INSTRUCTION MANUAL
PHILCO FM and AM SIGNAL GENERATOR
MODEL 7170

SPECIFICATIONS

FREQUENCY RANGE	
R.F. (AM)	100 kc. to 110 mc. (six bands)
R.F. (FM)	100 kc. to 170 mc.
AUDIO FREQUENCY	400 cycles
R-F OUTPUT AMPLITUDE	.6—1 volt (r.m.s.), depending upon range
A-F OUTPUT AMPLITUDE	1 volt (r.m.s.) approximately
SWEEP WIDTH	Variable from ±4 kc. to ±500 kc.
SWEEP RATE	60 c.p.s. (fixed)
CALIBRATION	Direct reading (for AM)
FM-OSCILLATOR FREQUENCY	60 mc.
OPERATING VOLTAGE	110—120 volts, 60 cycles, a.c.
POWER CONSUMPTION	25 watts
TUBE COMPLEMENT	6C4 (1), 7F8 (2), 6X5GT (1)

GENERAL DESCRIPTION

The Philco FM and AM Signal Generator Model 7170 is designed for precision alignment work, and for many tests employed by the radio-service technician and the laboratory engineer. In the design of this new generator, every effort has been made to attain a maximum of frequency stability, with ample output, combined with portability.

Unusual freedom from r-f leakage and radiation has been achieved, by careful attention to the shielding and filtering of power-line leads.

Special design and shielding of attenuator components give the instrument an excellent control of output, permitting meticulous adjustments on highly sensitive receivers. Complete control of r-f output, from the highest to the lowest amplitude, is obtained through the operation of the two rotary controls, the MULTIPLIER and the ATTENUATOR.

A new feature is the cathode-follower r-f output-coupling system, which affords excellent isolation for the r-f oscillators, to improve frequency stability.

The six-band r-f output provides complete AM coverage from 100 kc. to 110 mc.—all fundamental frequencies. The beat oscillator extends this range to 170 mc. for FM use.

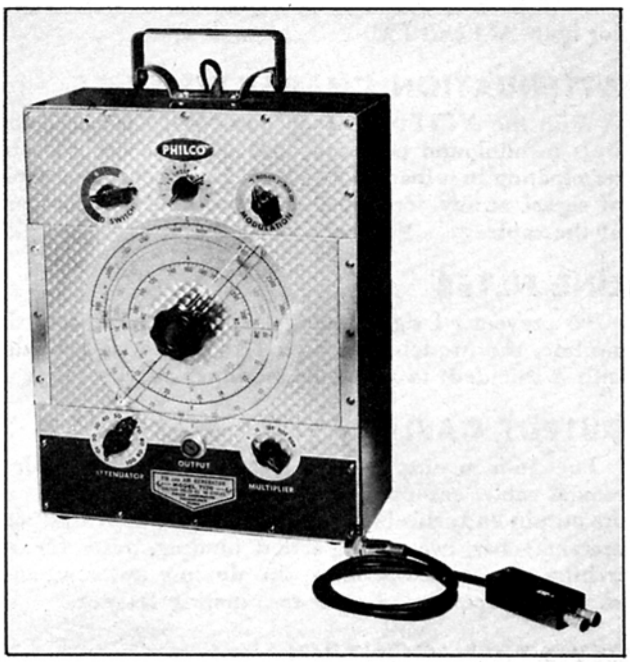
The busy serviceman will appreciate the new-style output-cable termination—a convenient bakelite terminal box with two spring-action binding posts for attaching the connector clips, the dummy antenna, or a cable-terminating resistor. No more repairing to do on broken leads and shielding at the business end of the cable.

The built-in audio modulator furnishes a 400-cycle audio test-signal output, of excellent wave shape, having many applications in the service laboratory.

The FM SWEEP WIDTH control offers the serviceman complete control of the amount of frequency deviation of the FM oscillator, providing a range of ±4 kc. to ±500 kc. about the center frequency to which the generator is set.

This variable deviation control makes the signal generator especially valuable for the alignment of police, mobile, and other narrow-band FM communications equipment, and in addition, increases the usefulness of the generator when servicing wide-band FM radios, which normally cover a range of 200 kc. deviation (only about half the maximum possible deviation provided in this instrument).

An auxiliary vernier scale is provided, to permit accurate resetting of the generator to within a tenth of a division.



MODEL 7170

FREQUENCY COVERAGE BY BANDS

BAND	RANGE
A	100 kc. to 310 kc. (AM)
B	300 kc. to 950 kc. (AM)
C	900 kc. to 3.1 mc. (AM)
D	2.9 mc. to 10.5 mc. (AM)
E	10 mc. to 35 mc. (AM)
F	34 mc. to 110 mc. (AM) 100 kc. to 170 mc. (FM)

CALIBRATION ACCURACY

The calibration is accurate within ±1% of the scale reading.

FREQUENCY STABILITY

Operating tests have proven that, after the initial warm-up period, frequency drift does not occur in excess of ½ of 1% during four hours of continuous operation. When the 400-cycle modulation is switched on or off the AM carrier frequency shift is less than 1/100th of 1%.

LINE VOLTAGE

The Model 7170 Signal Generator will operate satisfactorily with line voltages of 105 to 125 volts, a.c. Within these limits, the frequency of the generator output will hold to within ½ of 1% of the dial calibration for both AM and FM.

ATTENUATION CHARACTERISTICS

With the ATTENUATOR and MULTIPLIER controls in minimum positions, and with the output cable terminating in a load of 70 ohms, less than 5 microvolts of signal at any frequency is found at the output end of the cable.

LINE FILTER

To prevent r-f signal energy from being fed into the a-c line, the Model 7170 Signal Generator is provided with a shielded, two-section, modified pi-type filter.

OUTPUT CABLE

The 36-inch output cable is a high-quality, low-loss coaxial cable, equipped with a bakelite terminal box at the output end; this box (containing only the cable connections) has two spring-action binding posts for attaching the connector clips, the dummy antenna, and, whenever necessary, a cable-terminating resistor.

DEVIATION CONTROL

A variable FM SWEEP WIDTH control is provided on the front panel for setting the frequency deviation of the FM oscillator from a minimum total deviation of 8 kc. to a maximum total deviation of 1 mc. Thus, the correct amount of deviation is available for narrow-band FM, and more than sufficient deviation is available for wide-band FM.

CIRCUIT DESCRIPTION

The Philco FM and AM Signal Generator, Model 7170, contains a six-band AM r-f oscillator covering all frequencies from 100 kc. to 110 mc., an FM oscillator and modulator swept at the line frequency, a 400-cycle audio oscillator for modulation of the r-f signal and for separate audio output, a cathode-follower output stage, and the power supply. The audio output is controlled by the same attenuator system used for the r-f output.

R-F OSCILLATOR

On bands A, B, C, D, and E, covering 100 kc. to 35 mc., the 6C4 r-f oscillator tube operates in a tuned-grid, untuned-plate circuit (see figure 21). Resistance stabilization of the oscillator is employed; this control method, of long-established use in laboratory work, affords an r-f output of excellent wave shape, and a stability of frequency that makes the circuit substantially independent of line voltages and tube replacements.

On the highest frequency band (F), the same 6C4 tube operates in a Colpitts oscillator circuit; the high-frequency coil* is permanently connected to the tuning condensers and the grid of the oscillator tube. The presence of these components has no effect on the efficiency of the tuned-grid, untuned-plate circuit. The combining of these two oscillator circuits makes the high-frequency oscillator available without actually switching its vital elements. This feature insures reliable operation, since switch-contact resistance is avoided, and shorter leads are possible.

When any one of the five lower-frequency bands is selected, the band switch automatically grounds the grid sections of the remaining coils, to prevent absorption of r-f energy at any frequency of the range in use.

CATHODE FOLLOWER

The output of the r-f oscillator is fed through condenser C111 to the grid of one half-section of the 7F8 tube. This half-section functions as a cathode follower, minimizing the load on the oscillator, and providing a low-impedance output. The r-f output is taken from the cathode and fed to the attenuator, R116.

The r-f output signal is modulated by applying the modulation to the plate circuit of the cathode follower. This is done by supplying the plate current through a part of the plate winding of the modulator transformer in the audio-oscillator circuit. This method of modulating the r-f signal is particularly effective in avoiding the introduction of frequency modulation—a feature that insures more accurate results with the procedures for aligning FM detector circuits with an AM signal, as described under FM ALIGNMENT. It will be noted that the modulation level for different bands is controlled by the position of wafer BS-1(R) of the band switch. This wafer is so connected that, in certain positions, the series plate resistor R110 is used either with or without the plate shunt condenser C117 to attenuate modulation, while in other positions, R110 is shorted out to furnish a maximum modulation signal at the plate of the cathode follower. Thus, an average of 30% modulation is maintained for all bands.

A-F OSCILLATOR

For the audio output and modulation, the remaining section of the 7F8 tube operates in an audio oscillator circuit. Sufficient degeneration is employed to develop an output wave shape of good characteristics, with minimum distortion content. For audio output alone, the signal is taken from the plate circuit of the tube, through the tap of transformer T100, and fed through C115 and R115 to the attenuator.

ATTENUATION

The ladder-type attenuation system employs a network of eight fixed resistors, with a multiple-point switch for step adjustments and a 1000-ohm carbon-type potentiometer for fine adjustments. This system eliminates the necessity for separate high-power and low-power output jacks, and provides a low-impedance output circuit. The entire system is efficiently shielded to eliminate direct or indirect pickup from the oscillators.

POWER SUPPLY

The power supply employs a power transformer, a 6X5GT full-wave rectifier tube, and a filter circuit. Two sections of an electrolytic condenser and a pair of 5600-ohm resistors, in parallel, comprise the filter.

*Note: The high-frequency coil is made from a 7⅛-inch length of No. 10 copper wire.

FM OSCILLATOR AND MODULATOR

One half-section of a 7F8 dual triode is employed as a modified Colpitts oscillator with series plate feed, and the other half-section is employed as the reactance tube. The oscillator tank coil, L107, is slug-tuned. The output is taken from the grid circuit through a 1-mmf. condenser and applied to the grid of the cathode-follower output tube of the signal generator. The reactance-modulator-tube grid is supplied with a small 60-cycle a-c voltage from the FM SWEEP WIDTH control, R131, which is connected as a voltage divider from the 6.3-volt filament winding of the power transformer to ground. A phasing adjustment, condenser C120, is connected between the grid and plate of the modulator tube; this condenser and the oscillator slug of L107 are adjusted at the factory for a maximum deviation of 1 mc. at the 60-mc. center frequency of the oscillator.

As the modulator-tube grid is varied by the a-c input voltage, the modulator acts as a variable reactor shunting the oscillator, and varies the oscillator frequency both above and below the center operating frequency. The 60-mc. FM output of the oscillator is applied to the cathode-follower where it is mixed with the unmodulated r-f output of the AM r-f oscillator, to produce a number of beat frequencies. The beat-frequency output, consisting of the original frequencies and the sum and difference frequencies, also contains the FM component, so that for each setting of the signal-generator frequency control, four major output frequencies are produced. For example, with the generator set to 40 mc., there is the 40-mc. unmodulated r-f signal, the 60-mc. FM signal, the 20-mc. FM difference-frequency signal, and the 100-mc. FM sum-frequency signal.

Switch S102, which is a special double-pole double-throw type, is located on the rear of the FM SWEEP WIDTH control, and is connected so that the cathode of the 400-cycle audio oscillator is disconnected from ground in FM position of the control but is connected in AM (off) position. Simultaneously, plate voltage is applied to the FM oscillator and modulator tube in FM position of the control, but is disconnected in AM position.

When a 60-mc. FM output is desired, the 60-mc. output of the FM oscillator may be obtained directly by setting the BAND SWITCH on the signal generator to AUD. In this position of the BAND SWITCH, the AM oscillator is rendered inoperative so that only the FM-oscillator output is available.

HOW TO OPERATE THE MODEL 7170 SIGNAL GENERATOR

CONNECTING TO POWER SOURCE

Insert the power-cord plug into a 105—125-volt, 60-cycle power source. Turn on the power by turning the MODULATION control to MOD. ON.

CONNECTING OUTPUT CABLE

Insert the plug of the output cable into the OUTPUT jack on the front panel. Connect the two output clips to the circuit to which the signal is to be supplied; the ground connection, identifying the shield lead of the cable, is marked on the cable terminal box. For details on making connections to various types of circuits, refer to the information given on applications of the signal generator.

AM R-F OUTPUT

Allow the signal generator to warm up for at least ten minutes, to stabilize the frequency of the output signal. Turn the MULTIPLIER control to 1, and set the ATTENUATOR control about midway.

Locate the desired frequency on the calibrated dial and turn the tuning knob until the indicator line coincides with this mark. Note the identifying letter of the frequency band selected (letters above and below the tuning knob), and turn the BAND SWITCH to the corresponding letter.

Adjust the output by setting the MULTIPLIER control for the approximate level required, and making the fine adjustment by turning the ATTENUATOR control. When unmodulated output is desired, turn the MODULATION control to MOD. OFF.

AUDIO OUTPUT

Turn the MULTIPLIER control to 1, and set the ATTENUATOR about midway. Turn the BAND SWITCH to AUD., and the MODULATION control to MOD. ON. Adjust the output in the same manner as for r-f output.

FM OUTPUT

Adjust the generator as described under AM R-F OUTPUT, except set the calibrated dial to the desired center frequency plus or minus 60 mc. Turn the FM SWEEP WIDTH control toward position 10 until the switch clicks. At this setting of the control, minimum deviation is provided. To increase the deviation, continue to turn the control toward 10, setting it at the position from 1 to 10 which gives the desired amount of deviation. The MODULATION control is inoperative when FM output is being used. To secure a 60-mc. FM output, set the BAND SWITCH to AUD.

and adjust the FM SWEEP WIDTH control for the desired deviation.

Set the MULTIPLIER and ATTENUATOR controls for the desired output amplitude.

PRINCIPLE AND USE OF THE VERNIER SYSTEM

A vernier system, which consists of 2 scales (one called the main scale, and the other the vernier scale), makes possible the precision reading of fractions of the smallest divisions on a main scale.

The vernier scale is on the moving pointer, and consists of ten equal divisions. The main scale, which is on the transparent plastic mat, consists of 200 equal divisions. The ten divisions on the vernier scale span only nine divisions on the main-scale; therefore, each division on the vernier scale is equal to nine-tenths of a division on the main scale.

The method of taking a reading, is as follows:

1. The first number of the reading is the first printed numeral on the main scale to the left of the vernier index mark (the mark at the extreme left-hand side of the pointer with the dot below it).
2. The second number of the reading is the first main-scale division mark to the left of the vernier index.
3. The last number of the reading is the number of the first vernier division mark, to the right of the vernier index, which coincides with a main-scale division mark; disregarding the reading of the coinciding main-scale division mark.
4. If the vernier index coincides exactly with a printed numeral on the main scale, then that printed numeral is the complete reading. If the vernier index coincides exactly with any other main-scale division mark, then that main scale mark is the last number of the reading.

Examples of various vernier readings are as follows:

1. In figure 1a, the reading is 3.73.
2. In figure 1b, the reading is 12.46.
3. In figure 1c, the reading is 16.00.
4. In figure 1d, the reading is 3.70.

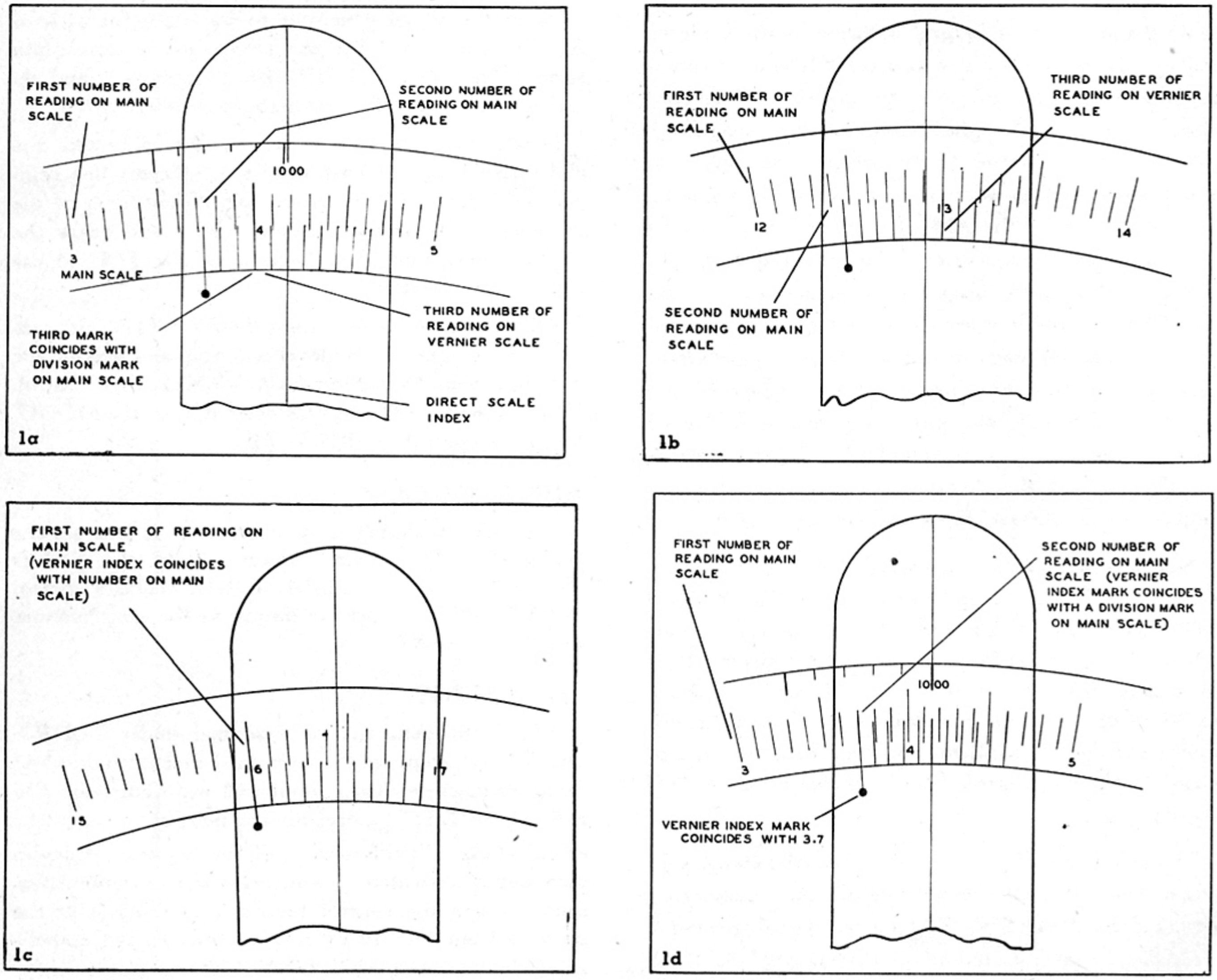


Figure 1. Examples of How to Read Vernier Dial (1a, 1b, 1c, 1d)

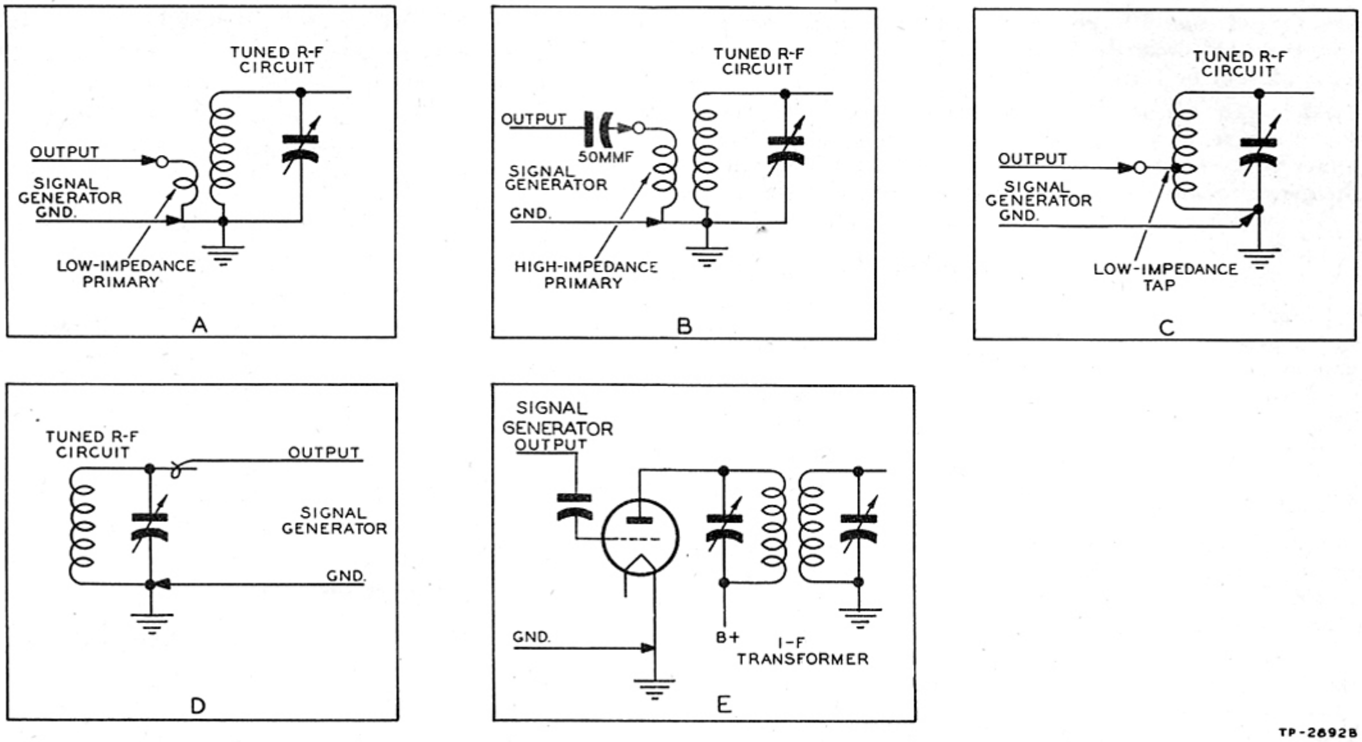


Figure 2. Connecting Generator to R-F and I-F Circuits

CONNECTING GENERATOR TO AC/DC RADIOS

If connections are not properly made to AC/DC radios, a-c modulation may be mixed with the generator input signal, making testing or alignment difficult. For AC/DC sets having no direct connection between the common negative connector bus (one side of a-c line) and the chassis, connect the ground lead of the generator to the common connector bus; care should be taken to prevent this connection from shorting across the chassis or to other circuits.

For AC/DC sets having the common negative bus connected to the chassis, the signal-generator ground lead may be connected to the chassis in the usual manner.

In cases where the generator ground connection is much more conveniently made to the radio chassis, it is sometimes possible to reverse the polarity of the radio power plug to obtain a satisfactory minimum of a-c modulation.

APPLYING R-F SIGNAL TO R-F AND I-F CIRCUITS

For testing circuits by the signal-substitution method, where the main interest is centered in pushing a signal through, it may be said, in general, that the coupling method is not too critical, provided that sufficient coupling is available. Therefore the generator output lead may be connected directly to the circuit for many applications in signal testing (the built-in series condenser provides d-c voltage blocking). However, for alignment, and for circuit testing in which the circuit tuning at the point of connection must be as nearly undisturbed as possible, consideration should be given to the manner of coupling the generator to the circuit.

It should be noted that, the nearer the generator connection to the high-potential end of a coil, the greater the chance of detuning that circuit (also any circuit to which the coil is coupled). This condition occurs because the low-impedance generator-output circuit appears as a near short circuit, in effect, when improperly coupled to high-impedance circuits. Therefore to avoid this condition, the generator must be loosely coupled to the circuit; this can be done by the use of a small series condenser in the output lead, or by attaching the output clip to an insulated portion of the lead into which the signal is to be fed. Figure 2 illustrates several self-explanatory examples of signal-generator coupling to various types of circuits.

If it is possible to connect the signal generator ahead of the circuit to be tested or aligned, so that the signal must first pass through a tube, then it is unnecessary to employ a special coupling method.

APPLYING A-F SIGNAL TO AUDIO CIRCUITS

The same principles outlined above apply to the methods of coupling the signal generator for audio testing. Most of the audio circuits to which the signal is supplied by the generator are high-impedance circuits; therefore, when it is desired to make tests without causing undue disturbance to high-impedance circuits, the output lead should be connected through a small series condenser. Usually the selection of a capacity around .001 mf. will be found satisfactory.

As in the case of r-f and i-f circuits, however, if the signal can be made to pass through a tube to the circuit under test, no special precautions need be taken, and the generator output lead can be connected directly.

AM ALIGNMENT

Probably the most important application of the r-f signal generator in the radio service laboratory is for alignment. Since there are many special problems connected with this phase of servicing, the following suggestions are given as an aid to the serviceman in solving these problems and obtaining accurate results.

PRELIMINARY

Before starting the alignment, it is advisable to make all the necessary repairs that are possible, do all the dusting, cleaning of switch contacts (particularly the band switch, if required), etc.

All new tubes required should be installed before making the alignment, and the adjustments should be made with the same tubes that are to remain in the set.

To avoid much unnecessary labor, it is recommended that the following operations be made a routine, preliminary to the starting of all alignments:

1. INSPECT TUNING-CONDENSER GANG. If the plates are dirty or dusty, clean them with a pipe cleaner; if they are too closely spaced for the pipe cleaner, use a length of soft twine of suitable size, to which a piece of wire is attached, for threading the twine between the plates.

Inspect the spacing between stator and rotor plates. If the spacing is not uniform, it will be impossible to secure the proper tracking between r-f and oscillator circuits; also, the dial calibration will be incorrect. If non-uniform spacing exists, it is better to detect the condition before wasting a lot of time in attempting to make a satisfactory alignment.

Inspect the rotor wiper contacts; if these require cleaning, or if the spring tension needs to be increased by bending, this should be done before making the alignment, since a change in tension of these springs may affect the spacing of the condenser plates.

2. CHECK DIAL-POINTER SETTING. The dial pointer should be adjusted to the proper index mark before starting the alignment. This adjustment is usually made with the tuning-condenser gang fully meshed. If in doubt about the proper method of indexing the pointer, consult the factory data for this information.

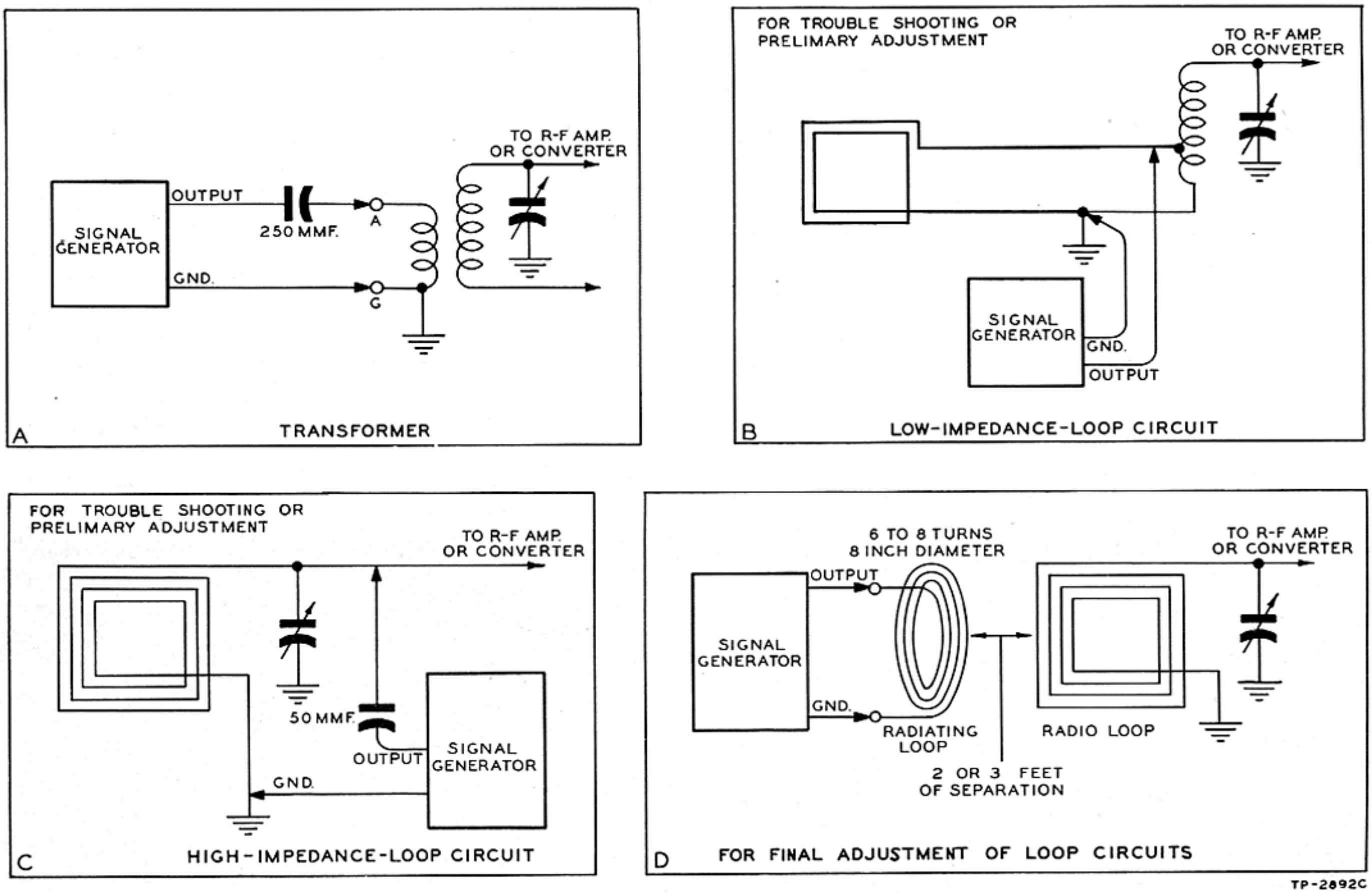


Figure 3. Connecting Generator to Aerial Circuits

CONNECTING GENERATOR FOR I-F ALIGNMENT

Since the i-f circuits must be properly aligned before the adjustment of r-f circuits can be attempted, various methods of connecting the signal generator for i-f alignment will be considered first. An output meter should be connected to the audio output stage of the radio; the connection may be made to the plate of the output tube or the voice coil of the speaker.

During alignment, the input signal should be kept low; use just sufficient signal to produce a satisfactory output indication.

When aligning radios having loop aerials, it is difficult to prevent the set from picking up extraneous electrical noises, especially during the adjustment of r-f and oscillator circuits. The noise may, in some localities, be of sufficient intensity to cause an increase in a-v-c action, and to require signal-generator input in excess of the low value desired for accurate adjustments. Therefore, if the electrical noise background is high, wait until the condition clears up before making an alignment.

When making the i-f alignment, the radio band switch should always be set for standard broadcast (except for FM alignments).

To avoid confusing beat notes in the output signal from the radio, it is advisable to "kill" the oscillator by shunting a .1 mf. condenser across the plates of the oscillator tuning condenser.

CONNECTING TO AERIAL CIRCUIT

When the radio has no r-f stage, and employs an intermediate frequency of 455 kc., 460 kc., 470 kc., or some closely-related frequency, the i-f signal can usually be furnished in adequate strength by connecting the signal generator to the aerial or loop circuit, and turning the tuning-condenser gang until the plates are fully meshed. The generator may be connected as shown in figure 3.

When insufficient signal strength is obtained by this method, the generator may be connected to the converter grid circuit, as described below.

CONNECTING TO CONVERTER (FIRST DET. AND OSC.) GRID CIRCUIT

The i-f signal may be fed into the converter control-grid circuit by connecting the generator output lead directly to the grid terminal of the tube. Usually, the most convenient point for this connection is the stator-plate terminal of the converter tuning condenser, as shown in figure 4A. There are certain radios, however, in which the tuned circuit of the converter is capacitively coupled to the control grid by a small condenser; in this type of circuit, if insufficient signal output is obtained by feeding the signal to the tuning condenser, the generator should be connected directly to the control grid of the tube, as shown in figure 4B.

The same condition created by the circuit of figure 4B is often noted when the radio band switch is set for short wave or FM. The reason for this is that, a tuned circuit (parallel resonant) in which the resonant frequency is greatly removed from the frequency of the input signal appears as a near short circuit to the output of the generator; therefore, by employing the reactance of the grid condenser in series with the tuned circuit, as shown, sufficient output signal voltage may be developed by the generator to satisfactorily operate the grid of the tube. In certain exceptional cases, particularly where the circuit does not use a grid condenser, it may be necessary to isolate the control grid from the tuned circuit by means of a 1-megohm series resistor, and feed the generator signal directly to the control grid.

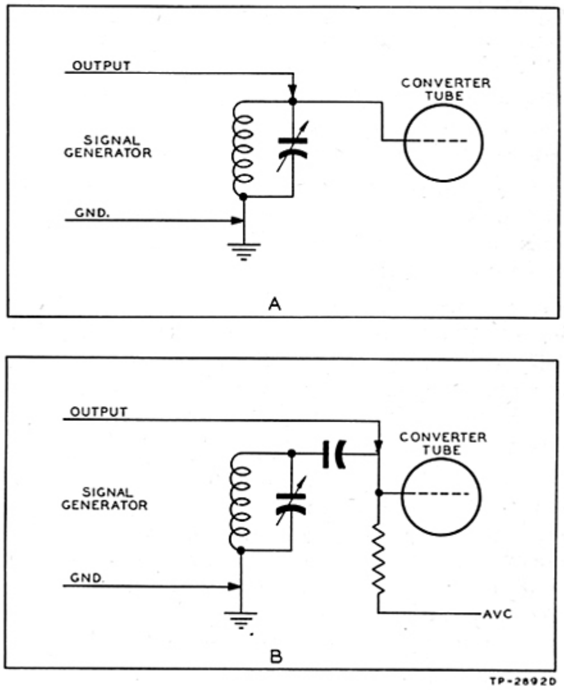


Figure 4. Connecting Generator to Converter Circuits

CONNECTING GENERATOR FOR STAGE-BY-STAGE I-F ALIGNMENT

Occasionally, the serviceman receives a set in which the circuits are so greatly out of alignment that the i-f signal cannot be heard when injected into the converter circuit. In such cases, the alignment must be made stage-by-stage, starting with the last transformer, using the following procedure:

1. Apply the signal to the grid of the last i-f amplifier, as shown in figure 2E and tune the secondary and primary of the last i-f transformer.

2. Connect the generator to the grid circuit of the preceding i-f amplifier, or converter, then tune the secondary of the next to the last i-f transformer, then tune the primary. When each i-f circuit has been tuned, the generator should be left connected to the converter, and each adjustment repeated in the same order (unless otherwise instructed in radio service manual), until maximum sensitivity is obtained.

IMPORTANT

If, during alignment, the radio develops oscillation when the adjustment approaches the point of maximum signal output, do not leave a trimmer detuned to avoid this condition. Oscillation in nearly all cases is caused by some defect in the radio—find the trouble and repair it, then start over again and make the complete alignment. The only exceptions to this rule occur in circuits having regeneration control, or in flat-top-tuned i-f circuits which require special methods of adjustment.

CONNECTING GENERATOR FOR R-F AND OSCILLATOR ALIGNMENT

Connecting the generator to the aerial or loop circuits of the radio involves one major consideration—injecting the signal without detuning the circuit. For this reason, the factory recommendations (when available) for the particular model of radio should be followed closely.

The alignment instructions will be found to specify certain dummy aerial components (capacitance or resistance) when required; these are connected to the generator output leads in series or in shunt.

For the final adjustment of loop circuits, use the radiating loop as shown in figure 3D; this loop should be placed far enough from the radio loop to eliminate any possible capacity effect between the two loops; 2 or 3 feet of separation is adequate.

When aligning the r-f and oscillator circuits of a radio having a loop, the loop should be so supported that its position with respect to the chassis of the radio is identical to its placement when both are mounted in the cabinet; otherwise, the r-f and oscillator circuits cannot be made to track properly. The final adjustment of the loop circuit should be made after the radio and loop have been re-installed in the cabinet.

ALIGNMENT OF SHORT-WAVE CIRCUITS

The adjustment of a short-wave circuit is more critical than that of a broadcast circuit.

The signal generator should be connected to the aerial circuit according to the factory recommendations for the particular model of radio. For aligning high-frequency circuits, the generator leads between the contact clips and the terminal box, must be kept as short as possible. If specific instructions are not available, the generator may be connected in the manner most commonly used, i.e., with a 400-ohm non-inductive (carbon or metallized) resistor in series with the generator output lead. For communications receivers, or others designed for transmission-line connection to a dipole-type aerial, connect a 70-ohm non-inductive resistor across the terminals of the signal-generator output cable.

When adjusting short-wave trimmers, use an all-fibre adjusting tool. Make the final adjustment of each trimmer screw a tightening motion—the adjustment will be much more permanent when made in this way.

There is nearly always a certain amount of interaction between the adjustment of oscillator and converter trimmers; therefore, after setting the oscillator frequency, always rock the tuning knob of the radio while adjusting the converter trimmer.

Always repeat the adjustment of oscillator and r-f circuits until no further improvement can be obtained.

NOTE: It is recommended that a 68 or 70 ohm, ¼-watt terminating resistor be bridged across the output terminals of the generator cable whenever band E or F is in use; this will reduce reflections in the output cable, thereby minimizing peaks or dips that might occur at various frequencies. Since this resistor removes the d-c isolation afforded by the blocking (coupling) condenser in the attenuator box, the resistor should be removed when connecting the generator output to a circuit in which a high d-c potential appears across the output terminals. The terminating resistor should be removed for 400-cycle audio output or for bands A, B, C, and D.

FM ALIGNMENT

Whenever possible, the alignment of FM circuits should be made according to the procedure given in the service manual for the particular radio.

There may be some occasions when the serviceman does not have specific alignment data on hand, or when the service manual specifies FM alignment equipment (including an oscilloscope) which is not available. To satisfy the need for information on the proper use of an ordinary amplitude-modulation signal generator for adjusting FM circuits, as well as the proper use of a frequency-modulation signal generator when an oscilloscope is available, two alignment procedures are given—FM alignment with AM signal and FM alignment with FM signal. Since Model 7170 Signal Generator provides both AM and FM signals, the choice of procedure is left with the serviceman.

FM ALIGNMENT WITH AM SIGNAL

Before attempting an FM alignment, the serviceman should understand what is taking place when the various circuits are tuned; therefore, the following brief description of the functioning of FM tuned circuits should be studied before making any of the adjustments.

FM I-F CIRCUITS

The essential difference between an i-f transformer for FM and one used for AM (aside from the operating frequency) lies in the width of the band of frequencies that is passed by the amplifier in which the transformer is incorporated. High-fidelity AM reception requires an overall amplifier band width of 10 kc. (shown by the response curve of figure 5), whereas the band width required

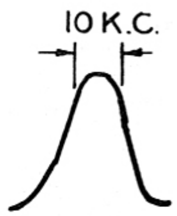


Figure 5

for FM is approximately 250 kc. Most of the FM i-f amplifier systems in use today are designed to provide a fairly flat response over this band (see figure 6), thus insuring high-fidelity reproduction.

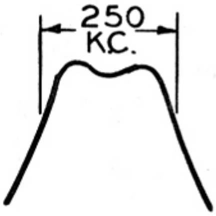


Figure 6

The wide-band flat-top response characteristic is usually obtained in the design of the i-f transformers, the most common method of achieving this result being "overcoupling" of the coils.

Overcoupled I-F Transformers

When the tuned primary and tuned secondary of a transformer-coupled stage are placed in inductive relationship with one another, there is a certain degree of coupling which produces maximum energy transfer without causing two maxima; this is "critical coupling." With this type of coupling, the response characteristic of the combined circuits, if shown graphically, would be similar to the curve in figure 7. A transformer with this type of coupling can be tuned by merely adjusting the trimmers for maximum output. Now if the coils are moved further apart (loose-coupled), it will be found that, although the maximum output of the stage is decreased, the tuning of the two circuits remains unchanged.


Figure 7

Now, if the two windings are brought closer together, past the point of critical coupling, the transformer is said to be "overcoupled". This type of coupling reduces the gain of the stage at the center frequency, but develops a somewhat flat-topped response characteristic, as indicated by the curve of figure 8.

An i-f transformer of the overcoupled type cannot be tuned by merely adjusting the trimmers for maximum peak output, as maximum peak output can only be obtained by throwing one, or both, circuits off the correct center frequency. If the adjustment were attempted in this manner, a response characteristic similar to that shown by the curve in figure 9 would result; the presence of the two sharp peaks can be determined by tuning the signal generator slowly across the intermediate frequency while watching the output or tuning indicator.


Figure 8

Before attempting to align an overcoupled stage with an AM generator, the transformer coupling must be reduced to some value below the critical-coupling value. This can be done quite easily, without changing the physical placement of the coils, by means of a loading network. This load may consist of a 5000-ohm non-inductive resistor in series with a .1-mf. condenser (the condenser is used for d-c blocking), connected across the transformer winding from its high-potential end to the chassis (see figure 10). The shunt resistance reduces the magnetic field of the coil, thereby effectively changing the coupling between the two coils to below the critical value. The circuit that is not loaded may now be accurately adjusted by tuning it for maximum output indication. By transferring the loading network to the circuit which has been tuned, the other circuit of the transformer can then be adjusted. This method gives good uniformity of response, and proper flat-top characteristics.

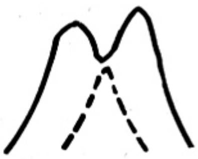


Figure 9

The response characteristic of each stage must, in itself, satisfy the condition for complete passage of the FM signal without imposing distortion on the signal.

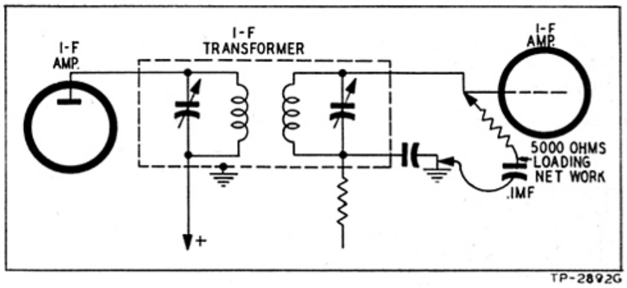


Figure 10. I-F Transformer with Loading Network Connected

For this reason, each i-f stage should be adjusted separately, starting with the last stage and working toward the converter (1st det. and osc.). The general procedure of FM alignment with AM signal to be given is based upon the circuit-loading technique and stage-by-stage test-signal injection and adjustment.

The adjustment of the FM detector circuit is given last, since the several different systems require special considerations.

Single-Peak I-F Transformers

Recent developments in FM detectors have produced circuits in which the inherent sensitivity to amplitude modulation is so low that it is possible to utilize i-f systems having relatively sharp response at the center frequency (see figure 11), the essential requirement being that the gain over the desired frequency band is sufficient for satisfactory operation of the system. The desired overall broadness in this type of i-f system is obtained by designing transformers with a lower Q.

An i-f amplifier having these characteristics can be aligned by merely tuning each circuit for maximum output. However, unless the serviceman knows he is dealing with single-peak transformers, it is recommended that the circuit-loading procedure given be followed for all alignments—no error will result from the adjustment of single-peak transformers by this method.

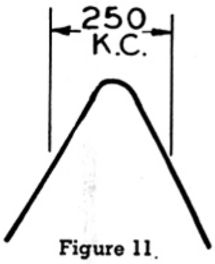


Figure 11

R-F and Oscillator Circuits

The r-f oscillator, and converter input circuits inherently provide sufficient damping for the necessary broadness of response, so that these circuits may be adjusted by the ordinary single-peak method.

CONNECTING THE OUTPUT INDICATOR

The circuit to which the output or tuning indicator is connected, as well as the type of indicator used, depends upon the particular FM detection system in the radio. In any case, the i-f, r-f, and oscillator adjustments are made while observing an indicator connected, so as to obtain an indication that varies in proportion to the signal strength; it is necessary to disable any circuit that prevents the passage of an AM signal to the circuit where the indicator is connected.

Limiter-Type Detector

The limiter-type detection system, which is used in many of the FM radios in the field, is characterized by a double-diode frequency discriminator (fundamental circuit shown in figure 12) and one or two limiter stages. The limiter stages remove the greater percentage of amplitude modulation from the i-f signal, so that it is impossible to employ an audio output meter for making the alignment. However, the i-f signal in the limiter stage causes d-c grid-current flow which is dependent

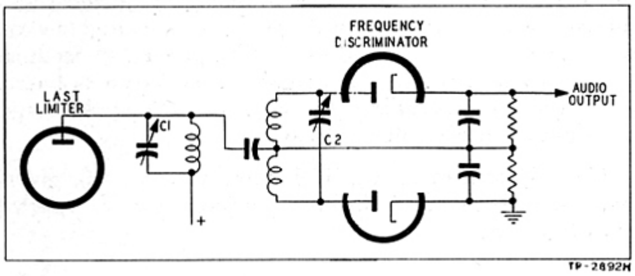


Figure 12. Limiter-Type FM Detector, Simplified Circuit

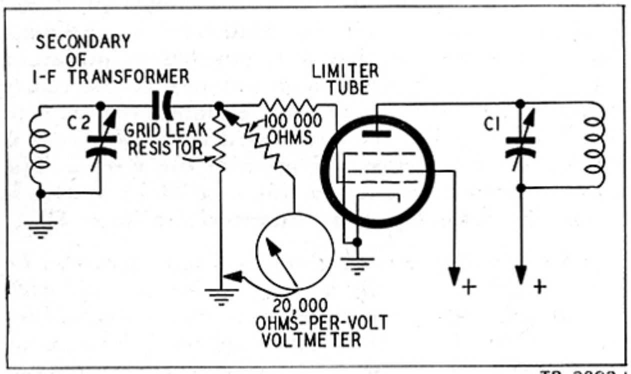


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Figure 13. Limiter Circuit with D-C Indicator Connected

upon the amplitude of the signal; therefore, the alignment indicator for all i-f and r-f adjustments can be a 20,000-ohms-per-volt voltmeter, connected across the grid-leak resistor, as shown in figure 13. Note that a 100,000-ohm isolating resistor is connected between the voltmeter prod and the grid circuit to avoid detuning the input circuit of the limiter. If two limiters are used, the meter is connected to the first limiter for i-f and r-f stage adjustments, then to the last limiter for adjustment of first limiter tuning.

The procedure for final adjustment of the ratio detector is given under Alignment of FM Detector Circuits.

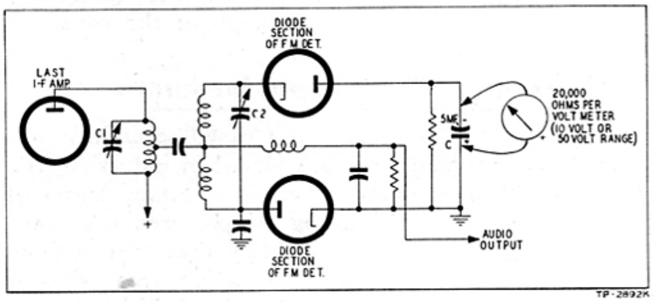

Figure 14. Ratio Detector with D-C Indicator Connected

Ratio Detector

The ratio detector (fundamental circuit shown in figure 14) employs two diodes in a somewhat different arrangement from those in the limiter-type detector. The high-capacitance condenser C charges to an average d-c potential determined by the amplitude of the i-f signal. The tuning indicator may be a 20,000-ohms-per-volt voltmeter connected as shown in figure 14.

The procedure for final adjustment of the ratio detector is given under Alignment of FM Detector Circuits.

Advanced FM Detector

This detector employs the new FM1000 tube of special design, in a circuit that inherently rejects amplitude modulation and noise.

Briefly, the circuit functions as follows: The first and second grids (pins 2 and 5) of the FM1000 tube (see figure 15) are used as grid and anode, respectively, of a modified Colpitts oscillator which nominally operates at the center intermediate frequency. The output of the i-f amplifier stages is fed into the injection grid (pin 6) of the FM1000 tube. The reactive coupling between the plate circuit of the FM1000 tube and the oscillator circuit causes the oscillator to lock in and follow the frequency variations of the i-f signal. The effect of the foregoing combination of elements is such that, as the oscillator frequency increases, the plate current through the audio load resistor R decreases, and, as the oscillator frequency decreases, the plate current increases. This variation is linear with respect to frequency deviation; the plate current, therefore, produces the same wave shape as the modulation of the FM carrier.

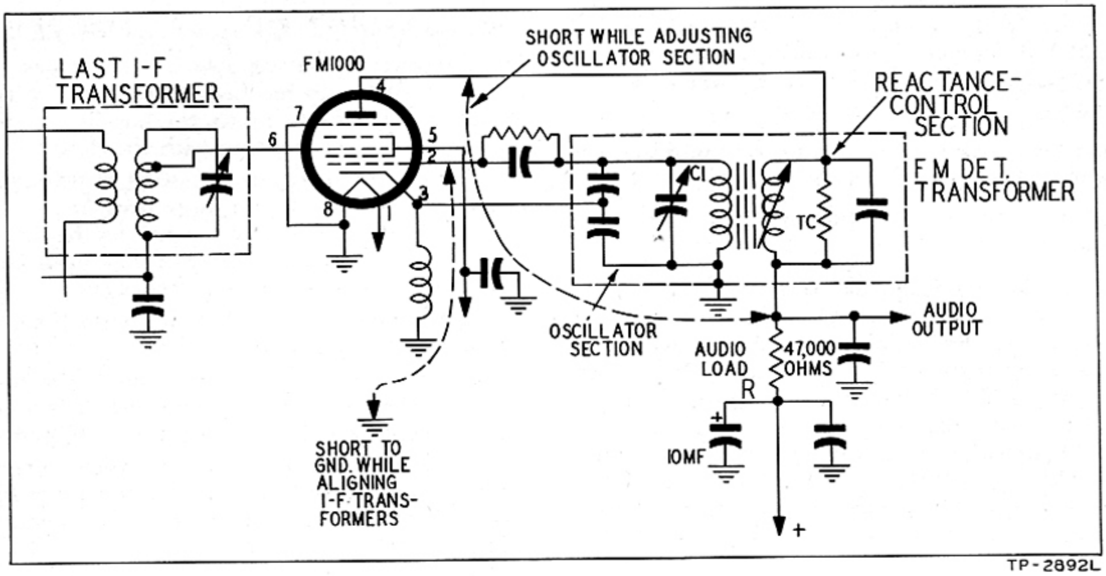

Figure 15. Advanced FM Detector Circuit

To align the r-f and i-f systems, the oscillating circuit is made inoperative by shorting the oscillator control grid (pin 2) to the chassis, as shown in figure 15; the pentode section then serves as an AM detector, the audio output being proportional to the amplitude of the signal at the last i-f transformer. The i-f, r-f, and oscillator alignment is made with a modulated r-f signal, and with an ordinary audio output meter connected to the audio output stage of the radio.

The procedure for adjustment of the oscillator portion of the circuit is given under Alignment of FM Detector Circuits.

ALIGNMENT OF FM I-F CIRCUITS

NOTE: Before starting the actual alignment, allow the radio and signal generator to warm up for about 15 minutes.

1. Connect the tuning indicator according to the type of detector circuit, as previously described.

2. Connect the signal generator according to the type of detector circuit, as follows:

For the limiter-type detector, connect generator to control grid of last i-f tube preceding the limiter (first limiter, if two limiter stages are used).

For the ratio detector, connect generator to control grid of i-f amplifier preceding last i-f amplifier tube.

For the Advanced FM detector, connect generator to control grid of last i-f amplifier tube.

A modulated signal may be used for adjusting any of the three types of circuits; for the Advanced FM detector, be sure to short-circuit the oscillator portion.

3. Connect loading network previously described, according to the type of circuit, as follows:

For the limiter-type detector, connect network across primary of limiter input transformer (plate of tube to chassis); if two limiters are used, connect load to first limiter.

For the ratio detector, connect network across primary of transformer preceding last i-f amplifier tube.

For the Advanced FM detector, connect network across primary of last i-f transformer (transformer following last i-f amplifier tube).

4. Adjust secondary trimmer for maximum output.

NOTE: Throughout the i-f and r-f alignment, use only sufficient input signal strength to obtain a readable output indication.

5. Remove loading network from primary, and connect across secondary of same transformer (control grid of tube to chassis). Then adjust primary trimmer for maximum output.

6. Connect the signal generator to the grid of the tube in the preceding i-f stage and repeat the above loading and tuning procedure, in the same order, for the secondary and primary of the transformer following that tube.

7. Follow this procedure until the final i-f adjustment is made by tuning the primary of the first i-f transformer, with the loading network connected to the secondary, and with the generator connected to the control grid of the converter tube.

8. Remove the loading network, and complete the r-f and oscillator adjustments, as given below, with the tuning indicator connected to the same circuit as for the i-f alignment.

ALIGNMENT OF FM R-F AND OSCILLATOR CIRCUITS

1. Connect a 68 or 70-ohm terminating resistor across the output terminals of the signal-generator cable. Connect the generator output leads to the FM aerial connectors.

NOTE: If the radio is equipped with an external all purpose aerial-matching transformer, remove this transformer and feed the signal directly into the FM aerial coil.

2. Set the generator frequency and the radio dial for 105 mc.; a modulated signal may be used.

3. Adjust shunt trimmer of FM oscillator circuit for maximum output.

4. To check the low-frequency tracking of the oscillator, set the radio dial to 88 mc. Tune in the signal by swinging the generator dial about this frequency. If the signal is heard with the generator set at 88 mc., no adjustment of oscillator tracking is required. If the signal is heard with the generator set below 88 mc., spread the turns of the oscillator coil until the signal is received with a generator setting of 88 mc. If the signal is heard with the generator set above 88 mc., make the adjustment by compressing the turns of the oscillator coil.

NOTE: Do not bend the coil excessively, since only a slight change is necessary at these frequencies.

5. Repeat the shunt trimmer adjustment and low-frequency tracking adjustment of the oscillator (steps 1 to 4) until no further improvement is obtained (the last adjustment made should be that of the shunt trimmer).

6. Set the generator and radio dials for 105 mc., and adjust the shunt trimmer of the converter (mixer) grid circuit for maximum output. Rock the radio tuning control back and forth while making this adjustment.

NOTE: If the FM circuit has no tuned r-f stage, make this adjustment by feeding in the generator signal with the two dipole aerials described in step 7.

7. Make two simple dipole aerials, to feed the signal from the generator into the radio. Each dipole may consist of two 30-inch lengths of rubber-covered wire. Connect one length of wire to each of the generator terminals, and one length to each of the FM aerial terminals on the radio; space the dipoles several feet apart. Using the 105-mc. input frequency, adjust the shunt trimmer of the r-f stage grid circuit for maximum output.

8. Set the signal generator and radio dials for 92-mc. Check the tracking of the converter tuned-grid circuit by means of a tuning wand. If the signal output decreases when either the brass or iron end is inserted in the coil, the tracking of this circuit is satisfactory. If the output is increased with brass inserted, spread the turns of the coil; if the output is increased with iron inserted compress the turns of the coil.

9. If the FM circuit employs a tuned r-f stage, adjust the tracking of this circuit at 92 mc. by the same procedure used for the converter input circuit (step 8).

10. Repeat the foregoing adjustments of r-f and converter circuits until no further improvement in output can be obtained (make the high-frequency trimmer adjustments last).

ALIGNMENT OF LAST LIMITER STAGE

For circuits having two limiter stages, after the i-f and r-f alignment has been made with the indicator connected to the first limiter, the last limiter should be adjusted before proceeding with the detector adjustments.

1. Since the original i-f setting of the signal generator was changed for the r-f alignment, the d-c tuning indicator should be left connected to the first limiter circuit until the signal generator has been correctly reset to the center intermediate frequency.

2. Connect the signal generator to the grid of the i-f tube preceding the first limiter.

3. Connect the loading network to the primary of the i-f transformer working into the first limiter, at the same point used for starting the i-f alignment.

4. Reset the generator to the center intermediate frequency by carefully tuning the generator for maximum d-c voltage on the tuning indicator. Remove the loading network.

5. Connect the tuning indicator to the grid circuit of the last limiter, as shown in figure 13.

6. Connect the signal generator to the grid of the first limiter tube.

7. Connect the loading network to the primary of the i-f transformer working into the last limiter. Adjust the secondary tuning of this transformer for maximum voltage on the indicator.

8. Connect the loading network to the secondary of the same transformer, and adjust the primary tuning for maximum. Remove the tuning indicator and loading network.

ALIGNMENT OF FM DETECTOR CIRCUITS

The final step in the FM alignment with AM signal is the adjustment of the FM detector circuit. When making these adjustments, use an all-fibre adjusting tool.

Limiter-Type Detector

This detector should be adjusted for minimum audio output at the center intermediate frequency, while using a modulated signal. The audio output meter may be connected to the audio output stage in the usual manner. Since the original i-f setting of the signal generator was changed for making the r-f alignment, the d-c tuning indicator should be left connected to the limiter circuit until the signal generator has been correctly reset to the center intermediate frequency.

1. Connect the signal generator to the control grid of the i-f tube preceding the limiter tube, at the same point used for starting the i-f alignment.

NOTE: If the circuit has two limiters, and the signal-generator setting has not been disturbed since the adjustment of the last limiter stage, disregard steps 1, 2, and 3 of this procedure; connect the generator to the grid of the last limiter tube, and start with step 4.

2. Connect the loading network across the primary of the last limiter input transformer, at the same point used for starting the i-f alignment.

3. Reset the generator to the center intermediate frequency by carefully tuning the generator for maximum d-c voltage on the tuning indicator. Remove the loading network and d-c voltmeter.

4. Turn the discriminator balancing trimmer (C2 in figure 12) down tightly, thus detuning the discriminator tuned circuit.

5. Set the generator output just high enough to provide a reliable indication on the audio output meter, and adjust the plate circuit trimmer (C1 in figure 12) for maximum audio output.

6. Adjust the balancing trimmer C2 for minimum audio output; the output should increase on either side of the correct trimmer setting (the ear is usually just as reliable as the meter for this adjustment, since the signal input can be kept very low).

Ratio Detector

1. Leave the d-c voltmeter connected to the high-capacitance condenser C (see figure 14). Use 10-volt or 50-volt range.

2. Connect the signal generator to the control grid of the i-f amplifier preceding the last i-f amplifier tube, at the same point used for starting the i-f alignment.

3. Connect the loading network across the primary of transformer preceding last i-f amplifier tube, at the same point used for starting the i-f alignment.

4. Reset the generator to the center intermediate frequency by carefully tuning the generator for maximum d-c voltage on the tuning indicator. Remove the loading network.

5. Adjust the diode-circuit trimmer (C2 in figure 14) for maximum d-c voltage indication.

6. Adjust the plate-circuit trimmer, C1 of the last i-f amplifier, for maximum d-c voltage indication. Remove the d-c voltmeter.

7. "Touch up" the adjustment of C2 to obtain minimum audio output; the output should increase on either side of the correct trimmer setting (the ear is usually just as reliable as the meter for this adjustment, since the signal input can be kept very low).

Advanced FM Detector

This detector circuit is adjusted by tuning its oscillator section to zero beat with the generator signal, which is set to the center intermediate frequency and fed into the i-f stage ahead of the detector.

Leave the audio output meter connected to the audio output stage, as for the i-f alignment.

1. Connect the signal generator to the control grid of the last i-f amplifier tube, at the same point used for starting the i-f alignment.

2. Connect the loading network to the primary of the last i-f transformer (transformer following last i-f tube), at the same point used for starting the i-f alignment.

3. See that the jumper is connected across the oscillator section (pin 2 of FM1000 tube to chassis), as used for the i-f alignment.

4. Using a modulated signal, reset the generator to the center intermediate frequency by carefully tuning the generator for maximum audio output; keep the input signal low for this adjustment.

5. Remove the jumper from pin 2 to chassis; also remove the loading network and the audio output meter.

6. Short out the reactance-control circuit of the detector by connecting the jumper across the plate coil, from the plate (pin 4) of the FM1000 tube to the audio load resistor R, as shown in figure 15.

7. Turn off the signal-generator modulation, and adjust the oscillator trimmer (C1 in figure 15) for zero beat; the beat note heard should increase in frequency on either side of the correct trimmer adjustment.

8. Remove the jumper used for step 7. Adjust the tuning core, TC, or the reactance-control section, for zero beat. The generator signal must be kept very low for this adjustment. When a single, sharp zero beat is obtained, the adjustment is correct.

FM ALIGNMENT WITH FM SIGNAL

Since it is helpful to know the approximate amount of deviation, the serviceman may wish to calibrate the FM SWEEP WIDTH control. It may be calibrated as follows: Loosely couple the output of the signal generator to an accurately calibrated receiver or heterodyne frequency meter. Choose any center frequency desired (1000 kc., for example), and set the generator frequency control to obtain this frequency (61 mc. or 59 mc. for a center frequency of 1000 kc.). Set FM SWEEP WIDTH control to 1. Tune the radio or frequency meter either side of the center frequency until the signal drops out, and note the amount of deviation. Repeat the procedure for each of the other numbered positions of the FM SWEEP WIDTH control. The amount of deviation when the control is set to a position between two numbers can be estimated by assuming that the amount of deviation changes linearly between the numbers.

A number of commonly used intermediate frequencies together with the generator settings required to obtain an FM output at these intermediate frequencies is given in the following table.

INTERMEDIATE FREQUENCY	GENERATOR SETTING
455 kc.	60.455 mc. or 59.545 mc.
1 mc.	61 mc. or 59 mc.
4.3 mc.	64.3 mc. or 55.7 mc.
9.1 mc.	69.1 mc. or 50.9 mc.
15 mc.	75 mc. or 45 mc.
22.1 mc.	82.1 mc. or 37.9 mc.

Note that each intermediate frequency may be obtained at two different generator settings. One setting is determined by adding the intermediate frequency to 60 mc., and the other setting is determined by subtracting the intermediate frequency from 60 mc. The generator settings for other intermediate frequencies may be quickly determined by either method. However, since addition seems easier than subtraction, it may be advisable to determine the setting in all cases by adding the intermediate frequency to 60 mc.

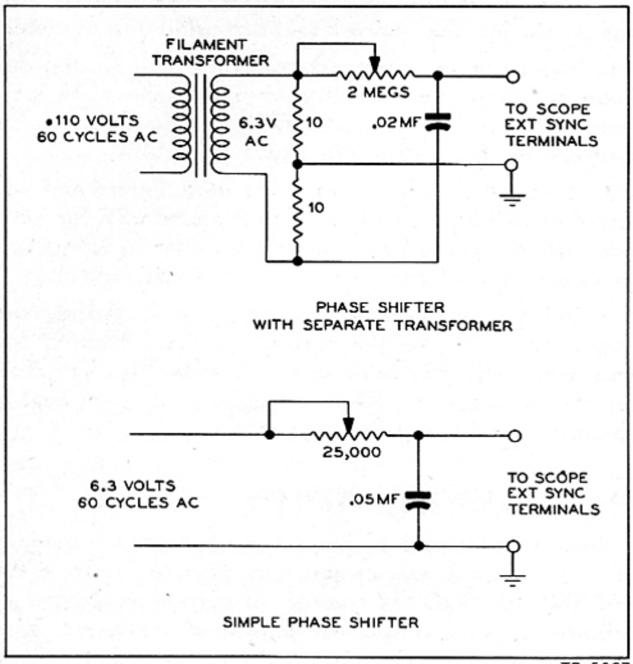

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Figure 16. Phase-Shifting Networks

When aligning an FM receiver with an FM signal, an oscilloscope must be used as an output indicator. The advantage of using the oscilloscope is that a complete response curve is visible during the alignment, so that the effects of any adjustment are immediately apparent. It must be remembered, however, that when aligning the discriminator or i-f stages, the oscilloscope used must have sufficient vertical gain to permit a stage-by-stage alignment. It is also necessary that sufficient voltage of the proper phase be supplied to the horizontal amplifier of the oscilloscope to produce the straight-line indication. The proper phase may be obtained by applying the voltage to the horizontal amplifier through a phase-shifting network. Both an elaborate and a simple type of phase-shifting network is shown in figure 16; the serviceman can use whichever is convenient.

ALIGNMENT OF I-F CIRCUITS

In an i-f alignment, the adjustments may be made until the response curve of each stage is correct. In most cases, however, the exact response curve for each stage will not be known, and the resulting alignment will be no better than that obtained by the ordinary peaking method. Therefore, it is suggested that only the discriminator curve be used while aligning the i-f circuits. The following general procedure makes use of this method. Before starting the alignment, allow the receiver, the signal generator, and the oscilloscope to warm up for a period of about 15 minutes.

1. Connect the vertical deflection terminals of the oscilloscope to the detector audio output and ground (usually an FM test jack is provided on the radio chassis for this purpose). Connect the horizontal-deflection terminals to the phase-shifting source and ground (see figure 17). Set the horizontal sweep control for external input.

2. Connect the signal generator according to the type of detector circuit, as follows:

For the limiter-type detector, connect generator to

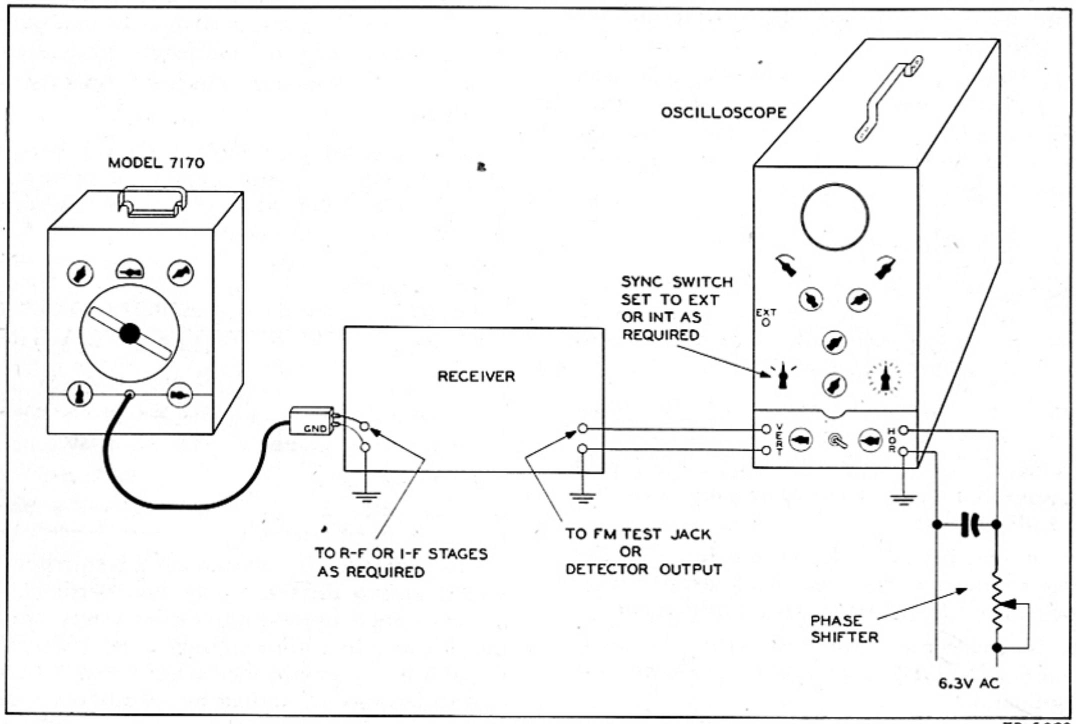

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Figure 17. Test-Equipment Connections for Alignment with FM Signal

control grid of last i-f tube preceding the limiter (first limiter if two limiter stages are used).

For the ratio detector, connect generator to control grid of i-f amplifier preceding last i-f amplifier tube.

For the Advanced FM detector, connect generator to control grid of last i-f amplifier tube. Be sure to short-circuit the oscillator portion of the Advanced FM detector by grounding pin 2 of the FM1000 tube.

3. Set FM SWEEP WIDTH control on signal generator to position 8 or for at least 200-kc. total deviation. Set generator frequency control to the intermediate frequency plus 60 mc. If the limiter-type or ratio-type of detector is used, proceed with step 4A; if the Advanced FM detector is used, proceed with step 4B.

4A. For the limiter-type or ratio type of detector, adjust the discriminator primary for the best possible "S"-shaped curve, then adjust the discriminator secondary for the steepest slope with the center frequency at the middle of the curve. See alignment of FM Detector Circuits. Where discriminator coupling adjustments are provided, adjust the coupling capacitor for a straight-line discriminator curve. Usually it will be necessary to adjust the phase-shifting network to obtain a single trace, because a phase difference may cause the pattern to appear as a modified ellipse or as some other curve that bears no resemblance to the discriminator curve.

4B. For the Advanced FM detector circuit, be certain that the oscillator section is grounded (since this makes the detector an AM type); then tune the secondary of the last i-f transformer for a broad curve, covering at least 200-kc. total deviation, and for the maximum amplitude that can be obtained while still retaining the 200-kc. band width.

5. Remove the signal-generator lead from the last i-f grid and connect it to the grid of the preceding i-f stage. Adjust the secondary and then the primary trimmers for a curve similar to that obtained in step 4A or 4B. Reduce the vertical gain of the oscilloscope to keep the pattern on the screen, as each adjustment increases the height of the pattern.

6. Continue advancing the signal generator, and tuning each stage in turn until the input of the first i-f stage is aligned.

7. After the i-f alignment is completed, align the Advanced FM detector. See Alignment of FM Detector Circuits.

Note that the i-f alignment procedures for the limiter-type and ratio-type detectors are similar, in that first the discriminator is aligned, and then the i-f stages are aligned to the discriminator. Where extreme accuracy is required, use a marker signal (inject an unmodulated signal of the correct frequency), and align the detector so that the marker pip appears on the discriminator curve at the correct point.

NOTE: The pip disappears at the exact center frequency, but reappears either side of this point if the marker generator is adjusted to either side of the center frequency.

ALIGNMENT OF FM DETECTOR CIRCUITS

The procedure for aligning the FM detector circuit (except the Advanced FM detector) with an FM signal is somewhat different from the procedure with an AM signal in that the discriminator is first aligned correctly, and then the i-f stages are aligned to the discriminator (rather than aligning the i-f stages first and then aligning the discriminator to the i-f stages). Since the discriminator is aligned first, a high signal-generator output, and a large vertical-axis oscilloscope gain is required.

Limiter-Type Detector

1. Connect the equipment as shown in figure 17.
2. Set the signal generator to 60 mc. plus the intermediate frequency; set the output at maximum.
3. Connect the generator between the grid of the last limiter and ground; set the FM SWEEP WIDTH control for approximately 200 kc. total deviation.
4. Adjust the discriminator primary for a curve of maximum amplitude and approximately "S"-shaped.
5. Adjust the discriminator secondary for a straight line, reducing the deviation until only the straight-line portion of the curve appears equally spaced above and below the center frequency. If additional equipment is available, a marker may be inserted by connecting an unmodulated AM signal of the desired frequency to the Output Terminals of the Signal Generator. The phase shifter will usually have to be adjusted to secure a single trace line, since the scope presentation will probably appear as a double image due to phase shift between the horizontal and vertical inputs.
6. Align the i-f circuits as directed under Alignment of I-F Circuits.

Ratio Detector

1. Connect the equipment as shown in figure 17.
2. Connect the output of the signal generator to the grid of the last i-f amplifier.
3. Set the generator frequency control to 60 mc. plus the intermediate frequency; set the output to maximum; adjust the FM SWEEP WIDTH control for about 200 kc. total deviation.
4. Adjust the primary trimmer for maximum amplitude, and the secondary trimmer for a symmetrical straight-line response about the center frequency. The phase shifter will probably require adjustment before a single trace line can be secured.
5. Align the i-f circuits as directed under Alignment of I-F Circuits.

Advanced FM Detector

To align the Advanced FM detector, perform the steps in the following procedure.

NOTE

With this type of FM detector, the i-f circuits can be aligned first, because the detector can be converted to an AM type by shorting the oscillator portion of the FM1000 tube. If the i-f circuits have just been aligned, steps 1 and 2 in the following procedure may be omitted.

Simply remove the short from the FM1000 tube, and leave the generator connected to the input i-f stage. (If the frequency setting of the generator was disturbed, it should be reset to the correct center intermediate frequency, by using the auxiliary vernier scale.)

1. Connect the equipment as shown in figure 17.

2. Apply the signal-generator output to the grid of the last i-f tube. Adjust the FM SWEEP WIDTH control for about 200-kc. deviation, set the output to maximum, and set the frequency control to 60 mc. plus the intermediate frequency.

3. Adjust the oscillator-section trimmer for an "S"-shaped curve. Then set the tuning-core (reactance modulator) adjustment for a straight line. It may be necessary to adjust the phase shifter to secure a single trace. The correct signal-generator output is determined as follows: reduce the output until the straight line becomes hooked at the ends, forming an elongated "S"; then increase the output until the hooks straighten out and become a part of the straight line.

REPLACEMENT OF TUBES IN MODEL 7170 SIGNAL GENERATOR

To replace tubes, first remove the cross-recess-head screws from around the edges of the front panel. Tilt the panel forward, remove the power-transformer plug from the socket in the line-filter shield, then remove the signal generator from its case. Since the r-f oscillator is well stabilized, replacement of the 6C4 tube should not cause appreciable change in calibration; however, because of certain variations in tubes of different makes, it is advisable, after replacing the oscillator tube, to check the calibration against stations of known frequencies in the broadcast and short-wave bands. If the calibration has shifted noticeably, try another tube (a tube of a different make may restore the calibration). If the desired accuracy is not obtained with available tubes, calibration adjustments may be made as described below.

CALIBRATION ADJUSTMENTS

AM ADJUSTMENTS

A separate trimmer condenser is provided for each r-f band, for correcting the calibration of the Model 7170 Signal Generator. Remove the signal generator from its case, as for replacement of tubes; the adjusting trimmers are located as shown in figures 18 and 19. To make accurate adjustments, it is necessary to use some calibrated signal source for obtaining a "standard" signal, against which the signal frequency of the Model 7170 can be compared; the signals are picked up on a radio that is capable of responding at the various frequencies to be used in making the adjustments. The calibration of the radio should be sufficiently accurate to permit identification of the frequency of the standard signal at each desired calibration point.

Any one of the following combinations may be used, according to the equipment available.

1. A crystal-controlled frequency standard and an all-wave radio; connect as shown in figure 20A.

2. Another r-f signal generator, known to be accurately calibrated, and an all-wave radio. See figure 20B.

3. An all-wave radio with aerial connected, for pick-

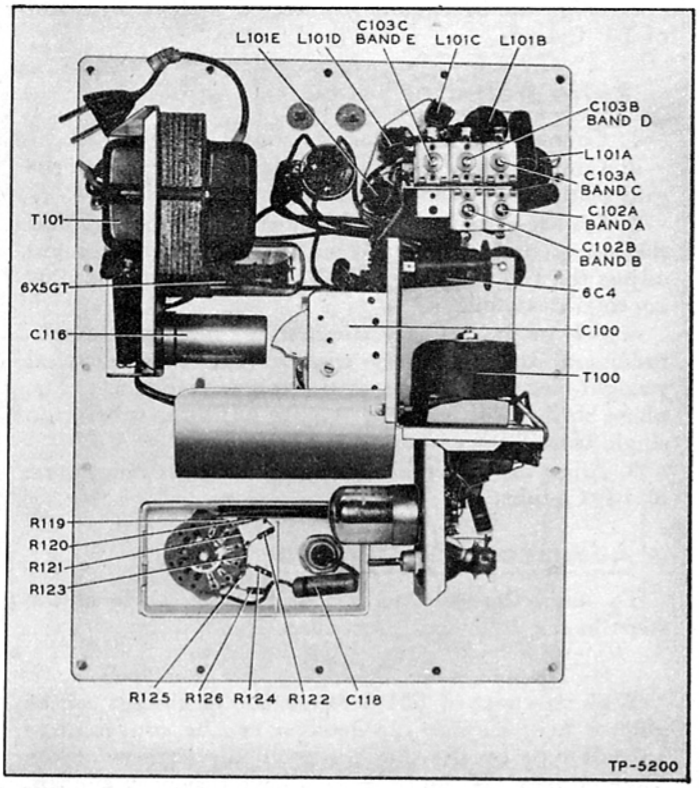

Figure 18. Location of Trimmers for Bands A, B, C, D, and E

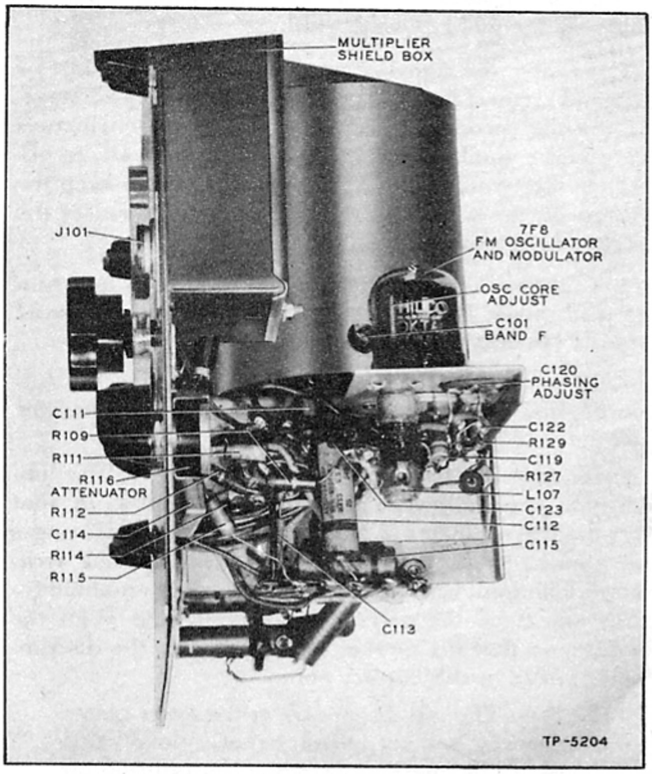

Figure 19. Location of Calibration Adjustments and Trimmer for Band F

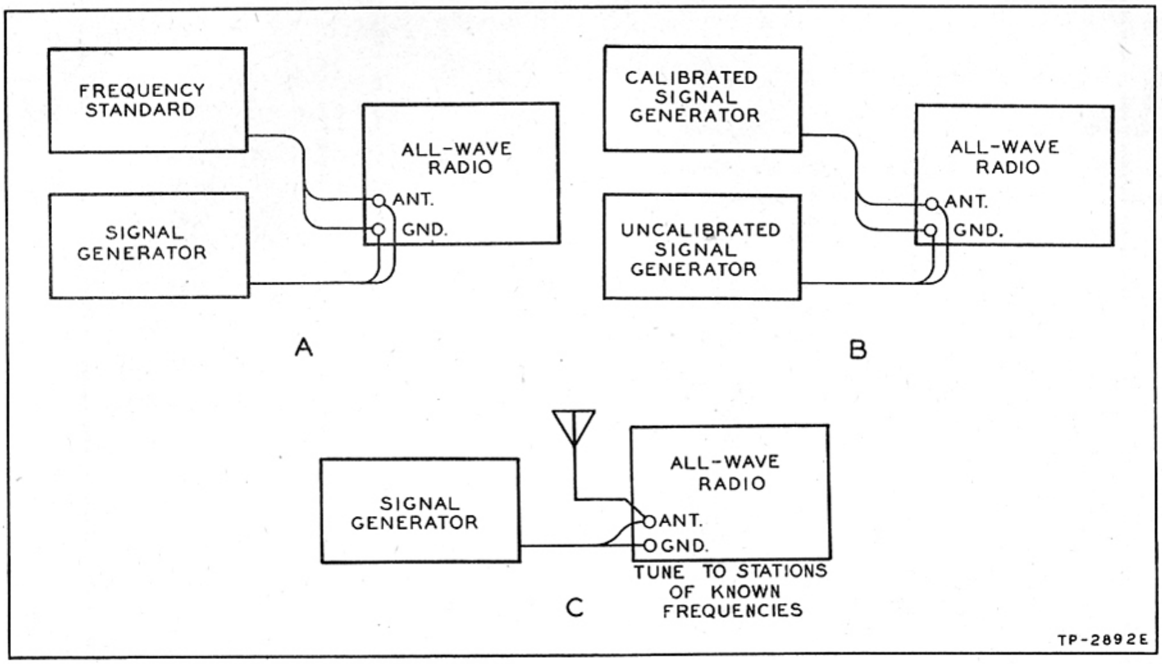

Figure 20. Equipment Combinations for Calibrating Signal Generator

ing up standard signals from broadcast or code stations of known frequencies. See figure 20C.

The adjustment of each trimmer should be made near the high-frequency end of the band to be calibrated. No special sequence of adjustments need be observed, since each trimmer and coil circuit is independent of the others.

Allow the signal generator and associated equipment to warm up for at least ten minutes. Turn off the audio modulation. Set the frequency standard to the desired frequency, and tune in the signal on the radio; the signal from the Model 7170 Signal Generator can then be zero beat against the standard signal.

With the BAND SWITCH of the Model 7170 properly set, turn the dial to the point at which the frequency is to be adjusted. Then turn the correct calibrating trimmer until the beat signal is heard in the radio, then carefully adjust the trimmer for zero beat; the sharpest zero beat indication will be obtained if the two signals are moderately weak. Repeat the adjustments for each band.

FM CALIBRATION ADJUSTMENTS

If the 7F8 FM-oscillator and reactance-modulator tube is ever replaced, the calibration adjustment outlined below should be performed, in order to retain the accuracy of the instrument.

1. Turn FM SWEEP WIDTH control from the extreme counterclockwise position until the switch operates. Leave the control at this position for minimum deviation.

2. Loosely couple the generator to a receiver, or to a frequency meter equipped with either a visual or aural indicator, and capable of tuning to 60 mc. Then adjust the FM-oscillator tuning core for a frequency of exactly 60 mc. (the generator tuning control should be set to some frequency other than 60 mc.)

3. Set FM SWEEP WIDTH control to its maximum clockwise position (greatest deviation), and set phasing adjustment C120 for a maximum deviation of ±500 kc. When the receiver or frequency meter is tuned to either side of 60 mc., the signal will disappear at a frequency which is just a little more than the amount of deviation. The signal sounds like rough a-c hash on an AM receiver, and like a smooth 60-cycle hum on an FM receiver.

4. Recheck the FM-oscillator center frequency; if it is not exactly 60 mc., retune oscillator core for correct frequency.

5. If necessary, repeat steps 3 and 4 until the center frequency is 60 mc. with a total deviation of 1 mc. (±500 kc.).

NOTE

Whenever the unit is removed from the case and then replaced, the alignment of the auxiliary vernier dial should be checked with the pointer set to its maximum counterclockwise position, the pointer center index line should coincide with the red line which divides the calibrated dial into two semicircles, and should also coincide with 1 and 19 on the vernier scale.

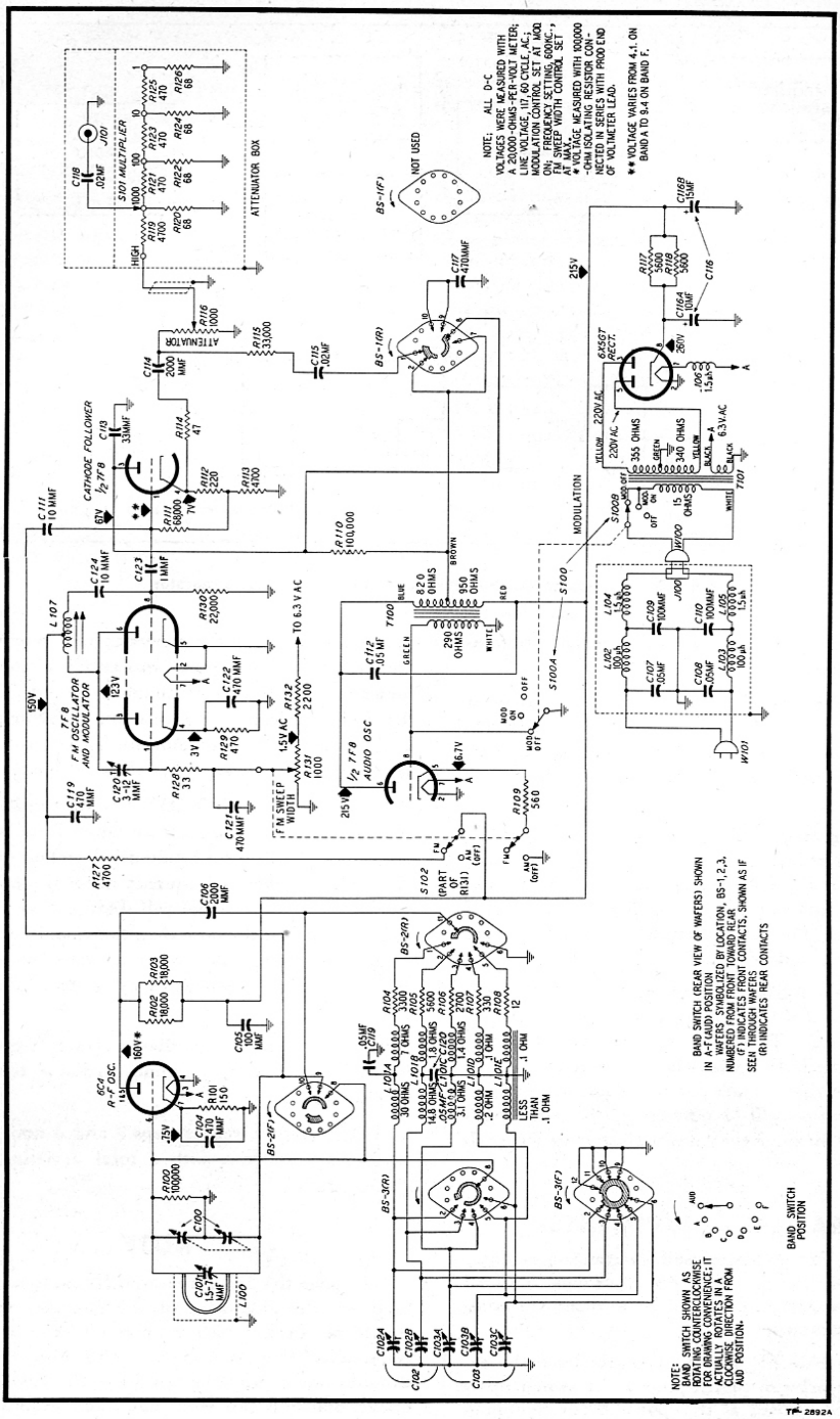

Figure 21. Philco FM and AM Signal Generator Model 7170, Schematic Diagram

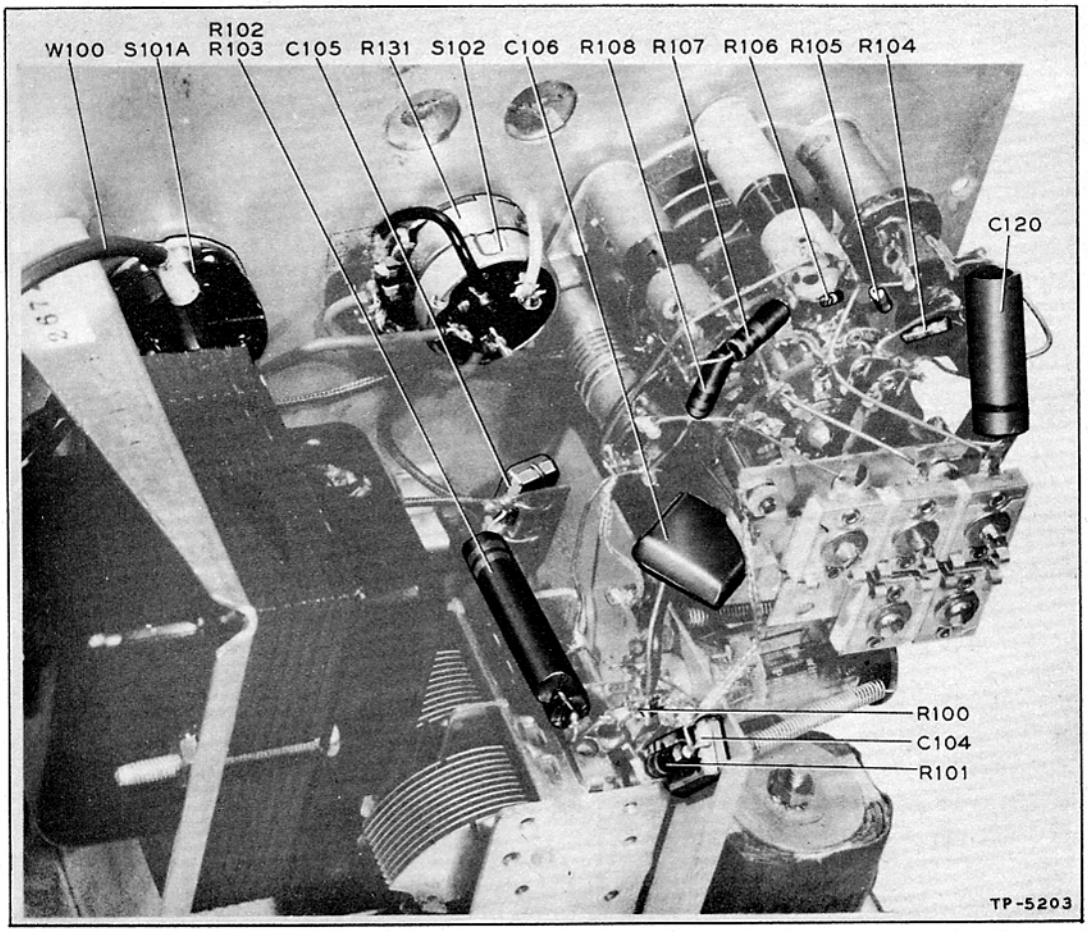

Figure 22. Band Switch and Oscillator Components

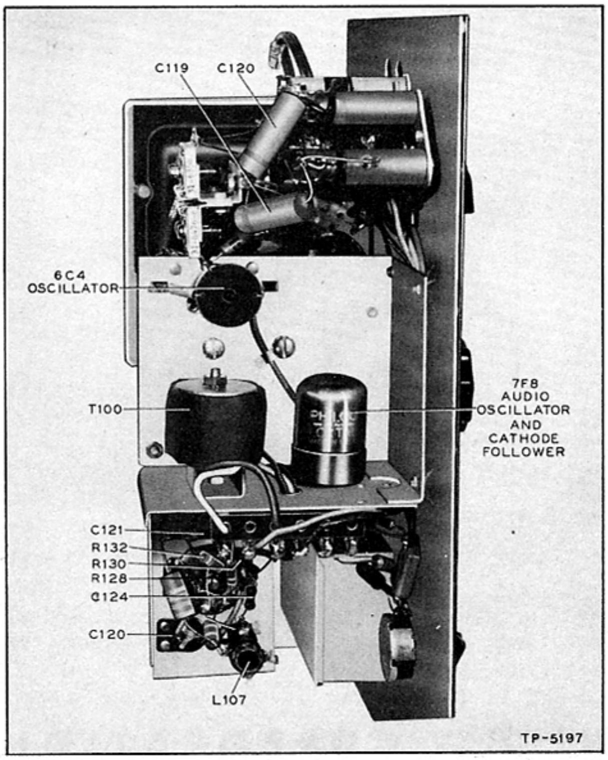

Figure 23. FM Oscillator and Modulator Components

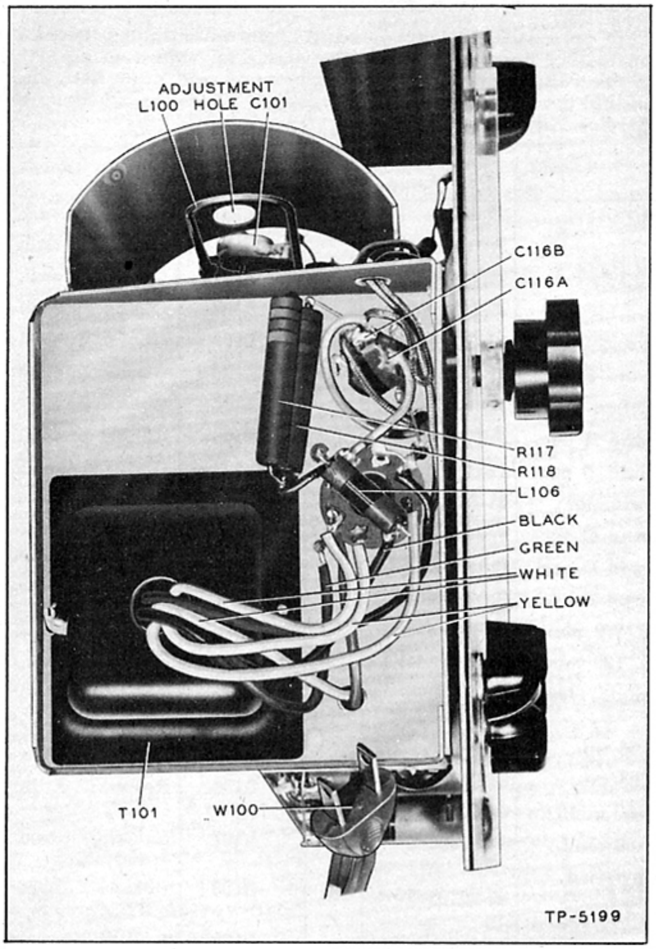

Figure 24. Power-Supply Components

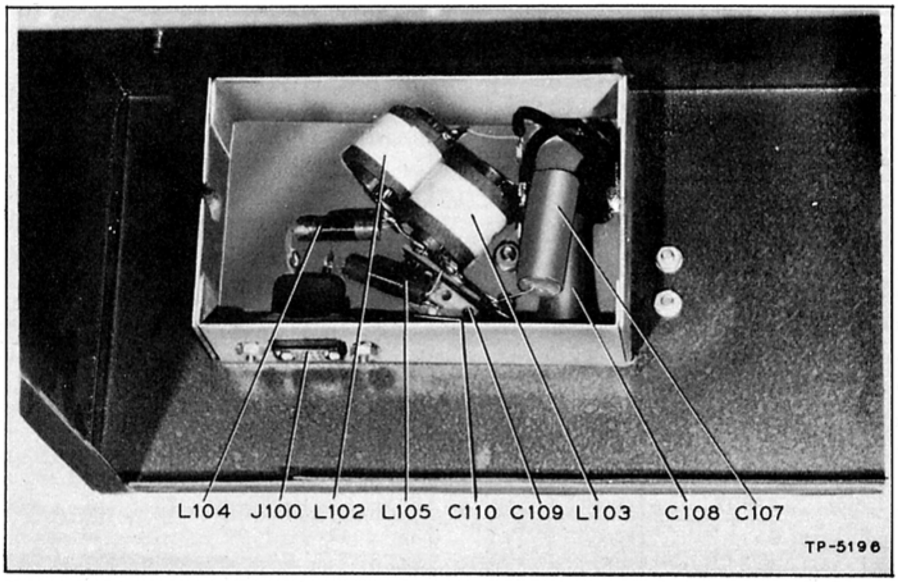

Figure 25. Line Noise Filter and Decoupler

REPLACEMENT PARTS LIST

NOTE: Parts marked with an asterisk (*) are general replacement items, and the numbers may not be identical with those on factory assemblies; also, the electrical values of some replacement items furnished may differ from the values indicated in the schematic and parts list. The values substituted in any case are so chosen that the operation of the instrument will not be affected. When ordering replacements, use only the "Service Part No."

Reference Symbol	Description	Service Part No.
BS	Band switch, 3-section	42-1737
BS-1	Wafer, band-switch	Part of BS
BS-2	Wafer, band-switch	Part of BS
BS-3	Wafer, band-switch	Part of BS
C100	Condenser, tuning, 2-gang	31-2642
C101	Condenser, trimmer, band F osc.	31-6480-2
C102	Condenser, 2-section, trimmer	31-6476-12
C102A	Condenser, trimmer, band A osc.	Part of C102
C102B	Condenser, trimmer, band B osc.	Part of C102
C103	Condenser, 3-section, trimmer	31-6358
C103A	Condenser, trimmer, band C osc.	Part of C103
C103B	Condenser, trimmer, band D osc.	Part of C103
C103C	Condenser, trimmer, band E osc.	Part of C103
C104	Condenser, r-f by-pass 470 mmf.	60-10475417
C105	Condenser, r-f by-pass, 100 mmf.	60-10105417*
C106	Condenser, r-f osc. plate, feed-back, 2000 mmf.	60-20205314*
C107	Condenser, line filter, .05 mf.	61-0122*
C108	Condenser, line filter, .05 mf.	61-0122*
C109	Condenser, line filter, 100 mmf.	60-10105407
C110	Condenser, line filter, 100 mmf.	60-10105407
C111	Condenser, output coupling, r-f osc. 10 mmf.	60-00105417
C112	Condenser, a-f osc. plate, feed-back, .05 mf.	61-0186
C113	Condenser, r-f by-pass, 33 mmf.	60-00305417*
C114	Condenser, output coupling, cath. fol. 2000 mmf.	60-20205304*
C115	Condenser, output coupling, a-f osc., .02 mf.	61-0108*
C116	Condenser, electrolytic, 2-section	30-2552
C116A	Condenser, power filter, 1st sec. 10 mf.	Part of C116
C116B	Condenser, power filter, 2nd sec. 15 mf.	Part of C116
C117	Condenser, amplitude limiting, a-f modulation, 470 mmf.	60-10475417
C118	Condenser, output coupling, r-f and a-f, .02 mf.	61-0108*
C119	Condenser, r-f by-pass, 470 mmf.	62-147001001*
C120	Condenser, phasing adjustment, 3—12 mmf.	31-6508
C121	Condenser, r-f by-pass, 470 mmf.	62-147001001*
C122	Condenser, r-f by-pass, 470 mmf.	62-147001001*
C123	Condenser, FM Coupling, 1.0 mmf.	30-1221-2
C124	Condenser, FM oscillator feed-back, 10 mmf.	30-1224-32
J100	Socket, a-c line filter	27-6212
J101	Connector, female, OUTPUT	76-2003-1
L100	Oscillator coil, band F	32-4010
L101	Oscillator-coil assembly	
L101A	Oscillator coil, band A	32-3901
L101B	Oscillator coil, band B	32-4009
L101C	Oscillator coil, band C	32-3902
L101D	Oscillator coil, band D	32-3903
L101E	Oscillator coil, band E	32-3904
L102	Choke, line filter, 100 microhenries	32-4011
L103	Choke, line filter, 100 microhenries	32-4011
L104	Choke, line filter, 1.5 microhenries	32-4178
L105	Choke, line filter, 1.5 microhenries	32-4178
L106	Choke, line filter, 1.5 microhenries	32-4178
L107	Coil, FM Oscillator	32-4285
R100	Resistor, grid leak, r-f osc. 100,000 ohms	66-4103340*
R101	Resistor, cathode r-f osc. 150 ohms	66-1153340*
R102	Resistor, voltage dropping, 18,000 ohms	66-3185340
R103	Resistor, voltage dropping, 18,000 ohms	66-3185340
R104	Resistor, degeneration, band A, 3300 ohms	66-2333340*
R105	Resistor, degeneration, band B, 5600 ohms	66-2563340*
R106	Resistor, degeneration, band C, 2700 ohms	66-2273340*
R107	Resistor, degeneration, band D, 330 ohms	66-1333340*
R108	Resistor, degeneration, band E, 12 ohms	66-0123340*
R109	Resistor, cathode, a-f osc. 560 ohms	66-1563240
R110	Resistor, amplitude limiting, a-f modulation, 100,000 ohms	66-4103340
R111	Resistor, grid leak, cath. fol. 68,000 ohms	66-3683340*
R112	Resistor, bias, cath. fol. 220 ohms	66-1228340
R113	Resistor, load, cath. fol. 4700 ohms	66-2473340*
R114	Resistor, cathode isolating, cath. fol. 47 ohms	66-0473340*
R115	Resistor, output coupling, a-f osc. 33,000 ohms	66-3333340
R116	Potentiometer, ATTENUATOR, 1000 ohms	33-5533
R117	Resistor, power filter, 5600 ohms	66-2565340*
R118	Resistor, power filter, 5600 ohms	66-2565340*
R119	Resistor, multiplier network, 4700 ohms	66-2471340
R120	Resistor, multiplier network, 68 ohms	66-0681340
R121	Resistor, multiplier network, 470 ohms	66-1471340
R122	Resistor, multiplier network, 68 ohms	66-1471340
R123	Resistor, multiplier network, 470 ohms	66-0681340
R124	Resistor, multiplier network, 68 ohms	66-0681340
R125	Resistor, multiplier network, 470 ohms	66-1471340
R126	Resistor, multiplier network, 68 ohms	66-0681340

R127	Resistor, plate dropping, 4700 ohms, 2 watts	66-2475340
R128	Resistor, grid return, 33 ohms	66-0333340
R129	Resistor, modulator cathode, 470 ohms	66-1473340
R130	Resistor, FM-oscillator grid leak, 22,000 ohms	66-3223340
R131	FM SWEEP WIDTH, deviation control, 1000 ohms	33-5561
R132	Resistor, modulator dropping, 2200 ohms	66-2228340
S100	Switch, rotary, 3-position, MODULATION	42-1769
S100A	Switch contacts, a-c power	Part of S100
S100B	Switch contacts, modulator	Part of S100
S101	Switch, rotary, 5-position, MULTIPLIER	42-1738
S102	Switch, FM, AM, ON-OFF	Part of R131
T100	Transformer, modulator	32-8275
T101	Transformer, power	32-8276-1
W100	Line Cord (with plug), external	L3183-1
W101	Line Cord (with plug), internal	L3183-2

MISCELLANEOUS

Description	Service Part No.
Box, termination, output cable	54-4438
Cable, output	41-3730
Connector, male, output cable	76-2895
Sleeve, male connector	56-4559
Coupling, tuning-condenser shaft	56-3183
Cover, output-cable terminal box	54-4437
Foot (8), mounting	54-4240
Handle assembly	76-1979
Knob (5), control	54-4281
Knob, tuning	54-7281
Nameplate, FM SWEEP WIDTH	56-5527
Nameplate, model information	56-5523
Panel, front	56-2684
Plate, name, "PHILCO"	76-2114
Pointer, lucite	54-4262-2
Post (2), binding, terminal box	76-2896
Resistor, output lead, 68 ohms ±5%, 1/2 watt	66-0683240*
Shaft assembly, vernier drive	31-2700
Socket, Loktal	27-6213
Socket, minature	27-6203-1
Socket, octal	27-6199*

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