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RADIO SERVICEMAN

RADIO MAINTENANCE

JULY 1947

SERVICING F-M RECEIVERS

TEST EQUIPMENT MAINTENANCE

TELEVISION RECEIVERS—
FLYWHEEL SYNCHRONIZATION

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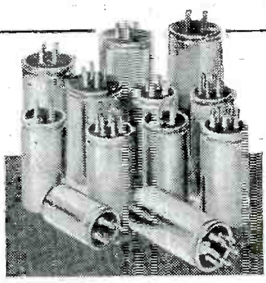

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Volume 3 JULY, 1947 Number 7

Contents

Next Month — Speaker Matching

In order to include additional material, the article on speaker matching, originally scheduled for this issue has been held over and will appear in August RADIO MAINTENANCE. If you are interested in audio distribution in systems using more than one speaker, don't miss this very useful and informative article.

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TEST EQUIPMENT MAINTENANCE

PART II

by
John B. Ledbetter

The author continues his explanation of maintenance methods which add to the life of the serviceman's test equipment and promote better business. Signal generator calibration is covered as well as information about tube testers and VTVM's.

TYPES OF TEST EQUIPMENT requiring maintenance are:

Tube tester, volt-ohm-milliammeter, vacuum tube voltmeter, signal generator, audio oscillator, signal tracer, oscilloscope, and other equipment and tools. In Part I, we discussed the components found in test instruments. In this discussion, the test instruments themselves will be treated, assuming that their components have been cared for as described in Part I.

Tube Testers

Most actual failures of tube testers to indicate properly are due to a defective rectifier, an open meter coil, or a blown line fuse. In present day testers, about the only condition resulting in overload of the meter is an incorrect setting of the selector switch or push buttons, which causes the meter to swing off-scale forcibly in either direction. The extent of damage in this case is a bent pointer if the force of swing is of sufficient magnitude. Gassy tubes will sometimes produce an off-scale deflection, but seldom is it strong enough to injure the indicating needle.

A large percentage of trouble in tube testers seems to be due to mechanical, rather than electrical, failures. Tube testers were not designed to bounce cross country at fifty miles an hour on the floor of a service truck, and should be treated accordingly. Keeping the case waxed and the panel clean and polished aids in preserving its appearance. A good grade of commercial wax polish should be used on wood cabinets and cases. Leather cases may be given a cleaning occasionally with a damp sponge or cloth covered with saddle soap. The soap should be applied with circular cleaning motions and immediately removed. The case should be dried at once with a soft cloth and a liquid or wax polish applied to keep the leather pliant and to avoid cracking. Metal panels may be waxed if desired, or simply polished with a soft cloth. Metal or bakelite panels having a crackle finish should be treated with an oil polish and immediately wiped dry.

Volt-Ohm-Milliammeters

The various meter ranges are more often subjected to overload than those of the tube tester since, in most cases, one cannot be *absolutely* certain of the voltage or current about to be checked. The highest range should be used in each test to obtain an approximation, then the correct scale employed. Carelessness is the *main* reason for overloads and burnouts.

Some models of pocket-size voltohmmeters will arc over when high voltages are checked, even though they are equipped with a high voltage range. The wiring in most cases is thinly insulated with poor insulation in the range switch. High voltages should be checked on standard volt-ohm-milliammeters. A word of CAUTION is now in order: With oscilloscopes, television sets, large PA systems and other electronic equipment employing voltages of 1000 and more, the serviceman must exercise extreme care to avoid serious injury and shock. Well insulated probes should be used, and meter connections should be made with power off, if possible.

Vacuum-Tube Voltmeters

Usually, difficulty in obtaining correct readings or a zero setting in the ohms adjustment is due to a defective tube. Low readings are usually due to a weak tube; a shifting or variation in zero seting as the ohms ranges are changed (with the test probes shorted) indicates a gassy tube.

Tube replacement makes necessary recalibration of both AC and DC ranges. This calibration varies according to the instrument design. The Radio City Products Model 663A is typical of electronic voltmeters, and the following calibration instructions are given as an example:

"After replacing the 6K6G, the instrument is calibrated as follows:

DC Volts

1. Remove the instrument from its case, turn on and allow the usual warm-up period. Check by setting the Circuit Selector to +DCV position and turning the ohms adjustment until the meter pointer reads zero. If the tubes have reached normal operating temperature, there will be no movement of the pointer when the Circuit Selector switch is turned from +DCV to —DCV position.

2. Set the Range Selector to 30V position and connect a known source of exactly 30 volts (batteries or accurate DC supply) across the test prods.

3. The rheostat with screwdriver slot, located directly behind the 6X5GT tube, is adjusted until the meter reads full scale.

AC Volts

Calibration is made as above. In this instance, a sine wave of exactly 30 volts RMS from a reliable AC source is connected to the test probes. The rheostat with screwdriver slot is located directly behind the VR105 tube. This rheostat is adjusted until the meter gives a 30-volt full scale reading, and the calibration is complete."

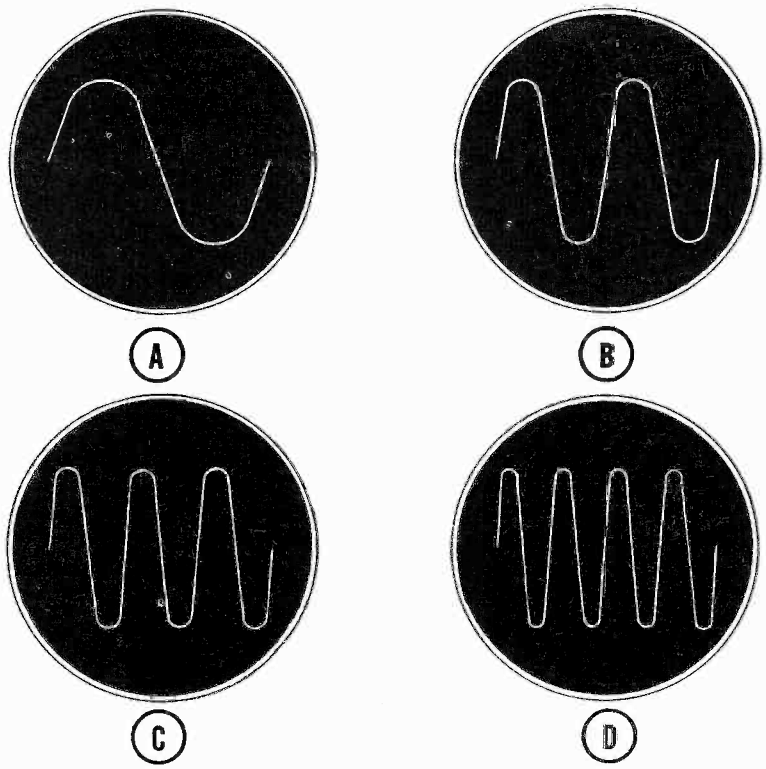

Fig. 1 Oscilloscope patterns obtained when calibrating an audio oscillator against a standard 60 cycle sweep. The frequencies are the fundamental and three harmonics: A 60 cycles, B 120 cycles, C 180 cycles, and D 240 cycles.

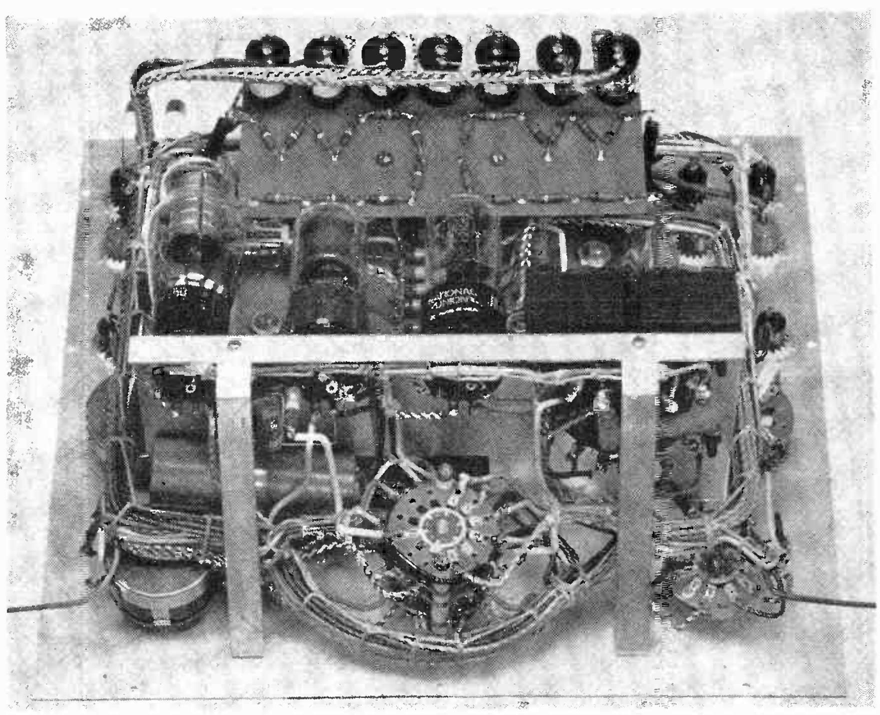

Fig. 2 Internal view of a typical multitester, showing arrangement of parts which are discussed in the text.

Signal Generators, Audio Oscillators

Erratic operation and instability in these instruments may be traced in most cases to defective tubes, dirty or corroded condenser rotors, loose bearings, worn bushings, or excessive end play in rotor shafts. Calibration readings which contain the same percentage of error at all

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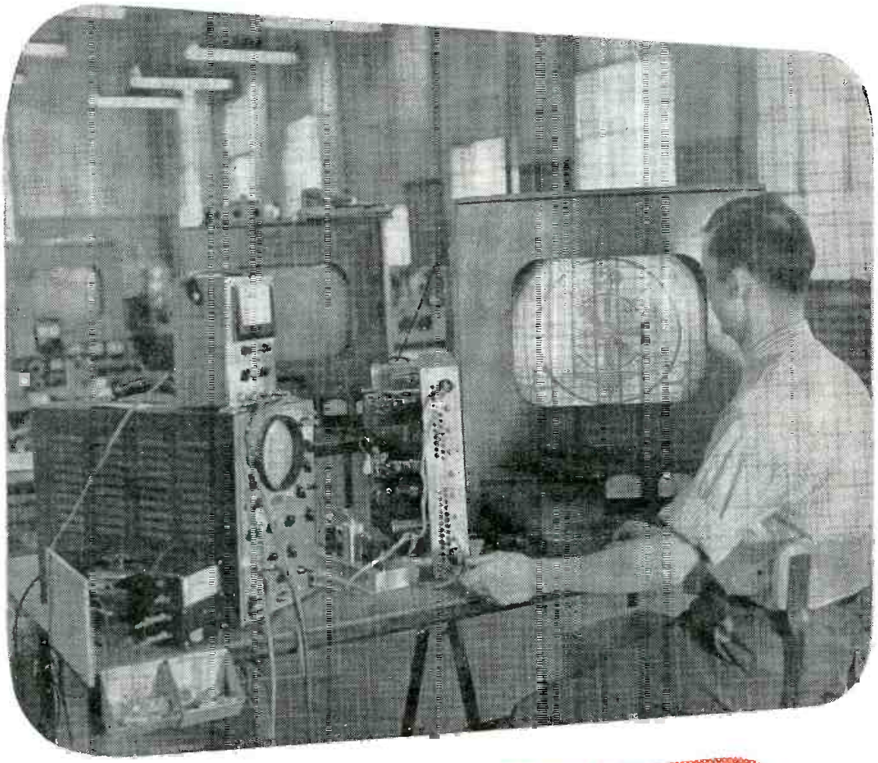

TELEVISION RECEIVERS

Flywheel SYNCHRONIZATION

by MORTON SCHERAGA

The author starts with this article a new series which will explain the latest developments in the growing television field. AFC sync., which will solve many noise interference problems, is the first subject covered.

In the previous series of articles on television receivers, the discussion of circuits was confined to pre-war designs in order to lay the groundwork in theory and servicing techniques which would enable the serviceman to understand the most recent models now coming on the market. Particular stress was also given to the receiver designed around the magnetically deflected and focused cathode-ray tube for the majority of the new sets will incorporate this type. Whereas one found electrostatically deflected tubes up to twenty inches in size in the old receivers, most manufacturers are now limiting their use to the lower priced sets with electrostatic picture tubes only as large as seven inches.

Beginning with this first article, we shall describe the new features that are becoming characteristic of the recent models. These changes in design have come about as a result of the experience that design engineers have gained in operating the old sets in the field under normal and adverse conditions. Such field testing in weak signal and noisy areas emphasized the need for a system to provide more stable synchronization of the sweep circuits. The biggest market for television receivers is around metropolitan areas; but it is in such areas that ignition noise from automobiles and man-made static are greatest. These spurious signals would cause the picture to tear and be displaced horizontally; and in some cases, for example, where automobile traffic was extremely heavy, the picture was not at all usable. Likewise, sets located near the edge of the service area of a television station, where the signal-to-noise ratio is low, suffered intermittent loss of synchronization and impairment of horizontal resolution.

One solution to this problem has been the development of automatic frequency control of the synchronization circuits. Observations in the laboratory and the field indicate that this new receiver synchronizing circuit affords an immunity from noise that is not found in receivers using conventional synchronizing methods. When it is used, random noises from diathermy, car ignition, and home appliances do not cause tearing of the picture in horizontal strips. AFC synchronizing also gives greater horizontal resolution at all noise levels for which the signal is usable.

Conventional Sync System

In the conventional synchronizing system, each individual synchronizing pulse triggers the scanning oscillator. The synchronizing of a blocking oscillator is illustrated in Fig. 1. As the plate current increases, the grid is driven positive, causing current to flow. This grid current builds up a negative voltage across resistance R-1, which in turn charges condenser C-1. When the plate current stops increasing and begins to decrease, the reversal in current through the transformer places a negative voltage on the grid. The negative charge on the grid condenser C-1 will then leak off slowly through R-1, until the grid reaches a potential where plate current can again flow. This cycle of grid voltage is shown in Fig. 1A. The oscillator is now running at its "natural" frequency which is determined by the values of R-1 and C-1.

If a synchronizing pulse is now applied to the grid at a time T which raises the grid voltage to a point where plate current can flow, the oscillator will trigger at T rather than at its natural frequency, as shown in Fig. 1B. Suppose, however, that there is a noise burst coming in along with the synchronizing signals. If the noise is of sufficient amplitude and occurs close to the natural frequency of the blocking oscillator, it too can trigger the grid, but it will do so at the wrong time as shown in Fig. 1C. In other words, the oscillation will occur ahead of time T with the result that the particular horizontal line will be displaced to the left. Since these noise pulses have no constant frequency, the displacement of horizontal lines in the picture will be non-uniform, resulting in a picture with ragged edges and distorted images.

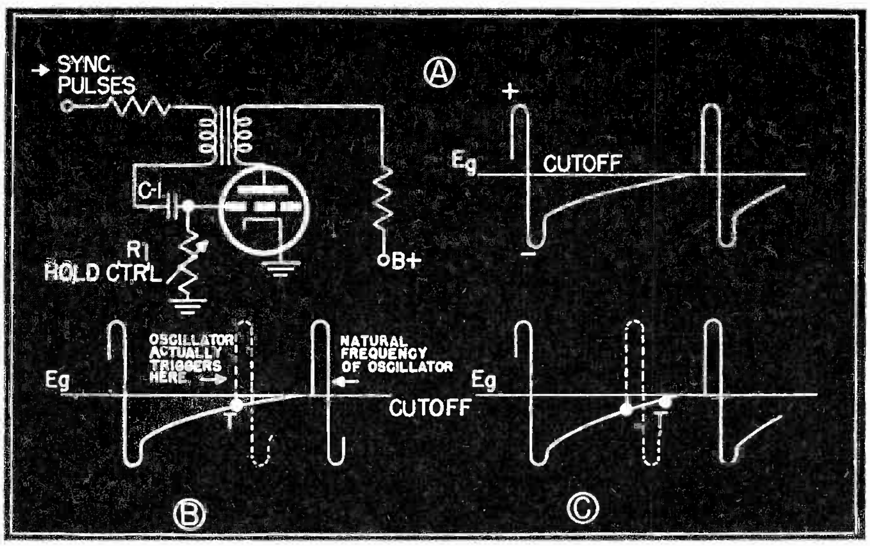

Fig. 1 How noise pulses interfere with synchronization. (a) circuit of blocking oscillator and grid voltage waveform when oscillator is running at its "natural" frequency. (b) Wave form of grid voltage when the blocking oscillator is triggered by a sync. pulse. (c) grid voltage wave form when oscillator is triggered before the correct time T by a noise pulse which is sufficiently large to drive the grid positive.

The shortcomings of the synchronization system where each sync pulse triggers the oscillator are obvious since the oscillator cannot distinguish between a sync pulse and a noise pulse. In the AFC system, a DC control voltage is used to set the frequency of the oscillator. This DC voltage depends upon the *average* frequency of the horizontal sync pulses so that noises occurring at irregular time intervals have little effect on the average control voltage.

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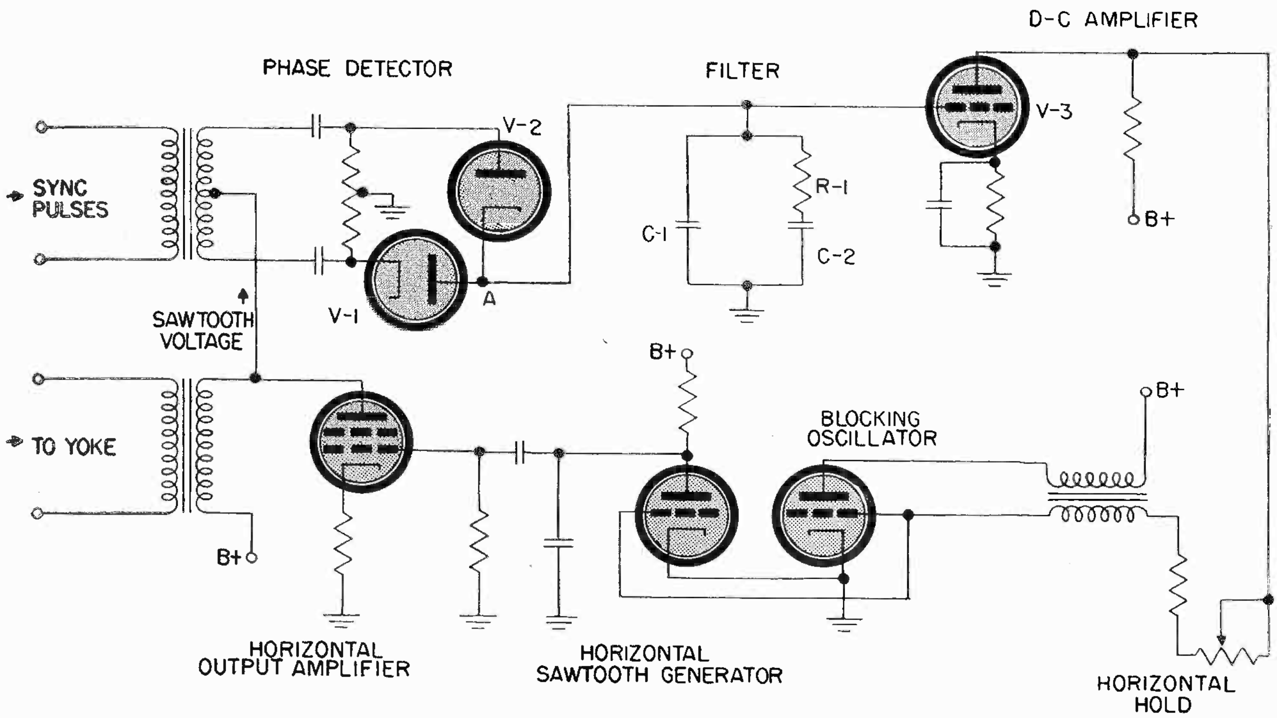

Fig. 2 Simplified schematic diagram of horizontal sweep system synchronized by AFC sync. circuits.

Fig. 2 is a simplified diagram of one type of AFC sync circuit which will be found in some receivers. As with conventional circuits, the sync is first clipped from the composite video and sync signal. But instead of the sync being fed to the grid of the oscillator, it is first injected into a phase detector which compares the relative phase of the incoming sync pulses and the saw-tooth voltage that is being generated in the deflection circuits.

Fig. 3 shows the potentials of the plates of V-1 and the cathode of V-2. The diodes V-1 and V-2 are peak detectors which hold the peaks of the sync pulses at zero potential as shown in the figure. Point A (Fig. 2) assumes the average potential of the two waves shown in Fig. 3. In the case illustrated, this potential is zero. However, if a small phase displacement occurs between sync pulses and the saw-tooth, the sync peaks continue to be maintained at zero potential; but the average potential at point A is raised or lowered depending on whether the pulse shifts to the left or right on the saw-tooth. Variations in the potential at point A are amplified by a DC amplifier stage (Fig. 2). This amplified DC voltage is then applied to the grid of the scanning oscillator as a bias control, and determines the oscillator frequency.

AFC Sync System

Let us review this cycle of operation of the AFC sync system. If the sync pulses and the generated saw-tooth voltages are in phase, the potential at point A is zero and the scanning oscillator is running at its correct frequency. Should the scanning oscillator now change speed, the saw-tooth will shift with respect to the sync pulses, and the potential at point A will no longer be zero. The resultant voltage at point A is then amplified and changes the bias on the grid of the scanning oscillator so that it comes back to its correct frequency. Thus, it is seen that there is a DC control voltage on the grid of the scanning oscillator rather than regularly recurring sync pulses.

What happens now if noise pulses come through? They are filtered out by the network shown between the phase detector and the amplifier in Fig. 2. The constants of this circuit are set so that rapid changes in the DC control signal, such as are produced by the vertical synchronizing pulse or noise bursts, are bypassed. In other words, the regularly recurring horizontal sync pulses determine the DC control voltage, but any random, rapid pulse has little effect. For this reason, this system is sometimes called *flywheel synchronization*.

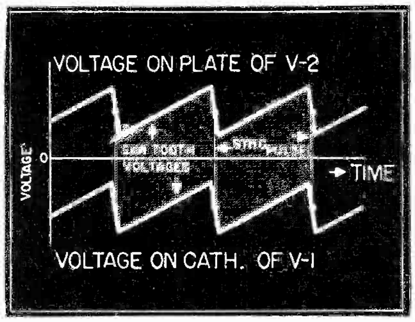

Fig. 3 Wave forms of voltages on plate and cathode of phase detector.

Actual photographs showing the improvement due to incorporation of AFC in the sync. circuit in a receiver. Left views are with ordinary "trigger" sync. and those on the right indicate results with "flywheel sync." The top test was made 70 miles from the transmitter, the bottom one with a strong local station and high noise level from automobile ignition.

Servicing

The serviceman will encounter no more difficulty in servicing AFC sync circuits than with conventional types. The setting of the horizontal hold control is usually the only adjustment that will have to be made. The control is first set near the center of the range of synchronization. The band selector is then momentarily turned to another channel and switched back to the first position. If the AFC receiver remains in synchronism, the speed adjustment is optimum. If the receiver does not rapidly pull into synchronization when switching channels, the hold control should be varied for the best condition. If no setting of the hold control permits rapid synchronizing, then the filter network (Fig. 2) should be investigated. The constants of the filter are fairly critical for successful operation of the AFC sync system. For example, if R-1 has changed in value and become larger, the sides of the image become scalloped; when R-1 is too small, the image as a whole vibrates in the horizontal direction. Substituting a potentiometer for the fixed resistor is the quickest means of determining the correct value of R-1. (This may be different from the original value of the resistor since the capacitors may have changed value.) Once the new resistance has been determined with the potentiometer, a fixed resistor may be soldered into place.

The points in the circuit to check in trouble-shooting this type of AFC sync system are as follows:

1. The primary of the phase detector transformer where the incoming sync pulse should be observed.

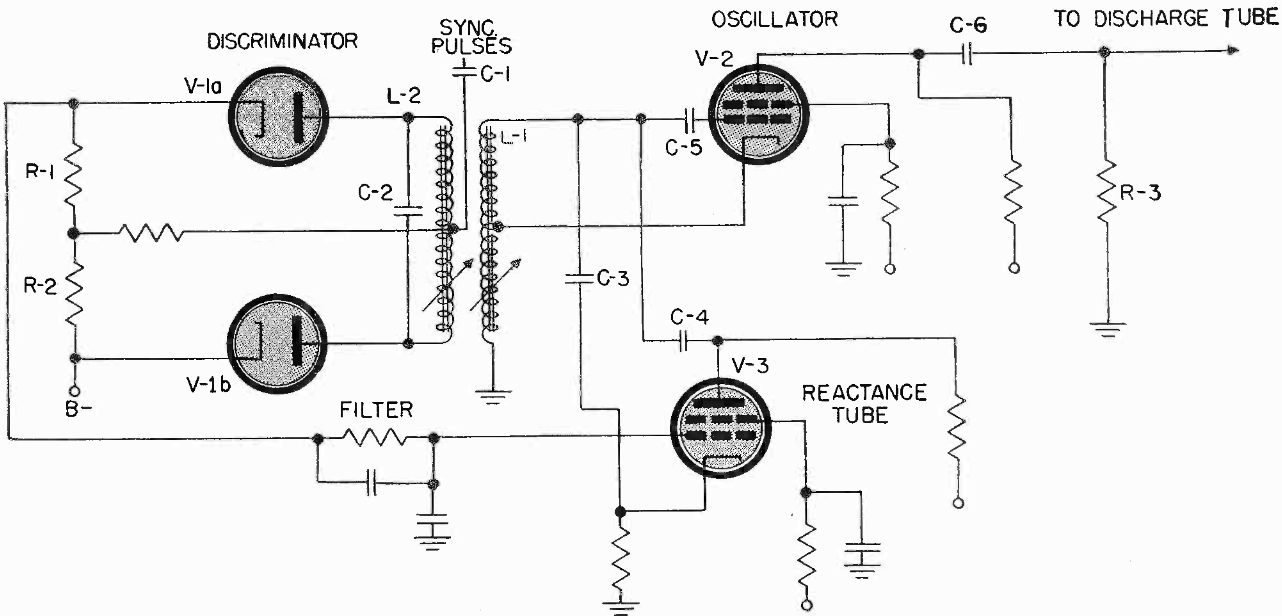

Fig. 4 Circuit for automatic frequency control of horizontal sweep system.

2. A check of the polarities of the pulses applied to the diodes should reveal a positive pulse on the plate and a negative pulse on the cathode.

3. The saw-tooth at the center tap of the secondary of the phase detector transformer should be of good waveform.

4. When the receiver is synchronized and operating corectly, the potential of point A should be zero (measured with a voltmeter).

An outgrowth of this type of AFC circuit is being used by some manufacturers which eliminates the need for the manual hold control; having this control was necessary because of the inherent frequency drift characteristic of blocking oscillators and multivibrators, the two most common types used in television receivers. By using a more stable oscillator, automatic characteristics of the flywheel system have been improved.

Second Type of AFC

Fig. 4 illustrates a second type of AFC sync circuit. As before, a sync pulse is fed to a discriminator tube, V-1, only in this case the sync is injected into the secondary rather than the primary of the transformer. Instead of feeding a saw-tooth voltage back from the scanning circuits into the phase detector, a separate sine wave signal is generated by tube V-2 and transformer-coupled to the discriminator. Thus, the object of this circuit is to compare the phase of the sync pulses and the locally generated sine wave. Any phase difference between the two signals sets up a DC control voltage which pulls the sine wave oscillator into synchronization with the sync pulses.

An electron-coupled oscillator V-2 which is extremely stable generates the sine wave at the horizontal line frequency of 15,750 cps. This sine wave voltage is induced in the discriminator winding L-2 which is slug tuned and resonated by condenser C-2. The induced voltages on the plates of V-1 are equal in amplitude and opposite in phase with respect to the center tap of L-2. Also appearing on the plates of the diode is a component due to the sync pulses fed from the sync separators to the center tap of L-2 through condenser C-1. The composite sync and sine wave voltages appearing on the plates of the two diodes are shown in Fig. 5A. For this condition, equal and opposite voltages appear across the diode load resistors, R-1 and R-2. The total voltage across the load is therefore zero.

Consider now the case where the sine wave oscillator has drifted in frequency with respect to the incoming sync pulses as shown in Fig. 5B. Here the peak voltage across R-1 is higher than that across R-2. The total voltage across the load thus becomes positive. Similarly, if the oscillator drifts in the opposite direction as in Fig. 5C, the total voltage becomes negative. Hence, if the oscillator shifts in frequency from that of the sync pulses, a DC control voltage is set up across the load of the discriminator. As with the previous AFC system, this varying DC voltage is applied to a filter network which by-passes any noise bursts. The DC output from the filter is then fed to the grid of the reactance

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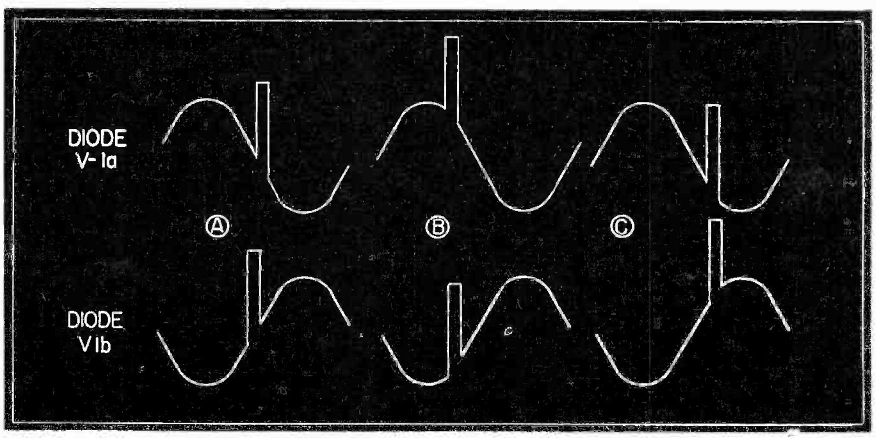


Fig. 5 Waveforms appearing on plates of diodes of discriminator.

servicing FM *receivers*

204 FM Stations Are Now On The Air!
Two Million FM Sets Will Be Produced In 1947!

This is the first of several articles designed to acquaint the serviceman with the latest information needed for testing, repairing, and aligning FM receivers which are now rolling off the production lines.

by Milton Kaufman
RCA INSTITUTE

ALTHOUGH THE ADVANTAGES of Frequency Modulation have been known for many years, moderately priced FM receivers have only recently been offered to the public in quantity. The use of FM sets high standards of reception by providing virtually noise-free reception, high fidelity of audio frequencies, and the elimination of fading.

Since FM is a fairly new art to the serviceman, this series first presents the basic theory of FM. This will be followed by analysis of receiver circuits and methods of alignment and signal tracing which are considerably different from the techniques used with ordinary AM receivers.

FM vs. AM Receivers

Before going into a discussion of the theory of frequency modulation, it is well to examine the basic differences between receivers used for ordinary broadcast reception and those used for FM reception. Fig. 1A shows a block. diagram of a conventional AM superheterodyne. This consists of an RF stage, local oscillator, mixer, IF amplifiers, AM detector, and audio amplifier. Compare this diagram with the block diagram of a typical FM receiver (Fig. 1B) and it will be seen that they are quite similar. In fact, if it were not for the FM detector, which is called a discriminator, it would be very difficult to tell the two receivers apart. Note that the RF stage, mixer, local oscillator, IF amplifiers, and audio amplifier are common to both types of receivers. Yet there are some very important differences.

1. Certain types of FM sets incorporate a limiter stage which is in fact an additional IF stage, operating under special conditions. The function of this stage is to prevent fluctuations in the strength of the carrier wave from affecting the discriminator output. Other recently developed types of FM receivers, now being sold in great quantity, do not require limiters.

2. Detection is accomplished by different means. The detector (discriminator) must reproduce the original audio tones from changes in the *frequency* of the carrier wave. This differs from the ordinary detector which must respond only to changes in the *amplitude* of the applied carrier.

These are the two major differences between an FM receiver and an AM set. A more detailed analysis will be presented later.

Advantages of FM

The important advantages of FM transmission may be classified as follows:

1. *Reduced receiver noise output.* This refers only to the noises actually generated within the receiver itself, such as tube noise and resistor noise. Noises of this nature take the form of a continuous hissing sound not heard on less sensitive broadcast receivers. However, an AM wave would have to be about fifteen times as strong as an FM wave at the antenna of a receiver for equally good noise suppression.

2. *Reduced interference from ignition noises, electrical appliances and atmospheric conditions.* This is

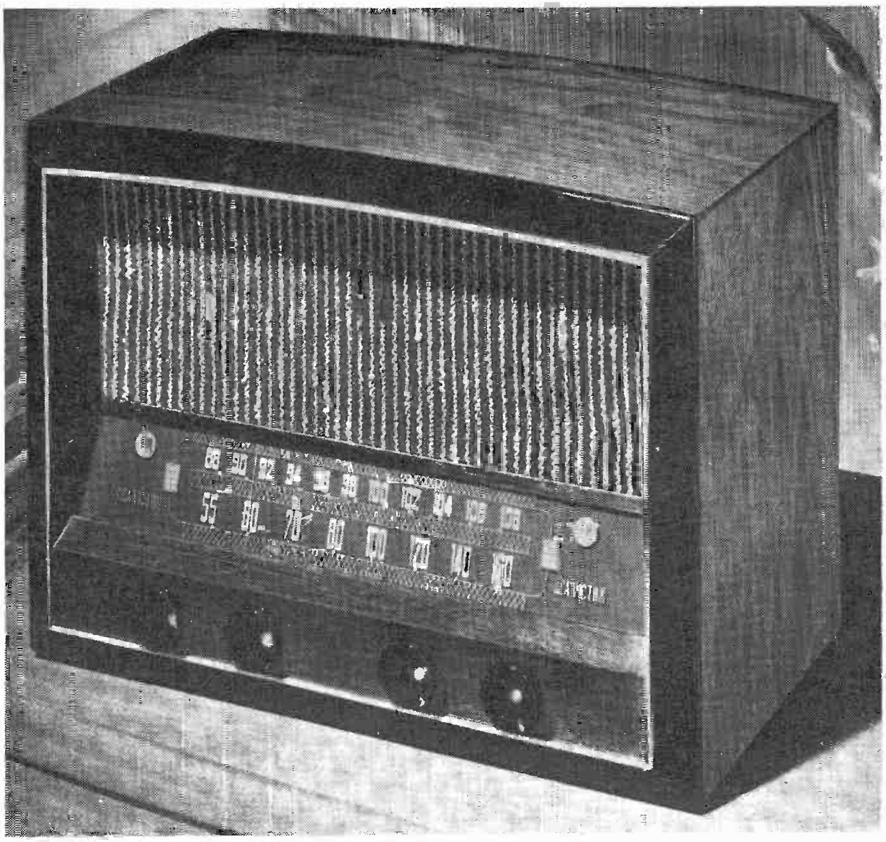
probably the greatest single advantage of FM. Military installations in tanks and other types of vehicles have shown that FM equipment is able to operate consistently under the most severe noise conditions where AM transmission would have been unintelligible. In home installations, where such interference as elevator noises, ignition noise pickup from cars, and other similar annoyances occur, the overwhelming superiority of FM has been demonstrated. Ignition noises are only important at the short waves and do not interfere with standard broadcasting.

3. *Greater audio frequency range.* In standard broadcast practice today, each station is assigned a channel 10 kc wide, which limits the sidebands to plus and minus 5 kc. This automatically limits the highest audio frequency to 5000 cycles. Higher audio frequencies are not reproduced and thus most of the brilliance of the music or voice is lost. Good FM receivers are capable of responding to audio frequencies of 15,000 cycles or even higher. It should be pointed out, however, that were broadcast stations allowed a greater channel width, say 30 kc, high fidelity of audio reproduction on an AM system would be possible. However, since the AM set does not discriminate against noise, the improvement in fidelity might be accompanied by an objectionable increase in noise output.

4. *Elimination of interference between stations on the same or adjacent channels.* For a desired station to "override" an undesired station completely on an AM receiver, it is necessary that the ratio between their signal strengths be on the order of 100 to 1, or 200 to 1. For this reason, it has been necessary that stations operating on the same channels be geographically far apart. FM receivers encounter no such difficulties since it is only necessary to achieve a ratio of 2 to 1 between desired and undesired signals in order to make the latter inaudible. Since AM channels are located adjacent to one another, it becomes difficult to separate stations without interference. Adjacent FM channels are separated by guard bands in which no transmission takes place, thus virtually eliminating interference from this source.

5. *Elimination of fading.* This is accomplished partially by the use of high frequencies for FM transmission (88-108 mc). At broadcast quencies, a phenomenon known as selective fading takes place when a wave propagated directly to the receiver combines with a wave which is reflected from a layer in the ionosphere which has traveled a longer distance. At some times, the waves are in phase and increase the signal strength, while at other times they are out of phase and lower the signal strength. At the very high frequencies which are used for FM, *practically* no ionospheric reflections take place, and selective fading is eliminated.

Types of fading which result from temporary reflections, such as those from airplanes, and vibration of the antenna in wind storms, are



New FM table model receiver. Various models, ranging from this size up to large console combinations are now being produced.

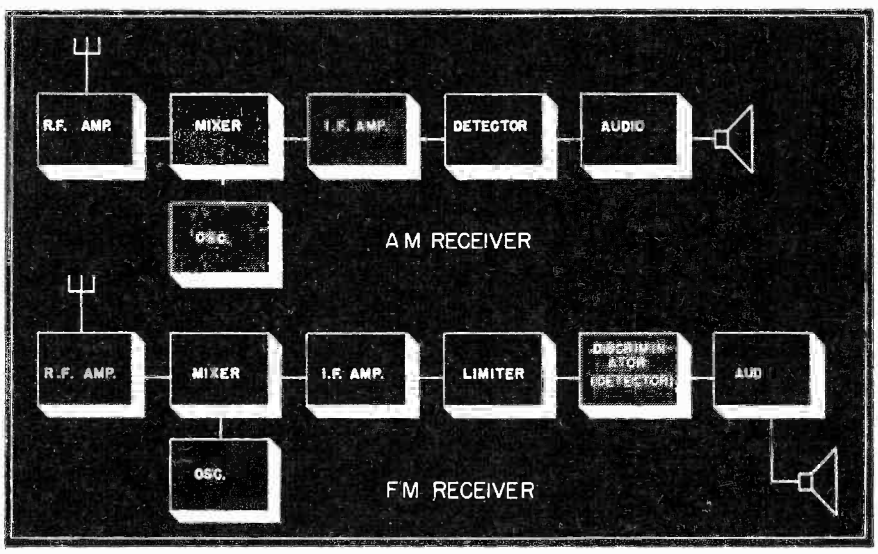


Fig. 1 Block diagrams showing relations and differences between AM and FM receivers.

minimized by the action of the limiter.

Modulation

The one factor which makes an FM wave different from any other wave is the method of modulation. Modulation may be defined as "The process of varying the characteristics of the carrier wave in accordance with the information to be transmitted."

The carrier wave consists of a series of continuous unvarying high frequency sine waves which do not change in amplitude, phase or frequency. The carrier wave of itself conveys no information, but is only the *medium* by means of which the information is sent. It is necessary, therefore, to cause variations in the carrier wave to send information—and this process is called modulation.

The simplest type of modulation consists of turning the carrier wave on and off at controlled intervals in the form of Morse code transmission.

At present, there are three types of modulation being used; amplitude modulation (AM), frequency modulation (FM), and phase modulation (PM).

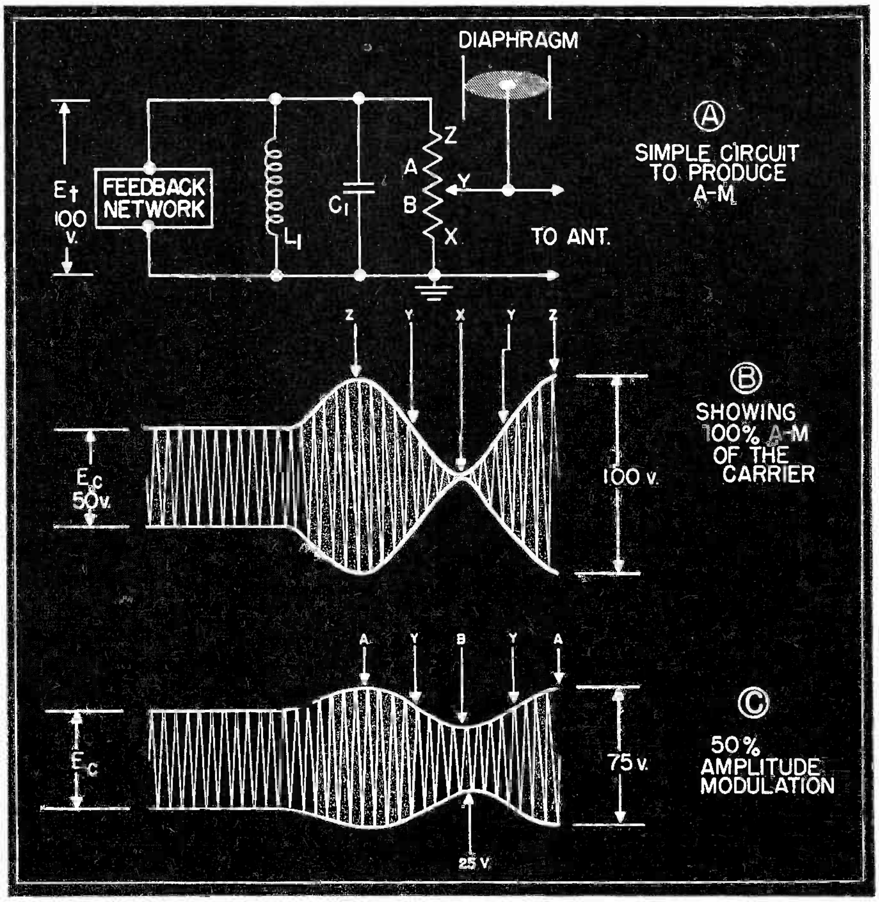


Fig. 2 A theoretical method for producing amplitude modulation and the carrier wave forms which would result for two different modulation percentages.

Amplitude modulation is the process of changing the *strength* of the carrier wave in accordance with the information to be transmitted. Fig. 2A shows a simple circuit which may be used to produce amplitude modulation. This consists of an oscillatory tank cirsuit L_1C_1 which we will assume has a resonant frequency of 50 mc. In order to sustain oscillations, a feedback network has been added. Across the tank circuit has been placed a high resistance with a sliding tap. A diaphragm which is free to vibrate upon the impact of sound waves is connected rigidly through a rod to the sliding tap. The tap connects directly to an antenna. With no modulation present, the diaphragm is at rest and the tap remains at the center point. It is assumed that the voltage across the tank circuit E_T is equal to 100 volts. Therefore, with the tap at the center point, there will be a constant output to the antenna of 50 volts. This corresponds to the amplitude of the carrier wave E_C. If a person should speak very loudly into the diaphragm, the tap would move between the limits of X and Z. With the tap at position Z, the full output of the oscillator, or 100 volts, will be sent to the antenna. When the tap is at Y, the center, only 50 volts will be applied, and at position X, there will be no output at all. The shape of the graph of the output signal would look as shown in Fig. 2B. This wave corresponds to 100 per cent modulation. The percentage modulation of an amplitude modulated wave may be computed from

$$\% \text{ mod.} = \frac{E\ max - E\ min}{2\ E\ av} \times 100$$

Substituting from Fig. 2B

$$\% \text{ mod.} = \frac{100 - 0}{100} \times 100\%$$

If a person wei to speak only half as loud as before, the tap would move only half as much and remain between the limits of A and B. The voltage would then vary from 75 volts to 50 volts to 25 volts, and so on. By substituting in the above formula, we find the percentage of modulation to be 50 per cent (Fig. 2C). Thus, it is seen that the *strength* of the carrier wave is changed according to the voice (or music) in amplitude modulation, and that the percentage of change depends on the loudness of the modulating signal.

The number of changes per second depends on the frequency of the modulating signal. These examples should be borne in mind as you will see that they have exact counterparts in frequency modulation.

For AM, then:

1. The *percentage* of amplitude change depends on the *loudness* of the modulating signal.

2. The *number* of changes per second depends on the tone *frequency* of the modulating signal.

Frequency Modulation

Frequency modulation is the process of changing the *frequency* of the carrier wave in accordance with the information to be transmitted. Only one word is changed from the AM definition, that is, the word frequency is substituted for *strength*. Fig. 3A illustrates a simple circuit for producing frequency modulated waves. As in the previous instance, we have a tank circuit and a feedback network to sustain oscillations. The tank circuit consists of L_2C_2 whose constants determine the frequency of oscillation. However, in this case, C_2 is a variable condenser which is made up of two metal tubes, one sliding within the other. The movable inner tube which is insulated from the outer section is connected rigidly to the diaphragm which vibrates upon the impact of sound waves. Since the capacitance is a function of the surface area between the two conductors, it will increase as the inner tube moves up, and decrease as it moves down.

Consider first that the diaphragm is at rest, there being no modulating sound waves present. The inner tube has taken a position halfway into the outer sleeve so that its top rests at the point Y. At this halfway position, the capacitance of C_2 is equal to 100 uufd, and the resonant frequency of the oscillator will be 50 mc. This frequency is known as the *resting* frequency or center frequency of the FM wave. If one were to speak loudly into the diaphragm, it would vibrate strongly, driving the inner tube to the top and bottom of the sleeve between positions X and Z. With the top of the inner tube at position Z, C_2 increases, and with the top of the inner tube at position X, C_2 decreases. This represents a change of capacitance of plus and minus, say, 5 uufd, from the resting position (Fig. 3B). The instantaneous frequency of the tank circuit is determined by

$$f = \frac{1}{2\pi\sqrt{LC}}$$

From this formula, it is seen that an increase in capacitance will decrease the frequency. Referring to Fig. 3B and 3C, it will be noted that when C_2 increases to its maximum, it causes a decrease in oscillator frequency of 75 kc. It follows then that a similar decrease in capacitance will cause an increase in oscillator frequency of 75 kc. Thus, the oscillator frequency varies plus and minus 75 kc. If one were now to speak into the diaphragm more softly, it is obvious that a smaller movement of the inner tube would take place above and below point Y, and a smaller change in capacitance. Thus, the frequency would not deviate as much as before and will now vary between the limits of, say, plus and minus 10 kc. This sequence of events serves to define the term *deviation* as used in FM. Deviation is the number of kc change of the carrier *frequency* from the resting point, and varies directly with the *loudness* of the modulating signal. This statement corresponds to the previous definition in amplitude modulation where it was found that the *percentage* of *amplitude* change varied directly with the *loudness* of the modulating signal. It can easily be seen that the *rate* at which the frequency *deviates* depends on the *pitch* or *tone* frequency of the modulating signal. A low pitch causes a deviation at the rate of, say, 200 cycles per second, and a high pitch at the rate of 15000 cycles per second.

By keeping in mind a picture of the diaphragm and moving inner tube operation, the preceding facts may be easily remembered.

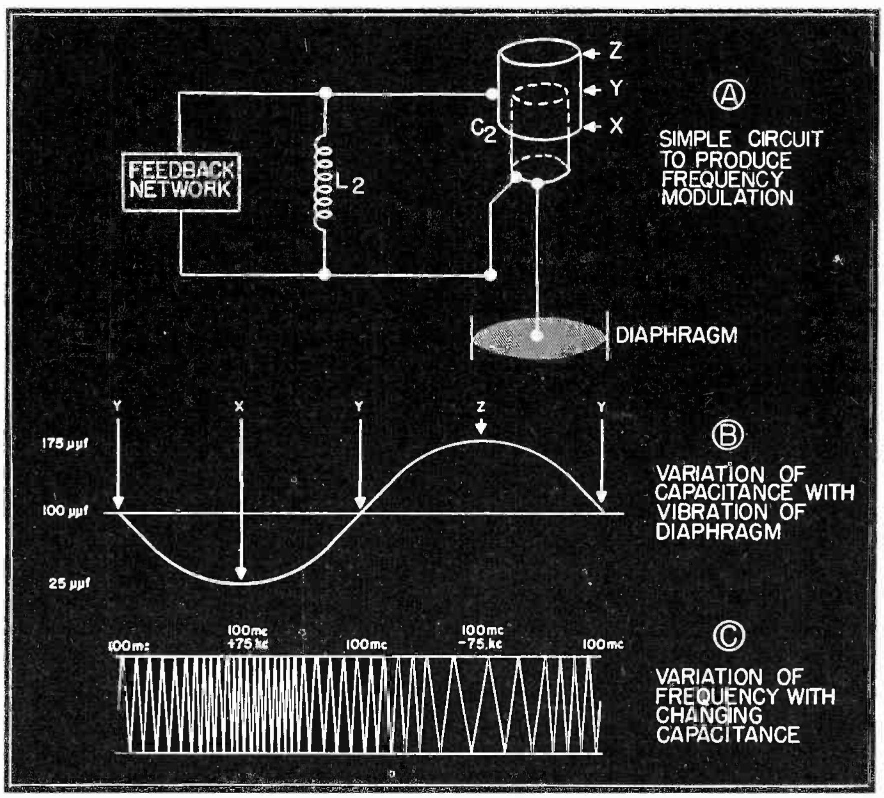


Fig. 3 Theoretical method for producing frequency modulation. The graphs show simultaneous capacitance and carrier wave variation. Compare this figure with Fig. 2, the amplitude modulation case.

Reactance Tube Modulator

While the preceding example served to show in simple terms how an FM wave could be produced, the method used is not practical, and actual FM transmitters may make use of reactance tube modulators and frequency multipliers. Reactance tubes are also important in receivers where they are used in connection with automatic frequency control circuits. A reactance tube modulator is an electronic circuit which is made to appear like a variable capacitance or inductance upon the application of the modulating voltage.

Before examining the circuit, it is necessary to review a few basic fundamentals. First: A reactance is a device which causes the voltage and current to have a phase difference of 90°. If we hook up a generator in series with a circuit hidden in a box Fig. 4A) and find

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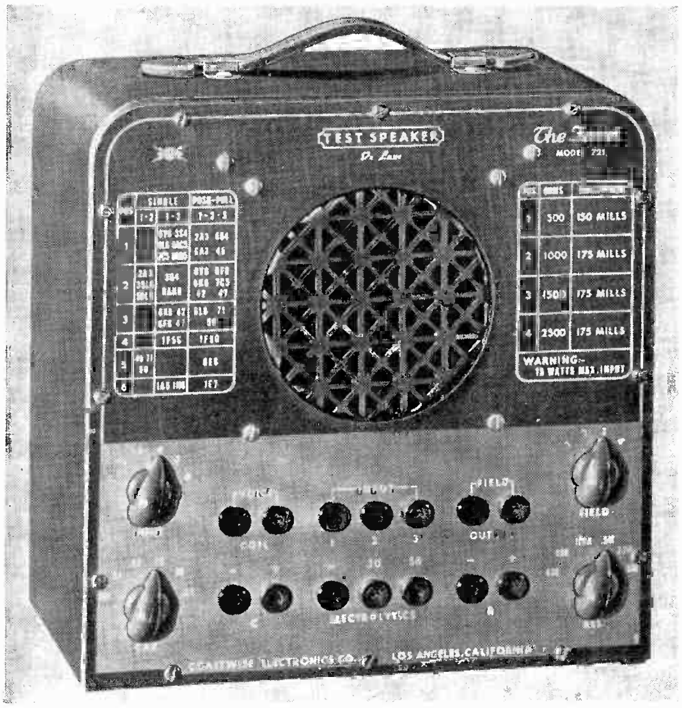

Radio Maintenance is presenting a number of short articles describing various pieces of commercially available equipment. All of the units described will be put through their paces on the bench before being presented. It is hoped that the information given will prove helpful when choosing from the great variety of instruments available.

TEST SPEAKER

by J. R. James

THE "FERRET" test speaker is a commercial version of the test speaker idea presented recently in RADIO MAINTENANCE. This unit is useful after the serviceman has completed tracing operations, and one or more particular components are suspected of causing the trouble. In a big percentage of cases, ohmmeter checks are not conclusive, and it becomes necessary to substitute a part which is known to be in good condition. This test speaker, manufactured by Coastwise Electronics of Los Angeles, provides a variety of substitute parts in a compact form. Connections, which are made by means of test leads, are from the front panel. Because the components themselves are never handled, deterioration is negligible and the parts are always available. That this is a definite advantage will be understood when we remember that extra resistor or condenser which we have been using for substitution and whose leads are broken and full of solder.

As can be seen in the photograph, tip jacks on the panel provide the choice of the *type* of component we want; the *value* of this component can be adjusted by means of the four selector switches. Now let us survey the methods of use for various types of repair jobs.

Speaker Voice Coil

Suppose we suspect the voice coil of the speaker in a set of being open or shorted. First, the leads from the output transformer to this voice coil are disconnected. Then, test leads are plugged into the two tip jacks marked "Voice Coil" on the panel of the test speaker. The other ends of these test leads are connected to the wires from the output transformer. If the trouble is in the voice coil of the receiver's speaker, then the set will play properly through the test speaker.

Output Transformer

Perhaps, in our example, the voice coil is okay but the output transformer is suspected. If our first test draws a blank, go to work on the primary of the receiver's output transformer. Unsolder the two primary leads (three for P.P. outputs). Then use the test leads to connect the plate(s) of the output tube(s) and B plus to the terminals marked "Input" on the panel of the test speaker unit. The tip jacks are marked 1, 2 and 3. The choice of which ones are used in each case depends on the output tube type and whether the output stage is single-ended or push-pull.

The proper arrangement for almost any type of output tube is given in the table printed right in the upper left hand corner of the panel. Choice of the correct impedance match is made by using the proper position for the test leads and by adjustment of the selector switch marked INPUT. In this manner, we choose from a number of taps on the primary of the output transformer in the unit.

Field Coil

Similar substitution for field coils which are suspected of failure is provided by means of the two jacks marked FIELD OUTPUT. The selector switch labeled FIELD allows a choice of any of four field resistance values from 500 through

→ To Page 16

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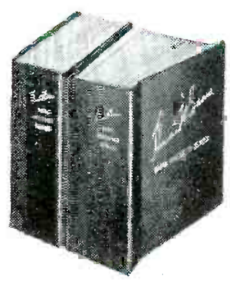
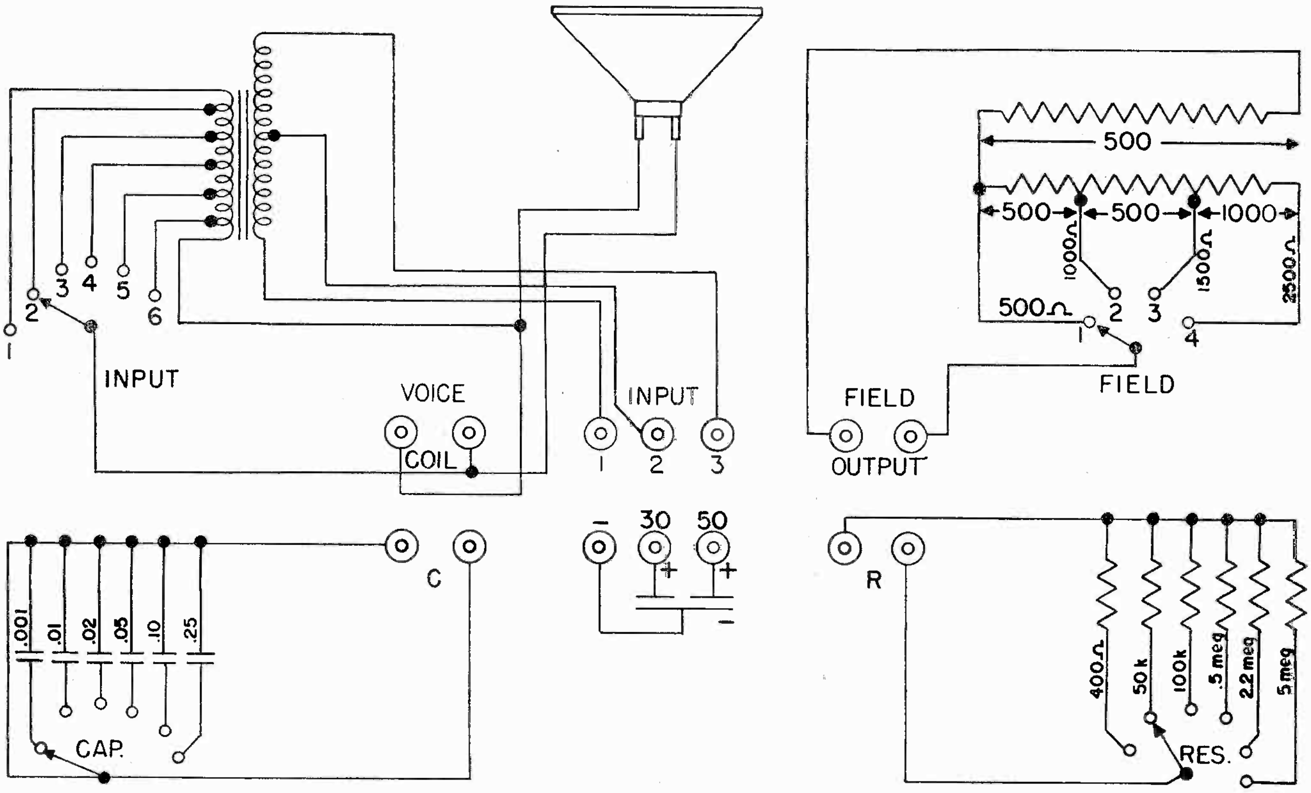




Schematic diagram of the Ferret test speaker.

→ **From Page 14**

2500 ohms. The table in the upper right corner of the panel is a guide for this selection.

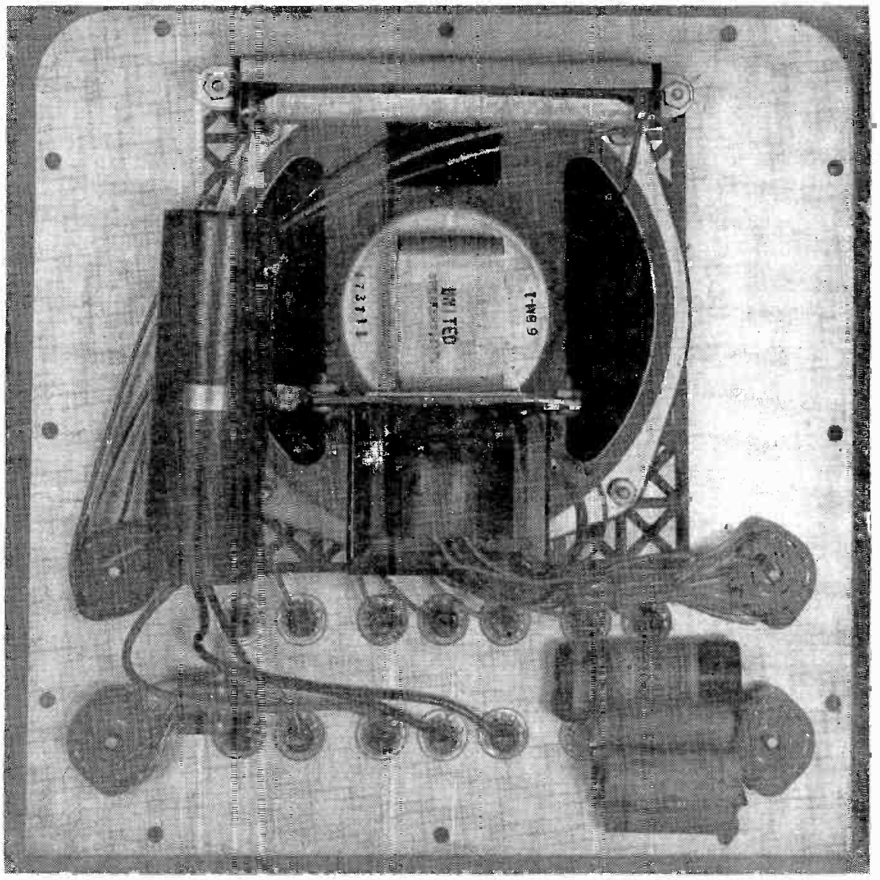
Condensers

In the bottom row, we have the jacks for use in substituting condensers. At the left end, marked C, are the leads from the paper condensers. Six different values are made available by settings on the switch marked CAP. These values are from .001 through .25. The three jacks marked ELECTROLYTICS provide two values of electrolytic condensers, 30 and 50 ufd. The paper condensers have a rating of 600 volts, the electrolytics 450 volts.

Resistors

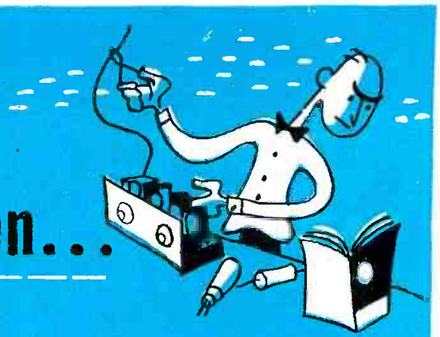
At the right hand end of the bottom row are the two jacks for resistors. These are used in conjunction with the selector switch RES, located just to the right. Values are available from 400 to 5000 ohms.

As can be seen in the photograph, the whole unit is enclosed in a compact cabinet and weighs only about five pounds. The internal view and schematic diagram show how the instrument is wired. ✓ ✓ ✓



View of the test speaker chassis after removal from the cabinet. In the center are the speaker and output transformer. Just to the left is the electrolytic condenser and at the top are mounted the resistors for the field coil connections.

FREE to servicemen...



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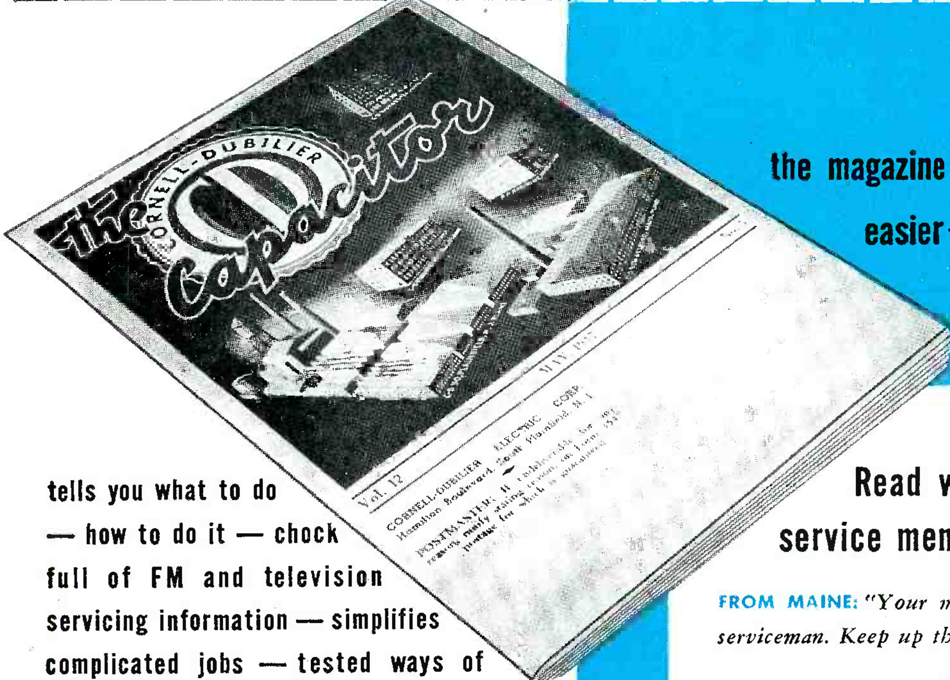

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The Organizations

In the last few years, there has been a marked increase in organizational activity in the trade. Feeling that the reader would like to know more about the organizations and their activities, Radio Maintenance is inaugurating this column containing correspondence received from servicemen's organizations. If you are a member of an organization, we would like to hear about the activities of your group.

George Payne writes to say:

"A meeting of the *Rochester Chapter, Radio Technicians' Guild,* enjoyed a very large attendance for the election of officers.

"President David Boyce and Treasurer William Frenzel were re-elected and the new support promises another good corps with Carl Putnam, Vice President; Hank Van Loon, Secretary; Bob Bryant as Sergeant-at-Arms. They were installed May 21st."

George Payne

"The regular meeting of the *Associated Radio Technicians of British Columbia* was held on May 12th with President Al Johns in the chair. Minutes of the previous meeting were read and adopted.

"President Johns, who with W. Munton attended a meeting of the Upper Island Branch, reported that this group has decided to revert to 'out of town' members of the *A.R.T.* The reason for this action is that they found it too difficult to hold regular meetings because of road conditions during winter, and scattered location in some cases requiring a trip of 70 miles (140 return) by car to attend meetings. To keep contact with this active group, it was suggested that joint meetings be held three or four times a year at Naniamo, or another suitable place, with delegations from Vancouver and Victoria attending.

"Jim Summerby was elected acting secretary during the absence of Barney Jensen who was granted three or four months' leave of absence while his duties took him to Edmonton, Alberta.

"The chairman of the entertainment committee was given the official sanction to proceed with arrangements to hold the annual picnic again at Balcara Park in July.

"Fred Stuckey reported good progress in organizing a Fraser Valley Branch of the A.R.T., with tentative arrangements to hold the first meeting at Abbotsford on June 4. Several cars are expected to carry a large delegation from Vancouver.

"Radio rental rates were mentioned; but as none of the members present catered to this trade, very little information was obtained.

"A brief discussion took place regarding the use, by some manufacturers, of parts or components requiring special wrenches or tools. An example mentioned was record changers requiring Bristol wrenches that are apparently not readily available from the distributors or parts jobbers. It was suggested that the service manager of firms would be the logical person to contact in this matter.

"A motion, authorizing the purchase of a typewriter for the secretary, was passed.

"Following the regular business, the meeting adjourned to listen to George Pearsall, on the service staff of Canadian General Electric, describe the operation and servicing of the C-250 and C-260 portable radios with rechargeable battery. Various component parts were passed along to be examined while listening to the informative descriptions. Every one agreed that more of these technical demonstrations should be encouraged to acquaint servicemen with such special features. The Philco 706 was described at a previous meeting."

S. Beyer, Publicity
Associated Radio
Technicians of B.C.

T. P. Robinson of the *Dallas Radio Sales and Service Assn., Inc.,* gives us the following information about his organization.

"Due to growing pains, and to much organizational work, it has been impossible for us to furnish you any news for the past month. Therefore, I shall attempt to bring you up to date concerning our organization.

"We have initiated three major projects which we are trying to put over. The first of these is a very close affiliation with the local Dallas Better Business Bureau. We are realizing that ethical practices are the most important factors entering into a successful operation of our line of endeavor. A large number of our members have also become members of this Bureau.

"Our second objective has been the planning of regular monthly associational meetings which will be of top interest. To that end it has been decided that each program will present a sales expert, a local distributor and his line of merchandise and will also include a free dinner for our members. Our third objective has been the launching of a program with a local broadcasting station, similar to that so successfully used by the Philadelphia Radio Service Men's Association.

"We do appreciate the interest your magazine is showing in the

→ To Page 30

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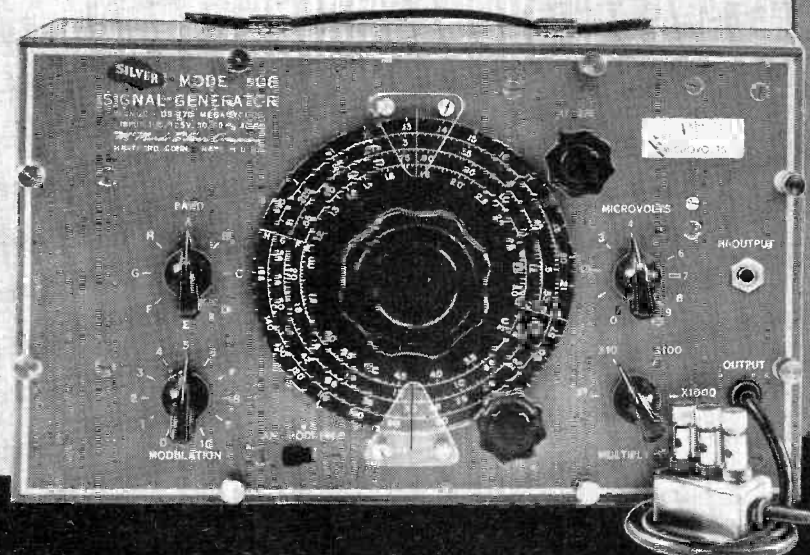

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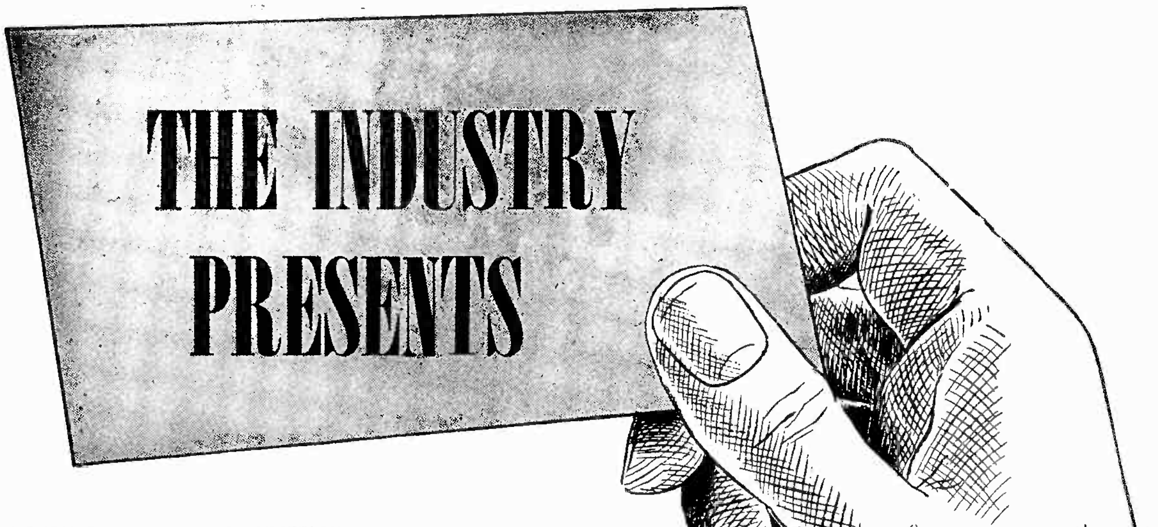

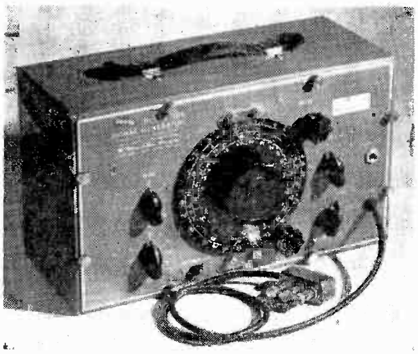

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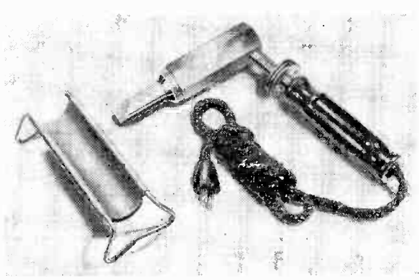
The new Silver Model 906 AM-FM signal generator provides fundamental output on any frequency in the range of 90 kc to 170 mc. All eight ranges are directly calibrated to 1% accuracy upon the 10:1 vernier-driven main dial. Amplitude modulation at 400 cycles, variable from zero to nearly 100%, is provided. Frequency modulation output is available at any frequency between 90 kc and 210 mc by a panel switch bringing into operation a 40 mc fixed-tuned oscillator which beats with the variable frequency oscillator to produce any desired carrier in the range. Sweep rate is 60 cycles, with frequency sweep variable from zero to over 500 kc.

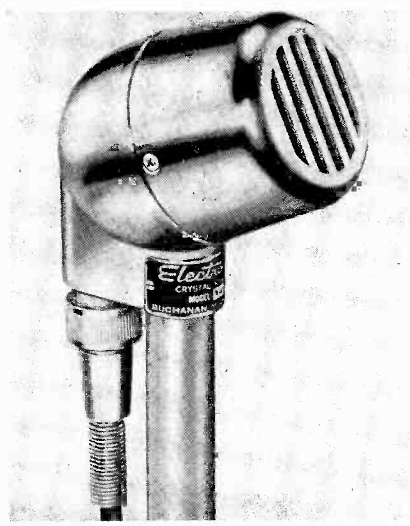
For further information, write the McMurdo Silver Company, Inc., 1249 Main St., Hartford, Conn.



HATCHET TYPE IRON

Hexacon Electric Company's new hatchet type electric soldering iron enables the operator to solder in a more natural position, eliminating fatigue which frequently results in poor soldered joints. Because of balanced weight, inherent in the hatchet design, a tight grip is unnecessary. Hard-to-get-at spots can be reached with this iron without stooping or bending. The heating element is housed in a damage-proof hexagonal shaped barrel that permits clamping in a vise for easy tip removal without danger of injuring the heating element.

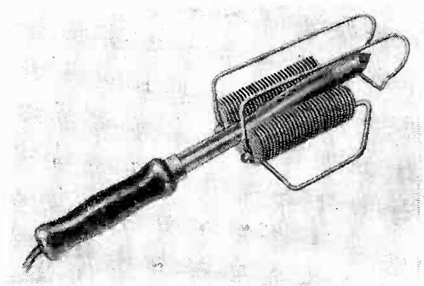
Further information is available from Hexacon Electric Co., 250 W. Clay Ave., Roselle Park, N. J.



CRYSTAL MICROPHONE

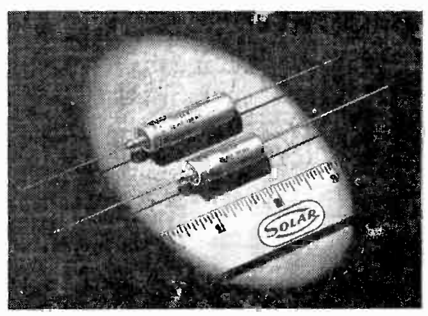
A new crystal microphone, Model 905, is announced by Electro-Voice, Inc. Frequency response is substantially flat from 50-7500 cps. Output level is —54 db. Makes a quality microphone available at low cost for general sound work, recording and communications. Recommended for schools, churches, hotels, theaters, auditoria, amateur radio communications, call and dispatching systems, business and industrial paging systems, home recording and semi-professional recording service. Polar pattern is non-directional at low frequencies becoming directional at higher frequencies. High impedance.

Write to Electro-Voice, Inc., Buchanan, Michigan, for E-V Catalog No. 101 which gives detailed information.



IRON TIP SAVER

The Tip Saver soldering iron control stand, manufactured by the Beyer Manufacturing Company, Omaha, Nebr., is designed to prevent excessive heat from reaching the tinned tip of the iron and to maintain a normal working temperature. The iron is always ready for instant use. Aluminum fins radiate the excess heat while the iron is at rest. This eliminates oxidation and burning of the tip, also prolonging the life of the element. Any size or make of iron can be used in the Tip Saver stand. There are no moving parts, and protective struts built of heavy gauge wire on top of the control stand eliminate the possibility of burning leads which might fall across the iron element.



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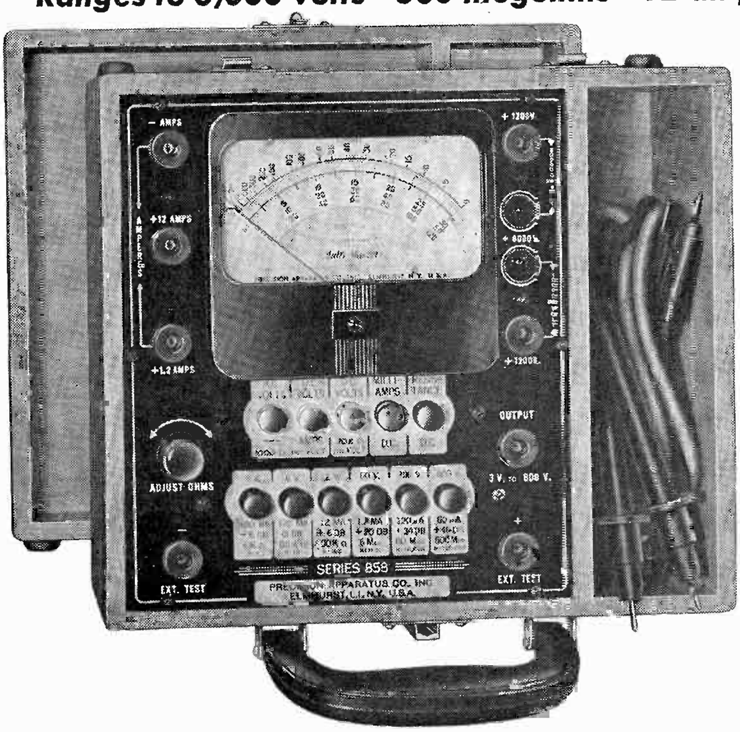

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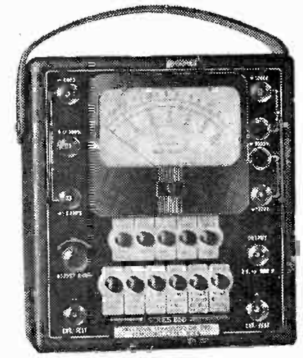

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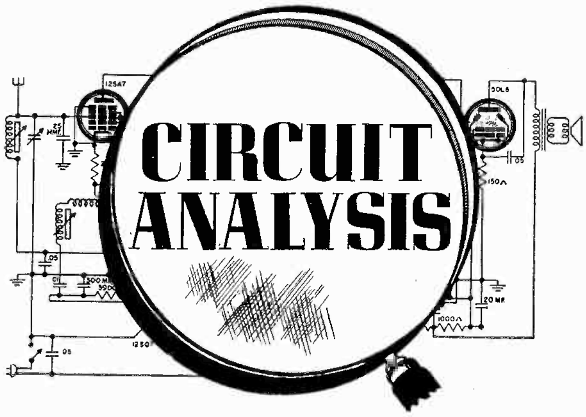

by
J. Richard Johnson

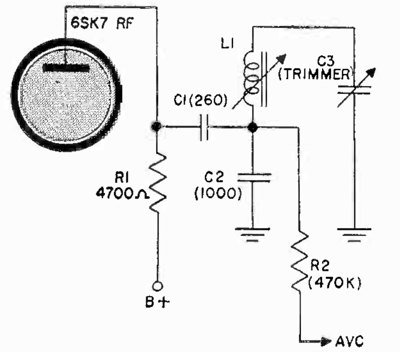

Fig. 1 Coupling circuit between the RF and converter sections of the Stewart-Warner Model 61T16-61T26.

WE START OUR ANALYSIS this month with the Stewart-Warner Model 61T16-61T26. This is a superheterodyne of the AC-DC type using 12 and 35 volt tubes in a six-tube circuit. Slug tuning is used for tracking the RF, mixer, and oscillator circuits.

A rather unusual feature is the type of coupling circuit used between the 12SK7 RF stage and the 12SA7 converter. This circuit is shown in Fig. 1. Notice that there is a plate load resistor, R1, connected in a manner similar to those used in audio amplifiers. The radio frequency output of the stage appears as a voltage across this resistor. Condensers C1 and C2 form an AC (RF) voltage divider between the top of R1 and ground. The portion of the voltage across C2 is in series with the tuned circuit formed by C2 and C3 in series and L1. Since this circuit is aligned by means of the slug tuner to tune to the incoming signal, the radio frequency energy thus fed in is built up to a high voltage on the signal grid of the 12SA7 converter tube. Bias from the AVC line is supplied to the grid through isolating resistor R2.

Another new feature is the use of the type 12SF7. Instead of the diode second detector being included with the first audio stage as in 12SQ7, here we combine the second detector and last IF tube, which is a pentode. Notice also that a high gain audio stage is used (12SK7) and this is probably why a decoupling circuit is provided in the plate circuit of the latter tube.

Distortion is reduced to a low value by the use of negative feedback. Audio amplifiers which use this feedback cause harmonics to cancel themselves at the point where the feedback is applied. Both of two methods are used in this set. First, the 35L6GT output tube cathode resistor is left unbypassed. This causes plate current signal fluctuations to produce a signal voltage across the cathode resistor which is applied, along with the bias, to the grid. But this voltage

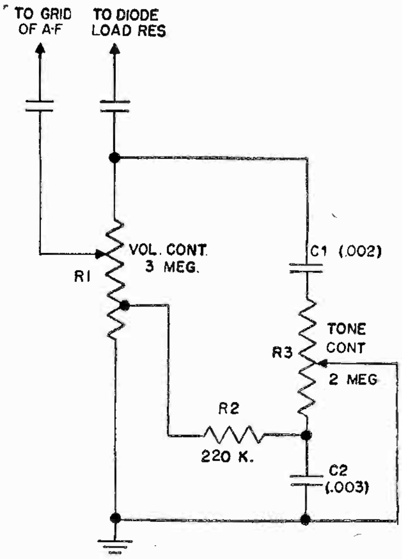

Fig. 2 Tone control and compensation circuit of the Farnsworth EC260 Model.

is out of phase 180 degrees from the original grid signal which produced it, and is therefore negative (inverse) feedback.

The other method of negative feedback is the use of the signal appearing across the speaker voice coil for the out-of-phase voltage.

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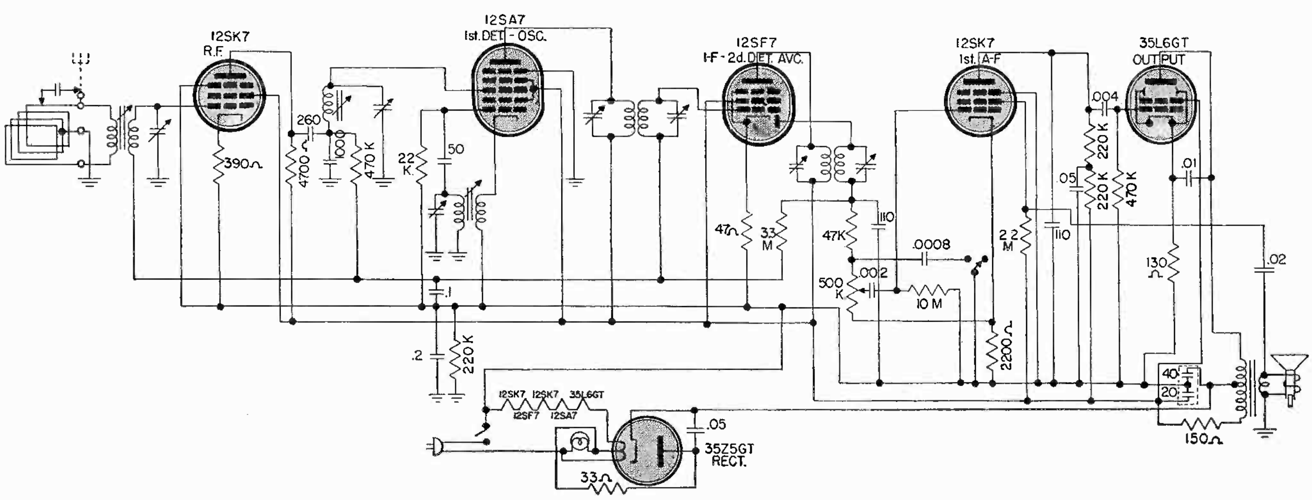

—Stewart-Warner Model 61T16-61T26

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FOR SALE—Three-wire intercom cable, each wire five stranded—$1.25 for 125 ft. Eugene Kay, 1575 Broadway, Buffalo 12, N. Y.

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FOR SALE—HRO low frequency coils Type G, H, and J, $45. HRO 6v power supply, $25. GE Industrial tubes FG-32 and FG-57, $5. each. RCA capacity-operated relay, $10. W. J. Arthur, 501 Ruffner ave., Charleston 1, W. Va.

FOR SALE—Navy Teleplex — teaches code by tape. Complete set of tapes and several blank tapes. $40. H. D. Bushman, Rt. 2, Box X141, Lodi, Calif.

FOR SALE — Voltohmmeter, Superior PB 100 in excellent condition, $25. Henry J. Nulewski, 168 Russell street, Brooklyn 22, N. Y.

WANTED—April 1935 issue of Radio Craft. Will pay $2. Robert A. Miranda Rm 2/C Tacron #2. USS Taconic (AGC 17). Nob Norfolk, Va.

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WILL TRADE—Solar C.E. condenser checker for Triplett 666H, Supreme 542 or similar multitester. Boyd Neustel, Box 889, Hermiston, Ore.

FOR SALE—McMurdo Silver "Vomax" A-1 condition, $50. J. W. Brown, Box #78, Pine Beach, N. J.

FOR SALE—New Hammarlund super pro SP400SX 1.25 to 40 mc. $260. F.O.B. R. Long, 184 L. street, South Boston, Mass.

FOR SALE OR TRADE—National 1-10 U.H.F. receiver complete with tubes and all coils. Want a Hallicrafters S-40 or a S-20R receiver. James D. Gysan, Belmont road, West Harwich, Mass.

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WANTED—Good used tube and set tester. Must be reasonable. Frank Bernstein, 112 Baruch Place, New York 2, N. Y.

FOR SALE—Two W.E. wire recording magazines, including heads, spools, wire, level wind, indicators. Needs only amplifier and motor for complete wire recorder. Perfect. $29.50 ea. express collect. M. Goldberg, 3336 Hull ave., Bronx 67, N. Y.

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SELL—Complete radio repair shop, $500. 14 Riders, neon radio sign, CE-Solar, CB-sig. generator, Superior Chanalyst, RCP tube & set tester, RCP wattmeter, bench, 18 meters, parts, tubes, etc.; Michael O'Lear, 1401 Cronk ave., Flint 6, Mich.

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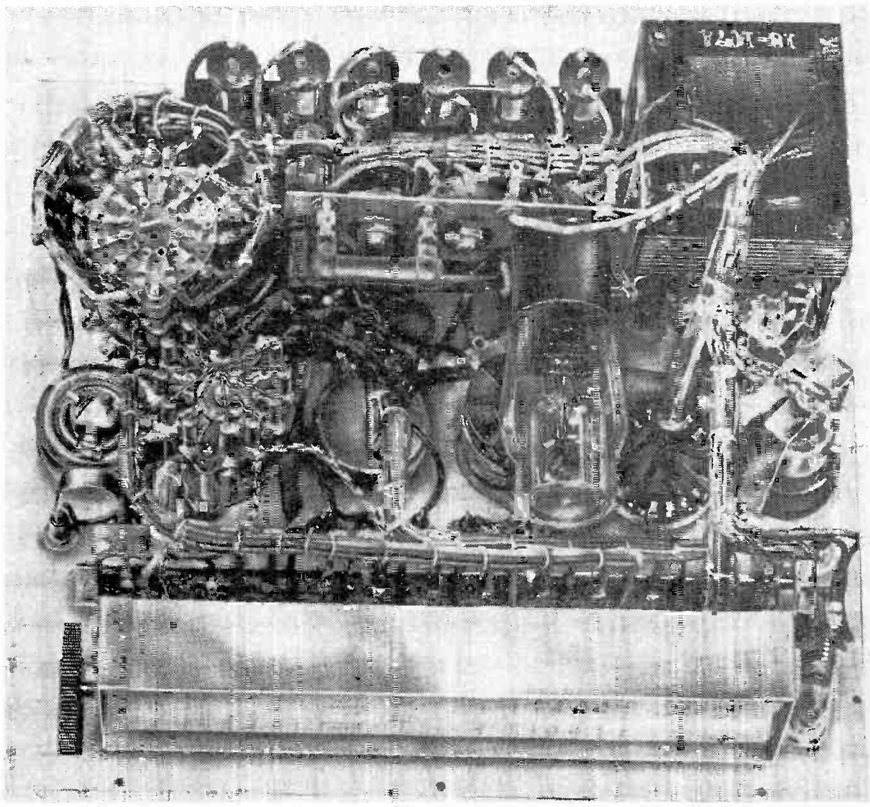

Fig. 3 An example of the tube and set tester type of instrument is shown in the wiring view above. Routine maintenance on equipment of this type can save the serviceman both money and time.

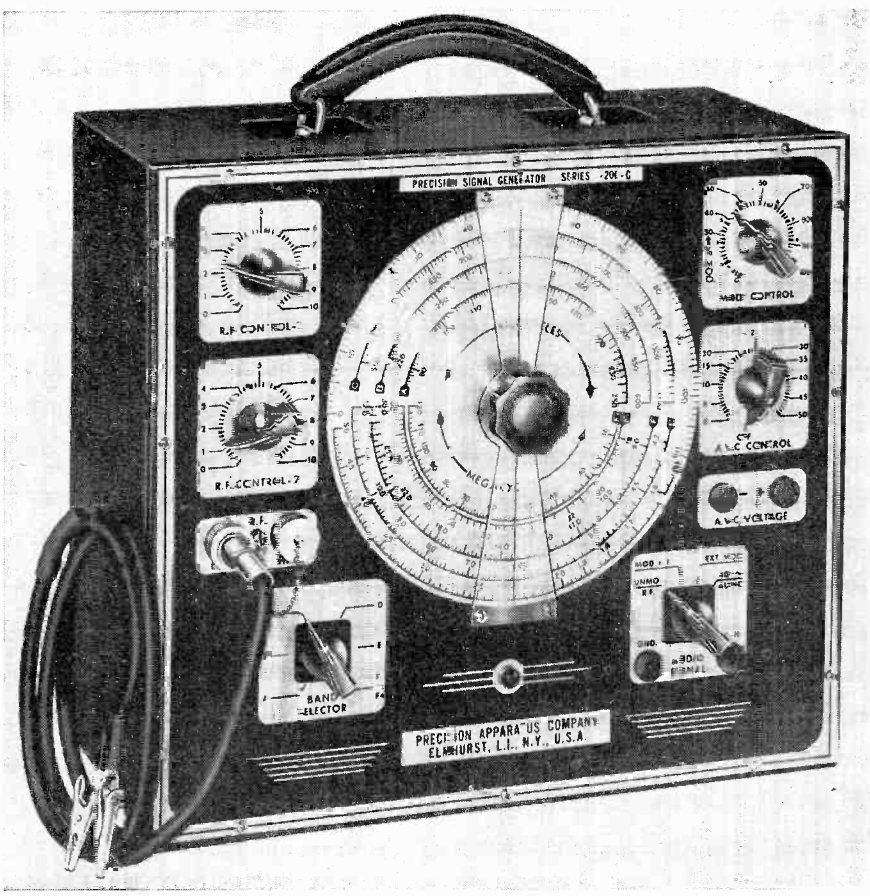

Fig. 4 Signal generator of the type used by many servicemen.

Test Equipment Maintenance

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points on the dial are probably due to condenser slippage in which set-screws were tightened before dial alignment was checked.

Undependable readings may be due to condenser backlash, loose set screws, dial slippage, loose or defective trimmer condenser plates, or an intermittent defect in the tubes or tuning circuits. Incorrect dial readings at one or more spots can be caused by a high resistance joint or partial short in the oscillator, IF, or RF coils, defective paper or mica by-pass condensers, or a change in trimmer capacity due to vibration or presence of foreign matter. Rough, erratic operation of the dial itself may be carried by dirty or worn gears, worn friction drive mechanisms, excessively tight or loose shaft coupling, or by misalignment between dial, panel, and tuning condenser. All couplings should be trued and checked for binding. Worn gears or drives should be replaced or repaired if possible. Occasional cleaning with tetrachloride and lubricating with a light oil will keep dial mechanisms in good operating condition. In the case of friction drives, care should be taken to prevent oil from contacting the actual surfaces of the drive. Oil reduces friction and, in many cases, renders the mechanism inoperative. Lubricate *only* the bearings.

Variable air condensers should be cleaned occasionally by blowing lint, dust, dirt and other foreign matter from between the plates with a low pressure air hose or blower, or by using pipe cleaners saturated with carbon tetrachloride. The same treatment is given fixed air condensers and small band-setting trimmers.

Dirty rotor shafts and corroded wiper arms may be cleaned with an alcohol-ether mixture or tetrachloride applied with a small brush. Corroded surfaces should be cleaned with fine sandpaper or crocus cloth and the residue removed with a small brush saturated with tetrachloride. A *very* thin film of acid-free lubricant (preferably Daven oil or a fine grade of clock oil) should then be applied to the condenser surfaces. For condenser bearings, a larger amount may be required at more frequent intervals. Excessive use of *any* lubricant is to be avoided since it serves only to collect more foreign matter.

Loose or corroded wiper arms should be removed, cleaned and the blades bent to provde greater contact pressure.

A bent or warped rotor shaft in the main tuning condenser necessitates replacement of the whole unit. Bent plates may be straightened if care is exercised. End play in the rotor may be eliminated by adjusting the set screw provided for that purpose. Avoid tightness and binding, and adjust until there is proper spacing between rotor and stator plates. Plates may be examined for warp and spacing by meshing them and viewing them from above. After such adjustments, a calibration check should be made. Worn ball bearings in either end of the condenser frame may cause rough, uneven vernier action and should be replaced.

Replacement of condensers in any of the tuned circuits will require recalibration. Tube replacement may also necessitate a small adjustment in calibration.

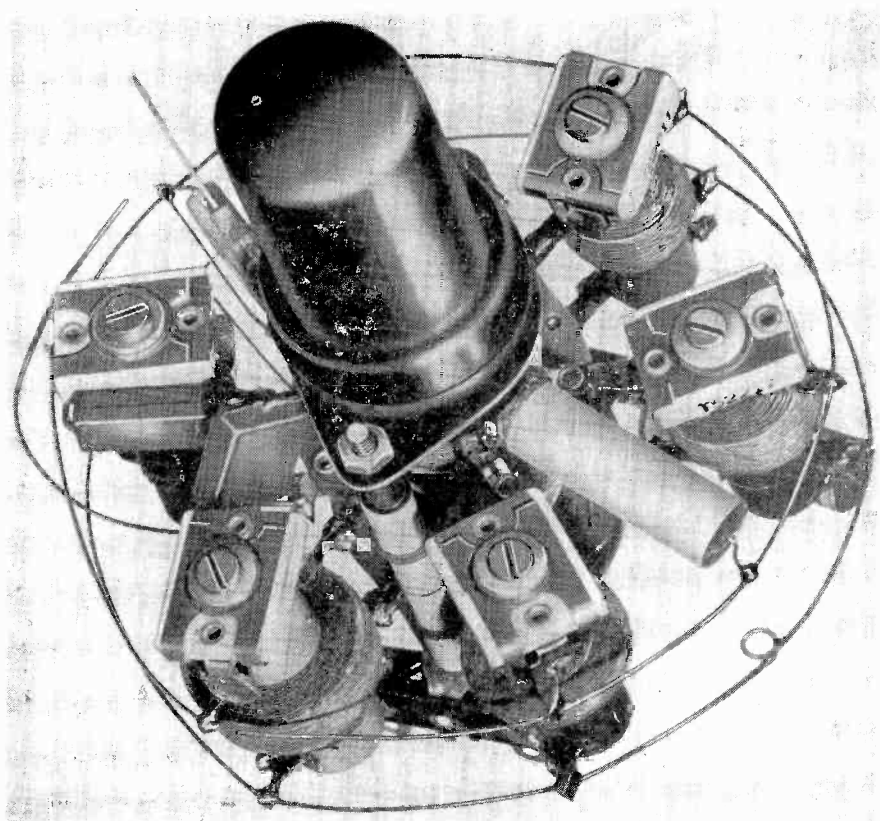

Fig. 5 View of the coil turret used in the signal generator shown in Fig. 4. The text describes how the trimmers may be adjusted when calibration is necessary.

Calibration

Extreme errors in dial calibration will require the attention of the manufacturer. Ordinarily, however, small variations (say 10 per cent) resulting from aging, vibration, and component replacement, can be adjusted quite easily by the serviceman. The only equipment needed is a receiver, preferably an all-wave type, but one with just broadcast coverage will be adequate for all but the short wave frequencies.

The method is as follows:

1. Set the generator for "pure RF" and select the range which covers most of the broadcast band.
2. Connect generator output leads to receiver antenna input circuit and tune the signal carrier in, adjusting the generator output until AVC action is slight.
3. Tune the receiver to a broadcast station of known frequency and readjust the generator until a "beat note," or whistle is heard. The pitch of the beat note will get lower until "zero beat" is obtained, at which point changing the generator frequency in either direction will cause a rise in pitch.
4. The dial on the generator should now indicate the frequency of the broadcast station. If it doesn't, trimmer adjustment should be made, using a frequency near the high end of the range.

For checking the low frequency band calibrations, the procedure is the same except that we now use harmonics of the generator to beat against the broadcast stations. A harmonic frequency is one which is equal to the fundamental frequency multiplied by any whole number. For instance, if the generator dial were set for 300 kc, it would also put out a second harmonic at 600 kc. If we are hearing a broadcast station on 600 kc, we will also get a "beat" between this station and the generator second harmonic, thus providing a check on the 300 kc marker on the dial. In using this method, we must be careful to make sure that the harmonic used is the right one. With a fundamental frequency of 450 kc, for instance, there will be two harmonics in the broadcast band, the second at 900 kc, and the third at 1350 kc.

For calibration at frequencies above the broadcast band, a short wave receiver is necessary. Convenient check points are provided by the Bureau of Standards Station WWV, which transmits continuous signals on 5, 10, and 15 mc. Check points can also be obtained from another signal generator whose calibration is known to be accurate.

On many generators, the highest bands use the second or third harmonic of lower bands. Once these lower bands are checked, the process need not be repeated for the harmonics.

Since broadcast stations are required by law to maintain extreme frequency accuracy, dial calibration by the above method can produce almost perfect results. The stability of the generator can also be checked by tuning it so that a low beat is produced, and noting whether there is any variation over a period of a few minutes.

The beat frequency method is also useful in calibrating audio oscillators. In this case, the power frequency (usually 60 cycles) and its harmonics provide check points. If we feed the audio signal into the audio section of a receiver, there will usually be sufficient residual hum in the speaker to beat against the oscillator signal. Beats will ap-

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Servicing FM Receivers

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that, as a result, the current leads the voltage by 90°, we would say hat there must be a capacitance in the box. However, instead of an actual physical capacitance in the box, there may be an electronic circuit which causes the current to lead the voltage by 90° and thus acts like a capacitance. The size of this capacitance and the manner in which it may be varied are also of great importance.

The magnitude of the capacitive reactance may be expressed by the formula

$$X_c = \frac{E_{ac}}{I_{ac}}$$

where E_{ac} is the applied voltage and I_{ac} is the current that flows as a result. This shows that the capacitive reactance is a function of the current in the circuit. Assuming constant voltage, if the current I_{ac} is caused to increase, then the value of the fraction is smaller and X_c has decreased. Thus the capacitance must have increased in value since $X_c = \frac{1}{2\pi FC}$. If the current I_{ac} is caused to decrease, the value of the fraction $X_c = \frac{E_{ac}}{I_{ac}}$ becomes larger, X_c has increased, and the capacitance value decreased.

Summarizing:

1. If the current leads the voltage in a circuit by 90°, the circuit is *capacitive*.
2. An increase in current *increases* the value of the capacitance.
3. A decrease in current *decreases* the value of the capacitance.

Variations in capacitance may be caused simply by changing the amount of current by means of an electronic device. If we place this device in parallel with the fixed value of C_3, (Fig. 4C) in the oscillator shown, and cause it to change in accordance with a modulating signal, a means for producing an FM wave will have been provided. This is the function of the reactance tube modulator. A simplified diagram in which the reactance tube modulator is substituted for the variable capacitor is shown in Fig. 5A.

A pentode tube V_1 is used as a variable capacitance and the circuit operates as follows: An RF voltage (E_T) is developed across A and B and applied to the series combination C_1R_1. The size of C_1 is chosen so that it will have a reactance about ten times R_1 at the operating frequency. Thus the effect of R_1 is negligible and for practical purposes the series combination becomes purely capacitive. Due to E_T, a current I_1 will flow through C_1R_1. Since this circuit is capacitive, I_1 will lead E_T by 90° (Fig. 5B). This leading current produces a voltage drop I_1R_1 which also leads E_T by 90°. It will be noted that the voltage I_1R_1 is applied directly to the grid circuit of reactance tube V_1. Therefore, the drop across R_1 is the operating grid voltage for V_1. Since this grid voltage is leading by 90° and because the plate current of a tube is in phase with its grid voltage, it follows then, that the plate current is also leading by 90°. We previously established the fact that when the current in a device led the voltage by 90°, a capacitance was present, and that is exactly what is now represented by the reactance tube V_1. This capacitance is in parallel with the tank circuit and thus affects its frequency. It remains now only to vary the magnitude of the capacitance in accordance with the modulating signal so that the oscillator frequency will be caused to follow this change.

It was previously stated that an increase in I_{ac} would be equivalent to an increase in capacitance, and vice versa. Thus, it is only necessary to cause the grid voltage of V_1 to vary and the plate current (I_p AC) will follow suit. This is done by applying the audio signal directly to the grid of V_1. On the positive half cycle of the applied audio wave, the plate current (I_p AC) will increase, corresponding to an increase in shunt capacitance, and the oscillator frequency will decrease. The negative peak will cause a decrease in plate current (I_p AC), the shunt capacitance represented by V_1 also decreases and the oscillator frequency increases. It is easily seen that the *amount* of frequency *deviation* depends on the instantaneous value of the audio signal.

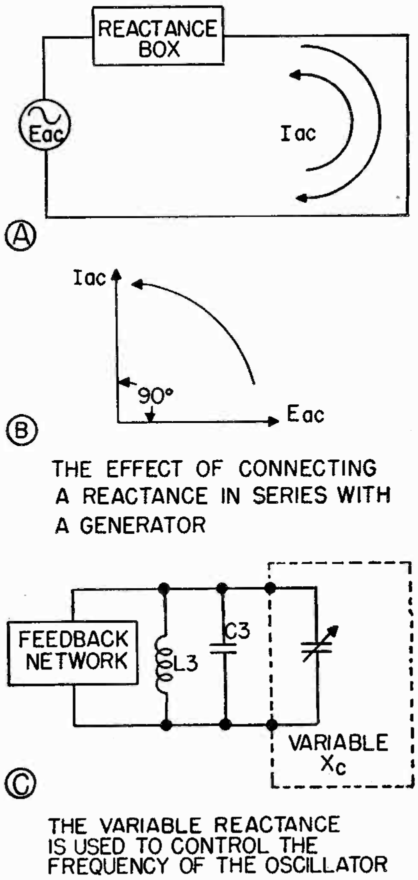

Fig. 4 How control of frequency variations is effected. A varying reactance placed across the tuned circuit of the oscillator produces corresponding variations in the frequency of the carrier wave.

The reactance tube modulator, in common with several other types of frequency modulators has the disadvantage of not being able to produce sufficient deviation directly. In order to increase the amount of deviation, use is made of frequency multiplication. As an example, assume a carrier frequency of 105 mc with a deviation required of plus and minus 75 kc maximum at the antenna. If the reactance tube modulator will give a useful deviation at the oscillator of plus and minus 5 kc, then a frequency multiplication of 15 times will be needed. As shown in the block diagram (Fig. 6) the oscillator frequency starts at 7 mc and is multiplied 15 times to become 105 mc. At the same time, the 5 kc deviation is also raised 15 times to 75 kc. Frequency multiplication is necessary whenever the frequency modulator is unable to provide the required deviation directly at the oscillator.

Phase Modulation

Phase modulation is the process

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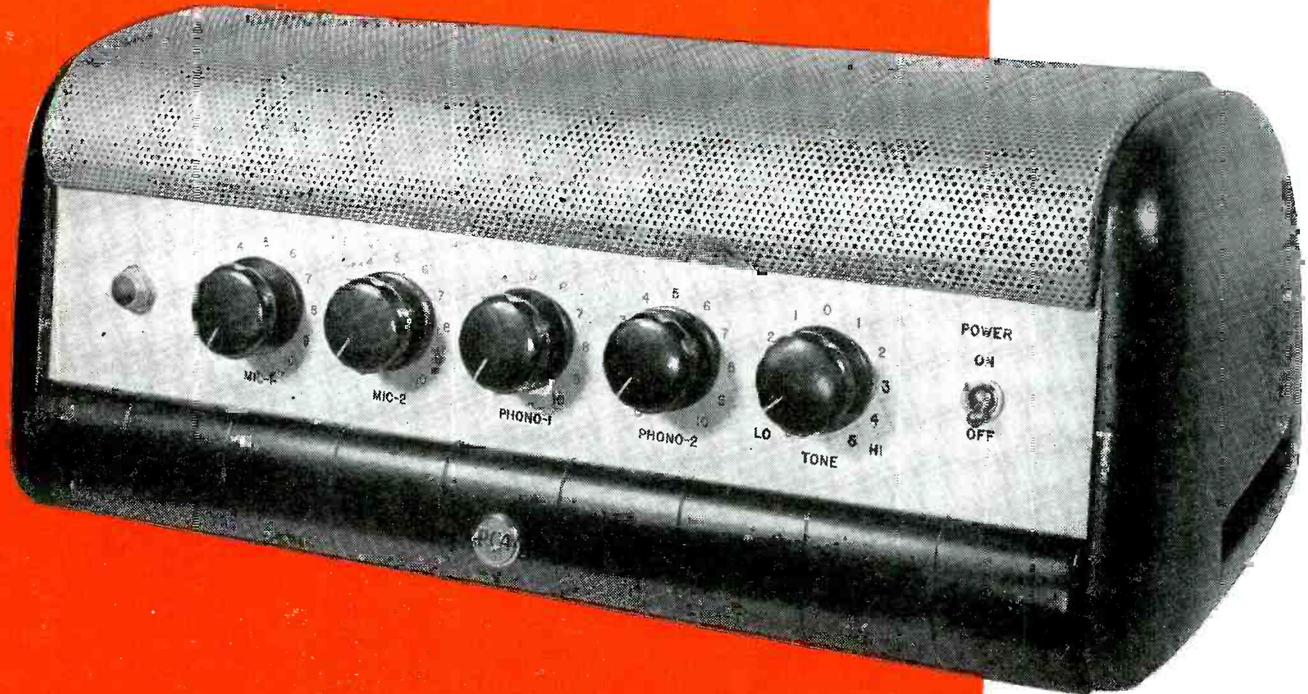
Full-powered RCA *"Package"* Amplifiers



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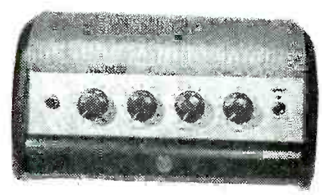


15-WATT Size Covers Broad Field! Medium power, high-gain amplifier, perfectly suited to many classes of work such as ballrooms, amusement parks, restaurants and taverns.

SOUND EQUIPMENT

RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

In Canada: RCA VICTOR Company Limited, Montreal

FM Receivers

→ From Page 26

whereby the *phase* of the carrier wave is varied in accordance with the information to be transmitted. A phase modulated signal can be received on the same type of receiver as a direct frequency modulated wave. This system has the advantage that a crystal controlled oscillator may be used, assuring frequency stability of the transmitter. Frequency multiplication must also be used with phase modulation to produce the necessary deviation of plus and minus 75 kc.

Pre-emphasis

A further advantage of FM is the possible use of a pre-emphasis network at the transmitter and a corresponding de-emphasis circuit in the receiver. In FM receivers, most of the noise output is concentrated in the high frequency audio range from 5000 to 15,000 cycles. The human ear is more sensitive to high frequency sounds and, therefore, high frequency noises are very objectionable. The system of pre-emphasis consists of increasing the relative degree of modulation at high frequencies so that at 15,000 cycles there will be about ten times the modulation which exists at 1000 cycles. At the receiver, a de-emphasis network reduces the high frequency level to normal, at the same time greatly attenuating all high frequency noises.

Transmission of FM

Since FM transmission takes place on very high frequencies (from 88 — 108 mc) it is subject to all of the difficulties attendant with any high frequency service. The sky waves are not reflected from the ionosphere and thus, except for "freak" conditions, direct long distance transmission is impossible. The ground wave is attenuated rather rapidly so that fifty or a hundred miles from the transmitter, it has virtually disappeared. Therefore, the best FM transmission must take place in a direct line from transmitting antenna to receiver under so-called "line of sight" conditions. This means that the transmitting and receiving antennas must be located as high as possible to achieve maximum coverage and best reception. A detailed discussion of this problem may be found in RADIO MAINTENANCE (March, April 1947) in the writer's articles on "Antennas . . . FM and Television."

In summary, a table has been prepared listing the important differences between FM and AM waves as used in regular broadcasting.

Next month's article will discuss the circuits of a conventional FM receiver. ✔ ✔ ✔

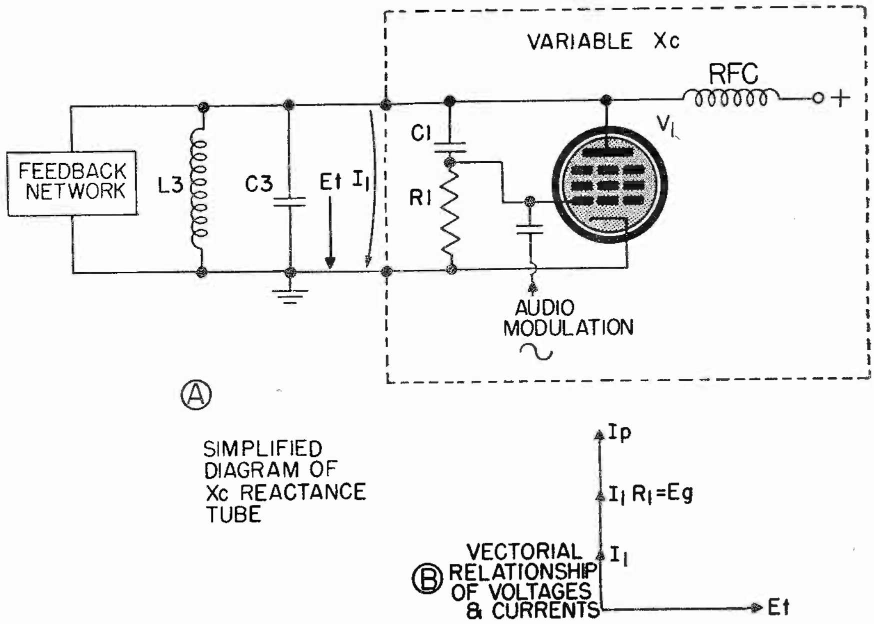


Fig. 5 Use of a reactance tube to produce frequency modulation. Audio control of an electronically produced capacitance changes the carrier frequency accordingly.

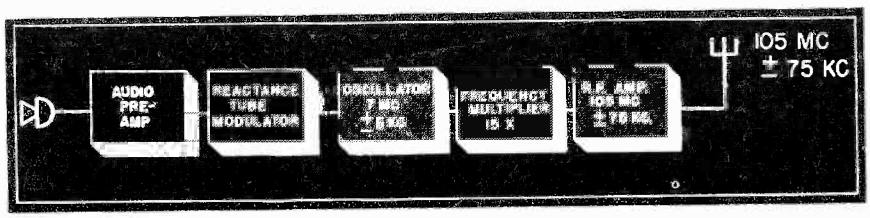
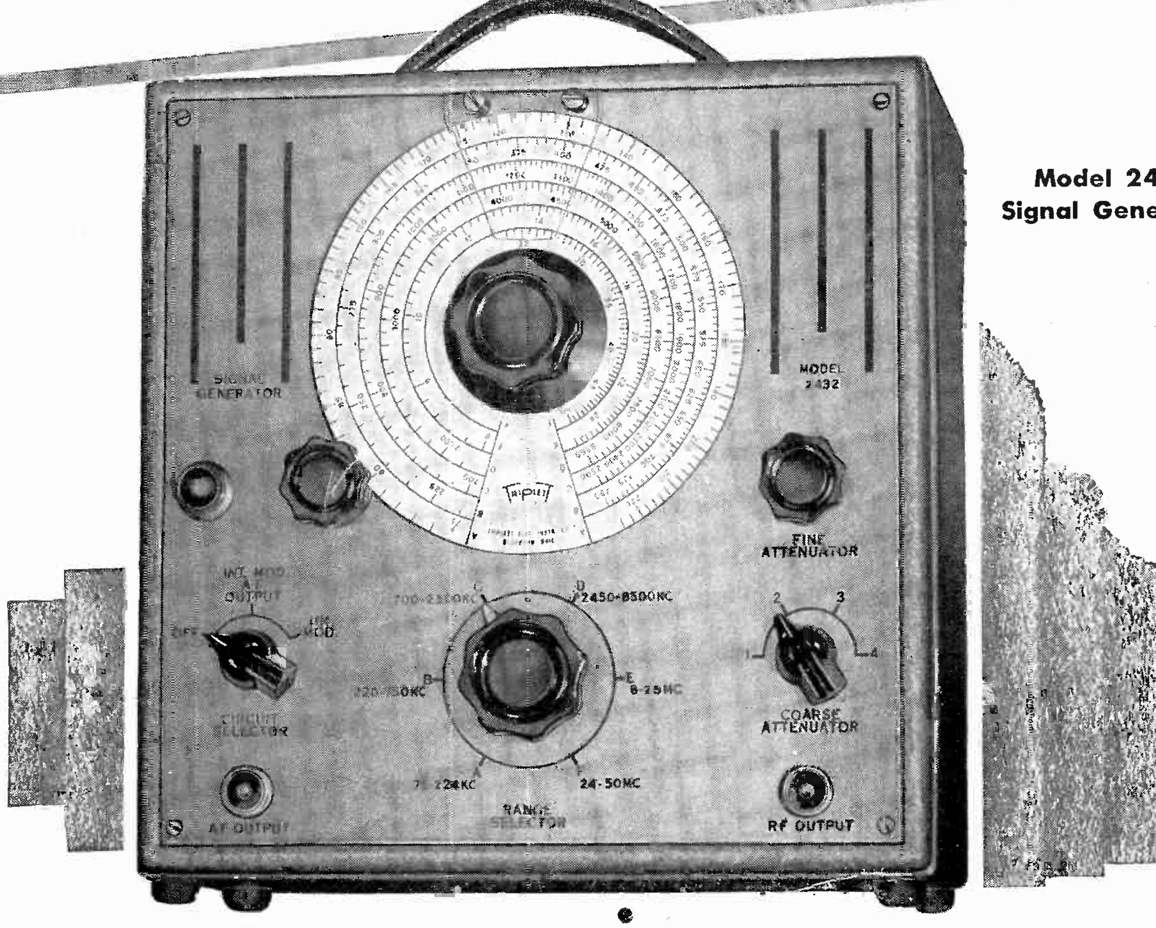


Fig. 6 Block diagram of FM transmitter using reactance tube modulator.

Characteristics	AM	FM
Carrier Amplitude	Varies with modulation	Constant with modulation
Bandwidth	10 kc maximum, varies directly with frequency of modulation	150 kc maximum, varies directly with the amplitude of modulation voltage
Modulation Voltage Amplitude	Causes changes in strength of carrier wave	Creates changes in frequency of the carrier wave
Modulation Frequency	Determines rate of change of amplitude variations	Determines rate of change of frequency variations

For the Man Who Takes Pride in His Work



Model 2432
Signal Generator

FM AND TELEVISION BAND COVERAGE ON STRONG HARMONICS STRONG FUNDAMENTALS TO 50 (MC)

Another member of the Triplett Square Line of matched units this signal generator embodies features normally found only in "custom priced" laboratory models.

FREQUENCY COVERAGE—Continuous and overlapping 75 KC to 50 MC. Six bands. All fundamentals. **TURRET TYPE COIL ASSEMBLY**—Six-position turret type coil switching with complete shielding. Coil assembly rotates inside a copper-plated steel shield. **ATTENUATION**—Individually shielded and adjustable, by fine and course controls, to zero for all practical purposes. **STABILITY**—Greatly increased by use of air trimmer capacitors, electron coupled oscillator circuit, and permeability adjusted coils. **INTERNAL MODULATION**—Approximately 30% at 400 cycles. **POWER SUPPLY** — 115 Volts, 50-60 cycles A.C. Voltage regulated for increased oscillator stability. **CASE**—Heavy metal with tan and brown hammered enamel finish.

There are many other features in this beautiful model of equal interest to the man who takes pride in his work.

Precision first ...to last

STANDARDS ARE SET BY TRIPLETT

Triplett

ELECTRICAL INSTRUMENT CO. BLUFFTON, OHIO

The Organizations

→ From Page 18

efforts of servicemen everywhere to promote successful organizations."

T. P. Robinson, Vice President
Dallas Radio Sales & Service Association, Inc.

Earl L. Pittsley of the *Southern Tier Chapter* of *Radio Servicemen of America* reports:

"Our April 15th meeting was a 'Ladies' Night' banquet. About forty attended and enjoyed the Quiz program which was aired by WINR. Questions and contests with WINR's M.C. and his wire recorder were hilarious, especially the balloon-blowing contest. Color travel movies also were shown.

"At present, we are negotiating with WNBF for free air time to acquaint the public with us and our aims. Will advise you at a later date as to the results.

"Also, we are planning to use any available movies from manufacturers which will increase our education technically, and enable us to run a more profitable business."

EARL L. PITTSLEY

Circuit Analysis

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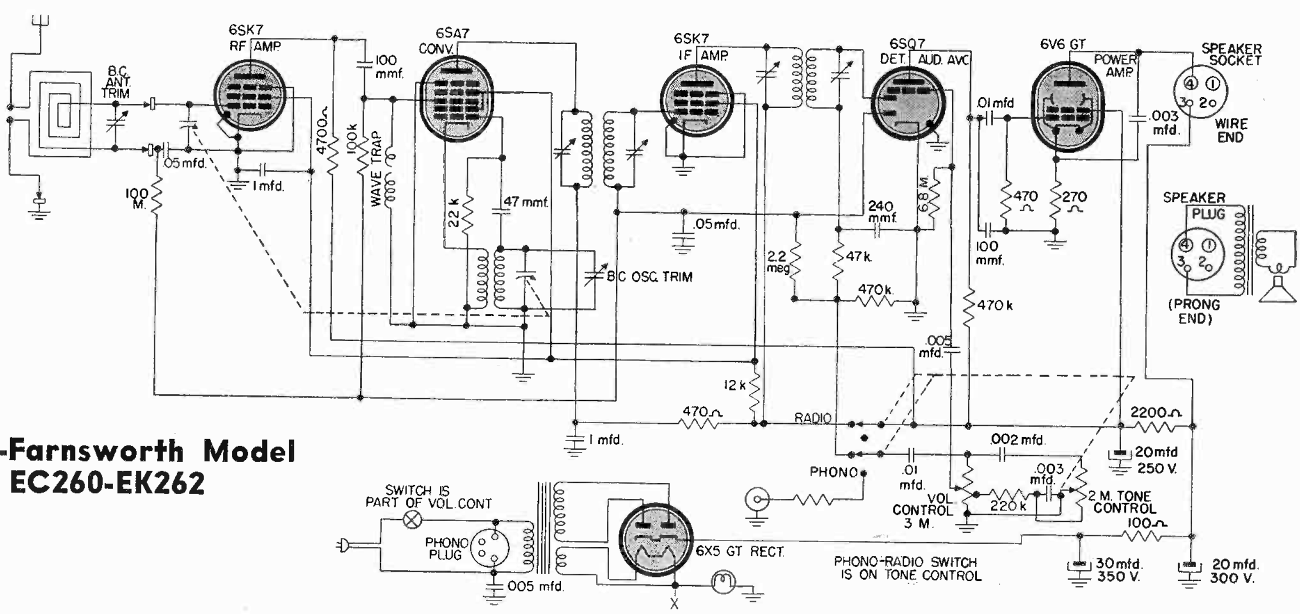
One side of this voice coil is grounded; voltage is fed from the other side to the screen of the 12SK7 tube. Since only one stage exists between these two points, the voltage fed back is out of phase 180 degrees with the voltage which normally builds up on the unbypassed screen of the 12SK7.

Notice that line short circuits from accidental grounding of the chassis are guarded against by isolating B minus from the chassis by means of a resistor and a condenser.

Next we examine Farnsworth Model EC260. This is an AC operated combination automatic phono-superheterodyne receiver. It includes six tubes — one stage of RF and a 6V6GT power output. An unusual type of wavetrap is used in the grid circuit of the 6SA7 converter. This trap consists of two coils wound together on the same form. The total inductance of the coils, with the capacitance existing between them, forms a series tuned circuit which resonates at the intermediate frequency. A condenser is thus not necessary.

The tone control in this set is a little easier to understand if redrawn as shown in Fig. 2. Resistor R2 and condenser C2 form a tone compensation network for the low end of the volume control. Since this combination has a higher impedance to lows than to highs, the lows are boosted more when the volume control is turned down. This is to compensate for the fact that the ear has relatively poor low frequency response on low amplitudes of sound energy. The tone control itself consists of C1 and R3. These two components in series shunt the volume control. When the arm of the pot (ground) is near the top, this shunt is nearly all capacity, and high frequencies are discriminated against, thus producing the "bass" effect. When the arm is all the way down, this shunt is nearly all resistive, bringing the high frequencies up again.



—Farnsworth Model EC260-EK262

Test Equipment Maintenance

→ From Page 25

pear as a "throbbing" noise, gradually decreasing in frequency until both frequencies are the same.

Other very accurate check points to beat against will be obtained on an all-wave receiver by tuning in Station WWV (previously mentioned) which is modulated at both 440 and 4000 cycles. It may be found advantageous to feed the oscillator directly into the speaker voice coil or output transformer when making this sort of check.

An even better way to detect the beat points is with an oscilloscope. Set the scope sweep on "60 cycles" (synchronized with line frequency) and connect the audio oscillator to the vertical plates. When the oscillator frequency is 60 cycles, the image on the screen will show one complete cycle; for 120 cycles a two-cycle image will appear. In the same manner, 180, 240, and 300 cycle frequencies will produce images of 3, 4 and 5 cycles, respectively. These relations are illustrated in Fig. 1.

Another method of detecting the beat signal is that which replaces the speaker or oscilloscope with an output meter. If an audio amplifier with an AC supply is used, sufficient 60-cycle hum may be present to operate the meter and provide the reference frequency, but in most cases, a separate 60-cycle source is desirable. This can be any small low voltage filament transformer; a potentiometer can be used to reduce the voltage to the desired value during test operations. When the output meter is connected, low frequency beat signals will appear as fluctuations of the needle and the "Zero beat" point can easily be recognized. Instead of the 60 cycle standard, another audio oscillator may be used to produce the beat. This method has the advantage that we can produce a fundamental reference at any frequency, but depends on the accuracy of the generator being used as a standard.

In Part III, we shall discuss drift checks of audio oscillators. Also to be treated are oscilloscopes, meter repair and calibration, power supply and vibropack maintenance, care of tools and other shop equipment. ✓ ✓ ✓

OVER THE BENCH

by John T. Frye

I WONDER HOW MANY of you old-timers remember that battery type Atwater Kent receiver that was built bread-board style. I think it was a Model 12. You will recall that the completely cased tuning condensers were arranged along the front of a highly polished board, and the remaining parts were distributed tastefully over the rest of the glorified plank. I wonder, too, how many of you have wished rather wistfully at times that modern receivers were as easy to "get at" for servicing as were those old AK's. I know that I have.

It is probably expecting a little too much to hope that the manufacturers will go back to this early type of construction just for the benefit of the serviceman — the housewife would have something to say about that—but I do think that the manufacturer could and *should* do some things to make his receivers easier to service.

Continuing satisfaction on the part of the customer is what it takes to produce repeat sales. A radio that is hard to service, either because of a lack of available service information or poor mechanical layout, will of necessity produce high service charges. If a serviceman has to spend two hours replacing an inaccessible screen by-pass condenser in set A; and if he could have replaced this type of condenser in half a dozen of set B in the same length of time, obviously, he has to have considerably more money for the job on set A. What is more, he is very likely to explain to the customer why the installation of such a low cost item resulted in such high charges. The result will not make the customer fond of the manufacturer of set A.

Another angle by no means to be lightly dismissed is that a great many people consult their servicemen when they are thinking of buying a new receiver. Personally, being a free-lance serviceman, I get several calls each week from customers who want me to recommend one brand or another of receiver. Do you think that I steer these customers in the direction of manufacturers who seem to delight in Rube Goldberg dial-drive assemblies, in by-pass condensers tucked away in spots where the set has to be half dismantled to reach them, or who act as though the service information I need were an atomic bomb secret? Huh-uh! I put in a good word for the sets that are well laid out, with all parts easily reached, and that have good service information right with them.

I know that I shall probably be called on to service these sets so in recommending the ones easy to service, I am simply taking care of my own interests; but beyond that, I have noticed that the trick circuits, the tortured layouts, and the spider-web dial drives give much more trouble than do the straightforward, well engineered sets. In recommending them, I serve both myself and the customer.

There must be some middle ground halfway between the bread-board receivers and the ones that are manufactured with absolutely no regard for ease of servicing. It is with this in mind that I should like to submit a few suggestions to the manufacturers. No radical or expensive ideas are included in this list, and each would be greatly appreciated by the radio service fraternity.

1. The model number should be plainly stamped on the chassis it-

→ To Following Page

Over the Bench

→ From Preceding Page

self instead of on the cabinet or on a piece of paper pasted to the cabinet or chassis.

2. Trimmers should be marked with colored dots of paint either on the trimmer or near it. The first dot could indicate the band with which the trimmer is associated; the second colored dot could indicate the function. For example: Brown-red could mean broadcast band oscillator; brown - green, BC band RF; brown - blue, BC Band antenna. Black - red could be the first short-wave band oscillator, etc. This system could be elaborated and standardized to cover every trimmer in the set.

3. Speakers and loop antennas should be arranged so that they can be *quickly* and *easily* removed from the cabinet. The judicious use of a few wingnuts would be of a great help.

4. The diagram should be pasted to the chassis if at all possible. It may be small, if clear, so that it can be read with a magnifying glass; but it should be there. In case of AC-DC midgets, it could be pasted to the cabinet.

5. The occasional practice of marking IF cans with the IF frequency should be universally adopted.

6. When the dial is contained on a glass that remains in the cabinet, alignment and travel - limit points should be plainly marked on the dial-pointer carrier.

7. Serious effort should be made to simplify some of the present nightmare dial cord arrangements.

8. When table model receivers have the speakers fastened to the cabinet, the leads should be long enough to permit the chassis to be slid out of the cabinet without disconnecting the speaker.

9. Parts that often require replacement should be placed where they are readily accessible. Tube sockets should not be placed so that the prongs cannot be reached with test prods.

10. Tube locations should be marked by stampings on the chassis or by marking on the sockets themselves, rather than by showing these locations on an easily lost bit of paper pasted to the cabinet or chassis.

11. Paper condensers should be plainly marked with capacity value and working voltage, rather than by a manufacturer's part number.

The above list is an outline of my personal desires in the way of manufacturing practice. I am sure that I have not exhausted the subject. You readers doubtless have many other suggestions as to things that you wish the manufacturers would and would not do. How about letting me hear some of them? ✓✓✓

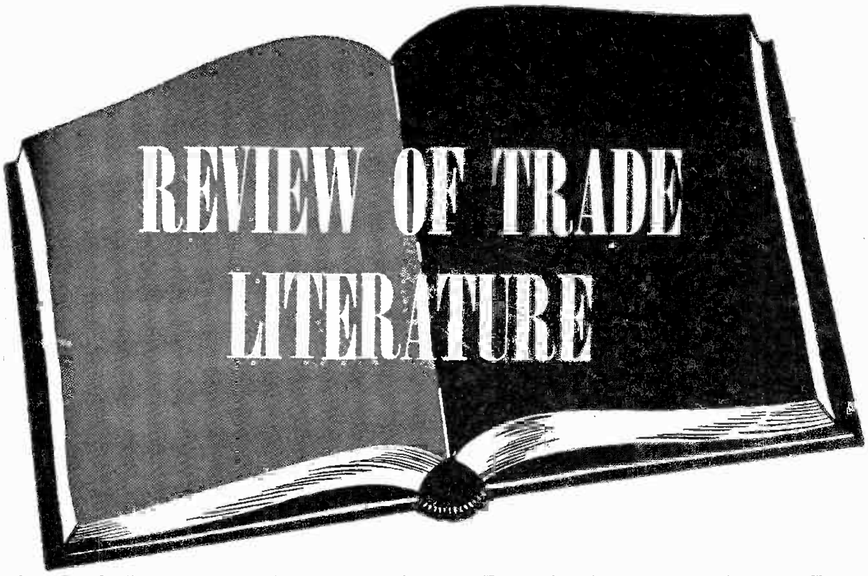
Industry Presents

→ From Page 20

capacitors has just been announced by Solar Manufacturing Corporation. Basis of the great size reduction achieved in Type LB capacitors is a new method of producing unprecedentedly high-gain and stable etched foil. These capacitors will free circuit designers from former space limitations when extremely high values of capacitance are necessary for bypass, coupling, and audio filter applications.

Capacitance values available for low ripple service in a 3/8" x 1 1/8" container range from 8 uf at 150 wvdc to 200 uf at 1.5 wvdc; in a 3/8" x 1 5/8" tube, maximum capacitance range from 12 uf at 150 wvdc to 300 uf at 1.5 wvdc.

Further information may be obtained from Solar Mfg. Corporation, 285 Madison Ave., New York 17, N. Y.



REVIEW OF TRADE LITERATURE

ANYONE who is interested in quality reproduction is referred to the booklet, "20 Steps to Perfect Amplification," presented by the Amplifier Corporation of America. This 24-page booklet interestingly describes 20 essentials for perfect amplification. Some of the unusual features covered include direct-coupling, scratch-suppression, increased musical range, signal-expansion, power requirements, noise, higher fidelity, extended dynamic range, "presence," hum elimination, distortion reduction, microphonics, response control, grid-current, delayed plate-voltage, fixed-bias, balanced audio signals, voice accentuation, reduction of thermal agitation, and cross modulation. Some of the semi-technical descriptions of these 20 fundamental features have never before appeared in print.

The booklet was written by Chief Engineer, A. C. Shaney, and is available to readers upon receipt of a 3c stamp to cover postage, from The Amplifier Corp. of America, 396-10 Broadway, New York 13, N. Y.

A new 70-page catalog and replacement guide for Radiart Vibrators is now available. This booklet (form 1146) lists model numbers of all receivers using vibrators, manufacturers' part numbers, Radiart numbers, and size and circuit arrangement of buffer condensers. Also included are descriptions of power packs and aerials. For a copy, write to The Radiart Corporation, Cleveland 2, Ohio.

Bulletin 431, issued by the Peerless Electrical Products Co., describes a full line of audio and power transformers and filter chokes produced by that company. Write Peerless Electrical Products Co., 6920 McKinley Ave., Los Angeles 1, Cal.

Various types of inter-communication systems are described in a new catalog (C4-45P) issued by the David Bogen Co., Inc., 663 Broadway, New York, N. Y.

The Tube Department of Radio Corporation of America has just issued a new 16-page booklet—"RCA Phototubes, Cathode-Ray Tubes, and Special Tubes (Form No. CRPS-102)." Full of useful technical information, this new booklet includes 113 types. Each tube type is covered by text description, tabular technical data, and terminal diagram. More important types are illustrated. The Phototube Section includes tube dimensional outlines as well as spectral-sensitivity curves, and is sufficiently complete for equipment-design work.

This new booklet, CRPS-102, may be obtained from RCA Tube Distributors at 10 cents a copy, or by sending 10 cents direct to Commercial Engineering, Tube Department, Radio Corporation of America, Harrison, N. J.

The Kurz-Kasch Corporation is offering a new catalog of various types of knobs and control balls. Included are instrument knobs, pointer knobs, lever knobs, control and miscellaneous knobs, and con-

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Flywheel Synchronization

→ From Page 9

tube V-3 which controls the frequency and phase of the electron-coupled oscillator. The effect of the DC voltage on the reactance tube will cause the oscillator to shift in phase and frequency in such a manner as to lock to the frequency and phase of the sync pulses. This will cause the control voltage to fall to zero.

The oscillator can now be used to trigger the sweep circuits since its frequency and phase are the same as that of the incoming sync pulses. In order to do so, a trigger pulse must be derived from the oscillator. The circuit of tube V-2 is arranged so that the high peak-to-peak voltage of the sine wave on the grid produces a square wave voltage on the plate. Oscillograms of the grid and plate voltage are shown in Fig. 6. This square wave voltage is applied to a differentiating network consisting of condenser C-6 and resistor R3. The resulting differentiated wave is a pulse sufficiently sharp to trigger the discharge tube.

Adjustment of this type of AFC circuit requires the setting of two controls (1) the frequency of the electron-coupled oscillator, determined by the inductance of the slug-tuned coil L-1 and (2) phasing the picture with discriminator coil L-2 so that there is about equal blank-

→ To Page 39

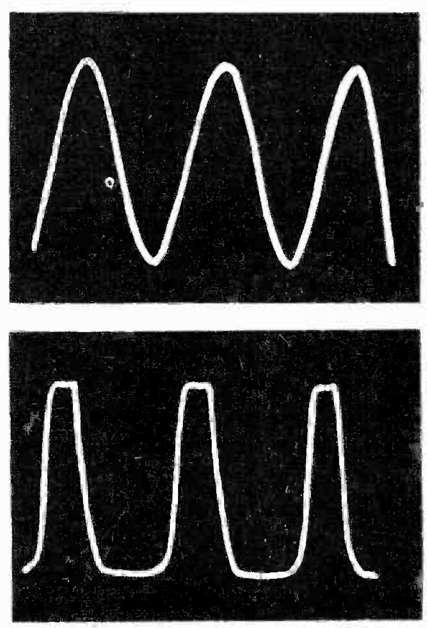
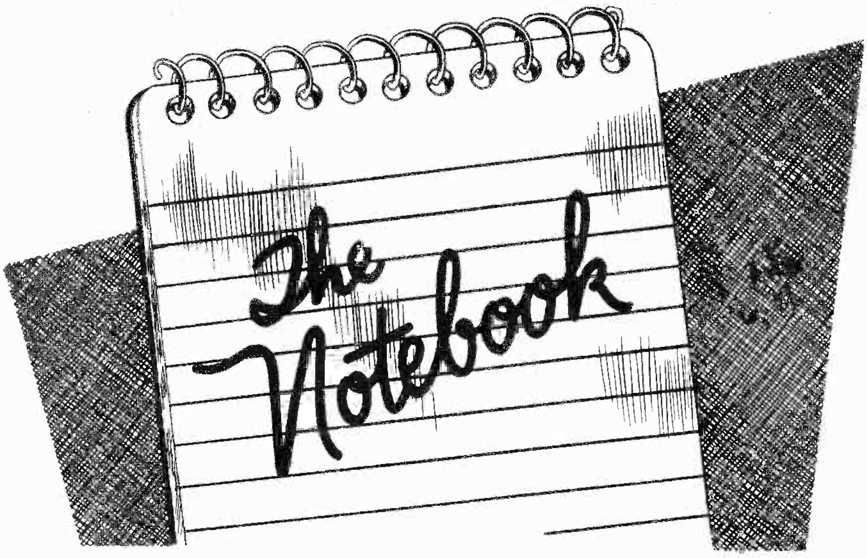
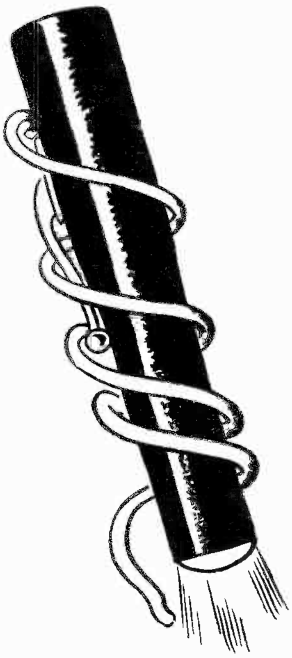


Fig. 6 Top—Sine wave voltage on grid of oscillator tube. Bottom — Square wave voltage on plate of oscillator tube.



Each month the reader sending in the best suggestion receives a crisp ten dollar bill. For all others published, RADIO MAINTENANCE will pay five dollars. Let's hear from you.



Soldering

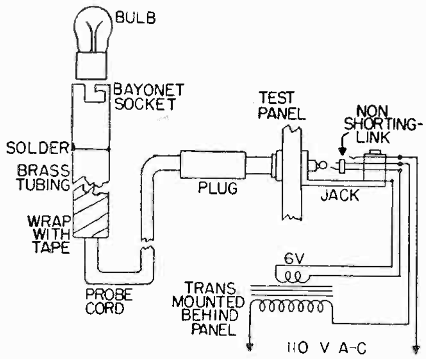
Soldering in dark, cramped spots will be made much easier by use of a "pen" type flashlight around which a coil of solder has been wound as shown in the illustration.

Joseph Novak
184 Oak Street
Binghamton, N. Y.

Straightening Records

The May 1947 Notebook contained a suggestion for flattening warped phonograph records. Another method is as follows: Fill an open can with about one inch of water and place over a source of heat until steam escapes. The warped record is then placed on top of the can and left to steam until it becomes pliable. Care must be taken not to let the record become too soft; and it must be removed before it starts to sag. When the brittleness has been removed, the record is placed between two sheets of glass and weighted down with some heavy object until cool. It is suggested that a record which is no longer useful be used first for practice.

John W. Grubb
Electronic Service
Flemington, Pa.



Automatic Trouble Light

A handy trouble light which is isolated from the power line can be constructed as follows:

A small 6-volt transformer is mounted on the back of the test panel or under the bench and con-

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BACK NUMBERS

Our first announcements of the availability of back numbers of RADIO MAINTENANCE brought a response much greater than we anticipated. As a result we are continuing to comply with the demand of radio servicemen for these back issues. We don't know how long we may be able to fill orders for the earlier issues as the supply is dwindling fast, and some are already sold out. Only those listed are now available, so if you are anxious to get them, send in your request as soon as possible.

JANUARY 1946

THE PROBLEMS OF ORGANIZATION
TELEVISION RECEIVER INSTALLATION — This article will initiate the serviceman into the first step in television—its installation.
RADIO MAINTENANCE IN AVIATION
USING THE OSCILLOGRAPH FOR DISTORTION MEASUREMENTS

APRIL 1946

PA SYSTEMS—This article covers a general discussion of all the opportunities and procedures for the serviceman about to enter the public address field.
A MIDGET AUDIO FREQUENCY OSCILLATOR
IF I WERE A SERVICEMAN
AN EQUALIZED AMPLIFIER FOR MAGNETIC PICKUPS

MAY 1946

PA SYSTEMS—This article covers initial layout of a modern PA system in bars, dance halls, auditoriums, etc.
TEST PANEL FOR THE MODERN BENCH
RINGING THE BELL

JUNE-JULY 1946

FUNDAMENTALS OF TELEVISION
VOLUME CONTROL TAPERS
THE ELECTRONIC VOLT OHMMETER
VECTOR ANALYSIS

AUGUST 1946

AVC CIRCUITS
FM TROUBLESHOOTING
TELEVISION RECEIVER FUNDAMENTALS
RECORD CHANGERS

NOVEMBER 1946

PART II TEST & ALIGNING TELEVISION RECEIVERS
DON'T FORGET THE DIAL LAMP
THE OSCILLOGRAPH . . . HOW TO USE IT
CRYSTAL PICK-UPS

DECEMBER 1946

TELEVISION RECEIVERS . . . THE RF SECTION
TUNING INDICATORS
PART II THE OSCILLOGRAPH . . . HOW TO USE IT
REPLACING AUTO CABLES

JANUARY 1947

SERVICING BY EAR
TELEVISION RECEIVERS . . . VIDEO CHANNEL
PART III THE OSCILLOGRAPH . . . HOW TO USE IT
MINIATURE TUBE CHART

RADIO MAINTENANCE MAGAZINE
460 BLOOMFIELD AVE.,
MONTCLAIR, N. J.

Please send me the back numbers checked here.... I am enclosing 35c for each copy.

☐ January 1946
☐ April 1946
☐ May 1946
☐ June-July 1946
☐ August 1946
☐ November 1946
☐ December 1946
☐ January 1947

☐ $2.00 for the set of eight

NAME ______________________

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Flywheel Synchronization

→ From Page 36

ing on both sides of the raster. As described above, signal tracing the AFC circuits with an oscillograph while looking for the proper waveforms will readily isolate any troubles. Most manufacturers will provide in their service manuals oscillograms of the characteristic waveforms in their own receiver circuits. These will differ for each design, and the serviceman will find it quite helpful to keep them on file.

It will be noted that the foregoing description of AFC sync systems was confined only to the horizontal synchronization circuits. AFC could also be used in the vertical circuits. In fact, in the earlier design stages, it was actually tried, but field tests indicated that random noises had little effect on the stability of the vertical synchronization, and a receiver provided with AFC on only the horizontal performed almost as well as one having it on both the vertical and horizontal. It takes a very severe and continuous noise disturbance to make the picture roll vertically, and such static is infrequent. Hence, few manufacturers are using the more expensive AFC system on the vertical, for the conventional sync circuits described in the March 1947 issue of RADIO MAINTENANCE have proved satisfactory.

In the next article, we shall discuss the latest developments in receiver power supplies. ✓ ✓ ✓

Picture Credits

July Issue

RADIO MAINTENANCE

Page 5—Precision Apparatus Co.

Page 6—Allen B. DuMont Labs.

Page 7—R.C.A.

Page 11—R.C.A.

Page 14—Coastwise Electronics Co.

Page 24—Top and bottom, Precision Apparatus Co.

Page 25—Precision Apparatus Co.

JOHN RIDER SAYS . . .

There's money in Warranty Service

The fact that fewer faults are showing up in receivers now being produced has led a number of service organizations to enter into warranty service contracts with local distributors and dealers. Such contracts can be profitable from the servicing angle because a fixed amount per receiver is paid the servicer—a fee he retains in any case.

In actual dollars and cents, the individual receiver fee is small. But because only a small percentage of the receivers actually require service during the warranty period, the over-all fee averages out to a substantial amount for each receiver serviced. And for those receivers which do require diagnosis and repair, the majority will be comparatively easy jobs, calling for a minimum expenditure of time. Such activity, too, helps to increase your active customer list for additional sales and service.

Trade Literature

→ From Page 35

trol balls for airplane and machinery controls.

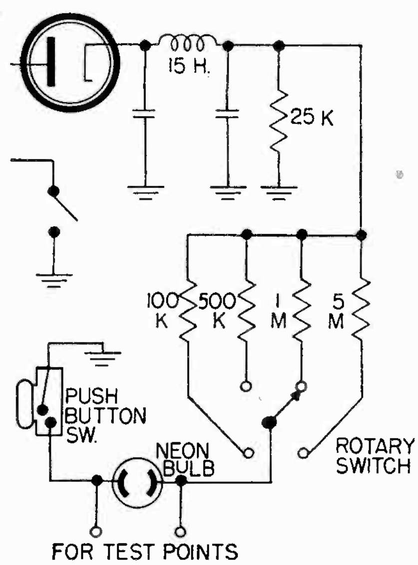
This 12-page booklet is printed in two colors and is copiously illustrated with photographs. A copy can be obtained by writing to Kurz-Kasch, Inc., 1434 South Broadway, Dayton 1, Ohio.

The Notebook

→ From Page 37

nected to a phone jack so as to energize the primary and connect the secondary to the bulb when the plug is inserted. When the plug is removed, the transformer is automatically shut off. The probe can be made by soldering a bayonet socket on the end of a short piece of brass tubing and covering it with tape.

Carl O. Williams
R. R. No. 1
Argos, Ind.



Condenser Leakage Tester

A convenient method for checking electrolytic condenser leakage is illustrated in the accompanying diagram. The supply voltage (DC), the voltage of the neon bulb, and the resistors can be adjusted by experiment. The relative leakage can be judged by the position of the switch on which the bulb just starts to light.

Enoch Smith, Jr.
Rosewood Drive, Rt. 4
Columbia, S. C.

HUGHES PRINTING CO.
EAST STROUDSBURG, PA.