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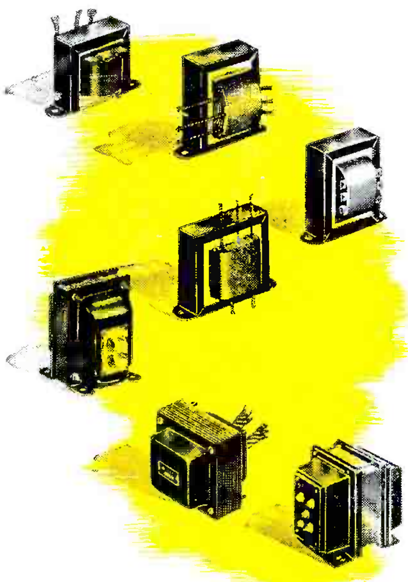

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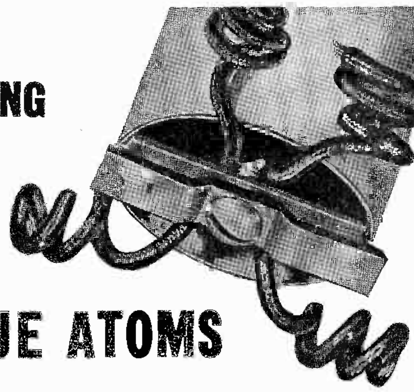

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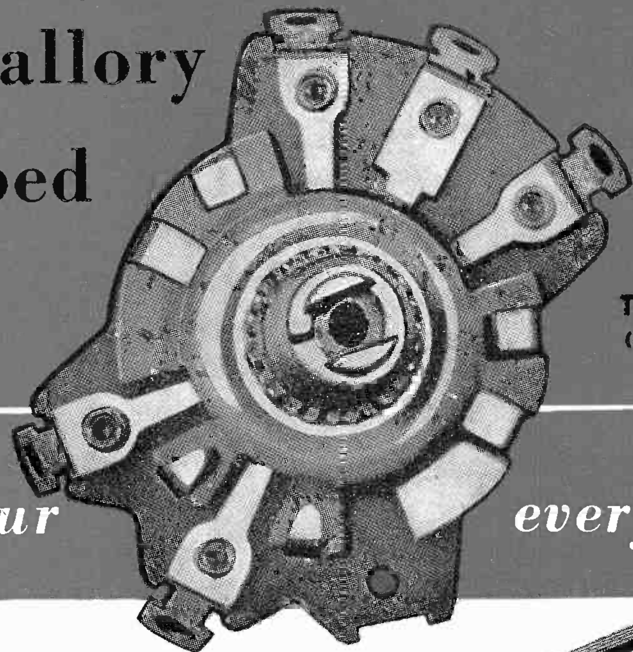

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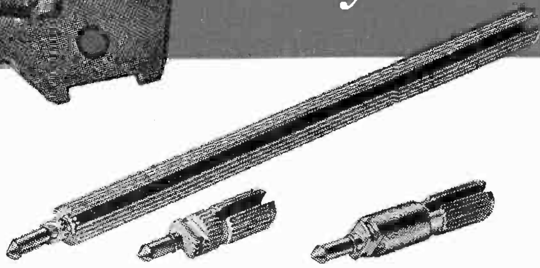

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Volume 3 MARCH, 1947 Number 3

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Radio Maintenance is published monthly by Boland & Boyce, Inc., at 34 No. Crystal St., East Stroudsburg, Pa., U.S.A.; Executive and Editorial Office, 460 Bloomfield Ave., Montclair, N. J. Subscription Rates: In U. S., Mexico, South and Central America, and U. S. possessions, $2.50 for 1 year, $4.00 for two years, single copies 25 cents; in Canada, $3.00 for 1 year, $5.00 for 2 years, single copies 30 cents; in British Empire, $3.50 for 1 year, $6.00 for 2 years, single copies 40 cents; all other foreign countries, $4.00 for 1 year.

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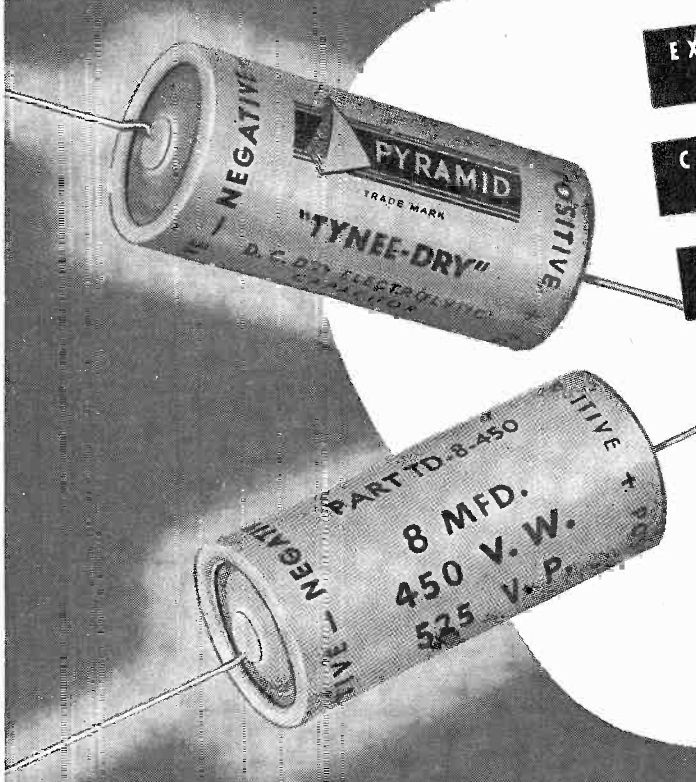

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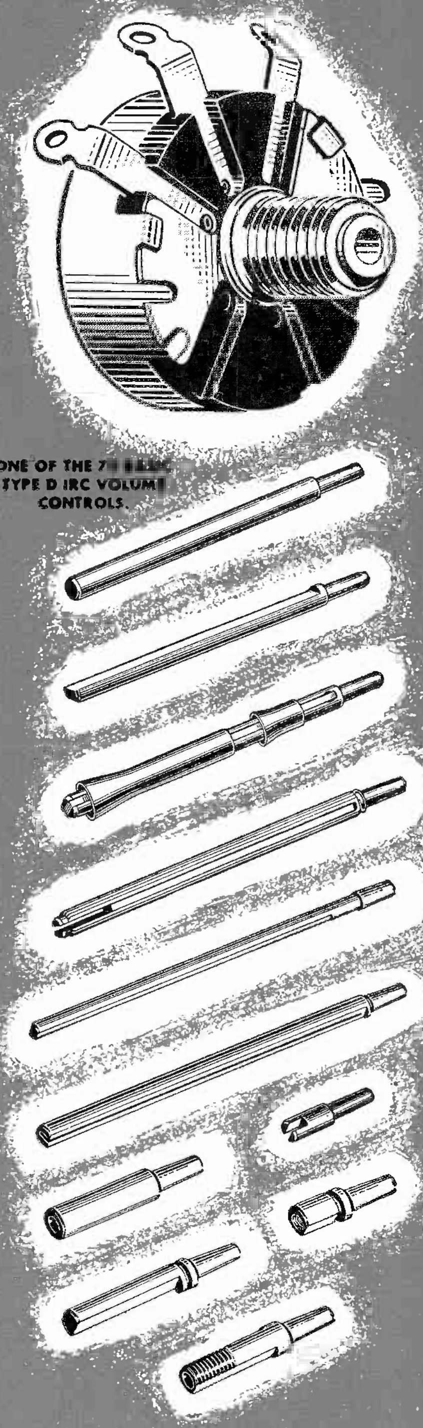

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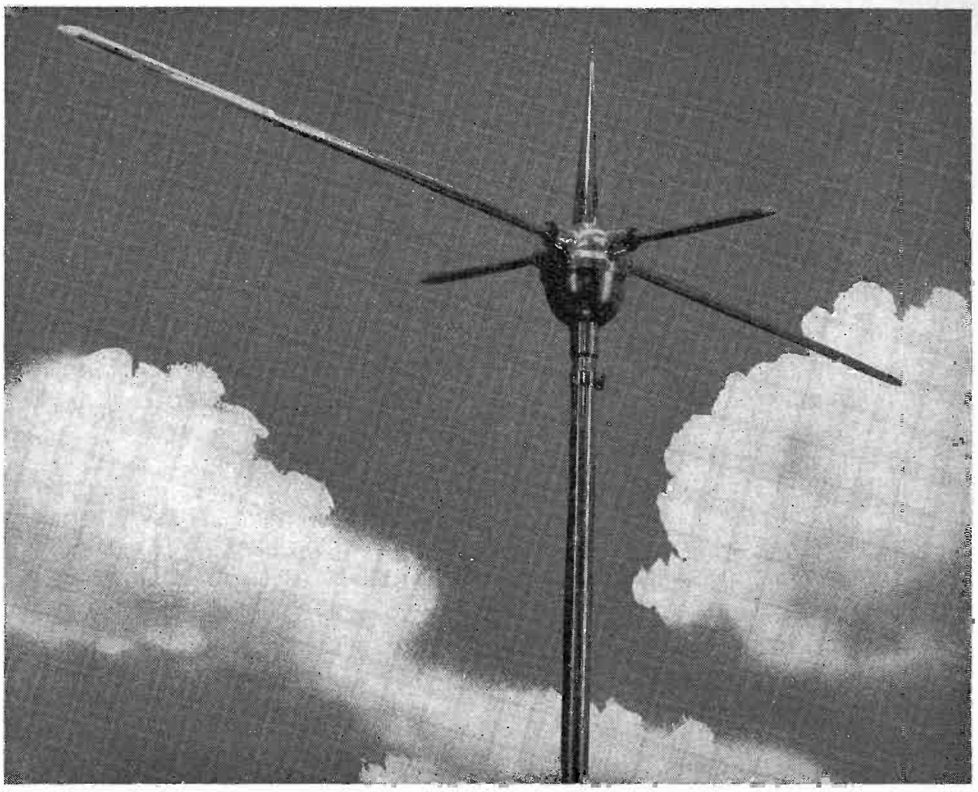

ANTENNAS... f-m and television

by
Milton Kaufman
RCA Institute

This is the first of two articles on FM and television theory. It gives an easily understood explanation of transmission lines and matching systems.

NOW THAT TELEVISION and FM sets are beginning to roll off the production lines in large quantities, the average serviceman will be called upon to select and install highly efficient antenna systems. It cannot be too strongly emphasized that the success or failure of obtaining satisfactory reception at the high frequencies used for these services depends to a great extent on the antenna installation.

In the case of the average broadcast band receiver, practically any antenna system chosen will usually be successful. The only penalties which might result from a haphazard selection would be either a reduction in signal strength without distortion, or an increase in noise pickup. This is not the case when dealing with the problems to be met in the television and FM bands.

The purpose of this series of articles is to provide the serviceman and technician with enough information and practical examples so that he may reach a successful solution to most of the difficulties to be encountered in the field.

The problems of antenna installation can be broken down into three major divisions:

1. The selection and installation of transmission lines.

2. The selection, installation and orientation of the antenna.

3. The proper matching of the transmission line to the antenna and receiver.

Each one of these divisions is of critical importance in the performance of the antenna system.

Transmission Lines

The function of a theoretically perfect transmission line is to convey the energy which is picked up by the antenna to the receiver in such a manner that no losses occur during the transmission. It is essential that the line itself does not pick any stray energy.

Three factors to which losses may be attributed are:

1. Dielectric loss which results from power dissipated in the form of heat within the insulation material.

2. Radiation loss, resulting from power being transferred into space or to nearby conducting objects.

3. Copper loss, due to the resistance of the conductor.

When considering losses in transmission lines used for receiving purposes, the copper loss can generally be neglected because of the small amount of power involved.

There are now commercially available a number of excellent transmission lines. The choice of the particular type to be used will depend upon each individual situation. Lines may be classified generally as follows:

1. Twisted pair
2. Shielded pair
3. Two wire parallel conductor
4. Concentric (or coaxial) line

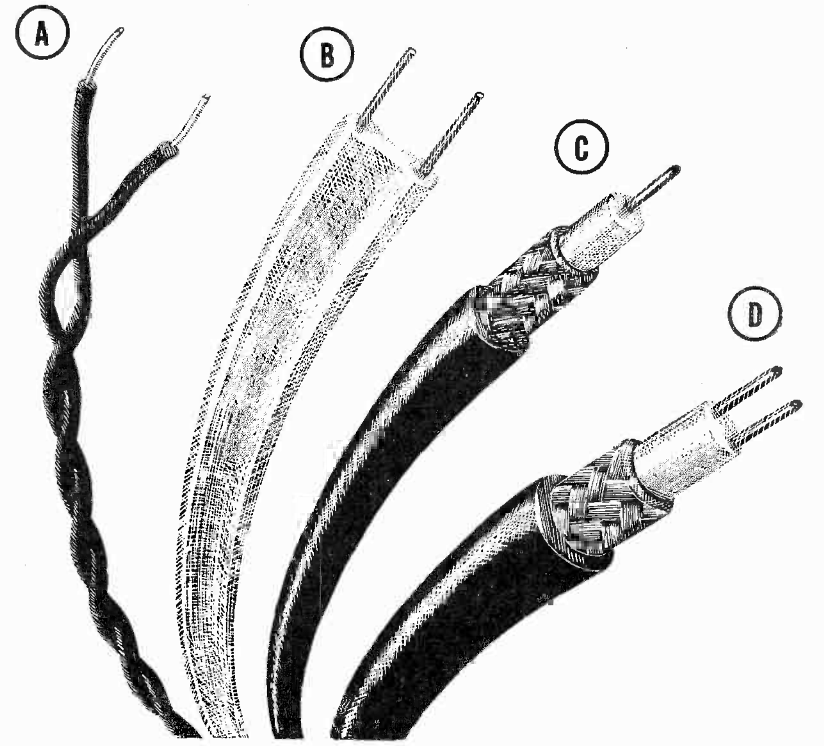

Fig. 1 Four types of transmission line now being used with FM and television antennas: (A) Twisted pair; (B) Two wire parallel conductor; (C) Coaxial cable; (D) Shielded parallel pair.

Twisted Pair

This consists of two insulated wires twisted upon each other to form a flexible line. A twisted pair has characteristic impedances ranging from 40 to 150 ohms. It is the most economical and flexible line, but has the greatest dielectric losses. One such typical line has a voltage loss of 4 db per hundred feet at 50 megacycles. This loss increases with frequency and results in an efficiency of less than 50 per cent for a hundred foot length (See Fig. 2).

The twisted pair line is recommended only for comparatively short lengths, 50 feet or less, and in regions of high signal strength. It is "balanced" to ground, but is unshielded. A line is said to be balanced when the capacitance between each conductor and ground is uniform along the entire length of the line. If radiation from an unshielded line is to be avoided, the current flow in each conductor must be equal in order to set up equal and opposite magnetic fields which cancel out. This condition will result only if the line is well in the clear of all conducting objects. The line should not be permitted to swing freely, but must be fastened securely at regular intervals with high quality insulators.

Shielded Pair

This consists of two separate parallel conductors which are insulated from each other by a low loss dielectric, such as the new plastic, Polythene. The conductors are contained within a tubing made of copper braid which acts as a shield. The entire assembly is covered with a rubber or plastic composition to afford weatherproofing. The shielded pair has two outstanding advantages. First, is the fact that the conductors are shielded against pickup from stray interference; and, secondly, the line is balanced to ground at all points due to the enclosing shield. Therefore, it may be run close to conducting objects without fear of its becoming unbalanced. The effect of unbalance would be to increase the losses resulting from radiation. This line may be used in areas where local interference exists. The efficiency, however, is not much better than for the twisted pair, and its length should be restricted to about 75 feet or less. The impedance values range from 50 to 100 ohms.

Two Wire Parallel Conductor

The two wire parallel conductor which is enclosed in a plastic ribbon of Polythene is rapidly becoming one of the most popular types in use today. Polythene is a synthetic plastic material with a yellowish waxy appearance. It has the best electrical characteristics of any material yet developed for this purpose. It is manufactured by the American Phenolic Corporation (Amphenol), Federal Telephone and Radio Corporation, and a number of other concerns.

The line features great flexibility and low loss, and is available in impedance values ranging from 75 to 300 ohms. A 300 ohm line of this type will match perfectly to a folded dipole antenna (to be described later), and to many television receivers which have an input impedance of 300 ohms. The attenuation of the line at 50 megacycles is approximately 1.2 db per hundred feet, which gives it an efficiency of almost 80 per cent. This means that, of all the energy picked up by the antenna, 80 per cent will be delivered to the receiver. However, since the line is of the balanced type and unshielded, the same precautions should be taken as with the

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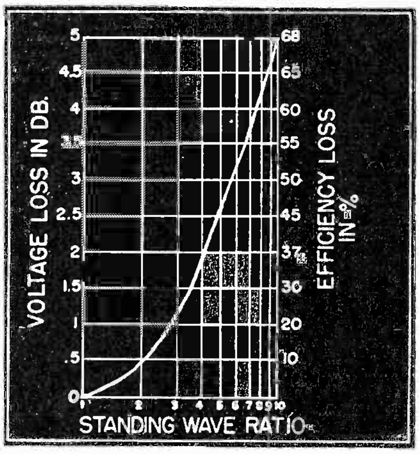

Fig. 2 A curve showing the voltage loss in db and the efficiency loss in per cent for various standing wave ratios.

→ From Preceding Page

twisted pair. It is not recommended for use in extremely noisy locations. Lengths up to 150 or 200 feet will give good results.

Concentric (or Coaxial) Line

This is by far the most efficient type of all. It consists of an insulated center wire enclosed by a concentric metallic outer covering which may be either solid or flexible. The signal energy is confined to the inside of the line; hence, there is no loss of power due to radiation. The outer conductor acts as a shield, thus the line is not subject to pickup from stray fields and may be used in noisy locations where other lines would be ineffectual. It is available in impedances ranging from 10 to 150 ohms. The line is of the unbalanced type and must be correctly terminated at the receiver with the shield connected to ground. The attenuation depends on the insulating material used, and for Polythene may be as low as 0.4 db per hundred feet. This results in a line efficiency of almost 95 per cent (See Fig. 2). If the length is to be more than 50 feet, the line should be made with high grade insulation, such as Polythene or Copalene, to keep dielectric losses to a minimum.

It must be remembered that whatever the type used, the line must be properly matched to both the antenna and the receiver if efficiency losses due to reflections are to be avoided.

In summary, Table I has been prepared, listing the important characteristics of the different lines. (See Fig. 3).

TYPE OF LINE	SURGE IMPEDENCE FROM	SURGE IMPEDENCE TO	ATTENUATION IN DB. PER 100 FT. AT 50 MC.	EFFICIENCY IN %	MAXIMUM RECOMMENDED LENGTH IN FEET	BALANCED OR UNBALANCED	SHIELDED OR UNSHIELDED
TWISTED PAIR	40	150	4	42	50	BAL.	UNS.
SHIELDED PAIR	40	100	1.5 – 3	50–78	50 – 75	BAL.	S.
TWO-WIRE PARALLEL (POLYTHENE)	75	300	1.2	75	150	BAL.	UNS.
COAXIAL (POLYTHENE)	10	150	.4	92	400	UNBAL.	S.

Fig. 3 The above chart shows the important characteristics of the various types of transmission line.

Characteristic Impedance

One of the most important expressions used in describing a transmission line is its characteristic (or surge) impedance, expressed in ohms. The characteristic impedance must be chosen properly so as to match the input impedance of the receiver and the impedance of the antenna. Otherwise, large standing wave ratios will reduce the efficiency of the antenna system. The factors which determine the magnitude of this impedance are the diameter of the conductors, the spacing between the conductors, and the dielectric constant of the insulating material used to separate them. The wider the spacing and the smaller the diameter of the conductors, the greater will be the value of the characteristic impedance. However, an increase in the dielectric constant above that of air will *reduce* the characteristic impedance. Useful values for television and FM range from 50 to 300 ohms.

For a two wire parallel line with air dielectric, the impedance is given by the formula

$$Z = 276 \log b/a$$

where b is equal to the spacing between the conductors measured from center to center, and a is equal to the radius of one conductor.

Fig. 4 shows values of characteristic impedance for various wire sizes and spacings. If the dielectric is other than air, the answer must be multiplied by a factor 1 over the square root of K, where K is equal to the dielectric constant. For Polythene dielectric, simply multiply the results obtained from the graph by 0.675.

For a coaxial line with air dielectric, the impedance is given by the formula

$$Z = 138 \log b/a$$

where b is equal to the inner diameter of the outer conductor, and a is equal to the outer diameter of the inner conductor. For a line using Polythene dielectric, multiply the results obtained from the graph (Fig. 5) by 0.675.

Standing Waves

It was previously mentioned that a mismatch of impedances between the transmission line and the receiver would cause standing waves to be set up on the line and a loss of signal strength at the receiver. The system shown in Fig. 6A is

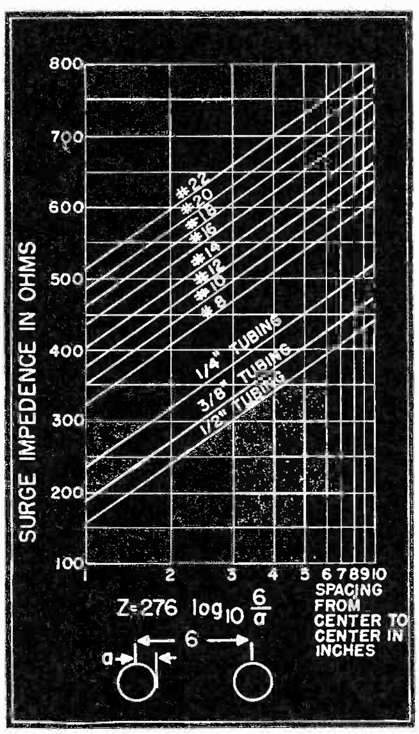

Fig. 4 A chart giving the impedance of two wire parallel transmission line (air dielectric) using various combination of spacing and conductor size.

perfectly matched. The input coil to the receiver has an impedance of 75 ohms which is being fed by a transmission line of 75 ohms, and this in turn is fed from a dipole antenna which also has an impedance of 75 ohms. Therefore, all of the energy going down the line will be absorbed at the receiver and no reflection will occur. Thus, there will be no standing waves on the transmission lines, and a maximum efficiency will result.

Now, refer to Fig. 6B and it will be seen that, although the antenna and transmission lines are matched, the transmission line is not matched to the receiver. This mismatch is in the ratio of 300 to 75, or 4 to 1. Therefore, the standing wave ratio is also 4 to 1.

Referring to the graph of Fig. 2, it is found that a standing wave ratio of 4 corresponds to an efficiency loss of 37 per cent, which is due only to the mismatch and does not include the dielectric loss. This loss, due to mismatching, occurs because some of the signal is not absorbed by the load (receiver input coil) and is reflected back to the antenna. The reflected wave, combining with the original, creates an effect known as standing waves.

The waves which are stationary in position along the line radiate into space and induce currents into nearby conductors. Not only is the efficiency reduced, but if the line is over 50 feet in length, ghost images may be seen on a television screen, due to the reflections. If the line is less than 50 feet long, the ghost effect will be negligible.

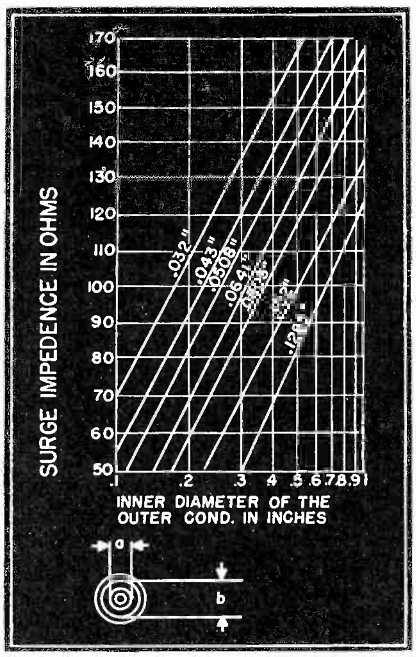

Fig. 5 A chart showing the impedance of concentric transmission line (air dielectric) for different combinations of inside and outside conductor sizes.

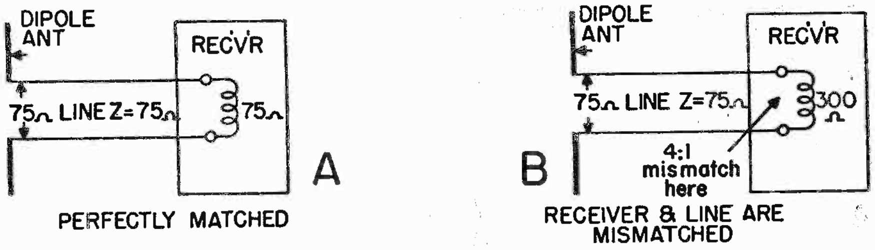

Fig. 6 Correctly and incorrectly matched antenna systems. In (A) the 75-ohm line matches at both the antenna and receiver ends; and, therefore, the match is correct. In (B) the 75-ohm line matches the antenna but does not match the input of the receiver.

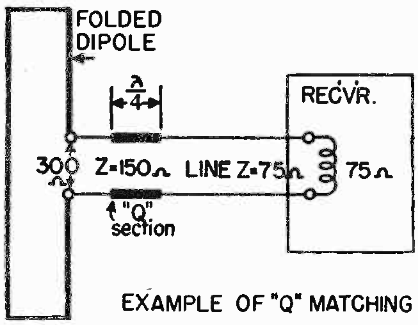

Fig. 7 A matched system using a Q section. The Q section acts as a transformer. To obtain desirable efficiency, the conductors used in the Q section should be of fairly large diameter.

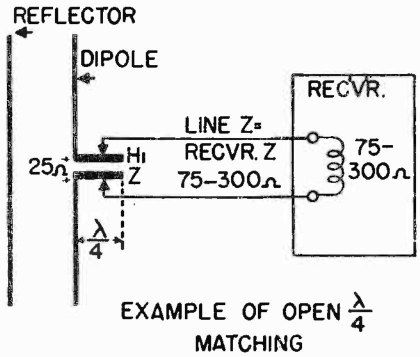

Fig. 8 An open end quarter wave stub used to match a 75 or 300 ohm line to a 25 ohm antenna.

It is important to note that mismatches as high as 2 to 1 are usually considered acceptable, and will reduce the efficiency by only 10 per cent (See Fig. 2). This means that a transmission line with an impedance of 150 ohms could be used to match antenna impedances from 75 to 300 ohms. However, it is always desirable to attempt as close a match as practicable.

Matching

To obtain maximum efficiency and the elimination of ghosts, the transmission line, antenna, and the receiver should be matched as closely as possible. Thus, it is sometimes necessary to make use of matching devices.

Of these, variations in the use of quarter wave matching sections are perhaps the most practical. Wherever used, the matching sections should be made of large diameter conductors, such as 1/4 inch tubing, to insure sufficient band width. Spacings and diameters for various values of impedances are given in Fig. 4.

The method of procedure to be used if matching becomes necessary is: First, select a transmission line to match the input impedance of the receiver; then if the mismatch from line to antenna is greater than 2 to 1, select the appropriate matching section. For example, a television receiver has an input impedance of 75 ohms, and it has been decided to use a folded dipole antenna which has an impedance of 300 ohms. Select a transmission line to match the receiver. Thus, the chosen line will have an impedance of 75 ohms. However, the mismatch of 300 to 75 is greater than the allowable 2 to 1, and the use of a matching transformer is necessary.

One of the most efficient schemes is the so-called "Q" matching section. This consists of a quarter wave stub of the proper impedance, placed between the antenna and transmission line (See Fig. 7). The impedance of the stub is given by the formula

$$Z = \sqrt{Za \times Z1}$$

where Za is equal to the impedance of the antenna, and Z1 is equal to the impedance of the transmission line. For the example in question

$$Z = \sqrt{75 \times 300} = 150 \text{ ohms}$$

The length of the stub depends on the center frequency of the antenna,

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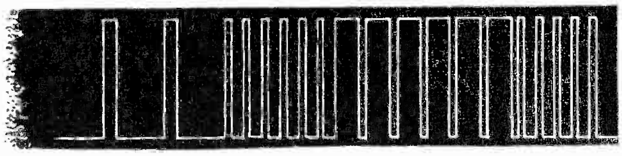
TELEVISION RECEIVERS



the VERTICAL SWEEP

Morton Scheraga
Allen B. DuMont Labs.

This is the fourth of seven articles discussing the various sections of the television receiver.

In previous articles, we have dealt with those circuits of a television receiver which select and amplify the video signal and bring it up to a level sufficient to drive the grid of the cathode-ray tube. In this article, we begin the study of the circuits that control the motion of the electron beam and cause it to trace out a picture in exact synchronism with that being scanned at the station.

The electron beam is simultaneously moved in two directions 15,750 times a second horizontally and 60 times a second vertically. After the electron beam scans 262½ lines horizontally and arrives at the bottom of the picture, a vertical synchronizing pulse is applied to the deflection system and brings it back again to the top of the screen. This vertical motion occurs 60 times a second and is the repetition rate of the vertical sweep system, which section we shall treat in detail in this article.

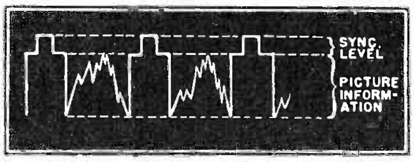


Fig. 2 A video signal showing the combined sync pulse and picture information.

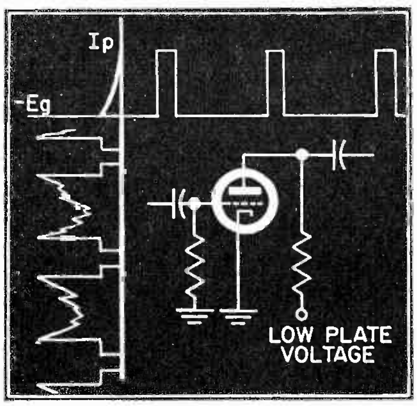


Fig. 3 Simplified circuit of a triode clipper and its input and output waveforms.

Fig. 1 is a block diagram of the vertical sweep circuits showing the signal path from the second video detector to the deflecting plates or coils. At the second detector, the composite video signal is obtained which carries both the picture information and the synchronizing pulses. These portions of the video signal are shown in Fig. 2. The picture information is applied to the grid of the cathode-ray tube, while the synchronizing pulses must be separated and directed to the sweep oscillators. This separating of the sync portion is known as *clipping* and is accomplished generally by a diode or a biased triode. A triode clipper and the resulting clipped sync level are shown in Fig. 3.

The chief advantage of the triode clipper over the diode is the amplification that is obtained in addition

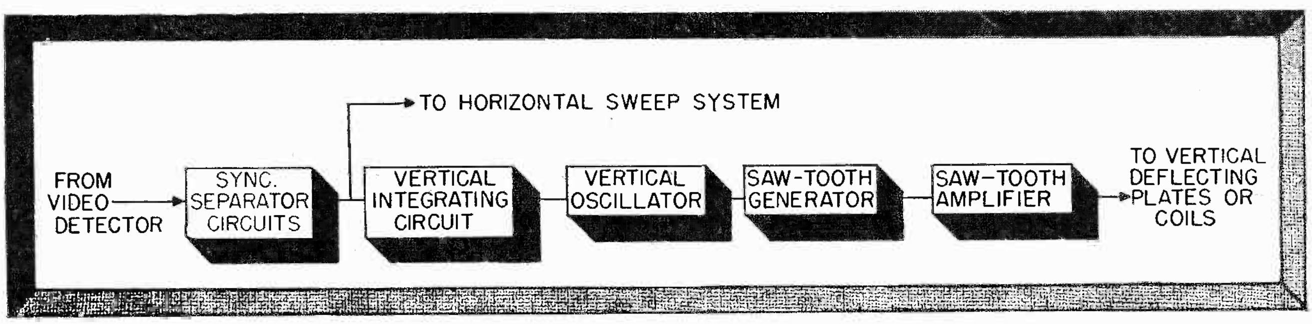
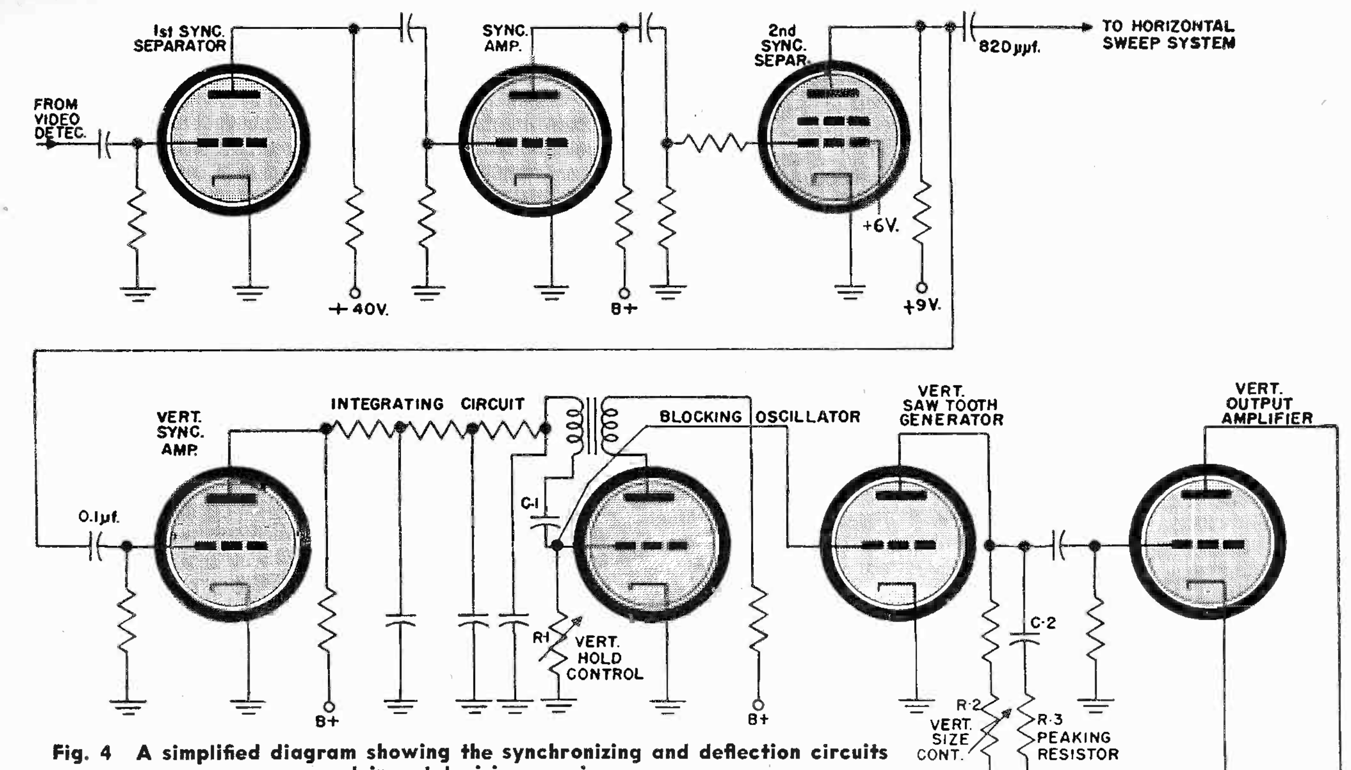


Fig. 1 A block diagram of the vertical sweep system used in a television receiver.



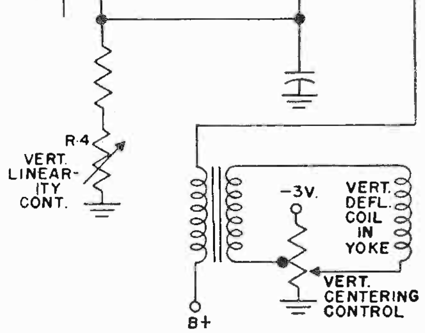


Fig. 4 A simplified diagram showing the synchronizing and deflection circuits used in a television receiver.

to the clipping action. Usually another stage of sync amplification is used; and sometimes even a second sync separator is introduced that clips noise pulses that might exist on the sync signal. Such a sync separation circuit is used in the RCA TRK 120 and is shown in Fig. 4.

With the sync pulses removed from the composite signal, it is then necessary to separate the 60 cycle vertical sync pulses from the 15,750 cycle horizontal sync pulses. This separation is accomplished by applying the combined sync signal to the filter network shown in Fig. 5. This network is known as an integrating circuit. It consists of a series resistance and capacitance, with the output taken across the capacitance. In some receivers, two and even three such networks are cascaded for better integrating action. The time constant of the RC circuit is approximately equal to the duration of the horizontal pulses, hence little charge is stored by the capacitance due to a horizontal pulse. The longer duration serrated pulses of the vertical sync signal, on the other hand, rapidly build up larger charges on the capacitors. The result is the integrated vertical signal shown in Fig. 6.

The polarity of the vertical pulses required at the output of the integrating circuit depends upon the type of synchronizing oscillator used, the two most common in television scanning circuits being the blocking oscillator and the multivibrator. For the former, a positive pulse is required, while the latter can be synchronized by either a positive or negative pulse, depending upon where it is introduced.

The synchronizing of the vertical oscillator by the integrated pulse will be illustrated for the blocking oscillator shown in Fig. 4. It consists of a tube whose grid is transformer coupled to the plate. 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 con-

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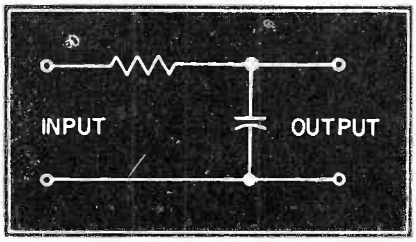

Fig. 5 A resistance capacitance network used to integrate the vertical serrated sync pulse.

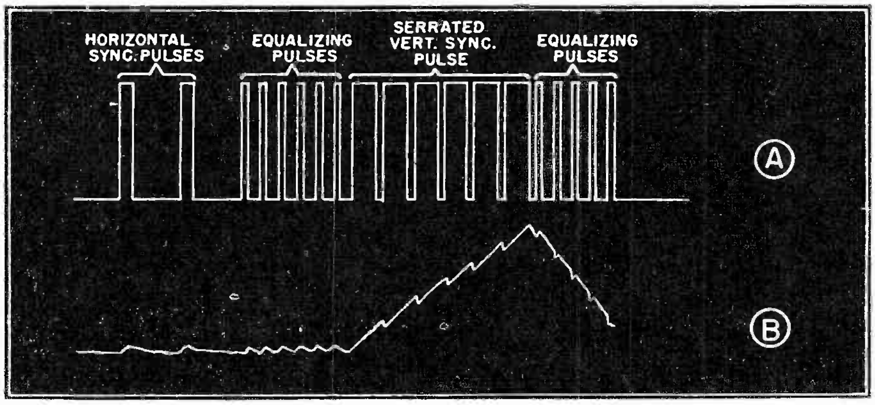

Fig. 6 A, a composite sync signal showing the horizontal sync pulses, the equalizing pulses and the vertical serrated sync pulses. B, the separated vertical sync pulse after it passes through the integrating circuit.

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denser 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 and 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. 7.

If now a synchronizing pulse is applied to the grid at a time T which raises the grid voltage to a point where plate current will flow, the oscillator will "trigger" at T rather than at its natural frequency. In this manner, the synchronizing pulses keep the blocking oscillator in step with the scanning motion occurring at the transmitter. The grid resistance R-1 controls the free running frequency of the oscillator. It is commonly called the *vertical hold control* and is usually variable so that it can be adjusted by the serviceman for best synchronization.

The synchronizing blocking oscillator is coupled to the vertical discharge tube which generates a saw-tooth voltage across condenser C-2. The amplitude of this saw-tooth voltage depends upon the RC constant of this circuit. R-2 is variable and is the amplitude control which is usually labeled the *vertical size control.*

For electrostatic deflection, it is only necessary to amplify the saw-tooth voltage and apply it to the plates of the cathode-ray tube. Electromagnetic deflection, however, requires that a saw-tooth current instead of voltage be passed through the deflection coil. To produce the saw-tooth current, a voltage as shown in Fig. 8D must be impressed across the coil. This type of waveform is generated by inserting a resistor in series with the charging condenser (R-3 of Fig. 4). This resistor is sometimes referred to as a *peaking resistor.*

The generated waveform D is fed to the vertical output amplifier which is transformer coupled to the yoke in order to match the high plate impedance to the low impedence presented by the yoke. Since the saw-tooth voltage output to the amplifier may not be perfectly linear, or distortion may arise in the transformer and yoke coupling, the cathode resistor of the amplifier is made variable. This permits adjusting the bias of the tube so that some non-linearity can be compensated for by operating the tube on a different part of its characteristic. R-4 is therefore referred to as the *vertical linearity control.*

This functional description of the vertical sweep system will enable us to understand the troubleshooting problems that generally arise in these circuits.

Common Troubles

No Vertical Sweep. If some portion of the vertical sweep system fails, vertical scanning ceases and a very bright horizontal line will appear on the cathode-ray tube. If the receiver is left on too long after the failure occurs, the line may be burned into the tube screen because

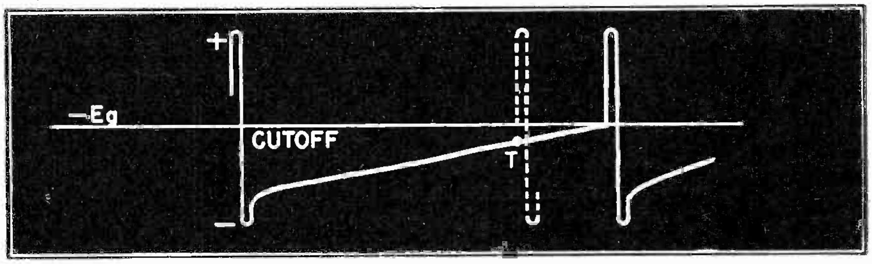


Fig. 7 The waveform of the signal on the grid of the blocking oscillator tube.

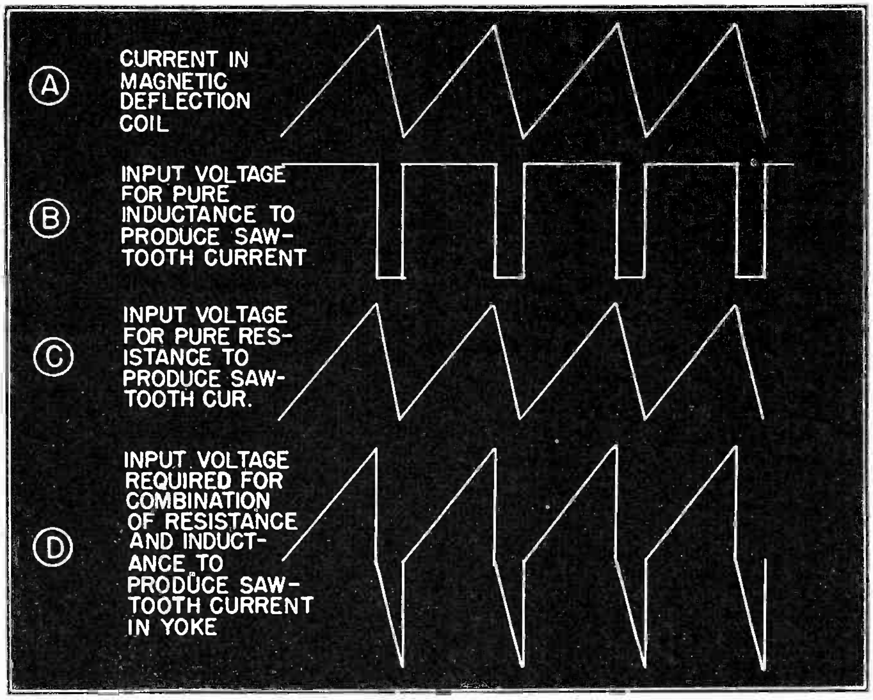


Fig. 8 The waveforms necessary to obtain magnetic deflection: A, the waveform of the current in the magnetic deflection coil; B, the input voltage necessary to produce a saw-tooth current in a pure inductance; C, the input voltage necessary to produce a saw-tooth current in a pure resistance; D, the input voltage required to produce a saw-tooth current in a combination resistance and inductance such as found in the yoke.

of the concentration of the electron beam on a small area of the tube. When attempting to locate the fault, the set can be left on; but turn the brightness control down so that the beam is barely visible.

An oscillograph is the instrument that will most rapidly facilitate the isolation of the troule. First, set the oscillograph for 60 cycle sweep so that the waveforms of the vertical sweep system can be observed. Starting at the grid of the oscillator, check the characteristic pulse at that point, as, for example, the grid waveform of a blocking tube oscillator shown in Fig. 7. If this stage is oscillating, proceed to the plate of the discharge tube where a saw-tooth voltage should be observed. Continue tracing the signal path to the grid of the amplifier tube where the saw-tooth voltage is injected. If the signal is coming through to the grid, the next point to observe the saw-tooth voltage is the high side of the yoke secondary. Do not place the oscillograph across the high side of the coupling transformer primary for an induced voltage as high as 1000 volts may be generated in some circuits which would break down the input components of the oscillograph.

By signal tracing the vertical scanning system and knowing which waveforms to look for, any open circuit can readily be detected.

Loss of Vertical Synchronization. This condition is shown in Fig. 9 where the pattern rolls and the blanking bars are observed. Usually readjustment of the vertical hold control will lock the oscillator in again if it has drifted out of synchronization. In some cases, a component may have failed in the integration circuit or in the separation circuits so that no sync pulse is present, permitting the oscillator to run free. To check quickly for a good synchronizing pulse, pull out the oscillator tube and place the oscillograph across the grid pin of the oscillator tube socket. If no sync pulse appears at this point, go back to the input of the integrator circuit where the composite clipped sync should be present. Continue the signal tracing, if need be, to the input of the sync clipping circuits and finally to the output of the second detector. If the sync level appears compressed at the second detector, or a poor video signal is obtained at this point, then the fault lies in the video IF or RF circuits and should be tracked down as outlined in Parts I and II.

Vertical Size Too Large or Small. Adjust the vertical size control until the correct size is obtained. See Fig. 10 for an example of an incorrectly set size control.

Poor Vertical Linearity. Adjust the vertical linearity control for the best linearity. This adjustment may affect the size so that the size control should be simultaneously readjusted.

Fold-over at the Top of the Picture. If the peaking resistor is off value, fold-over as shown in Fig. 11 will take place. First check the waveform at the grid of the output amplifier to see if a peaking pulse such as that shown in Fig. 8D is present. Now substitute a variable resistor for the peaking resistor and adjust it until a peaking pulse strong enough to eliminate fold-over is obtained. The value of resistance can then be measured on an ohmmeter and a fixed resistor equal in value soldered in its place.

Picture off Center. See Fig. 12 for an illustration of this fault. Adjust the vertical centering control to bring the picture into correct position. The vertical positioning is usually accomplished by injecting a variable DC voltage in series with the yoke. A typical positioning circuit is shown in Fig. 4.

These are the common faults to look for when troubleshooting the vertical sweep system. Several other troubles may arise which the serviceman has little control over; yet it is well to be aware of them. For example, momentary loss of synchronization may be due to line voltage surges or ignition interference from a passing automobile. Severe RF interference may also cause unstable synchronization; and unless it can be trapped out of the RF stages, there is little use in looking for the fault in the sweep circuits. Usually, however, most troubles in the vertical scanning system can be located and corrected by signal tracing and adjustment of the variable controls.

In the next article, we shall discuss the horizontal sweep system which is analogous in many ways to the vertical circuits. ✓ ✓ ✓

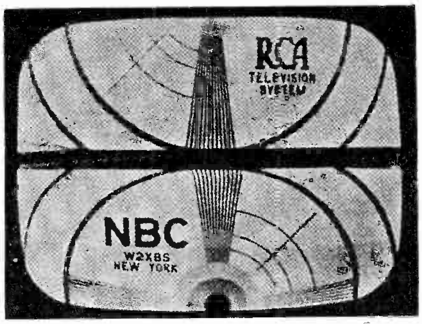


Fig. 9 A test pattern showing the loss of vertical synchronization.

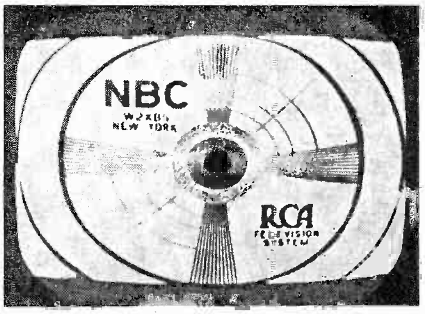


Fig. 10 A test pattern illustrating the effect of an incorrectly set vertical size control.

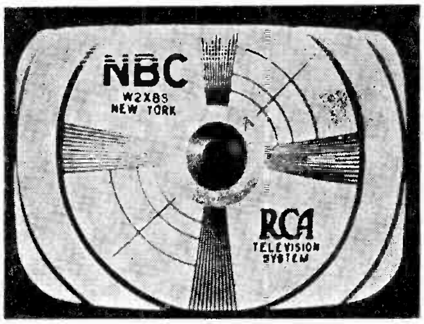
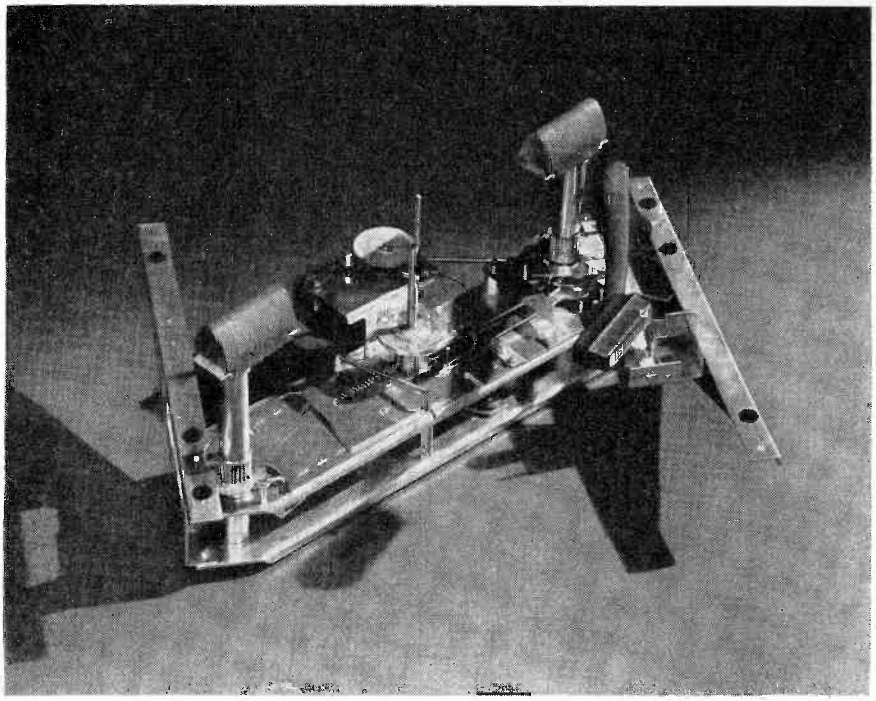


Fig. 11 A test pattern showing fold-over resulting from improper peaking of the vertical saw-tooth voltage.

Fig. 12 A test pattern illustrating the effect of an incorrectly set vertical centering control.



by Norman L. Chalfin

Servicing Automatic Record Changers

IN THE PAST FEW YEARS, a number of sound recording and reproducing devices which utilize magnetic tape, magnetic wire, and various embossed groove plastic tapes have been developed. While these devices have already found their place, there is little likelihood that they will displace disc reproducing equipment in the near future.

With the new improved types of automatic record changers now on the market, and public interest constantly increasing, all indications are that the disc recording business will be bigger than ever. The serviceman is going to encounter many more record changer phonographs and receivers equipped with record changers than he has in the past. An understanding of the operation of changers and the ability to repair them will be vital. Complete understanding of record changer mechanisms can only come after careful examination of the various types. This article is designed to assist in that understanding and to point out some of the more common faults.

Record changers may be grouped into two broad categories: The single side sequence changers, and those which turn each record over and play the second side.

The single-side sequence changer is by far the most common. There are two types of single-side changer: The drop type, in which each new record drops from the bottom of a stack onto a turntable (See Fig. 1), is played and remains there while the next record drops on top of it; and the obsolete ejector changer, in which the record is pushed off the turntable into a hopper after being played.

A record changer can be broken down into four groups of parts, each group doing a specific part of the job. The first group is the electrical system comprising the motor and the power source. The second group consists of a combination of cams, gears, and mechanical linkages which derive their power from the turntable motion and provide the sequence of change cycle. The third group is the record stacking or supply mechanism, and the fourth is the tone arm.

The majority of record changers employ synchronous AC motors. These motors have very few parts which wear or burn out. A few units have been made which employ universal type motors. In this type there are brushes, commutators, and in some instances gear trains and governor assemblies.

The drop type, single-side sequence changer, as stated previously, is the most common type of record changer in use today. Reference will be made to other than drop type equipment when the principles involved are the same.

The following sequence of operation is basic for all drop type record changers:

The sequence begins at the moment the starting lever or button is pushed. (1) The tone arm is lifted from the rest position and moved out of the way to permit (2) the record to fall into place on the turntable. (3) The tone arm is lowered onto the record. A slight start is given to get the stylus into the first groove (most records have a run-in groove). (4) After playing the record, the tone arm trips the cycling mechanism which, in turn, lifts it off the record and moves it out of the path of the next record. (5) The operations described in (1), (2), (3), and (4) are repeated through all the records in the stack until the end of the last record is reached. (6) When the end of the last record is reached, either one of two actions takes place, depending upon the type of changer. In some changers, the tone arm is lifted to its rest post and the motor shuts off; in others, the motor does not shut off for the last record in the stack and, thus, the record is played over and over until the mechanism is turned off.

Even though all drop type changers are alike in their sequence of operation, the mechanical means used to accomplish these operations vary tremendously. In order to understand any particular type of changer, a great deal of time can be saved if its operation is observed through several cycles. In doing so, pick out a single operation and concentrate on it until it is understood. Unlike the electrical and electronic equipment which the serviceman usually works with, a record changer is a mechanical device and its operation can be observed with the eye. This makes the job of understanding a changer very simple.

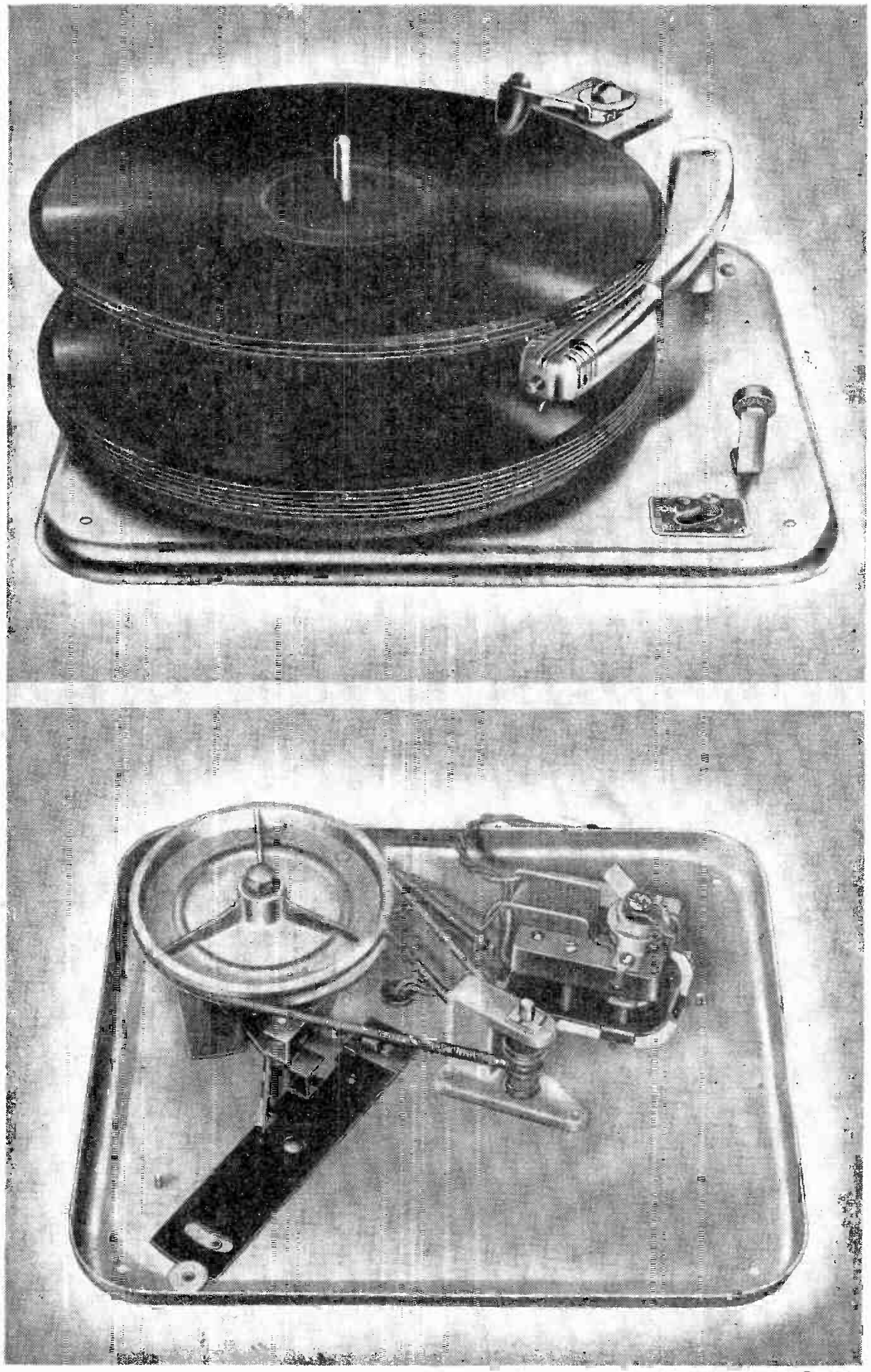


Fig. 1 A toggle post drop type record changer. This type of record changer is rapidly gaining in popularity.

The fact that a number of operations take place at the same time does make the record changer seem complex at first glance; but by breaking the operation down into a sequence, as we have done here, the problem is simplified.

Keep in mind the fact that most of the motions are initiated by a previous action. For example, the tone arm moving across the record trips the mechanism which moves the arm out of the way and drops the next record on the table.

Some actions take place simultaneously as in the above where the tone arm is being moved out of the way and the next record is being dropped.

There are two common types of drop record feed: The slicer type which has been in use for quite a few years, and the new toggle post type which is gaining rapidly in popularity.

In the slicer type, the unplayed stack of records rests on two or three slicer blades which are mounted on posts as shown in Fig. 2. In these changers, the turntable

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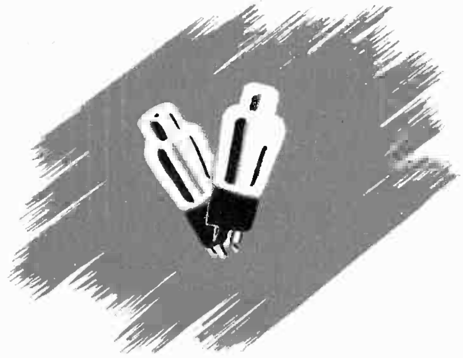
Since the advent of the superheterodyne, a large number of circuits have been devised for the purpose of converting the incoming signal to the intermediate frequency. The author discusses these circuits and some of their peculiarities.



OSCILLATORS *and* CONVERTERS

by MONROE M. LANGE

SINCE THE ADVENT of the superheterodyne receiver, innumerable tubes and circuits have been designed to produce the desired intermediate frequency. All have had their advantages and disadvantages, but progress is constantly being made toward the "ideal" circuit. While it is common knowledge to the radioman that the local oscillator "beats" with the incoming signal frequency, thus creating the intermediate frequency, a more thorough understanding of the critical circuits involved will undoubtedly reduce the time spent analyzing and repairing sets having defects in these circuits.

Before discussing the various oscillators and converters (or mixers) found in the modern receiver, it will be advantageous to review certain fundamentals. Fig. 1 is a partial block diagram of a superheterodyne. Frequently a stage of RF amplification (preselector) is added before the first detector to give increased selectivity and sensitivity. The first detector is either a converter, if the local oscillator and first detector are combined into one tube, or a mixer if a separate oscillator tube is utilized. The term "first detector" may be confusing as detection in the sense of separating the audio component from the RF does not occur. However, the tube is biased almost at cut-off in order to have rectification take place. This is necessary if a difference frequency is to be produced. Incidentally, just as in an ordinary plate detector, the tube also acts as an amplifier.

Fig. 2 is a simplified diagram of how the resultant IF wave is obtained. Two facts should be borne in mind in regard to this heterodyning action. One, that the greater the difference between the amplitude of the two voltages, the more nearly will the IF approach a sine wave. Secondly, that the amplitude of the resultant will be proportional to the smaller (in this case the signal). The illustration shows the normal condition where the oscillator voltage is greater than the incoming signal voltage. If the oscillator and signal voltages are equal, distortion of the IF results. When the oscillator voltage is less than the incoming signal, a loss results. In the case of a modulated signal, that modulation is transferred to the difference frequency envelope also.

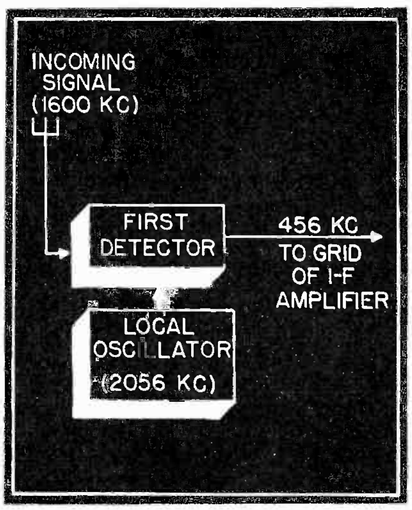


Fig. 1 A partial block diagram of a superheterodyne receiver showing the first detector and local oscillator.

Appearing in the plate circuit then, are the applied frequencies, their sum and their difference. By placing a parallel resonant circuit, which has a low impedance to all frequencies *except* the difference frequency, in series with the plate, maximum voltage at this latter frequency will be developed and fed to the IF amplifier grid.

That, in brief, is the overall picture of what takes place in the initial stages of a superheterodyne receiver. However, let us contemplate the specific methods used and the problems which may arise in this part of the receiver.

Oscillators

Considering the oscillator first, what major requisites should it have? Stability, naturally, is of prime consideration. In fact, the more expensive receivers employ special automatic frequency control circuits (see October 1946 RADIO MAINTENANCE) to make sure that the frequency is correct. Two, the oscillator must be able to cover the band to be received, and also to "track" with the mixer and preselector with which it is ganged. In other words, although it tunes over a different band of frequencies, there must always be a constant difference between it and the signal frequency. As previously mentioned, the amplitude of oscillations has to be greater than the signal voltage to insure the governing of the IF by the signal. A higher conversion transconductance (the ratio of the IF output current to the signal input voltage) is achieved by the same means. This oscillator voltage usually varies from 5 to 15 volts peak RF, depending on the circuit. The limiting factor is the amount of control grid bias on the first detector. A consideration of how to measure this oscillator voltage and its effects on the operation of a receiver will be dealt with in the latter part of the article under servicing problems.

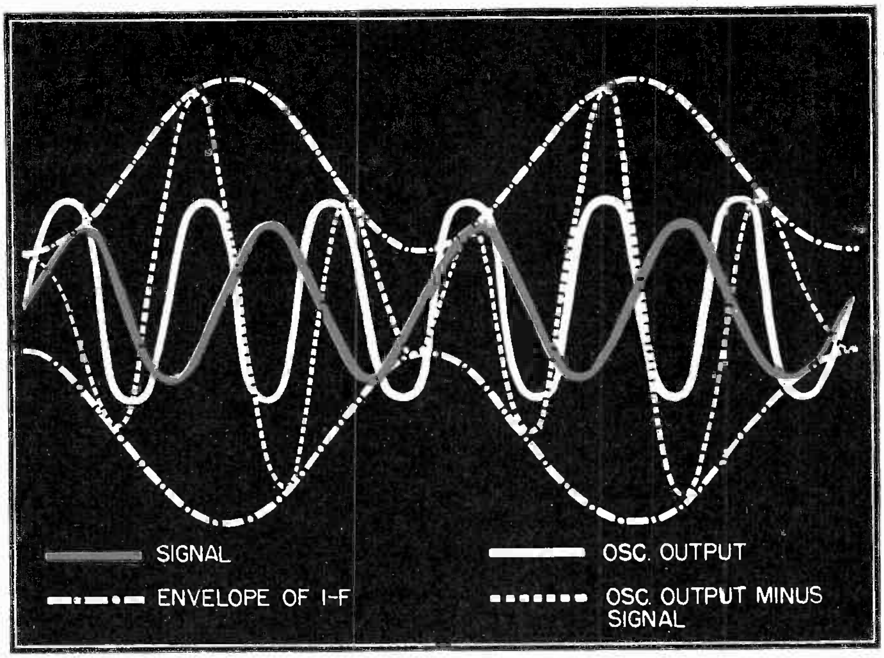


Fig. 2 Pattern showing the incoming signal, the oscillator output and the signal at the input to the IF.

The four most common types of basic oscillator circuits in use to satisfy the above conditions are the modified Hartley, the tickler feedback (the tuned grid or tuned plate), the Meissner and the Colpitts (Fig. 3A, 3B, 3C, 3D). The latter is especially adaptable where permeability tuning is employed. In the Hartley, feedback is accomplished inductively through a common tank circuit for the plate and grid. The tickler oscillator is similar except that two separate coils are used and are placed near one another for coupling. The Meissner circuit uses a floating tank to couple mutually the two coils, and the Colpitts employs capacitive feedback. Instead of going into any detail regarding these circuits, let us make a general observation of how a power oscillator works.

An oscillator is actually an AC generator. In order to accomplish this, the tube must first of all be an

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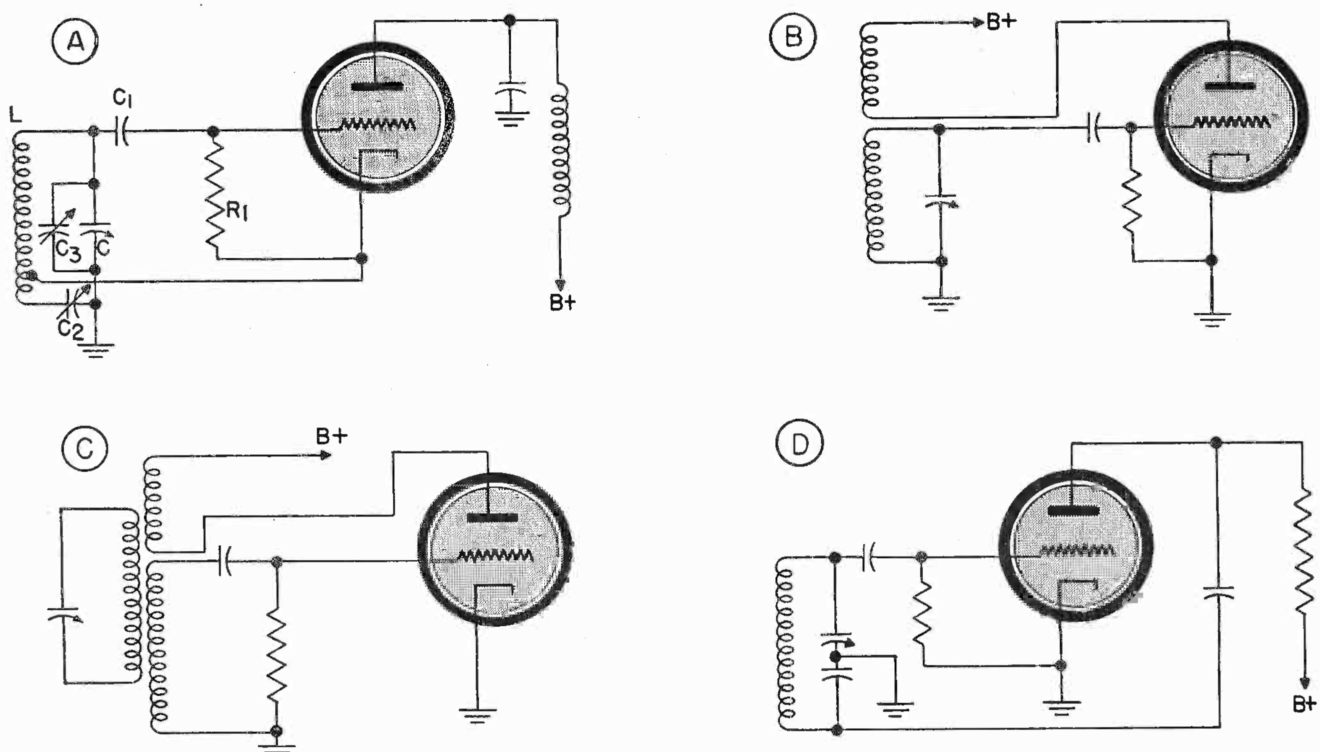

Fig. 3 Four types of oscillator circuits: A, a modified Hartley; B, a tickler feedback type; C, a Meissner; D, a Colpitts.

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amplifier. This is necessary because a portion of the output must be fed back to the grid circuit to make up for the losses there. The feedback must be regenerative, that is, positive in order to sustain oscillations. This is equivalent to giving a swinging pendulum a "kick" at the proper time to keep it going.

Optimum coupling between plate and grid must be supplied to insure a constant amount of feedback voltage, at both high and low frequencies. The determination of the amount of coupling needed is the design engineer's job and is governed largely by the number of turns on the grid and plate coils and their proximity. It will be of help to the serviceman to recognize the effects of insufficient or excessive coupling. The former will cause the oscillations to stop at the low end, and the latter will cause the well known "birdies" to appear.

A compensating device is needed to keep the amplitude of oscillations constant. For this last reason, as well as to make the oscillator self-starting, automatic grid-leak biasing is used (R_1 and C_1 of Fig. 3A). The "fly-wheel" action of the tank circuit, which is the charge and discharge of C through L of Fig. 3A, generates the AC and determines the frequency

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

When the tube is oscillating, the grid is driven positive for a small part of the cycle. Consequently, some electrons are attracted to it, charging up the grid condenser C_1. This condenser subsequently discharges through the grid leak resistor, R_1, to ground, furnishing the required class C negative bias.

Up to this point, no mention has been made as to the choice of frequency range of the oscillator aside from the fact that it differs from the signal frequency by the amount of the intermediate frequency. Assuming a signal of 800 kc and an IF of 456 kc, the oscillator may operate at 800 plus 456, which is 1256 kc, or 800 minus 456, which is 344 kc, and still provide a difference frequency of 456 kc. Why then, in broadcast receivers, is the higher frequency used? The answer lies in the comparative tuning range needed in each case. Using the low frequency side and assuming an intermediate frequency of 456 kc, with a receiving range of 550 kc—1600 kc, the oscillator must tune from 94—1144 kc. The ratio of oscillator frequency change in this case is 1600:550 or approximately 3:1. The great difference between these two ratios of change results in a tracking problem physically difficult to overcome. By using the high frequency side, the oscillator frequency must be varied from 2056 kc to 1006 kc, which is equal to a ratio of 2:1. This ratio is much closer to the antenna ratio of 3:1 and, therefore, presents a much simpler tracking problem. For this reason, the oscillator is universally operated on the high side of the intermediate frequency.

The oscillator tuning condenser is ganged to the antenna and mixer to provide single dial control. Some means must therefore be taken to provide for the different LC products necessary, in each case, to cover the respective frequency bands. This may be done in two ways: By making the oscillator tuning condenser physically smaller, or by placing a comparatively large variable condenser called a "padder" in series with the main tuning condenser to accomplish the same results (C_2 in Fig. 3A). At the high frequency end, a small trimmer (C_3 of Fig. 3A) is utilized.

Intermediate Frequency

No discussion of a superheterodyne oscillator would be complete without mentioning the factors governing the choice of the intermediate frequency. These factors are selectivity, gain, image rejection, and the heterodyning of stations. Good selectivity and maximum gain are obtained by using a low IF. On the other hand, the higher the IF, the better the image rejection. Therefore, a compromise is made with most modern receivers using 455, 456 or 465 kc.

An image is the result of two signals, differing by twice the IF, combining with the oscillator to produce the same difference frequency. For example, signal 800 kc, oscillator 975, IF 175 kc; also signal 1150 kc, oscillator 975 kc, IF 175 kc. If both signals are present at the antenna, both will be heard in the output unless the antenna circuit is very selective which is not common.

Assuming an IF of 465 kc, the oscillator will be operating at 1265 kc and the image at 1730 kc. Not only will this be beyond the broadcast band but the percentage of difference between the desired and image signal will be greater.

The other consideration is why not choose some IF like 450 or 460 kc? Once again the engineer did not merely pull a number out of a hat. Since broadcast stations are separated by 10 kc, it is possible to receive two signals at let us say 1000 kc and 550 kc which will heterodyne to product an IF of 450 kc. This phenomenon is actually familiar to anyone who has ever aligned a set with a signal generator that was off frequency. After the alignment is completed, no matter where the receiver dial is set, a confusion of two stations is always heard. When this occurs, setting the IFs off a few kilocycles is usually a solution.

Thus far, oscillation of the proper frequencies and amplitude have been created. This oscillator voltage must then be injected into the first detector. Depending on the type of first detector, various methods of injection may be used. Fig. 4A, 4B, 4C, 4D and 4E illustrate some convention systems used.

The disadvantages of control grid and cathode injection are twofold: The danger of driving the control grid positive, producing grid current thus lowering the selectivity and sensitivity of the circuit; and the possibility that a strong signal will "interlock" with the oscillator causing a loss of useful heterodyning action. If a mixer stage does show a loss of gain, it is advisable to insert a low range milliammeter in series with the signal to check for grid current. If a current reading is obtained, it is an indication of inadequate bias on the first detector, ex-

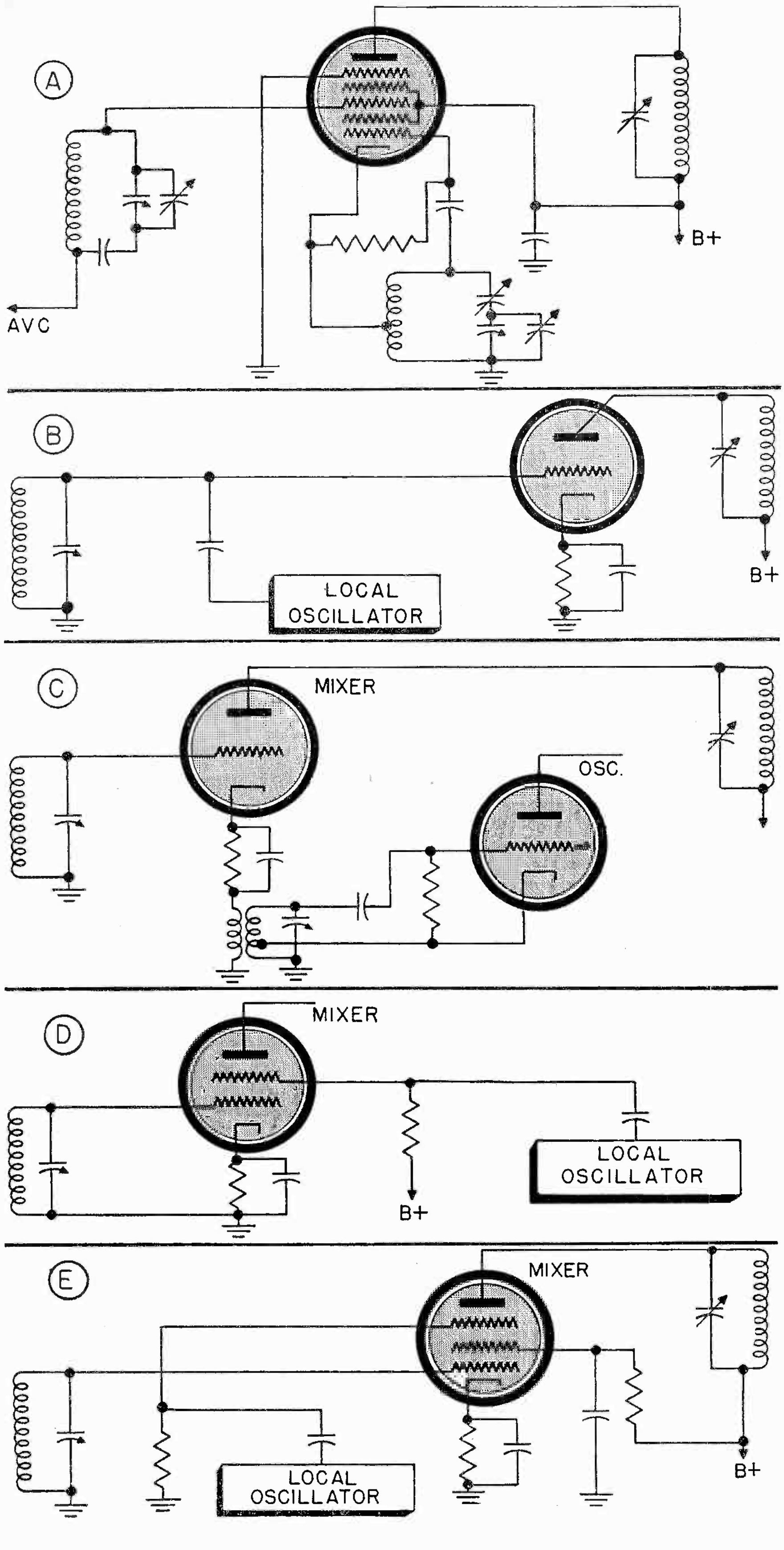

Fig. 4 Five types of converter circuit: A, the pentagrid converter using electron coupling; B, control grid injection, capacitive coupling; C, cathode injection, inductive coupling; D, screen grid injection, capacitive coupling; E, suppressor grid injection, capacitive coupling.

cessive oscillator plate voltage, too large a value of grid leak resistance or coupling condenser, or both.

When screen or suppressor injection is employed, the signal and oscillator voltages are mixed in the electron stream. The principal objection here is that the oscillator voltage must be higher since the amplification of the screen and suppressor is lower. The overall performance of the plate tank suffers also because of the lowered Q.

Pentagrid Converters

The above difficulties led to the development of the now familiar pentagrid or five grid tubes. The 6L7 mixer is typical. It is pictorially represented in Fig. 5A and schematically in Fig. 5B. Grid number one, the top cap, is closest to the cathode and is the signal grid of the remote cut-off variety for use with automatic volume control. Grid number two and number four, the screen grids, are connected internally, electrostatically shielding grid number one from grid number three (the oscillator input grid) and effectively reducing the capacitance between them. Grid number 5 is the suppressor. Two factors, then, control the electrons leaving the cathode: The signal and the oscillator. The electron stream is therefore modulated by both frequencies causing the difference frequency to appear in the plate current. As there is very little coupling between the oscillator and the signal, the 6L7 gives satisfactory results when used for short-wave reception.

For economy in both cost and space, the pentagrid converter has been devised. Typifying these are the popular 6SA7 and the 6A8. Not only has economy been achieved but excellent operating characteristics as well. Nevertheless, the converter has proved to be the root of many superheterodyne troubles. Very often after having localized the difficulty to the converter, it is necessary to experiment with two, three or even more tubes, before getting the circuit to work properly. This, even though all check good on a checker. Indeed, this substitution may prove to be just a temporary relief. Hence, it will be well worthwhile to analyze the theory of operation of these two converters.

Referring to Fig. 6, grid one and

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OSCILLATORS AND CONVERTERS

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grid two of the 6A8 are the triode oscillator grid and anode respectively. Grids three and five are internally connected, forming a shield around the variable mu signal grid, number four. The oscillator grid may be considered as a gate controlling the current pulses to the rest of the tube as it goes alternately positive and negative. Due to the high positive charge on grid three and the negative potential on grid four, a cloud of electrons forms in front of grid four, called *the virtual cathode*. The signal voltage will then determine the number of electrons the plate draws from the virtual cathode. This explains how it is possible to have plate current, even though grid one may be 30 volts negative. Here again the plate current is modulated by both the oscillator and signal, and the IF appears in the output.

While the operation of this type converter is very satisfactory, slight variations of the oscillator frequency can occur due to the repulsion of the electrons in the virtual cathode, back to the actual cathode. Automatic volume control bias applied to the signal grid often causes this, resulting in a distorted output. How this is overcome in the newer 6SA7 tubes, together with their other advantages, will be seen shortly.

The 6SA7 (see Fig. 7) has all the electrodes brought down to the base, allowing shorter, rigidly constructed connecting leads. This is important in preventing spurious oscillations from occurring. A simple, three-connection, tapped oscillator coil is generally employed with the lower resistance between cathode and ground.

Grid number one is the oscillator

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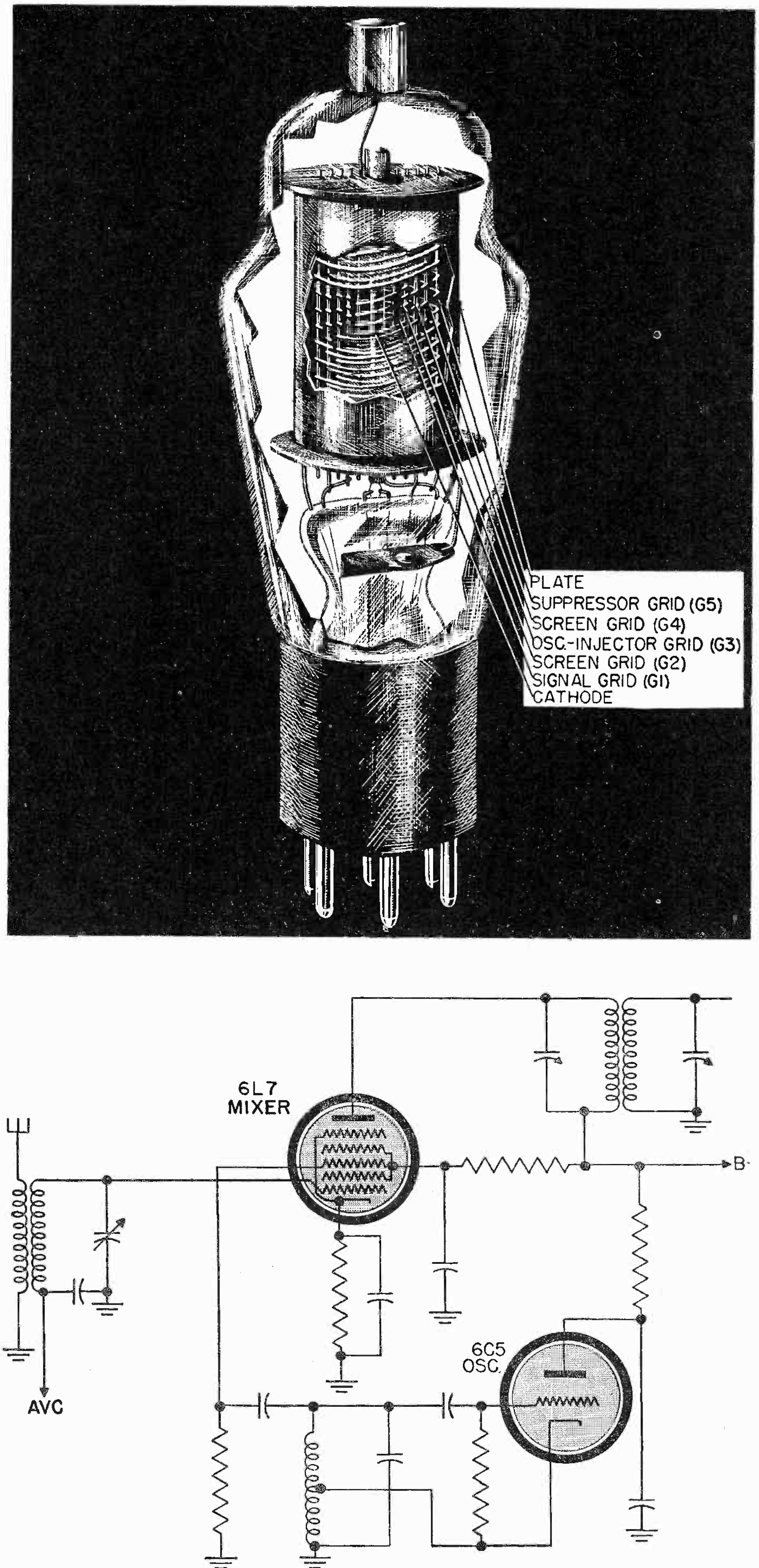

Fig. 5 A, the internal construction of a pentagrid vacuum tube. B, a schematic diagram showing a 6L7 pentagrid mixer.

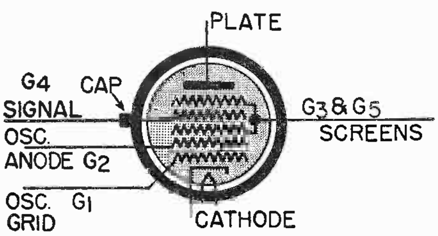

Fig. 6 6A8 pentagrid converter.

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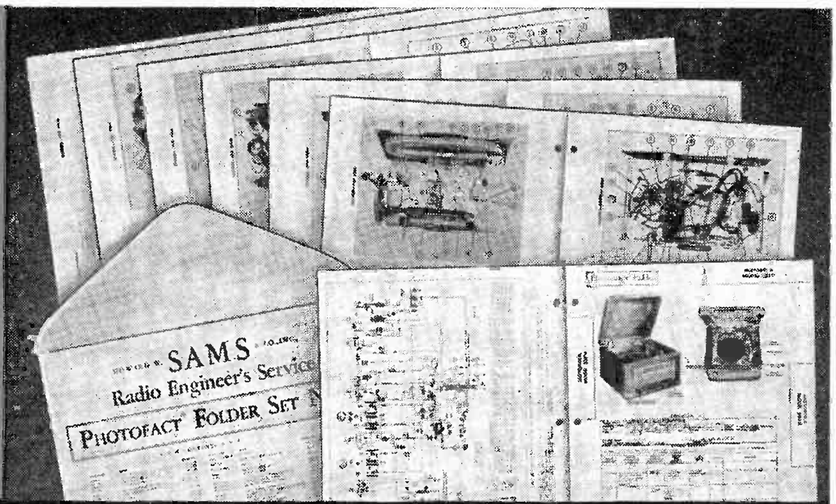

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OSCILLATORS AND CONVERTERS

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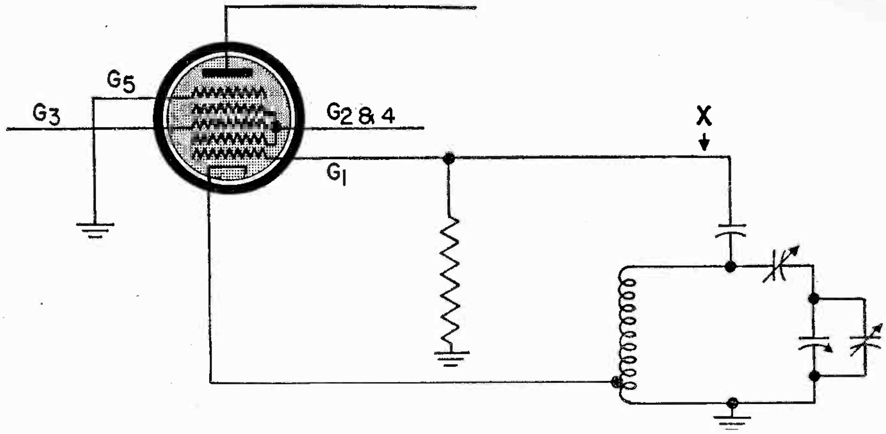

Fig. 7 6SA7 pentagrid converter.

grid; grids two and four are the screens and act as the oscillator anode. The signal is introduced to grid three, and grid five is the suppressor. It is connected to the outer shell; and when grounded, automatically furnished a shield if a metal 6SA7 is used. Occasionally when a glass tube is used to replace a metal one, undesired oscillations are produced. A pair of collector plates are connected to grid two; and due to their strategic position and positive charge, intercept any electrons which might be repelled back to the cathode by the signal grid. Just as in the 6A8, the electron stream is varied at both oscillator and signal frequencies.

The other two general classifications of converters with which the radio repairman will come in contact are the *two-in-one* type, like the 6J8 and the 6K8. The former, called a triode-heptode, is merely a 6L7 with a built-in triode section which takes the place of the 6C5 oscillator (see Fig. 5B). The 6K8, triode-hexode (see Fig 8) looks rather complicated at first glance; but if broken down it will be seen that a single cathode is used for the triode and hexode. The oscillator grid completely surrounds the cathode, serving the dual function of an oscillator grid and first grid of the mixer. The oscillator plate is on one side of it and the remainder of the tube on the other. The side of the oscillator grid facing the plate of the triode is the oscillator control grid, and the other side modulates the electron stream going to the plate of the hexode, similar to the action of grid number one of the 6A8. The remainder of the hexode section functions as a 6A8, except that the oscillator anode is removed from the path of the electrons travelling to the mixer plate. As the oscillator and mixer sections are so well isolated, the 6K8 may be used at higher frequencies without danger of interaction between the oscillator and signal. This separation also eliminates trouble from the AVC system.

Now, with the theory of oscillators and converters behind us, let us see how we will deal with some of their common servicing problems.

What are the symptons of oscillator-converter (mixer) troubles? Reception on just part of the band, reception of one station only, loss of either short-wave or standard broadcast signals on combination sets, images, annoying oscillations, hum, hiss, motorboating, distortion, poor sensitivity, and naturally a completely dead receiver, may all be due to these circuits. Of course, the presence of some of the above indications might perhaps be caused by some other stage. Consequently, as in all troubleshooting, the prime objective is first to localize the difficulty. The usual methods, such as the injection of a signal from a test oscillator, the use of a signal tracer, the "shock" method, voltage and resistance readings, etc., may be used to accomplish this, depending on the nature of the difficulty.

As the oscillator is the more critical of the two circuits being discussed, it more frequently is the reason for abnormal reception. One of the things necessary, then, is to be able to determine whether it is oscillating or not. Recalling the theory of the oscillator, as discussed above, it will be remembered that the oscillator grid goes positive for part of the cycle, drawing grid current which furnishes the bias. What, then, is the bias condition when the tube is not oscillating? Obviously, it is zero. Therefore, a simple means of testing for oscillations is merely to measure the voltage drop across the grid leak resistor (negative in respect to ground). This measure should be taken with a vacuum tube voltmeter, if possible, to avoid loading down

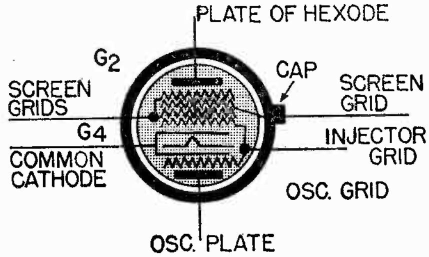

Fig. 8 6K8 Triode-hexode.

the circuit. The reading should be between 5 and 30 volts, depending on the circuit. The ganged tuning condenser should be rotated slowly while making the measurement to observe whether it remains fairly constant over the entire frequency range. A reading of a fraction of a volt is merely due to the contact potential (electrons haphazardly striking the grid and leaking off through the grid leak, causing an IR drop). Subnormal or zero voltage may be caused by a poor tube, an open circuit, shorted coil, shorted or too small a grid leak resistor, a shorted tuning condenser or an open coupling condenser. Another less apparent cause of erratic readings is the rearrangement of parts from their original position while making a repair. Great care should be taken to avoid this as the oscillator energy may then be absorbed by a nearby circuit. The cause of reception of one station only, of reception on just part of the band, or no reception at all, may be detected in the above manner.

An abnormally high reading can be due to a high resistance solder joint developed by corrosion, too large a value of grid leak resistor, excessively high plate voltage, or overcoupling. These may be the

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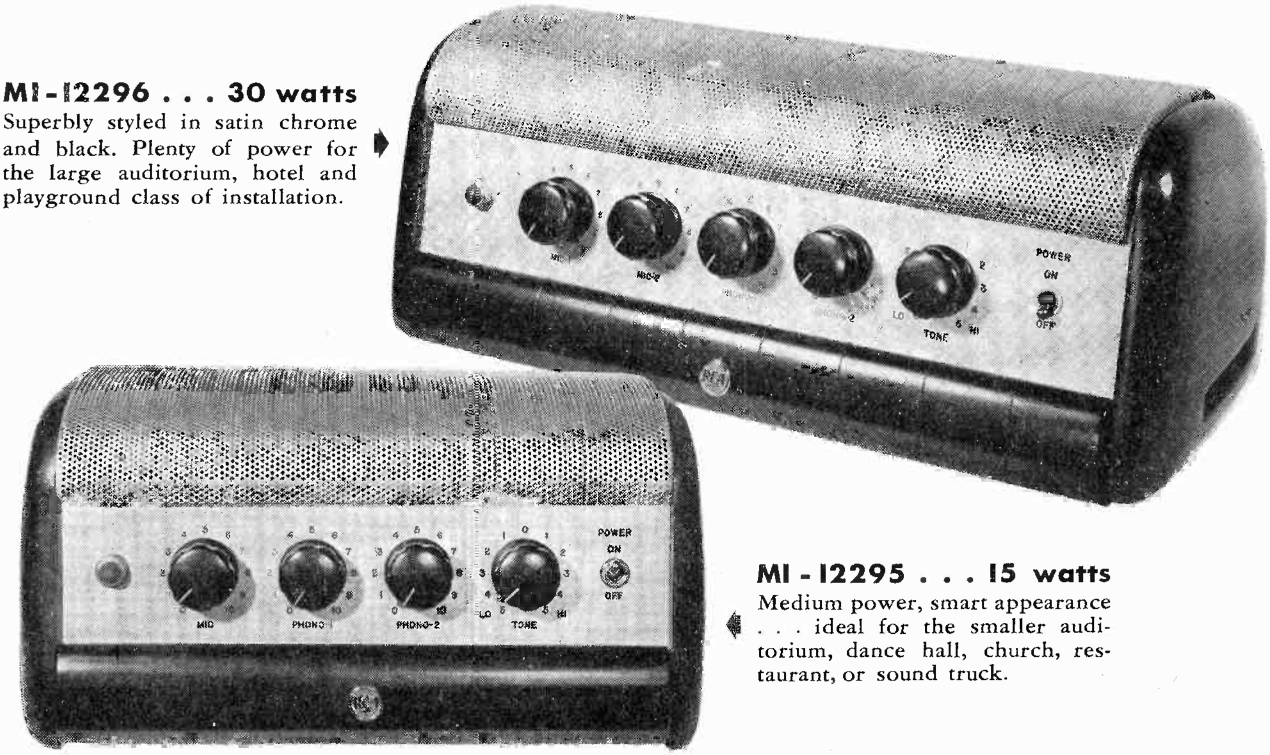

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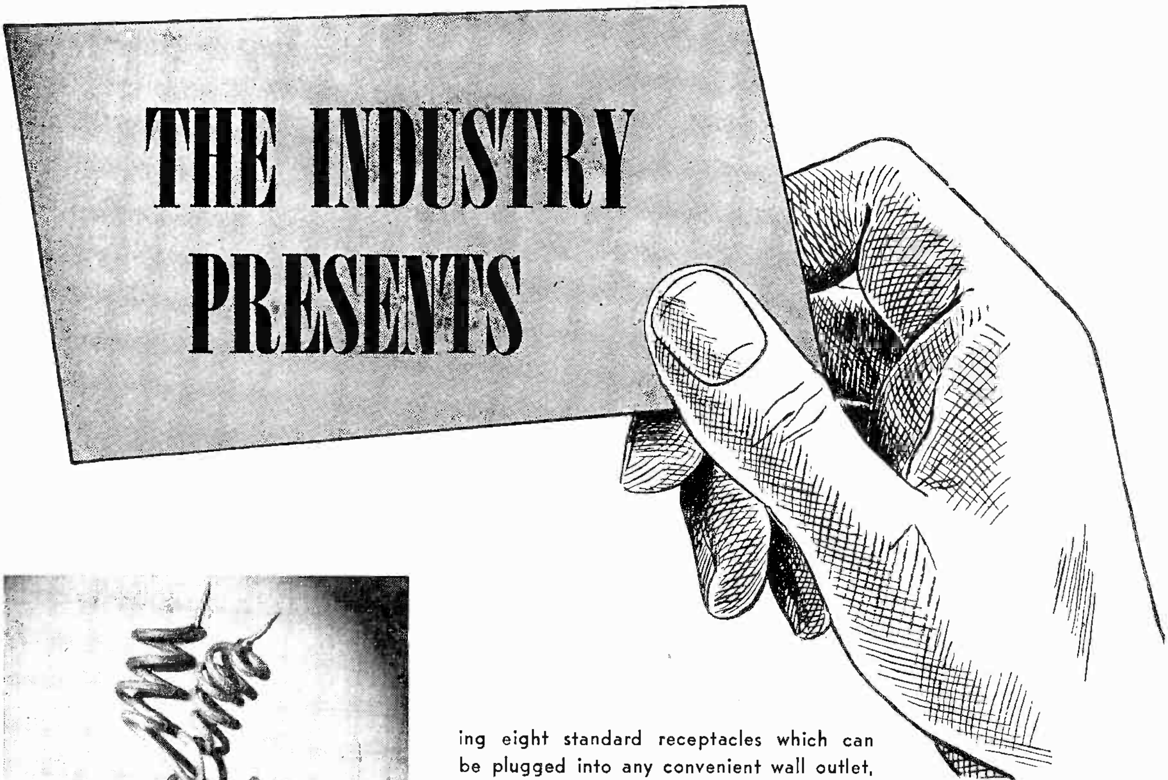
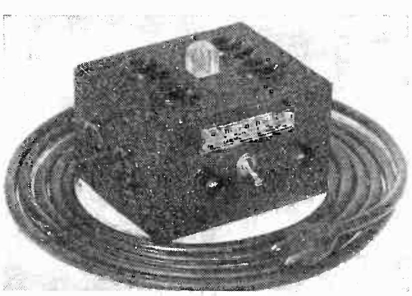


CAPACITOR MOUNTING DEVICE

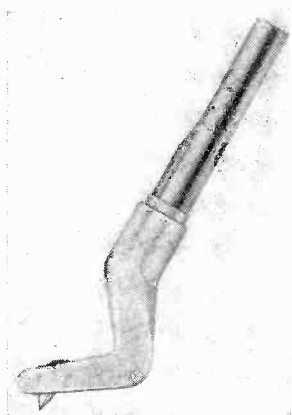
A new easy-mounting stud-disc and plate mounting device is now being used on all Solar Type DH dry electrolytic capacitors. The new design permits secure clamping of the capacitor to set chassis in a vertical position when Type DH units are used to replace old screw-base or twist-prong electrolytics. No additional chassis holes are required. For flat under-chassis mounting, the stud-disc is easily removable by bending two tabs; capacitors may then be fastened by a universal mounting strap packaged with each capacitor.



MULTI-PLUG OUTLET BOX

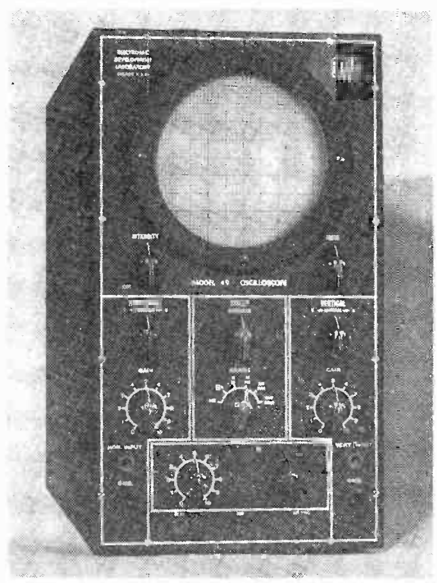
Allied Laboratory's new multi-plug outlet box, Model 3001-A, is a small unit containing eight standard receptacles which can be plugged into any convenient wall outlet, AC or DC, 110-125 Volts. The boxes can be pyramided, that is, one can be plugged into another. Two fuses protect the main line against shorts and overloads.

A neon pilot light tells AC from DC, and signals "voltage on all plugs"; long stroke toggle switch breaks both legs of the line. The Multi-Plug comes complete with 15 amp. fuses, 12 ft. of heavy duty rubber appliance cord, and unbreakable flat plug. It has convenient fuse-extractor posts for easy replacement and rubber mounting feet. Cabinet dimensions are 3" x 4" x 5", net weight—1 lb. 9 oz.



NYLON PHONOGRAPH NEEDLE

A phonograph needle with a nylon plastic knee is being introduced by Webster-Chicago Corporation. The internal resistance or self-damping characteristic of nylon greatly suppresses all mechanical resonances such as needle scratch and surface noises, and improves tracking at low needle pressure. The nylon knee, between aluminum shaft and sapphire jewel tip, absorbs and reduces needle and surface noises, prolongs the life of the tip, protects records, and produces a high fidelity of record reproduction.



CATHODE-RAY OSCILLOSCOPE

Electronic Development Laboratory of Chicago has announced two new cathode-ray oscilloscopes, the Model 41 equipped with a 3" tube and the Model 49 equipped with a 5" tube. Both models have a deflection sensitivity of 0.5 volt RMS per inch and a frequency response essentially flat from 10 cycles to 300 kilocycles. The new instruments are mounted in welded steel, black wrinkle-finish cabinets. These instruments are designed for use by the serviceman. For further information, write to Electronic De-

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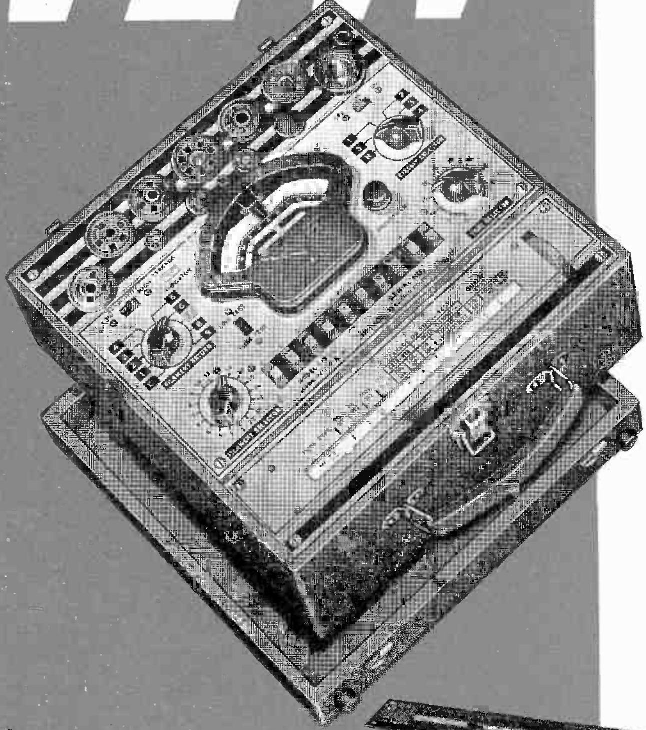
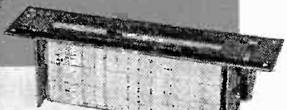
NEW . . . Simpson Model 305RC Tube-Tester with "No Backlash"* Roll Chart





***6 Exclusive Features Make This the Finest Roll Chart Ever Designed for Tube-Testers . . . . .**

- "No Backlash" feature of this Roll Chart automatically takes up all slack in the paper chart and, by keeping it in constant tension, makes it impossible to turn the selector wheel without turning chart. Gives precision selection at all times. Also prevents chart from tearing or getting cut of alignment.
- Gearing is such that only 6 turns of selector wheel will run the entire length of the 12½ ft. chart.
- Easy to read. The clear Lucite window is just wide enough to show 2 tube settings, or both settings on a multi-purpose tube.
- Entire unit removable by taking out four screws. Just lift from receptacle to make new entries or install new chart.
- Chart ingeniously fastened to rollers, affording easy replacement and constant alignment.
- Rigid, light-weight construction. Gear driving mechanism incorporates heavy-duty precision brass gears and parts.

With the addition of the new Simpson "No Backlash"* Roll Chart to the 1947 version of our Model 305, this famous instrument becomes beyond question the finest tube-tester on the market in its price range. Read the description of this new Roll Chart in the panel below.

Model 305RC provides for filament voltages from .5 volts to and including 120 volts. It tests loctalc, single ended tubes, bantams, midgets, miniatures, ballast tubes, gaseous rectifiers, acorn tubes, Christmas tree bulbs, and all popular radio receiver tubes.

Like other Simpson tube-testers, the Model 305RC incorporates 3-way switching which makes it possible to test any tube regardless of its base connections or the internal connections of its elements. This method, the result of exhaustive research and expensive construction, protects the Model 305RC against obsolesence to a degree not enjoyed by competitive testers. No adapters or special sockets are required. In addition to having a complete set of sockets for every tube now on the market, this tester has a spare socket, to provide for future tube developments.

The Model 305RC has provision for testing pilot lamps of various voltages as well as Christmas tree bulbs. It tests gaseous rectifiers of the OZ4 type—also tests ballast tubes direct in socket for burnouts and opens. Has neon bulb of proper sensitivity for checking shorts. This tube-tester is fused, and has the latest improved circuit. It provides for line adjustment from 100 to 130 volts, with smooth vernier control.

Model 305RC is distinguished for its beautiful exterior. It has a two-tone metal panel in red and black on a satin-finished background. Sockets and controls are symmetrically arranged for quick operation. The large, modern, fan-shaped instrument has an exceptionally long scale. It has "good" and "bad" English markings, also a percentage scale for matching and comparing tubes. Cases, both portable† and counter style, are made of strongly built hardwood, durably and beautifully finished.

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SERVICING AUTOMATIC RECORD CHANGERS

→ From Page 15

spindle is long enough to project through the unplayed records, thus guiding them as they fall onto the turntable. The most common trouble developed by these changers is due to the non-uniform thickness of records which often causes bending of the slicer blades.

The toggle post type of changer, as shown in Fig. 1 and Fig. 3, consists of a long spindle into which is incorporated a small toggle. The upper part of the spindle is tilted so that the records set on it are held at an angle. The outside edges of the records rest on a shelf. One of the common troubles of this type of changer is bending of the toggle post.

A number of the more expensive record changers are equipped with a mechanism which shuts off the unit when the last record has been played. In one of the methods used, the weight of the unplayed records holds a switch closed. This switch is in parallel with a motor circuit switch which is opened by the tone arm each time it reaches the rest position. When the last record has dropped on the turntable, the switch held closed by the pressure of the unplayed records opens and, thus, when the tone arm reaches the rest position and the motor switch opens, the mechanism is shut off. If there are unplayed records stacked on the pressure-actuated switch, it will remain closed during the time the tone arm-actuated switch is open, keeping the circuit complete and permitting the motor to continue operation. See Fig. 4.

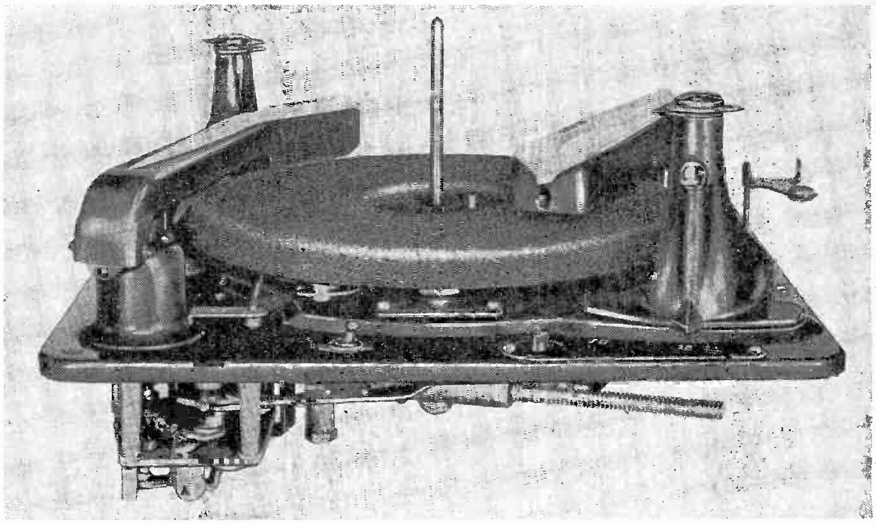


Fig. 2 The slicer type record changer. This changer is equipped with a recording as well as a playing head.

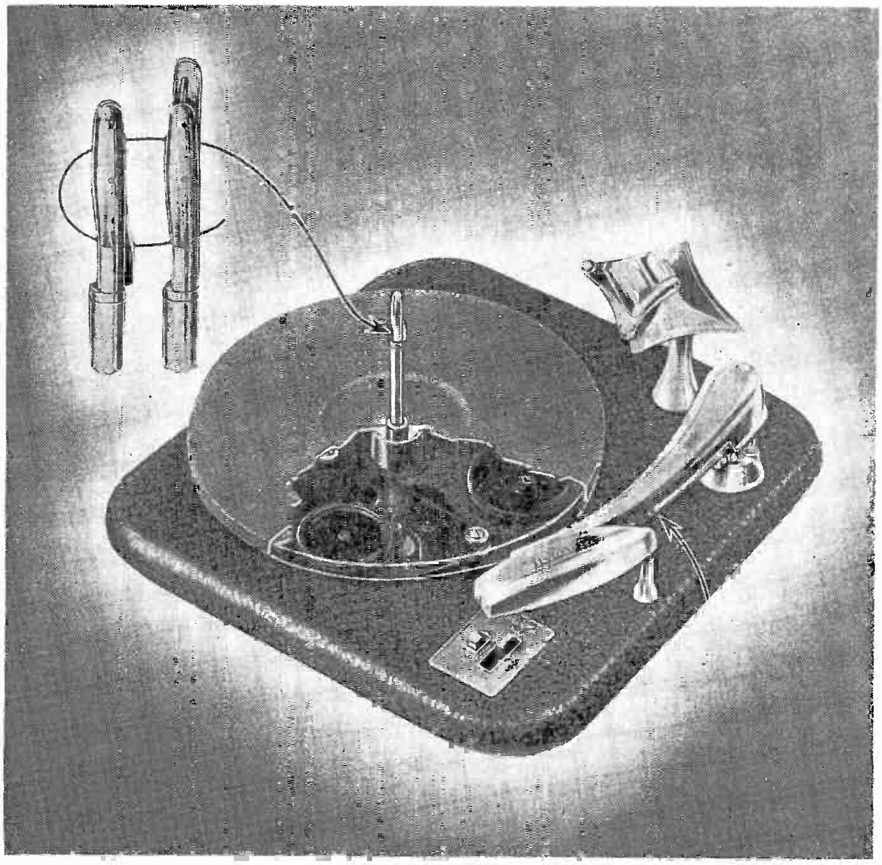


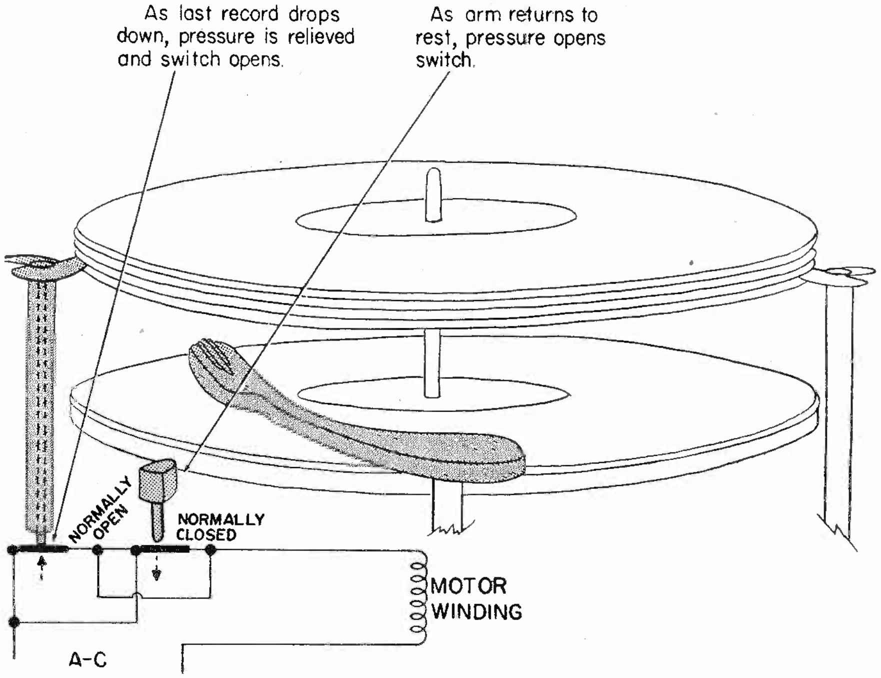
Fig. 3 A toggle post changer with an enlarged view of the spindle. The spindle on the left is in normal position; the spindle on the right is in position to drop a record onto the turntable.

Common Faults

Most record changer faults are difficult to anticipate because they are usually characteristic to a particular type and make of changer. There are, however, a few faults which are common to many different makes. The blades used in the slicer type are often bent out of shape by too thick or too thin records. This trouble manifests itself in the chipping of records or in the complete jamming of the mechanism.

In the toggle post type of record changer, the spindle is often bent by rough usage. This causes the toggle to become inoperative and thus records will not drop onto the turntable properly.

Reproducing cartridge troubles are common to all types of record changers. American made changers use piezo-electric crystal cartridges almost exclusively. These units are subject to fracture when dropped or violently knocked about, and to disintegration when exposed to excessive heat or moisture. In either case, the symptom



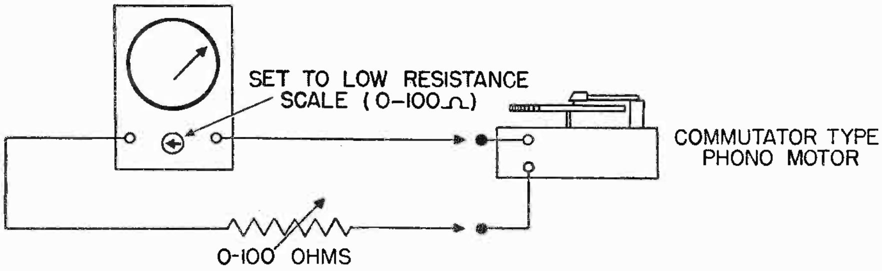


Fig. 5 A resistor and ohmmeter connected across the commutator as shown above is used to check brush contact as described in the text.

is extreme distortion. If distortion is present in a unit, the cartridge itself should be checked with a pair of headphones connected across the pickup leads.

The stylus in the permanent stylus type of cartridge is often chipped. A chipped stylus will cause severe damage to records and should be rectified before it is used again. Broken styli in this type of cartridge can only be replaced by returning the units to the manufacturer.

In record changers which use motors having commutators, motor trouble due to malfunctioning of the brushes is quite common. Worn brushes permit the brush holder parts to come in contact with the commutator and cut into it. In some cases, foreign substances such as metal particles, sand, or dirt, get between the brushes and the commutator and cause marking.

These difficulties can be avoided by periodic inspection, cleaning, and replacement of the brushes when they have become worn. Replacing brushes is a simple operation, but must be done carefully in order that the brushes make proper contact with the commutator. The surface of the brush must have the proper contour so that its entire surface rests against the commutator segments. Poor contact results in sparking which will mark the commutator and eventually make the motor inoperative.

A simple test for good brush-to-commutator contact can be made by disconnecting the motor from the power line and connecting an ohmmeter and a suitable resistance in series across the brushes as shown in Fig. 4. The resistance should be such that it gives a mid-scale indication on a low resistance range. The armature should be spun by hand; and

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OSCILLATORS AND CONVERTERS

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cause of a receiver blocking or howling.

If the oscillator is suspected, definate proof may be obtained in the following manner. Referring to Fig. 7, the oscillator circuit should be broken at point X. A signal generator with a DC blocking condenser may then be connected from grid to ground. The receiver is set to some local station and the signal generator tuned to that frequency plus the IF, using an *unmodulated* output. The signal generator is thus being used as the local oscillator; and as the receiver and signal generator are varied over the entire band (always keeping the signal generator at a frequency higher than the receiver) all stations should be tuned in normally. If such is the case, the oscillator is without a doubt at fault.

If the complaint is poor sensitivity and distortion, it is advisable to check for mixer signal grid current as previously described. This grid current, remember, is due to the fact that the oscillator signal voltage is exceeding the first detector grid bias.

Many times, a customer will bring in a set saying that it sounds more like a motor boat than a radio. Too large a time constant (R times C) of the grid leak and coupling condenser will cause the oscillator to block, that is, to remain cut off for too long a period. This starting and stopping of oscillations may appear as a motorboating sound in the speaker. The trouble may also be due to a poorly regulated power supply which causes the oscillator anode voltage to shift. Circuits are often used which make this voltage somewhat independent of the rest of the receiver. A separate tap on the power supply is utilized. In this case, an extra R-C hum filter is usually added for this voltage. Incidentally, it is the failure of one of the components of this filter which gives rise to tunable hum.

Depending on the type of converter used, difficulty may be experienced when automatic volume control is used. If it is necessary to

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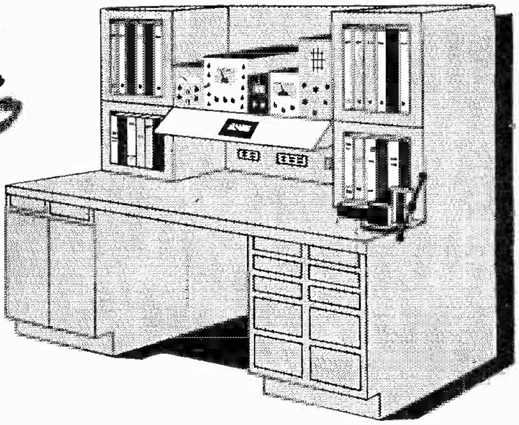

The Radio Service Bench

Repairing Aged TRF Receivers

By Max Alth

THE SERVICING of an aged TRF presents a threefold problem; not only must the defective unit be repaired or replaced, but the entire set usually needs an overhaul. Often circuit changes must be made to improve its performance.

Starting at the front end, you will run into some dated circuits: Antennas connected directly to the grid of the first RF tube, as shown in Fig. 1, with a resistor, or an untuned RF coil shunted to ground, dual volume controls, one half of which act as a shunt across the antenna circuit. It will be recalled that these sets were designed for operation in the day when broadcasting stations were far apart and few between. The problem then was not to obtain good selectivity but to get as much of the weak signal into the set as possible.

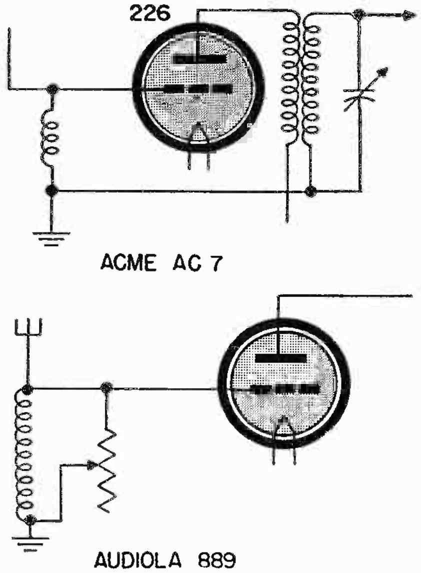

Fig. 1 In the older TRF's, the antenna is usually connected directly to the grid of the first RF amplifier as shown in the simplified schematics above.

These circuits should be changed. All controls in RF circuits should be removed, and control of volume effected by a simple "pot" arrangement in the grid of the first audio stage. If feedback and hum are encountered, use shielded leads and ground the case and shaft of the volume control. The reason for this change is to secure quieter control action and to eliminate detuning when the volume control is used.

A coil, wound so that its base or lowest frequency is higher than the set's highest tuning frequency, should be connected between the grid and ground, or between the grid and cathode circuit of the first RF stage, and the resistors (or what have you) removed. Since this coil is not being tuned by the variable condenser, its peak must be left above that of the other RF coils in order to prevent uneven gain over the tuning range. For example, if the new coil were peaked at 600 kilocycles, the set would have several times more gain at 600, 1200 and 1800 kc than at other points in the band. The RF stage would be in line at these frequencies.

An antenna coupling coil should be wound on the same coil form. Use only a few turns, as shown in Fig. 2, so as to keep it a "link" and not a tuned circuit. Adjust the coupling, bearing in mind that the greater the coupling, the less the selectivity, and vice versa. Slide it up, and down, and vary the number of turns until an optimum point is reached. Then it can be fixed with a few drops of cement. One

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tune back and forth across a station three or four times before it can be received properly, this may be the trouble. The AVC voltage changes the amount of current drawn by the converter which detunes the oscillator. In this case the AVC system must be checked.

In conclusion, it should be stressed that when oscillator voltages are measured, the filament voltage should not be neglected, especially in automobile and portable sets. Too low a filament voltage will either mean non-operation or poor performance. Insufficient operating voltages on the other elements cause a "hiss." In all the above instances, it has been taken for granted that the set is in perfect alignment. Naturally, if this is not the case, proper operation will not be achieved.

From the foregoing discussion and from experience also, the serviceman will readily concede the fact that repairing a set with oscillator-converter defects is a job requiring skill and knowledge of the principles involved. Much time can be saved and improved customer relations maintained by applying the theory of the circuit in question to the practical problem at hand. ✓ ✓ ✓

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if the brushes are making good contact, there will be very little fluctuation of the ohmmeter needle. Erratic brush contact will result in fluctuation of the ohmmeter needle. Erratic brush contact is caused by the brush difficulties already described, and also by loose brushes, high spots and/or a pitted commutator.

A badly pitted commutator can often be repaired by removing it and turning it down on a lathe. Slight pits or high spots can be removed with fine sand- or glasspaper. Never use emery paper on a commutator as it is an electrical conductor and will become embed-

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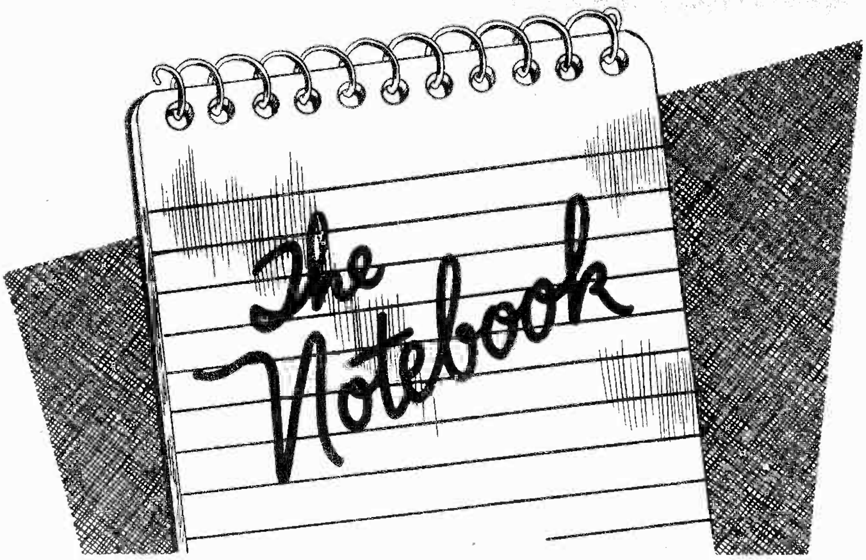
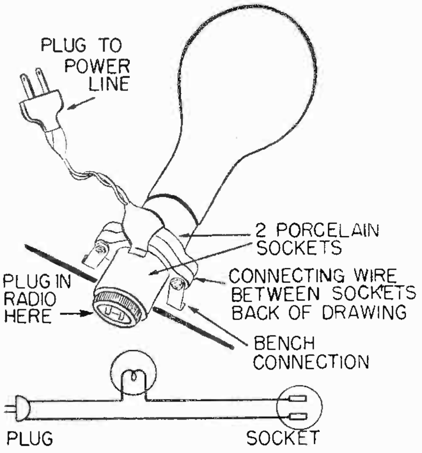


Each month the reader sending in the best suggestion receives a crisp ten dollar bill. For all others published, RADIO MAINTENANCE will pay five dollars. Let's hear from you.

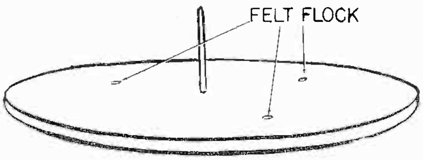


Checking Power Supplies

A SOCKET AND BULB mounted and connected as shown in the accompanying illustration are useful in making a quick and accurate check for power pack troubles. When a set is plugged in, the 100 watt lamp will light and then dim as the tube filaments heat if the set is okay. If the lamp burns brilliantly, there is a short in either the power transformer, the rectifier tube or some other unit in the power supply.

Using this method to check a set eliminates the possibility of further damage due to shorts. A 100 watt lamp should be used.

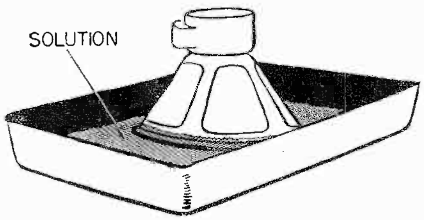
Frank H. Geilfuss
2704 Stratford Rd.
Columbia, S. C.



Warped Records

When a customer is having trouble with warped records which are particularly valuable to him and which do not play properly because of slippage, it is often possible to fix his record player so that he may play them. Three small round spots of felt flock are mounted on the turntable as shown in the illustration. The flock is held on by blue undercoat and should be about 3/8 inch in diameter and as thin as possible.

James C. McGuire
Hollywood Radio Supply Inc.
Los Angeles, Calif.



Removing Speaker Cones

Speaker cones which are cemented to the speaker frame can be easily removed without damage by immersing the speaker rim in sol-

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ded between the commutator segments and cause shorts.

When installing new brushes, they may be given the proper contour by wrapping a piece of fine sandpaper around the commutator, inserting the new brushes, and rotating the armature manually while applying pressure on the back end of the brushes.

These are but a few of the many troubles which will be encountered in the servicing of automatic record changers. When working with a changer, always remember that it is a delicate mechanical device and should not be forced or handled roughly. Proper lubrication is of primary importance. Record changers often freeze and become completely inoperative because they are not lubricated.

While, as previously stated, this article does not cover the complete story of record changers, it is hoped that the information contained herein will be of help to the serviceman in his work on this type of equipment. ✓ ✓ ✓

ANTENNAS-FM AND TELEVISION

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assumed to be 70 megacycles, and is given by the graph in Fig. 9 as 3.34 feet. A standard 150 ohm line may be used, but the conductors should be of fairly large diameter.

Another use of the quarter wave section as an impedance matching device is shown in Fig. 8. This is known as the open end stub. A dipole used with a close spaced reflector has an impedance of about 25 ohms. It is assumed that the transmission line which is matched to the receiver has an impedance of 75 ohms.

If a "Q" section were to be used, its impedance would have to be equal to 44 ohms. This is a rather awkward value to attain, but two 75 ohm sections in parallel giving an impedance of 37½ ohms could be used.

A more practical method, however, would be to use the open quar-

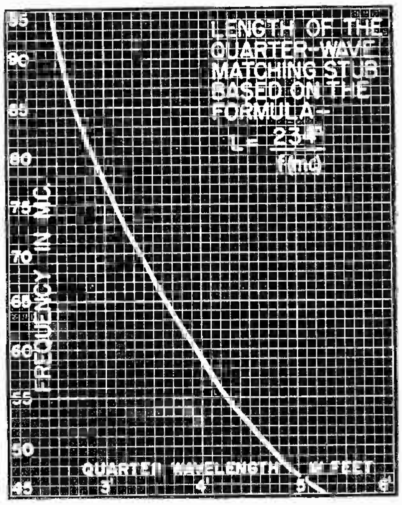

Fig. 9 The length of a quarter wave matching stub for the various FM and television frequencies is shown in the above chart.

ter wave section. While the impedance at the antenna is equal to 25 ohms, the open end of the section has a very high resistive impedance. Thus, between the antenna and the open end, there exists what amounts to a continuously varying impedance transformer with a low impedance at the antenna and a very high impedance at the open end. It is only necessary to select the correct position by means of a simple clamp in order to match any desired impedance. A few experimental positions will soon reveal the proper point by obtaining maximum signal strength at the receiver and the elimination of ghosts due to line reflections.

In conclusion, several important considerations are presented here as a summary:

1. The transmission line should be chosen to match the impedance of the receiver.

2. A mismatch at the antenna of 2 to 1 is permissible, although a better match is advantageous.

3. If the mismatch of impedances between the antenna and the transmission line is more than 2 to 1, use a matching system which is most suitable.

4. If a matching system is used, large diameter conductors are best for band width considerations.

Next month's article will deal with the various types of antennas, and practical hints for correct installation. ✓ ✓ ✓

OVER THE BENCH

by John T. Frye

HOW MUCH EQUIPMENT do you need to service radios?

That is a question that is asked every day—often by the serviceman of himself—and the answer is not so simple as some might think.

In the first place, there is no one right answer. Each individual case requires a separate analysis and a different solution. There are, however, certain broad generalities that apply to all cases and aid materially in their solution; and it is the purpose of this article to discuss these basic considerations.

Personally, I firmly believe that every instrument or tool on the service bench should justify its presence there by bringing in a substantial increase in revenue to the serviceman beyond its initial cost and its upkeep. This applies to everything from the dentist's mirror for examining "hidden" socket connections to the very latest thing in super-duper, crystal-controlled, frequency-modulated signal generators. This by no means excludes the "handy" gadgets. These devices invariably permit us to do our work more easily and in less time; and in the radio service game, time *is* money. What I do mean is that every piece of equipment should work. I do not hold with the theory that a lot of expensive instruments are worth buying simply because "they impress the customer." The only thing that really impresses the customer is how his set performs when he gets it home. Instead of buying equipment to make you *look like* a better serviceman, buy instruments that will *make* you a better serviceman.

Location and the class of patrons you have have much to do with the equipment you need. If your shop is in a sparsely settled section of the country and your customers own straightforward receivers, if the volume of your business is regulated more by geography than anything else, and if that volume is not so great that you cannot take care of it easily, the basic analyzer-tube-tester-signal-generator combination will probably enable you to give as satisfactory service as if you had a modern electronic laboratory at your disposal; moreover, the purchase of a five-inch oscilloscope would add practically nothing to your income.

On the other hand, a serviceman in a metropolitan area, especially one in a wealthy neighborhood, almost *has* to have a 'scope, a vacuum tube voltmeter, a signal tracer, and a signal generator for aligning FM sets. If he has many sound systems to service, a good audio oscillator is another "must." Competition being keen, he needs every possible aid to enable him to turn out the finest possible work in the shortest possible time. He must be equipped to service every type of electronic device up to and including the most modern television set. Inability to do so, even though it is entirely due to his lack of proper equipment, will be charged up to his lack of knowledge. The valuable word-of-mouth advertising that can snowball into more and more business may easily go into reverse and cut into the class of trade he *is* equipped to handle. It is a funny quirk of human nature that we like to have even our simplest problems solved by an expert. The reasoning goes that if you can repair Mr. A's complicated television set, you are the man to fix Mr. B's punch-board midget. Is there a one of you who has not had a customer tell you

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ELECTRONICALLY SPEAKING

ONCE AGAIN PIONEERING the field, Howard W. Sams & Co., Inc., are opening a radio service clinic. The purpose of the clinic is to determine which servicing routines are the fastest and most economical and to develop time charts and suggested consumer charges. All routines and methods will be developed in actual practice as the clinic will do work for a score of retail service shops, dealers and jobbers on a consulting basis.

The Howard W. Sams Institute is at present publishing a group of monographs on subjects of vital interest to every radio serviceman. Among those already completed are: "How Much Is Your Labor Worth?"; "Accounting Procedures for Radio Service Engineers"; "How to Make Radio Cabinet Repairs"; and "How to Increase Your Business." These and other helpful services are available to the subscribers to the PhotoFact Folder Service.

ACCORDING TO Walter L. Lawrence of the RCA Engineering Products Department, the 57 licenses or station construction permits which have been granted by the FCC assure that 32.8 per cent of the nation's population will have television. Licenses and construction permits have been granted for thirty metropolitan districts.

AN ALL-ELECTRONIC single picture tube, color television system has been patented by Color Television, Inc., of San Francisco. According to the company, the system does not use rotating or mechanical discs, and receivers can be manufactured at a cost of approximately $25 to $35 more than the cost of present black and white receivers. The received images are reproduced in a group on a single picture tube and are then projected through filters and combined optically to form the color picture on the screen.

GE's 100TH FM radio broadcast transmitter has been shipped from its electronics plant, becoming the first company to reach the century production mark in this expanding new radio field. At present, General Electric is working to fill more than a hundred additional orders for these FM units. Most of the units have gone to newspapers and broadcasters, though some have been received by colleges and universities.

TELEVISION BROADCAST SERVICE for Latin America is being considered by leaders of the radio broadcasting industry in Mexico, Cuba, Puerto Rico, Brazil, Argentina and Chile, following RCA's first demonstration in Mexico City of modern television.

A NEW DEVELOPMENT whereby pictures and sound can be transmitted from one point to another over a light beam instead of radio waves was demonstrated recently. The new invention has been named "photovision" by its author, Dr. Allen B. Du Mont. It simplifies the problem of transmitting television programs in short range relays, as from a football field to the main transmitter. The system operates in light or darkness and without any interference from static or other interference inherent in radio and will transmit color pictures as well as black and white images.

The coaxial cable transmission systems similar to those now in use are tremendously expensive to in-

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she wants *you* to fix her dial cord because she has been told you are the best radioman in town?

The most of us are between these two extremes. Many of us live in towns beyond the reach of television or FM stations, but we are called upon to service fine radios and combinations, and we do have more work than we can do. In such cases, a vacuum tube voltmeter and a signal tracer make the soundest of investments, for they enable us to do more work and so make more money in a given amount of time. It is possible that we can use our knowledge of our art to do as good a job without these instruments as we can with them; but we do so at the expense of time; and that time, as we must never forget, means money. An example that comes to mind is in the aligning of an AFC circuit. It is possible to open the cathode circuit of the control tube and by inserting a milliammeter to arrive at the proper setting of the discriminator tuning condenser; but it is much easier and faster to use a vacuum tube voltmeter.

There is something to be said for buying instruments before you actually need them in order to increase your knowledge of your field and to prepare yourself to use these instruments when a need for them does arise. However, it must be remembered that radio service instruments grow obsolete very, very quickly because of the rapid progress of radio itself. If you can afford to purchase a piece of equipment you do not actually need in your work but that you would like to "play" with, go ahead and buy it; but consider first whether or not there is some tool or instrument the possession of which would expedite the progress of a set through your shop. If there is, you would do better to buy that instead of the plaything.

There is, though, one piece of equipment, in a manner of speaking, that is absolutely essential in every shop in the land; and that is a reliable, up-to-the-minute source of information as to what is going on in the field of radio servicing.

Do you remember when they used to refer to a good doctor as "well read"? Well, reading is what makes a good serviceman. It makes him familiar with new circuits long before he sees them in his shop; it keeps him abreast with the latest methods and tools for doing his work; it enables him to transfer from his tiny village service bench to a large city service shop without faltering or feeling ill-at-ease. Yes, reading is the one thing that will keep in tiptop condition the most valuable and indispensable service instrument of them all: His intelligent mastery of his craft.

THE NOTEBOOK

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vent as shown in the diagram. About ¾ inch of solvent should be poured into the pan. The speaker is placed face down in the solvent for a few minutes and the cone will come free. The solvent can be stored in a bottle to prevent evaporation when not in use.

Joseph Tusinski
1214 Seaboard Ave.
South Norfolk 6, Va.

Phono Switch

When attaching a phonograph to a set not designed for use with one, it is necessary to provide a switch which will be most convenient and seemingly built in. If the set uses push buttons of the switch type, one of the push button circuits can be disconnected and the phono On-Off switch connected in its place.

Karl Kiser
45 West 76 Street
New York, New York

THE SERVICE BENCH

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end of this coil can be grounded, the other connected to the antenna, or both ends can be brought out and connected to a transmission line. A twisted pair of rubber covered wires will do, as shown in Fig. 2.

Some of the sets use a multi-tuned circuit preceding a series of untuned RF stages. You can be tricky with these sets and replace the ganged tuner with a factory-made iron core push button unit. Or you can use a single or double tunable iron core arrangement. The iron core tuners will deliver more signal with greater selectivity because of their much higher "Q,"

The untuned RF amplifiers are constructed rather peculiarly and some of the servicemen meeting them for the first time will have a little difficulty. They are usually made by taking two wires and winding them together on a single coil form (See Fig. 3). Usually the winding is made in three or four pies, each pie wound in a different direction. When unwinding the coils, both wires must be unwound simultaneously. The coils are prone to inter-wire leakage and, when defective, can easily be rewound. Use *new* double cotton or silk covered wire. Do not splice a break and re-

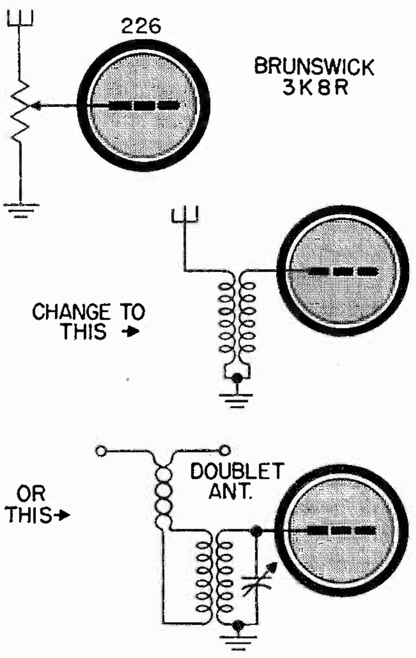

Fig. 2 Either one of the above methods of coupling the antenna is an improvement over the original.

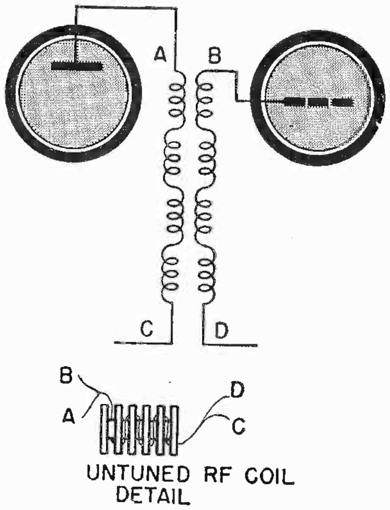

Fig. 3 The construction of an untuned RF coil used in the older receivers.

wind using the old wire. The winding need not be exact as anything within a dozen turns will do.

After the antenna and volume control changes have been made, all the resistors and condensers that form part of a tuned circuit should be carefully checked. If these condensers are of paper, or of open mica and brass construction, they should be replaced. The resistors should conform to specifications. Leakage across a condenser in a tuned circuit broadens the response of that circuit and defeats our purpose.

Next, the RF stages should be aligned. Do this with a buzzer, static, or any type of broad signal generator. With a broad signal, you can adjust the padders without rocking the condenser gang. The signal rocks for you. Check the broadness of tuning of each stage and the set's overall gain. In most cases, it will be necessary to remove the RF coils and bake them. Occasionally you will find a coil with beeswax protecting it. Do not touch this type. Generally the coils are merely shellac-covered and moisture seeps in. Bake them dry and cover them with several coats of coil cement.

Replace the coils and check the alignment over the entire band. Many of the early manufacturers constructed their gang condensers of sheets of aluminum set in white metal. This metal warps and cracks with age. It is very possible that some of the plates have visibly moved. Don't try bending the

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plates back into place unless you absolutely have to; the white metal breaks very easily. Make your corrections by bending and cutting the end plates. Some of the condensers are already slotted for this purpose. Use a tuning rod to determine first whether or not a circuit can be brought into tune, or whether it is shorted or open.

Many of the sets using 26s and 27s are neutralized. A tube with its grid tuned to the same frequency as its plate will go into oscillation if its grid to plate capacity is high enough. The cure is the impression on the grid of an out of phase voltage equal to the inter-electrode voltage. This is accomplished by connecting a small variable condenser from the grid to a point on the plate coil as shown in Fig. 4. The condenser is adjusted until the out of phase voltage equals the inter-electrode capacitance voltage. Use an open filament tube in the stage to be adjusted, or slip a piece of drinking straw over the filament prong, and turn the condenser until the signal heard in the speaker is at minimum. If the silent spot is broad, turn up the volume or use a stronger station.

Now the set should be permanently aligned and the wave traps, if any, adjusted. There are two basic types of wave trap. One is the absorption type in which the tuned circuit is coupled to the antenna coil (as shown in Fig. 5). When the trap is tuned to the unwanted frequency, it absorbs and dissipates some of the signal. The other type consists of a series tuned circuit. In this hook-up, the tuned circuit is in series with the antenna and offers greatest resistance to the passage of current at the frequency it is tuned to. A series wave trap can easily be constructed with a broadcast frequency RF choke and a 50-350 uufd padding condenser (See Fig. 6).

It is sometimes possible to replace low gain tubes with higher gain tubes. For example, a 56 will replace a 27 and give a gain of nine

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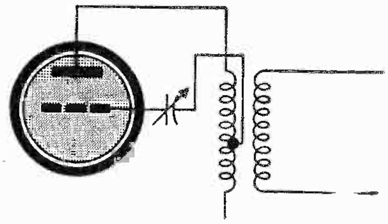

Fig. 4 Method used to neutralize a stage to prevent oscillation and instability.

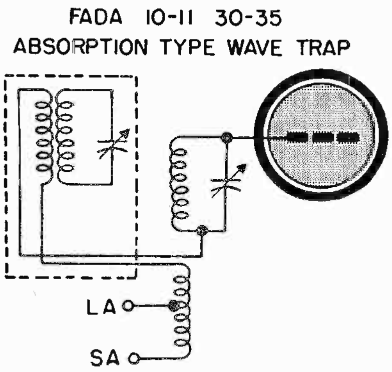

Fig. 5 An absorption type wave trap.

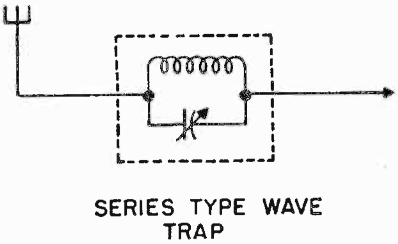

Fig. 6 A series type wave trap which can be constructed from an RF choke and a trimmer condenser.

OCTOBER 1945

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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

SEPTEMBER 1946

Sold Out

OCTOBER 1946

Sold Out

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

FEBRUARY 1947

SELENIUM RECTIFIERS
THE AUDIO OSCILLATOR
PART IV—THE OSCILLOGRAPH . . . HOW TO USE IT
TELEVISION RECEIVERS—THE SOUND CHANNEL

RADIO MAINTENANCE Magazine
460 Bloomfield Ave.
Montclair, N. J.

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→ From Preceding Page

as compared to a gain of three, with no circuit changes. This change and other changes will not always work as the increased gain will sometimes throw the set into oscillation and cause blocking despite neutralization and increased shielding. ✔ ✔

ELECTRONICALLY SPEAKING

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stall and have, therefore, been a major obstacle to television in small communities. The new system will result in a great reduction in the cost of transmission. ✔ ✔ ✔

INDUSTRY PRESENTS

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velopment Laboratory, 2655 West 19 Street, Chicago 8, Ill.

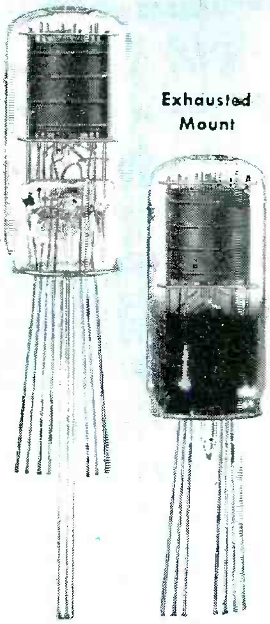
PORTABLE RADIO

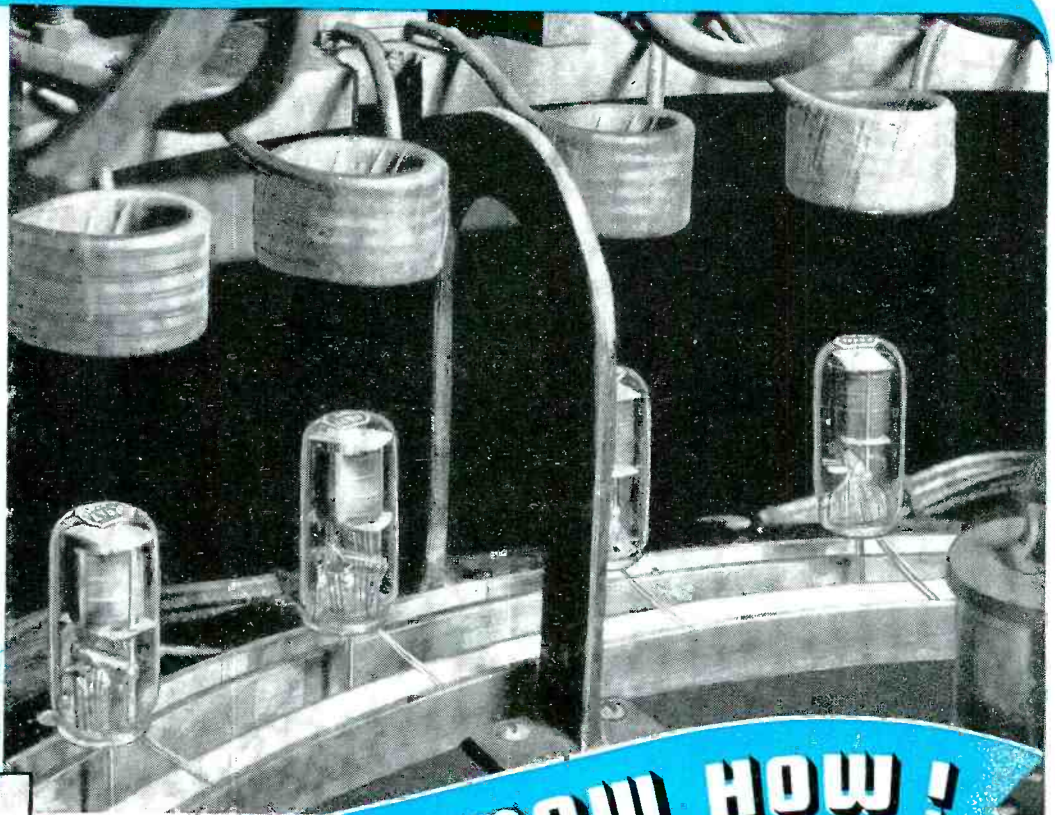
A new portable radio, the Rejuven-Air, is available from Electromatic Manufacturing Corporation, New York City. It comes in a two-color leatherette carrying case, 10½" x 12½" x 4½" and weighs about eleven pounds.

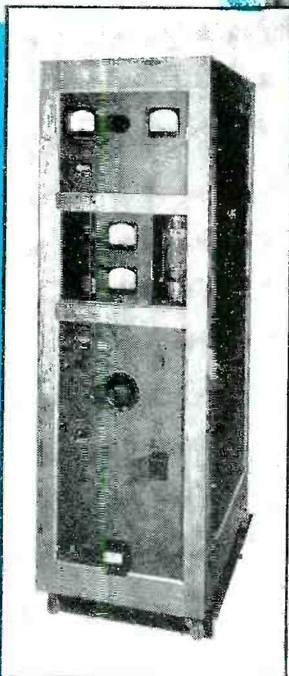
VIS-O-GLOW ARRESTER

A revised model of the Vis-O-Glow lightning arrester for radio is being introduced by the L. S. Brach Mfg. Corp. of Newark, N. J. In this arrester, use is made of a highly sensitive rare gas tube in multiple with heavy conductive plates, forming an auxiliary air gap. The air gap plates do not function except when the current enters the antenna in excess of the capacity of the tube. Inductive discharges are taken care of by the rare gas tube. The casing has a slow-burning inhibiter.

MAKING TUBES IS EASY..







If you know how!

BIG TUBES MAKE LITTLE ONES

That's right. Big power tubes help build little receiving tubes. Secret of the electronic tube is its ability to pass a controlled stream of electrons through a vacuum. During the intricate exhaust process, electronic induction heating assists in creating that vacuum.

The induction heater (small illustration) is a 750-kilocycle, 6-tube, 10-kilowatt power oscillator whose tank coil is coupled to the exhaust coils. Four of these coils poised over Hytron 12SA7GT sealed-in mounts are caught by the camera a split second before the exhaust machine automatically positions them around the mounts.

High frequency current in the coils quickly heats red hot by induction the internal metal parts of the mounts. Gas driven off is sucked through the exhaust tube of each mount by the vacuum pumps. Heater leads riding in the two circular tracks supply filament power to activate each cathode. Also by induction heating, "getters" are flashed to absorb residual gasses. Fingers of gas flame finally melt and seal off the exhaust tubes.

An intricate machine – assisted by electronics itself – performs the ticklish exhaust job easily, speedily. Again know-how supplants the element of human error with the infallibility of the machine. Machine-paced, a sequence of finely-controlled precision operations gives you Hytron tubes of typically uniform quality.

SPECIALISTS IN RADIO RECEIVING TUBES SINCE 1921

HYTRON RADIO TUBES

HYTRON
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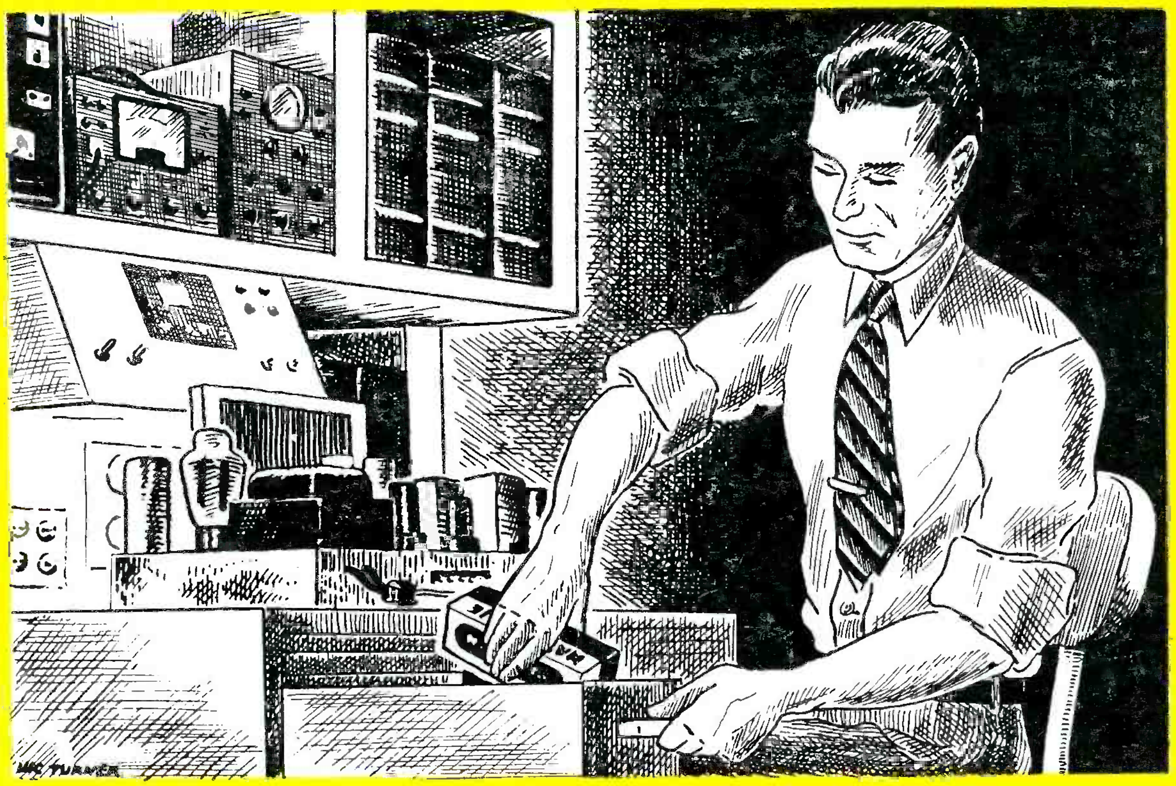
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