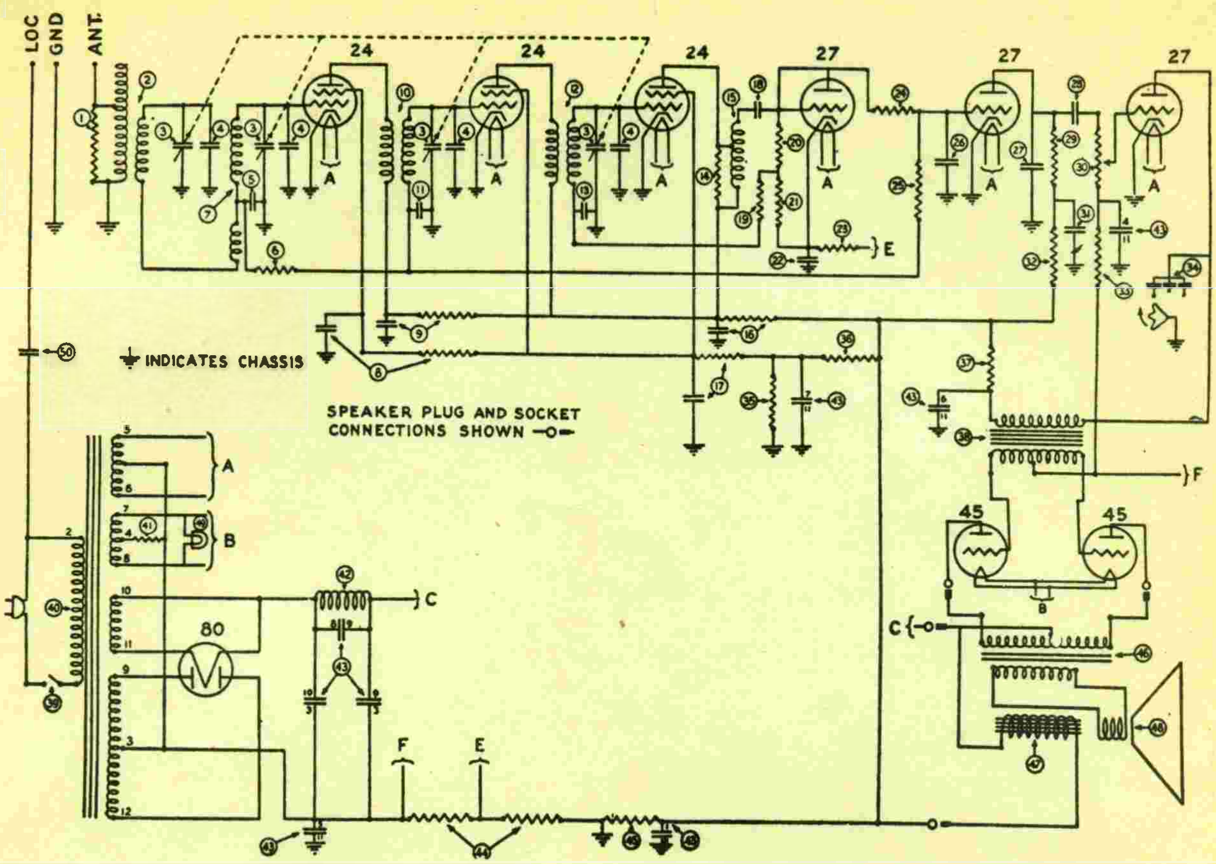

LESSON 26 R

TUNED RADIO FREQUENCY RECEIVERS

RADIO-TELEVISION TRAINING SCHOOL, INC.

5100 SOUTH VERMONT AVENUE • LOS ANGELES 37, CALIFORNIA, U. S. A.

A. C. OPERATED T. R. F. RECEIVERS

A large number of well-performing tuned radio frequency receivers were developed for electric operation, and many of them are still in active use and are giving satisfactory service. These sets all resemble the earlier battery-operated models, and merely contain additional circuit refinements for obtaining more stable operation, sharper tuning, and hum-free performance on the A. C. electric lines.

The majority of these sets contain three or four stages of radio frequency amplification- in the earlier sets type 26 or 27 tubes were used with some form of neutralization to overcome the tendency toward oscillation, and in the later sets screen grid tubes of the 24A and 35 type, neutralization not being necessary with these tubes. The detector is usually of the grid bias type with a No. 27 or 24A tube. Some sets have two stages of transformer coupled audio frequency amplification, but in the greater number the first stage is resistance coupled and this in turn is coupled through a special transformer to a push-pull output stage.

The power supply systems contain the usual input transformer that supplies the necessary plate and filament voltages, a type 80 rectifier tube for converting the high A.C. voltage to a D.C. potential, a filter consisting of several chokes and large capacity condensers for smoothing out the voltage ripples, and lastly a voltage divider that breaks up the high D.C. voltage into the values needed in the various parts of the circuit.

The receivers discussed on the following pages are a few of the more popular T.R.F. sets that were sold in large numbers; and as many of them are still in common use, they will bob up frequently for repair and adjustment service. Since these sets are all of widely varying design and construction, the balancing and alignment instructions given for them can also be adapted to other sets that may be encountered.

MAJESTIC MODELS 71 AND 72

The Majestic Models 71 and 72 which use the No. 70 and 70B chassis, are 8-tube receivers that employ three stages of tuned radio frequency amplification equipped with type 26 tubes. These are followed by a detector and two stages of transformer coupled audio amplification. The receiver consists of two parts, the chassis itself and the power unit. The circuit diagram of the chassis is illustrated in Fig. 1 and of the power unit in Fig. 2A. Fig. 2B is the power unit for Model 70B which has a few circuit changes.

The coupling circuit between the antenna and first tube is of unique design in that it is a combination input and volume control. A 10,000-ohm variable resistor is connected across the antenna and ground, the antenna end being connected through a tuned coil to the grid of the first tube. The inductance of the tuned coil is varied by means of a metal cap which slides over the coil. This cap thus forms an antenna trimmer or selectivity control. The variable resistor controls the amount of input to the first tube, but the arrangement is such that all R.F. tubes can always operate at maximum efficiency.

The necessary grid bias for the three R.F. tubes is obtained by grounding the grids of the tubes through the R.F. coils and placing a positive potential on the filament. This is accomplished by connecting the tap of a 20-ohm filament resistor through a 550-ohm biasing resistor to the ground. Similarly the grid of the first audio tube is biased by grounding the center tap of its filament resistor through a 1400-ohm resistor. All parts of the filament and plate circuits are by-passed to ground by a .5-Mfd condenser.

Neutralization of the internal tube capacity in the R.F. stages is effected by feeding part of the signal from the secondary of the coupling transformer back into the grid circuit. These feed-back circuits are clearly illustrated in the diagram.

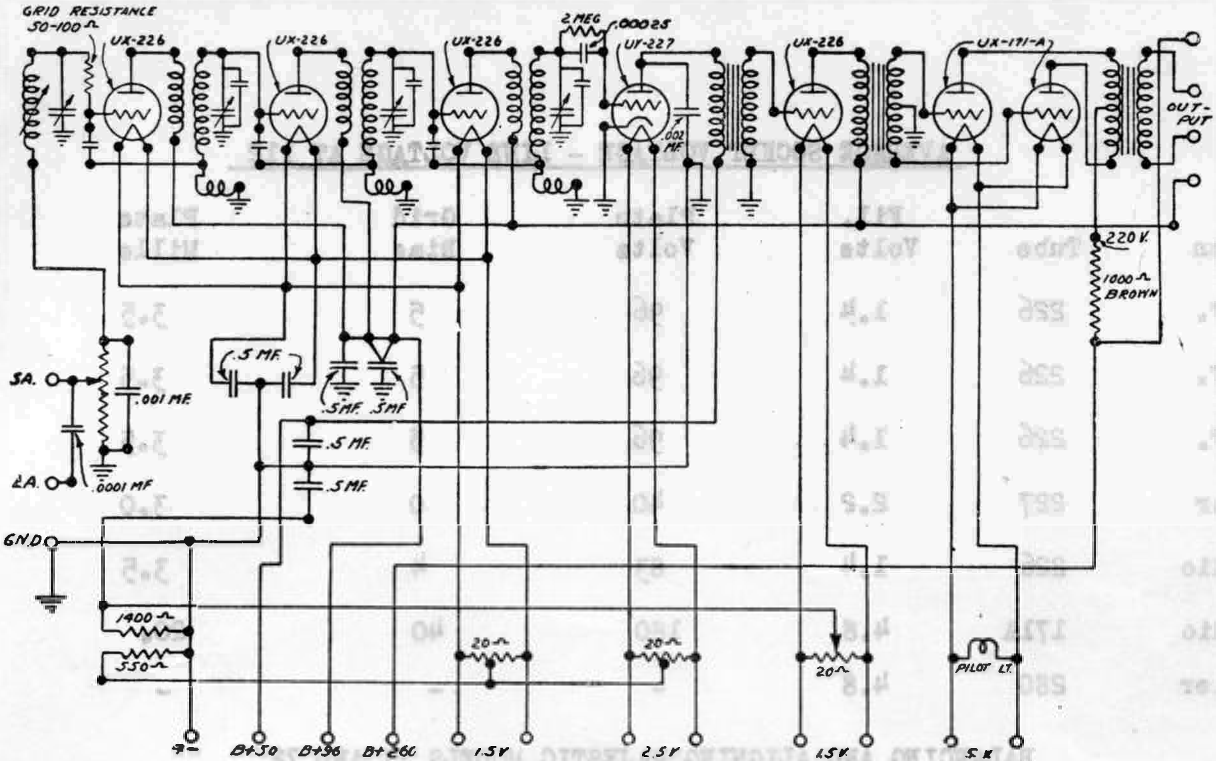

Fig. 1. Circuit diagram of the Majestic Models 71 and 72.

The power unit contains two input transformers, one for the filament supply and the other for the high voltage plate supply. The filter circuit has two chokes and two filter condensers in addition to the voltage dividing resistor with its by-pass condensers. A ballast resistor is used in series with the A.C. line and the two transformer primaries in order to maintain a constant voltage input, even though the line voltagemay vary considerably. The speaker used is of the electrodynamic type with the field connected so as to form an additional choke for the filter system. In the Model G-1 used in the No. 70 chassis the field has a resistance of 3100-ohms, while in the 70B chassis the Model G-2 speaker is used which has a resistance of 2730-ohms.

Chassis 70 and 70B are alike except that they have a different speaker and the 70B has a 1000-ohm resistor in series with the plate circuit of the output transformer.

AVERAGE SOCKET VOLTAGE - LINE VOLTAGE AT 112

Position	Tube	Fil. Volts	Plate Volts	Grid Bias	Plate Mills
1st R.F.	226	1.4	96	5	3.5
2nd R.F.	226	1.4	96	5	3.5
3rd R.F.	226	1.4	96	5	3.5
Detector	227	2.2	40	0	3.0
1st Audio	226	1.4	83	4	3.5
2nd Audio	171A	4.8	180	40	20.
Rectifier	280	4.8	-	-	-

BALANCING AND ALIGNING MAJESTIC MODELS 71 AND 72

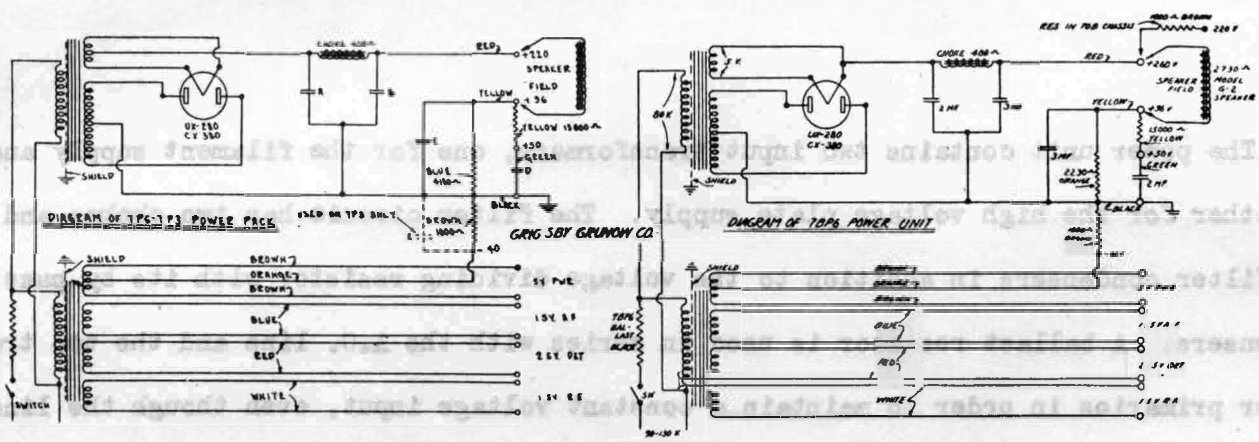

Fig. 2. Power units for Majestic Models 71 and 72 radio receivers.

To put the radio frequency amplifier in the Majestic Models 71 and 72 into proper operation, two adjustment processes are necessary. The first consists of balancing the neutralizing condensers so that the correct amount of R.F. feedback occurs to suppress oscillation. The second consists of aligning the trimmers on the gang condenser so that the successive amplifier stages operate in perfect synchronism, that is, in step with each other.

For balancing or neutralizing, the chassis is removed from the cabinet and put into operation on the service bench so that all adjusting points are accessible. A 1350 Kc. signal from a suitable service oscillator is supplied to the input of the receiver, and the set is tuned to exact resonance. The volume control on the set is turned to maximum. A dummy or balancing tube (a tube with an open filament circuit) is then inserted in the first R.F. stage, and the balancing condenser adjusted for minimum output. The dummy tube is next moved to the second, third and fourth stages successively and each balancing condenser adjusted for minimum output. The entire process should then be repeated, beginning with the first R.F. stage, to pick up any slight misadjustments.

For aligning purposes the dummy tube is removed and a 950 Kc. signal supplied to the input of the receiver. As before, the set is tuned to perfect resonance at this frequency and the volume control turned full on. The successive trimmers on the gang condenser are then adjusted for maximum output. Since the ear is not very sensitive for selecting the point of maximum loudness, some form of output indicator should be used. A number of convenient output indicating devices are taken up in a later paragraph.

In each of the preceding operations all shielding cans (including that over the dummy tube) must be in place, and the receiver be in normal operating condition with the volume turned full on. If the output is too strong for the indicating meter on hand, the signal should be attenuated (cut down) at the output of the oscillator. For balancing the output indicator should be disconnected.

MAJESTIC MODEL 90B CHASSIS

The Majestic Model 90B chassis, the circuit diagram of which is illustrated in Fig. 3, is built around an 8-tube circuit with four stages of tuned radio frequency amplification using type 27 tubes. A 5-section tuning condenser is used, the first of which tunes the antenna coupling coil. The detector is transformer coupled directly to a push-pull audio output stage. Oscillations in the R.F. amplifier are suppressed by feeding back part of the energy from the transformer secondary into the input grid circuit.

The cathodes of the first three tubes are connected together and brought to ground through two variable resistors connected in series. The first is a 75,000-ohm unit and serves as a volume control. It is operated with a knob on the front panel. The second unit has a resistance ranging from 500 to 2500-ohms and varies the grid bias of the first three tubes. It is mounted on the end of the main condenser shaft, and as the receiver is tuned, the R.F. bias is varied so that the sensitivity is maintained practically uniform over the entire range. The cathode of the fourth R.F. tube is grounded through an individual 1800-ohm biasing resistor. Bypass condensers of 0.5-Mfd. are used in the various cathode and plate circuits.

The same system of balancing and aligning is used with these receivers as was explained in the previous section for the Majestic Models 71 and 72.

AVERAGE TUBE VOLTAGE AT 115 VOLTS LINE PRESSURE

Position	Tube	Fil. Volts	Plate Volts	Grid Bias	Plate Mills
1st R.F.	'27	2.35	130	8	5.5
2nd R.F.	'27	2.35	130	8	5.5
3rd R.F.	'27	2.35	130	8	5.5
4th R.F.	'27	2.35	130	9	5.0
Detector	'27	2.35	270	30	1
Audio	'45	2.45	250	50	32

SCHEMATIC DIAGRAM FOR MODEL 90-B MAJESTIC CHASSIS
25-40 AND 50-60 CYCLE

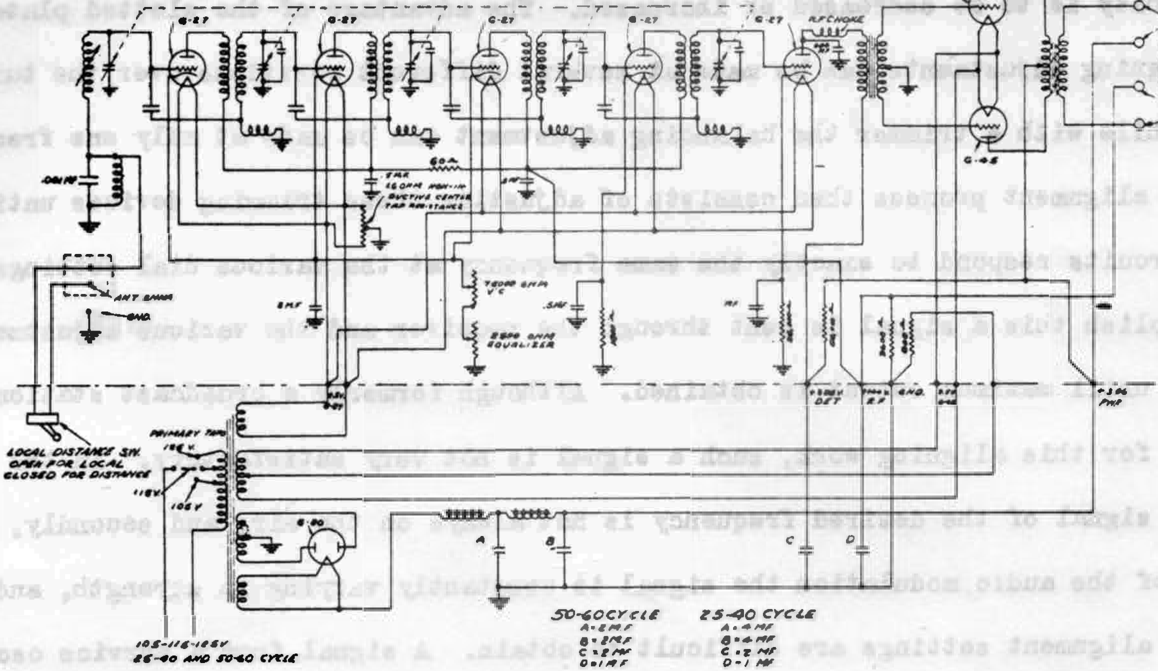

Fig. 3. Circuit diagram of the Majestic Model 90B chassis.

THE NEED OF A CALIBRATED SIGNAL GENERATOR

Unless the successive stages of a tuned radio frequency receiver operate in perfect synchronism, that is, all tune to exactly the same frequency at every setting of the dial, the receiver will lack both sensitivity and selectivity and the output volume will be low. In other words, maximum amplification is not obtained. Lack of synchronism may be due to slight differences in the coils and condensers or to stray capacities caused by different lengths and locations of the connecting wires.

To compensate for these factors that disturb the tuning, some gang condensers have the individual sections shunted by small trimmer condensers that can be adjusted with an insulating screw driver or socket wrench (special aligning tools are available for this purpose), while others have one plate of each section slotted into about five segments. Adjustments are then made by bending these segments out or in according to whether

the capacity is to be decreased or increased. The advantage of the slotted plate is that aligning adjustments can be made at several different positions over the tuning range, while with a trimmer the balancing adjustment can be made at only one frequency.

The alignment process then consists of adjusting these trimming devices until all tuned circuits respond to exactly the same frequency at the various dial settings. To accomplish this a signal is sent through the receiver and the various adjustments are made until maximum output is obtained. Although formerly a broadcast station signal was used for this aligning work, such a signal is not very satisfactory. In the first place, a signal of the desired frequency is not always on the air; and secondly, on account of the audio modulation the signal is constantly varying in strength, and accurate alignment settings are difficult to obtain. A signal from a service oscillator, or signal generator as it is now more commonly called, is more suitable.

The service oscillator is essentially a miniature broadcast station the operating frequency and output signal strength of which are under convenient control. Thus any desired frequency can be obtained at any time it may be needed. The oscillator is a high-frequency signal generator that employs a vacuum tube as a power converter to convert the current from a group of batteries or electric power unit into a high-frequency alternating current. Through a suitable tap part of this energy is then made available for operating the receiver to be serviced.

ALIGNMENT PROCEDURE FOR T.R.F. SETS

Although some manufacturers issue special instructions for balancing and aligning certain sets, the following method of procedure is quite general in its applications and can be employed for most T.R.F. sets that will come in for alignment service. Disconnect the aerial from the receiver and connect the "high" side of the oscillator to the aerial post, also connect the low side of the oscillator to the ground post on the receiver with the regular ground connection remaining undisturbed. Connect the output meter into the circuit, and then turn on the receiver and the oscillator.

If the sections of the tuning condenser are equipped with trimmers, set the oscillator at 1000 Kc. and also bring the receiver dial to this frequency so that the signal can be heard in the speaker. Turn the volume control on the receiver full on and the output adjustment on the oscillator down low enough so that the pointer on the output meter stands at about the middle of the scale for the lowest usable range. Do not forget the 1-Mfd. condenser if it is not built into the meter.

Start with the trimmer on the condenser section tuning the last R.F. stage next to the detector, and with an insulating screw driver or aligning tool, whichever happens to be needed, turn the trimmer adjustment up or down so that the output meter indication increases. Continue until turning the trimmer in either direction causes the output to decrease.

Next proceed in a like manner with the trimmer across the next section of the tuning condenser, and continue toward the antenna tuning section. As the work progresses and the sensitivity of the receiver increases, the output will also increase and the meter pointer swing to the right. To keep the meter pointer near the middle of the scale reduce the oscillator output from time to time, and always leave the receiver volume control full on.

After all sections appear to be balanced, go over the entire process again, for it will be found that in nearly every case some minor readjustments are needed.

Note! Important! During this aligning process the tuning adjustment on the receiver must not be touched or altered in any way, for this would throw off the entire results obtained and necessitate a repetition of the whole job.

IMPORTANT POINTERS TO OBSERVE

Care should be taken in carrying out the above adjustments that the operator's hands as well as other parts of his body are kept well away from the condenser sections and coil units, for their presence will introduce sufficient capacity to affect the tuning of the various circuits. Do not attempt to use a balancing wrench that is not made of insulating material. When the best setting for a condenser section appears to be found, remove the wrench, and if the output meter pointer does not move, that setting is correct. But if the pointer shifts either up or down, then body capacity effects are present and the condenser sections are not properly aligned. Also, if the chassis is a completely shielded one, it is very important that all shields be in place before aligning operations are attempted, otherwise when the shields are put in place, the inductance and capacity values may be changed sufficiently to upset the entire balance.

ALIGNING CONDENSERS WITH SLOTTED PLATES

If the condenser sections have slotted end plates also, the aligning procedure is slightly different, but all the precautions outlined previously must be just as carefully observed. Adjust the oscillator and receiver to the highest frequency note the set will tune in. Turn the receiver volume control full on and cut down the oscillator output so that the output meter pointer stands between one-third and one-half full scale deflection. After these preliminaries are completed, carefully adjust each of the condenser trimmers as was done previously, starting with the section nearest the detector and working toward the antenna. Be careful not to alter the tuning adjustment during these operations.

Then with a bakelite or fiber rod see if the end plate segments which are partly in mesh with the stator plates need any adjustment, generally none is required. Turn the condenser in slowly so that the second segment of the slotted end plates are just in mesh, and with the aid of the insulating rod see if this second segment must be bent in or out as illustrated by the output meter pointer. Always start with the condenser section nearest the detector and work toward the antenna. Turn the condenser in further so that the third segment is just in mesh and make any adjustments that may be required. Proceed with the fourth segment, and with the fifth segment in a similar manner, using the utmost care and precision in every step.

ADDITIONAL OPERATING SUGGESTIONS

When the work is completed and you feel satisfied that all adjustments are as close as they can be made, disconnect the oscillator and output meter, and put the antenna back on the receiver. If the workwas done right, the set should now operate with better volume, have better sensitivity on weak stations, and improved selectivity as indicated by sharper tuning on the more powerful stations. It is generally recommended that such aligning work be done only in the shop and not in the customer's home.

The small trimmer condensers that are electrically shunted across the various sections of the main tuning condenser are generally mounted right on the condenser frame so that they appear to form an integral part of it. In a few cases these trimmers are mounted separately on the chassis. Some trimmer adjustment screws require a screw driver tip, while others require a square or hexagon socket wrench. In any case, only a tool made of bakelite or fiber or other insulating material should be used to eliminate all stray capacity effects.

When the tuning condenser is mounted on top of the chassis, these trimmers are readily accessible; but if the condenser is mounted underneath, the chassis may have to be turned upside down for balancing and aligning. Sometimes small holes are provided in the chassis or shielding through which these trimmers can be reached.

RECEIVER OUTPUT INDICATING DEVICES

During the process of balancing or aligning a radio receiver, either of the tuned radio frequency or superheterodyne type, some form of output indicating device is necessary, for the ear is not sufficiently sensitive to detect small differences in volume such as must be recognized when an accurate aligning job is to be done. Some form of meter must be employed that gives a visual and accurate indication of the receiver output at every instant. Such an output meter need not necessarily be calibrated in volts or other absolute values, as long as it indicates on some form of graduated scale the relative signal output strength at all times.

The signal in the output circuit of a receiver is in the nature of an audio frequency pulsating voltage, and some form of A.C. voltmeter is needed. However, the ordinary movable iron type A.C. voltmeter is not applicable here, for this meter is suitable only for low frequency A.C. voltages and would not respond to the audio frequency pulsations that are to be measured. Also, this meter absorbs too much power for its operation and it would form an excessive load on the circuit, considering the small amount of power that is available.

However, it is possible to use satisfactorily a 0-1 D.C. milliammeter in connection with a suitable rectifier and the necessary multiplying resistors, for then the pulsating voltages are rectified and measured on a highly sensitive D.C. moving coil type meter that has very low energy consumption. Either a crystal or vacuum tube can be used or a copper-oxide rectifier such as is employed in commercial types of output meters.

SIMPLE AND EASILY ARRANGED OUTPUT INDICATORS

One of the simplest arrangements for an output indicating device consists of a crystal detector hooked in series with a 0-1 D.C. milliammeter shunted by a 500-ohm variable resistor and the entire assembly connected across the secondary of a standard output transformer having about a 4 to 1 step-down ratio. The system is illustrated in Fig. 4. The primary of the transformer is connected into the plate circuit of the output tube. The pulsations induced in the secondary are rectified by the crystal and cause a proportional deflection in the meter. The purpose of the variable resistor is to serve as a shunt for keeping the meter deflection near the center of the scale.

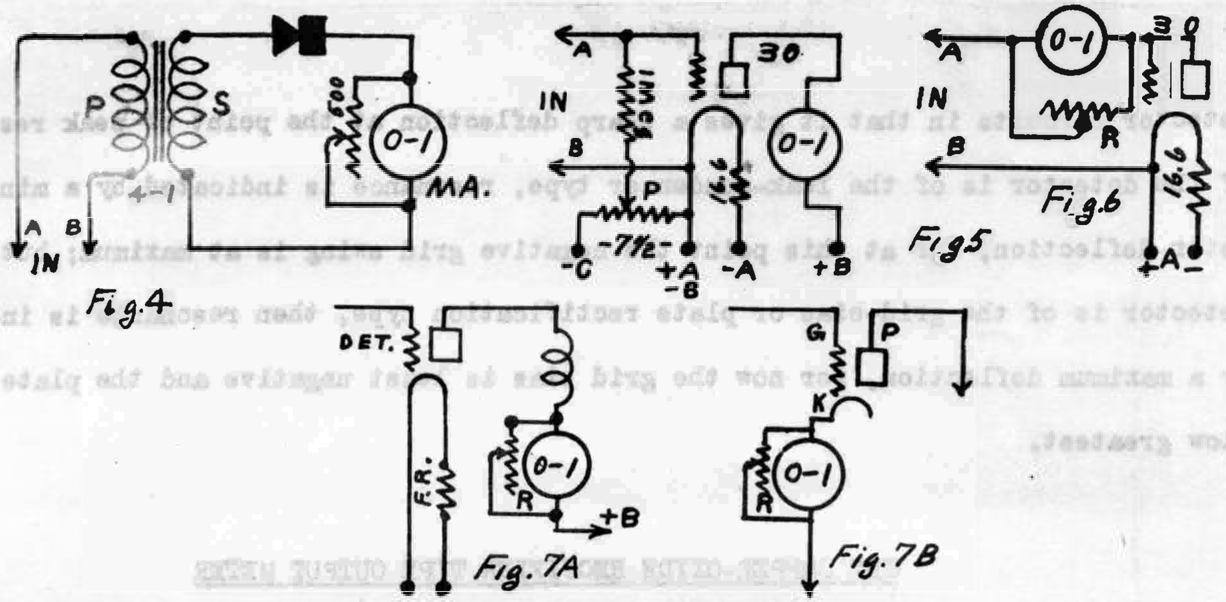

Fig. 4 to 7. Simple output indicating devices.

This scheme is fairly satisfactory, but has the disadvantage that it is somewhat unstable. Also, since the crystal oxidizes readily at the point of contact with the needle, frequent readjustment is necessary.

A more sensitive adaptation of the same principle employs a vacuum tube as a rectifier, as is illustrated in Fig. 5. A type 30 tube can be used to good advantage with 45 volts plate pressure. The potentiometer "P" is a 10,000-ohm unit connected across a 6 or 7½-volt C-battery, and by adjusting it to the left the negative grid potential is increased to the point at which the plate current is reduced to zero. When the input terminals "A" and "B" are then connected across the output circuit, the grid is swung positive and the plate current as registered on the 0-1 milliammeter increases in proportion to the signal strength impressed on the grid. Another modification in which the tube is used as a pure rectifier is illustrated in Fig. 6.

Still another very simple method of using a 0-1 D.C. milliammeter as an output indicating device is to insert it in series with the detector plate lead in the cathode return as illustrated in Fig. 7A and 7B. Although this is not really an output meter, it serves excellently as a sensitive resonance indicator for the radio frequency and detector circuits in that it gives a sharp deflection at the point of peak resonance. If the detector is of the leak-condenser type, resonance is indicated by a minimum meter deflection, for at this point the negative grid swing is at maximum; but if the detector is of the grid-bias or plate rectification type, then resonance is indicated by a maximum deflection, for now the grid bias is least negative and the plate circuit flow greatest.

THE COPPER-OXIDE RECTIFIER TYPE OUTPUT METER

Since the signal output of a radio receiver is in the nature of an audio frequency pulsating voltage, and since this voltage cannot be measured readily with the straight A.C. voltmeter of the movable iron type, the copper-oxide rectifier type A.C. voltmeter has been adapted for such service. With this type of meter the ordinary range of A.C. voltages can be measured and at the same time the high sensitivity retained of the moving-coil permanent magnet type D.C. meter with its low power consumption. Any such rectifier type meter can be used directly as an output indicating instrument, except that it is necessary to connect in series with it a 1 or 2-Mfd. condenser of at least a 400-volt rating, to protect the meter against the high D.C. plate voltages that are operative in receiver output circuits.

Commercial output meters such as the Weston, General Radio, etc., employ copper-oxide rectifier type A.C. voltmeters as was explained and in addition have a resistance network across which the meter is connected so that the impedance of the instrument always remains the same. The value commonly used is 4000-ohms. As different meter ranges are selected with a rotary switch, different resistor values are connected in series and in parallel with the meter, so that the impedance of the instrument is kept constant. The advantage of having this constant input impedance is that if the receiver output voltage is known as indicated by the meter, the power output can also be calculated since this voltage is set up across the impedance of the instrument, which it was stated is commonly set at 4000-ohms.

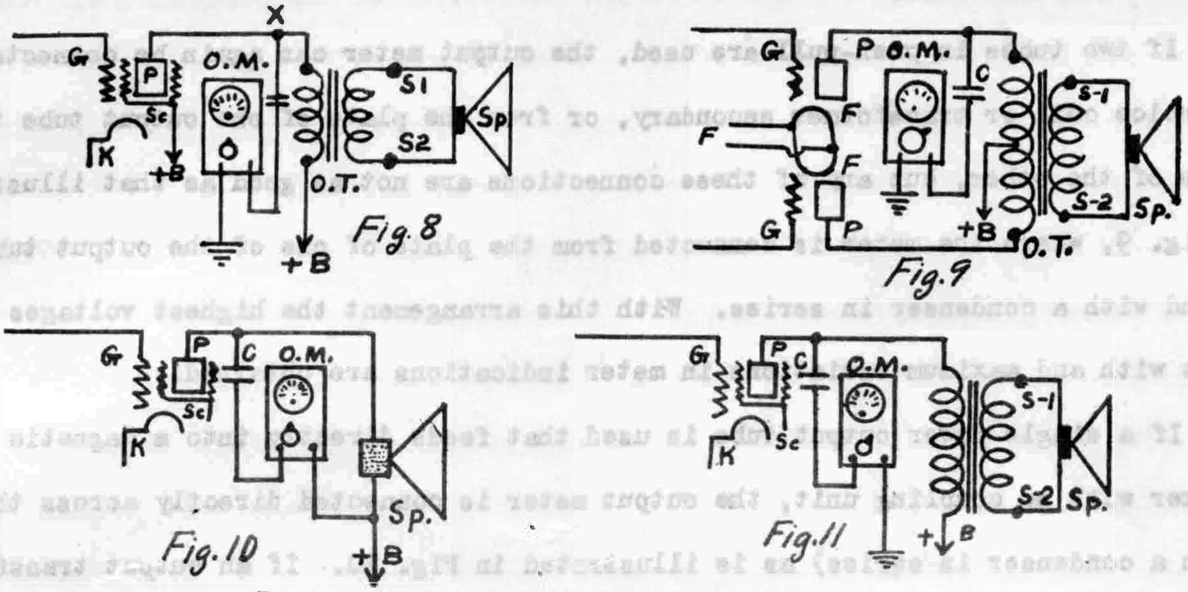

Fig. 8 to 11. Methods of connecting an output meter to a radio receiver.

METHODS OF CONNECTING OUTPUT METERS

The method of connecting an output meter into a circuit system depends upon the kind of output circuit employed, whether a single output tube is used or two tubes in push-pull, and if a magnetic or dynamic speaker is used. If a single power output tube is used to operate a dynamic speaker as is illustrated in Fig. 8, the output meter can be connected either directly across the voice coil terminals on the speaker or the secondary terminals S1 and S2 on the output transformer. This arrangement is satisfactory, except that the voltages in this circuit are rather low, and consequently small variations in output caused by adjusting the trimmer condensers do not produce appreciable changes in meter indication. Also, these terminals are sometimes hard to reach for making connections. A better system is to connect the output meter directly from the plate of the output tube to ground with a 1-Mfd. condenser in series. This connection is illustrated at point "X" in Fig. 8. Here the output signal voltage variations are greater, and adjustments on the trimmers produce more noticeable pointer used in the R.F. amplifier. A 5000-ohm resistor is connected across the primary of the antenna coupler to flatten any resonance peaks and to insure a more uniform gain over the entire wave length range. A local-distance switch is also provided by means of which another resistor of only 20 ohms is shunted across the antenna primary. When static or interfering noises are excessive, this switch is thrown to the local position. In this condition strong local stations will also tune in more sharply.

The detector circuit is of a novel arrangement in that two type 227 tubes are used. The first of these acts as the detector proper, the plate and grid being connected together. It thus functions as a true two-electrode rectifier. It is absolutely linear in response and free of distorting or blurring. The second 227 is the detector amplifier. Instead of having one detector tube serve two distinct purposes, both rectification and amplification, the work is divided so that the first tube does the rectifying and the second tube provides the amplification.

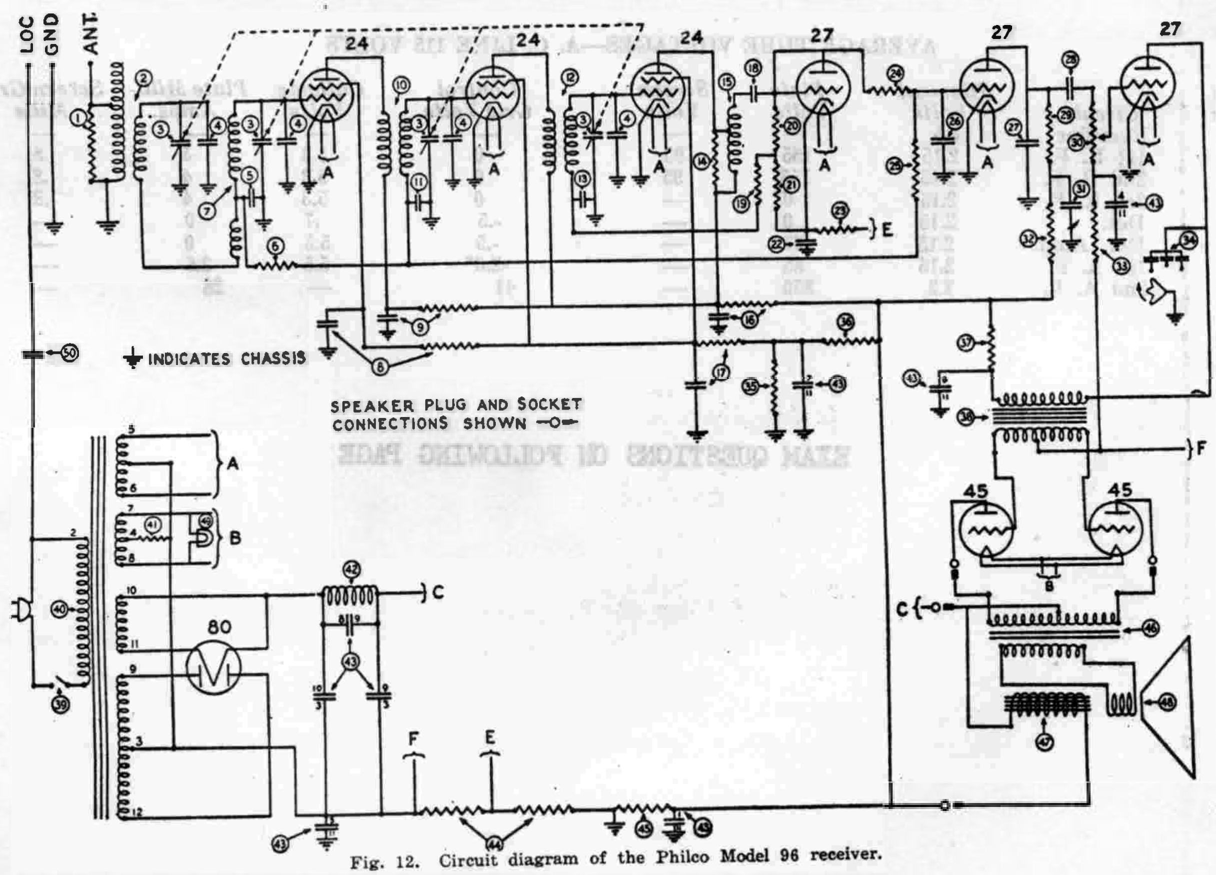

Fig. 12. Circuit diagram of the Philco Model 96 receiver.

used in the R.F. amplifier. A 5000-ohm resistor is connected across the primary of the antenna coupler to flatten any resonance peaks and to insure a more uniform gain over the entire wave length range. A local-distance switch is also provided by means of which another resistor of only 20 ohms is shunted across the antenna primary. When static or interfering noises are excessive, this switch is thrown to the local position. In this condition strong local stations will also tune in more sharply.

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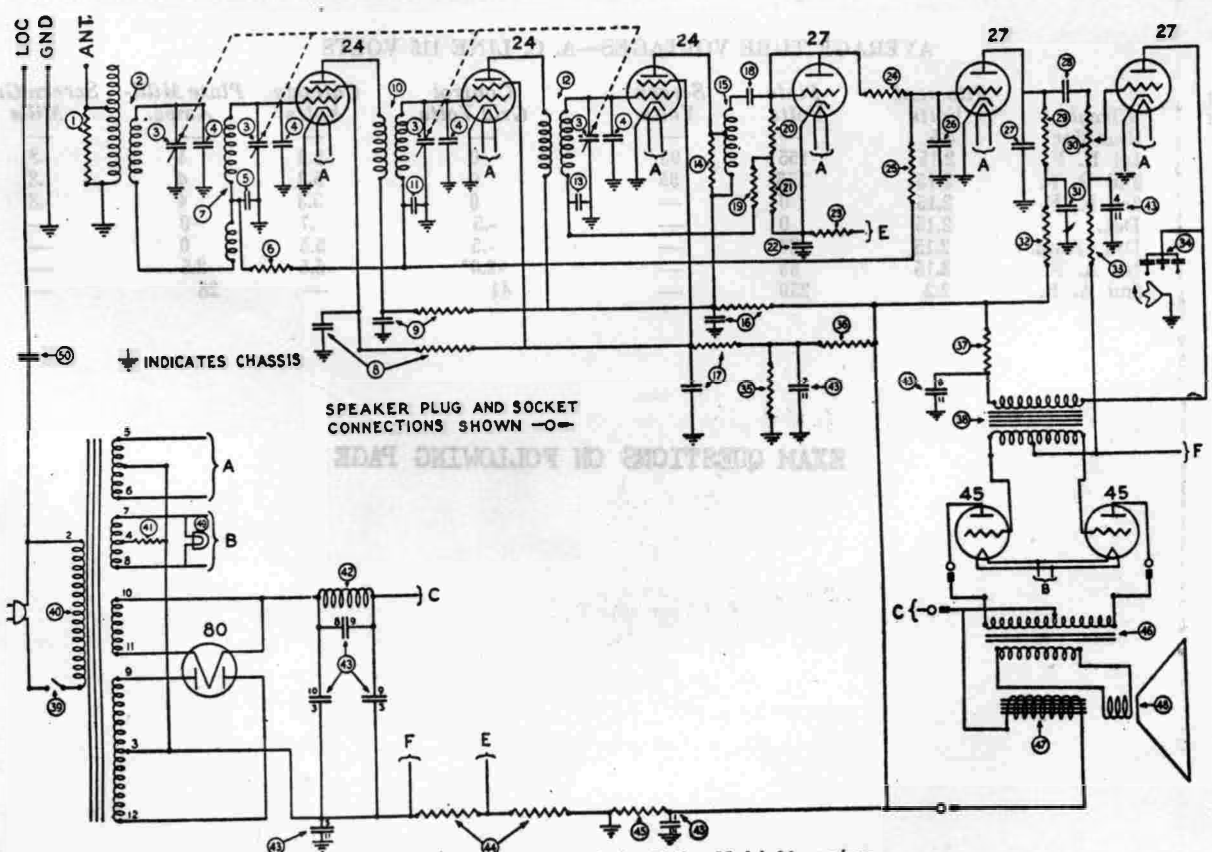

Fig. 12. Circuit diagram of the Philco Model 96 receiver.

The automatic volume control is associated with the detector and R.F. amplifier and by means of it the bias voltage of the control grids of the three screen grid R.F. tubes is automatically adjusted in proportion to the strength of the signal, to increase or decrease the radio frequency amplification and also the volume output of the receiver.

There are two audio frequency stages. The first one uses resistance coupling into a 227 tube. The input to the grid of this tube passes through a variable resistor which serves as a volume control. The second audio is a push-pull stage coupled to the first by means of a standard input transformer. Two type 245 tubes are used. The output of these tubes is supplied directly into the voice coil of an electrodynamic speaker.

AVERAGE TUBE VOLTAGES—A. C. LINE 115 VOLTS

Type Tube	Circuit	Filament Volts	Plate Volts	Screen Volts	Control Grid Volts.	Cathode Volts	Plate Milli-Amps.	Screen Grid Mills
280	Rectifier	4.5	—	—	—	—	—	—
224	1st R. F.	2.15	155	95	0	5.3	4	.8
224	2nd R. F.	2.15	155	95	0	5.3	4	.8
224	3rd R. F.	2.15	0	—	0	5.3	4	.8
227	Det.	2.15	0	—	-.5	.7	0	—
227	Det. Amp.	2.15	27	—	-.5	5.5	0	—
227	1st A. F.	2.15	85	—	-2.0*	5.5	2.5	—
245	2nd A. F.	2.2	250	—	41	—	28	—

EXAM QUESTIONS ON FOLLOWING PAGE