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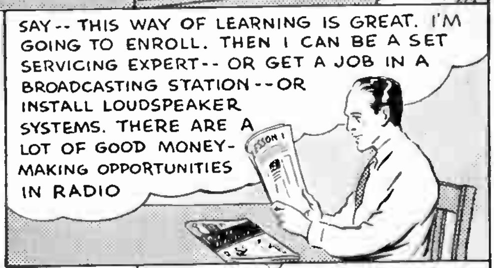

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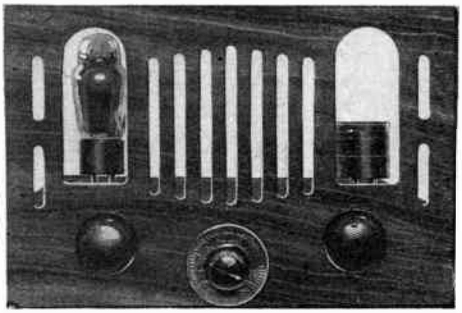

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Table of Contents for SEPTEMBER, 1937

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The Importance of CONSTANT IMPEDANCE

Controls in Public Address Circuits

By William H. Fritz
Centralab

WHY use constant impedance controls? A good question, and one that most radio servicemen and many public address installers would find difficulty in answering. We shall endeavor to explain why constant impedance controls must be used if performance commensurate with the investment is to be realized from a public address installation. We shall also explain how to connect such controls in circuit.

For purposes of explanation consider any source of power, an ordinary dry cell, for example. All dry cells generate voltage, or electromotive force, and possess internal resistance. Now if no load is placed across a dry cell's terminals, a high resistance voltmeter will measure the electromotive force (e. m. f.) generated by the battery with negligible current drain. Now let a heavy-duty variable resistance of low value be connected across the cell

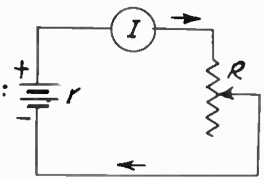

FIG. 1
E is a cell or battery across which is a low-ohmage rheostat, so that considerable current flows. The ammeter I reads the current.

and be varied from maximum to minimum values while current values for each resistance setting are observed. Our circuit would look like Fig. 1. In this illustration I is the ammeter for reading current at various settings of R, the external variable resistance. The internal resistance of the cell is indicated by r. The battery e. m. f. is indicated by E.

CURRENT AND POWER DETERMINED

By Ohm's law, the current drawn from the battery will equal the no-load e. m. f. of the battery divided by the total resistance of the circuit. This can be expressed by the equation

$$I = \frac{E}{R+r} \quad \ldots\ldots (1)$$

Knowing the e. m. f. and the internal resistance of the cell, we can calculate or observe the values of current that correspond with different settings of R, also the power dissipated in this load resistor. The general equation for power is

$$P = I^2R \quad \ldots\ldots (2)$$

For our particular case, the power dissipated in the load resistor can be written

$$P = \left(\frac{E}{R+r}\right)^2 \times R \quad \ldots\ldots (3)$$

This is obtained by substituting for I from equation (1) in equation (2). The internal resistance of a typical dry cell is about .05 ohm and the no-load e. m. f. about 1.5 volts. We can

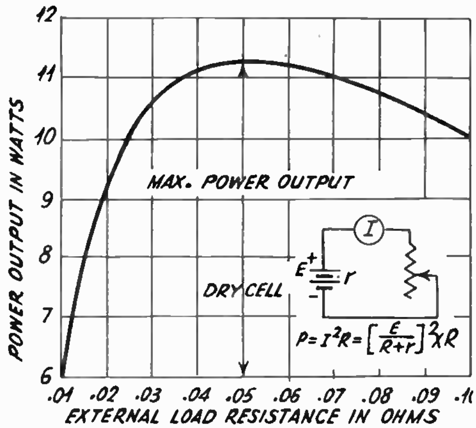

FIG. 2
Output power is compared to various settings of the rheostat in this curve. This illustrates the principle that if maximum power is to be transferred, the resistance of the load must equal the internal resistance (.05 ohm) of the generator.

substitute these values in equation (3). So doing, gives us

$$P = \left(\frac{1.5}{R+.05}\right)^2 \times R \quad \ldots\ldots (4)$$

(Continued on following page)

(*Continued from preceding page*)

Substituting values for R in equation (4), we get the following tabulation for values of output power, P, corresponding to different settings of R.

R Ohms	*P* Watts
.01	6.25
.02	9.2
.03	10.7
.04	11.1
.05	11.25
.06	11.2
.07	11.0
.08	10.7
.09	10.4
.10	10

MOST POWER WHEN R = r

These values, when plotted with power output as a function of external load resistance, form the curve shown in Fig. 2.

This curve illustrates a very important principle, namely, if maximum power is to be transferred from a generating source into its load, the resistance of the load must equal the internal resistance of the generator. Now how does all this apply to public address circuits? We have been talking about direct current batteries and load resistors. The currents flowing in microphones, transmission lines, amplifiers and speakers are alternating at voice and music frequencies.

Fortunately the same principle applies, whether we are dealing with direct current and plain resistance, or alternating current and complex impedances. The principle as stated for direct current would be altered somewhat when alternating current is considered. It would be something like this: If maximum power is to be transferred from an alternating current source to an external load, the numerical value of the load impedance must equal the numerical value of the internal impedance of the generator. Now that we have some idea of the importance that impedance matching bears in public address circuits, we can proceed with the application of the principle.

Fig. 3 illustrates a typical sound installation of the simplest form. A carbon microphone with an internal impedance of 200 ohms is connected to the input of a conventional amplifier. The master gain control, usually connected as a grid potentiometer in the first or second amplifier stage, controls the volume in a perfectly satisfactory manner. A 200 ohm to grid input transformer is used at the amplifier input, and a plate to 8 ohm output transformer is used between the last stage tube plates and an 8 ohm speaker voice coil. At every junction of the three components in Fig. 3, impedance match is maintained. Under these conditions maximum output will be realized for any input at the microphone.

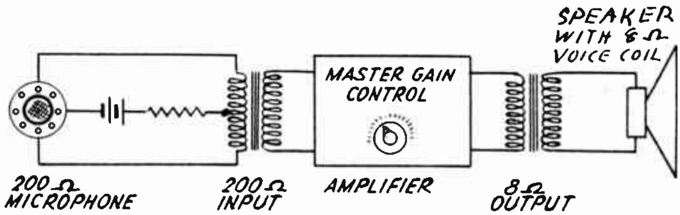

FIG. 3
Simplest form of typical sound installation. A microphone feeds a transformer primary. The secondary works into an amplifier. The speaker is connected to the amplifier through a matching transformer.

MORE COMPLEX EXAMPLES

If all sound installations were as simple as the one illustrated in Fig. 3, there would be no need for constant impedance attenuators, for all attenuating is done by means of the master gain control, which is a part of the amplifier proper. Most sound installations include two or more microphones or two or more speakers, in various combinations at input and output circuits. This is where constant impedance controls come into play. Before show-

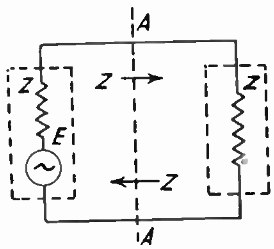

FIG. 4
Z is the impedance of the source of alternating voltage, and to this source is connected a load impedance, Z, of equal value. Dotted line indicates the usual place for injecting an attenuator at A.

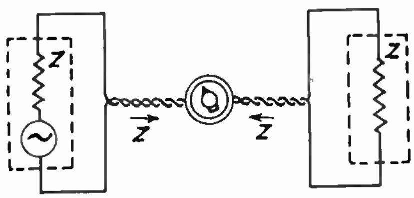

FIG. 5
The same source and load are present as in Fig. 4, but a constant-impedance control is inserted in the line. Volume now may be controlled from maximum to zero, yet the impedance in either direction through the control is constant and equal to Z ohms.

ing actual circuits with controls in place, we shall digress a little to illustrate how a constant impedance control operates.

Consider an alternating source of voltage of Z ohms internal impedance. This is connected to a load impedance of the same value. Fig. 4 illustrates this circuit. If the source is a microphone and the load is the amplifier input, it is frequently desirable to put an antenuator in the circuit at the point indicated by the dotted line, A-A, to control the volume level. While volume is varied from zero to maximum,

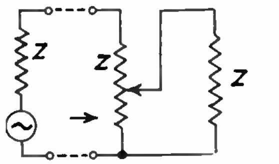

FIG. 6
Middle Z is always in series with the line voltage, except for maximum and zero voltage settings, hence impedance is inconstant.

the impedance looking in either arrow direction through the control must equal Z ohms for all settings.

Fig. 5 shows the same source and load as Fig. 4 with a constant impedance control inserted in the line. With this set-up, volume can be controlled from zero to maximum level, while the impedance in either direction through the control is constant and equal to Z ohms.

Ordinary potentiometer controls do not maintain constant impedance when they are rotated.

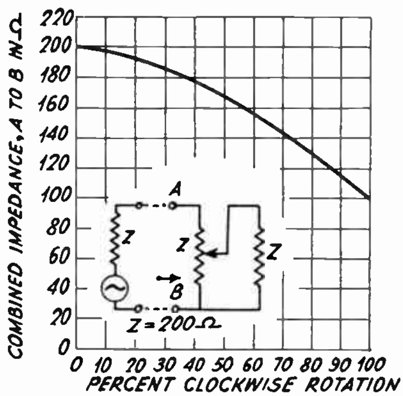

FIG. 7
In this curve the volume control positions, in degrees, are plotted against the effective impedance of A and B, in ohms, showing that for Z-200 ohms, the variation is from 100 to 200 ohms, or 50 per cent.

To illustrate this statement, we show a circuit in Fig. 6 with a potentiometer connected across the line as an attenuator. For all cases except zero and maximum volume positions, the upper part of the potentiometer resistance is in series with the line and the remainder or lower part shunts the load. If we assume that Z is 200 ohms and we plot the combined impedance of the potentiometer and load resistance against rotation, we obtained a curve like the one shown in Fig. 7. The control does not maintain constant impedance because the sum of the series and shunt portions of the control must always equal the maximum resistance of the control.

L PAD, PRO AND CON

A control with separate resistance sections of the correct values for the series and shunt

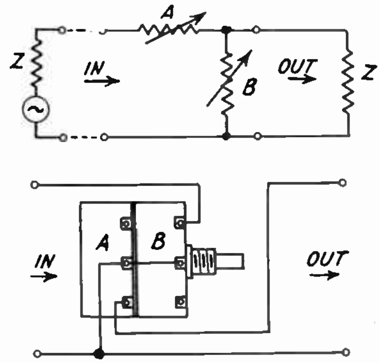

FIG. 8
Schematic and pictorial representations of an L pad. A is the series leg and B the shunt leg. This maintains constant impedance looking out but not looking in.

legs operated by a common shaft *will* maintain a constant load impedance on the source regardless of the shaft position. Such a control is known as an L pad.

Fig. 8 shows an L pad, both schematically and pictorially. A is the series leg and B the shunt leg. By using the correct values and properly tapering the resistance sections, an L pad will provide straight line attenuation and constant impedance looking through the control into the load. The L pad has one disadvantage, however. It does not maintain constant impedance looking from the load side back into the source.

The ideal constant impedance control is one that maintains constant impedance in both directions and provides straight line attenuation when it is rotated. By straight line attenuation, we mean that it attenuates any signal passing through it in direct proportion to the percentage of knob rotation. At the most counter-clockwise position the attenuation is infinite, the output is zero, and the impedance in either direction through the control equals the nominal line impedance. At the most clockwise position the attenuation is zero, the output is maximum, the previous impedance relations still hold, and there is no loss in the pad. In this position conditions are exactly the same as they would be if the control were entirely out of the circuit.

There are three fundamental circuits that can be used to approximate closely the functions of an ideal constant impedance control. They are the T pad, the π (pi) pad and the delta-T pad. Fig. 9 shows the three types, both schematically and pictorially. Notice that both the T and π types of control require three separate variable resistors operated by the same shaft.

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The delta-T pad, only recently made available to the trade by Centralab, requires two tapered variable resistors and two fixed resistors of the same resistance value as the line impedance. With this arrangement, a constant impedance control is available at little more than a good potentiometer costs.

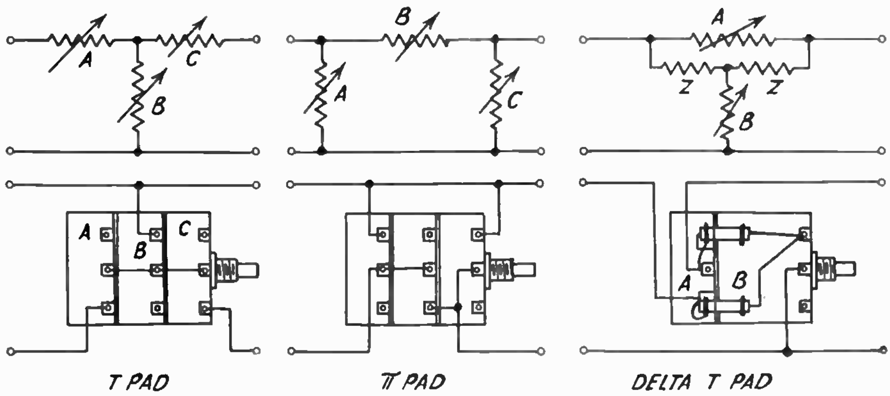

FIG. 9
The three types of pads, T, pi and delta-T, each shown both schematically and pictorially.

PRACTICAL APPLICATIONS

The discussion thus far has been devoted to reasons for using constant impedance controls and how constant impedance controls are made. The next step is how to apply the principles previously discussed. There are two general classes of constant impedance controls: input circuit and output circuit types. Input circuit controls do not dissipate appreciable power. In many mixer panels the power level is below standard zero level of .006 watt, so power handling capacity is not of prime importance. The chief requirement for input circuit controls is low rotational noise level. Carbon type units are well suited to this application. Output circuit controls, such as are used for individual control of speakers, have opposite requirements. Power handling ability takes precedence over noise level. For most output applications, controls should be wire-wound to carry the heavy currents. The inherently higher noise level of wire-wound controls can be tolerated, because no amplification follows the control in output circuits.

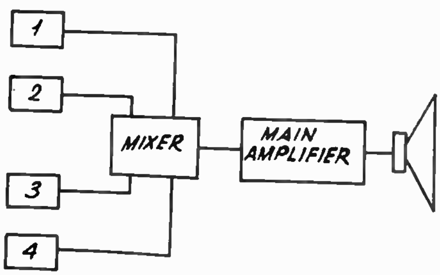

FIG. 10
Simple form of a typical multiple-source amplifier.

Fig. 10 illustrates in simple form a typical multiple-source amplifier. Our problem is to mix the inputs from all four sources to any desired degree. Such systems are widely used to pick up various orchestra sections one at a time or simultaneously.

Fig. 11 is a detailed sketch of connections from microphones through the mixing panel to the amplifier input for the same circuit. Assume that four 200 ohm velocity microphones are used and an amplifier with a 200 ohm input transformer is available. Fig. 11 shows a convenient method of mixing all four inputs and still maintaining the impedance relationship. The controls used in this illustration are 200 ohm delta-T pads, but 200 ohm T pads can be substituted without changing the circuit. As long as the lines from microphone to mixing panel are short (25 feet or less), the circuit will perform as shown.

EQUALIZING METHODS

When long lines are used, either balanced 200 to 200 ohm mixer transformers must be inserted in the four input lines ahead of the mixing controls, or H pads must be used in the mixing panel to preserve circuit balance. Long unbalanced lines will result in hum pickup. In the mixer panel shown, the input from each of four channels can be independently controlled. The fifth attenuator controls the level of the entire input. The ultimate in performance and flexibility is realized with a mixer of this type.

It is possible to go on and on enumerating mixer panel combinations, but every case is different, so something that can be applied in all cases should be helpful. The circuit of Fig. 11 is a common series-parallel arrangement with two parallel branches each made up of two 200 ohm impedances in series.

The resultant impedance of this combination can be calculated by the series-parallel formula. In general this is

$$R = \frac{1}{\frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3} + \ldots + \frac{1}{Z_n}}$$

Where Z_1, Z_2, Z_3, etc., are individual parallel branch impedances and R is the resultant impedance. For Fig. 11, $Z_1 = Z_2 = 2 \times 200$ ohms, since two 200 ohm lines are in series in each branch. The resultant impedance is

$$R = \frac{1}{\frac{1}{2 \times 200} + \frac{1}{2 \times 200}} = \frac{1}{\frac{2}{2 \times 200}} = 200 \text{ ohms.}$$

This resultant impedance exactly matches the input to the amplifier. As much as 25% mismatch is not perceptible to the ear, as far as the introduction of distortion into the system is concerned.

In general, when we have n parallel branches each consisting of m equal units of Z impedance, the resultant impedance, R can be found by this formula

$$R = \frac{m}{n} \times Z$$

For example, the resultant impedance of three branches, each consisting of two 200 ohm impedances in series is

$$R = \frac{2}{3} \times 200 = 133 \text{ ohms}$$

The correct input impedance to match this network would be 133 ohms. The resultant impedance of two branches each containing three 200 ohm impedances in series is

$$R = \frac{3}{2} \times 200 = 300 \text{ ohms}$$

These examples illustrate how the same total number of identical input lines can be juggled to match different input transformer primaries.

When all input lines are in series, $n = 1$. Then

$$R = m \times Z$$

This is familiar to everyone, for it illustrates how series impedances are added to give the total impedance. When there is only one line in each branch of a parallel system, $m = 1$. Then

$$R = \frac{Z}{n}$$

These formulas are presented to show how impedances can be matched in mixer panels. To have them apply, it is only necessary to have equal input line impedances. The best method of attack is to start with the incoming line impedances and using the above formulas, cut and try until the input impedance of the amplifier is matched, or nearly so.

CONSTANT IMPEDANCE OUTPUT CONTROLS

We have pointed out the need for constant impedance input controls. There is just as great need for constant impedance output controls. In most multiple speaker installations it is desirable to control the volume level of individual speakers. To control the volume of any one speaker in a group operating from a single amplifier

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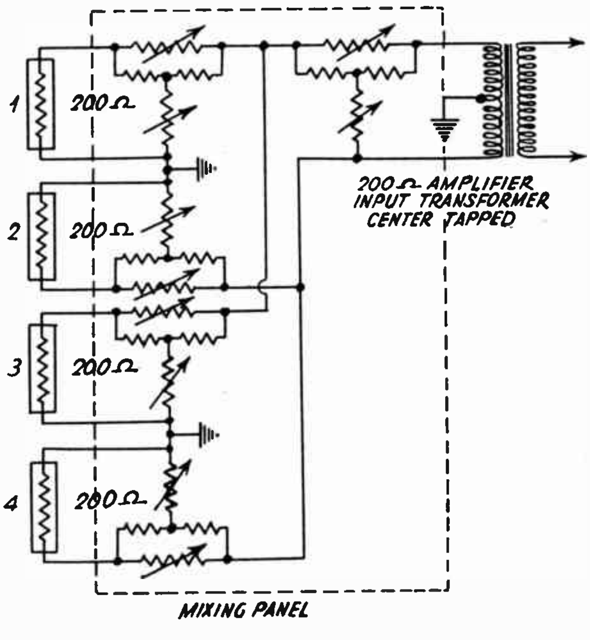


FIG. 11
The microphone is assumed at upper right. The input is made to the primary of the microphone transformer, the secondary of which has 200 ohms impedance, center-tapped. A convenient method of mixing all four inputs and still maintaining the impedance relationship is illustrated. The controls are 200-ohm delta-T pads, but 200-ohm T pads may be used without changing the circuit.

(Continued from preceding page)
without affecting the level of the other speakers, use constant impedance controls. Hotels, hospitals, schools and factories are typical cases where this type of control is desirable.

Fig. 12 shows pictorially how eight magnetic speakers, each with an impedance of 1,000 ohms, would be connected to match a 500 ohm amplifier output transformer. The same formula for resultant impedance applies for speakers as well as input lines. For Fig. 12, n, the number of parallel branches, equals 4; m, the number of a control for each speaker in Fig. 12. In all cases the speaker impedance governs the choice of L pad. Use a control designed to match the speaker voice coil or driving coil impedance. Usual ranges of speaker L pads are 1,000 to 2,000 ohms for magnetic types and 5 to 50 ohms for electro-dynamic or permanent magnet-dynamic speakers.

A FIVE-POINT PLAN

In laying out a required speaker system follow this outline in designing the layout:

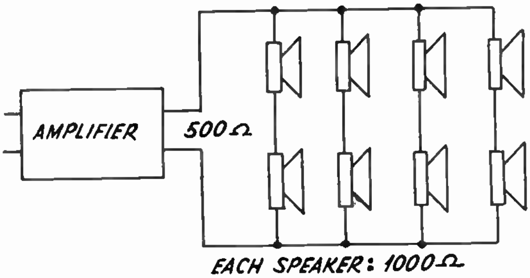


FIG. 12
Here we have eight speakers, composed of four pairs. Each pair consists of units in series. All four series combinations are in parallel with the amplifier. Each speaker has 1,000 ohms impedance, or the impedance looking into the amplifier is 500 ohms.

equal impedances in series in each branch equals 2; Z, the impedance of each speaker equals 1,000 ohms. Substituting in the resultant impedance formulas previously given, we get,

$$R = \frac{m}{n} \times Z = \frac{2}{4} \times 1{,}000 = 500 \text{ ohms}$$

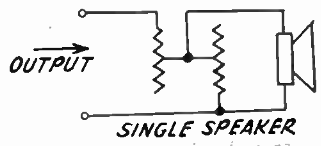
To work out different speaker combinations, take the available amplifier output impedances; use the resultant impedance formula and knowing the speaker impedances, cut and try until the resultant impedance of the speaker network equals, or nearly equals, the output impedance.

Thus far we have not shown how to connect individual controls to speakers. In all cases, L pads will satisfactorily control speaker volume. Fig. 13 shows how to connect an L pad to control a single speaker, also how to install

1. Note the available amplifier output impedances.
2. Note the impedance value of the speakers to be used.
3. Use the resultant impedance formula to cut and try for a series, series-parallel, or parallel speaker network that matches the amplifier output.
4. Obtain output L pads to match speaker impedances, *being sure that the power rating of the controls is adequate for the application.*
5. Proceed with the circuit and installation as shown in Figs. 12 and 13.

The power rating note stressed in step 4 is of great importance, especially with 40, 50 or 60 watt amplifiers. If all speaker impedances in an installation are equal, the maximum power dissipated by each can be simply found by dividing the total maximum output by the number of

At right, the connection is shown for an L pad, made to a speaker. Such pads are entirely acceptable for controlling speakers.



Below are shown the L-pad controls of the individual speakers shown in Fig. 12. The impedance of the pads are 1,000 ohms each.

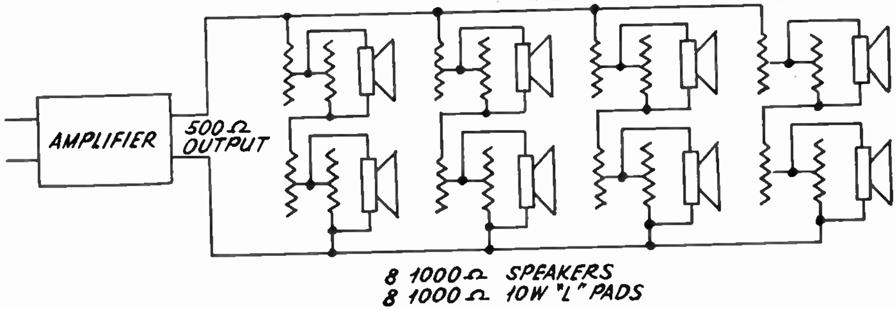


FIG. 13

RIGHT OR WRONG?

Propositions

1. Marconi, who died recently, reduced to practice the theories of Maxwell, proved that radio waves shoot off into space instead of following the curvature of the earth, and was therefore the inventor of radio.

2. The reason why test oscillators are commonly provided with a single note for 30 per cent. modulation is that 30 per cent. is the approximate average of the modulation percentage of a complex audio wave at a station that is capable of even 100 per cent. modulation.

3. Sun spots always adversely affect radio reception, and always occur in cycles.

4. The biggest developments in radio are still taking place in the standard broadcast band, while short-wave and ultra-wave improvements have practically ceased.

5. Noise-reducing antenna systems work on the principle that they cancel out the noises that are picked up by them, and thus free reception of much interference.

Answers

1. Wrong. Marconi contributed much to the dramatization, polularization and utilization of radio, but no one person invented it. Hertz, not Marconi, reduced the Maxwell formulas to practice. Marconi introduced still more practice and proved that the wave's penetration over long distance includes the curvative of the earth.

2. Right. The percentage modulation capability is one thing, the momentary percentage modulation is another, and constantly changing, because of voice and music at the studio.

3. Wrong. Sometimes no adverse effects are noticed. Not all the sun spots occur in cycles. The predominant ones do.

4. Wrong. Developments are taking place in all frequency divisions of radio, and also in audio realms, but the high or ultra-frequency developments may be the most important because opening up new channels for communication.

5. Wrong. The principle on which noise-reducing antenna systems work is that the antenna is placed free and clear of the noise fields, which are usually rather close to ground, and that a transmission line is used to conduct to the set the energy picked up by the antenna. A transmission line is a coupling system that does not pick up or radiate and that carries energy from source to destination almost without loss.

speakers. For example, if 10 identical speakers are operated by a 60 watt amplifier, each L pad should be designed to dissipate at least 6 watts. Where speakers of unequal impedance are used in the same installation the power dissipated by each will have to be calculated. The choice of output control will depend upon the power dissipated by each individual speaker. Rhetorical formulas that will be helpful in this phase of the work are:

1. Speakers in series dissipate power in proportion to their impedances. If two speakers are in series and one has twice the impedance of another, the one with the higher impedance will dissipate twice the power that is dissipated by the one with lower impedance.

2. Speakers in parallel dissipate power in inverse proportion to their impedances. If two speakers are in parallel and one has twice the impedance of another, the one with the higher impedance will dissipate one-half the power that is dissipated by the one with lower impedance.

It has been our aim to outline the definite need for constant impedance controls, describe how constant impedance controls are made, and show how they should be used. The methods described have been general in nature to have the widest application. Particular installations should be more readily laid out and installed with a thorough knowledge of the factors discussed.

TESTS of Insulating Materials

By R. Burns

Materials Engineering, Bell Telephone Laboratories, Inc.

FIG. 1
Air conditioning tests can be made in desiccator jars. The humidity of the air is controlled by the solution in the base of the jar.

THE electrical and mechanical properties of insulating materials may vary greatly with changes of temperature and humidity, exposure to light or immersion in liquids. An increase of humidity usually degrades the electrical characteristics while moderately high ambient temperatures, which are ordinarily accompanied by a low relative humidity, frequently result in improvement. Mechanical strength is quite likely to be decreased by drying out and the dielectric constant of some insulating materials may be somewhat affected by high temperatures.

In choosing suitable insulating materials all of these factors have to be taken into consideration and attention must be given not only to the conditions under which tests are made but also to those to which the material has been subjected for some time prior to the tests. Hence the need for conditioning to provide a common background for the material regardless of its history and thus assure reproducible results.

Conditioning tests are not ordinarily severe enough or carried far enough to provide complete equilibrium of the material, because this would be uneconomical, in many cases, in view of the time required. All that is necessary is to approach the condition of stability so nearly that variations in the results are small compared with the requirement value.

THE EXPOSURE TESTS

Where exposure tests are made they are usually chosen to approximate as nearly as practicable the conditions likely to be encountered in actual use, but the testing time can sometimes be shortened by using more severe

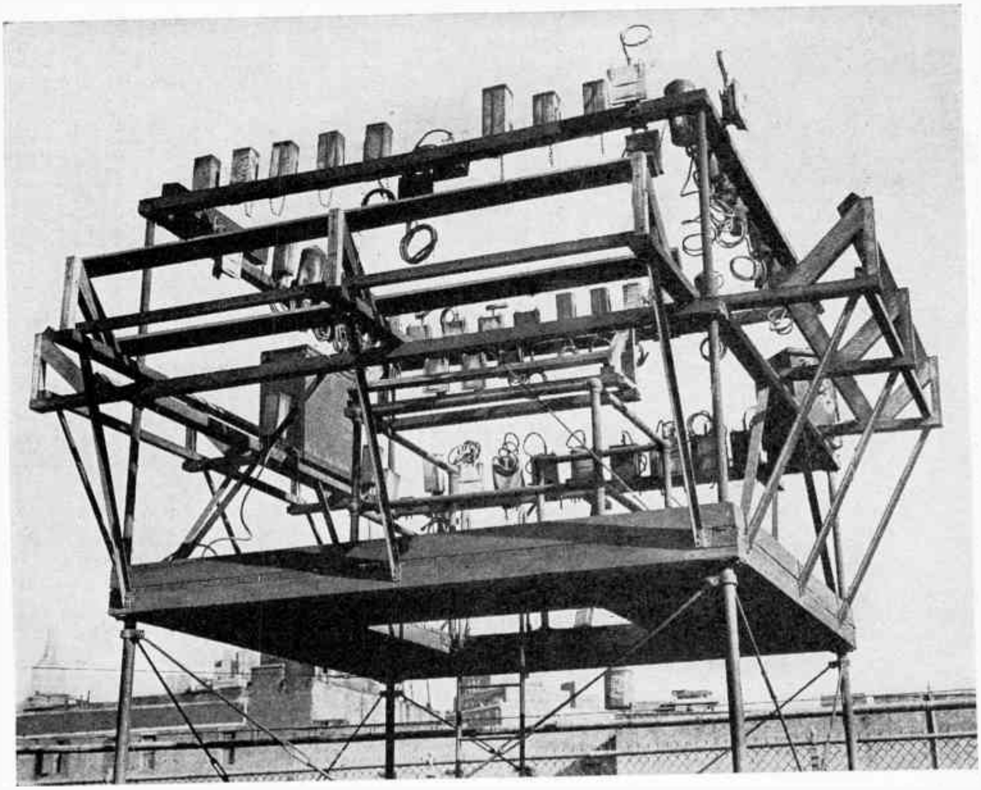


FIG. 2
Insulating materials are exposed on a roof rack and measurements "before" and "after" compared.

exposures than those expected in service. In determining the extent and type of the conditioning exposure it is necessary to select tests which will not affect the inherent characteristics of the materials significantly. It is also desirable that conditions be chosen which can be easily and economically controlled during such tests.

Test specimens are generally dried by exposing them to air over a desicator or to moderately high temperatures. The latter is preferred whenever practicable since it requires less time.

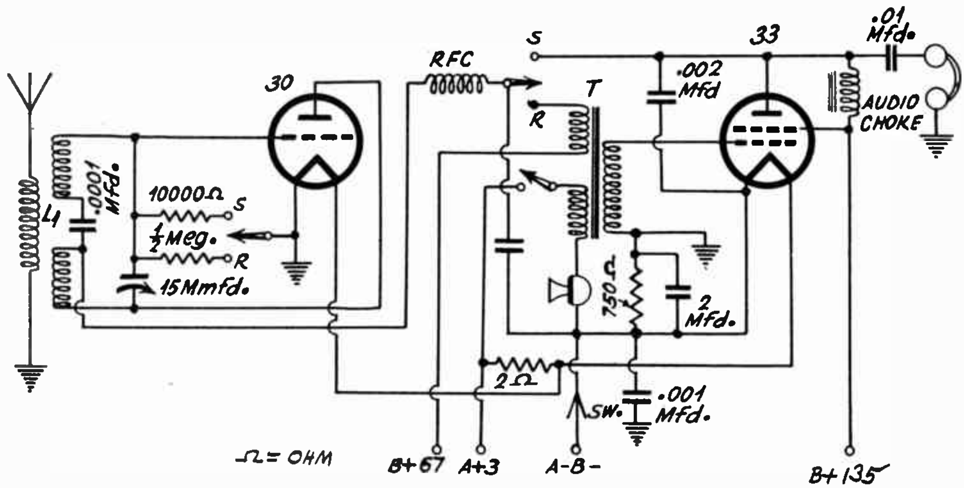
LIGHT AFFECTS HARD RUBBER

Exposing materials to controlled humidity and temperature is far more difficult since large testing apparatus frequently necessitates conditioning a room of substantial size, in which the temperature and the relative humiditv can be closely maintained. For less extensive but more precise work, such as the measurement of critical electrical properties, the vapor pressure method is widely used. This consists of exposing the specimens in a closed chamber which contains a dish of sulfuric acid or salt solution. The air above such a solution will be humidified a definite amount, depending on the kind of salt used or the concentration of the acid solution. In such a closed chamber the relative humidity will stay constant as long as the temperature does.

Although drying and humidifying are highly significant for many materials, there are notable cases where other forms of conditioning are necessary. Hard rubber, for example, which is extensively used as an insulating material, is very sensitive to light. In studying its physical and electrical properties samples are exposed to the radiation from a quartz mercury-vapor lamp, or, if more time is allowed, to sun lamps or natural sunlight. One lamp shown used is of the mercury vapor type. The photo-chemical action is primarily due to ultra-violet light. Since this short wavelength radiation is not present in sunlight at the earth's surface, however, the results obtained with this kind of lamp have to be used with discretion. For exposure to direct sunlight, apparatus and materials are mounted on racks and exposed on the roof or some other outdoor place. Sometimes it is desirable to protect the racks by housings to keep out rain.

It is frequently necessary to combine drying, humidifying and exposure to light in one conditioning cycle. In other cases the specimens are exposed continuously to high humidity for long periods while in still others the humidity is varied daily.

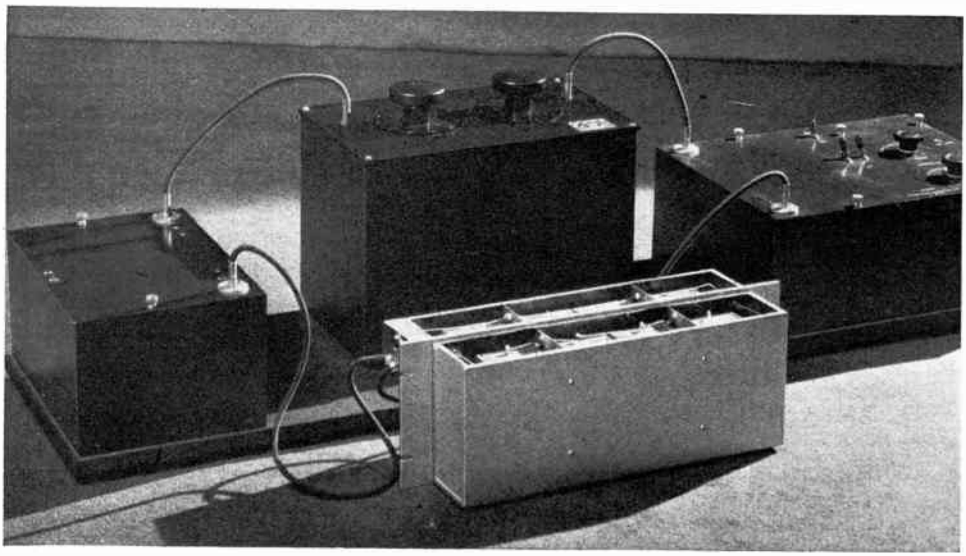
FINALLY A TRANSCEIVER CALLED "BUGLESS"



After many experiments M. N. Beitman, service authority, finally got all the "bugs" out of a portable transceiver, whereupon the diagram above resulted. The 3 volts for filament are from two No. 6 dry cells in series. The audio choke was the secondary of an AFT. Conventional coils for 5 or 10 meters are used.

The sending on the set diagrammed above is done with switches at position S, the receiving at position R. It is usual to gang the switches, to make one control do, when three would be required. The on-off switch (lower right of center) is separate.

SEPARATION AND SHIELDING ARE IMPERATIVE



Measurement of attenuation at high frequencies is a serious problem, and some recent advances have been noted. A method was set forth in last month's issue. By this method the input and output sections of the measuring set (above) are in separate shielded compartments, with space for the apparatus under test and the standard attenuator.

From Nothing Much To Something Good In Television

By Ralph R. Beal
Research Supervisor, Radio Corporation of America

THE ELECTRONIC SYSTEM TRACED FROM CRUDE START TO PRESENT HIGH-DEFINITION PICTURE

Mechanical systems of television having been eclipsed by electronic methods, the following article lays a substantial basis of an understanding of television "with no moving parts." The author is in charge of the television transmitting and receiving experiments of RCA, performed in conjunction with the subsidiary NBC. The article is reprinted from the "Journal" of the Society of Motion Picture Engineers, to whose convention the author in person addressed his remarks in Hollywood. —Editor.

TELEVISION and motion pictures have in common the objective of reproducing on a viewing screen images which, to the eye, appear to have uninterrupted motion. While some of the fundamentals through which this objective is attained in the two arts may be closely related, others are widely different. Objectively and to some extent technically, the problems parallel in the illumination of the subject, in creating the illusion of motion, in realizing an acceptable standard of definition and in obtaining appropriate brightness and size of reproduced image on the viewing screen. An outstanding difference appears in the system by which the reflected light from a subject is transmitted to the viewing screen.

RALPH R. BEAL

In motion pictures, the reflected light from a subject is converted to a film record. Transmission from the film record to the viewing screen is effected through the agency of light. In television, transmission is effected through the agency of electricity. Reflected light from a subject is converted into electrical impulses. These may be transmitted by radio or by special cables from the point at which a subject is located to a point far removed from that locality, and then reconverted into light images on the viewing screen. The reproduced image may originate from a subject or from a film record of a subject.

The development of a television system by which images of high definition may be transmitted electrically and reproduced on a viewing screen has required intensive research by RCA for more than ten years. This research has passed through many stages, beginning with early mechanical arrangements and advancing to the present all-electronic system which is now under field test in the New York City area.

Some of the requirements of a high definition system may be indicated by a brief description of a system patterned after a suggestion made by Carey about 1875. The elements of this system are illustrated in Fig. 1. A pickup area is

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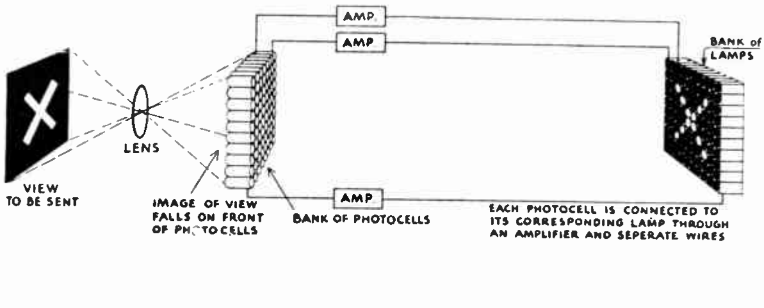
FIG. 1
The elements of an electronic system suggested about 1875 by Carey. The object is the cross-field at left. A lens projects the image on a photo-cell bank. Each cell has its amplifier to actuate a separate lamp.



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constructed of a bank of photoelectric cells and a viewing screen of a like number of incandescent lamps. Each photocell in the bank is connected by an electric circuit through an amplifier to the correspondingly positioned lamp in the viewing screen. The light image to be transmitted is focussed on the bank of photocells. Electric current then will flow through the circuits connecting those of the photocells which receive light to the corresponding lamps in the viewing screen. A reproduction of the subject will appear as an illuminated picture.

A LIMITED SYSTEM

In this system, the amount of detail which can be transmitted is limited by the physical dimensions of the individual photocells in the pickup area. Each photocell represents an element of picture area and the details in any area of the picture smaller than the area of the photocell cannot be transmitted. An electrical circuit is required to transmit information concerning the brightness of each element of picture area. As the amount of detail increases, the number of electrical circuits increases. Such a multiple circuit method is not practicable for transmitting images electrically over long distances. A single channel must be employed for this purpose. This requires methods which involve dividing the light into elements, converting the illumination on each element into electrical impulses, transmitting these impulses in orderly sequence and reconverting them into appropriately positioned light on the viewing screen.

In the RCA high definition television system, the first step in this process occurs in the "Iconoscope," which converts the light image into electrical impulses. The final step takes place in the "Kinescope," which transforms the electrical impulses into a light image on the viewing screen.

The "Iconoscope" which is illustrated in Fig. 2, consists of an electron gun and a photosensitive mosaic in a highly evacuated glass envelope. The electron gun produces a fine pencil or beam of electrons which is focused to a spot on the mosaic. This beam is moved horizontally and vertically and so caused to scan the mosaic. The motion of the scanning beam is produced by appropriately applied electromagnetic fields.

CONSTITUTION OF MOSAIC

The mosaic consists of a vast number of tiny electrically isolated photosensitized silver globules. These cover one side of a thin sheet of mica. The other side of the mica is covered with a conducting film, and this film is connected to a single lead. The mosaic may be thought of as a very large number of minute photocells, each of these shunted by an electrical condenser which couples it to the common signal lead. When the mosaic is illuminated, these condensers are charged positive with respect to their equilibrium potential, due to the emission of photoelectrons. This positive charge is proportional to the quantity of light received.

The electron beam as it scans the mosaic from left to right drives to equilibrium the elements over which it passes and thus releases the charges and induces current impulses in the signal lead. The train of current impulses thus generated constitutes the picture signal output of the "Iconoscope." These current impulses will appear in orderly sequence as the electron beam scans the area of the mosaic, one horizontal line at a time from top to bottom. It is in this order that the current impulses are transmitted as television signals. Fig. 3 is a photograph of a representative "Iconoscope."

In the "Iconoscope," the charging process in any specific element of the mosaic continues for a time equal to the picture repetition interval; that is until the beam, in the process of scanning, returns to that element. The electrical charge stored in the condenser increases with this passage of time. The greater the electrical charge, the greater will be the current impulse

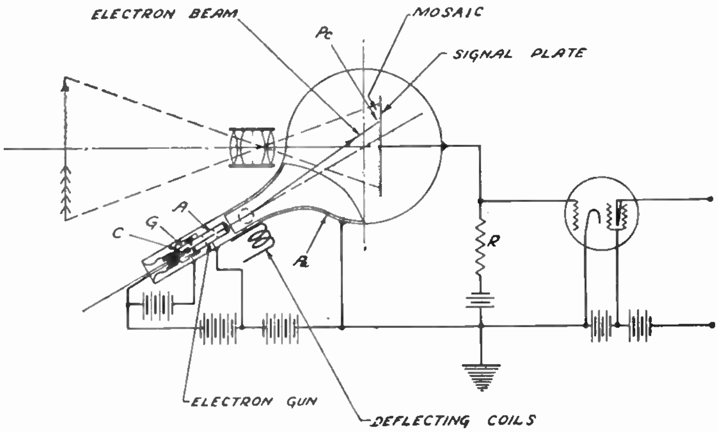

FIG. 2

The Iconoscope consists of an electron gun and a photo-sensitive mosaic in a highly-evacuated glass envelope. The electron beam is focussed to a spot moved horizontally and vertically to scan the mosaic. Electro-magnetic fields impart the motion to the beam.

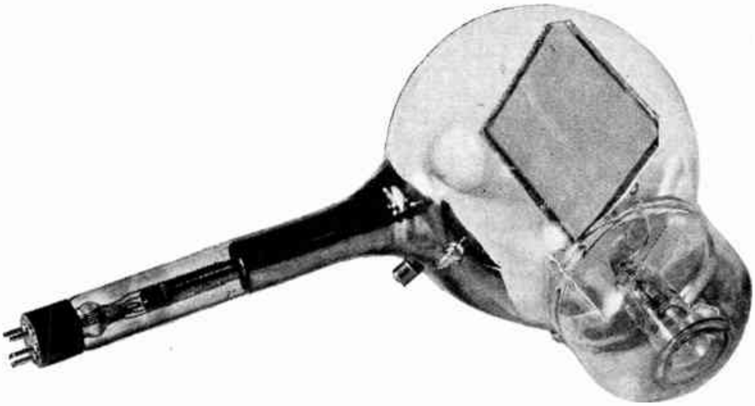

FIG. 3

A representative Iconoscope. The terminals are located at the base and also at heads on the glass envelope. The tilted mosaic on which the electron stream from cathode plays is in practice reflected on a mirror on a console receiver.

induced in the signal lead. This storage principle makes the "Iconoscope" a very effective pickup device for television.

NOW AS SENSITIVE AS FILM

The sensitivity of the "Iconoscope" is of great importance in picking up a wide variety of scenes, both indoors and out, under practical lighting conditions. This sensitivity, at the present stage of development, is about the same as that of ordinary negative film. Research in progress is disclosing methods by which it may be possible greatly to increase the sensitivity.

The color response of an "Iconoscope" depends upon the activation schedule used in producing the mosaic and upon the composition of the photosensitive material. The color response characteristic may be varied over a range comparable with that covered by photographic emulsions available for motion picture work. The color response characteristic of a representative "Iconoscope" is shown in Fig. 4.

The "Iconoscope" and its associated optical parts, correspond, in the RCA Television system, to the camera in motion pictures. This unit of equipment is called the "Iconoscope" camera. "Iconoscope" cameras having the same elements but differing in physical form are used for direct pickup of indoor and outdoor scenes and for the transmission of motion picture film material.

A photograph of an "Iconoscope" camera for use in indoor studios is shown as Fig. 5. The camera may be moved about the studio during a performance; it is raised and lowered by a motion driven mechanism; the usual provisions are made for following the motion and action of the scene; it is silent in operation. The "Iconoscope" moasic is about 4" x 5" or about six times larger than one 35-mm. motion picture frame. Therefore the "Iconoscope" camera lenses are of greater focal depth than those employed in motion picture cameras. Present "Iconoscope" cameras are equipped with lenses of 6.5" or 18" focal length. Fig. 6 shows this camera with the housing raised. The picture signals and the necessary power supply currents are carried by a cable which connects the camera

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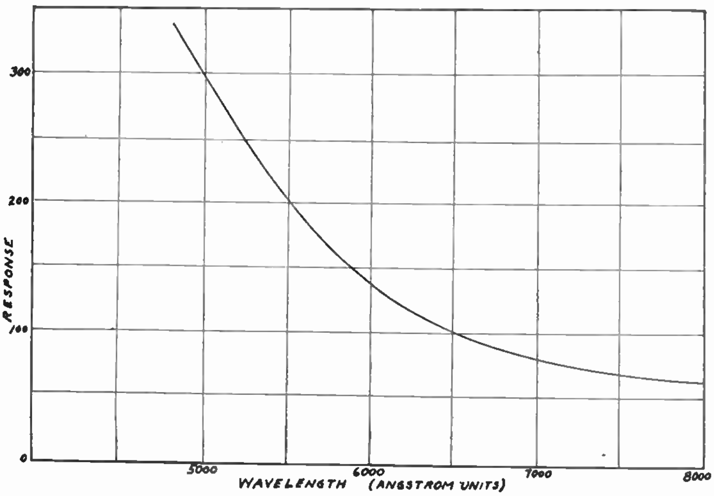

FIG. 4

The 454 Iconoscope has an inverse characteristic with frequency—most sensitive around 5,000 angstroms, and least around 8,000.

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to the system. A wide band pre-amplifier for amplifying the picture signal produced by the "Iconoscope" is included in the camera.

MODULATION AS TO SOUND

The picture signals generated by the "Iconoscope" in the camera are amplified and delivered to the radio transmitter. These signals are caused to modulate the carrier wave of the transmitter in a manner analagous to that employed in sound broadcasting. The radio signal thus produced is picked up at the distant point by the receiving antenna and delivered to the television receiver. Here it is restored to its original form as a train of impulses. These impulses are fed through amplifiers to the "Kinescope" which transforms them into a light image on the viewing screen.

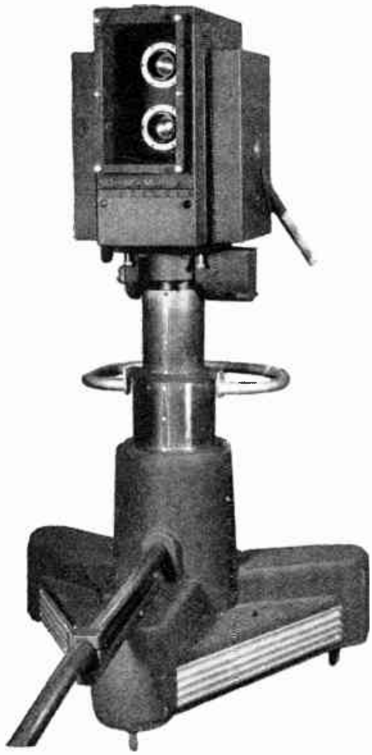

FIG. 5

Indoor type Iconoscope camera. It may be moved about, raised and lowered, and follow the movements of the character in the usual "pursuit" fashion.

The "Kinescope" is an evacuated glass envelope which contains, as the essential elements, an electron gun and a luminescent screen. The electron gun produces an electron beam similar to, but of greater current carrying capacity than, the gun in the "Iconoscope." Light is produced when the electron beam bombards the luminescent screen. The amount of light thus produced is proportional to the current in the beam. The electron beam is caused to scan the viewing screen by appropriately applied electromagnetic fields.

The scanning beams in the "Iconoscope" and the "Kinescope" are accurately synchronized. The team beams are on corresponding points of the mosaic of the "Iconoscope" and of the luminescent screen of the "Kinescope," at any instant. The brightness of a point on the luminescent screen is proportional to the current in the bombarding beam. This current is produced by voltages related to the picture signals generated by the "Iconoscope."

SYNCHRONIZATION OF BEAMS

These picture signals represent, by electrical impulses, information concerning the brightness of each picture element. Since the electron beam in the "Iconoscope" and "Kinescope" are in exact synchronism, the brightness of any point on the "Kinescope" screen will be a function of the brightness of the corresponding point on the mosaic of the "Iconoscope." Thus the image projected as the mosaic of the "Iconoscope" will be reproduced with exactness on the viewing screen of the "Kinescope."

The electron beams in the "Iconoscope" and "Kinescope" are synchronized by transmitting synchronizing impulses at the end of each scanning line and at the end of each picture or frame. A synchronizing amplifier in the receiver separates the synchronizing signals from the composite signal by amplitude selection, separates horizontal and vertical synchronizing signals from each other by frequency selection and delivers the impulses to the respective deflecting oscillators in proper amplitude and polarity for synchronization. The requirement of accurate synchronization between the scanning beams at the transmitting and receiving ends of the circuit is one of the important factors necessitating a uniform standard for all television systems to be used in broadcasting services in this country.

As in motion pictures, the degree of technical perfection of the reproduced image may be measured in part by the detail it contains. To produce a system which will transmit and reproduce pictures of acceptable detail has presented one of the most severe problems in television. The solution was found in the all-electronic system.

NUMBER OF ELEMENTS IMPORTANT

The amount of detail which can be transmitted by a television system depends upon the number of picture elements resulting from the scanning process. The number of picture elements depends upon the number of lines by which a complete picture is scanned. A picture element has a height equal to the distance between the centers of adjacent scanning lines, that is, the scanning line pitch, and a length of 56% greater than its height, for equal horizontal and vertical resolution in the picture. The number of picture elements, hence the amount of detail, increases with the number of scanning lines. In a system which employs the "Iconoscope" and other electronic devices the number of scanning lines, hence the picture detail, may be greatly increased over that obtainable by earlier devices and methods. The "Iconoscope"

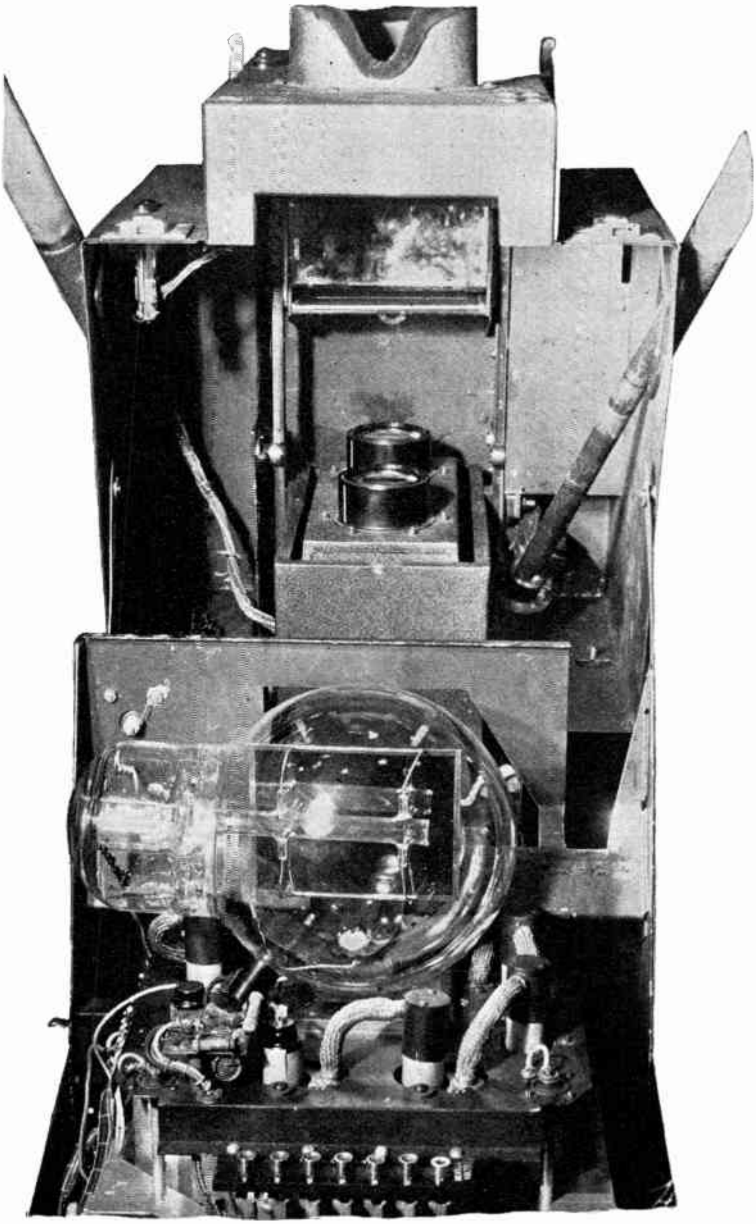

FIG. 6

The Iconoscope camera with the housing raised. A cable carries power and picture signals to the instrument.

mosaic does not limit the detail because many of the tiny photosensitive elements in the mosaic contribute to a single picture element.

The detail which may be obtained by different numbers of scanning lines is indicated at Fig. 7. These are synthetic representations developed in the course of the studies of the subject. Pictures of less than 60 lines were used in early experimental systems. The electronic system embodying the "Iconoscope" and other electronic devices produces pictures of satisfac-

(*Continued on following page*)

(*Continued from preceding page*)

tory detail with 441 scanning lines. This amount of detail corresponds approximately to that obtained with 16 mm. motion picture film. A photograph of an actual 441 line television picture is shown as Fig. 8. This is a photograph of an image on the viewing screen of the "Kinescope." The picture was transmitted by the RCA system now under test in the New York City area.

FIG. 7A
The 60-line scanning of the early mechanical systems yielded a result like this. The subject is a Mickey Mouse cartoon.

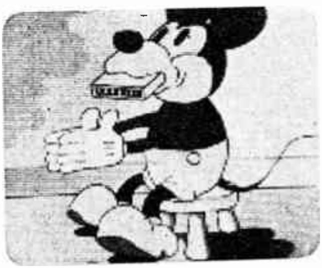

FIG. 7B
Doubling the scanning lines improves detail and definition. This is an electronic result.

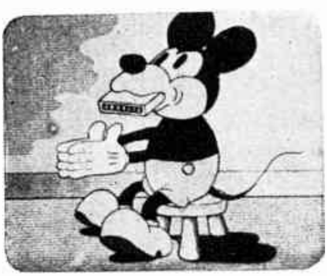

FIG. 7C
At 180 lines the separate lines begin to be invisible at reasonable distance from the screen.

FIG. 7D
At 240 lines the picture begins to produce results freed from some earlier objections.

NATURALNESS AND NO FLICKER

In television, as in motion pictures, two considerations are involved in determining the rate at which the scanning operation must be repeated. The rate of repetition must be great enough to give the appearance of reasonably continuous and natural motion in the reproduced scene and it must be great enough to minimize unsteadiness or flicker in the reproduced picture. Continuity of motion is maintained with a repetition rate of 16 pictures or frames per second. At least 48 frames per second are required, however, to minimize flicker unless some artifice is employed. Motion pictures are projected at the rate of 24 frames per second and the artifice to reduce flicker takes the form of an extra blade on the shutter which interrupts the light while the film is being pulled down from one frame to the next. Thus, as far as flicker is concerned, the projection is, in effect, at the rate of 48 frames per second.

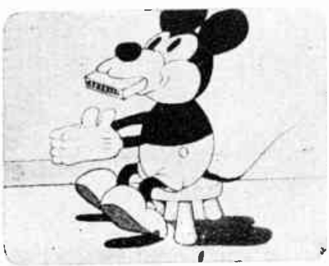

FIG. 7E
A photographic enlargement of the cartoon, where foreground definition alone is retained.

Such an artifice is not applicable in television. Some other method must be devised. Interlaced scanning is employed in the RCA system. This provides satisfactory freedom from flicker. In interlaced scanning, instead of scanning the picture in adjacent lines from top to bottom, alternate lines covering the entire area of the picture are first scanned and then the beam returns and scans the omitted lines. The entire picture is scanned 30 times per second, but the picture area is covered in alternate lines 60 times per second.

Another requirement for consideration in television is the relation which should exist between the frequency of the power supply to the transmitter and receiver and the repetition rate. It is desirable that the repetition rate be an integral divisor of the power line frequency. This is

FIG. 8

Naturalness and no flicker are the results of 441 lines and interlaced scanning. The camera faced the mirror of the experimental receiver when this photograph was taken of the televised image of Betty Goodwin, television announcer.

necessary to minimize certain synchronous interference effects which otherwise might be detrimental to the picture. The television transmitter and receivers of the RCA field test system operate from a 60 cycle power supply. Hence a repetition rate of 30 frames per second fulfills the requirements.

WIDE BAND NEEDED

It should be noted that although the scanning beams of the "Iconoscope" and the "Kinescope" must be in exact synchronism, it is not necessary for the frequencies of the power supplies to the transmitter and the receiver to be synchronous, that is, interconnected, provided they have the same nominal frequency and both systems are regulated in frequency accurately enough for the operation of electric clocks.

The transmission electrically of high definition images over a single channel requires very wide frequency band apparatus and circuits. This is occasioned by the rate at which information must be transmitted concerning the brightness of a very large number of picture elements. A 441 line picture with an aspect ratio of 4 to 3, as transmitted by the RCA system, will con-

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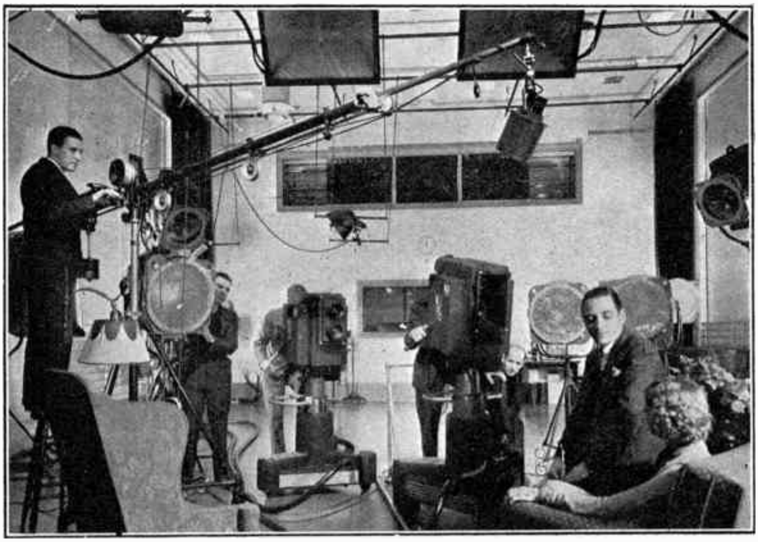

FIG. 9

The equipment in the Radio City television studio as used for program work. The Iconoscope cameras, of which two are plainly visible in center, pick up scenes in sequence, by being suitably switched in as desired. At left an operator is guiding a standard velocity microphone suspended from the end of the boom.

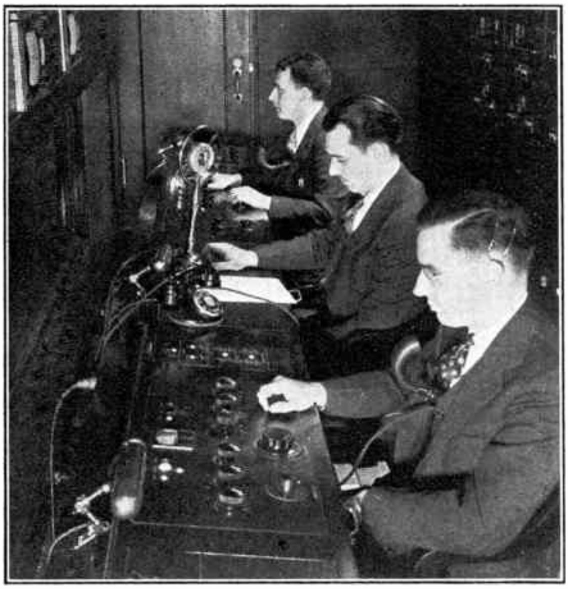

FIG. 10

The control room. This adjoins the studio and occupies an elevated position. From this room the different cameras are switched in, in fact all sound and sight monitoring is performed here.

(*Continued from preceding page*)

tain 165,957 picture elements, for equal resolution horizontally and vetically. This is derived from the product of the square of the number of scanning lines and the aspect ratio, divided by 1.56, the dimension of the picture element in terms of scanning line pitch.

When 30 pictures per second are scanned, information must be transmitted concerning the brightness of 30 × 165,957 or 4,978,710 picture elements each second. One cycle of the picture signal provides such information for two picture elements; hence the total frequency band required for transmitting a picture as above described is about 2,500,000 cycles. This is the width of the frequency band which must be amplified and carried by the apparatus and cir-

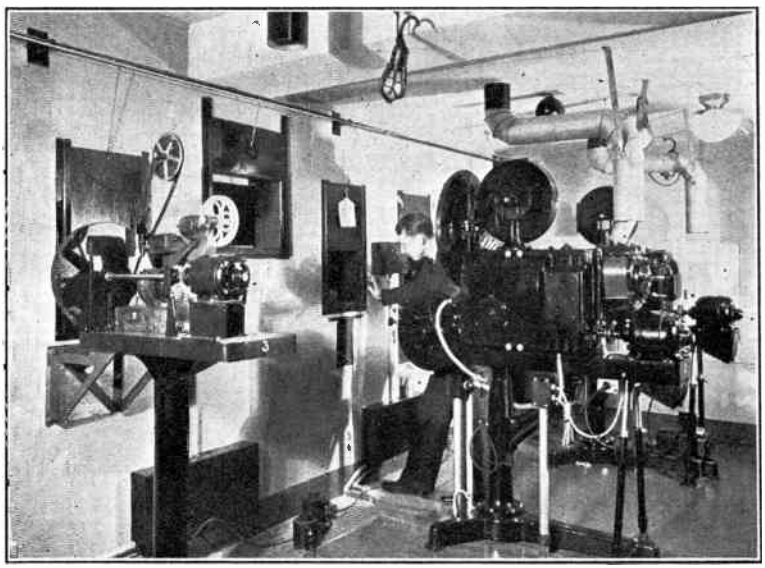

FIG. 11

The film projector equipment.

cuits in the system. It is the frequency band by which the carrier wave of the radio transmitter must be modulated. The total radio transmitting channel width will be 5,000,000 cycles when the carrier is modulated by the picture signal. This is equal to the combined widths of 500 sound broadcasting channels of 10,000 cycles each.

WHEN THE ULTRAS ARE USED

Channels of such great width are not available in the frequency spectrum now used for radio services. For this and other reasons related to technical requirements, the ultra high frequencies or ultra short waves are used, for television. Frequencies above 30 megacycles (wavelengths of less than 10 meters) are employed. Ultra short waves have quasi-optical properties in propagation. The range over which satisfactory high definition television pictures may be reliably transmitted by ultra short waves is limited practically to the distance of the horizon from the height at which the transmitting antenna is placed. Under some abnormal conditions, pictures may be received over greater distances for periods of very short duration, but primarily television stations will serve local areas. The signals from the stations in these local areas will be stable and will have about the same intensity during the day and night hours, and during the seasons of the year.

Television networks for the simultaneous distribution of programs originating at one point will consist of interconnected local stations. The circuits which interconnect these stations must be capable of transmitting the very wide frequency band required for high definition television. Existing circuits, either wire or radio, cannot fulfill this requirement. Now facilities must be provided and while wide frequency band circuits either cable or radio, are feasible technically, to provide them for extensive, nationwide networks becomes an economic problem of magnitude.

NEW METHODS FOUND

The development of a high definition television system has required technical advances over a broad front. Fundamental research in the field of electronics was very important. Extensive research in an unexplored portion of the radio frequency spectrum was required to determine the laws of propagation of ultra short waves and to produce methods and devices by which they may be applied. Entirely new methods and apparatus had to be produced for picking up images, and converting them into electrical impulses for transmission. Ne. methods and devices were required for amplifying, transmitting and receiving the very wide frequency bands on ultra short waves. The fundamental character of the work and its extensiveness constitute practically the development of a new art.

The technical advances made through a step-by-step program of research in the laboratory and practical tests in the field, have been incorporated in the television system RCA now has under experimental test in the New York City area. The equipment provided for this field test is installed under conditions which closely correspond with the requirements of a television broadcasting service. The field tests are comprehensive in scope. They embrace studies of the functioning of the equipment under field conditions, the collecting of engineering information and data related to signal and noise levels within the service area; experiments to develop program technique and observations on receivers in the field by technical personnel.

This system is now using standards of which

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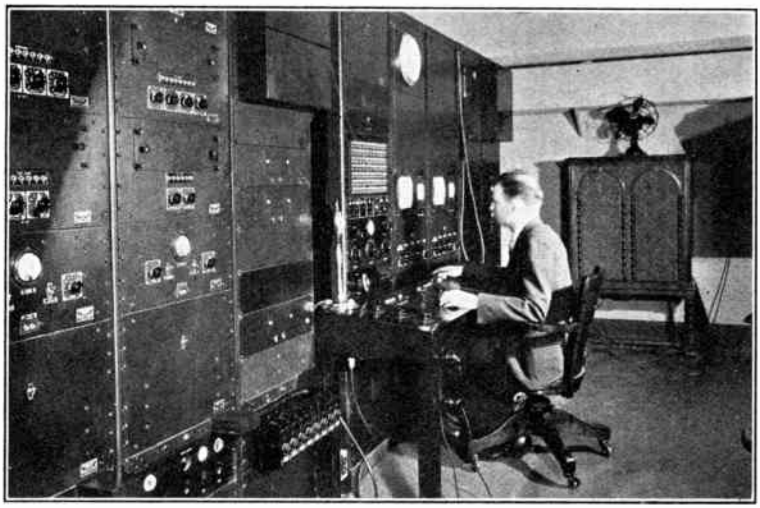

FIG. 12
The film projection room has its own separate control room.

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the essentials are 441 lines per frame, a frame frequency of 30 per second, a field frequency of 60 per second (interlaced). negative polarity of transmission and a video-audio (picture-sound) carrier frequency spacing of 3.25 mc. The picture signals are transmitted on a frequency of 49.5 mc. and the sound at a frequency of 52.75 mc.

The studios in which artists perform and the photograph, the "Iconoscope" cameras are employed to pick up scenes to be transmitted in sequence by switching from one camera to the other. The switching operation takes place in the studio control room, which is located in an elevated position at one end of the studio. The sound which accompanies the picture is picked up by a standard velocity microphone equipped with a windshield and attached to a boom.

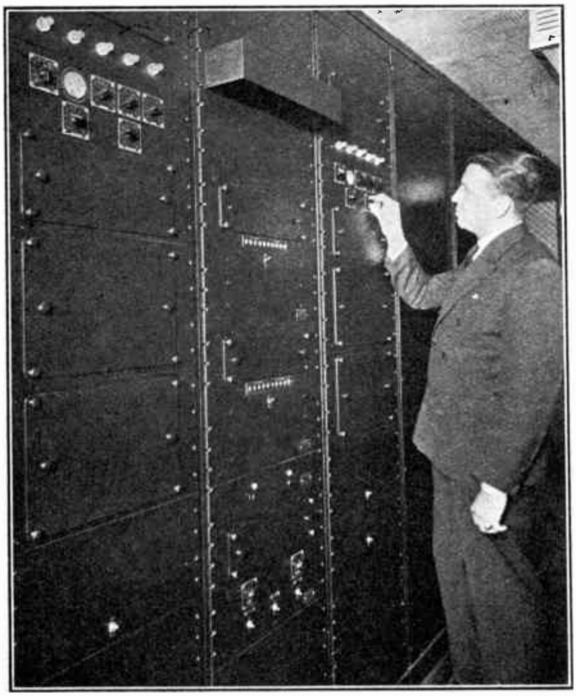

FIG. 13
The synchronizing supply is pictured. The video line amplifiers feed the signal to the Empire State Building.

from which motion picture film is transmitted are located in the RCA Building, Radio City. The radio transmitting equipment is installed in the Empire State Building and the transmitting antenna on top of the building. The picture signals from the Radio City studios are sent to the radio transmitter in the Empire State Building either by coaxial cable or by ultra short wave radio relay. The accompanying high fidelity sound is carried over special cable circuits.

TELEVISION STUDIO

The terminal equipment at Radio City includes three "Iconoscope" cameras for direct pickup in the artists' studio and two motion picture film projectors of special design, each with its "Iconoscope" camera. This equipment includes the video or picture signal amplifiers and the deflecting and control apparatus for each "Iconoscope" camera, the "Kinescope" monitors, the synchronizing generators, the line amplifiers and other associated apparatus.

The equipment in the Radio City television studio is shown in Fig. 9, as it is used for a program transmission. In the scene shown in

The studio is about 30′ x 50′ with a ceiling height of about 18 ft. It is an NBC studio formerly used for sound broadcasting. The studio is equipped with incandescent lamps of various types, having a total power consumption of more than 50 kw. The lighting equipment is flexible to enable comprehensive studies of a variety of effects in experimental programs. Rifles, floods and focussing spots with ratings between 2 and 5 kw. each are most numerous, although there are several large units of special design. Key lighting and back lighting units are suspended from the ceiling; modeling lights are operated on the studio floor. The present sensitivity of the "Iconoscope" requires an incident light intensity on a set of about 1,000 to 2,000 ft. candles.

STUDIO CONTROL ROOM

Adjoining the studio and at such an elevation that the operating engineers have a clear view of the studio scene, is the studio control room. This control room is shown in Fig. 10. The sound and video signals from the studio are monitored in this room. The scenes are picked up by the "Iconoscope" camera and reproduced on the two monitoring "Kinescopes" shown at the left of the photograph. One monitor shows the scene being transmitted and the other the scene picked up by the second "Iconoscope" camera preparatory to transmission. The operating position in the foreground of the photograph controls the sound from the studio. The video controls are at the opposite end of the control board. The racks of equipment behind the engineers include the video amplifiers and the synchronizing and control equipment associated with each "Iconoscope" camera.

FILM STUDIO

Motion picture film material originates in a film studio in another part of the National Broadcasting Company plant. This studio consists of two rooms, in one of which are installed two special 35 mm. motion picture projectors and other supplementary equipment, and in the other, two "Iconoscope" cameras with video and monitoring and control apparatus. The projectors are so designed that standard 24 frame motion picture film is used to produce television pictures at 30 frames per second. In these projectors a changing rate of intermittent drive is used for the picture portion of the film and a constant 24 frame rate of feed for the sound portion. Pictures from the projectors are focussed on the mosaics of the "Iconoscopes" cameras located in the same control room beyond the partition separating the two rooms. The film projector equipment is shown in Fig. 11.

FILM STUDIO CONTROL ROOM

A control room is associated with the film projection room. A view of this room is shown in Fig. 12. The equipment in the film studio control room includes two "Iconoscope" cameras with their video voltage amplifiers and associated synchronizing and control equipment and audio equipment for the control of sound from the film. The two "Iconoscope" cameras are so mounted that they may be shifted from side to side for use with either of the film projectors in the adjacent room.

SYNCHRONIZING

The panels containing the electronic synchronizing generator equipment, and the video line amplifiers which feed the viedo signal to the Empire State Building are shown in Fig. 13. This equipment is installed in the main equipment room of the National Broadcasting Company plant.

INTER-BUILDING TRANSMISSION

The inter-building ultra short wave radio relay transmitter (Fig. 14) is installed on the 10th floor of the RCA Building. It operates on a frequency of 177 megacycles and has a channel width adequate to carry the full video frequency band. Equipment is provided for monitoring the signal at this point. The transmission distance between the two buildings is approximately .9 mile. The signal obtained at the Empire State Building is free from noise, and pictures transferred by radio relay are as satisfactory as those for which the coaxial cable is used.

EMPIRE STATE BUILDING
CONTROL PANEL

The coaxial cable and radio relay channels, and the channel for the sound accompanying the picture from the studios in Radio City terminate at the Empire State Building control board. (Fig. 15). From left to right the control board consists of the sound channel panel, a video monitoring panel, the radio relay receiver panel and battery and switching panels. The video

(Continued on following page)

FIG. 14
The inter-building ultra short wave radio relay transmitter.

(Continued from preceding page)
monitor may be switched either to the radio relay or the coaxial cable channel.

TRANSMITTERS

The video and audio transmitters installed in the Empire State Building are shown in Fig. 16. The video and audio transmitters are entirely separate and are specially designed for high power operation on ultra high frequencies. The modulator of the video transmitter is capable of handling the wide side bands required for the video frequencies. Both transmitters are coupled to a common transmission line which is connected to the single antenna on top of the building.

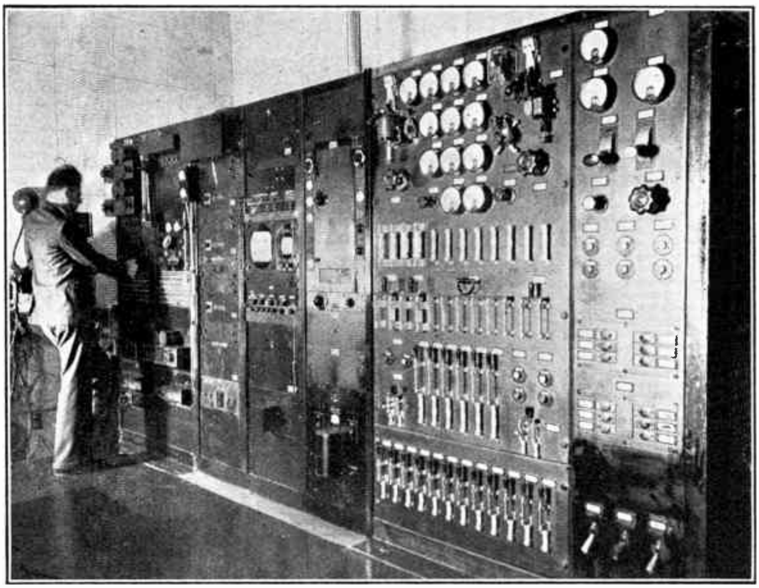

FIG. 15
The coaxial cable and relay channels.

ANTENNA

This antenna produces a horizontally polarized field with a pattern essentially circular in the horizontal plane. The antenna has a power gain in the horizontal plane of about 2.1 or 3.2 db. as measured with reference to a vertical dipole. The Empire State Building having a height in the order of 1,250 feet provides a location from which a maximum transmitting range may be obtained. The distance from the antenna to the horizon is approximately 43 miles. Fig. 17 shows a view of the Empire State Building transmitting antenna.

EXPERIMENTAL FIELD TEST RECEIVERS

The experimental field test receivers resemble in appearance a console broadcast receiver. Fig. 18 is a photograph of the type of receiver now in use. This receiver is of the superheterodyne type and has a tuning range of 40 to 84 megacycles. It receives the picture and the accompanying sound. The "Kinescope" is mounted vertically and the television image is viewed in the mirror mounted inside the cover of the cabinet. Tuning is accomplished by a single knob controlling the radio frequency circuit and the single oscillator which heterodynes both carriers to produce two intermediate frequencies.

Of the seven knobs on the front of the receiver the center knob tunes the picture and the accompanying sound. The three knobs on the right, from top to bottom, are the sound volume control, the treble tone control and the bass tone control. The three knobs on the left, from top to bottom, are the picture contrast control, the detail control and the background brightness control. These receivers operate on the ordinary 110 volt, 60 cycle power supply and draw about 350 watts of power.

These receivers have been used to produce two sizes of pictures. For the first few months of the tests, the picture size was 5¼" x 7½". At the present time most of the receivers have "Kinescopes" which produce pictures 7½" x 10" in size. Fig. 18 shows a 9" Kinescope which produces a 5¼" x 7½" picture. A "Kinescope" about 12½" in diameter is required to produce a 7½" x 10" picture. The shape of the picture, defined by the aspect radio 4 to 3, is the same as that used in motion picture practice.

COLOR AND BRIGHTNESS

The brightness of the reproduced picture is such that it can be viewed in a moderately lighted room. The color of the "Kinescope" screen depends upon the composition of the fluorescent materials. Many screen colors have been produced. At the present time a slightly greenish yellow screen and a more nearly white screen are being used. The present yellow screen used for the 7½" x 10" picture has a brightness in the high lights of about 4 foot lamberts. This may be compared with the tentatively proposed standards of 7 to 14 foot lamberts for the brightness of motion picture theatre screens.

The optimum viewing distance for a 441 line picture of the 7½" x 10" size is in the order of three to four feet. At this distance the line structure is not resolved by the eye. The screen angle or the angle subtended by the picture at the eye is about 20 degrees. At a viewing distance of 12 feet, the screen angle is about 5 degrees, which in general, is in the order of magnitude of the minimum acceptable screen angle in motion pictures. The size and brightness of the 7½" x 10" picture of 441 lines appears to reasonably satisfy the requirements for pictures to be viewed in the home by the average family group.

PROGRAM MATERIAL

In connection with television program technique, it is too early to accurately predict the technique which ultimately will develop in television programming. It is clear to those who are closely associated in the development of a system that, although some parts of the program technique may parallel the technique of the stage, motion pictures and sound broadcasting, it will be distinctive from any of these. In effect, a new art form must be created.

In general, television program material may fall under three principal classifications. These are direct pickups from indoor studios and other points, outdoor pickups and motion picture film. Spontaneity eventually may be an important element in television programming. The televising of outdoor events as they occur is entirely feasible under the light conditions which prevail during fair weather. Studio programs and motion picture film probably will find liberal use in television programming but here again the requirements peculiar to television will affect the nature and composition of the material.

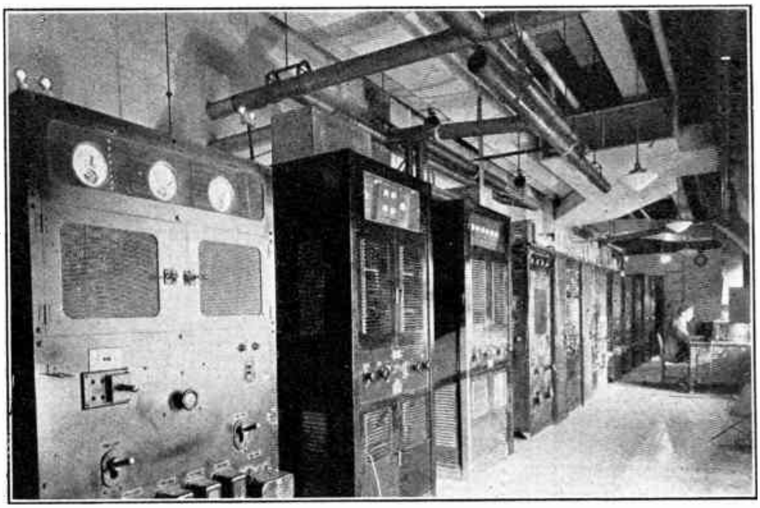

FIG. 16
The video and audio transmitters in the Empire State Building.

The field tests in the New York City area are contributing to further technical advances. Pictures of 441 scanning lines have been transmitted and satisfactorily received within a service area having a radius of 30 miles or more from the Empire State Building. Good pictures are regularly received at one observing point in a suburban home over a distance of 45 miles.

MUCH WORK AHEAD

Much remains to be done. When it will be completed cannot be accurately predicted. The engineering information and data collected and the experience gained from operating the system under field conditions are pointing the way toward the realization ultimately of a high definition television broadcasting service.

This new service, just as have many new services in the past, will supplement and not supplant existing services or agencies which represent older arts. The telephone did not supplant the telegraph; it supplemented it. Sound broadcasting did not supplant the theatre and motion picture. On the contrary, it increased public interest and appeal in them and thereby contributed to their advancement and financial profit. And so it will be with television. When it is successfully accomplished, we will have added another service to

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the continually growing list. There will be some things which television can do that previous arts cannot do; a few things which it can do better than they; but there will be many things which they can continue to do which television cannot do. We may therefore welcome the advent of a great new public service, which will come not to displace but to augment our agencies of entertainment and information, thereby making the world a more interesting place in which to live.

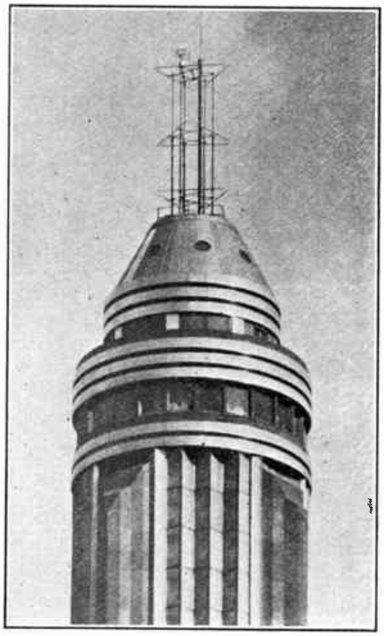

FIG. 17
Tower of the Empire State Building, with the television antenna system at top.

FIG. 18
Experimental television receiver.

Applause

I have read your publication regularly for two years, and think your magazine improves in nearly every issue. It surely has the real dope for me—more than any other in the radio field today. I look forward to the readable and enjoyable articles on television and radio.

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* * *

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* * *

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SOLUTIONS OF AUDIO BEAT FREQUENCY PROBLEMS

By H. J. Bernard

Safeguarding Low Frequencies Practically to Zero

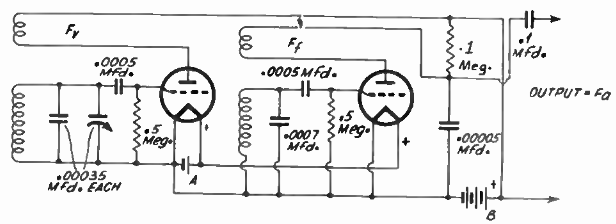
Avoidance of Dead Spots

Insuring Adequate Facts on Output in Cycles and Volts

Substantially Same Voltage Output at All Frequencies

High Capacities Insure High Stability

Strictly Sine-Wave Output Obtained



A battery-operated beat frequency oscillator. Fv represents the r-f oscillator that may be tuned to different frequencies, and Ff the r-f oscillator that has a fixed frequency. With no more than stray coupling, the audio frequencies, Fa, can be heard in the 'phones, though weakly, while with intentionally introduced coupling between the r-f oscillators the note is much louder, but the lowest frequencies disappear.

If the coils used for the diagram of the battery-operated beat frequency oscillator are of the intermediate frequency type, primary and secondary tuned, the condensers may be left across these coils, and the capacities built up to .00035 mfd. The audio frequency span would be around 20,000 cycles.

The A and B supply common to both tubes, the capacity of wiring and other effects, introduce coupling even without any special coupling unit.

The fixed-frequency oscillator, at right, is used as the detector, also. All leak-condenser oscillator circuits detect well. No zero adjustment method is shown, but one may be introduced, as explained in the text, either visual or aural.

THE type of audio oscillator that gives the most nearly uniform output voltage over a continuously variable range, that may readily have excellent frequency stability, and thus meets important requirements, is the beat frequency oscillator.

This sort of oscillator is familiar to all who have any experience in radio. In discussing the measurement instrument we respectfully refer to the sounds as frequencies, but when the same general condition obtains in a receiver, and the sounds constitute interference, we refer to them contemptuously as squeals. If one operates a regenerative receiver so that the detector tube nearly "spills over" in tuning in a station, we may hear no program, but a sustained audio note, alterable by turning the tuning condenser knob just a trifle. In certain forms of radio reception, relating to messages, where the carrier is taken off and put back on the air at intervals representing the dots and dashes of code, the receiver has an auxiliary oscillator working at a frequency only a little different from some other radio frequency in the set. Thus when the carrier is "on," a note equal to the difference is heard. This form of transmission and reception is known as continuous wave (c. w.) and the carrier, itself unmodulated, is given all the attributes of code modulation by the on-and-off operation. In this way great distance may be economically covered.

FIT FOR BIG BOOK

So it is not something unfamiliar that we are dealing with, but the same condition whereby one frequency is fixed, at least temporarily so, and the other is adjustable continuously, but both maintained fixed at any moment of observation.

The two radio frequencies are nearly alike and combined in a detector tube, the output of which is the audio note equal to the difference between them. So if the two radio frequencies are f_2 for the higher and f_1 for the lower, the tone frequency f_x equals f_2 minus f_1. Surely there could not be any theory easier and simpler than that. It is the same as two plus two, except that it is a case of four minus two. There are some other exceptions. Hardly could a ponderous volume be written about four minus two, but one could be written about beat frequency oscillators.

We hear a great deal about adding machines. Perhaps it is not well known that there are also subtracting machines. Of course the beat frequency oscillator is a subtracting machine. One frequency is taken from another, leaving a difference. But the mechanical machine will give you only one answer, for all it does when set for subtraction is to subtract, and you can rely on the accuracy of the answer. The electrical device that operates on the difference principle can and does contribute spurious answers along with genuine ones, and defy you to distinguish between them. Also the electrical device may have dead spots. That is a case of "no answer."

A STANDARD SETTING REQUIRED

It would be very exasperating to construct an elaborate beat frequency oscillator, only to find that at two places on the dial, each covered by relatively large displacement, nothing is heard save the residual hum of a too inexpensively filtered rectifier. Moreover, squeals superposed on the intended squeals are present, or spurious ones actually almost drown out the genuine, just as the parasite may take over the host in entirety. Many troubles can be experienced. It is far more serious a stroke of engineering than four minus two would indicate.

However, if the dead spots are eliminated, and if the oscillators are stable, some method must be used for setting the device to a predetermined frequency. Since the whole operation depends on differences, and differences are

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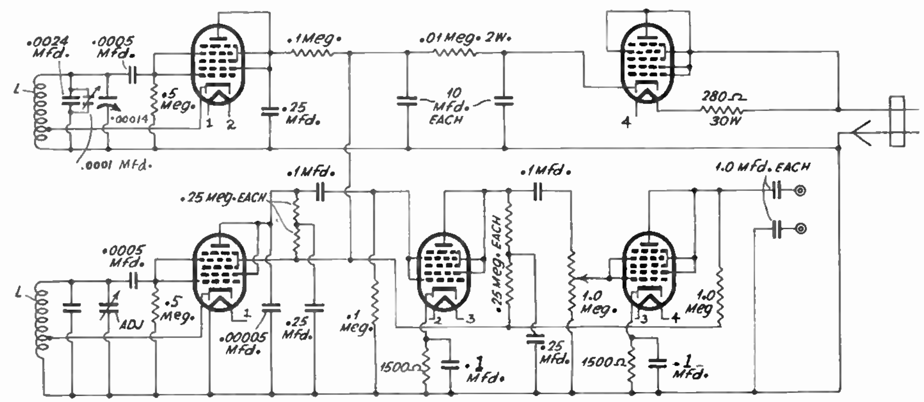
Zero Adjustment

For the battery type audio oscillator amplification would be required, and adjustment for zero difference made with a ray indicator tube, biased three volts negative and coupled by a resistor-condenser to a-f output.

For the ac-dc type, only on a.c., but of any frequency, is the finite adjustment made. Zero adjustment would require a meter or a ray-indicator tube.

The a-c model follows the ac-dc model, but is good for only 50-60 cycle line frequency, not, as the universal is, for all line frequencies.



Ac-dc or so-called universal model of a beat frequency oscillator, covering 0-10,000 cycles. Enough output is provided so that the note is heard loudly in the 'phones, even though the coupling between the r-f oscillators is so loose that a frequency difference of one-tenth of a cycle could be established without locking.

In this audio oscillator the output voltage is raised to two volts by amplification. All the tubes are of the 6A7 type because they happened to be around when the experimenting was done.

Because resistance-coupled audio-frequency amplification is used, and the r-f oscillators themselves draw little plate current, the total B current drain is small. That makes hum filtration easier, so that the .01 meg. resistor replaces a choke, but resistance-capacity filters are needed additionally, and these are shown as B plus returns interrupted by another resistor, with the capacity from resistors' joint to B minus.

The two coils L are equal, of 40 microhenries inductance, and tapped near the line end, for cathode connection. The upper r-f oscillator is the variable one, across which is a .0024 mfd. fixed condenser, plus a trimmer of the air-dielectric type, large enough to bring the total real capacity, including everything, up to .0025 mfd. (2,500 mmfd.), hence the difference between the two stated values is .0001 mfd. or 100 mmfd. The required capacity is assumed established correctly.

The next step is to adjust the fixed-frequency r-f oscillator, so that there is either no practical difference in frequency between the two r-f oscillators, meaning zero beat, or that there is a means of adjustment to some other standard. Though the diagram does not reveal it, such a system prevails. The line hum can be heard a little if the attenuator is at a very low resistance setting, and at the same time the generator output is reduced almost to zero. Therefore the attenuator is turned until the two notes of equal amplitude, though somewhat unequal frequency, are heard together, and the adjuster, a 100 mmfd. air trimmer, is turned until the two frequencies are audibly the same. With a little practice it is easy to have the two come in very close agreement.

(Continued from preceding page)

dangerous to accuracy, one point, accurately calibrated for a particular frequency, must be referred to, time and again, to compensate for any changes in circuit constants and conditions. Tiny though these original changes are, the frequency differences they introduce may cause an intended tone to be 50 per cent in error, or more.

If one frequency is 700 kc and another is 700.06 kc, the difference is .06 kc, or 60 cycles, and may be compared to the line frequency of the power supply for a satisfactory standard. Visual methods are commonly used, whereby the frequency difference is made zero, or as nearly that as practical, denoted by a steady shadow angle following a moving one, or a meter needle or a line standing still, or nearly so. Thus the adjustments favor some low frequency, because the inaccuracy would be worse at the low than at the high audio frequencies.

SAFEGUARDING ACCURACY

We can imagine the second frequency mentioned above as being intended for 700.06 kc, yet because of a large temperature change or some extraordinary moisture in the air affecting condenser plates or tuning coil, respectively, the second frequency was 700.1 kc. Surely a small difference, only .04 kc, yet the audio mixture is equal to 700.1 — 700 = .1 kc, the condenser setting is calibrated for 60 cycles at that position, and the error is 67 per cent. By careful adjustment the 60-cycle reading is made to coincide with the 60 cycle generation and then the accuracy is 5 per cent. or a little better and is maintained through the scale.

Differential Interference Cured

Customers Satisfied by Inexpensive Method

By R. K. Wheeler

UNTIL recent months the signals from the two local broadcasting stations in the writer's district presented no particularly difficult problems in the way of interference to the experimenter or serviceman. At that time these stations used fairly low power, 1,000 watts, one operating at 1,230 kc and the other on 1,400 kc. It will be noted that their frequency difference is 170 kc. The transmitters were located some twenty miles apart, one being north of the city, and the other south.

NO HELP FROM WAVE TRAP

Some months ago, both stations received permits to move and increase power to 5,000 watts for daytime operation. The new transmitters were located about four miles apart, and both a short distance north of the city. Immediately set owners began to experience the usual troubles that arise when local stations increase power, especially those listeners residing on the North Side within a few miles of the transmitters.

The most trouble was experienced by owners of receivers having 175 kc intermediate amplifiers, in that both stations were received simultaneously when the receiver was tuned to any frequency in the broadcast band above 1,230 kc, that is, 1,230 to 1,500 or 1,600 kc. It will be recalled 1,230 kc is the frequency of the lower of the two stations. Although the most publicity has been given the 465 kc intermediate frequency in the past two years, there is a large number of 175 kc superhets still in use, and a large percentage of receivers requiring service are of that type; so it was considered desirable to find an inexpensive, easily applied solution. It can be seen therefore that strong stations differing in frequency by approximately the frequency of the intermediate channels, can produce a mixture that sends the modulation of both through at the i. f. level. This may be called differential interference because due to the difference equalling the i. f.

CHANGE OF I.F. HELPED SOME

Since the writer's own receiver was of this type and the trouble was present in a very obnoxious form, the trouble-shooting was conducted at odd times on this set. The tube complement of this reciver is typical of most of its kind, that is: 58 r. f., 2A7 converter, 58 i. f., and a 55 or 2A6 as detector-amplifier, with associated power amplifier. Like the receivers of most radio men it is usually in an experimental state, and is used as a proving ground most of the time.

As a first step a 175-kc trap was installed in the antenna circuit, but this did not reduce the interference.

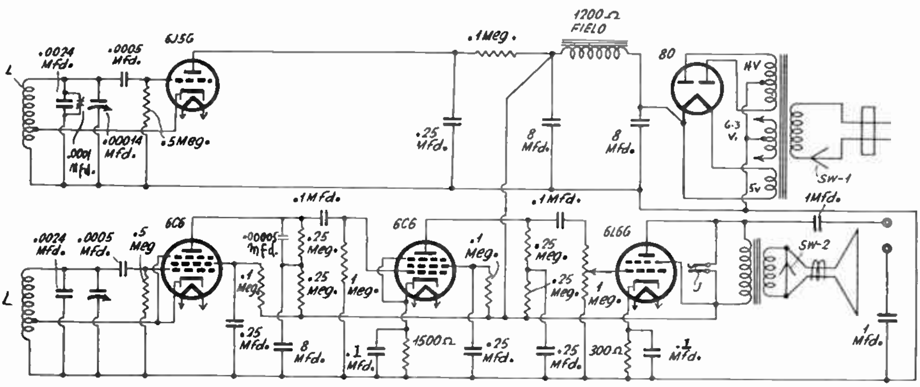
Next the intermediate frequency was shifted to 185 kc, which greatly reduced the interfering signals, but this was not considered desirable as it was necessary to adjust the i-f transformer condensers to a point where their setting was not stable, and could not be relied upon to hold permanently. Also, enough mistracking was introduced to cause several undesirable birdies at lower frequencies.

The receiver was connected to a 45-foot flat-top antenna, which was not considered excessively large, but it was obvious from the number of birdies between 1,000 and 1,500 kc that the input was somewhat too great. The antenna length was reduced physically until the birdies and local interference were eliminated, but the signal strength of out-of-town stations was reduced too much, the set noise and hiss of the mixer being much too prominent when such stations were received. Better results were obtained by using a 75-foot antenna with a .0001 mfd. variable condenser in series, which was adjusted until the desired results were obtained. In this specific case the required series capacity was approximately 35 mmfd. However, the overall results were not considered satisfactory as the out-of-town stations were still too weak.

LOADING COIL DID TRICK

Antenna transformers with high and low impedance primaries were tried, with negligible results, nor did the degree of shielding affect the results. While the high-impedance primary resonates at a lower frequency, outside the broadcast band, thus reducing the sensitivity somewhat at the higher frequencies, apparently the increased voltage drop due to the high-impedance primary compensates to some extent for the loss of sensitivity.

After some consideration of all the facts learned from these experiments, the writer decided that the pickup at the higher frequencies must be reduced, and a ready way to do this was to increase the electrical length of the antenna by installing the almost forgotten loading coil. An antenna transformer with a 15-turn primary was installed, with a 2 millihenry coil in series with the antenna, not inductively couped to the transformer, and the most satisfactory results were obtained. The birdies at the high frequency end of the band were largely eliminated and the interference between the two local stations entirely disappeared. The signals from out-of-town stations were sufficiently strong to override the receiver and tube noise.



The same considerations applying to the universal type oscillator are applicable to the a-c-operated device, though here the output is greater. The device has earphone jack, also separate output nonconductive to d.c., besides speaker connections, and was designed by Dr. Harry Smejkal for scientific development.

For scientific development Dr. Harry Smejkal, optometrist, required an audio oscillator, so designed one that would give a flat characteristic over the span of 0-10,000 cycles, and providing for plugging in earphones, or using a filtered output, as for oscillography, and besides including speaker service. However, when the coupling between the two oscillators was so loose that the radio frequencies remained independent down to practically zero difference, then there was scarcely enough output strength for good response from the speaker, although fully adequate for 'phones, or for input to any audio amplifier.

It is not generally appreciated how small is the audio output from a beat frequency oscillator by itself, and how great therefore is the need for amplification. Always one stage is found necessary. Here two stages are used. Thus instead of the quarter-volt output considered minimum requirement for many tests, between two and three volts output are obtained, while safeguarding very low frequencies.

The capacities of circuit and tubes accumulate, so there is sufficient high audio frequency filtration due to this sum capacity, and the radio frequencies will not get through. However, a .00005 mfd. condenser is put at the audio output of the lower tube at left, simply as extra precaution.

The particular reference point is so-called zero frequency in so many instances that the device for establishing the coincidence is called a zero adjuster, but any low frequency may be used, provided a standard, such as a line frequency, in a synchronized power supply system. The word zero refers then to the difference.

The stability so vitally necessary in such a twin oscillator is almost invariably obtained by using a high ratio of capacity to inductance in the tuned circuits. Sometimes coils as commonly found in intermediate-frequency transformers are used, and the capacity increased by using a tuning condenser of, say, .00035 mfd. and putting across it a fixed condenser of equal capacity.

Thus the variation is from .00035 mfd. to .0007, a capacity ratio of 2 to 1, and a frequency ratio of 1.4, or one component of the system might be tuned from 50 kc to 70 kc. The difference is 20 kc and represents the audio span, no matter if the zero difference is established at 50 kc or at 70 kc. That is, two oscillators are required. One is fixed at, say, 70 kc. The variable oscillator covers 50 to 70, and the low audio frequencies are crowded, because the differences on which these depend take place near the high capacity position of the variable condenser, where capacity change is large, hence frequency difference large. So the practice is to tie down the two circuits at the minimum capacity setting, or close thereto. In that way the low frequencies, concerning which accuracy is most greatly risked, are more readily repeated according to a pre-calibration.

0-10,000 CYCLES FOR SERVICING

The example cited accounted for a difference of 20 kc. Since there is practically no limit, except that established by definition where audio frequencies cease and radio frequencies start, the difference might be 50 kc or 100 kc, etc. We are interested in audio frequencies only. Also we want the measurements to be made as accurately as possible, and that requires the best possible spreadout under the circumstances. Since we are interested in audio channels in receivers and transmitters, or in power ampli-

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fiers alone, we want to make measurements only up to the highest frequency intended to be passed. That would be 10 kc for nearly every example, so we select automatically 10 kc as the upper frequency limit of the difference, especially as 10 kc is the frequency by which adjacent carrier channels are separated in the standard broadcasting spectrum. Thus by keeping the total span of frequencies small we do not use up valuable dial space for frequencies of no value to the present instrument's acoustical purposes.

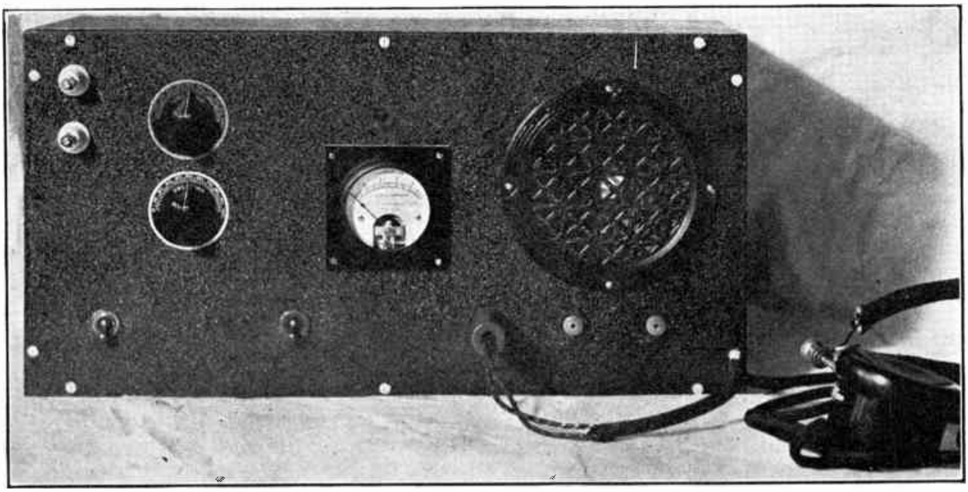
It can be seen that the capacity ratio is established by using a large fixed condenser across the variable condenser in the adjustable frequency circuit, and since the same coil may be used in the fixed frequency circuit, the total capacity in this instance would be equal to the minimum capacity present in the variable-frequency oscillator. The inductance is selected so that the span is 10 kc or so. Or, if the proper inductance is at hand, the capacity ratio capacities are selected so that the same resultant frequency difference of 10 kc accrues.

AVOIDING DEAD SPOTS

It would seem attractive to use large inductance coils, for the large capacity condensers usually at hand (.00035 mfd. etc.) could be used readily, but if for any reason the radio frequencies are low (30 or 40 or 50 kc or so), then the audio notes could produce harmonics of sufficient intensity to beat with one or both of the radio frequencies producing them, causing squeals superposed on squeals, or, if the phases are opposite, actual dead spots.

The dead-spot trouble will be the first one to be considered. One inserts earphones to test the new audio oscillator, and while the sound is all right at the start, it stops at two or even perhaps three places, and not for just one little division of the dial, but for a broad expanse. To avoid the principal cause, the smaller inductance coils are used. Much trouble was experienced with dead spots until coils of 28.5 millihenries, 2.05 millihenries and one millihenry were discarded and instead coils of 40 microhenries used. It can be imagined what happened to the intensity of the oscillation when across only 40 microhenries was a fixed capacity of .0024 mfd, plus a tuning condenser of .00014 mfd. Coils build up intensity of oscillation; condensers across the coils, when increased in capacity, reduce the intensity.

So we come to the second most obvious trouble, and that is, we reach a certain low frequency, say, 150 cycles, or perhaps 100 cycles, and the audio tone disappears. At first one may suspect this is due to the headphones, since it is well known their sensitivity at 100 cycles is very low. Then we recall that low sensitivity does not mean we can't hear anything, since headphones are among the most sensitive instruments we use. No, the loss of response is due to the fact that zero frequency difference is established too soon. The common impedance of the two oscillators is too great, so when the radio-frequency difference becomes relatively small, the higher impedance oscillator takes hold, and both oscillators oscillate at one frequency. This is called locking. Hence there is no difference in frequency and no response, though the dial reading is at 150 kc. And there should be response.



Front view of Dr. Harry Smejkal's audio oscillator shows two variable condenser knobs, one for 60-cycle adjuster, the other for calibrated frequencies resultant from the beat of the two radio frequencies. The on-off switch is at lower left, next the voice coil shorting switch when using 'phones, next the 'phone jack, and then two binding posts for filtered output. The two insulators are for taking out radio frequencies, after a circuit rearrangement, not included in the diagram. The meter may be in the cathode leg of the last audio tube, and may be used as zero beat indicator.

Some form of intentional coupling is usually present in the early experiments, but with the sensitivities of modern circuits one finds that the stray coupling is sufficient, therefore the diagrams herewith show no specially introduced coupling. The impedance common to both r-f oscillators always will be sufficient to yield the note, and since a main consideration is to continue response down to practically zero frequency, only weak coupling will do this.

STRAY COUPLING SUFFICES

For instance, if the intention is to have the frequencies adjusted to zero for accuracy, it is necessary to be able to produce or approximate zero. Establishing real zero frequency difference is almost impossible, but as close as one can get to zero, passes satisfactorily for zero within the accuracy limit of 5 per cent., which is good for an audio beat frequency oscillator.

A strange thing may have happened. To be able to attain zero beat we dispensed with formal methods of coupling and seemed to have left all to chance, though there is no chance about it. Yet the signal may be gone, all along the line! Can't be heard on earphones! No, the tubes have not stopped oscillating. Room noise masked the sound. It is there, all right, but so weak that it is almost of no use. And so we come to the third trouble—not enough volume.

Here is the rear view of Dr. Smejkal's audio oscillator. The zero beat method of adjusting the two r-f oscillators is being used by Sidney S. Fleischman, laboratory technician. Either the zero-beat or the 60-cycle standard may be used, or both.

MORE OUTPUT NEEDED

When the two oscillators are coupled as weakly as they should be, and the audio tone is taken simply from a detector—

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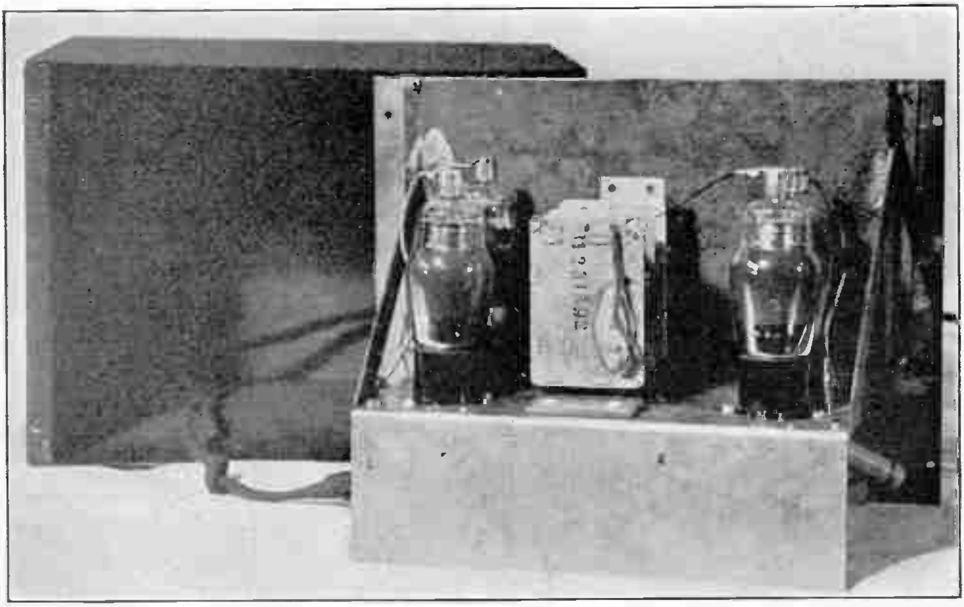
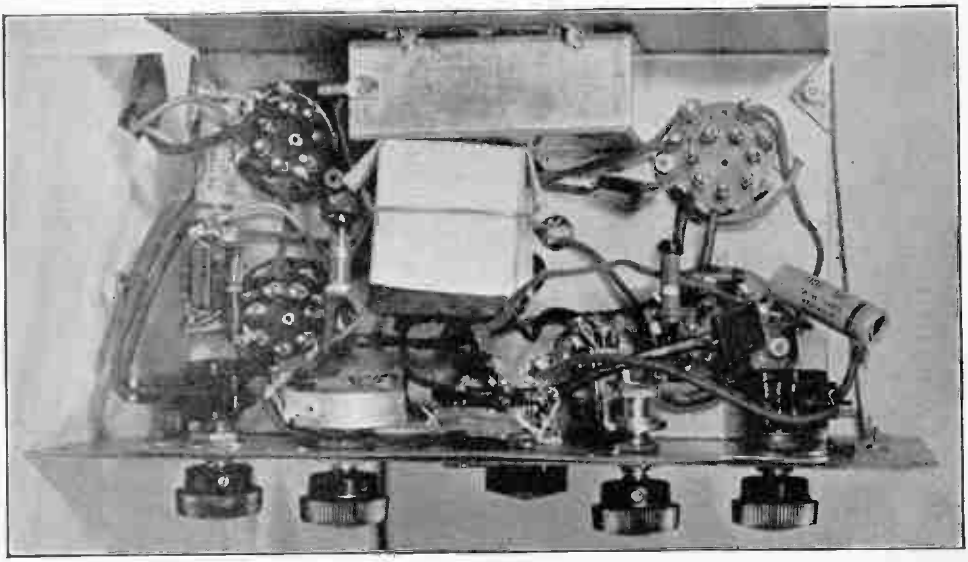
which in fact may be one of the two r-f tubes, usually the fixed-frequency one—microvolts output may be expected and this is not enough. You can not put the output into an audio amplifier and load it up to the standard (.05 watt), test output, neither can you light a lamp with a few microvolts or do any number of other acts deemed advisable. And so you must resort to amplification. The practical audio beat frequency oscillator must have a built-in amplifier.

Come we now to the fourth problem. If we must have amplification, we must have linear amplification, or, for the whole practical audio range, 50 cycles to 10,000 cycles, or .05 kc to 10 kc, the amplification should be the same. That is a difficult attainment, but can be approximated. At least the even amplitude that prevailed at detector output remains equal over a very large part of the 9,950 cycle span, falling off being present below 150 cycles and above 8,000 cycles. The results below 150 cycles can be improved considerably by using large inductance chokes in series with plate load re-





These are views of a four-tube beat frequency oscillator, which is the same as the universal five-tube model, except that an amplifier tube is omitted. There is still plenty of output for satisfactory 'phone use, and feeding audio amplifiers, around one-quarter volt.

sistors, and very large bypass condensers across biasing resistors (25 mfd. or more), while the response above 8,000 cycles can not be improved, but amplification made flatter only at the expense of the lower frequencies. This is because high-frequency audio attenuation is due to the inherent capacities across the audio amplifier tubes, and the wiring capacity.

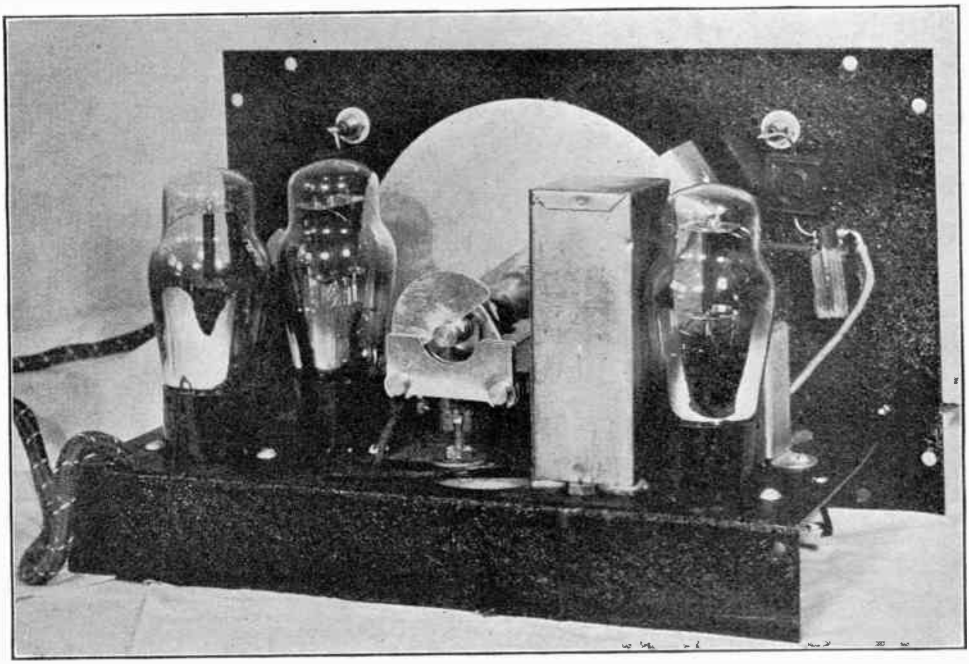
The inter-element capacities and other capacities accumulate, so that with a two-stage amplifier there may be all-sufficient capacity for bypassing the radio frequencies. Otherwise these frequencies too would go through the amplifier, which handles all frequencies, and perhaps cause trouble.

If one has to solve what is here tabulated as the fifth problem, that of calibration, he may have a good six hours' work ahead of him, hence should allot a working day to the task. The object is to get the frequencies right. No guesswork is allowed. The easy solution afforded by much lower frequencies, which yield abundant harmonics in the broadcast band, is to evaluate the radio frequencies of the variable oscillator, establish the fixed oscillator at the highest of these, and then for audio calibration simply use the difference between the known radio frequencies. While very numerous points will not be found, nevertheless sufficient could be obtained from very low original radio frequencies to enable drawing a curve from which all desired frequencies are obtainable by extrapolation. Harmonics to the fiftieth or more would be required.

To do this, therefore, get a sheet of cross-section paper, let the notation along the bottom be in terms of degrees, 0-180, and on the upright, put the audio frequencies, 0-20,000 or 30,000. The upright should be long, as only 0-10,000 will be desired, though the extra frequencies may show up because the capacity ratio of tuning is too great for the inductance. It is assumed the circuit will be arranged so that practically 0-10,000 cycles occupy the whole dial spread.

When the points are established the curve is drawn. For the circuits shown the curve will not be so far from a straight line. The radio frequencies are written at left, and afterward are changed to audio resultants, by subtracting the variable from the fixed frequency. It has been consistently recommended that the fixed frequency equal the high extreme of the variable, hence the specified sequence obtains: all other radio frequencies of the variable are lower.

While the radio-frequency method just outlined has been recommended for low radio frequencies that yield harmonics beating in the standard broadcast band, if one has a short-wave receiver, some very high frequency is accurately tuned in, preferably by using the harmonic of a generator that is itself made accurate by beating with a standard-band broadcast station. Then the accuracy is good, and the harmonic situation obtains, e.g., harmonics of the variable frequency section of the intended beat oscillator will furnish responses.

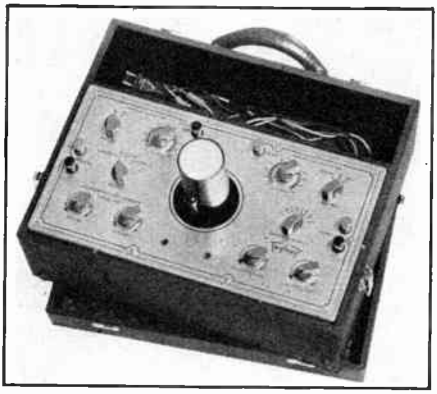


It is entirely practical to use a much smaller tuning condenser than .00035 mfd. or .00014 mfd., for even a three-plate condenser, capacity around 20.mmfd., will suffice.. However, there will not be as good stability, because the total capacity in the tuned circuit is small, or the radio frequencies prohibitively high.

NEW PRODUCTS

Triplett's Precision Line Greatly Enlarged

Many new instruments have been added to the continually-expanding Triplett line, manufactured by Triplett Electrical Instrument Com-



The Triplett oscilloscope.

pany in its most modern, air-conditioned factory at Bluffton, O. Triplett has forged to predominant instrument leadership.

An exclusive turret type mounting is used in the complete oscilloscope with 2 in. screen. This is Model 1690 and has a linear sweep from 15 to 25,000 cycles, besides all standard oscilliscope features.

An outstanding signal generator for extreme accuracy and zero leakage is Model 1630. Triple shielding where necessary eliminates all possibility of even negligible leaks.

Large, widely spaced dial (direct-reading vernier type) from 100 kc. to 30 mc. (in six ranges) has total scale length of 52⅝ in. Accuracy ½ to 1%. Each coil is individually calibrated and tracked for linearity over the entire range. A continuously variable attenuator of the pad type offers steps from zero output to full output.

Model 1631 is the same as Model 1630 but in addition incorporates electronic frequency modulation, for use with all cathode-ray oscilloscopes in alignment applications without separate frequency modulator.

The Model 1601 De Luxe Set Tester has the following features:

25,000 Ohms Per volt.

D. C. Volts—10-50-250-500-1000-2000 at 25,000 ohms per volt.

A. C. Volts—10-50-250-500-1000-2000 at 1000 ohms per volt.

D. C. Current—250 Microamperes; 1-10-50-250-500 milliamperes; 1 and 2 and 20 amperes.

Resistance—0.500 low ohms, backup circuit; 0-20,000 and 0-200,000 ohms; 2 and 20 megohms.

Condenser Tester—Ranges for capacity checking, .0001 to 30 mfds. Electrolytic leakage test.

Free Point Tester—Makes all series and parallel meter connections through five sockets with standard RMA markings.

Modernistic Indicating Instrument — Newly engineered indicating instrument in beautifully designed case. Extra large dial and easily readable scale. (Tester also has shadowgraph meter for line voltage control.)

This season most Triplett test equipment is furnished with beautifully colored etched panels. Testers of the 1500 series are furnished with fine quality silver and black panels while the popular Master units will be supplied with attractive silver, black and red etched panels.

Model 1770 tests all automotive and home battery radio receiver vibrators under actual performance conditions. Load of 5,000 ohms, recommended by vibrator engineers, is applied. Three scale meter: 0-10 volts scale shows input voltage to the vibrator; good-bad scale shows output; scale marked 0-100 per cent shows per cent of output voltage as reflected by the change in input voltage. Low damped meter permits needle to follow voltage fluctuations caused by faulty vibrator contacts. Metal case with black wrinkle finish is larger than regular Master unit size, 11⅜"x7⅞"x4". Attractive etched panel in black, silver and red combination. Attached leather strap carrying handle.

A new and improved Model 1241 condenser tester also is announced.

Besides there is a series of de luxe laboratory test panels.

Slide-Out Power Packs in Operadio P.A. Unit

A 25-watt, mobile public-address system, Model 132-BAC, has been brought out by Operadio Manufacturing Co. It uses beam power tubes, provides electronic mixing of one microphone and one phonograph, and includes a hand type dual-diaphragm crystal microphone. It can be used, however, with velocity, velotron and high impedance microphones. Two 12-inch permanent-magnet speakers, specially designed for public-address work, are included, and the power packs are interchangeable for 6 volts d. c. and 110 volts a. c. These packs are separate units, the one not desired being slid out and the one desired, carried extra, being slid in. The finish is backed black stipple. Specifications and further details are obtainable from Laurence A. King, Dept. RW, Operadio Manufacturing Co., St. Charles, Ill.

National Union Leads With 2" Tube for 'Scope

National Union factories have swung into production on the new National Union cathode-ray tube, Type 2002. This size tube is being widely used in smaller oscillograph units and will find its way into other application where compact size combined with complete performance of larger size Cathode Ray Tube is a factor. The new National Union Type 2002 is being produced after many months of laboratory experimentation in which structural features were developed to permit use of the small bulb size. List price is $7.50.

Rating and characteristics of the new tube are as follows:

GENERAL CHARACTERISTICS:
Screen size ....2 inches
Overall length ....6½ inches
Number of deflection plates...........4 (2 common)
Base........medium octal 8-pin-based same as 1" tube

Pin 1: Anode No. 2 plates D2 and D4	Pin 5: Control grid
Pin 2: Heater and cathode	Pin 6: Lower plate D3
Pin 3: Anode No. 1	Pin 7: Heater
Pin 4: Upper plate D1	Pin 8:

Screen ....short persistent
Color of screen.................................greenish
Type of cathode.........................indirect heater

ELECTRICAL CHARACTERISTICS:
Heater voltage (A.C. or D.C.)..................6.3 volts
Heater current.............................. .6 amperes

MAXIMUM RATINGS:
High voltage electrode (anode No. 2)....600 max. volts
Focus electrode (anode No. 1)...........300 max. volts
Grid voltage............................never positive
Grid voltage for current cut-off...... —60 approx. volts
Power per sq. cm. of screen.........10 max. milliwatts

TYPICAL OPERATING CONDITIONS:

Anode No. 2 voltage	400	500	600 volts
Anode No. 1 voltage	80	100	120 volts

Grid voltage adjusted for suitable spot.

DEFLECTION SENSITIVITY:

Plate D1 and D2	.21	.17	.14 mm/volt D.C.
Plate D3 and D4	.23	.19	.16 mm/volt D.C.

C-D House Organ Aids Servicers and Experimenters

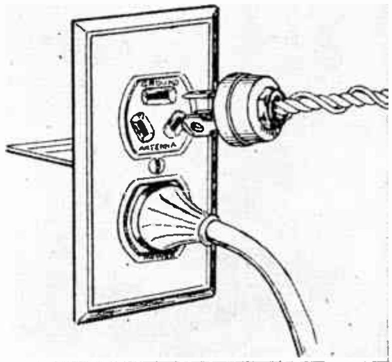
A new and interesting magazine for the radio serviceman, amateur, engineer and experimenter is maintained by the Cornell-Dubilier Electric Corporation. The publication, entitled "The C-D Condenser," is printed in digest form and sent free.

Highlights of the magazine include feature articles on technical subjects, biographies of personalities well known in the radio industry, a reading guide to current radio magazines and "The Radio Trading Post," a free market place where sellers, buyers, swappers, job-offerers and job-seekers can meet to mutual advantage.

To receive copies of "The C-D Condenser," released bi-monthly, applicants send their name and address to the C-D Condenser, Cornell-Dubilier Corporation, South Plainfield, New Jersey.

General Electric Offers New Radio Outlet

An outlet for noise-reducing or doublet antennas, which eliminates the wiring connections characteristic of most radio receivers installed in the home, was announced by General Electric Company. The outlet affords separable attach-



A new combination outlet for antenna-ground and power connections.

ment for ground and antenna (two-wires), and power leads for a radio set. Leadin wires are thereby eliminated.

The new outlet has three slots in the upper portion, one for ground, two for the doublet, with the usual power connections below. A metal divider is attached securely to the body of the outlet to separate the low and high tension circuits. A special cap is also available, with polarity prongs arranged so as to prevent antenna and ground circuit from connecting with the power side of the outlet. The circuit connections are clearly indicated on the face of the outlet.

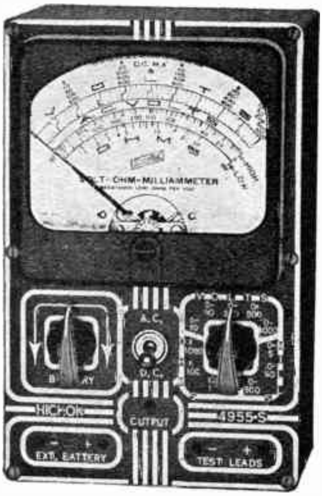
AC-DC Patent Allowed To Harry G. Cisin

Patent Office issued Patent 2,086,526, to Harry G. Cisin on a circuit that permits interchangeable operation of radio sets and other electronic devices from the ordinary 110-volt house-lighting circuit regardless of whether alternating or direct current is supplied. It has the further advantage of doing away with bulky and expensive power supply and filament transformers.

Many of Mr. Cisin's technical and constructional articles have appeared in this publication. Mr. Cisin is the designer of the well known line of Air Scout All Wave Receivers and is the head of Allied Engineering Institute, 98 Park Place, N. Y. City.

Hickok Announces New Volt-Ohm-Ammeter

The Hickok volt-ohm-milliammeter, model 4955-S, is a new instrument, equipped with one of the Hickok square meters, 4" scale length,



for general testing on both a-c and d-c circuits. A special low ohms range tests r-f, i-f and voice coils.

The instrument has high sensitivity (350 microampere movement), a rotary switch, eliminates jacks, and has contact resistance so low that it does not affect readings.

Scale ranges are as follows: a-c and d-c volts, 0-10, 0-60, 0-250, 0-500 and 0-1000. Ohms, .05-30, 15-10,000, 50 ohms to 1 meg, 500 ohms to 10 meg, d-c milliamperes, 0-1, 0-5, 0-50, 0-500. A resistor built in to permit reading to 10 meg. with external battery. The a-c voltmeter serves also as output meter, using same scale as a-c volts.

The instrument is guaranteed within 2% accuracy on all ranges. Adjustment can be made for changes in rectifier efficiency.

The panel is engraved Bakelite. The steel case measures 7" x 4½" x 3¼". The unit is complete, self-contained, with rheostat to adjust meter to batteries. Four-foot leads fit all tube sockets. The manufacturer is The Hickok Electrical Instrument Co., Cleveland, Ohio.

Superior Has New BFO and "Infinite" Voltmeter

Two new products announced by Superior Instruments Company, 136 Liberty Street, New York City, are an audio beat frequency oscillator, 0-10,000 cycles, and an infinite resistance voltmeter for measuring a.c. and d.c. For a.c. measurements a thermionic detector is used. The audio device has a two-stage amplifier, total five tubes. The other measures 0-1.5-5-15-50-100-150 volts, a.c. or d.c.

General Electric Enters Intercommunication Field

A new intercommunication system, known as the "Handy-Phone," is being made by the General Electric Co. Essentially a loud-speaker phone system, the new apparatus is designed for use in offices, hospitals, stores, homes, or any similar place where speedy voice communication is desired.

The system consists of one master station and from one to four remote speaker-phone stations. The remote stations may be located at any points within 2,000 feet of the master unit, or at greater distance with special arrangements.

An individual at the master station of the Handy-Phone may have two-way conversations with any of the remote stations, or may speak to all of them at one time. He turns the five-point selector switch to the desired position, presses down the "talk-listen" control lever, and speaks. When he is ready for his answer, he releases the lever and it automatically returns to the "listen" position. Remote stations may talk back to the master station without the operator using hands, switches, or keys.

How Long Life Is Built Into Compact Condenser

The photograph shows the "inside" story of one of Cornell-Dubilier's popular etched foil dry electrolytics. This extremely compact and

View of the C-D etched foil condenser, with container partly broken away to expose the internal construction.

efficient unit, type JR, is first dipped in wax, then encased in an inner cardboard container which is vacuum impregnated. Into the space between the inner liner carton and the condenser section is poured a special chemically pure asphalt compound which surrounds and hermetically seals the condenser unit.

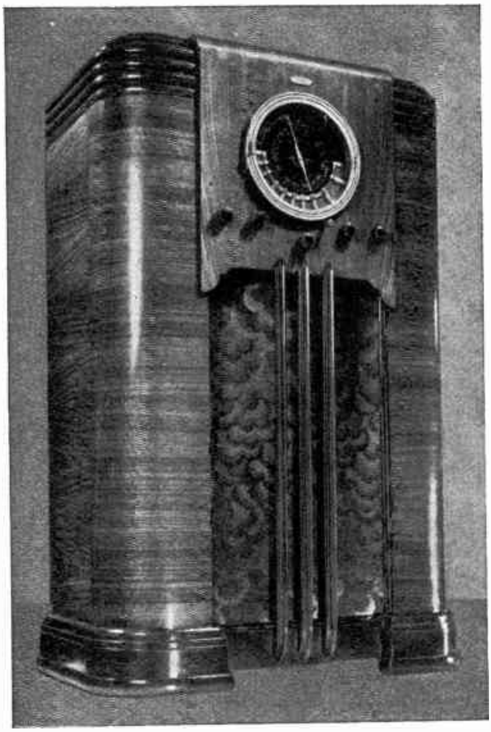
After passing C-D's rigid test requirements, this sturdy condenser is sealed in an attractive silvered cardboard container, equipped with universal flanges for mounting in the tight places you never thought you could fit a condenser.

HAUBENS BACK FROM TRIP

Maxwell M. Hauben and his young wife just returned from an ocean trip to Mexico. Mr. Hauben is president of Eastern Radio and Television Co., N. Y. City.

Allied Features Knight 11 As Outstanding Receiver

Among the new Knight Radios featured by Allied Radio Corporation, 833 West Jackson Boulevard, Chicago, is the Knight 11 with



View of the Knight 11 console.

automatic dialing, shown in the accompanying illustration. Favorite domestic stations are tuned "quick as a flash" by means of this unique device. The Knight 11 tunes three full bands: 16 to 54 and 52 to 178 meters for short-wave domestic and overseas programs, as well as amateur and police signals; and 174 to 560 meters for American and Canadian standard broadcast programs.

Other advanced features are: giant color-band dial, metal tubes, 9 watts power output, 12-inch electro-dynamic speaker, automatic frequency control, automatic tone control, automatic volume control, interstation noise silencer, 3-gang tuning condenser, r-f pre-selection and double push-pull audio. The console cabinet measures 41" high, 26½" wide and 14½" deep.

The Knight 11 is one of the 53 Knight radios featured in the 156-page Allied catalog.

The Allied business has been steadily increasing, so that greatly enlarged quarters are being occupied. Thus it is assured Allied will retain its reputation for "lightning delivery." Its radio stock is one of the most comprehensive in the world.

FORUM

THE GROUND SITUATION

We seem to have different results with grounds out here than experienced by A. J. Ward who wrote an article on grounds in the August issue. Not all mortals see eye to eye, of course.

I find no fault with the intention of the author and appreciate the difficulty of establishing a true ground when living in tall buildings.

The part which I object to is the statement that with the ground off the r-f noise level is lower when caused by electric motors and kindred electrical interference. We live in the northeasternmost part of Connecticut, where there is considerable electrical interference from power lines and probably coming great distances along that path. In fact, there are sections here where the interference is so severe that some of the listeners can get only one station without too much interference.

The nearest station to this locality is about 20 miles airline. And not too powerful at that—WTAG of Worcester, Mass. Good noise-reducing antennas have been successful only if the ground terminal is connected to a water pipe ground. It might appear from the above that all we do is ground out the noise that comes through the power transformer but automobile radio sets in the same locality pick up the interference as well as the home sets. I have grounded the car frame as well as the set chassis and obtained much better results, i.e., a lower noise to signal ratio when the chassis or r-f input primary of first stage is grounded to earth through a water pipe or equivalent ground.

In conclusion, Mr. Ward is correct when he says "it is elusive," but from a practical viewpoint good old Mother Earth is useful in rural as well as urban centers here in bypassing motor noises and electrical interference away from "audibility."

VALMORE M. LA PIERRE
(Serviceman),
68 Groveland Avenue,
Putnam, Conn.

Optimistic Note Sounded By Kranz, Head of Thor's

Michael Kranz, head of Thor Radio, 65 Cortlandt Street, reported business good, especially so for Summer, but said he looked for the real new set buyers just after Labor Day.

"The models for 1938 are so beautiful, the tone so marvelous, that even the most casual listener is captivated into buying," he continued.

"Ease of operation is a big selling point this season."

He demonstrated this feature by tuning in several different stations merely by pressing buttons on the cabinet panels.

First Hi-Fi Earphones

Developed for Monitoring Broadcasts and Sound Movie Recording

By F. S. Wolpert

Transmission Instruments Development, Bell Telephone Laboratories, Inc.

FIG. 1
The high-quality headset used for monitoring in the broadcast and sound picture fields.

IN connection with electrical recording, transmission, and reproduction of speech and program material in the sound picture and broadcast fields, the ability to monitor in a satisfactory manner at various points is essential in the production of a high-quality performance. When recording sound for a talking motion picture, for example, it is essential to be able to determine at the time the recording is made as nearly as possible how the sound will be reproduced in the theatre when the picture is shown. In other words, it is desirable to see the action on the set and to hear the corresponding sound as it would come from the loudspeakers in the theatre. For this purpose, a monitor room or portable monitor booth is frequently provided on the sound recording stage. There are many circumstances, however, such as outdoor locations, where the use of a monitor room or booth is impossible. It is also recognized that greater facility of recording operations may be obtained on the sound stage if the mixer can be seated in the open alongside the director rather than in the booth or distant monitor room. For these purposes, it is necessary to use a pair of headphones for monitoring in place of the usual loudspeakers.

The work of a mixer consists in determining whether the sound picked up by the microphone will make a suitable sound record, adjusting the volume to a suitable amount, and making sure that no undesirable sounds are picked up. In addition to his own personal judgment of sound quality he must be equipped with sound reproducing apparatus capable of giving him a faithful indication of the sound transmitted to the recording machine.

BROADCAST APPLICATION

Very similar to the sound recording job is the work of the technician in operating speech input equipment in broadcast studios or remote pickup points. In transmitting the program material over telephone lines, such as the extensive nation-wide networks, it is important that the test room forces at the various intermediate offices be able to check the quality of transmission in connection with identifying and locating troubles and other service difficulties.

Up until recently it has been necessary, in order to monitor on a high-quality basis, to make use of loudspeakers comparable with those used in theatres and high-grade radio receiving sets. The headphone receivers which have been available for monitoring purposes have not been satisfactory for a quality job. Most telephone receivers in common use give rather low response at low frequencies, a high peak in the neighborhood of 1,000 to 2,000 cycles, and extremely low response at frequencies above these.

Considerable progress has been made within the past few years in the development, design and manufacture of moving coil receivers (earphones) for various applications. These receivers are characterized by a wide frequency range, uniform response, and very little non-linear distortion, so that they are particularly suitable for use in monitoring sound records. A receiver of this type, known as the D-97689, has recently been developed particularly for this purpose. It is intended to replace the less efficient and more expensive moving coil receivers previously available. A photograph of the new receiver forming part of the D-97690 high-quality headset is shown in Fig. 1.

EARPHONE CONSTRUCTION

The construction of the receiver is shown in Fig. 2. The moving coil element is made of aluminum ribbon wound on edge and insulated with a varnish enamel which serves also as an adhesive for holding the adjacent turns together. It is cemented rigidly to the diaphragm and the leads are brought out between paper insulating washers. The coil is located in the air gap of the magnetic field produced by a permanent magnet of cobalt steel. The gap is between an outer pole plate and an inner dome-shaped pole piece, which are concentrically aligned to make the gap uniform.

The diaphragm is made of duralumin and has a dome-shaped center portion which extends to inner edge of the coil. Beyond the coil the diaphragm is so shaped that its effective radiating area and its efficiency are increased. The flexible outer surface is held around its periphery by the clamping elements of the receiver frame. The diaphragm and coil vibrate substantially as a piston throughout the desired frequency range and are relatively free from other modes of vibration.

The action of the diaphragm under the influence of the varying current in the moving coil depends on the characteristics of the diaphragm, of the air chambers in front of and behind it,

(*Continued on following page*)

Telephone Receivers Are Wolpert's Specialty

F. S. Wolpert was graduated from the Newark College of Engineering in 1927 with the B.S. degree in Electrical Engineering. After a year of sales engineering work with the Weston Electrical Instrument Corporation, he joined the technical staff of the Bell Telephone

F. S. WOLPERT

Laboratories, Inc., and became associated with the Apparatus Development Department in the preparation and issuance of manufacturing specifications.

In 1930 he was transferred to the Transmission Instruments Group in the Research Department, where he has been engaged in the development and design of earphones both of the moving coil and magnetic types.

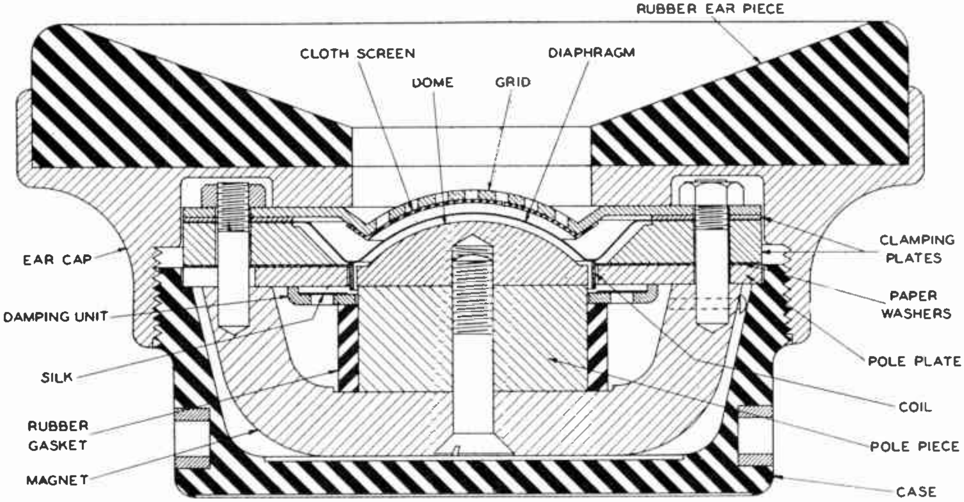


FIG. 2
Cross-section of the moving-coil receiver

(*Continued from preceding page*)

and of the air chamber formed between the cap and the ear. The overall frequency response characteristic of the instrument depends largely on the design of these elements. By suitably proportioning these parts the response may be made to approach very closely to the necessary requirements for modern sound picture recording.

CIRCUIT REPRESENTATION

The characteristics of the diaphragm and coil alone can be represented electrically as a simple resonant circuit of resistance, inductance and capacitance, as shown in the upper part of Fig. 3. The inductance represents the mass of diaphragm and coil. The two capacitances represent the stiffness of the diaphragm and that of the ear cavity. The response of these elements, as measured on a closed coupler, would be similar to the Curve A of Fig. 4.

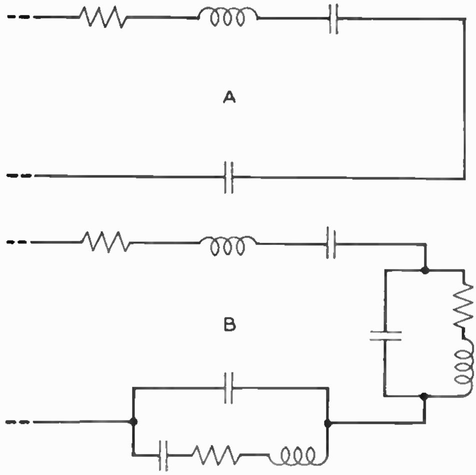


FIG. 3
Equivalent electric circuits corresponding to the moving-coil receiver: above, for the coil, diaphragm, and ear cavity; below, circuit for the complete receiver.

The chamber below the diaphragm is totally enclosed except for an acoustic resistance element consisting of a series of holes covered by a silk screen. A rubber gasket is provided to seal off this air chamber and to hold the acoustic resistance unit firmly in place against the pole-plate.

The air chamber in front of the diaphragm is enclosed except for a group of small holes in the dome-shaped center portion of the cap grid. It is through these holes that the sound waves pass after leaving the receiver diaphragm. They also provide additional resistance, mass, and stiffness, which affect the response of the receiver. A layer of bolting cloth placed over the grid holes excludes metallic dust from the interior of the receiver and helps to protect the diaphragm from injury. The equivalent electrical circuit for the complete receiver is shown in the lower part of Fig. 3. Curve B of Fig. 4 shows a typical frequency-response characteristic curve for a receiver of this type.

FLEXIBLE CHARACTERISTICS

The characteristics obtainable with a moving coil receiver are very flexible since the design of the acoustic networks associated with the diaphragm may be readily modified without changing the overall dimensions. Once the fundamental requirements to be met by a receiver are known, it is possible to obtain the characteristics desired by changing the design of these elements. In the D-97689 monitoring receiver they were adjusted to produce substantially uniform pressure in the ear chambers over a frequency range from 100 to 6,000 cycles.

The receiver unit is housed in a black phenol plastic case with spring contacts to engage flat strips terminating the coil leads on the receiver. A sponge rubber ear-piece is cemented to the metal cap, and serves to reduce external noise and also to improve the low frequency response by providing a tighter seal between the receiver and the ear. The receiver is slightly larger than the monitoring receivers of previous design, but it is about 15% lighter.

Many favorable comments have been received from sound technicians in the motion-picture field on the performance of these receivers when used with monitoring circuits. Considerable thought has been given to simplifying their manufacture, and their resulting lower cost, compared with moving coil receivers of previous designs, opens up many fields of use, particularly where high quality is of prime importance.

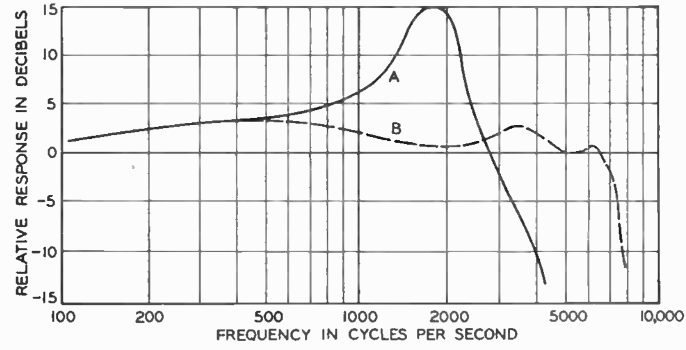


FIG. 4
Frequency-response characteristics for the D-97689 receiver: curve "A" shows the response of diaphragm, coil, and ear cavity alone; and curve "B" shows the response characteristic of the complete receiver.

RADIO CONSTRUCTION UNIVERSITY

Answers to Questions on the Building and Servicing of Radio and Allied Devices.

CURES FOR INTERNAL FADING

I AM told that the greatest amount of trouble is due to internal fading. Will you please give a few pointers on the cause and cure?—L. E. E.

By such fading is meant any change of intensity of the received signal that is not due to transmission. A large variety of causes may produce such fading. The most troublesome fading is intermittent, the on-and-off popping type. Neither is this traceable to any common source. One of the first things to suspect when there is fading is some paper-dielectric bypass condenser. Condensers filtering screen and plate voltages (outside the main B supply filter), especially with resistance in series to maximum B plus, are particularly suspicious. The reason is too low a voltage rating condenser is used, and when the set is turned on, there is practically no current flow through the series resistor, so the full B voltage appears across the condenser of too-low rating. When checking condensers that have resistances across them it is necessary to disconnect the resistor from the circuit. It is sufficient to open one resistor lead. Also resistors themselves are fading contributants, particularly in the grid circuit of the last stage (power tube). Let this be one of the first resistors checked. An ohmmeter in the megohm range may be used. Seldom is the fading due to coils. The type of fading from which the word fading was originally derived, due supposedly to out-of-phase reception of carrier wave components, may be minimized by use of automatic volume control, but there is no known cure for such fading. Some individuals and laboratories, however, are working on the problem.

* * *

JUSTIFICATION FOR I.F.B.

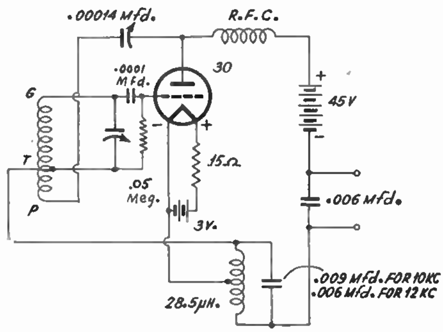
ON what basis does inverse feedback deserve its reputation for reducing the distortion to a very low level?—Q. G.

Inverse feedback consists of taking a part of the amplified audio voltage and returning it to a prior audio stage, in such a way that the phases are opposite. Gain is sacrificed considerably, distortion reduced proportionately, but such feedback is becoming popular because gain is not such a great consideration any more. Tube improvements permit atoning for the sacrifice in gain at small expense. Thus the power output may be brought up to what it was before, with extra driving, yet distortion reduced from 5 per cent. to 1.5 per cent. or less. It turns out that the percentage distortion is reduced at the same rate that gain is reduced, but that when the compensating gain is added, the previously reduced figure of distortion percentage stays reduced, and does not go up with the gain in amplification.

* * *

SUPER-REGENERATOR

WHAT is wanted is a super-regenerative one-tube battery circuit, that will perk in the broadcast band, also above in frequency.—A. L.



A super-regenerator that works at frequencies even as low as in the standard broadcast band.

The diagram is given herewith. The tapped coil GTP is selected for the desired reception band. This and the 28.5 millihenry coils are commercially obtainable.

* * *

WHAT LISSAJOUS FIGURES ARE

WHEN causing patterns to appear on the screen of a cathode-ray tube, just when are the figures of the Lissajous type, and when are they of the other type, whatever the name?—L. R. L.

When frequency comparisons of a harmonic nature are made on the 'scope, one frequency injected into one set of plates, the other frequency into the other set of plates, the patterns are said to be simple, so long as the phase is the same. Whenever the two frequencies are not integral multiples or submultiples of each other, i. e., not 1:1, 2:1, 3:1, etc., or 1:2, 1:3, etc., but nonharmonic multiples or submultiples, as 3:16, 2:15, 2:9, the figures take the name of Lissajous, for the Frenchman who first re-

(Continued on following page)

(*Continued from preceding page*)
vealed their significant relationships. By extension his name is applied to all non-simple figures, including harmonic relationships where phases differ.

* * *

AUTOMATIC FREQUENCY CONTROL

WILL you kindly give a very pithy explanation of the automatic frequency control?—L. A. M.

This consists of a method of preventing mistuning of a radio receiver, by causing the circuit itself to select the stronger of two stations and adjust itself to bring in the single station with best fidelity. This is accomplished by setting up a circuit that affects the local oscillator tube in the receiver, to change the frequency, or make the mechanical setting of the dial right for the stronger station. Thus two tubes may be used, one for discriminating between too high and too low off-resonant frequencies; second, a control tube to translate the discrimination into equivalent inductance change of the local oscillator's tuned secondary. This it does by manipulation of phases, whereby the phase change is produced by bias alteration, and is such phase shift as would be accomplished if the inductance were truly altered. When the control tube applies the correction, the local oscillation frequency is made right for the dial position, both r-f and oscillator frequencies. The r. f. is right because there has to be a certain amount of broadness or bandpass to give leeway to the local oscillator's shift by the control tube. The reason for a. f. c. is that, despite indicating devices, so many users of sets permit the sets to be tuned off resonance, which results in considerable distortion in modern receivers, particularly those having automatic volume control.

* * *

LINEAR METER?

IN the construction of a multiple meter arrangement, since I intend to fix up my own scale, is it safe to assume the meter is linear on d.c.? Can the multipliers be regarded as constant factors, after the meter resistance becomes negligible?—R. G.

It is not safe to assume that the meter is linear. It is likely to be otherwise. A good way to check this is to get ten equal resistors, put them in series, and have them of such value that they will drew far more current from the source than will the meter you intend to arrange as voltmeter. Then adjust the voltage to full scale by an extra rheostat in series with the chain, and insert the series or limiting resistor in the meter circuit that exactly establishes this intended full-scale deflection. The voltage is determined by another and quite accurate meter, kept in circuit while the rest of the work is performed. The voltage distribution along the series network is in equal steps. Say full scale was 10 volts. Now the jumps are 1 to 10 volts. If the meter has a scale reading simply 0-10 linearly, check the settings against the known voltage. If there is lack of coincidence there is reason to believe lack of linearity exists in the meter, the only other pos-

(*Continued on following page*)

Literature Wanted

Readers whose names and addresses are printed herewith desire trade literature on parts and apparatus for use in radio construction. Readers desiring their names and addresses listed should send their request on postcard or in letter to Literature Editor, Radio World, 145 West Forty-fifth Street, New York, N. Y.

Jim F. English, 4207 N. Jefferson, Spokane, Wash.
Jack Morgan, 4324 Michigan Ave., Los Angeles, Calif.
Edward Deehan, 2096 Amsterdam Ave., New York, N. Y.
George Renn, 919 Lanvale Street, Hagerstown, Md.
Donald Woolery, 21 Crown Ave., Dayton, Ohio.
International Radio Sales & Services, 27 Hankow Rd., Kowloon, Hong Kong, China.
Estevao Tamas, Travessa Cassiano, 19, Rio de Janeiro, Brazil, S. A.
Anselme-Laperriere, 39 Chateauguay St., Quebec, P. Q., Canada.
Richard A. TenEyck, W2JJT, 9 Conger Ave., Haverstraw, N. Y.
Daniel Farkas, W2INO, 1140 College Ave., New York, N. Y.
Henry J. Geist, Box 12, Churchville, Pa.
Henry H. Wilson, Box 636, Santa Barbara, Calif.
Eric T. Ledin, 244 Excelsior Lane, Sausalito, Calif.
Charles E. Reed, W7ANN, 303, North 13th St., Shelton, Wash.
Sidney D. Shaw, Route 6, Salem, Ore.
E. A. Reichmann, 409½ East First St., Uhrichsville, Ohio.
Carl A. Kowalski, 149 Andrew Place, W. Lafayette, Ind.
I. A. Willett, 2411 Arunah Ave., Baltimore, Md.
L. J. Kunert, 66-11 74th St., Middle Village, L. I., N. Y.
Albert Maas, 9 S. Howard Ave., Bellevue, Pa.
Stanley Wiggins, Spruce Street, Riverside, Conn.
R. Sadites, Box 973, Timmins, Ontario, Canada.
B. L. Cockran, Meadoes of Dan, Va.
Manson McNamara, 435 Clinton Ave., Albany, N. Y.
Robert Hayes, 211 Remington St., Bridgeport, Conn.
T. Spencer Richardson, 146 S. Tennessee Ave., Atlantic City, N. J.
Geo. A. Phillips, P. O. Box 174, Aline, Okla.
Cornelia O. Manley, 2907 W. Sharp Ave., Spokane, Wash.
Raymond Adams, 50 Washington Ave., North Plainfield, N. J.
James B. Reid, Box 294, Houston, Miss.
Paul Tenaki, P. O. Box 248, Attica, N. Y.
R. L. Halliburton, Box E., Pedro Miguel, C. Z.
Debendranath Ganguli, No. 9, Haldarpara Rd., Kalighat, P. O. Calcutta, India.
F. V. Kingsley, 932 East 4th St., Erie, Pa.
O. A. Sullivan, Naylor, Missouri.
Robert L. Gaw, Yardville, N. J.
Louis B. Kellogg. Unionville, Ohio.
Harry G. Richardson, 505 Margaret St., Pittsburgh, Pa.
Dick Dooan, 1657 N. Wisconsin St., Racine, Wisc.
Elisabeth S. Brush, 1127 N. Euclid Ave., Pittsburgh, Pa.
D. B. Johnston, 1501 Arlington Ave., Bessemer, Ala.
A. Brown, Rt. 2, Colona, Mich.
James Jimenez, 302 E. 111th St., Apt. 11, N. Y. C.
R. J. Kammel, 516½ New St., Allentown, Pa.
M. Walker, 404 Central Ave., Lakewood, N. J.
T. Curley, 315 Eastern Pkway, Brooklyn, N. Y.
Victor Scemeca, 226 East 6th St., N. Y. C.
The Woodworkers' Shop, 616 W. Market St., San Diego, Calif.
Charles Miesel, 60-35 Sauders St., Elmhurst, N. Y.
W. A. Taylor, 123 W. 34th St., Richmond, Va.
Louis Moore, P. O. Box 722, Nogales, Arizona.
Leslie King, 4339 Lake St., Omaha, Nebr.
B. M. Marrit, P. O. Box 274, Dearborn, Mich.
Gerard M. de Broekert, 1472 W. 8th St., Eugene, Ore.
E. D. Coker, P. O. Box 91, Drayton, S. C.
Walter Johnson, 5235 Alcott Ave., St. Louis, Mo.
Frank Shea, 1422 Main St., East Hartford, Conn.
C. Wilson, 2829 4th St., Richmond, Va.

(*Continued from preceding page*)

sibility being that the scale is non-linear but the meter is linear. This could be checked independently. Because meters normally are not linear, readings from about two-thirds to full-scale are favored for accuracy, which accounts for so many scales, at small increments of voltages, in some meters.

* * *

READING A.C. FROM D.C.

AS I have no high-frequency measuring equipment, can you suggest some way that I may obtain known output volts from some a.c. device, to be used for calibrating some other device?—R. C. W.

The only method we know of accomplishing your otherwise difficult requirement is to set up a radio-frequency oscillator, at any known frequency, and provide a resistive-loaded output. In series with the plate put a d.c. current meter of suitable sensitivity and buck out the d.c. component of the plate current, also bypass the meter. The meter reading equals the voltage of the second harmonic of the generator frequency. The method was set forth in detail in the July issue.

* * *

THE OSCILLATING RECTIFIER

IS it true, as I have head, that a rectifier tube can be made to oscillate, and if so, why and how?—K. R.

We believe it is true, although we have not actually performed the test. The possibility applies to the mercury-vapor type of rectifier, which has a negative resistance slope, and therefore could be made to oscillate, as does the dynatron and the positive mu oscillator for the same general reason. In fact, the gurgling interference present when such rectifiers are intended for use as rectifiers, and requiring 2 millihenry chokes to smooth out the trouble, may be oscillation due to the negative characteristic.

* * *

SOLDERING TO NICKEL PLATE

MY soldering operations sometimes include nickel-plated pieces and I have considerable difficulty in making a proper joint.—I. L.

Nickel and solder do not mix well and naturally you have trouble. It is advisable to remove nickel plating at the point where the soldered contact is to be made. It is not good practice to solder to the plated part. It can be done but is not reliable.

* * *

COEFFICIENT OF COUPLING

SOMETIMES I run across the expression coefficient of coupling, symbol k, in reference to coils, and I would like to know what is the proper expression for this.—W. D. C.

If k is the coefficient of coupling, M the mutual inductance, and L_1 and L_2 the respective self-inductances of which M is the mutual, then $k = M \div \sqrt{L_1L_2}$. In other words, the coefficient of coupling is the ratio of the mutual inductance to the square root of the product of the self inductances.

LINEAR DB METERS

USUALLY meters are shown with db scales that are not linear, whereas recently I have noticed some meters, though for db purposes only, that do have a linear scale. Will you kindly explain how this is accomplished?—D. D. M.

The usual d-c ammeter is designed to have equal spacing on the scale for equal increments (changes) of current. This is obtained by having the moving coil, to which the pointer is attached, rotate in an air gap of equal flux density throughout. The flux is constant, so the torque on the coil will be proportional to the current. Since the pointer acts against a spring providing a restoring force proportional to the deflection, equal deflections are obtained for equal increments of currents. To maintain this evenness of scale, though the meter applies to db only, which are not proportional to current, but to the logarithm of a ratio, the width of the air gap is varied from one extreme position of the coil to the other extreme position. The flux, therefore, instead of being the same at all positions of the coil, would increase toward the positions of greater loss. The right-hand extreme of such a scale would be marked 0 db loss, the position for maximum current. The decrease in current for successive losses becomes less and less and thus linearity is retained.

* * *

ACORN TUBE IN VTVM

I HAVE been trying out a 956 in a high-frequency tube voltmeter but do not seem to get the expected results. Will you please give me the pertinent characteristics?—M. J. B.

The 956 is a 6.3-volt heater-cathode glass tube of the remote cutoff type and requiring a special socket. It is intended for operation to .7 meter. Perhaps your trouble is you use the tube more as an amplifier than as a detector. Try the following: plate volts, 250; screen volts, 100; negative grid bias adjusted until the plate current equals 1.75 ma (requires usually minus 10 volts). The tube is of the acorn type and has very small element capacities: grid to plate, .007 mmfd.; grid to cathode, 2.7 mmfd. and plate to all other elements, 3.5 mmfd.

* * *

I.F.'S NEARLY ALIKE

PLEASE state the intermediate frequencies of the following receivers, as I assume them to be the same from experience:

(a) United Motors Service, Model 2035; (b), Wells-Gardner, Model 6V.—L. A. E.

The intermediate frequencies are (a) 262 kc and (b) 262.5 kc.

* * *

PHASING SPEAKERS

WHAT is meant by the phasing of a loudspeaker and what is a method of having multiple speakers properly phased?—C. D. S.

By phasing of speakers is meant that they work in step. When multiple speakers are connected together and mounted near each other or

(*Continued on following page*)

(Continued from preceding page)

one another, the bobbins should operate in synchronism. If a 1.5-volt dry cell is connected across voice coils, whether these coils be in parallel or in series, the cones should all move in the same direction.

* * *

WRONG VOLTAGES READ

I DO not seem to be able to justify the commonly accepted voltage relationships in the series heaters of ac-dc sets. I use an electromagnetic a-c voltmeter.—W. D. C.

The commonly accepted considerations are correct. Your voltmeter draws so much current that when you insert it across a tube heater, or across a chain of heaters, you cause so much more current to be drawn that you upset the true voltage conditions as exist in the operating receiver and set up a new and false set of voltages, which persist until your voltmeter is withdrawn.

* * *

NEW ACOUSTICAL IDEA

RECENTLY I have been reading about the infinite baffle approximation by some acoustical treatment, and would like to have an explanation of this.—R. F. G.

You probably refer to the bass reflex principle, which tends to create a condition something like that of an infinite baffle, and in some instances superior to what an infinite baffle would be. It has been recognized that a large baffle is required for low notes. The bass reflex principle achieves in a cabinet of acceptable dimensions the reproduction of sounds lower in frequency and more accurate in character. The principle involves the coupling of a cone type speaker to an aperture, in an otherwise totally enclosed cabinet, so that an acoustic circuit is accomplished. The enclosed volume is as an element of this circuit. In this manner the pressure delivered at the back of the speaker diaphragm (which otherwise performs its normal function) causes a compression within the enclosure. This compression acts on the air in the aperture and through oscillation creates an auxiliary source of sound. This auxiliary or driven source of energy is restricted to the relatively narrow band of frequencies in which it is wanted. Thus one or more octaves of low-frequency response are acquired.

Big New WGY Plant to Have Vertical Aerial

Excavation for the studio building of WGY, Schenectady, N. Y., outlet of the NBC-Red Network, was begun, with the expectation that one of the oldest broadcasting stations in the country will be operating in one of the most newest plants by late December. The building is a part of NBC's recently announced plans for expansion and improvement in key cities of the Blue and Red Networks.

Work also has started on a new, 600-foot vertical radiator antenna at WGY's transmitter site in South Schenectady, which is expected to result in a material increase in the station's effective area of coverage.

G.E. Engineers in Cars To Test 5-Meter Pickup

ALBANY, N. Y.—Workmen erected a 20-foot pole atop the State Office Building preparatory to the installation of a short-wave, high-frequency transmitter, which may solve some of the problems bothering radio engineers today.

Costing the General Electric Company approximately $20,000, the equipment will be installed as an experiment.

The transmitter will operate on five to seven meter wavelengths and will have a receiving radius of about 30 miles.

Unlike the ordinary radio wave used in broadcasting commercial programs, these high-frequency waves are similar to light waves. They travel in a straight line to the horizon, bounce off buildings and other obstacles in the same manner as a mirror reflects a beam of light. These peculiarities are some of the things General Electric engineers hope to understand more fully.

Engineers in automobiles will circle the office building in a 30-mile radius. In each automobile there will be a portable receiving set. These engineers will observe receiving results. In localities where the best results are noted, a more permanent receiving station will be temporarily erected for further observation and measurement.

P. W. Mack Represents One Firm 23 Years

Friends recently congratulated P. W. Mack, sales representative, of 1270 Broadway, N. Y. City, on his completion of twenty-three continuous years representing Murdock headphones. When he started at it in 1914 there were only twelve dealer customers in the United States.

Mr. Mack also represents in New York and New England the Beede meter manufacturer, Precision Instruments and the Wirt Co., of Philadelphia, resistor manufacturers. Mr. Mack was one of the executives of Acme Apparatus Co. in the lush days.

Gadget Bulletin Issued

The Radio & Technical Publishing Co., 45 Astor Place, N. Y. City, has just issued a two-color bulletin which gives complete descriptions of the new "Home-Radio" and "Auto-Radio" twin pocket trouble shooter gadgets, which have just been devised by Alfred A. Ghirardi, author of "Radio Physics Course," "Modern Radio Servicing," etc.

RCA BUYS RAY TUBE PATENT

Allen B. DuMont Laboratories, Inc., of Upper Montclair, N. J., has sold U. S. Patent No. 2,014,106 to the Radio Corporation of America. This patent covers the combination of cathode-ray tube and three-element vacuum tube in a single glass envelope, the basis of the electric eye tuning indicator.

300 Megacycles Now Useful

Special Tube Extends Transmission Spectrum—100 Watts at 150 Mc—20 DB Gain as Amplifier

By A. L. Samuel

Vacuum Tube Development, Bell Telephone Laboratories, Inc.

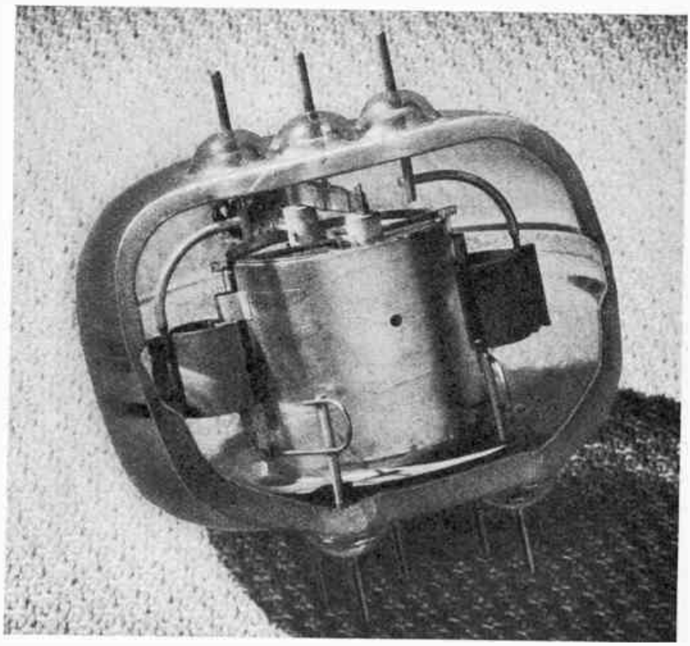


FIG I
View of the tube that extends the usable spectrum to 300 megacycles.

THE development by the Laboratories of an amplifier tube capable of handling a moderate amount of power at frequencies as high as 300 megacycles per second now makes possible an appreciable extension of the usable portion of the radio-frequency spectrum. The use of conventional vacuum tubes at these very high frequencies has been found unsatisfactory because of certain effects which at lower frequencies are of secondary importance. For an appreciation of these effects, certain concepts are necessary.

One of them has to do with the time required for the electrons to travel from the cathode to the anode within the tube structure. This time is the so-called electron-transit time. At low frequencies it can be neglected; at high frequencies it must be considered. One effect it produces is a lag in the phase of the output current with respect to the grid potential.

The calculation of this delay is complicated by an important distinction which must be drawn between the rate of arrival of electrons at the plate and the plate current. As an electron approaches the plate it induces in that plate an image charge. The magnitude of this charge varies with the proximity of the electron to the plate. The flow of current in the conductor to provide this charge actually constitutes the plate current. Viewed in this light the component of plate current due to any given electron commences to flow when this electron leaves the cathode and ceases to flow at the instant of the electron's arrival at the plate. Nevertheless, the net effect of the transit time, as may be shown by a detailed analysis, is to produce an appreciable phase difference between the grid potential and the plate current.

EFFECT OF GRID LOADING

A further consequence of the finite transit time is that under operating conditions (that is with alternating potentials on the tube electrodes) the electrons arriving at the plate will usually have velocities greater than the velocity corresponding to the potential of the anode at the instant of their arrival.

The excess energy corresponding to the greater velocity is obtained from the alternating component of the electrode potentials, and its dissipation at the plate in the form of heat decreases the useful output obtainable from the tube. Part of this energy comes from the grid

(Continued on following page)

(*Continued from preceding page*)
circuit, and is responsible for the so-called input impedance or active grid loading. The practical effect of this input loading in an amplifier is to increase the power demands placed upon the input supply. Its effect is by no means negligible even at only moderately high frequencies, and at ultra-high frequencies this input loading becomes of major importance.

A second important concept for the correct understanding of ultra-high frequency tube design has to do with the increased importance played by the interelectrode capacitances and the lead inductances. The difficulties encountered in the use of the simple three-element tube as an amplifier at moderately high frequencies as a result of feedback or singing caused by the interelectrode capacitances are, of course, well known. Such difficulties are greatly increased at higher frequencies. They may be largely overcome by the use of a multi-element tube structure. At ultra-high frequencies, lead inductances common to both input and output circuits produce a similar effect, and so must be avoided in the tube design.

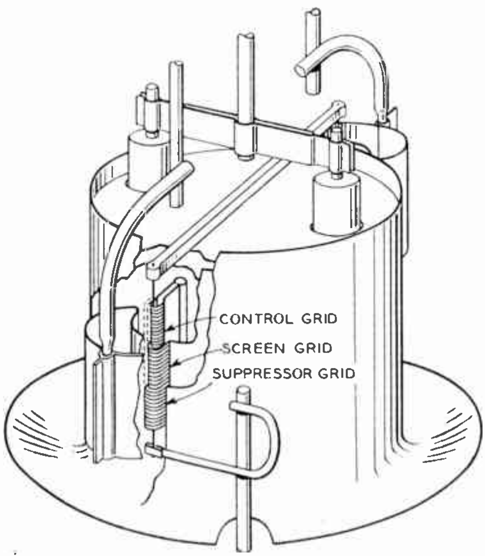


FIG. 2
Perspective sketch of the new high-frequency double pentode.

TWO RATES DIFFER

The large charging current required by the interelectrode capacitances at high frequencies affects the cathode design. At low frequencies the rate at which electrons leave the cathode at any instant is identical with the rate at which they arrive at the anode. At high frequencies this is no longer true. The peak instantaneous emission may greatly exceed the value that would be required for operation under identical voltage conditions but at a lower frequency. The high charging current is also responsible for an increase in the resistance losses in the tube leads. The resistance of these leads is, of course, greatly increased at high frequencies because of the so-called "skin" effect. Resulting losses decrease the efficiency of the tube and may, in a power tube, produce enough local heating to cause a more or less rapid deterioration of the lead-to-glass seals, which may ultimately destroy the vacuum. Short, heavy leads are therefore required for ultra-high frequency operation.

The interelectrode capacitances together with the lead inductances are responsible for still another difficulty. The frequency to which the input and output circuits of an amplifier may be tuned is set by the natural frequency formed by the interelectrode capacitances and their associated lead inductances. For most practical purposes the operating frequency of an amplifier must be well below these values. This places an upper limit on the permissible values that the interelectrode capacitances and lead inductances can have.

REDUCTION OF DIMENSIONS

Many of the factors which have been discussed can be compensated by reduction in dimensions. It can be shown, in fact, that if all the dimensions of a vacuum tube are reduced in the same proportion, the trans-conductance, plate current, and amplification factor for fixed electrode potentials will remain unchanged while the values of interelectrode capacitances, lead inductances, and electron-transit time will be reduced in direct proportion to the reduction in size.

Unfortunately, a reduction in dimensions without a corresponding reduction in all operating voltages is possible only at the expense of an increased demand on the emission capabilities of the cathode. The required emission per unit area must vary inversely as the square of the linear dimensions. Added to this is the increased demand caused by the high-frequency charging currents already discussed.

The available emission is fixed by the character of the cathode surface, and cannot easily be increased. A proportionate reduction in cathode dimensions, therefore, is not feasible. Furthermore, the proportionate reduction of the anode dimensions would require an increase in the power dissipation per unit area—again inversely proportionate to the change in linear dimensions. While the heat-dissipating ability of the anode can be increased in a number of ways, most of these will increase the tube capacitances. The high grid temperatures which may result from the reduction in dimensions also makes necessary the introduction of cooling provisions. Because of these effects one must combine a reduction of dimensions with the introduction of special mechanical arrangements to overcome the otherwise harmful effects of this reduction.

TUBE'S CONSTITUTION

All these factors have necessarily been taken into account in the development of the new tube. As may be seen in Fig. 2, and somewhat in Fig. 1, it consists of two relatively large concentric metal cylinders and two sets of tube elements diametrically opposite each other outside the outer cylinder. The cylinders act as a shield between the input leads to the control grid and the output side of the tube, as supports for the screen and suppressor grids and as a radio-frequency by-pass condenser between them, and as low-impedance leads interconnecting the two sets of screen and suppressor grids.

The control grids are of an unusual design, consisting of a cooling fin to which are attached loops of tungsten wire encircling the thoriated tungsten filament. One of these is shown in Fig. 3. These control grids project through the slots in the cylinders and are in turn surrounded by loops of wire attached to the inner and outer cylinders and acting as the screen and suppressor grids respectively. The control grids are supportedly directly on their leads which project through one face of the tube envelope. The semi-cylindrical anodes are also supported directly on their leads which project through the opposite face of the tube envelope. This unusual construction is made desirable by the ultra-high-frequency requirements which have just been described.

THE CHARACTERISTICS

In spite of the unusual form of the tube, electrically it is the equivalent of two conventional negative-grid, pentode tubes. Its performance at frequencies as high as 300 megacycles is quite comparable with the performance of conventional tubes at much lower frequencies.

TABLE I

Operating Characteristics and Constants of the Double Pentode Tube

Filament current (each side)	5.0 amperes
Filament potential (each side)	1.5 volts
Rated anode dissipation (each anode)	15 watts
Rated screen dissipation (each side)	5 watts
At Anode and Screen Potentials of 500 Volts and Anode Current of 0.030 Ampere—Characteristics of each Side	
Transconductance	1250 micromhos
Anode resistance	200,000 ohms
Normal control grid potential	-45 volts
Interelectrode Capacitances (When Properly Mounted)	
Direct control grid to control grid	0.02 mmfd.
Direct plate to plate	0.06 mmfd.
Total control grid to ground (each side)	3.8 mmfds.
Total plate to ground (each side)	3.0 mmfds.
Control grid to plate (each side)	0.01 mmfd.
Lead Inductances	
Total grid to grid	0.07 microhenry
Total plate to plate	0.08 microhenry
Rating as Class A Amplifier	
Max. direct plate potential	500 volts
Max. direct screen potential	500 volts
Max. continuous plate dissipation (each)	15 watts
Max. continuous screen dissipation (total)	10 watts
Max. output at 150 megacycles with distortion down 40 decibels	1 watt
Nominal stage gain at 150 megacycles	20 decibels
Nominal control grid potential	−45 volts
Rating as Class B Amplifier	
Max. direct plate potential	500 volts
Max. direct screen potential	500 volts
Max. space current (total)	150 milliamperes
Max. continuous plate dissipation (each)	15 watts
Max. continuous screen dissipation (total)	10 watts
Max. output at 150 megacycles	10 watts

Operating characteristics and constants are listed in Table 1. Special attention is directed to the values of interelectrode capacitances and lead inductances. It will be observed that while the interelectrode capacitances are low they have not been reduced in proportion in the re-

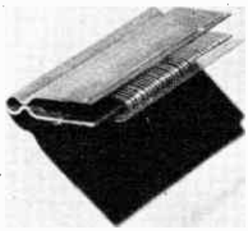


FIG. 3
One of the grid structures of the new tube shown slightly more than three times actual size.

duction of operating wavelength. A more important feature, however, is the reduction of the lead inductances.

For a tube which is to be used at ultra-high frequencies, certain characteristics not ordinarily considered are of particular significance. One of the most important of these is the active grid loss which, as already mentioned, comes about because of appreciable electron transit time. Fig. 4 gives a plot of the push-pull input shunting resistance of this tube as a function of frequency. The value of 30,000 ohms at 150 megacycles is to be compared with 2,000 ohms, a typical value for two conventional tubes in push-pull. At 300 megacycles the input resistance of the twin pentode is still above 6,000 ohms, while for conventional tubes it is so low as to make them entirely inoperative. The variation in the input resistance with the operating conditions of the tube for a constant frequency of 150 megacycles is shown in Fig. 5. It is evident that if a high value of input resistance is to be realized, high anode potentials with low space currents must be used. The reduction in the filament-grid spacing made possible by the unusual construction is in a large measure responsible for the improvement in the input resistance just noted.

SOMETHING DOING AT 500 MC

A characteristic measurable only at the operating frequency is the interaction between the input and output circuits which results from the residual value of the gridplate capacitance. This reaction differs from that predicted for the low-frequency capacity measurements on a cold tube because of the inductance of the screen-grid lead, and because of the electron space charge. The reaction can be measured by observing the variation in the input impedance resulting from the tuning and loading of the

(Continued on following page)

(*Continued from preceding page*)
output circuit. Experimentally determined values are given in Fig. 6.

The double pentode tube has been found useful as a high quality class A amplifier, as a class B amplifier, as a frequency multiplier, and as a modulator at frequencies of 300 megacycles per second and below. Its performance in these various modes of operation is quite comparable to the performance of conventional pentodes of similar ratings at much lower frequencies.

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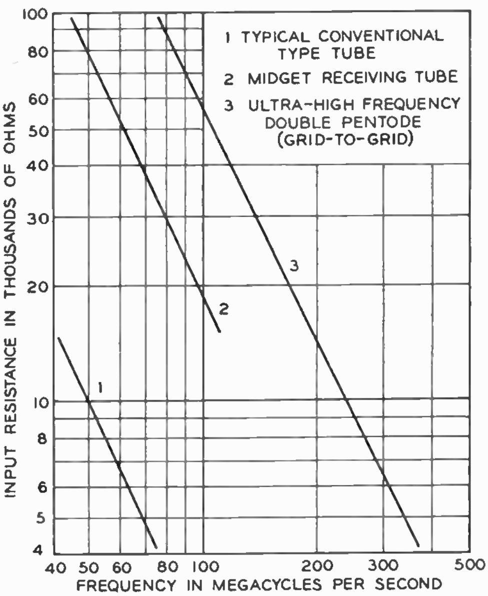


FIG. 4
Push-pull input shunting resistance as a function of frequency.

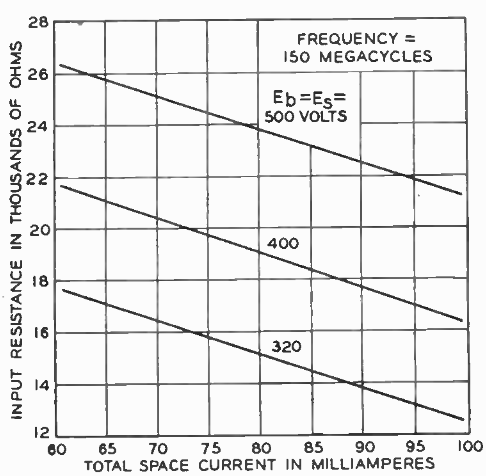


FIG. 5
Variation in input resistance with operating conditions at 150 megacycles

Author an Expert on High-Frequency Tubes

A. L. Samuel, after getting an A.B. degree from the College of Emporia (Kansas), went to the Massachusetts Institute of Technology where, as the result of a cooperative course

A. L. SAMUEL

with the General Electric Company, he received an S.B. degree in 1925 and an S.M. degree the following year. He remained as an instructor in the Electrical Engineering Department for two years. In 1928 he joined the technical staff of the Bell Telephone Laboratories, Inc., working on the early development of gas-filled tubes until 1931. Since then he has been engaged in research and development work on vacuum tubes intended for use at ultra-high frequencies.

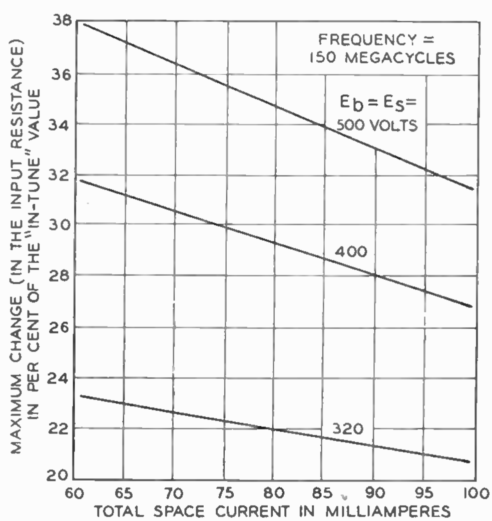


FIG. 6
Input-output reaction determined experimentally at 150 megacycles.

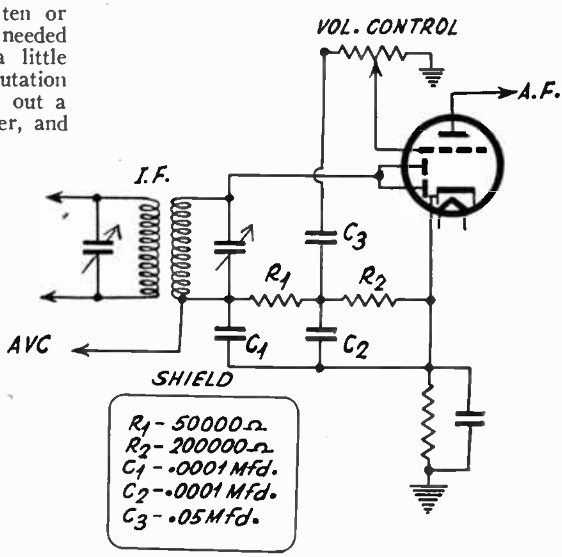
FEEDBACK of I.F.'s

Second Harmonic ELIMINATED

By Little Extra Shielding about Detector

By R. K. Wheeler

IN the carefree days of radio some ten or twelve years ago, little more was needed than a kit of Neutrodyne essentials, a little mechanical skill, and a neighborhood reputation as a "radio expert," for a man to turn out a fair receiver to deliver to an eager buyer, and collect a hard-earned $150! Selectivity and interference problems as we have them today did not exist, and practically no consideration was given to tone quality.



A typical diode second detector. Parts enclosed in a shield are evalued in square at bottom. The volume control ordinarily is 500,000 ohms. The biasing resistor is 1,000 ohms for transformer audio, 5,000 ohms for resistance audio, with 25 mfd. across.

However, with the rapid advancement of the radio art, both in transmitters and receivers, these happy days as rapidly disappeared, and the results demanded from receivers multiplied and became increasingly difficult of solution, and apparently the skill and ability of many home-constructors and experimenters have not kept pace, but fall far behind the requirements of impartial judgment. It is the writer's opinion, based upon several personal inspections, that very few of the home-built receivers remotely approach the ideal of 100 per cent all-around performance, in regard to sensitivity, selectivity, tone-quality, freedom from squeals and other irregularities.

NEEDS ATTENTION, SAYS MILLEN

The last named trouble—squeals—seems to be most commonly prevalent in home-built superheterodyne receivers, and not entirely absent from many commercially-made receivers.

(*Continued on following page*)

(*Continued from preceding page*)

Stable operation with some gain has been obtained at frequencies as high as 500 megacycles. When operating as a class A amplifier at 150 megacycles, an output of 1 watt is obtained with the distortion 40 decibels below the fundamental. Under these conditions the stage gain is 20 decibels. Outputs of 10 watts with a plate efficiency of 60 to 70 per cent and a gain of 10 db result when operation is Class B.

The development of this tube demonstrates that power amplifier tubes of the negative-grid type are usable at higher power levels and frequencies than have been reported previously. This type of development removes a practical barrier which, up to the present, has prevented the successful utilization of frequencies that extend above one hundred megacycles.

(Continued from preceding page)

One source of trouble is always present, the squeal from the i-f harmonics, which was commented on as lately as January, 1937, by James Millen of the National Company, as a problem requiring special attention.

It has generally been the practice with most home builders and many factories to ignore this squeal as an unavoidable evil, and generally only half-hearted attempts are made to correct it, although of course in some laboratories the problem is given serious attention and satisfactorily solved.

The author experienced this difficulty with his own receiver, which is generally in an experimental state, seldom remaining intact for more than a few weeks at a time. Experiments and research are conducted in spare moments, when the writer takes a "postman's holiday" and does some radio work at home. However, it is felt that the experience and knowledge gained are well worth while, being of considerable aid in solving problems arising in the service business.

FEEDBACK LOOP LOCATED

In this case the i-f was 180 kc, and a very strong squeal was present on WGN, at 720 kc. At the same time a sort of choked quality was present in the output, which strongly indicated feedback to the r-f input. It was suspected that both conditions were due to the same cause, and a number of corrections was attempted without benefit.

Practically all types of filters commonly suggested for such conditions were installed without worthwhile results, and it was fairly obvious that the feedback was not through the power-supply, or carried by the receiver wiring. It was finally found that the feedback was external, that is, transmitted through the air to the input of the receiver, and bits of shielding, placed experimentally around the components of the diode detector circuit, reduced or eliminated the squeal, and at the same time cleared up the audio tone quality.

The tuner chassis was the common type, with the bottom open, and a small strip of shielding across the bottom directly over the diode socket and associated parts, reduced the feedback acceptably. The final step was obvious, that is, complete shielding of all parts in the diode circuit. The two load resistors, the two .0001 mfd. condensers, and the .05 mfd. coupling condenser were all installed in a small shield can, and all troubles from that source were eliminated.

METHOD OF CHECKUP

The double .0001 mfd. condenser supplied by Philco is very convenient for this purpose, being enclosed in a Bakelite case with hole for a single mounting screw, and at the same time is sufficiently spaced from the chassis. When the above-mentioned parts are installed it is good practice to have them at least one-half inch from the walls of the shield can in order to avoid any possible loss of high frequencies.

After this solution was found, several commercial receivers were checked, and the same conditions existed in many instances, in varying degrees, especially in the receivers in the lower price ranges. Where the i-f was 450 kc the squeal was heard at 900 kc, and where the i-f was 465 kc the squeal was present at 930 kc.

A convenient way to check for this condition is to put the receiver in operation with antenna attached, turn the dial until the squeal from the harmonic is heard. Then vary the position of the leadin, with relation to the chassis, particularly that part where the second detector is located, and if there is any noticeable variation in the intensity of the squeal, the feedback is external, and the shielding should be done as indicated.

As a rule it is not absolutely necessary to include the coupling condenser in the shield, but if space permits it may be done as a precautionary refinement.

Although not generally used in many commercial receivers, it will be found that the second .0001 mfd. condenser, connected at the joint of the load resistors is well worth installing.

There are generally other advantages to be obtained by eliminating this external feedback, other than eliminating the harmonic squeal. When the nuisance is present it will usually be found that there is a general tendency toward instability in the r-f or i-f stages, and that the tone quality is affected to a certain extent. The correction is well worth the small amount of material and labor required.

Speaker Covers a Mile; Aids Safety at Beach

Atlantic City, N. J.

A powerful new loudspeaker capable of projecting speech and music upwards of a mile with full clarity was demonstrated by RCA Victor engineers for the first time recently as a valuable new means of promoting safety on Atlantic City's beaches. City officials witnessed the demonstration.

Chief value of the new development, according to RCA, is that lifeguards will be able to maintain more complete control over the beach areas and adjoining waters by directing the powerful beam of sound on a movable swivel to the desired spot. By this means bathers and even watercraft can be warned away from dangerous tides, order maintained on the beaches, lost children located and other beach patrol services greatly facilitated. Other possible uses for the new sound projector have been developed.

Two Books by Rider

"Aligning Philco Receivers," by John F. Rider, 1440 Broadway, N. Y. City, gives tabulated data on 9,000,000 receivers. The jacket mentions 8,000,000, but between the time it was prepared and the actual date of publication, the figure went up a million. Cloth cover, 136 pages, this $1 book is of value to servicemen.

Another and later dollar book by Rider is "Automatic Frequency Control Systems."

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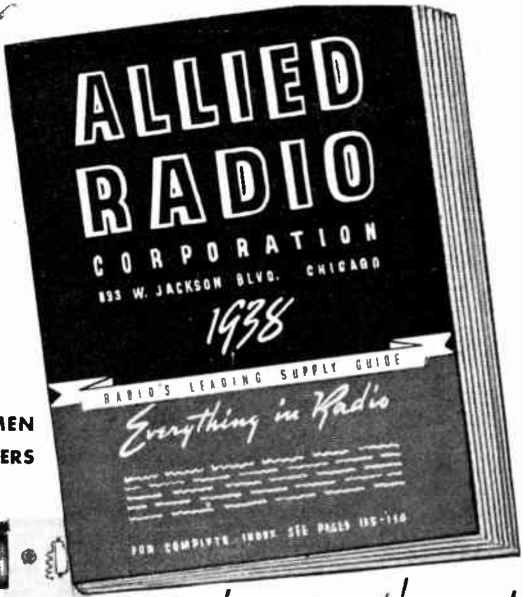

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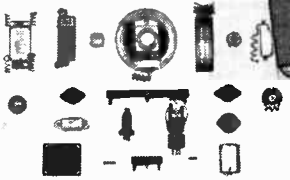

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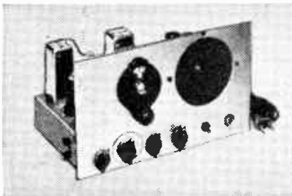

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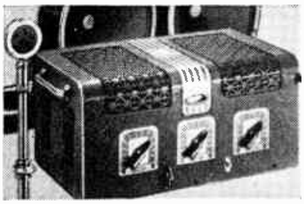

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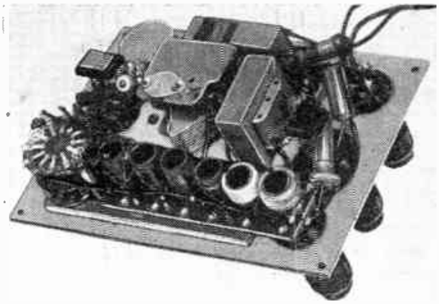

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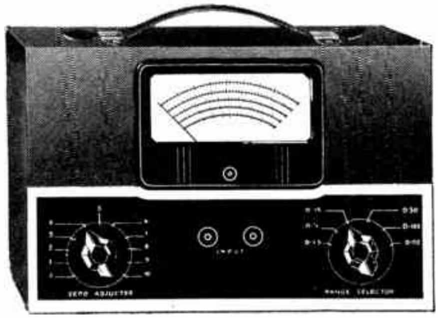

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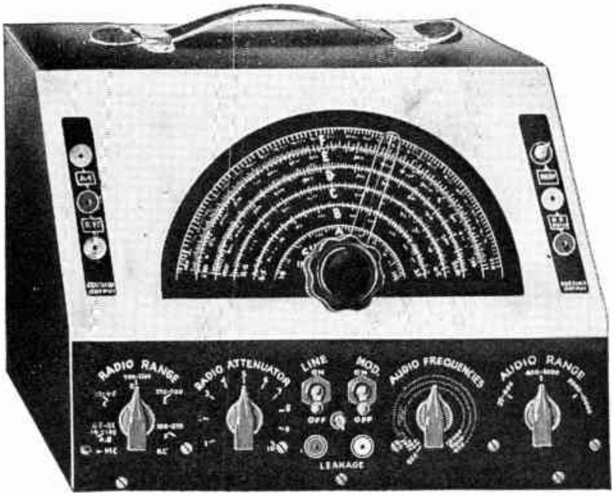

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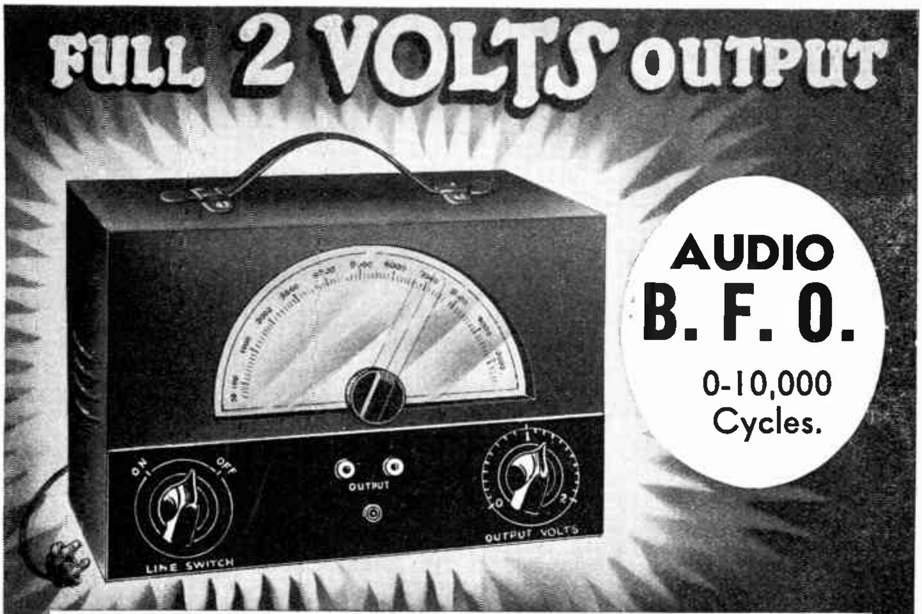

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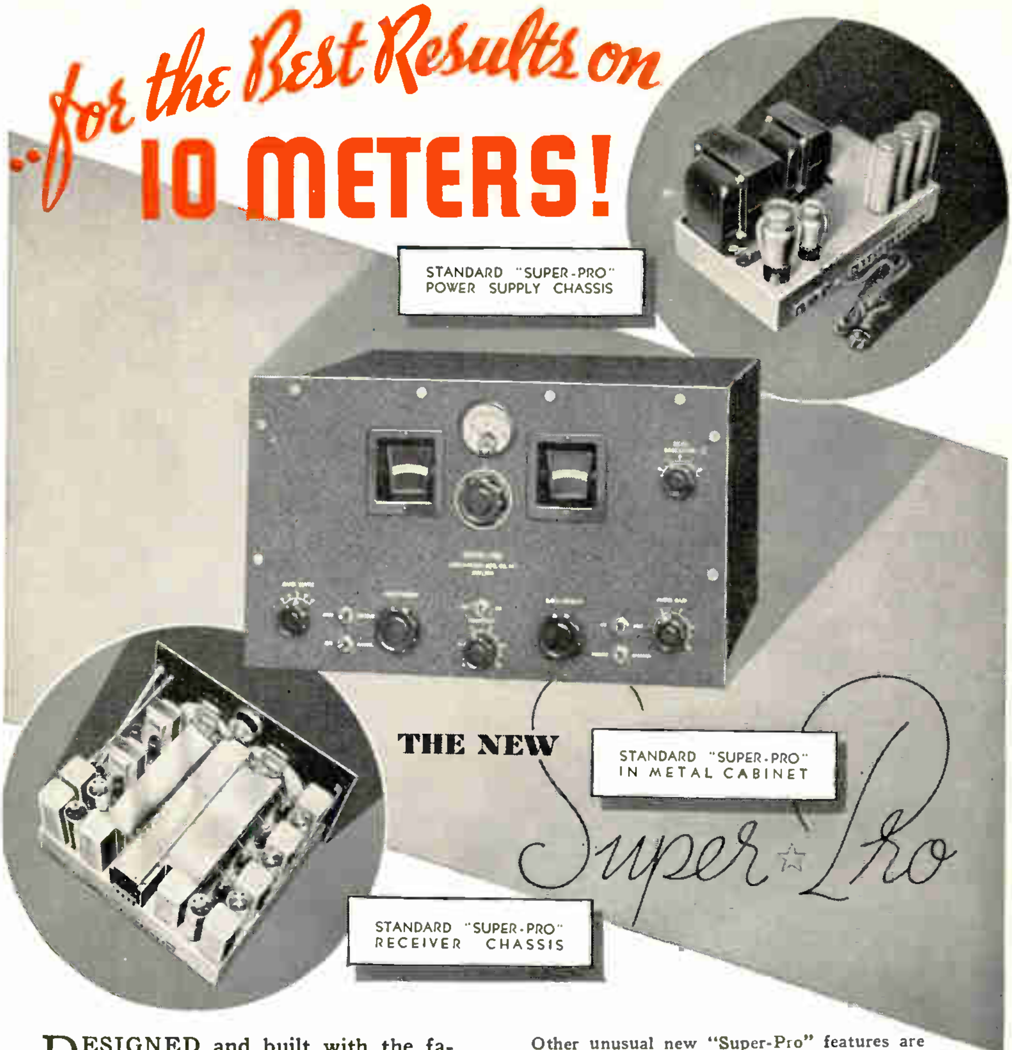

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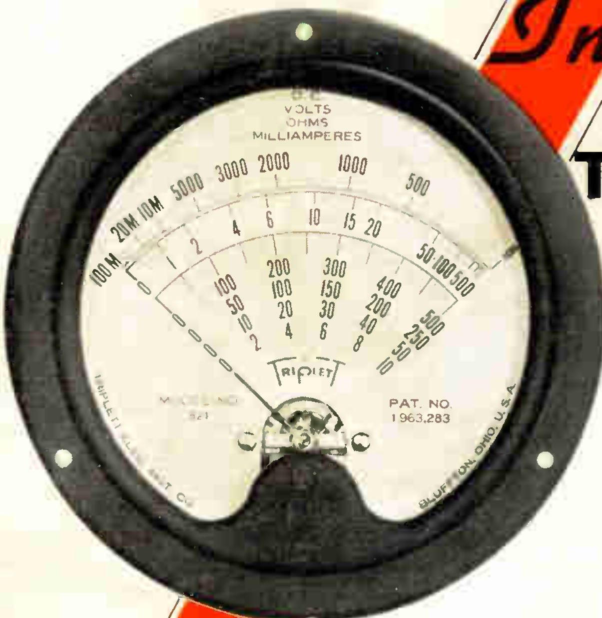

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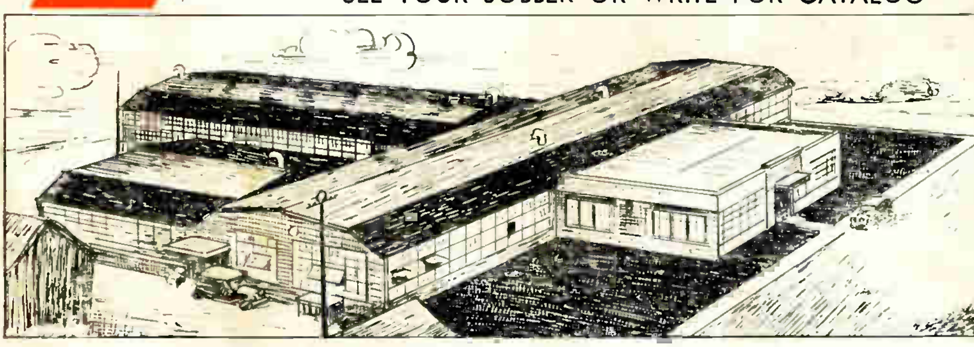

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