

946P

Western Electric

**407A-4 RADIO
TRANSMITTING
EQUIPMENT**



Instruction Bulletin No. 946P

In - 18,000 Farmer Supply

— Granite Surge Protector

ESP-609507

PR-52P

B.I. for protector - Wamco - Westinghouse -

WESTERN ELECTRIC

407A-4 RADIO

TRANSMITTING EQUIPMENT

Instructions

For Use

Preliminary Instruction Bulletin No. 946P

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WESTERN ELECTRIC
RADIO TRANSMITTING EQUIPMENT

407A-4

Instructions for Use

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407A-4 RADIO TRANSMITTING EQUIPMENT

INTRODUCTION

The 407A-4 Radio Transmitting Equipment consists essentially of the following: a quartz-crystal controlled oscillator operating into a three-stage radio-frequency amplifier; a three-stage audio-frequency amplifier; a modulating amplifier having two water-cooled tubes in parallel; a power amplifier stage having two water-cooled tubes in a high-efficiency circuit; also plate and grid supply rectifiers, associated control and power apparatus, and water-cooling equipment. These elements are combined for generating a constant-frequency carrier which may be modulated by a broadcast program signal, and for amplifying the modulated carrier and transmitting it to an antenna.

The unmodulated carrier power which is normally supplied to the antenna from the radio transmitter is 50 kilowatts.

Approximately 135 kilowatts is drawn from a 460-volt, three-phase, 60-cycle power supply at a power-factor of 0.92 to operate the equipment at its normal unmodulated carrier output. During modulation by a program the power drawn from the line varies syllabically between this value and a peak value of approximately 170 kilowatts. 

The total heat dissipation from the equipment during operation is about 85 kilowatts (4900 B.T.U. per minute), of which approximately 62 kilowatts (3500 B.T.U. per minute) is in the water-cooling system.

This equipment includes facilities to permit the final (50-kw) amplifier stage and its associated high-voltage and

grid-bias supply equipment to be switched out of circuit and the equipment operated at 5-kw carrier power, using the preceding radio-frequency stage (modulated stage) as the output amplifier. This is an assurance against lengthy program interruption due to tube or equipment failure in the final stage or associated power equipment. Also, in the event of power failure it permits operation of the transmitter at 5-kw from an emergency power supply capable of supplying 45-kw at 460 volts, 3 phase, 60 cycles.

Protection against accidental contact with high voltage is provided by the control circuit and the manner in which the apparatus is assembled. The transmitter units are completely enclosed and are equipped with doors which cannot be opened with voltage on, nor can dangerous voltages be applied with the doors open. In addition to the removal of high voltage, interlocks are provided which require grounding of the high-voltage parts.

The operation of the transmitter is controlled by means of circuits and relays associated with the toggle switches mounted on the front panel of the control unit. The transmitter may be automatically started and stopped by means of these control switches and the operating condition of the various circuits is indicated by a group of signal lights.

DESCRIPTION OF APPARATUS

General

The apparatus constituting the radio-frequency circuits of the transmitter is mounted in four units which are intended for assembly on the main floor of the transmitter building. These units, together with a fifth unit containing the control equipment, are mounted together to form a continuous panel front. The space in the rear of this assembly is partitioned into two enclosures: a "50-kw enclo-

sure" within which are installed the 50-kw high voltage rectifier, filter choke and condensers and grid bias rectifier unit; and a "5-kw enclosure" within which is the corresponding power equipment for 5-kw operation, including the 5-kw high-voltage transformer, and in addition the power distribution panel. The 50-kw high-voltage transformers, the plate and auxiliary voltage regulators, and the water-circulating equipment are usually located in the basement.

To facilitate reference to particular pieces of apparatus, each piece is designated by a combination of two letters with a numeral between them, such as C3A. These designations are used throughout the text of this instruction bulletin and on the drawings. In the units of the transmitter these designations are marked either on the piece of apparatus itself or adjacent to it. The first letter of the designation indicates the type of apparatus. For example, a condenser is designated by the letter "C". The number distinguishes between pieces of apparatus of the same type located in each unit. The last letter refers to the unit in which the apparatus is located according to the letter classification given below. The letters designating the several types of apparatus are:

C - Condenser	PR - Protector
CB - Circuit Breaker	R - Resistance
D - Switch	S - Relay
E - Indicator Lamp	T - Transformer or Regulator
F - Fuse	TC - Thermocouple
G - Spark Gap	V - Vacuum Tube
J - Jack	VS - Vacuum Tube Socket
L - Inductance	X - Rectox Rectifier
M - Meter or Pressure Gauge	W - Door Lock
MB - Motor-Blower	Z - Water Valve
MP - Motor-Pump	

The letters assigned to the units and assemblies of apparatus are:

Unit A - D-99110 Oscillator - Amplifier

Unit C - D-151135 Modulating Amplifier

Units D and E - D-99118 Power Amplifier

Unit F - Special D-99116 Control Unit

Unit G - Special D-99114 Rectifier Unit

Unit H - D-99119 Rectifier Tube Unit

Unit J - Antenna-Coupling Unit

Unit K - D-99120 Bias Rectifier

Unit N - Nitrogen Gas System

Unit P - Power Apparatus

Unit W - Water System

Main Transmitter Assembly

The five transmitter units in the main panel assembly are in the form of metal cabinets with doors in front providing access to the interior. The contents of the individual units are briefly summarized below:

D-99110 Oscillator-Amplifier (Unit A): This unit contains two 702A Oscillators, the three-stage radio-frequency amplifier, the three-stage audio-frequency amplifier, the plate-supply rectifier and control apparatus for these amplifiers, and feedback and monitoring rectifiers.

D-151135 Modulating Amplifier (Unit C): Two 232B water-cooled tubes are mounted in this unit together with their input and output circuits, tuning controls, individual filament regulators, and insulating water piping.

D-99118 Power Amplifier (Units D and E): The two units constituting the high-efficiency 50-kilowatt stage contain the two 298A water-cooled tubes complete with their input and shielded output circuits, tuning controls, individual filament regulators, and a harmonic filter. The coaxial

transmission line to the antenna-coupling unit, and the coaxial harmonic shunt line, connect directly to the output terminals of this power amplifier.

Special D-99116 Control Unit (Unit F): The major elements of the control system which supplies power in the proper sequence to the various parts of the equipment, together with the signal lamps and their associated relays, are located in this unit.

Equipment in 50 kw Enclosure

D-99119 High-Voltage Rectifier Tube Unit (Unit H): In this unit are mounted seven 255B mercury-vapor rectifier tubes (one a spare tube ready for quick connection) with their arc-back relays and air blower. The grounding switch associated with the main enclosure gate is also a part of this assembly.

D-99120 Grid-Bias Rectifier (Unit K): This unit supplies bias to the modulating amplifier and power amplifier.

Special D-99775 Condenser and Switch Assembly (FC50P): This assembly includes the high-voltage filter condensers, its charging resistor and associated contactor, and two current-limiting resistors.

High-Voltage Filter Choke Coil (L51P): This choke coil, together with the main filter condenser, forms the plate-supply filter for the two water-cooled stages. A Thyrite Surge Protector (PR52P) is associated with the choke coil to prevent the building up of excessive voltages in the event of sudden overloads.

Equipment in 5-kw Enclosure

Special D-99114 Rectifier (Unit G): This rectifier provides plate and grid-bias supplies for Unit C, for emergency operation at 5-kw. It includes seven 315A mercury vapor rectifier tubes (one a spare tube ready for quick

connection), comprising the three-phase plate rectifier. It also includes a single-phase full-wave rectifier, supplying grid voltage to the two tubes in Unit G, for emergency operation at 5-kw.

Power Distribution Cabinet (DP50P): This unit contains contactors, disconnect switches and circuit breakers for the various 460-volt circuits of the transmitter, filament starting resistors for the 50-kw stage, and power-supply transformers for the preliminary stages.

5-kw Plate Transformer (T58P): This is a three-phase plate-supply transformer, supplied with 460 volts regulated power for emergency 5-kw operation.

D-99774 Condenser and Switch Assembly (FC51P): This assembly includes the high-voltage condenser for filtering the output of Unit G, its charging resistor and associated contactor.

High-Voltage Filter Choke Coil (L52P): This coil together with the above condenser forms the plate-supply filter for Unit G, for emergency operation at 5-kw output.

Equipment Outside Enclosures

Water-Cooling Equipment (Unit W): This equipment consists of two water-pumps (one a spare), two air-blast radiators with their blower motors and associated disconnects, a tank, and the necessary valves and fittings. The insulating ceramic piping for the power amplifier stage is usually supported below the basement ceiling.

High-Voltage Transformer Equipment (T53P, T54P, T55P, T56P): This equipment consists of three high-voltage plate-supply transformers, and an induction regulator (T56P) for varying the primary supply voltage to these transformers. These units have been designed for out-of-door or in-door mounting.

Auxiliary Voltage Regulator (T57P): This is an automatic regulator controlling a constant-potential a-c bus from which all filament and bias voltages, and the plate voltages in the preliminary stages, are derived.

Auxiliary Power Distribution Cabinet (DP51P): This unit contains two power contactors supplementing those in the main cabinet DP50P.

RF Transfer Contactor (S3E): This contactor transfers the outgoing transmission line between the 50- and 5-kw radio-frequency outputs of the transmitter.

DESCRIPTION AND ADJUSTMENT OF CIRCUITS

The following description of the circuits of the radio transmitting equipment is taken up through analysis of the complete circuit into its component parts such as the power circuit, the control circuit, and the radio-frequency circuit. These component circuits usually extend through several of the transmitter units. The identification of a particular part of a circuit and its association with a particular unit or group of apparatus is readily made by the apparatus designation and by reference to the schematic drawings which give the essential internal circuits and also the interconnecting terminal designations. Adjustment of the circuits and apparatus is given in separate sections under each component part.

Power Circuits (Schematic Figure 1)

The 460-volt, 3-phase, 60-cycle power for the operation and control of the transmitter is fed to the various circuits through the power distribution cabinet (DP50P). A schematic of this unit and associated power circuits is shown on Figure 1. Referring to this sketch the 460-volt source of supply is connected through terminals 101, 102

and 103 of this unit to the circuit breaker CB51P, which is equipped with both thermal and instantaneous magnetic overload tripping devices and provides for manually disconnecting all power from the transmitter and also for emergency overload protection.

The application of power to the high voltage rectifier circuit is controlled by CB65P; this is a motor-operated circuit breaker containing magnetic and thermal trips in addition to the no-voltage trip coil which is deenergized by the action of any of the overload relays associated with the water-cooled tubes. Power through this breaker is supplied to the high-voltage rectifier transformers T53, 54, 55P through the automatic induction regulator T56P which regulates the voltage supplied to these transformers. The regulator returns to the minimum voltage position when CB65P is opened and adjusts itself in a few moments after power is applied to the position which results in the proper plate voltage for the high-power tubes. It may, however, be operated from a manual control in the control unit. In conjunction with the taps on T53, 54, 55P, the regulator provides the proper plate voltage over a wide range of fluctuation in power line voltage.

CB52P serves as protection to the 460-volt 3-phase circuit which enters the control unit for connection to the line-voltage voltmeter and the transformer T1F for supplying control-circuit power.

CB53P protects the motor circuit of the plate-voltage regulator T56P.

CB54P supplies power to the auxiliary induction regulator T57P, the output of which provides an automatically regulated source of 460-volt 3-phase power from which all filament and bias voltages and the plate voltage on the

preliminary stages are derived.

CB55P and contactor S51P control the application of power to the cooling-unit motors. Selection of the unit MB1.1W or MB1.2W is controlled by the positions of D4.1W or D4.2W.

CB56P protects the circuit which supplies power to the pump motors MP1.1W and MP1.2W and to the filling-pump motor MP2W. Selection of the active pump is accomplished by D1.1W and D1.2W.

CB57P controls the application of power to the primaries of T51P and T52P, which step the 460-volt 3-phase power to 230-volt 3-phase for energizing the modulating amplifier filaments through CB59P and S53P and also the oscillator amplifier unit through CB60P and S54P. In addition, 230-volt single-phase power is supplied through CB58P to the motor of T57P.

CB61P and S55P control the application of power to the bias rectifier for the modulating amplifier, for 5-kw emergency operation only.

CB62P and S56P control the application of power to the bias rectifiers for the modulating and power amplifiers for normal operation.

CB63P and S57P control the filament circuits of the high-voltage plate and the bias rectifiers.

CB64P in connection with S58P, S59P and S62P and the starting resistors R51P, R52P and R53P control the filament power for the 298A tubes.

CB73P, D55P, D56P and D57P form an isolating and bypass circuit to permit maintenance work on motor-operated circuit breaker CB65P without interruption of station operation. CB73P is manually operated.

CB74P provides protection for the supply circuit to

plate transformer T58P during 5-kw emergency operation.

S63P and S64P are contactors which transfer the 460-volt output of the Plate Regulator between the high-voltage transformers T53P, T54P, T55P (for 50-kw operation) and T58P (for 5-kw emergency operation). These contactors are located in auxiliary power distribution cabinet DP51P.

For 50-kw operation, L51P and C51P are the inductive and capacitive elements of the power-amplifier plate-supply filter. PR52P is an oil-immersed thyrite surge arrester, which under transient conditions absorbs the energy stored in L51P, thus avoiding destructively high voltages. Resistor R55P prevents C51P from drawing an excessive charging current when high voltage is applied. This resistor is automatically shorted by contactor S51P after C51P is charged to the operating voltage. R56P and R57P are surge-limiting resistors which prevent excessive currents from flowing under trouble conditions. D57P and D58P are disconnect switches.

Any accumulated dust should occasionally be blown out of coil L51P by dry compressed air. The proper oil level should be maintained by PR52P.

For 5-kw emergency operation, L52P and C52P form the high-voltage filter. R58P is the charging-current limiting resistor for C52P, and is shorted by contactor S67P after C52P is fully charged.

D-99119 Rectifier Tube Unit
(Unit H, Schematic Figure 2)

Circuit Description

This unit contains the six tubes V1H to V6H inclusive connected in a three-phase full-wave bridge type rectifier circuit. The tubes convert the three-phase high-voltage power furnished by the three-phase supply transformers into

unidirectional current which after being filtered by choke coil L51P and condenser C51P is connected to the anode circuits of the 298A water-cooled amplifier tubes. The seventh tube, V7H, with its anode and filament both connected to busses, is provided for use in case of failure of any of the other tubes. This tube may be quickly connected in place of a faulty tube by transferring its pair of disconnecting links (D8H to D19H inclusive) to these busses. The filament of V7H is run at reduced voltage when not in service and is raised to normal voltage by shorting R9H by means of the "Spare Tube" switch D4H. The blower MBLH is thermostatically controlled and provides a means of cooling the tubes when the air temperature exceeds 30° C (86° F.). Its motor may be disconnected by means of switch D5H. Relay S8H prevents the application of high voltage to the rectifier until the filaments are energized and the motor switch D5H is closed.

Protection from accidental contact with the high-voltage circuits of the rectifier is afforded by the mechanically interlocked switches D1H, D2H and D3H. D1H grounds the three-phase high-voltage supply and short-circuits the high-voltage condenser. D2H energizes the door-lock circuit and D3H opens the high-voltage circuit breaker.

Relays S1H to S6H, inclusive, light lamps on the control panel to indicate arc-back failures of the rectifier tubes. Under normal operating conditions, the anode current of each tube is a pulsating direct current in the form of rectangular blocks which last for approximately 120 electrical degrees of each cycle. This unidirectional current produces a voltage drop across the respective relay shunts R1H to R6H. Copper-oxide rectifiers X1H to X6H are poled in such a way that this unidirectional voltage across the shunts produces no current in the relays. If, however,

a tube arcs back, an alternating current flows through the shunt associated with the faulty tube and current flows through the copper-oxide rectifier and associated relay, thus opening the relay contacts and giving an indication on the control panel of the particular tube which has arced back.

Relay S7H is provided to indicate excessive current drawn from the rectifier and to open the high-voltage circuit breaker.

Circuit Adjustment

Relay S7H may be properly adjusted by passing 15 amperes direct current through the resistance R7H, setting the armature gap at 10 mils and the spring pressure of the back contact at 10 grams, then decreasing R8H until the relay just operates. If it operates with a maximum value of R8H, increase the spring pressure or increase the armature gap.

The correct operation of relays S1H - S6H requires an accurate adjustment of the relays and the proper functioning of the copper-oxide rectifiers X1H - X6H. To adjust relays S2H, S4H and S6H, adjust the separation between the heel piece and head plate to 1 or 2 mils. Make sure that the armature moves freely without binding. Adjust the pressure of the contacts at the bottom of the relays to 15 to 30 grams. With the relay operated the contacts should open approximately $1/32$ inch. Turn the screw in the face of the armature so that with the relay operated the armature does not make actual contact with the pole face but provides a very small clearance. With the relay operated the distance between the operating arm and stop should not exceed $1/32$ inch.

Adjust relays S1H, S3H and S5H for an armature gap of 10 mils and a contact pressure of approximately 10 grams.

The operation of each relay S1H to S6H may then be checked by connecting the secondary winding of one of the filament transformers T1H to T6H momentarily across the shunt associated with the respective relay. The relay should operate when this is done. A further check may be made to determine the condition of the copper-oxide rectifier by applying 4 to 6 volts from a storage battery across each shunt, first in one direction and then in the reverse direction. The relay should operate when the positive terminal of the battery is applied to the anode connection of the shunt and should not operate when the battery connections are reversed.

Tube Filament Adjustment

In order to obtain the maximum life from the 255B rectifier tubes, it is necessary to control the filament voltage, room temperature, and phase relation between filament voltage and anode current. A constant three-phase voltage of 460 volts \pm 2 per cent is automatically maintained at terminals 34, 35 and 36 by means of the induction regulator T57P. Taps are also provided on the filament transformers T1H - T7H, which should be connected to obtain a value close to 5 volts.

It is recommended that the room temperature be maintained at 70 degrees or higher, as at lower temperatures the voltage drop in a tube rises and causes a more rapid deactivation of the filament.

The phase relation between the filament voltages and anode currents of the six rectifier tubes, as installed, is such that the filament voltage of each tube undergoes a reversal at the middle of its anode conduction period. This provides the optimum condition with respect to tube life. If during operation this phase relation is questionable because of change of wiring or apparatus it may be

checked by the following means. (Note paragraph marked "Caution" below.) Connect a wattmeter into the circuit of rectifier tube VLH with its current coil (10-ampere coil) in series with the anode of VLH and its potential coil across the 460-volt winding of TLH; also connect an ammeter (0-10-ampere scale) in series with the current coil of the wattmeter to insure that normal load current is flowing when the test is made. With the rectifier in operation and a normal carrier load on the transmitter tubes, the wattmeter should give zero reading. If it reads an appreciable amount, try other combinations of phase connections to terminals 34, 35 and 36 until a zero or minimum reading is obtained.

When the correct connections to terminals 34, 35 and 36 are obtained, try the same procedure on tubes V3H and V5H. When one tube is phased properly, the others should be correct if the internal wiring of the unit is correct.

CAUTION In order to protect the personnel, mount the meters within the enclosure on a small table so located that the meters may be read by an observer outside the enclosure. The wattmeter current coil and ammeter should be protected by a telephone-type carbon-block protector connected between the tube anode and ground, so that an open circuit in the meters will not result in raising the potential on the meters to that of the high-voltage rectifier.

Do not connect the wattmeter into the circuits of V2H, V4H, or V6H, as both filaments and plates of these tubes are at high potential.

A change in the power-line supply phasing will not affect the relationship of plate and filament phasing.

The direction of rotation of the blower motor will be reversed at each change of phase connection to terminals 34, 35 and 36, but this can be corrected at the motor terminals.

D-99120 Bias Rectifier Unit
(Unit K, Schematic Figure 3)

Circuit Description

Three rectifiers for supplying bias voltage to the 232B tubes in the D-151135 modulating amplifier and the two 298A tubes in the D-99118 power amplifier are mounted in this unit.

The single-phase full-wave rectifier consists of power-supply transformer T1K, filament transformer T2K, 249B vacuum tubes V1K and V2K, choke coils L1K and L2K, filter condensers C1K and C2K, load resistor R1K, and voltmeter multiplier R6K (which is associated with protector PR2K). It supplies a potential of approximately 600 volts d-c for biasing the grids of the 232B tubes in the D-151135 modulating amplifier. Some adjustment of this voltage may be obtained by means of the slider on R1K.

One of the three-phase half-wave rectifiers consists of power-supply transformer T6K, filament-supply transformer T5K, 249B vacuum tubes V5K, V6K and V7K, choke coil L5K, and load resistor R2K. It supplies approximately 500 volts d-c for biasing the 298 vacuum tube V1E of the D-99118 power amplifier. Filter condensers for this rectifier are located in the D-99118 unit E. Taps are provided on T5K for adjusting the filament voltage applied to the terminals of V5K, V6K and V7K to a value as close as possible to 2.5 volts. Taps on the primaries of T6K permit a variation of the rectifier output voltage. They should be set to obtain a value as close as possible to 500 volts.

The other three-phase half-wave rectifier consists of power-supply transformer T8K, filament transformer T7K, 249B vacuum tubes V8K, V9K and V10K, choke coil L6K, load resistor R3K - R4K, and voltmeter multiplier R5K with its protector PR1K. It supplies approximately 1200-volts d-c for biasing the grid of the 298A tube V2D of the D-99118 power amplifier. Filter condensers for this rectifier are located in the D-99118 unit D.

Taps are provided on T7K for adjusting the filament voltage of V8K, V9K and V10K to a value close to 2.5 volts. Taps on the primaries of T8K permit a variation of the rectifier output voltage. They should be set for a value as close as possible to 1200 volts.

Special D-99114 Rectifier Unit
(Unit G, Schematic Figure 3A)

Circuit Description

The plate-rectifier circuit of this assembly contains the six mercury vapor tubes V1G to V6G inclusive, connected in a three-phase full-wave circuit. The tubes convert the three-phase high-voltage power furnished by transformer T58P into unidirectional current which, after being filtered (by L52P and FC51P), supplies the plate current of the two power amplifier tubes in Unit C, for 5-kw emergency operation. The seventh tube, V7G, is kept in operating condition by heating its filament at a reduced voltage obtained through resistances R3G and R4G. In case of failure of any of the other six tubes, this tube may be substituted; it is ready for instant operation. During regular 50-kw operation, the filaments of tubes V1G to V7G inclusive are heated at reduced voltage to facilitate rapid "cut back" to 5-kw, should this become necessary.

An overload relay, S1G, is provided to indicate exces-

sive current drawn from the rectifier and to open the high-voltage circuit breaker. Resistance R2G may be used to adjust the operate point of this relay.

Protection from accidental contact with the high-voltage circuits of the rectifier and other apparatus within the main enclosure is afforded by the mechanically interlocked switches D1G, D2G, and D3G, which are operated by a hand-wheel located at the 5-kw enclosure gate. When operated to open the gate, D3G opens the circuit of the transmitter gate switches, which in turn opens the high-voltage circuit breakers; D1G then grounds the high-voltage supply circuit to the rectifier and also the output circuit of the rectifier; finally D2G energizes the door-lock circuits of Units C and G.

A single-phase full-wave bias rectifier, using two mercury-vapor tubes, is also mounted in this assembly. This rectifier supplies grid bias potential to the two water-cooled vacuum tubes of the D-151135 Modulating Amplifier, for 5-kw emergency operation. Relays S3G and S4G transfer the bias connection on Unit C, between Unit K (for 50-kw) and Unit G (for 5-kw). Switch D5G serves to close the three-phase supply to the rectifier for reduced power operation; for 50-kw operation this switch is normally open. Switch D6G is the 50-5 kw transfer switch, operation of which energizes one or the other of each of several pairs of contactors which complete the control, power supply, bias, and radio-frequency circuits as required for either operating condition.

Special D-99116 Control Unit and Control Circuits
(Unit F, Schematics Figures 4 and 5)

General

The special D-99116 control unit is the center of the

control circuits which extend throughout the system. This unit provides independent control of the oscillator amplifier, of the water system and amplifier filament circuits, and of the rectifier-tube filaments and bias rectifiers. The high-voltage control is interlocked with these branches. With this control circuit, preheating of mercury vapor rectifier tube filaments, testing, and servicing of the various components of the transmitter may be done with ease without sacrificing any protection of the equipment or operating personnel.

An unregulated three-phase 460-volt branch circuit from the power-distribution unit supplies power to terminals 168F, 169F and 170F for the control circuit. Line voltmeter switch D6F permits switching supply voltmeter M1F across any phase of this supply as well as across any phase of the regulated 460-volt supply which is brought into terminals 165F, 166F and 167F from the rectifier tube unit. Transformer T1F connected across one phase of the control circuit power supply steps the voltage down to 230 volts for the control circuit proper. The center tap of the secondary of T1F is grounded. A no-fuse type manual circuit breaker is in the secondary of T1F for protection and serves as a disconnect for the complete control circuit. One side of the 230-volt circuit which may be considered the return side is connected to terminals 141F to 147F for control apparatus external to the control unit. The other side of the 230-volt circuit connects to D10F, D2F and D1F for the three major independent branches of the control circuit: the oscillator-amplifier, the water system and amplifier filaments, and the rectifier filaments.

Oscillator-Amplifier

Closing D10F "Oscillator Amplifier Filaments" supplies

230 volts through terminals 3F, 4F and 5F to terminal 6 of distribution panel DP50P. This energizes contactor S54P, which supplies power from terminals 116 and 117 of DP50P to terminals 3A and 4A. D2A and D3A are normally in the "ON" position so that filament transformers T2A, T3A and T4A are energized.

Water System and Amplifier Filaments

Closing D2F "Water System" supplies 230 volts through terminals 7F, 8F and 9F to terminals 1, 2 and 3 of the power-distribution unit. This operates contactor S51P supplying power to the circuit for the blowers on the radiators. Terminal 2 - DP50P is also connected to the line starters of the pump motors.

From terminals 3 and 29 of DP50P, 230 volts is supplied to terminals L1 and L2 of the transformer in water relay S2W. This transformer steps the voltage down to 12 volts. Contacts C2 and E2 on the Rotax flow controller close the circuit to the relay when the water flow reaches 40 gallons per minute. The relay is then locked up through a second contact P2 and a contact on the relay. If the flow drops to less than 35 gallons per minute the relay releases.

From terminal 9F, 230 volts is supplied to a contact and to one side of the coil of relay S1F. The other side of the relay coil is connected through contacts on flow relay WD1W in the water circuit of V1C and V2C in the modulating-amplifier. With S1F operated, the control circuit from terminal 9F is continued to switch D3F - "Amplifier Filaments."

With D3F in the "ON" position the control circuit through terminals 15F, 16F and 17F to terminals 4 and 19 of the distribution panel DP50P operates contactor S53P, energizing the filaments of the modulating-amplifier, and con-

tactor S58P. The operation of S58P energizes the power amplifier filaments through the starting resistors R51P, R52P and R53P. As the filaments heat up, increasing in resistance, the proportion of the supply voltage appearing across the filament transformers also increases. Relay S62P, connected across one phase of the filament transformer supply, is adjusted to operate when the voltage (and hence the resistance of the filaments) has increased to a value at which it is safe to apply full voltage to the filaments. The operation of S62P connects the coil of contactor S59P across one phase of the power supply. The operation of S59P shorts out the starting resistors R51-53P.

Rectifier Filaments and Bias

Closing D1F "Rectifier Filaments" supplies 230V through terminals 21F, 22F and 23F to terminal 15 of the distribution panel and operates contactor S57P. Assuming switch D21H to be closed, the filament circuits of rectifier units H and K are energized. The filament circuit of Unit G is energized at reduced voltage assuming switch D5G to be open, and at full voltage if D5G is closed. For 50-kw operation, the 230-volt circuit is continued through the auxiliary contacts of S57P to the contacts of relay S8H which is operated when the filaments of rectifier units H and K are energized and the blower motor switch D5H is closed. For 5-kw operation, the control circuit extends through the contacts of relay S18F, which is operated when switch D5G is closed to energize the filaments of rectifier unit G. The control circuit then passes through the 50-5 kw transfer switch D6G and returns to terminal 24F, operating hour meter M5F and lighting E5F - "Rectifier Filaments." Delay relay S2F is energized (50-kw operation only), and 115 volts is supplied through L1F to terminals 1 and 2 of S16F. A detailed

description of the operation of S16F, which controls the re-heating of the rectifier tubes in case of power failures, is given under the paragraph "Power Interruptions." Under original starting conditions S16F will operate and close its contacts on terminals 3 and 4 about 18 seconds after S16F is energized. Three minutes after S2F is energized its contacts close and operate S3F (50-kw operation only). The control circuit continues through the contacts of S2F and S3F in parallel then through the contacts of S16F to relay S4F, which locks itself up from a point on the control circuit ahead of the contacts of S2F. K1F, a momentary-contact push button, is also connected from ahead of the S2F contacts directly to S4F and may be used to operate S4F instead of waiting for the delay relays to perform that function. The control circuit continues through the other set of contacts S4F to light E10F "Rectifier Filament Delay" and then goes to D11F "Osc.-Amp. Control."

It will be noted that "delay make" relay S2F and "delay release" relay S3F are out of circuit for 5-kw emergency operation.

Bias Rectifiers

With D11F in the "operate" position the circuit is connected through terminal 30F to terminal 6A, through the oscillator-amplifier gate switches D9.1-9.4A and terminals 7A to 31F, and through D11F again to 32F. Gate switches for the antenna coupling unit are connected between 32F and 33F. From terminal 33F the control circuit continues through the gate switches in the modulating amplifier, the power amplifier units, the bias rectifier, the high-voltage rectifier grounding switch (D3H for 50-kw operation, D3G for 5-kw), and the switches on the doors to the transmitter enclosure, transformer vault, and water tube room. It then is divided into two branches by the auxiliary contacts of S63P (50-kw)

and S64P (5-kw), one branch returning to D11F and the other to either S56P (50-kw) or S55P (5-kw). The former branch is connected through D11F in the "Operate" position to terminal 26F, then to terminal 10A and through D4A and 15A to 137F, through D5F, 133F and 16A to the relay S3A which applies power to the high-voltage rectifier in the oscillator amplifier. The other side of S3A returns through 13A, 25F and D11F to the return side of the control circuit. The other branch of the control circuit proceeds from terminals 43 and 48 of DP51P to operate either S56P (50-kw) or S55P (5-kw), energizing the associated bias rectifiers. The auxiliary contacts of these contactors extend the control for the application of plate voltage, from appropriate points in the amplifier filament branch of the control circuit.

Power Interruptions

When the rectifier filaments are energized, 230 volts from the control circuit are applied to auto-transformer L1F which in turn supplies 115 volts to terminals 1 and 2 of S16F. Rectox RF1 and condenser C1 then provide a d-c voltage across voltage divider R3. Condenser C2 starts charging through R1. When the voltage across C2 reaches the proper value, V1 breaks down and starts conducting between the two principal electrodes. As soon as the tube starts conducting there will be a conducting path established from the third electrode to one of the main electrodes. Relay S1 in series with this third electrode will operate and close its contacts connected to terminals 3 and 4. The back contact removes an equivalent load from the circuit when the relay is energized. If S16F is de-energized, C2 will discharge through R1 and R3 and for a very short time will maintain a current between the electrodes through R2. If voltage is reapplied while the condenser is still at

sufficient voltage to be maintaining the current between the electrodes through R2, the relay S1 will operate immediately. If, however, C2 has discharged to such a value that the tube is no longer conducting between the electrodes when the power is reapplied, C2 must be recharged to the value necessary to break down the tube. The time required to recharge C2 will be a function of the length of time C2 has been discharging. Hence the delay in the operation of S1 will be proportional to the length of time power is off. If C2 is completely discharged the delay on S1 will be approximately 18 seconds. If the power interruption occurs after V1 has broken down, C2 will maintain the conduction in the tube for about one-half second. If the power is reapplied during this half-second S1 will operate immediately. For any other condition of charge on C2 the delay in S1 closing will be intermediate between instantaneous and 18 seconds.

S16F is energized at the same time as S2F. S4F is operated through the contacts of S16F and S2F in series. When S16F and S2F are energized, S16F will close its contacts in about 18 seconds. In about 3 minutes S2F will operate and energize S4F which locks up. S3F is also operated. In case of a power interruption S4F and S2F will release. However, S3F whose contacts are in parallel with S2F, will not release for a period of about 7 seconds. If power is reapplied during this seven-second period S3F will be locked up and S16F will be operated after the delay explained above. As soon as S16F operates, S4F will lock up and the transmitter will be restored to operation. If the power interruption is longer than the seven-second period the full delay for the operation of S2F is required before S4F is locked up. Thus for power interruptions up to about seven seconds the delay for reheating the rectifier fila-

ments is controlled by S16F, and the delay is proportional to the length of power interruption.

High Voltage

The high-voltage control circuit is common with the amplifier filament control from D2F through S1F and D3F to S53P. At this point the high-voltage control is connected in series through the auxiliary contacts of S53P, S59P, and S56P (for 50-kw operation; S53P and S55P for 5-kw emergency operation). This interlocks the high voltage with the filament and bias supplies. From terminal 10 of DP50P the control circuit is continued to terminal 27C and through the link switch D30.1C and terminal 28C to 53F. From 53F the circuit is connected through D4F "High Voltage Rectifier" and 56F to 57F. S10F is energized, which applies voltage to the undervoltage release coil on circuit breaker CB65P. Voltage is applied to one contact of S8F, to one side of the circuit breaker motor through terminal 63F, and to the reclosure relay S12F. Voltage is also applied through the back contact of S12F to 58F and thence to 59F through an auxiliary switch in the circuit breaker which is closed when the circuit breaker is open. From 59F, relay S8F is energized through the back contact of S9F. Relay S8F locks up through one contact; through the other contact it energizes S12F through R30F, and through terminal 62F it energizes the circuit-breaker closing motor. E64F slows up the operation of S12F so that S8F is positively locked up before S12F latches up. When the circuit breaker closes, its auxiliary contacts close connecting terminals 60F and 61F to the return side of the control circuit. Relay S9F is energized through 61F, locks up through the make contact, and deenergizes S8F through the break contact. When S8F releases, the motor mechanism on the circuit breaker and

the operate coil of S12F are deenergized and S9F is released. Through 60F, relays S13F and S14F are energized. S14F extinguishes lamps E27F "Circuit Breaker Open" and completes the circuit of S50F to the positive of the 24-volt relay circuit. S13F, a delay relay, operates after 2 seconds to energize S61P and S67P, the contacts of which short-circuit the charging resistances in series with filter condensers FC50P and FC51P. E26F "Circuit Breaker Closed" is energized through 60F, as is the timing motor in S12F. If the breaker remains in the closed position for a period equal to the preset adjustment of the timing motor, the release coil in S12F will be energized and restore S12F to normal. If for any reason the circuit breaker is tripped by the overload circuit the above closing sequence is again started by the auxiliary contact of the breaker between 58F and 59F. If, however, the breaker is tripped out before the timing motor resets S12F, the breaker will remain open until the manual push button K2F "Circuit Breaker Reclose" is operated to energize S8F.

Emergency Plate-Circuit Breaker

Switches D55P, D56P, D57P and circuit breaker CB73P have been provided in the distribution cabinet to permit removing the motor-operated plate circuit breaker CB65P from circuit for maintenance or test and to provide an emergency method of operation in case of trouble with the breaker. For normal operation D55P and D57P are in the upper position and D56P is closed. CB73P must be kept in the "OFF" position. In an emergency when it is necessary to operate without the motor-operated breaker in circuit, first make certain that CB73P is "OFF" then open D56P and throw D55P and D57P to the lower position. "H.V. Rectifier" switch D4F should be kept in the "ON" position.

Circuit Breaker CB73P will now be the only control of the application of high voltage, and it is the responsibility of the operator in charge to make sure that all personnel are out of the enclosure, that all gates are closed, and that the transmitter is ready for the application of high voltage before CB73P is closed.

The auxiliary contacts of CB73P parallel the auxiliary switch on CB65P. This auxiliary switch controls the delay relay S13F and thereby controls the condenser-charging contactor S61P; switch D57P connects into the control circuit one or the other of the undervoltage release coils of circuit breakers CB65P and CB73P, respectively. For either of these circuit breakers to close it is necessary to first connect in circuit its undervoltage release coil by operating D57P.

Overload Tripping Circuit

The plate-circuit breaker CB65P is equipped with both instantaneous and inverse time a-c tripping elements and d-c undervoltage release coil. In case of large overloads such as caused by arc-backs in the rectifier tubes, the a-c trip elements open the breaker directly. The undervoltage release coil is supplied from the 24-volt rectifier X1F through the series resistance R31F. The armatures of the overload and arc-back relays are connected to the positive side of the 24-volt supply. The make contacts of the overload relays connect to one side of the undervoltage release coil so that the operation of the relay short-circuits the coil and thus trips the breaker. The back contacts on the overload relays and on the arc-back relays connect to the holding windings of associated lamp relays. The holding windings return to the 24-volt supply through a holding contact on the relay. The operate windings of the lamp relays are

connected across the 24-volt supply through "Lamp Reset" key K3F. The lamps are energized from the secondary of T2F through the lamp contact of each relay.

Protective Circuit

The protective relay S3D operates to close its contacts when any change occurs to disturb a balance between the input and output circuits in the power amplifier. The negative side of the 24-volt circuit goes through the contacts of S3D, then to the coil of relay S10A. Positive of the 24 volts is supplied to the other side of the coil and one armature of S10A through disconnect switch D12F. The positive side of the circuit continues through the back contact of S10A to the holding and operate windings of the lamp relay S51F.

Plate Regulator

The plate-voltage regulator is a self-contained unit. 460-volt, 3-phase power is supplied from the distribution cabinet to operate the motor. 230-volt single-phase power is obtained from terminals 139F and 145F in the control unit for the control circuit of the regulator. The normal control circuit of the regulator is completed through D8F in the automatic position. If the control switch on the regulator is left in the automatic position, either automatic or manual operation may be selected at the control unit by the operation of D8F. With D8F in the manual position, K7F and K6F may be operated to energize directly the secondary relay of the regulator to raise or lower the voltage.

Note: The three indicating lamps should be removed from the plate regulator at installation. Otherwise lamps E28F and E29F in the control unit, will not operate properly.

Oscillator-Amplifier Control

If for testing or servicing it is desired to operate the oscillator-amplifier unit switch D11F may be thrown to the "TEST" position. This acts to open the gate switch chain insofar as the operation of the control circuit of the rest of the equipment is concerned. Power for the control of the unit is then taken from the power supply to the oscillator-amplifier. From 5A, one side of the 230-volt supply is connected through 28F, D11F and 30F to 6A, through the gate switches D9A, to 7A, 31F, D11F and 29F to 25F and 13A and through R66A to S3A. The other side of S3A returns to 16A, 133F and 134F to 135F, through D5F to 137F and 13A, through D4A, 10A, 26F, D11F and 27F to 14A which is the other side of the 230-volt power supply.

With D11F in the "TEST" position there is no automatic delay for the protection of the rectifier tubes in the oscillator amplifier. Be sure that the filaments of this unit are energized at least 15 seconds before the "Plate Rectifier" is turned "ON".

CAUTION There is a potential of 1500 volts on the bus between the D-99110 Oscillator-Amplifier and Condenser C37C in the D-151135 Modulating-Amplifier whenever the D-99110 Unit is operating with D11F in the "TEST" position although the rest of the transmitter is shut down. Therefore no work should be done in the other units of the transmitter within the 5-kw enclosure while the Oscillator-Amplifier Unit is operating. If it becomes absolutely necessary to work in the other units while this unit is in operation, the bus from the Oscillator-Amplifier Unit to C37C should first be removed.

Miscellaneous Circuits

Transformer T2F supplies 24 volts for the overload lamps. One-half of the secondary winding also furnishes 12 volts for the window latches through an auxiliary contact on the safety switch of the high-voltage rectifier tube unit. The other half of the winding supplies 12 volts for the alarm bell BLIF through the contacts of the water thermometer TD1F.

Water-Cooling System (Figure 6)

General

The distilled-water cooling system of the 407A-4 Radio Transmitting Equipment is designed to maintain the temperature of the water-cooled vacuum tubes within safe limits. The system is simple in principle; as shown diagrammatically on Figure 6, it consists of a water reservoir, a pump which draws water from the reservoir and forces the water through the vacuum tube cooling jackets, and a cooler through which the water passes from the vacuum tubes back to the water reservoir.

Because the vacuum-tube cooling jackets are at high potentials, it is necessary to insulate them effectively from ground. This insulation is provided insofar as the water-cooling system is concerned by long lengths of ceramic tubing leading the water to and from the tube jackets. This tubing provides very effective insulation as long as the distilled water remains uncontaminated. It is, therefore, extremely important that any loose dirt or solder flux be completely flushed out of the system before operation of the tubes is attempted, and that nothing but high-grade distilled water be used for regular service.

A constant check is kept on the effectiveness of the insulation of the water and water connections by the leak-

age current meter (M8F) which indicates the current to ground through the water.

The safety devices for the protection of the vacuum tubes consist of an alarm-operating thermometer (TD1F) to warn of the approach of the water temperature to a safe high limit, and water flow relays (WD1W and WD2W) which serve automatically to disconnect the high-voltage supply from the tubes if insufficient water flows through the tube jackets. The proper flow through the two water circuits is controlled by throttle valves (Z3W, Z4W). A pressure gauge is provided in the pump room at the low-pressure side of each throttle valve and at the high-pressure side of the cooler by-pass valve, and the valves themselves are furnished with position indicators for quick and easy observation and resetting. The pressures at the entrance to the inlets to the insulating tubing are indicated on a duplex pressure gauge in the control unit.

The pumps furnished are capable of circulating an excess flow of water so that some throttling is always necessary for normal operation.

For convenience of operation, the indicating flow meter (WD2W) in the power-amplifier branch is provided with indicator scales showing the flow in gallons per minute. Also, in the pump room, there are provided three thermometers, one (M1W) to read the temperature of the water being pumped to the tubes, another (M2W) to read the temperature of the water returning from the tubes, and a third (M3W) to read the temperature of the water returning to the reservoir.

For safety in cold weather, provision is made for automatically draining the outdoor cooling equipment when the pump stops.

Various degrees of cooling, to suit weather conditions,

are obtained by separate control of the cooler blowers and by manipulation of the by-pass valve (Z18W). The safety by-pass valve (WZ1W) protects the cooler radiators from excessive head pressure and the vacuum tube sockets from excessive back pressure.

In addition to the above-mentioned controls, indicators, and safety devices, other valves and piping are installed for quick and easy isolation and drainage of the several branches of the water circuit, and for isolating and draining either cooling unit without disturbing the operation of the system as a whole. Provision also can be made for diverting the hot water into the house heating system and so utilizing its heat in cold weather.

Installation Notes

When the piping has been completely connected, the system should first be checked and flushed thoroughly with clean water. To do this, insert vacuum tubes or dummies in all sockets and close all valves including socket valves, drain cocks, and gauge cocks, excepting only the tank water gauge valves. Fill both tanks with clean water and proceed as follows:

Observe and make notation of exact level of water in each tank. Then open the following valves:

Tank inlet valves Z20.1W and Z20.2W

Tank outlet valves Z21.1W and Z21.2W

Pump inlet valves Z1.1W and Z1.2W

Isolating valve Z1C, in unit C

Isolating valve Z11W

By-pass valve Z18W

Gauge cocks at M4W and M5W

Open vents on pump chambers until water flows from vents, showing pumps are primed, and then close vents.

Start first pump MP1.1W and observe for proper direction of rotation. The pump stuffing boxes should be allowed to leak about twenty drops per minute for the first half hour, and thereafter about five drops per minute. Turn pump outlet valve Z2.1W full open, and then slowly open throttle valve Z3W till pressure on gauge M4W rises to approximately 30 pounds. Examine all piping to the modulating amplifier (unit C) including porcelain piping in unit C, for leakage. If a leak is found, stop pump, eliminate leak, and restart pump. Then slowly close isolating valve Z11W and again examine piping of unit C for leakage. If leak is found, stop pump, open valve Z11W, eliminate leak, restart pump and slowly close valve Z11W. With valve Z11W closed, pressure at M4W should increase to about 90 pounds. If pressure does not come up, examine pump motor and starter for proper electrical connections. Stop pump MP1.1W and close pump outlet valve Z2.1W.

Start second pump MP1.2W and examine for proper direction of rotation. Slowly open pump outlet valve Z2.2W. Pressure on M4W should rise to about 90 pounds if pump motor and starter are correctly connected.

Open isolating valve Z12W and socket valves Z1D, Z2D, Z1E and Z2E (if installed; valves Z1D and Z2D open when lever at socket VS2D is pushed backward; valves Z1E and Z2E open when lever at socket VS1E is pushed backward.) Slowly open throttle valve Z4W until pressure at M5W rises to approximately 30 pounds, and examine all piping to units D and E for leakage. If leak is found, stop pump, eliminate leak and restart pump. Slowly close isolating valve Z12W and again examine the D and E unit piping for leakage. If leak is found, stop pump, open valve Z12W, eliminate leak, restart pump and slowly close valve Z12W.

Open inlet drain valves Z5W and Z6W and increase settings of throttle valves Z3W and Z4W to full open. After five minutes, open outlet drain valves Z9W and Z10W and close drain valves Z5W and Z6W. After five minutes, open isolating valves Z11W and Z12W and close drain valves Z9W and Z10W. Allow water to circulate thus for fifteen minutes or more. Then open first radiator return valve Z17.1W, vent cock Z16.1W, and inlet valve Z14.1W. Open cock on cooler manifold gauge M8W. Slowly reduce setting of by-pass valve Z18W until water flows steadily from vent cock Z16.1W. Make record of cooler manifold pressure (M8W). Examine first cooler piping for leaks.

Open second radiator return valve Z17.2W, vent cock Z16.2W, and inlet valve Z14.2W. Close first radiator inlet valve Z14.1W. Close first radiator return valve Z17.1W. If necessary, readjust valve Z18W till water flows steadily from vent cock Z16.2W. Make record of cooler manifold pressure M8W. Examine second radiator piping for leaks. Stop main pump.

Next, check the auxiliary-pump circuit, as follows: Close first tank inlet valve Z20.1W and second tank outlet valve Z21.2W. Open auxiliary-pump inlet valve Z23W and auxiliary-pump outlet valve Z25W to tank manifold. Start auxiliary pump MP2W, observing that water is then pumped from first tank into second tank. When the water level in first tank is lowered to about one foot head, stop the auxiliary pump, close auxiliary pump outlet valve Z25W, and open tank inlet valve Z20.1W and tank outlet valve Z21.2W.

When the piping has been checked, the water system should be drained, refilled with clean water, flushed again thoroughly, and checked for volume of distilled water required. Then the flow relays should be checked for proper

operation, and if necessary, adjusted as described in separate instructions. Finally, the system should be drained, refilled with distilled water, and adjusted for normal service operation.

To Drain System Completely

Open the following:

Waste valve Z22W

Auxiliary pump valves Z25W and Z26W

Tank outlet valves Z21.1W, Z21.2W

Tank inlet valves Z20.1W, Z20.2W

Pump inlet valves Z1.1W, Z1.2W

Pump outlet valves Z2.1W, Z2.2W

Throttle valves Z3W, Z4W

Isolating valves Z11W, Z12W

Drain valves Z5W, Z6W, Z9W, Z10W

Cooler return valves Z17.1W, Z17.2W

Cooler inlet valves Z14.1W, Z14.2W

Waste cocks Z7W, Z2C

For electrical and mechanical reasons, no piping is attached to waste cocks Z2C and Z7W. It is, therefore, necessary to catch the small amount of waste water in a container or in a funnel attached by a rubber hose to a waste pipe. The waste water from Z2C will not exceed two quarts while that from Z7W may be as much as 3.5 gallons.

If it is desired to hasten the draining, close valves Z22W and Z25W and start auxiliary pump MP2W.

CAUTION Stop auxiliary pump as soon as tanks are empty. Open valve Z22W and Z25W when auxiliary pump is stopped. System should then drain completely through valves Z22W, Z25W and Z26W.

To Fill System

First close the following:

Tank outlet valves Z21.1W, Z21.2W

Waste valve Z22W

Auxiliary pump valves Z25W, Z26W

Drain cocks Z2C, Z7W

Pump outlet valves Z2.1W, Z2.2W

Drain valves Z5W, Z6W, Z9W, Z10W

Then open isolating valves Z1C, Z11W, Z12W and by-pass valve Z18W. Close throttle valves Z3W, Z4W. Open outlet valve Z21.1W or Z21.2W, from whichever tank is to be used, and pour 150 gallons of distilled water into that tank. Open air vent cocks on main pumps until the pumps are primed.

Start one main pump. (NOTE Always keep pump outlet valve Z2.1W or Z2.2W closed at the pump that is not in service.) Slowly open throttle valves Z3W, Z4W until flow meters WD1W, WD2W, indicate normal flow. Continue pumping until level in tank stops falling. If necessary, add enough distilled water to bring the level up to about 16 inches from the inside bottom of the tank.

NOTE During operation, the water level in the active tank must be maintained at not less than 12 inches from the inside bottom of the tank. Add water as required from time to time.

Automatic Drainage of Cooling Units

For cold-weather protection it is necessary that an idle cooling unit have its radiator drained. This draining is normally accomplished by opening the drain valve Z15.1W or Z15.2W. However, automatic drainage is provided by means of a 3/16-inch hole drilled through the gage of each drain valve Z15.1W and Z15.2W. This hole will provide complete drainage in reasonable time for an idle radiator without

by-passing too much around an active radiator. For automatic drainage, vent cocks Z16.1W and Z16.2W must be left open. Also, the cooling units must be located far enough above the water tanks so that the pipes to and from the radiators are adequately pitched to assure rapid drainage.

Adjustment of Water-Cooling System

For simplicity, consider the cooling system as two circuits in series. The first circuit, in which the water gathers heat, is through the pumps and vacuum tubes as far as the cooling unit manifold. Normally, the only adjustment of this circuit is to throttle the two branches for a minimum flow of 10 gallons per minute through the modulating amplifier branch, using valve Z3W, and for 40 gallons per minute through the power amplifier branch, using valve Z4W. This adjustment is wholly independent of weather. The second circuit, in which the water loses heat, is through the cooling-unit radiators. This circuit adjustment is dependent upon operating efficiency, percentage of modulation, and weather conditions. The guide is the temperature of the water being returned to the tanks, as indicated by thermometer M3W.

For normal operation, valves should be set as follows:

<u>Valves Fully Open</u>	<u>Valves Fully Closed</u>
Pump Inlets Z1.1W, Z1.2W	Pump Outlet Z2.2W <u>or</u> Z2.1W
Pump Outlet Z2.1W <u>or</u> Z2.2W, for whichever pump <u>is</u> in service.	for whichever pump is <u>not</u> in service.
Isolating, Z1C	Drain Z5W, Z6W.
Sockets Z1D, Z2D, Z1E, Z2E	Waste cocks Z2C, Z7W
Isolating, Z11W, Z12W	Drains Z9W, Z10W
Cooler Inlet Z14.1W <u>or</u> Z14.2W	Cooler Inlet Z14.2W <u>or</u> Z14.1W
Cooler Vents Z16.1W, Z16.2W	Cooler Drains Z15.1W, Z15.2W
Cooler Outlets Z17.1W, Z17.2W	

Valves Fully Open

(Tank Inlet Z20.1W or Z20.2W
(Tank Outlet Z21.1W or Z21.2W
Cocks on gauges M4W, M5W, M6W
M7W, M8W, M10F

Two side valves on manifold
at WD2W

Auxiliary Pump Inlet Z23W

Valves Fully Closed

(Tank Inlet Z20.2W or Z20.1W

(Tank Outlet Z21.2W or Z21.1W

Center valve on manifold
at WD2W

Auxiliary Pump Outlets
Z25W, Z26W

Waste, Z22W

House Heater Z27W, Z28W.

Throttle valves Z3W and Z4W are normally adjusted for flows of 10 G.p.m. and 40 G.p.m. in their respective branches. By-pass valve Z18.W (usually kept closed) may be opened, if desired, to increase water temperature.

With valves set for normal operation, no manipulation is required when shutting down or restarting the water cooling system.

In cold weather, the hot water may be circulated through the house heater by opening valves Z27W and Z28W and by closing (partly or fully) cooler inlet valve Z14.1W or Z14.2W. Stopping the blower MB1.1W or MB1.2W will raise the water temperature, if that is desired.

When outdoor temperatures fall to freezing, some manipulation of valves and switches is necessary at each daily stopping and starting of the radio transmitter:

Stopping in freezing weather

Close cooler inlet valves Z14.1W and Z14.2W.

Open cooler drain valves Z15.1W and Z15.2W.

If house heater valves Z27W and Z28W are not open, open by-pass Z18W.

Set blower motor switches D4.1W and D4.2W to "off" position.

Close cooler drain valves Z15.1W and Z15.2W after water has drained from cooling units.

Starting in freezing weather

Before starting, have valves and switches set as specified above for stopping:

Cooler inlet valves Z14.1W and Z14.2W closed.

Cooler drain valves Z15.1W and Z15.2W closed.

By-pass Z18W or house heater valves Z27W and Z28W open.

Switches D4.1W and D4.2W at "off" position.

After starting, when water temperature at M1W or TD1F rises to 100 degrees, open cooler inlet valve Z14.1W or Z14.2W.

Close by-pass valve Z18W.

If temperature continues to rise or again reaches 100 degrees, start cooling unit blower by closing switch D4.1W or D4.2W.

The cooling system should be regulated to keep tank thermometer (M3W) reading between 90 and 125 degrees Fahrenheit. Then amplifier inlet temperature (M1W) will remain between 85 and 130 degrees Fahrenheit. The alarm on contact making thermometer TD1F should be set at 135 degrees Fahrenheit.

The water temperature may be controlled as follows:

1. Very rapid and large changes are obtained by starting or stopping the blower in the cooling unit.
2. Small increases of temperature are obtained by increasing opening of by-pass valve Z18W.
3. Small decreases of temperature are obtained by increasing opening of throttle valves Z3W and Z4W.

Power should be decreased if inlet temperature at M1W or TD1F rises above 145 degrees Fahrenheit and should be

shut off completely if the inlet temperature exceeds 165 degrees.

A sudden or excessive rise of water temperature indicates a failure of the cooling circuit due to: (a) improper valve settings, (b) blower motor failure, or (c) clogging of the radiator by leaves, paper, etc.

The immediate remedies for such failure are: (a) readjustment of valves; (b), (c) starting second cooling unit blower and diverting all hot water through second radiator; then (b) repairing motor failure or (c) cleaning radiator by washing it down with a hose from inside.

RADIO-FREQUENCY CIRCUITS

D-99110 Oscillator-Amplifier

(Unit A, Schematic Figure 7)

Circuit Description

Oscillators

The carrier frequency of the transmitter is supplied by either one of two 702A oscillators, which are mounted in the slide rail assemblies in the upper compartment of the oscillator-amplifier unit.

All connections to the oscillator units are made by means of spring contacts which engage when the units are properly inserted.

Each oscillator contains the quartz crystal Y1, the vacuum tube V1, and associated circuits, and the temperature-control circuit consisting of the heater resistance R6 and thermostat TD1.

The intermittent operation of the heater and thermostat maintains the crystal at a constant temperature. Power for the heater is obtained through the transformer T7A and is supplied as soon as power is connected to the transmitter, irrespective of its operation. Lamps E1A and E2A indicate

when the thermostats are closed and current flows in the heater circuits.

Each oscillator is adjusted as a unit to the operating frequency and will maintain its calibration well within ± 10 cycles.

The radio-frequency output obtained from terminal 3 of each oscillator is connected to the "Oscillator" switch D5A, which permits connecting either oscillator to the grid circuit of the first amplifier tube. Plate supply for the oscillator is also connected through this switch and is obtained from a slider on resistance R62A.

First Radio-Frequency Amplifier Stage

The radio-frequency input voltage to the first amplifier tube V1A is impressed across resistance R3A. Condensers C1A, C2A, and C3A provide radio-frequency paths to the cathode of V1A and to ground. The gain of this stage and thus the output to the transmitter is controlled by changing the setting of the "R.F. Output" control R4A, which varies a bias voltage applied to the grid of V1A through the resistances R47A and R3A. The potential drop in R4A is obtained through the "Reduced Power Adj." potentiometer R56A, from the lowest slider on R61A. The plate of V1A works into the anti-resonant circuit consisting of the inductance L1A in parallel with the variable condenser C5A which is tuned by the control "Plate Circuit Tuning V1." Condenser C4A provides the radio-frequency return path to the cathode of V1A. Plate potential of V1A is supplied through tuning coil L1A, choke coil L2A, and resistance R6A from a slider on resistance R60A in the rectifier load circuit. Screen voltage is obtained through R5A from a slider on R60A. Condenser C3A provides a radio-frequency by-pass from screen grid to cathode. Plate current of V1A is measured by the potential drop

across resistance R7A and is indicated by the "Test Meter" switch D10A in position "V1 Plate X20." "Plate current" as measured in this equipment indicates the total current from the tube cathode, a portion of which may flow to other elements of the tube than the plate, such as the grid and screen.

Second Radio-Frequency Amplifier Stage

The output of V1A is coupled to the grid circuit of the second amplifier tube V2A through the condenser C6A. Resistance R8A and R9A provide a grid load and path for the negative bias which is obtained by the potential drop in the resistance R10A and R11A, between cathode and ground. Grid current in this tube is indicated by the potential drop across R8A and is obtained with the test meter switch in position "V2 Grid X5." Total space current is indicated by the potential drop in R10A and is obtained with the test meter switch in position "V2 Plate X100."

The plate of V2A works into the tuned transformer L3A. The tuning is accomplished by the adjustable condenser C10A, the control of which is designated "Plate Circuit Tuning V2." The coupling of this transformer is varied by the control designated "Output Coupling V2." A tap on L3A provides a connection through the condenser C11A and terminal 51 for a radio frequency monitoring circuit. The secondary of L3A is tuned by the inductance L5A and condenser C14A which is varied by the control designated "Output Circuit Tuning V2." This condenser is shunted by the radio-frequency load resistance R93A.

Plate potential for V2A is obtained from the upper strap on R60A through R13A, L4A and R90A, and the primary of L3A. Screen-grid potential is supplied through R12A from the lower strap on R60A. Condensers C7A, C8A, and C9A provide radio-frequency by-passes to ground.

Third Radio-Frequency Amplifier Stage

Resistances R93.1A and R93.2A constitute the grid load of the third amplifier tube V3A. The plate circuit contains the anti-sing assembly L19A and R83A operating into the transformer L9A and into the coupling circuit through condenser C19A. The secondary of L9A in series with the adjustable condenser C15A provides a circuit, the control of which is designated "Neutralizing 3rd Amp.". The coupling circuit consists of transformer L10A, the primary of which is tuned by condensers C51A and C20A, the control of the latter being designated "Plate Circuit Tuning 3rd Amp.". The adjustable coupling of this transformer is termed "Output Coupling 3rd Amp.". Its secondary is tuned by inductance L11A in series with condensers C22.1A and C22.2A, which are shunted by the adjustable condenser C21A, the control of which is designated "Output Circuit Tuning 3rd Amp.".

Audio Amplifier

The amplifier which provides the necessary audio-frequency modulating voltage has one transformer- and two resistance-coupled stages employing tube V6A in the first stage, tubes V7A and V8A in parallel in the second stage, and V4A and V5A in parallel in the third stage. The input to the second stage is the difference of two voltages, one the signal from the speech-input equipment through the first stage across resistance R70A, the other a portion of this signal fed back from the output of the transmitter, demodulated by a full-wave rectifier V9A, and applied across resistances R48A and R50A. The speech-input circuit consists of the input transformer T10A, the resistance networks R73A to R82A inclusive, and the contacts of relays S8A and S9A. The grid bias of each tube is obtained by the potential drop across resistances between each tube cathode and

ground. Each tube space current is measured by the drop across meter shunts that are provided in the circuits. The output circuit of V4A and V5A is connected to terminal 65, so that audio-frequency power is connected to the D-151135 modulating amplifier across terminals 65 and 61 in series with the radio-frequency output across terminals 54 and 55. The audio plate blocking condenser is provided in the D-151135 modulating amplifier.

The radio-frequency rectifier tube V10A, associated with its input transformer T9A and output transformer T11A, furnishes a means of audi-frequency monitoring.

Power-Supply Circuits

The filaments of all vacuum tubes in the oscillator-amplifier unit are heated by alternating current from transformers T2A and T3A. A single-phase full-wave rectifier employing mercury-vapor tubes V12A, V13A, V14A, and V15A (with V16A as a spare) supplies all screen and plate potentials. The lower potentials are obtained from sliders on the potentiometers associated with the filter circuits of the rectifier.

Circuit Adjustment

Preliminary

With the "Power" and "Plate Rectifier" controls in the "OFF" position, place vacuum tubes in their respective sockets according to Table 9.

Turn the "Power" switch "ON" and allow sufficient time for all vacuum-tube filaments to become properly heated. For normal operation the heating time is automatically taken care of by delay circuits. However, the filaments of new mercury-vapor tubes should be heated at least 15 minutes before the high voltage is applied. This preheating removes any particles of mercury adhering to the sides or

elements of the tubes after shipment or handling, thus minimizing the possibility of flashovers. With the "Oscillator-Amplifier Control" switch, D11F, of the special D-99116 control unit in the "Test" position there is no automatic delay for the protection of the rectifier tubes. Under these conditions a filament heating time of at least 15 seconds should be allowed before applying the plate voltage.

After the 702A oscillators have been inserted and the heater power has been applied by placing the "Osc. Heater" switch in the "ON" position, the indicator lights will be on continuously until the unit has reached the normal operating temperature (approximately 60 degrees Centigrade) as indicated by the thermometer. When starting from normal room temperature this time should be approximately one hour. Thereafter the lights should be alternately "ON" and "OFF" for periods of about 30 seconds, the exact time depending upon the ambient temperature.

Make preliminary adjustments of the radio-frequency circuits according to Table 3.

First Radio-Frequency Amplifier Tuning

Resonance is obtained in all plate circuits by an adjustment for minimum d-c plate current of the tube whose tuned output circuit is being adjusted. In tuning any of the radio-frequency circuits, care should be taken that no circuit is tuned to the second harmonic of the fundamental frequency. Should two points of resonance be found with coarse adjustment as specified, the one at which the capacitance of the variable condenser is maximum is the correct adjustment. This will correspond to the point of higher dial reading and higher output current.

Before applying plate voltage open links D6A and D7A. Place the "Plate Rectifier" switch in the "ON" position and

the "Test Meter" switch on the "V1 Plate X20" position. With the "RF Output" control set at about 80, adjust the "Plate Circuit Tuning V1" control until the "Test Meter" indicates a minimum, or until the "Test Meter" indicates a maximum when turned to the position "V2 Grid X5."

Second Radio-Frequency Amplifier Tuning

With the "Output Coupling V2" control set at zero and the "Test Meter" switch on the "V2 Plate X100" position adjust the "Plate Circuit Tuning V2" control until the "Test Meter" indicates a minimum. With the "Output Coupling V2" control at approximately 10, adjust the "Output Circuit Tuning V2" control until the "Test Meter" indicates a maximum. This completes the preliminary adjustments of the second amplifier plate and output circuits. Place the "Plate Rectifier" switch in the "OFF" position and set the "RF Output" control on zero before proceeding with the neutralization of the third amplifier.

Third Radio-Frequency Amplifier Neutralization

Connect the radio-frequency rectifiers in the closed circuit by placing link D17A in position 1-3. Check that D6A and D7A are open. Adjust the tap on L10A which is associated with D17A for a number of turns above ground equal to about 15 per cent of the total active turns. Set the "Test Meter" control on "V10 Plate X20." Place the "Output Coupling 3rd Amp." control at zero and close the "Plate Rectifier" switch. Set the "Output Coupling V2" control at approximately 30 and then slowly vary the "Plate Circuit Tuning 3rd Amp." control in conjunction with the "RF Output" control until the "Test Meter" indicates a maximum. Continue by increasing the "RF Output" control to a maximum, meanwhile adjusting the "Neutralizing 3rd Amp." control to keep the "Test Meter" reading below 5 milliamperes. Check

the tuning by readjusting the "Plate Circuit Tuning V2," "Output circuit Tuning V2" and "Plate Circuit Tuning 3rd Amp." controls until the "Test Meter" indicates a maximum. Then adjust the "Neutralizing 3rd Amp." control until the "Test Meter" indicates practically zero. The adjustment of the "Plate Circuit Tuning 3rd Amp." control should be checked before the "Neutralizing 3rd Amp." control is set for a minimum deflection of the "Test Meter." When this has been accomplished the third amplifier is neutralized. Open the "Plate Rectifier" switch and place link D17A in an open position. Link D17A should be placed in the 1-2 position after the entire transmitter has been tuned and feedback is to be applied.

Third Radio-Frequency Amplifier Tuning

Place a short-circuiting strap across L31C-C32C of the D-151135 modulating amplifier. The filaments of this amplifier should be off while adjustments are being made on the oscillator-amplifier. Close links D6A and D7A and set the "RF Output" control at zero. Close the "Plate Rectifier" switch and increase the "RF Output" control until the "3rd Amp. Plate Circuit" meter indicates approximately 1.5 amperes. Check the tuning of this circuit by adjusting the "Plate Circuit Tuning 3rd Amp." control for a minimum indication on the "3rd Amp. Plate Current" meter. Then set the "Output Coupling 3rd Amp." control at approximately 10 and adjust the "Output Circuit Tuning 3rd Amp." control for a minimum indication on the "3rd Amp. Plate Circuit" meter. Adjust the "Output Coupling 3rd Amp." control in conjunction with the "RF Output" control until the "Grid Load Current" meter of the D-151135 modulating amplifier indicates 300 milliamperes and the "3rd Amp. Plate Current" meter reads between 200 and 250 milliamperes. The "3rd Amp. Plate Circuit" meter should then read $1.5 \pm .5$ ampere. If the read-

ing is low it is an indication that the inductance of the circuit associated with that meter is too high and the number of active turns should be reduced.

Final Adjustment of the Second RF Amplifier

After all circuits of the D-99110 oscillator amplifier are turned, the following final adjustments should be made to obtain vernier action with the "RF Output" control. With the "RF Output" control at 85 and the "Output Coupling V2" control at zero set the "Test Meter" switch on the "V2 Plate X100" position and place the "Plate Rectifier" switch in the "ON" position. Check the adjustment of the "Plate Circuit Tuning V2" control for a minimum plate current as indicated by the "Test Meter." Turn the "Output Coupling V2" control until a slight indication is obtained on the "Grid Load Current" meter of the D-151135 modulating amplifier and check the "Output Circuit Tuning V2" control for a maximum indication on this meter. It is important that the "Plate Circuit Tuning V2" and "Output Circuit Tuning V2" control settings are not changed when making the following adjustments. Place the "Plate Rectifier" switch in the "OFF" position. With the "RF Output" control set at 85 and the "Output Coupling V2" at 100, place the "Plate Rectifier" switch in the "ON" position. Turn the "Output Coupling V2" control counter-clockwise until the "Grid Load Current" meter of the D-151135 modulating amplifier indicates 300 milliamperes. Thereafter, the RF output should be controlled by means of the "RF Output" control.

After the entire transmitter has been tuned turn the "Output Coupling V2" control to 100 and set the "RF Output" control at 85. With all plate voltages on, turn the "Output Coupling V2" control counter-clockwise until the normal carrier output current is obtained. The adjustment of antenna or output current should thereafter be made by

means of the "RF Output" control only.

If any tendency toward parasitic oscillations exists after the above adjustments are completed, the neutralizing of the third radio-frequency amplifier should be checked. This should be done without changing any of the other radio-frequency adjustments.

Adjustment of Sliders on R61A

The sliders on R61A provide the potentials for the "RF Output" control potentiometer. With this control at 20 and all plate voltages on, the radio-frequency output should be essentially zero. Raising the upper slider on R61A will reduce the output, while lowering it will increase the output. With this slider adjusted to give essentially zero output, set the "RF Output" control at 85 and the Test Meter switch on the "V2 Grid X5" position. If the grid current is not within the specified limits of 2 to 4 milliamperes, it will be necessary to adjust the lower slider on R61A. Raising this slider increases the grid current as well as the RF Output of the transmitter. After the proper position of the lower slider has been determined, check the position of the upper slider for zero radio frequency output when the "RF Output" control is set at 20". When the proper adjustment of the sliders is obtained set the "RF Output" control at 85 and readjust the "Output Coupling V2" control until normal carrier output is obtained. The final position of the "Output Coupling V2" control should be such that turning this control counter-clockwise produces an increase in antenna or output current.

Routine tests should be made with the "RF Output" control to determine that carrier cut-off definitely takes place when this control is between the limits of 0 and 20. This should be done to assure carrier cut-off when the protective circuit of Unit D operates.

The slider adjustment on resistances R60A, R61A, R62A and R63A, with the approximate resistances and voltages which should be obtained are given in Table 4. Measurements of these resistances can be made after removing the interconnecting and ground leads from R61A and R62A.

Adjustment of Feedback and Associated Circuits

After the entire transmitter has been tuned, adjustments of the feedback circuit and associated circuits should be made. Approximately 28 db of feedback is required to obtain the desired low noise level of 60 to 65 db below 100 per cent single-frequency modulation.

To measure the feedback, remove the feedback rectifier tube V9A of the oscillator amplifier and modulate the transmitter with a single frequency of 400 cycles. The audio input level should be approximately -32 db at 100 per cent modulation. When the tube is replaced the audio input level for 100 per cent modulation should be -4 db. The difference of the two input levels, -32 db and -4 db, or 28 db is then the value of feedback.

The following procedure should be followed to obtain the above value of stable feedback. For initial tests the capacity value of condenser C37A should be 50 mmf. However, after the adjustment of the transmitter is approximately complete, and before distortion measurements are made, condenser C37A should be slightly readjusted for minimum distortion at the higher audio frequencies. The "Feedback Adj." control should be set at about 50. With the "RF Output" control set at zero, operate the "High-Voltage Rectifier" switch on the control unit. Slowly increase the transmitter output and observe the carrier on an oscilloscope. If spurious oscillation appears on the carrier, it will be necessary to adjust either one or both elements of

the series circuit, composed of R44A and C13A, until the undesired oscillation disappears. When the carrier is adjusted for normal output modulate the transmitter with a single frequency of 400 cycles, and observe the wave for different values of modulation. If a spurious oscillator appears it will be necessary to adjust one or both elements of the series circuit until the oscillation is eliminated. The setting of the "Feedback Adj." control should be increased and the above procedure followed for each setting until a total feedback of 31 or 32 db is obtained. This would represent an input level of approximately 0 db at 100 per cent, 400 cycle modulation. Observations should also be made with carrier output from zero to normal and when modulating at different levels with an audio frequency of 50 cycles. The final value of R44A should not be less than 500 ohms when all adjustments are completed. When the tests indicate no spurious oscillations for this value of feedback the "Feedback Adj." control should be reduced until the input level for 100 per cent, 400-cycle modulation is -4 db or the value of feedback is 28 db. This gives an operating margin of 3 to 4 db.

Whenever major adjustments of the radio-frequency circuits of the transmitter are to be made, the feedback should be removed by opening link D17A. For minor radio-frequency adjustments the feedback can be eliminated either by removing tube V9A or reducing the setting of the "Feedback Adj." control to zero.

Audio Monitoring Rectifier

A radio-frequency rectifier tube V10A and its associated circuit furnish a source of audio monitoring output from the transmitter. A 500 ohm termination should always be provided for the output of T11A. This can be either in the form of a resistor or a matching transformer. The output level with

single-frequency 100 per cent modulation is approximately +10 db.

The direct-current component of this rectifier is used to operate relay S8A, which in turn closes the audio input circuit when the carrier output is normal. Reducing the carrier to zero either manually or by the protective circuits that are provided removes all the feedback voltage. If the audio input were not removed under these conditions the audio system would be overloaded by an amount equal to the normal value of feedback.

D-151135 Modulating Amplifier

(Unit C, Schematic Figure 8)

CAUTION: See Caution Note on page 28 regarding C37C.

Circuit Description

The modulating amplifier employs two tubes V1C and V2C connected in parallel, driven by the radio-frequency output of V3A in the oscillator-amplifier unit, and grid-bias modulated by tubes V4A and V5A in that unit. V1C and V2C are neutralized by the series circuit L5C-C5C. The radio-frequency input is applied across R32C and indicated by M4C. The audio modulating voltage is applied through the audio plate blocking condenser C37C, across R5C, through which negative grid bias is supplied to the unit. R5C is bypassed for the carrier frequency and DC grid current by the series tuned circuit L31C-C32C and the circuit R31C-L32C respectively. By-pass condensers C7C and C8C are protected against excessive voltages by thyrite protector PR1C, while gap G30C protects the other equipment in the grid circuit. The cathode resistors R33C and R34C, used to secure local feedback, are protected by gaps G1C and G31C. Switch D31C permits the use of a cathode-ray oscilloscope connected at jack J1C for tuning the series circuit across R31C. Link

switch D30C, which for safety is interlocked with the control circuit, permits checking of neutralization by connecting a cathode-ray tube at jack J2C.

C6C and C31C are the output tuning condensers for the amplifier, while L30C couples the output to the grid circuit of the D-99118 power amplifier. C3.1C, C3.2C, C4.1C, C4.2C, C35C and C36C are radio-frequency filament by-pass condensers. R1C-L1C and R2C-L2C are anti-sing assemblies for the plate circuits of the tubes. L4C is the plate choke coil and R30C the plate current limiting resistor. C38C is the plate blocking condenser. R3C and R4C are shunts for the individual tube overload relays. M1C and M2C read the plate currents of the individual tubes, and the voltmeter M3C is switched by K1C to read the filament voltage of either tube. T1C and T2C are the filament transformers the voltage to which is controlled by the regulator transformers T3C and T4C. These are in turn fed from two phases of the transformer T5C.

The circuit components C39C, L33C, L34C, M5C, S3C, S4C, D6C, R35C and PR2C are associated with the use of this unit as the output amplifier for 5-kw emergency operation. C39C and L33C form an impedance-matching network between the output of the unit and the transmission line. L34C is a reactance to facilitate adjusting the feedback to Unit A. M5C is a transmission line thermoammeter for 5-kw operation. Contactors S3C and S4C serve to arrange the connections between the output of Unit C and the input of Units D and E, for either normal or emergency operation. Switch D6C transfers the plate voltage connection between the output of rectifier unit H (for 50-kw) and unit G (for 5-kw). R35C is the multiplier for plate voltmeter M7F, and PR2C is the voltmeter protector.

NOTE: Units C, D and E should be completely adjusted for 50-kw operation before adjustments for 5-kw emergency operation are attempted, and accordingly D6G (control transfer switch) should be in the 50-kw position, D2H (50-kw Rect. Fil. Switch) closed, and D5G (5-kw Rect. Fil. Switch) open.

Adjustment of Input Circuit

The only adjustment necessary in the grid circuit of this stage consists in tuning circuit L31C-C32C to series resonance at the carrier frequency. The short-circuiting strap used in tuning the D-99110 Oscillator Amplifier Unit having been removed from this circuit, a cathode-ray tube is connected by means of jack J1C "RF By-Pass Tuning," with switch D31C closed, and excitation is applied from the oscillator amplifier unit. C32C "RF By-Pass Tuning" is then adjusted to minimum deflection on the cathode-ray tube. If a minimum is not obtained within the range of C32C, new taps are chosen on L31C until the required minimum is obtained. Switch D31C is then opened.

After this adjustment has been made, the tuning of the oscillator-amplifier should be found to be the same as when L31C-C32C was short-circuited.

Neutralization

The modulating amplifier is neutralized by applying excitation with switch D30C in the test position and with a cathode-ray tube connected at jack J2C "Neutralizing." C5C "Neutralizing" is adjusted for minimum deflection on the cathode-ray tube. This minimum should be obtained at between half and full scale setting of C5C. A tap on L5C should be chosen that will give this result.

In adjusting L5C, if there are more than five or six unused turns they should be shorted to avoid the building up of excessive voltages.

When neutralization is completed a readjustment of condenser C31A "Output Circuit Tuning 3rd Amp." may be required because of the change in input capacity of the modulating amplifier.

Output Circuit Tuning

In adjusting the output circuit a preliminary tap is chosen on L30C to give an estimated inductance that will tune a capacity of 375 mmf. at the carrier frequency. It is preferable to leave most of the overhanging turns at the ground end rather than at the high-potential end.

In choosing the number of turns a simple inductance formula may be used, such as the following:

$$\underline{L} = \frac{\underline{a}^2 \underline{N}^2}{9\underline{a} + 10\underline{b}} \text{ microhenries}$$

where N is the number of turns and a and b are respectively the radius and length of the coil in inches.

The connection to the coil from terminal 63 is then made at a point approximately one-third of the way up from the ground connection of the coil.

Until the grid circuit of the 50-kilowatt stage has been tuned, it will be sufficient at this point to apply plate voltage and excitation to the modulating amplifier, with disconnecting switch D58P left open to prevent the application of plate voltage to the final stage and with switch D3D closed to disable the radio-frequency protective circuit. The modulating amplifier is tuned to minimum plate current by means of condenser C6C "Plate Circuit Tuning." With sufficient excitation on the modulating amplifier to give a minimum plate current of approximately 0.3 ampere per tube there should be a readable indication on the grid load current meters of the final stage.

D-99118 Power Amplifier Unit
(Units D and E, Schematic Figure 9)

Circuit Description

This power amplifier employs two tubes, V1E and V2D, connected in a high-efficiency circuit, driven by the output of the D-151135 modulating amplifier and connected to the antenna system by a coaxial transmission line.

The radio-frequency input is applied directly to the grid of V2D but reaches the grid of V1E through the phase-shifting condenser C15E, with its associated trimmer C13D. C6D and C6E are grid blocking condensers. The currents in grid load resistors R1D and R1E are indicated by ammeters M4D and M4E. The grid phase-shifting circuit is completed by coil L3E and by condenser C12E with its associated trimmer C14E. The sampling circuits L5D-C3D and L5E-C5E permit checking the phases of the grid voltages on the tubes by connecting a cathode-ray oscilloscope at jacks J2D and J2E.

Coils L12D and L9E neutralize tubes V2D and V1E by anti-resonating their internal capacities. L12D and L9E are designed for the station's carrier frequency and no adjustment is required.

The tuned output circuit of V1E consists of coil L1E and variable condenser C1E. The sampling circuit L4E-C13E permits checking the phase of the output voltage of V1E at jack J1E. The output circuit of V1E is coupled to that of V2D by means of coil L2D, which also serves to carry the d-c plate current from V2D to V1E.

The tuned output circuit of V2D consists principally of variable condenser C1D (to which is added a fixed condenser C5D at certain carrier frequencies) and the transmission-line coupling coil L1D. The sampling circuit L7D-C4D permits checking the phase of the output voltage of

V2D at jack J1D. Coil L8D and resistance R6D provide a small part of the output of the amplifier at terminals 61 and 62 to be used for stabilized feedback.

Between the transmission-line coupling coil L1D and the line there is connected a radio-frequency harmonic filter consisting of coil L2E and condensers C2.1E, C2.2E, C3.1E, C3.2E, C4.1E, and C4.2E. Additional harmonic suppression is afforded by an auxiliary transmission line connected across the input terminals of the main line. The current fed into the main transmission line is indicated on M2E.

Connected respectively to the radio-frequency input bus and to a tap on L7D are two coils L10D and L11D, associated with a protective device which also serves as an overall tuning indicator for the amplifier. The other elements in this protective device are the rectifier tube V1D, with its filament transformer T4D and filament by-pass condensers C12.1D and C12.2D; the shunting resistance R8D for this tube, with a disabling switch D3D; a relay S3D; and a d-c milliammeter M1D for reading the rectified output of V1D.

The high-voltage plate supply is fed to the power amplifier through plate choke coil L4D. The two grid-bias supplies are fed to the tubes through grid chokes L3D and L8E, the higher bias being employed for V2D. The grid-bias voltage for V2D is filtered by C8D through a stabilizing resistor R9D. C8D is protected against abnormal voltages by thyrite protector PR1D. The corresponding grid-circuit equipment for V1E consists of C8E, R9E, and PR1E.

The plate currents of the individual tubes are indicated on M3D and M1E and the total plate current on M2D. These meters are equipped with shunts R4D, R4E, and R5D. The Overload relays S1D and S1E are likewise equipped with shunts, designated R3D and R3E.

An anti-sing assembly consisting of R2D-L9D is connected in the plate lead of V2D. A similar circuit consisting of R2E-L7E is connected in the plate lead of V1E.

Plate blocking condensers C7D are used for V2D, and blocking condensers C7E for V1E. C9D and C9E are filament by-pass condensers.

The antenna current is indicated by ammeter M3E which operates in parallel with ammeter M7A from the thermocouple TC3A, and which is provided with a calibrating resistor R6E.

The individual filament voltages on the tubes are indicated by M7D and M7E.

Circuit Adjustment

Preliminary

Antenna Coupling Equipment

The output of the 407A-4 Equipment is usually fed to one or more tower radiators through concentric transmission lines and suitable coupling circuits. The coupling equipment and its arrangement are specified individually for each installation, and are not described herein. However, the antenna installation should be complete and the coupling equipment adjusted prior to adjustment of the output stage of the transmitter, so as to provide a suitable load for the latter.

Harmonic Suppression Line

The harmonic shunt line supplied with this equipment should have an electrical length of exactly one quarter wave, with its inner and outer conductors connected together at the far end. When its length is correctly adjusted, it will have no appreciable effect at the fundamental frequency, but will be practically a short circuit on the transmitter output for all even harmonics.

Experience has shown that for a given frequency the

wavelength in a coaxial line of the type supplied is about 0.98 of the nominal wavelength in space; accordingly, if harmonic radiation is not unusually severe, sufficient suppression may be obtained by carefully measuring and cutting the shunt line to a length of 0.245 times the operating wavelength.

If, however, it is necessary to obtain the maximum suppression, proceed as follows:

1. To the station end of the main transmission line connect the output of a radio-frequency oscillator adjusted exactly to the second harmonic of the station frequency. This exact adjustment may be made by beating the oscillator output against that of the oscillator amplifier unit of the transmitter.
2. At the antenna-coupling unit, connect to the main line a radio receiver equipped with an output meter.
3. At the far end of the shunt line vary the short-circuit point until the receiver meter indicates a null. (For this purpose a piece of flexible bronze or brass bent in a U shape and attached to the end of a dry stick will provide a convenient means for changing the short-circuit point within the line.
4. Cut off and cap the line at this indicated point.

Tuning of Output Circuit

Adjustment of harmonic Filter

The first step in tuning the output circuit of the D-99118 power amplifier is the adjustment of the radio-frequency harmonic filter. The condensers in the harmonic filter are supplied to correspond to the station's frequency, and the only adjustment to be made is that of coil L2E. When this coil is properly adjusted it will anti-resonate with condensers C4E at the third harmonic of the carrier fre-

quency and give a high degree of suppression at this harmonic.

L2E is adjusted by measuring the input impedance of the harmonic filter at the carrier frequency when the filter is terminated in a non-inductive resistance of 62.5 ohms. In making this measurement the filter is disconnected from the transmission lines at one end and from L1D at the other. The measurement may be made with a radio-frequency bridge arranged for measuring either series or parallel components of grounded impedances. L2E should be adjusted to give a series or parallel input resistance to the filter of 75 to 80 ohms. The reactive component should be found to be not more than 10 per cent.

When this adjustment has been completed, the filter should be reconnected to the transmission lines and to L1D.

Adjustment of Load Impedances

This consists in finding the proper tap on coil L1D to give the desired load impedance, approximately 600 ohms, for the combined output of both tubes, and then the proper tap on coil L2D to give the desired load impedance, approximately 2800 ohms, for tube V1E when this tube is supplying the smaller instantaneous outputs without assistance from tube V2D.

The adjustment of load impedances should be carried out with the water system filled so that the resistances of the water columns will be included in the measurements. Choose a preliminary setting for coils L2D and L1E to give an estimated reactance of 1200 ohms for each at the carrier frequency, and a preliminary setting for coil L1D to give an estimated reactance of 200 ohms at the carrier frequency. In choosing the number of turns a simple inductance formula may be used, such as that given under "Modulating Amplifier - Output Circuit Tuning."

By means of a radio-frequency bridge, arranged to measure parallel components of grounded impedances, and with terminal 55 of unit E grounded, measure the parallel resistance between the tube socket of V2D and ground at the carrier frequency. This parallel resistance is controlled entirely by the reactance of L1D. L1D should be adjusted to give a value for this resistance of 600 ± 20 ohms. Condenser C1D "Plate Circuit Tuning V2" should then be adjusted until the parallel reactance at this point is infinite, i.e., until the the impedance is purely resistive. The parallel resistance will not change when C1D is varied.

Next remove the ground from terminal 55 of Unit E and connect the bridge to measure the parallel impedance between the socket of V1E and ground. The parallel resistance at this point is controlled entirely by the reactance of coil L2D, and L2D should be adjusted to give a value of 2800 ± 50 ohms for this resistance. Then adjust condenser C1E "Plate Circuit Tuning V1" until the parallel reactance is infinite, i.e., until the impedance is purely resistive. The tap on L1E may be changed, if necessary, to bring C1E on scale. Adjustment of C1E and L1E has no effect upon the parallel resistance. It is desirable to arrive at a setting for C1E between 10 and 20 divisions on the scale.

Tuning of Grid Circuit

The grid load resistor R1E should be set for 308 ohms, and the grid load resistor R1D should be set for approximately 1000 ohms.

The tuning of the grid circuit consists in adjusting the inductance L3E, with its associated trimmer capacity C14E, to obtain a 90-degree phase difference between the potentials on the grids of V1E and V2D. This phase relation will be obtained when the total shunt susceptance

across the grid of V1E has a positive value equal to the negative susceptance of the inter-grid coupling condenser C15E and its associated trimmer capacity C13D.

To obtain this relation, choose arbitrary taps on L3E and on the sampling coils L5D and L5E, and apply excitation to the final stage with plate voltage still removed from this stage by means of disconnect switch D58P, and with switch D3D still closed to disable the radio-frequency protective circuit. With the "Inter-Grid Coupling" control set at mid-scale, observe the phase relation of the two grid voltages on a cathode-ray oscilloscope whose two pairs of plates are connected respectively to the "V1 Grid" and "V2 Grid" jacks. A 90-degree relation is indicated by an elliptical pattern with the axes of the ellipse horizontal and vertical. The phase may be varied by adjusting the "Grid Circuit Tuning" control, which varies C14E. If a 90-degree relation is not obtained at any setting of C14E, a new tap on L3E is required. If the best tuning is obtained at a minimum capacity of C14E, the inductance of L3E should be reduced; if maximum capacity gives the best tuning, the inductance of L3E should be increased.

Inspection of the cathode-ray pattern is ordinarily facilitated if the taps on the sampling coils are so chosen that the vertical deflection is somewhat greater than the horizontal deflection.

With the grid-circuit tuning completed, condenser C6C "Plate-Circuit Tuning" on the modulating amplifier should be readjusted to give minimum plate current in that stage.

The power amplifier is now ready for final tuning adjustments.

Final Tuning of D-99118 Power Amplifier

Close switch D58P so that plate voltage may be applied

to the final stage. Place the entire transmitter in operation. After a warming-up period at minimum plate voltage, raise the plate voltage to 16,000 or 18,000 volts and apply excitation until the "Plate Current V1" meter reads about 2 amperes. Check the 90-degree grid-circuit relation, making a readjustment if necessary. Next observe the phase relation of the plate potentials of the two tubes, using the "V1 Plate" and "V2 Plate" jacks. Adjust condenser C1D by means of the "Plate Circuit Tuning V2" control for a 90-degree phase difference. This is the only control which affects the relative phases of the plate potentials. Check the adjustment of the "Plate Circuit Tuning" control on the modulating amplifier. A new setting of this control may be necessary with the Power Amplifier in operation.

Condenser C1E is next tuned by means of the "Plate Circuit Tuning V1" control until a cathode ray oscilloscope connected to the "V1 Grid" and "V1 Plate" jacks shows a straight line pattern, indicating a pure phase reversal in the tube.

With the two grid potentials 90 degrees apart and the two plate potentials 90 degrees apart, and with a pure phase reversal in V1E, the grid and plate potentials of V2D should now obviously be 180 degrees apart. This may be checked with the cathode-ray oscillograph using the "V2 Grid" and "V2 Plate" jacks.

Next increase the excitation until, with 18,000 volts plate potential, the output of the transmitter is the required 50 kilowatts, as indicated by meter M2E "Transmission-Line Current."

At the 50-kilowatt output check the phase adjustments and observe the plate currents of the tubes. The plate current of V2D should be between 0.5 and 0.8 ampere and the

total plate current should be between 4.55 and 4.7 amperes. The plate current of V2D may be increased or decreased by changing the setting of the "Inter-Grid Coupling" control. This requires a slight readjustment of the "Grid-Circuit Tuning" control to maintain the 90-degree phase relation.

If the plate current of V2D at 50 kilowatts output cannot be made high enough by adjustment of the "Inter-Grid Coupling" control, lowering the grid load resistance R1E by short-circuiting some of the resistance cards will have the same effect. This resistance should not be reduced to lower than 280 ohms.

It is also possible to adjust the distribution of load between the tubes at the carrier output by varying the bias supply voltage to one tube or the other by means of the taps on the bias rectifier transformers. It is usually found, however that best results are obtained with the specified biases of approximately 485 and 1200 volts.

With the required carrier output, observe the plate current of the modulating amplifier. This should be between 0.5 and 0.8 ampere total for the two tubes. It may be adjusted to within these limits by changing the number of turns on L30C at the high-potential end, or by changing the position of the tap which connects terminal 63 to this coil. For each new adjustment on L30C, condenser C6C should be adjusted to minimum plate current.

Place link D17A of the oscillator-amplifier in the 1-2 position and observe the feedback current as indicated on the "V9 Plate" setting of the test meter in the oscillator amplifier Unit. The taps on the feedback coil L8D should be adjusted to give a feedback current, at the full carrier output, of 8 ± 1 milliamperes.

Adjustment of Radio-Frequency Protective Circuit

The adjustment of this circuit consists in choosing

proper taps on coils L10D and L11D to obtain a null indication on meter M1D "Protective Circuit" when the power amplifier is tuned.

Open switch D3D. Choose arbitrary taps on L10D and L11D. On L7D, having chosen a tap for the cathode ray inspection circuit giving a suitable voltage at jack J1D "V2 Plate," connect the tap for L11D at a point about one-fifth of the way up from this first tap toward the high-potential end of L7D. Place the entire transmitter in operation. At the full carrier output check the phase relations with the cathode-ray oscilloscope. Observe the reading of M1D "Protective Circuit" and note the change in this reading as condenser C1D "Plate Circuit Tuning V2" is adjusted above and below the tuning point determined from the oscillograph. At a reading of between 7 and 10 milliamperes the protective circuit should operate to remove and reapply the excitation at intervals, provided switch D12F "Protective Circuit" on the control unit is in the "ON" position. Note the minimum reading obtained on M1D. Remove plate voltage and bias and choose a new tap on either L10D or L11D and repeat the above observations. The taps eventually chosen should give a minimum reading on M1D of not more than 2 milliamperes at 50 kilowatts output, and the setting of C1D for this minimum should be in close agreement with the cathode-ray indication. If the taps do not come out nearly the same on the two coils, a new tap on L7D should be used to make them more nearly alike.

Later, when modulation is applied, M1D should be observed again. If, with modulation applied, the reading should increase to a value likely to cause undesired operation of the protective circuits, the sensitivity of the device may be reduced by using more of the turns on L10D and L11D, keeping the ratio approximately unchanged.

Modulating the Transmitter

With the final stage adjusted to the proper operating conditions at the unmodulated carrier output, it is necessary next to observe the operation with modulation applied.

For ideal distortionless operation with no carrier shift the antenna current should rise 22.5 per cent at 100 per cent modulation. In transmitters not employing negative feedback, a failure of the antenna current to rise to this extent ordinarily indicates distortion in the modulated wave. With the distortion removed by feedback, the only result of such "carrier shift" is a slight decrease in transmitted signal; for example, if the antenna current rises only 19 per cent, the loss in transmitted signal with a distortionless wave is only 0.25 db. The tendency for carrier shift to occur depends on local conditions, such as instantaneous line regulation, as well as on the adjustment of the transmitter.

This equipment is designed to permit 100 per cent modulation with no carrier shift, provided the line-voltage regulation is such that the plate voltage on the power amplifier does not change more than 2 per cent between the modulated and unmodulated condition. It is left to the judgement of the operator, however, whether the circuits should be adjusted for zero carrier shift or whether a small amount of carrier shift (downward) should be tolerated for the purpose of increasing tube life through a reduction in filament voltage.

The adjustment for the desired antenna current rise involves adjustment of filament voltages on water-cooled tubes and proper setting of the coupling circuit between the modulating amplifier and power amplifier, which determines the load impedance for the former. A lower load impedance (i.e., a higher plate current) on the modulating amplifier increases the antenna current rise, provided the filament

emission of the tubes in the power amplifier is sufficient to furnish the increased peak power.

To facilitate the modulating adjustment, the operator should calculate in advance what his antenna current or transmission-line current is to be at complete modulation, in accordance with the rise he wishes to obtain with respect to the carrier current.

Adjust the "Feedback Adjustment" control on the oscillator-amplifier to about one-fifth full scale. With the filament voltages adjusted to 27 volts on the power amplifier and 18 volts on the modulating amplifier, and with 50 kilowatts carrier output from the transmitter, apply to the audio input terminals the output of a 400-cycle oscillator of good wave form. The modulated output wave of the transmitter may be observed by means of a cathode-ray oscillograph connected at jack J1D "V2 Plate." Increase the audio input until on the downward swing of modulation the radio-frequency amplitude comes just to zero. Inspect the wave form to make certain that there is no singing at any part of the wave. If the antenna current rise is not as great as is desired with 27 volts on the filaments, the load impedance to the modulating amplifier should be lowered by changing the tap at the high-potential end of L30C or by changing the position of the tap connecting terminal 63 to this coil. For each tap setting the tuning condenser C5C "Plate Circuit Tuning" should be adjusted for minimum plate current on the modulating amplifier. The total plate current of the modulating amplifier should not be increased to more than 0.8 ampere at the carrier output.

To reduce the antenna-current rise, the filament voltages on the power-amplifier tubes should be reduced alternately in 0.5-volt steps until a further reduction for either tube would bring the antenna-current rise below the

desired value by approximately the same amount.

By the above process the proper filament voltage settings are found for maximum tube life at the required peak power output of the transmitter. This is a procedure which should be repeated monthly so that as the tubes age the filament voltage may be kept just sufficiently high to supply the required emission. A monthly test should also be made on the modulating amplifier tubes by measuring the antenna-current rise of the transmitter with these tubes operated both at 18 volts and at a higher voltage. These tubes should be operated at a voltage such that an increase of 0.5 volt would cause no appreciable change in the antenna-current rise.

Adjustments for 5-kw Emergency Output

After all adjustments for 50-kw operation have been satisfactorily completed and all readings and settings logged, proceed with the adjustment of Unit C for reduced power operation as follows:

Open the main circuit breaker CB51P. Latch contactor S3E in the 5-kw position by hand. With a radio-frequency bridge, arranged to measure the series components of an unknown impedance, connected from the bus between L33C and S4C (23 on Fig. 5) to ground, adjust L33C until the bridge indicates a series resistance component of 65-100 ohms with a negative reactance of 85-120 ohms. Remove the bridge.

Disconnect the transmission line from terminal 68 of Unit C, and by means of the bridge measure and record the characteristic impedance of the line at that point. Then remove the bridge and restore the line connection.

Place control-transfer switch D6G in the 5-kw position, close switch D5G, operate D6C to the 5-kw position, and remove tube V9A from its socket. Place the clip lead (24 on Fig. 5) about two turns nearer the ground end of L30C than

the 50-kw clip (21 on Fig. 5). Start up the transmitter in the normal manner with the RF Output Control in the minimum position. Increase the setting of this control until there is an indication of plate current on meters M1C and M2C, and adjust condenser C6C for a minimum indication of M1C and M2C. Then increase the RF output control setting until meter M5C indicates a 5-kw output based on the transmission-line impedance, measured as indicated above. The total plate current, as indicated by the sum of meters M1C and M2C should be 1.25 amperes \pm 0.1 ampere (approx. 0.625 ampere per tube). If the total plate current exceeds the above limits the clip lead (24) should be moved to include less turns between the clip and the ground end of the coil, and the amplifier again tuned for minimum plate current by means of C6C. If, however, the total plate current is less than the limits the clip should be moved to include more turns.

After the proper plate current has been obtained the bias voltage should be adjusted by changing the tap on R5G until the 5-kw output, as indicated by meter M5C, is obtained with the "RF Output Control" at the same position as for 50-kw operation. This will insure the cutback to 5-kw without the necessity of readjusting the "RF Output Control." The setting of C6C for 5-kw output should be approximately the same as previously determined for 50-kw operation.

The feedback should now be adjusted for the 5-kw condition. Replace vacuum tube V9A in its socket and adjust the number of active turns of L34C until with 5-kw output, the feedback current, as indicated by the "Test Meter", with the test meter switch in the "V9A Plate x 20" position, is the same as obtained for 50-kw operation. This completes the adjustment for 5-kw operation.

STARTING THE TRANSMITTER

Preliminary

To start the transmitter, all the manual circuit breakers in the Power Distribution Unit except the emergency plate breaker CB73P should be thrown to "ON". Check the voltage of the three phases of the power supply by means of the "Power Supply" meter (M1F) and "Line Voltmeter" switch (D6F). Each phase should be approximately 460 volts. Throw the "A-C Control Circuit" switch (D53F) and the "D-C Control Circuit" switch to "ON". All meter lamps should light. The green lamps above the switches "Oscillator Amplifier Filaments" (D10F), "Water System" (D2F) and "Rectifier Filaments" (D1F) should also light.

Switches D6C, D5G, and D6G should be in the 50-kw positions. D21H should be closed. Full-reduced power contactors S3C, S3G, S3E, and S63P should now be in the operated position.

Rectifier Filaments

In order to allow proper preheating of the rectifier tubes the filaments should be energized before the rest of the equipment. Throw the switch "Rectifier Filaments" (D1F) to "ON". The red light above this switch should light. Check the voltage of the three phases of the regulated supply by means of the "Line Voltmeter" switch (D6F). Keep the switch D5H in the "ON" position so that the blower (MB1H) may start when the filaments are energized. Relay S8H operates and lights "Rectifier Filaments" lamp (E5F). Delay relays S2F and S16F are energized. After about 20 seconds S16F operates, and after three minutes S2F operates followed by S3F and S4F, lighting the "Rectifier Filament Delay" lamp (E10F). With the "Oscillator-Amplifier Control" switch (D11F) in the "Operate" position, all gates closed, and the

high-voltage grounding switch open, all the gate lamps will light and the bias contactor S56P will operate, energizing the bias rectifiers (Unit K) and lighting the "Mod. Amp. Bias" lamp (E21F) and "Power Amp. Bias" lamp (E22F). The bias voltmeters (M2F, M3F and M4F) should indicate the proper bias voltages.

Oscillator-Amplifier Filaments

The oscillator-amplifier filaments may be energized at any time but preferably should be started a few minutes before the rectifier filaments have been completely preheated. Throw the "Osc. Amp. Filaments" switch (D10F) to "ON" operating contactor S54P. Keep all switches in the oscillator-amplifier itself in the "ON" position.

Water System

Keep the safety disconnect switches D3.1W and D3.2W closed except when servicing the associated cooler. Close the switch D4.1W or D4.2W depending on the particular cooler it is desired to operate. Press the push button on line starter D1.1W or D1.2W, depending on the pump it is desired to have operate, to the "ON" position. Set the valves of the water system as instructed in the section covering this system; then place the system in operation by closing the switch "Water System" (D2F) to "ON". S51P operates, starting the cooler motor and operating the line starter which starts a pump.

When the proper water flow is obtained the flow relays WD1W and WD2W and relays S2W and S1F operate. Lamp E8F "Water System" lights and the green lamp above the switch "Amplifier Filaments" (D3F) lights indicating the filaments may be energized. In cold weather the cooler motor may be started by D4W after the amplifier filaments are energized as described in the section covering the "Water System".

Amplifier Filaments

Close the switch "Amplifier Filaments" (D3F) which energizes S53P supplying power to the modulating amplifier filaments, and S58P supplying power to the amplifier filaments through the starting resistors R51-53P. After a delay of a few seconds S63P operates, energizing S59P which shorts R51-53P and applies full voltage to the filaments.

High-Voltage Control

At the same time that the bias rectifiers are energized, the control circuit is complete to the high-voltage control of the oscillator-amplifier unit. With the switch "Plate Rectifier" (D4A) in the "ON" position, the green lamp above the switch "Oscillator-Amplifier Plate Voltage" (D5F) lights. Throw this switch to "ON" operating S3A and energizing the plate rectifier of the oscillator-amplifier unit.

As soon as all amplifier filaments and bias rectifiers have been energized and if link switch D30C is in the D30.1C position, the control circuit of the high-voltage rectifier for the power amplifier is completed and the green light above the switch "High-Voltage Rectifier" (D4F) lights.

With the switch "Plate-Voltage Regulator" (D8F) and the "Automatic-Manual" switch on the regulator (T56P) both closed to "Automatic" the green light "Plate-Voltage Regulator-Minimum" (E28F) lights.

Close the switch "High-Voltage Rectifier" (D4F) energizing the closing circuit for the plate circuit breaker. The lamp "H.V. Rect. Circuit Breaker - Open" (E26F) lights. As soon as the breaker is closed the lamp is extinguished and the lamp "Closed" (E27F) lights. The rectifier is energized and the meter "Power Amp. Plate" (M7F) should read about 14 kv. The plate regulator immediately starts increasing the voltage to 18-kv and then holds it at that value. The "Lamp Reset" (K3F) should be pushed to light

the overload lamps.

5-kw Emergency Operation

The cut-back to 5-kw is effected as follows:

- (1) Open "H.V. Rectifier" switch D4F. This opens plate circuit breaker CB65P, removing the 460 volt supply from Unit H, and taking the transmitter off the air.
- (2) Close the 50-kw rectifier grounding switch D1H. This removes the 460 volt supply from Unit K, and grounds the high voltage circuits of Unit H. Enter the 50-kw enclosure.
- (3) Close the 5-kw rectifier grounding switch D1G (if open). This grounds the high-voltage circuits of Unit G. Enter the 5-kw enclosure.
- (4) Operate the following switches, the complete functions of which are repeated below:
 - (a) D5G, a DPST switch located in the 5-kw enclosure, which when closed applies full voltage to the filaments of the 5-kw rectifier. These filaments are heated at half voltage at all times during 50-kw operation.
 - (b) D6G, a 4PDT switch located in the 5-kw enclosure which sets up the control circuits for either 50-kw or 5-kw operation. Operation of this switch energizes one or the other of each of several pairs of contactors which complete the control, power-supply, bias, and radio-frequency circuits as required for either operating condition.

These contactors and their functions are as follows:

<u>50-kw</u>	<u>5-kw</u>	<u>Function</u>
S3E Left	S3E Right	To transfer transmission line between 50- and 5-kw outputs and to ground unused circuits.
S3C	S4C	To transfer output of unit C between input to units D and E, and input to harmonic suppression network of unit C, and to ground unused circuit.
S3G	S4G	To transfer bias connection to unit C between unit K and Unit G.
S56P	S55P	To transfer control circuit connections; also to transfer 460-volt supply between bias rectifiers, units K and G.
S63P	S64P	To transfer control circuit connections; also to transfer 460-volt regulated supply between 50-kw and 5-kw high-voltage transformers.

(c) D6C, a SPDT switch located in Unit C which connects the plate circuit of this unit to either the 50-kw filter condenser assembly (FC50P) or the 5-kw assembly (FC51P).

- (5) Leave the 5-kw enclosure, close door, and open the 5-kw rectifier grounding switch.
- (6) Close "H.V. Rectifier" switch D4F.

This places the transmitter back on the air at 5-kw, without further adjustment. If desired, operations (1) and (6) above may be omitted, since if switch D4F is left closed, operation of the grounding switches will serve to remove and restore the carrier.

After the above procedure the filaments of units D, E, H and K, and the motor blower in Unit H, are still "ON". The 460-volt supply to the two rectifiers may be cut off by

opening switch D21H and the 460-volt supply to the amplifier units by opening circuit breaker CB64P in the Distribution Cabinet. During 5-kw operation there are no voltages within the accessible enclosure exceeding the line voltage (460 volts 3-phase a-c), accidental contact with which is prevented by barriers. The power-distribution cabinet DP50P, voltage regulators T56P and T57P, and the water cooling system function the same as for 50-kw operation.

SWITCH FUNCTIONS

Oscillator-Amplifier

- D1A - "Oscillator Heater" - Disconnect switch in power supply to the oscillator heaters. Leave in "ON" position.
- D2A - "Power-Supply Circuit Breaker" - Circuit breaker in power supply to oscillator-amplifier. Leave in "ON" position except when working in this unit.
- D3A - "Power" - Disconnect switch to turn oscillator-amplifier "ON" and "OFF". Leave in "ON" position.
- D4A - "Plate Rectifier" - Controls high-voltage rectifier in oscillator-amplifier unit. Leave in "ON" position and control this rectifier from D5F in control unit.
- D5A - "Oscillator" - This switch selects either of the oscillators provided in the unit.
- D6A - Link Switch in d-c plate supply of 3rd RF. amplifier. Leave closed except when neutralizing this stage.
- D7A - Link switch to remove plate voltage on 2nd audio stage. Mechanically coupled to D6A.
- D9A - Gate switches.

- D10A - "Test Meter" - Connects the test meter M2A to the various circuits in this unit.
- D13A - Link switch for adding capacity to neutralizing condenser C15A. Leave open.
- D15A) - Link switches to connect thermocouple TC2A in D16A) circuit. Leave thermocouple out of circuit except when tuning.
- D17A - Link Switch - Close to position 3 to neutralize 3rd RF. amplifier. Close to position 4 to tune modulating and power amplifier. Close to position 2 to adjust feedback and monitor rectifiers. Leave in position 2.

Modulating Amplifier

- D1C - "Door Release" - Momentary push button to operate electric door latches. Energizes the latches only if both rectifier switches D1G and D1H have been operated to ground the high voltage.
- D2C
to - Gate Switches
- D5C
- D6C - 50 - 5-kw plate Supply Transfer Switch
- D30C - Link Switch - Put in D30.2C position to neutralize this stage. To operate leave in D30.1C.
- D31.1C) - Link Switch - Close to tune series circuit L31-
- D31.2C) C32C. Leave in open position.
- K1C - "Filament Voltage" - Switches M3C to filament of either tube. Leave in either position.

Power-Amplifier

- D1D) - Gate Switches - deenergizes bias and high voltage rectifiers.
- D1E) age rectifiers.
- D2D) - Door Release - Momentary push button to operate
- D2E) electric door latches. Energizes the latches

only if the rectifier switch DLH has been operated to ground the high voltage.

D3D - Disabling switch for protective circuit. Leave open unless trouble is experienced with this circuit.

Control Unit

- D1F - "Rectifier-Filaments" - Operates contactor to energize bias and high-voltage rectifier filaments. Energizes rectifier filament delay relays, the gate switch chain and bias rectifiers. Put in "ON" position to start and operate transmitter.
- D2F - "Water System" - Operates contactor to start cooler motor and line starter to start pump. Put in "ON" position to start and operate transmitter.
- D3F - "Amplifier Filaments" - Operates contactors to energize tube filaments of modulating and power amplifiers. The operation of this switch is effective only if the water system is operating properly. Put in "ON" position after D2F.
- D4F - "H.V. Rectifier" - Close to operate circuit breaker to energize the high voltage rectifier. This control is dependent upon the water system, amplifier filaments, and bias rectifiers, door switches, etc.
- D5F - "Osc. Amp. Plate Voltage" - With D4A closed this switch is used to apply and remove plate voltage in the oscillator-amplifier unit.
- D6F - "Power-Supply Voltmeter" - Connects M1F to any phase of regulated or unregulated power supply.
- D8F - "Plate-Voltage Regulator" - Transfers the con-

trol of the plate regulator from fully automatic to manual control by means of push buttons K6F and K7E. Leave in "Automatic" position.

- D10F - "Osc. Amp. Filaments" - This switch operates a contactor to supply power to the oscillator-amplifier. Throw to "ON" position to start and operate transmitter.
- D11F - "Osc. Amp. Control" - In the test position this switch permits operation of the oscillator-amplifier unit alone. The bias rectifiers for the modulating amplifier and power amplifier are de-energized. In the operate position, the gate switches and plate control of the oscillator-amplifier are tied in to the control circuit of the rest of the transmitter. Leave in the "Operate" position.
- D12F - "Protective Circuit" - This switch removes the control power from the protective circuit. Leave in "ON" position, except for tuning of power amplifier.
- K1F - "Rect. Fil. Delay Release" - A momentary-contact push button to lock up S4F without waiting for operation of delay relays. May be operated in an emergency after a power interruption when the operator may prefer to risk a shortening of the life of rectifier tubes in order to avoid loss of program time.
- K2F - "Circuit-Breaker Reclose" - This momentary-contact push button may be operated to reclose the plate circuit breaker after it has been tripped open twice in rapid succession and the recloser will not operate automatically.

K3F - "Lamp Reset" - A momentary-contact push button which may be operated to reset the overload lamps after any overload indication has been obtained.

Power Equipment

All manual circuit breakers in the distribution cabinet, except CB73P, should be kept in the "ON" position. In case any of these breakers trip open due to an overload they should be reclosed by first throwing to the "OFF" position to latch the handle and then throwing to "ON". The safety switch on the plate regulator should be kept in the "ON" position. The control switch on this regulator should be left in the "Automatic" position. Link switches D57P and D58P in the filter condenser assembly FC50P should be kept closed except when it is desired to remove plate voltage to neutralize.

Water System

Safety disconnect switches D3.1W and D3.2W for the cooler motors should be kept in "ON" position except when it is desired to service a particular cooler. Motor switches D4.1W and D4.2W are used to select the particular cooler it is desired to use. One switch should be kept in the "ON" position. The circuit breakers in the line starters D1.1W and D1.2W should be kept in the "ON" position except when it is desired to service a pump. A particular pump is selected for operation by the push buttons. The push-button on one line starter should be kept in "ON" position.

LAMP FUNCTIONS

Operation Lamps

(Associated with each lamp is a series resistor. The lamp will be extinguished by a failure of the lamp or resistor.)

- E1F - Green lamp above D1F "Rectifier Filament".
- E3F - Green lamp above D2F "Water System".
- E54F - Green Lamp above D1OF "Osc.-Amp. Filaments".

These lamps light as soon as power is supplied to the control circuit. They are extinguished only by opening the main disconnect circuit breaker CB51P, the branch circuit breaker CB52P, the a-c control circuit breaker D53F, or a failure of T1F.
- E2F - Red lamp above D1F "Rect. Fil." lights when D1F is "ON".
- E4F - Red lamp above D2F "Water System" lights when D2F is "ON".
- E55F - Red lamp above D1OF "Osc.-Amp. Fil." lights when D1OF in "ON".
- E5F - "Rect. Fil." lights if D1F "Rect. Fil." is "ON", S57P is operated and if D5H is "ON" energizing relay S8H and permitting thermostat to control the Blower MB1H.
- E6F - Green lamp above D3F "Amplifier Filaments" lights when the water system is "ON" and the flow relay WD1W has operated to energize S1F.
- E7F - Red lamp above D3F "Amplifier Filaments" lights when D3F is thrown to "ON" providing the green lamp is also lighted.
- E8F - "Water System" lights under same conditions as E6F.
- E9F - "Amplifier Filaments" lights when D3F is "ON" and has energized the filament contactors S53P and S59P.
- E1OF - "Rectifier Fil. Delay" lights provided E5F has lighted and delay relays S2F and S16F have

operated or K1F has been operated to energize S4F.

- E11F - "Osc. Amp. Gate" lights after E10F lights provided D11F is in the "Operate" position and all doors on the oscillator amplifier unit are closed.
- E12F - "Ant. Coup. Gate" lights after E11F provided gates on the antenna coupling unit are closed.
- E13F - "Mod. Amp. Gate" lights after E12F provided all doors on the modulating amplifier unit are closed.
- E14F - "Power Amp. Gate" lights after E13F provided both doors on the power amplifier units are closed.
- E15F - "Bias Rect. Gate" lights after E14F. The gate switches on this unit are strapped out when this unit is inside the enclosure. When an enclosure is not provided but backs are used on all units, this unit has gate switches on the doors.
- E16F - "H.V. Rect. Gate" lights after E15F provided the high voltage grounding switch D1H is open, the gate to the 50-kw enclosure is closed, and the power and water tube room doors are closed.
- E19F - Green lamp above D5F "Osc. Amp. Plate Voltage" lights after E16F provided D4A "Plate Rectifier" is left in "ON" position. Indicates D5F may be operated to apply plate voltage in the oscillator amplifier unit.
- E20F - Red lamp above D5F "Osc. Amp. Plate Voltage" indicates D5F is in "ON" position provided E19F is lit.
- E21F - "Mod. Amp. Bias" lights after E16F to indicate that the plate supply circuit to the modulating amplifier bias rectifier has been closed.

- E22F - "Power Amp. Bias" lights after E16F provided contactor S56P operates to energize the power amplifier bias rectifiers.
- E23F - Green lamp above D4F "H.V. Rectifier" lights after E9F "Amp. Fil.", E21F "Mod. Amp. Bias", and E22F "Power Amp. Bias" provided the link switch D30.1C is closed. Indicates the transmitter is ready for the application of high voltage.
- E24F - Red lamp above D4F "H.V. Rectifier" lights with E23F if D4F is thrown to "ON".
- E26F) - "High Voltage Rect. Circuit Breaker", "Open" -
- E27F) "Closed" indicates the position of the plate circuit breaker after D4F has been thrown to "ON" and E24F lights. If E24F is lighted E27F indicates the breaker is in the "OPEN" position. The breaker may be closed by operating K2F "Circuit Breaker Reclose." E26F will then light.
- E28F) - "Plate Voltage Regulator", "Min" and "Max";
- E29F) these lamps only light when the plate-voltage regulator T56P has operated to the extreme buck or boost position.
- E53F - "Filter Condenser Switch" lights when the plate circuit breaker is closed and after the delay relay S13F has operated S61P and S67P, short-circuiting the condenser charging resistances. This is the last "Operate" lamp to light and indicates that all power supplies have been properly energized.

Overload Lamps

These lamps are energized from T2F through contacts on associated lamp relays. The relays are energized from the rectox X1F supplied from

T4F. The failure of T1F, T2F, or T4F or the opening of "A-C Control Circuit Power" or "D-C Control Circuit Power" will extinguish all of the overload lamps. These lamps are lighted only by the operation of K3F. Once lighted they are extinguished only by the operation of some overload circuit.

- E30F - "Mod. Amp. V2" extinguished by the operation of overload relay S2C.
- E31F - "Mod. Amp. V1" extinguished by the operation of overload relay S1C.
- E32F - "Power Amp. V2" extinguished by the operation of overload relay S1D.
- E33F - "Power Amp. V1" extinguished by the operation of overload relay S1E.
- E42F - "High-Voltage Rect. V1" extinguished by the operation of arc-back relay S1H.
- E43F - "High-Voltage Rect. V2" extinguished by the operation of arc-back relay S2H.
- E44F - "High-Voltage Rect. V3" extinguished by the operation of arc-back relay S3H.
- E45F - "High-Voltage Rect. V4" extinguished by the operation of arc-back relay S4H.
- E46F - "High-Voltage Rect. V5" extinguished by the operation of arc-back relay S5H.
- E47F - "High-Voltage Rect. V6" extinguished by the operation of arc-back relay S6H.
- E48F - "High-Voltage Rect. DC" extinguished by the operation of overload relay S7H.
- E50F - "H.V. Rect. Cct. Bkr." extinguished by any circuit operation that opens the plate circuit breaker. If E50F is extinguished without any other lamp indicating some circuit abnormality,

then the a-c trip elements in the breaker have operated to open the breaker or the control circuit for the breaker has opened.

E51F - "Protective Circuit" is extinguished by the operation of S3D which energizes S10A to momentarily remove the carrier.

SUPPLEMENTARY NOTES

Apparatus Information

Fuses

The only fuses used in the equipment are as listed in Table 8. Each fuse should be tested for continuity before placing in the fuse mounting.

Indicating Lamps

Western Electric Type K1 lamps are used for indicating lamps in the Control Unit and Oscillator Amplifier Unit. The 116 Tool is provided for removing these lamps and 319B Tool for removing the lamp caps.

General Electric Mazda No. 46 Lamps are used to illuminate the meters.

Vacuum Tubes

The types of vacuum tubes used in the 407A-4 Equipment and their corresponding designations are given in Table 9.

Rectifier Tubes

The life of the 255B and 315A vacuum tubes is greatly affected by the care that is taken to make certain that these tubes have been thoroughly warmed before the application of plate voltage. The relay S2F which is incorporated in the control circuit of this equipment prevents the application of plate voltage for 3 minutes (for 50-kw operation only), but is advantageous when time permits to use a longer preheating time, particularly when the ambient temperature is low. Tubes which have not been operated for 48

hours should be run with filament voltage only for 30 minutes before applying plate voltage. New tubes should be operated with filament voltage only for at least 2 hours before application of plate voltage. If at the end of this time it appears that any mercury is still condensed on the anode or upper part of the tube, particularly on the glass near the anode seal, the heating should be continued until all of this mercury has been evaporated and deposited in the lower end of the tube. If this preheating is done at reduced filament voltage, as is done when the tube is inserted in the spare tube socket, the preheating time should be increased to 4 hours. If a new tube arcs back on application of plate voltage, the filament should be heated further and the tube tried again before the tube is rejected.

When first received, all 255B and 315A Vacuum Tubes should be tested, after first warming the tube filaments as described above, by operating the tubes in the rectifier at reduced plate voltage for 5 minutes. The tubes should then be operated at full voltage for approximately 10 minutes. Tubes kept as spares should be given a similar test monthly to make certain that slow leaks or other troubles may not have developed while in storage.

All 255B tubes, including spares, should be rotated in service, one at a time, by replacing an active tube by one from reserve stock every two weeks. An accurate record of these changes should be kept.

Water-Cooled Tubes

The handling and care of the 232B and 298A water-cooled vacuum tubes, as described in the booklets accompanying the tubes, should be carefully observed. The adjustment of the filament voltages of these tubes in order to obtain optimum life is described in the section covering the D-99118 power amplifier under the paragraphs entitled "Modulating the

Transmitter."

During regular operation, a 298A vacuum tube can be changed with a minimum of service interruption by cutting back to 5-kw operation, and opening CB64P to deenergize the filaments of the 298A tubes. The cooling-water supply to these tubes may be shut off either by operating valves Z1D, Z2D, Z1E, Z2E, if units D and E are supplied with these valves, or if not so supplied, by the following procedure:

- (a) Close valve Z4W.
- (b) Close Z12W, and open drain valves Z6W and Z10W.
- (c) Change either 298A tube as required.
- (d) Close Z6W and Z10W, and open Z12W.
- (e) Gradually open Z4W until the proper pressure and volume are obtained.

Foxboro Rotax Flow Controller (WD2W)

Description

The Foxboro Rotax Flow Controller is employed as a protective relay to safeguard the water-cooled vacuum tubes in the power amplifier against damage if the rate of flow of water should fall below the safe minimum.

The Rotax instrument combines, in one housing, a differential pressure indicator and electrical contacts operated by the differential pressure. It is connected to a venturi, and is calibrated to indicate the water flow through the venturi, in gallons per minute. The instrument reads full scale when the differential pressure is 100 inches of water. The electrical contacts may be set to operate at any desired rate of flow.

There are three electrical connections to the Rotax instrument, designated C, E and P. Connection C is a common or non-breaking connection. E is a circuit closing and locking up connection. P is a circuit breaking connection.

As the indicator reading (and water flow) increase, contact P closes before contact E closes. As the indication decreases, contact E opens before contact P opens.

These contacts are of the brush and commutator type, and in this equipment their function is to control relay S2W. The contacts are adjusted before leaving the factory to give a spacing equal to 5 per cent of the total linear scale length. This spacing should not be reduced below 1 per cent. The contacts are protected by means of fuses accessible by removing the front of the instrument. If the contacts become inoperative, inspect the fuses. If fuses are burned out, inspect the wiring for short circuit or other defect before replacing fuses.

The Rotax instrument is provided with a three-valve manifold and two vapor traps. The manifold assists in the installation, checking and servicing of the instrument. The vapor traps maintain accuracy of calibration when small amounts of air are entrapped in the piping between the Rotax and venturi.

Installation

The Rotax instrument must be rigidly mounted and carefully leveled so that the float does not drag on the side of the float chamber.

To attach the three-valve manifold and vapor traps:
Blow out manifold piping and valves to remove all dirt. Separate the two unions on the manifold and attach them to the 1/4 inch nipple and to the tube having 1/4 inch male pipe ends furnished loosely with the manifold.

Screw 1/4 inch pipe nipple into top of upper chamber of instrument, in place of plug.

Screw tube into top of lower chamber of instrument in place of plug.

Screw vapor traps into valve manifold, in place of plugs.

Attach valve manifold and traps to pipe nipple and tube by means of unions, bending tube as required to fit in place.

Connect the left-hand end of the three-valve manifold to the upstream or entrance of the venturi.

Connect the right-hand end of the manifold to the throat or small diameter of the venturi.

Shipping Stop

Each Rotax differential pressure instrument is made with a "shipping stop" to prevent any damage to the float or other mechanism while the instrument is being shipped. This stop is closed during shipment, the stop engaging the top of the float stem. To release the float for operation, remove the high-pressure chamber cover, release shipping stop screw sufficiently to permit raising the stop and turning it to a position permitting full scale travel of the float stem. Tighten shipping stop screw. Replace high-pressure chamber cover, taking care not to crimp gasket. If original gasket is stretched, use new one. All cover screws must be set up tight.

Operation and Maintenance

Filling Mercury Chambers

The importance of getting the correct quantity of mercury into the chamber cannot be emphasized too strongly. In operation the vertical travel of the steel float is transferred into the rotating motion of the indicator arm through a simple lever and shaft. The lever travels through an angle causing the indicator to travel at a non-uniform rate, faster at the ends of the scale than at the center. To obtain correct rate of indicator travel, the instrument is provided with a metal bar or displacement stick fastened

to the cover plate of the low-pressure chamber and extending down into the mercury. The volume of this "stick" is so distributed that the displacement of mercury at any point will be such as to produce the proper reading on the chart.

THEREFORE, FOR ANY GIVEN POSITION OF THE INDICATOR ARM THERE IS ONE POSITION ONLY OF THE MERCURY IN THE TWO LEGS OF THE "U" TUBE TO GIVE THE CORRECT READING FOR THE CORRESPONDING DIFFERENTIAL.

For this reason it is vitally important in setting up the instrument and putting it into calibration that the correct quantity of mercury be put into the chambers. Follow these instructions very carefully. Remove needle point screw in center of filling plug (see Fig. 10). Pour mercury into instrument through open filling plug until pen rests slightly below zero line. It is well to rap instrument with the hand during this operation to insure the prompt settling of the mercury. Replace screw in filling plug.

Filling Chambers and Piping with Water

Close L.H. and R.H. valves on manifold.

Open center valve on manifold.

Open bleeder valves on top of vapor traps.

Remove plug from high-pressure chamber and fill chamber with water. Replace plug.

Remove plug from low-pressure chamber and fill chamber with water. Replace plug.

With L.H. and R.H. valves on manifold closed, start water circulating through the venturi.

Close center valve on manifold.

Crack L.H. valve and bleed air from top of L.H. vapor trap. Close L.H. bleeder and L.H. valve.

Open center valve on manifold.

Crack R.H. valve and bleed air from top of R.H. vapor trap. Close R. H. bleeder and R.H. valve.

Zero Adjustment

Close all three valves on instrument manifold, circulate water through the venturi.

Open center valve very slightly.

Crack L.H. valve until indicator shows approximately 5 to 10 per cent of full scale.

Slowly close (not completely) center valve to cause indicator to rise to full scale. Open center valve sufficiently to allow indicator to return to zero. Manipulate center valve so that indicator sweeps from zero to full scale several times. This will settle the mercury in the instrument. Close L.H. valve and open center valve. If indicator returns below zero, there is too much mercury in instrument. Carefully and slowly withdraw mercury through needle drain at the bottom of loop below the two chambers of the instrument. See Fig. 10. Withdraw only enough mercury to cause the indicator to move to zero.

If indicator rests above zero, there is not enough mercury in chambers. Stop flow of water through venturi and drain that line. Drain mercury and water through bottom valve, opening side valves and top bleeders to allow complete drainage. Repeat operation of filling chambers with mercury and water as described above.

To Put Meter in Operation

Slowly open, in sequence mentioned, L.H. valve and R.H. valve in instrument manifold. Close center valve. The instrument is then in operation.

To Put Meter Out of Operation

Slowly close, in sequence mentioned, L.H. valve and R.H. valve. Open center valve.

To Remove Air from Instrument

The vapor traps should be vented when no water is flowing through the venturi. At first, this should be done daily. Thereafter it should be done as often as necessary to keep vapor traps always partly full of water.

To Lubricate Bearing (Figure 11)

Loosen valve screw.

Tighten lubricator screw the desired amount to sufficiently lubricate bearing.

Tighten valve screw.

NOTE: One-half turn every two weeks is usually sufficient to lubricate bearing. Experience may show that it is not necessary to lubricate this often.

To Refill Lubricator (Figure 11)

With valve screw tightened remove lubricator screw.

Insert lubricant in lubricator barrel.

Replace lubricator screw and tighten.

CAUTION: Valve screw must always be screwed up tight except when feeding bearing with lubricant.

Any additional supply of lubricant may be purchased from the Foxboro Company.

Nitrogen Gas System

Description

In the 407A-4 Radio Transmitting Equipment, dry oil-pumped nitrogen gas under pressure is used in the concentric transmission line and harmonic shunt and also in the adjustable plate-circuit condensers associated with the 50-kilowatt amplifier tubes.

The increase in flash-over voltage afforded by gas pressure has permitted the design of the condensers with much smaller dimensions than would be necessary at atmos-

pheric pressure. In addition to the enhanced factor of safety obtained, the gas pressure in the concentric transmission line prevents the entrance of moisture and gives an indication of faults which may develop in the soldered or gasketed joints. The escaping gas at such a fault excludes foreign material between the conductors.

In this equipment two distinct gas systems are used, as illustrated schematically in Figure 12. One system is for the condensers which are maintained at 200 pounds pressure, and the other for the line and harmonic shunt which are operated at approximately 45 pounds. In each system two cylinders of gas are connected through valves and a manifold to a pressure regulator which reduces the cylinder pressure to that of the system. A high-pressure gauge and low-pressure gauge are connected to the regulator. On the low-pressure side of the regulator, a manifold is attached and to it are connected outlets to the different points being supplied. Each outlet is connected through an outlet valve to a pressure gauge and a copper pipe which leads to the apparatus under pressure. There are also connected to the low pressure manifold a hand-operated bleeder valve and a safety blowoff valve which is set at about 250 pounds for one system and 60 pounds for the other, to prevent injury to the apparatus which might result from improper operation of the regulator. All of this apparatus is mounted on one panel known as the "Nitrogen-Control Manifold" (CM1N for the transmission lines and CM2N for the condenser supply).

Operation

CAUTION: OPERATING PRESSURES OF 45 POUNDS IN THE TRANSMISSION LINES AND 200 POUNDS IN THE CONDENSERS SHOULD NEVER BE EXCEEDED, EXCEPT THAT SMALL INCREASES ABOVE THESE LIMITS, DUE TO TEMPERATURE RISE, MAY BE DISREGARDED.

WHILE MECHANICAL WORK IS BEING DONE ON LINES
OR CONDENSERS, THE GAS PRESSURE SHOULD BE RE-
MOVED THEREFROM.

To fill the transmission line, harmonic shunt or condensers proceed as follows: Connect a 200 cubic foot cylinder of oil-pumped nitrogen to each of the two cylinder connection pigtailed on the manifolds. (Cylinders of oil-pumped nitrogen of any manufacture are painted red on the upper half and yellow on the lower half and are equipped with left-hand threads on the outlets.) It is advisable to open slightly or "crack" the cylinder valve momentarily before connecting it in order to discharge any dirt particles which may be present in the valve recess. Close all valves on the manifolds and close the regulators by turning their adjusting handles all the way counter-clockwise. Open one cylinder valve and its cylinder connection valve on each manifold. The high-pressure gauge on the regulators should now read about 2200 pounds per square inch. Turn the regulator adjusting handles clockwise until the low-pressure gauge reads 45 pounds per square inch in the case of CM1N and 200 pounds per square inch in the case of CM2N.

The control manifolds are now ready for filling the apparatus. To fill condensers C1D and C1E, open valves Z8N and Z9N on the control manifold CM2N, filling the condensers to 200 pounds pressure which will be indicated on M7N and M8N. Close valves Z8N and Z9N, leaving the condensers under pressure for a few minutes, observing the condensers and the connecting tubing for leaks. Then release the gas in order to drive out any moisture by closing the regulator ZR2N and opening the bleeder valve Z10N. Repeat this process and then refill the condensers a third time, leaving them ready for operation.

To fill the 2-5/8 inch transmission line, open Z4N on CM1N, filling the line to 45 pounds pressure as indicated by M4N. Close Z4N and observe whether the pressure in the line remains stable or whether the pressure gradually decreases, indicating a leak. (One method of locating leaks is to apply a soap solution at all connections.) If the pressure is found to be stable, open Z4N and the bleeder plug at the far end of the line, allowing dry gas to flow through the line and carry out any accumulated moisture. The period of this drying process should vary with the total length of the line. An amount of free gas equal to about twice the volume of the line should be sufficient. The 2-5/8 inch line has a volume of approximately 3.5 cubic feet per 100 feet of length. Thus, to release gas equal to twice a hundred-foot length or 7 cubic feet of gas, a pressure decrease of approximately 70 pounds will be noted on the high-pressure gauge MLN.

The 2-5/8 inch diameter harmonic shunt connected to the manifold through Z3N may then be filled by opening Z3N. Bring the pressure up to 45 pounds as indicated by a stable reading of M3N. Close Z3N, observe the leaks, then open Z3N and the bleeder plug at the end of the shunt, blowing gas through the shunt equal to about twice the volume of the shunt.

During operation the apparatus should be left with all the outlet valves closed, the regulator set at the operating pressure, and the valves from all cylinders closed. Temperature changes will probably cause a slight increase of pressure during the warm parts of the day. This is of no consequence as the safety valve will present pressures dangerous to the apparatus.

There will undoubtedly be minor leakage of gas at gaskets and joints. As explained above, this will be indi-

cated by a gradual reduction in gauge readings. If a more serious fault should develop in the transmission line or in the condensers, the leak must be discovered and repaired at the next shutdown period. In the meantime a frequent check of the gauge readings must be made and the pressures restored to normal as required. To provide for emergency, about four additional full tanks of gas should be kept on hand. The maintenance of the operating pressure is not as important in the transmission lines as in the condensers. For short emergency periods the transmission line may be used at reduced or even at atmospheric pressure. The condensers, on the other hand, must be maintained above 175 pounds per square inch; otherwise they may sustain some permanent injury.

A gas cylinder should be replaced before the supply therein is completely exhausted. Change it when the internal pressure is about 50 pounds per square inch above the operating pressure of the system to which it is connected. To change a cylinder, close both the valve on the cylinder and the cylinder connection valve which is in use and turn the adjusting handle on the regulator to its extreme counter-clockwise position. Open the valves of the second cylinder connected to the manifold, or unscrew the pigtail connection of the first cylinder and substitute a full cylinder; then open its valves and turn the regulator handle clockwise until the low pressure gauge indicates a slight change from its operating pressure.

The station routine should include hourly inspection of the pressure gauges of both control manifolds. Faults will in this way be detected soon after they occur.

In bleeding the line for any reason whatever, it should be remembered that nitrogen, while entirely non-poisonous,

does not support life; if it should wholly fill a room, a person in that room would suffocate from lack of oxygen. For this reason the bleeder and blowoff valves are vented to the exterior and proper precautions should be taken in discharging cylinders or performing any other operations involving the freeing of the gas.

DESCRIPTION AND SERVICING OF TYPE Dn CONTACTORS
LOCATED IN POWER DISTRIBUTION CABINET

Magnet

The magnet is of the solenoid type, a form least likely to produce accidental closing due to tilting or shock. The armature is of flexibly stacked laminations, minimizing the chance of objectionable magnetic noise or hum. The stationary magnet may be removed for replacement of the coil by first removing the armature stop bracket, held to the front of the magnet by two screws, and then removing the two screws securing it to the back plate.

Operating Coil

The coil is designed for continuous duty at 100 per cent of its rating. It will operate the contactor satisfactorily at from 85 to 110 per cent of its rated voltage.

To remove the coil, first disconnect the coil leads and remove the magnet stator from its place on the back plate. Then loosen the coil retaining screw and slide out the two channel-shaped armature guides, allowing the coil to drop free from the magnet frame.

Contacts

The self-aligning double-break moving contacts are carried on a crossbar of insulating material secured to the armature of the magnet. There are no shunts or sliding contacts to wear or produce other trouble. The contact tips are of silver, requiring almost no attention. Only in cases

of extreme beading is it necessary to treat them. Dressing should be done with a fine file, not with emery cloth, as abrasive granules imbedded in the contact surfaces may raise the contact resistance and produce a tendency of the contacts to weld.

Replacement of the moving contacts is effected, when necessary, by removing the armature stop bracket, secured to the front of the stationary magnet by two screws, and withdrawing the armature and crossbar assembly downward thru the arc box. The contacts can then be removed from their supports without the use of tools.

The stationary contacts are supported by the arc box and are held in place by screws readily accessible from the front. The contact tips are of silver, and will require as little attention as those of the moving contacts.

Correct spring pressures should be maintained as follows:

<u>Initial</u>	<u>Final</u>
<u>Pressure</u>	<u>Pressure</u>
5 ounces	10 ounces

The contact gap should be seven thirty-seconds of an inch.

Maintenance

The contactor will require little attention. However, it should be inspected periodically to see that no impairment of electrical or mechanical functioning occurs. Accumulations of dust may be removed with a dry cloth or a compressed-air jet. Avoid oily cloths, as an oil film quickly attracts dust. The magnet armature should be removed at intervals and accumulations of smudge on it and its guides removed with benzine or a similar solvent.

MAINTENANCE OF MOTOR-OPERATED PLATE CIRCUIT BREAKER

Circuit breakers, as distinguished from other types of circuit-interrupting devices such as contactors and relays, are primarily designed for infrequent interruptions of extremely heavy overloads. The maintenance required on a circuit breaker will depend upon the number of overload operations the breaker has performed. It is recommended that the following maintenance schedule be followed for the plate circuit breaker:

Daily

At shut-down each night the case of the breaker should be felt to determine whether it is at any materially higher temperature than normally exists after regular operation.

Monthly or After 20 Overload Operations, Whichever Occurs First

The cover of the breaker should be removed and the contacts and arc-splitters inspected. If it appears necessary, the stationary contacts or the arc-splitters may be replaced. If the moving contacts or other parts of the breaker need replacing or servicing, the work should be referred to the service department of the Westinghouse Electric and Manufacturing Company, Haynes Ave. and Lincoln Highway, Newark, N. J., attention Mr. L. M. Brown.

In addition to the visual inspection, a dielectric test should be made on the breaker. To do this the breaker should be isolated from the other power circuits in the distribution cabinet by opening switches D55P and D56P. With the breaker closed, 2200 volts should be applied between each pole and ground, and with the breaker open the voltage should be applied between the line and load terminals of each pole. The test voltage can be obtained from a potential transformer equipped with primary fuses. The breaker

should be replaced with a new breaker or returned to the manufacturer for complete servicing if any failure of the breaker develops during these tests.

Detailed information for the installation, operation, and inspection of this circuit breaker is supplied at the time of installation, and should be retained for future reference.

TABLE 1
D-99110 OSCILLATOR-AMPLIFIER
TYPICAL METER READINGS

<u>Design No.</u>	<u>Title</u>	<u>Reading</u>
M1A	Power Supply (Ser. 101-106 only)	225 to 235 Volts
M3A	Plate Rectifier	1450 to 1550 Volts
M4A	3rd Amp. Plate Current	200 to 300 Milliamperes
M5A	3rd Amp. Plate Circuit	1.2 to 1.8 Amperes
M7A	Antenna Current	
M2A	"Test Meter" Switch Position:	
	Osc. #1 Grid ÷ 2	60 to 100 Microamperes
	Osc. #2 Grid ÷ 2	60 to 100 Microamperes
	Osc. Plate x 10	2 to 3 Milliamperes
	V1 Plate x 20	1 to 12 Milliamperes
	V2 Grid x 5	0.5 to 4 Milliamperes
	V2 Plate x 100	40 to 60 Milliamperes
	3rd Amp. Grid x 10	Not Used.
	V3 Plate x 200	Not Used.
	V4 Plate x 200	140 to 165 Milliamperes
	V5 Plate x 200	140 to 165 Milliamperes
	V6 Plate x 10	5 to 7 Milliamperes
	V7 Plate x 100	30 to 35 Milliamperes
	V8 Plate x 100	30 to 35 Milliamperes
	V9 Plate x 20	6 to 10 Milliamperes
	V10 Plate x 20	6 to 10 Milliamperes
	Bias Load x 200	Not Used.

TABLE 2

D-99110 OSCILLATOR-AMPLIFIER
PLATE, SCREEN, AND FILAMENT VOLTAGES

<u>Desig. No.</u>	<u>Plate</u>	<u>Screen</u>	<u>Filament</u>
V1A, V2A, V7A & V8A	450 to 500	180 to 200	12.4 to 12.8
V6A	200 to 250	170 to 190	9.8 to 10.2
V3A, V4A & V5A	1400 to 1600		13.7 to 14.3
V9A & V10A			6.1 to 6.5
V12A to V15A incl.			2.45 to 2.55
V16A			1.3 to 1.7
V1A of 702A Osc. #1 & #2	240 to 260 at Term. 2		1.95 to 2.05

TABLE 3

D-99110 OSCILLATOR-AMPLIFIER
COIL ADJUSTMENTS

<u>Freq.</u>	<u>L3A</u>		<u>L5A</u>		<u>L10A</u>		<u>L11A</u>	
	<u>Active Turns</u>	<u>Unused Turns</u>	<u>Active Turns</u>	<u>Unused Turns</u>	<u>Active Turns</u>	<u>Unused Turns</u>	<u>Active Turns</u>	<u>Unused Turns</u>
550	56	Open	55	Open	42	Open	35	Shorted
600	50	Open	50	Open	40	Open	32	Shorted
700	46	Open	43	Open	35	Open	26	Shorted
800	42	Open	37	Open	32	Open	22	Shorted
900	39	Open	32	Open	29	Open	18	Shorted
1000	36	Open	28	Open	27	Open	14	Shorted
1100	34	Open	24	Open	25	Open	11	Shorted
1200	31	Open	21	Shorted	24	Open	8	Shorted
1300	29	Open	18	Shorted	22	Open	5	Shorted
1400	28	Open	15	Shorted	21	Open	0	
1500	27	Open	13	Shorted	20	Open	0	
1600	25	Open	11	Shorted	18	Open	0	

L1A
550 - 1000 KC Use entire coil.
1010 - 1600 KC Short upper section.

CONDENSER ADJUSTMENTS

It will be necessary to add fixed condensers C51A and C22A to variable condensers C20A and C21A respectively, at frequencies below 1000 KC.

TABLE 4

D-99110 OSCILLATOR-AMPLIFIER
RESISTANCE ADJUSTMENTS

<u>Resistance Designation</u>	<u>Terminations On Designated Resistances</u>	<u>Approx. Resistance in Ohms</u>
R61A	First slider to lower end	600
R61A	First slider to second slider	400
R60A	Second Slider on R61A to first Slider on R60A	5000
R60A	First slider to second slider	4200
R62A	First slider to lower end	5000
R62A	First slider to second slider	5000
R63A	Second slider on R62A to slider on R63A	5600

VOLTAGES WITH ABOVE ADJUSTMENTS

<u>Designation</u>	<u>Termination On Designated Resistances</u>	<u>Approximate Voltage</u>
R61A	First slider to lower end (ground)	14 to 20
R61A	Second slider to ground	30 to 50
R60A	First slider to ground	190 to 210
R60A	Second slider to ground	460 to 510
R62A	First slider to ground	80 to 100
R62A	Second slider to ground	240 to 250
R63A	Slider to ground	430 to 450

TABLE 5

D-151135 MODULATING AMPLIFIER
TYPICAL METER READINGS

<u>Desig. No.</u>	<u>Title</u>	<u>Reading (50 KW)</u>	<u>Reading (5 KW)</u>
M1C	Plate Current V1	0.25 to 0.4 amp.	0.625 amp.
M2C	Plate Current V2	0.25 to 0.4 amp.	0.625 amp.
M3C	Filament Voltage	18 volts	18 volts
M4C	Grid Load Current	275-325 ma.	275-325 ma.
M5C	Trans. Line Current (5 kw)		9 amps.

TABLE 6
D-99118 POWER AMPLIFIER
TYPICAL METER READINGS

<u>Desig. No.</u>	<u>Title</u>	<u>Reading</u>
M1D	Protective Circuit	0 to 2 ma.
M2D	Total Plate Current	4.55 to 4.7 amps. (no mod.) 6.4 to 7.0 amps. (100% mod.)
M3D	Plate Current V2	0.5 to 0.8 amp. (no. mod.) 2.0 to 2.5 amp. (100% mod.)
M4D	Grid Load Current V2	0.65 to 0.75 amp. (no mod.)
M7D	Filament Voltage V2	26 volts
M1E	Plate Current V1	3.8 to 4.2 amps.
M2E	Trans. Line Current	28.3 amps. (no mod.) (for 62.5 ohms)
M3E	Antenna Current	*
M4E	Grid Load Current V1	2.1 to 2.6 amps.
M7E	Filament Voltage V1	26 volts

*The antenna current in amperes for 50 kilowatts output is related to the antenna resistance R by the formula

$$I = 224 / \sqrt{R} .$$

TABLE 7
SPECIAL D-99116 CONTROL UNIT
TYPICAL METER READING

<u>Desig. No.</u>	<u>Title</u>	<u>Reading (50 KW Output)</u>	<u>Reading (5 KW Output)</u>
M1F	Line Voltmeter		
	Line Supply	450 to 475 volts	450 to 475 volts
	Regulated Supply	455 to 465 volts	455 to 465 volts
M2F	Mod. Amp. Bias	600 volts	300-400
M3F	Power Amp. Bias V1	485 volts	-
M4F	Power Amp. Bias V2	1200 volts	-
M7F	Power Amp. Plate	17.8 to 18.2 KV	11.5 to 12.5 KW
M8F	Leakage Current	4 ma. maximum	4 ma. maximum

TABLE NO. 8

FUSES

<u>Desig. No.</u>	<u>Current Rating</u>	<u>Cat. No.</u>
F1.1A	5 Amps. 250 Volts	D&W Cat. #1456
F1.2A	5 Amps. 250 Volts	D&W Cat. #1456
F2.1A	2 Amps. 250 Volts	D&W Cat. #91002
F2.2A	2 Amps. 250 Volts	D&W Cat. #91002
F3A	1 Amp. 2500 Volts	D&W Cat. #2760

TABLE 9

VACUUM TUBES

<u>Unit</u>	<u>Designation</u>	<u>Code No.</u>	<u>Designation</u>	<u>Code No.</u>
D-99110 Osc. Mod.	V1A	RCA 837	V10A	345A
	V2A	RCA 837	V12A	249B
	V3A	241B	V13A	249B
	V4A	241B	V14A	249B
	V5A	241B	V15A	249B
	V6A	310A	V16A	249B
	V7A	RCA 837	V1 of 702A Osc. #1	247A
	V8A	RCA 837	V1 of 702A Osc. #2	247A
	V9A	345A		
D-151135 Mod. Amp.	V1C	232B	V2C	232B
D-99118 Power Amp.	V1D	274A	V1E	298A
	V2D	298A		
D-99119 H.V. Rect.	V1H	255B	V5H	255B
	V2H	255B	V6H	255B
	V3H	255B	V7H (Spare)	255B
	V4H	255B		
D-99120 G.B. Rect.	V1K	249B	V7K	249B
	V2K	249B	V8K	249B
	V5K	249B	V9K	249B
	V6K	249B	V10K	249B
Spl. D-99116 Cont. Unit	V1 of S16F	313C		
Spl. D-99114 Rect. Unit	V1G	315A	V6G	315A
	V2G	315A	V7G (Spare)	315A
	V3G	315A	V8G	249B
	V4G	315A	V9G	249B
	V5G	315A		

TABLE 10
RELAY SETTINGS

<u>Time Delay Relay</u>	<u>Delay to Make</u>
S2F	3 to 4 min.*
S3F	5 to 8 sec.* (delay to release)
S12F	10 sec.
S13F	1.5 to 2 sec.*
S16F	maximum 17 sec.*

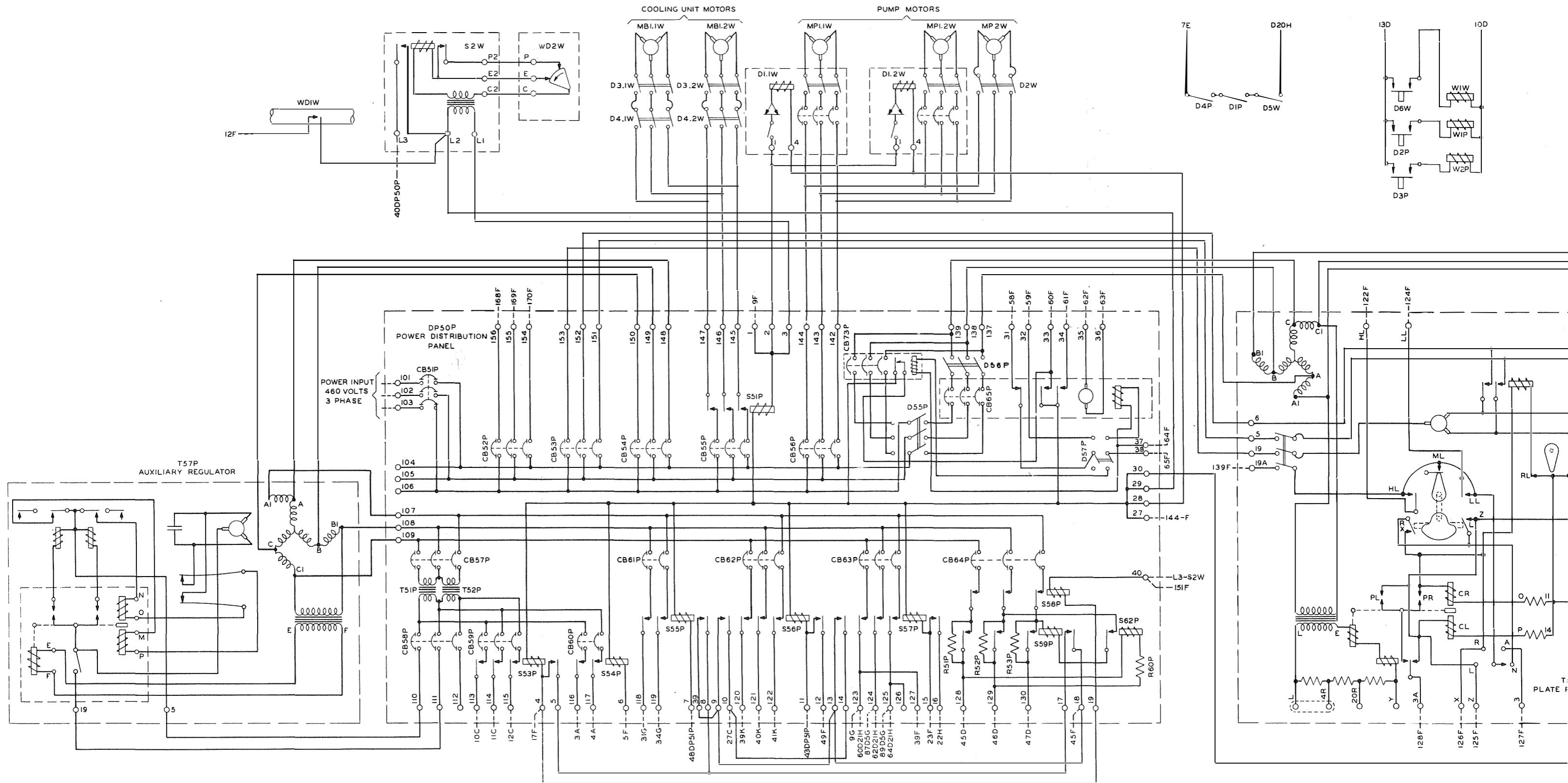
*Not adjustable

<u>Arc-Back and Overload Relays</u>	<u>Current Through Shunt to Operate</u>
S1D (R3D)	5 to 6 amps.
S1E (R3E)	6 to 7 amps.
S1C (R3C) & S2C (R4C)	1 amp. \pm 10%
S1G (R1G)	3 amps.
S1H to S6H	20 amps. AC 10 amps. DC with positive of battery connected to anode side of shunt. Not to operate with the battery reversed.
S7H	15 to 20 amps.
S62P	Voltage Relay - Operates when voltage across coil and resistance R60P reaches 295 volts.

TABLE 11
Gap Settings

G1C	.02 in.	G31C	.02 in.
G30C	0.12 in.	G1H	.02 in.





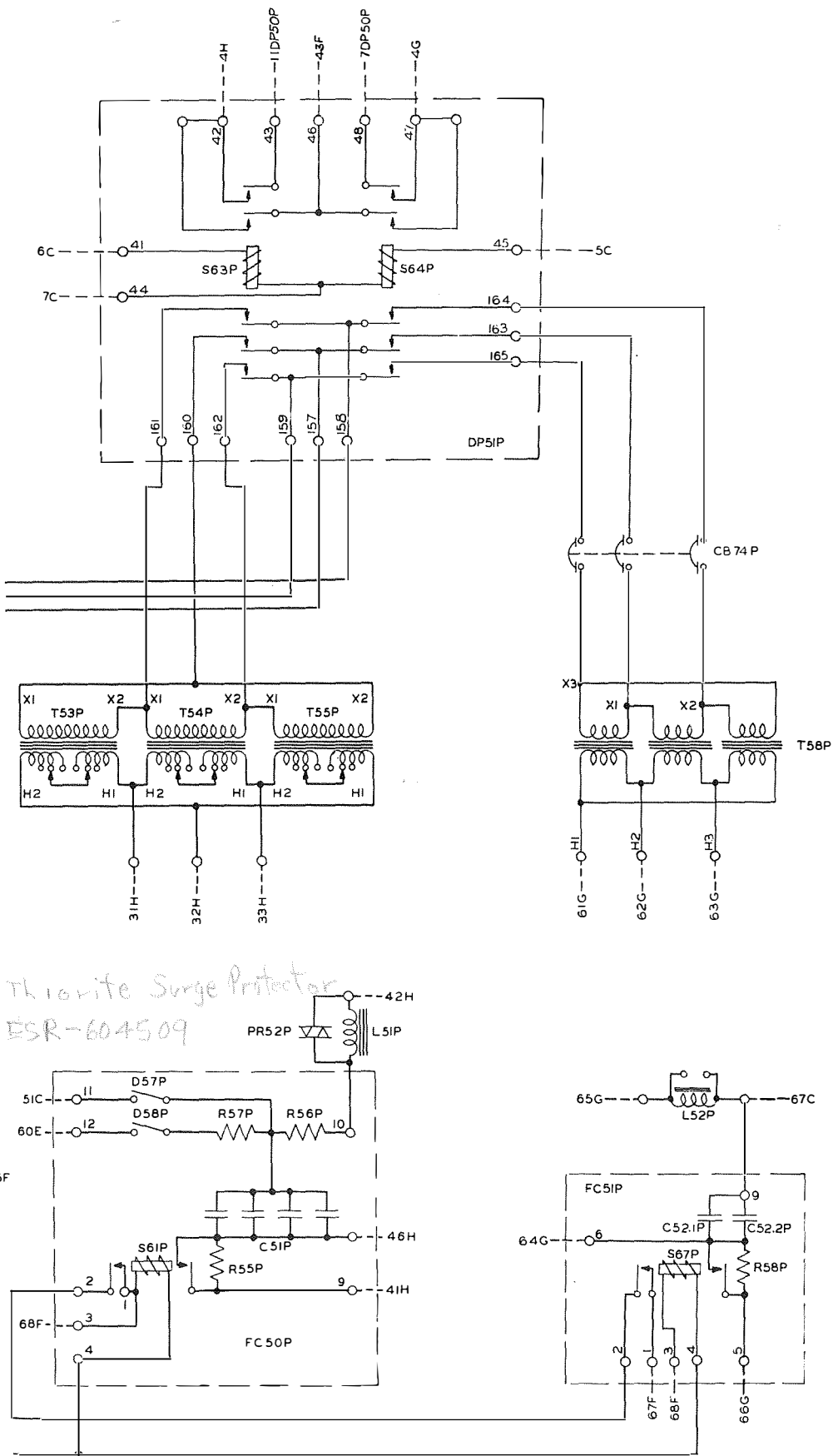


Fig. 1 - Power System - Schematic

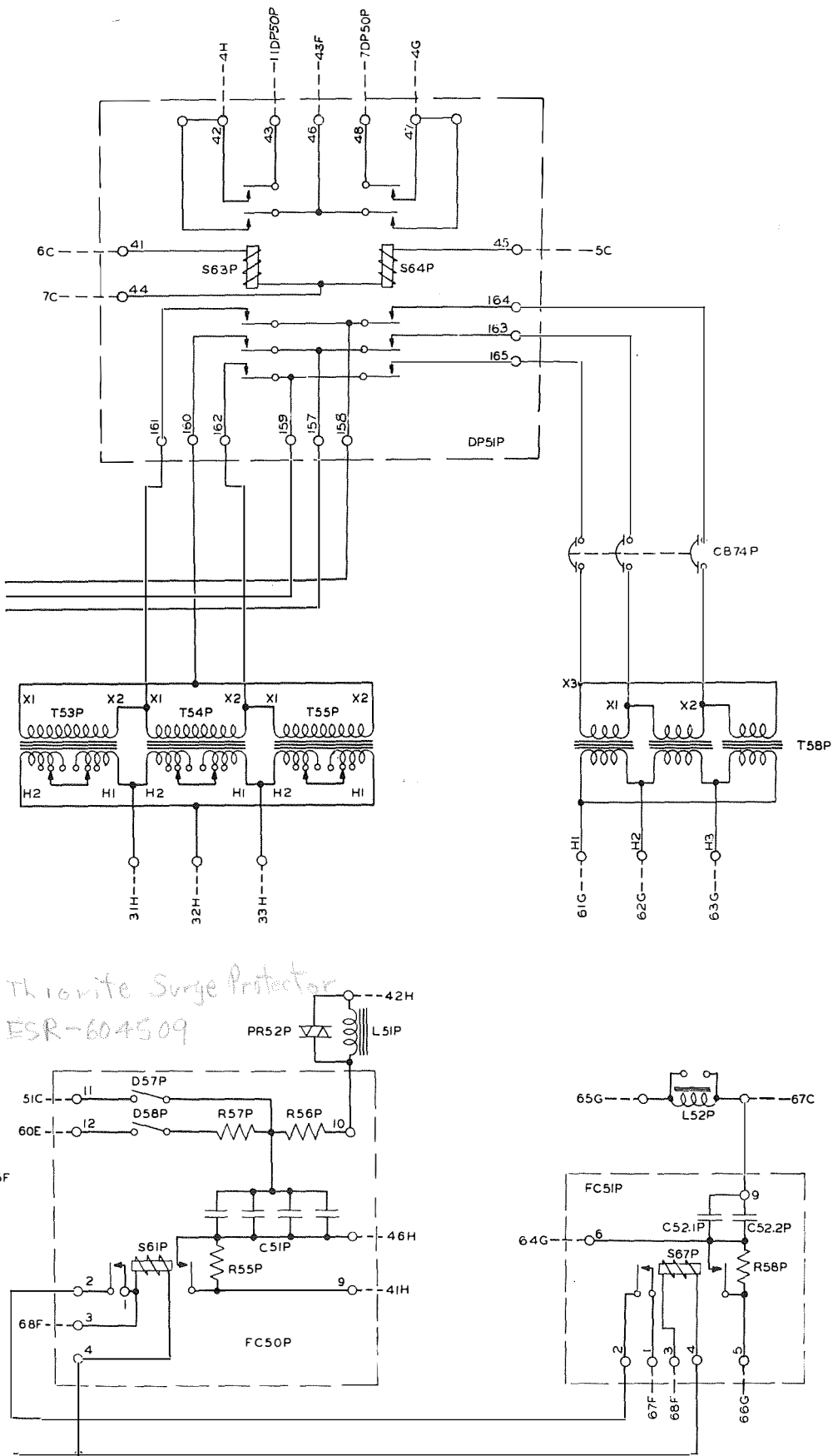


Fig. 1 - Power System - Schematic

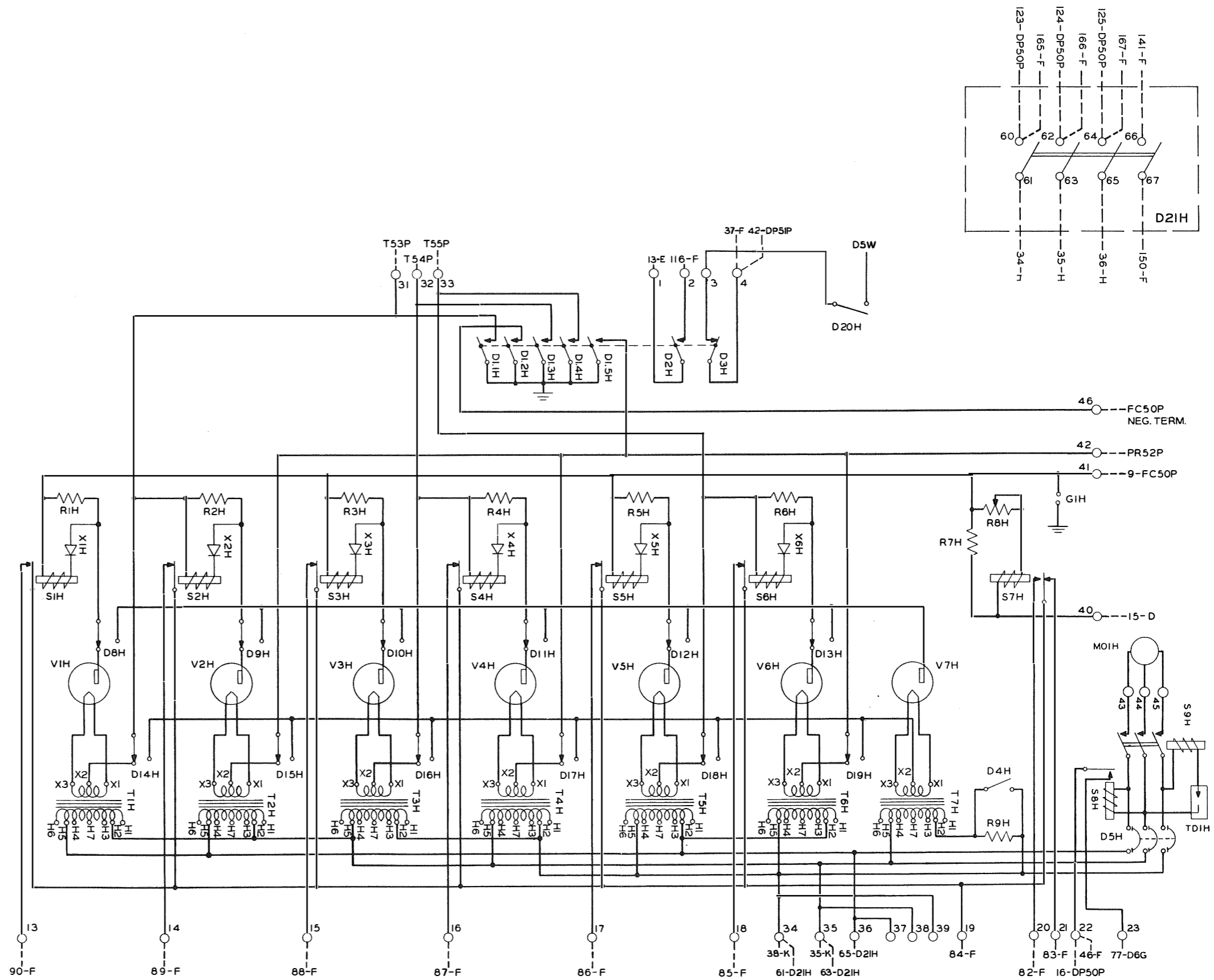


Figure 2 - Unit H - D-99119 Rectifier Tube Unit - Schematic

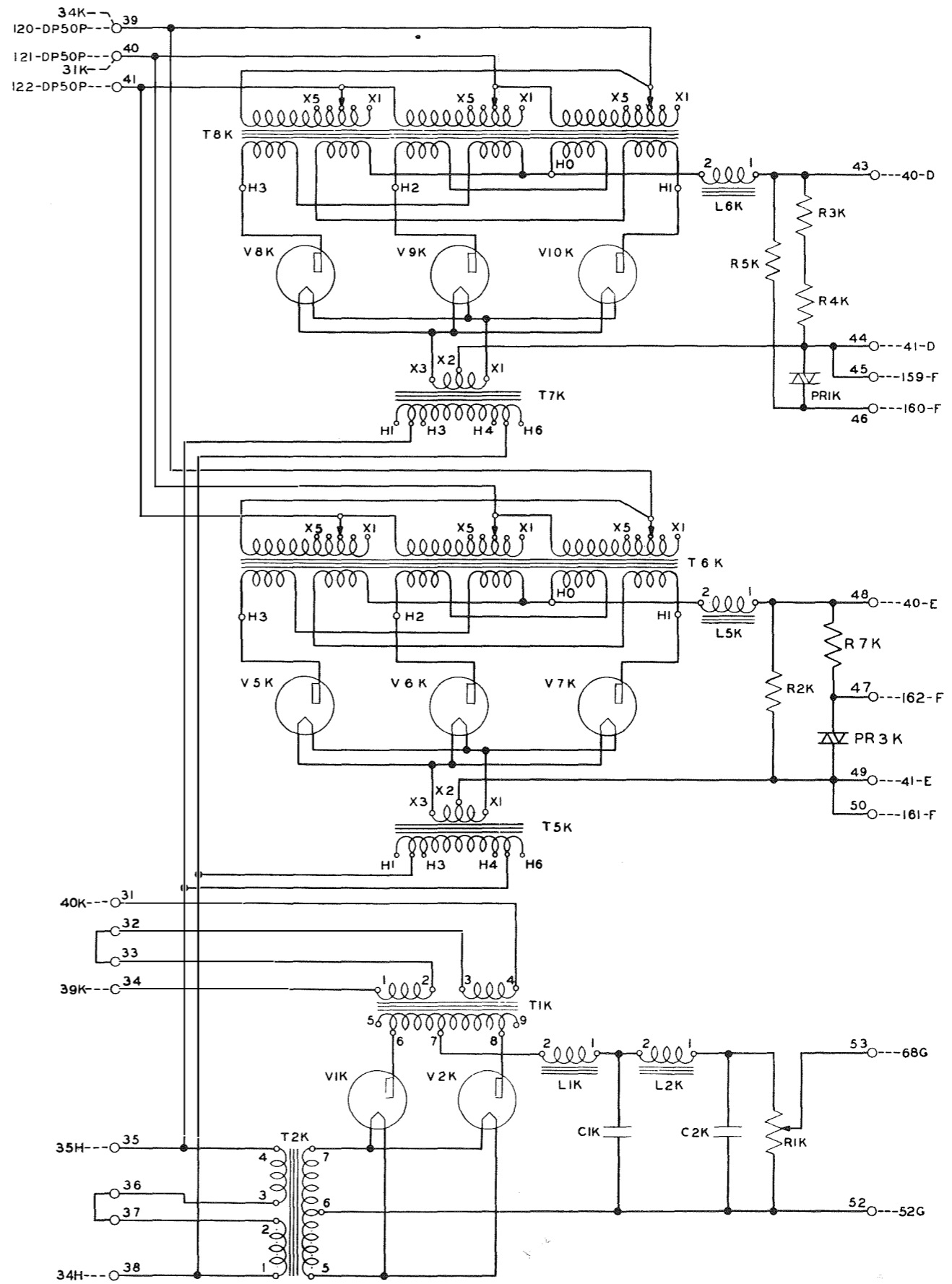


Figure 3 - Unit K - D-99120 Bias Rectifier Tube Unit - Schematic

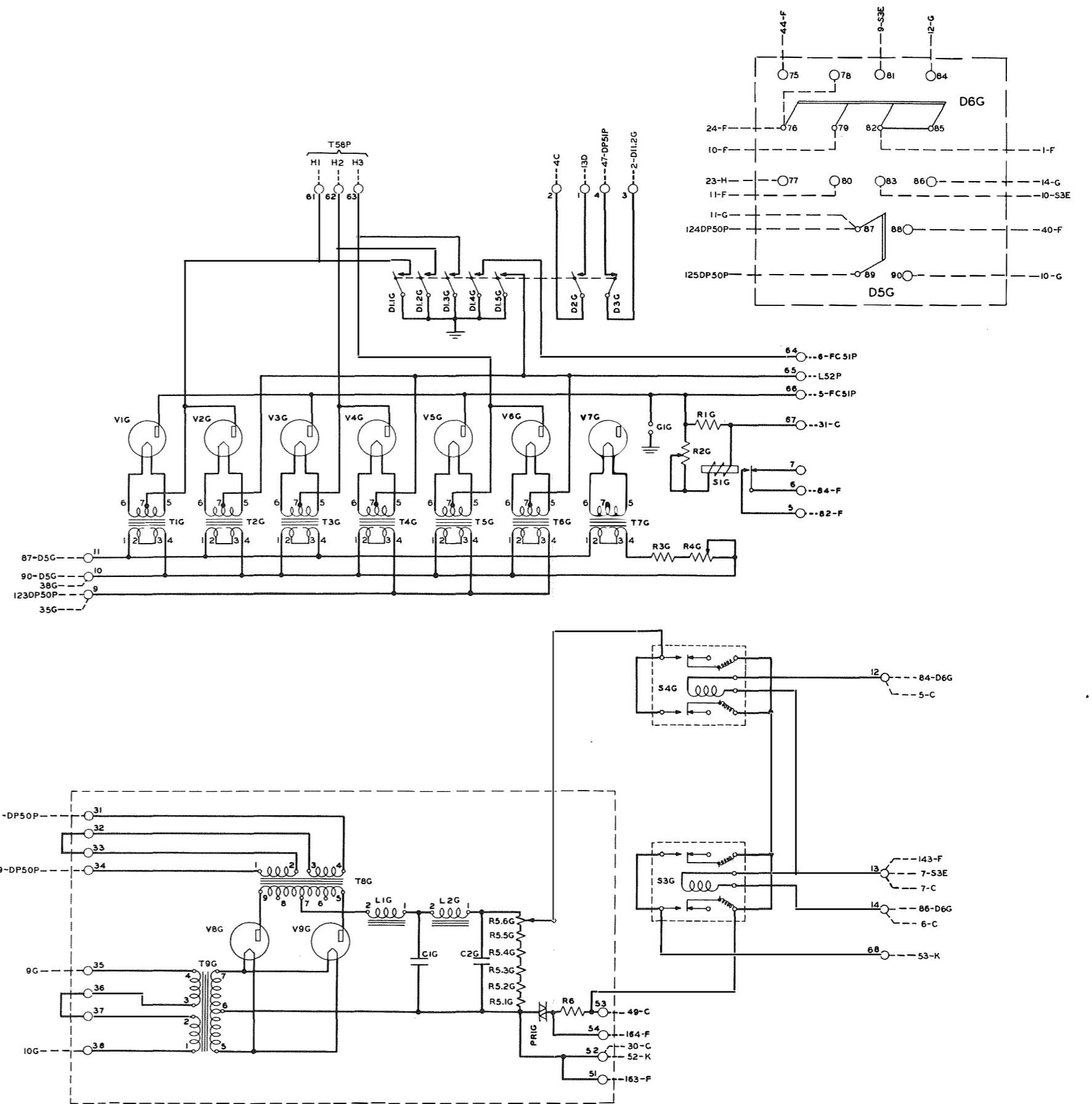
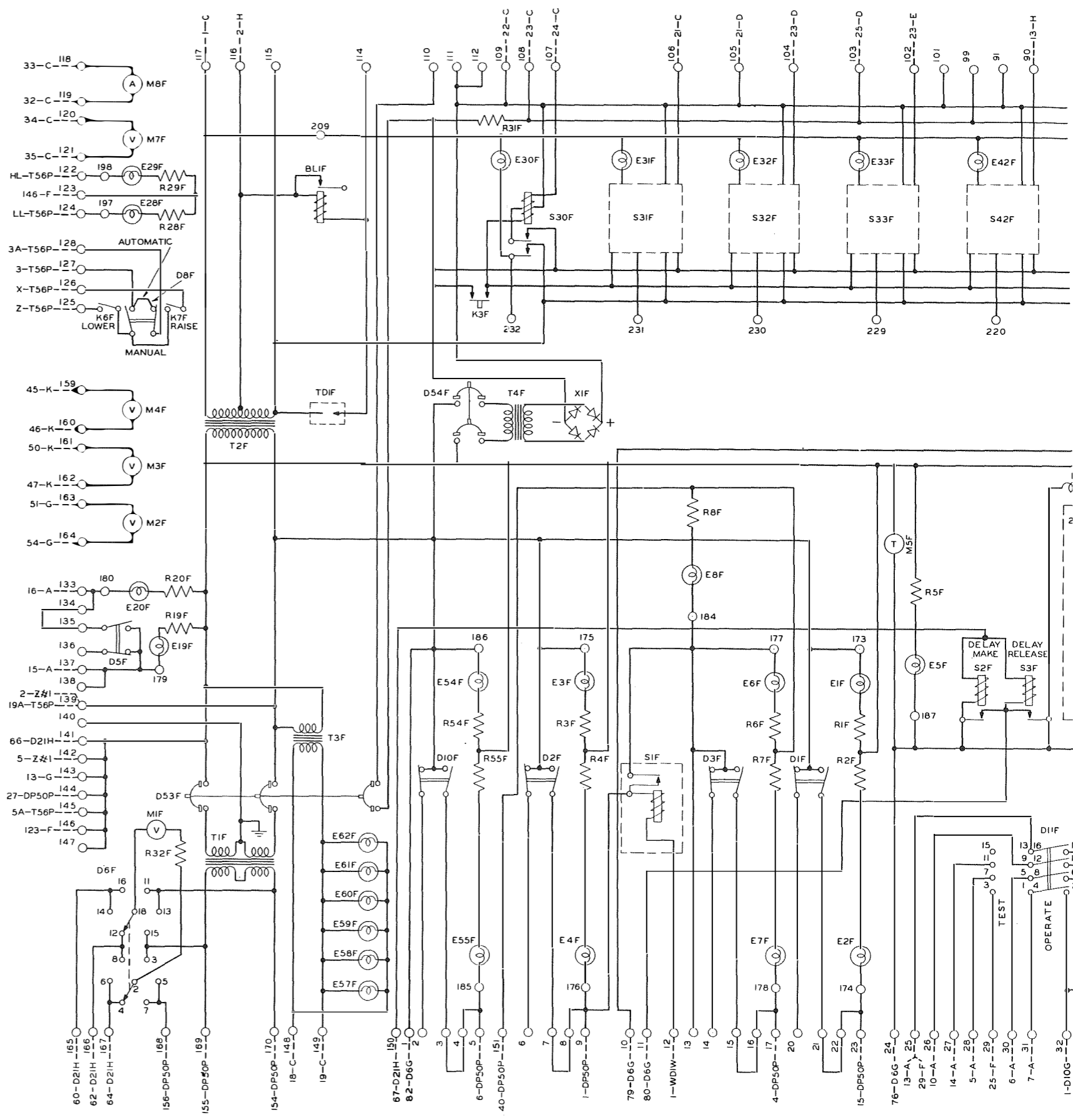


Figure 3A - Unit G - Special D-99114 Rectifier Unit - Schematic



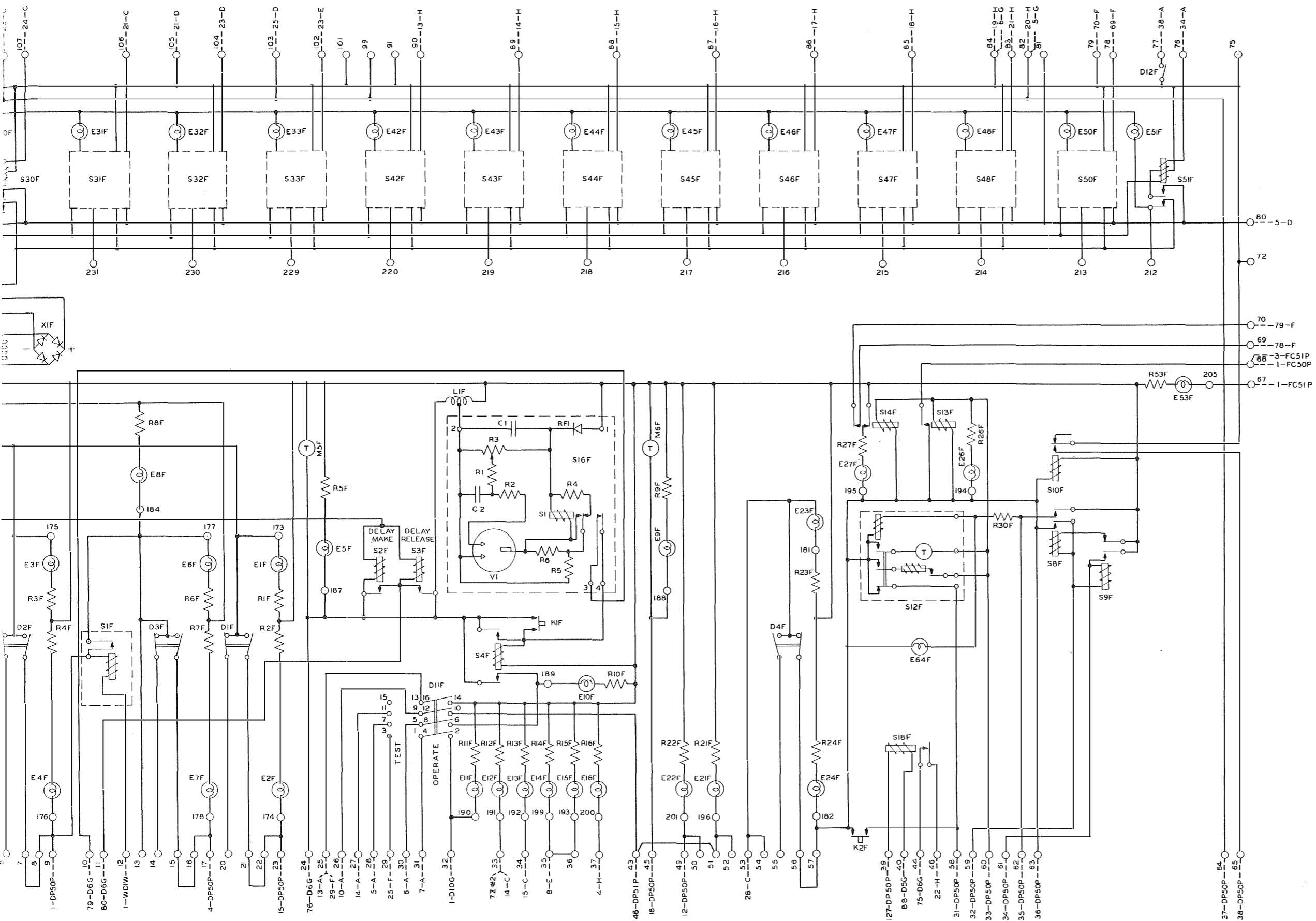
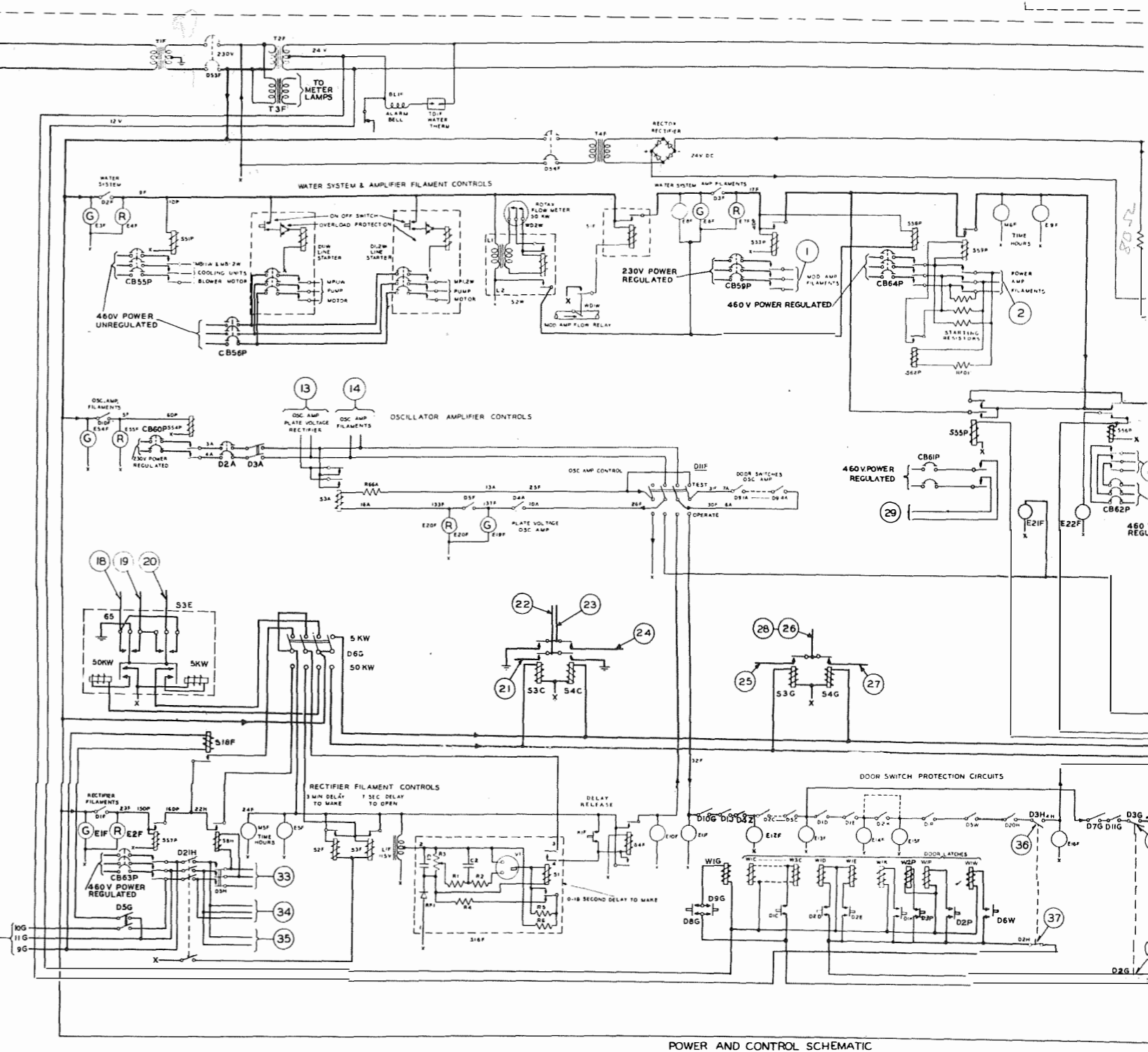
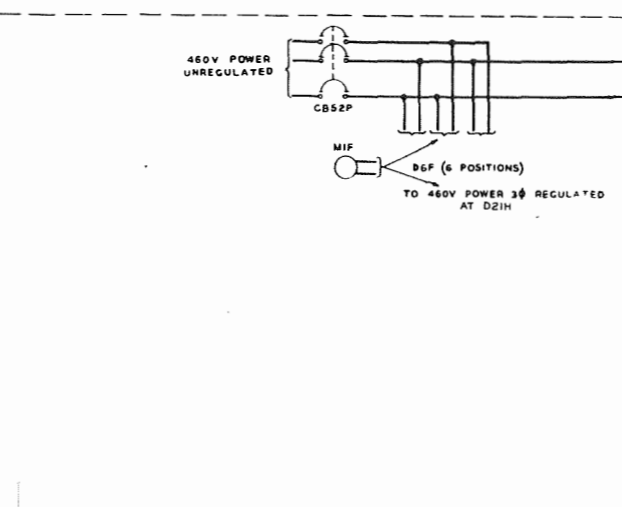
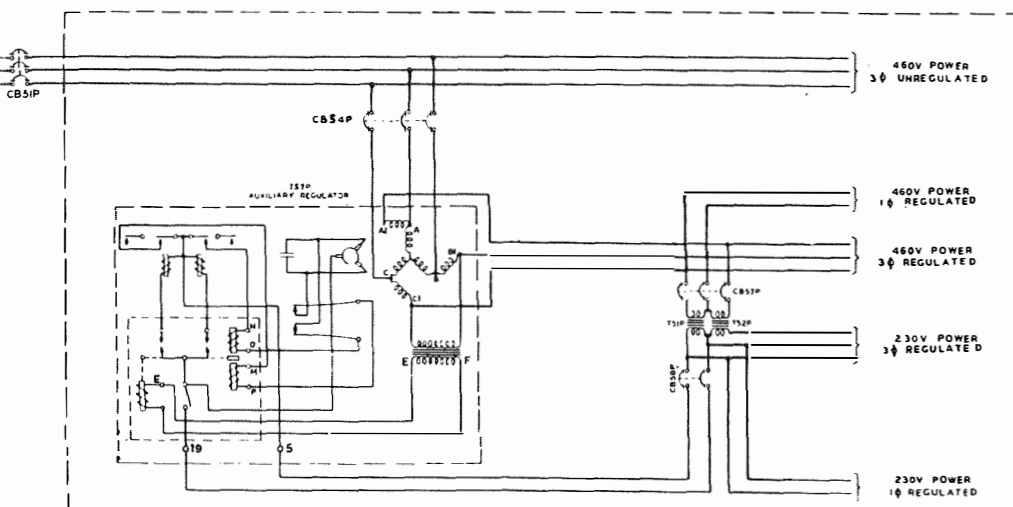
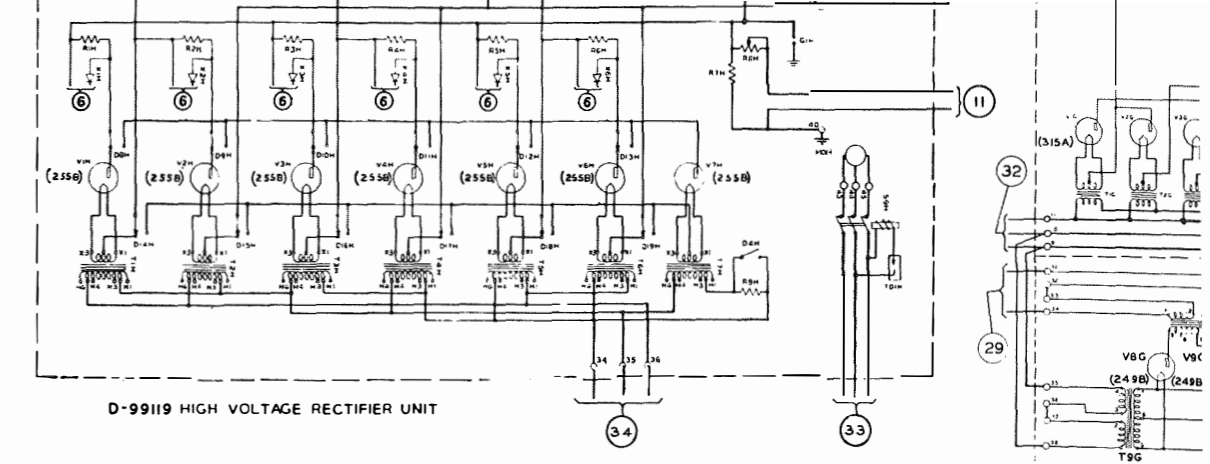
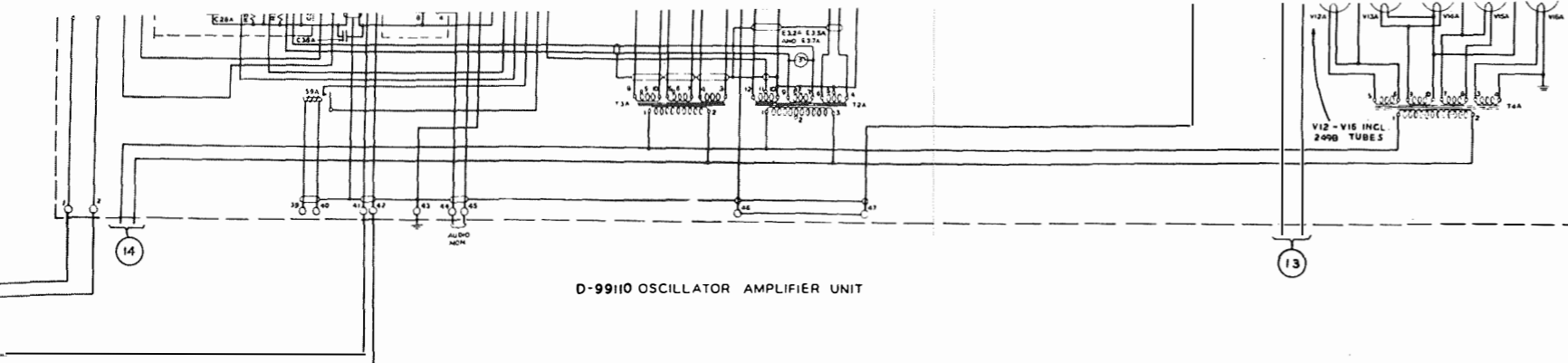


Figure 4 - Unit F - Special D-99116 Control Unit - Schematic



NOTES:

- NUMBERS SHOWN AS (13) ARE CROSS REFERENCES BETWEEN SCHEMATICS OF TRANSMITTER UNITS AND CONTROL SYSTEM SCHEMATIC.
- THE LETTERS DESIGNATING THE SEVERAL TYPES OF APPARATUS ARE:

C - CONDENSER	G - SPARK GAP	MP - MOTOR PUMP	TC - THERMOCOUPLE
CB - CIRCUIT BREAKER	J - JACK	FR - PROTECTOR	V - VACUUM TUBE
D - SWITCH	L - INDUCTANCE	R - RESISTANCE	VS - VACUUM TUBE SOCKET
E - INDICATOR LAMP	M - METER	S - RELAY	X - RECTOX RECTIFIER
F - FUSE	MB - MOTOR-BLOWER	T - TRANSFORMER OR REGULATOR	W - DOOR LOCK

THE LETTERS ASSIGNED TO THE EQUIPMENT UNITS ARE:

UNIT A - D-99110 OSCILLATOR-AMPLIFIER.	UNIT J - ANTENNA COUPLING EQUIPMENT.
UNIT C - D-151135 MODULATING AMPLIFIER.	UNIT K - D-99120 BIAS RECTIFIER.
UNITS D AND E - D-99118 POWER AMPLIFIER.	UNIT N - NITROGEN GAS SYSTEM.
UNIT F - D-99116 CONTROL UNIT.	UNIT P - POWER APPARATUS.
UNIT G - D-99114 RECTIFIER TUBE UNIT.	UNIT W - WATER COOLING SYSTEM.
UNIT H - D-99119 RECTIFIER TUBE UNIT.	

ACCORDINGLY M6A IS METER NO. 6 IN THE D-99110 OSCILLATOR-AMPLIFIER.

407A-4 RADIO TRANSMITTING EQUIPMENT SYSTEM SCHEMATIC

POWER AND CONTROL SCHEMATIC

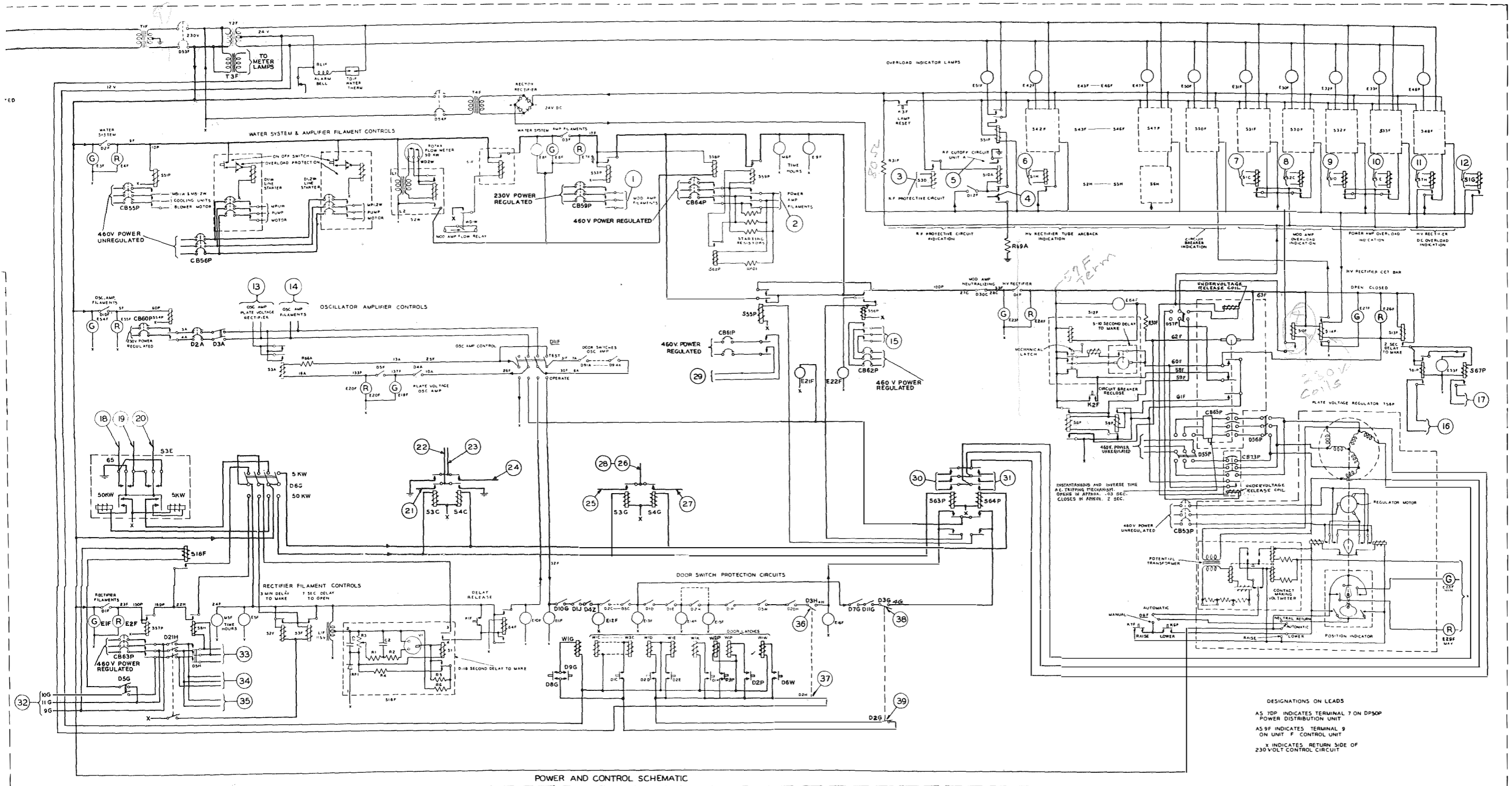
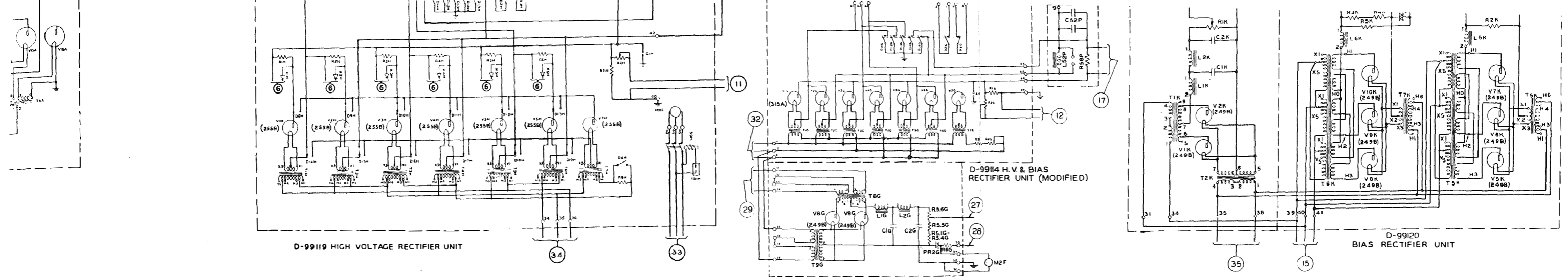
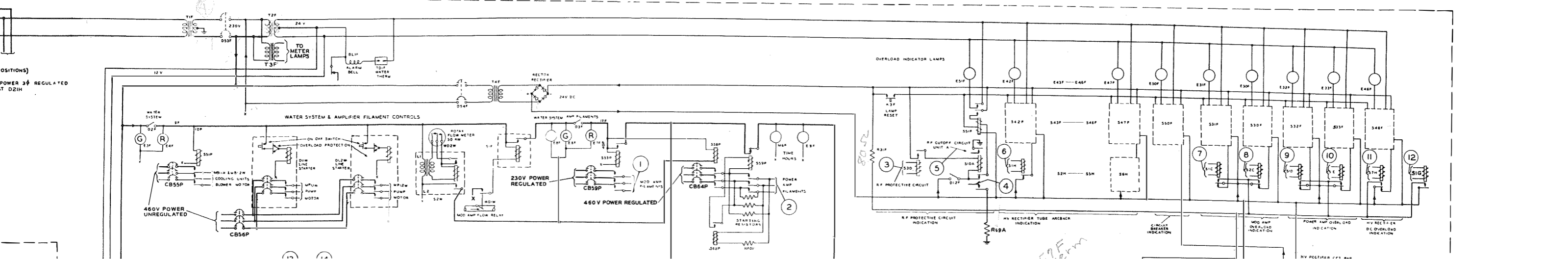
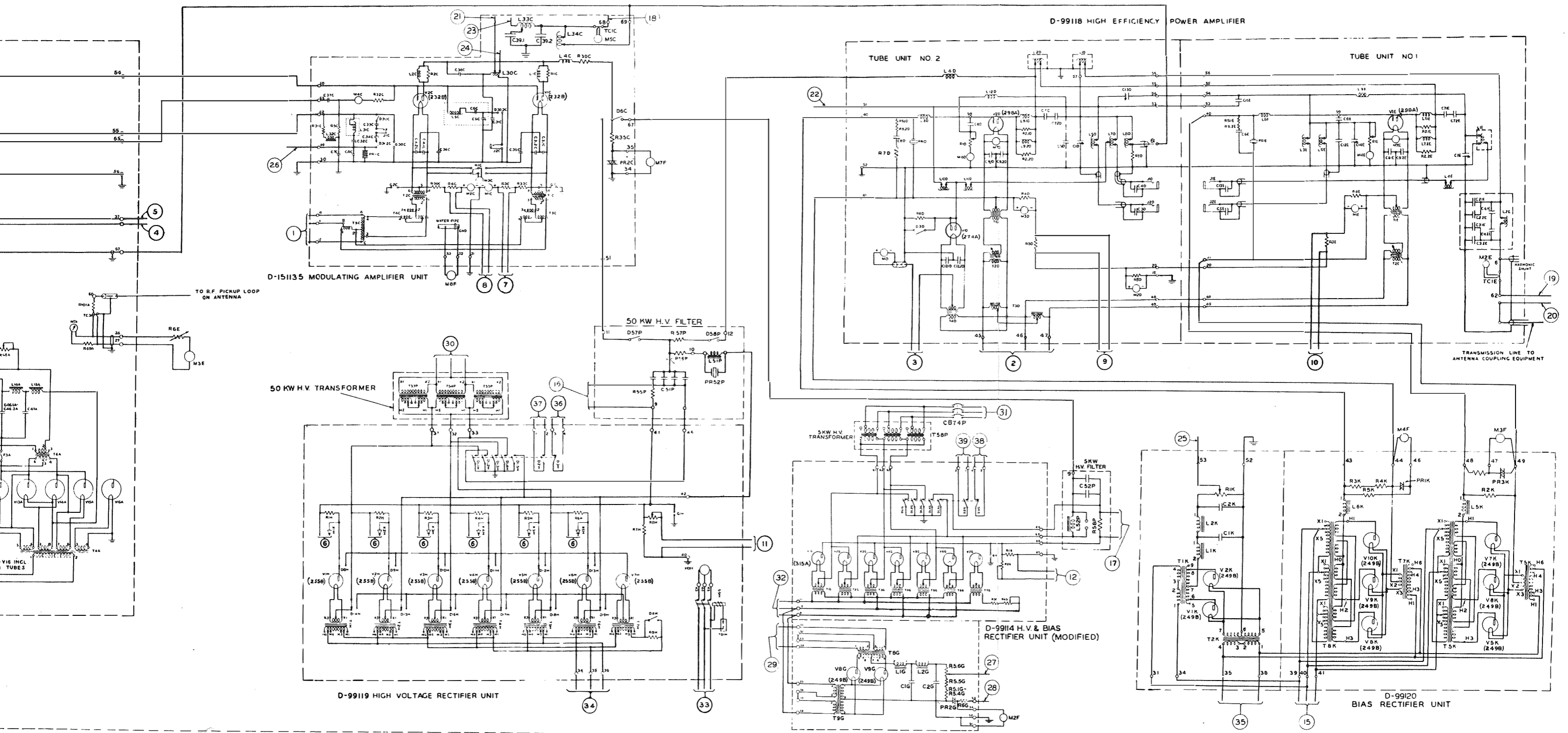
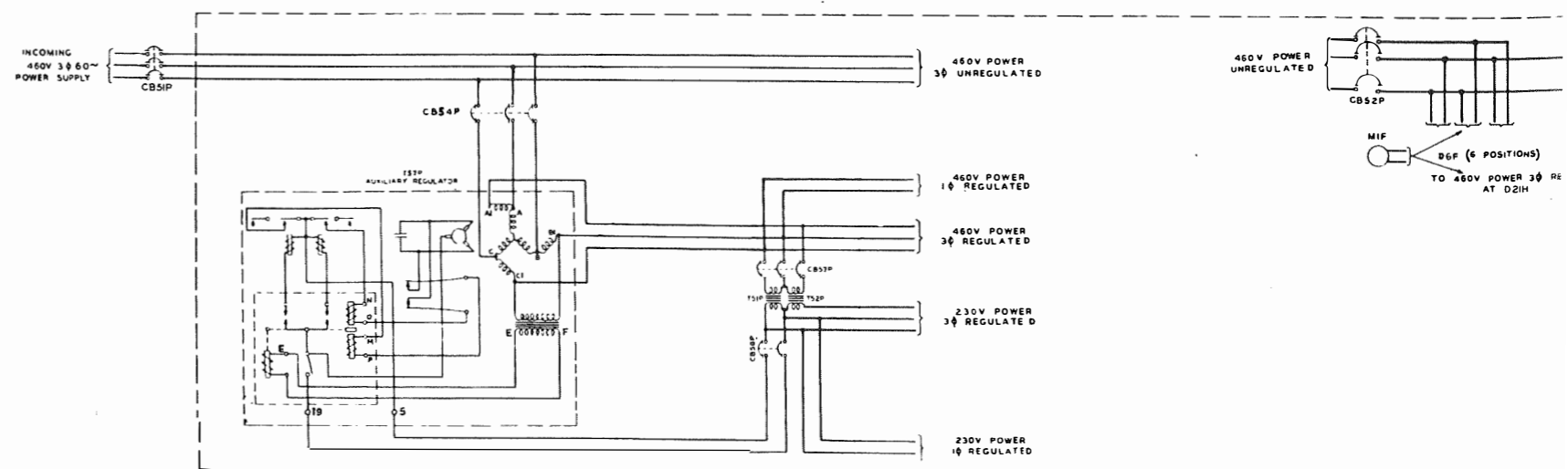
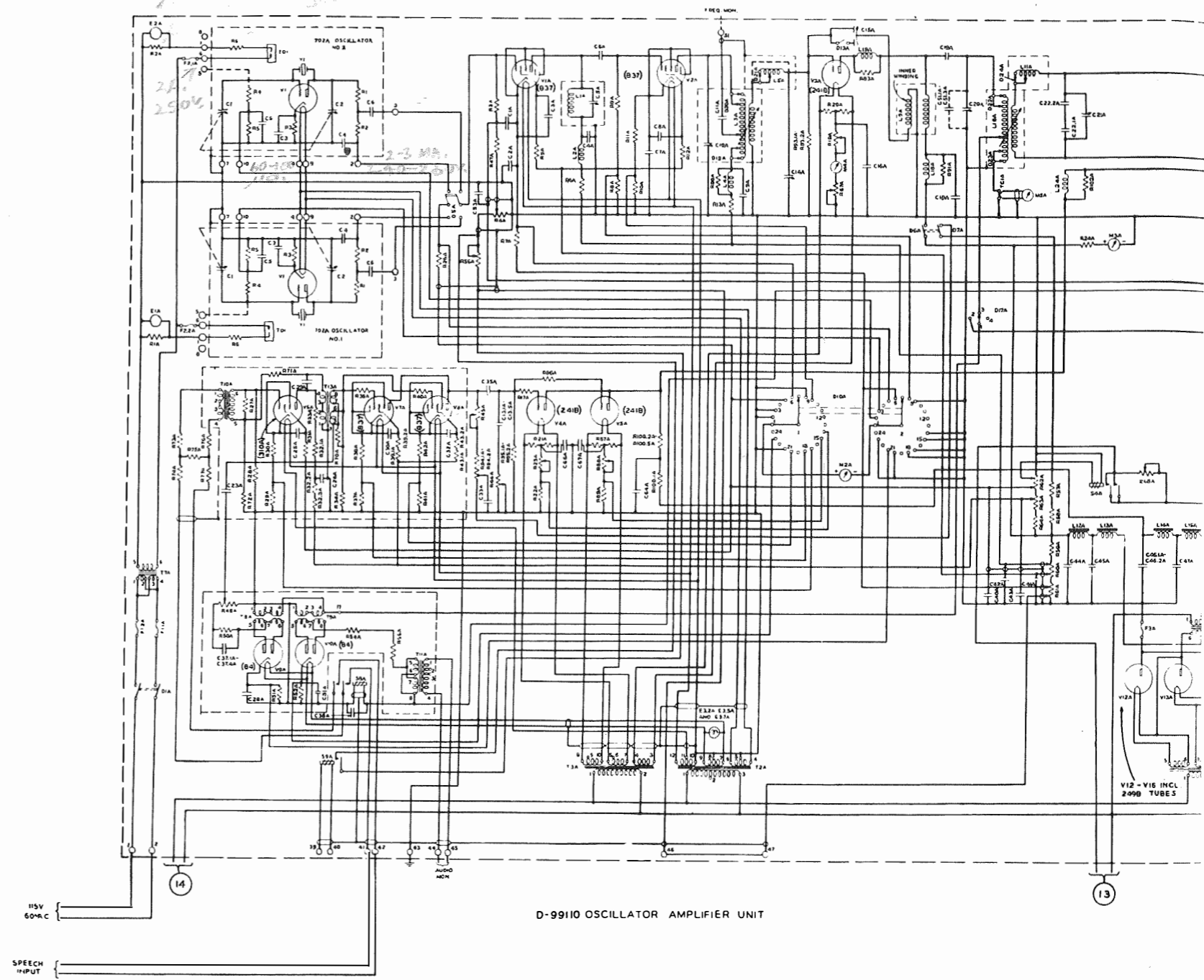
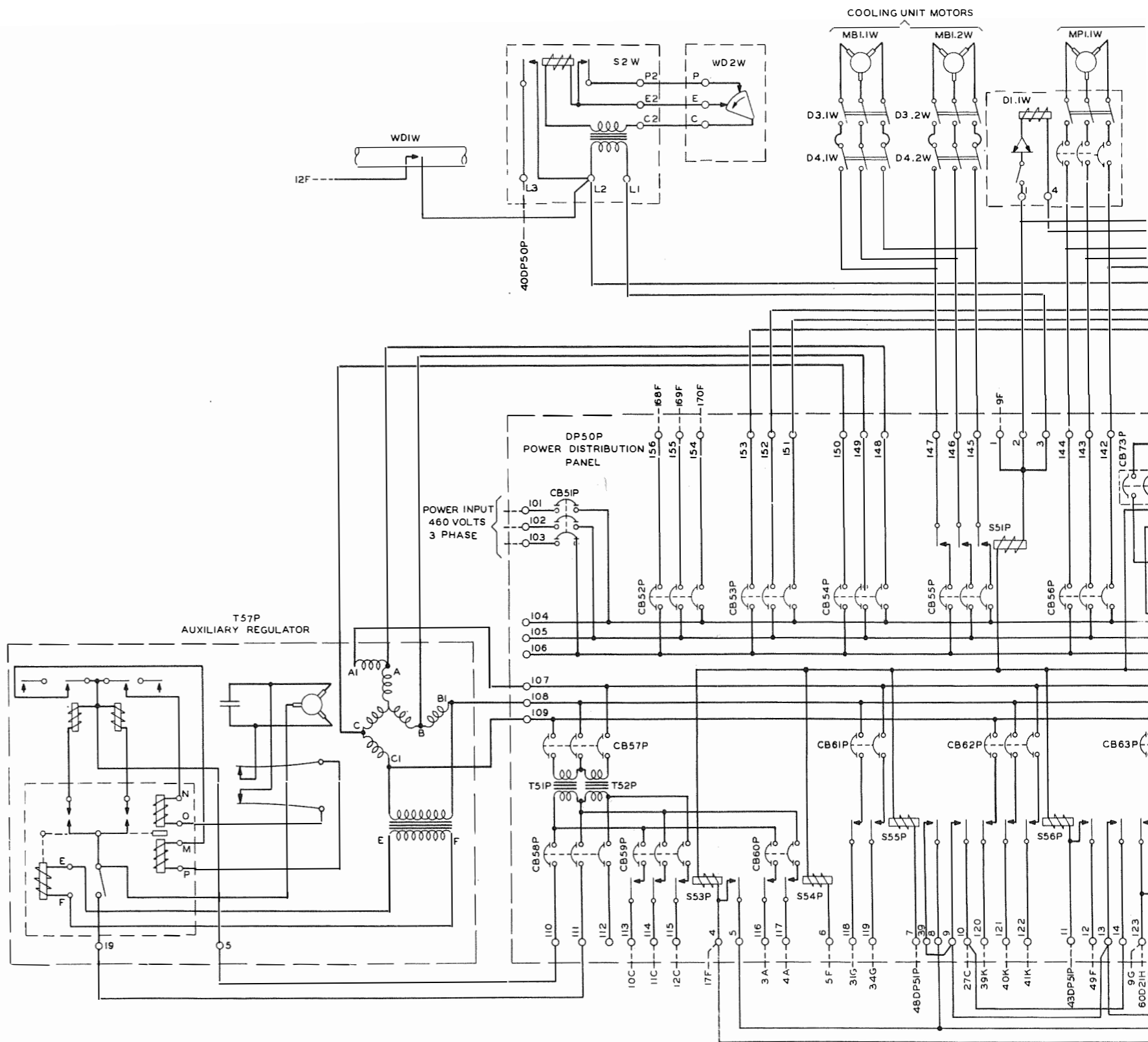


Figure 5 - System Schematic







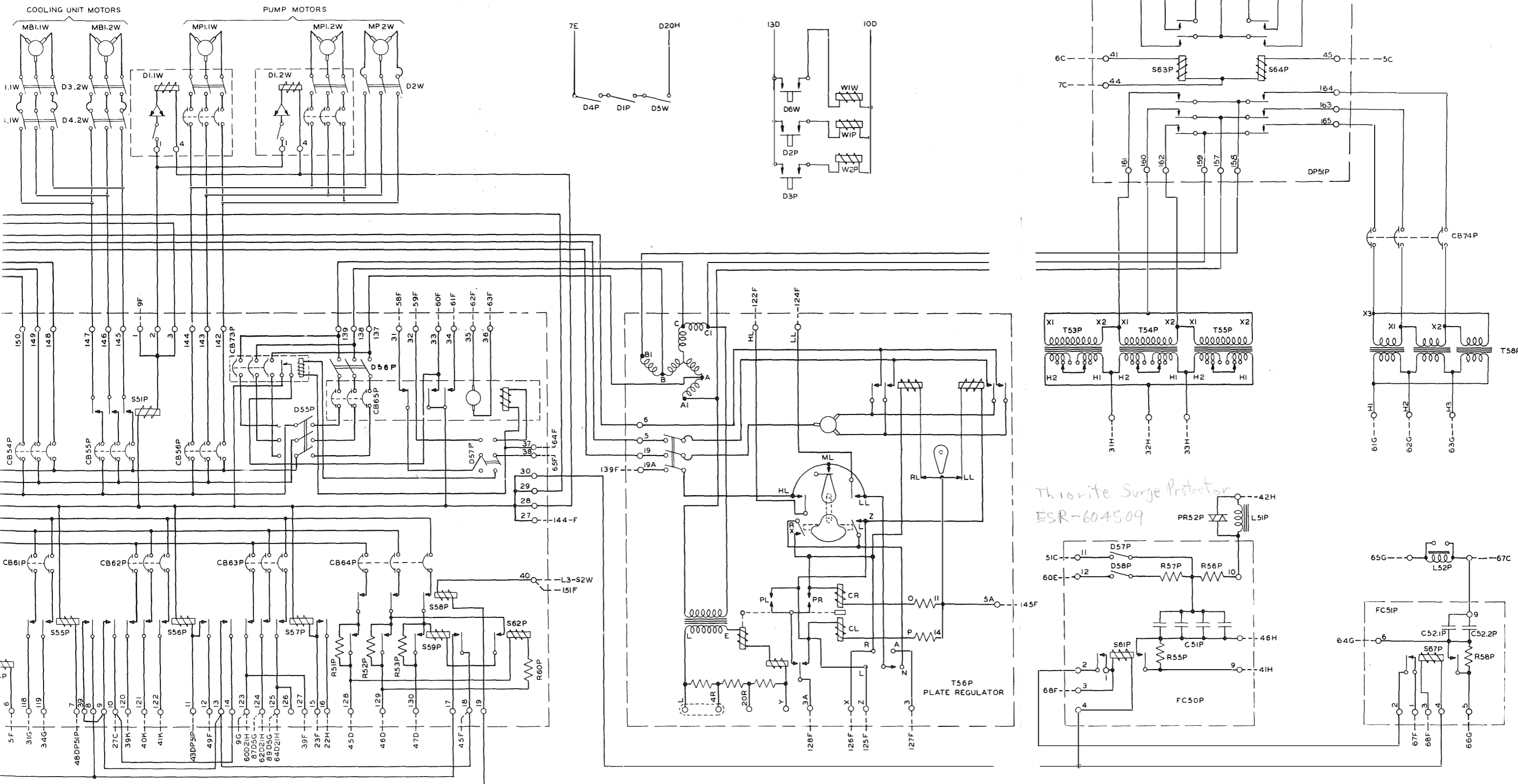


Fig. 1 - Power System - Schematic

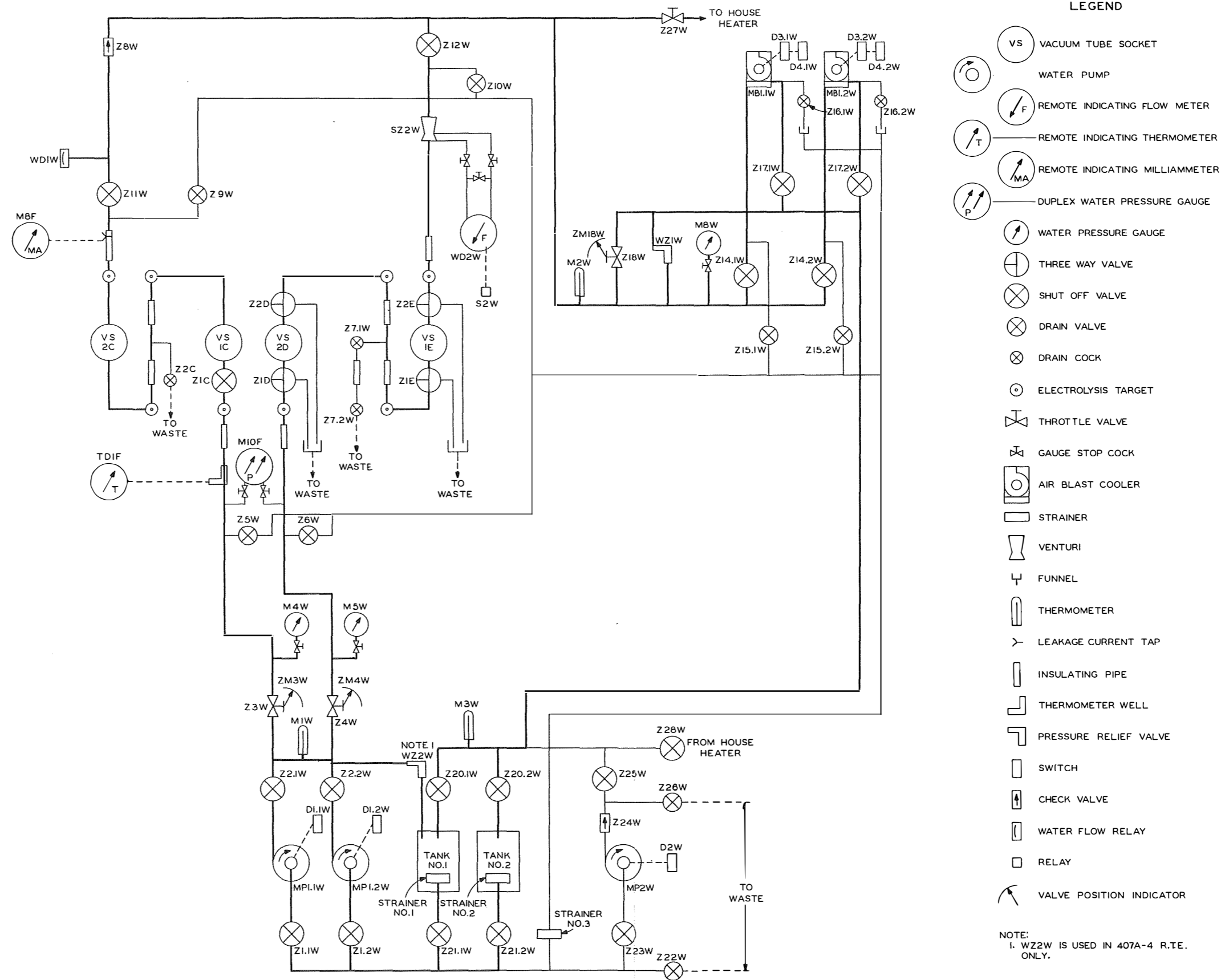


Figure 6 - Water-Cooling System - Schematic

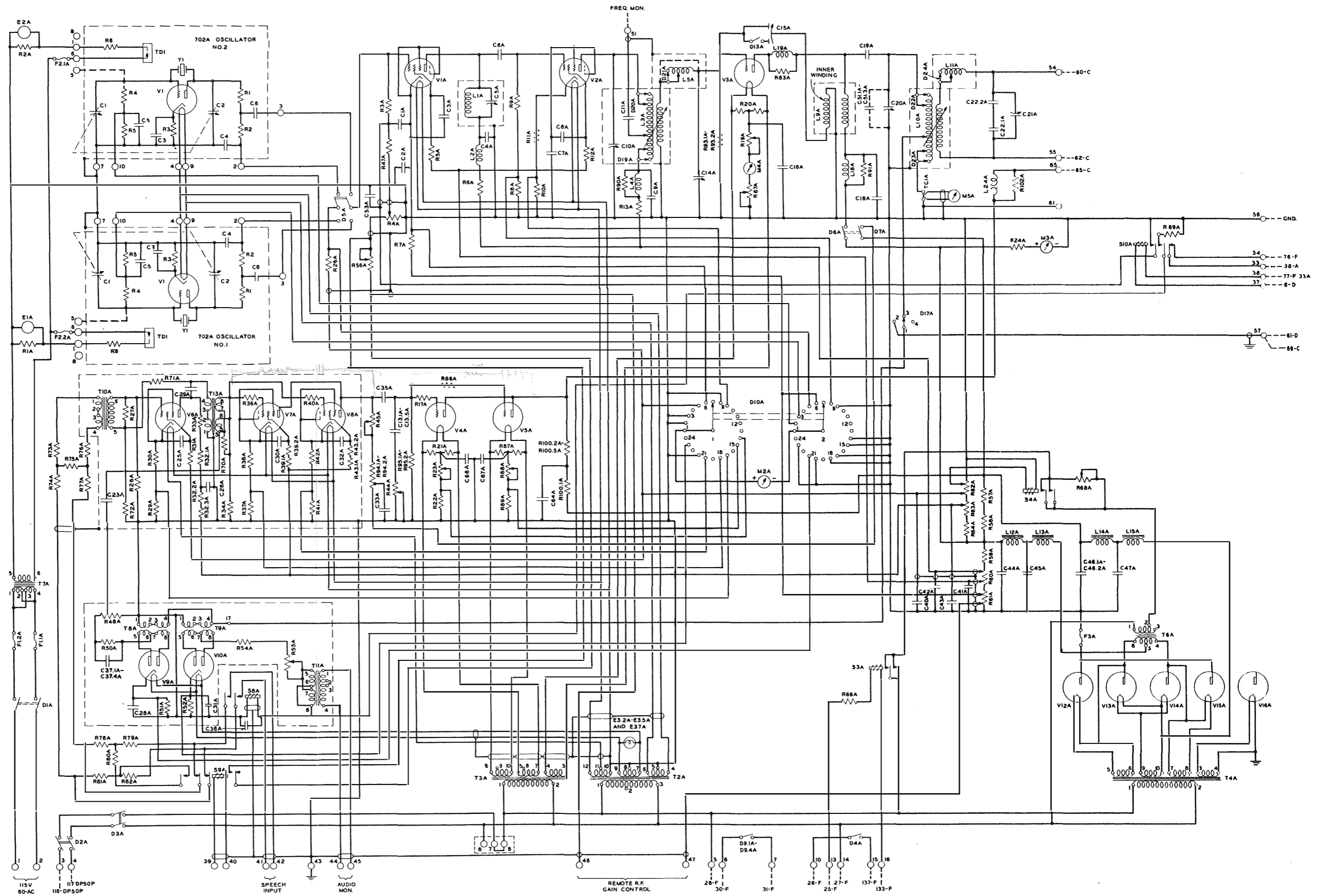


Figure 7 - Unit A - D-99110 Oscillator Amplifier - Schematic

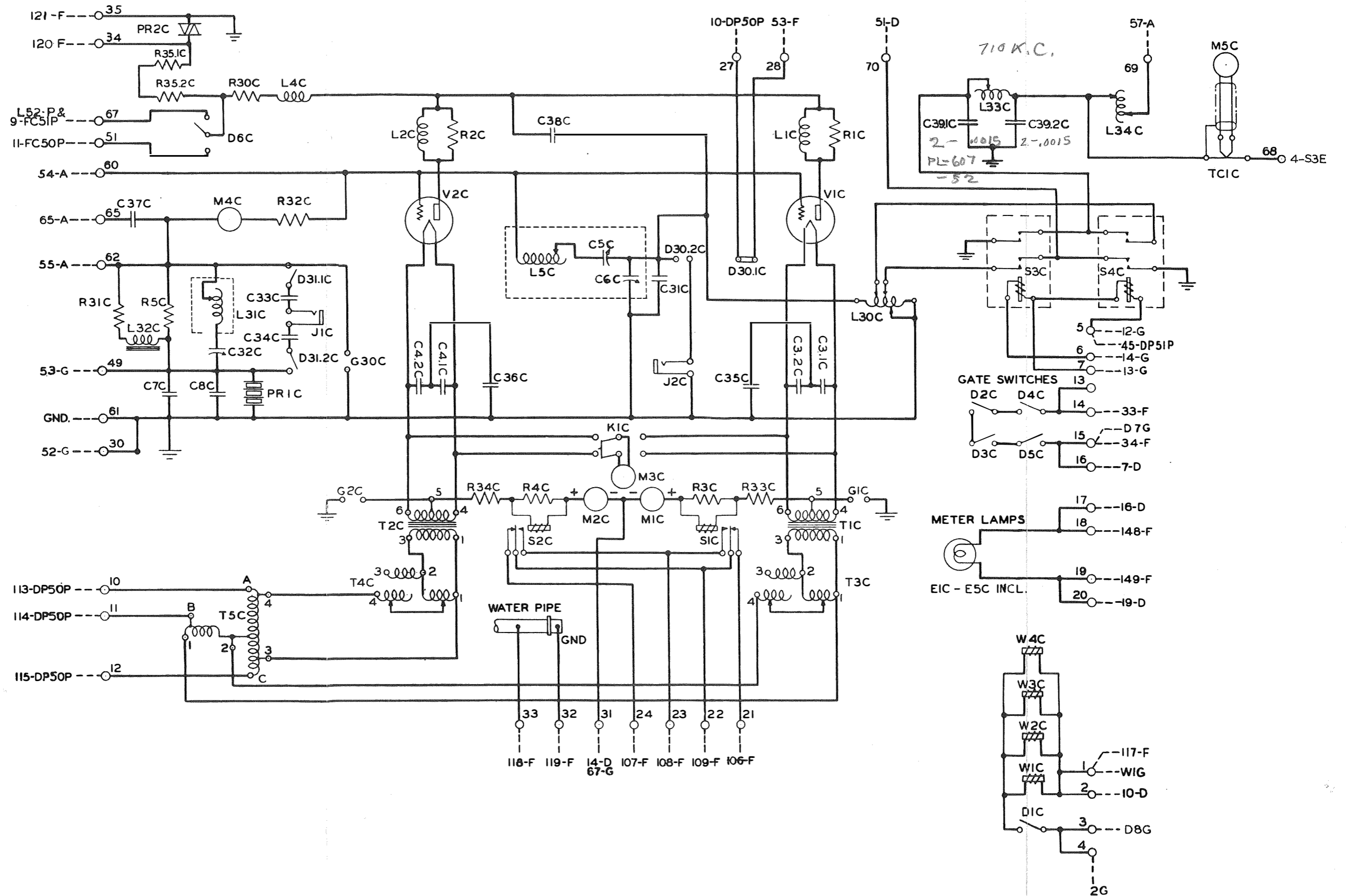
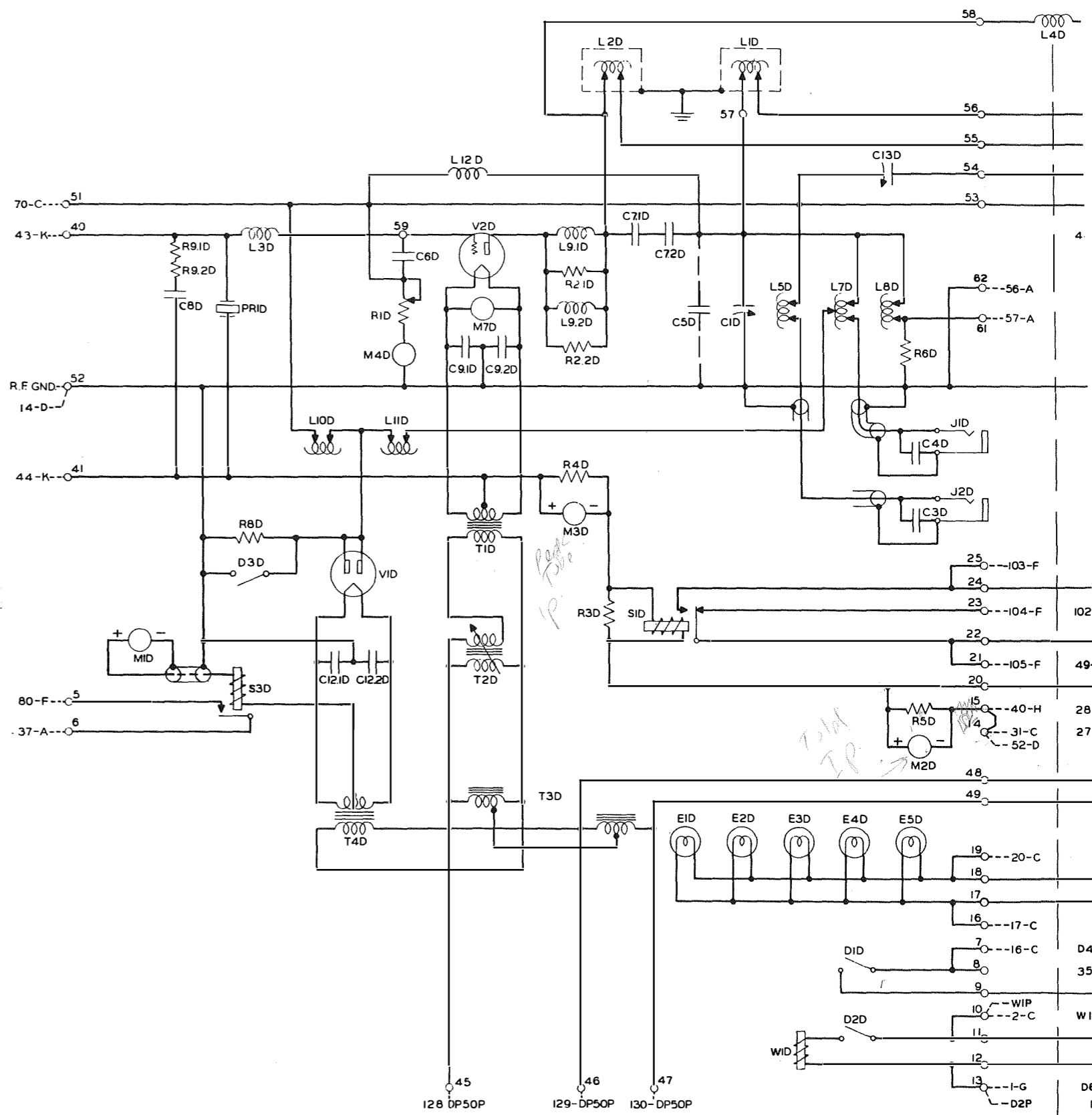


Figure 8 - Unit C - D-151135 Modulating Amplifier - Schematic



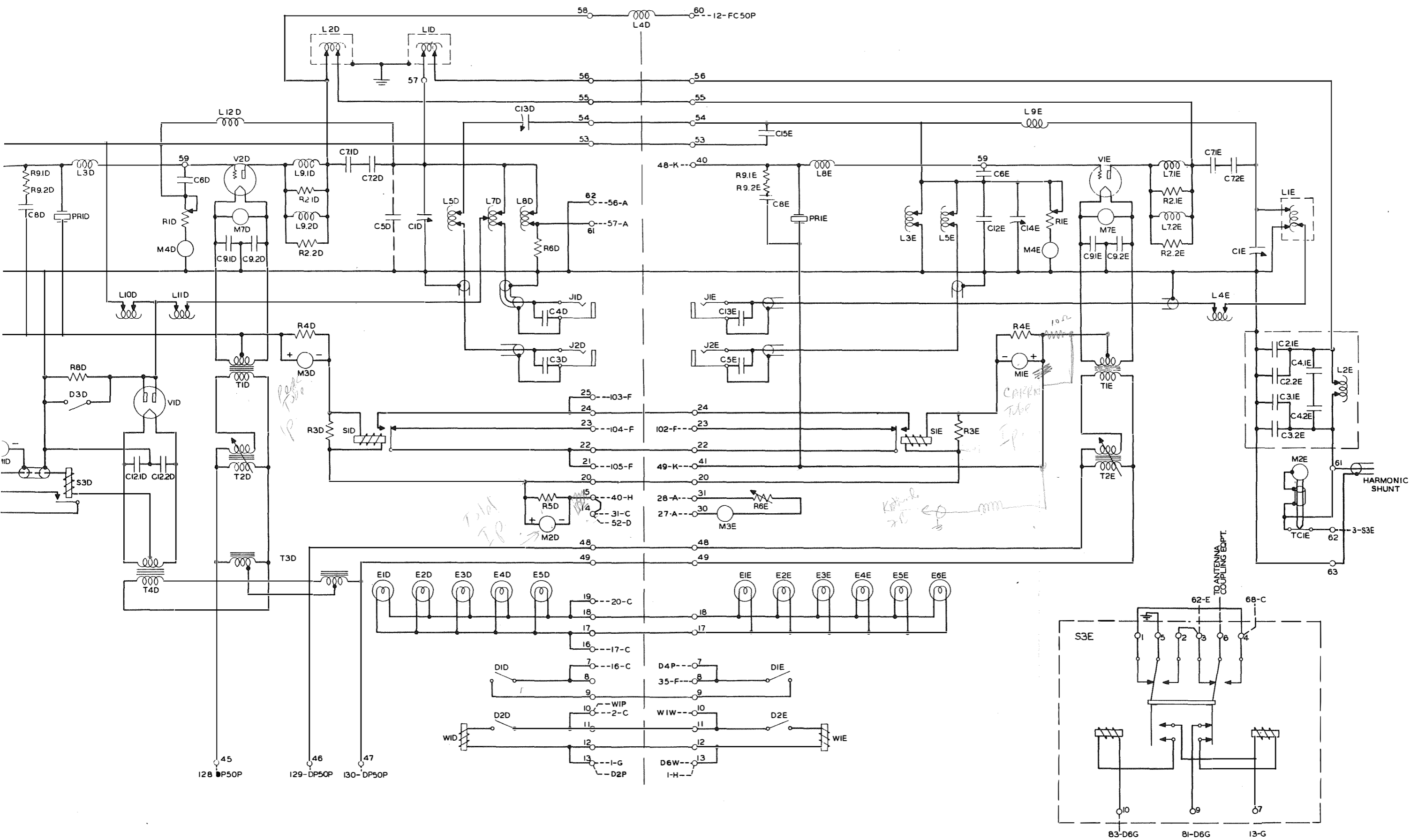


Figure 9 - Units D and E - D-99118 Power Amplifier - Schematic

ROTAX FLOW CONTROLLER

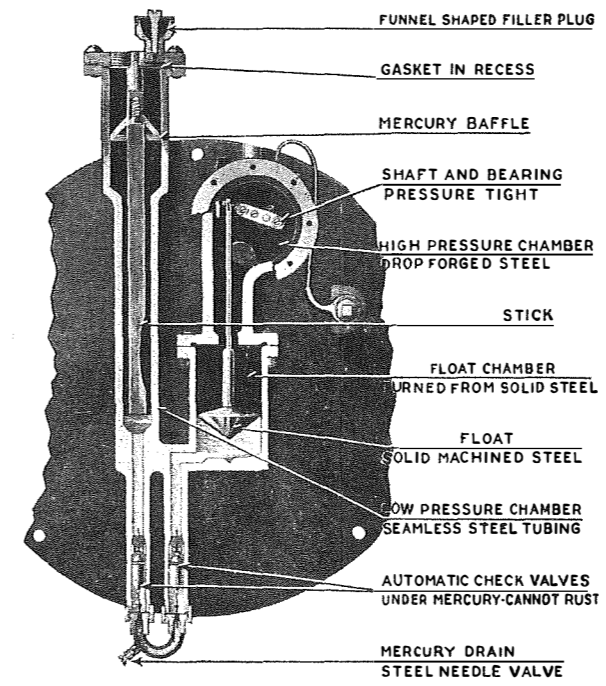


Figure 10 - Cross-Section of Chambers

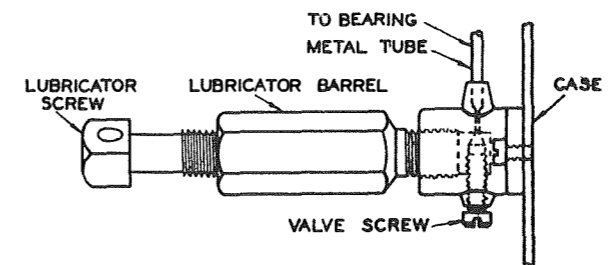
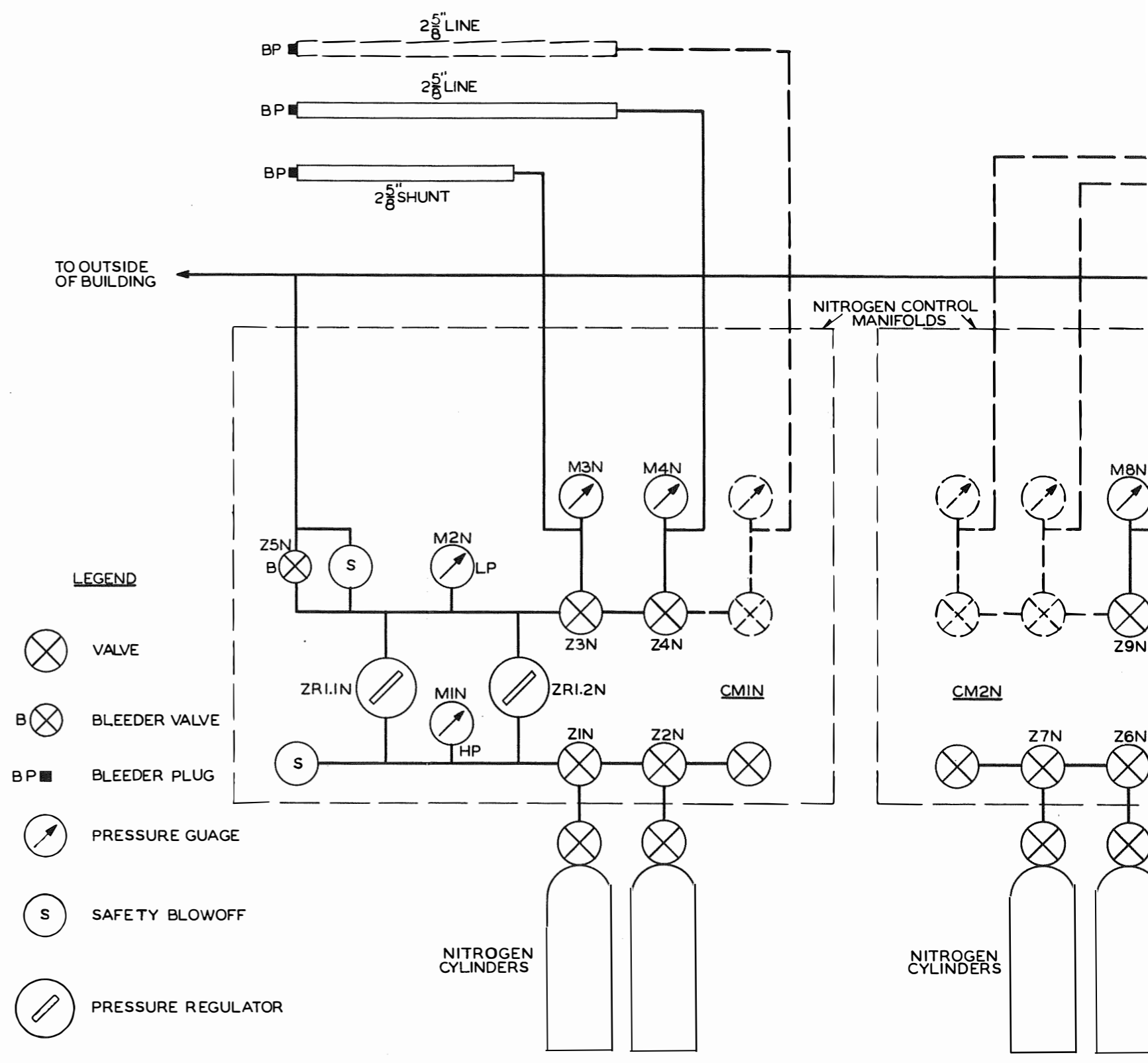








Figure 11 - Lubricator



LEGEND

-  VALVE
-  BLEEDER VALVE
-  BLEEDER PLUG
-  PRESSURE GAUGE
-  SAFETY BLOWOFF
-  PRESSURE REGULATOR

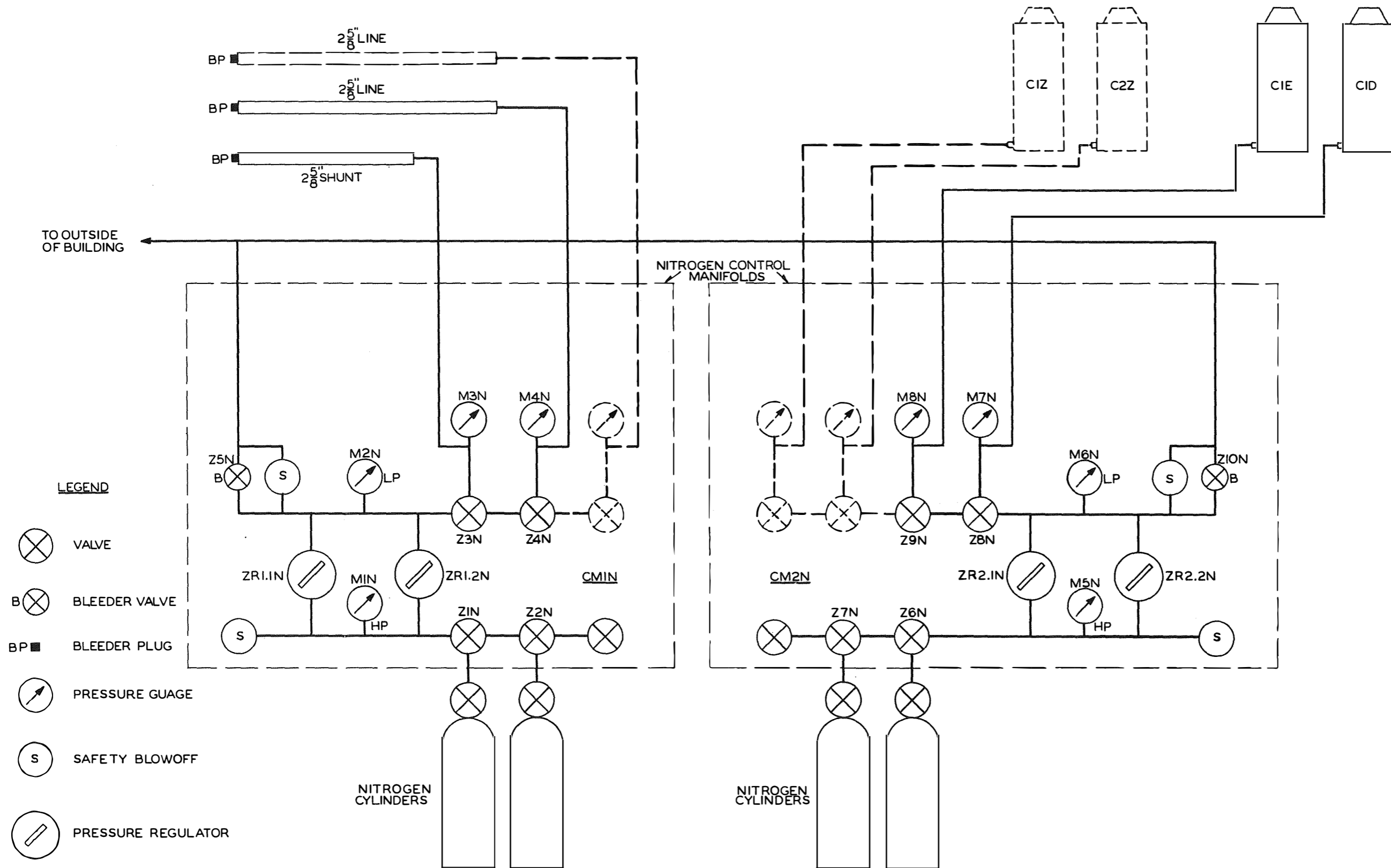


Figure 12 - Nitrogen Gas System



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