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WORLD WIDE INSTRUCTION

Technical Lesson **54**

ELECTRICALLY OPERATED TUNED R-F AND SUPER-HETERODYNE RECEIVERS

In the first part of this lesson we take up Tuned Radio-frequency Receivers. Since the theory of operation of all tuned radio-frequency circuits are practically the same we make use of a standard Majestic A-C set which incorporates the principles to be discussed. In the second part of the lesson on Electrically Operated Super-heterodyne receivers the Radiola 60 is used as a means of acquainting you with the principles of this type of circuit.

A schematic diagram of the Majestic receiver is shown in Figure 1. Eight vacuum tubes are employed, seven of which operate in the receiver proper, and the eighth in the socket power unit. The latter tube is a filament type rectifier used for converting the a-c supply into direct current. By referring to Figure 1 it will be seen that the receiver is of the conventional radio-frequency type employing ganged variable condensers which permit the use of a single dial tuning control. The tuning condensers are marked on the diagram C-1, C-2, C-3 and C-4. It can be observed that each tuning condenser is connected across both the secondary inductance of the radio-frequency transformer and a balancing coil. The purpose of the latter coil is explained in a subsequent paragraph. A special feature is the use of a push-pull power amplifier circuit. This arrangement provides an undistorted output and is designed to operate in conjunction with an electro-dynamic speaker. The speaker obtains its d-c energizing current from the output of the rectifier.

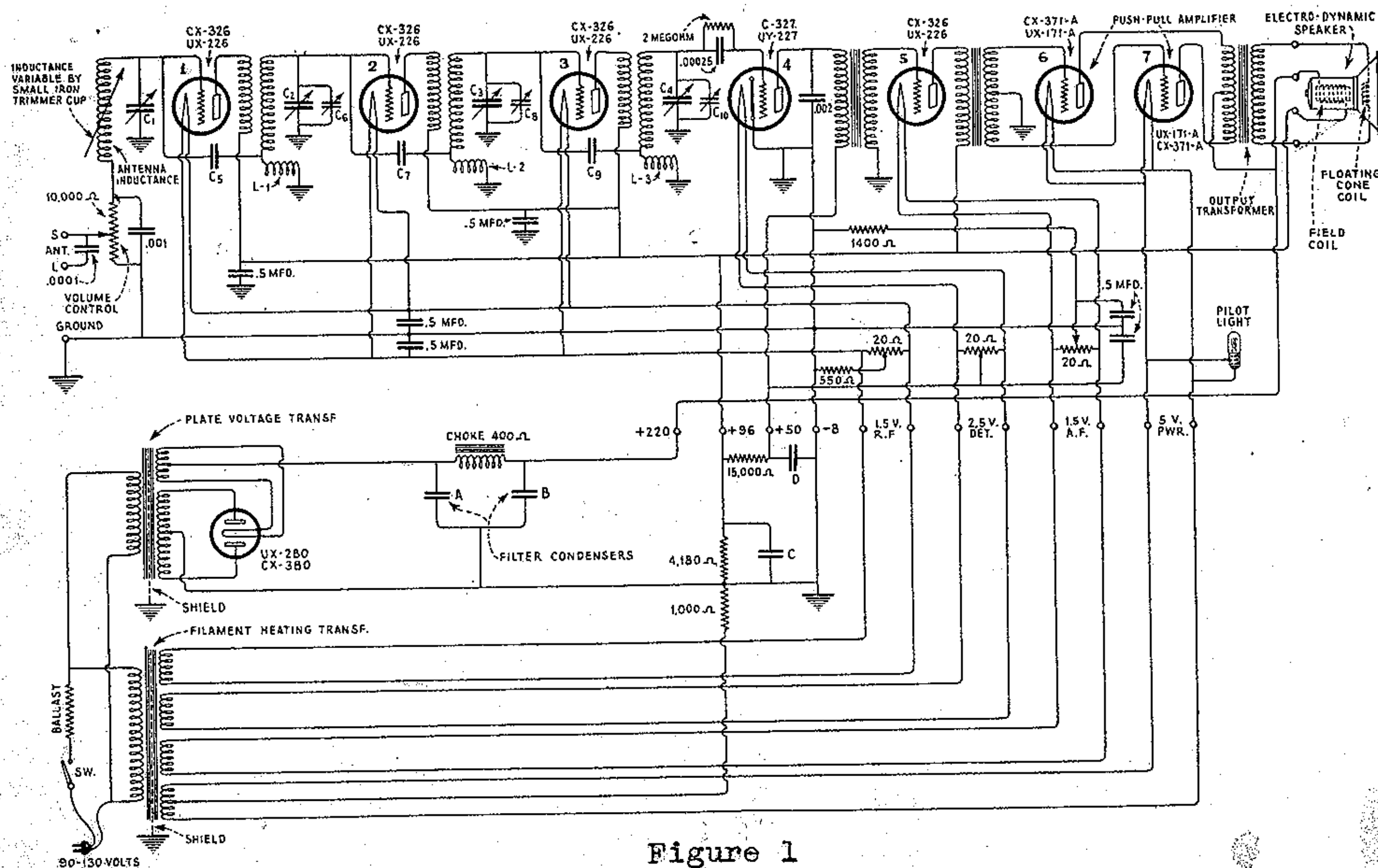

Figure 1

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The design of the input system, which delivers energy from the signal oscillations passing through the antenna to the grid of the first tube, and volume control which regulates the amount of this signal energy, require special consideration. The control of volume is effected by varying the amount of resistance used in the antenna circuit and thus any desired voltage drop may be obtained from across this unit providing, in turn, any degree of volume. The selectivity of the input circuit is controlled by the antenna "trimmer" which is an integral part of the antenna inductance. Adjustment of the position of the trimmer cup with respect to the inductance alters the inductance of the antenna and consequently its frequency. The radio frequency field surrounding the inductance is affected by the presence of this metal cup. By moving the cup, as we have just stated, the input circuit can be adjusted to exact resonance with the other three tuned circuits. Distant stations may often be tuned-in because of the selectivity provided by the trimmer control which is desirable where a number of local stations are spread well over the broadcast frequency range.

Figures 2 and 3 illustrate the schematic diagram and wiring diagram respectively of the input system. The internal view of the chassis with bottom removed is shown in Figure 4.

The five units which comprise this receiver are classified as follows: (1) The chassis, on which is mounted the input circuit with volume control, the balancing condensers, by-pass condensers, and the three audio frequency transformers. (2) The tuning condenser assembly, which consists of four-gang variable air condensers, and the panel lamp which illuminates the dial. (3) The radio frequency transformers are mounted within individual metal containers which act as an electrostatic and electromagnetic shield. (4) The terminal strip for the power cable on which is mounted the grid condenser, the grid leak, the detector plate radio frequency by-pass condenser, the center-tapped resistances, and two bias resistance units, and (5) the wiring cable completes the assembly units. The reverse side of the set terminal block showing the fixed resistors is illustrated in Figure 5.

All of the tube filaments are supplied with raw a-c. from the several secondaries on the power transformer. The arrangement of the tubes in the receiver, looking at the chassis from the rear and counting the order from left to right is as follows: The radio frequency amplifier tubes, type UX-226 or CX-326, are Nos. 1, 2, and 3. The detector is No. 4 using the heater cathode type tube, UY-227 of C-327. Tube No. 5 is the first audio amplifier, type UX-226 or CX-326. The push-pull power amplifiers are Nos. 6 and 7 and are of the UX-171A or CX-371A type. The e.m.f. at the terminals of the filaments is slightly less than their normal voltage rating, this being done to increase the useful life of the tubes.

The stabilizing of each radio frequency amplifier circuit to prevent self-oscillation is accomplished through a balancing circuit known as the LMC circuit, this design being licensed by the Radio Frequency Laboratories. This circuit uses a fixed value of inductance and an adjustable capacity. The inductance is a small coil mounted within the transformer secondary and at right angles to it. The balancing inductances and capacities are easily recognized in the diagram. Each radio frequency amplifier consists of an inductance and condenser which is associated with each circuit.

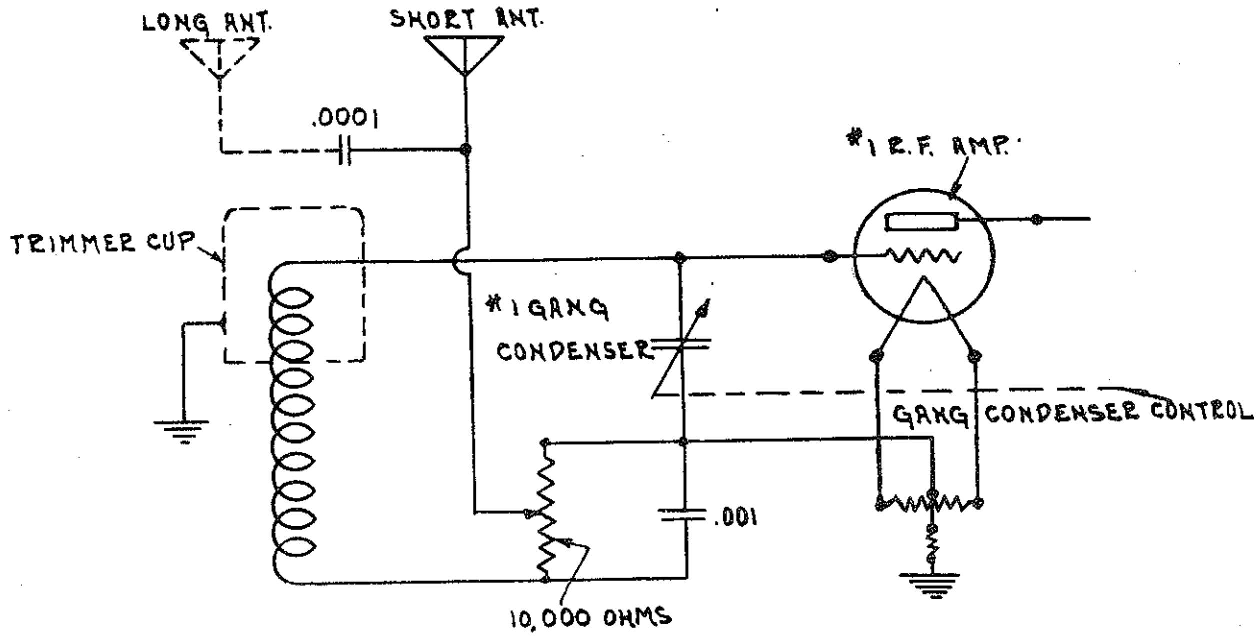

Figure 2

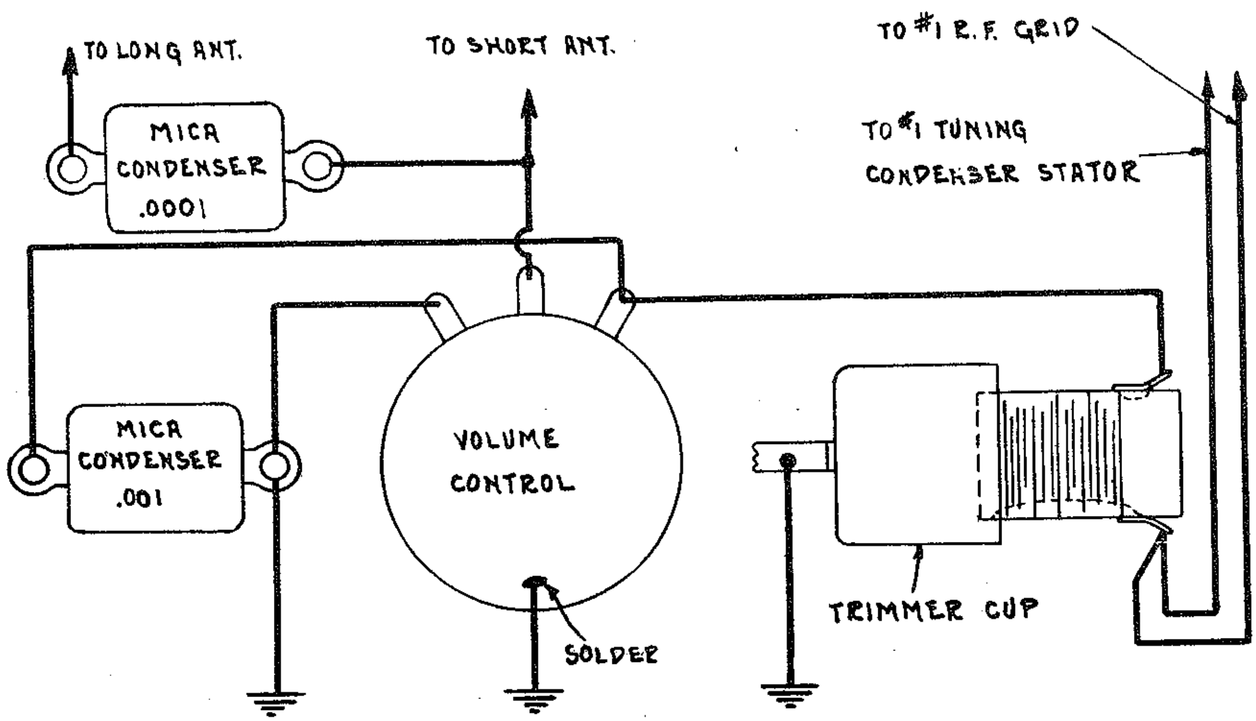

Figure 3

They are marked as follows: C-5 and L-1 constitute the balancing circuit for the first radio amplifier; C-7 and L-2 for the second amplifier; C-9 and L-3 for the third amplifier. The input tuned circuit to the detector does not require neutralizing.

The main tuning condensers, C-1, C-2, C-3 and C-4 are each shunted by a small adjustable condenser, known usually as the trimmer condenser, used for the purpose of establishing synchronism between the tuned stages. These trimmer condensers are marked C-6, C-8 and C-10. After once adjusting these condensers they do not as a rule require further adjustments unless parts are replaced in the tuned stages.

The input signal voltage obtained from the antenna resistance is impressed across a 0.001 mfd. condenser which is part of the resonant circuit of the first r.f. amplifier. This form of coupling the antenna to the first tube input circuit is known as "conductive coupling." The degree of coupling is controlled by the relative reactances of the component parts of the circuit.

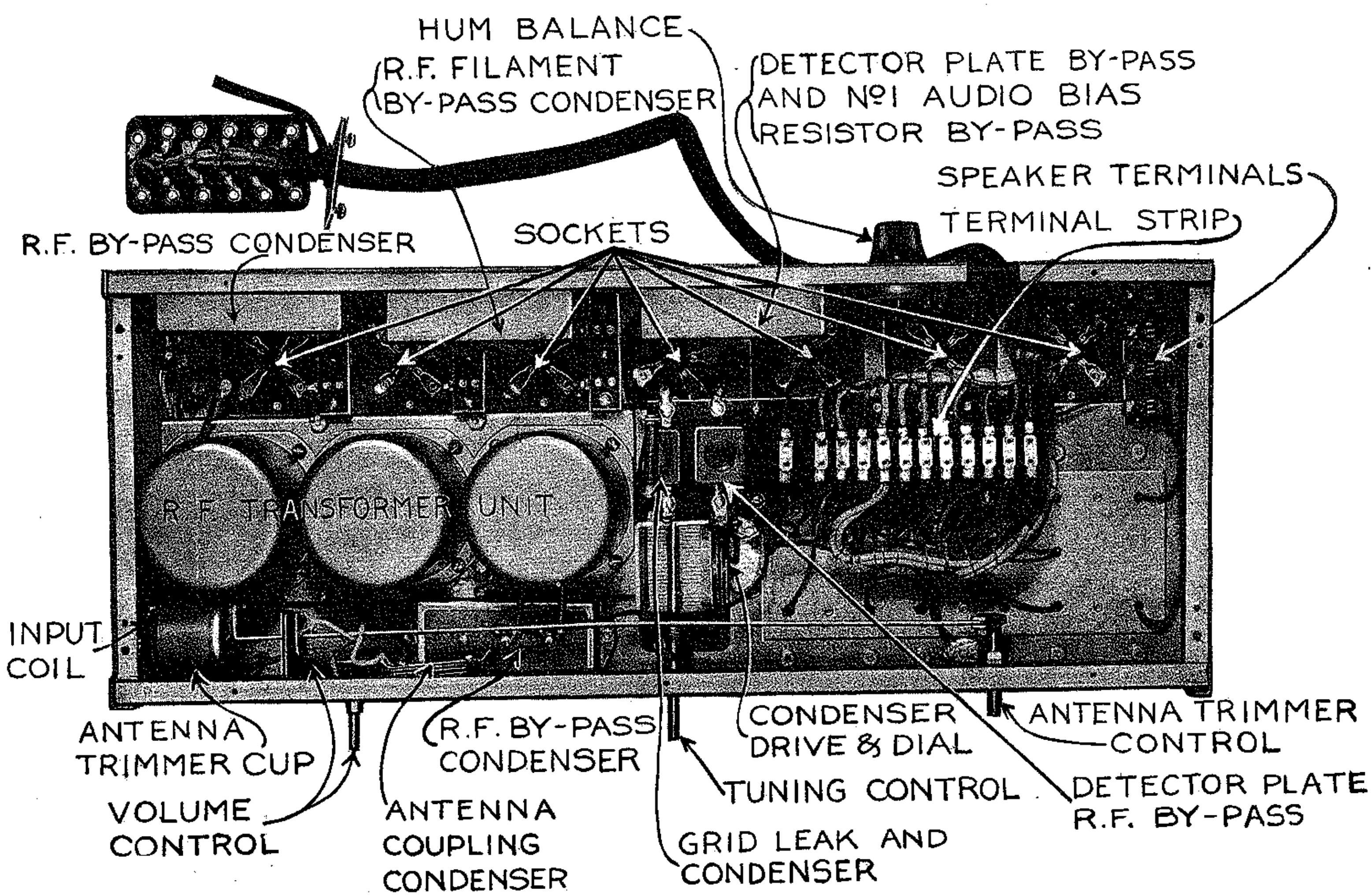

Figure 4

The antenna resistance is operated as a potentiometer or simple voltage divider and connected across the 0.001 mfd. condenser and, as can be readily seen in the diagram, the movable arm attached to the antenna lead controls the amount of resistance used and hence controls the signal voltage impressed across this condenser. This provides the volume control that we have already referred to in a foregoing paragraph.

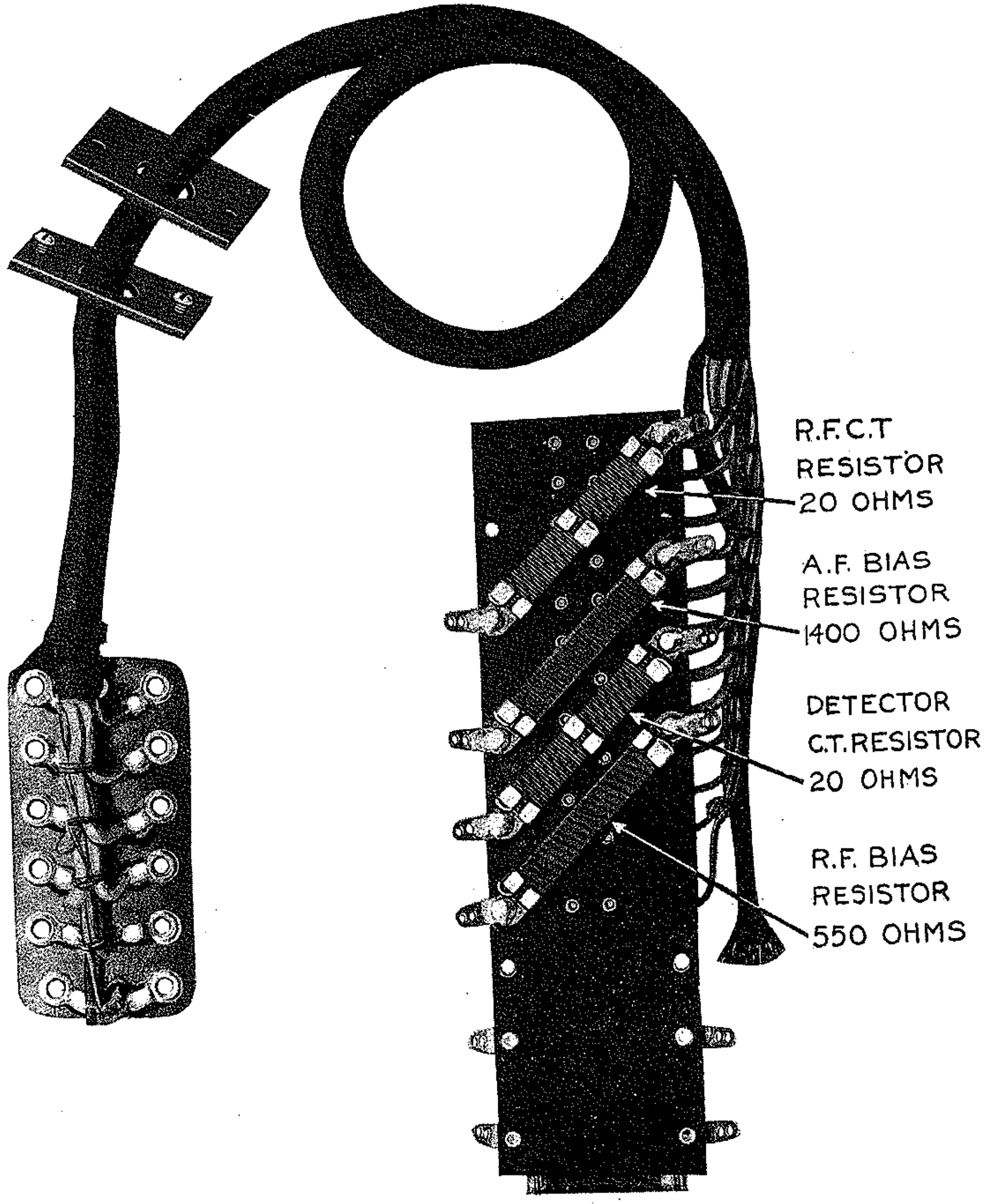

Figure 5

The purpose of the antenna trimmer is to provide means for establishing resonance between the input tuned stage and the following three tuned radio frequency stages. In effect, the antenna trimmer acts as a vernier adjustment varying the inductance of the input system and therefore it can be used to compensate for the difference in reflected antenna capacities at the various broadcast frequencies throughout the range of the receiver.

In the event a very short antenna is used, and if the radio frequency tube shields are not in place, a condition which might happen; for example, when a set is being serviced, it will be noticed that the minimum volume does not occur when the volume control knob is in the extreme low position, a few degrees toward the left but rather at some advanced position a few degrees toward the right. This peculiar result is to be expected in such circumstances because of the differential action between the small pickup of energy from a short antenna and the correspondingly large pickup of the unshielded tubes themselves. Anyone who services receiving sets should make a mental note of this condition as it will often save considerable time for it is a natural result and one might at first thought attribute it to a defective volume control.

A clear and simple diagram of the socket power unit is shown in Figure 1. Two power transformers are used, one for the plate voltage supply and the other for the filament heating current of the tubes. The alternating current output of the plate voltage transformer feeds into the full-wave rectifying tube. The pulsating direct current provided by the rectifying action of this tube passes to the choke coil and to the dynamic speaker field coil and condensers comprising the filter system. Hence the smoothed out d-c. flows through the various resistors to give the proper plate voltages for energizing the various tubes and the proper "C-bias" to the two power tubes. An examination of the diagram shows that the inductance of the field of the dynamic speaker is used as one choke coil in the filter system. Also the resistance of this winding utilizes the fall of potential method to reduce the high "B-voltage" output of the rectifier tube to the lower voltage required for the three radio frequency tubes and the first audio frequency amplifier tube. It requires a dynamic coil resistance of 3100 ohms to drop the voltage from 220 volts to 96 volts, the coil being shown connected to the terminals marked 220 volts and 96 volts. The lower voltage is used for the radio and first audio amplifiers as previously mentioned. Thus it can be seen that the speaker field coil serves a double purpose in this power unit, the first is to furnish the strong and steady magnetic field in which the small cone coil from the output of the power tubes transformer is placed, and the second to provide resistance to obtain a certain voltage drop for tube place excitation.

The resistance of 1500 ohms provides a voltage drop of 46 volts, thus reducing the 96 volts positive to 50 volts positive for the detector plate supply. The fall of potential across the 4180 ohms when current flows is 50 volts, hence the lower end of this unit is the -B side of the power circuit. The high grid bias of the -40 volts is obtained from the voltage drop across the resistor marked 1000 ohms.

A resistance ballast is incorporated in the design of the power transformer. This resistor is connected in series with the primaries of the transformers and it functions as an automatic line voltage control to give a practically uniform voltage across the transformers for line voltage fluctuations between the limits of 90 and 130 volts. This feature insures that a practically normal voltage will be supplied to the filaments, plates and the grids requiring a bias, under all normal conditions.

A skeleton wiring diagram of certain portions of the receiver and power unit showing the bias and center-tapped resistors and by-pass condensers is illustrated in Figure 6. The "hum" balance potentiometers are shown connected across the power transformer secondaries. The values of the potentiometer resistances are marked on the diagram, as well as the values of the d-c. plate voltages, the plate resistors, and filament terminal voltages. The plate current to the individual tube circuits can be easily traced when using a diagram of this kind. It would be excellent practice if you would try your skill drawing a circuit of this type from the main schematic diagram of any model receiver and in this way you will undoubtedly become familiar with the exact construction of the various circuits of modern socket powered radio receivers. It may be difficult to do this at first, but persevere and you will eventually find it quite simple to take the complexity out of any diagram.

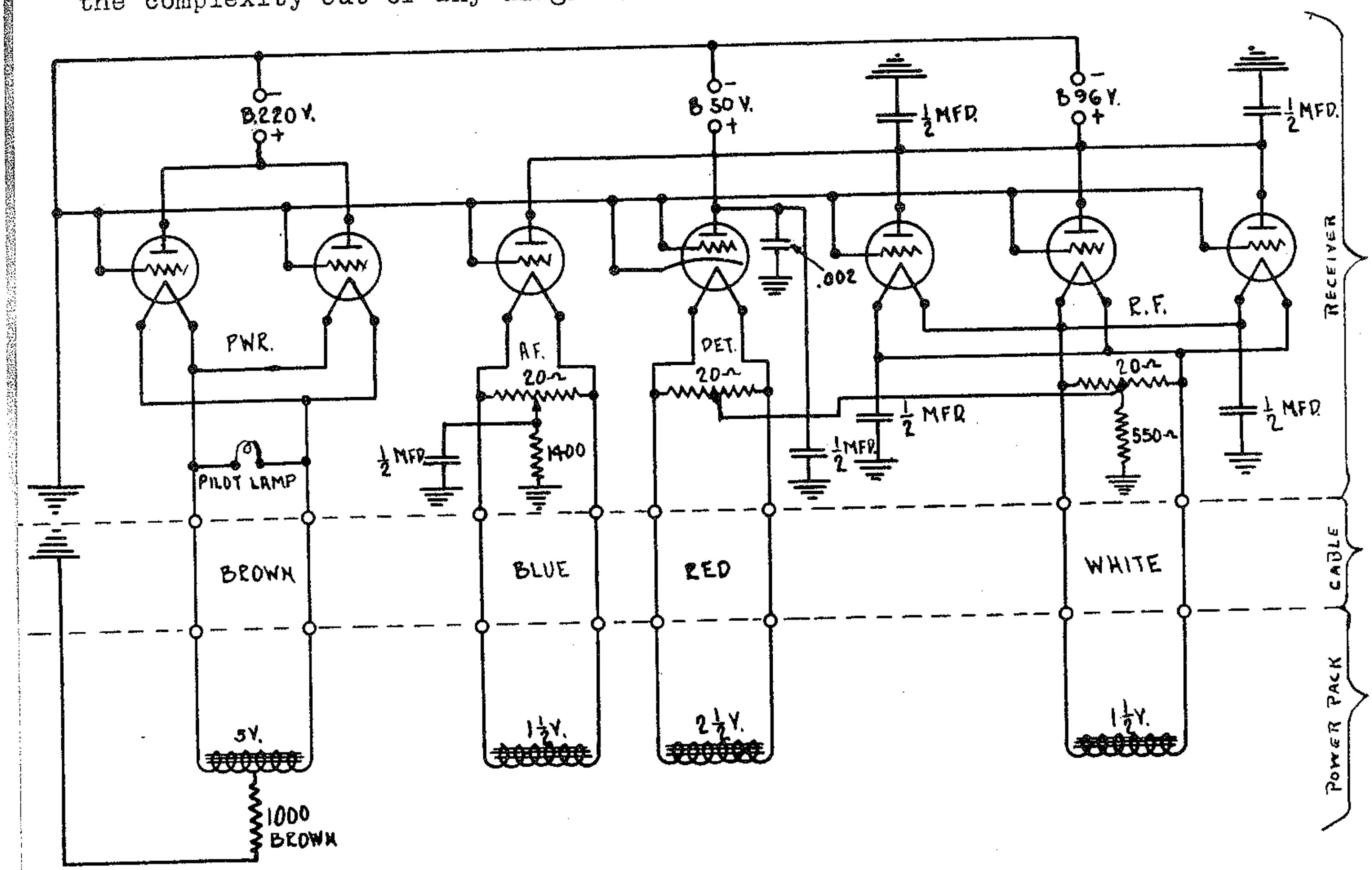

Figure 6

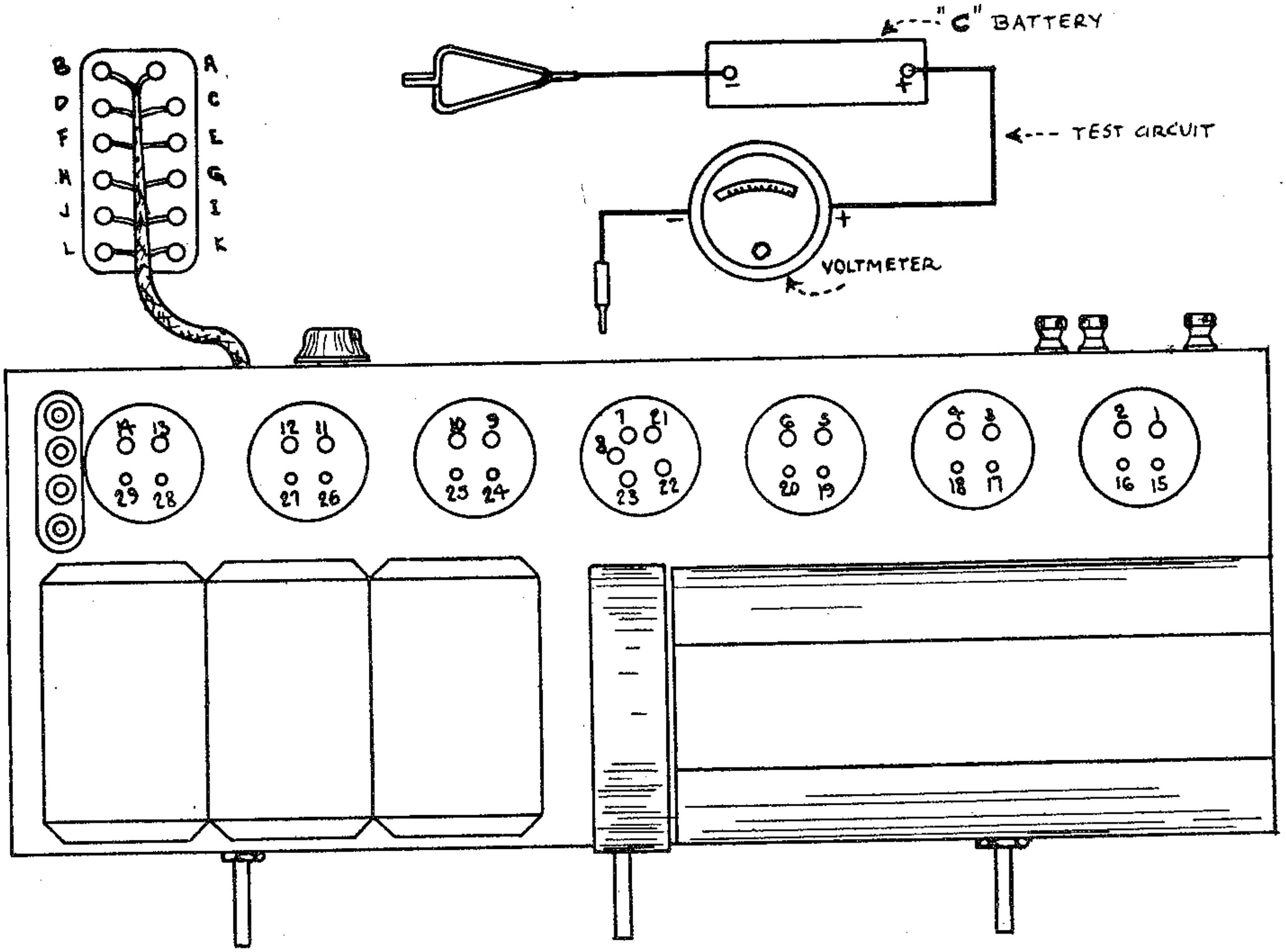

Figure 7

The method used in this receiver for obtaining the grid biases is by grounding the grids of the amplifiers and applying a positive potential to the filaments. It will be recalled that in some types of battery operated sets the filaments are at ground potential and a negative bias is applied to the grids themselves by a "C" battery. The methods differ only in application because it is obvious that in either case we have a difference of potential between the grid and filament of the tube that constitutes the bias.

There are twelve continuity tests to cover this receiver immediately following. They are to be used with the continuity chart in Figure 7 which shows the seven tube sockets and the terminal strip.

When the test clips are placed at the locations suggested in the accompanying test chart and a reading is obtained on the voltmeter, when making each test with the exception of No. 12, it indicates that the respective circuits are continuous from one end of the respective cable leads to the spring contacts in the sockets. This procedure tests both the wiring and the associated apparatus.

TESTS

1. To determine if the filament circuits of the radio frequency tubes are continuous, test from socket terminals, 1, 2, 3, 4, 5, 6, continuous to both E and F on the terminal strip.

2. To determine if the filament circuit of the detector is continuous, test from socket terminals 7 and 8 continuous to both G and H.

3. To determine if the filament circuit of the first audio tube is continuous, test from socket terminals 9 and 10 continuous to both I and J.

4. To determine if the filament circuits of the push-pull power tubes are continuous, test from socket terminals 11, 12, 13, and 14 continuous to both K and L.

5. To determine if the grid circuits of the three radio frequency and three audio tubes are properly grounded, test from socket terminals 15, 17, 19, 24, 26 and 28 continuous to ground.

6. To determine if the grid circuit of the detector is continuous, test from socket terminal 22, through the grid leak, continuous to ground.

7. To determine if the plate circuits of the three radio frequency tubes and the first audio frequency tube are continuous, test from socket terminals 16, 18, 20 and 25 continuous to C.

8. To determine if the detector heater and plate circuits are continuous, test from socket terminals 7, 8 and 21 continuous to B.

9. To determine if the plate circuits of the two 171A power tubes and the primaries of the input push-pull transformer are continuous, test from socket terminals 27 and 29 continuous to D.

10. To determine if the detector cathode circuit is continuous, test from socket terminal 23 continuous to ground.

11. To determine if the center-tapped resistors and bias resistors of the three radio frequency tubes and the first audio frequency tube are continuous and effective in their respective circuits, test from socket terminals 1, 2, 3, 4, 5, 6, 9 and 10 continuous to ground.

12. To determine if the filament circuits of the two power tubes and the heater circuit of the detector are not grounded at any point, test from socket terminals 7, 8, 11, 12, 13 and 14 <u>open</u> to ground.

Disconnect the power unit system from the terminal strip before proceeding with all tests given above.

The R.C.A. Model 60 Super-heterodyne receiver is completely socket power operated by simply plugging the extension cord of the power unit into a convenient lighting socket. The transformer in the power unit is designed to operate on 50-60 cycles a-c. of from 105 to 125 volts. By replacing a 50-60 cycle transformer with another one having suitable electrical characteristics, the receiver may be operated on 25-40 cycles. A replacement of this kind should only be undertaken by one who is familiar with general servicing and repair of receivers.

Each one of the eight tubes in the super-heterodyne circuit performs one distinct function and no reflexing is used. The circuit employs seven tubes of the cathode-heater type, UY-227, and one type UX-171A in the receiver unit. Rectification of the voltages for plate and grid supply throughout the receiver is accomplished by the full-wave rectifying tube,

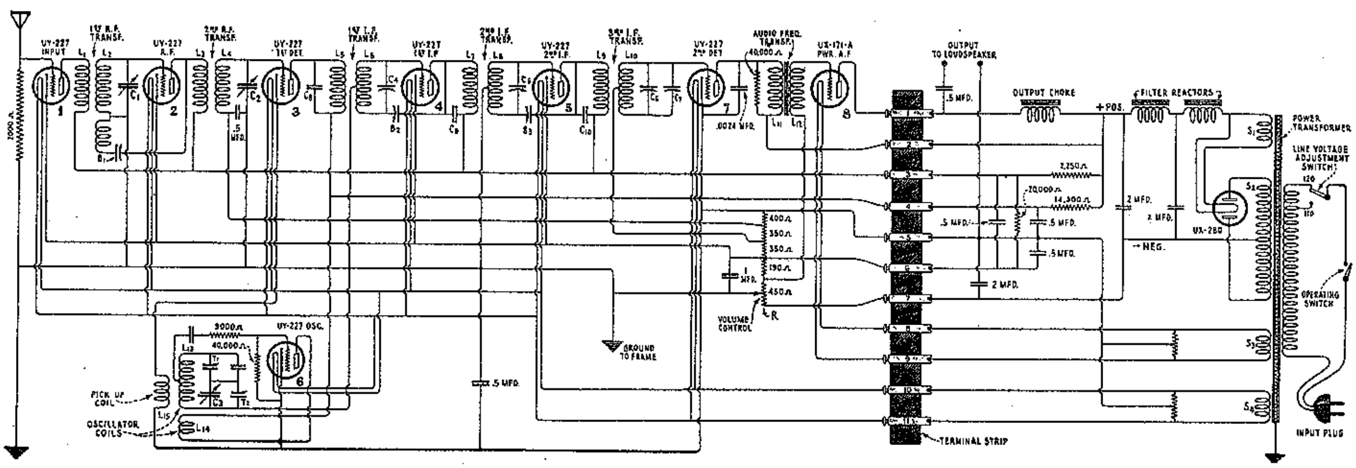

Figure 8

type UX-280, located in the socket power unit. Because of the indirectly heated cathode used in the UY-227 the use of this tube in all sockets, except the power tube socket, assures almost complete freedom from the "hum" characteristic. Remember that the electron liberating cathode consists of an oxide-coated sheath covering an insulating sleeve and the heater wire passes through the center of the insulated sleeve.

The receiver circuit comprises one untuned coupling stage, one tuned radio frequency stage, one tuned heterodyne detector (first detector) circuit, an oscillator circuit, two stages of intermediate frequency amplification, a second (power) detector, and one stage of power audio frequency amplification.

The schematic diagram of the receiver assembly and socket power unit is shown in Figure 8. Tuning of this receiver is accomplished entirely by single-dial control, and in addition, the other controls necessary for operation are the volume control and the "OFF" and "ON" power switch. A small pilot light used to illuminate the dial also serves as an indicator that the current is "on" or "off."

The component parts of the Model 60 are shown in the four views in Figure 9. The front of the panel is shown in the upper view with control knobs and with the toggle type power switch. Next is the top view of the receiver assembly showing the drum dial, the eight sockets and the three ganged tuning condensers mounted, in a rigid steel "tub" which maintains them in perfect mechanical and electrical alignment thus permitting uni-control. The photograph next below is the receiver sub-chassis assembly showing the location of various parts, while the lower view is the socket power unit.

We frequently hear the question asked, "How much does it cost to operate an a-c. receiver?" A set utilizing as many as eight tubes, citing this receiver as an example, operates at a cost of about one fifth the cost of an electric flat iron. To be more precise, such a set will consume 90 watts an hour and, estimating the average rate of electrical power at 10 cents per kilowatt hour (this rate, of course, varies according to the power companies) the expense for current per hour will average about one cent.

The volume control, shown in Figure 8, changes the bias on the radio frequency and intermediate frequency tubes. This method gives a certain reduction of signal strength even on nearby stations. In the study of radio receivers we find that any one of several methods of volume control

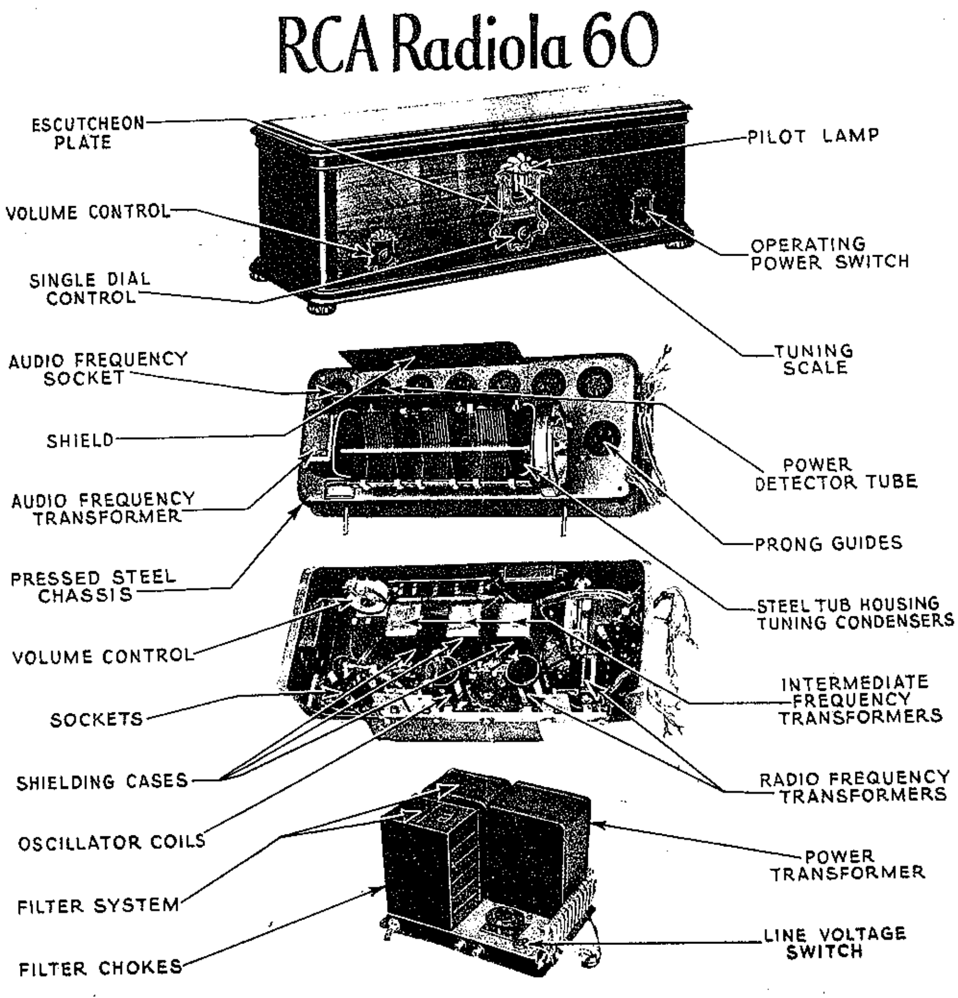

Figure 9

can be employed, such as the control of grid bias voltage as used in the circuit under discussion, the reduction of filament temperature, variable resistance in the antenna circuit, or resistance across either radio frequency or audio frequency transformers.

The sequence of the tubes in the receiver, not including the rectifying tube which is located in the socket power unit, is shown in Figure 10. In this sketch we also find the location of the adjustments for intermediate frequency neutralizing and tuning condensers, oscillator trimming condensers, and the radio frequency compensating condenser. These condensers are used to accurately balance all circuits and, in part, make possible the reduction of tuning dials to a unit-control. A metal shield is mounted directly in back of the tube sockets, as shown in the second view in Figure 9, to prevent inter-action between the tube elements and the variable tuning condensers.

Let us now discuss the basic principles involved in the reception of a broadcast signal, and its amplification and detection in the circuits of the super-heterodyne receiver. The circuit is shown in Figure 8.

First we will give in concise form the general operation of a circuit of this type. The circuit employs radio frequency amplifying stages in order to build up the incoming signal carrier frequency which feeds into the first detector; this circuit may be thought of as a mixing circuit. A separate vacuum tube circuit consisting of the oscillator and its associated inductances and capacities is operated to produce radio oscillations of a predetermined frequency and this energy also feeds into the mixing circuit, or first detector. The tuning of the circuits is so designed that the transmitting frequency (carrier frequency) of the station received will be unlike the local oscillator frequency. Thus two oscillating currents of different frequencies are simultaneously introduced into the first detector.

These energies now combine, or "heterodyne," with the result that a "beat" effect causes the setting up of another frequency of a lower order and different from either of the two frequencies which produced it. The frequency obtained through this phenomenon of heterodyning is known as the "intermediate" frequency. All of the modulation characteristics of the incoming signal are preserved in the modulated intermediate frequency. The oscillator can be made to keep a constant frequency difference when tuned with a ganged condenser, and intermediate frequency transformers can be designed with square topped tuning characteristics. This permits the modulated intermediate frequency to be passed through two intermediate stages of amplification which will efficiently pass the high frequencies without affecting the selectivity. A large signal voltage is obtained in this manner and delivered to the grid of the second detector. The second detector converts the modulated intermediate frequency to a modulated direct current known as the "audio frequency." The audio frequency output of the second detector is amplified in the customary way and finally passes into the loudspeaker circuit. The super-heterodyne circuit may or may not employ a loop antenna. The Model 60 receiver uses a short outdoor or indoor antenna which is more satisfactory than a loop, particularly in apartment houses and shielded locations..

Referring to the schematic diagram in Figure 8 we find that the full-wave rectifier UX-280 is connected to the plate winding S-2 and to a small heating winding S-1 of the power transformer. The power transformer is impregnated with a moisture-proof compound and shielded as shown in Figure 9. Again returning to Figure 8, the rectified alternating current supplied by the UX-280 passes to the filter system consisting of two filter reactors (chokes) and two 2 mfd. condensers for the purpose of smoothing out the pulsations in the rectified output. The filter reactors, working in conjunction with the high voltage condensers, provide a substantially steady flow of direct current to the voltage divider resistances. Two low voltage secondary windings, S-3 and S-4, supply alternating current of the correct voltage to heat the filaments of the power amplifier and the seven cathode-heater type tubes. Note that the seven UY-227's are all connected in parallel and to S-4. Two potentiometer resistors across S-3 and S-4 respectively provide the electrical center of the filament supply and are for "hum" balance.

If all of the receiving tubes were removed for any reason, with power entering the set, the load on the rectifier system would be reduced with a consequent rise in voltage in the output of the power unit. To avoid such a condition a fixed resistance of 20,000 ohms is shunted across the supply circuit as shown in the diagram.

As we have previously mentioned the d-c. from the output of the filter system is delivered to the voltage divider section composed of various resistor units. The electrical values for these units are indicated on the diagram.

The terminal strip between the receiver unit and socket power unit provides a convenient location for taking voltage readings across the a-c. and d-c. leads which carry power to the receiving tubes. Also the circuits of the receiver and power unit can be quickly isolated by removing the leads connected to the terminal lugs on this strip.

A line voltage adjustment switch, provided in the primary of the power transformer, permits the receiver to be operated without overloading the tubes on a-c. circuits within the limits of 105 to 125 volts. It has been demonstrated by experience that line voltage variations are within this range throughout various sections of the country. The "two-way" switch is located in the power unit. It is good practice to keep the switch in the 120-volt position unless it is definitely known that the line voltage is always below 115-volts; that is, at all hours and from day to day. Nothing short of a voltmeter reading should be accepted as an indication of the line voltage. Bear in mind that the tubes are likely to be damaged or their useful life shortened if the switch remains in 110-volt position when the set is connected to a supply line exceeding 115-volts. A little reflection on the subject of turns ratio and voltage transformation in a power transformer will immediately tell you why the precautions we have just outlined are both practical and necessary.

Let us again examine the schematic diagram in Figure 8 for the purpose of determining how the various grid, filament, and plate voltages are obtained. The diagram in Figure 11 also illustrates the arrangement of the voltage supply system and in this form the electrical relation between the component elements can be easily visualized. In Figure 8 the tapped resistor R provides the various grid and cathode voltages. The voltage drop across each section of this unit is equal to the product of the resistance in ohms times the value of the current flowing through. The resistance values are indicated on the diagram. They can be checked when trouble is experienced with a receiver, and when it is thought that the difficulty is centered in these parts. This check can be made by means of a wheatstone bridge or, if this instrument is not available, a close approximation can be obtained by employing the "volt-ampere" method. The voltage and current readings obtained permit a quick computation for determining the value of an unknown resistance. Refer to your lesson on Ohm's Law. Resistances of high values, such as several thousand ohms or more, can be checked in practical work by measuring the voltage drop across them with a high resistance d-c. voltmeter of suitable range while current of a known value flows through. (Note that the resistor strip R is placed in series with the plate return lead.) Control of volume is accomplished by moving the slider along the resistance marked 450 ohms; this change in resistance regulates the grid biasing voltage on the r.f. and intermediate tubes, as explained in the foregoing paragraph.

How the plate voltage supply for all receiving tubes is obtained can be understood by tracing out the continuity of the plate circuit, beginning at the high potential side of the power unit at the location marked "+POS." From this point note that the voltages are distributed to the plates as follows: The plate d-c. supply for the power amplifier tube, No. 8 in the circuit, passes through the output choke coil which is used in conjunction with the 0.5 mfd. condenser to couple the receiver output to the loudspeaker. The voltage on the plate of No. 8 is the difference between the voltage at point "+Pos." and the voltage drop across the output choke. The plate of second detector, No. 7, is supplied directly through the audio transformer primary around which is shunted a 40,000 ohm resistor. The voltage on the plates of the oscillator and first detector, tubes No. 6 and No. 3, is the difference between the voltage at "+Pos." and the voltage drop across the series plate resistance of 14,300 ohms. All of the radio frequency and intermediate frequency tubes receive their plate excitation through the 2,250 ohm resistance which provides the requisite voltage drop. Thus it is seen that the resistors must have correct resistance values in order to provide the specified voltages for the plates.

In order to obtain maximum performance from the super-heterodyne receiver the UY-227 tubes should be interchanged in the sockets. It is obvious that the UX-171A cannot be transposed with the other receiving tubes, it being a different type and equipped with only four prongs. The tubes best suited for particular functions are determined as follows. A tube which will not oscillate should be inserted in the tuned radio frequency stage, marked No.2. The compensation condenser can be readjusted to suit a particular tube until no oscillations occur. A tube giving the loudest signal when the set is tuned-in should be used in the oscillator stage, marked No. 6. The second detector should be a tube which will give the greatest volume before overloading occurs. The other tube circuits are not critical. Among any seven tubes of similar type no difficulty will be found in obtaining a good line up by transposing them in the sockets.

The Model 60 Super-heterodyne differs from the Model 62 and Model 64 in the following respects. A new type dynamic speaker is an integral part of the Model 62. The d-c. of correct voltage for the electromagnetic field of the reproducer unit is obtained from a dry disc type rectifier which permits the load on the rectifier tube UX-280 to be maintained at a minimum value. The Model 64 employs a UX-250 power tube to drive the dynamic speaker. An automatic volume control operated by a special tube offsets the effects of fading by maintaining the signal at a predetermined level regardless of the strength of the signal pick-up. A meter is mounted on the front of the panel as a means for tuning with precision by sight rather than by sound. The sensitivity of the receiver is also under the control of the operator.

The following continuity tests are applicable to the Model 60.

Before attempting to make any of the following continuity tests disconnect the antenna and ground leads. Also disconnect the twelve leads on the terminal strip which connects the receiver to the socket power unit, and the attachment cord at the lighting socket outlet.

FROM	TO	CORRECT EFFECT	REMARKS
			GRID CIRCUIT TESTS
Antenna lead	Ground lead	Meter deflection	No reading indicates open antenna resistor
"	G1 (Grid of tube No. 1)	" "	No reading indicates open connection
G2	Ground	" "	No reading indicates open secondary of 1st R.F. transformer
G3	Lug No. 5	" "	No reading indicates open secondary of 2nd R.F. transformer
G4	Ground	" "	No reading indicates open secondary of 1st I.F. transformer
G5	"	" "	No reading indicates open secondary of 2nd I.F. transformer
G7	"	" "	No reading indicates open secondary of 3rd I.F. transformer or resistance unit

G8	Lug No. 6	"	"	No reading indicates open secondary of audio transformer or resistance unit
Lug No. 5	Lug No. 7	"	"	No reading indicates open resistance unit or volume control
Ground	Lug No. 7	"	"	No reading indicates open volume control contact arm or poor connection
				PLATE CIRCUIT TESTS
P1	Lug No. 3	"	"	No reading indicates open primary in 1st R.F. transformer
P2	Lug No. 3	"	"	No reading indicates open primary in 2nd R.F. transformer
P3	Lug No. 4	"	"	No reading indicates open primary in 1st R.F. transformer
P4	Lug No. 3	"	"	No reading indicates open primary in 2nd I.F. transformer
P5	Lug No. 3	"	"	No reading indicates open primary in 3rd I.F. transformer
P6	Lug No. 4	"	"	No reading indicates open plate coil of oscillator coils
P7	Lug No. 2	"	"	No reading indicates open primary of audio transformer
P8	Lug No. 1	"	"	No reading indicates open connection
				FILAMENT CIRCUIT TESTS
Cathodes Nos.1, 2, 4 and 5	Lug No. 6	"	"	No reading indicates open connection

Cathodes Nos. 3, 6 and 7	Lug No. 5	" "	No reading indicates open pick-up winding of oscillator or connection
Lug No. 8	One filament contact of socket No.8	" "	No reading indicates open connection
Lug No. 9	Other closed filament contact socket No. 8	" "	No reading indicates open connection
Lug No.10	One heater contact of sockets Nos. 1, 2, 3, 4, 5,6 and 7	" "	No reading indicates open connection
Lug No.11	Other heater contact of sockets Nos. 1, 2, 3, 4, 5, 6 and 7	" "	No reading indicates open connections
			MISCELLANEOUS
G2	P2	No deflection	Reading indicates shorted compensating condenser
G4	P4	" "	Reading indicates shorted neutralizing condenser
G5	P5	" "	Reading indicates shorted neutralizing condenser
G6	Cathode 6	Weak deflection	No reading indicates open oscillator grid leak
G8	Lug No. 5	deflection	No reading indicates open resistance unit or secondary of audio frequency transformer
G8	Lug No. 7	"	No reading indicates open secondary of audio frequency transformer or open volume control

Socket Power Unit Continuity Tests

Before proceeding with the tests outlined in the chart below remove the rectifier tube UX-280 and disconnect the leads attached to the terminal.

FROM	TO	CORRECT EFFECT	REMARKS
			Tests at UX-280 socket
Grid	Plate	Deflection	No reading indicates open high voltage winding (plate winding) of power transformer
Terminal No. 1	No. 3	"	No reading indicates open in resistance unit or output choke
Terminal No. 1	No. 4	"	No reading indicates open in resistance unit or output choke
Terminal No. 3	No. 6	"	No reading indicates open resistance unit
Terminal No. 4	No. 5	No reading	Reading indicates shorted 0.5 mfd. condenser
Terminal No. 5	No. 6	" "	Reading indicates shorted 0.5 mfd. condenser
Terminal No. 5	No. 7	" "	Reading indicates shorted 0.2 mfd. condenser
Terminal No. 8	No. 9	Deflection	No reading indicates open in UX-171A filament heating winding of power transformer and resistance unit (potentiometer)
Terminal No. 10	No. 11	"	No reading indicates open in UY-227 filament winding and resistance unit
One loud-speaker jack	No. 1	No reading	A deflection on meter would indicate a shorted output condenser
The other loudspeaker jack	No. 5	Deflection	No reading would indicate an open connection somewhere in this circuit
Test across the filament contacts of UX-280 socket		"	No reading indicates open UX-280 filament heating winding of power transformer
Test from one filament contact of UX-280 socket to terminal No. 1		"	No reading indicates open in output choke or filter reactors

A.C. AND D.C. VOLTAGE READINGS

A shield covering the terminal strip must be removed before any voltage measurements can be made. No. 1 on the terminal strip is the terminal near the front of the set and the numbers increase toward the rear, No. 11 being near the rear.

TERMINALS				CORRECT VOLTAGE	
Take measurements					
From	1	to	7	200	d-c.
"	2	"	7	210	d-c.
"	3	"	7	160	d-c.
"	4	"	7	110	d-c.
"	8	"	9	5	a-c.
"	10	"	11	2.25	a-c.

Theory of Operation and Adjustment of Circuits. Looking at the schematic diagram in Figure 8 you will observe that adjustable condensers are located in the intermediate frequency stages. It is of utmost importance to the performance of the super-heterodyne set that its intermediate stages be correctly synchronized. This is accomplished by means of the adjustable condensers just referred to above, and you will find them placed across the secondaries of intermediate transformers which are the air-core type. The condensers are marked C-4, C-5, C-6 and C-7, the latter two being connected in parallel. Notice that the primary condensers, C-8, C-9 and C-10 are of the fixed type. The balancing of the intermediate stages is necessary because a circuit of this type lends itself to a constant "band pass," by which is meant the voice and musical frequencies super-imposed upon the carrier wave radiated by a broadcast station antenna will be amplified equally over the entire tuning range of the receiver; that is, from one end of the scale to the other.

The tuning process consists of placing the intermediate stages in resonance with each other at a frequency of 180 kc., which is the frequency of the beat note of the first detector output. The correct adjustment is determined by the visual method. When adjusting the tuning condensers the observer will be sure that resonance has been established between the intermediate stages when a maximum reading is indicated on a milliammeter inserted in series with the second detector plate supply. When this condition obtains each intermediate stage is tuned to a frequency of 180 kc.

Let us now consider the procedure for neutralizing the circuits and the equipment needed for this work. Figure 10 shows the location of the adjusting screws for the tuning condensers of the three intermediate stages. It will be necessary to take the following steps before the actual task of adjusting the condensers can be started. The receiver assembly and socket power unit are first removed from the cabinet. The main variable ganged condenser assembly mounted in the steel tub must then be removed from its position on the chassis because the adjusting screws are located under this unit. In order to remove the condenser assembly a screw holding the ground lead in contact with the chassis frame must be removed and it should be carefully replaced to make good contact after the ganged condenser assembly is removed. All of the leads in the cable except No. 2, indentified by a red colored braid, should be connected to the terminal strip. A milliammeter with a 0-50 m.a. scale, or lower, should be connected in series with this "red" lead and the No. 2 terminal post on the strip, which places this resonance indicating meter in the second detector plate circuit. A special test oscillator circuit designed to transmit radio power on a frequency of 180 kilocycles is now set up and a coupling lead and coupling coil is connected from the output of this test oscillator, called the "driver," to the grid coil, L-4, of the first detector. The next step is to place the coupling coil under the center coil of the transformer, marked 2nd R.F.

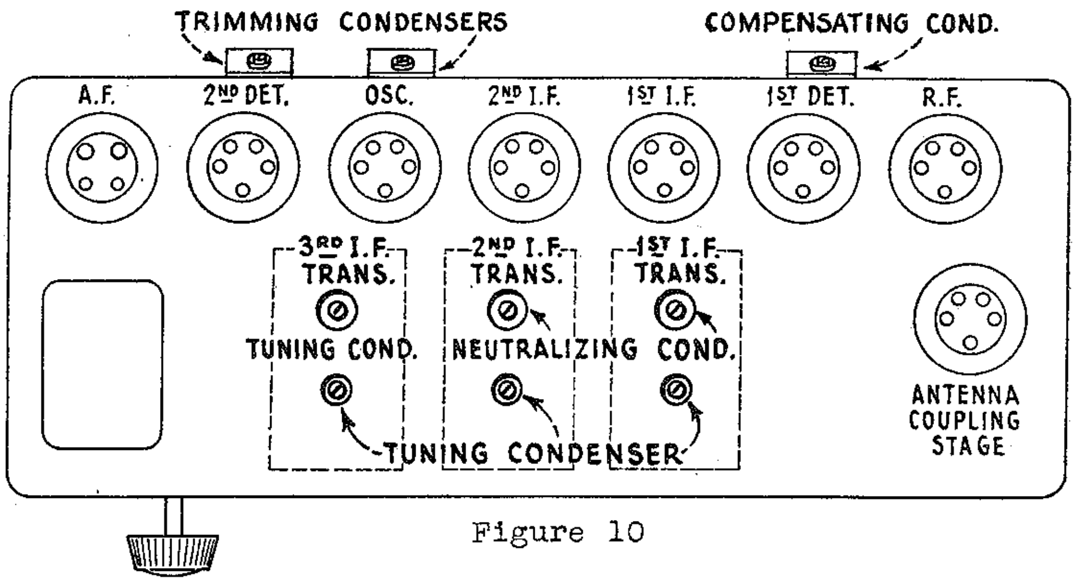

Figure 10

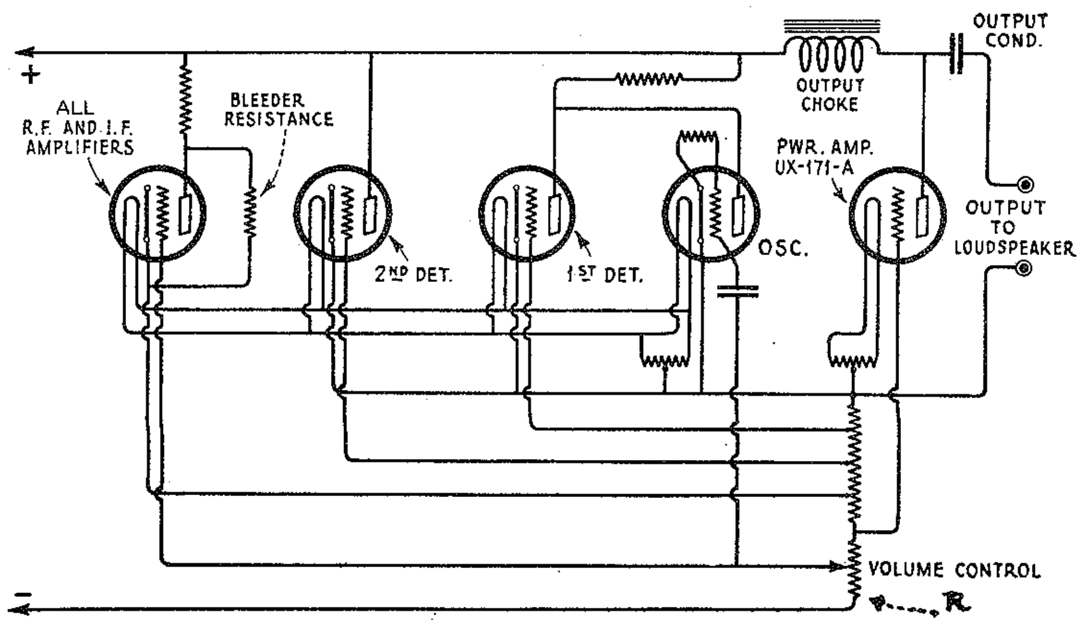

Figure 11

transformer in the diagram, insert all tubes in their sockets except the oscillator tube, and connect the loudspeaker to the pin jacks provided for that purpose. Both circuits should now be placed in operation. The receiver is operated by throwing the toggle type power switch, and the driver by placing its operating switch in the "on" position. The frequency of the driver is set by means of its vernier condenser at 180 kc., and the note generated is transmitted through the coupling lead and coil to the receiver and it will be heard distinctly in the houdspeaker when the set is tuned. Using a non-metallic screw driver the tuning condensers are adjusted on the third, second, and first intermediate frequency transformers for maximum deflection of the meter vane, and also for the loudest response in the loudspeaker. If the milliammeter scale is too low for the second detector plate current when resonance is established, the volume control should be reduced until the vane will not go beyond the scale. Suppose that you hear a loud howl, or perhaps no signal comes through, then you may be assured that the neutralizing condensers B-2 and B-3 of the intermediate stages are set at either extreme and a readjustment of their capacities will be necessary.

Now remember, that if you intend to check the neutralization of the intermediate frequency stages do not disturb any of the adjustments just made as outlined above, or alter the position of the testing apparatus. The proper adjustment of capacities B-2 and B-3 is made by substituting a headset for the loudspeaker, and employing a specially prepared UY-227 type tube. This tube should be normal, but with one heater prong sawed off, so that its filament will remain cold when the tube is inserted in the socket. Some service men have found it practicable to use a tube already in the set and simply insulate the heater prong of the tube from the socket spring contact by placing an ordinary soda fountain drinking straw over the prong. With the circuit in operation and the "cold filament tube" in the first intermediate frequency socket, the neutralizing condenser B-2 on the first intermediate transformer condenser is adjusted for a condition of either "no signal" or "minimum signal." The adjustment is not critical. Now replace the normal tube in the first intermediate socket and this time use the special tube, or the regular tube with its heater prong insulated in the manner suggested, in the second intermediate tube socket. Condenser B-3 on the second intermediate transformer should be adjusted until the position of minimum or zero signal is again obtained. After completing this test the main ganged tuning condensers should be replaced and all connections made as originally found.

The single-dial control in a super-heterodyne receiver is made possible by the design of the oscillator and its associated circuits which require that the adjustable capacities be correct, otherwise faulty operation may be expected. It is advisable to check the adjustments of the oscillator trimmer condensers, T-1 and T-2, shown in Figure 8, while the oscillator test circuit or driver is set up. The adjustment of these condensers is made by placing the coupling lead of the driver near the antenna lead of the receiver. With the receiver in complete operation; i.e., all tubes in place, adjust the driver circuit by means of its vernier condenser to a frequency of 1400 kc., and then tune the receiver to this signal. A maximum reading on the milliammeter will indicate resonance. This reading should be improved if possible, by adjsuting the trimming condenser on the left, at the rear of the chassis, as shown in Figure 10. After this adjustment at 1400 kc. is completed shift the frequency of the driver to 600 kc., and again tune in the signal for maximum intensity by manipulating the knob controlling the main tuning condensers. Again try for maximum deflection of the pointer by adjusting the second trimming condenser, the one to the right and at the rear of the chassis. One more adjustment might be required in the event the radio frequency stage tends to oscillate at any point throughout the tuning range when tuning in broadcast stations of different frequencies. An oscillating condition in the radio amplifier circuit can be corrected by changing the capacity of the compensating condenser B-1 in Figure 8. It is, of course, understood after the completion of such tests the receiver unit and socket power should be returned to the cabinet and the whole assembly placed in normal operating condition.

NOTES ON THE DYNAMIC TYPE SPEAKER

There is usually little servicing to be done on the dynamic speaker because its construction is so very simple. Of course, a cone winding or a magnet winding may possibly break at some place and open the circuit, but such occurrences are rare. Extreme care should be exercised when assembling or servicing a speaker of this type in order to prevent small foreign particles, especially iron filings which sometimes attach themselves to the iron core of the large magnet, from lodging in the air gap between the cone collar and the electromagnet. Also, the small collar on which is wound the cone coil should not be permitted to strike any stationary part of the unit which might be the cause of a rattle or buzzing sound in the output of the speaker. This is a very important consideration and if at any time the center aligning screw is loosened it should not be screwed down in place for final adjustment unless the small collar is exactly centered to provide sufficient clearance, thus allowing it perfect freedom of motion. Remember that the small coil is an integral part of the cone collar and its movements set up the sound vibrations from the cone. The fluctuating magnetism around the small coil, when signal currents pass through it, is acted upon by the strong and steady magnetism of the main magnet coil and therefore the motion of the small coil with its collar must not be impeded in any way.

EXAMINATION - LESSON 54

1. (a) How many tubes are employed in the Majestic receiver? Name each tube in sequence according to its function in the circuit. (b) What method of coupling is used between the output of the receiver and the loudspeaker? Why is this necessary?

2. What is the trimmer cup, how is it controlled, and what purpose does it serve in this receiver?

3. Discuss briefly how the control of volume is accomplished.

4. (a) From what source is the dynamic speaker field coil energized? (b) Do you know of any other function performed by this magnet coil in addition to its use in the loudspeaker?

5. (a) What method of neutralization is employed in the tuned radio frequency circuits of the Majestic receiver? (b) Name the parts required in each tuned radio frequency circuit in order to neutralize the circuit. Now draw a simple sketch of only one tuned radio amplifier stage showing the input and output circuits (the source of the e.m.f's. need not be shown) and properly connect the necessary parts you have just mentioned. (c) Would you proceed to neutralize this receiver in the same manner as in the case of any other make or model receiver which also utilized adjustable balancing condensers? (d) Suppose you were actually neutralizing a receiver and while adjusting one of the balancing condensers you found it possible to almost reduce the incoming signal to a point of inaudibility. (You will recall that a tube not supplied with filament heating current is used in the socket of the radio frequency circuit under adjustment.) Explain briefly just what this elimination of the signal means to you in regard to the principles of neutralization.

6. Name and give the function of each tube employed in the super-heterodyne receiver Model 60.

7. (a) Does the incoming signal energy actually pass through the oscillator of this receiver? (b) Could this receiver reproduce a broadcast program if the oscillator tube suddenly ceased to function? State your reasons.

8. (a) What is the purpose of balancing the intermediate frequency transformers? (b) If you thought that the improper operation of a certain super-heterodyne receiver was due to a lack of synchronism between the intermediate amplifier stages how would you proceed to correct this?

9. (a) Why is it sometimes necessary to interchange tubes of similar type in the different sockets? (b) Is this a very important consideration? (c) Are all of the eight tube circuits of the super-heterodyne critical in this respect? (d) If you were servicing this receiver how would you decide when the tube best suited for a particular socket had been found Answer fully.

10. Suppose that no output d-c. voltages from the power unit could be obtained as would be indicated when taking readings across the different terminals on the terminal strip with a d-c. voltmeter and also assume that you noticed that the filaments of the UX-280 rectifier did not light. Where do you think the trouble might be centered and what tests would you make in order to locate the trouble?