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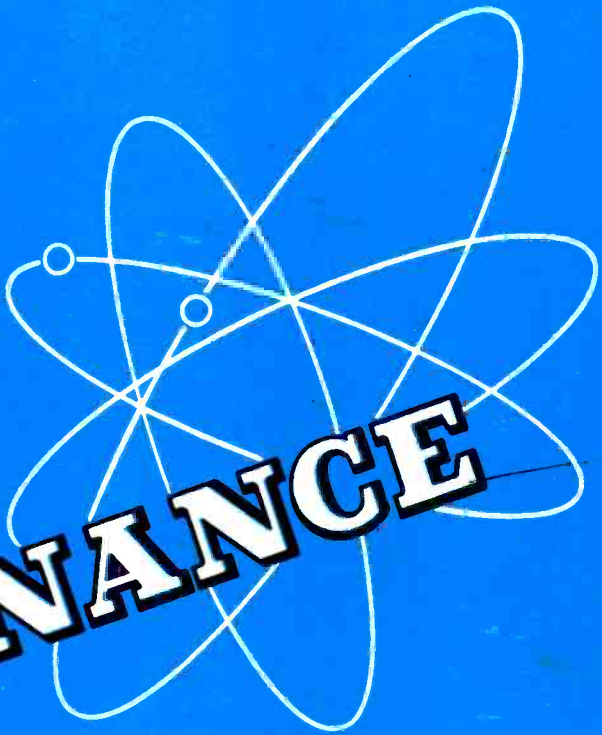

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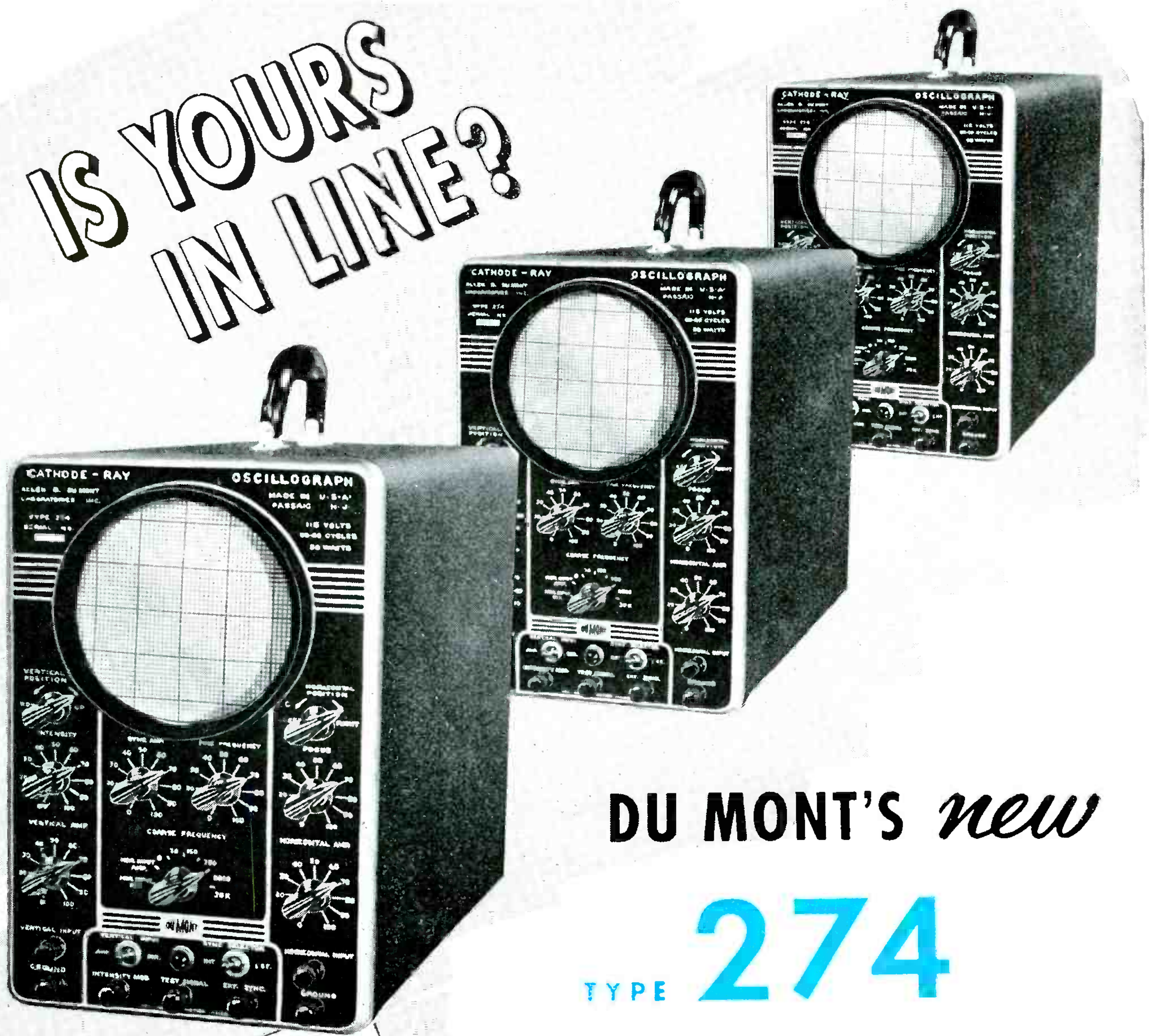

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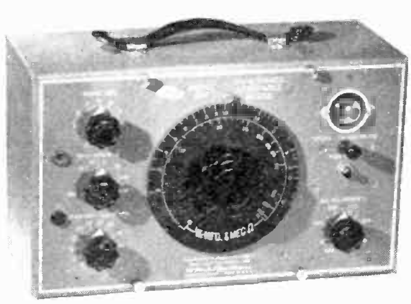

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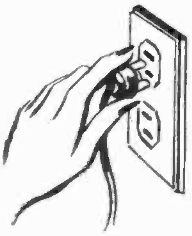

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Radio Maintenance is published monthly by Boland & Boyce, Inc., at 34 No. Crystal St., East Stroudsburg, Pa., U.S.A.; Executive and Editorial Office, 460 Bloomfield Ave., Montclair, N. J. Subscription Rates: In U.S., Mexico, South and Central America, 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. Application for entry as second class matter is pending at the Post Office, East Stroudsburg, Pa.

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SHOWN ABOVE IS THE ATLAS RE-ENTRANT PROJECTOR DR-72.

The general aspects of components used in PA systems.

C. G. McProud

Sound EQUIPMENT

As with the proverbial chain, a public address system is no better than its weakest link—the links being the components which make up the system. Each element of a complete system has its own problems—each must be selected carefully to insure the best performance from the entire system. To make these selections intelligently, it is first necessary to know the characteristics and limitations of each individual component.

Microphones, amplifiers, and speakers are the principal components of all PA systems; turntables and record changers, microphone stands, radio tuners, and so on, are accessory items. In order to understand public address systems thoroughly, it is essential that the reader be familiar with the characteristics of each.

Microphones

There are two ways in which microphones may be classified: By construction and by characteristics. Microphones may be carbon, dynamic, ribbon, crystal, or a combination of these types. This is grouping by construction; and since it does not identify the characteristics of the microphone sufficiently to enable the user to choose the right one for any particular service, it may safely be said that this method of classifying them is outdated. It may be assumed that all microphones of standard manufacture are satisfactory, regardless of type, *when they are used in the manner for which they were designed.* In other words, it makes little difference how the electrical signal is generated by the action of the sound wave upon the microphone. The user has only to consider the limitations of certain types, and then make the selection on the basis of directivity pattern desired. These limitations are simple and few: Ribbon microphones are not especially desirable for outdoor use where wind may strike them; crystal microphones should not be used where they are subjected to extreme heat (crystals lose their piezo-electric properties permanently at about 130° F.) or to extreme humidity (crystals are soluble in water) even though the crystals are moisture-proofed as completely as possible; carbon microphones, generally, have a higher output level, but they also have a high noise or "hiss" level.

One other consideration in the selection of microphones is that of impedance. Most PA amplifiers are designed for use with high-impedance microphones. Ribbon and dynamic microphones are inherently of low-impedance. Ribbons always have a transformer within the case, and its secondary impedance may as well be 10,000 ohms as 200 or 50; dynamics have impedances of 30 to 50 ohms, but a built-in transformer can raise this impedance to any desired value.

Carbon microphones are low-impedance devices, and in addition, require some source of low voltage DC supply. The grid circuit of *any* tube is of high impedance, and any amplifier that has low-impedance inputs has a transformer between the input jack and the first tube. Therefore, at least *one* transformer must be used between the microphone and the grid of the first tube when low-impedance units are used. When microphone cables must be longer than about thirty feet, the use of low-impedance microphones is recommended to reduce hum pickup and loss in high-frequency response.

The most important characteristic in the selection of a microphone is that of its directivity pattern (a curve showing the relative sensitivity of the microphone to sounds coming from all angles). For example, a non-directional microphone is equally sensitive to sounds from all directions, so its pattern is a circle with the microphone at the center, as in Fig. 1. This method of classification permits the user to select the type best suited to his particular requirements.

Classification by directivity pattern limits the number of types to three principal groups—non-directional, bi-directional, and uni-directional. The non-directional type includes most of the diaphragm, or pressure-actuated, microphones. Their response to sounds from all directions is essentially uniform, since a pressure microphone is one in which the electrical signal is caused by the variation in pressure of the sound wave reaching the diaphragm. For general use, this type of microphone will serve quite well, in spite of the fact that its lack of directional characteristic limits its application to some extent. For comparative quality, non-directional microphones are generally less expensive than other types, but they often give trouble from feedback. Their use is not recommended with systems of a portable nature, since the conditions encountered on various jobs may make this particular type of microphone unusable. For many permanent installations, they are very useful, since the position of the performer is not limited.

Bi-directional microphones have a pattern composed essentially of two circles tangent at the microphone, as in Fig. 2. This is the general form of the directivity pattern of the "velocity" microphone, sometimes referred to as the "pressure-gradient" type. While the non-directional microphones have an output proportional to the pressure of the sound wave impinging upon the diaphragm, the bi-directional types have an output proportional to the *difference* in pressure at two points in space. Assuming the "diaphragm" or ribbon to be open to sound pressure on both sides, the output will be a function of the difference in pressure on the two sides —hence, a sound source at the side will cause no output since the sound pressure from such a source is equal on both sides of the diaphragm. Ribbon microphones are the most common of this type and they are especially useful since it is possible to utilize the "dead" area at the sides to reduce effects from feedback. In addition, the ribbon type is conceded by sound men throughout broadcast and sound picture studios as being capable of the finest quality of music pickup. They are also very useful when it is desired to have two people speaking, one on either side of the microphone; and it is primarily for this reason that they have such general use in broadcast studios.

Since the electrical output resulting from sounds striking the two sides of a ribbon are 180° out of phase, and since the output from a pressure microphone is of the same phase, regardless of the direction of the sound source, it is possible to obtain a uni-directional response by combining a bi-directional unit with a non-directional unit. When the sensitivities of the two sections are equal, sound waves from the back will be cancelled out, resulting in the familiar "cardioid" pattern of Fig. 3. This makes a microphone which has maximum response from the front, reducing to one-half at the sides, and to zero at the rear. By reducing the output from one or the other of the sections, this pattern may be modified to some extent, resulting in the "super-cardioid" which has a small pickup from the rear is in Fig. 4. For all-around use, the uni-directional microphone is recommended, in whatever type of construction desired—crystal, ribbon, or combination of ribbon and dynamic. Fig. 5 shows the new Electro-Voice Cardyne, a combination crystal and dynamic microphone. Some of these are furnished with a switch which permits the microphone to be used with various directional characteristics, making it possible to have the advantages of all three types in one unit. Regardless of the type selected, the frequency response should be as wide as possible, in order that the best overall quality can be obtained. There should be no peaks in the response, the curve being smooth from 50 to 8000 cps at least, with a still wider range advisable if optimum quality is desired.

The uses of the different types have been mentioned briefly, but to sum up, the non-directional type is advantageous where a number of sound sources are distributed all around the microphone; the bi-directional type serves best for orchestra pickup, or for conditions where two people are carrying on a dialogue, one on either side of the microphone; the uni-directional type is most useful where feedback is troublesome, with particular advantages gained from its use on a stage, where noises from the audience should be kept to a minimum. A combination of all three types in one unit, selectable at will, is most suitable for all applications. It is especially recommended when only one microphone is to be purchased.

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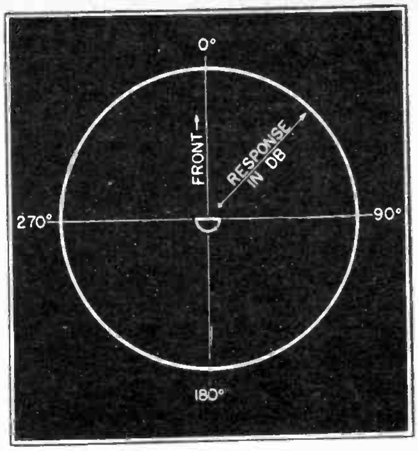

Fig. 1 Directivity pattern of pressure-actuated microphone. Curve shows unit to be equally sensitive in all directions.

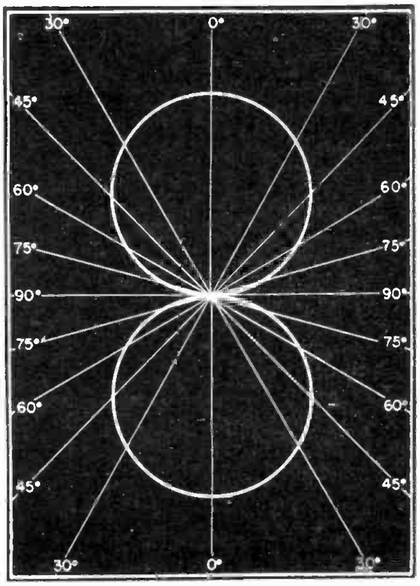

Fig. 2 Curve for "velocity" microphones shows them to be bi-directional.

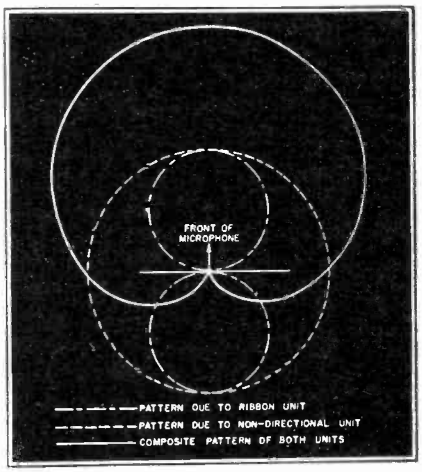

Fig. 3 Addition and subtraction of the sound energy received by the two sections of the uni-directional microphone produce the overall pattern known as a Cardioid.

Sound Equipment

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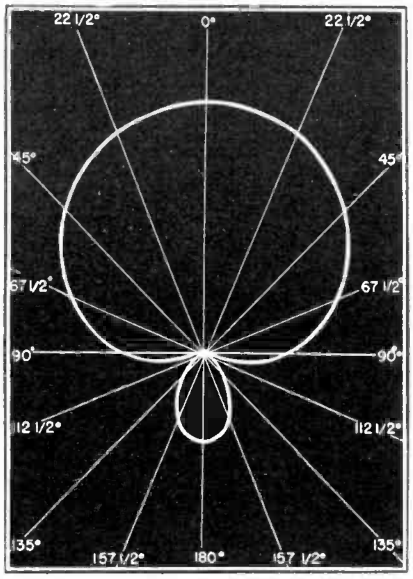

Fig. 4 The Super-Cardioid, resulting from varying sensitivity of one element with respect to the other.

Fig. 5 The new Electro-Voice Cardyne Model 726—a cardioid microphone in which two units are combined to obtain uni-directivity.

Speakers

Speakers may be classified best by physical characteristics, since, like microphones, good quality units of any type can have sufficient power handling capacity and an adequate frequency response. The choice is governed by the application.

Physically, the classification of speakers includes the projector types and the cone types. The projectors consist of trumpets of different designs, including the folded or re-entrant models, Fig. 6, which double back upon themselves to reduce length. There are many forms of the cone type, the most common being the ordinary radio speaker, as shown in Fig. 7, mounted either in a wood enclosure or in a metal horn-type baffle. For wider frequency ranges, a large cone may be combined with a small one, as shown in Fig. 8, to make the co-axial type, the signal applied to each being restricted to a certain frequency range. Thus, the larger cone may be constructed to handle more power at greater efficiency over the low-frequency ranges, and the small cone may be designed especially for the high-frequency range, where little power is present. For a still wider frequency range, a large cone-type speaker may be combined with a small high-frequency diaphragm-type unit as shown in Fig. 9, giving wide distribution to the otherwise sharply directional high frequencies. This type of speaker is recommended for applications requiring the highest fidelity of reproduction.

For outdoor use, the re-entrant horn is the most convenient to use, is quite directional, and may be equipped with one or more diaphragm-type units, Fig. 10, capable of handling up to 50 watts each, when necessary for large installations. They may be secured almost completely weatherproof, and are recommended for all outdoor uses.

Both types of speakers are obtainable with permanent magnet fields or with separately excited fields. In general, permanent magnet fields are recommended for all PA applications, particularly since recently developed magnetic materials have made possible extremely high flux densities. The use of PM fields reduces the number of wires required in the speaker cable, and avoids the necessity of either a separate field supply, or connections to the amplifier for this purpose.

Power handling capability and efficiency are related to a large extent. If 50 watts of power are fed to a speaker that is only 10 per cent efficient, the acoustic output is only 5 watts; the remaining 45 watts must be dissipated as heat. If a speaker

Fig. 6 A re-entrant horn type speaker—the Jensen Hypex.

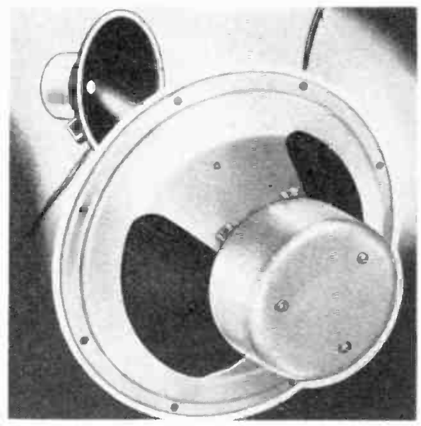

Fig. 7 A straight cone speaker—the Quam-Nichols 12-inch P.M. heavy duty.

Fig. 8 A large and a small speaker combined to give wider frequency response and greater efficiency—the Jensen JAP-60 coaxial speaker.

is used that has an efficiency of 25 per cent, only 20 watts of power will be necessary to obtain the same "loudness," and only 15 watts of power will be dissipated as heat. Thus, there is a saving both in amplifier power requirements as well as in the heat-radiating ability of the speaker itself. High quality speakers of the cone type reach efficiencies of 25 per cent, and most horn units are built with about this degree of efficiency. A few extra dollars spent for an efficient speaker will save money in the original cost, as well as in cost of operation, of the amplifier.

The frequency response of cone-type speakers, particularly the co-axial and duplex types, is considerably better than that obtainable from the horn types, especially in the low-frequency ranges. A good co-axial or duplex speaker, mounted in a well designed bass-reflex baffle cabinet, is capable of really superior reproduction, and is recommended for applications requiring the highest fidelity. When a system is used primarily for speech, horn-type units are recommended. A further saving in power and an increase in efficiency may be obtained from horn-units by restricting the frequency range of the amplifier to about 150 to 5000 cps, thus relieving the horn unit of the necessity of dissipating as heat all of the sound energy below the 150-cps point, since the average horn will not radiate much sound below that frequency. Speaker resonance is a factor in selection, but when units of high efficiency are used, it may be overlooked, since resonance is reduced considerably by high flux density which is the main governing factor in increased efficiency.

Many types of horns and baffles are available, and the location, coverage, and frequency response must be taken into account in making the selection. For use with horn units, the ordinary re-entrant trumpet covers an angle of 30 to 45 degrees, both horizontally and vertically; the radial horn covers about 30° in a vertical direction, but in a horizontal direction, it covers 360° which makes it especially useful when the speaker must be mounted in the center of a room, for example. Wall-type cabinets are suitable for the smaller cone speakers, increasing in size up to six or eight cubic feet for 15-inch co-axial or duplex units. A minimum volume of about six cubic feet will insure good low-frequency reproduction when used with 12- or 15-inch speakers.

Amplifiers

The main classifications of amplifiers are with respect to power output and gain, with secondary consideration being given to frequency response, distortion, input and output impedances, number of inputs, and controls.

The output requirements have been covered previously (See May Issue), but it should be restated that a minimum of 15 watts should be supplied for the smaller installations, such as restaurants or small night clubs. Power needs will range up to 150 or 200 watts for large outdoor installations such as baseball fields, race tracks, and so on. One manufacturer has recently announced complete systems which are so designed that additional 30- or 45-watt power stages can be connected to an original 30- or 45-watt amplifier simply by plugging in, no tools except a screwdriver being required. The power is thus doubled, making a very convenient arrangement particularly for a portable system, since it is possible for the user to increase the overall power output of his system without discarding any of the previously acquired equipment.

The gain required from a PA amplifier which is intended for use with microphone inputs is from 110 to 130 db, and most PA amplifiers fall within this range. Auxiliary inputs for phonograph pickups should have at least 65 db of gain. Adequate gain is essential to provide satisfactory operation; and if the amplifier selected has amplification of this order, it will be capable of supplying sufficient gain for practically any application.

The response from modern amplifiers is generally uniform over a wide range of frequencies in order that the reproduced sound may bear a close resemblance to the original. It is relatively simple to design and build amplifiers which have a response flat within ±2 db from 50 to 10,000 cps, which is adequate for the average PA system. Higher frequencies are not reproduced by any but the finest speakers, even if they are present in the original and are picked up by the microphones in use. Frequencies lower than 50 cps require large and complex speaker structures for efficient radiation without distortion. Therefore, there is no necessity in most cases for wider frequency response, and excellent reproduction can be had with any system that is flat over this range, *provided that there is little distortion in the entire system.* This demands that all components be selected with the distortion characteristic given full consideration. Distortions not exceeding 2 per cent may be obtained from modern amplifiers. The figures quoted for any amplifier refer to the distortion at the *rated* output, so the use of a 30-watt amplifier from which only 15 watts of power are required will give improved quality. The untrained ear will not detect distortions of less than 2 per cent, and it is interresting to note that tube manufacturers rate their power tubes in watts output at *ten* per cent distortion. A push-pull 6L6 stage is capable of satisfactory operation to about 30 watts of output when used with inverse feedback circuits of proper design, and a pair of 6V6's will put out 15 watts of power under the same conditions. The addition of more pairs of these tubes will increase the available power output so that 45 watts may be obtained from a 6-tube push-pull-parallel 6V6 amplifier.

The application to which a system is to be put will determine the number of inputs that are required in the amplifier. Two, three, four or even more microphones may be mixed to-

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Fig. 9 A combined cone speaker and high-frequency horn to obtain wide frequency response and increased efficiency — the Jensen HNP-51 coaxial speaker.

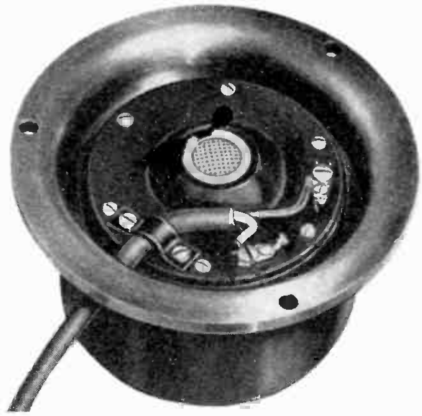
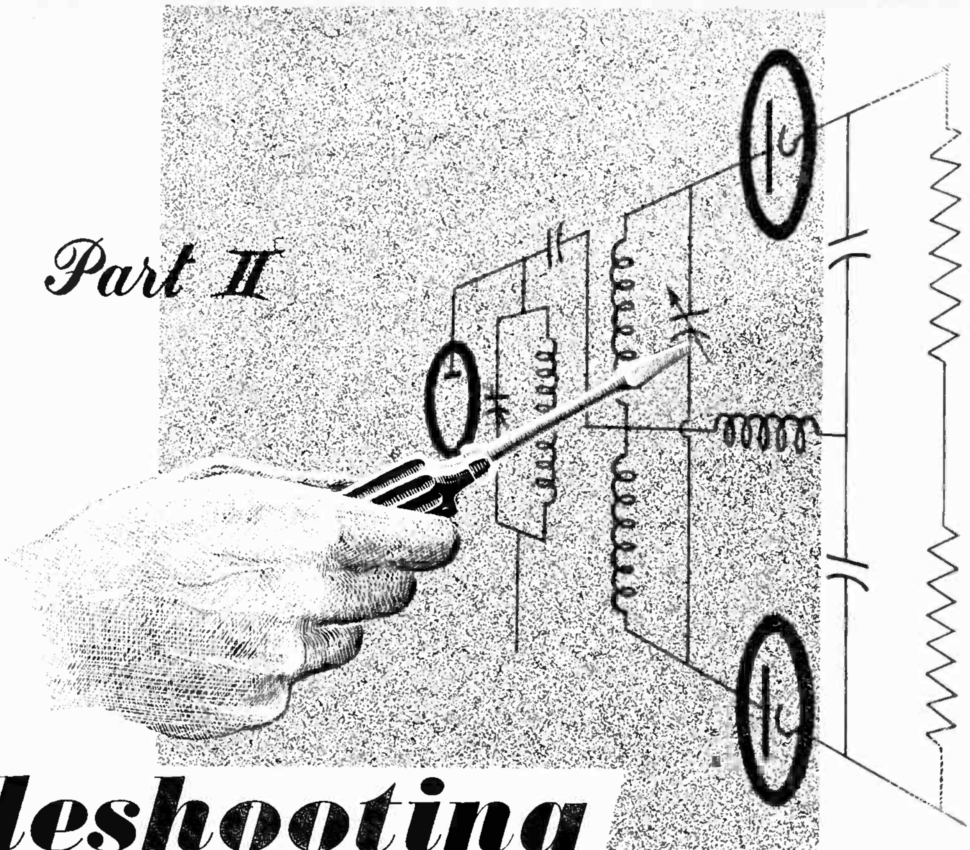


Fig. 10 A diaphragm type reproducing unit—the Jensen Hypex is equipped with a unit of this type.

Part II



FM troubleshooting

Ralph B. Roland

This second article on FM Troubleshooting describes alignment and common faults of the FM receiver

PART I WAS PRIMARILY devoted to test equipment setups of varying complexity for testing FM receivers, and to general troubleshooting throughout the set. This article is mainly concerned with troubles to be encountered in the discriminator and limiter circuits. A discussion on alignment of tuned circuits in FM receivers will also be presented.

Troubleshooting in the Discriminator

Since the discriminator is significantly different from circuits encountered in AM sets, a brief description will be given of typical discriminator circuits used in some of the more common receivers. A typical discriminator, known as the Foster-Seeley type, is shown in Fig. 1. In this circuit, the IF signal on the limiter plate is coupled into the discriminator circuit in three distinct ways:

(1) By mutual coupling between L-1 and L-2.
(2) By mutual coupling between L-1 and L-3.
(3) By direct coupling through C-2 and L-4.

Equal voltages are induced in L-2 and L-3 by the familiar center-tapped transformer action.

In the upper half of the detector circuit of the schematic diagram of Fig. 1, the voltages across L-4 and L-2 are added directly in series and are detected by V-2, causing a positive DC voltage to appear between the junction of R-1 and R-2 and the cathode of V-2. In the lower half of the diagram, the AC voltages across L-4 and L-3 are likewise added in series; and due to detection by V-3, a negative DC voltage appears between the cathode of V-3 and the junction of R-1 and R-2. Since the two diodes are connected differentially, the DC output measured from the cathode of V-2 to ground is either positive or negative depending upon whether the voltage across R-1 exceeds that across R-2, or vice-versa. At the mid IF frequency, the two detected voltages are equal, so that the net difference is zero. Hence the discriminator output is zero when the input signal is undeviated in frequency. At frequencies above the mid-frequency, the net output is positive, and conversely, at lower frequencies, the net output is negative. This effect is represented in the discriminator response diagram of Fig. 2. As the signal frequency is swept through the IF band, the discriminator output will alternately swing positive and negative at an audio rate. The linear range of the discriminator response is limited, as shown in Fig. 2. Beyond the linear range, on either side, the discriminator response flattens off and then falls to zero for frequencies far removed from the mid IF frequency.

With an understanding of the operation of the discriminator, as described above, it is now possible to see what specific troubles may arise in the circuit and how they may be corrected.

(1) *Severe Amplitude Distortion.* During high audio signal levels, the quality might be very poor even though the audio amplifier of the receiver is capable of accepting large signals without overloading. In this case, the most obvious difficulty is poor tuning of the discriminator input. In this connection, it should be remembered that high level audio signals correspond to wide frequency deviations about the mid-IF frequency. If the discriminator is badly tuned, far from resonance, it is likely that a widely deviated signal will go "over the hump" of Fig. 2. Even if the misalignment is not quite so bad, the re-

sponse might leave the linear portion of the curve and get onto the flat part of the peak. The results of this are shown in Fig. 3. To correct, adjust condenser C-1 or C-3, the primary or secondary tuning condenser of Fig. 1. Another possibility is that either L-2 or L-3 is opened or shorted, or condenser C-2 might be opened. Any one of these troubles will cause one or more of the AC voltages in the detector circuit of Fig. 1 to vanish and this will introduce bad distortion.

(2) *Special Tuning Precautions.* The discriminator is dependent upon the phase shift characteristic of the interstage transformer between the limiter and discriminator; and for this reason, it is important that the primary (L-1, C-1) and the secondary (L-2, L-3, C-3) of Fig. 1 both be tuned to resonance simultaneously. Since two mutually coupled tuned circuits are involved, it is possible to obtain a satisfactory IF amplitude response by staggered tuning effects without the primary and secondary being independently tuned to resonance. By making such an error, it is quite possible to destroy the phase response of the transformer and thereby introduce distortion into the discriminator.

Specific Troubleshooting in the Limiter

The limiter circuit is peculiar to FM receivers and its operation should be understood. In general, the main function of the limiter is to pass no more than a set signal level. Once the "threshold level" has been reached, any noise or amplitude modulation added to the FM signal will be eliminated in great measure from the signal in the limiter output.

There are various types of limiter circuits in existing receivers, but all operate on the same basic principles to achieve limiting action:

(1) The tube is operated so that the grid-swing between the conditions of cut-off and zero grid volts is of the order of 3 volts. The limiter tube is invariably a sharp cut-off pentode.

(2) The limiter stage is always operated with low screen voltage (50 to 100 volts) to achieve a low cut-off voltage.

(3) The plate current is limited by several factors, the most important of which are:

(a) The loading of the input tuned circuit by the flow of grid current which tends to short circuit the grid

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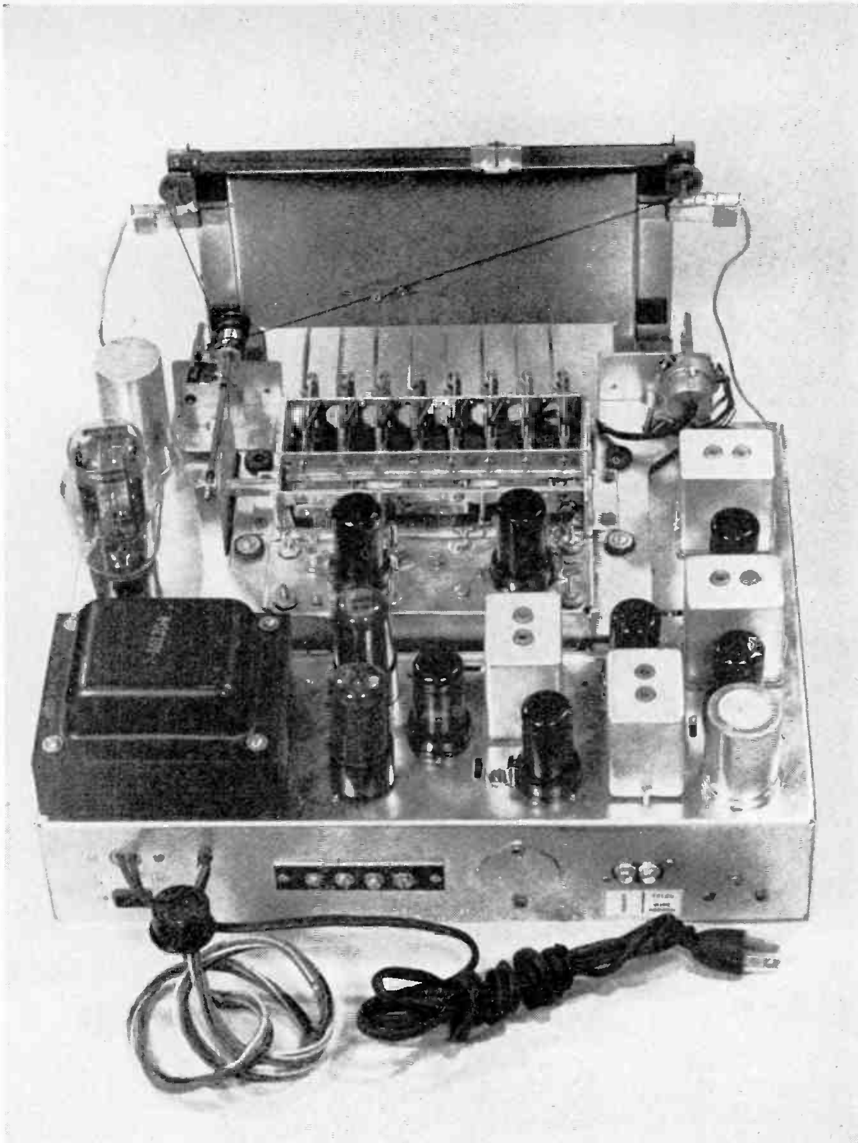

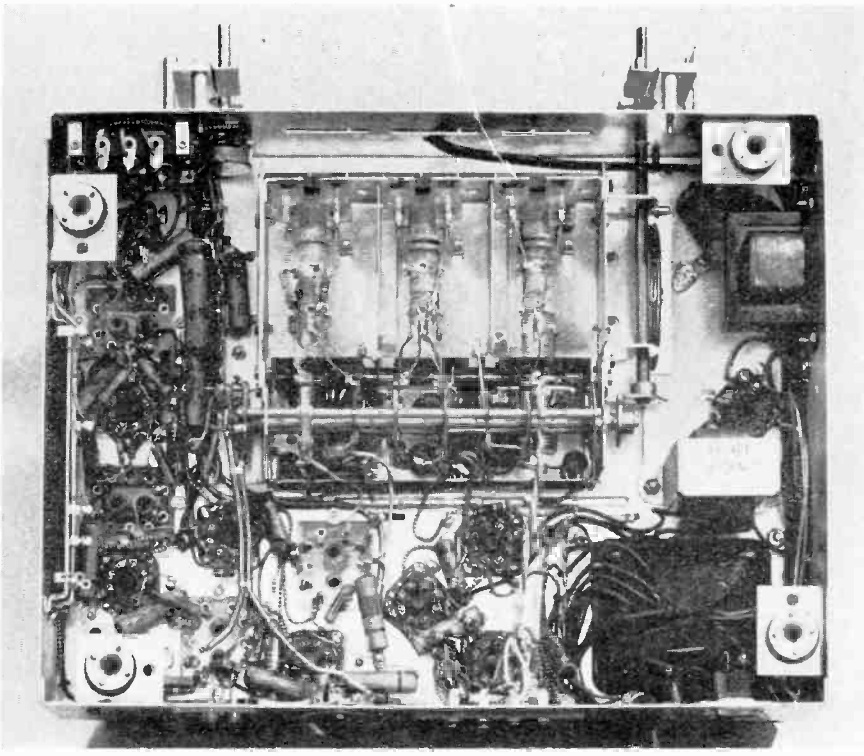

Photos at the right show a Stromberg-Carlson FM receiver chassis. This is an example of the better quality FM receiver construction.

FM Troubleshooting

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input during positive gridswings.

(b) If the plate supply to the tube is very low (100 volts or less), and if the plate voltage swings below the screen voltage during the peaks of plate current flow, all additional cathode current will flow to either the control grid or the screen grid. In this manner, plate current saturation is reached.

These effects confine the flow of plate current between zero (cut-off condition) and plate current maximum (saturation condition—usually for zero grid volts) regardless of the amplitude of the input signal, once the threshold has been reached. The resulting effect is shown in the limiter response diagram of Fig. 4. For most commercial receivers, the threshold occurs at RF input levels of 50 microvolts or less.

One of the simpler and more common limiter circuits is shown in Fig. 5. The input connection to the limiter stage is made through the transformer which couples to the last IF amplifier. The limiter stage itself is operated at a reduced supply voltage, on the order of 75 to 100 volts, with the screen voltage somewhat lower than the plate by virtue of the dropping resistor R-2. The stage is operated without steady bias, but derives bias from the DC voltage developed across R-1, C-4, due to the flow of grid current. Such a circuit is called "peak-riding," because the DC bias is always equal to the peak of the AC wave, and grid current flows only during the very peak of the input grid-swing. A typical case of operation might be with a tube which cuts off at 3 volts, and an input signal with a peak swing of 20 volts. This obviously indicates Class C operation, since plate current only flows in short bursts when the grid voltage is between —3 and 0 volts.

With the foregoing discussion as a basis, we may now investigate the most probable sources of trouble in the limiter, and the necessary remedies. Other than complete failure of the stage, one of the more common difficulties is high screen and plate voltages. If this is the case, the grid base will be considerably lengthened and the "threshold" might change as much as 50 to 150 microvolts. This difficulty will arise if some of the dropping resistors become partially shorted or change their values in some other manner.

Another possible failure in the

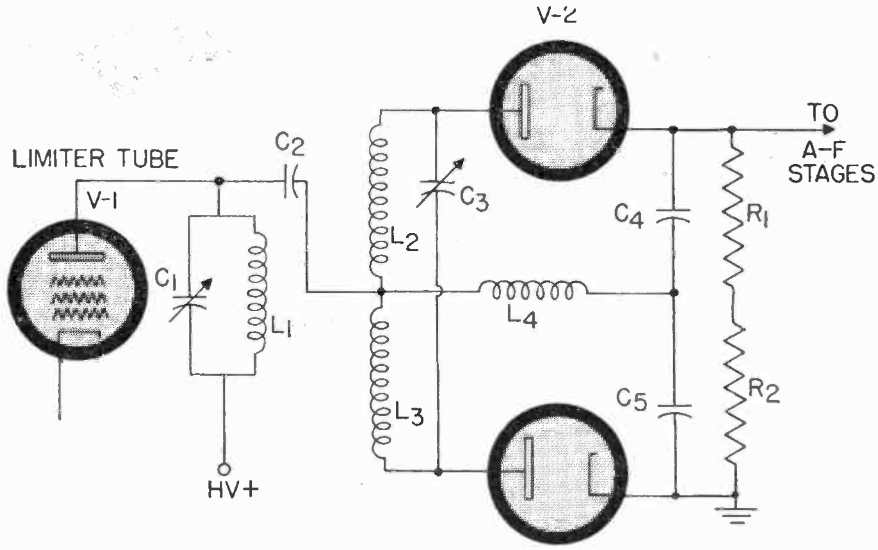

Fig. 1 A typical discriminator circuit, Foster-Seeley type.

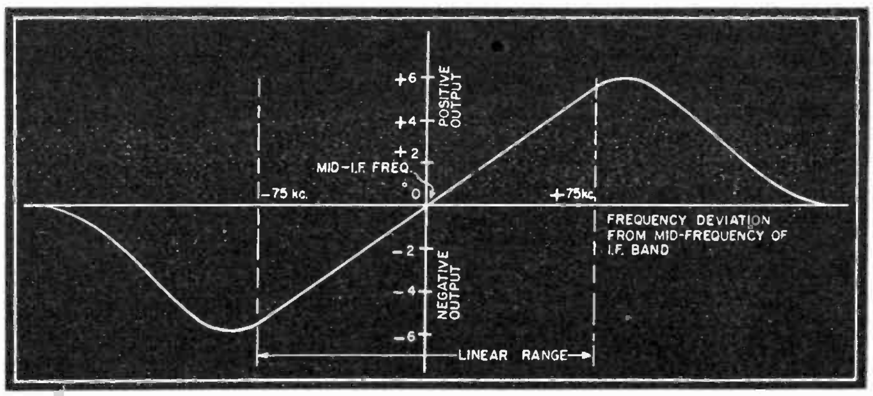

Fig. 2 Output curve of a typical discriminator.

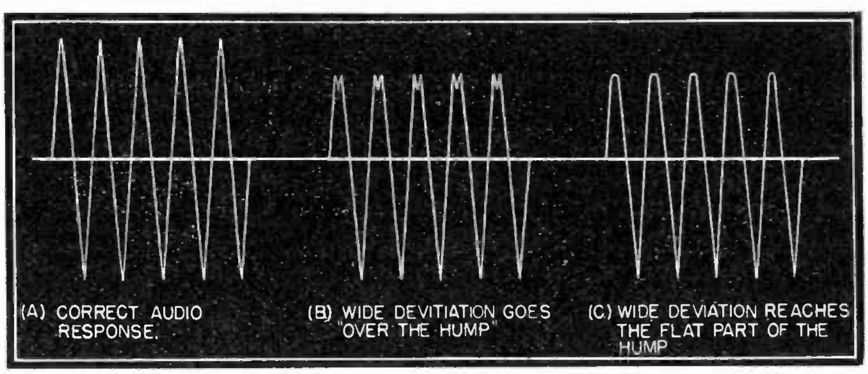

Fig. 3 The effect on the output of a discriminator of a too widely deviated signal.

limiter of Fig. 5 is blocking of the grid. As was previously mentioned, such a limiter is a peak-riding limiter because the bias developed across R-1 —C-4 is derived from the grid current flow during the peaks of grid voltage swing. The exact operation is that condenser C-4 charges through the grid-cathode path of the tube and discharges through the resistor R-1. If R-1 should open, there is no way for the condenser C-4 to discharge. Hence, if a large burst of signal, of noise, is received, C-4 will immedi-

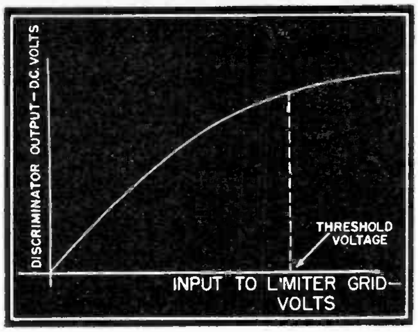

Fig. 4 Output response curve of a limiter stage — threshold voltage is usually on the order of 50 microvolts or less.

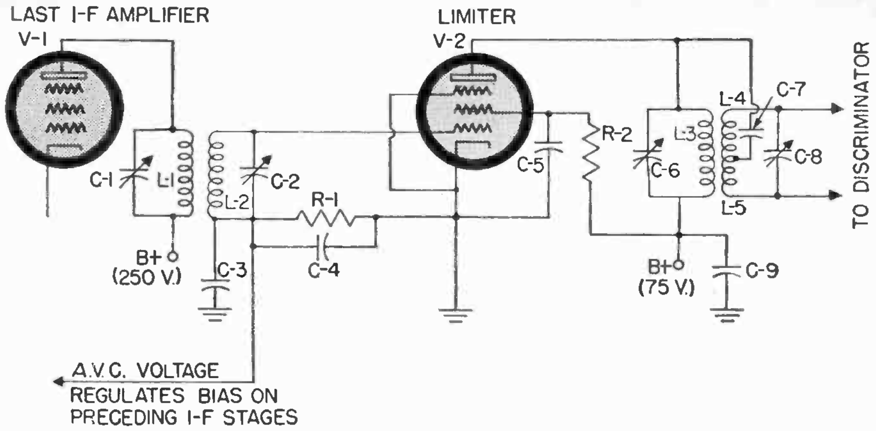

Fig. 5 A simple limiter circuit.

ately charge to a large bias voltage. However, after the burst has passed, the high bias does not decrease and the ordinary signal level is not sufficient to swing the grid above the cut-off voltage. The effect of such a fault is to cause the receiver to appear dead for long periods of time, and the only thing which can be heard are sharp noise clicks, etc. Even if conditions are not as bad as pictured, the limiter operation can still be faulty.

The diagram of Fig. 5 indicates that R-1—C-4 not only serves to bias the limiter tube, but also provides AVC bias for preceding IF stages. If R-1 should open or become exceedingly high in resistance, the AVC voltage fed back to the preceding stages will reduce the gain of the amplifier during a noise burst but will not recover sufficiently fast. The result will again be dead intervals in the reception until the AVC has had sufficient time to recover.

Another type of limiter which is to be found in the better quality sets is the double limiter shown in Fig. 6. This circuit does not have any AVC circuit, as shown, but by a simple rearrangement of resistors and condensers, AVC can be obtained. Such variations in design can be expected from one manufacturer to the next. The purpose of two limiter stages is to make for an improved limiter response. The first limiter is subjected to the most severe fluctuations in amplitude coming from the antenna, whereas the second limiter receives a signal which has already been clipped down to nearly constant amplitude. The second limiter makes it possible to maintain the signal at an almost perfectly uniform level.

We may summarize the discussion of the limiter by pointing out the importance of maintaining a small grid base by operating at low plate and screen potentials; and by insuring that the grid circuit is not blocked by the long discharge time required for the bias condenser. In addition to this requirement, it is also necessary that the tuned circuits be properly aligned.

Another important group of tests is the alignment and checking of the gain of the IF amplifier. Since the limiter is also a tuned IF stage, it is also included in this category. In general, it is true that the gain of any stage and its frequency response are mutually dependent, so that if one is wrong, the other will be wrong also. The only exception occurs in the case of a faulty tube, or where the control grid or screen grid bias voltages are incorrect.

Following the same approach as in the first of these articles, we will describe the alignment procedures for various types of test setups. The first method assumes only the simplest of available test equipment, consisting of a good signal generator and a DC electronic (or 20,000 ohms-per-volt) meter.

To check the alignment of the IF amplifier with only a signal generator and a DC meter is somewhat difficult. First, to check the alignment of the limiter, it is preferable that grid current not be drawn. To prevent the flow of grid current, an external bias source may be connected across the AVC condenser, C-4, which normally appears in the grid circuit of the limiter (see Fig. 5). Connect the signal generator to the limiter grid and the DC voltmeter to the discriminator output. The primary of

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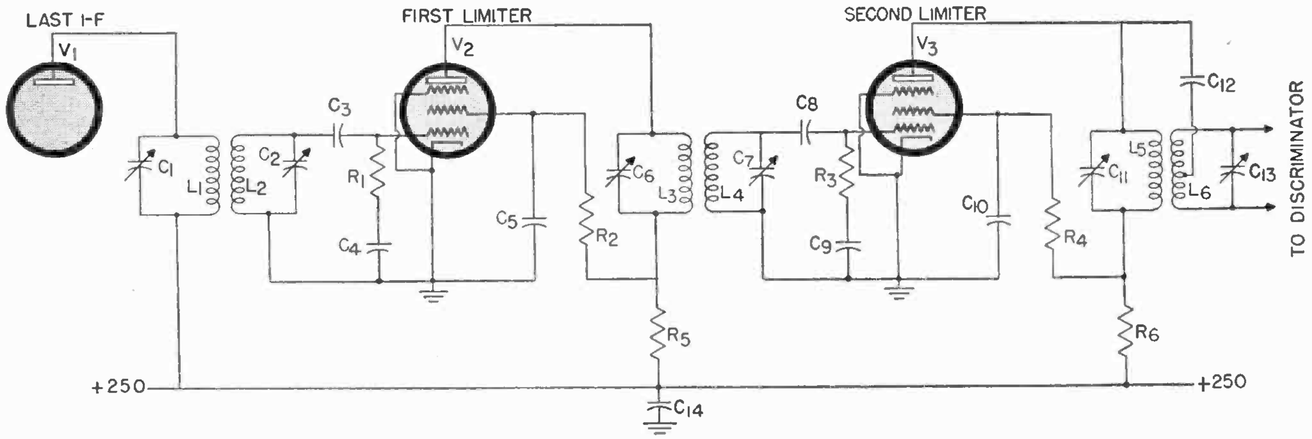
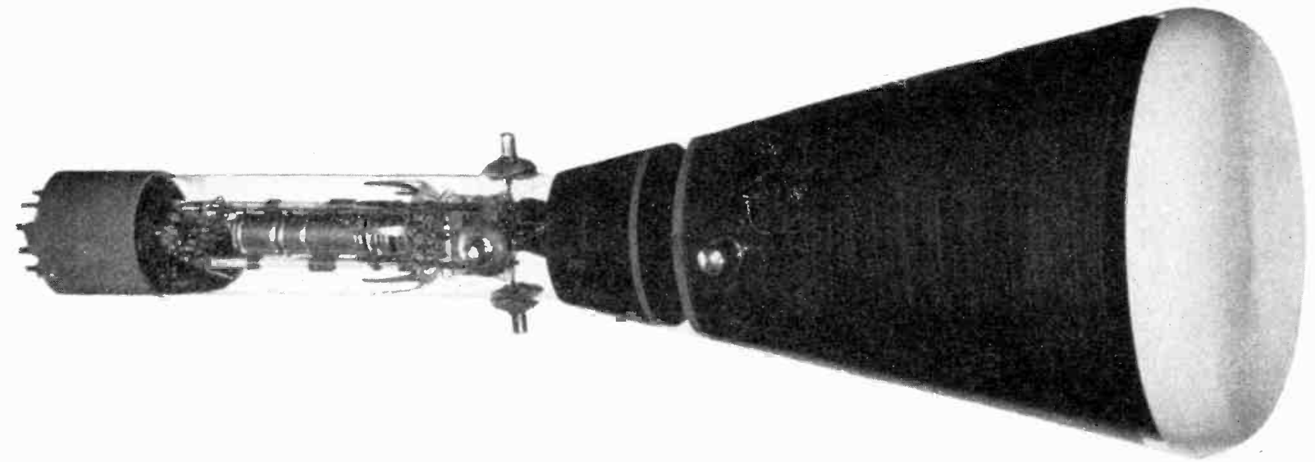


Fig. 6 A two-tube or double limiter circuit.

the Oscillograph ...how it works



COURTESY ALLEN B. DUMONT LABORATORIES

Karl R. Alberts

This is the first of a series of articles on using the oscilloscope in radio servicing. The theory, operation and application of this test instrument will be completely covered in these articles.

In recent years, one of the most useful and versatile instruments to become a part of the radio maintenance man's tools is the cathode-ray oscilloscope, or oscillograph. Its extreme utility comes about through the fact that so much useful information can be gained from it practically at a glance and with a minimum of effort. It is not, however, a "push-button" instrument in the sense that a totally unqualified and untrained operator can hope to use it successfully: A certain degree of familiarity with the theory of the oscilloscope, a knowledge of exactly what the functions of the various controls are, and the ability to improvise with the instrument are almost essential to its successful operation. It is proposed in this article, and in those to follow, to present the oscilloscope in all its details to the serviceman, to give him a working knowledge of the instrument so that he may use it to its full capabilities.

Among the many uses of the cathode-ray oscilloscope are:

1. Checking of voltage wave-forms.
2. As a voltmeter:
   DC, AC, sine wave and complex wave-forms; current and power in a circuit.
3. Measurement of an amplifier's gain.
4. Measurement of phase-shift.
5. Measurement of distortion in an amplifier.
6. Detection of "singing" in amplifiers.
7. Measurement of per cent modulation (in broadcast or amateur transmitters).

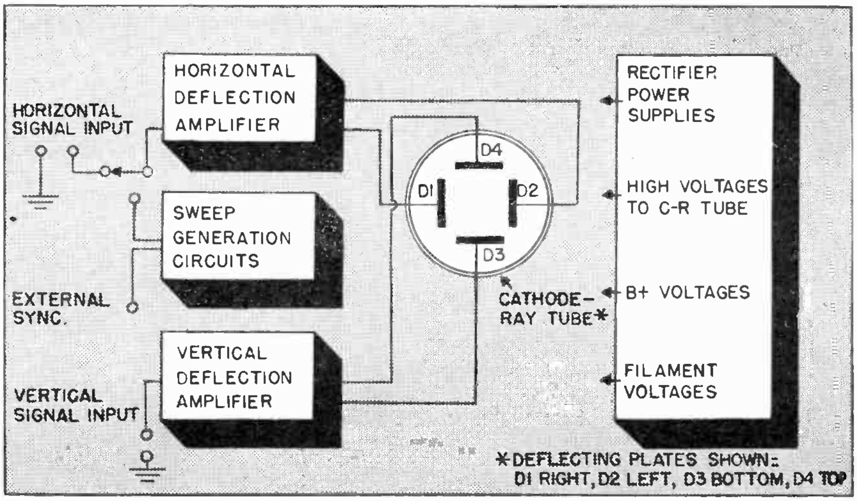


Fig. 1 Block diagram of a cathode-ray oscilloscope.

8. Convenient check of band-pass of an amplifier.
9. Frequency measurements.
10. As output indicator in signal tracing.
11. Alignment of audio, IF, and RF tuned circuits.
12. Rapid check of characteristics of a vacuum tube.
13. Simultaneous observation of two signals (with some additional external electronic equipment), e.g., comparing the input and output of an amplifier, etc.

These, and other, uses of the cathode-ray oscilloscope will be gone into more thoroughly in later articles in this series. For the present, we shall consider only the oscilloscope itself—a brief theory of the cathode-ray tube, a description of the electronic control circuits, and how the two work together.

The Cathode-Ray Tube

The oscilloscope consists essentially of a cathode-ray tube, high voltage power supplies for the cathode-ray tube, horizontal sweep circuits, horizontal and vertical amplifier circuits, and B+ power supplies.

Fig. 1 is a block diagram of a typical cathode-ray oscilloscope. The units and terms shown will be more fully explained later. Fig. 2 shows the external and internal construction of a typical test oscilloscope, the Du Mont Model 208B.

At the heart of the oscilloscope is the cathode-ray tube. This tube provides a visual means of examining currents and voltages in electrical circuits. It is a special type of vacuum tube in which electrons are emitted from a hot cathode and caused to move at a tremendous velocity, under the influence of a high-voltage electric field. The electrons are formed into a narrow beam and are then allowed to strike a fluorescent chemically-prepared screen which glows at the point where the electron beam strikes. The electrons, being almost weightless, can be deflected very rapidly at the cost of negligible energy expenditure. This enables the cathode-ray tube to be used for measuring currents and voltages which vary many thousands of times a second.

There are two general types of cathode-ray tubes: The electrostatic and the electromagnetic. The electrostatic type employs two pairs of metal plates at right angles to each other (as shown in Fig. 1 and 3) which deflect the electron stream electrostatically. The electromagnetic type employs a "pancake" coil about the neck of the tube which deflects the electron

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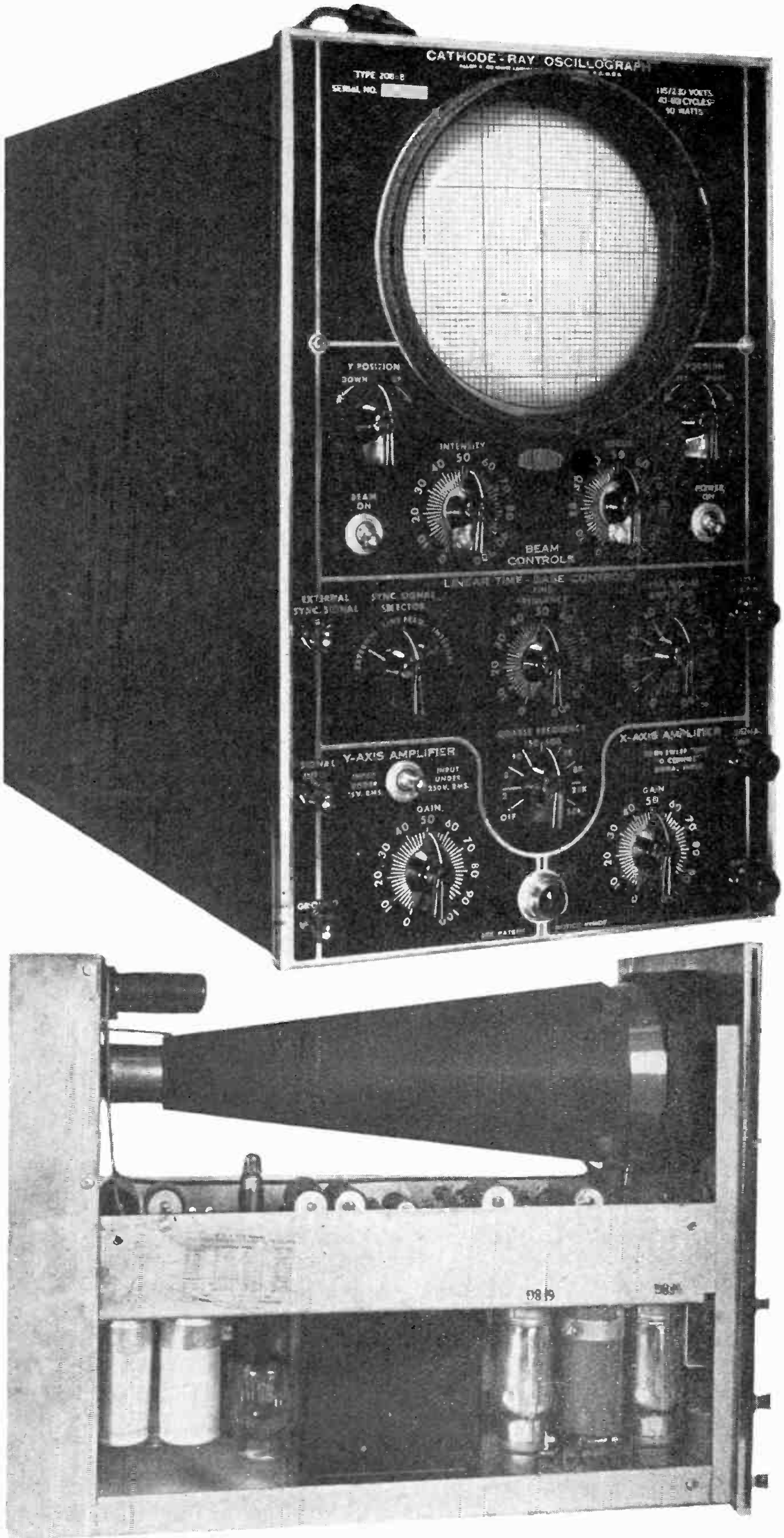

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Fig. 2 External and internal views of a typical cathode-ray oscilloscope.

The Oscillograph...How It Works

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stream by means of the electromagnetic field resulting from current flowing through it. Since most testing cathode-ray oscilloscopes employ the electrostatic type tube, this discussion will be confined to it.

The elements of an electrostatic-type cathode-ray tube comprise the "electron gun" structure (heater, cathode, intensity control grid, first anode, second anode), the horizontal and vertical deflecting plates, and the fluorescent screen. The first anode is used for focussing the electron stream and the second anode is used for accelerating the stream. The action of the focus and accelerating anodes on the electron stream is somewhat akin to the action of a lens system on a beam of light. Some tubes also employ a ring close to the screen, called the intensifier or third anode, which is held at a higher potential than the accelerating anode in order to produce a still brighter and more highly concentrated beam.

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Fig. 3A

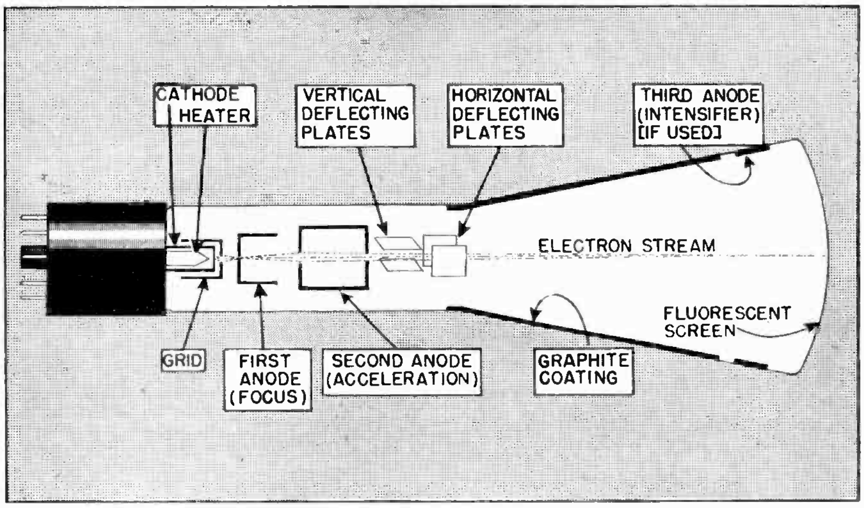

Fig. 3 The upper illustration shows a 3" electrostatically deflected cathode-ray tube of the type commonly found in test oscilloscopes. The lower illustration shows the internal construction of this type of tube.

The Electron "Gun"

The electron gun consists of a heater, a cathode, a control grid, and focussing and accelerating anodes. The cathode is a small nickel cylinder coated with a layer of oxide. It is indirectly heated by a spiral-wound heater coil which is completely enclosed and insulated by the cathode cylinder. The intensity of the electron stream emitted from the cathode (and hence the brightness of the spot on the screen) is controlled by the grid which is another metal cylinder around the cathode cylinder, having a small hole at the far end through which the electron beam emerges.

The grid acts in two ways to control the intensity of the beam: (a) It acts like any vacuum tube grid to control the amount of emission from the cathode, and (b) it acts as a lens to concentrate the electrons into a small beam which passes through the hole in its end. The grid voltage is always negative with respect to the cathode; the greater this negative voltage, the less intense is the electron beam. If this voltage is made sufficiently great (usually about —30 to —50 volts) complete cut-off will occur and no spot will appear on the screen.

The focussing (or first) anode is a metal cylinder following the cathode and grid. The accelerating (or second) anode is either a metallic cylinder after the focussing anode, or a graphite coating on the inside of the tube. Both anodes are positive with respect to the cathode, the focus anode 100 to 500 volts and the accelerating anode anywhere from 1000 to 2000 volts. Basic law states that like charges repel and unlike charges attract each other; therefore, the electrons in the stream, being negatively charged, will be attracted by the increasingly greater positive voltages on the focus and acceleration anodes. If these voltages are carefully adjusted, the electron stream will be narrowed into a sharp beam by the time it emerges from the second or accelerating anode. The degree of sharpness of focus is controlled by adjusting the voltage on the focus anode with respect to cathode. Focus voltage in general has to be changed for different beam intensities, i.e., different intensity grid voltages. The accelerating anode voltage is held constant.

The Deflecting Plates

From the rule stated in the last paragraph that like charges repel each other and unlike charges attract, it will be seen that if a stream of negatively charged electrons is made to pass between two conducting plates which are oppositely charged (like a condenser charged by a voltage) they will be attracted to the positive plate and repelled from the negative plate. The voltage difference between the two plates constitutes an electrostatic field. The electron stream passing between the two plates will be attracted towards the positive plate, and the degree to which it changes direction from its original course depends on how fast the electrons are being pulled through the field and on the intensity of the electrostatic field. If the force driving the electrons between the plates is great enough, the electrons will merely be deflected from their original course (as in Fig. 4); if the driving force is too low, the electrons will be pulled into the positive plate and will not emerge from the electrostatic field at all.

In the electrostatic cathode-ray tube, two pairs of deflecting plates (like the pair described above), one pair for vertical and one pair for horizontal deflection, are mounted next to each other. (See Fig. 3.) The first pair of plates, being mounted horizontally, cause the beam to be deflected up or down when a voltage is applied between them; the second pair are mounted vertically and, hence, cause deflection to the right and left. With correct voltages applied to the intensity grid and the focus and accelerating anodes, if there is no voltage between the horizontal deflecting plates (i.e., if both plates are at the same potential) and if there is no voltage between the vertical deflecting plates, the electron beam will continue straight through between both pairs of plates undeflected and will strike the fluorescent screen at its center. If the right deflecting plate is made positive with respect to the left plate (or if the left is made negative with respect to the right), the beam will be reflected to the right and will strike the screen to the right of center. Similarly, if the upper deflecting plate is made positive with respect to the lower plate (or if the lower plate is made negative with respect to the upper plate), the beam will be deflected upwards and will strike the screen above the center. The amplitude of deflection from the center of the fluorescent screen depends on (1) the voltages on the deflecting plates, (2) the accelerating anode potential, and (3) the distance of the screen from the deflecting plates.

Since for a given tube the spacing of the tube elements is constant, and for a given oscilloscope the second anode potential is maintained constant, the spot movement on the screen will depend entirely on the deflecting plate voltages. Manufacturers of cathode-ray tubes list, among the tube characteristics, a property known as the deflection sensitivity. Deflection sensitivity is the amount the beam will move across the screen in millimeters for one volt applied between a pair of deflecting plates. A related characteristic, deflection factor, is the number of deflecting plate volts required to move the spot one inch on the screen. These figures are given for both pairs of plates. A typical tube, the 5BP1, has a deflection factor of 20-25 volts/inch, with an accelerating anode voltage of 1500 volts.

The Fluorescent Screen

The rounded end of the cathode-ray tube is coated on the inside with a phosphor chemical which emits light when bombarded with electrons. Different chemical materials are used to produce different light colors: Blue, green, yellow, or white. Green is the color most commonly used in cathode-ray oscilloscope tubes. The intensity of light depends on the concentration of electrons in the electron beam; hence, the grid which controls the intensity of the electron beam controls directly the intensity of light on the screen.

Some screens are so coated that the fluorescence persists for a measurable time after the spot on the screen is struck with the electron beam. Such a screen, called a "long persistence" screen, is useful in observing phenomena which do not recur rapidly. For most oscilloscope applications, the phenomena being observed are of the rapidly changing variety; and, hence, since even moderately long persistence or "afterglow" would confuse the screen pattern, "short persistence" tubes are usually furnished.

The first number in the tube type is the size of the screen, and the last number is the degree of persistence. Thus, the 5BP1 is a five-inch diameter tube with short persistence; the 3BP7 is a three-inch long-persistence tube.

Functioning of the Tube

A peculiarity of the human eye is that it retains an image for about one-fifteenth of a second, and no longer. Therefore, if a changing voltage (e.g., a sine wave voltage) which alternates less than 15 times per second is applied to a pair of deflecting plates, the eye will be able to follow the motion of the brightened spot on the screen quite clearly. If the voltage alternates more than 15 times per second (e.g., a 60-cycle sine wave), the spot will be swept back and forth

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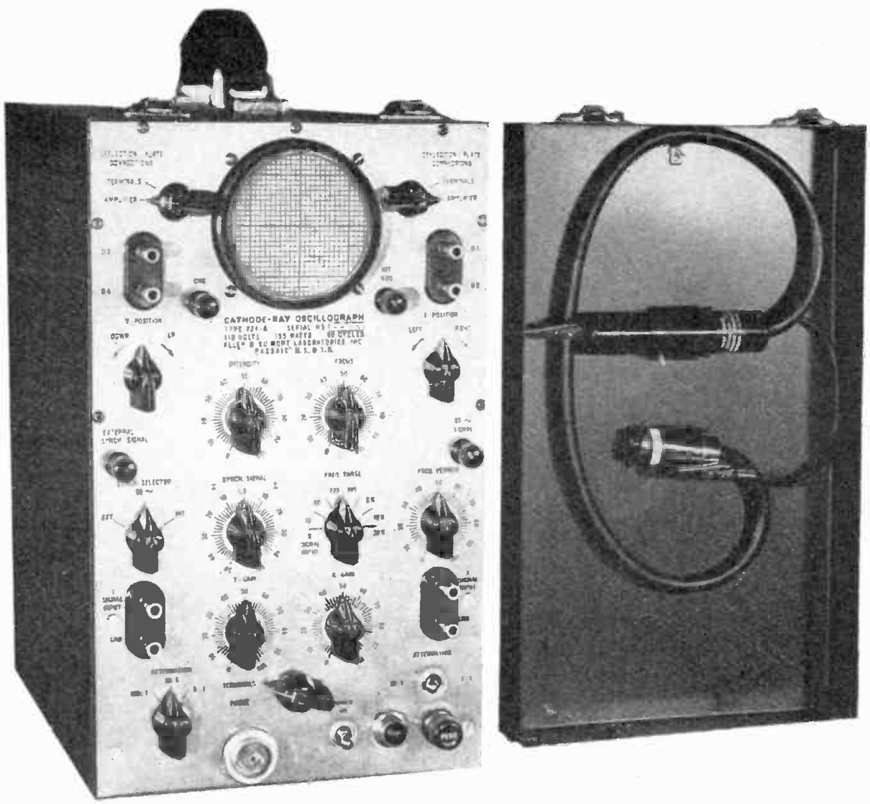

Allen B. DuMont Type 224-A Oscillograph.

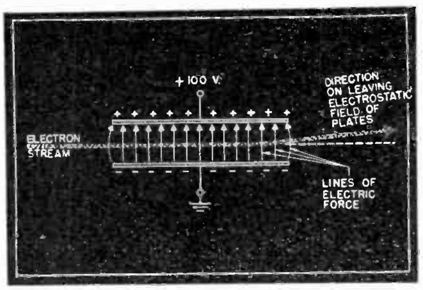

Fig. 4 The electrostatic field set up by the potential applied to the plates changes the direction in which the electron stream is travelling.

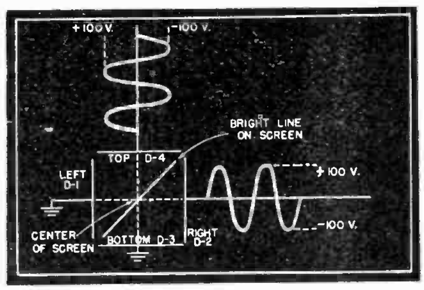

Fig. 5 When two sine wave voltages which are in phase are applied to the vertical and horizontal plates of a cathode-ray tube, the beam forms a straight line on the screen as shown.

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at this rate and the eye will perceive a straight line, with no flicker, which represents the path of motion of the spot.

If voltages are simultaneously applied to both pairs of deflecting plates, then the spot will be deflected right or left and up or down at the same time. If, for example, the bottom plate is grounded, the top plate put at +100 volts, the left plate grounded, and the right plate put at +100 volts, the spot will be deflected up and right by approximately the same amounts. (Actually, since the horizontal plates are physically after the vertical plates, the spot will move slightly more up than to the right.) If the voltages are, say, 1000 cycle sine wave with a peak value of 100 volts each, a 45° straight line will result. (See Fig. 5)

Lissajous Figures

Fig. 5 is actually one form of a whole series of pictures which can be obtained on a cathode-ray oscilloscope screen when sine wave voltages are applied to both pairs of deflecting plates. These pictures are known as Lissajous figures, after the man who first discovered their significance. A 45-degree straight line results when the horizontal and vertical voltages are of the same amplitude (size), in phase, and of the same frequency. By "in phase" is meant that the horizontal and vertical voltages start at exactly the same point on the wave. One complete cycle of a sine wave is usually considered to consist of 360 degrees. Taking the horizontal voltage of Fig. 5, for example, the starting point is 0 degrees, the first positive peak is 90°, the point where the wave crosses the axis is 180°, the negative peak is 270°, and the next point where the wave crosses the axis is 360° (or 0° again). Two complete waves are shown.

If the voltages applied to the horizontal and vertical plates are not in phase, a pattern will be obtained which can take on the appearance of anything from a straight line to an ellipse to a circle and back to a straight line, depending on the degree of phase difference. In Fig. 6, if the vertical voltage is always the same and the horizontal voltage takes on five different phase relationships with the vertical voltage, the five patterns shown will result. (Note that in all cases one complete cycle only is shown on the horizontal channel for the one vertical cycle, which means the *frequency* of the horizontal and vertical waves is the same. It is only the *phase* of the wave we are changing.) The first figure, A, is actually a repeat of Fig. 5. B shows the pattern obtained for a 45° phase difference, C for 90°, D for 135°, and E for 180°. Going back from bottom to top, D will also be the pattern as the phase increases from 180° to 225°, C for 270°, B for 315°, and A for 360°

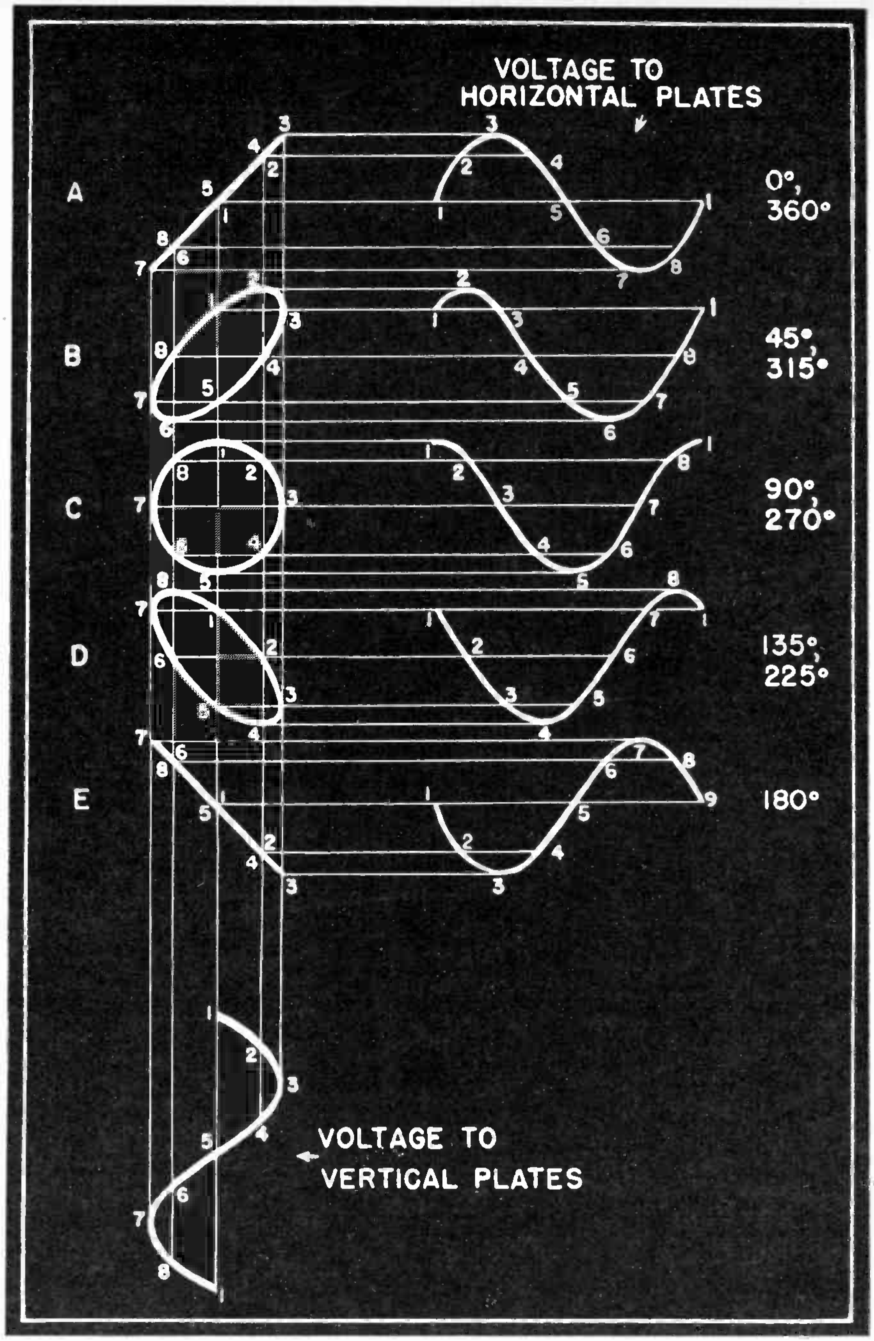

Fig. 6 Various types of patterns obtained with different phase relationships between the vertical and horizontal voltages applied to the cathode-ray tube.

Thus, if a known sine wave voltage is applied to one pair of deflecting plates and an unknown sine wave voltage applied to the other pair, and if a pattern like one of those of Fig. 6 is obtained, or somewhere between any two patterns of Fig. 6, then it can be deduced that the unknown voltage is of the same amplitude and frequency as the known voltage and differs from it only in phase, the amount of phase difference depending entirely upon the shape of the pattern. The effect of difference of size (or amplitude) between the two waves will be a change of shape of the pattern. For example, for 0° we will still have a straight line, but with a slope slightly off 45°. The 90° circle will no longer be a pure circle but a stretched-

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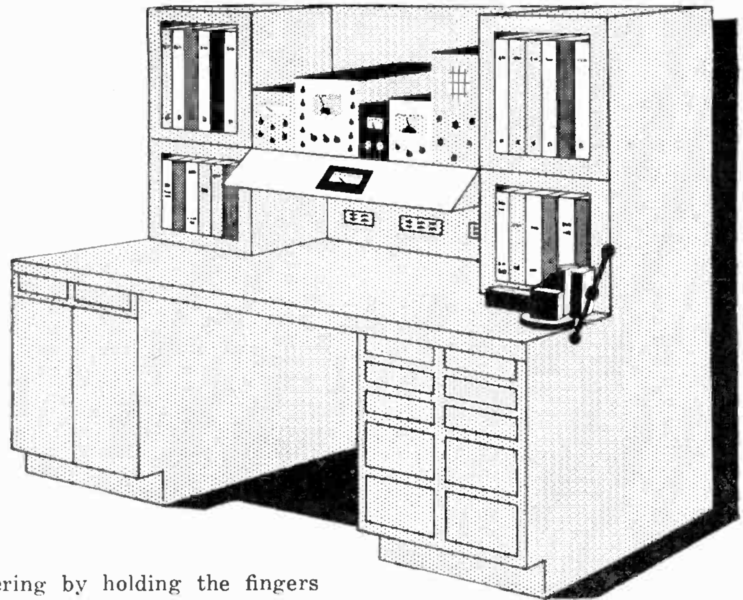
The Radio Service Bench



by Max Alth

SPEAKERS ARE STILL difficult to obtain; and since very often a faulty speaker can be quickly placed in operating condition, it is a good idea to review some of the common speaker troubles and how they may be corrected.

Speaker breakdowns fall into two general categories, electrical and mechanical. Visual examination and use of an ohmmeter are all that is needed to locate faults in the speaker.

Electrical faults will be found in the voice coil or field coil. A break in the voice coil can sometimes be reached and repaired by unwinding a turn of the coil. Unwinding more than one turn will change the impedance noticeably; and, therefore, is impractical. If, upon examining the voice coil, a break should be found within one turn of either end of the coil, the turn may be removed and the flexible bronze cable soldered to what is then the end of the voice coil. The lead should then be secured to the cone with a large drop of speaker cement. This will confine bending of the lead to the flexible cable.

An open field coil usually must be discarded. Heavy current fields can sometimes be unwound a few turns; and, if the break is near the surface of the coil, they may be repaired. Small speakers using high resistance fields are almost impossible to repair. For this reason, it is best not to waste time looking for a break any further than the end of the lead. A grounded field coil can often be repaired by removing the coil, locating the point which is causing the ground, and insulating it from the speaker frame.

Mechanical difficulties consist of tears in the cone, off-center cones, loose voice coil turns, dust and dirt in the air gap, broken spiders, loose field coils, etc. A cone can be checked for centering by holding the fingers around the cone near the voice coil and carefully forcing the cone in and out. Pressure should be exerted equally around the edge of the cone when using the above method.

If the voice coil is rubbing the center pole piece or magnet, and the set is turned on, it will be felt as well as heard. Another check can be made by turning the set on and moving the cone back and forth with the fingers while listening to the background hum or rush. If the pitch of the hum can be lowered or completely removed, the cone is probably off center. Dirt in the air gap or a warped coil give the same effect as a coil which is off center. Should the cone move freely but the speaker rattle or sound fuzzy, the trouble is probably a loose voice coil or broken spider.

Should the speaker show symptoms of one of the above faults, it should then be examined in order to determine whether or not it can be taken apart. Some speakers are welded in a manner which makes it impossible

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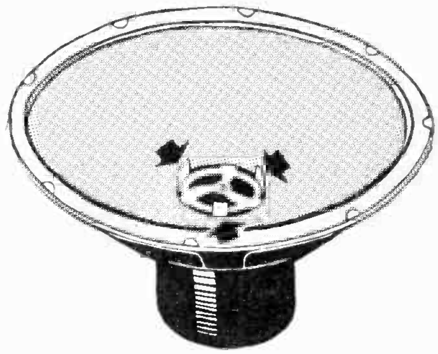
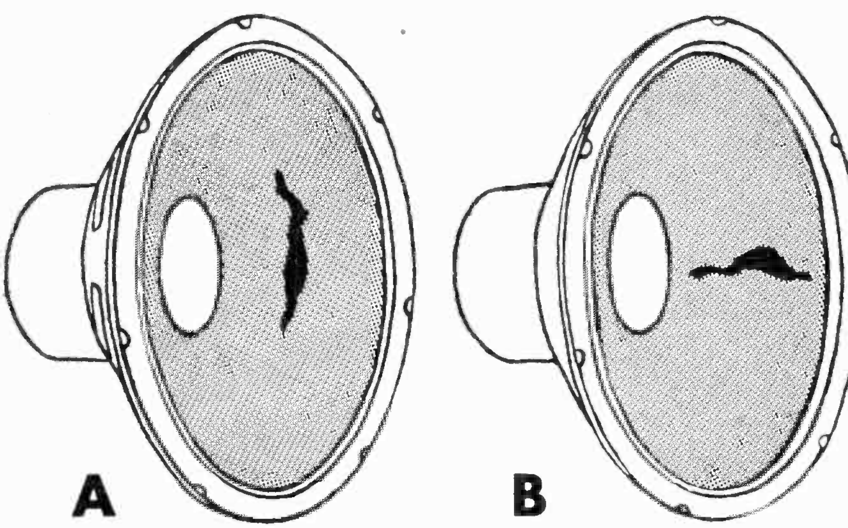


Fig. 1 Placement of shims used when realigning the voice coil of a speaker.



The tear A can be repaired while the one on speaker B cannot.

ELECTRONICALLY SPEAKING

THE NEW AUTO RADIO PLANT of RCA Victor has started production in Chicago. It is the first plant in the country devoted exclusively to the manufacture of automobile radios and is RCA's first factory in the Chicago area, according to Mr. J. B. Elliott, Vice President, RCA Victor Home Instrument Department.

The new plant, with 160,000 square feet of space and an expected personnel of 700 employees, will eventually be a completely self-sustaining factory for the manufacture of radios for the automobile industry.

In the assembly section of the modern, daylight plant, four production lines are set up using latest techniques in straight-line production. Assembly operations start at one end of the line, running the length of the building, and the radios progress on a movable conveyor through testing cages to the end of the line where they are packed.

THE RADIO RECEIVER TUBE INDUSTRY "will produce sufficient tubes to provide for the currently discussed going rate of approximately 18 million receiver sets during the next twelve-month period" and will "satisfactorily take care of reasonable export plus domestic replacements," says Mr. M. F. Balcom, Chairman of the RMA Tube Division and Vice President of Sylvania Electric Products.

His report shows that tube production for 1936 will be in excess of the 139 million receiver-type tubes produced in 1945. Production has been made doubly difficult because of strikes, labor and raw material shortages, and the rise of material and labor costs which caused tube manufacturers to produce at a serious financial loss.

TRAFFIC INCREASES ON RADIO HIGHWAYS for the next few years have been estimated by the Federal Communications Commission as follows:

Standard broadcast stations, from 1000 to 1400;

Frequency modulation (FM) stations, from 50 to 3000;

Television stations, from 6 to 200 or 300;

Radio-equipped planes, from 3000 to 50,000;

Aviation ground stations, from 700 to 2500;

Two-way service for autos, taxicabs, etc., from one city to 200 cities;

Radio-equipped railroads, from one road to 150;

Fire department radio, from none to 5000 cities;

Citizens walkie-talkie, from none to 200,000;

Amateur operators, from 60,000 to 100,000.

AN EXPOSITION by the Electronics Industry will be held at the Grand Central Palace, New York City, next month, October 14-19. Thousands of the public will have their first opportunity to see for themselves many of America's radio secrets which helped win the war, including radio, loran, shoran, and the proximity fuse. The purpose of the exhibition, according to its managers, Harry G. Cisin and V. M. Eitingon, of Electronic Exhibitors, is to show the public wartime advances in electronics and how they have been harnessed to peacetime uses.

The exposition's advisory committee comprises leaders in electronic science drawn from the fields of research, communications, industry, medicine, Army and Navy, as well as outstanding figures, as follows: Dr. Lee De Forest; Robert A. Millikan, Nobel prize winner and electronics pioneer; E. F. W. Alexanderson, famous research engineer and inventor; Commodore H. A. Shade, Director of the Naval Research Laboratory; Admiral Julius A. Furer, retired, U. S. Navy Office of Coordinator Research and Development; and Dr. Samuel K. Allison, Director of Nuclear Research, University of Chicago.

The exhibition will cover communications, broadcasting, and industrial applications of electronics. Exhibits under communications will be grouped into aviation, marine and industrial categories. Broadcasting will be subdivided into AM and FM radio, television and facsimile. Industrial applications will show equipment used in industry, medicine, science, music and crime detection, as well as basic materials used in manufacture, such as plastics, glass, metals, etc.

Special features include models of inventions, a Hall of Fame of the great figures who have contributed to electronics, and daily lectures with demonstrations by notable experts.

For the serviceman, the most interesting feature will probably be the showings of their latest models by the leading radio manufacturers who have been invited to exhibit.

MULTI-WEAVING, a new process being used by General Electric Company to "weave" various metals for decorative grilles in radio receivers, can also produce many patterns of woven plastics, wood and rubber for various domestic and industrial applications, according to E. A. Malling of the GE Specialty Division, Syracuse, N. Y.

The strands and fillers used in multi-weaving are held securely in position under tension at the points of intersection. The metal or other material used does not vibrate under

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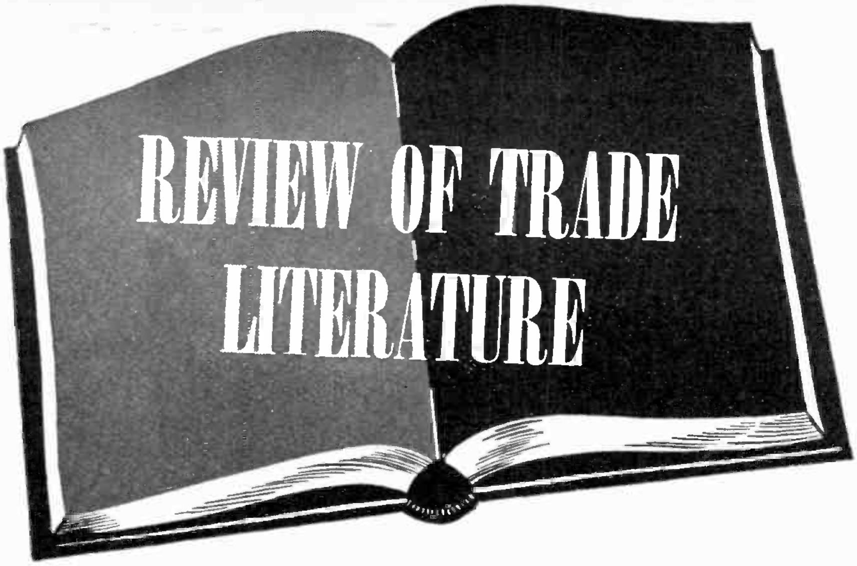

REVIEW OF TRADE LITERATURE

To avoid delay when writing to the manufacturer give issue and page number.

THE SHALLCROSS MANUFACTURING Company has just announced a large wall chart on resistor engineering data which it is making available. The chart contains complete data on the Shallcross line of Akro-ohm precision resistors. The chart also contains all necessary information on the electrical characteristics of the resistors, as well as mounting and terminal specifications.

To secure your copy of this chart, write to the Shallcross Manufacturing Company, Collingdale, Pa.

The General Electric Company has just released their new brochure covering vacuum capacitors. The catalog gives a complete listing of the GE line. Also included in the catalog are structural data, outline drawings, performance data and applications.

To secure a copy, write to the Tube Division, General Electric Company, Schenectady, N. Y.

The Centralab Division of Globe-Union, Inc., has begun a policy of issuing temporary bulletins that will bring pertinent information to customers and prospects as quickly as possible. The company states that this is being done because of the changing conditions in the radio industry. The bulletins will later be incorporated in permanent catalogs.

The first bulletin is No. 933 on the new Centralab B C capacitors. It includes part numbers, standard values, tolerances, working voltages, power factor limits, leakage resistance and color code and dimensions of the new parts.

You can obtain a copy by writing Centralab, Division of Globe-Union, Inc., 900 East Keefe Avenue, Milwaukee 1, Wis., requesting Form 933.

The Electronic Laboratories' brochure on Standard Vibrators for Power Supplies can be obtained by writing the company at 122 West New York Street, Indianapolis 4, Ind.

This booklet gives comprehensive information on vibrators, including a general description, how to order Electronic Laboratories vibrators, schematics, standard container data, mounting and other useful material.

The AEROVOX RESEARCH WORKER, which is distributed free to those engaged in radio-electronic work, has fully recovered from wartime handicaps and is back on schedule. Present issues carry an excellent series on ultra-high-frequency theory and practice.

To receive a free subscription of this fine little publication, write the Aerovox Corporation, New Bedford, Mass.

Bulletin SFF-100 describes three new Solar "Elim-O-Stat" radio interference filters for fluorescent lamps. The filters are of two basic electrical types: A balanced twin-pi filter for maximum attenuation; and a delta capacitor filter for normal usage, the former Type EF-100 and the latter Types EF-101 and EF-102 in "bathtub" and cylindrical metal housings.

Copies are available on request from Solar Manufacturing Corporation, 285 Madison Ave., New York 17, N. Y.

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● It's good to have these metal-can electrolytics available once again. In fact, the Aerovox postwar line contains the greatest choice of electrolytics yet offered. There are many different types of metal-can electrolytics now available. Because of generous sections and metal containers, these electrolytics really "can take it"—hour after hour, day in and day out, month after month—in equipment that simply must stand the gaff.

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In Canada: AEROVOX CANADA LTD., Hamilton, Ont.

Gentlemen:

I have been receiving your excellent magazine ever since the first issue. I believe that no serviceman would go amiss in subscribing to it.

I welcomed particularly the articles on television, and am looking forward to more in the same vein. Much has been said on the servicing of television receivers, and most servicemen have lapped it up eagerly. But many are looking forward to it apprehensively, uncertain even with the tremendous amount of reading they are doing.

The trouble, as many of them say, is that they have never handled one or seen the insides except on paper. Many of them are of the opinion that several thousand amateurs building television receivers will do more to stimulate the sale of factory sets than the most elaborate pump priming of distributor and wholesale organizations. Several reasons can be noted for this opinion, one being the same unfamiliarity of the potential consumer with television technicalities, and another, the uncertainty of economical maintenance and repair.

I believe that this would be a good opportunity for your magazine to run a series of articles in which a television receiver would be built. An average serviceman under the guidance of a trained engineer could do the assembling.

An enterprising company could furnish the circuit, and get itself a great deal of free advertising plus many men trained to repair and handle its circuits. The latter would be a great advantage in establishing public confidence in their product.

Sincerely yours,
S. GROSS
326 East 96 Street
Brooklyn 12, N. Y.

Editor: Are there any other readers of the same opinion as Mr. Gross?

Gentlemen:

I have been a subscriber to your magazine since the first of the year and from experience I can say it is the best of its kind on the market today.

I have one small gripe to make, if you can call it that. Up to this time, you have been mailing your magazine folded. I am one who appreciates every issue and takes pride in keeping them in a binder. The gripe is that when the magazine is folded, it is inconveniently creased permanently, is rather bulky, and is defaced rather badly.

Why not roll every issue and then mail it? It doesn't take as much time and certainly doesn't cost any more and it will be a blessing to us servicemen who rely on our copies from time to time for reference. Here's hoping you will grant us this one small privilege.

Yours truly,
BUDDY FALOR
North Georgia Trade School
Clarkesville, Ga.

Editor: Material shortages make it impossible to get suitable wrappers. This issue was mailed flat without a wrapper in hopes that it would reach readers in better shape. We would like to know the condition in which it is received by you.

Dear Editor:

Your magazine started out to do a wonderful job for the service man and I was happy to become a subscriber. However, in six short months it has degenerated into a monthly advertisement for the Silver "Vomax" and little else. I call your attention to your "June-July 1946" issue in which pages 10-33 are devoted exclusively to a none-too-honest "plug" for the single product of *one* manufacturer (and a product of questionable merit at that) and I want my resentment to be known to you. Surely you must own considerable stock in McMurdo Silver, Incorporated—previous issues have fairly burst with praise (and space) for this one product.

I subscribed to your magazine in the hope of acquiring useful information, but since it has become a mere "house-organ" for the Silver Vomax, I find it unworthy of my time—I'm far too busy to spend money on monthly advertising of one product. Accordingly, you may cancel my subscription upon receipt of this letter.

Very truly,
JULIAN H. SILVERMAN
834 Carlston Avenue
Oakland 10, California

Editor: We can only say we wish you were right (about owning stock in the McMurdo Silver Company).

Gentlemen:

I have received the June-July issue and was very much satisfied with its contents.

I was very much interested in your article on the Silver "Vomax" because I have been using one since the latter part of February and it is the best piece of test equipment it has been my pleasure to use. I also use a Precision Electronic Model 200 signal tracer for "aural" signal tracing. My other equipment consists of a Precision E200 signal generator and Superior 450 tube tester.

I am in agreement with Mr. Merwin regarding some of the brain storms put out by radio design engineers. While some of the circuit designs are "screwy," some of the mechanical arrangements really "take the cake." I have in mind one permeability tuned job put out by a well known company. On this particular

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Sound Systems

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gether in the average PA amplifier, with additional provision for one or two turntables. It is possible to obtain amplifiers with accommodation for almost any desired number of inputs. In selecting the amplifier, the user must keep in mind the microphones he intends to use with it—if low-impedance microphones are to be used, it is necessary that the amplifier be equipped with necessary transformers to match them. For general use, high-impedance input circuits will result in a less expensive installation, but high-impedance circuits have their disadvantages when the microphone cables must be long.

A sufficient number of output impedances must be available to permit the connection of the required number of speakers. In general, it is recommended that speakers each be equipped with a transformer matching the voice coil impedance of the speaker to a 500-ohm line in order that the losses in the speaker lines may be kept to a minimum. If 500-ohm speaker lines are used, it is convenient to have output impedances of 500, 250, 167, 125, and 100 ohms for connection to 1, 2, 3, 4, or 5 speakers, respectively.

Controls

In order that the PA equipment may be adjusted to meet the varying conditions found within a given installation, a number of controls of different types are generally provided on the amplifier. These controls are of four general types: *Gain*, both individual to each input, and "inclusive" for all inputs; *Tone*, either treble or bass, or both; *Compression*, to limit overloads and to reduce amplification on high level source material; and *Expansion*, to increase the contrast between low and high level passages. The latter two are not commonly available, but for high quality installations they are often of great use.

To provide adequate mixing facilities so that the sound outputs from various microphones may be combined in any desired degree to obtain the best overall effect, a separate gain control is necessary for each input circuit. In addition, it is convenient to have one control which can vary the gain of the entire amplifier, making it possible to increase or decrease the signal from all inputs simultaneously. This control is known as a master gain control, or in professional applications, the "inclusive." The individual controls should be so con-

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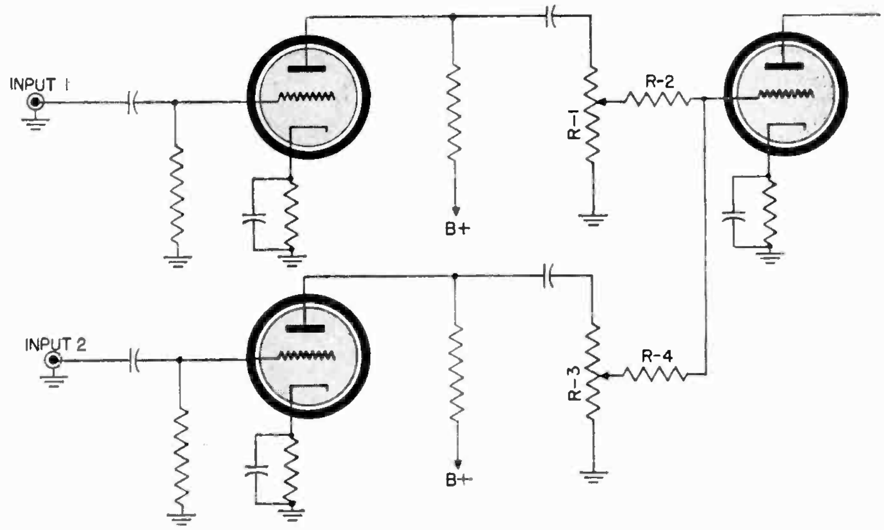

Fig. 11 One method of mixing inputs from two microphones. This method is in common use, and is quite satisfactory.

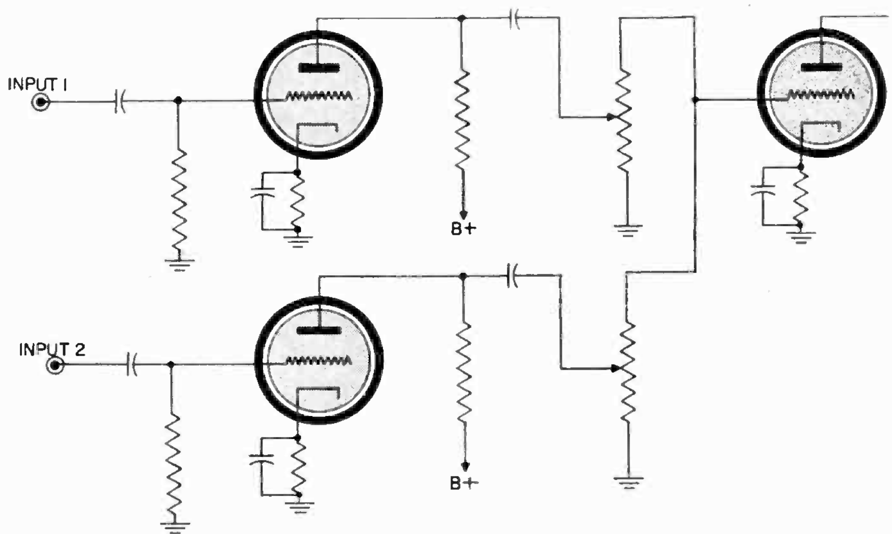

Fig. 12 This circuit is satisfactory for mixing two inputs, although some loss in low frequencies results at low settings of the controls.

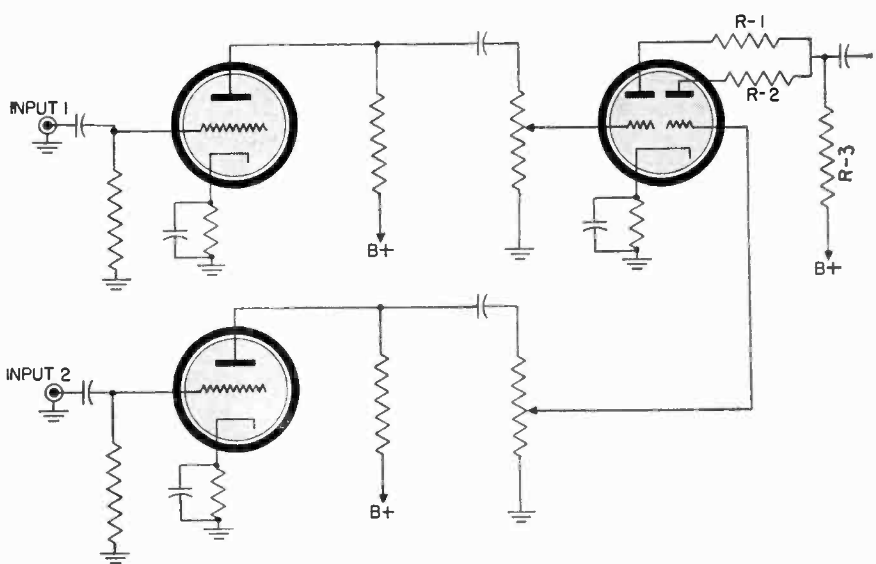

Fig. 13 Third type of mixing circuit, also satisfactory.

Sound Equipment

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nected in the circuit that it is possible to vary any one source without disturbing the signal from the others. Many different circuits are used for this type of combining; those of Fig. 11, 12 and 13 are considered satisfactory, while those of Fig. 14 are not, since they do not give complete control of the entire output of the separate channels. Capacities C_t between the various elements of the dual tubes are sufficient to "talk through" at high frequencies, and these circuits should be avoided.

Separate bass and treble tone controls should always be available on a PA amplifier, since it will often be found that improved performance may be had if it is possible to increase or decrease the response of the upper and lower ranges separately. In many installations, the effects of feedback may be eliminated by the reduction of amplification at specific frequencies, rather than by reducing the overall gain of the amplifier.

Compression controls, with the associated tube circuits, are very convenient to avoid overload when an unexpected loud sound is applied to the microphones. Another use for the compression feature is to provide a nearly constant output from a source with varying sound intensity. This feature is not in general use, but is helpful in some applications.

Expansion controls are sometimes provided on modern amplifiers. Since the maximum volume range of phonograph records is around 45 db, and the normal volume range of a full orchestra is in the order of 65 db, expansion will give a high degree of realism. Expansion controls are not desirable for use with direct pick-up from live performers or from an orchestra. Their use should be restricted to the reproduction of music from records.

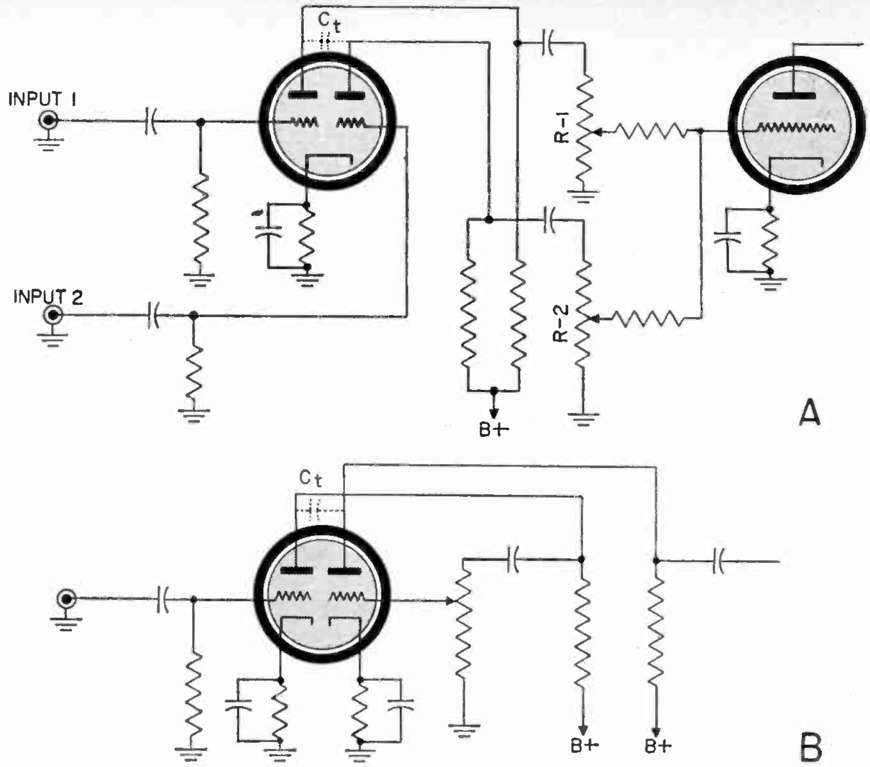

Fig. 14 Capacity C_t between tube elements results in crosstalk between channels. These circuits are not satisfactory.

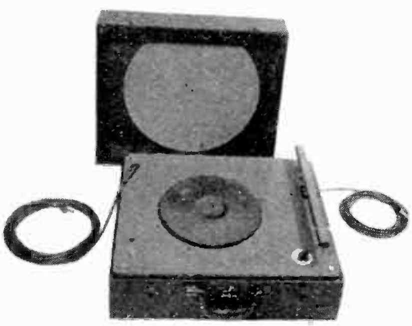

Fig. 15 The new RCA portable variable-speed record player for use with PA systems.

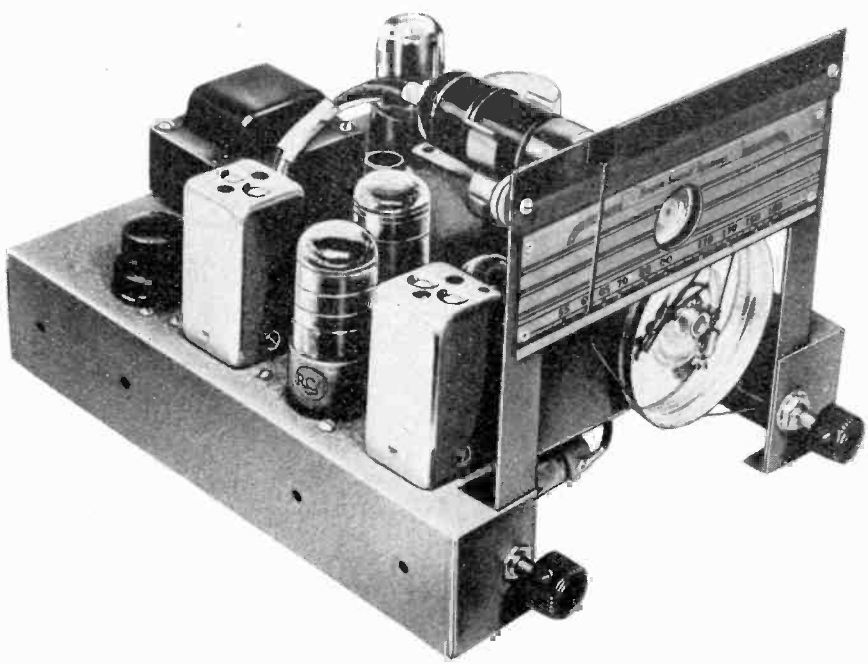

Fig. 16 A radio tuner especially designed for use with PA systems—made by the Bogen Company.

Remote Control Equipment

Some types of amplifiers use "electronic" mixing in which the gain of a tube is controlled by a varying DC bias applied to one or more of its grids. When this type of circuit is used, it is quite simple to extend the controls some distance from the amplifier. In many installations this is an advantage since it permits a small control box to be placed anywhere in the room or auditorium, leaving the amplifier nearer the microphones. Since all amplifiers do not have this type of mixing, it is not always possible to attach a remote control to them. If this feature is considered desirable for a particular installation, it is well to make certain when choosing an amplifier that it may be equipped with these facilities. Some more complicated arrangements provide remote tone controls, but these are uncommon and the use for them is very limited.

If complete remote control is necessary, it is advisable to install a separate pre-amplifier for each microphone or other input, and to connect their outputs at low impedance to a mixer panel which may be located anywhere that is convenient. The outputs of the various mixer controls may all be connected to an inclusive control, and may be followed by any required type of tone control, equalizer, or filter, prior to feeding the booster and power amplifiers.

Turntables and Pickups

Many PA installations require the use of a phonograph turntable for reproduction of recorded music in various forms. For restaurant use, for example, a changer is often desired, preferably one which will play at least ten or twelve records. For many uses, a simple turntable and pickup are quite sufficient, however, and the application will determine which is to be employed.

Turntables and pickups comprise a subject that will probably never be settled completely. Some users prefer crystal pickups while others prefer magnetic or dynamic types. Some prefer rim-drive motors, while others prefer different types. Each has its advantages and limitations. The choice will be governed largely by the cost and the importance of the application. For best results, it is well to choose a heavy-duty motor, regardless of the type of drive employed. Fig. 15 shows an excellent portable record player designed for use with PA equipment.

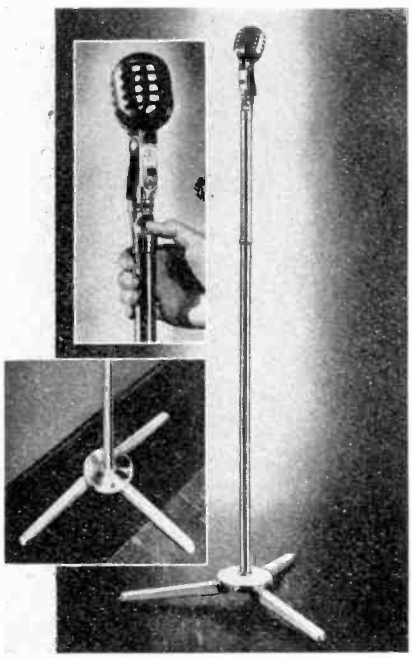

Fig. 17 The new Electro-Voice floor-type microphone stand.

The crystal pickup used for phonograph records is somewhat easier to equalize, especially when used with an amplifier with high-impedance inputs. High quality magnetic or dynamic pickups are of considerably lower output level than the crystal types, and they require as much equalization, though of a different type. The recording characteristic used with ordinary phonograph records will not reproduce "flat" with *any* type of pickup unless some equalization is employed. Crystals must be equalized on the high-frequency range, and magnetic and dynamic pickups must be equalized on the low-frequency range.

Radio Tuners

While many PA installations require the use of a radio tuner, it seems that there are very few of these devices on the market that are designed especially for this application. There are, however, a few high quality tuners which will give excellent reproduction from radio pickup. For applications which require this service, an ordinary radio set may be connected to the phono input of a standard PA amplifier simply by running a shielded wire from the "high side" of the volume control on the radio set to the amplifier. This arrangement is not particularly recommended for permanent installations, but will serve when a radio input is required for occasional use. For permanent use, a tuner especially designed for this purpose, such as the one shown in Fig. 16, should be installed.

Miscellaneous Items

A complete PA installation will require the use of a number of miscellaneous items, among them being cable connectors, line transformers, microphone stands, fuse boxes, and the items of wiring and cabling. The latter items will be described in a section of this series under "Installation." Cable connectors are required for microphone and speaker circuits. For the former, several satisfactory types are available. Amphenol cable connectors are suitable for permanent indoor installations, where the connections are not often disturbed. For outdoor use and for portable equipments, heavier plugs and receptacles

→ To Following Page

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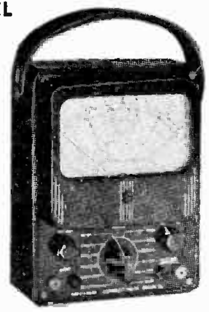

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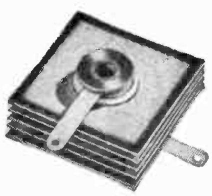

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Sound Equipment

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of Cannon or Hepco manufacture are much more satisfactory. Speaker circuits are best connected by means of Hubbell "Twist Lock" plugs and receptacles. To avoid possible damage from plugging speakers into power circuits, it is advisable to use three-wire plugs for the speaker circuits.

When low-impedance microphones are used with amplifiers having only high-impedance input circuits, it is possible to use transformers designed to be connected in the cable circuits between microphone and amplifier. These units are not much larger than a standard cable plug, and are generally provided with male and female ends for direct connection with standard cable plugs. The only precaution regarding their use is to make sure that they are not exposed to AC fields, causing hum pickup.

Microphone stands appear to be a very simple problem—until you have chosen the wrong type and have to put up with its limitations. Stands are available in a number of forms for different purposes. For general use in permanent installations, the use of heavy-based stands is suggested, with as noiseless a means of adjusting height as it is possible to obtain. Fig. 17 shows a stand which will give excellent all around results. The height adjustment mechanism is quiet and easy to use. Flexible couplings are available for isolating vibrations of the floor from the microphone itself. Lightweight, collapsible stands similar to music racks are convenient for use in portable systems, although they are limited to use with lighter microphones. When heavy microphones are used on light stands, there is a great possibility of their being upset. Short stands are particularly useful when microphones are to be used for dinners and banquets. They are similar in appearance to ordinary floor stands, but shorter in length. Deskstands of various types are available, and in some cases they are equipped with flexible "gooseneck" tubing, permitting adjustment to almost any required position. For use around a piano, a "boom" type stand is useful, supporting the microphone where desired at a distance of some three to four feet from the stand proper.

For complete protection, both sides of the power line feeding an amplifier should be fused. When the amplifier itself is not fused, a small box can be made up containing two plug fuses—one for each side of the line. A line cord and one or more outlet receptacles should be provided.

Conclusion

This compilation of the characteristics of PA equipment is offered with the desire to familiarize the prospective PA man with the problems involved, and the factors that must be considered in the assembly of a complete system. The installation of PA systems is not complicated, but there are a number of "rules of the thumb" that must be followed to achieve success, as well as the personal satisfaction of doing a good job. ✓ ✓ ✓

More PA articles are on the way in forthcoming issues of RADIO MAINTENANCE

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Service Bench

→ From Page 17

to repair the voice coil. If it is possible to take the speaker apart, proceed as follows: If the speaker has a felt dust cap, place a few drops of acetone on the edge of the cap, and after a few moments, gently pull it off. If the dust cap is of paper and is part of the cone itself, it will have to be cut out (it can be replaced later with a piece of felt). Next, the spider should be loosened. If it is a glued ring, loosen it by applying acetone. Now the outer edge of the cone should be loosened. Place three shims of equal thickness around the voice coil as shown in Fig. 1. The spider may then be fastened. When the spider is in place, the outer edge of the cone should be tightened.

Warped voice coils may often be repaired by removing the cone from the speaker, carefully applying acetone to the voice coil until it has softened, and then placing a cork cut to proper size in the coil as shown in Fig. 2. When dry, the coil should be

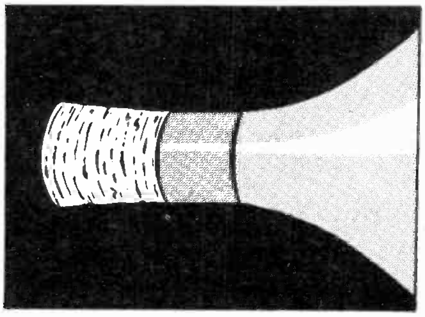

Fig. 2 Cork is placed in voice coil as shown.

coated with a thin mixture of cement.

A loose voice coil can be repaired by rubbing it with the fingers in the direction of winding and then applying a coat of thinned cement. Several layers of cement are usually necessary.

Torn cones can usually be repaired, providing the tear is not too large. Quite long tears which run parallel to the outside rim of the speaker as in Fig. 3A, can be repaired with a strip of paper. If the tear runs from the center of the speaker toward its outer edge, as in Fig. 3B, and is over an inch or two long, it is not practical to repair it due to the way in which the cone must flex in normal operation.

Loss of bass response in a speaker is an indication of a weakened magnet or a shorted field. If the difficulty is in the magnet, the magnet may be remagnetized with a coil consisting of approximately one pound of #16 wire and a 6-volt storage battery. A small compass will be found helpful in order to find the proper direction of magnetization.

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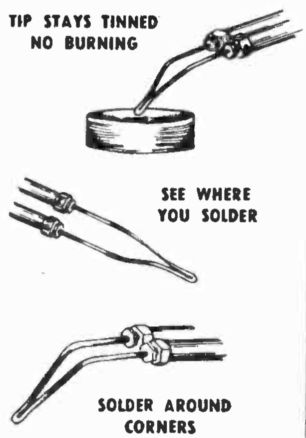

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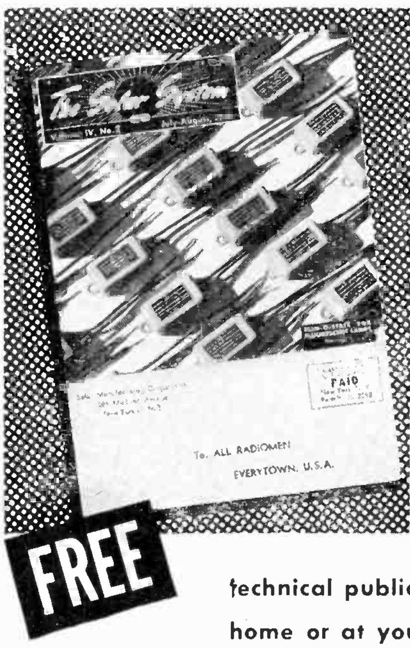

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FM TROUBLESHOOTING

→ From Page 11

the transformer in the limiter plate circuit should be tuned to give the proper resonance curve around the intermediate frequency. This curve should be flat within 3 db from 75 kc below to 75 kc above the nominal IF. The actual types of tuned circuits may differ from one manufacturer to the next, but it can usually be assumed that the coupling and loading of the transformers are correct. Usually, only the resonant frequency will have to be readjusted if a tube is replaced.

In the case of all IF stages prior to the limiter, one must again exercise special precautions. In normal operation, the limiter draws grid current and consequently loads down the tuned circuit at the limiter grid. Since the grid circuit loading also affects the tuning, the IF stages ahead of the limiter must be tuned when a large signal is impressed on the limiter grid. To align each of these stages, connect the signal generator to the grid, and the DC voltmeter across the AVC condenser in the limiter grid circuit. Since the AVC voltage is proportional to the signal level at the limiter grid, these DC voltage readings are a good measure of the signal strength. The overall response from the first IF tuned circuit to the limiter grid should be flat within 3 db over a range of ±75 kc from the nominal intermediate frequency. It must be strictly emphasized that any DC readings in the *Discriminator output* have no relation to the frequency response of the IF stages ahead of the limiter. All DC measurements, in this respect, must be made in the *limiter* grid circuit (such as across the AVC condenser). Furthermore, since the AVC voltage is usually small, and since the AVC resistor is usually large, the resistance of the voltmeter must be very high, which virtually dictates the use of an electronic voltmeter.

The manufacturer will usually give sensitivity figures, or it may be determined in other ways that the gain of the IF section is too low. In this case, tubes should be tested and biases should be checked. In many cases, the gain may be increased by increasing the screen potential, reducing the grid bias, or by tapping down on the AVC resistor so that not too much AVC bias is fed back to the IF grids.

With the IF sections properly aligned, we can turn to the RF amplifier (if any) and converter sections of the receiver. In the simplest setup, the only test equipment needed for RF is a rudimentary oscillator with just a few calibrated frequencies in the FM band. This will be enough to align the local oscillator to track properly. The RF signal is fed to the grid of the mixer and the separate trimmer controls of the local oscillator are adjusted so that it beats with the RF to give the correct intermediate frequency. The RF oscillator should be at a frequency in the FM band, around 100 mc. If the IF is 10 mc, the local oscillator will be 10 mc higher or lower in frequency than the RF oscillator, depending upon the manufacturer.

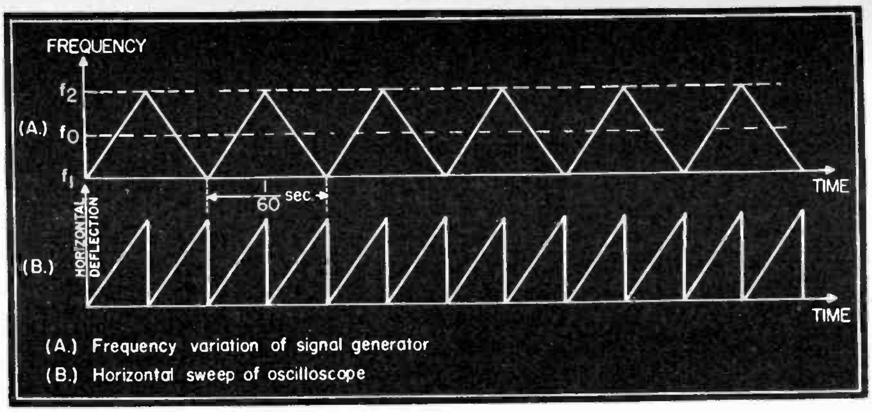

Fig. 7 The frequency variation of the signal generator and its relation to the horizontal sweep of the oscilloscope.

The condition of proper tracking can be easily recognized by a maximum voltage reading on the DC voltmeter in the limiter grid circuit.

It now remains to align the RF tuned circuit. Since the receiver is now quite sensitive, and since the local oscillator is properly aligned, the RF section can be aligned against actual broadcast signals. Two or three different stations, at either end of the band and in the middle can be picked up. The RF trimmer adjustments should be made against these broadcast stations so that maximum DC voltage is observed in the limiter grid circuit. The receiver should now be sensitive, selective, and sufficiently broad band for high fidelity reception.

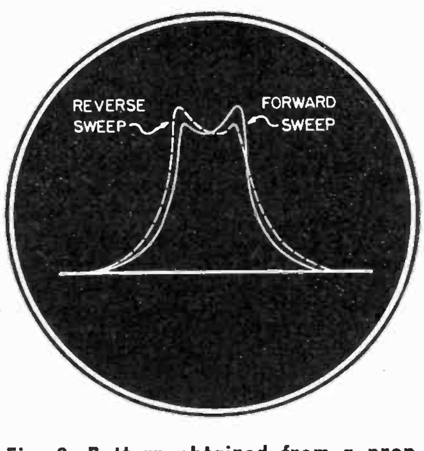

Fig. 8. Pattern obtained from a properly aligned discriminator using the method described in the text.

The foregoing description of alignment procedure with regard to FM receivers is based on the assumption that only a minimum of test equipment is available. However, one must be prepared to pay in time for what one does not possess in test equipment. With the above material as a basis, we can now progress to more elaborate test setups for alignment purposes.

Frequency Swept Signal Generator

In the first of these articles on FM troubleshooting, we described briefly the use of a frequency swept signal generator and oscilloscope in testing the discriminator, limiter, and IF stages of an FM receiver. It was pointed out how valuable a time-saver this apparatus would prove to be since, in a single presentation on the oscilloscope screen, the entire frequency response of a given stage or group of stages can be observed in one glance. The following is a description of the way in which this equipment is used.

The frequency swept signal generator normally has the following adjustments:

1. IF mid-frequency
2. Extent of frequency deviation
3. Attenuator adjustment for controlling the amplitude of the signal
4. Marker frequency control, which produces a pip on the oscilloscope pattern at a desired frequency (or pair of frequencies) for identifying purposes.

Also, a synchronizing voltage or phasing control is usually available to lock the oscilloscope sweep to the sweeping rate of the signal generator. The frequency of the signal generator is swept by a motor-driven condenser which rotates at a 60-cycle rate. Thus, sixty times per second, the signal frequency changes from the lowest to the highest frequency and back. The variation of frequency versus time is a triangular wave, as shown in Fig. 7a. This triangular wave has a repetition rate of sixty full sweeps per second. The oscilloscope horizontal sweep is normally a 120-cycle sawtooth as shown in Fig. 7b. The final result of this combination of waveforms is that during one sweep of the oscilloscope, the frequency response of the stage under test is presented as the frequency is swept from the lowest frequency F-1 to the highest F-2. During the next sweep across the screen, the reverse pattern is presented, corresponding to the same frequency response as the signal frequency is swept from f-2 to f-1.

By proper synchronization and phasing of the sweep generator and the horizontal deflection of the oscilloscope, a symmetrical and centered pattern of the frequency response is seen at all times. This is illustrated in Fig. 8.

The alignment of the IF stages is accomplished by connecting the oscilloscope across the AVC resistor in the limiter grid circuit, and connecting the frequency-swept oscillator to each successive grid of the IF strip. The mixer output transformer can also be aligned by connecting the frequency-swept IF signal generator to the mixer grid. Again, a useful oscilloscope pattern is presented, and this will be the true IF response. The picture should be similar to Fig. 8 (which shows a reverse pattern). The alignment is best done stage by stage, moving the signal generator successively from the grid of the last IF amplifier stage back through the receiver to the grid of the mixer stage.

One very important point should be kept in mind. The response of the IF amplifier cannot be measured at any point beyond the limiter grid. Therefore the oscilloscope (or DC voltmeter) must be connected across the AVC circuit or across the screen grid of any of the IF stages. This point is very important since the limiter completely distorts the amplitude variations of all signals, and its output is in no way related to the frequency response of the circuits ahead of the limiter.

Test Procedure Summary

The following is a review of the procedure to be followed in checking an FM receiver.

(1) Check audio amplifier for high fidelity response—feed at any point as far back as the discriminator output, and measure signal across the speaker. If an oscilloscope is available, monitor the audio signal to find source of distortion.

(2) Check discriminator for alignment and balance, according to the detailed discussion of the discriminator.

(3) Check limiter for alignment and threshold voltage. Apply voltage from a signal generator to the grid of the IF stage ahead of the limiter and measure:

(a) Discriminator output for threshold and limiting action;

(b) DC bias developed across limiter grid to check alignment of interstage transformer between last IF and limiter.

(4) Line up the IF amplifier stage by stage using any of the methods applicable to the test equipment available. Apply the signal generator to successive IF grids and always measure the DC bias developed in the limiter grid circuit.

(5) Check local oscillator tracking by AM methods.

(6) Check RF amplifier by AM methods. To perform (5) and (6), high frequency measuring techniques must be employed.

The particular test equipment required in each of these tests depends

→ To Following Page

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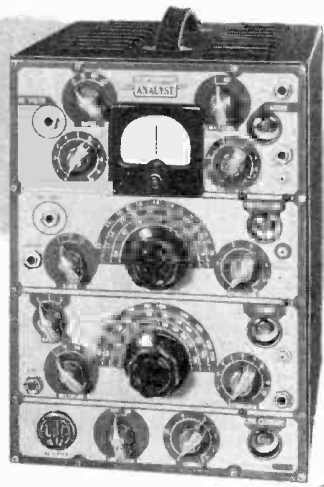

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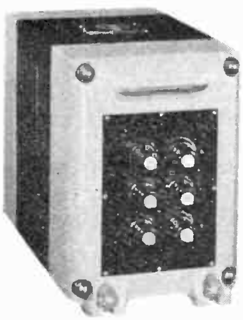

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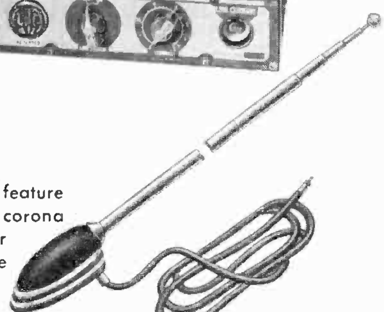

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FM Troubleshooting

→ From Preceding Page

upon the equipment available to the technician. The better the test equipment used, the better the job. Good test equipment makes it possible to align and repair FM receivers quickly and efficiently. ✓ ✓ ✓

Oscillographs

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out circle or oval. The ellipses will similarly be distorted.

If the two voltages are in phase (no phase difference) but differ in frequency, interesting patterns like those of Fig. 7 result. Fig 7 shows a 1:2 ratio in frequency. A is for the voltages in phase, B for a 180° phase difference. Note that the same basic pattern applies, regardless of phase. Phase differences anywhere between 0° and 360° will produce patterns which lie somewhere between A and B.

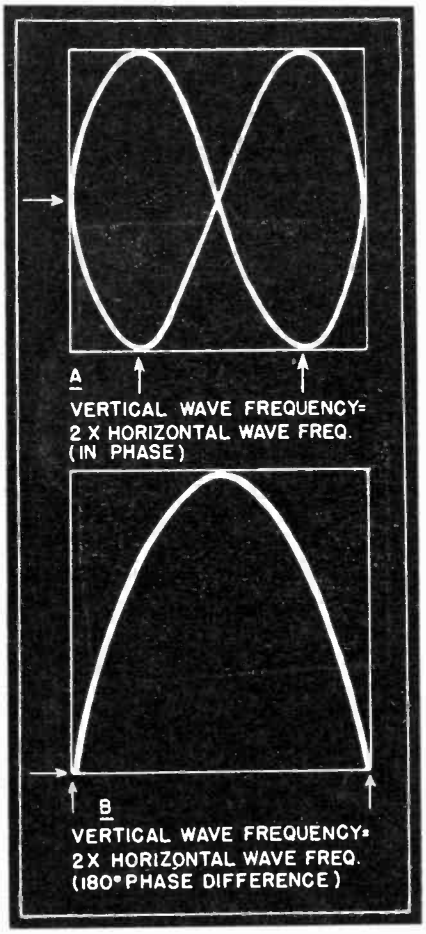

Fig. 7 *A* shows the pattern obtained when two voltages in phase (one which is twice the frequency of the other) are applied to the vertical and horizontal plates of a cathode-ray tube. *B* shows the pattern obtained from the same voltages when one is 180° out of phase with the other.

Fig. 8A is for a 2:3 ratio with some phase difference also.

It will be noted that if a square or rectangle be drawn about the pattern of Fig. 7 (A or B), the horizontal sides of the square will be touched by the pattern at two points, and the vertical sides of the square will be touched by the pattern at one point. Remember that the frequency of the vertical wave was twice that of the horizontal wave. This shows the general rule: The ratio of the horizontal wave's frequency to the vertical wave's frequency equals the ratio of the number of points at which the pattern figure is tangent to (or touches) a vertical line, to the number of points at which the figure is tangent to a horizontal line.

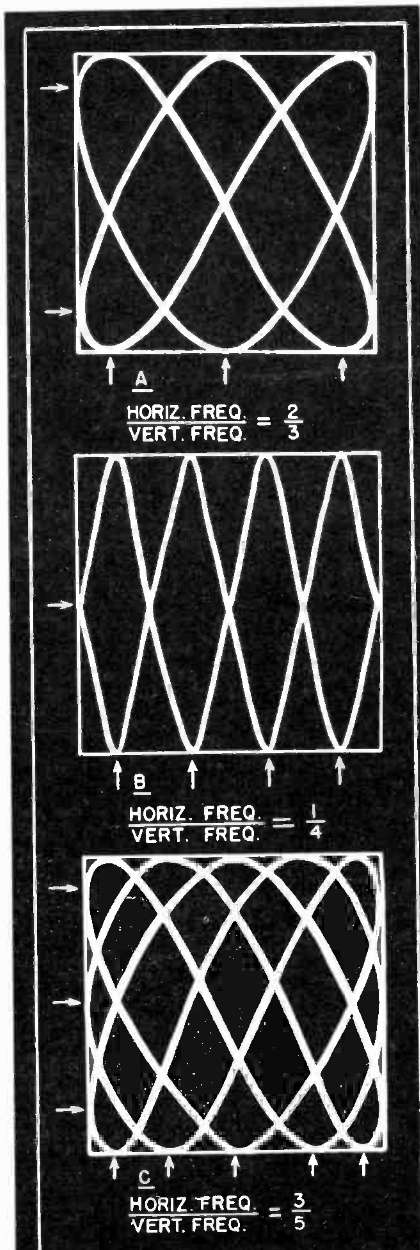

Fig. 8 *A* is the pattern for a 2:30 frequency ratio between the horizontal and vertical voltages; *B* with a 1:4 ratio; and C with a 3:5 ratio.

Note how this rule works out for Fig. 8A also. Here a horizontal line of an enclosing square will be touched at 3 points; a vertical side will be touched at 2 points. The horizontal wave frequency is 2:3 times the vertical wave frequency.

Fig. 8B shows a 1:4 ratio, and Fig. 8C shows a 3:5 ratio.

Other very interesting and instructive patterns can be obtained with different frequency ratios, and with phase and amplitude differences. In all cases, if the simple rules laid down above are applied, complete information about the waves can be obtained. (Ed. Note: The next article in this series will discuss the circuits used in the oscilloscope. It will be followed by a group of articles on use.) ✓ ✓ ✓

Electronically Speaking

→ From Page 18

acoustical or mechanical force, and has a stiffness factor which prevents buckling or wrinkling. The weight and size of the multi-weave design are determined by the gage of the material desired, and the machine makes single or multiple, wide or narrow strands in a variety of colors and finishes.

Some possible applications are air conditioning and heating grilles, window blinds, screens, protective railings and attractive flooring.

Television was demonstrated at the Iowa State Fair, August 21-30, when International Harvester and Station KRNT presented an extensive series of television programs in cooperation with RCA Victor. RCA's new Image Orthicon television cameras were shown for the first time in a field demonstration of closed circuit television.

There was a varied series of programs showing prize winners of all sorts which the super-sensitive cameras were able to record even in dim light. The television crew of technical and programming experts from RCA Victor covered horse races, stock shows and other events.

Complete studio facilities were exhibited at the Fair and twelve television home receivers including several experimental large-screen projection models, were installed. ✓ ✓ ✓

Radiomen's Opinions

→ From Page 20

set, the chassis is made in two parts. To take a voltage check, it is necessary to pull the two halves of the chassis apart and disconnect two leads from the translator coil. In this state, the receiver is not in operating condition. However, rather than hang these gentlemen, don't you believe that, if they were made to service a few of these sets themselves, conditions would change in a hurry?

I have one criticism to offer in regard to the June-July issue. Why seventeen pages of advertisement for the Silver "Vomax"? You know this instrument is good, I know it is good, and I believe that any radio man who will read the technical details will realize that it is a very fine instrument. This instrument with its known high performance and low price, compared with any other vacuum tube voltmeter which I know about, should sell without advertising.

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CLARENCE F. HARTZELL
2527 Eighth Avenue
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Very truly yours,
EDWIN W. JACOBSEN
30 Martinview addition
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Yours very truly,
LEVI ROSS
820 East 16 Avenue
Pine Bluff, Ark.

Trade Literature

→ From Page 19

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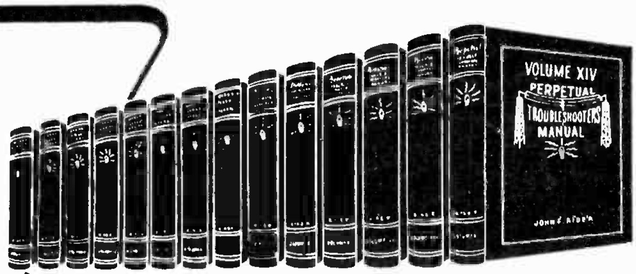

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Akron—Olson Radio Warehouse
Ashtabula—Morrison Radio Supply
Canton—Armstrong Radio Supply
Burroughs Radio
Cincinnati—Chambers Radio Supply Co.
Schuster Elec. Co.
United Radio, Inc.
Cleveland—Goldhamer, Inc.
Northern Ohio Laboratories
Winteradio, Inc.
Columbus—Hughes-Peters, Inc.
Whitehead Radio Co.
Dayton—Hughes-Peters, Inc.
Standard Radio & Electronic Prod. Co.
East Liverpool—Hausfeld Radio
Kent—Kladag Radio Labs.
Lima—The Northwestern Radio Co.
Mansfield—Burroughs Radio
Marion—Bell Radio Supply
Springfield—Standard Radio & Electronic Prod. Co.
Steubenville—D & R Radio Supply
Hausfeld Radio
Toledo—Toledo Radio Specialties
Warren—Radio Specialties
Youngstown—Appliance Wholesalers

OKLAHOMA

Enid—Standard Measuring & Equip. Co.
Oklahoma City—Radio Supply, Inc.
Southern Sales Co.
Tulsa—Radio, Inc.

OREGON

Portland—Bargelt Supply
Harper-Meggee, Inc.
Portland Radio Supply Co.

PENNSYLVANIA

Allentown—Radio Elec. Serv. Co.
Beaver Falls—Reliable Motor Parts Co.
Easton—Radio Elec Serv. Co.
Erie—John V. Duncombe Co.
Harrisburg—Radio Distributing Co.
Lancaster—Eshelman Supply Co.
George D. Barbey Co.
Norristown—Kratz Bros. Co.
Philadelphia—Almo Radio Company
Consolidated Radio Corp.
Electric Warehouse
Emerson Radio of Pa.
Radio Elec. Serv. Co.
N. W. Cor. 7th & Arch Sts.
5133 Market St.
3145 N. Broad St.
Eugene G. Wile
Pittsburgh—Hamburg Bros.
The John Marshall Co.
Radio Parts Co.
Pottsville—Jones Radio Co.
Reading—George D. Barbey Co.
St. Marys—B & R Electric Co.
Scranton—Broome Dstg. Co., Inc.
Wilkes-Barre—General Radio & Elec. Co.
Radio Service Co.
Williamsport—Williamsport Radio Supply

RHODE ISLAND

Providence—William Dandreta & Co.
W. H. Edwards Co.

SOUTH CAROLINA

Columbia—Dixie Radio Supply Co.

SOUTH DAKOTA

Aberdeen—Danielson & Brost Co.
Sioux Falls—Power City Radio Co.
United Radio Supply

TENNESSEE

Knoxville—Bomar's
Chemcity Radio & Elec. Co.
C. M. McClung & Co.
Memphis—McTyier Radio Supply
Nashville—Currey's Radio Service
Radio & Appliance Corp.

TEXAS

Abilene—R & R Supply Co., Inc.
Amarillo—R & R Supply Co., Inc.
Austin—The Hargis Company
Beaumont—Montague Radio Co.
Corpus Christi—Wicks-DeVilbiss Co.
Electronic Equip. & Engin. Co.
Dallas—All-State Dstg. Co.
Crabtree's Wholesale Radio
Southwest Radio Supply
Wanslow & Co.
Fort Worth—Electronic Equipment Co.
Fort Worth Radio Supply Co.
Houston—A. R. Beyer Company
Lubbock—R & R Supply Co., Inc.
San Antonio—Olsen Radio Supply
Tyler—Lavender Radio Supply Co.
Waco—The Hargis Company
Wichita Falls—Wichita Falls Bat. & Elec.

VIRGINIA

Norfolk—Ashman Distr. Company
Roanoke—Leonard Elec. Sup. Co.
Richmond—Johnston Gasser Co.

WASHINGTON

Bellingham—Waitkus Supply Co.
Seattle—General Radio, Inc.
Harper-Meggee, Inc.
Sunset Electric Co.
Spokane—Harper-Meggee, Inc.
Tacoma—Wible Radio Supply

WEST VIRGINIA

Bluefield—Whitehead Radio Co.
Charleston—Chemcity Radio & Elec. Co.
Hicks Radio Supply
Clarksburg—Trenton Radio Co.
Huntington—Electronic Supply, Inc.
Morgantown—Trenton Radio Co.
Parkersburg—Randle & Hornbrook
Wheeling—Wheeling Radio Supply

WISCONSIN

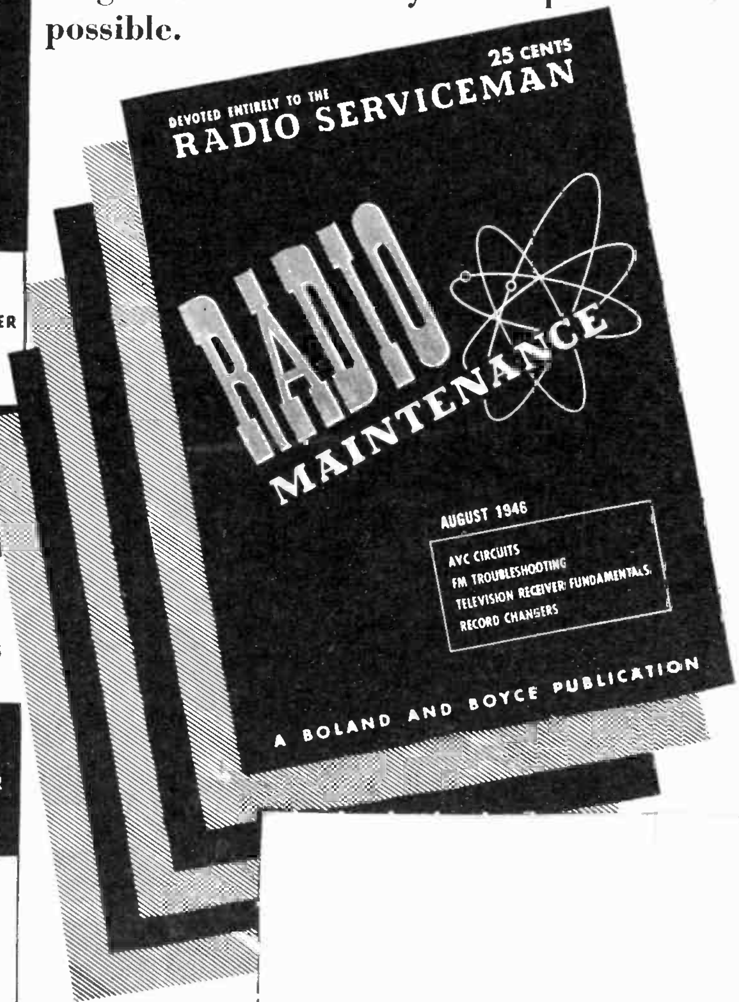
Green Bay—Neslo Electronic Dstrs.
Madison—Radio Dstrs. of Madison, Wis.
Milwaukee—Radio Parts Co., Inc.

M RESISTORS

*REG. U. S. PAT. OFF.

MORE BACK NUMBERS

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



OCTOBER 1945
- ANTENNAS FOR FM AND TELEVISION
- BUSINESS MANAGEMENT FOR THE RADIO DEALER
- RADIO MAINTENANCE FOR AVIATION
- USING THE SIGNAL GENERATOR AND OSCILLOGRAPH

JANUARY 1946
- THE PROBLEMS OF ORGANIZATION
- TELEVISION RECEIVER INSTALLATION
- RADIO MAINTENANCE IN AVIATION
- USING THE OSCILLOGRAPH FOR DISTORTION MEASUREMENTS

FEBRUARY 1946
- MODERN BENCH CONSTRUCTION
- SYMPOSIUM ON TEST EQUIPMENT
- FUNDAMENTALS OF VACUUM TUBE VOLTMETERS
- REPAIR OR RECONDITIONING

MARCH 1946
- TROUBLESHOOTING TELEVISION RECEIVERS
- APPLICATIONS FOR LOW COST SIGNAL TRACER
- RADIO REPAIRMEN'S ASSOCIATIONS
- RADIO SERVICE ALONG THE AIRWAYS

APRIL 1946
- PA SYSTEMS
- A MIDGET AUDIO FREQUENCY OSCILLATOR
- IF I WERE A SERVICEMAN
- AN EQUALIZED AMPLIFIER FOR MAGNETIC PICKUPS

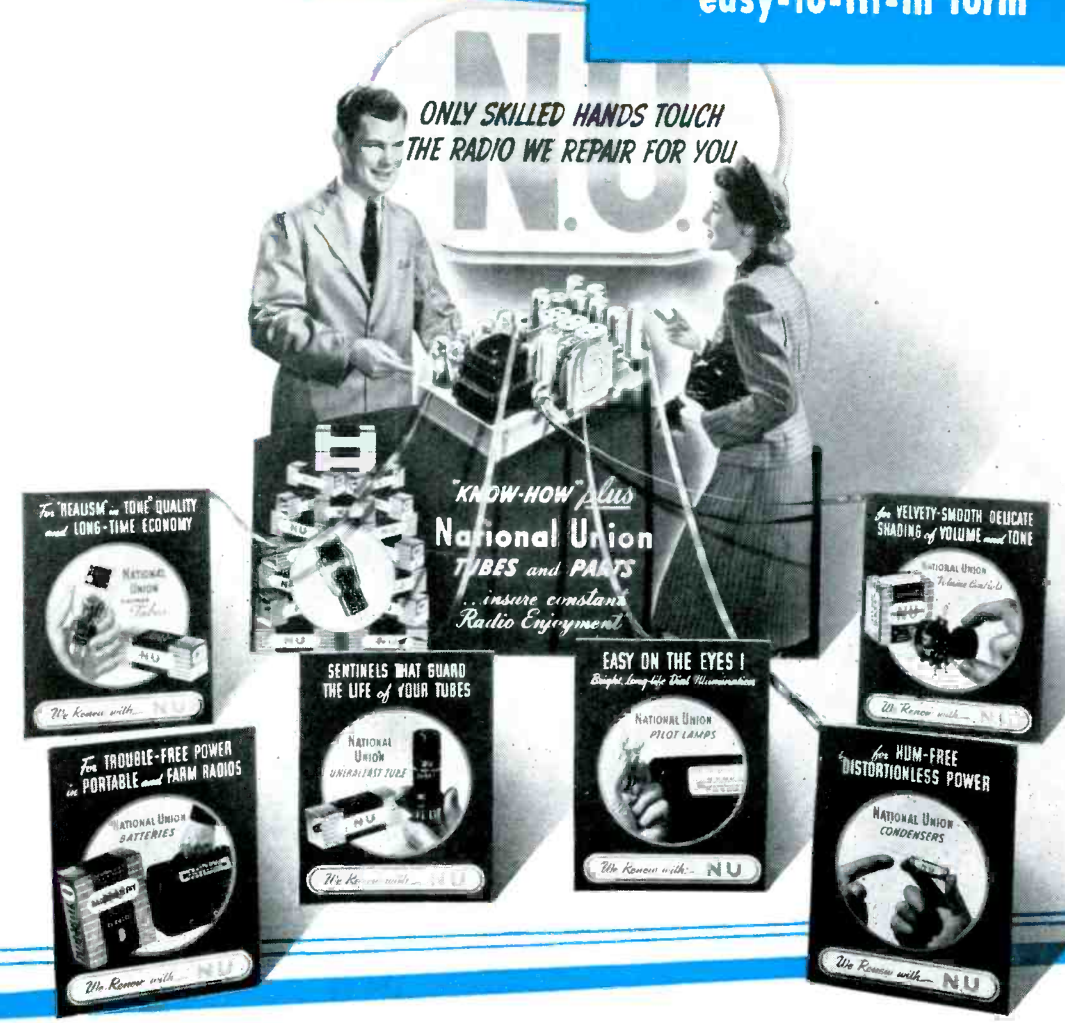
MAY 1946
- P A SYSTEMS
- TEST PANEL FOR THE MODERN BENCH
- RINGING THE BELL

JUNE-JULY 1946
- FUNDAMENTALS OF TELEVISION
- VOLUME CONTROL TAPERS
- THE ELECTRONIC VOLT OHMMETER
- VECTOR ANALYSIS

AUGUST 1946
- AVC CIRCUITS
- FM TROUBLESHOOTING
- TELEVISION RECEIVER FUNDAMENTALS
- RECORD CHANGERS

NEW 7-PIECE STORE DISPLAY FOR N.U. DEALERS

A store-wide promotion in a new, flexible, easy-to-fit-in form



Order yours today from your N. U. Distributor

Be one of the first to show this brand new display idea—that sells your service skill and tells customers how and why you can insure their radio enjoyment. Full of life, action and interest—printed in 10 colors on heavy cardboard—each unit is a complete display with easel and ribbon streamer. Display them as a group or as individual window, counter or shelf cards. Order from your N.U. Distributor now for immediate shipment.

NATIONAL UNION RADIO CORPORATION, NEWARK 2, NEW JERSEY

NATIONAL UNION

RADIO TUBES AND PARTS

Transmitting, Cathode Ray, Receiving, Special Purpose Tubes • Condensers • Volume Controls • Photo Electric Cells • Panel Lamps • Flashlight Bulbs

IMMEDIATE DELIVERY

New 30-WATT AMPLIFIER!

Cast Aluminum
25 lbs.

MECK
MODEL A-30

3 INPUT CHANNELS, 2 MICROPHONES, AND 1 PHONO, ALL WITH SEPARATE CONTROLS

- ☆ Attractive lightweight cast aluminum housing, 14⅝" x 9¾" x 8½".
- ☆ 30 Watts at impedances of 4, 8, 15 and 250 ohms.
- ☆ Illuminated transparent plastic dial.
- ☆ Two distinctly separate frequency response controls . . . 1 for treble boost . . . 1 for bass boost.
- ☆ Built-in remote control circuits for both microphone channels.

— COMPARE THESE FEATURES —

NEW STANDARDS OF FREQUENCY RESPONSE CONTROL

The Meck A30 Amplifier is equipped with two distinctly separate frequency response controls—1 for treble boost and 1 for bass boost. The adjustment of either or both of these controls does not appreciably affect the over-all volume of the amplifier. These controls may be quickly adjusted from the front panel to give any variation from straight line frequency response between 40 and 10,000 cycles to any combination of broad band bass boost and broad band treble boost.

MICROPHONE AND PHONO INPUTS

Any high impedance dynamic or crystal microphone may be connected to either of the two identical channels. Any high impedance phonograph pickup may be connected to the Phono input channel. All cable connectors are marked and located on the rear of the amplifier.

OUTPUT CONNECTIONS

The two speaker plugs furnished and the speaker sockets located on the rear of the amplifier chassis provide a convenient means for connecting speakers to the amplifier . . . Speaker load impedance is adjusted by connecting the spade lug on the terminal strip to the proper tap 4, 8, 15 or 250 ohms. Additional 2 ohm and 500 ohm taps are available at the output transformer.

REMOTE CONTROL CIRCUITS

Remote volume control circuits for both microphone channels are built into the amplifier so that the volume of either microphone channel may be controlled up to 1000 feet from the amplifier using any 2 conductor unshielded cable and an inexpensive control box.

TUBE COMPLEMENT

2—6SF5—As microphone preamplifiers.
1—6SL7—Dual triode cascaded as voltage amplifier and grid choke driver for the power amplifiers.
2—6L6G—Power amplifiers in push pull.
1—5U4G—Power rectifier.

POWER REQUIREMENTS

Amplifier operates on 105-124 volts 60 cycles AC current only. Power consumption is 175 watts. Power circuit is fused with a 3 ampere type 3AG easily replaceable fuse mounted on the rear of the chassis.

ASK YOUR MECK JOBBER

MECK SOUND AMPLIFIERS

J. M. I. SALES CORPORATION · 35 E. WACKER DRIVE, CHICAGO 1, ILLINOIS