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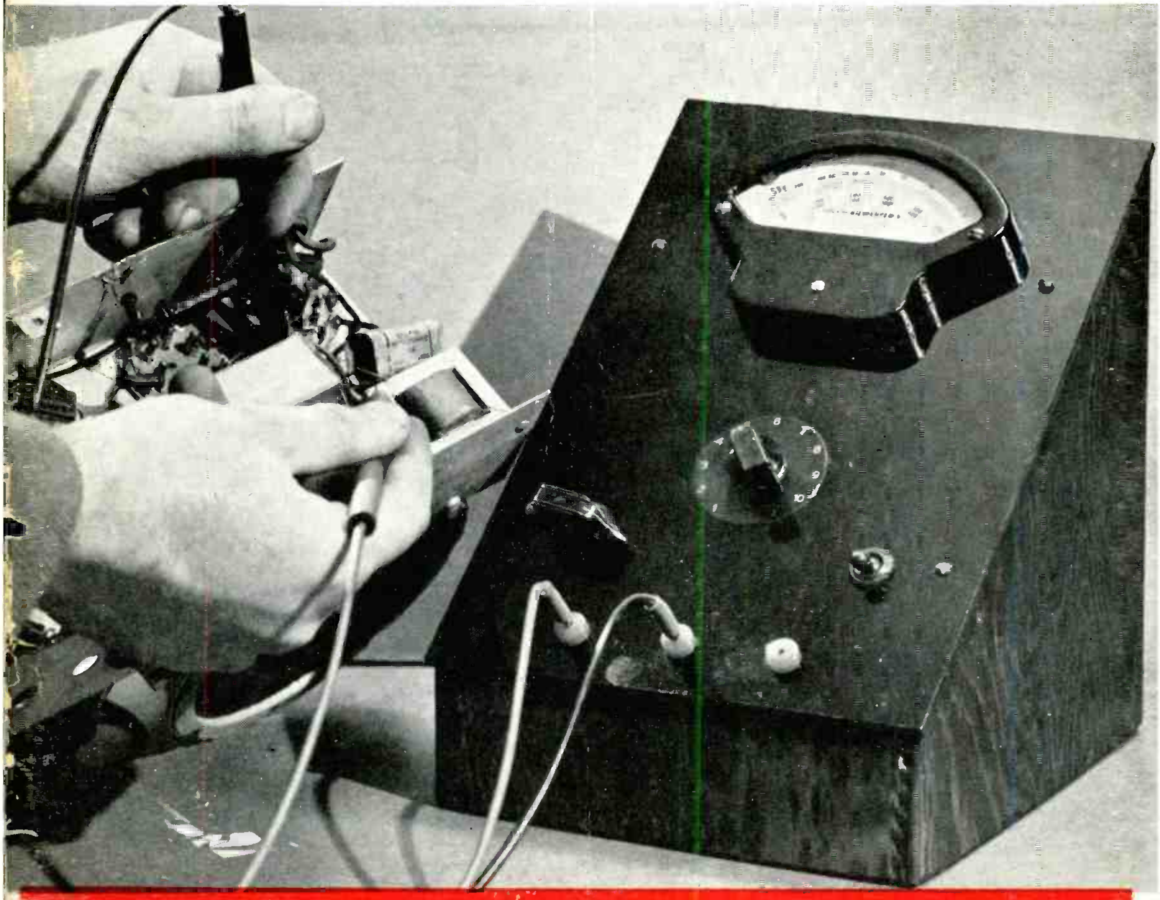
BUILDING A VOLT-OHM-MILLIAMMETER

(See Page 32)



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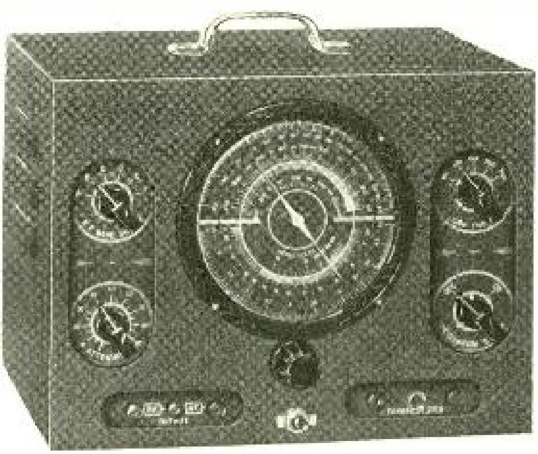

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Sixteenth Year

ROLAND BURKE HENNESSY, *Editor* — H. J. BERNARD, *Publisher* — HERBERT E. HAYDEN, *Advertising Manager*

TABLE of Contents for MAY, 1938

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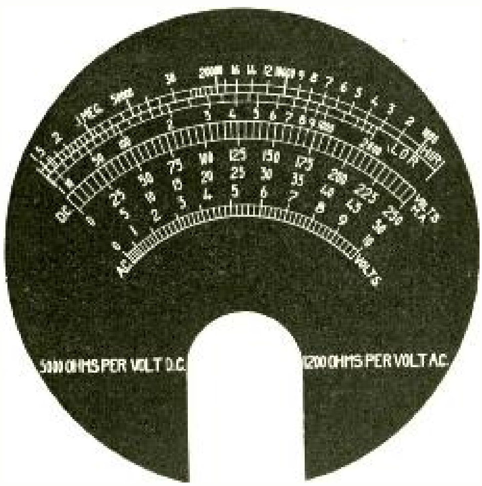
It Fits Both Your Pocket and Your Pocketbook

Does This Universal Volt-Ohm-Milliammeter

By H. J. Bernard



Full-sized scale of the pocket instrument's 0-200 microammeter. For reading 200 microamperes multiply the 0-250 d-c scale by 0.8 or the 0-50 scale by 4.

THE design for a pocket type volt-ohm-milliammeter, shown in the diagram, features a separate switch position for each normal service, and, while measuring both a.c. and d.c., uses the electromagnetic meter for d.c. at its base sensitivity of 5,000 ohms per volt. Moreover, the switching is accomplished with a single-circuit, twelve-position standard switch, for selection of purposes and ranges, while an added attraction is the combination of the ac-dc switch with the ohms adjusting rheostat.

This simplification, which is particularly attractive in a pocket-sized instrument, is made possible by the special rectifier arrangement (patent pending). By selecting a certain predetermined d-c voltage drop across the rectifier, well within the allowable maximum, and measuring it (0.6 volt full scale d.c.), rectifier heating is practically eliminated, since for all ranges this potential difference across the rectifier is practically the same. As more and more series resistance is included, in each ascending a-c voltage step, the extra drop is taken up by extra multiplier resistance.

DOUBLE SAFETY

Therefore a d-c meter with limiting resistor, here 3,000 ohms, offers a stable method of a-c measurement, because the rectifier is never overheated, except by overloads, which must be avoided in all instruments, although overloads of 200 per cent, would not cause damage to the rectifier, because it is originally worked at less than half its maximum rating, and that rating itself permits doubled input, without damage, if not maintained for long periods.

It is well-known that a.c. passed through a d-c meter in any quantity, although not necessarily affecting the needle movement, may work havoc with a calibration, since there could be a tremendous unobserved overload, with consequent damage to the electromagnet or the meter coil. While the total a-c voltage drop across the rectifier is maintained practically constant on all ranges, and is small at that, the total a-c voltage drop never appears across the meter, but is limited by the 3,000-ohm multiplier. Since the meter may have a resistance of around 400 ohms, accounted for by the resistance of the wire of which the meter's coil is wound, the proportion of the a-c voltage appearing across the meter would be $400/3{,}000 \times 0.6 \times 1.41 = 0.055$ peak volt. This is entirely negligible and represents a most agreeable condition.

LINEARITY AND SENSITIVITY

Another effect of introducing the d-c voltmeter circuit across the rectifier, for measurement of a.c., is to make the scale more nearly linear than under most other conditions whereby a.c. is measured on a universal instrument.

The higher the multiplier resistance (shown as 3,000 ohms), the closer to linearity does the a-c scale become, but the a-c sensitivity is reduced, so a compromise is established between linearity and sensitivity on a.c., whereby on a.c. the sensitivity is about one-quarter what it is on d.c., or 1,200 ohms per volt, compared to 5,000 ohms per volt. Transformer secondaries, heater voltages, etc., where most a-c measurements are made in radio servicing practice, are of low impedance, and 1,200 ohms per volt represents negligible loading of the measured circuit.

The extra advantage of combination of the ac-dc switch with the ohms-adjusting rheostat is derived from the very same special rectifier circuit, because by using a single-pole, double-throw switch on this rheostat, the 3,000-ohm limiting resistor is shorted out at the d-c position (left), while the rectifier is omitted from circuit at the same time, but for a.c. both the resistor and the rectifier are included. This permits the same two binding posts or tip jacks to be used for all voltage measurements, a.c. and d.c.

Since users are in the habit of leaving the selector switch at one extreme terminal or the other, settings representing greatest safety are selected for these, and the rotation from left to right (clockwise), represented by the ascending order of selector switch position numbers, 1, 2, 3, etc., is for descending d-c voltages in five ranges: 2,500, 500, 250, 50 and 10 volts. Because measurements of d-c voltages are the ones most frequently made, five ranges were provided, out of the possible total switch positions of twelve, leaving seven positions for all the rest.

MEASURING HIGH RESISTANCE

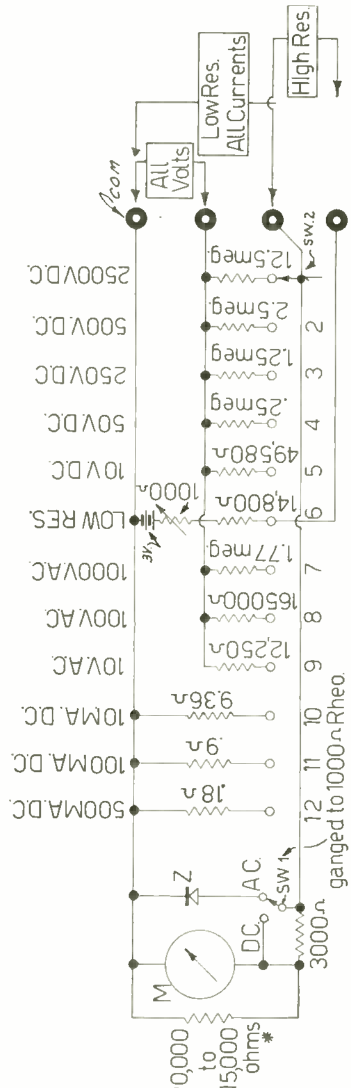
The sixth position of the selector switch is used for the low resistance measurement, by meter shunting. One ohm to 1,000 ohms, are read between the common negative binding post and the arm of the selector switch. For high ohms the switch is thrown to the next position on either side, No. 5 or 7, and the measurement is made between a special binding post for this purpose, and the arm of the selector switch. Thus the common terminal is common for everything, except for high resistance.

High resistance readings are from 1,000 ohms to 1,000,000 ohms.

Positions 7, 8 and 9 are used for measuring direct current and the terminals are the same as for low ohms. These values are 10, 100 and 500 milliamperes.

Since the meter is of the 200 microammeter type, and it may be desirable at times to have access to the meter at its base sensitivity, this may be accomplished by using the terminals for direct current, as before (common and selector switch arm) and having the selector switch at any voltage position (1, 2, 3, 4, 5, 7, 8 or 9).

One would not normally consider doing this, and there is no indication on the face of the instrument of this purpose, because use of the meter that way, without protection, is always a danger in rapid service practice. So this use of the meter at base sensitivity must be applied with great caution, and with foreknowledge of the low quantity of current flowing.



A greatly simplified circuit for accurately measuring a-c and d-c volts, d-c currents and resistance, using a new method with meter M and rectifier Z.

**Value determined by calibration.*

LOW CURRENT MEASUREMENT

Naturally, the safest measurement practice is to start at 500 ma, then go to 100 ma, then to 10 ma, and when practically unable to read the current on the 10 ma scale, because so small, introduce the highest-sensitivity range, say, at position 9, which is most convenient then, because the next position.

Although 9 is intended for the 10-volt a-c range, it may be used as stated, for 200 μa,

(Continued on following page)

VALUES OF CONSTANTS

D-C Voltage Ranges

Selector Position No.	*Ohms Multiplier*	*Volts Range*	*Ohms Per Volt*
1..........	12,500,000	2,500	5,000
2..........	2,500,000	500	5,000
3..........	1,250,000	250	5,000
4..........	250,000	50	5,000
5..........	49,580	10	5,000

Resistance Ranges

Selector Position No.	*Ohms Multiplier*	*Rx*
6..........	13,800 fixed 1,000 variable	One ohm to 1,000 ohms
5 or 7......	Same as above	1,000-1,000,000 ohms*

A-C Voltage Ranges

Selector Position No.	*Ohms Multiplier*	*Volts Range*	*Ohms Per Volt*
7..........	1,770,000	1,000	1,777
8..........	165,000	100	1,650
9..........	12,250	10	1,225
7, 8, 9......	3,000	Between meter and rectifier	

Calibration resistor selected by experiment, between 10,000 and 15,000 ohms, for exactly 200 microamperes full-scale deflection.

**The negative post, otherwise common for all purposes, is not used for high resistance measurements, but a special post, fourth from top in diagram, and the post connecting to the main selector switch arm, third from top, are used instead.*

(Continued from preceding page)

without external resistance introduced, provided the ac-dc switch is at d.c., as it must be for current readings, as a-c currents are not read on this instrument.

Another precaution would be to use the voltage posts of Position 9 for measuring 200 microamperes or less, because only 12,500 ohms are introduced, not large enough to change the current seriously in the measured circuit, except a self-biasing cathode resistor circuit, yet large enough to provide some protection for the meter. For instance, if it is desired to open the load resistor circuit of a second detector, where the current due to rectification of the i-f carrier is small, the resistance is usually 500,000 ohms or more, and the extra 12,250 ohms makes no momentous difference. Besides, if desired, the leads may be changed to the current position, from the voltage position, if elimination of even the 12,250 ohms is desired, as in measuring self-grid-biasing circuits.

The sensitivity of the meter is high enough to be of service in the diode circuit as described, but for actual current measurements, the 250 scale on the meter is used, and the reading multiplied by 0.8, or divided by 1.25, and called microamperes. There is no scale on the face reading 200. Or the 0-50 d-c scale may be multiplied by 4.

ALSO 2.5 VOLTS D.C.

Thus there are five d-c voltage ranges, four d-c current ranges, two resistance ranges and three a-c voltage ranges, or fourteen services, using a twelve-position switch. If an additional or fifteenth service, 2.5 volts d.c., is desired, this may be enjoyed by throwing the ac-dc switch to the d-c position, and using the 10-volt a-c range, Position 9.

The values of the multiplier resistors are based on a full-scale deflection of exactly 200 microamperes. It is of small use to have 1 per cent accurate limiting resistors, unless the full-scale deflection accuracy is almost perfect. So the meters themselves are manufactured to a slightly higher sensitivity, so that, if there must be any error, the correction is introduced by shunting the meter. This permanent shunt, for calibration purposes, is determined by an accurate measurement of its resistance and the simultaneous measurement to almost perfect accuracy of the 200 microamperes.

Since the shunt will range between 10,000 and 15,000 ohms, it will have some small effect on the upper resistance values of the low ohms scale, hence this scale is calculated for a meter resistance of 400 ohms. Actually the meter resistance is 420 ohms, but 10,000 ohms across it reduces the value to nearly 400 ohms, whereas if the shunt were 15,000 ohms, the effective resistance would be 437 ohms. Actually the shunt value falls normally quite close to 10,000 ohms, thus highly validating the low ohms scale. However, even if there had to be some sacrifice in the low ohms accuracy, in favor of improving the d-c volts, high resistance and a-c volts accuracy, this would be a most sensible operation, because of the preponderating importance of accurately measuring d-c volts and high resistance (1,000 to 1,000,000 ohms) in all service measurements. They account for about 90 per cent. of all measurements made. Thus, too, the closeness of accuracy at the terminal aids accuracy over the rest of the scale, for currents as well as for all volts and high resistance, so though guaranteed at 2 per cent the accuracy may be in practice really one per cent. in a large number of instances.

Pencil type 1.5-volt dry cells are used, two in series, to constitute 3 volts for the resistance-measuring circuits. Thus if the voltage is 3 volts the total limiting resistance for 200 microamperes (.0002 milliampere) would be just 15,000 ohms. However, the meter will represent about 400 ohms of this, a fixed limiting resistor would take up part of the difference and the ohms-adjusting rheostat the remainder. It is then a matter of choice of values. If 13,800 ohms can be obtained fairly accurately, a 1,000-ohm variable will be used at around 800 ohms, leaving 200 ohms to spare in the variable. If it is necessary to turn the 1,000-ohm rheostat all the way up, indicating a battery resistance of 200 ohms, it is a sign that it is time to renew the cells.

RIGHT OR WRONG?

Propositions

1. When a vacuum-tube voltmeter is of the type that has a negative bias on the grid of a triode, pentode, etc., with suitable other terminal voltages, and the unknown input voltage to be injected at the grid is well within the value of the d-c bias voltage, the tube voltmeter is of the infinite impedance type, hence draws no current from the measured source.

2. A decibel scale or calibration is applicable only to the conditions under which the scale or calibration was made, which requires that the required, definite ohms load be used, and that an accepted definite power in that particular ohms load constitutes the zero level. Hence, for any other ohms load, or any other power level for accepted zero, the scale or calibration would not apply.

3. When two lamps are lit the eye can judge fairly well when the brilliance of both is equal, therefore if the power through one of the lamps is known, the power through the other lamp may be estimated fairly closely, the two being equal when the brilliance is equal.

4. Since the same wave from the same source arrives at different times at aerials spaced any distance apart, the fading due to phase conditions is not instantaneously equal in such antennas, and if multiple spaced antennas are used for common feed to a receiver, the multiplicity of the phases of the fading will cause an averaging effect which tends to remove the audible effect of fading. In other words, this is at least a partly-effective remedy for fading.

5. Carrier pigeons are sensitive to radio waves, so that if they are in proximity to a generating source of such waves, they may suffer reduction of the homing instinct, and thus be of impaired usefulness in carrying messages, especially important in time of war, and therefore now giving some concern to the Army.

6. An inverse feedback amplifier tube causes a change in current through the tube to be greater, the higher the amplification factor of the tube, assuming the applied voltages are the same.

Answers

1. Wrong. The grid circuit may be closed to cathode or ground through a high resistance, normally in the order of megohms, hence with such a circuit the resistor is always across the measured source, and the impedance can not be said to be infinite, because the resistor accounts for some current draw, though perhaps negligible in some uses. Another aspect is that even if no grid resistor is used for closing the circuit, which then requires that the unknown source, whether of a-c or d-c, have d-c continuity, if the frequency is high enough the input capacity becomes a ratable factor since it requires charging current, taken from the measured source.

2. Right. The decibel notation must be considered as something comparative, and therefore the basis of comparison must always be the same. That basis is the relative zero level, which represents a rated power in a rated ohms load, e. g., .006 watt (six milliwatts, the radio standard) in 500 ohms.

3. Right. Power measurements, sometimes difficult to make at radio frequencies, are satisfactorily compromised in this manner, the known often being fed by d-c. The lamps, however, must be equal by test.

4. Right. Reflections from various layers of the ionosphere are partly ironed out by this method, hence the effect of fading reduced in the receiver.

5. Right. There is some disagreement as to whether the effect is very general. But Army officers complained about pigeons' reduced homing instinct, an effect of short duration, and subsequent tests by officers and others confirmed there is some relationship between exposure to some radio waves and reduction of this sense.

6. Wrong. The change in current is not dependent on the amplification factor but on the mutual conductance, or transconductance, as the same quality is called in referring to multi-element tubes. With inverse feedback, even the tubes of higher conductance behave about the same as any other tubes, because the greater the change, the greater the limit to the change, since inverse feedback is a limiting agency. It is used for purposes of linearity.

Simplified Analysis of a Complex Wave

By Murray S. Rifkin

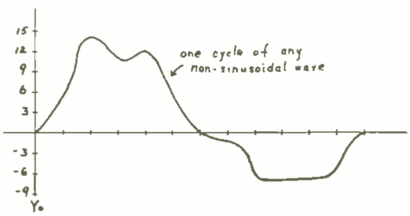


FIG. 1
The wave to be studied is drawn on paper, usually by tracing the image on the screen of a cathode-ray.

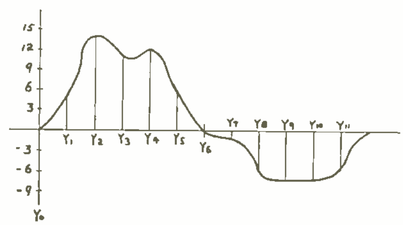


FIG. 2
How the ordinates are established at equally-spaced positions for analysis of harmonic content.

IT is very often necessary to determine accurately the harmonic content of a complex wave. This complex wave may be, for instance, the output of an audio amplifier as observed on an oscilloscope. If a pure sine wave input is certain, and the output is non-sinusoidal, it is an indication that the amplifier is definitely introducing harmonics.

Without an accurate knowledge of the number and magnitudes of these harmonics, corrective measures cannot be taken intelligently. Students of radio engineering are familiar with the various methods of calculating the harmonic content of a wave; however, these methods demand a knowledge of mathematics which the average experimenter and serviceman do not possess. It is the purpose of this article to present a direct method for determining the components which make up any complex wave.

HOW TO PROCEED

This method is a simplification of a rather complicated system known as the "twelve ordinate schedule analysis." It will later be apparent that it is possible, with this system, to evaluate any harmonic separately without first determining the entire series. The only mathematics involved is simple arithmetic. The range of the series is from the d-c component to the sixth harmonic, inclusive. The accuracy of the method is largely determined by the amount of care taken in the actual graphical work involved. When the procedure is thoroughly understood by the user, many applications will make themselves evident.

The procedure to be followed for breaking a complex wave into its harmonics and evaluating each one, is as follows:

1—On a sheet of graph paper, draw as nearly a perfect reproduction as possible of the complex wave to be studied. This wave form is most easily obtained by the use of an oscilloscope. (Only one cycle of any wave is used in the analysis.) See Fig. 1.

2—On the vertical axis, Y_0 (Fig. 1), lay off a voltage scale which will make every value of voltage on the reproduced wave correspond with the true voltage as measured by the scale of the oscilloscope's screen. Divide the length of horizontal axis which is taken by the wave into 360 degrees. This is to be divided in steps of 30 degrees. Through each 30-degree mark draw a line vertically from the horizontal axis to the wave, either above or below the horizontal axis. Label these lines as shown in Fig. 2.

3—Using the voltage scale on the vertical axis, Y_0, determine the voltage where each line touches the wave. All voltage on the wave above the horizontal axis is positive; below the axis is negative. Tabulate these values in order, for future use.

4—Substitute the proper numerical values which were just obtained for the Y's, in each of the following list of equations. Perform the indicated arithmetic, being very careful of handling all negative values correctly. In other words, if part of an equation is $Y_2 - Y_5 - Y_8$, and the numerical values for the three Y's was found to be (4), (—3), and (2), respectively, then by substitution, it becomes (4) — (—3)

— (2) which by simple arithmetic is $4 + 3 - 2 = 5$.

SUBSCRIPTS FOR Y

The numbers enclosed in parenthesis in the following equations are the subscripts of the Y values which are to be used as indicated.

$$A_0 = \frac{(0+1+2+3+4+5+6+7+8+9+10+11)}{12}$$

$$A_1 = \frac{0.5\,(1+5-7-11) + 0.866\,(2+4-8-10) + (3-9)}{6}$$

$$B_1 = \frac{(0-6) + 0.866\,(1+11-5-7) + 0.5\,(2+10-4-8)}{6}$$

$$A_2 = \frac{0.866\,(1+2+7+8-4-5-10-11)}{6}$$

$$B_2 = \frac{0.5\,(1+5+7+11-2-4-8-10) + (0+6-3-9)}{6}$$

$$A_3 = \frac{(1+5+9-3-7-11)}{6}$$

$$B_3 = \frac{(0+4+8-2-6-10)}{6}$$

$$A_4 = \frac{0.866\,(1+4+7+10-2-5-8-11)}{6}$$

$$B_4 = \frac{-0.5\,(1+2+4+5+7+8+10+11) + (0+3+6+9)}{6}$$

$$A_5 = \frac{0.5\,(1+5-7-11) - 0.866\,(2+4-8-10) + (3-9)}{6}$$

$$B_5 = \frac{(0-6) - 0.866\,(1+11-5-7) + 0.5\,(2+10-4-8)}{6}$$

$$B_6 = \frac{(0+2+4+6+8+10-1-3-5-7-8-11)}{12}$$

Interpretation of results:

The subscripts of the letters, A and B, are the numbers of the harmonics; thus, A_1 is the magnitude of the first harmonic (known as the fundamental); A_4 is the magnitude of the hourth harmonic, etc. The same applies to the B's. There is a technical difference between, for instance, A_3 and B_3. The A term represents the sine component of the third harmonic, while the B represents the cosine component of the third harmonic.

EFFECTIVE VALUE DETERMINED

When an analysis of a wave yields both an A and B term for the same harmonic, regardless of the magnitudes, the effective value which the experimenter is interested in is found by taking the square root of the sum of the squares of A and B. In mathematical form, this is indicated $\sqrt{A^2 + B^2}$.

It should be remembered that this operation is necessary or possible only when the A and B terms are for the same harmonic.

All numerical values obtained in this system are the maximum values to which the voltage (or current) of the harmonics will rise. Thus, A_5 is the maximum value of the fifth harmonic. The r-m-s value can be obtained by multiplying maximum value by 0.707.

A harmonic is absent from a complex wave if, after substitution, both the A and B term is found to be zero. If either the A or B term has a numerical value other than zero, the effective value of the harmonic is given by the value of that term. The first term, A_0, is the d-c component.

EXAMPLE CITED

A specific example will serve to clarify all the operations outlined in the procedure. The wave form shown in Figs. 1 and 2 will be used throughout.

In Fig. 1, the horizontal axis covered by the wave is shown divided into the twelve equal parts as directed in No. 2 of the procedure. The vertical axis, Y_0, is divided according to the scale used. In Fig. 2, the vertical lines have been drawn from the horizontal axis to the wave, at every 30 degree mark (Procedure No. 2).

The next step is to determine the numerical value for each Y, from the scale on the vertical asis. For the wave shown, the tabulation of these values would be as follows:

$Y_0 = 0$	$Y_4 = 12$	$Y_8 = -6$
$Y_1 = 5$	$Y_5 = 6$	$Y_9 = -7$
$Y_2 = 14$	$Y_6 = 0$	$Y_{10} = -7$
$Y_3 = 11$	$Y_7 = -1$	$Y_{11} = -5$

Substituting the proper values for each Y in each of the equations and solving, it is found that the following information is obtained:

$A_0 = 1.83$	$A_4 = 0$
	$B_4 = -0.83$
$A_1 = 10.9$	
$B_1 = 0.81$	$A_5 = -6$
	$B_5 = 0.64$
$A_2 = 0.87$	
$B_2 = -1.3$	$B_6 = 0.67$
$A_3 = -0.17$	
$B_3 = -.0.17$	

The algebraic sign of the A and B terms

(Continued on following page)

Field Energy Used in New Meter to Measure High Currents, 5-42 Mc

A JEWEL-BEARING oscillating-ring electrodynamic ammeter was described recently to the members of the New York section of the Institute of Radio Engineers in a paper presented by Harry R. Meahl of General Electric's Engineering Laboratory. The author explained his method for calibrating this instrument, and showed it to be a standard of currents above one ampere. at high frequencies.

Past investigators of high-frequency phenomena have wondered why some practical standard of current at high frequencies was not found long ago. The reason is that many efforts were made to use the heating effect of the current, and only a few to use the energy in the magnetic field. Even on direct current, an instrument uring the heating effect of the current is not a standard, because of the difficulty of accurately calculating its characteristics. The performance of the electrodynamic ammeter can be accurately calculated from measurements of length, mass and time, giving a standard of current at high frequency.

HOW RING OSCILLATES

This instrument is used with currents from 3 to 6 amperes over the 5 to 42 megacycle frequency range with an accuracy of plus or minus one per cent.

A high-frequency current flowing in the exciter loop imparts energy to the oscillating ring which then oscillates about the 90 degree position at a rate proportional to the magnitude of the current, and nearly independent of the frequency of the current. The ring continues to oscillate until the energy is used up in air and bearing friction, usually 20 seconds or more.

A photoelectric oscillation counter is used with a two-pen chronograph and the primary standard of frequency to time the oscillating ring with accuracy. A standard second of time contactor on the primary frequency standard 1,000-cycle clock actuates one pen of the chronograph, while the photoelectric oscillation counter actuates the other.

DIRECT COMPARISON

Thus a tape is obtained on which appears a direct comparison of the period of the oscillating ring with time.

In addition to being a standard of current, this instrument has lower impedance than commercial instruments and therefore has less effect on the circuit into which it is connected. According to Mr. Meahl, it should prove valuable in improving the accuracy of current measurements at high frequencies.

Personnel

Ward Leonard Electric Co. announces the appointment of Charles D. Southern, 430 W. Rudisill Blvd., Fort Wayne, Ind., as representative for the sale of Ward Leonard radio products. Mr. Southern's territory covers the entire state of Indiana.

* * *

Tobe Deutschmann, Canton, Mass., has appointed the Rowe Radio Research Laboratory Company, 1103 Bryn Mawr Avenue, Chicago, as technical sales representative for the Chicago area. Harry Rowe, head of the company, has spent many years in radio engineering. The Tobe technical equipment—Audi-O-Graph, Impedance Bridge, Bridge Analyzer, Null Indicator and other instruments—will be displayed at the Rowe Laboratory.

(*Continued from preceding page*)

is an indication of the initial direction of the harmonics, and may be disregarded by the experimenter or serviceman. However, the signs contained within the equations should strictly be observed.

VALUES DETERMINED

The final step is to take the square root of the sum of the squares of the A and B term of each harmonic, only when there are numerical values for both. In this wave, it is seen that the fourth harmonic has a B term only, in which case the magnitude of the fourth harmonic is the numerical value of the B term. The A_0 term, being the d.c. component is not subject to the square root operation. Since this series includes the B term only of the sixth harmonic, that term itself represents the magnitude. Performing the square root operation where necessary, and tabulating the results, the following information is obtained:

D. C. value of wave................	= 1.83
First harmonic (fundamental).......	= 11.00
Second harmonic....................	= 1.57
Third harmonic.....................	= 0.24
Fourth harmonic....................	= 0.83
Fifth harmonic (approximately).....	= 6.00
Sixth harmonic.....................	= 0.67

Inspection of this information shows that the fundamental is present in large magnitude, while the most prominent harmonics are the fifth harmonic, quite large, and the second harmonic, which is comparatively small. The other harmonics are present, but in extremely small relative magnitudes. (As stated before, the above harmonic magnitudes are maximum values.) The wave to be analyzed can represent voltage, current, etc.

Equipment and Methods For Facsimile Service

By Charles J. Young

Research and Engineering Division, RCA Manufacturing Company, Inc. Camden, N. J.

Introduction

SOME ten years ago, when the first extensive tests were being made of radio facsimile transmission for messages and pictures, the thought developed of using this process for actually printing a newspaper in the home by radio broadcast. It grew from a sudden realization that carbon paper offered a very simple way of making a mark on a piece of paper, and that it might be possible to design a mechanical scanning device which would spread carbon dots on the receiving sheet so as to form a facsimile reproduction. A stylus type of machine was tried first. In a short time, however, the printer bar and helix type of recorder was devised, and it then became apparent that a receiver simple enough for home use was an actual possibility.

During the years since then many machines have been built and many problems encountered and solved. In the recorder itself the printer unit is the heart of the device and this has been constantly improved with resulting better definition of copy. Various methods of synchronization have been investigated and some of them applied to actual operation. The structure of the recorder has passed through many stages from purely laboratory apparatus to finished designs for particular applications. Paper and paper-feeding systems have been studied. Some of this work was directed to commercial communication services, operating from shore to ship and from city to city; but the central and motivating idea has always been the one of making practical a facsimile broadcast service.

As work proceeded toward this objective, much assistance has naturally come from the parallel growth of facsimile or picture transmission equipment for wire-line and radio circuits.[1] In particular, many methods of printing the received image on the paper have appeared[2] and these have been tested and considered for the

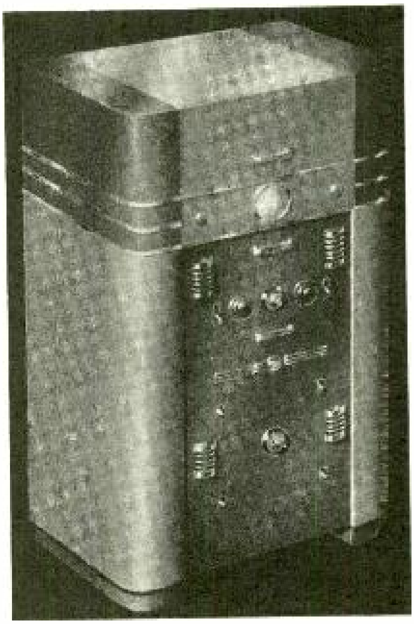


FIG. 1
Complete scanning equipment

home broadcast receiver. Each method has advantages and disadvantages and they have been judged on the basis of the following factors:

FIVE CLASSIFICATIONS

(a) Appearance of finished copy, in terms of definition, color, etc.
(b) Sheet recorded damp or dry.
(c) Processing, if any, subsequent to recording.
(d) Possible speed of recording.
(e) Cost of paper.

After comparing in this way the various processes, it was concluded that, in the present

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[1]The hearty cooperation of Mr. J. L. Callahan and his group at RCA Communications, Inc., has been helpful. Their system has been reported in "Photoradio Apparatus and Operating Technique Improvements" *Proc. I.R.E.*, Vol. 23, No. 12, Dec., 1935.

[2]"Photoradio Transmission of Pictures," Henry Shore, presented before the Photographic Society of America, April 26, 1937.

(Continued from preceding page)

state of the art, the carbon-paper recording was best suited to a home-use machine.

In addition to a long period of work on the sending and receiving apparatus itself, there have been a number of facsimile trials over actual radio circuits. The equipment made for receiving weather maps on shipboard had an extensive test over a span of several years, during which time evidence was accumulated on facsimile propagation in the range from 4,000 to 18,000 kilocycles. Early field trials of broadcast-facsimile receivers were made in Schenectady in 1929 in this same band. In New York City in 1931 broadcast operation was carried on for a short time on 2,100 kilocycles. In 1932 further trials were made on 44 megacycles with the machines self-synchronized on both a-c and d-c power systems. More recently extensive studies were completed of ultra-high-frequency urban coverage with automatic recorders operating many hours per day. Naturally much information was accumulated on the effects of fading, interference, and multipath propagation. This mass of data was very helpful when it came to choosing operating standards for a broadcast system.

Having given this brief review of the background, the rest of this paper will be devoted to the actual equipment which is now available to broadcasters, in order that they may make such trials of broadcast facsimile as will demonstrate the public value of this new service.

In designing the scanning equipment and the receivers this object has been kept in mind. In other words the receivers have been made as simple as is consistent with reliable performance and with clear printing of copy. All extra devices, such as paper cutters to break the recorded copy into sheets, have been eliminated. At the scanner, on the other hand, some expense has been added to provide voltage regulators and timing devices which will make it more certain that a regular and consistent program can be broadcast, even in the hands of a relatively inexperienced operator.

SCANNING EQUIPMENT

The appearance of the scanning equipment is shown in Fig. 1. All parts are mounted in an attractively styled steel cabinet which is approximately 52 inches high, 32 inches wide, and 16 inches deep. The upper section of this case is a hinged cover. When thrown back it exposes a table-like surface on which is mounted the actual scanning machine. Below this level is the timer, and then come three standard panel units, the compensating amplifier, the power-supply panel, and the voltage regulator. The apparatus thus forms a complete device ready for installation in a broadcast studio or newspaper office. The only connections required are a source of 60-cycle 110-volt power and a broadcast-control line to the radio transmitter.

The scanning machine proper is of the conventional rotating drum type, but with modifications to suit it to broadcast service. The subject-drum is rotated at 75 r.p.m. by a synchronous 60-cycle motor with a reducing gear having a ratio of 24 to 1. This motor and gear is very similar to those used in high-quality automatic phonographs. Between the motor spindle and the drum there is a single-position clutch, so that the drum can be stopped for change-of-subject copy and then re-engaged without losing the relative frame position with reference to the 60-cycle power system. The motor continues to run during this loading operation and a commutator on the

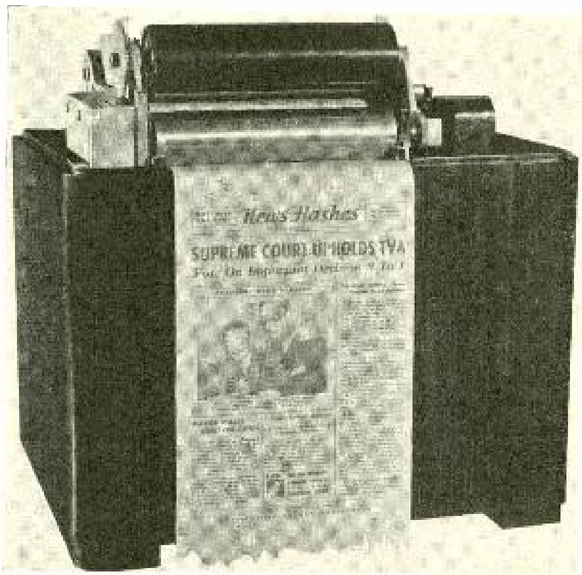

FIG. 2
Front view of recorder with cover removed

spindle shaft supplies an artificial frame-line signal to keep the recorders in step.

During transmission the scanning head, which is mounted behind the subject-drum, traverses slowly down the length of the copy. It is driven by a lead screw and suitable gearing from a second motor identical with the drum motor, its rate of progress being such that 125 scanning lines are drawn per inch of drum length.

DIRECT REFLECTIONS AVOIDED

The parts of the head are an optical system, a phototube, and a phototube amplifier. The light source—a 75-watt exciter lamp—illuminates a small diaphragm, and the opening in this is focused through an objective lens onto the paper, making a bright rectangular spot 0.008 inch long in the direction of the drum axis and 0.003 inch wide in the direction of travel along the scanning line. The incident light beam is normal to the surface of the paper. The reflected light is taken off by a pick-up lens and passed to the phototube, this beam being in the same horizontal plane and at 45 degrees to the incident light. The solid angles formed by the objective and pick-up lenses are so arranged that no direct reflections from the paper can reach the phototube. This limitation naturally reduces the light efficiency, but it is of real assistance where various sorts of subject-copy are used. In a direct-reflection system, for example, a shiny black ink may sometimes reflect as much light as the white paper.

The phototube is a standard gas type and is connected to a special pre-amplifier. The first stage is a direct-current amplifier. It actuates a modulator to provide signal impulses in the form of an audio tone of varying amplitude. Either phase of modulation may be used, but the system is normally adjusted for maximum on black and minimum on white. The tone voltage is supplied by a tube oscillator mounted in the same case and set to produce approximately 20,000 c.p.s. This relatively high frequency is chosen because it makes possible the recovery of faithful direct-current picture signals in the compensating amplifier, without the use of filter networks following the demodulator. Distortion of the impulse shape is thus reduced.

ANOTHER MODULATION

One may well ask why such an indirect method is adopted to produce the picture impulses in the compensating amplifier. The answer is that these signals must extend down to zero frequency and that a straight d-c amplifier of sufficient gain is not easly made stable. Thus the intermediate step of tone amplification and subsequent rectification is used. Even so, all voltage supplies must be closely regulated to prevent drift of the initial d-c stage, because the maximum output of the phototube on black is only about 0.2 volt. A bias potentiometer on the amplifier provides a static setting of this first tube, the proper conditions being chosen by observing the output-signal meter on the scanner base for black and white areas under the scanning beam.

In the compensating amplifier the modulated 20,000-cycle tone is amplified and rectified to produce signal impulses similar to those delivered by the phototube. These are operated upon by special circuits in the next two stages to produce a predetermined alteration in amplitude characteristic, the need for which will be discussed in a later section. Finally the impulses again modulate a carrier tone, this time of about 3200 c.p.s. This carrier and its side bands can be comfortably transmitted over a standard broadcast-wire line. The output to this line is normally set by meter at zero level.

The middle panel in Fig. 1 directly below the compensating amplifier is a power-supply unit for the amplifiers and exciter lamp. The heater current in the phototube amplifier is regulated by a ballast lamp and the plate voltage by gas regulator tubes. The line-voltage regulator forms the lower panel and further improves the stability by holding constant the 110-volt supply to the whole system, thus regulating the lamp brilliance also. The need for this careful regulation lies, of course, in the fact that the shading of pictures depends directly on the amplitudes of the signal impulse, and that any fluctuations result in incorrect tone values.

No modifications are needed in a standard telephone or broadcast transmitter to handle the facsimile signals. The percentage of modulation should, of course, be set at a fixed value for "black," i.e. for maximum sub-carrier amplitude, and should not change during the schedule. It may be worth noting that this maximum modulation is a definite predetermined value and may therefore be set at 100 percent if desired without fear of overshooting.

FACSIMILE BROADCAST RECEIVER

The facsimile receiver is shown in Fig. 2 with the cover removed and with the recorded copy feeding out the front. It is a complete unit, in that it includes the radio receiver chassis, and a time switch; and thus requires only an antenna and a source of 60-cycle power. It is worth emphasizing this arrangement and the reasons for it. It might have been simpler to provide only a recorder for attachment to an existing radio receiver, but the proposed conditions of operation must be considered. The schedules are to be sent out, at least according to most existing plans, over regular broadcast stations between midnight and six in the morning, a period when the channel is otherwise idle. The recorders are to be turned on and off by time switch at the proper hours. Consequently, if the recorder were made as an attachment, the user, on going to bed, would have to leave his radio set accurately tuned to the right station, with volume correctly adjusted, and otherwise in a condition so that it would come on by the clock and print. This nightly pre-setting is too much to expect of anyone but an enthusiast with a good memory. On the other hand, the use of a special chassis made for facsimile service only, has technical advantages in that it can be more efficiently designed, and can give more reliable performance. This, therefore, appeared to be the best solution.

The placement of the receiver chassis and the

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time switch is shown in the back view of the cabinet in Fig. 3. Although the chassis could be designed for any suitable wave band, most present requirements call for operation between 550 and 1,600 kilocycles. This is met by modifying a standard broadcast receiver of the type designed for push-button tuning. The sensitivity of this receiver is approximately 500 micro-volts per meter at the lower limit of good automatic volume control. This figure is based on the intention of the broadcasters to operate facsimile recorders within the primary service area of their stations. All but two of the several tunings are eliminated and the audio system is replaced by a rectifier and printer amplifier.

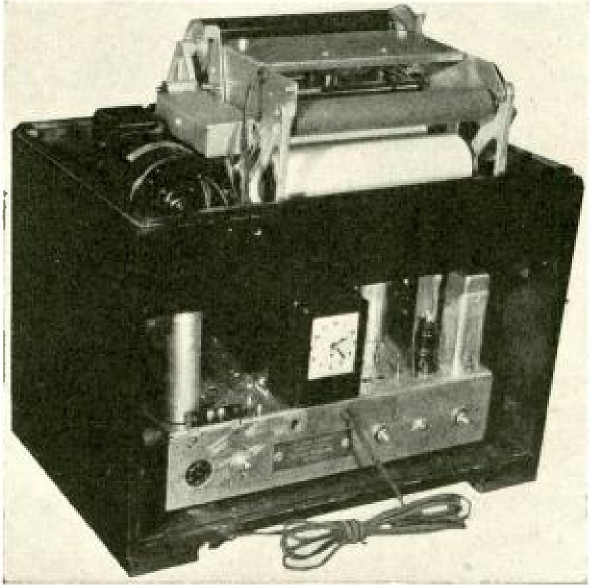

FIG. 3
Back view of recorder showing chassis and time switch

WHAT THE CIRCUITS ARE

The circuits use approximately the same number of tubes, and are shown schematically in Fig. 4. It will be seen that the 6V6 output tubes pass plate current alternately, forming a sort of push-pull direct-current amplifier. The lower or "black" tube is biased to cut-off with no signal input, but passes plate current as the bias becomes zero under full signal. The upper or "white" tube passes plate current at no signal, but no plate current at full input. The controlling bias voltages are obtained by rectification of the 3,200-cycle sub-carrier, after a stage of amplification. The coils of the magnetically operated printer unit are connected as shown in the plate circuits of the printer tubes.

The facsimile recording machine is mounted in the upper section of the cabinet and is covered by a removable lid. Its structure can be fairly well seen in Fig. 5. The active parts are supported between two cast side-plates, the driving motor being on the far side out of view, and the paper-feed gearing in the right foreground. The recording drum with the raised helical ridge on its surface can be seen in the center, and above it the course of the white and carbon papers, which have been torn back to afford a clearer view. The carbon paper is wound up after use on the core at the top; the white is fed out from the front of the cabinet by a cylinder like a typewriter roll. This roller can be seen under the carbon take-up core. In taking this view the printer unit was swung back to the left into the paper-loading position. The actual operating position of the printer bar is shown by the steel rule which was placed over the papers for this photograph.

The method by which a carbon recording is produced can be easily seen by considering the helix drum as rotating at its normal speed of 75 r.p.m. Whenever a signal for black is received from the transmitter, the printer bar (represented by the rule) is sharply depressed along its whole length by the two electromagnetic drivers. See Fig. 4.

ORGANIZATION OF DOTS

Obviously it pinches the carbon paper against the write at the point where its edge intersects the single turn raised helix; and because of the rotation, this intersection point repeatedly scans across the page right in step with the traverse of the light spot across the original at the scanner. If complete synchronization is maintained, the dots will organize themselves into a facsimile of the original subject.

The definition obtained at a given speed depends on the rapidity with which the magnetic drivers can move the mass of the printer bar. Consequently great care has been taken in the design of this unit. As indicated schematically in Fig. 4 the bar is mounted on a frame structure with a rigid pivot at the axis of the supporting tube. It is driven at two points through connecting springs from the balanced-armature electro-magnetic drivers. These are basically similar to early forms of magnetic loudspeakers, but are much improved in constructional details. The fixed field for both units is supplied by a single permanent magnet mounted between them. The natural query as to why electromagnetic rather than moving-coil dynamic drivers are used is simply answered by pointing out that the bar must respond to direct-current conditions; and that it is not very practical either to supply heavy direct-current components from the amplifier for an ordinary voice coil, or to provide enough turns on the coil to work with output tubes of reasonable size.

One loading of paper in the recorder includes a 345-foot roll of white paper on a large cardboard core, and a small roll of about 95 feet of carbon paper. The latter is slipped inside the white roll to make a compact shipping package. When reloading the machine the old carbon rolls are thrown out, as the coating has been thoroughly used after one passage through the recorder at about one-quarter the speed of the white sheet. The large core from the used white roll is saved and put in position as a wind-up spindle for the succeeding loading of carbon paper.

SIMPLER THAN MOST CAMERAS

The new white roll is placed in the machine first and then the carbon roll. Each is snapped in position on centers like the film in a camera, both releases being operated by the strap handle seen on the near side plate of Fig. 5. The white paper is drawn over the helix drum and passed through the feed-roller system just as a sheet is turned into a typewriter. The carbon strip is attached to the wind-up core by a gummed leader, the printer then lowered and latched in place, and the recorder is ready to function. The description of this paper-reloading process has been given in some detail to show that it can be carried out by the user of the machine without too much inconvenience. It is more difficult than loading a typewriter, but probably simpler than most cameras. It is the only service which the owner of the machine need perform himself; and it will not come often, as one loading will last over a month on a 10-page-per-day schedule.

The recorders are assumed to be completely adjusted at the time of installation. The receiver is tuned to the chosen station and the time switch set to turn it on soon after midnight and off again some time later, according to the established facsimile schedule. The volume control is correctly adjusted and the printer position checked. A cover strip is then placed over the controls leaving only the clock face exposed, so that it may be reset if necessary after a power failure. A self-starting synchronous-clock movement is employed as being probably the most satisfactory timekeeper for the purpose.

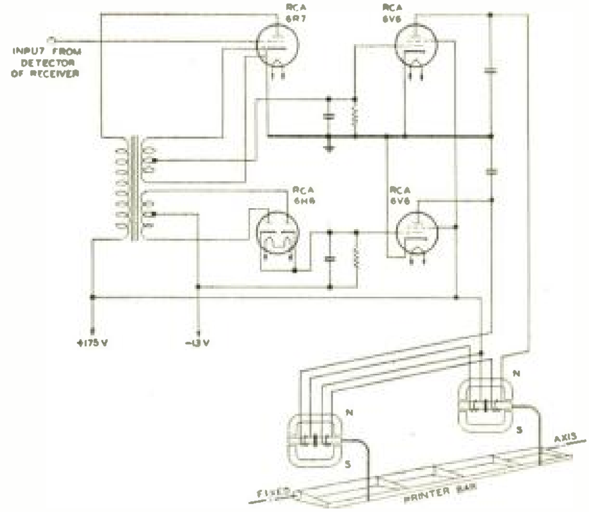

FIG. 4
Schematic of printer amplifier

SYNCHRONIZATION

There are two parts to the problem of synchronizing facsimile recorders and scanners; first, the one of insuring that the rate of travel of the printing point in the recorder is exactly the same as that of the light spot in the scanner; and second, that of starting the stroke in the recorder in phase with the start of the scanning line at the sending end. If the former condition is not fulfilled the recorded picture will be distorted and askew, and will soon slant off the sheet. If, however, the speed is maintained, the image will be square; but it will not necessarily fall in the center of the page. The scanner may have started its stroke

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half a line ahead of the recorder and the machines are said to be out of frame.

The first part of the problem, that of speed control, is easily solved in a broadcast service

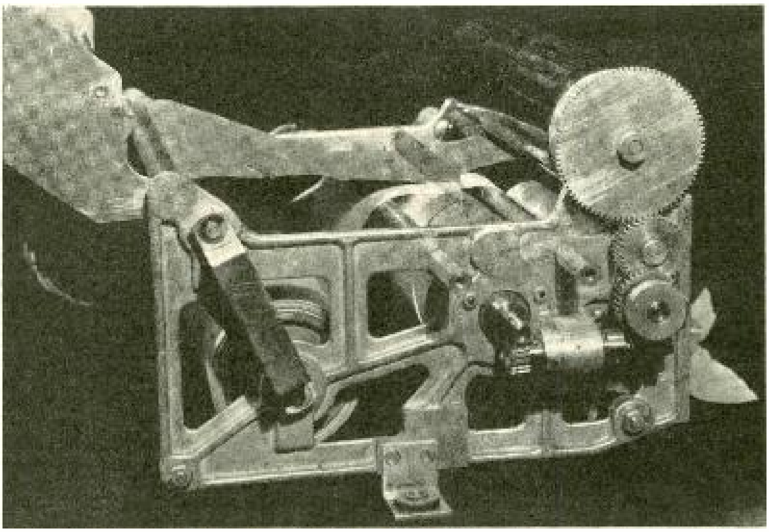


FIG. 5
Close-up photo of recorder

by operating both sending and receiving machines with synchronous 60-cycle motors driven from common or interconnected-power systems. This method is used in the equipment described here and makes for very perfect and unvarying synchronization with no additional apparatus in the receiver. It is open to criticism that there are several places in the country where independent and unconnected-power companies operate in the primary-service area of a single broadcast station; and there are also the cases where downtown business districts still use direct-current power. But these are the exceptions, for in most cases, the homes in the suburban and adjacent country around a city are all served by a common-power system. Thus for an initial program of facsimile broadcasting, synchronization can be well obtained in this way for a large percentage of the market.

THE SECOND PART OF WORK

In areas where there are two independent 60-cycle systems, as around Cleveland or New York, for example, a possible method of working is to divide time between the two systems. The receivers which are supplied by power from company A might be set for 12 midnight to 2:00 A.M. and all on the lines of company B for 2:00 A.M. to 4:00 A.M. The facsimile schedule would then be broadcast twice, once with the scanner synchronized on the A system, and again with it synchronized on the B system. This is easily accomplished at the scanner because the motors only require some 50 watts. The scheme is not very economical as it doubles the time on the air. It is mentioned here as an expedient which may be adopted for preliminary operation.

With further growth of broadcast-facsimile service it is to be expected that self-synchronizing recorders will become available when a simple system has been worked out and reduced to a reliable design. There is already much background on the subject and there is actual experience with facsimile installations made for commercial service. Perfect synchronization has been obtained between remote points by the use of tuning fork control; and there have also been a number of systems set up with a control transmitted over the radio circuit along with the picture.

The line framing or synchronization of the picture received at the recorder is the second part of synchronization. It is accomplished in these machines by a circuit-breaking device used in conjunction with a line-framing relay. The circuit-breaking device may be mounted on the helix-drum shaft or coupled thereto, and carries a breaking arrangement which comes under the relay armature at the instant the intersection or scanning point in the recorder goes off the edge of the paper. If the line-frame signal generated at the scanner by the clamps on the scanning drum arrives at this same instant, the circuit is such that the relay is not actuated, and the motor drives the recorder steadily in its correct line-frame position. If, however, the recorder circuit-breaking device is in another position when the line-frame signal comes in, the relay momentarily opens the motor circuit causing it to slip below synchronous speed. This will occur each revolution of the drum until the recorder reaches correct frame.

The automatic framing function normally takes place only at the start of the program, and the machines thereafter run continuously in perfect synchronism. The only exceptions occur when the power at the recorder fails, or when the signal fades out completely. In such exceptional cases the machines will attempt to reframe as soon as normal conditions are restored, but may not complete the cycle until the margin space comes through at the end of the sheet. The remaining pages of the schedule will then be properly placed as before.

SUBJECT COPY FOR TRANSMISSION

It is not within the province of this article to attempt a prophecy of the kind of copy which broadcast facsimile can most profitably publish. On the other hand, the make-up of the copy and the nature of the printing and pictures is very definitely controlled by the characteristics of the equipment. The major factors to be considered are the size of the print, or the black and white detail, as limited by the resolution of the system; and the kind of original pictures needed to give the most pleasing halftone recordings.

With reference to definition, the present system, when in optimum adjustment and under favorable conditions, will transmit and record 6-point newsprint type so it is legible. The formation of the letters, however, is not very clear, and text of this size would be tiresome to read. Furthermore, it is advisable to make some allowance for production variations in recorder performance, and for some loss of signal quality in transmission due to minor maladjustments and possible interference. For these reasons it is being recommended that no type size smaller than 10-point (approximately equal to typewriting) be used until the practicability of finer definition is proven in the field. Bold or expanded type faces are desirable and lettering should be avoided which has alternate heavy and very light strokes in its design. As to margin lines and drawings, it is being suggested that lines be at least 0.020 inch wide and that the smallest space between them be at least the same width.

LIKE NEWSPAPER PROBLEMS

The halftone or picture characteristics of the system are described in the next section. In actual practice it is found that photographs with a wide range of shade values are naturally easiest to transmit, and that it is desirable to prepare the prints so that the areas of interest are delineated in terms of the middle range of grays, rather than in the very dark or very light tones.

The problems are much the same as in the preparation of pictures for newspaper printing, and one is perfectly justified in using the same tricks of trimming, retouching and the like. The actual picture placed on the scanner drum should be a photograph made on thin paper so that it can be pasted in place on the page. Pictures which have been printed from a screened plate are not satisfactory unless the screen is either finer than 150 lines per inch or of the rotogravure type which gives a random-dot arrangement. Coarser screens often result in bad moiré patterns due to interference with the facsimile line structure.

In the preparation of a complete program a series of pages can be made up and printed on the standard size sheet, 8½ inches wide and 12 inches long. The text may be set by hand or linotyped, and a single copy pulled on a proof press for each page. If finished appearance is not so important, the text may be typewritten, preferably on an electric typewriter which gives a uniform impression.

HALFTONE CHARACTERISTICS

Any facsimile system which is to send pictures must record them with shade values which correspond fairly closely with those of the original. This requirement means that close attention must be paid to the amplitude characteristic throughout the scanner and recorder. If there is unavoidable distortion at some points, compensation must be provided at others.

In carbon-paper recording the major distortion occurs in process of transferring the color to the white sheet. A certain amount of pressure is needed on the printer bar before any carbon comes off, then, as the pressure increases, more color is transferred, until saturation is reached at the darkest tone available with the particular papers used. This condition is shown in the central square on Fig. 6.

Grouped around are the amplitude curves of the other parts of the system, all of them so arranged that reference lines corresponding to all tone values can be carried through complete sequence. For example, suppose an original gray shade, which might be called 50 per cent black, is chosen on the scale of original tone values at the top center. Proceeding along the dotted line to the left it is found that the scanner head amplifier will deliver instead 60 per cent of its maximum signal, because of the residual output on white. After passing the compensator this will correspond to a 35 per cent tone amplitude on the line to the transmitter.

PRINTER BAR PRESSURE

The transmitter modulation curve and the receiver up through the second detector are assumed to be linear. The lower right-hand characteristic applies to the printer amplifier shown in Fig. 4. The plate currents of both "white" and "black" output tubes are shown, and their algebraic sum. This differential current is really fictitious as it does not exist as such in the output circuits; but it does represent the resultant effect of the "black" and "white" currents on the printer armatures. Returning to Fig. 6, measurements show that the pressure developed on the printer bar is proportional to this difference current as shown by the straight line. The non-linear characteristic of the carbon paper has already been mentioned. Again following the dotted line, turning on the carbon-paper characteristic, one arrives finally at a recorded tone value of about 43 per cent of full black. This is seen to be the true middle-gray point for the recorder, as the maximum carbon blackness only reaches 86 per cent of the density of the original black ink. If other tone values are plotted around the chart, the final straight fidelity characteristic will be

(Continued on following page)

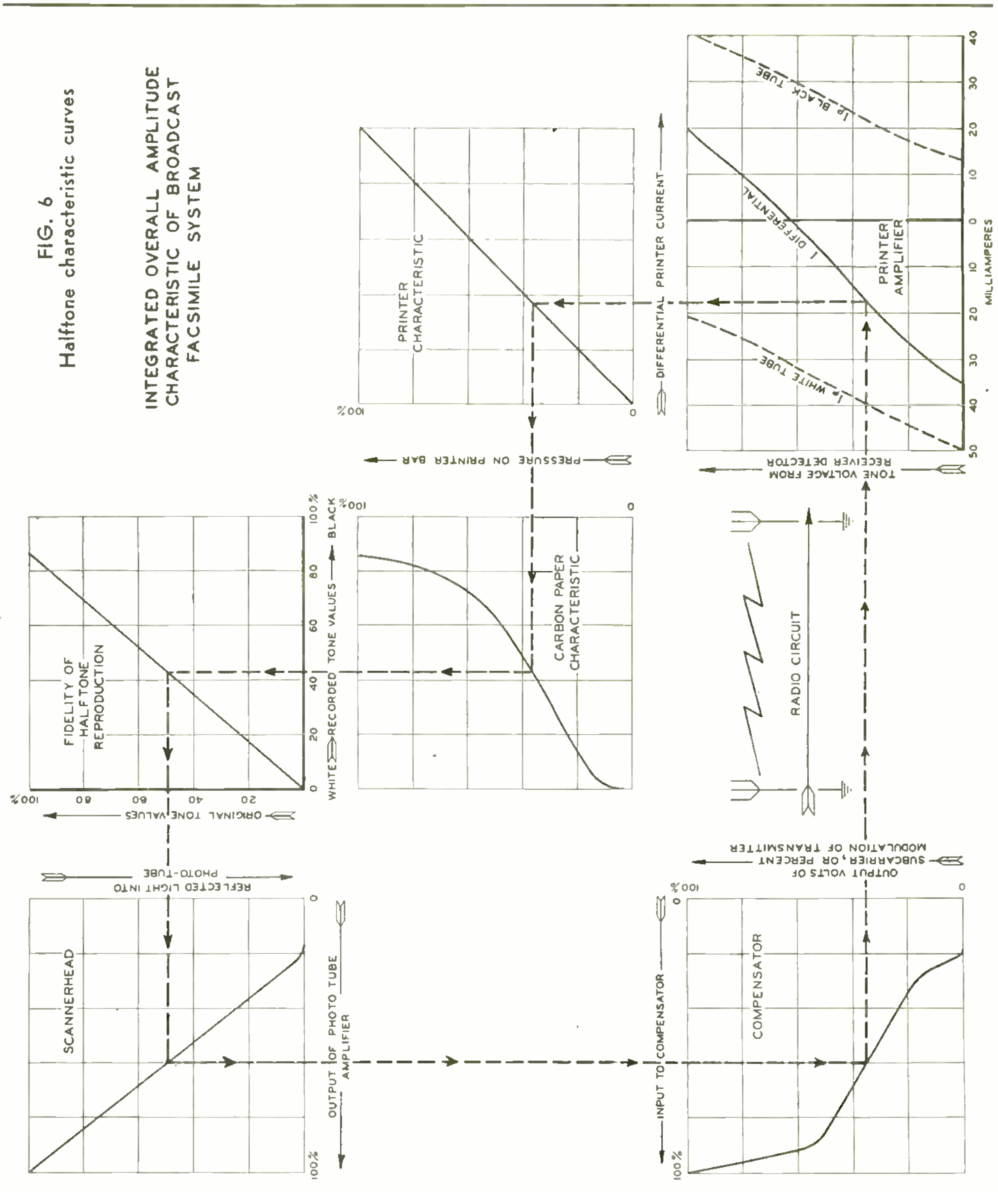


FIG. 6
Halftone characteristic curves

(Continued from preceding page)

developed. Obviously this happens because the characteristic of the compensating amplifier has been worked out so as to neutralize the carbon transfer and other distortions of the system.

CONSTANTS OF THE SYSTEM

The operating speeds, paper sizes, and so on, have been referred to already, but can be more easily visualized from the following tabulation:

Number of scanning strokes per minute (r.p.m. of drums)......	75
Total length of stroke...........	8¾ inches
Lines per inch.................	125
Width of paper on scanner......	8½ inches
Length of paper on scanner......	12 inches
Width of paper at recorder......	8½ inches
Maximum width of copy.......	7½ inches
Proposed length of page.......	12 inches
Useful length of page allowing top and bottom margins......	11 inches
Number of pages per hour.......	3
Length of white paper roll......	345 feet
Length of carbon roll (for this amount of white paper)......	95 feet

The first three figures given above are the basic operating parameters. For example, any discussion of standards should probably start here. The product of the total length of stroke by the number of lines gives the Facsimile Index, which in this case is 1093.75. Any two drum-type facsimile systems will work together which have the same drum speed and the same index, although an enlargement or reduction may take place in true proportion.

WHY WIDTH WAS CHOSEN

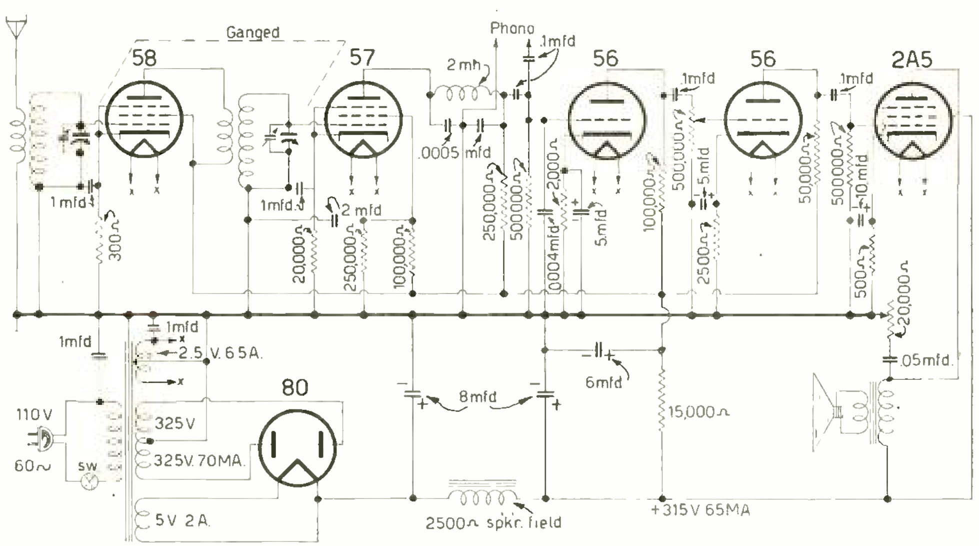
The 8½-inch wide paper was chosen for the recorded as a practical compromise between a page too narrow to give a good illusion in the reproduction of pictures, and a sheet so wide as to make the recorder bulky and expensive. The number of lines per inch is sufficient to permit definition of the smallest type size which the average man can comfortably read. Present apparatus does not reach this goal, and so this figure must be considered as an allowance for future improvement. A choice of fewer lines per inch would mean a loss of detail which may otherwise become possible; a finer-line structure would reduce the speed of the system for the sake of an improvement in resolution of questionable advantage.

The drum speed of 75 r.p.m. was chosen as one which could be conveniently obtained from a synchronous 60-cycle motor and which would result in well-defined copy on the carbon printer. It gives a 12-inch page in 20 minutes. If allowance is made for the margins a printed area 7½ inches wide remains, and there will be 4½ square inches of useful recording in one minute. In terms of words this is not so slow as it seems. With a solid block of typewriting it means 45 words per minute, with 10-point type about 65, and with a typical page of newsprint about 110 words per minute.

ACKNOWLEDGMENT

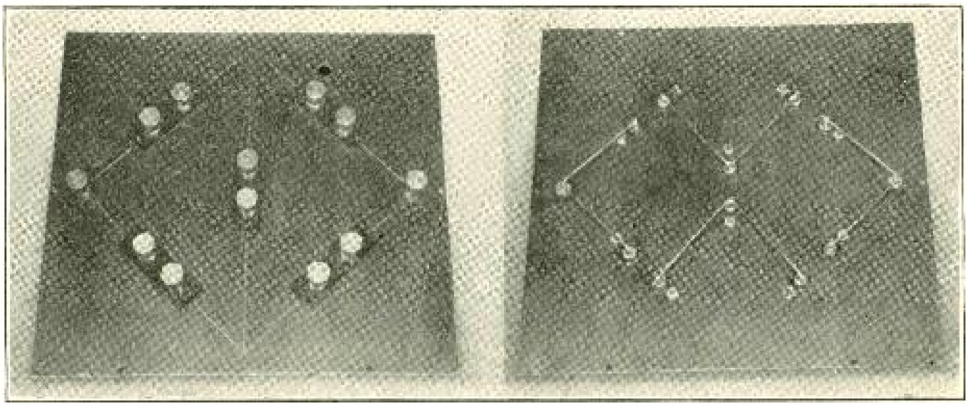
In preparing this article the author has attempted to give a general view of the equipment which has been developed for broadcast-facsimile use, the way it operates, and some of the reasons for particular solutions of its problems. Much work lies behind this practical design of facsimile equipment. Credit is due especially to Mr. Maurice Artzt who has been with the project from the beginning, and whose persevering and ingenious attack has solved many of the problems. More recently Mr. H. J. Lavery has made substantial contributions to the structure of the printer; whereas the actual design of the appartus has been brought into finished form by Messrs. R. G. Shankweiler, B. E. Lane, and A. Blain.

Experimenter Designs T-R-F Set for Good Results on 6 Tubes



This six-tube t-r-f set requires only a two-gang condenser. If it is desired to use a three-gang condenser, thus including an extra stage of t.r.f., the circuit of the first 58 is repeated, only the primary is then in the plate circuit of the first r-f amplifier tube, and the antenna stage would be wired as shown.

This design of a simple receiver was worked out and tested by H. David Petree, of 820 North Eighth Street, Reading, Pa. He was well satisfied with results, using the circuit exactly as shown, and therefore kindly sent in the diagram, so that any others who might have use for the same type of circuit would be spared considerable experimental work.



An Experimental Bridge
How to Make and Use It

By Emil H. Buchwald

ONE of the most important circuits in the radio field is the bridge circuit. It is used in numerous ways, including the full-wave rectifier circuit, the crystal filter circuit in the receiver and of course measuring circuits. The last includes the Wheatstone Bridge for measuring resistance, and a number of combinations for measuring inductance, capacity, tube resistance and so forth.

The experimenter is frequently faced with a problem dealing with a bridge circuit. This in itself is not particularly alarming, since the circuit is simple and may be hooked up temporarily for the test. This entails a number of resistors, or other components, and mass of wires which makes the thing look somewhat haywire. It also increases the chances of error when any changes are made in the circuit.

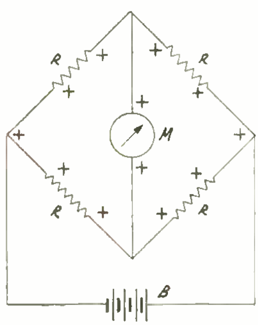


FIG. I
The Wheatstone bridge, particularly valuable for close measurement of resistance values, in which case one of the R's would be the unknown.

To bring order out of chaos, only the circuit itself, minus the electrical components is incorporated on a panel with a number of binding posts for connections. Such a contraption would keep the circuit proper in plain view and would show the correct connections, the position of the components in the arms, the diagonal connections and of course, the power supply connections. Furthermore this idea is not limited to one form of circuit or measurement, since there are no fixed units, hence it is possible to devise any number of schemes and connections in conjunction with the experimental bridge. In other words, it is a "connector block" laid out in the form of a bridge circuit as seen in the conventional circuit diagrams.

A MULTIPLE DEVICE

Everyone associated with the radio technical field is familiar with the Wheatstone Bridge circuit, which is illustrated in Fig. 1. The R's are the resistors, M is the balance-indicating meter and B is the battery.

Now suppose this picture is altered somewhat by erasing the resistances R, the meter M and battery B and its connecting wires. The result is a number of broken lines shaped like a diamond with an incomplete diagonal. A binding post is placed at each point marked X and the line connected firmly to the post. The resistors, meter and battery may now be replaced and connected to the binding posts, or if desired, other units may be connected to the posts.

Mechanically, the bridge, if it may be named that, is complete. Electrically, however, it is incomplete, requiring only the circuits components to make it function for whatever purpose the experimenter may have in mind. The device becomes versatile now in that there are four arms open for any value of resistances. The resistances may be wire-wound, or other types; inductive, capacitive or even the plate resistance of a tube, and so forth. The meter circuit is also available for any type of instrument, sensitive or coarse, alternating current or direct current. The battery, or power circuit, is open for any engagement, be it a clear note

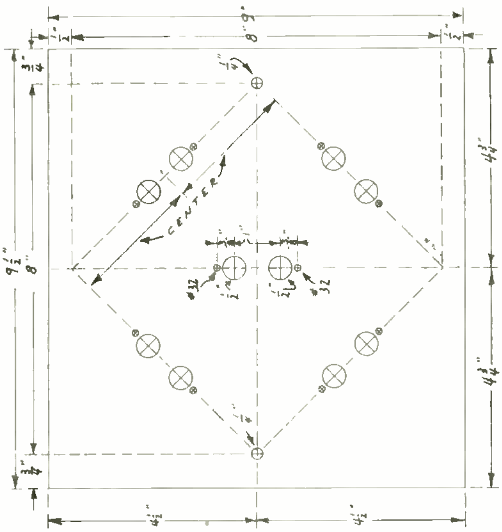


FIG. 2

of a thousand cycles, or the smoothly flowing power of a storage battery.

Fig. 2 shows the panel layout of a bridge as described before. The panel consists of aluminum, but other material may be used, depending on what is available.

PREPARATION OF PANEL

After the drilling and machining operations, the panel is painted black. When the paint is thoroughly dry, the panel is rubbed with steel wool to remove the gloss. This in turn is rubbed with a rag containing a few drops of oil to produce a dull glossy finish.

To insulate the binding posts from the panel the posts are mounted on small Bakelite strips, as shown in Fig. 3. The completed binding post assemblies are then mounted on the panel, one on each arm and one on the diagonal, as in Fig. 1. The holes for the insulated binding posts are drilled large enough in the panel to avoid contact between the posts and panel. Two single posts are also mounted on the panel, with Bakelite washers for insulation, one at each of two extremities of the Diamond. These posts handle the battery wires.

To keep the circuit of the bridge in view, fine lines are scribed on the panel connecting the various binding posts. The lines may be made with a scriber, or any other instrument having a sharp point. Ordinary chalk, or any whitening agent, may be rubbed into the scribed lines, causing the lines to appear in greater contrast with the black panel.

The photograph showing the reserve side of the bridge discloses the wiring, which is ordinary No. 16 gauge copper wire. To insure good contact and also to avoid loose connections, the wire is soldered directly to the screw of the binding post. Fig. 4 shows the circuit and wiring diagram.

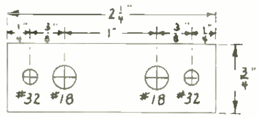


FIG. 3
If a metal panel is used a 1/8" thick Bakelite strip for binding posts is made, as shown full size.

The complete outfit may be mounted on a small plywood box, or metal, as the constructor desires. Incidentally, a Bakelite panel may be used instead of metal. This obviates the use of the small Bakelite strips for the binding posts as the posts may be mounted directly on the bakelite panel.

The bridge is limited to direct current and medium frequency alternating currents, such as audio frequencies. Higher frequencies will cause error, due to capacity effects, etc.

The following will outline a method for using the bridge. Suppose it is desired to produce a resistance duplicating the value of one that is on hand. Assuming the value to be one hundred ohms, the following set-up may be used.

The bridge and circuit are then set up as in Fig. 4. B is a battery of two dry cells, SW is a switch connected in series with R_4, a resistance of two or three ohms which in turn is connected across meter M, of 0-1 milliammeter, or a meter having a range close to this value. R_1 is a 150-ohm rheostat and R_2, R_3

(*Continued on next page*)

Technology Exchanged by Musical Hobbyists

Anyone interested in the construction and features of musical instruments in general, and particularly in reference to radio and sound recording, should welcome the idea of taking this matter up on a scientific basis. Recently this has been made possible in England, where a new Institute of Technology of Musical Instruments has been estabilshed in connection with the Northern Polytechnic, London.

The members will especially cooperate in exchanging points of view regarding the tonal beauty of string instruments such as the famous old Italian violins. The new institute calls attention to new theories and developments concerning the acoustic action of the resonating body of the violin. About this subject an article "The Violin," by Paul Jarnak, has appeared in the March, 1938, issue of "The Journal of the Franklin Institute," Philadelphia.

(*Continued from preceding page*)

are 100-ohm resistors. All the resistance values given so far are not critical and mav deviate without causing an error in the measurement. The scheme of course is to have the values in the arms of the bridge close to the value of the resistance being checked. X is the resistor to be duplicated.

The bridge is balanced by adjusting the rheostat until the meter reads zero. The switch is opened and the rheostat adjusted again for zero.

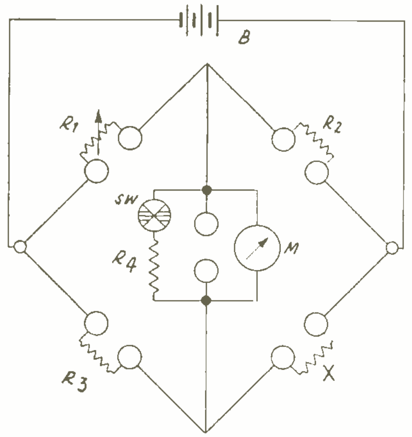


FIG. 4
The experimental bridge, with X the unknown, and with suitable protection provided for the meter. No computation is necessary.

Incidentally, the switch and resistance are a protective device for the meter and all changes and adjustments should be made with the switch closed. After the bridge has been adjusted, the switch may be opened for a "fine" adjustment.

SIGNIFICANCE OF BALANCE

When equilibrium has been reached, the switch is closed and X removed. The duplicate resistance is now inserted in place of X and the reading on the meter noted. If the needle does not indicate zero then the duplicate does not equal the X resistance. It is then necessary to manipulate the wire on the duplicate resistance until the meter reads zero. When a balance is obtained it indicates that the resistance of the duplicate equals the resistance of X.

Thus it is possible to produce as many resistances as desired which equal the resistance value of X.

Record Players Add to Servicers' Income

An increasing number of radio service men have found a profitable means of increasing their income by taking along one of the new, compact little RCA Victor record-players on service calls.

Many extra sales have resulted from impromptu home demonstrations. The most successful procedure is for the service man to connect the record-player to the radio receiver he has just repaired, presumably as a test, and play a lively record or two. This technique never fails to interest the set owner. With rising public interest in recorded music it is usually a simple matter to clinch the sale, because the record-player provides a high standard of performance at extremely low cost.

RCA Victor has recently announced a new record-player which, although it has been improved technically, retails at a lower price than ever before ($14.95, FOB Camden). This new model is expected to find particular favor with new converts to recorded music.

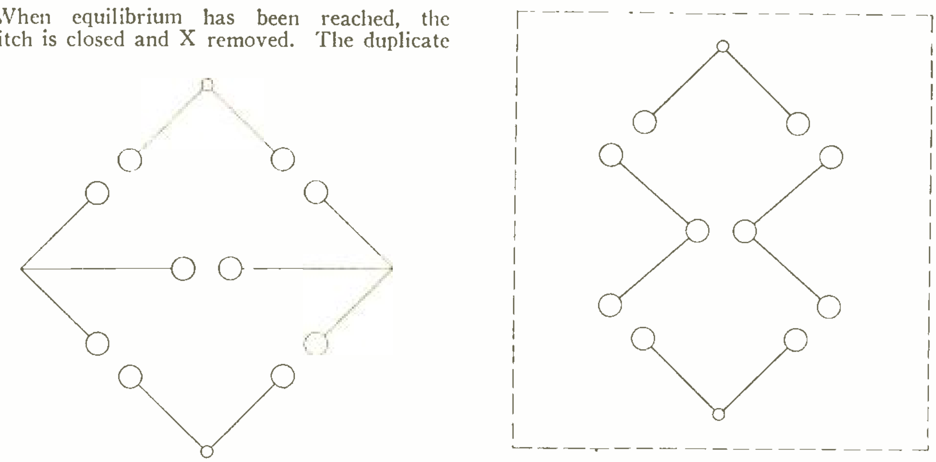


FIG. 5
The top of the mechanical setup appears as at left, while the underneath view is at right.

Distortion Expungers Going Into NBC Transmitters

BECAUSE of the success of a device reducing the slight tonal distortion caused by transmitting equipment at stations WJZ and WEAF, key stations of NBC's two networks, to one-thirtieth of its formal level, engineers are to install it in all stations owned and managed by the National Broadcasting Company, O. B. Hanson, NBC vice-president and chief engineer, announced today.

Listeners in areas served by these stations, said Hanson, will notice a considerable improvement in reception quality when the work is completed. Installation has also been completed at station WTAM, Cleveland.

Work on preparing the giant NBC transmitters for incorporation of the new device, called "reverse feedback," began more than a year ago. Following a long period of study of transmitter characteristics, NBC engineers under the direction of Raymond F. Guy, radio facilities engineer, undertook extensive overhauling of the WEAF and WJZ transmitters to reduce transmitter harmonics to their absolute minimum.

WHAT REVERSE FEEDBACK DOES

Equipment was replaced and new circuits were devised before "reverse feedback" was built into the transmitters.

"Reverse feedback," said Hanson, "represents the idea of cancelling a plus quantity with a minus quantity. We have applied this to transmitter harmonics.

"These false harmonics are inherent in vacuum tube circuits and radio transmitters. We may, for instance, deliver a perfectly pure tone to the transmitter, but in passing through great amplifying tubes it accumulates some harmonic distortion.

"In using reverse feedback at our two New York City stations, we take a small amount of energy as it leaves the transmitter, but before it goes to the antenna. This energy, of course, carries with it the unwanted harmonics that distort radio signal quality. Then we completely reverse its phase; we turn it upside down, so to speak.

DIPS OFFSET PEAKS

"Where there was a peak in the original energy wave, we create a corresponding dip. Then we bring this energy around to the point where the program is entering the transmitter and feed it into the circuit. The re-introduced harmonics, being negative in relation to those created in the transmitter equipment, cause almost complete cancellation of the latter.

"It is the combination of this new 'reverse feedback' with extensive overhauling of our transmitters that has reduced this annoying form of distortion to practically zero at the WEAF and WJZ transmitters. I am sure that listeners in other parts of the country served by NBC owned and managed stations will be delighted with the new purity of tone they will notice when the operation has been repeated on all our transmitters."

TONE QUALITY GAINING

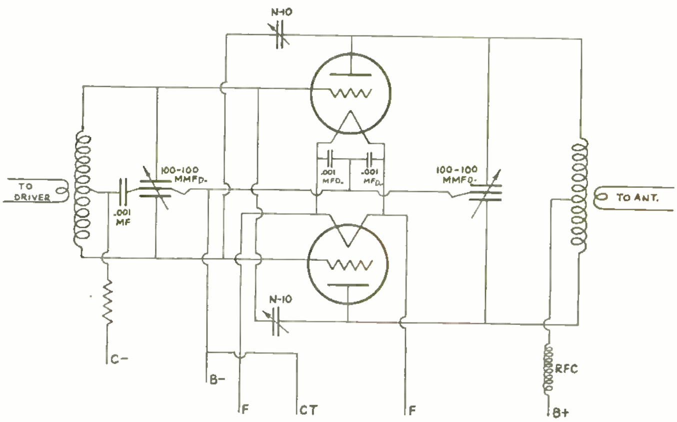
Besides inverse feedback in amplifiers, so far concerned mainly with audio in receivers, it is being used in transmitters and in signal-generator oscillators. Besides infinite impedance detectors are popular in receivers, so that tone quality is winning its rightful place.

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.

W. A. Peters, 6 So. Front St., New Castle, Penn.
Charles Hopkins, 12 Raymond St., Everett, Mass., on P.A. and service equipment, and service parts.
Lee Lauer, 1473 Washington Ave., Bronx, New York City.
W. J. Carpenter, 2160 Merchant St., Abilene, Texas.
J. J. Lawranowicz, 6619 Hoppensack, Cleveland, Ohio.
Bob's Radio Service, 2011 South Central, Los Angeles, Calif.
C. R. Bonstrom, 1307 Emerson Ave., N., Minneapolis, Minn.
Gailerd E. Erickson, Sr., Radio Servicing, Kanawha, Iowa.
Homer V. Thompson, 708 E. Gadsden St., Pensacola, Florida.
Jimmy Kelly, 208 Congress, East McKeesport, Penn.
A. A. Gillespie, "The Mayo Miner," Mayo, Yukon Terr., Canada.
K. R. Cooper, Cooper's Radio Service, 303 East Choctaw, McAlester, Okla.
Andrew M. Lavish, 2124 Eye Street, N.W., Washington, D. C.
R. A. Weyer, 117 Roosevelt Ave., Syracuse, N. Y.
Geo. W. Crosby, 231 34th St., North Bergen, N. J.
Albert Bosak, 1817 So. Millard Ave., Chicago, Ill.
F. N. Serio, Serio's Service Station, Morganza, Louisiana.
John Joy, 116 Broadway, Menands, N. Y.
John Janeco, 83 Easy St., Uniontown, Penn.
C. D. Cox, 421 No. Illinois Ave., Stevens Pt., Wisc.
Jos. A. Nave, 133 Poplar Ave., Memphis, Tenn.
Draper W. Cooper, Charlotte, N. C.
J. W. Watson, McDade, Texas.
Edwin P. Schaper, 1108 East 7th St., Houston, Tex.
Geo. S. Keyes, Box 216, Odessa, Texas.
Thomas Blakeley, 21 East 113th St., New York City.
Allen Vaile, Grandview, Missouri.
Max Glavish, 5111 University Ave., Chicago, Ill.
Joseph Sofranko, 189 Easy St., Uniontown, Penn.

Unit Construction in Amateur Transmitters



Circuit diagram of an amateur transmitter, intended for an advanced mechanical and electrical design. The unit is a push-pull radio-frequency power amplifier.

MECHANICAL arrangement of mateur transmitters has always presented quite a problem. First, we had the bread-board layout and that was followed by the now popular chassis method of construction. Neither of these arrangements is completely satisfactory. They are both great space users and prevent the construction of compact apparatus.

With proper mechanical construction, many present evils may be overcome. However, all amateurs do not have available the tools and machinery necessary to make the fancy brackets and oddly-shaped pieces of metal which are necessary for modern type construction. Then too, there are many amateurs who are not mechanically inclined and find it difficult to do a really neat job in building their transmitters. All of these constructional difficulties have been eliminated by the Hammarlund Manufacturing Company, Inc.

FOR 100 TO 300 WATTS

The unit shown in the front cover photograph is a push-pull radio-frequency power amplifier designed to use any of the popular triode tubes having ratings of from 100 to 300 watts output per pair.

Much time has been spent in the design and arrangement of this unit. All parts associated with the amplifier proper, are joined together with brackets of various shapes. This hardware is available in kit form and the only tools necessary for assembling and wiring are a screw-driver and soldering iron. When finished, it is a self-supporting unit which can be bolted to a panel with the mounting screws furnished with the variable condenser; no chassis is necessary.

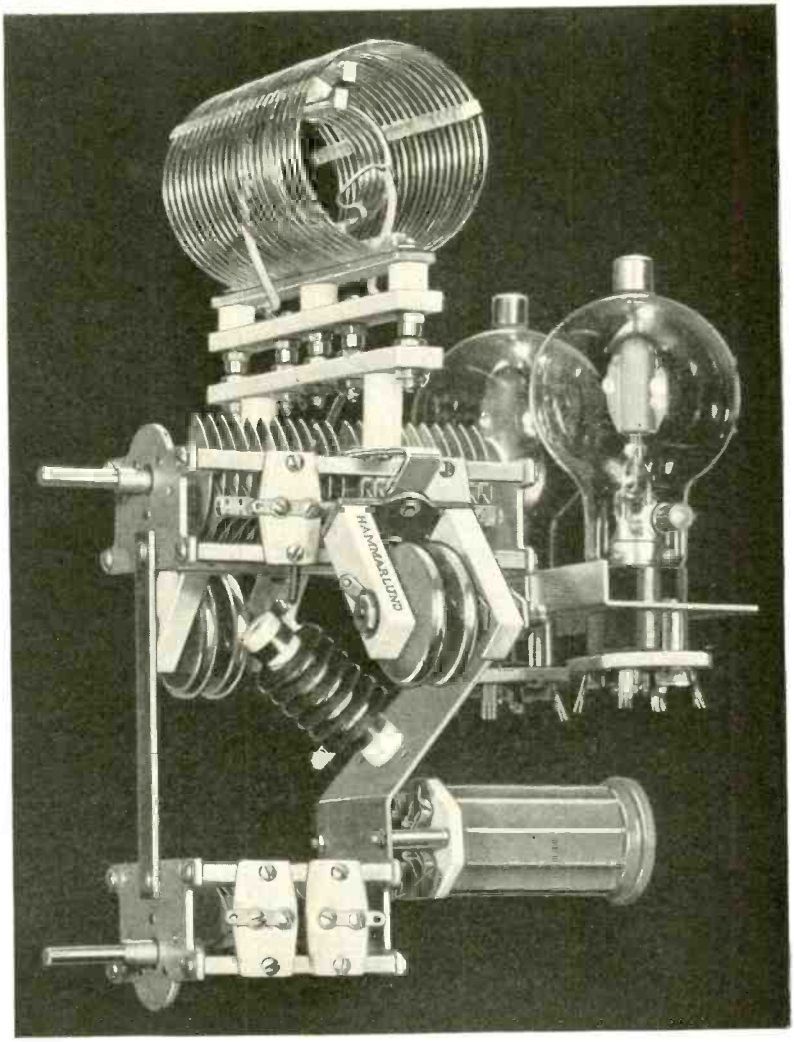
Mounted on the two side bars of the large variable condenser, an "MTCD-100-B," are two brackets which support the plug-in plate coil and the two "N-10" neutralizing condensers. The lower condenser, ("MTCD-100-C") for tuning the grid circuit, is fastened to the large condenser with an angular shaped back plate. At the top of this plate we find another horizontal bracket which serves as the mounting for the two tubes.

At the lower edge of the back plate is mounted the plug-in grid coil. This plate is also drilled for mounting the radio frequency choke (CH-500) and the two filament by-pass condensers together with the grid biasing resistor. All brackets are completely drilled and machined and have a silver-like finish.

The entire arrangement is constructed so as to permit direct and short wiring leads. The tubes shown in the unit are RCA 808's. However, as mentioned before, any of the popular triodes may be used, depending entirely upon power output desired. Overall dimensions are 13 inches high, 8½ inches wide and 8 inches deep.

LIST OF PARTS

1—MTCD-100-B (Variable condenser)
1—MTCD-100-C (Variable condenser)
2—N-10 (Neutralizing condensers)
1—CH-500
2—S-4 (sockets)
1—S-5 (socket)
Plug in plate coil
SWF coil forms for plug-in grid coils (5 prongs)
1—Complete set of hardware, including brackets and screws.



Smartness of appearance and peak of performance marks this ham rig, designed by Hammarlund for home construction, embodying the unit principle of erection.

Electronic Frequency Counter Aids Precision in Music

Providing high accuracy, a frequency counter or pitch standard recently installed in the Allen B. DuMont Labs., Upper Montclair, N. J., is particularly useful in the musical art.

Master tuning forks employed in this precision equipment are checked at frequent intervals against the 440-cycle tone signal transmitted daily by the Bureau of Standards through WWV. The tuning forks are electrically driven and their respective frequencies picked up electrically, amplified and made available for any circuit. It the case of the frequency counter, the given standard frequency from the master tuning fork is caused to beat against the unknown frequency of a tuning fork or musical instrument under test. The beat note difference causes the dial of an electromagnetic counter to indicate the number of cycles of difference between standard and tested tones in any given interval of time.

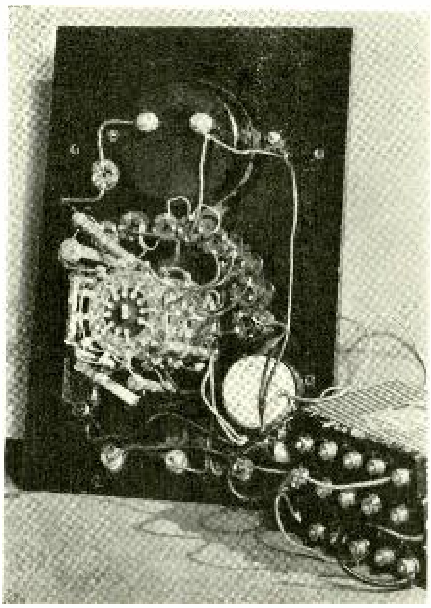
Meanwhile, a cathode-ray oscillograph provides a visual indication of the beat note, and shows whether the tested tone is sharp or flat with regard to the standard. If the wave pattern drifts to the right, the tested tone is sharp, if to the left, it is flat. The rate of drift indicates the degree of pitch difference.

The tested tone is picked up electromagnetically in the case of a tuning fork, or by means of a microphone in the case of the musical instrument. The main purpose of the frequency counter is to check up DuMont Resonoscopes, or cathode-ray musical pitch standards and comparators. However, the DuMont organization is collaborating with various musical instrument manufacturers in checking their pitch standards.

Kit for VOMA at 20,000 Ohms Per Volt

By M. N. Beitman
Allied Radio Corporation

THE modern receivers with complex circuits calling for intricate adjustments force the servicemen to use highly sensitive instruments. In the field of ohm-volt-milliammeter units this general trend to higher sensitivity and greater accuracy is no exception. The first jump from the low resistance meters to 1,000 ohms-per-volt, then to 5,000 ohms-per-volt, and now to 20,000 ohms-per-volt instruments indicates the response of the manufacturers to the servicemen's demand and need for instruments of greater sensitivity. A kit for home-construction of a 20,000-ohms-per-volt VOMA therefor has been developed by Allied Radio Corporation, Chicago, under the Allied trade name of Knight.



View of assembly from rear.

The heart of the kit is the fan-shaped Knight-Beede foundation meter. The Bakelite case measures 4½ by 3⅜ inches and is easily mounted into a 2¾ inches in diameter round hole. The d'Arsonval movement is carried on sapphire jewel bearings and provides an accuracy of 2%. The clear figures, 3⅜ inch scale, and knife edge pointer help to obtain accurate readings.

WHY SENSITIVITY IS NEEDED

All meters operate on a current measuring principle and require a current inversely proportionate to their sensitivity. A 1,000 ohm-per-volt meter requires one milliampere for full scale deflection. Ordinary circuits are not upset electrically when an extra milliampere or smaller additional drain is introduced, and the voltage measured by the instrument will be essentially correct.

In all circuits where a single meter is used for a number of functions including the measurement of voltage, a group of resistors is introduced. These multiplier resistors in the present circuit corresponding to switch settings from 7 to 11. These resistors are used to reduce the voltage measured to a value corresponding to the voltage needed to produce a correct scale indication.

What circuit changes necessitated the use of higher sensitivity units? When the serviceman tested the voltage of the power supply in the process of servicing a radio, the one milliampere maximum drain of his ordinary voltmeter was comparatively insignificant draw. But when screen-grid voltages were obtained through a high resistance voltage-divider circuit, the additional drain of even one milliampere upset the circuit, and the actual, true voltage could not be measured directly. Approximate measurements were in order.

GUESSING PREVAILED

Servicemen guessed and estimated true voltages from the indicated readings. And then came circuits that absolutely prevented the use of instruments having ordinary sensitivity.

The analysis of a-f-c and a-v-c circuits calls for a meter having a movement of 50 microamperes full-scale deflection. The actual plate voltage of a resistance-coupled high-mu triode and the voltage at any point of a high-resistance voltage-divider circuit could then be accurately measured, also the d-c voltage drop across diode load resistors in second detectors, etc.

The use of low-current drain, sensitive meters also extended the possibilities of measuring minute currents. When 50 micro-amperes (.0005 ampere) gives full-scale deflection, values down to one-half microampere can be easily read. With the instrument described you can measure diode circuit current and local oscillator grid current. External connections should be brought out directly from the meter for this purpose. Of course, an instrument of high sensitivity can be used for all standard requirements, or if need be, the sensitivity can be decreased by inserting a shunt.

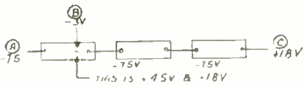
RANGES IN SHORT STEPS

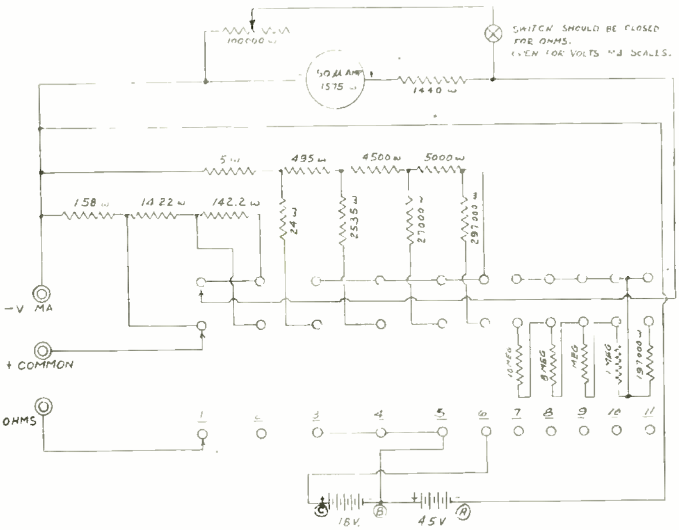
The usefulness of any meter is directly related to the ranges available and the scale size. The meter of this kit has very wide ranges for measuring direct current, voltage, and resistance. The ranges for voltage measurement are 0-10-50-100-500-1,000 with a sensitivity of 20,000 ohms per volt. The resistance measurements are made in ranges of 0-1000, ohms, 0-100,000 ohms, 0-1 megohm and 0-10 megohms using only a 22.5-volt battery for the highest scale. The zero point is adjusted by means of a variable 100,000-ohm shunt. The ohmmeter scale is of the reversed logarithmic type, allowing easy reading of values down to ½ ohm on the 0-1,000 ohm scale. Current measurements of 10 and 100 ma may be made by setting the selector switch on point 2 and 1, but as mentioned before, for 50 microampere full-scale deflection, terminals must be provided and must be connected directly to the meter terminals. However, if added resistance of 200,000 ohms is negligible, compared to the resistance in the circuit under measurement, the 10-volt range may be used for 50 microamperes.

EASY TO WIRE

The essential parts, including the meter, precision resistors, and three deck 11 point switch, are available in kit form. The versatile serviceman can easily design his own case. The wiring is simple and may be completed in less than one hour.

[*Other illustration on front cover*]





The diagram of the volt-ohm-milliammeter circuit, for kit construction is shown at right, while the method of battery connections is detailed directly above. A switch is used for introducing a rheostat shunt across the voltmeter circuit composed of meter and 1,440 ohms in series. When ohms are to be read this switch is to be closed. For all other purposes the switch is left open.

SCALE RANGES

Switch Tap	*Meter Scale*
1	100 M.A.
2	10 M.A.
3	1,000 Ohms
4	100,000 Ohms
5	1 Megohm
6	2 Megohms
7	1,000 Volts
8	500 Volts
9	100 Volts
10	50 Volts
11	10 Volts

LIST OF PARTS

1 Foundation Meter, 50 Micro-apere movement, 1,575 ohm internal resistance. Scale marked 0-500 V., 0-1000 V., and 0-1000 ohms

1 Multiplier Resistor Kit, consisting of:
- 1 5 ohm wire-wound precision resistor
- 1 24 ohm wire-wound precision resistor
- 1 495 ohm wire-wound precision resistor
- 1 1,440 ohm wire-wound precision resistor
- 1 2,535 ohm wire-wound precision resistor
- 1 4,500 ohm wire-wound precision resistor
- 1 5,000 ohm wire-wound precision resistor
- 1 27,000 ohm semi-precision carbon resistor
- 1 197,000 ohm semi-precision carbon resistor
- 1 297,000 ohm semi-precision carbon resistor
- 2 1 megohm semi-precision carbon resistor
- 1 8 megohm semi-precision carbon resistor
- 1 10 megohm semi-precision carbon resistor
- 1 100,000 ohm potentiometer

1 shunt resistor Kit, consisting of:
- 1 1.58 ohm wire-wound precision resistor
- 1 14.22 ohm wire-wound precision resistor
- 1 142.2 ohm wire-wound precision resistor

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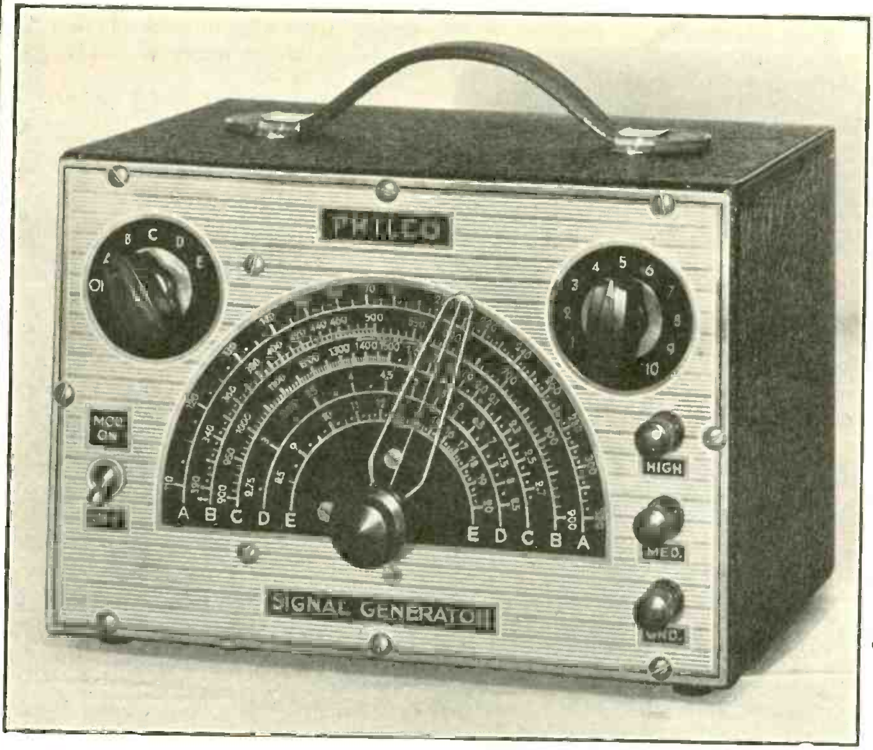

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The 902 A New 2-Inch Cathode-Ray Tube

THE 902, a high-vacuum cathode-ray tube having a fluorescent viewing screen two inches in diameter, was introduced recently by RCA Radiotron. This tube, designed for oscillographic application, is provided with two sets of electrostatic plates for deflection of the electron beam and will operate with an anode voltage as low as 400 volts. The 902 produces a brilliant, luminous spot having a greenish hue. This tube is electrically interchangeable with the 913 (one-inch screen) provided the anode No. 2 supply is 400 volts or more.

The electron source of the 902 is a substantial cathode indirectly heated. The cathode, control electrode (grid), and focusing electrode which functions also as an accelerating electrode, constitute an electron gun for projecting a beam of electrons upon the fluorescent screen. The resulting luminous spot, easily visible in a well-lighted room, can be regulated as to size and intensity by suitable choice of electrode voltages.

ADAPTED TO PORTABILITY

The two interconnected sets of electrostatic plates in the 902 produce fields at right angles to each other, and consequently deflections at right angles. One set serves to reproduce the phenomena under observation; the other is used for the time sweep.

Because of its small size and its ability to produce a bright image at low voltages, the 902 is especially suited for compact, portable, oscillographic equipment. These features, in addition to the relatively low cost of the 902 and its associated apparatus, make this tube practicable for use in many types of test equipment where a larger cathode-ray tube would not ordinarily be employed.

INSTALLATION

The *base* pins of the 902 fit the standard octal socket which may be installed for the operation of the tube in any position. The socket mounting preferably should be adjustable.

The bulb of this tube, except for the screen surface, should be enclosed in a grounded metal case. If an iron or steel case is employed to minimize the effect of extraneous fields on tube operation, care should be taken in its construction to insure that the case is completely demagnetized.

The *heater* is designed to operate at 6.3 volts. The transformer winding supplying the heater power should be designed to operate the heater at the rated voltage under average line-voltage conditions. *If the circuit design is such as to cause a high voltage between the heater winding and ground, the heater transformer should be adequately insulated to withstand the high voltage.*

The *cathode* is connected within the tube to one side of the heater. The terminal for this common connection is base pin No. 2, to which grid and anode returns should be made.

The *fluorescent screen* employed in the 902 is of the phosphor No. 1 (medium persistence) type. It has good visual properties as well as high luminous efficiency.

The *d-c supply voltages* for the electrodes may be conveniently obtained from a vacuum-tube rectifier. Since a cathode-ray tube requires very little current, the rectifier system

(*Continued on page* 38)

TENTATIVE CHARACTERISTICS AND RATINGS

Heater Voltage (A.C. or D.C.)	6.3	Volts
Heater Current	0.6	Ampere
Fluorescent-Screen material	Phosphor No. 1	
Direct Interelectrode Capacitances:		
Control Electrode to All Other Electrodes	8.0 max.	mmfd.
Deflecting Plate D_1 to Deflecting Plate D_2	3.0 max.	mmfd.
Deflecting Plate D_3 to Deflecting Plate D_4	2.8 max.	mmfd.
Overall Length	7-7/16"±3/16"	
Maximum Diameter	2-1/16"	
Bulb (For dimensions, see page 8)	J-16	
Base (For connections, see page 8)	Medium Shell Octal 8-Pin	

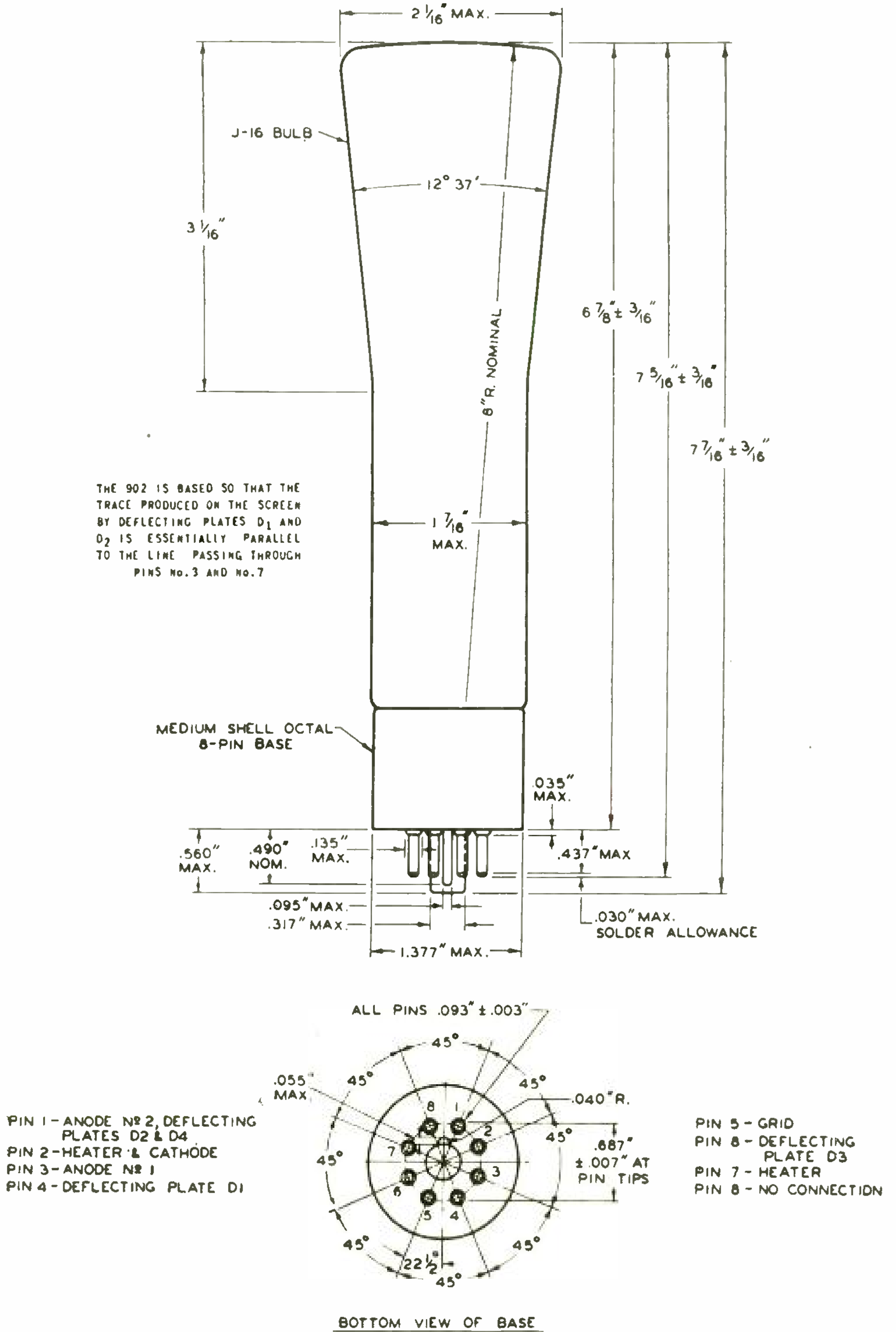
MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

High-Voltage Electrode (Anode No. 2) Voltage	600 max.	Volts
Focusing Electrode (Anode No. 1) Voltage	175 max.	Volts
Control Electrode (Grid) Voltage	Never Positive	
Grid Voltage for Current Cut-Off*	—80 approx.	Volts
Peak Voltage Between Anode No. 2 and any Deflecting Plate	350 max.	Volts
Fluorescent-Screen Input Power Per Sq. Cm.	5 max.	Milliwatts

Typical Operation:

Heater Voltage	6.3	6.3	Volts
Anode No. 2 Voltage	400	600	Volts
Anode No. 1 Voltage (Approx.)	100	150	Volts
Grid Voltage	Adjusted to give suitable luminous spot		
Deflection Sensitivity:			
Plates D_1 and D_2	0.28	0.19	Mm/Volt D.C.
Plates D_3 and D_4	0.33	0.22	Mm/Volt D.C.

*With maximum voltage applied to Anode No. 1 and No. 2.



Dimensions of the tube and data on socket connections. Observe the rotation at left center about the position of the trace of plates D_1 and D_2.

(*Continued from page 36*)

can be of either the half-wave or the voltage-doubler type. For the same reason the filter requirements are simple. A 4 to 8 mfd. condenser will ordinarily provide sufficient filtering. If this is inadequate for a particular application, a two-section filter is recommended.

THE DEFLECTING PLATES

Where a separate d-c power supply is used for the electrode voltages (see circuit), it is recommended that anode No. 2 be grounded rather than the cathode terminal.

With this method, which places the cathode and heater at a high negative potential with respect to ground, the high voltage leads can more easily be made inaccessible. Where the anode voltage is obtained from the power supply of other equipment (the negative terminal of which is grounded), the No. 2 anode of the 902 should be operated at a positive potential with respect to ground; in addition, d-c blocking condensers (about 0.1 mfd.) should be inserted in all signal-input leads to the deflecting plates, so that the anode supply can not be shorted by the signal circuit and the operator will be protected from the anode voltage.

Two sets of *electrostatic plates*, producing fields at right angles, provide for deflection of the electron beam. The electrostatic field of each pair of deflecting plates deflects the beam parallel to the axis of the field; therefore, the deflections produced by the two fields are at right angles. One deflecting plate of one set is connected within the tube to one plate of the other set, to anode No. 2, and to the conductive coating on the inner surface of the glass bulb.

To maintain the free plate of each set at essentially the d-c potential of anode No. 2, each of these plates should be connected through a resistor of one to ten megohms to the anode No. 2 socket terminal. This arrangement permits choice of resistor value such that the electron beam is not distorted by d-c potentials built up on the deflecting plates. In general, the resistance of the deflecting-plate resistors should be as low as external circuit conditions will permit.

CARE AND CAUTION REQUIRED

If, during operation, the zero axis should be permanently deflected, it is usually because the beam current is too high for the resistors used. The beam current should ordinarily be kept low. In cases where the fluorescent spot is off center, a variable d-c bias voltage of the necessary polarity should be connected in series with one or both of the deflecting-plate resistors and ground. The polarity of each control voltage should be such that the spot can be shifted in the desired direction, or preferably in both directions so as to provide a pattern-centering adjustment.

The *deflection sensitivity* for each set of plates for typical anode No. 2 voltages is given under Maximum Ratings and Typical Operating Conditions.

The voltages at which the 902 is operated are dangerous. Care should be taken in the design of the apparatus to prevent the operator from coming in contact with these voltages. Precautions include the enclosing of high-potential terminals and the use of "interlock" switches to break the primary circuit of the high-voltage power supply when access to the apparatus is required.

In the use of cathode-ray tubes, it should always be remembered that high voltages may appear at normally low-potential points in the circuit, due to condenser breakdown or to incorrect circuit connections. Therefore, before any part of a cathode-ray tube circuit or its associated circuit is touched, the power-supply switch should be turned off and both terminals of any charged condensers grounded.

APPLICATION

The cathode-ray oscillograph is an instrument adaptable to a wide variety of applications. A few of the more important are: the study of wave shapes, measurement of modulation and peak voltages, adjustment of and location of faults in radio receivers and a-f amplifiers, comparison of frequencies, and the indication of balance in bridge circuits. Due to the relatively low cost of the 902 and its associated apparatus, to the low voltages at which it can be operated, and to the small size and portability of equipment in which it is employed, this tube should find very general use by engineers, radio servicemen, radio amateurs, and school laboratories.

An oscillograph, reduced to its simplest form, can be designed to use only the cathode-ray tubes and a bleeder circuit with provision for connection to external anode and heater supplies. The diagram illustrates a more elaborate circuit for the use of the 902 in an oscillograph.

The electrode voltages are obtained from a bleeder circuit connected across a separate high-voltage supply. A bleeder current of two or three milliamperes is usually satisfactory; considerably larger values may require the use of more filtering than that provided by a single condenser shunted across the d-c supply. With small bleeder currents, a single condenser filter is usually adequate. A variable d-c voltage for the control electrode and for anode No. 1 is obtained from potentiometers in the bleeder circuit. One set of electrostatic deflecting plates is used for the phenomena under observation; the other set, for the time sweep which serves to spread the tracing across the fluorescent screen. Two a-f voltage amplifiers are shown—one for the vertical and one for the horizontal deflecting plates. Many applications, however, do not require the signal-voltage amplifier, and others can dispense with the linear time-sweep oscillator and its amplifier.

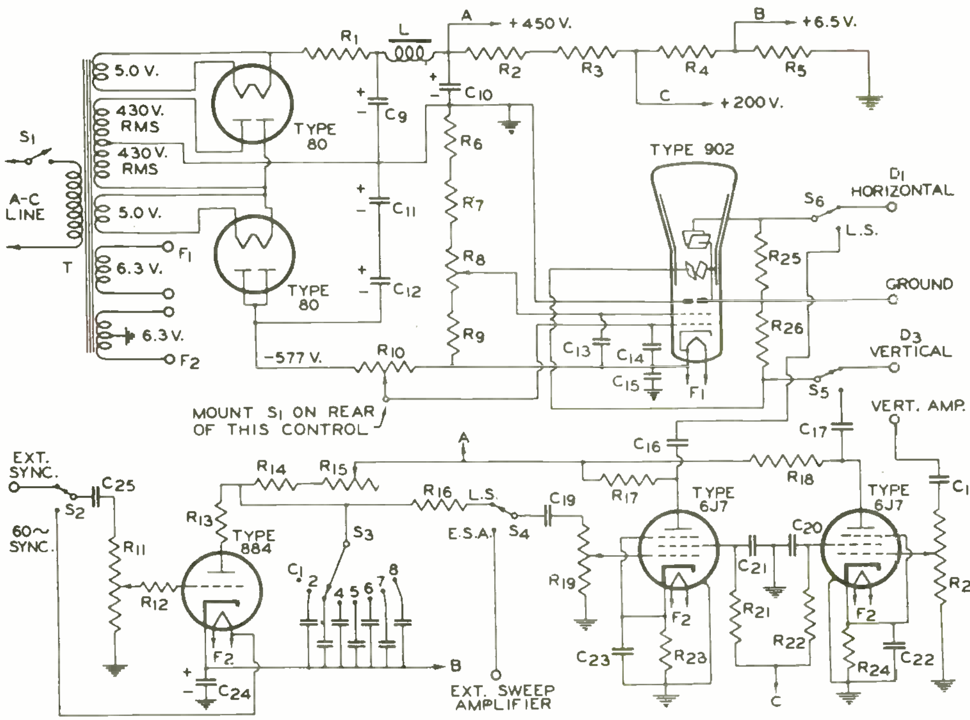
Focusing of the fluorescent spot produced by the beam is controlled by adjustment of the ratio of anode No. 2 voltage to anode No. 1 voltage. Ordinarily, the ratio is varied by adjustment of anode No. 1 voltage, as shown in the circuit diagram.

THE SPOT

Regulation of *spot size and intensity* can be accomplished by varying anode No. 2 current and/or voltage. The current to anode

(*Continued on page* 40)

OSCILLOGRAPH CIRCUIT WITH LINEAR SWEEP AND AMPLIFIERS



C_1 = STRAY CIRCUIT CAPACITY*
C_2 = 0.0008 μf, 500 V.
C_3 = 0.002 μf, 500 V.
C_4 = 0.005 μf, 500 V.
C_5 = 0.015 μf, 500 V.
C_6 = 0.05 μf, 500 V.
C_7 = 0.15 μf, 500 V.
C_8 = 0.25 μf, 500 V.
C_9 C_{10} C_{11} C_{12} = 8 μf, 475 V. (Working)
C_{13} C_{14} = 0.1 μf, 250 V.
C_{15} = 0.1 μf, 600 V.
C_{16} C_{17} = 0.25 μf, 500 V.
C_{18} C_{19} = 0.5 μf, 500 V.
C_{20} C_{21} C_{25} = 0.25 μf, 250 V.
C_{22} C_{23} = 0.003 μf
C_{24} = 25 μf, 15 V.
R_1 = SEE NOTE 1
R_2 = 10000 OHMS, 2 WATTS
R_3 = 15000 OHMS, 2 WATTS
R_4 = 20000 OHMS, 5 WATTS
R_5 = 650 OHMS, 0.5 WATT
R_6 R_7 = 50000 OHMS, 1 WATT
R_8 = 30000-OHM POTENTIOMETER
R_9 = 15000 OHMS, 0.5 WATT
R_{10} = 20000-OHM POTENTIOMETER
R_{11} = 250000-OHM POTENTIOMETER
R_{12} = 25000 OHMS, 0.5 WATT
R_{13} = 500 OHMS, 0.5 WATT
R_{14} = 300000 OHMS, 0.5 WATT
R_{15} = 2-MEGOHM POTENTIOMETER
R_{16} = 1 MEGOHM, 0.5 WATT
R_{17} R_{18} = 100000 OHMS, 1 WATT
R_{19} R_{20} = 0.5-MEGOHM POTENTIOMETER
R_{21} R_{22} = 200000 OHMS, 0.5 WATT
R_{23} R_{24} = 1000 OHMS, 0.5 WATT
R_{25} R_{26} = 2 MEGOHMS, 0.5 WATT
L = 30 HENRIES, 15 MA.
T = POWER TRANSFORMER
S_1 = A-C LINE SWITCH
S_2 S_4 = S.P.D.T. SWITCH
S_3 = S.P. 8-POINT SWITCH
S_5 S_6 = S.P.D.T. LOW-CAPACITY SWITCH

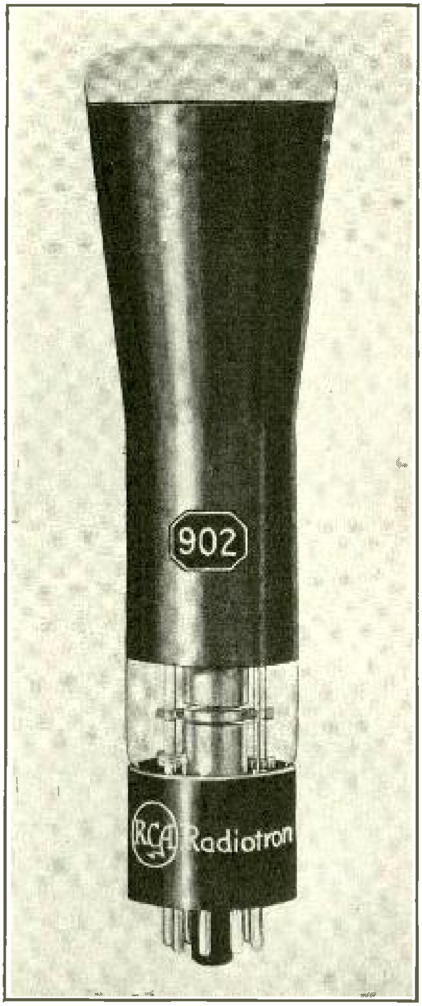
NOTE 1: Choose value of R_1 to give 450 volts at point A. Start with 10000 ohms and decrease value until desired voltage is obtained. This method of adjustment protects condensers C_9 and C_{10} from excessive voltage.

* The 884 will not oscillate when S_3 is set at C_1. This point can be used to stop the saw-tooth oscillator when the linear sweep is not being used.

Diagram of a complete circuit for the new tube with all constants given.

(*Continued from page* 38)

No. 2 may be increased by decreasing the bias voltage applied to the control electrode (grid). An increase in anode No. 2 current increases the size and intensity of the spot. An increase in the voltage applied to anode No. 2 increases



View of the new cathode-ray tube.

the speed of electrons which increases spot intensity and decreases spot size. When any of these adjustments are made, consideration should be given to the limiting voltage and power ratings shown under Maximum Ratings and Typical Operating Conditions.

In applications involving voltage measurements, the anode No. 2 current should be reduced to the minimum value consistent with the desired brilliance of pattern. Where high brightness is an important consideration, the voltage applied to anode No. 2 may be increased to the maximum rated value. The procedure, however, is not always desirable because the greater speed of the electrons in the beam causes reduced deflection sensitivity.

KEEPING SPOT IN MOTION

The 902 is designed to provide as high a current in the electron beam as is consistent with good focusing quality. This high current capability is a distinct advantage for obtaining bright patterns covering a relatively large area, but must be used with caution when the spot traverses slowly any portion of a large pattern, or when the pattern size is small. Where recurrent phenomena are involved, the pattern, or some portion of it, having too high a power input per unit area, may cause the rating of the fluorescent screen to be exceeded. A "slowly-moving" spot is tentatively defined as a fluorescent spot which is traveling slowly enough to be seen as a spot, rather than a trace or line. With patterns of this type, the power input to the screen should be limited, as in the case of a stationary spot.

It is important that the maximum input power to the fluorescent screen should not exceed 5 milliwatts per square centimeter. The use of the screen input power in excess of this value will adversely affect the fluorescent coating, depending on the magnitude and duration of the power input. The resultant injury to the screen may be a temporary loss of sensitivity, or a permanent destruction of the active screen material.

The high intensity spot should be kept in spot by the application of voltage to the deflecting system, so not to exceed the maximum fluorescent screen input rating. Until this voltage is applied the screen input power should be kept low, either by the application of a high negative control electrode-bias, or by removal of the voltage from anode No. 2.

VERICHROME FILM RECOMMENDED

Photographs of recurrent phenomena (producing stationary patterns) appearing on the viewing screen of the 902 can be made with an ordinary camera. Due to the low anode voltage and moderate screen input power at which the 902 is operated, the photographing should be done in subdued light in order to obtain as much contrast as possible between the fluorescent pattern and the background. The time of exposure will depend on the speed of the camera lens, the kind of film or plate emulsion used, the magnification of the pattern, and the brightness of the image on the viewing screen. Verichrome film gives excellent results.

OHMS AND LINEARITY

Resistance measurements are now made with a circuit having a limiting resistor and a voltage supply, the unknown put in series. This is a reciprocal form and also involves the subtraction of the limiting resistor. A form of bridge circuit makes linear readings practical, also ohms read up from zero current, instead of backwards.

Filters, Transformers, Antennas

As Means of Reducing Interference

By Alfred A. Ghirardi

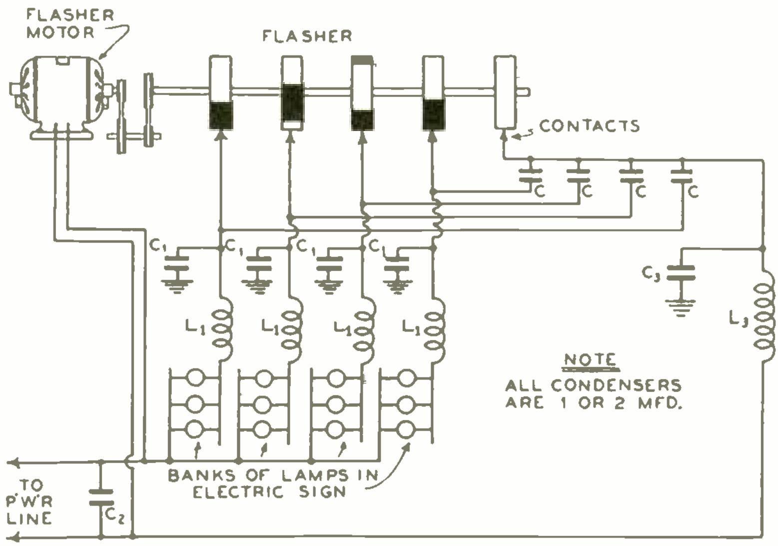


FIG. 1
Filter arrangement for eliminating the electrical interference created by electric sign flashers.

[*The following is an instalment of "Reducing Electrical Interference," reprinted from Alfred A. Ghirardi's "Modern Radio Service," by permission of the publisher and copyright owner, Radio & Technical Publishing Co.*—EDITOR]

ELECTRO-MEDICAL equipment, particularly violet-ray, X-ray and dithermy apparatus, is probably the most prolific producer of interference. This is all high-frequency apparatus, and the interference generated by it is not only radiated directly into space in all directions for a short distance, but the greater part of it is fed back into the power line where it may be *conducted directly* to receivers located considerable distances away, or may be *re-radiated* to other power wiring, telephone circuits, etc., which may carry it along and *re-radiate* it to radio receiving equipment located as far as a few *miles* away. Thus it may not only create interference in the immediate locality, but over a large area as well. Service men should remember this, and not be too quick to hold such apparatus blameless because it happens to be located at what appears to be a considerable distance from the location where the interference is received.

Complete elimination of the interference from these machines involves:

(a) elimination of the feeding of the high-frequency energy back into the power line.

(b) elimination of the direct radiation of interference from the machine.

The first problem is solved by connecting a filter between the machine and the power line. Due to the intensity of the interference from this type of apparatus and the fact that it is of the "shock excitation" type, his filter must be unusually effective and should be designed preferably to suppress the particular band of high frequencies which these machines produce. Special commercial filter units designed especially

(*Continued on following page*)

(*Continued from preceding page*)

for these machines are available. The current which these machines draw from the a-c line varies from 6 amperes (small size) to 25 amperes (the very large size).

It is not practical to install filters in the output (high-frequency) circuit of the diathermy machine in order to solve the second problem by suppressing the high-frequency interference at its source and thus preventing its radiation since, if such filters were effective in suppressing radiation of the interference they would also prevent the passage of high-frequency currents to the body of the patient, and would thus render the apparatus ineffective in the treatment of disease.

REQUIRES COMPLETE SHIELDING

It is, therefore, evident that this problem can only be solved by complete shielding, i.e., completely enclosing the entire machine, the line filter unit, the operator and the patient taking the treatment in a large screening cage, (since the application of the electrodes to the body of the patient causes the patient to act as a broadcasting antenna which will radiate the interference). It has been found than an enclosing cage measuring about 7x5 feet and 6½ feet high constructed with a wooden framework and completely covered with ordinary galvanized iron screening (exact size of mesh not important) on all four sides as well as on the top and bottom (a hinged screen door is used for entrance and exit) serves the purpose. The complete continuity of the screening must be maintained at all joints in it by providing firm metallic contact between the various sections of which it is composed. Several parts of the cage should be well grounded to earth.

It is important to note that any wiring which enters the screen booth must pass through the filter, otherwise, interference will be picked up on this wiring and carried out of the cage, thus reducing the value of the shielding. In other words, any lighting fixtures used for illuminating the interior of the cage must be mounted above the top of the booth so that the light shows through the screen, or if they are installed within the booth must be connected to the load side of the filter. Doorbell, annunciator, or telephone wiring must also be kept outside the screen, otherwise, the interference will be picked up on this wiring and carried out into the building, thus nullifying the value of the filter and screening.

Electric sign flashers are often a source of interference which can be prevented by the use of suitable filters of the capacitive and inductive type. The interference heard from signs of the type in which various sections flash on and off is a steady series of "clicking" noises noticeable whenever a section of the sign is flashed on or off. Although interference from this type of sign is extremely annoying, it is not so objectionable as that created by those signs which have a running border or "bursts." This type of sign produces interference which sounds like the steady rattling of machine-gun fire in the radio receiver which picks it up. These running borders or "bursts" are controlled by high-speed rotary switches mounted on a long drum which is revolved by an electric motor operated from the line. These clicks are caused by the make and break of the circuits as different parts of the sign are switched on and off. The switching action sets up oscillations in both the supply lines to the flasher mechanism, and in the connecting lines between the flasher mechanism and the lamps in the sign.

DIRECT RADIATION

The complete schematic circuit arrangement of a typical electric sign flasher installation with all the chokes and by-pass condensers necessary for the complete elimination of interference from it is shown in Fig. 1. The interference created by the motor (if any) and that created by the flashing circuits is blocked from being conducted back into the power supply line by the filter system composed of line condenser C_2, plus condenser C_3 and choke L_3 which are in the common load lead at the right.

Interference may also be caused by direct radiation caused by the oscillation set up in the leads between the flasher contacts and the lamps in the sign. This radiation may be picked up by the supply line and re-radiated to radio receiving antennas at points further along it, or it may be picked up directly by the antenna system of any receiver within several hundred feet of the sign. If the leads between the flasher contacts and the sign are very short and run in metallic conduit, no suppression need ordinarily be applied to them. However, if they are long, it is necessary to apply a proper capacitive-inductive filter to *each* of the leads. This may consist of an inductance L_1 in series with each lead, and a by-pass condenser C_1 from the lead to the frame of the flasher. In addition, a by-pass condenser C is connected directly across each flasher contact, as shown. Of course, all condenser leads should be kept as short as possible. It is important to keep in mind that a filter must be connected in *each* of the flasher leads—if a single one is left unfiltered, that lead will radiate interference, and the effect of the filters in the other leads will be reduced materially. Also, each filter section should be shielded from the rest. Also, in most cases all grounds should be made to the frame of the flasher, and any actual "earth ground" to the flasher frame should be removed.

LITTLE TROUBLE FROM NEON SIGNS

Flashing signs drawing a total of as much as 10,000 watts and having from 25 to 50 contacts on the flasher are not uncommon. Naturally, the filter inductances which must be applied to large signs must be constructed of heavy wire able to carry the current in each flasher circuit. Such inductances are rather difficult for the individual radio service man to construct himself. Commercial filter units containing all the necessary units in a single case are available for suppressing interference from flashing signs of all sizes, and are designed especially for this purpose.

Neon signs which operate steadily (are not flashed) will seldom cause any radio interference if they are in good electrical and mechanical condition—even though they are operated from high-tension transformers. If interference is traced to such a sign, the sign itself should be inspected and repaired before any filtering arrangements are tried. It may need cleaning, the electrodes may require rebushing, loose connections between the transformer and the neon tubes (or between separate sections of the tubing) may have to be tightened, a larger transformer may have to be substituted because of overloading, the transformer case and the metal sheaths of any connecting wires may have to be thoroughly grounded, etc. All of these possibilities should be checked carefully.

If the interference still persists after all of these details have been attended to, an inductive-capacitive type filter should be connected at the primary side of the transformer used for supplying the high-tension current for operation of the sign.

If the sign is of the "on-off" variety or is of the type which consists of a number of sections operated by a rotary sign flasher, both the line circuit and *each* flasher circuit will have to be filtered as shown in Fig. 1.

REQUIRES JUDGMENT

The question as to whether it is better to attempt to suppress the interference directly at its source so that it does not reach the receiving equipment at all, or whether it is best to concentrate attention on the receiving equipment instead and take steps to prevent the interference from affecting it, should be answered only after a careful, level-headed consideration of the installation conditions which each case presents has been made. There is no single "sure-cure" formula for interference elimination. Before making any decision, the following points should be considered carefully:

(1) Is the interference reaching the set by way of; (a) the power line; (b) the ground lead; (c) the lead-in and aerial; (d) a combination of these?

(2) Is the nature of the immediate vicinity surrounding the place where the receiver is installed such that you would expect to find that the interference was caused by only one (or a few) electrical devices which can be located fairly easily, or is it likely that a large number of elusive devices are contributing to the interference?

(3) Is the interference likely to be caused by a device that can be suppressed effectively by a filter or other means which the owner of the device is willing to allow the service man to install and which either the owner of the interfering device or the owner of the receiver is willing to pay for?

(4) If it has been determined that at least a good part of the interference is reaching the receiver by way of the aerial and lead-in, is it likely that the *aerial* can be erected in a location which is reasonably free from the disturbance so that this portion of the antenna will not pick up noise even after a noise-reducing lead-in arrangement has been installed?

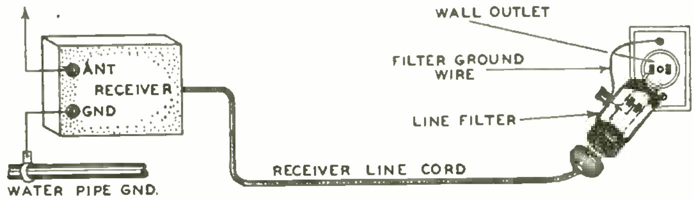


FIG. 2

Correct method of connecting a line filter unit directly at the power line outlet so that no interference will enter the receiver line cord and be radiated to the receiver wiring or antenna system from it. The "ground" terminal of the filter unit should be grounded to the conduit of the line—not to the receiver ground. It is preferable to locate the filter unit at the main service switch of the building if it is possible (see text).

The answers to these important questions (and to any others which the service man's experience on noise-elimination jobs in the particular locality has shown him are very important), are the factors which should determine his course of action. They should tell him whether it is advisable to attempt to track down the source of interference and suppress it right at its source, whether to employ a line filter at the power line outlet to which the receiver is plugged, or whether to erect a special noise-reducing antenna arrangement instead, etc. The economics of the situation, and the degree of freedom from the interference which each remedy will finally provide are the key considerations in each case.

CONVENIENT WAY

There is little question it is usually very convenient to minimize the interference at the receiving equipment rather than at the source

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whenever this is the best course to follow. Such a procedure often results in decreased cost of filtering apparatus, decreased cost in terms of time consumed in locating the source, and probably better results when the interference originates from several sources as is common in congested city districts. A consideration of what has been said here must show that there are many cases where it is not economical to devote the large amount of time required to hunt down the source of interference in the veritable maze of electrical disturbances which may exist in the locality. In others, it is just plainly impossible to locate it, and the sooner the service man realizes it the better. This condition is very common in cities (especially where apartment houses are crowded together). With these facts in mind, let us see how interference may be prevented from affecting the receiver by taking proper steps *at the point of location of the receiving equipment.*

Let us assume that tests show conclusively that the interference (or at least a good part of it) is being *conducted* directly to the receiver from an outside source of disturbance by way of the power supply line, and that it has been decided for one reason or another that it would not be wise to attempt to hunt down the source of this interference. What should be done?

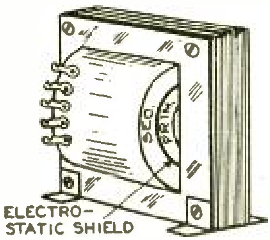


FIG. 3
How the electrostatic shield is placed between the primary and secondary windings of a power transformer.

Noise entering the receiver by direct conduction via the power line can be minimized in two ways: first, by the insertion of a filter between the line and the receiver, and second, by the use of a shielded power transformer in the receiver. The first expedient makes use of a suitable filter (one of the types designed especially for use at the noise-generating device may be used). This filter may consist of condensers alone, or combinations of condensers and chokes, placed in a shielded container. When used at the receiver, it should be placed *as close to the electrical outlet as possible in order to prevent the receiver supply cord from radiating noise over its length from the outlet to the receiver wiring or to the lead-in wire.*

FILTER NEAR LINE METER

Whenever it is at all practical to do so (especially in private homes) it is best to connect the filter at the incoming "service" switch near the house meter. By connecting the filter right at this main switch, the disturbances are prevented from circulating through the electric wiring of the building. This prevents them from reaching the receiver via the power line and also prevents them from setting up fields which might also affect the receiving antenna system. Keep the leads to the condensers as short as possible, and connect their junction point to a good ground. This ground should be preferably a separate ground from the one used for the receiver—generally made quite conveniently to the metal conduit in which the supply wires are run. In fact, even if the filter is connected at the outlet to which the receiver is plugged, its "ground" terminal should not be connected to the ground terminal of the receiver—it is usually much more effective to ground it to the metal conduit of the line by connecting it to the outlet plate as shown in Fig. 2. In fact, in many cases this "ground" may be found to have more effect on eliminating the interference than the filter itself has. And don't use a line filter the size of a thimble. Remember that it is the capacity (or inductance) of the filter that does the trick. Therefore, if the filter is one of those tiny things that are often seen, it does not have much capacity in it, and consequently will not do much filtering.

The use of a shielded power transformer is common practice in many medium-priced (and in all well-designed) modern receivers. An electrostatic shield is built in between the primary and the secondary windings of the power transformer in the receiver as shown in Fig. 3. The presense of this shield prevents line interference from getting across from the primary winding to the high-voltage secondary winding. Two by-pass condensers of about 0.1 mfd. each are also often connected across the supply line in the receiver. Of course, it is not generally necessary to replace an unshielded type power transformer with one having an electrostatic shield when noise is entering the set via the power line, but it is well to know why some receivers (with unshielded power transformers) are noisier than others (with shielded transformers) even though chassis shielding is about the same in both.

There are many commercial compact, inexpensive line filter units designed with a male plug at one end (which plugs into the wall outlet) and a female socket at the other end into which the plug on the line cord of the receiver is inserted. When properly installed, as shown in Fig. 2, they automatically connect into the line between the wall outlet and the receiver line cord.

EVEN LITTLE DEVICES RADIATE

Let us now consider the case where the tests show definitely that the interference (or at least a major part of it) is being picked up by the antenna system of the receiver. The interference may get to it in either (or both) of the following ways:

(1) By *direct radiation* from the distburing device.

(2) By *indirect radiation* from the power supply line or some other circuit which has picked up the disturbance.

[*Another instalment next month*]

0A4-G, New Control Tube

Avoids Signal Current Drain When Remote Receiver is Inoperative

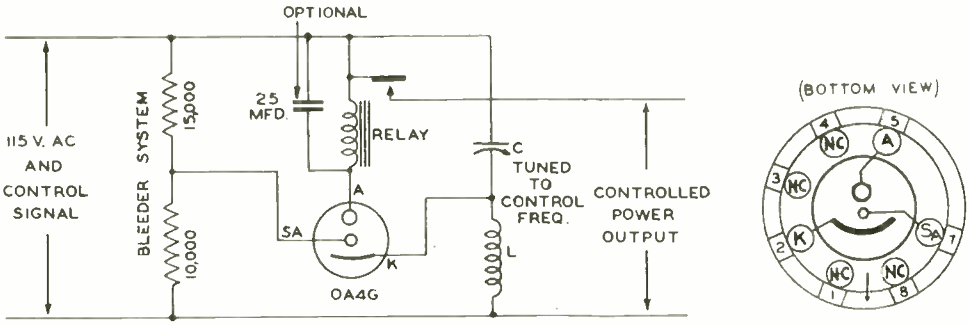


Diagram courtesy of Sylvania

FIG. 1

The OA4-G in a typical circuit and (at right) bottom view of the socket, revealing where the pins connect. NC means "no connection"; K is cathode; A is anode, and S_A is starter anode.

THE use of the a-c, and even d-c house and factory lines for conducting carriers as in call systems and some remote-control operations, invites solutions of absence of current draw in a control device while the live-operated main unit is not functioning. One such solution is found in the new OA4-G tube, which is of the gas-filled, cold-cathode type. The tube may be used also as a voltage regulator or as a relaxation oscillator (saw-tooth wave form as used in oscilloscopes).

Sylvania has supplied the data contained in the table printed herewith, and also makes the following explanation of the design and use of the new tube:

"The tube consists of a cathode, anode and starter-anode. Its characteristics are such that with no voltage on the starter-anode a relatively large voltage (A) is required between the cathode and anode to cause the tube to start.

"The application of a proper signal voltage (B) to the starter-anode will cause a cathode to starter-anode current (C) to flow. This will produce a glow discharge and reduce the voltage for breakdown (D) between cathode and anode to the point where the tube will conduct at normal line voltage. Therefore, there need be no stand-by current flowing while the circuit is inoperative.

TYPICAL CIRCUIT

"The accompanying circuit (Fig. 1) of a remote control relay is a typical application of the Type OA4-G in a-c service. It will be noted in the circuit that full line voltage is applied between the anode and cathode and that a bleeder system is used to maintain a voltage on the starter-anode just below that required for breakdown. The capacity and inductance, C and L, is a high-Q tuned circuit for r-f signals. When an r-f signal is transmitted on the power line a resonant voltage appears across the inductance and capacity. The voltage across condenser C increases the negative potential peaks on the cathode and increases the potentials between the cathode and starter-anode. A discharge between the cathode and starter-anode is started by these peaks. This discharge produces free ions which enable the discharge to transfer to the anode when sufficient starter-anode current flows. After this transfer occurs, current flows through the relay.

VOLTAGE PRECAUTIONS

"Precautions should be taken in the application of the Type OA4-G so that at high line voltages the a-c voltage applied to the starter-anode will not be great enough to reach the breakdown point.

"Precautions should also be taken so that at low line voltages the carrier voltage will be large enough to make up for the lowest line voltage. Therefore, a minimum r-f starter-anode voltage of 55 volts peak should be provided.

"The Type OA4-G may be operated from d-c power lines. However, after the tube has started to conduct through the application of a signal it will continue to conduct even after the signal is removed, since the voltage supply on the anode circuit is continuous. Therefore, to reset the tube for a further operation to a non-conducting state, it will be necessary to remove the anode voltage or drop it below 60

(Continued on following page)

Constants for 0A4-G

CHARACTERISTICS

Anode to Cathode Breakdown Voltage (A) (Starter-Anode tied to Cathode)	225 volts Min.
Starter-Anode to Cathode Breakdown Voltage (B)	70 Volts Min. 90 Volts Max.
Starter-Anode Current for Transition of Discharge to Anode at 140 Volts, Peak (D)	100 μamps. Max. (C)
StarStarter-Anode to Cathode Operating Voltage Drop	60 Volts Approx.
Anode to Cathode Operating Voltage Drop	70 Volts Approx.
Anode to Cathode Current (continuous)	25 Ma. Max.
(instantaneous)	100 Ma. Max.

TYPICAL OPERATING CONDITIONS (A-C SUPPLY):

Anode-Supply Voltage (RMS)	105-130 Volts
Starter-Anode Voltage (Peak) A-C	70 Volts Max.
Starter-Anode Voltage (Peak) R-F	55 Volts Min.
Sum of A-C and R-F Starter-Anode Voltages (Peak)	110 Volts Min.

Standard octal socket is used.

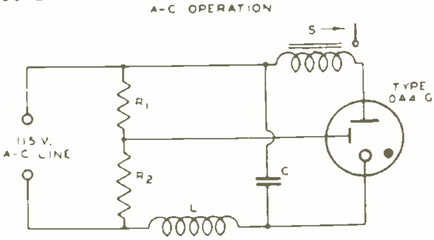
(Continued from preceding page)
volts, instantaneously, after the signal has been removed."

REPORT BY RCA

RCA Radiotron, in its announcement of its OA4-G, refers to it as a new cold-cathode, glow-discharge gas-triode, adding:

"The OA4-G is intended primarily for service as a relay tube and is designed especially for use in an electrical system for the remote tuning and control of line-operated radio receivers. It can be actuated by r-f impulses generated under the control of the user and transmitted over the power line that supplies the radio receiver. Only a small amount of electrical energy is required to actuate the OA4-G. Being of the cold-cathode type, it does not consume power when the receiver is not in use. A remote-control system using the OA4-G provides a simple method for eliminating special cables and gives the user a large choice of control positions.

SCHEMATIC RELAY CIRCUIT USING TYPE OA4-G
A-C OPERATION



C, L = HIGH-Q TUNED CIRCUIT FOR R-F SIGNAL
R_1 = 15000 OHMS (½ WATT)
R_2 = 10000 OHMS (½ WATT)
S = RELAY—CHOSEN FOR DESIGN REQUIREMENTS
● = GAS TUBE TYPE

FIG. 2
Full line voltage is applied between anode and cathode.

"The remote-control capabilities of the OA4-G can be utilized by the ingenious experimenter in numerous ways."

As a relay tube the OA4-G should be operated according to the conditions given under Maximum Ratings and Typical Operating Conditions.

Fig. 2 is a schematic circuit from RCA showing the use of this type. In this circuit, full line voltage is applied between anode and cathode. The starter-anode is maintained at a potential just below that required for breakdown by means of the bleeder consisting of R_1 and R_2. The inductance L and the condenser C constitute a tuned circuit in series with the line. When a carrier having the frequency of the tuned circuit is impressed on the power line, a resonant voltage appears across L and C. The effect of the voltage across the condenser C is to increase the negative potential peaks on the cathode and thus to increase the potentials between cathode and starter-anode. These peaks start a discharge between cathode and starter-anode. This discharge produces free ions which enable the discharge to transfer to the anode if circuit values are such that sufficient starter-anode current flows. After the discharge occurs between cathode and anode, current flows through the relay S to close the contact of a local circuit. Because a.c. is supplied to the anode, the OA4-G ceases to discharge when the carrier is removed.

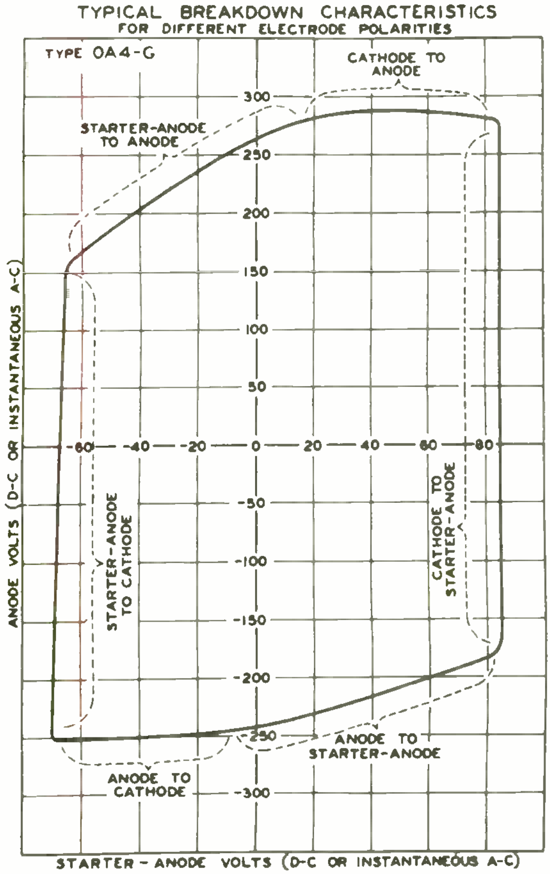
If the OA4-G is to be operated from a d-c power line, it will be necessary to provide means for reducing the anode voltage to a value under 60 volts (extinction voltage). This can be conveniently done by opening the anode circuit.

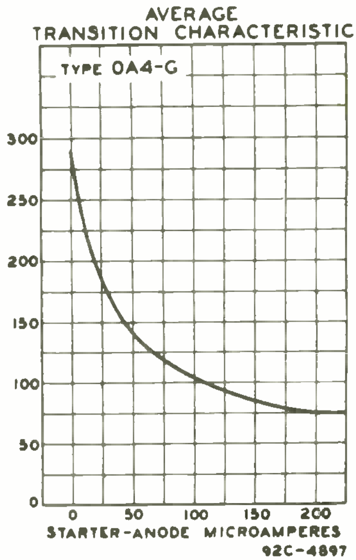
It will be noted that most of the voltage on the starter-anode required to cause breakdown is supplied by the bleeder circuit. As a result, the tuned circuit is required to supply only the difference between breakdown voltage and applied a-c voltage. Precautions should be taken in the design of equipment so that at the highest line voltage, the a-c voltage applied to the starter-anode will not be sufficient to cause the OA4-G to break down; and so that at the lowest line voltage, the carrier voltage will be high enough to make up for low line voltage. It is recommended, therefore, that provision be made to supply an r-f starter-anode voltage having a minimum peak value of 55 volts.

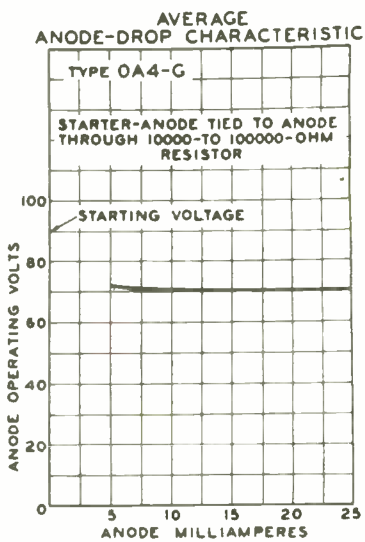
Typical breakdown characteristics of the OA4-G are shown in Fig. 3 for conditions where the starter-anode and anode are either positive or negative, respectively. The tube is designed to be operated so that the discharge takes place when the starter-anode and anode are both positive (first quadrant). For purposes of illustration, values are also shown in the other quadrants for other polarity combinations. Operation in these quadrants is unstable.

200 MA MINIMUM FOR A_s

In the first quadrant, it will be noted that the OA4-G breaks down between cathode and starter-anode when the starter-anode voltage reaches 85 volts approximately. This discharge initiates a discharge between cathode and anode, provided the anode potential is adequate. The required anode potential is a function of the current flowing in the starter-anode circuit. The relationship between anode voltage and starter-anode current is shown in Fig. 3. In practice it is desirable to have a current of at least 200 microamperes flowing in the starter-anode.







Diagrams courtesy RCA Radiotron

FIG. 3
The breakdown characteristics are shown above. At top, right, is Fig. 4; at bottom, right, Fig. 5.

Curing Troubles in a VTVM for AC

Calibration Follows D.C.—Negligible Loading, Except at Peak

By H. J. Bernard

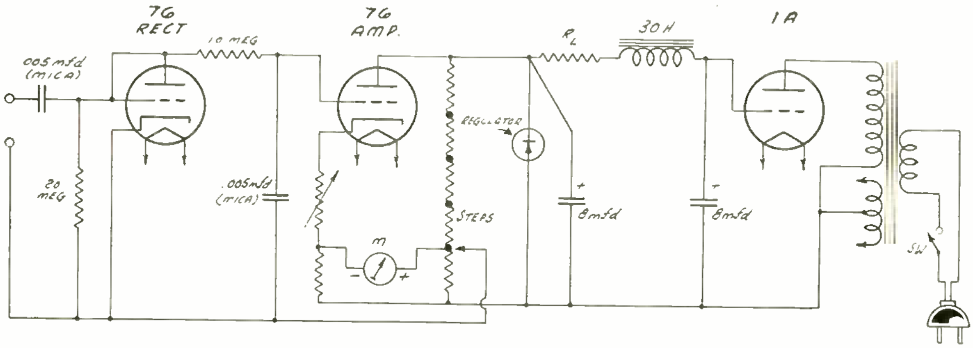


FIG. 1.
A four-range vacuum-tube voltmeter for measuring a.c. of any frequency, to 10 megacycles.

ONE OF the most difficult devices to construct and use is the vacuum-tube voltmeter and it is one of the most important. The instrument may be described as a vacuum tube with an indicating meter that reflects changes in the unknown input voltages, the device drawing little or no current from the measured source. It is difficult to construct because for drain of little or no current a voltage-dividing system, or bleeder network, should be avoided, and yet the range should be adequate. It is difficult to use because it should introduce minimum disturbance of the circuit that is being measured.

There is practically no radio service meter that covers wide range without drawing any current from the measured source,

So far nothing has been said about the maximum frequency, or lowest wavelength, to be measured, but so soon as the frequencies are greater than 10 megacycles, capacity effects that may be disregarded at low frequencies, become of considerable hindrance to accuracy. That is true, because, though the capacity may remain practically constant, the effect of the capacity increases with frequency.

SIMPLE DIAGRAM

A solution of the problem was found by General Radio Company, as set forth in the August, 1937, issue of RADIO WORLD, whereby the unknown a-c voltage is fed to a condenser-diode rectifier, while an inverse-feedback direct-current amplifier influences the meter. A half-wave rectifier of the a-c voltage, for B supply, was found adequate, and plate volatge may be medium (around 200 volts).

The diagram, Fig. 1 is extremely simple, and the attainment of the lowest voltage range is likewise easy, but pains are necessary for proper addjustment to successively higher voltage steps, also there are a few unusual conditions that have to be watched. Of the precautions that must be taken this article will deal principally.

A few words about the theory of the circuit will clarify the adjustment data to follow.

The rectifier of the unknown a-c input is a diode, which may be composed of a triode with grid and plate interconnected. If high frequencies, deep in the megacycle range, are to be measured, then it is advisable not only that the diode-connected triode be a 955, but that a gooseneck or low-capacity cable with prods be used. The tiny acorn tube, besides having low electrical capacity, also is made for practically socketless utilization, so additional significant capacity is avoided, and also, with special receptacles of finer grade materials, leakage due to external causes is made extremely low. The gooseneck, or similar extension, for measurement by probing, is imperative for high frequencies, where the measurement is thus made clinically, as is done in the General Radio commercial unit.

USE OF ORDINARY TUBE

Assuming, however, that an experimenter does not desire to go to this extreme, lacking the facilities, and also being content to stop at a few megacycles or so in his measurements, the first tube, or rectifier, may be a 76, as in the diagram. The load resistance between effective anode and cathode must be very high, and is shown as 20 meg., since this is readily obtainable. It is, for instance, a standard value of the type BT resistors of International Resistance Company. If possible, make the resistor even higher, up to 50 meg., which is the value General Radio uses.

Between the anode side of the resistor and the "high" input binding post is a .005 mfd. mica condenser. The circuit now has d-c continuity. The unknown voltage, during the peak of the positive cycle, makes the diode conductive; pulsating direct current flows through the tube and the load resistor. It would not be practical to put a meter in series with the cathode-to-ground lead and call it a day, as first, the meter would require undue sensitivity, say a 0.5 microammeter (not half a milliampere full-scale, but half a microampere full-scale, thus a thousand-times more sensitive); and besides the load resistor would have to be changed three times for four ranges.

POLARITIES NOTED

A d-c voltage thus appears across the load resistor, negative to anode, positive to cathode of the diode, so it is apparent that the grid of an amplifier tube may be connected to the anode of the first 76, or diode, and the higher the unknown voltage, the more negative will be the grid of the amplifier tube, without need of any voltage divider. This scheme, then, works in the desired direction. Notice that the worst that can happen, by this method, is that if the unknown input voltage is excessively high for the amplifier, the plate current in that amplifier will be cut off. This is to be remembered in connection with a simple solution to be discussed later.

Naturally, the 76 amplifier requires a B supply, and this is provided in the usual way, but the arrangement for the amplifier in connection with the B supply is unusual, and requires special attention. R resistor R_L may be used for reducing excessive B voltage.

We found a negative d-c voltage developed at the anode of the diode, but this contains pulses, and it is necessary to provide a filter. The simplest one consists of a resistor and a condenser. Therefore, if instead of directly connecting the anode to the grid of the amplifier, a high resistance is interposed between the two, a condenser from grid of amplifier to cathode of diode will provide the filtration.

HAS LITTLE REACTANCE

Since we are dealing with high resistance loading, we require condensers that of themselves have a very low leakage, or very high leakage-resistance, and the mica type of condenser meets that requirement.

Also what are generally regarded as medium-capacity units may be expected to have lower leakage than higher capacity units, hence as small a capacity as is practical is selected, and this may be .005 mfd. in the two instances. The leakage resistance of excellent mica units of this type may be in the multi-megohm range, as proven in the case of the Cornell-Dubilier condensers that were used in the experimental setup.

This tube voltmeter is practically non-reactive, from the lowest audible frequency to deep in the megacycle region. Naturally, the question will arise: How can such small capacities be considered as adequate for low frequencies, say, 60 cycles? The habit of thinking about normally-met circuits, of relatively low impedance, and the effect on them of condensers of medium capacity perhaps makes one feel doubtful.

But let us examine the case of the condenser-diode rectifier. We have a capacity of .005 mfd. and a resistance of 20 meg. We therefore have a product of 20 x .005 or 0.1. The product of the resistance in megohms and the capacity in microfarads is called the time constant. The lowest frequency at which the filter is effective is represented by the reciprocal of the time constant, i. e., frequency equals $1 \div 0.1 = 10$ cycles. So we need not worry about 60 cycles if we accommodate even ten cycles.

CHARGE AND DISCHARGE

The condenser charges up to practically the peak value of the unknown wave, and discharges through the resistor. The total voltage drop (a.c.) is divided between the condenser and the resistor, but the resistor is 20,000,000 ohms, and the condenser, at 60 cycles, looks to the circuit like 530,000 ohms, and less at higher frequencies, so about forty times as much voltage is dropped across the resistor as across the condenser, so the error, 60 cycles compared, say, to 600 kc, is only 2.5 per cent at the low frequency. If the resistor is 50 meg. the disparity is only 1 per cent.

Now we have the pure d. c. injected into the amplifier grid circuit. In the cathode leg of the amplifier is a resistor (shown as a rheostat), and if this value is high, the scale of the meter M will be linear for a. c. At least 2,000 ohms should be used for the minimum value, whereupon linearity does not prevail, but the departure is not serious.

Now, to complete the circuit, the cathode biasing resistor is returned through the meter to a tap on the B supply voltage divider, and the diode's cathode is connected to the same point. There will be idling plate current, hence the meter will read something (perhaps even off scale) with no voltage input at the posts. The positive side of the meter is returned to negative B so that current flowing through the meter in the direction opposite to the plate current will cancel the idling current and cause meter to read zero at no input, in the absence of strays.

(Continued on following page)

(*Continued from preceding page*)

However, the amplifier is direct-coupled to the diode, except for the filter circuit, which does not change the aspect of what is to be discussed, so the greater the unknown voltage, the less current through the meter. You will recall the earlier remark that only cutoff of plate current results from an excessive voltage input. Therefore the meter, first reading zero,

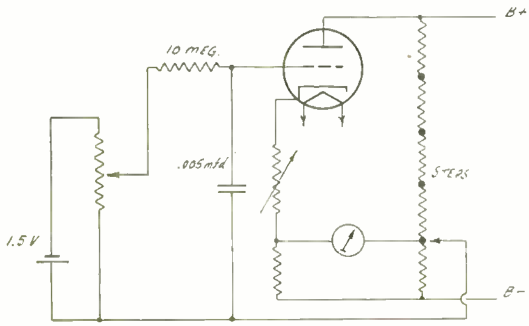


FIG. 2.

A calibration made for d.c. suffices for a.c. For the lowest voltage range a 1.5-volt dry cell and 1,000-ohm potentiometer may be used. For higher voltages increase the battery and the potentiometer equally.

where input is supplied will read below zero as far as it can. In other words, the needle moves the wrong way. The solution of course is to reverse the meter in the circuit, so meter negative is to cathode and meter positive is to a tap on the divider. Now the meter will read upward, or as if the current were increasing with increase of unknown voltage, whereas in fact upward movement spells less current through the meter, due to meter being reverse-connected, and full-scale deflection represents no current through the meter. There is no danger, therefore, of injuring the meter due to the unknown being excessive, as the worst that can happen is that the amplifier plate current will cut off, and there will be no current through the meter, although needle is at full-scale.

Therefore the danger to the meter, if there is any danger, is curiously at the zero-reading end, and not at the other end. However by proper adjustment, the maximum current will not seriously exceed the meter's sensitivity, as another phenomenon of the vacuum tube is invoked, namely, saturation, which means that as much current flows as can flow, and no more will flow even if the voltage input is increased.

IMPORTANT PRECAUTIONS

Thus we have the circuit for a single range, but even as to that some precautions are to be followed.

First, as to the input. We are dealing with very high impedance circuit here, and if we use binding posts we must be very certain that they are the best we can obtain. Leakage must be at a minimum, and other electrical properties should be of the best. Suitable Isolantite or similar standoff insulators, as used in small amateur equipment, serve the purpose well.

The socket should have low leakage resistance and any socket made of the specially good material for such purposes may be used, but not the run of cheap receiver sockets. Not so much attention need be given to the amplifier tube socket, although to an extent the same considerations apply, and it would be advisable to use a high-grade socket here. Excellent sockets for these purposes are made by Hammarlund Manufacturing Company.

WHAT NOT TO DO

Do not introduce a filament type rectifier tube, because such a tube causes the B voltage to appear almost instantly, whereas the plate current through the 76 is delayed, due to the cathode warming up slowly, hence you have bucking voltage before there is anything to buck, and the meter needle will bang against the stop at the zero end. We remember this is the dangerous end, not representing zero current but maximum current, so we make sure that the rectifier is of the heater type, and if there is to be any difference in the heating rates, preferably the rectifier should heat up more slowly than the amplifier.

Having taken the necessary precautions, the meter device may be set up for the lowest range. What this will be depends on the sensitivity of the electromagnetic meter. It does not depend on the amplifier, because practically any amplifier tube will give the same results. The amplification produced by the tube is not of any consequence, rather the current change, or conductance, and due to inverse feedback, this is practically a constant.

RANGES CONSIDERED

The usual 0-1 milliammeter was tried, and the lowest range was around 2.5 volts conveniently, but then a 200 microammeter was substituted, and the range became one volt easily. It is advisable to have an accurate a-c meter so that the calibration may be run, by connecting the known meter and the unknown voltage to the tube voltmeter. The input voltage is reduced by using a potentiometer. The 60-cycle line frequency may be used, but somewhat better results obtain when 1,000 kc or so is the test frequency.

The calibration may be made with sufficient accuracy, if one lacks the preferable a-c equipment, by using d.c. The 10 meg. is disconnected from the 76 grid and between that grid and its cathode is placed the potential source (a 1.5-volt dry cell for the first range) and the voltage divider. This is shown in Fig. 2. The equivalent a-c volts are in peak values, by equal d-c voltages, so to convert to r. m. s. multiply the d. c. by 1.41. You multiply this time because the quantity of r. m. s. is smaller than the quantity of peaks, hence the number of r. m. s. is larger in the same boundaries.

A quirk sometimes exists whereby at no intended input meter reads full scale. This is due to strays. If the input circuit is shorted the trouble disappears. In large cities or anywhere

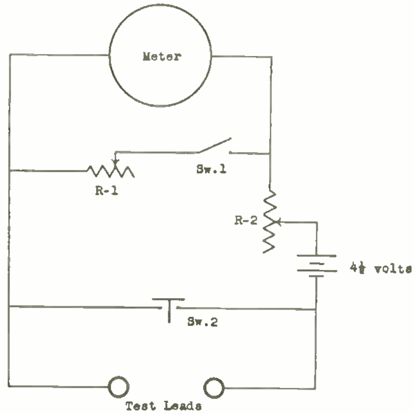
(*Continued on following page*)

Continuity Tested, Even for Low Ohms

It is very often necessary for the experimenter and serviceman to check the windings of various types of transformers for both open and short circuits. Almost any continuity check will indicate an open winding. But, with low-resistance windings, it is practically impossible to distinguish between a short circuit and a normal winding, with the ordinary continuity check or average omhmeter. By using the circuit shown in the diagram it is possible to tell a shirt circuit from a perfect winding, even on a voice coil winding. The procedure is as follows:

Adjust R_1 so that all the resistance is in the circuit. Close Switch 1. Hold Switch 2 closed and set R_2 until a deflection of about ¾ full scale of the meter is obtained. Release the push-button switch (2) and place test leads on suspected winding. Press Switch 2 and carefully notice the meter. The slightest deflection will indicate a good winding. Open and close Switch 2 several times. Tach time there should be a deflection for a good winding. If the needle does not move, disconnect the test leads, close Switch 2, adjust R_1 for less resistance, reset R_2 for a ¾ deflection and repeat the test. As R_1 is decreased, the sensitivity of the instrument is increased. When Switch 1 is open, the instrument is a continuity tester. A Readrite meter was used for ruggedness and durability.

—MURRAY S. RIFKIN



R-1 - 10 ohm rheostat
R-2 - 50 ohm rheostat
Sw.1 - Toggle switch
Sw.2 - Push-button switch
Meter - 0 - 1 volt d.c. (moving-vane type)

A continuity tester that is effective even for transformers with very low resistance windings.

(*Continued from preceding page*)

else, near strong stations or other sources, this trouble appears. Complete shielding is indicated. Otherwise short the input for zero adjustment with the rheostat and confine tests to unknown circuits not having very high impedance. It is much better to shield properly.

VOLTAGE REGULATION

The main possible annoyances in operating at the single range have been eliminated, but there remains one that requires consideration. Sudden line voltage changes will cause abrupt though small changes in the meter readings. A lot of time is lost waiting for equilibrium to be resumed. On the other hand, one may not know of the line voltage condition, and may take a reading assumed accurate, but really somewhat in error. Later, unknown to the observer, who has turned away to do something else, the normal condition or equilibrium is re-established. Especially in running a calibration would the line-voltage trouble cause kinks in the curve and otherwise inexplicable results. So it is advantageous to include a line-voltage regulator tube.

Another form of line-voltage change consists of slow drifts, and these, too are defeating. Hence the regulator tube should take care of the sudden shifts and the slow changes. Since there are tubes that perform these functions, one of them really ought to be included, and be connected in the manner recommended by the manufacturer. RCA Radiotron Company and Hygrade-Sylvania Corporation have bulletins on voltage regulator tubes.

The remaining problem is to increase the range. Suppose we have a one-volt range at first, the next probably would be five volts, the next 15 volts, and the next 25 volts. Perhaps a fifth range, to 100 volts, would be desired. However, most measurements are made on the lowest range, next greatest number on the second range (5 volts let us say), especially for input voltage and gain-per-stage measurements in receivers and amplifiers. It is well therefore to include as sensitive a meter as possible, and 200 microamperes is an excellent choice, not usually beyond one's means, either, since such a meter may be purchased for $4.65.

HIGHER RANGE METHOD

The range extension may be seen to consist of (a) increasing the cathode load resistance and (b) moving the grid return (made through the high resistors) to a higher potential on the bleeder source to equal the increase of voltage drop in the cathode resistor. In general, the range is increased in proportion to the increase of the cathode resistance, while the B potential to which amplifier grid is returned is likewise increased proportionately. So if the cathode resistance is 3,500 ohms for the lowest range, and the top to which grid is returned is 2 volts, to increase the range five-fold, the resistance is 5 x 3,500 = 17,500 ohms and the voltage top above B minus is 2 x 5 = 10 volts.

Effect of Receiving Antenna on Television Fidelity

By Stuart Wm. Seeley

License Laboratory, Radio Corporation of America

SUMMARY—Interference between direct and reflected signals from a single transmitter injects a factor into antenna design for television receivers which is not present in broadcast-receiver installations.

Means for minimizing such interference when it exists in free space and for preventing the production of multiple signals in the antenna system itself are explained.

Some data are given on the behavior of transmission lines and long wire antennas. The latter may become necessary at, or near, the boundaries of service areas to improve adverse signal to noise ratios.

I. NATURE OF THE PROBLEM

IN broadcast-receiver practice a simple wire of from a few feet to one hundred or more in length will suffice as a receiving antenna, and its operation is completely satisfactory if the received signal is sufficiently above the local and extraneous noise level. A television receiving antenna will have to be erected with much more care and must conform to more complete specifications. This is true because of the introduction of an additional factor in visual reception not present in sound broadcasting. This factor is the necessity for preventing reflected waves, which have traveled a few hundred feet or more further than the direct wave, from entering the receiver. Fortunately this can be done in all cases, and quite easily in most cases. It is the object of this paper to point out that the problem exists in visual reception, and to describe certain methods of meeting it which have been found effective.

SPACE WAVE REFLECTIONS

When reproducing a 441-line, 30 field per second picture, the cathode-ray spot travels across the screen of a 12-inch Kinescope at a speed of about 2½ miles per second. This is $\frac{1}{75{,}000}$ times the speed of light or radio waves in free space. In other words the spot will move about 0.060 inch while a radio wave is traveling 400 feet. Therefore, if both a direct and a reflected wave arrive with comparable magnitude at the input terminals of a television receiver, and one has traveled 400 feet further than the other, a double image will result. The displacement of the two images in such event will be about one-sixteenth of an inch and will cause blurring of all vertical lines in the picture. Actually such a condition results in even more complication than is immediately apparent from the above example. The reflected wave may have any phase with respect to the direct wave. Furthermore, each has its own side components, and those of the direct and reflected wave may be entirely different. Thus interference in the form of cancellation or reinforcement frequently causes a black line to be repeated as a white line or vice-versa. If the reflected wave travels 1,000 feet or more further than a direct wave a distinct double image will result.

Thus it is readily apparent that the antenna must supply a television receiver with one signal only from a desired transmission. In metropolitan areas, reflections from large buildings may give rise to several images and the problem of proper construction, location and orientation of the receiving antenna becomes extremely important. However, at *any* location an improperly constructed antenna or antenna network and feed system may produce multiple signals of sufficient intensity and time-phase displacement to be objectionable.

TRANSMISSION LINE REFLECTIONS

Under ordinary conditions at most installations, it is necessary to use transmission lines between the antenna proper and the receiver in order to control properly the point of signal pick-up. If the maximum dimension of the antenna system (transmission line plus antenna) is of the order of 100 feet or more, and the line is not properly balanced and terminated at the receiver, reflections in the antenna network may cause a loss of detail in the reproduced picture. Thus the problem of preventing blurring or double images caused by multiple-signal reception may be divided into two parts. First, the antenna must be made non-susceptible to strong secondary waves from external reflecting media, and second, the antenna and its transmission line must be so constructed and terminated that reflections from the receiver end of the system can not bound back to the outer end of the antenna and be reflected there to re-enter the receiver as a delayed signal.

It is difficult to describe in words the appearance of images produced by multiple-signal reception, and difficult to show it clearly by illustrations produced by the photographic and printing processes necessarily involved. Figs. 1 to 4 are illustrations showing a small section of a Kinescope screen reproducing a transmitted pattern, under different conditions of multiple-signal reception. The illustrations are of course not clear or representative of the general appearance of the screen when viewed by the eye, and are intended merely to show the relative effects of antenna changes. The pictures were taken on the same receiver with different antennas, but without any changes in receiver tuning. A detailed description of the antennas and the effect of each on the received image will be given later.

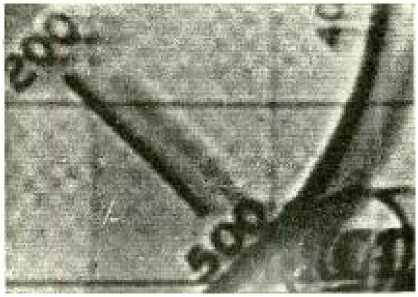


FIG. 1

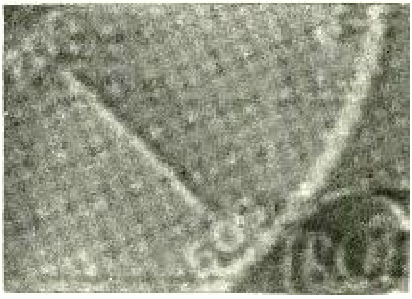


FIG. 2

II. Source of Space Wave Reflections

It is to be understood that the reflecting medium need not be a metallic object. The specific inductive capacities of building stone, brick, paving material, and ordinary soil, are sufficiently greater than that of air to have high coefficients of reflection for television frequencies at some angle of incidence. Therefore almost any surface can act as a reflector, if its dimensions are comparable to, or greater than one-half wavelength.

If the transmitting antenna is within line of sight of the receiving antenna, and a plane surface parallel to the ground is located between the two and within sight of both, the strength and delay factor of the reflected energy will depend upon all of the dimensions of the geometrical orientation of the three objects. However, it can be shown by simple calculations that only within a radius, from the transmitter, of about six times the combined transmitting and receiving antenna heights (above such a surface) can reflections of this nature be sufficiently delayed to cause a loss of detail in the reproduced image. This, of course, is based on our present standard of 441-line, 30-frame per second transmission. Therefore, at most receiving locations, more than a mile or two from the transmitter, where reflections are troublesome, the reflecting area must lie in some plane other than that parallel to the ground.

Large buildings surrounding a receiving location offer ample opportunity for multiple-path reception even when the transmitting and receiving antennas are within line of sight. If the two are hidden from each other by tall buildings or by hills, the direct signal may be so greatly attenuated that the reflected energy exceeds that which travels the direct path.

One example of this was noticed recently at a receiving location which was hidden from line-of-sight of the transmitting antenna by a nearby building. In this case, the single strong reflected wave produced an image misplaced by an amount which indicated it had traveled about nine hundred feet further than the direct wave. The receiving doublet was rotated to a position which eliminated the direct signal (which was much the weaker of the two) and good reproduction was obtained.

DOUBLET ON A POLE

The most satisfactory indicator for determining the presence of undesired reflected waves and for aiding in the determination of their source, is a television receiver equipped with a portable doublet on the end of a long pole. It is necessary, of course, that the transmitter be in operation at the time of test, and that the transmitted image be stationary and of such a nature that either blurring of horizontal detail (at the edges of vertical lines) or the presence of a secondary image, is readily apparent. A single black vertical line in the middle of a white background would suffice.

The effect of orientation and rotation of the portable doublet on the relative strength of the direct and reflected signals, as reproduced by the receiver, together with a calculation of the difference in path lengths by a measurement of the displacement of the two images on the screen, will usually indicate the probable source of the reflection quite accurately. However, in many cases such information may turn out to be

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of only academic interest, since it will often be found that the correct answer to the problem of proper location and construction of the fixed receiving antenna can be determined only by empirical investigation.

III. Minimizing Secondary Signals

Probably the most generally useful type of television-receiving antenna will be a simple doublet, or double doublet, connected to the receiver by means of a low-impedance, twisted-pair transmission line. At the majority of receiving locations this will undoubtedly give completely satisfactory reception if normal care and thought are used in its installation. Even at many places where multiple-path reception is encountered, the same type of antenna may be made to serve satisfactorily by orientation to minimize the reflected signal, or by shielding it from the reflecting source. This might be done by placing it in proper relation to existing conductors such as metal flashings, copings, eaves-troughs, etc.

Usually such location can be found only by trying different positions and noting the effect on the received image. Another method of shielding a receiving doublet from reflected waves is to place a second, unloaded, dipole near it and in proper position to minimize the reflection image. Here again the cut-and-try method will probably yield the best results.

If several strong reflected signals are present at the receiving location more drastic action will probably be necessary. This was the case at the RCA License Laboratory which is located about 6,000 feet north of the transmitter on the Empire State Building. Fig. 1 was taken to illustrate the maximum number and relative strength of reflected signals which could be picked up at this location. The antenna was a half-wave doublet at the end of a 60-foot twisted pair which, however, was connected with the two wires in parallel to act as a "T" antenna against ground. In this case the first reflection arrived with proper phase and intensity to invert a large amount of the direct-signal detail into negative values of light intensity. This was followed by five more reflected signals varying in time of arrival and amplitude. The last of these is displaced by an amount which indicated that it had traveled 3.8 microseconds longer, and thus about 3,700 feet further, than the direct wave.

TROUBLE DUE TO REFLECTION

It is interesting to note that in this case horizontal synchronization of the receiver was seriously impaired. The whole pattern moved to the left as though the receiver had synchronized on one of the reflected signals. This was undoubtedly the case due to partial destruction of the true horizontal pulse by the strong, short-delay, out-of-phase reflection.

Fig. 2 was taken with the doublet and transmission line connected normally to the balanced-input terminals of the receiver, and with the doublet adjusted to the position which minimized secondary images. However, it can be seen that this antenna would be entirely unsatisfactory for good reception. Two principal reflections are still apparent. These are displaced by amounts which indicate additional path lengths of 800 feet and 2,300 feet. A very faint trace of the 3,700-foot reflection, which is strong in Fig. 1, still remains.

The antenna for Fig. 3 was the same as for Fig. 2 except that one end of the doublet was lengthened by adding a three and one-half wavelength wire toward the transmitter. This was supported one-quarter wavelength above a wide copper coping parallel to, and about 150 feet directly above, Fifth Avenue. Resistance termination at the outer end of this antenna had little or no effect on the reproduced image, so Fig. 3 was taken with the far end open. In this case the 2,300-foot reflection is still faintly visible, but probably represents an acceptable minimum of direct to reflected-signal ratio.

Of a large number of antennas tested, that used for Fig. 3 seems to be the only one which gives acceptable performance for reception at this location. Reflection conditions at this point are unusually severe and do not, by any means, represent the average to be expected. Although objectionable secondary images are picked up by the simple half-wave doublets at various locations within the range of the transmitter, there are many more where no reflections are apparent.

IV. Behavior of Transmission Lines and Long Wire Antennas

The long wire antenna at the License Laboratory is necessary only because its directional characteristics improve an adverse direct to reflected-signal ratio. At, or near, the boundaries of the service area of a television transmitter it will sometimes be necessary to use something other than a simple dipole and twisted pair for the antenna system in order to raise the signal well above the receiver hiss level.

Rubber-dielectric, twisted-pair lines dissipate a considerable amount of the received energy if they are more than a few wavelengths long. Measurement of several types of such lines indicates that the average attenuation to be expected is between 1.5 and 2.0 db per wavelength at 50 mc. Therefore, a fair increase in signal strength at the receiver can often be obtained by the use of an open-wire line, particularly if the distance from the antenna to the receiver is 50 feet or more. The attenuation of the average, close-spaced, open-wire line is about one-tenth of that of twisted pairs. However, if an open-wire line is used, its increased impedance will cause the antenna to operate less efficiently unless the two are connected together in such a manner that the damping of the antenna is about the same as with the lower-impedance line. This can be done by the use of the well-known Y connection which is common in amateur transmitter practice.

It is also necessary for the input impedance of the receiver to be at least approximately matched to the higher-impedance line in order to realize the increased-signal level. In some recent tests it was found convenient to have a small residual-inductive component as part of the input impedance at the balanced-input terminals of the receiver. The resistive component of this impedance measured about 100 ohms; therefore, when using a 100-ohm line, two small series condensers (one in each wire) were inserted to cancel the reactance. If, however, the reactance was cancelled by shunt tuning, the input resistance became 500 ohms, which was the impedance of the open-wire line. This made it possible to analyze the behavior of the two lines without making changes in the receiver input-coupling circuit.

Under some conditions the energy picked up by the two wires of the transmission line acting in parallel may exceed that in the antenna proper. If the entire system, and the receiver input in particular, is well balanced to ground, the signals from this source cannot enter the receiver. If, however, an unbalance does exist, energy from this source may give rise to considerable trouble. This is particularly true if the entire length of line and antenna is of the order of 100 feet or more. In this case the unwanted signals may be reflected back and forth between the receiver and the outer end of the antenna producing a new image, slightly displaced from the previous one, on each round trip, and thereby obliterating much of the horizontal detail.

The energy loss in twisted-pair lines is usually sufficient so that signals cannot travel in them (back and forth) for a sufficient length of time to cause blurred reproduction before being attenuated below a disturbance level. However, energy traveling on the two wires in parallel is often subjected to much less attenuation and can make trouble, if lack of balance in the system allows some of it to enter the receiver.

A marked example of this effect was noticed recently. At at particular location, a half-wave doublet and twisted-pair line gave no indication of extraneous reflections, but the signal level (about 800 microvolts) was somewhat too low for a good signal-to-receiver-noise ratio. Therefore, it was decided to install some type of long-wire antenna and open-wire line as an experiment to determine just how much this could be increased without resorting to means other than those which will be at the disposal of the average serviceman. Existing supports were not available for a rhombic antenna which would have had to extend from the lead-in point in a direction toward the transmitter. Therefore a single-wire, five-wave-length antenna, was placed between two tall trees which were on a line about 20 degrees from the direction of the transmitter. The 2-inch spaced transmission line was Y connected to the antenna across a point one-quarter wavelength from the end toward the transmitter.

With this arrangement it was realized that the major portion of the received energy would have to travel to the far end of the antenna, be reflected there, and then travel back the entire length before entering the transmission line. Furthermore, the whole system was, of course, unbalanced with respect to ground.

A test of the operation of this antenna showed that it delivered about ten times as much signal voltage to the receiver as the doublet and twisted pair. A large portion of this was due to an increase in height above the old antenna; the rest of it was accounted for by increased antenna and transmission-line efficiency. However, the reproduced image was decidedly poor. The radical loss of horizontal detail which resulted was at first assumed to be due to a too sharply defined resonant characteristic of the antenna proper; however this proved not to be the case. The cause of the trouble was found to the end-to-end reflection of that energy which flowed down the transmission-line wires in parallel. The distance from the receiver to the outer end of the antenna was about 175 feet. The blurring of the edges of vertical lines extended for a distance which indicated that at least three complete round trips (1,050 feet) were made over this path by the extraneous signal before it was sufficiently attenuated to the unnoticeable.

The difficulty was corrected by shorting and grounding the transmission line at its bottom

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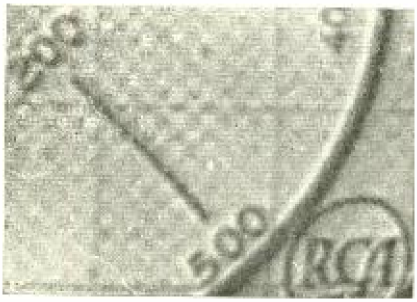

FIG. 3

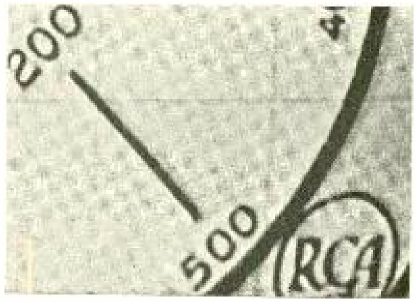

FIG. 4

Figs. 1, 2, and 3 show a small section of the Kinescope screen to illustrate the effect of various receiving antennas on reproduction. The receiver was operated with reduced contrast for best photographic results. Fig. 4 is the same as 3 except that the receiver was operated with normal contrast.

RCA Building Hundreds of Facsimile Receivers; Television is Progressing

By DAVID SARNOFF
President, Radio Corporation of America

Various broadcasting stations will shortly commence experimental transmission by facsimile of news bulletins and pictorial material to a limited number of receivers in their local areas. The RCA Manufacturing Company is now building facsimile transmitters and several hundred receivers which have been ordered by independent broadcasting stations for this purpose. The fundamental technical problems of facsimile have been solved, and the immediate question is largely that of determining useful and self-supporting services for the medium.

While the technical and economic problems of television are far more complicated, progress towards their solution continues to be made. Television pictures are larger, sharper, and more brilliant than a year ago, due to marked improvements in both transmitting and receiving apparatus. Developments now under way look toward the acceptance by the industry of definite technical standards, which must be established before any public television service is practicable.

Meanwhile, the NBC is continuing its study and experiments with television programs, both inside and outside the studio. The new NBC mobile television unit, the only apparatus of its kind in the United States, is being tested on outside pickups. This is an all-important field for experiment, since on-the-spot pictures of news events are certain to furnish one of the most useful and popular services of television.

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end and tapping off a short length of low-impedance line (for a lead-in) at an empirically determined point a few feet above the ground rod. It would normally be expected that a terminating resistor between the shorting bar and the ground connection would be required to prevent reflection of unbalanced signal energy at that point; in this case it was not necessary.

In its final form the antenna delivered somewhat less signal to the receiver than when first tried with a direct connection; but it still gave a 15 db improvement over the half-wave doublet. This was sufficient to raise the signal well above an acceptable minimum.

Conclusions

Some locations within the service area of a television transmitter will require individual receiving-antenna study and design to meet conditions at those locations.

It appears at present that a standard antenna design, or any single preventative of multiple reception, can not be prescribed for all receiving locations, especially where service from two transmitters in the same area is to be obtained.

Satisfactory performance has been obtained in every case studied, by means described in the paper.

Cornell-Dubilier Lowers Dykanol Condenser Prices

The Cornell-Dubilier Electric Corporation announces a substantial reduction in prices of their entire line of type TJ-U Dykanol filter capacitors, effective April 15th.

Enlarged production facilities, due in the most part to the increased demand for the units by the U. S. Army, Navy and Signal Corps, accounts for the price reduction.

The Carnell-Dubilier type TJ-U high voltage filter capacitors are impregnated and filled with Dykanol, the non-inflammable, non-explosive dielectric impregnant. Universal mounting brackets are furnished at no extra cost with each of these units.

For complete listing of new type TJ-U prices see you local C-D jobber or write to the Cornell-Dubilier Electric Corporation, South Plainfield, New Jersey.

WOR Time Signal Note Now Frequency Standard

The characteristic musical tone sounded by WOR of Newark, N. J., and the Mutual Broadcasting System, is now sufficiently accurate to serve as a musical pitch standard. The Allen B. DuMont Labs., Inc., of Upper Montclair, N. J., built the electrically-driven tuning fork which emits a pure 440-cycle tone with an accuracy within .002%. The fork operates continuously, its frequency being picked up and delivered to the control amplifier when needed for a time signal announcement. Because of its musical precision, the signal may be used by musicians and by technicians as a tone or frequency standard.

G.E. PAYS $85,000 FOR IDEAS

General Electric Company employess during 1937 received nearly $85,000 for new ideas submitted through the Company's suggestion system. During the year almost 37,000 suggestions were made by workers, and more than 12,000 were adopted. During the past 11 years nearly $600,000 has been paid out to employees for new ideas adopted for use.

First Public Schedule Gives Television Impetus

THE first public schedule of RCA high-definition television broadcasts for the New York City area was made recently when the Radio Corporation of America and the National Broadcasting Company established a period of experimental transmissions from W2XBS in the Empire State tower. The schedule of five full hour broadcasts a week began April 19th.

In resuming field tests after being off the air for several months, NBC radiated two series of broadcasts, one at an afternoon hour and the other during the evening. Living talent shows and selected films were broadcast from the NBC studios in Radio City on Tuesday and Thursday between 8 and 9 p.m. The live entertainment included dramatic productions adapted for television, a variety of educational features and a musical show. News reels and educational films also were used in this series. These television programs, although strictly experimental, were broadcast under conditions as near as possible to those governing a regular public service.

TEST CHARTS TRANSMITTED

Afternoon broadcasts, on Tuesdays, Wednesdays and Thursdays beginning at 3 o'clock, consisted entirely of intricate test charts and still pictures. Of no entertainment value but of great assistance in judging quality of transmitted pictures and testing performance of receivers, these images were put on the air for the sole benefit of television experimenters.

The series of television broadcasts was primarily for the use of NBC and RCA officials and engineers with receivers in their homes. Amateurs in the metropolitan area, however, who were building, or had built, receivers were able to look in on the telecasts and judge the success of their efforts.

Good reception of the broadcasts, said O. B. Hanson, NBC vice-president and chief engineer, was limited to the area north of the station, because broadcasting was from an experimental antenna array on the north side of the Empire State tower. Hanson explained that the steel and masonry of the tower itself would act as a shield to prevent the ultra-short waves from penetrating directly to the south. The only signals received south of the transmitter, he added, were those reflected by tall buildings to the north. This results in multiple images at the receiver, each image overlapping the others. NBC engineers, accordingly, used receivers in the northern area.

IMPROVEMENT IN ARRAY

The antenna array regularly used, mounted on the top of the Empire State tower, is being redesigned to incorporate several engineering changes in the array itself and the associated transmission lines connecting it with the transmitter on the eighty-fifth floor level. When the work is completed the station's normal service range of about fifty miles in all directions will be restored. W2XBS has occasionally been picked up as far away as seventy miles.

A triple purpose was served by the television broadcasts. The W2XBS transmitter had been off the air for several months during a period of extensive engineering redesign. Several important changes have been made in the system of transmission and twenty hours on the air will give engineers a chance to observe the results of their work.

New program techniques and devices, developed in recent months by the NBC television staff, were checked. Television, it was pointed out in the announcement, has definitely shown itself to be different from motion pictures and radio in program requirements.

Finally, with definite technical standards yet to be established for common use of television transmitters, the experimental period will enable associated NBC and RCA research men to obtain engineering data for assistance in the formulation of such basic standards.

FREQUENCIES USED

Television will probably be a competitive activity in the United States and broadcasters recognize the necessity of adopting uniform technical standards in the interest of the home audience. A single receiver must be capable of being tuned to all television stations in a locality.

The all-electronic system to be used in the tests was developed by the RCA laboratories. It transmits pictures in 441 lines at 30 frames a second. Picture signals are broadcast on a frequency of 46.5 megacycles and accompanying sound is on 49.75 megacycles. W2XBS, operated by the National Broadcasting Company since 1931, began its transmissions of 441-line images more than a year ago. Before that time images of lower definition, in 343 lines and less, were broadcast experimentally.

Crystal Pickup, Motor, Offered by RCA-Victor

RCA Victor has a newly designed crystal pick-up and tone arm at $4.95 and a synchronous motor at $6.50. The tone arm and motor are of simple design. The crystal pickup is completely sealed against moisture. It has a frequency response from 70 to 7,000 cycles. Needle pressure is 2.7 ounces, with the arm swiveled for easy needle insertion. Shock-proof mounting parts are included with the arm.

Street Make-up for Television Satisfactory, Says Philco

THERE has been much ado about the various colors and combinations of colors which will have to be used in make-up for television broadcasts. Famous make-up artists have been pictured employing shades of greens, blues and browns so that the face will "reproduce naturally" for television. There are other make-up experts who have devised special creams and pencils for treating the face to be televised. All this is done purportedly to increase the "natural" effect—yet many of the methods advocated are so far from being natural as to be grotesque, says Philco, adding:

"The make-up question for television is reminiscent of sound effects in the early days of radio broadcasting. An example of this is one classical case where sound engineers struggled for days to find a sound effect which would properly express a kiss.

O.K. FOR STREET MAKE-UP

"Many ingenious devices were used by none of them seemed to hit the mark until someone made a simple enough suggestion that hadn't been tried. He suggested using a kiss in front of the microphone. It was done and the sound effect was perfect.

"Television make-up is very much in the same position. In spite of all the various and wondrous make-up combinations, experiments have proven that ordinary street make-up for women serves as well as anything else.

"Fashion models, movie actresses and people of national prominence have appeared before Philco's television cameras without special make-up and without difficulty. There has been much discussion about blondes being difficult subjects for television because of the neutral color of the hair."

Miss Toby Wing, well-known on stage and screen, recently appeared in a Philco television demonstration. Miss Wing is a decided blonde, even to her eyebrows. However, using only ordinary street make-up, she registered perfectly on the television receiving screen without loss of detail or shading.

Albert F. Murray, engineer in charge of Philco's television research, predicts that, with the technical advances being made, television will offer no make-up problem whatsoever.

"Years ago when the 60-line screen was the best television could offer, there was a great deal of difficulty in bringing out detail and facial features," said Murray. "Red lipstick showed almost white, and such things as eyebrows were hardly apparent. Artificial make-up employing heavy brown colors were resorted to in order to obtain a picture which would be distinguishable.

AN ENGINEERING PROBLEM

"At precent," Murray continued, "with the use of the 441-line screen, there is no difficulty in obtaining clear and detailed reproduction without make-up. Our tests have proven that the make-up problem really has been more of an engineering problem than one of cosmetics.

"Still further developments in television engineering will completely eleminate any thought of make-up, much less necessity for it. It would be hard to conceive of television as an instrument of widespread utility or mobility, if every speaker or subject had to undergo a special make-up treatment before every broadcast."

Murray, who is chairman of the Television Committee of the Radio Manufacturers Association and one of the country's outstanding authorities on television, declares technical improvements have already eliminated the so-called make-up problem in television.

"This may be a blow to make-up experts," he concluded, "but I'm sure it's good news to everyone else who may be concerned with television, present and future."

Thor in Larger Quarters; Stock, Activities Increased

Thor Radio Company, a dominant factor in the retail trade in the Cortlandt Street district almost since the beginning of radio, has moved to larger quarters at 60 Dey Street, corner Greenwich Street, N. Y. City.

A considerable enlargement of the mail order activities has been perfected, and in addition the large stock carried has been greatly increased, particularly by new lines. Electrical merchandise has been added to the customary list of radio sets, parts, tubes, service equipment, accessories, amplifiers, manuals and cameras.

The presiding genius of the institution is Michael Kranz, who is assisted by his brother, Louis, and a large staff. Michael Kranz is one of the best-known radio retail merchandisers in the country. The staff also includes Mac Pecker, Jack Weber, George Du Buc and Myron Graye.

New Battery Charger Is Announced by G.E.

A new copper oxide rectifier for telephone service, providing an output adjustment over an extremely wide range in very small steps, has been announced by the automotive products section of the General Electric Company, Bridgeport, Conn.

A new variable transformer has replaced the customary transformer taps and rheostat, and a small knob on the front of the panel controls the transformer and provides easy adjustment of the charging rate. The rectifiers, which may be obtained in various sizes from three to 12 amperes, will provide a full charge for small batteries and a trickle charge for large ones. The exact charging rate is at all times indicated by an ammeter, while quiet operation is assured by a built-in filter reactance. The unit, in a sturdy case, is easily mounted on a wall.

"Base" at Top Marks WGY Record-Height New Antenna

FROM a new steel antenna tower 70 feet higher than the Washington monument, General Electric's station, WGY, in Schenectary, N. Y., will soon be radiating its 50,000-watt signals to the four corners of the country. Located on the company's 65-acre transmitter laboratory plot, three miles from Schenectady, engineers predict this new 625-foot tower will greatly increase the strength of signals and extend the coverage area many miles, yet in no way will tend to blanket the reception of programs from other stations.

This new antenna, which will be used for National Broadcasting Company's programs, is unique in that it rests on a point, instead, as might be expected of a tower, of coming to a point at the top.

RESTS ON INSULATOR

The lofty steel structure, nine feet square, rests on a porcelain insulator but 20 inches in diameter at its base. The porcelain unit insulates the "live" tower from the ground, for the entire tower, ladder and platforms included, is the active antenna or radiator. The porcelain insulator bears a total weight of 500,000 pounds and before installation was tested by the Bureau of Standards to an ultimate strength of 2,180,000 pounds.

The tower is supported on this point by eight messive steel guy lines, two attached to each of the four sides of the tower. Four guy lines are attached at 250-foot level and four at 500-foot level. These lines are stretched out 450 feet from the tower to concrete anchors buried deep in the ground.

Each cable is strung with seven insulators to prevent any diversion of signal strength from the antenna. At the point of attachment to the tower the guy starts with a 700-pound insulator; and then at intervals along the steel cable, breaking the cable into segments, are six insulators, each weighing 300 pounds.

20 ACRES INVOLVED

While the tower itself occupies relatively little land, the complete antenna system with the ground system covers 20 acres. Thirteen miles of copper ribbon, one inch wide and fifteen-thousandths of an inch thick, are buried 18 inches under the ground and radiate out to a distance of 625 feet from the base of the tower.

A 1,000-watt flasher beacon at the top will give warning to aviators, and in addition there will be constantly glowing lights at different levels of the tower. To provide greater visibility during dull and misty days, the tower has been painted in alternate sections of orange and white.

The new antenna is expected to be in operation within the next 30 days.

NICE WORK

MY interest in RADIO WORLD has increased the last few years. The point I wish to impress is expressed on page 24 of the February, 1938, issue (W. Fletcher). I am sick and tired of wading through magazines for reading matter detoured through the whole book. Your consecutive-page method of presenting articles is best.

GEO. S. KEYES,
P. O. Box 216, Odessa, Texas.

* * *

I congratulate you on your magazine. It is one of the best technical magazines published. I am an experimenter. RADIO WORLD is very valuable to me for all data, experimental work, and latest information of what's new in radio. I assure you that it will always be on my work bench.

CURTIS F. KEIRSTEAD,
28 Linden St., Framingham, Mass.

Ohmite Announces Two Precision Resistor Types

Ohmite Manufacturing Company, 4835 W. Flournoy Street, Chicago, announces Bulletin No. 108 covering Riteohm "71" vitreous enameled, 1% accurate, 1 watt resistors, and Riteohm "81", 1% accurate, vacuum-impregnated, non-inductively pie-wound precision resistors.

This bulletin illustrates and describes two types of precision resistors completely covering the field for accurate resistors for voltmeter multipliers, laboratory equipment, radio and electrical test sets, and similar use. It contains a complete tabular listing of stock sizes and gives handy engineering information such as maximum voltage and current in milliamperes for all stock resistances.

Inverse Feedback Use Is Becoming Widespread

Inverse feedback, reverse feedback or negative feedback (all three signify the same thing) is being used more and more in amplifier and transmitter circuits, as an agency of purity of wave form and stability.

TRADIOGRAMS

Display Cards Increase Cornell-Dubilier Sales

Display card supplied to jobbers by Leon L. Adelman, of Cornell-Dubilier.

Cornell-Dubilier's progressive jobber merchandising program reached a new peak recently when the corporation supplied to each of the jobbers cleverly conceived display cards featuring "the tiniest electrolytics ever developed," the C-D type BR Beavers. The new counter display is C-D's fourteenth, the second of their second series.

These point-of-sale reminders are highly effective jobber sales aids, asserted the C-D salesmanager, Leon L. Adelman, pointing to the noticeable sales jumps of the units featured on these counter placards.

Jobbers desiring information on this effective method of boosting capacitor sales are invited to write to the Cornell-Dubillier Electric Corporation, South Plainfield, New Jersey.

BEITMAN BACK WITH ALLIED

M. N. Beitman, formerly employed as engineer by Allied Radio, Chicago, resigned from another position recently and returned to the employ of Allied.

Knight Table Model Has Electric Motor Tuning

Two-band coverage, electric motor push-button tuning, slide-rule dial scale, and several new circuit refinements are among the features of a new Knight 6-tube Superheterodyne offered by Allied Radio Corporation, of Chicago. Reception is offered on the 16-54 and 175-560 meter ranges, thus covering the major short-wave and standard broadcast bands.

The Knight 6 is built around a new superheterodyne circuit incorporating octal glass tubes, i-f wavetrap, automatic volume control, Variable tone control, and a 6-inch electro-dynamic speaker. The tuning mechanism includes electric motor tuning of any six selected broadcast stations plus a 6-inch slide rule dial for manual tuning.

This new model is presented in a matched walnut cabinet measuring 16½" x 10" x 9".

Knight Radios are distributed exclusively by Allied Radio Corporation, 833 West Jackson Boulevard, Chicago.

RCA's New Oscillator Features Giant Dial

A new ac-operated test oscillator, incorporating one of the largest dials ever built into such an instrument, is announced by RCA. The new instrument has a frequency range of from 100 kc to 30,000 kc and a maximum output of one volt.

Known as Model 153, the new oscillator lists at $29.95, the lowest price at which an RCA ac-operated oscillator has ever been available. The instrument is complete in itself, and is designed so that external frequency modulation may be added for the cathode-ray oscillographic method of servicing.

The airplane type dial is nearly seven inches in diameter and gives a scale length of over 50 inches. The high-frequency range alone covers over 10 inches. Six ranges cover every frequency necessary for servicing receivers of any type. Calibration accuracy of 2% is guaranteed.

The high r-f output (one volt) makes the 153 oscillator extremely valuable for locating trouble in an inoperative or completely misaligned set, or for single stage alignment work. Compact size and light-weight make this oscillator equally applicable for use in the customer's home or in the service shop.

RADIO CONSTRUCTION UNIVERSITY

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

STUMPED BY HUM

WHENEVER I run into hum trouble I feel stumped, as on most occasions I can't find a way to get rid of the hum—I. G.

That nicely describes being stumped. There are three general classes of hum: (1) due to poor filtration in the B supply; (2) due to carrier modulation; (3) due to thermal coupling between cathode and heater. When there is insufficient filtration it is always a good plan to increase the capacity of the filter condensers, at least doubling them, assuming there was no defect in the condensers originally, and also to put rather large series resistors in the amplifier and detector plate legs, bypassed to B minus with large capacities. The effect of even moderately-sized capacities, 1 mfd. or more, across high resistance, is marked. Carrier modulation is often cured simply by connecting a condenser of .05 mfd. from one side of the a-c line to B minus. Or, two condensers of that capacity may be used across the a-c line, and joint of these capacities connected to B minus. Hum due to thermal coupling between cathode and heater, sometimes pronounced in sets using the infinite impedance type detector, is somewhat harder to cure. Naturally, using d.c. on the heater will accomplish the result. Except in special experimental installations, nobody would likely want to stand for introducing d.c. A compromise is to use only part of the voltage drop across the cathode load resistance, in other words, use two resistors, one between cathode and joint, other between joint and B minus, and put the stopping condenser to the joint, other side of this condenser to the grid resistor of the succeeding stage. A .00025 mfd. mica bypass condenser goes from cathode to ground for resistors of more than 50,000 ohms, and a .0005 mfd. condenser for resistors of 50,000 ohms or less. The resistor from joint to ground may be 50,000 ohms, the other resistor, to cathode, of equal value, and the grid resistor for the next stage 80,000 ohms. This would support detection of high percentage modulation signals.

* * *

COINCIDENCE OF A.C. AND D.C.

PLEASE tell me to what extent the a-c voltages may be made to coincide with the d-c voltage ranges in a universal type meter, and what is the real reason for the discrepancy—O. K. E.

In the general, the two are not the same, due to the current density of the rectifier. The rectifier therefore may be considered as an agency that possesses inertia, and "prefers" to remain in its static state, hence current does not change much for small increments of voltage starting from zero voltage, but once the change has set in substantially, the rectifier begins to go along fairly evenly. A separate scale for a.c. is required. If only high voltage ranges are to be considered, then linearity could be produced (a.c. equivolent to d.c.), because the limiting resistor is large, and with limiting resistance "pure," and preponderant, the relatively small resistance effect of the rectifier is masked. What is usually done is to shunt the d-c meter for d-c measurements, to make the terminal voltages agree for the same multiplier resistors. Another method, shown in this issue, is to use separate resistors for a.c. and d.c., which avoids this shunting, so that the full sensitivity of the meter obtains on d.c., whereas on a.c. the sensitivity is less, as always, unless the d-c sensitivity is sacrificed to atone for the difference, as already explained.

* * *

TEST OF CURRENT DRAW

CAN you tell me what is a good method to test whether a vacuum-tube voltmeter is drawing any considerable current?—W. R.

In the absence of a suitably sensitive meter to make this measurement, inject a voltage to create full-scale deflection on the lowest range, then insert a 1 meg. resistor in series with the voltage under measurement. If the meter needle does not move away from full-scale (to the left), the meter draw is negligible. If the needle moves back a few divisions out of fifty, the draw is considerable.

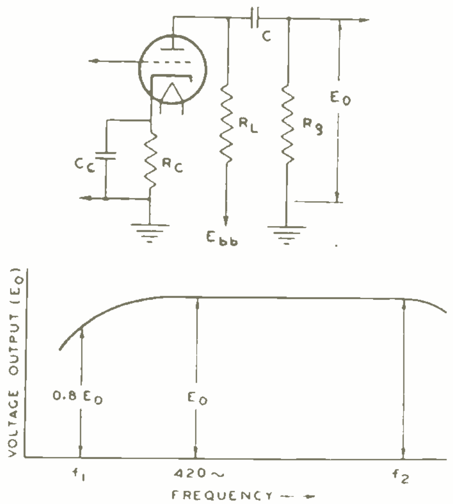
* * *

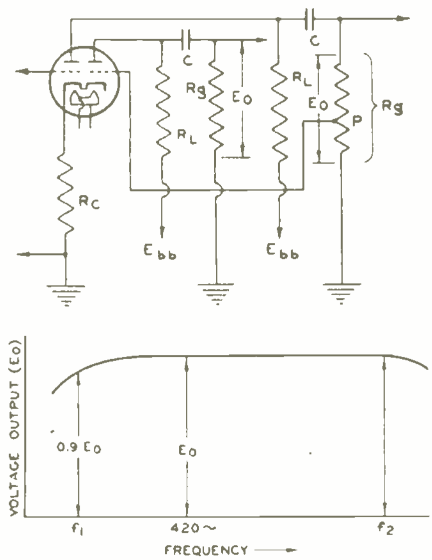
A.C. FOR RESISTANCE TEST

WHY can not resistance be measured on a.c., which is readily obtained from the house line, without the bother of rectification for d-c measurement of resistance?—W. S. F.

Because d.c. is steadier and more reliable, the

(Continued on following page)





The signal input is supplied to the grid of the left-hand triode unit. The grid of the right-hand unit obtains is signal from a tap (P) on the grid resistor (R_g) in the output circuit of the left-hand triode unit. The tap (P) is chosen so as to make the voltage output of the right-hand unit equal to that of the left-hand unit. Its location is determined from the voltage gain values given in the Chart. For example, if the value of voltage gain is 20 (from the Chart), (P) is chosen so as to supply 1/20 of the voltage across (R_g) to the grid of the right-hnd triode.

For phase-inverter service, the cathode resistor (R_c) should not be by-passed by a condenser. Omission of the condenser in this service assists in balancing the output voltages. The value of (R_c) is specified on the basis that both units are operating simultaneously at the same values of plate load and plate voltge.

CONSTANTS FOR RESISTANCE AF

Choice of proper constants permits use of single or double triodes in resistance-coupled circuits. Constants for these circuits will be published next month. The low-frequency cutoff is easily arranged in advance.

A. Condensers C and C_c have been chosen to give output voltages equal to 0.8 E_o for f_1 of 100 cycles. For any other value of f_1, multiply values of C and C_c by $100/f_1$.

In the case of Condenser C_c, the values shown are for an amplifier with d-c heater excitation. When a-c is used, depending on the character of the associated circuits, the gain, and the value of f_1, it may be necessary to increase the value of C_c to minimize hum disturbances. It may also be desirable to have a d-c potential difference of approximately 10 volts between heater and cathode.

B. $f_2 =$ frequency at which high-frequency response begins to fall off.

C. The voltage output at f_1 for n like stages equals $(0.8\ E_o)^n$.

D. Decoupling filters are not necessary for two stages or less.

E. For an amplifier of typical construction, the value of f_2 is well above the audio-frequency range for any value of R_L.

F. Always use highest permissible value of R_g.

G. A variation of ± 10% in values of resistors and condensers has only a slight effect on performance.

(*Continued from preceding page*)

measurements are preferably made on d.c. Many have tried the a-c method, but it is not as good. Also, batteries in general are more stable than rectified a.c., unless special precautions are taken to hold the a-c input steady, as by inclusion of a regulator tube.

* * *

METER FOR VTVM

IS it desirable to have a sensitive meter in a vacuum-tube voltmeter, or is a 0-1 milliammeter sufficient?—W. D. C.

The meter choice is affected by the circuit design. If it is desired to minimize the amount of amplification, then the meter should be more sentitive, to take care of a low scale of, say, 0-2 volts. Around 200 microampere sensitivity is satisfactory, as a compromise between desired high sensitivity, and ruggedness of meter construction. As may be inferred, the ruggedness may decline at about the rate that the meter sensitivity is increased. A vacuum-tube voltmeter for measuring a.c. is shown elsewhere in this issue, and trouble-shooting directions are given also.

Cornell-Dubilier Cites Value of Ceramic Casing

View of a C-D mica-ceramic encased condenser.

A recent bulletin from the Cornell-Dubilier Electric Corporation cites the advantages of a mica-crenic casing combination for high-voltage use.

Referring specifically to the Cornell-Dubilier type 86 unit, illustrated here, the corporation stated that by the use of mica, the loss of power flowing through the (1) capacitor is 1/20th that of ordinary flint glass dielectric capacitors; (2), that ceramic casing insulates the condenser from interfering ground capacity, as distinguished from metal cased capacitors; (3), that ceramic casing prevents field absorbtion, hence, permits lower r.f. resistance; (4), that Cornell-Dubilier's internal mica assemblies eliminate all corona effects; (5), that capacity remains constant at high frequencies and at temperatures that would materially damage glass dielectric condensers.

The Cornell-Dubilier twpe 86 mica capacitors are recommended by the corporation for amateur plate blocking, grid and tank condenser applications.

Choice of Ray-Tube Screens

Although the medium-persistence green cathode-ray tube pattern is generally used in standard oscillograph practice, there are other screens available where the applications vary from normal requirements, say DuMont engineers.

For very rapidly changing phenomena, there is the short-persistence blue screen, the image of which is so short-lived that there is no piling up of successive patterns to confuse the observer.

For the study of transient phenomena, particularly when comparisons are desired between them, there is the long-persistence time delay screen. The pattern traced by a single phenomenon remains on the screen for as long as a minute. If desired, several phenomena may be placed on the screen and compared. Also, the screen patterns may be readily photographed because of their persistency.

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COMPLETE AC and DC VOLTAGE and CURRENT RANGES

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DC Current:	0-1,	0-15,	0-150,	0-750 Ma.
AC Current:	0-15,	0-150,	0-750 Ma.	

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INFORMATION IS SOUGHT OF HARRY (HERSCHEL) WYLER alias WHITE, a driver of a radio sound truck and radio repairman, who disappeared from San Francisco, Calif. in March 1937 and since then has made no provision for his wife, Clee, and their two small children, Marlene and Terry, as a result of which the family is in dire need. This man was born in Minneapolis in July 1905, is 5 ft. 9 in. tall, weighs 175 pounds, has light brown hair, blue eyes, wears glasses. Anyone knowing of his location is requested to communicate with the National Desertion Bureau, 67 West 47th Street, New York City.

★

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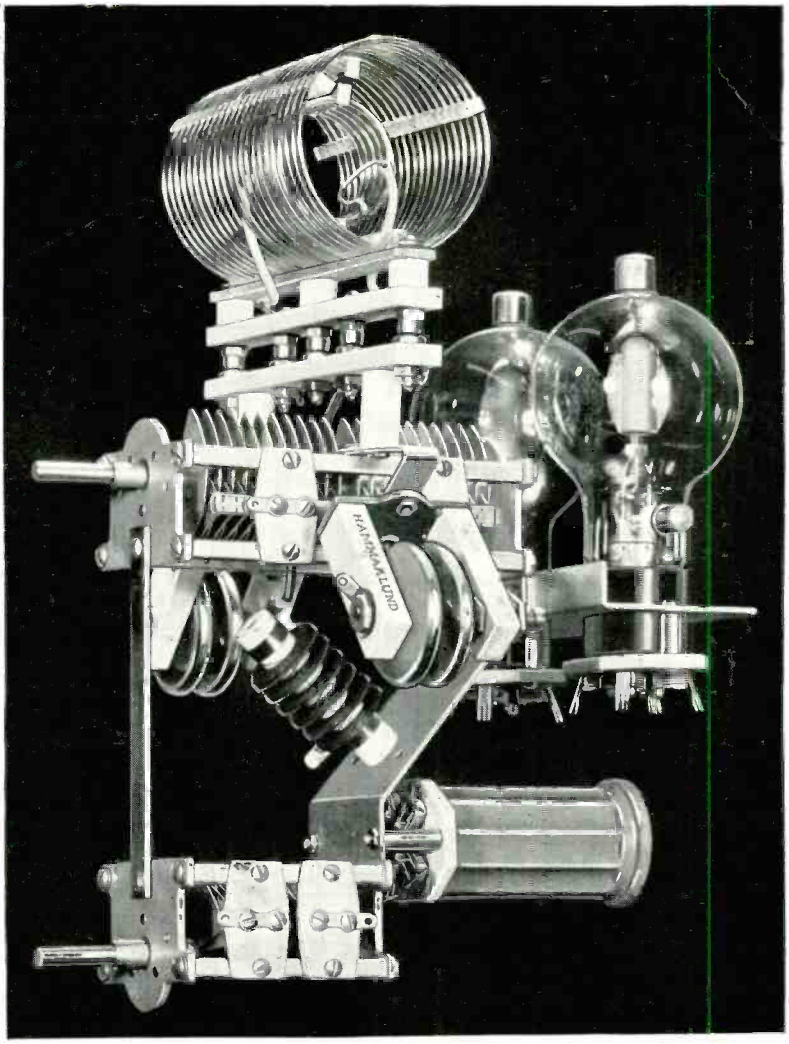

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