily—

Check all control circuits for proper operation. Check water level in water storage tank.

(B) Weekly—

Carefully clean entire equipment inside and out. This cleaning should be extended to include the antenna tuning equipment.

Clean and adjust all contactor contacts and relay contacts. Fine sandpaper may be used for this purpose. The operation of all contactors and relays should be assured by trial.

Clean commutators on generators.

Check water system for leaks in hose connections and water pump packing.

Check resistivity of the cooling water.

Check operation of interlocks and clean contacts with fine sandpaper, if necessary.

(C) Monthly—

Check all water cooled tubes for formation of scale. Refer to tube instruction pamphlets for directions for removal of scale.

Check omission of all thoriated filament tubes. A reduction of filament voltage of 10% should cause no appreciable drop in plate current.

Clean all filament and grid connections using fine sandpaper.

Wipe off blades and jaws of all manually operated air disconnected switches. The blades and jaws of these switches should then be lubricated with a light grease.

Inspect and tighten all electrical connections.

(D) Quarterly—

Check all cooling water hose for possible hardening. Replace if necessary.

MISCELLANEOUS HINTS ON MAINTENANCE

The appearance of the panel will be improved if rubbed occasionally with a cloth moistened with a medium body oil.

The iron work such as frame and fittings should be kept painted to avoid rusting.

The appearance of the copper tubing, not including connections, can best be cared for by cleaning with fine emery cloth immediately after installation and then applying a coat of clear lacquer.

The impregnated wooden strips used as supports for tank coils, resistor, etc., should be painted once a year with linseed oil.

The disintegration of water hose is hastened by moisture on the outside of the hose and for this reason, the outside of the hose should be kept dry.

Electrolytic action will cause disintegration of hose nipples. This action is hastened with decreasing water resistance and also with the age of the water hose due to the formation of a deposit on the inside of the hose.

It is important that the resistivity of the water be carefully watched and maintained as high as possible. If the resistivity of the water becomes low, it will cause a decrease in output by loading the water cooled stages. No adjustments should be made to compensate for this other than changing the water. The increased loading of the water cooled stages will also introduce distortion by upsetting the optimum operation conditions.

It is advisable to check antenna tuning occasionally due to possible varying conditions of ground, antenna sag and so forth.

Intermittent noises of a scratching or nonuniform nature which show up in the carrier are almost always the result of loose connections or poor contact in some part of the equipment. For this reason, it is of the utmost importance to keep all connections tight.

XIII. APPENDIX A

PARTS LIST 1 KW. TYPE 1C BROADCAST TRANSMITTER
OSCILLATOR MODULATOR AMPLIFIER UNIT
(Refer to Schematic Wiring Diagrams, Figure 23)

Schematic Number	Name	Data	Quantity
	OSCILLATOR AMPLIFIER HEATER CONTROL UNIT		
20	Rectox Unit		1
21	D-C. Relay Unit	6 V. D-C.	2
22	Snap Switch	Cat. # 2403	1
	Rectox Resistor	10 Ohms, Size 0	1
	CRYSTAL UNIT (Two required)		
101	Crystal Holder		1
102	Osc. Plate Choke Coil		1
103	First Buffer Ampl. Grid Res.	24000 ohms Code # 38N	1
104	Metastatic Thermoregulator		1
106	Meter By-pass Condenser	Model F .01 mfd.	1
107	Heater Ammeter	Type BA-250 mills. S# 477455	1
108	Crystal Heater Coil		1
109	Crystal Unit Change Over SW		1
110 110-A 110-B	Tube Socket		3
112	Crystal Osc. Grid Leaks	1000 or 7000 ohms	1
113	Plate By-pass Condenser (Crystal Oscillator)	Class A .015 mfd.	2
114	1st Buffer Plate By-pass Condenser	Class A .010 mfd.	1
115	Coupling Condenser	.002 mfd. Model F	1
116	Crystal Osc. Plate Ammeter	Type BX Proj. Mtg. 0-50 m.a.	1
117	1st Buffer Screen Grid By-Pass Condenser	Class A .010 mfd.	2
118	Fil. Voltmeter	Type BA Proj. Mtg. 0-10 V.	1
119	Voltmeter Changeover Switch		1
120 121	Plate Voltage and Multiplier	Type BX Proj. Mtg. 600 V.	1
123	Voltmeter By-pass Condenser	Model F .01 mfd.	1
124	1st Buffer Plate Choke Coil		1
125	1st Buffer Tank Coil	Type 577-C	1
126	Tank Condenser	Type 247-F 500 mmf.	1
127	Series Heater Resistor	Type QCK-1924017	1
128	1st Buffer Plate Ammeter	100 mil Type BX Ammeter	1
130	Coupling Condenser (Grid)	.0002 mfd. Model F	1
131	Grid Resistor 2nd Buffer Amp.	Type ST 10,000 ohms 7½ Watt size	2
132	Screen Grid By-pass Cond. 2nd Buffer	.003 mfd. Model F	2
133	Screen Grid Resistor 2nd Buffer	Type B-400, 40000 ohms	1
134	2nd Buffer Plate By-pass Cond.	Class A .010 mfd.	2
135	2nd Buffer Tank Cond.	Type 247-F Variable 500 mmf.	1
136	2nd Buffer Tank Inductance	Type 577-C	1
137	Plate Choke Coil 2nd Buffer		1
138	Plate Ammeter 2nd Buffer	Type BX Proj. Mtg. 100 mils	1
139	Plate Ammeter By-pass Cond.	Model F .01 mfd.	1
140	Fil. Rheostat	Cat. # 60111-A 2.5 ohms 6.5 amp.	1
141	Capacitor	.002 mfd. Class "A"	1
	UX-860 BUFFER AMPLIFIER		
201	860 Buffer Amp.—Tube Socket	Type UR-542	1
202	Fil. Resistor	1.5 ohms S# 281238-A	1
203	Grid Choke Coil		1
204	Grid Resistor	1000 ohms Size B Ferrule Term.	1
205	Screen Grid By-pass Cond.	UC-1884 .001 mfd.	1
206	Plate By-pass Cond.	UC-1884 .001 mfd.	1
207	Tank Condenser for Coil 209	UC-2617 .0005 mfd.	2
208	Grid Meter By-pass Cond.	Model T .006 mfd.	1
209	Tank Coil for UX-860		1
210	Plate Choke Coil for UX-860		1
211	Screen Grid Choke for UX-860	Honeycomb Coil	1

UX-860 BUFFER AMPLIFIER—Continued

Schematic Number	Name	Data	Quantity
212	Screen Grid Series Resistor	15,400 ohms Size T	4
213	Grid Ammeter 1st Amp. H. F.	S# 563197 50 ma. Type CX	1
214	Plate Ammeter 1st Amp. H. F.	CX S# 563202 250 ma.	1
215	Plate Ammeter By-pass Cond.	Model T .006 mfd.	1
216	Grid Coupling Cond.	UC-1857 .005 mfd. Case 11	1
	MODULATED AMPLIFIER		
301	860 Tube Sockets	S# 552120	2
302	Grid Choke Coil		1
303	Screen Grid By-pass Condenser	Type UC-1884 .001 mfd.	1
304	R. F. By-pass Condenser	Type UC-1885 .004 mfd.	1
305	Plate Blocking Condenser	Type UC-1808 .0001 mfd.	1
306	Fil. Resistor for UX-860 Tubes	1.5 ohms S# 281238-A	2
307	Plate Choke Coil		1
308	Screen Grid Choke Coil	Honeycomb Coil	1
309	Screen Grid Resistor	Type T 10,000 ohm	5
310	Grid Resistor	Type B Clip Term. 2500 ohms	1
311	Grid Ammeter By-pass Cond.	Model T Type 3 .006 mfd.	1
312	Grid Ammeter—Mod. Amplifier	Type CX S# 563199 100 ma.	1
313	Plate Ammeter	Type CX S# 563202 250 ma.	1
314	Plate Series Resistors	1650 ohms S# 145367-A	6
315	Audio Coupling Cond.	3.5 mfd. S# 374984	1
316	Plate Ammeter By-pass Cond.	Model T, Type 3 .006 mfd.	1
317	Tank Condensers	Type UC-2543 .000075 mfd.	3
318	Tank Inductance—Coil UX-860		1
319	Grid Coupling Cond.	Type UC-1885 .004 mfd.	1
320	Grid By-pass Filter	4 mfd. S# 512723	1
321	Load Resistor—Tank	125 ohms 200 watt	2
322	Capacitor	UC-1811 .0003 mfd. Case 5	1
	POWER AMPLIFIER		
401	Tank Changeover Sw.		1
402	W. C. Tube Jacket		1
403	Plate Choke Coil		1
404	Neut. Condenser	S# 669232	1
405	Tank Inductance Coil		1
406	R. F. Ammeter—(Tank)	20 amp. CX S# 628611	1
407	Tank Condensers	Type UC-2392 .0016 mfd.	3
408	6000 V. Plate Circuit Sw.		1
409	Plate Ammeter—Power Ampl.	Type CX S# 563151-1.5 amps.	1
410	Grid Choke Coil		1
411	Grid Ammeter—Power Ampl.	Type CX S# 563202-250 ma.	1
412	Plate Blocking Condenser	Type UC-2366 .002 mfd. Case 77	1
413	Power Factor Correcting Res.	30 ohms S# 475609	1
414	Grid Ammeter By-pass Cond.	Model T, Type # 3 .006 mfd.	1
415	Plate Ammeter By-pass Cond.	Model T, Type # 3 .006 mfd.	1
416	H. V. Voltmeter with External Resistors	S# N-611557	1
417	Capacitor—Grid By-pass	UC-1015-A	1
418	Resistor—Grid Parasitic	30 ohm. W. L. Size "B"	1
420	Filament Voltmeter	0-50 V. D-C. S# 563171	1
421	Power Amplifier Neutralizing Meter	1.5 Amps. S# 568331	1
	AUDIO SYSTEM		
501	849 Tube Socket 2 Parts	G-2, P-7702030 G-2, P-7702031	1
502	849 Plate Ammeter—Modulator	Type CX S# 563204 0-500 m.a.	1
504	203-A Fil. Filter Choke	.5 H.-3.25 amps.	1
505	849 Grid Resistor	5000 ohms Size B	1
506	Heising Choke	30 H .5 amps.	2
507	849 Fil. Resistor	1.1 S# 281229-A	1
508	849 Grid Resistors	Type T 15,000 ohms	3
509	203-A Series Plate Resistors	10,000 ohms S# 389102	5
510	847 Plate Ammeter By-pass Cond.	Model T Type 3.006 mfd.	1
511	Coupling Condensers	Type UC-2209-E 1 mfd. # 56 Case Faradon	2
512	203-A Tube Socket	Type UR-541	1
513	203-A Bias Battery	Type 5540 22½ V.	1
514	203-A Grid Resistor	2000 ohm Type A-53-2000	6
515	Speech Input Transformer	Type GW-164	1
516	203-A Plate Ammeter By-pass Cond.	Model T Type 3 .006 mfd.	1
517	849 Grid Ammeter By-pass Cond.	Model T Type 3 .006 mfd.	1
518	203-A Plate Ammeter	Type CX S# 563199 100 m.a.	1
519	203-A Fil. Changeover Switch	S# 554199	1
520	849 Grid Ammeter	Type CX S# 563192 10 m.a.	1

Schematic Number	Name	Data	Quantity
	CRYSTAL UNIT RECTIFIER		
601	Plate Transformer	S# 379536	1
602	Trans. Primary Rheostat	S# 309639-B, 60 ohm	1
603	Filter Condenser	4 mfd. S# 512723	1
604	Filter Condenser	4 mfd. S# 512723	1
605	866 Tube Socket	Type UR-542	1
606	866 Tube Socket	Type UR-542	1
607	Filter Reactor	15 H. .25 ampere	1
608	Filter Condenser	4 mfd. S# 512723	1
609	Potentiometer	2823 ohms S# 460652-A Resistors	2
610	Transf.—Pri. Resistor	43 ohms S# 204547-A	1
611	Voltmeter—Rectifier Fil.	Type CA# N-714242	1
	BIAS POTENTIOMETER AND SUPPLY		
701	Filter Reactor	15 H. 250 ma.	1
702	Mod. Bias Potentiometer	Type # 371, 18,000 ohms	1
703	Filter Condenser	4 mfd. S# 512723	1
704	Filter Condenser	4 mfd. S# 512723	1
705	Bias Potentiomener	600 ohms S# 281417-A	4
706	Filter Condenser	4 mfd. S# 512723	1
	POWER SUPPLY AND CONTROL SYSTEM		
801	Main Supply Fuses	Fuses S# 292848 Link S# 292838	3
802	Fuses—Control System	Cat. # 1860	2
803	Push Button Station		1
804	Master Contactor		
	Contactor	12 F. 5 S# 559637	1
	Coil	S# 585571	2
	Contactor	15 F. 5 S# 579135	1
805	Water Pump Motor	3 ph., 60 cy., 220 volts ½ Hp.	1
806	Water Pressure Gauge and Interlock	0-25 lbs. S# 253961	1
807	Water Temp. Interlock—Thermostat	S# 372536-C	1
808	Fuses	Cat. # 1857	2
809	Water Pressure Ind. Light		
	Receptacle	S# 549463	1
	Lamp	S# 549474	1
	Lens	S# 549470	1
810	Fuses	Cat. # 1860	2
811	Fil.—M. G. Contactor	S# 437405 Type 10-K	1
	Coil	S# 472459	1
812	Water Interlock Relay	S# 546346 Type K. M.	1
	Coil	S# 546335	1
813	Series Res. Water Int. Relay	1250 ohms S# 232235	1
814	Fil. Start Switch	Cat. # 3962	1
815	Fil. M. G. Interlock Relay	S# 518924 Type KG-2	1
	Coil	L-199688	2
816	Fil. Indicator Light Recep.	S# 549463	1
	Lamp	S# 549474	1
	Lens	S# 549469	1
817	Bias Voltage Relay	S# 559638	1
	Coil	S# 585571	1
818	Plate Voltage Ind. Lamp	S# 549474	1
	Receptacle	S# 549463	1
	Lens	S# 549468	1
819	Bias Interlock Relay	S# 595407	1
	Coils	L Spec. 249694—S# 760306	2
820	Plate Control Switch	Cat. # 3962	1
821	Filter Cond. 1500 V. Circuit	3.5 mfd. S# 374984	1
822	1500 V. Filter Reactor	15 H. 250 ma.	1
823	Overload Relay	Type KN-S# 205,000 Coils S# 295001	1
824	Fil. Field Rheostat	11,000 ohm similar to S# 309683-A	1
825	Condenser } Spark Absorber	1 mfd. Type UC-490-A	1
826	Resistor } Spark Absorber	Size 7000 ohm Type B Clip Term.	1
827	Fil. Generator D-C.	1.33 Kw. 19 V.	1
828	Fil. M. G. Driving Motor	4 hp., 220 volts, 3 ph., 60 cy.	1
829	H. V. Field Rheostat	6500 ohm similar to S# 309683	2
830	H. V. Generators	3000 V. D-C., 4.5 Kw.	2
831	3000 V. Filter Reactor	S# 651442	1
832	3000 V. Filter Condenser	3.5 mfd. S# 374984	1
833	3000 V. Filter Condenser	3.5 mfd. S# 374984	1
834	H. V. Filter Condensers	S# 637390	3
835	H. V. Filter Reactor	S# 651442	1
836	3000 V. Plate Knife Sw.	S# 189800	1

POWER SUPPLY AND CONTROL SYSTEM—Continued

Schematic Number	Name	Data	Quantity
837	Fil. M. G. Magnetic Line Starter	Class 11-400-A5 S# 581681 3 ph., 60 cy., 220 v.	1
838	Plate M. G. Magnetic Line Starter	Class 11-400-A5 S# 581682	1
839	Door Interlocks	Cat. # 2356	5
840	Plate M. G. Driving Motor	15 hp., 220 volt, 3 ph., 60 cy.	1
841	1500 V. Plate Switch	S# 189800	1
842	550 V. Exciter and Bias Gen.	550 V. D-C. .9 Kw.	1
843	110 V. Ind. Lamp	S# 549474	1
	Receptacle	S# 549460	1
	Lens	S# 549473	1
844	220 V. Ind. Lamp	S# 549474	1
	Receptacle	S# 549463	1
	Lens	S# 549473	1
845	500 V. Ind. Lamp	S# 549474	1
	Receptacle	S# 549463	1
	Lens	S# 549473	1
	Resistor	Size T 2500 ohms	1
	Resistor	Size T 1000 ohms	1
846	22 V. Ind. Lamp	S# 549474	1
	Receptacle	S# 549462	1
	Lens	S# 549473	1

MONITORING RECTIFIER

901	Coupling Coil		1
902	Plate Blocking Condenser	.002 mfd. Class A	1
903	280 Tube Socket	Type UX S# 9040	1
904	Series Fil. Resistor	4.75 ohms Size B Screw Term.	1
905	R. F. Choke Coil		1
906	Resistor	350 ohms Size 0 Screw Term.	1
907	Condenser	.05 mfd. Tinytobe	3
908	Audio Choke Coil		1
909	Adj. Meter Monitoring Rec. Plate Current	50 ma. Type CX S# 563197	1
910	Signal Light Relay	Type E-525 220 ohm Coil	1
911	Audio Vol. Control Pot.	10,000 ohm Adjustat 507-77	1
912	Filter Condenser	1 mfd. Tobe Type 201	1
913	Filter Choke		1
914	Coupling Condenser	2 mfd. Tobe Type 202	1
915	Audio Choke Coil		1
916	Modulation Meter	5 Ma. Type CX	1
917	Plate Resistor	2600 ohms Size 0 Scr. T.	1
918	280 Tube Socket	Type UX S# 9040	1
919	Series Fil. Resistor	4.75 ohms Size B Scr. T.	1
920	By pass Condenser	.001 mfd. Class A	1

ANTENNA COUPLING AND TUNING UNIT

1020	Loading Coil		1
1021	Series Condenser	Type UC-2577 .0012 mfd.	1
		Type UC-2604 .0065 mfd.	1
1022	Drain Choke Coil		1
1023	Drain Resistor	10,000 ohm S# 324082	2
1024	Antenna Ammeter	0-10 Amps. R. F. Type CX S# 568336	1
1025	Tank Condensers	Type UC-2366 .002 mfd.	2
		Type UC-2325 .001 mfd.	1
1026	Trans. Line Tank and Coupling Coil		1
1027	Trans. Line Coup. Coil		
1028	Antenna Ammeter	S# N-612885 Type CX	1
	Thermocouple	S# N-611200	1
	Protective Circuit		1
	Coil	Type 577-C	2
	Condenser	Class A .03 mfd.	2

GENERATOR BRUSHES

827	Fil. Generator	S# 761473	4
842	Bias Generator	S# 761507	4
830	Plate Generator	S# 777871	4 per generator

HOSE CONNECTIONS FOR POWER AMPLIFIER TUBE JACKET

Jacket Lower Connection	7750805—P-1	1
Jacket Upper Connection	7750805—P-4	1
Water Piping	7750805—P-4	2

XIV. APPENDIX B

Construction and Installation Drawings

WIRE SIZES FOR INSTALLATION

CONNECTION DIAGRAM

For 60 cycle 3 phase 220 volt

Power Supply

Connection Number Denoted by (#)	Number of Conductors	B & S Gauge	Insulation and Voltage Rating
1	3	# 1	600 V. RILC
2	2	# 12	600 V. RILC
3	3	# 4	600 V. RILC
4	3	# 12	600 V. RILC
5	3	# 8	600 V. RILC
6	2	# 12	600 V. RILC
7	1	# 12	600 V. RILC
8	2	....	Note # 1
9	8	# 18	Note # 2
10	1	# 1	600 V. RILC
11	1	# 1	600 V. RILC
12	1	# 12	600 V. RILC
13	1	# 12	3000 V. RILC
14	1	# 12	6000 V. RILC
15	1	# 12	600 V. RILC
16	1	# 12	600 V. RILC
17	5	# 12	600 V. RILC
18	2	# 18	Note # 3
19	1	# 12	2500 V. RILC
20	4	# 12	600 V. RILC
21	2	# 12	600 V. RILC
22	12	# 12	600 V. RILC
23	2	# . .	Note # 4
24	1	# 12	600 V. RILC
25	1	# 12	3000 V. RILC
26	1	# 12	600 V. RILC
27	1	# 12	600 V. RILC

Note # 1: 3/8" copper tubing to lead out insulators. R.C.A. to specify transmission line from lead out insulators to antenna turning house.

Note # 2: To consist of 4 cables each containing 2 # 18 wires, these cables to be twisted lead covered cables. RILC wire.

Note # 3: Two # 18 wires RILC twisted pair.

Note # 4: Two wires RILC twisted, resistance of loop to be .644 ohms. Size of wire determined by length of run and the stated resistance value for the loop. Wire length from meter terminals to thermocouple terminals.

GENERAL CONDUIT NOTE————

1. Wires 3, 4 and 5 may be run from terminal board in same conduit to first branch.
2. Wires 6 and 7 may be run in same conduit as far as first branch.
3. Wires 10 and 11 may be run in same conduit.
4. Wires 12, 13, 14 and 19 may be run in same conduit.
5. Wires 15 and 16 may be run in same conduit.

XV. APPENDIX C

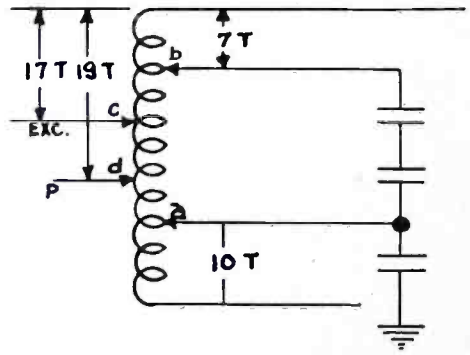
The adjustment of this transmitter requires considerable care. The following information should prove to be a valuable aid to the operating personnel in making the necessary adjustments.

CRYSTAL OSCILLATOR UNIT

For frequencies higher than 1200 kilocycles the lower half of the plate circuit inductance coils in both of the buffer amplifier stages should be permanently short circuited. When adjusting the condenser settings, care should be taken to see that the dial readings are approximately the same at all times, otherwise the crystal oscillator unit will double its initial frequency in the last buffer stage.

A table of the approximate tank circuit condenser connections for each of the remaining R. F. stages is given below.

At the right is shown a schematic view of typical tank adjustment for 1230 kc.

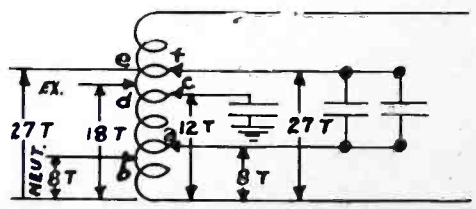


3rd Buffer Amplifier: (1230 kc.)

a. Ground and Tank 10 turns from bottom of coil
b. Tank 7 turns down from top
c. Excitation tap. 17 turns down from top.
d. Plate Tap 19 turns down from top

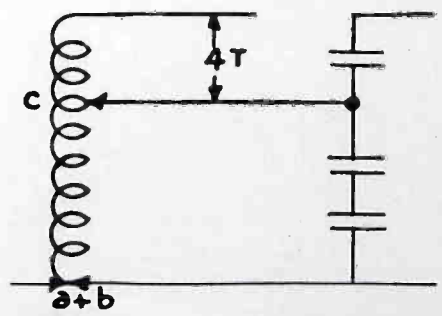
Modulated Amplifier: (1230 kc.)

a. Tank 8 taps up from bottom
b. Neutralizing tap 8 turns up from bottom
c. Ground 12 taps up from bottom
d. Excitation 18 taps up from bottom
e. Plate 27 taps up from bottom
f. Tank 27 taps up from bottom



Power Amplifier: (1230 kc.)

a. Tank Bottom Turn
b. Plate Bottom Turn
c. Tank 4 turns down from top



Coupling Coil:

For a 600 ohm load 6 turns were used.

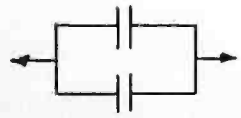
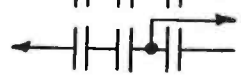
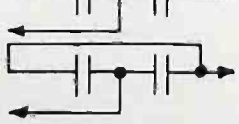
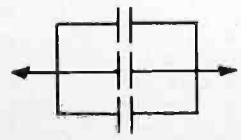
TABLE OF INDUCTANCE AND CAPACITY SETTINGS FOR 1500 KC.

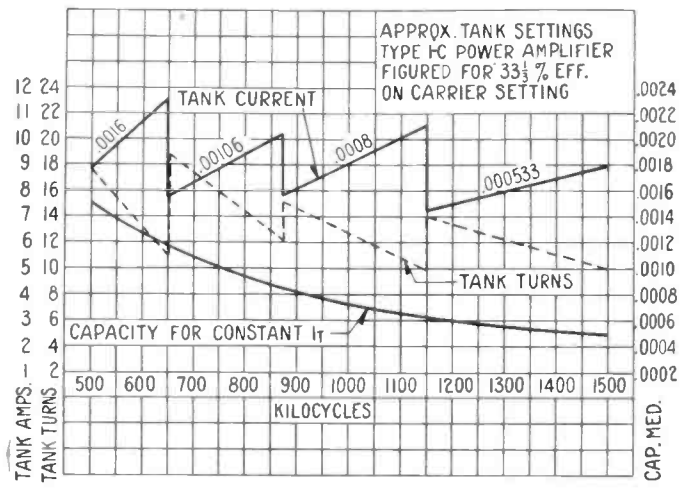
3rd Buffer Stage (All taps up from bottom of coil)		
Tank	14 turns	
Plate Feed	14 turns	Tank Capacity .00025 mfd.
Excitation	25 turns	
Plate	36 turns	
Tank	38 turns	
Modulated Amplifier (All taps up from bottom of coil)		
Tank	11 taps	
Neutralizing	12 taps	Tank Capacity .00015 mfds.
Ground	14 taps	
Excitation	17 taps	Resistor 10 ohms
Plate	23 taps	
Tanks	24 taps	
Power Amplifier (All taps up from bottom of coil)		
Tank	2 turns	Tank Capacity .0008 mfds.
Plate	3 turns	Grid Resistor 11.8 ohms
Ground	12 turns	

TABLE OF INDUCTANCE AND CAPACITY SETTINGS FOR 550 KC.

3rd Buffer Stage (All taps up from bottom of coil)		
Tank	7 turns	
Plate Feed	7 turns	Tank Capacity .001 mfd.
Excitation	20 turns	
Plate	44 turns	
Tank	43 turns	
Modulated Amplifier (All taps up from bottom of coil)		
Tank	3 taps	
Neutralizing	14 taps	
Ground	20 taps	Tank Capacity .000225 mfds.
Excitation	32 taps	
Plate	42 taps	Resistor 60 ohms
Tank	42 taps	
Power Amplifier (All taps up from bottom)		
Tank	3 turns	Coupling 5 turns into 600 ohms
Plate	½ turn	Line
Ground	12 turns	Grid Resistor 30 ohms

TABLE OF CAPACITY COMBINATIONS FOR EACH STAGE

OPERATING		STAGE					
Wave Length	Freq.	Third Buffer		Modulated Amplifier		Power Amplifier	
Meters	Kc.	Capa. Mfds.	Connection	Capa. Mfds.	Connection	Capa. Mfds.	Connection
200	1500	.00025		.00015		.00053	
265	1130			.00015		.0008	
300	1000	.0005		.00015			
545	550	.001		.000225		.0016	



APPROXIMATE TANK SETTINGS TYPE 1-C POWER AMPLIFIER—Curve 183903

NOTE ON THE ADJUSTMENT OF CRYSTAL OSCILLATOR UNIT

For operation of the crystal oscillator on frequencies greater than 1000 kc. the following revisions are necessary.

Tank circuit coils on both amplifiers, designated as items 125 and 136 on schematic diagram Fig. 23 must be revised by short circuiting one half of the coil. A short circuiting link is provided for this purpose. The excitation tap to the next stage must also be moved to come directly to the same tap which goes to the plate of the tube.

A similar plate coil designated as item 102 must be revised by short circuiting one half of the coil winding by means of the removable link provided for this purpose.

TABLE OF TYPICAL METER READINGS

Crystal Oscillator Unit:

Filament Voltage	7.5 volts	
Crystal Oscillator Plate Current		35 milliamperes
1st Buffer Amplifier Plate Current		20 milliamperes
2nd Buffer Amplifier Plate Current		20 milliamperes
Crystal Oscillator Plate Voltage	210 volts	
Buffer Amplifier Plate Voltage	450 volts	

3rd Buffer Amplifier:

Filament Voltage	10 volts	
Plate Voltage	1500 volts	
Screen Grid Voltage	700 volts	
Grid Bias Voltage	375 volts	
Plate Current		60 milliamperes
Grid Current		20 milliamperes

Modulated Amplifier:

Filament Voltage	10 volts	
Plate Voltage	1600 volts	
Screen Grid Voltage	500 volts	
Grid Bias Voltage	475 volts	
Plate Current		140 milliamperes
Grid Current		40 milliamperes

Modulator:

Filament Voltage	11 volts	
Plate Voltage	3000 volts	
Grid Bias Voltage	135 volts	
Plate Current		100 milliamperes

Power Amplifier:

Filament Voltage	14.5 volts	
Plate Voltage	6000 volts	
Grid Bias Voltage	550 volts	
Plate Current		500 milliamperes
Grid Current		20 milliamperes

Speech Amplifier

Filament Voltage	10 volts	
Plate Voltage	1000 volts	
Bias Voltage	22.5 volts	
Plate Current		40 milliamperes

These readings with the exception of the value for filament voltage are only typical and may be used as a guide toward the proper adjustments. Under some conditions of adjustment the actual readings may deviate slightly from the values given in this table.

XVI. APPENDIX D

General Information

ASSEMBLY AND ADJUSTMENT OF PRECISION CRYSTAL TEMPERATURE UNIT

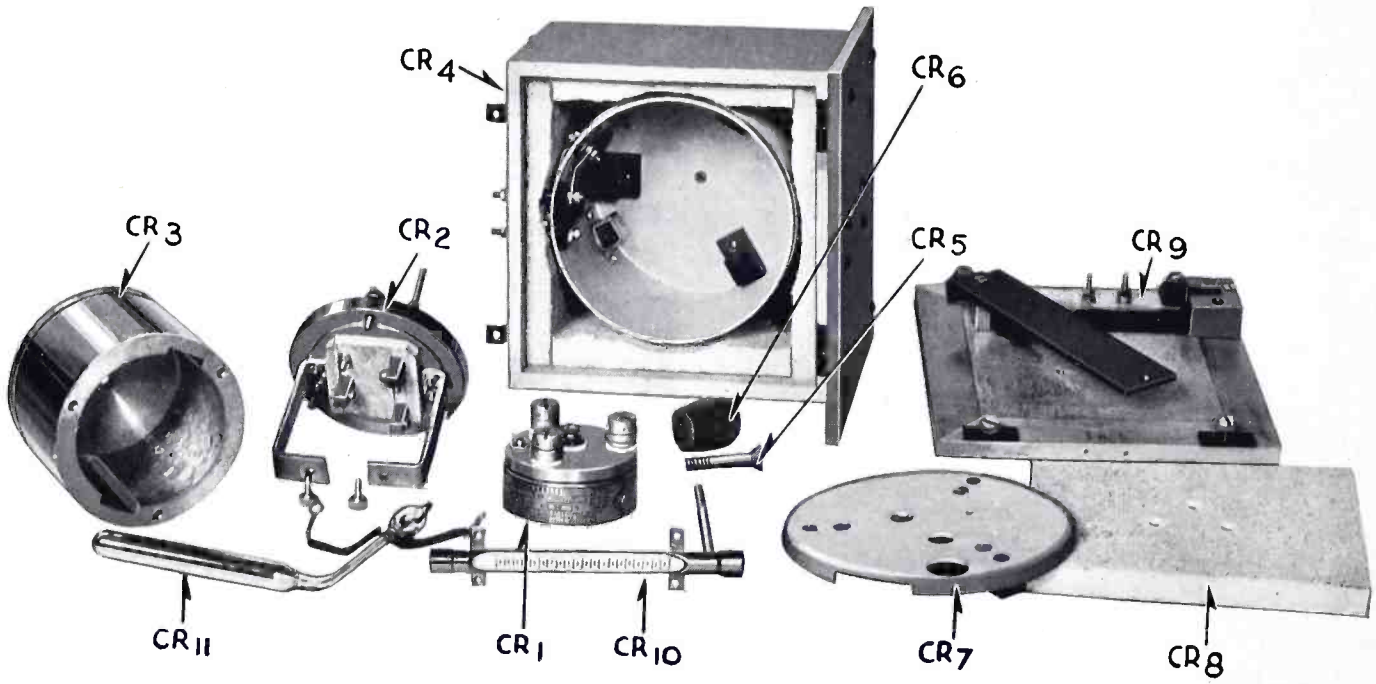


FIG. 1—PARTS COMPRISING CRYSTAL BOX ASSEMBLY

CR_1—Crystal Holder with Quartz Plate
CR_2—Crystal Mounting
CR_3—Crystal Well
CR_4—Heater Box with Heater Winding (R_{12})
CR_5—Fibre Screw
CR_6—Felt Thermometer Insulator
CR_7—Cover for Heater Box
CR_8—Celotex Insulating Cover
CR_9—Wood Box Cover
CR_{10}—Thermometer with Guard
CR_{11}—Metastatic Thermoregulator

Caution—To insure correct results when assembling or disassembling this apparatus, the following instructions must be carefully observed.

Unpacking—The crystal heater box, as shipped from the factory, is completely assembled with the exception of the crystal well, the metastatic thermoregulator and the thermometer, which are separately packed for security in transit. All parts of the shipment should be unpacked with the greatest care to avoid damage to the apparatus which is inherently fragile. If any parts were broken in shipment, the matter should be taken up with the transportation company. Save all the shipping boxes for use if the crystal unit is returned to the factory for servicing.

Equipment—As received, therefore, the equipment will consist of a crystal heater box, a special "L" thermometer, a crystal well and crystal holder complete with quartz plate and a metastatic thermoregulator.

Assembly of Apparatus—In order to assemble the apparatus for use, it is first necessary to dismantle the crystal heater box. To

FIG. 2—PLACING CRYSTAL MOUNTING IN WELL

Note:—This shows assembly of crystal holder and mounting but does not show connection from crystal holder to terminals.

1—Terminal to Oscillating Crystal
2—Thumbscrews for Assembling Mounting and Well
3—Locating Pin

do this, open the box by loosening the four top thumbscrews, and lifting the cover free. With the little finger placed in the large hole in the Celotex insulating cover, remove this piece also. Then lift out the aluminum heater box cover. The heater compartment is now open.

All of the parts which constitute the assembly of the crystal box are at hand, as shown in Fig. 1, which also shows the crystal well open and crystal holder removed. From here the process of assembly is as represented in Figures 2 to 6 inclusive. Attach the crystal holder to the crystal mounting, examine the crystal for cleanliness by looking at it toward a light. When the mounting is vertical, there should be a small air gap between the crystal plate and the upper electrode of the holder, this gap should be clean and free from dust. If necessary, blow any dust away from the crystal surface or pass a piece of thin lintless paper between the plate and the electrode. The presence of dust or dirt might cause the crystal to be inoperative.

Do not remove the crystal from **holder or tamper with crystal holder in any way because its calibration may be altered, and the quartz plate damaged.** Connect the rim of the top plate of the precision crystal holder to one of the insulated terminal posts in the support and the central terminal of the crystal holder top plate to the other insulated post. The central terminal must be connected to the insulated post nearest the center of the crystal

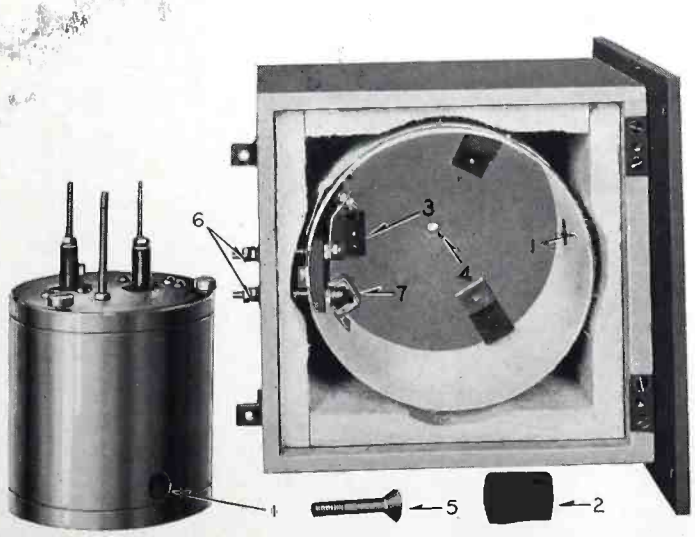


FIG. 3—CRYSTAL WELL ASSEMBLY AND HEATER BOX

1—Hole for Thermometer
2—Felt Insulating Washer to be around Thermometer in space between Heater Box and Crystal Well
3—Hole for Crystal Well Locating Pin
4—Hole for Fibre Screw to fasten Crystal Well
5—Fibre Screw
6—Terminals for Heater
7—Seat for Thermoregulator Bulb

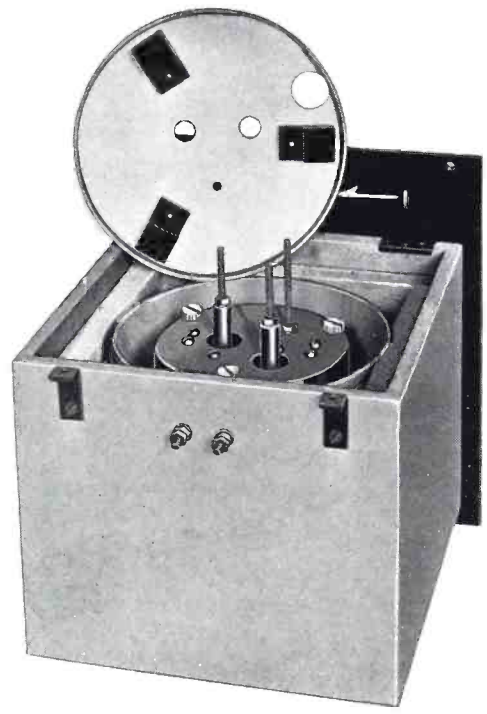


FIG. 4—CRYSTAL WELL MOUNTED IN HEATER BOX

1—Heater Box Cover about to be put into place.

well top plate. Figure 2 shows the crystal holder and mounting assembled and ready to be placed in the crystal well. This can be done in only one way. Clean the well out thoroughly before inserting the crystal mounting. **Do not drop the crystal mounting into the well—lower it carefully,** and fasten down the three thumb screws, **with the fingers only.** It is not necessary to use a screw driver.

Near the bottom of the well is a hole for the thermometer, and on the bottom there is a small locating pin. The well is lowered into the heater box with the thermometer hole to the front in line with other similar holes, and with the pin of the well in a small hole in the bottom of the box, provided for lining up purposes. When located this way (Fig. 3) insert the flat head fibre screw in the bottom of the box to fasten the well permanently in place. Use care in tightening this screw so as not to break it and yet have it tight. Next, take a pencil or similar device and push it through the thermometer holes from the front of the panel to see that this passage is clear. Then take the thermometer and slip it into place in the hole. While this is being done, the felt washer (used to insulate the thermometer where it passes through the dead air space between the heater and the well) is put into place over the thermometer bulb as it is pushed through. In placing the thermometer, it should move freely into place, without inter-

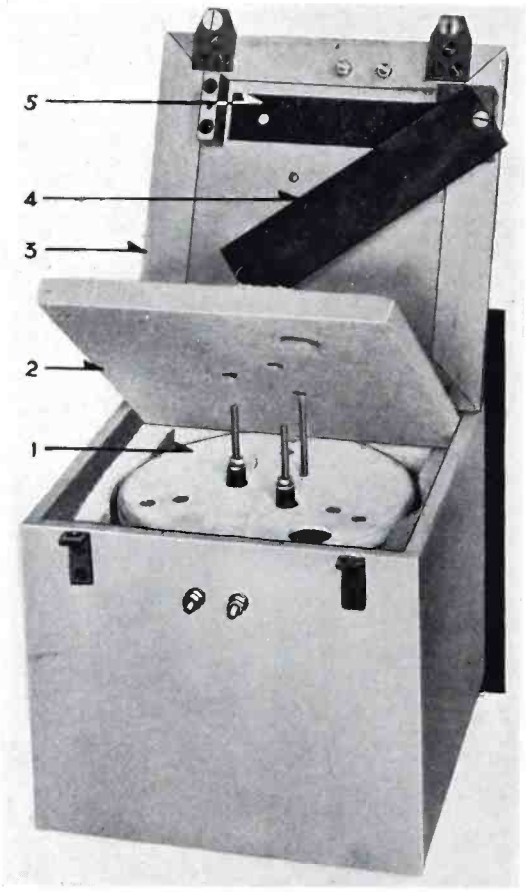


FIG. 5—ORDER OF PLACING COVERS ON CRYSTAL BOX

1—Heater Box Cover in place
2—Celotex Insulating Cover
3—Wood Box Cover
4—Guard for Thermoregulator partially removed
5—Hole for Thermoregulator Bulb

ference. **Do not push it** if it seems to be obstructed or the glass will be broken. Clear the passage by aligning the holes or clearing the heater insulation (felt). When in position, fasten with four screws that pass through the thermometer guard into the front panel.

After the thermometer is located in accordance with the front view (Fig. 7), proceed to put the heater cover on the heater box (see Fig. 4), then the Celotex cover, and then the wood box cover (see Fig. 5). Secure the latter with its four thumbscrews, and put the washers and nuts on the crystal terminals projecting through the middle of the wood cover, as in Figs. 5 and 6.

Next comes the work of putting in the Metastatic Thermoregulator, a delicate instrument which must be handled with the utmost care. With a screw driver, remove the screws that fasten the bakelite guard for the regulator (Fig. 5, part 4) and remove the guard and the felt piece (Fig. 6, part 3) that fits into Part 4, Fig. 6. Take a pencil to see if the regulator bulb hole is clear. Then remove the regulator from its box, and prepare to calibrate it for use at the crystal temperature specified on the crystal unit nameplate by the instructions given under "ADJUSTING THE METASTATIC THERMOREGULATOR" (Page 47). When calibrated to control at the correct crystal temperature, insert it into the crystal heater box, as shown in Fig. 6. Lower carefully, grasping the regulator with two fingers on the **bulb portion** of the stem and not by the small "L" portion. See that the regulator bulb eventually seats in the proper place (Fig. 3, part 7). This is located by sense of feeling. Place the folded felt pad over the tip and replace the bakelite guard. Connect the two coiled wire connectors of the regulator to the terminals provided and fasten securely.

The complete assembly of crystal holder, heater and box is now ready to be inserted into the circuit where it may be connected and put into operation.

Return Instructions—Keep all the boxes used by the factory to ship the apparatus, and use them for returning same when necessary. The apparatus should be returned exactly in the same manner as received origi-

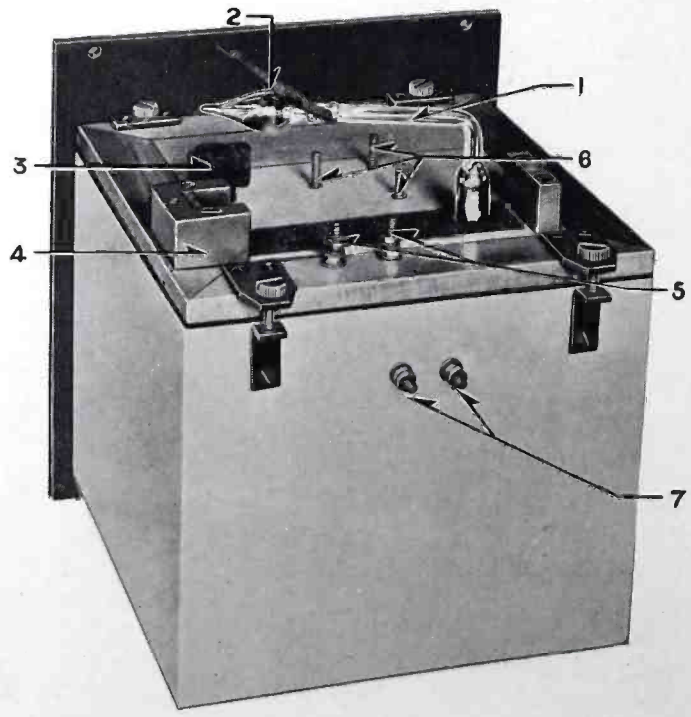


FIG. 6—ASSEMBLED CRYSTAL BOX AND INSERTION OF THERMOREGULATOR

1—Metastatic Thermoregulator partially inserted
2—Connectors for Regulator Contacts. Attach to (5)
3—Felt Pad (Fits over tip of regulator in 4)
4—Felt Pad Retainer and Guard for Regulator Tip
5—Terminals for Regulator Contacts
6—Oscillating Crystal Terminals
7—Heater Terminals

nally—crystal well, crystal box and unit, thermoregulator and thermometer all separately packed with great care.

Replacement Parts—Order replacement parts by referring to the nameplate readings in your order, and identify by the numbers given in the legend of Fig. 1.

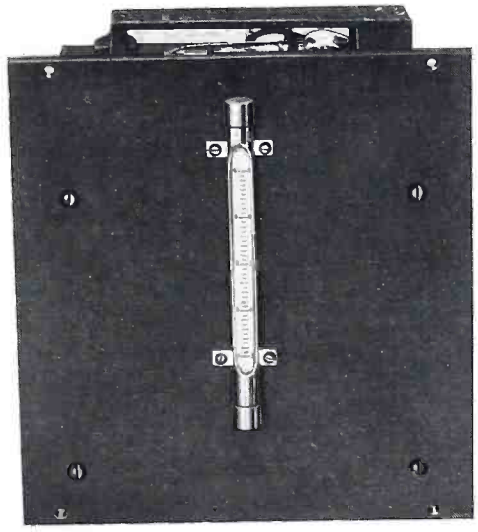


FIG. 7—FRONT VIEW OF COMPLETELY ASSEMBLED CRYSTAL BOX

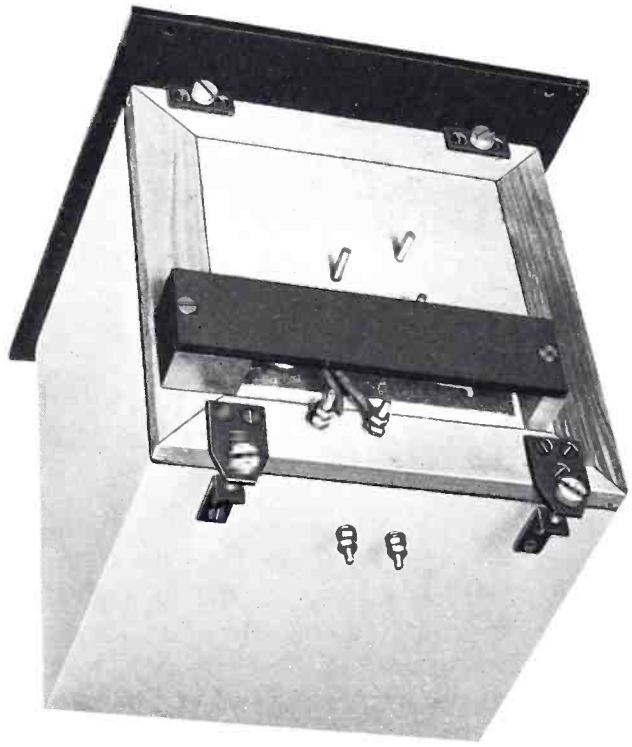
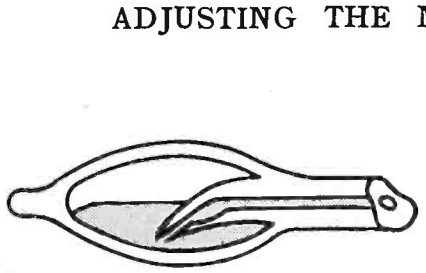
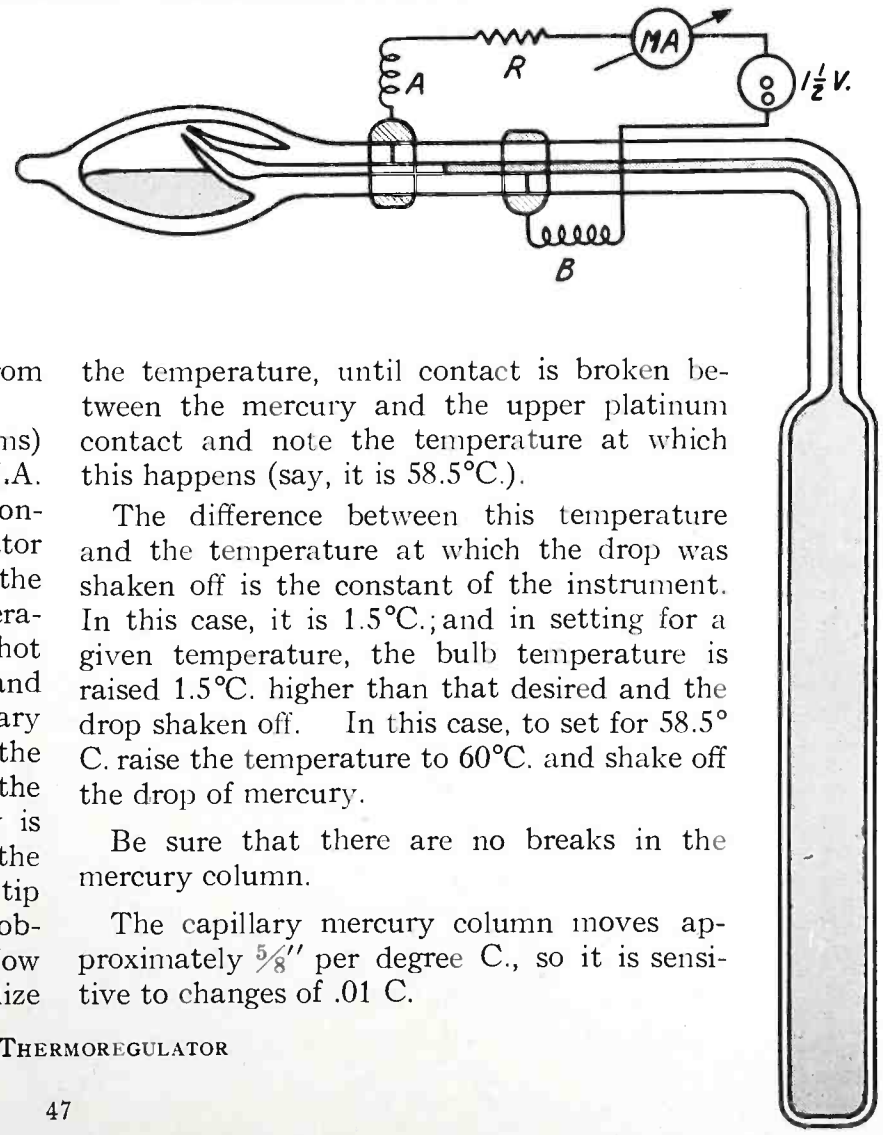


FIG. 8—REAR VIEW OF COMPLETELY ASSEMBLED CRYSTAL BOX

ADJUSTING THE METASTATIC THERMOREGULATOR



Position for Setting



1. Carefully remove thermoregulator from quartz crystal oven.

2. Connect a resistance, R, (about 50 ohms) in series with a milliammeter (50 or 100 M.A. d-c. meter), a dry cell (1.5 volts), and the contacts on the regulator; then hold the regulator in the position for setting (Fig. 9) and heat the bulb by immersing it in hot water (its temperature may be controlled by adding more hot water or cold water and stirring it up) and heating it until the mercury in the capillary joins that in the reservoir. Now allow the water temperature to become steady; tip the regulator so that the tip of the capillary is above the surface of the mercury; shake the small drop of mercury remaining on the tip of the capillary off into the reservoir, and observe the temperature (say it is 60°C.). Now cool the water slowly, stirring it well to equalize the temperature, until contact is broken between the mercury and the upper platinum contact and note the temperature at which this happens (say, it is 58.5°C.).

The difference between this temperature and the temperature at which the drop was shaken off is the constant of the instrument. In this case, it is 1.5°C.; and in setting for a given temperature, the bulb temperature is raised 1.5°C. higher than that desired and the drop shaken off. In this case, to set for 58.5° C. raise the temperature to 60°C. and shake off the drop of mercury.

Be sure that there are no breaks in the mercury column.

The capillary mercury column moves approximately $\frac{5}{8}$" per degree C., so it is sensitive to changes of .01 C.

FIG. 9—THERMOREGULATOR

CARE AND OPERATION OF BALL BEARING MOTOR-GENERATOR SETS (A-C. MOTOR, D-C. GENERATOR)

Initial Inspection—After unpacking the motor generator examine it carefully to see that no damage has occurred during shipment. Turn the shaft by hand to see that it turns freely. Check the nameplate data to make certain that the rating is correct for the power supply and load.

Do not apply voltage to the motor without noting carefully the requirements outlined below.

Mounting—The location should be clean, dry, well-ventilated, accessible, free from acid fumes, dripping water, oil, steam and excessively high temperatures. If protecting shields or guards are used, they must permit a free flow of air over the motor and generators.

The motor—generator set should be securely fastened to a rigid foundation using bolts or screws of the size provided for by the drilling in the bedplate. The motor generator must rest evenly on all mounting pads.

GENERAL INFORMATION

The generators are designed to deliver direct current of the voltage stamped on the Company's nameplate when operated at its rated speed. It will operate satisfactorily on a 5 percent variation of voltage or speed, but not necessarily in accordance with the standards of performance established for operation at the normal rating. This Company assumes no responsibility for its operation outside of these limits.

The motor will operate satisfactorily with a 10% variation in voltage, a 5% variation in frequency, or a combined voltage and frequency variation of 10%, but not necessarily in accordance with the standards of performance established for operation at normal rating. Low voltage reduces the torques. Guard against this condition. High voltage lowers the power factor and generally increases the temperature rise.

The insulation of the windings will withstand a maximum observable temperature of 90° Centigrade. Special insulation is required for operation under high temperature conditions. Special lubricants are required for operation under extreme temperatures either hot or cold.

Operation and Repair—Motor—generators should be inspected at regular intervals, noting particularly that the mounting bolts, bracket bolts, and coupling are tight and that the bearings are properly lubricated. Increase in operating temperature, localized heating, or excessive noise indicate approaching failure and should be investigated at once.

It is desirable to thoroughly clean the motor and generators at intervals of one to two years, but is not essential unless motors and generators are operating in an atmosphere containing dust or lint. Revarnishing the windings when motors and generators are overhauled will lengthen their life. Only special insulating varnish should be used on high voltage generators.

Coupling halves should have a close sliding fit on the shaft extensions and must be securely locked to avoid hammering out in operation. If it is necessary to drive the part into position, it is important, on ball bearing motors, that the end of the shaft opposite the extension be backed up so that the force of the blow is not taken in the bearing. For removing tight couplings a pinion puller should be used.

Ball Bearings—Standard ball bearing motors and generators are properly lubricated (about ⅔ full) when they leave the factory. In ordinary service, the motors and generators will run for a year as received. It is recommended, however, that a small quantity of neutral, medium consistency grease be added every four or six months to maintain an even lubricating condition. The grease must be free from grit and must not separate into soap and oil when left standing or when subjected to temperatures which occur in the bearing. Soda base soap greases are preferred on account of their higher melting point.

When overhauling the motor and generators, the bearings and enclosures should be washed with carbon tetrachloride or a similar solvent to remove the residue of soap which is left from the grease. On motors and generators provided with cartridge construction, this can be done without removing the bearing from the shaft. If it is necessary to remove a bearing, pressure should be applied when possible against the inner ring of the bearing.

Brushes—The carbon brushes supplied have been carefully selected for this particular service and for the best results only this make and grade should be used.

The brushes should make good contact with the commutators along the whole face of the brush. If necessary, they should be ground in with fine sandpaper. Brushes should always have a good sliding fit in the brush holder. Never permit brushes to become stuck in the holder. When necessary, remove brushes from their holders and clean thoroughly, both the brushes and the holders.

Maintain the brush spring tension at the correct value. The actual pressure that should be used depends on the grade of brushes and on local service conditions. It should be as low as possible, consistent with maintaining good contact between brushes and commutator.

Commutator — The commutator surface should be kept clean and smooth. Ordinarily it will require only occasional wiping off with a piece of canvas. Burning and roughening of the commutator may he due to improper brush pressure, improper position of brush, or high mica. The first two causes may be corrected without taking the armature from the frame provided no great damage has been done to the commutator. If the commutator is rough or has high mica, the only approved procedure is to have the commutator accurately turned and mica properly undercut. Great care must be exercised to see that all mica is removed be tween bars to the depth of the under cutting.

Slip Rings (When Used)—The slip ring surface should be kept clean and maintained in a smooth and true condition. Ordinarily it will require only occasional wiping off with a piece of canvas to keep the surface clean.

Burning and roughening of the ring surface may be due to improper brush pressure. A grooved ring is usually the result of excessive brush pressure while a burned or roughened ring is caused by too light a brush pressure. However, all slip rings tend to become elliptical with use with the result that burning may occur at the low spots. When this condition becomes pronounced the rings should be accurately turned or ground. Do not endeavor to correct this condition by smoothing the ring with sandpaper or emery cloth as this accelerates the formation of elliptical rings.

RENEWAL PARTS

If renewal parts are needed, write to the nearest district office of this Company, giving full particulars together with the complete reading of the nameplate. The omission of this information from your letter will positively cause delay.

1. Name the part.
2. Give name plate reading.
3. State whether shipment is to be made by express, freight or by parcel post.
4. Send all orders or correspondence to the nearest sales office of the Company.
5. Small orders should be combined, so as to amount to a value of at least one dollar, as order handling and shipping expenses prevent us from billing a smaller amount.

TYPE F MAGNETIC CONTACTOR, FRAME No. 15-F5

INSTRUCTIONS

Description

The type 15-F-5 is a 3-pole alternating current contactor, and can be supplied either with or without blowout. The contactor is designed for mounting on slate or ebony asbestos panel up to two inches thick.

Rating—The contactor is designed for 25 amperes eight hour rating, 30 amperes one hour rating, 50 amperes peak load. Insulation is for 600 volts maximum.

Operating Coil—The operating coil is designed for continuous service, and will successfully operate the contactor at from 85 to 110% of rated voltage.

Armature Lever—The armature lever is made from pressed steel. The floating armature is supported on the armature lever by means of a hinge pin. This arrangement permits the floating armature to be self aligning when the operating coil is energized and the contactor is closed. All corroding parts, except the magnet face, are treated to prevent oxidation.

Magnetic Iron—Pole face of all a-c. magnets are greased to prevent oxidation. This grease should be removed when the apparatus is ready for service.

Arc Shields—The arc shield is moulded from a very durable heat resisting compound and is securely fastened to the iron pole pieces of the blowout coil. The pole piece of the arc shield is hinged so that the complete arc shield may be easily raised by hand to make inspection and renewal of the contact tips.

Contact Tips—The contact tips are made of hard drawn copper of sufficient cross section to insure long contact life. They are designed to open with a rolling action so that the burn occurs only at the extreme tip of the contact, and does not affect the current carrying surfaces. The contactor has been designed so that a slight wiping action is given to the tips on opening and closing. This action insures a clean low resistance contact area. A steel compression spring gives a positive and sufficient contact pressure up to the maximum life of the contact and produces a quick opening on the tips.

Shunts—The current carrying shunt is made of a flexible braided copper cable which gives complete freedom to the moving armature, and has ample

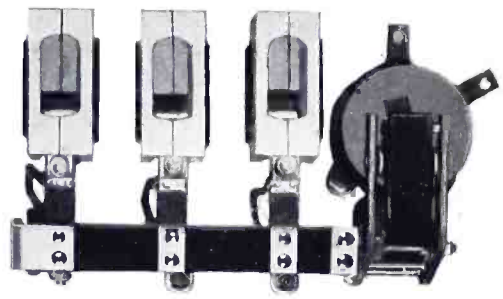


Fig. 1—Frame No. 15-F5 Contactor

capacity to withstand the maximum current for which the contactor is rated.

Maintenance

Bearings—The bearings of the armature shaft require no lubrication. Oil quickly collects dust, and unless the parts are frequently cleaned, will make the contactor sluggish in opening, thus causing the arc to hang on longer.

Arc Shields—The arc shields should always be down so that the arc is broken within the field of the blowout coil, otherwise the shield will not give satisfactory results. The arc shield should always be renewed before the moulded material is burned away sufficiently to expose the steel pole pieces.

Operating Coil—The operating coil may be removed by taking out the main hinge pin, which allows the armature to be lowered, then disconnecting the terminal leads and removing the screw in the back of the coil, which holds it in place.

Contact Tips and Spring Pressure—Use no oil or other lubricant on the copper contacts. The contacts normally wear to give the best contact surfaces without any attention. The roughened appearance of the contacts is no indication that good contact is not being obtained. The contacts should be replaced when the maximum usefulness has been reached in order that the contact pressure will not fall below the minimum value for which it is designed. The contact pressure for this unit, measured at the heel of the contact tip should be between seven to ten ounces. To measure the final spring pressure, close the contactor mechanically, place a thin piece of paper between the tips, then measure the pounds pull necessary to separate the tips by means of a hook spring balance attached to the head of the screw which holds the moving contact tips in place. Read the pounds pull required at the instant the paper can be moved. In case the contact pressure is below the minimum value, after the tips have been replaced, additional insulating washers should be added under the spring. Low spring pressure should be guarded against to avoid heating of the contacts. Heating increases the resistance which may cause arcing and welding the tips together.

Magnet Noise—The magnet on the a-c. contactor may hum. Should it become excessive, check to see if any of the following conditions exist.

1. The pole face of the magnet may be corroded, which will not permit the magnet to seal properly.
2. The armature lever may be distorted through rough use, which will not allow the floating armature to find a square seat. Check this by placing a sheet of paper between the two pole faces and close the magnet electrically, this will leave an impression on the high points. Full contact is not actually necessary but should be over a large portion.
3. The voltage may be below the minimum rating of the operating coil.
4. The shading coil on the magnet may be broken.
5. The spring pressure may be too high.

Contact Gap—The contact gap on the 15-F5 contactor should be approximately ½ inch when the magnet is in the full open position, measured at the heel of the contact tips when they are new. A greater gap may prevent the magnet from picking up on the minimum voltage for which the operating coil has been designed.

Failure to Close—A magnet may fail to close for any of the following reasons.

1. The lead wire to the operating coil may be disconnected.
2. The operating coil may be open circuited.
3. There may be mechanical friction.
4. The voltage may be below normal.

Failure to Open—Failures may be caused by mechanical interference or friction. The contact tips may be welded together. Residual magnetism may be holding magnet due to low spring pressure.

RENEWAL PARTS DATA

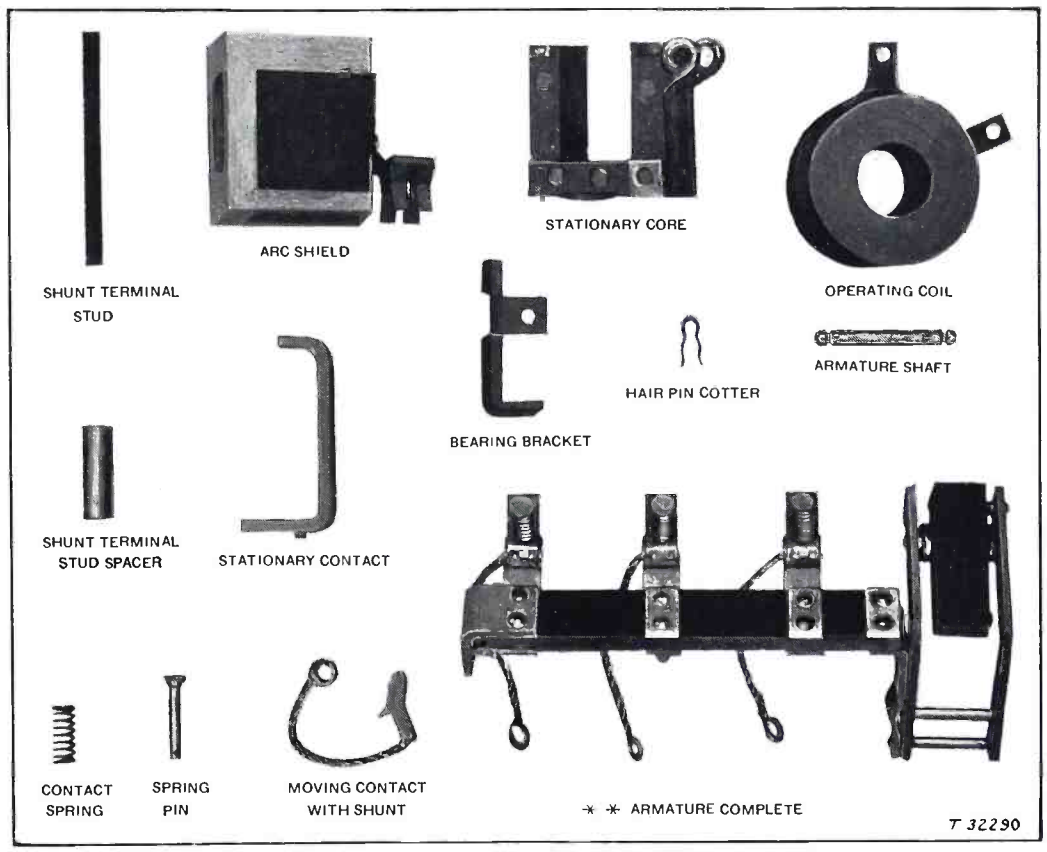


Fig. 2—Renewal Parts for Type F Magnetic Contactor, Frame No. 15-F5

**When ordering armature complete, specify whether right or left hand is desired (right hand is illustrated)

RECOMMENDED STOCK OF RENEWAL PARTS

FOR TYPE F MAGNETIC CONTACTORS

For contactors in use up to and including.....		1	5
Name of Part	No. Per Contactor	Recommended For Stock	
Armature Complete.....	1	0	0
Moving Contact with Shunt.	3	3	6
Contact Spring.....	3	0	2
Spring Pin.....	3	0	1
Arc Shield.....	3	0	2
Stationary Contact.....	3	3	6
Operating Coil.....	1	1	1

Parts indented are included in the part under which they are indented.

ORDERING INSTRUCTIONS

Quick shipments from local stock and prompt replies to inquiries without the necessity of referring to the Works for information, are possible only when complete identifying information for the parts are given. Careful observance of the following points on inquiries or orders is essential for correct shipments and prompt service.

Fig. 3—Name Plate

1. Name the part, using the name shown on the illustration, figure 2, and state the quantity desired. When ordering operating coils, always give the style or L-number that is stamped on the metal tag attached to the old coil, or voltage and frequency of control circuit.

2. Give the contactor name plate reading, if used as shown on the illustration, figure 3. If the contactor has no name plate, give the name plate reading of the complete controller, and mention the contactor for which the parts are wanted.

3. State whether shipment is to be made by express, freight or by parcel post.

4. Send all orders or correspondence to the nearest sales office of the Company.

5. Small orders should be combined, so as to amount to a value of at least one dollar, as order handling and shipping expense prevent us from billing a smaller amount.

CONTROLLERS

Inspection Upon Receipt of Shipment:

1. The packages received should check with the items on the shipping notice.
2. Examine each package to see that no damage has been done in shipment.
3. Bolts, small brackets, and extra parts are usually shipped in cloth bags with tag attached, indicating contents.
4. Special instructions are given on tags accompanying individual pieces of apparatus and should be carefully observed.
5. When necessary to store prior to installation, leave the apparatus in the original package and keep it in a safe dry location.
6. Unpack carefully, particularly the instruments, relays and shunts; these are usually packed in a double container; the outer box is nailed and inner box fastened with screws.

Location:

The **control equipment** should be located within plain view of the motor and as close to it as conditions will permit; in a direct line, if possible between the power supply and the motor, to save cable and resistance losses. In determining this location, the following points should be considered:

1. Safety and convenience of the operator.
2. Accessibility for inspection or repairs.
3. Protection of the controller from corrosive gases, excessive heat, moisture, vibration, abrasive dust, inflammable material or accidental injury.
4. Conformity to the fire and safety codes that govern the locality.
5. Ventilation of the resistor, and other parts that dissipate heat.
6. Natural lighting, if possible, to facilitate reading meters and inspecting equipment.
7. Working space about controller for safety and convenience in inspections or adjustments; including mechanical clearance for lifting arc shields, etc.
8. Arcing clearance between live parts and nearby metal parts (where this is insufficient, barriers must be placed between these parts and the adjacent apparatus).
9. Master switch or push button stations; locate where convenient for the operator, and if possible where the machinery is in full view when starting. Locate emergency stop buttons where easily reached.

Installation:

1. The name plate readings of the controllers should agree with the power supply and motor characteristics.
2. Foundations should be solid to prevent vibration. When the controller is provided with a channel iron base, the base should be grouted.
3. In wiring and connecting apparatus, the National Electric Code, the Associated Factory Mutual Fire Insurance Companies, and local fire underwriters' rules should be followed.
4. Make connections in accordance with the wiring diagram furnished with the controller.
5. Before making any connections be certain that all leads to be handled are dead.
6. Make connections to power leads last.
7. A disconnecting switch should be installed ahead of the controller, unless such a switch is included as a part of the controller.
8. Do not put individual alternating-current conductors in single conduit on account of the transformer action produced.
9. Fill oil dash pot relays and screw dash pots up to the proper calibration setting.
10. On high voltage controllers the line contactors are usually immersed in oil in a tank. Make certain that the tank is filled with oil to the proper level before the starter is put into operation.

Inspection of Installation:

1. With the power off, operate contactors, relays and electrical interlocks by hand to see that they work freely and that they make good contact.
2. Mechanical interlocks should prevent the contacts of one contactor from touching while the other contactor is closed.
3. See that the armature hinge pins are in place, and that the cotter pins at each end of the hinge pins are in place and properly spread.
4. Turn the handles of rheostats throughout their travel to see that the contact arm does not stub in passing over the contacts.
5. Note whether the pilot lamps and fuses are good.
6. See that all units are tight.
7. See that all terminals and current carrying contacts are clean and tight.
8. No lubrication is necessary or desirable on contact bearings or on surfaces making contact.

Operation:

1. When first starting, the load may be disconnected and the sequence of the controller checked without operating the motor.
2. After the control sequence is checked the motor may be tested for correct rotation.
3. Inspect the controller periodically to see that it is clean and in good operating condition and that the parts subject to greatest wear are replaced when necessary.
4. Do not file contacts; continual use will wear them to a satisfactory seat.
5. Contacts should be replaced before wear makes it impossible to maintain the proper operating pressure. Low pressure causes excessive heating.
6. In the event of trouble that can not readily be remedied, communicate at once with the nearest Sales Office or service representative.

Renewal Parts:

When ordering renewal parts give the complete name plate reading. Always give the name of the part wanted. State whether shipment is desired by express, freight or by parcel post. Send all orders or correspondence to nearest sales office of the company. Small orders should be combined so as to amount to a value of at least one dollar, as order-handling and shipping expenses prevent us from billing a smaller amount.

TYPES KG-2 AND KG-2A RELAYS

INSTRUCTIONS

Description

The types KG-2 and KG-2A are direct current relays of pressed steel construction. The magnet frame is so designed that either 2 inch or $2\frac{15}{16}$ inch coils may be used on each core. Two insulated stationary contacts provide a normally open and normally closed circuit, with the moving contact as a common point. The magnet gap is adjustable by turning the stud on the stationary contact. The relay is magnetically closed in one position and spring closed in the other.

Application:

This relay may be used in a number of ways, for example:

1. Fluttering relay for automatic field regulation during acceleration or deceleration.
2. It may be used as an adjustable current or voltage relay for general purpose, which then gives low voltage protection.
3. By using two separately connected coils, the relay may be used as a differential or reverse current relay.
4. By using two interconnected coils, the available setting range may be approximately doubled.
5. It may be used as a transfer relay in case of voltage failure.

Rating:

Contacts are designed for 5 ampere continuous service and 30 amperes arc rupturing capacity. Operating coils are designed for continuous duty on direct current only. Insulation is for 600 volts. Operating coils may be series or shunt, depending upon the application.

Operation:

The operation of the relay depends upon the application to which it is applied. A number of adjustments may be made which will give various conditions, for example:

1. The magnet gap may be increased or decreased by changing the position of the stationary contact.
2. The spring on the armature may be adjusted to varying degrees of tension, which will vary the pick up and drop out value.

Frame:

The magnet frame is made from a steel plate with two steel cores assembled to it for mounting the operating coils.

Armature:

The armature is made from pressed steel and is attached to a support by means of a hinge pin. A coil spring is attached to the armature for pulling it open.

Moving Contact:

The moving contact is a copper strap attached to the armature by means of a screw. This contact is renewable and can be replaced if necessary.

Stationary Contact:

The stationary contacts are made from graphalloy and are adjustable to compensate for wear and give adjustment for the contact gaps.

Arc Shield:

The arc shield is mounted on two brackets which act as supports for the two stationary contacts. The supporting brackets also serve as pole pieces for quenching the arc. The complete bracket and arc shield assembly is held in place by countersunk head screws.

Shunt:

The current carrying shunt is made from round flexible braided copper cable, which gives complete freedom to the moving armature and has ample capacity to withstand the maximum current for which the relay is rated.

Maintenance

Cleaning:

The relay should never be cleaned with an oily rag or waste. A film of oil will collect dust particles which will decrease the creepage, and may cause an arc between adjacent parts.

Bearings:

The bearing of the relay should not be lubricated; oil quickly collects dust and, unless parts are frequently cleaned, may cause the relay to become sluggish in action, thus causing excess arcing. It is important that the bearing pin is not tight. This should be examined occasionally.

Stationary Contacts:

Do not use oil or other lubricants on the contacts. The contacts will give satisfactory results with very little attention. Their roughened appearance is no indication that good contact is not being made. It may be necessary to make adjustment as they burn away in order not to lose the correct current or voltage setting to which the relay was originally set, when first put in service. This is done by loosening the lock nut on the end of the stud and setting the contacts to the desired contact gap and then tightening the nut again.

Operating Coil:

The operating coil may be replaced as follows:

> Remove the armature hinge pin and release the spring, this will permit getting at the two countersunk head screws which hold the brackets and coil in place. Take out these screws and the coils are free to be removed.

Adjustments:

The relay may be adjusted by changing the spring tension or by changing the magnet gap. Increasing the spring tension will require higher voltage or current values to pull in the armature and also will cause it to drop out at the higher values.

Increasing the open position gap will increase the voltage or current at which the relay will pull in.

The magnet gap is changed by the positions of the back stationary contact. Decreasing the gap will hold the relay in longer and to a lower current and voltage value.

General Care:

1. Examine the contacts to see that they are not burned away beyond their useful values.
2. Examine the shunt to see that it is not broken and is making good contact.
3. Examine the armature and armature pin to see that it is free to operate.
4. Examine all bolts, screws and nuts to make sure they are tight.

Relays on controllers shipped to customers are tested at the factory and should be ready for service. However, they may be out of adjustment due to handling. It may be necessary to make corrections as explained in the foregoing paragraph. Before making any corrections, examine the relay carefully to determine definitely, whether or not the relay is out of adjustment.

RENEWAL PARTS DATA

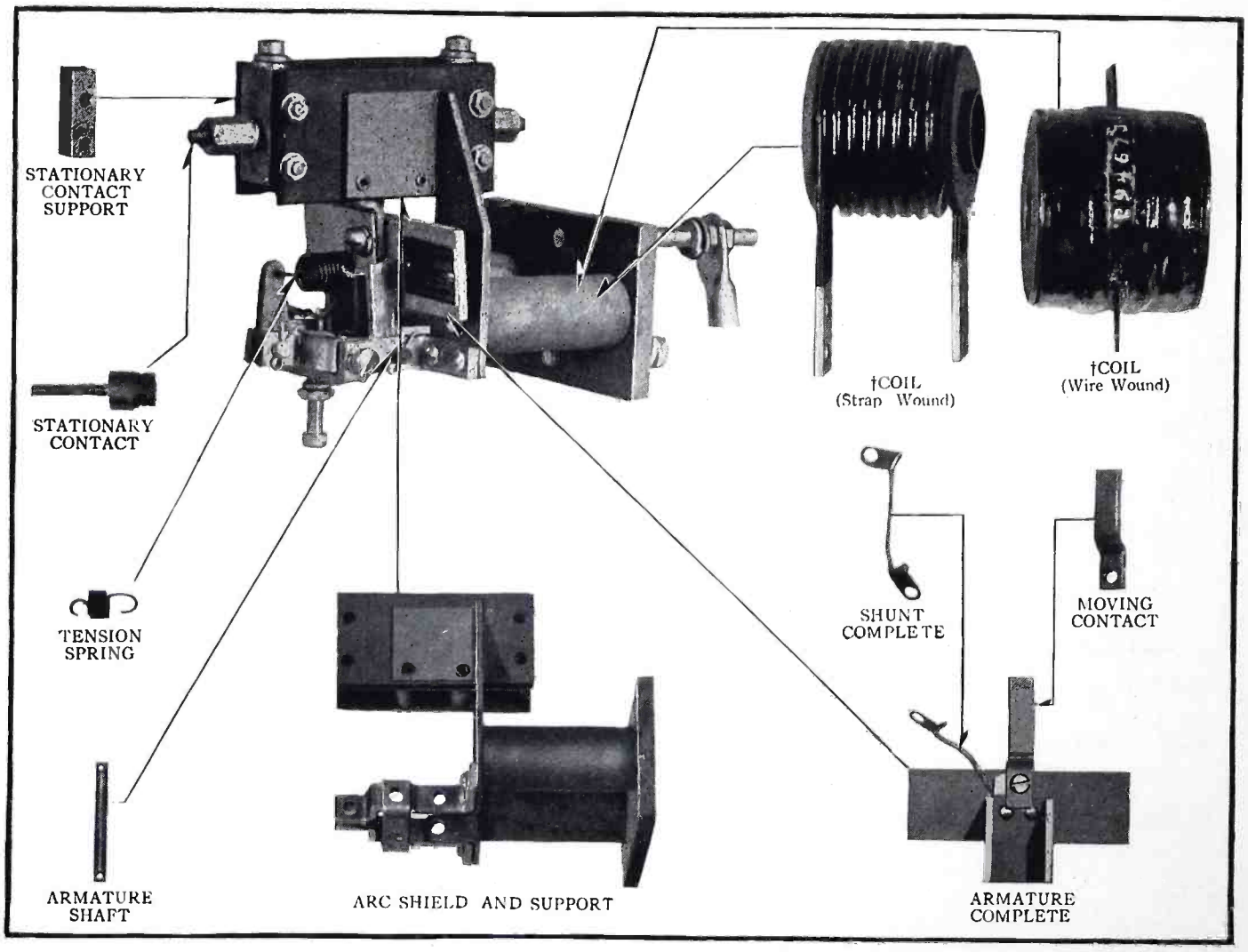


FIG. 1—RENEWAL PARTS FOR TYPES KG-2 AND KG-2A RELAYS

RECOMMENDED STOCK OF RENEWAL PARTS

Type of Relay				KG-2	KG-2A
Style Numbers of Relays				518924-A 518925-A 670932-A	594507 ....
Relays in use up to and including		1	5	.....	.....
Name of Part	No. Per Relay	Recommended For Stock		Style Number of Part	
Armature Complete	1	0	0	531784	531784
Moving Contact	1	0	2	203862	203862
Shunt Complete	1	0	1	276960	276960
*Spring Clip	1	0	0	560113	560113
Stationary Contact	2	0	4	286553	286553
Stationary Contact Support	2	0	0	276964	276964
Armature Shaft	1	0	0	560112	560112
Tension Spring	1	0	0	325395	325395
Arc Shield and Support	1	0	1	532622	532622
†Coil—Wire Wound	†	0	0	†	†
†Coil—Strap Wound	†	0	0	†	†

*Not Listed on Illustration.

†Coils are either wire wound or strap wound: the number used depends upon the application of the Relay. When ordering strap wound coil give the number stamped on one of the arms and when ordering wire wound coil give the number stamped on the tag, which is fastened to the coil.

Parts indented are included in the part under which they are indented.

This is a list of the Renewal Parts and the quantities of each that we recommend should be stocked by the user of this apparatus to minimize service interruptions caused by breakdowns. The parts recommended are those most subject to wear in normal operation, or to damage or breakage due to possible abnormal conditions.

This list of Renewal Parts is given only as a guide. When continuous operation is a primary consideration, additional insurance against shutdowns is desirable. Under such conditions more renewal parts should be carried, considering the severity of the service and the time required to secure replacements.

ORDERING INSTRUCTIONS

Name the part and give its style number. Give the complete name plate reading. State whether shipment is desired by express, freight or by parcel post. Send all orders or correspondence to nearest Sales Office of the Company. Small orders should be combined so as to amount to a value of at least one dollar, as order-handling and shipping expenses prevent us from billing a smaller amount.

TYPE TA THERMAL OVERLOAD RELAY

INSTRUCTIONS

Construction

The type "TA" thermal overload relay makes use of bimetallic elements, to break a circuit when an overload occurs. It has been designed in two sizes, to obtain different ranges of current ratings. The relay with bimetal strips .030" thick is used in connection with heaters rated from 1 to 40 amperes. The relay with bimetal strips .040" thick is used in connection with heaters rated from 41 to 95 amperes.

When used in circuits having normal currents above 95 amperes, transformers are used with the relay. These transformers are specially designed to allow for the longer time required to accelerate larger motors to full speed.

Installation

To Mount Heaters—To mount heaters (see Fig. 1), remove screws and washers from the heater supports. Place heater so that the U opening straddles the bimetal strip and heater lugs rest on heater supports. Replace washers and screws, and adjust heater to give $\frac{1}{32}$" to $\frac{1}{16}$" clearance between heater and bimetal. Do not bend or change position of bimetal in any way as this will alter the rating.

Heater screws must be kept tight. Periodic inspection is advised to keep these heater screws tight at all times.

Rating

The relay will operate in both A-C. and D-C. circuits up to 600 volts with current ratings from 1 to 95 amperes.

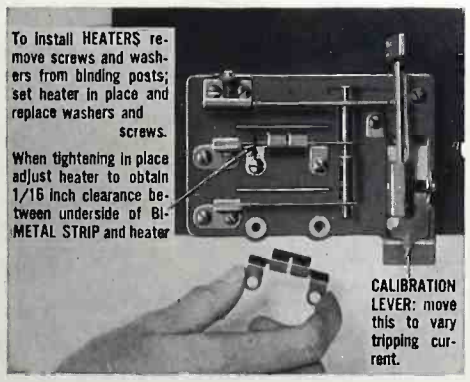


FIG. 1—TYPE TA THERMAL OVERLOAD RELAY SHOWING HOW HEATERS ARE INSTALLED

When used in air temperatures that are much different from 40°C., a slight adjustment of the calibration lever will be necessary.

The rating stamped on the heater is the current that will trip the relay in 15 to 20 minutes at 40°C. air temperature. The heater rating should be 115% to 130% of the motor rating. The relay rating may be varied from 80% to 120% of the value stamped on the heater by moving the calibration lever along the calibration scale. If a change in rating greater than 20% is desired, other heaters may easily be applied.

It is desirable to have relay heaters of such a size that relay **will trip at as near to 80% setting** on the desired overload as possible.

Operation

Heaters are located in the circuit leading to the motor and are in close proximity to bimetal strips. When heated, one side of the bimetal strip expands more than the other causing the strip to curl or bend. The movement of the bimetal is transmitted through the push rod to the free end of the latch arm which holds the relay contacts closed. When the latch arm is raised a certain amount, the end falls through an opening in the reset lever, allowing the reset lever to be moved quickly to the left. The contact finger is thus moved away from the stationary contact, breaking the control circuit. Normal motor current passing through the heater will not generate sufficient heat to cause the bimetal to bend enough to trip the relay, but an overload of appreciable duration will cause the bending necessary to trip the latch arm.

A definite period of time is required for the relay to trip, depending on the magnitude of the overload. The greater the overload, the shorter the time. This time delay is sufficient to allow the motor to be started with the relay in the circuit, but with sustained overload the relay will trip. A shorter time must elapse before the relay can be reset after an overload trip has occurred. The curve (Fig. 2) shows these characteristics.

If relay trips too frequently, the calibrating lever should be set at a higher point on the scale. If the motor is overloaded too heavily without a trip, the lever should be set at a lower point.

To Reset Relay After Overload Trip—To reset by hand, move the reset lever to the right until latch arm falls out of hole in reset lever. At the same time, the contact on the right is closed and is held so by the latch arm.

No oiling or attention is necessary, except to reset when an overload trip occurs.

The relay will not protect the motor from a short-circuit. **Fuses, having a current rating equal to four times the full load current of the motor, must be used.**

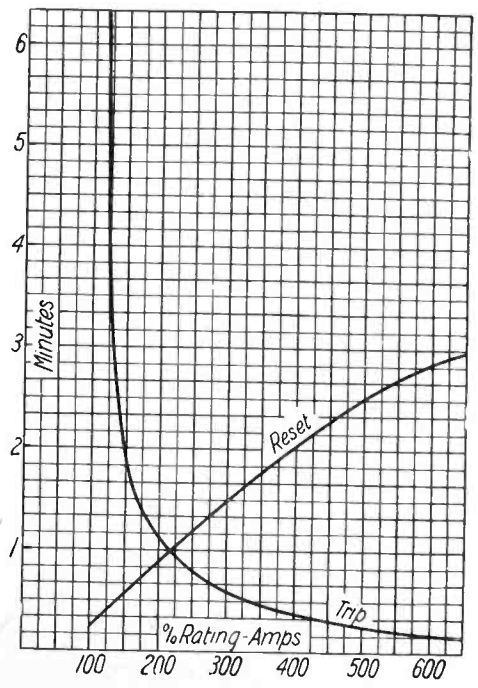
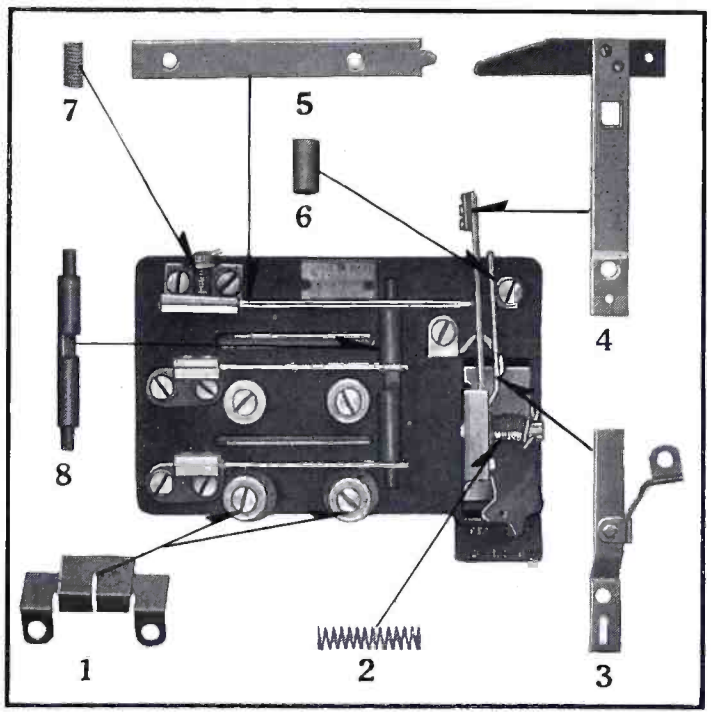


FIG. 2—28°C. AMBIENT TEMPERATURE READINGS TAKEN AT 5-MINUTE INTERVALS FROM RESET

RENEWAL PARTS DATA



Below is a list of the Renewal Parts and the quantities of each that we recommend should be stocked by the user of this apparatus to minimize interrupted operation caused by breakdowns. The parts recommended are those most subject to wear in normal operation or those subject to damage or breakage due to possible abnormal conditions.

This list of Renewal Parts is given only as a guide. When continuous operation is a primary consideration, additional insurance against shut-downs is desirable. Under such conditions more Renewal Parts should be carried, the amount depending upon the severity of the service and the time required to secure renewals.

ORDERING INSTRUCTIONS

Name the part and give its style number. Give the complete name plate reading. State whether shipment is desired by express, freight or by parcel post. Send all orders or correspondence to nearest sales office of the Company. Small orders should be combined so as to amount to a value of at least one dollar, as order-handling and shipping expenses prevent us from billing a smaller amount.

RECOMMENDED STOCK OF RENEWAL PARTS

Characteristics of Relays	Standard Relays			Oil Immersed Relays		Glass Covered Relays	
Style Numbers of Relays (Without Heaters)	468488 468489 470414 475486 475487 482440 489129 489130 546344 546345 576241 576242	468487 475485	525526	532328 532329	705904 705905 710139 710140	584324 584325 666493 666496 715692 715694	666494 666495 666497 666498 715693 715695 ....
For Relays in use up to and including.....	1	5					

Ref. No.	Name of Part	No. Per Unit	Recommended For Stock		Style Number of Part						
1†	Heater	2	2	4	†.....	†.....	†.....	†.....	†.....	†.....	†.....
2	Contact Finger Spring	1	0	1	526597	526597	526597	526597	526597	526597	526597
3	Contact Finger with Shunt	1	0	2	490053	490053	490053	532333	532333	695606	490053
4	Reset Lever	1	0	0	490052	490051	547279	490052	700918	695605	695605
5	Latch Arm	1	0	0	478776	478776	478776	478776	478776	478776	478776
6	Stationary Contact	1	0	2	467961	467961	467961	467961	467961	467961	467961
7	Latch Spring	1	0	0	485926	485926	485926	485926	485926	485926	485926
8	Latch Push Rod	1	0	7	478778	478778	478778	478778	478778	478778	478778

†When ordering Heaters, specify style number obtained from Table of Heater Ratings.

TABLE OF HEATER RATINGS

Based on Terminal Current Marked on Motor Name Plate

Motor Amps. per Terminal	Relay Rating Amperes	Heater Style No. 2 Req'd.	Motor Amps. per Terminal	Relay Rating Amperes	Heater Style No. 2 Req'd.
.70 to .90	1.0	511342	9.60 to 11.0	13	474420
.91 to 1.20	1.4	511341	11.10 to 13.0	15	474421
1.21 to 1.45	1.7	511263	13.10 to 14.5	17	474422
1.46 to 1.65	1.9	511264	14.60 to 17.5	20	502915
1.66 to 1.80	2.1	511265	17.60 to 20.0	23	474425
1.81 to 2.00	2.3	511261	20.1 to 22	26	474426
2.01 to 2.25	2.6	511262	22.1 to 25	29	474427
2.26 to 2.70	3.1	551944	25.1 to 27	32	501695
2.71 to 3.10	3.6	551941	27.1 to 31	36	474429
3.15 to 3.65	4.2	551942	31.1 to 35	40	474431
3.70 to 4.10	4.7	551943	32.0 to 35	41	501694
4.20 to 4.90	5.7	551937	35.1 to 42	48	760593
5.00 to 5.80	6.7	551938	42.1 to 50	58	474432
5.90 to 6.70	7.7	551939	50.1 to 58	68	474433
6.80 to 7.30	8.4	551940	58.1 to 62	71	474434
7.40 to 7.80	9.0	511343	62.1 to 70	81	474436
7.90 to 9.50	11.0	474419	70.1 to 83	95	539018

TYPE TF THERMAL ACCELERATING RELAY

Application

This relay is used to give time delay between points of acceleration in the starting of a-c. motors. It is interlocked with a contactor so that the contactor can reset the relay. The relay is for use on a-c. circuits where operations are not too frequent. The relay may be adjusted for time delays of from 1 to 12 seconds. The frequency of operation depends on the time setting of the relay as follows:

One 12 second delay every 4 minutes
One 6 second delay every 2 minutes
One 3 second delay every 1 minute
One 1 second delay every 20 seconds.

Construction

The relay consists of a bi-metal trip arm, primary and secondary coils, cast iron frame and a time adjusting screw and spanner nut. The bi-metal trip arm is connected through studs to the secondary coil, so as to make an electric circuit through the bi-metal and the secondary coil. A cross-bar moving contact support is hinged at the center pin of the contactor. A spring tends to rotate the cross-bar moving contact and support about this center, but it is constrained from rotating by the bi-metal trip arm. There are two stationary contacts, one at each end of the cross-bar moving contact. The circuit is made through these contacts when they are bridged by the cross-bar moving contact, when it is released by the bi-metal trip arm. A different type of cross-bar moving contact, support spring, etc., are required for each of the contactors with which the relay is used.

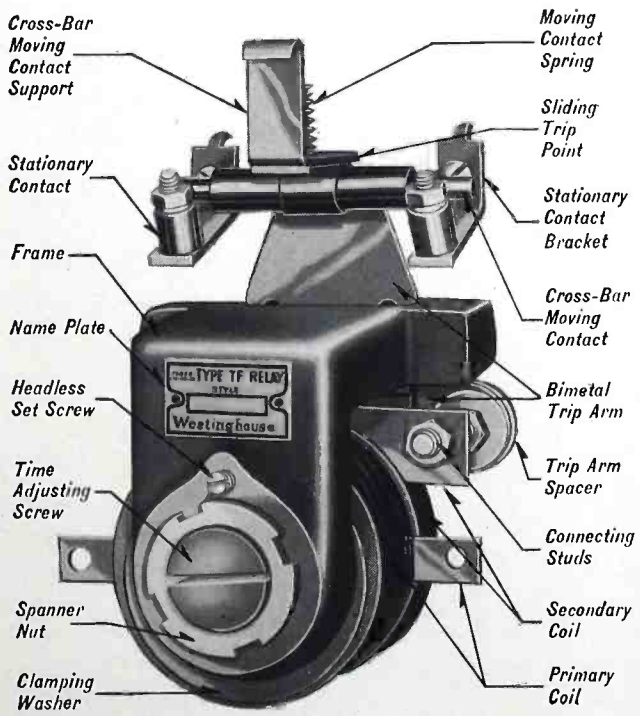


Fig. 1—Relay Parts

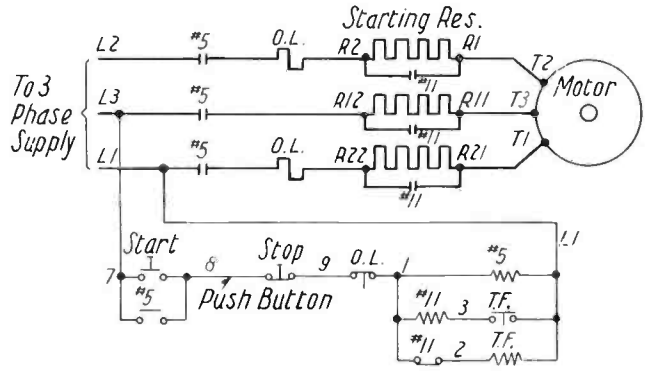


Fig. 2—Diagram of Connections

Operation

The primary coil of the relay is connected across the line through the starting switch. A voltage is induced in the secondary winding and a current flows through the bi-metal trip arm which produces heating and causes the arm to bend, thus allowing the cross bar moving contact support to fall, so that the cross-bar moving contact will bridge the contacts. This operation closes the circuit of a contactor coil which cuts out a step of resistance in the motor circuit and opens the circuit to the relay primary coil. In opening, the contactor resets the relay by raising the moving contact support sufficiently to allow the bi-metal trip arm to assume its original position preparatory for a new start. The time-adjusting screw is used to change the starting time interval. The time is adjustable for a ratio of 3 to 1. To lengthen the time, turn the screw out of the frame and vice versa. For each voltage there is a primary coil to be used for time intervals of from 1 to 3 seconds, and another coil for intervals of from 4 to 12 seconds.

When the contactor is opened, the cross-bar moving contact support must be raised clear of the bi-metal arm, so as to allow the latter to assume a straight position. When the contactor closes, the bi-metal arm should strike the cross-bar moving contact support approximately $\frac{7}{64}$" from the end of the latter. This is the distance that the trip arm must move to trip the contacts.

In case the relay is operated at a greater number of operations per minute than that listed for the corresponding time delay, the operating time will become slightly shorter than the initial time interval.

It is important that the relay coil circuit be opened as soon as acceleration is completed.

If the circuit connections are removed for any reasons, the circuit should be checked when rewiring to make sure that the coil circuit of the relay is opened after the relay operates. This is necessary to prevent burn out since the relay is designed for intermittent duty only.

RENEWAL PARTS DATA

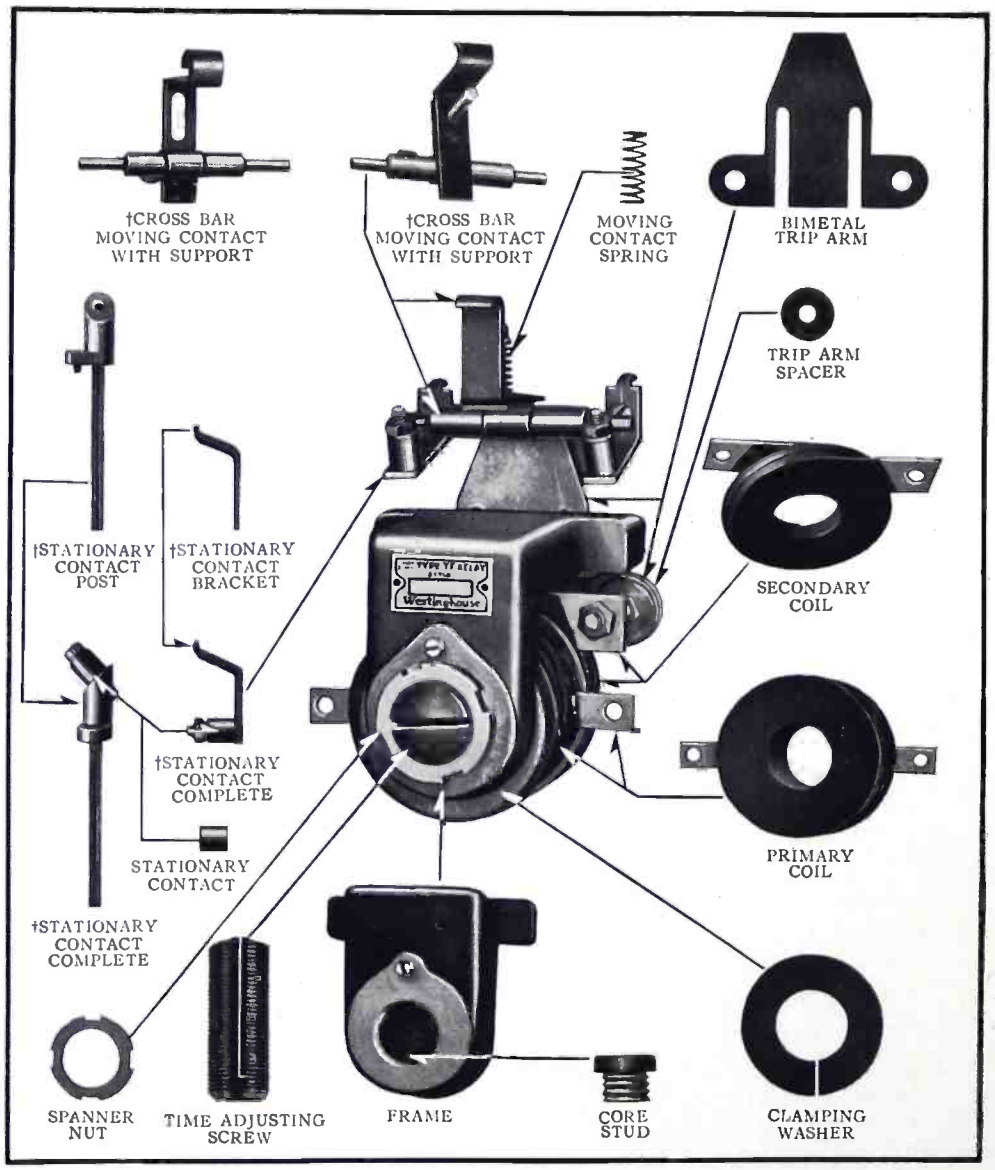


Fig. 3—Renewal Parts for Type TF Relay

†When ordering these parts, give frame number of contactor or starter name plate reading, in addition to relay name plate reading. When ordering stationary contact post or same complete with contact, specify whether left hand or right hand is desired.

NOTE:—Stationary contacts complete, as shown on the relay in the illustration, are now mounted by a fillister head machine screw and lock washer.

RECOMMENDED STOCK OF RENEWAL PARTS

For Relays in use up to and including	2	5	15
Name of Part	Quantity Recommended		
Cross bar moving contact with support	1	2	5
Moving contact spring	2	5	10
Bi-metal trip arm	1	2	5
Stationary contact	2	4	8
Secondary coil	1	1	2
Primary coil	1	1	2

Ordering Instructions

Quick shipments from district office stock and prompt replies to inquiries, without the necessity of referring to the works for information, are possible only when complete identifying information for the part is given:

1. Name the part, using the name shown on the illustration and state quantity desired.
2. Give the relay name plate reading. See Fig. 4.
3. State whether shipment is to be made by freight, express or by parcel post.
4. Send all orders or correspondence to the nearest district office of the Company.
5. Small orders should be combined so as to amount to a value of at least one dollar, as order-handling and shipping expenses prevent us from billing a smaller amount.

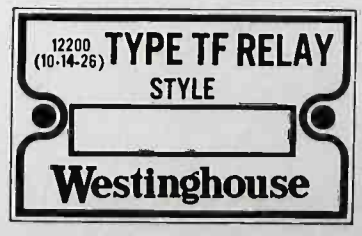


Fig. 4—Relay Name Plate

TYPE KN SINGLE AND DOUBLE POLE OVERLOAD RELAYS

Construction

The standard type KN relay is made in single pole and double pole forms. The double pole construction is obtained by combining two single pole relay elements in a common magnet frame with a common moving contact. Inverse time limit is obtained by means of an oil dashpot which is attached to each plunger. Quick opening of the contacts is obtained by providing a by-pass in the dashpot wall which opens at a suitable height and allows oil to flow freely to the under side of the piston. The speed of the plunger is thus very much increased at the end of the travel and the plunger hits the stem with a hammer blow which opens the contacts very rapidly. Quick return of the plunger after the overload is cleared, is obtained by means of a flat washer carried in the piston cup, which acts as a check valve to allow free motion downward, but not upward.

Application

The relay can be supplied for any one of three methods of resetting the moving contact, namely: (1) Automatic reset, (2) hand reset, and (3) electric reset. The moving contact of the hand reset relay, when opened, is held by a spring latch which must be depressed by hand in order to release. The automatic reset feature is obtained by omitting the spring latch, which permits the moving contact to close automatically when the overload is cleared. The action of the electric reset relay is the same as that of the hand reset relay except that the reset lever is depressed magnetically.

Hand reset or electric reset relays must be used on "low voltage release" service where the resetting of the relay would automatically re-energize the controller. This is the case when the relay is used on full magnetic control apparatus which is started by an automatic master switch, such as a float switch or pressure gauge master switch or a manually operated master switch, which maintains its contact until it is released by the operator.

Automatic reset relays may be used on "low voltage protection" service where the resetting of the relay will not automatically re-energize the controller. This is the case when the relay is used on full magnetic control apparatus, which is started by a momentary contact push button or a master switch, which does not maintain the starting contact in the operating position or on manually operated controllers.

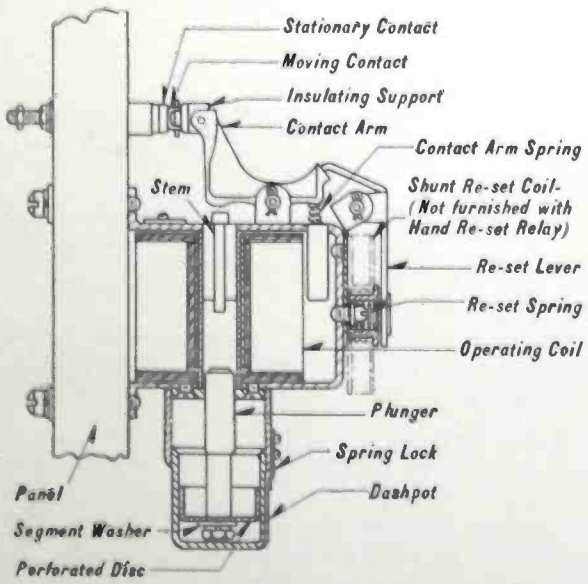


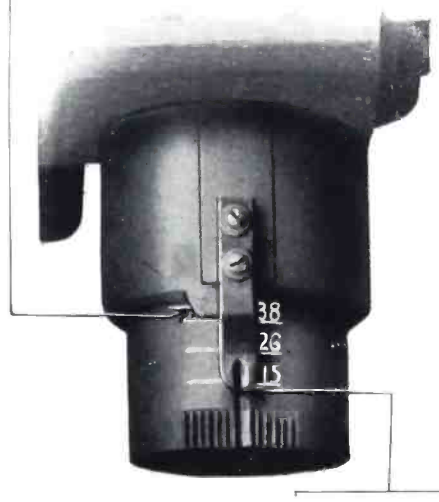
Fig. 1—Type KN Relay

Installation

Before putting the relay in operation, the dashpots must be removed to receive the special dashpot oil supplied with the relay. To avoid air pockets, remove the pistons and fill the dashpots half full of oil. Replace the pistons and try the suction by pulling on the plunger. If the suction seems weak or unreliable, inspect the condition of the check valve surfaces to see whethers the washer is being held away from its seat by particles of dirt. Great care should be taken to keep the interior of the dashpots clean, as dirt will spoil the valve action and will also change the time settings.

Replace the dashpots and screw up to the current setting desired as indicated by markings on the dashpot. As shown in Fig. 2, the correct indicating point for the current setting is the lower edge of the lug on the bottom of the stationary casting, and not the spring clip. The dashpots have three calibration lines marked with

To adjust overload setting, turn Dashpot until proper calibration line coincides with lug on bottom of upper casting.



The clip is only to prevent turning of Dashpot and consequent change of setting due to vibration.

Fig. 2—Dashpot

tripping current values and any intermediate current values may be estimated from the marked points.

Operation

The time element depends upon the number of holes covered by the segment washer on the bottom of the piston. Relays are usually shipped with all holes closed giving a maximum time element. To decrease the time element, move the washer so that one or more holes are uncovered.

The oil furnished with these relays is specially adapted for this purpose and will give satisfactory operation at all ordinary temperatures. Relays subjected to temperatures below freezing require a lighter oil. If temperatures are so high that the relay does not give sufficient time element, a heavier oil should be used.

Style No. 229296 includes enough oil for two dashpots.

When a relay, with hand or electrical reset, is supplied and an automatic reset is desired, remove the reset parts by removing two screws in front of frame.

Inspection of the relays should be made regularly to see that the current limit setting has not been changed, that there is sufficient oil in the dashpot and that the contacts are in good condition.

RENEWAL PARTS

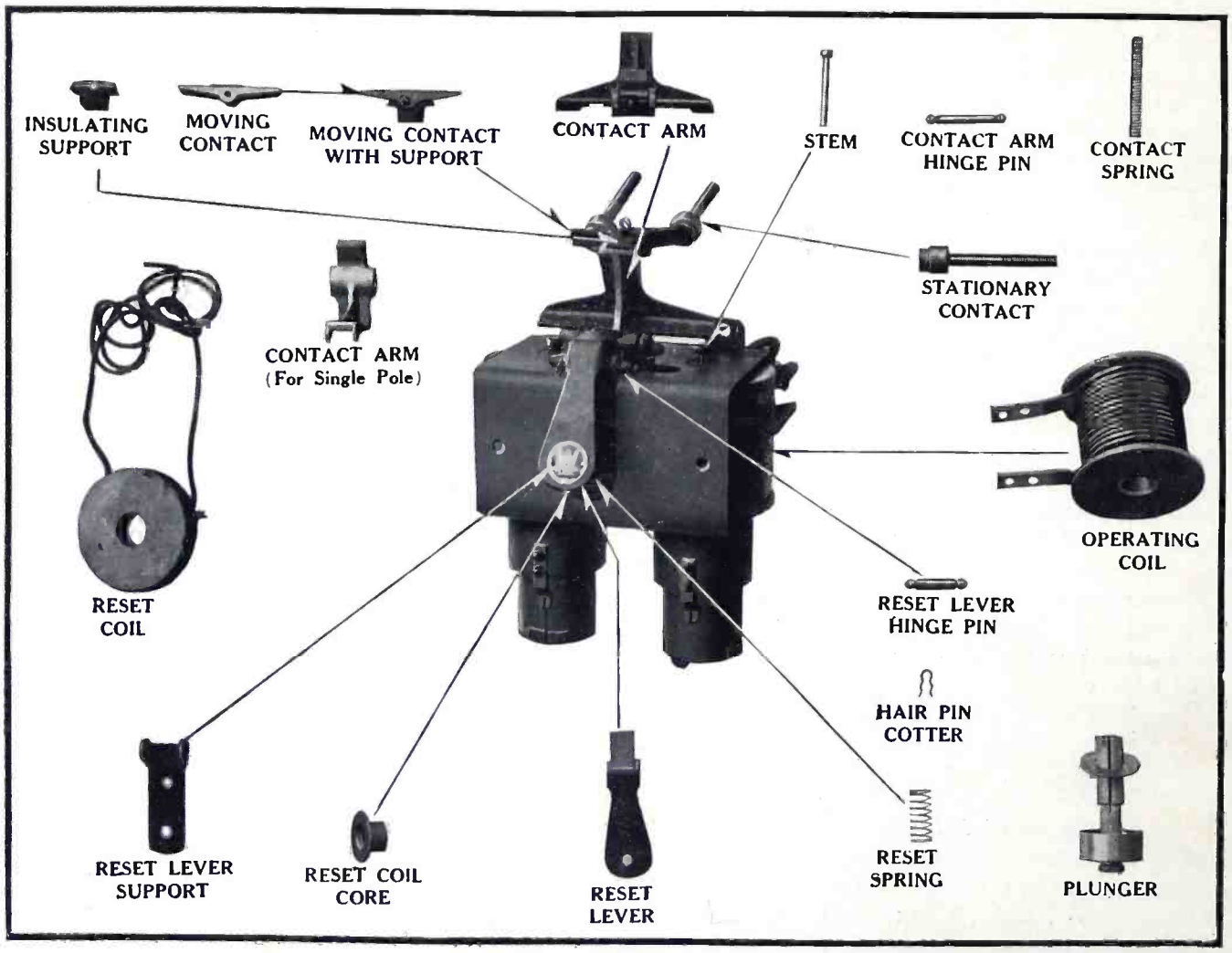


Fig. 3—Renewal Parts for Type KN Overload Relay

RECOMMENDED STOCK OF RENEWAL PARTS

For relays in use up to and including		2	5	15
Name of Part	No. Per Unit	Recommended for Stock		
Moving contact with support	1	0	0	1
Moving contact	1	1	2	4
Insulating support	1	1	2	4
Contact arm (for single or double pole)	1	0	1	1
Contact spring	1	1	1	2
Contact arm hinge pin	1	0	1	1
†Plunger	1	0	1	1
†Stem	1	0	1	1
Hair pin cotter	2	4	8	16
Stationary contact	2	2	4	8
Dashpot oil in can	1	1	1	2
Operating coil	1	1	1	2

Parts indented are included in the part under which they are indented.

†Double pole uses two instead of one and two should be carried in stock for 15 relays.

ORDERING INSTRUCTIONS

Quick shipments from district office stock and prompt replies to inquiries, without the necessity of referring to the works for information, are possible only when complete identifying information for the part is given. Careful observance of the following points on inquiries or orders are essential for correct shipments and prompt service:

1. Name the part, using the name shown on the illustration above and state quantity desired.

Fig. 4—Type KN Overload Relay Name Plate

2. Specify the style number of the relay that is shown on the name plate. (See illustration.) When ordering coils, give the number stamped on the old coil.

3. State whether shipment is to be made by freight, express or by parcel post.

4. Send all orders or correspondence to the nearest sales office of the company.

5. Small orders should be combined so as to amount to a value of at least one dollar, as shipping expenses prevent us from billing a smaller amount.

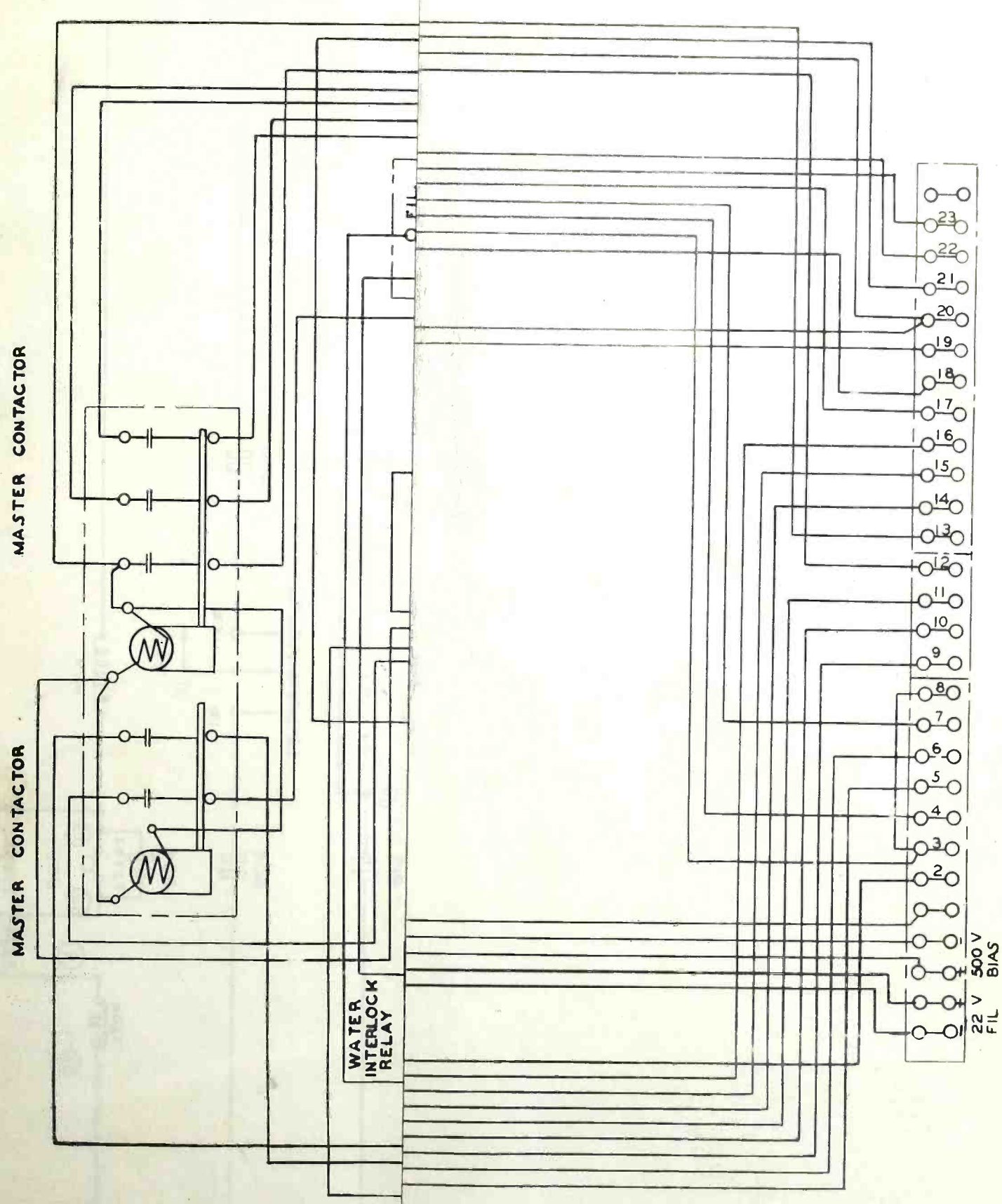

MASTER CONTACTOR
MASTER CONTACTOR
WATER INTERLOCK RELAY
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
22 V FIL
500 V BIAS

FIG. 6

RENEWAL PARTS

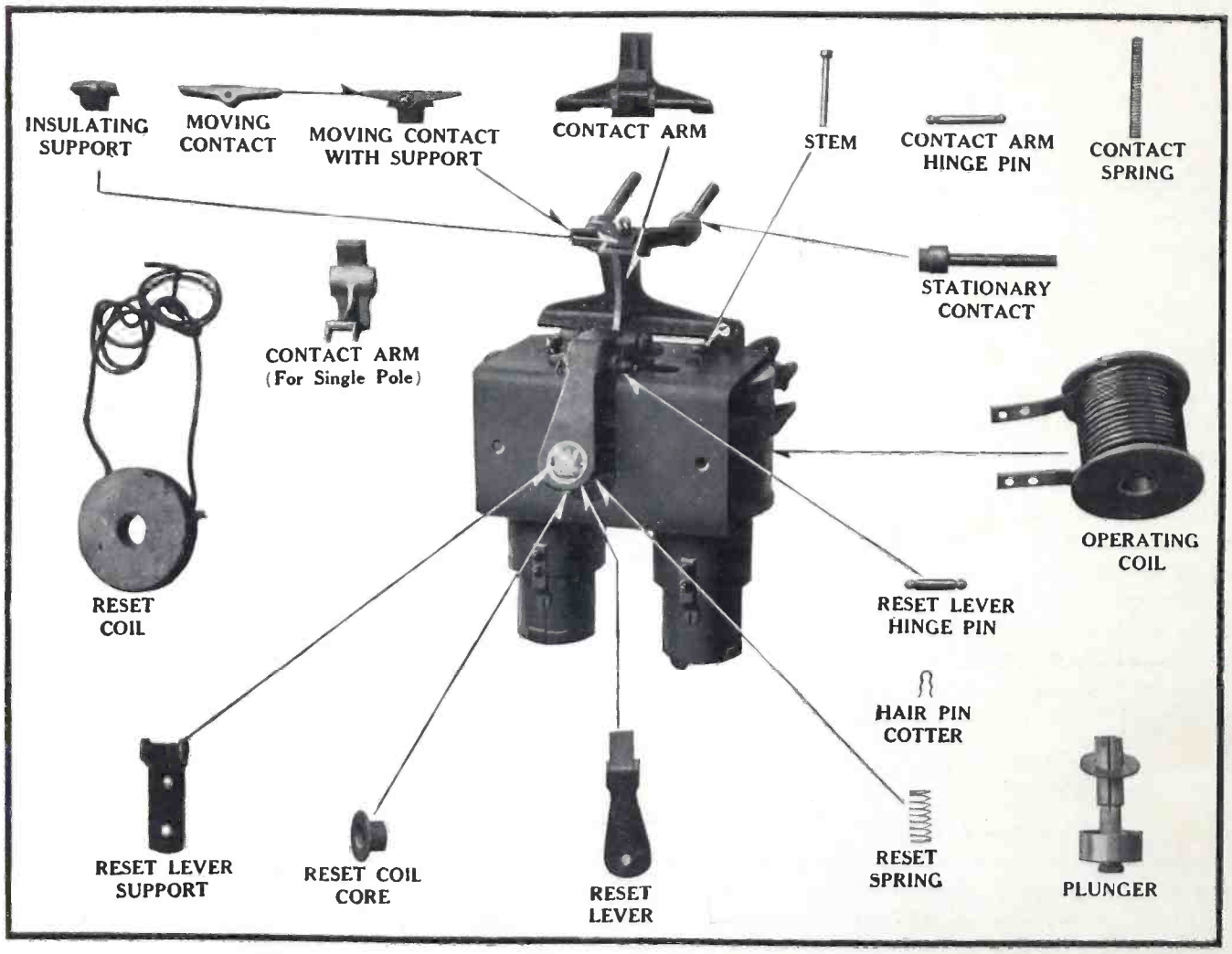


Fig. 3—Renewal Parts for Type KN Overload Relay

RECOMMENDED STOCK OF RENEWAL PARTS

For relays in use up to and including		2	5	15
Name of Part	No. Per Unit	Recommended for Stock		
Moving contact with support	1	0	0	1
Moving contact	1	1	2	4
Insulating support	1	1	2	4
Contact arm (for single or double pole)	1	0	1	1
Contact spring	1	1	1	2
Contact arm hinge pin	1	0	1	1
†Plunger	1	0	1	1
†Stem	1	0	1	1
Hair pin cotter	2	4	8	16
Stationary contact	2	2	4	8
Dashpot oil in can	1	1	1	2
Operating coil	1	1	1	2

Parts indented are included in the part under which they are indented.

†Double pole uses two instead of one and two should be carried in stock for 15 relays.

ORDERING INSTRUCTIONS

Quick shipments from district office stock and prompt replies to inquiries, without the necessity of referring to the works for information, are possible only when complete identifying information for the part is given. Careful observance of the following points on inquiries or orders are essential for correct shipments and prompt service:

1. Name the part, using the name shown on the illustration above and state quantity desired.

Fig. 4—Type KN Overload Relay Name Plate

2. Specify the style number of the relay that is shown on the name plate. (See illustration.) When ordering coils, give the number stamped on the old coil.

3. State whether shipment is to be made by freight, express or by parcel post.

4. Send all orders or correspondence to the nearest sales office of the company.

5. Small orders should be combined so as to amount to a value of at least one dollar, as shipping expenses prevent us from billing a smaller amount.

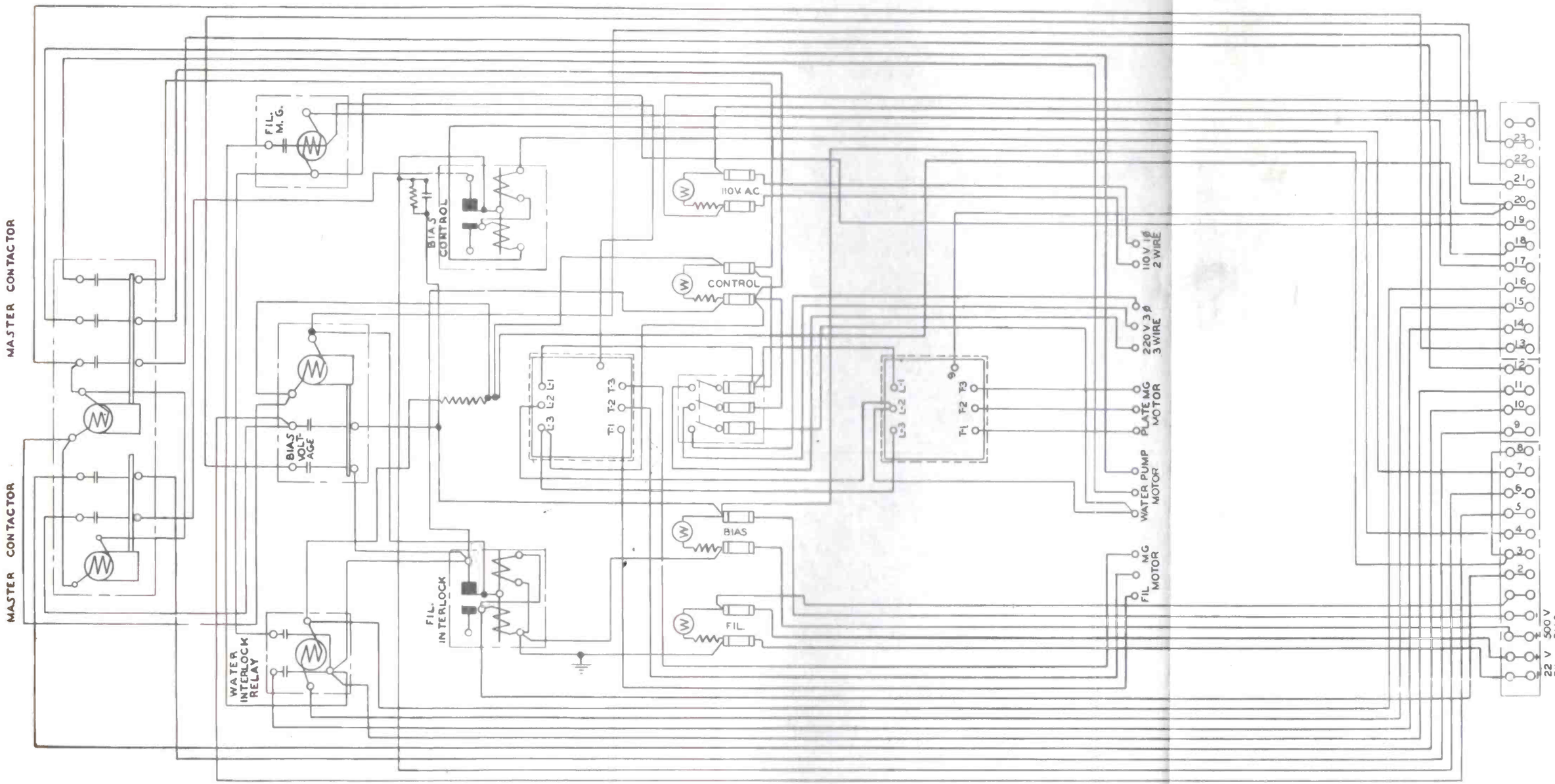


FIG. 6 - CONNECTION DIAGRAM POWER CONTROL PANEL
DWG. P-7703723

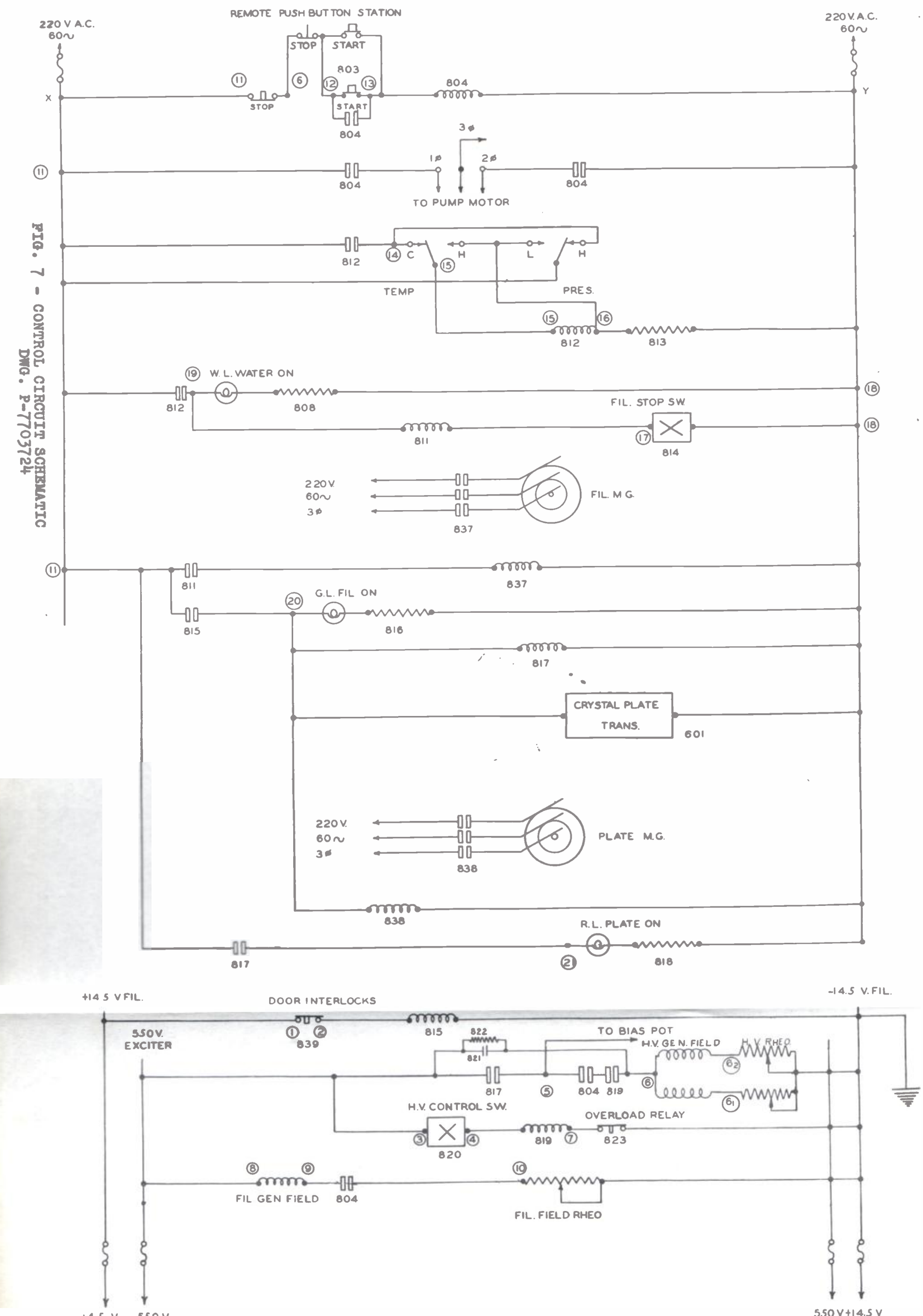


FIG. 7 - CONTROL CIRCUIT SCHEMATIC DWG. P-7703724

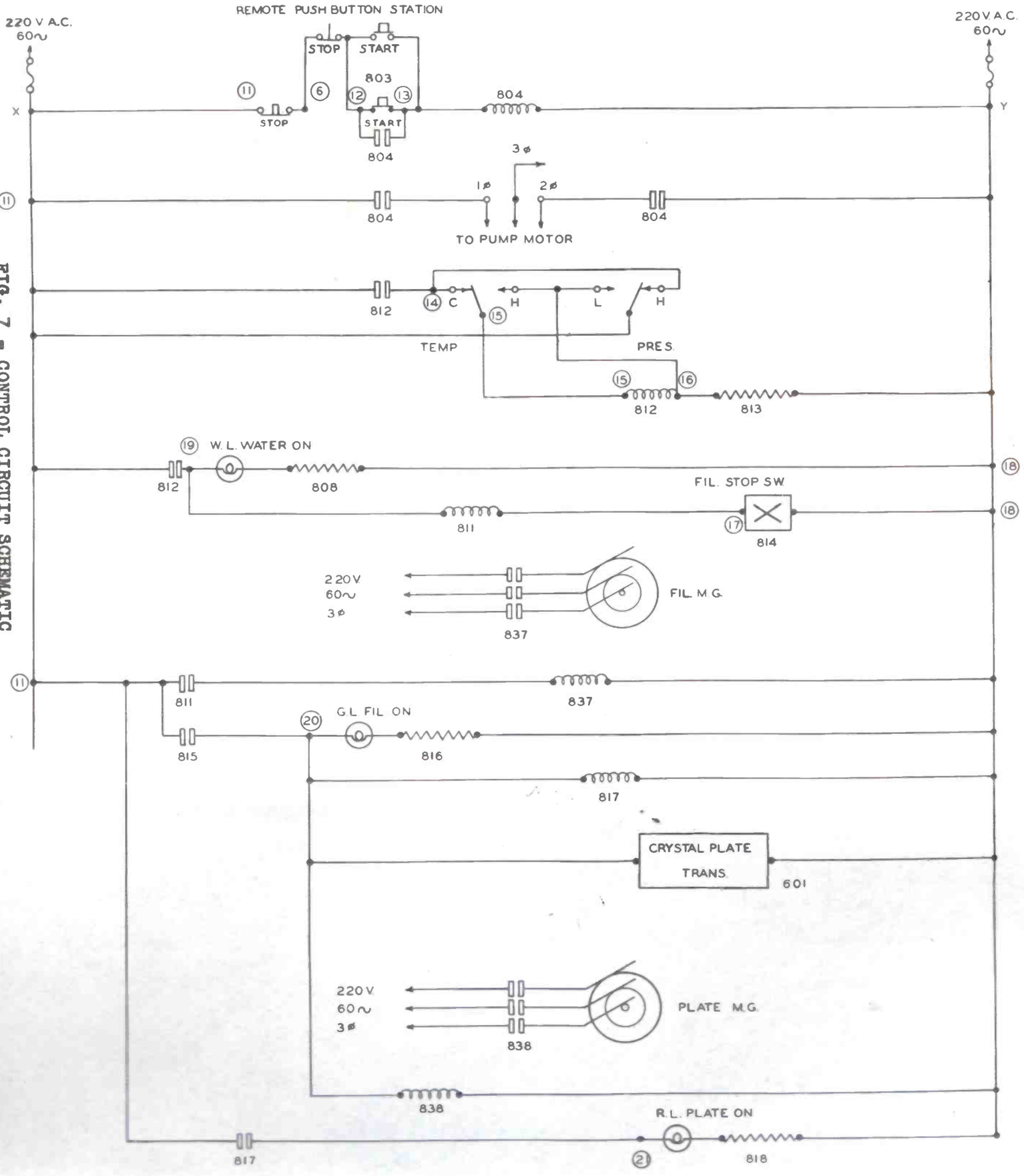
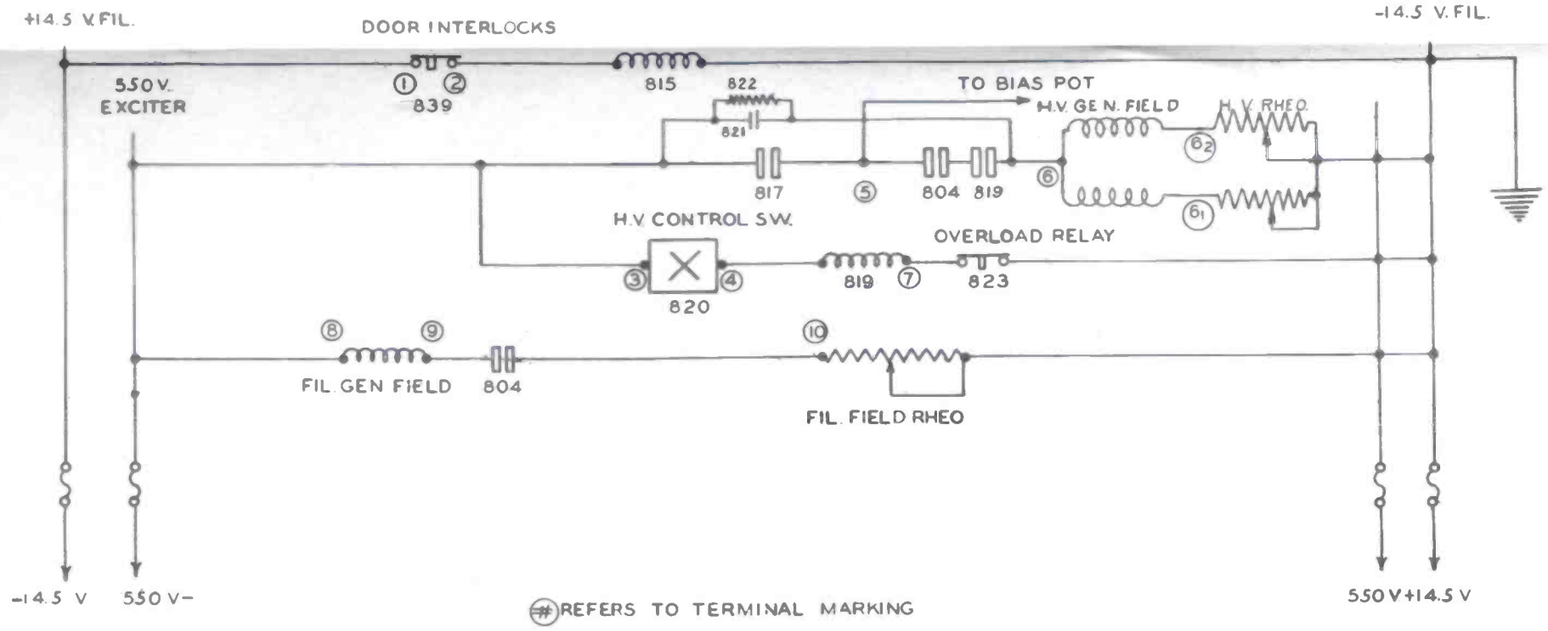


FIG. 7 - CONTROL CIRCUIT SCHEMATIC DWG. P-7703724



(#) REFERS TO TERMINAL MARKING

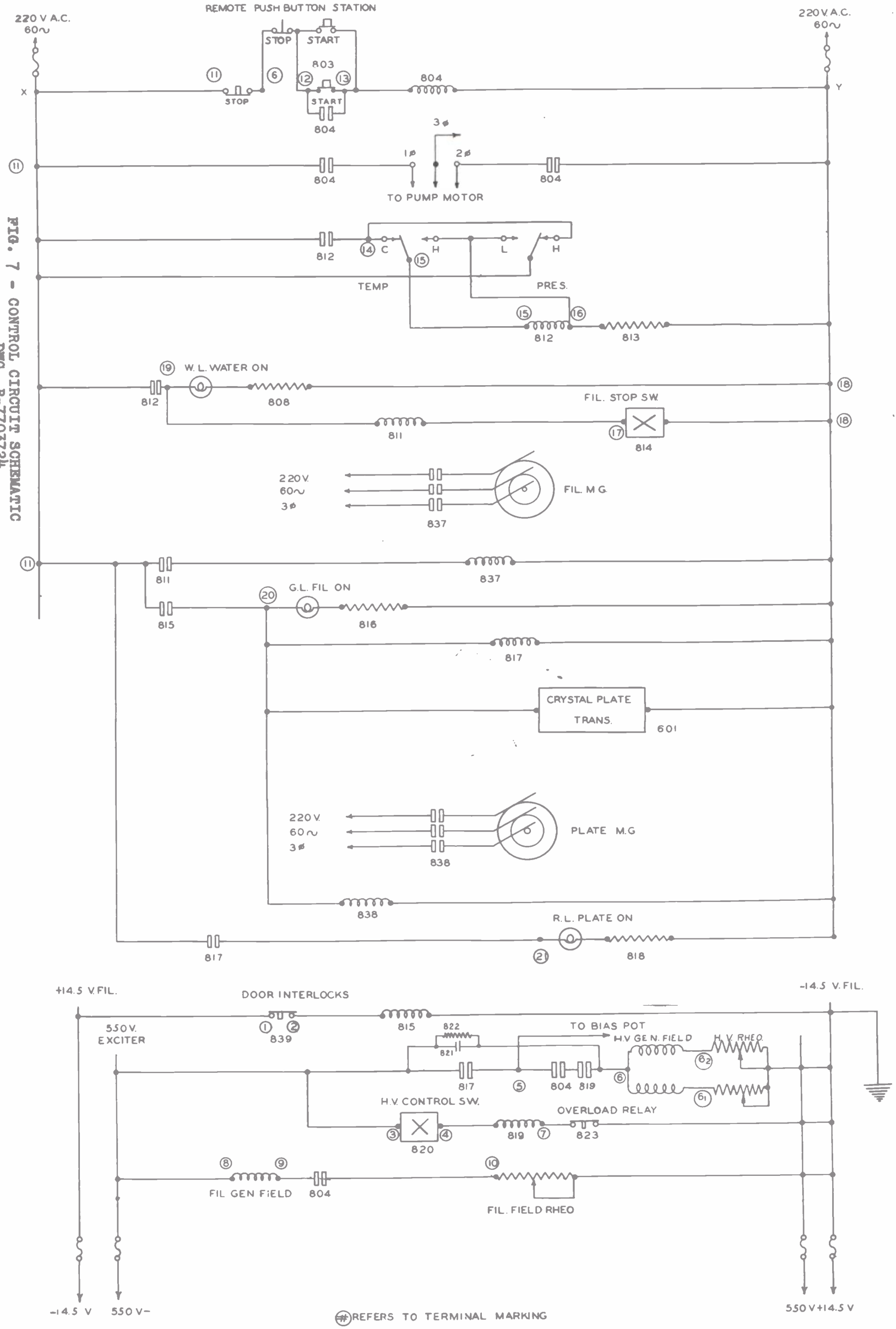


FIG. 7 - CONTROL CIRCUIT SCHEMATIC DWG. F-7703724

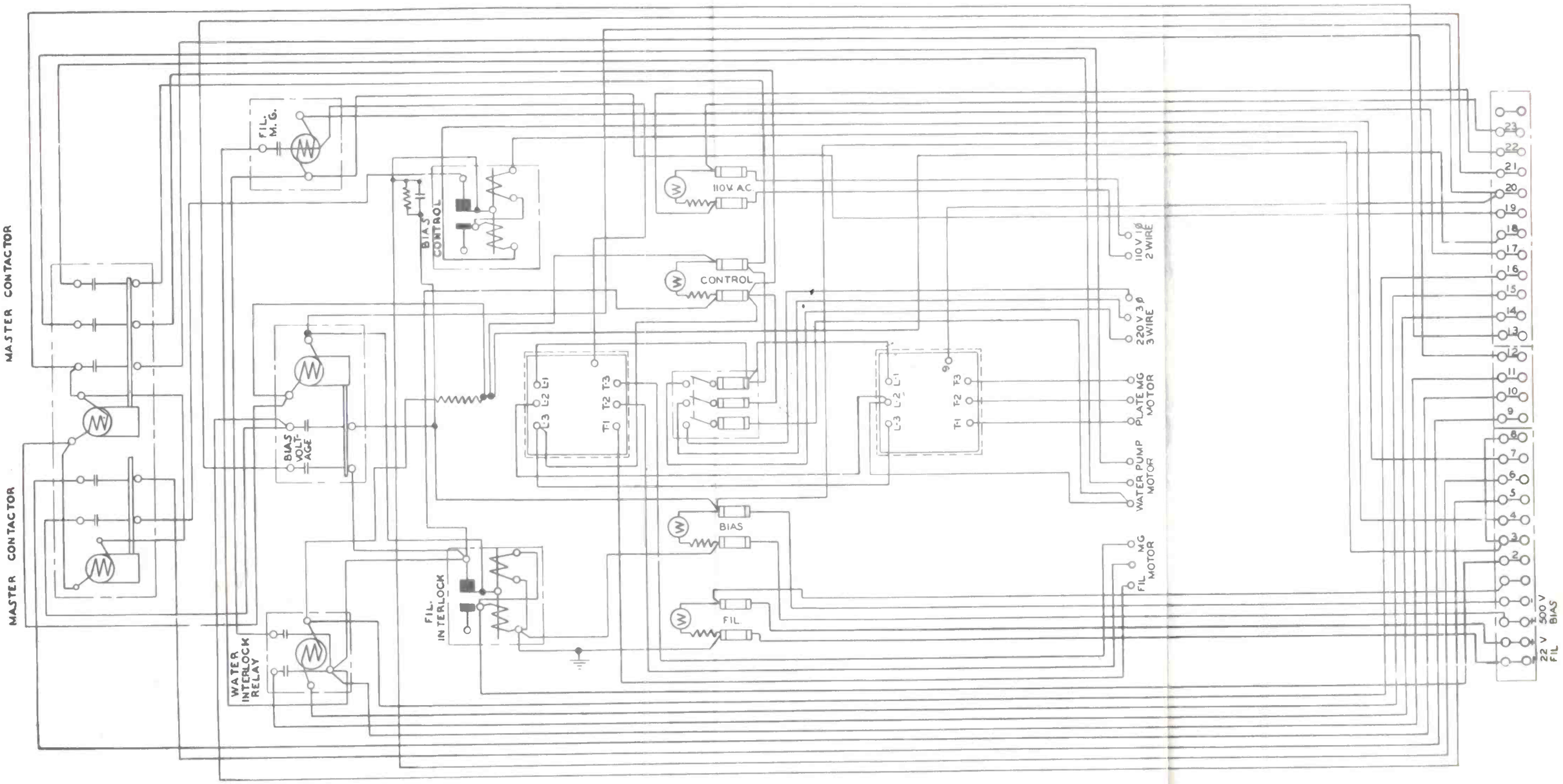


FIG. 6 - CONNECTION DIAGRAM POWER CONTROL PANEL
DWG. P-7703723

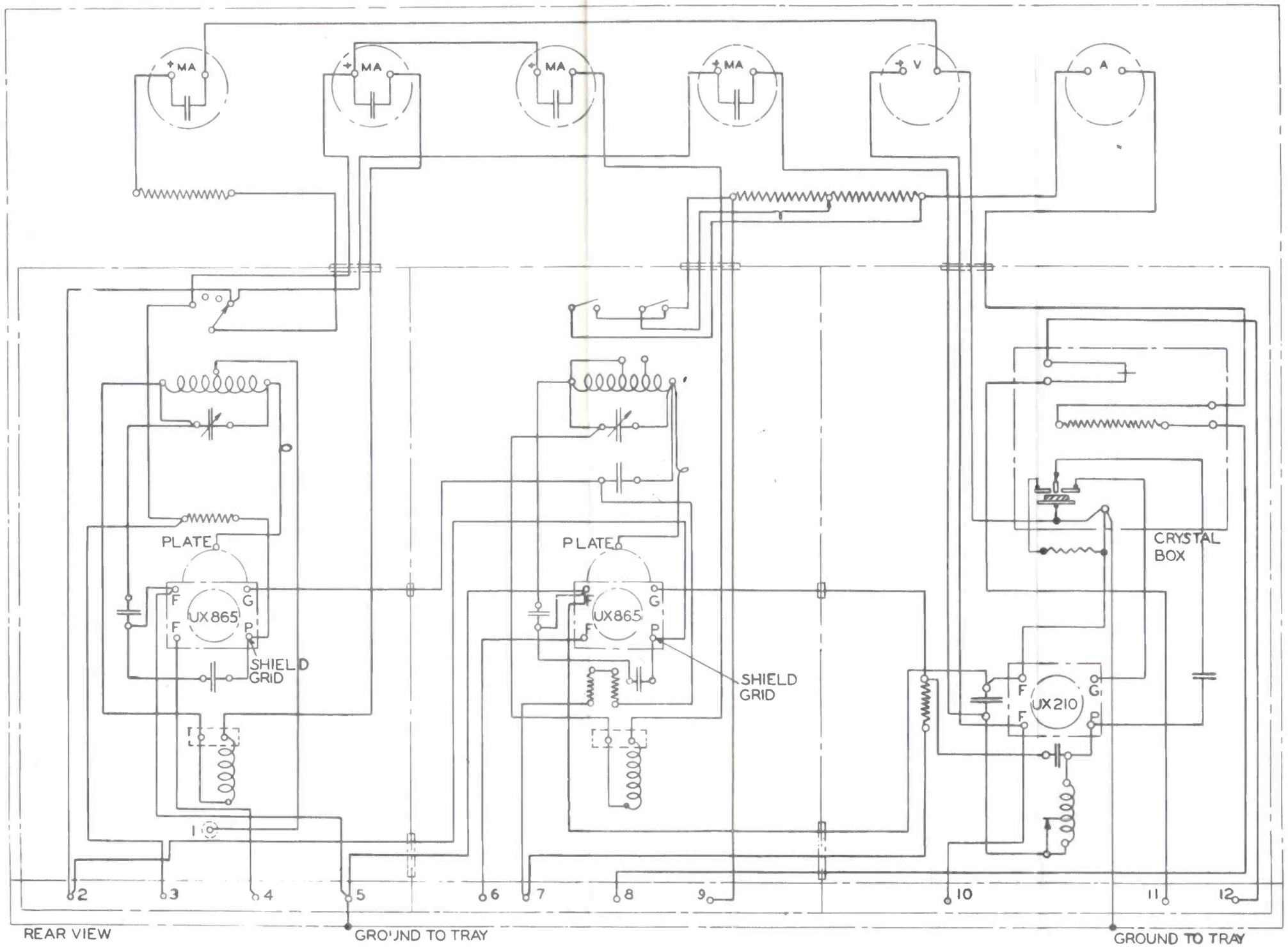
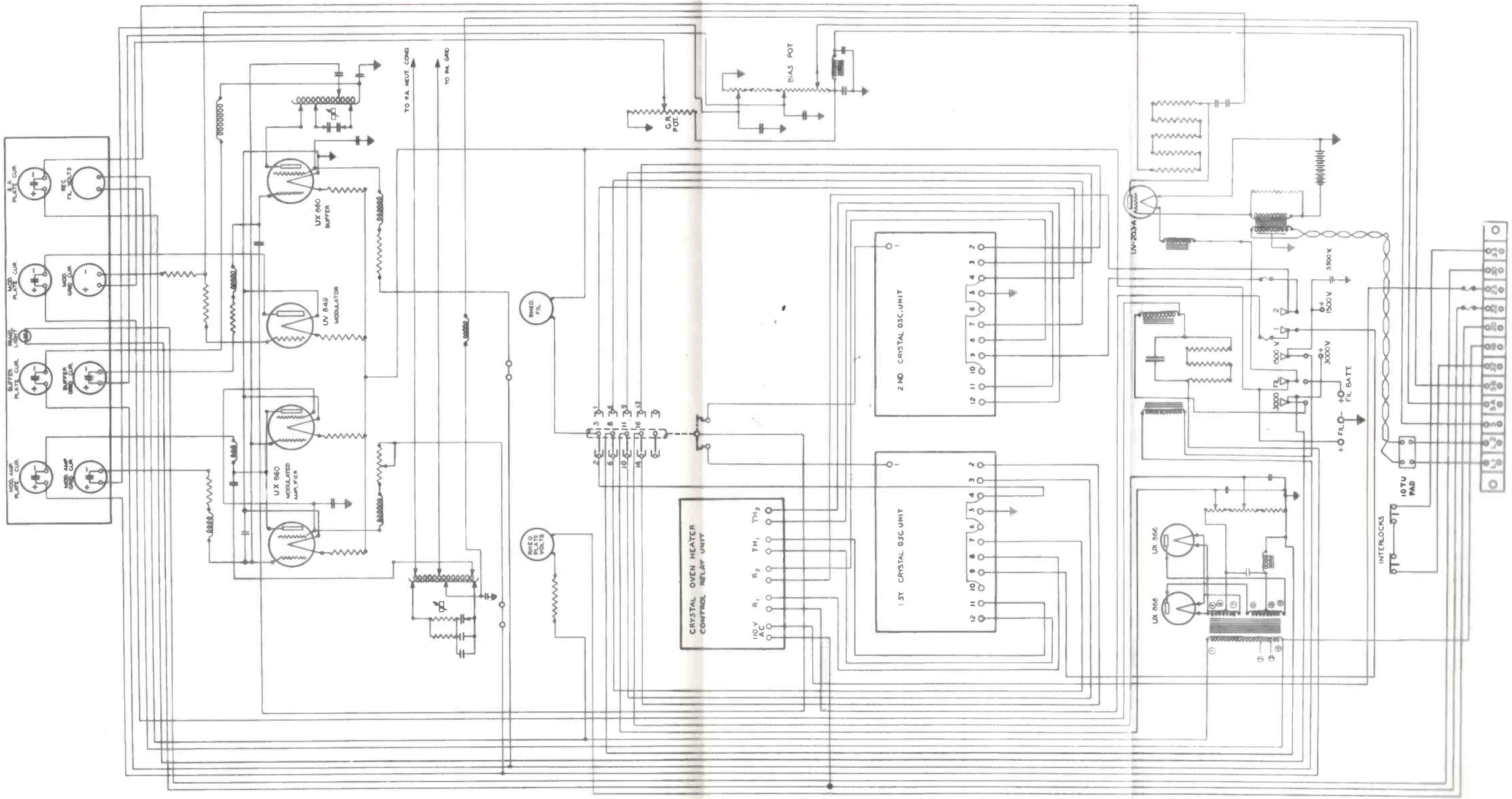


FIG. 12 - PANEL WIRING DIAGRAM FOR CRYSTAL OSCILLATOR AND AMPLIFIER UNIT TYPE OA-1-B
DWG. P-7703726



FOR 60 CYCLE POWER SUPPLY

FIG. 13 - MODULATED EXCITER UNIT PANEL WIRING
DWG. T-7600766

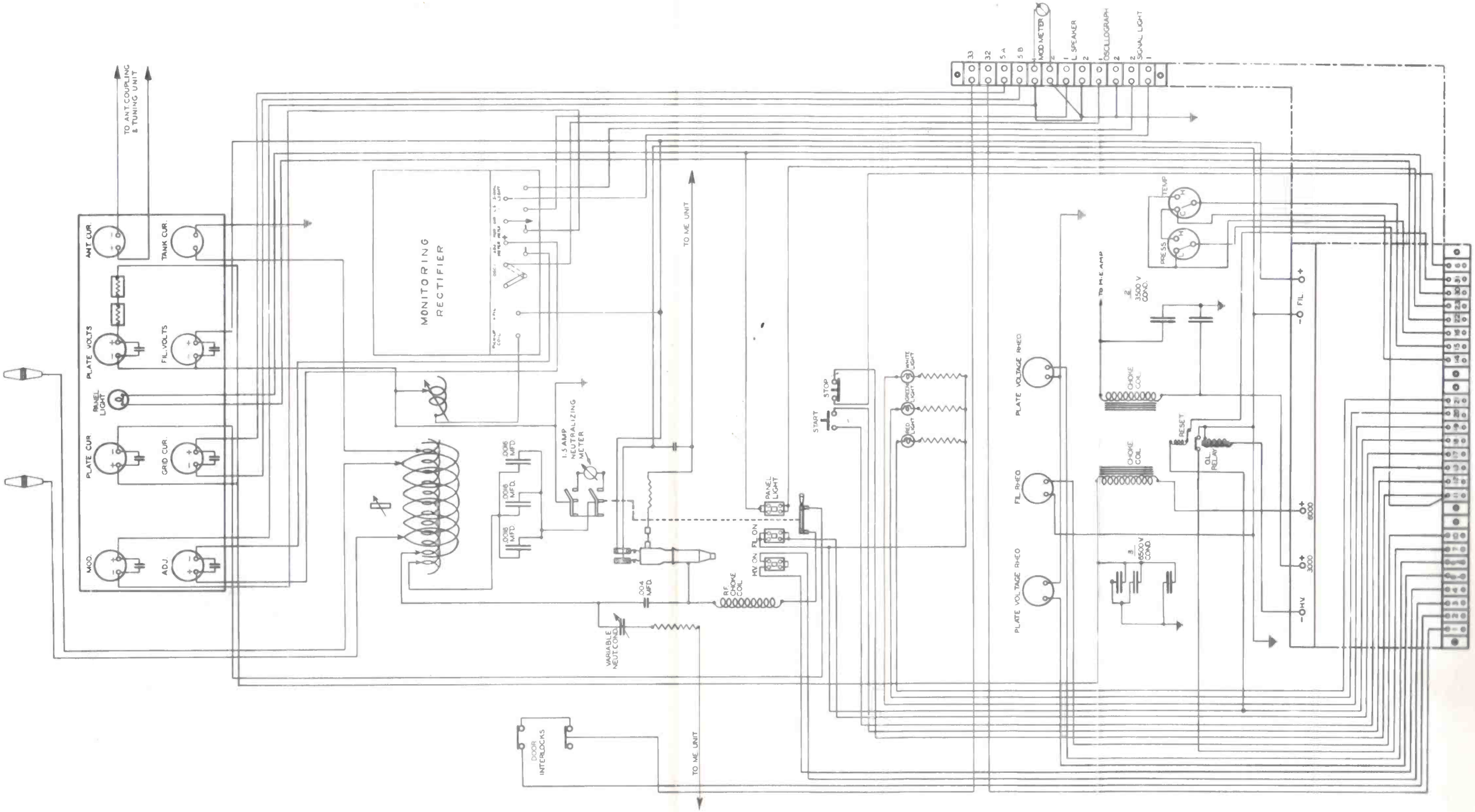


FIG. 15 - POWER AMPLIFIER AND CONTROL UNIT WIRING
DWG. T-7600771

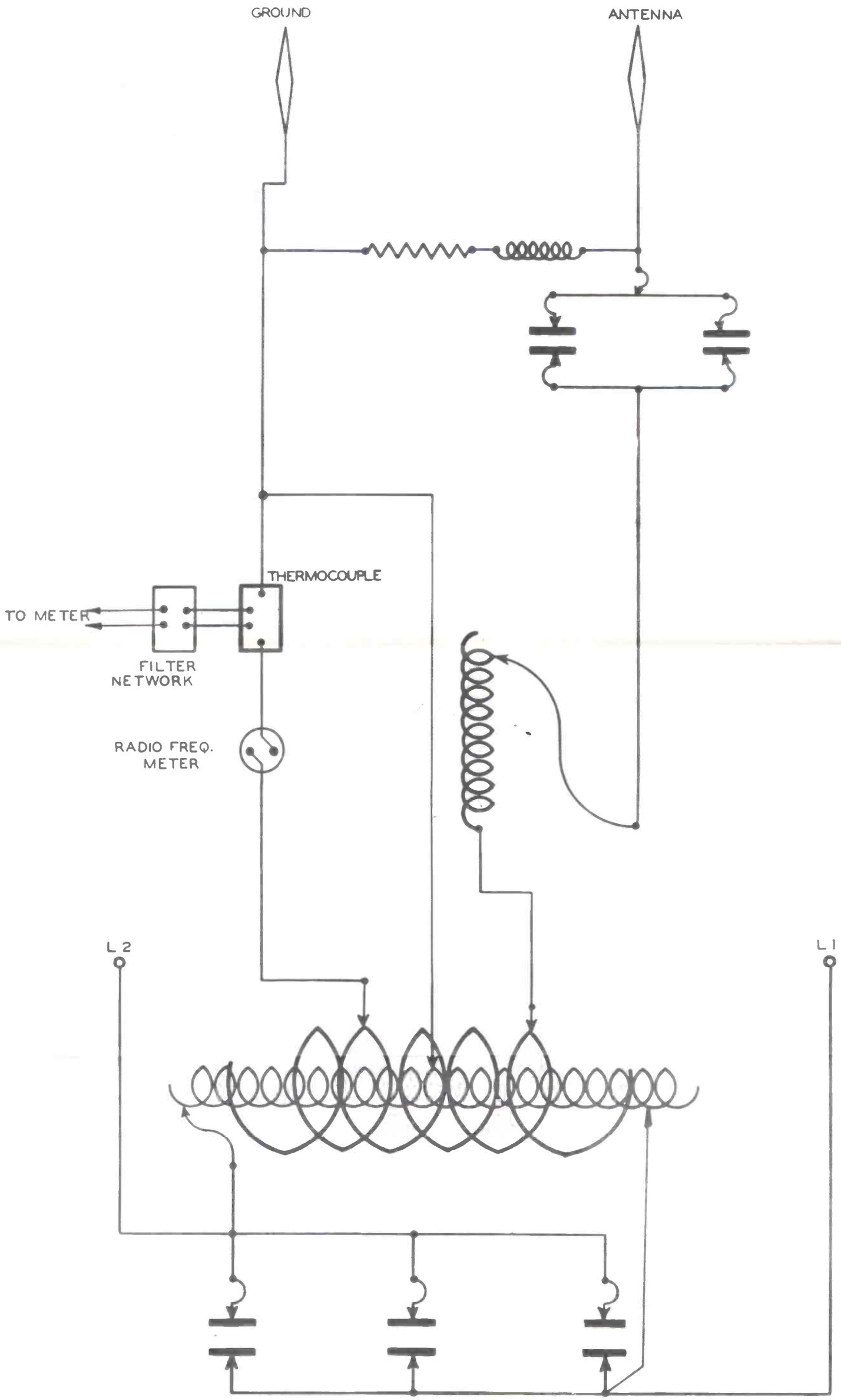


FIG. 18 - ANTENNA COUPLING AND TUNING UNIT WIRING DWG. P-7703739

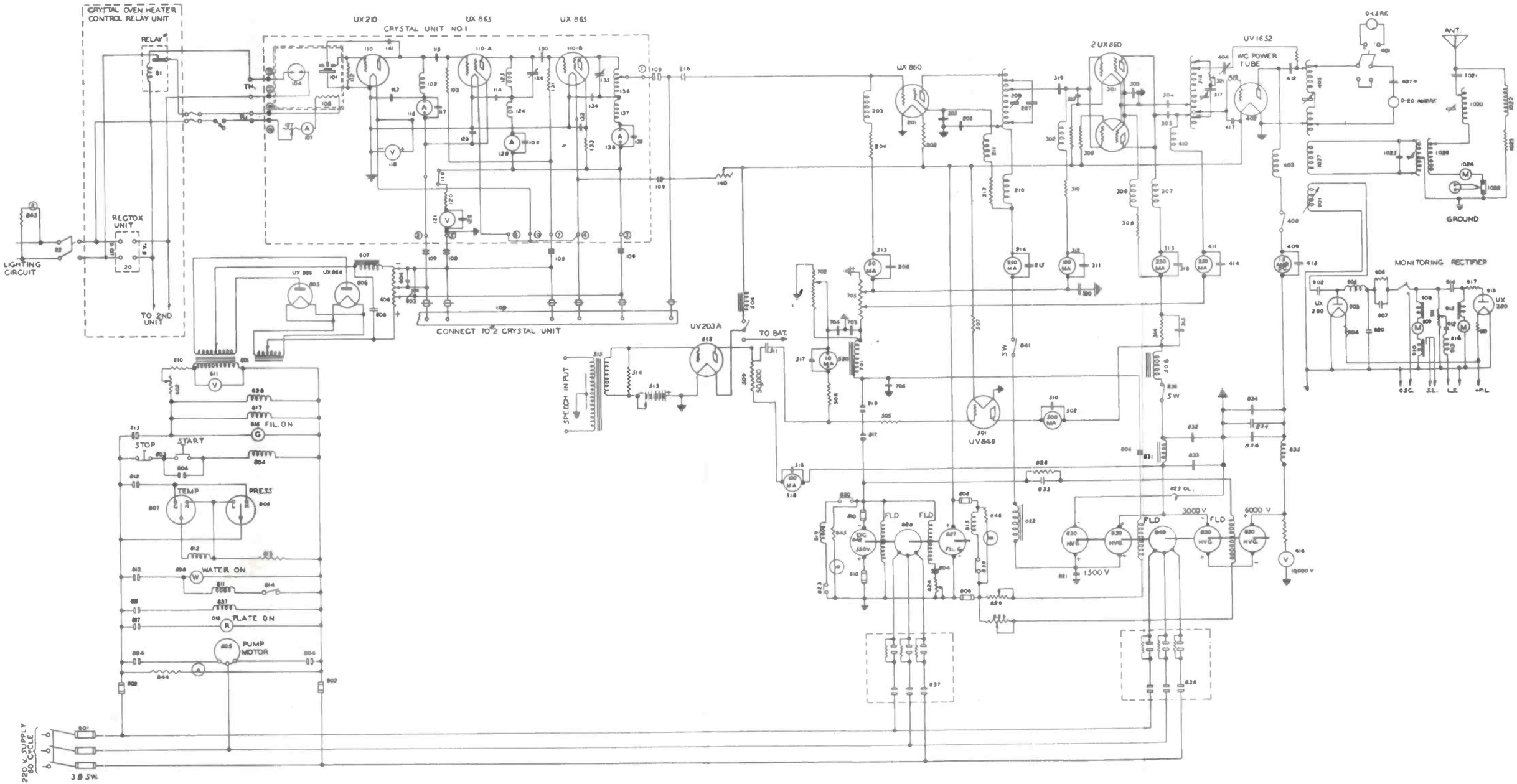


FIG. 23 - TYPE 1-C BROADCAST TRANSMITTER SCHEMATIC DIAGRAM
DWG. T-7600704

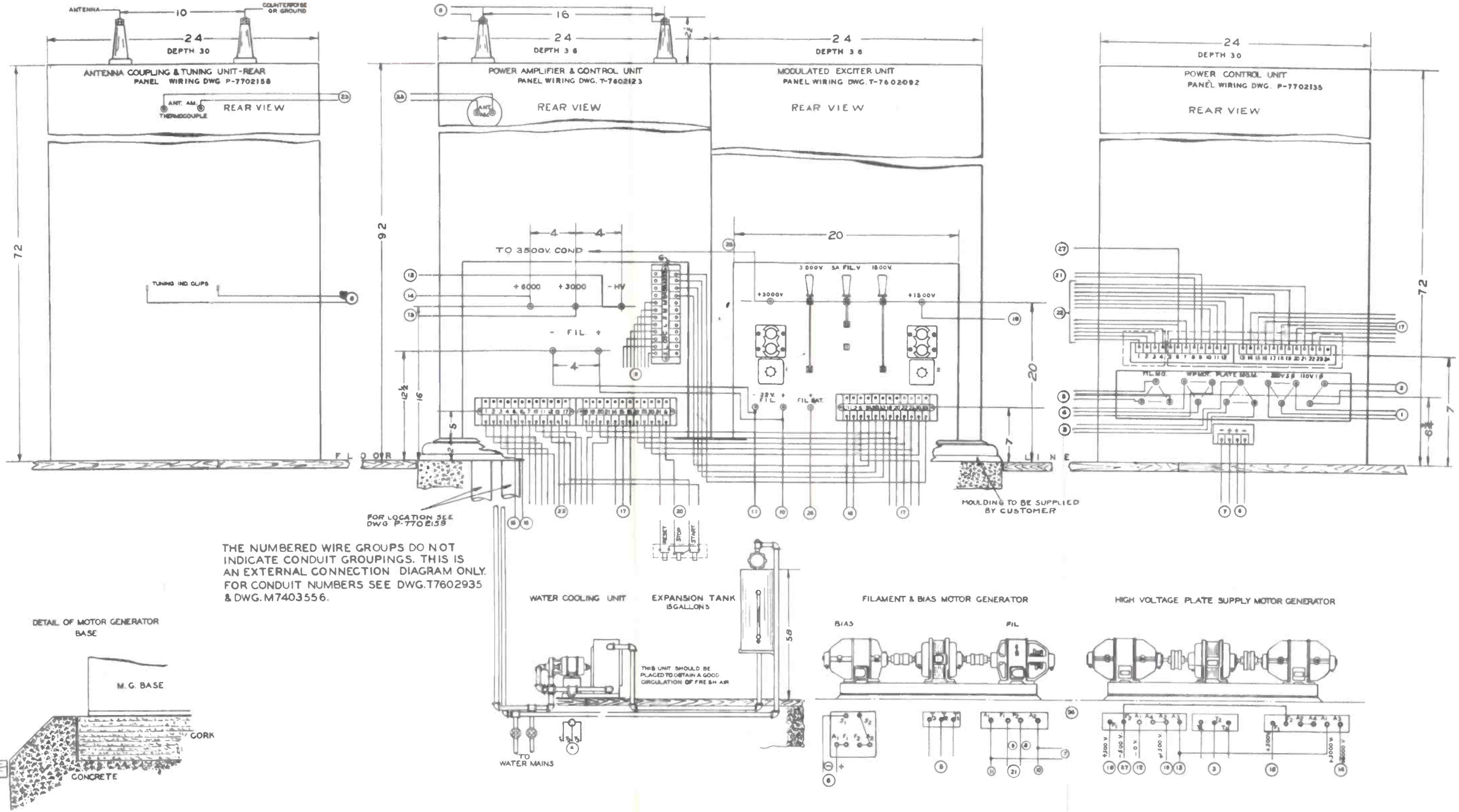
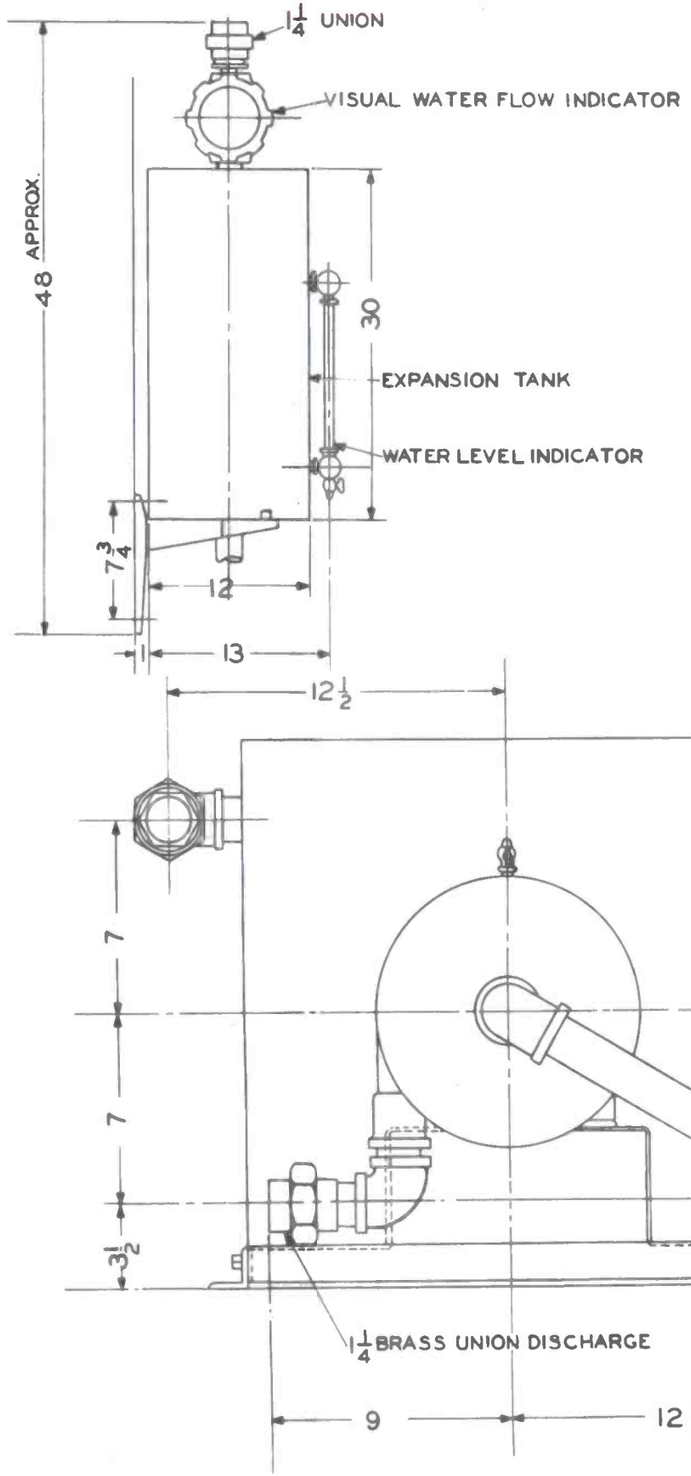
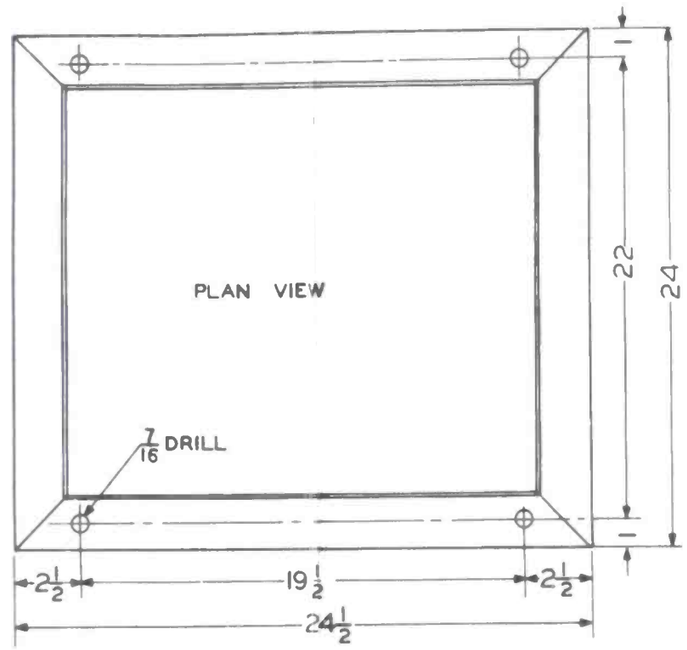


FIG. 24 - INTER-PANEL WIRING DIAGRAM, TYPE 1-C BROADCAST TRANSMITTER
DWG. T-7600774

RADIO TUBE COOLING UNIT

220 VOLT 3ø —— 60 CYCLE





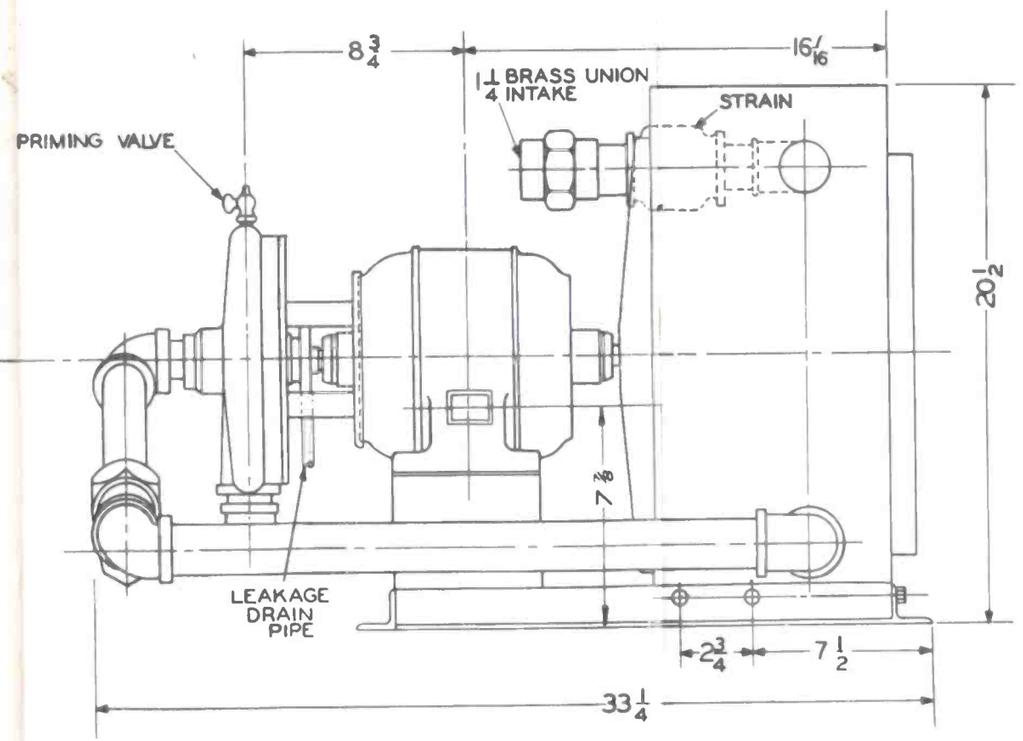


FIG. 25 - WATER COOLING UNIT OUTLINE
DWG. P-7703740

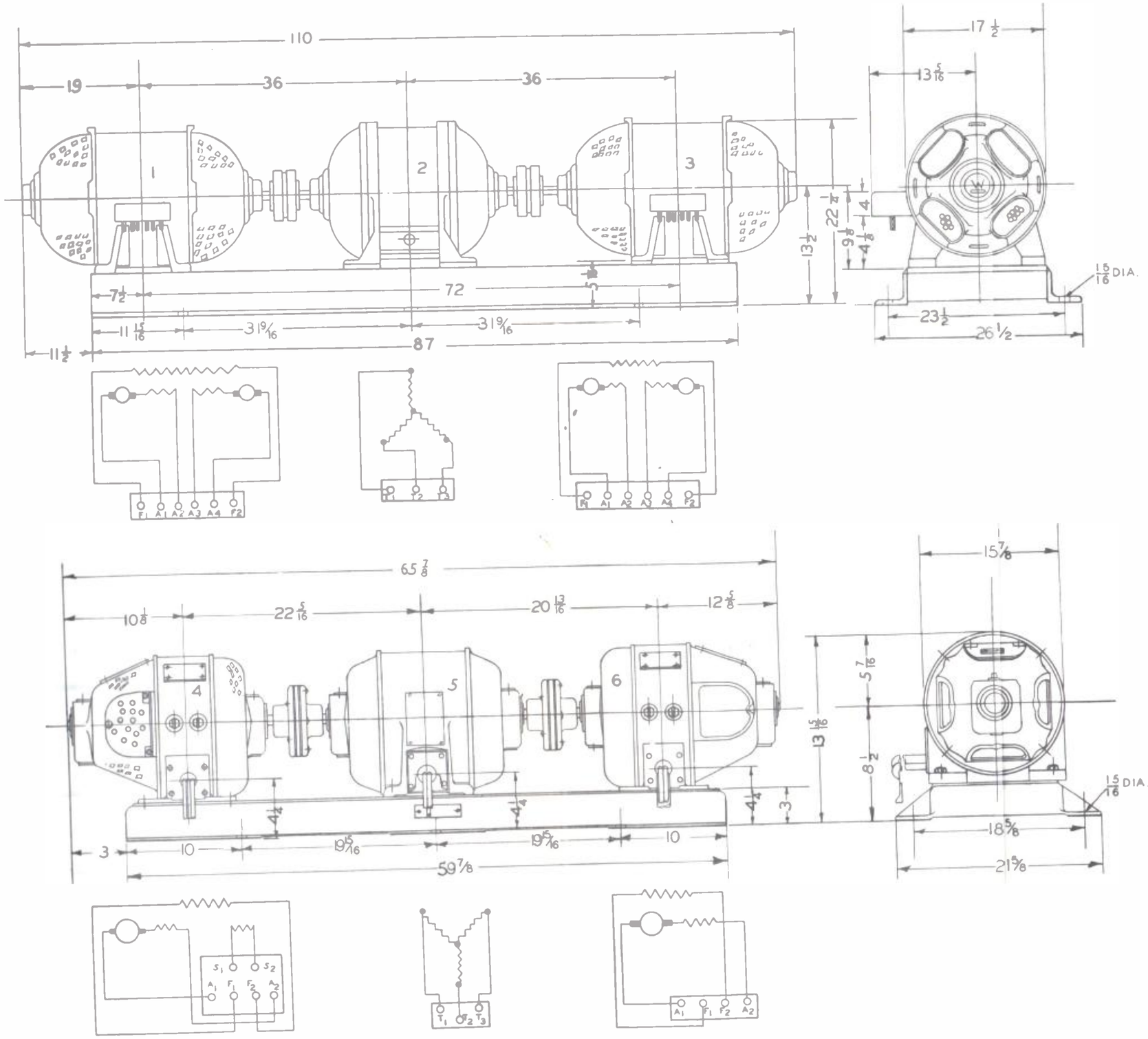
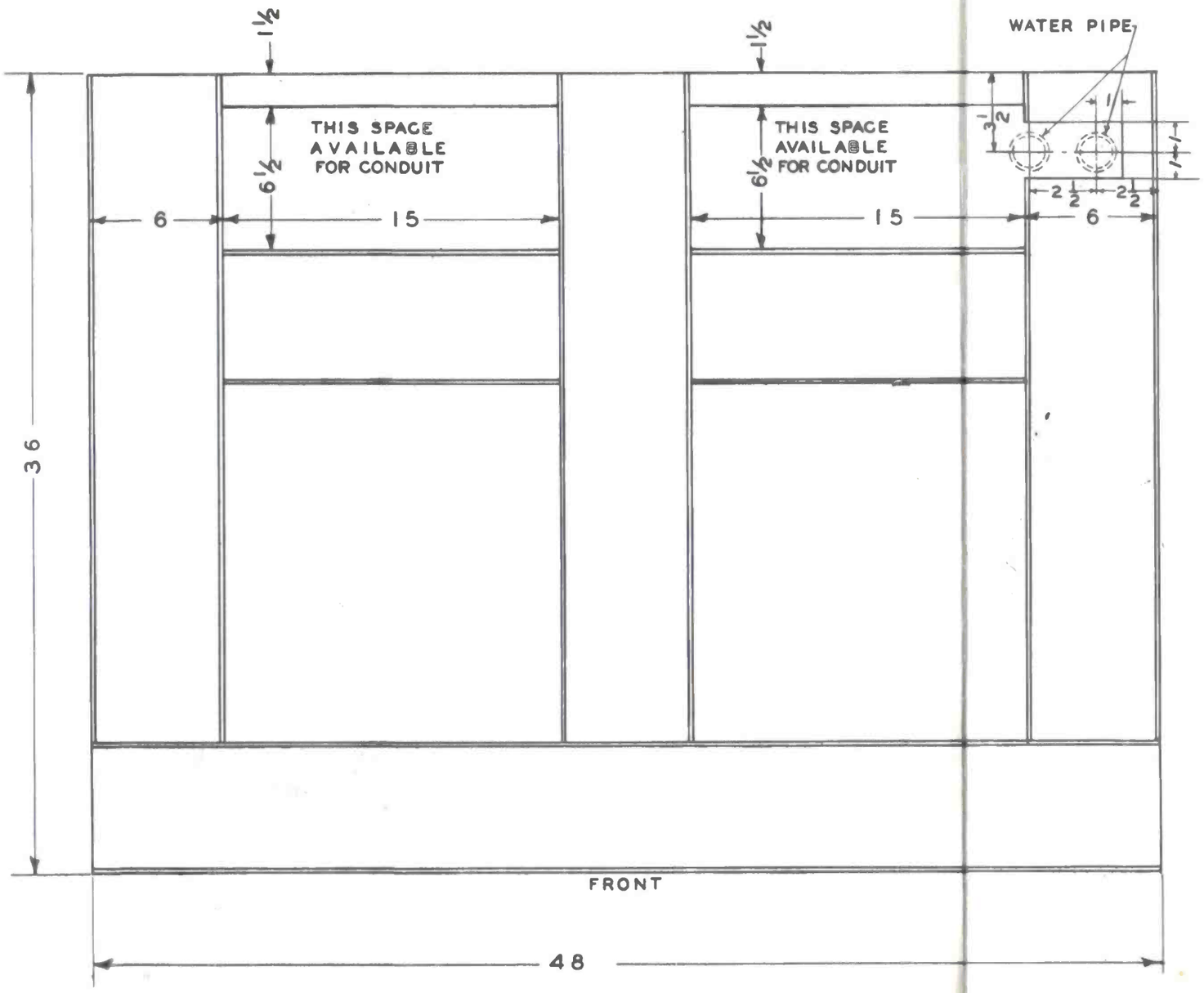
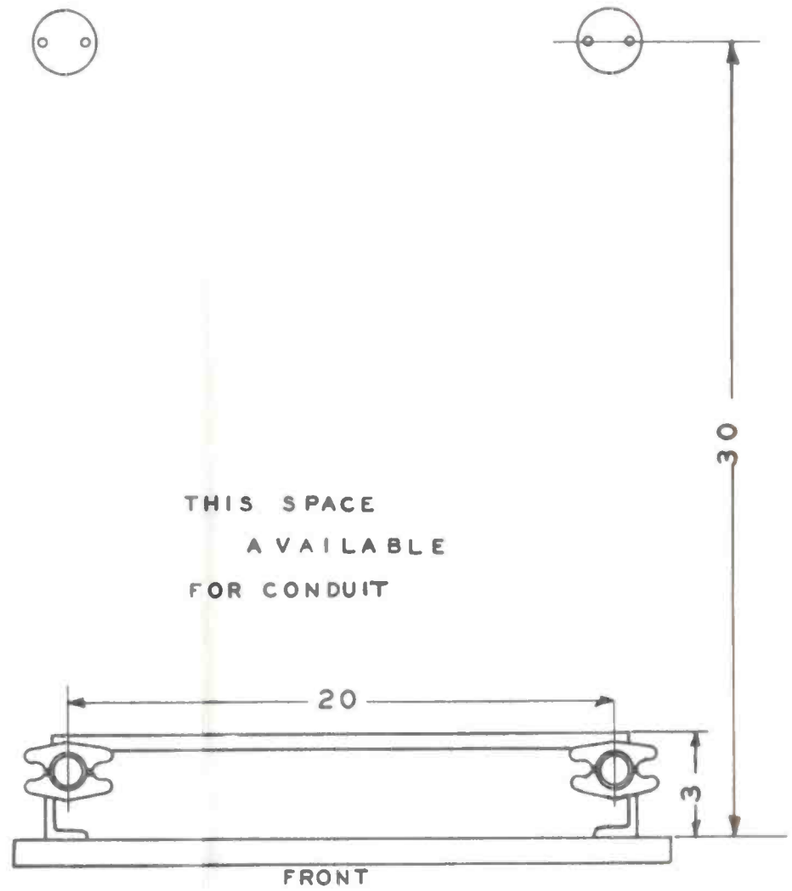


FIG. 26 - OUTLINE DIMENSIONS OF POWER UNITS
DWG. P-7703750



PLAN OF RADIO FREQUENCY UNITS



BOTTOM VIEW OF CONTROL & ANTENNA UNITS

FIG. 27 - CONDUIT SPACE LAYOUT SHOWING LOCATION OF WATER PIPING
DWG. P-7702159