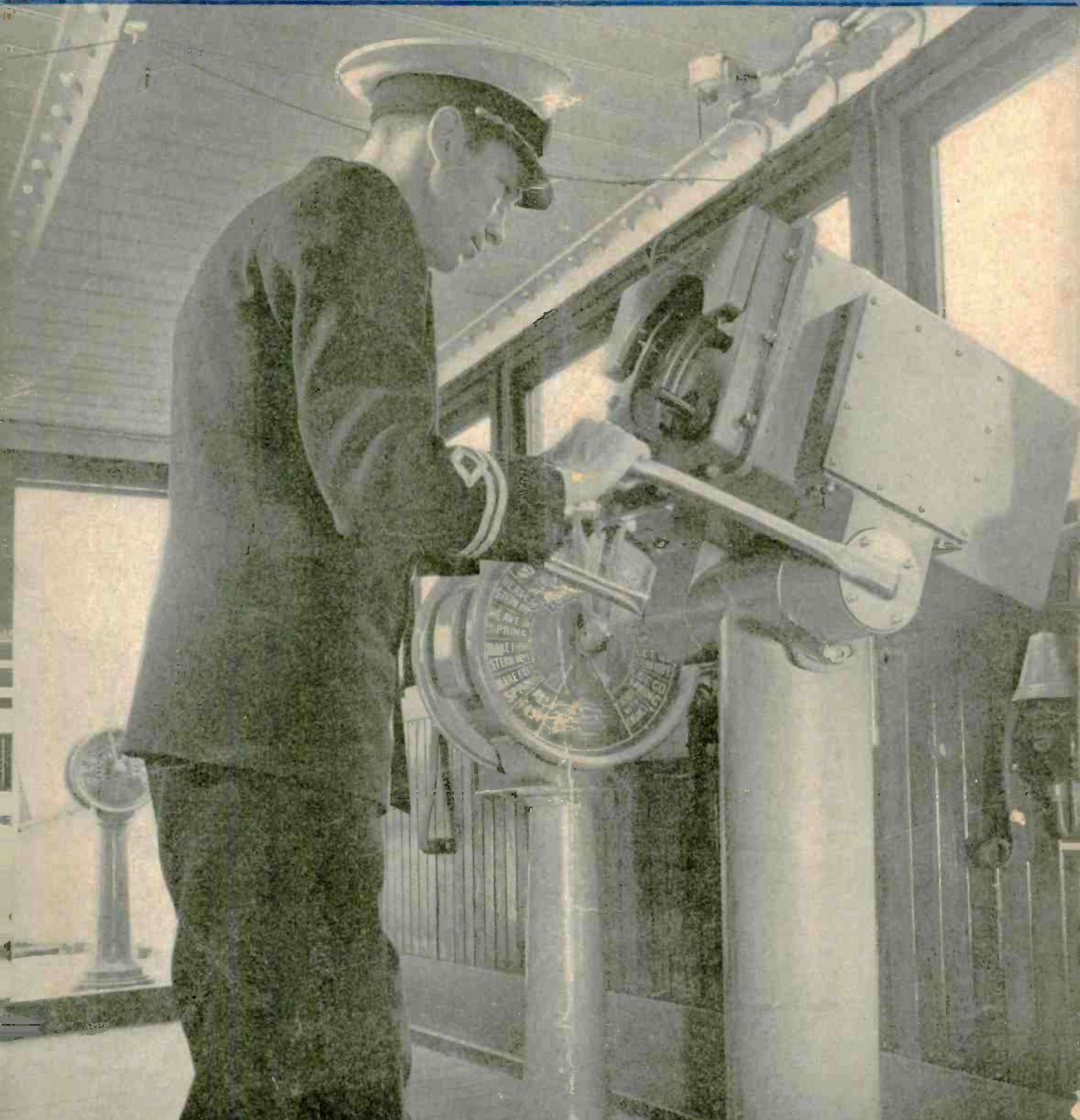
JULY, 1946

RADIO

MANUFACTURING AND BROADCASTING

The Journal for Radio & Electronic Engineers



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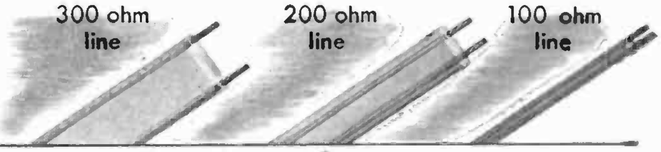

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Export Distributor:
International Standard Electric Corporation

Newark 1, New Jersey

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RADIO

Published by RADIO MAGAZINES, INC.

John H. Potts..............Editor
Sanford R. Cowan........Publisher

JULY, 1946 Vol. 30, No. 7

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RADIO Magazine (title registered U. S. Pat. Off.) is published monthly at Boston Post Road, Orange, Connecticut, by Radio Magazines, Inc. Executive and Editorial Offices at 342 Madison Avenue New York 17, N. Y. Subscription rates—United States, U. S. Possessions & Canada, $3.00 for 1 year, $5.00 for 2 years; elsewhere $4.00 per year. Single copies 35c. Printed in U.S.A. Entered as Second Class Matter May 10, 1945 at the Post Office at Orange, Conn., under the Act of March 3, 1879.

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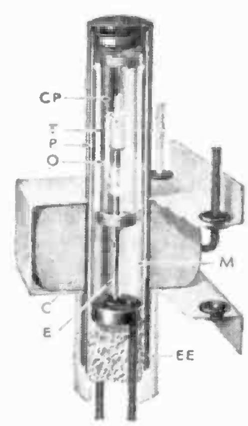

ENERGIZED—Coil C pulls plunger P down into mercury M. Mercury thus displaced enters thimble T through orifice O. Inert gas in thimble gradually escapes through ceramic plug CP.

Mercury now fills thimble T, is completely leveled off and mercury-to-mercury contact established between electrodes E and EE. Degree of porosity of ceramic plug CP determines time delay.

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electrical pipe-line

Microwaves make their journey from apparatus to antenna not by wire, cable, or coaxial — but by *waveguide*.

Long before the war, Bell Laboratories by theory and experiment had proved that a metal tube could serve as a pipe-line for the transmission of electric waves, even over great distances.

War came, and with it the sudden need for a conveyor of the powerful microwave pulses of radar. The metal waveguide was the answer. Simple, rugged, containing no insulation, it would operate unchanged in heat or cold. In the radar shown above, which kept track of enemy and friendly planes, a waveguide conveyed microwave pulses between reflector and the radar apparatus in the pedestal. Bell Laboratories' engineers freely shared their waveguide discoveries with war industry.

Now, by the use of special shapes and strategic angles, by putting rods across the inside and varying the diameter, waveguides can be made to separate waves of different lengths. They can slow up waves, hurry them along, reflect them, or send them into space and funnel them back. Bell Laboratories are now developing waveguides to conduct microwave energy in new radio relay systems, capable of carrying hundreds of telephone conversations simultaneously with television and music programs.

EXPLORING AND INVENTING, DEVISING AND PERFECTING FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE

BELL TELEPHONE LABORATORIES

Transients

BATTLE OVER OPA

★ At the moment of writing the fate of OPA is being debated in Congress. Regardless of the outcome, it seems likely that OPA control in the radio industry will either pass completely out of existence or remain in a greatly emasculated form. In any event, those manufacturers who have found OPA to be one of the greatest stumbling blocks to full scale production are now free to go ahead without hindrance from that source.

If this new-found freedom is to be of real help to the industry, it must be realized that freedom entails a great degree of responsibility. If goods are over-priced, temporary profits will be wiped out by buyers' strikes from a resentful public, as well as increased wage demands from production workers. Over-stocked retailers will slash prices to reduce inventories and will start buying on a hand-to-mouth basis, causing reduced production, layoffs, and industrial unrest. There are already indications that such conditions are approaching in other lines. It is up to radio manufacturers to see that it does not happen here.

It is not going to be easy to exercise the required degree of self-control. The temptation to gather quick, easy profits without regard to the future is going to be difficult to resist. If the leading manufacturers of radios set a good example to the others, the industry will pass through its most difficult period of readjustment without losing its self-respect as well as that of the public.

ASPECT RATIO

★ An industrial designer has come forth with the suggestion that television be presented as an upright, rather than as a horizontal, picture. While the present aspect ratio of 4:3 necessarily represents a compromise, the industry seems to have been peculiarly fortunate in choosing a ratio which affords an excellent presentation of the most popular types of entertainment. Such features as boxing matches, football games, stage productions, and the like, certainly fit into the present aspect ratio much better than they would in upright form.

Of course, there might be some point to a system of masking the camera lens when making close-ups so as to increase the dramatic effect, or perhaps the same result could be achieved by proper lighting. But the sorely beset television receiver manufacturer should not be plagued with the possibility of changes in aspect ratio which would involve redesign of the apparatus.

NEW TUBE TYPES

★ Those of us who had developed a certain degree of familiarity with a great many of the multitudinous tube types existing before the war find ourselves rather appalled at the number of new types which have blossomed forth in recent years. In many instances the designation gives no clue to the application, nor even to its generic type.

Before radio production gets going full blast, it might be a good idea to revamp the list of preferred types of tubes, eliminating those which have been superseded by better designs and, above all, getting rid of the constantly increasing number of obsolete tubes. And this might also be a good time for tube manufacturers to get together and promise, never, never, to enter into agreements with small manufacturers to turn out a new tube type in consideration of an order for a production run of a few thousand tubes. Plenty of such hybrids still clutter up tube manuals, dealers' shelves, and manufacturers' warehouses. The slight immediate profit resulting from such practices has resulted in a long-term loss to the manufacturer as well as annoyance to others in the industry.

J. H. P.

TECHNICANA

PROJECTION TYPE T-V TUBES

★ Correcting plates may form the end wall of a projection-type c-r tube, as announced in a communication from the E. M. I. Laboratories to the editors of *Electronic Engineering,* June 1946. The essentials of the technique are illustrated in *Figs. 1* and *2*.

When the televised image traced on the fluorescent screen is to be projected by means of a spherical mirror, it is essential to include a plate to correct for spherical aberration introduced by the mirror. The new technique provides a suitably curved end-plate carrying the fluorescent material.

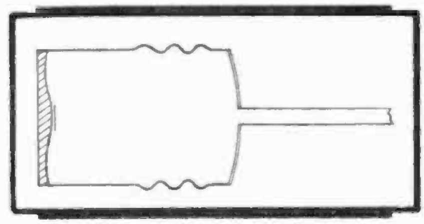


Figure 1

The shoulder of the tube is given a spherical curvature and is silvered to provide a mirror. When it is necessary to adjust the distance between the mirror and correcting plate, a bellows section of copper, for example, is designed into the side wall of the tube, as shown in *Fig. 1*. Alternatively, the spherical mirror may be formed on a support close to, but not a part of the tube wall, with support rods extending through elongated external pips on the tube shoulder as shown in *Fig. 2*. A limited amount of focusing adjustment is possible after softening these pips.

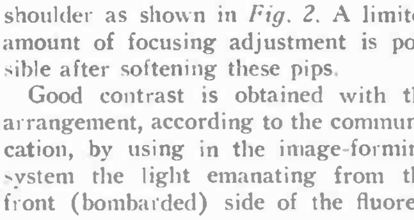


Figure 2

Good contrast is obtained with the arrangement, according to the communication, by using in the image-forming system the light emanating from the front (bombarded) side of the fluorescent screen.

F-M I-F TRANSFORMER DESIGN

★ Design criteria for i-f transformers in f-m circuits are discussed by H. A. Ross in the *Amalgamated Wireless* (Australia) *Technical Review,* issued March 1946.

At the outset, the designer should know the deviation ratio, the maximum audio modulating frequency $f_{s(max)}$, and the intermediate frequency f_0. It is desired to determine values for k and Q for the i-f transformers so that the amount of AM which is introduced may be suppressed by the limiter (where k and Q have conventional connotations). Since this AM is a maximum when the degree of FM is 100%, design is based on maximum frequency deviation.

More AM can be tolerated with an improved limiter characteristic, and this must ultimately be decided for the individual case. A typical value of K is 0.33, corresponding to 6 db attenuation at a bandwidth equal to twice the deviation frequency Δf, K being termed the modulation factor.

$$K = (\rho_1 - 1)/(\rho_1 + 1)$$

where ρ_1 is the attenuation at $\beta = 2\Delta f/f_0$. Δf is defined as the maximum frequency deviation.

The percentage of introduced AM is graphed in *Fig. 3* against $Q\beta_1$ where

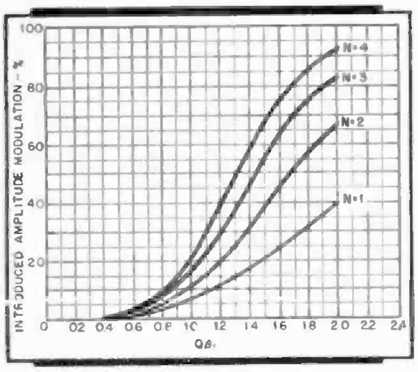


Figure 3

$\beta_1 = 2\Delta f/f_0$ for N critically coupled transformers, N being the number of transformers in the filter. If ρ = attenuation of one i-f transformer at δf cycles off-tune, then $\rho_N = \rho^N$ for N transformers, and the author shows that $\rho_N^{2/N} = 1 + Q^4\beta^4/4$. Finally,

$$Q\beta_1 = 2^{1/2}\{[(1+K)/(1-K)]^{2/N} - 1\}^{1/4}$$

which is the relationship shown in *Fig. 3*. From this equation Q may be found and $k = 1/Q$.

A second useful family of curves has been prepared by the author, as shown in *Fig. 4*. From these the selectivity characteristic may be plotted without computation when k is known. Likewise, the value of k corresponding to a value of $\rho_N^{1/N}$ may be found for a given value of β. These curves may be used to design an f-m transformer as follows:

1. Compute $\beta_1 = 2\Delta f/f_0$.
2. Find ρ_1 for the specified value of K.
3. From *Fig. 4*, using the value of β_1 found above, obtain k for the condition $\rho_N^{1/N} = \rho_1^{1/N}$.
4. Then $Q = 1/k$.
5. The bandwidth for other values of

TECHNICANA

[*from page 7*]

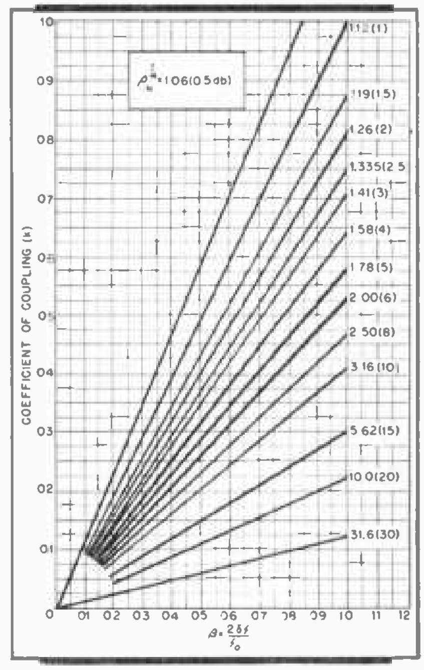


Figure 4

$s^{1/N}$ may be found by reading the values of β from the intercept of the various curves of the family with a line drawn through the value of k parallel to the axis of β. Thus the selectivity characteristic may be plotted.

The author discusses calculation of stage gain, analysis of over-coupled i-f transformers, and power relations in an f-m current which has passed through a selective circuit. For details of these topics, as well as derivations of the design data involved, the reader is referred to the original article.

CONTACT RECTIFIER

★ A German copper contact rectifier which converts a.c. into d.c. with 98% efficiency will be investigated by two industry experts, the technical industrial intelligence branch of the Department of Commerce announced. The rectifier was developed by the Siemens-Schuckert firm, Berlin, during the war for use in electroplating, aluminum extraction, chlorine manufacture, and other electrolytic processes.

The investigation is being directed by TIIB, but costs will be borne by the ITE Circuit Breaker Co. The investigators' report will be made public through the OPB, Department of Commerce. The German rectifier is said to be 10% more efficient than the mercury arc converter now generally used here.

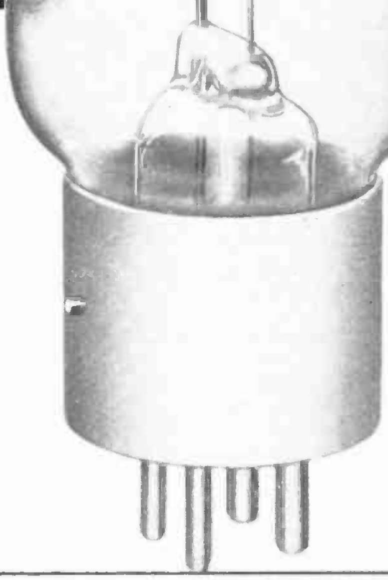
The rectifier is described in the following report, for sale by OPB: Otto Jensen, "Report on High Voltage Switch Gear" (PB-3477; photostat, $3; microfilm, 50 cents; 30 pages).

A BETTER 35TG

The famous Eimac 35TG VHF tube, with its low inter-electrode capacitances, its logical terminal arrangement, its lack of internal hardware, *is further improved.* It now has a non-emitting grid, an improved filament, and a cooler operating plate. These improved elements, the result of wartime developments in manufacturing technique, are being incorporated in many Eimac tubes and are consistently resulting in vastly increased life.

The 35TG is a power triode of wide applicability. It will function as a Class-C oscillator or amplifier, or as a Class-B audio or supersonic amplifier, and in such service will give excellent performance, due to its stability and low driving-power requirements.

Longer operating life is but one of the many advantages afforded by Eimac tubes. It will pay you to keep informed... see your nearest Eimac representative today, or write direct.



EIMAC
35TG
POWER
TRIODE

ELECTRICAL CHARACTERISTICS

Filament: Thoriated tungsten	
Voltage	5.0 volts
Current	4.0 amperes
Amplification Factor (Average)	39
Direct Interelectrode Capacitances (Average)	
Grid-Plate	1.8 uuf
Grid-Filament	2.5 uuf
Plate-Filament	0.4 uuf
Transconductance (i_b = 100 ma., E_b = 2000 V., E_c = −30 V.)	2850 umhos
Frequency for Maximum Ratings	100 mc

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TIM COAKLEY (W1KKP), 11 Beacon Street, Boston 8, Massachusetts. Phone: Capitol 0050.

Low Noise Microwave

W. J. ZABLE
Sperry Gyroscope Co, Inc.

DESIGN FACTORS of low-noise microwave receivers are important to the engineer when over-all systems are taken into consideration. A 6-db increase in receiver sensitivity theoretically doubles the range of the received signal. More important in certain systems where weight, power drain, size and signal-to-noise ratios versus distance are written into a system, a gain of 4 or 5 db in receiver sensitivity can be the deciding factor in meeting specifications.

Naturally, a directional antenna can be used to get large gains but even this is not sufficient in some cases. In particular microwave recording systems 1 db has been shown to either make a system work or fail. An increase of 4 or 5 db in this case is quite a safety factor. It is important to note that if the increase in power is to be accomplished by increasing the microwave tube output, as for example, from 2 to 5 watts, while still maintaining low voltage power supplies and maximum tube life, the task will be a difficult one.

A microwave receiver which is 15 db above theoretical noise ($KT\Delta F$), the noise power generated by the receiver, is still considered a good instrument. But if the receiver can be designed to 9 or 10 db above $KT\Delta F$, the improvement in carrier-to-noise is considerable.

If conditions are set down for a microwave receiver where the i-f frequency is 30 mc and the bandwidth of the receiver input circuit is 15 mc, it can be seen from

$$E^2 = 4KTR\Delta F \qquad (1)$$

where

E = effective noise voltage
K = Boltzmann's constant
T = absolute temperature degrees Kelvin
R = value of the equivalent noise resistance
ΔF = bandwidth of receiver to half power point

that T or R can be reduced to get less receiver noise. Since reducing the temperature of an input circuit is impractical, this leaves only the equivalent noise resistance.

Low-Noise Circuit

The circuit found to have a low equivalent noise resistance is the combination of a neutralized triode and a grounded-grid amplifier as shown in *Fig. 1.*

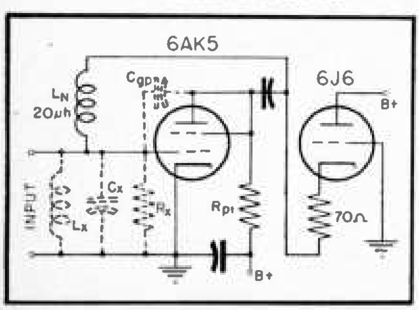


Fig. 1. Circuit of low-noise amplifier uses a neutralized triode followed by a grounded-grid output tube.

The input circuit of the neutralized triode does not present a capacitive component, such as a non-neutralized pentode, but also reflects an inductive reactance across the input terminals. The reflected components are shown in *Fig. 1* as L_x, C_x and R_x. L_x is the neutralizing coil and is equal to approximately 20 mh and R_x is a pure resistance.

$$L_X = \frac{L_N}{(1 + A_1)} \cong \frac{L_N}{(1 + \mu)} \qquad (2)$$

$$C_X = C_{gp}(1 + A_1) \cong C_{gp}(1 + \mu) \qquad (3)$$

$$R_X = -\frac{1}{W A_2 C_{gp}} \qquad (4)$$

A_1 and A_2 are the real and imaginary components of the r-f plate-to-grid voltage ratio, A; and ω is the frequency in radians.

$$A = -\frac{E_p}{E_g} \qquad (5)$$

The factor A can also be expressed through the tube and circuit parameters

$$A_1 = \frac{\mu Z_a}{Z_a + R_p} \qquad (6)$$

$$Z_a = X_r + jX_i \qquad (7)$$

where

Z_a is the complex impedance of the load
R_p is the internal tube resistance
μ is the amplification factor ≅ 0.7
X_r is the real series resistance
X_i is the reactance series component

A is generally complex and can be shown as

$$A = A_1 + jA_2 \qquad (8)$$

From equations (5), (6) and (7) it is possible to express the real and imaginary components, A_1 and A_2, as functions of the tube parameters

$$A_1 = \frac{\mu R_r X_r + Z_a^2}{(R_p + X_r)^2 + X_i^2} \qquad (9)$$

$$A_2 = \frac{\mu R_p X_i}{(R_p + X_r)^2 + X_i^2} \qquad (10)$$

A_2 drops out at resonance since X_i is equal to zero and A_1 can be assumed to be approximately equal to μ. If accurate figures are required A_1, A_2, X_r and X_i can be calculated by an inversion diagram.

At resonance $Z_a = X_r = R_p$, where R_p is the parallel resistive load of the anode circuit. We can, therefore, calculate the exact A_1 to use for calculating L_x and C_x. R_x at resonance goes to infinity.

Stability Requirements

In our particular case we can assume $A_1 = \mu$. It is interesting to note that if a stable amplifier is desired it can be shown that it is best to keep R_x far above the grid resistor, keep the Q of the grid circuit high and that of the anode circuit low.

In the neutralized triode under discussion L_x is equal to approximately 12 micro-henries and C_x is equal to approximately 2.8 µµf. Since the grid-cathode capacitance is 5.4 µµf, the total input capacitance would be 8.2 µµf.

The impedance or reactance of this circuit can be calculated from the development of a parallel circuit, where R is equal to the equivalent series resistance in the circuit.

$$Z = \frac{1}{\frac{1}{1/j\omega C} + \frac{1}{R_L + j\omega L}}$$

$$= \frac{\frac{R}{(\omega C)^2} - j\left[\frac{R^2}{\omega C} + \frac{L}{C}\left(\omega L - \frac{1}{\omega C}\right)\right]}{R^2 + (\omega L - 1/\omega C)^2} \qquad (11)$$

This input circuit tunes to approximately 15 mc. At 30 mc the impedance can be calculated from the following development and determined accurately as mentioned in the following discussion of the input circuit.

To calculate the impedance at 30 mc. it is necessary to replace ω by 2ω in equation (11)

$$Z_2 = \frac{\frac{1}{(2\omega C)^2} - j\left[\frac{R}{2\omega C} + \frac{L}{C}\left(2\omega L - \frac{1}{2\omega C}\right)\right]}{R^2 + (2\omega L - 1/2\omega C)^2} \qquad (12)$$

Assuming that there is low loss and that the power factor is unity, then at resonance,

$$\omega L = \frac{1}{\omega C} \qquad (13)$$

Substitute equation (13) into (12), then the result is

$$Z_2 = \frac{\frac{(\omega L)^2 R}{4} - j\left[\frac{R^2 \omega L}{2} + \frac{3(\omega L)^3}{2}\right]}{R^2 + \frac{9(\omega L)^2}{4}} \qquad (14)$$

Since $R << \omega L$ in a low-loss circuit and can be neglected, equation (14) can be simplified to the result,

$$Z_2 = \frac{R}{2} - j\frac{2\omega L}{3} = -j\frac{2\omega L}{3} = -725 \text{ ohms} \qquad (15)$$

Equation (11) will also yield the required impedance by substituting the numerical values for ω, L, and C. Terms in R can be neglected again.

The input circuit commonly used to couple this load to the microwave crystal mixer is a double-tuned transformer or a single coil tapped at the proper impedance matching point. Both meth-

Video Receiver Design

New design factors for low-noise input circuits are derived on the basis of recent investigations

ods are not satisfactory because for wide bandwidth the coefficient of coupling is quite large and is not an easy problem to solve in production.

Coupling Circuit

The practical coupling circuit to use in this case is a pi network. Design information is limited to the use of pi networks for r-f coupling circuits and the cut-and-try method is confusing due to the change in parameters when any one of the three variables is changed. The importance of the input pi network cannot be overstressed because to understand its characteristics may mean the difference between a satisfactory receiver and an excellent receiver.

From transmission theory, the impedances of *Fig. 1* across *1-2* and *3-4* are developed by assuming that *1* and *2* are open and shorted; and *3* and *4* are open and shorted, giving

$$X_1 = \frac{-R_1 X_2}{R_1 \pm \sqrt{R_1 R_2 - X_2^2}} \qquad (16)$$

$$X_2 = \frac{-R_2 X_2}{R_2 \pm \sqrt{R_1 R_2 - X_2^2}} \qquad (17)$$

where

R_1 = generator impedance
R_2 = load impedance
X_1 = one leg of pi network
X_2 = middle leg of pi network
X_3 = third leg of pi network

Equations (16) and (17) give the values required of X_1 and X_3 to match R_1 and R_2. It is also important to realize that in order to have this match it is necessary that the quantity

$$R_1 R_2 \geq X_2^2 \qquad (18)$$

If X_2^2 is greater than $R_1 R_2$ it will be impossible to get maximum efficiency from the network or a match regardless of what is done to X_1 and X_3. In other words X_1 and X_3 will take on imaginary values.

To simplify the pi network for treatment an equivalent circuit of the L type as shown in *Fig. 3* can be developed if X_3 is made infinite in value. X_3 in this case will drop out if the negative sign of the radical $R_2 \pm (R_1 R_2 - X_2^2)^{1/2}$ is used and a value of R_1 used so that $R_2 = (R_1 R_2 - X_2^2)^{1/2} = 0$

It is possible to correlate *Fig. 2* and *Fig. 3*, since R_L is now taken as the reflected resistance of the load and the equivalent circuit of a coupled network. At resonance X_1 is equal to X_2. The impedance into which we are to work is R_L, the image impedance of the network. With Q's of about 9 or more the parallel impedance at resonance is given by the formula

$$Z = R_1 = \frac{X^2}{R} = XQ \qquad (19)$$

In this case

$$X_1 = X_2 = \frac{R_1}{Q} \qquad (20)$$

and

$$R_L = \frac{X^2}{Q} \qquad (21)$$

X_1 and X_2, therefore, are fixed at any desired Q.

From equations (20) and (21), R_L can also be found to be

$$R_L = \frac{X_2}{\frac{R_1}{X_2}} = \frac{X_2^2}{R_1} \qquad (22)$$

Equations (20), (21) and (22) give considerable information. Although the L network has a minimum impedance value of R_L it is possible to see what happens in the network if the load is different from R_L. In other words, equations (20), (21) and (22) show that one value of a resistive load will give a match. If the load is higher than R_L of the L network the load can be made to look like R_L by shunting the load with a reactance. A reactance in series with the load will also result in a change. If a condenser is added in series it will subtract from X_2 and if an inductance is added it will add to X_2. This changes equation (20) and results in a mismatch to the generator. If the load is smaller than R_L of the L network equations it is impossible to get a match. In this case the generator impedance would have to be lowered, which in turn would lower R_L.

Since the use of series reactances is limited it is interesting to note the effect when a load is shunted by a reactance to make it look like R_L.

The parallel circuit in question is shown in *Fig. 4* and *Fig. 5*, its series equivalent where R_2 is a load higher than R_L of equation (21). X_3 is the shunted reactance necessary to make R_2 look like R_L and X_{3S} is the series equivalent resulting from the shunted reactance across R_2. From equation (22) it can be seen that this is equivalent to reducing X_2 of *Fig. 1*. To maintain the original conditions X_2 would have to be increased by the amount of X_{3S}. Attention is called to the fact that varying the values of the pi network results in bandwidth change as shown by equations (21) and (22).

The amount of X_{3S} necessary to shunt a load, R_2, to make it look like the lower R_L can be developed from the equivalent parallel-series circuits of *Fig. 4* and *Fig. 5* where the parallel circuit is equal to the series circuit. The values are

$$-j\frac{R_2 X_3}{R_2 - jX_3} = R_L - jX_{3S} = \frac{R_2 X_3^2 - jR_2^2 X_3}{R_2^2 + X_3^2} \qquad (23)$$

The real component is

$$R_L = \frac{R_2 X_3^2}{R_2 + X_3^2} \qquad (24)$$

The reactive component is

$$X_{3S} = \frac{-R_2^2 X_3^2}{R_2^2 + X_3^2} \qquad (25)$$

Equation (10) gives the solution for X_3

$$R_L(R_2^2 + X_3^2) = R_2 X_3^2$$

$$R_L R_2^2 + R_L X_3^2 = R_2 X_3^2$$

$$R_L R_2^2 = R_2 X_3^2 - R_L X_3^2 = X_3^2 (R_2 - R_L)$$

$$X_3^2 = \frac{R_L R_2^2}{R_2 - R_L}$$

$$\therefore X_3 = -R_2 \sqrt{\frac{R_L}{R_2 - R_L}} \qquad (26)$$

[Continued on page 30]

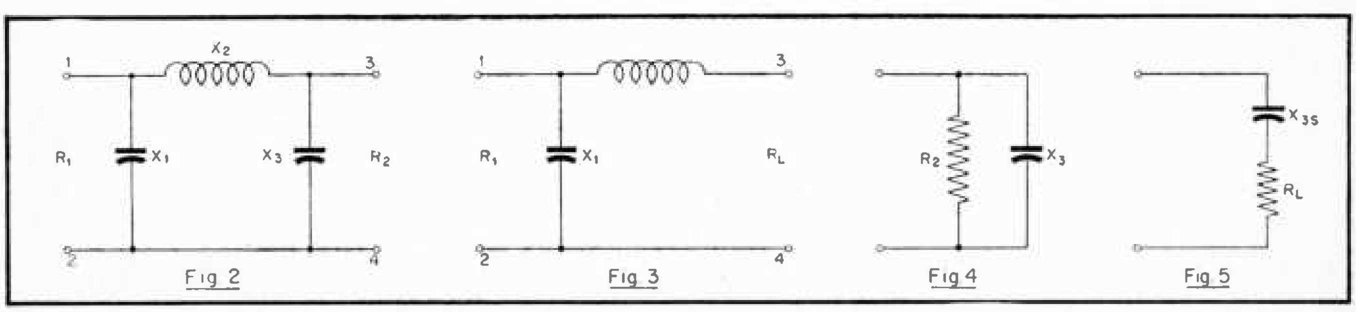


Fig. 2. Basic pi network utilized to couple crystal mixer to neutralized triode. Fig. 3. Equivalent L circuit for a analysis of pi filter design factors. Fig. 4. Shunted load used to simulate R_L. Fig. 5. Equivalent series circuit of Fig. 4.

SIMPLIFIED METHOD OF

L. S. BIBERMAN
Radio Corporation of America

A SIMPLE AND QUICK method for plotting attenuation curves on semi-logarithmic paper is shown in the following discussion. As an illustration, the attenuation characteristics of single and coupled resonant circuits and a low-pass filter are shown by straight lines with origin and slope determined from equations of the curves. The straight line characteristic is correct for frequencies far away from resonance and the curves are approximated for frequencies close to resonance with fair accuracy. Application of this method may be of great value to design engineers and is quite helpful for many practical purposes.

Single Resonant Circuit

The equation of a single resonant circuit (see *Fig. 1*) is:

$$U = (f/f_0)(S^2+1)^{1/2} \qquad (1)$$

where

U is attenuation
S is the detuning function $= \beta Q$
β is the frequency deviation ratio $2[(f-f_0)/f_0]$
f_0 is the resonant frequency

For small values of $\beta\ f/f_0$ is approximately unity and equation (1) becomes

$$U = (S^2+1)^{1/2} \qquad (2)$$

For values of S larger than 3 the equation becomes

$$U = S \qquad (3)$$

and the attenuation in db $= 20 \log S$ or an attenuation of 6 db/octave of S.

From equation (3) the value of S for zero attenuation is 1. A straight line is drawn from this point with a slope of 6 db/octave of S. However, the actual attenuation for $S = 1$ is

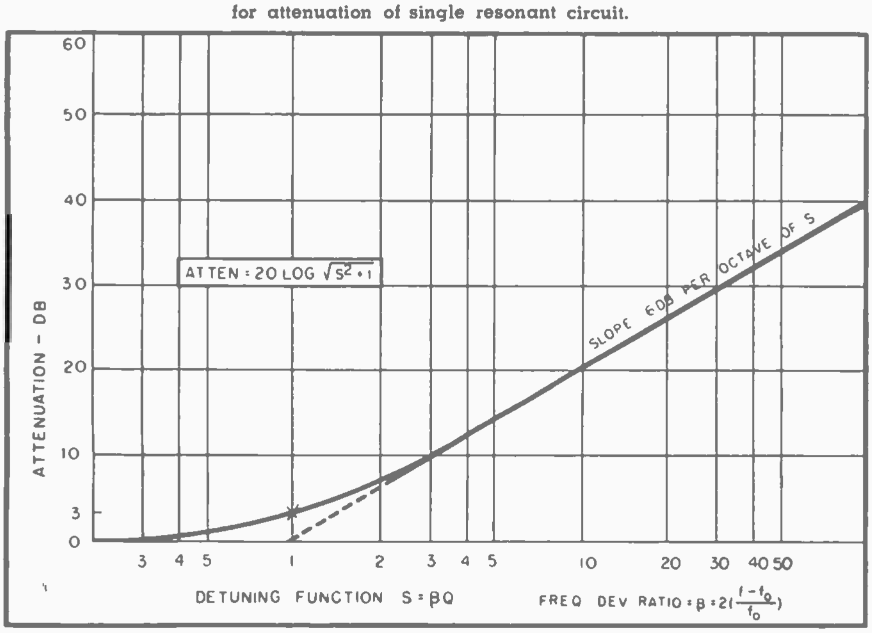
$$U = (S^2+1)^{1/2} = 2^{1/2} = 3 \text{ db}$$

The straight line curve is then modified by swinging an arc at this point tangent to the straight line and X axis.

For values of S above 3 the curve is exact, and for less than 3 the degree of accuracy is less than ½ db, which is fairly well within the limits of practical design work.

[Ed. Note—To express the slope of the straight portion of the plot otherwise, we may write db $= 20 \log S$ as $S = 10^{db/20}$, or as $S = 10^{m(db)}$, an equation which plots as a straight line in semi-log coordinates. The scale value of semi-log paper may be expressed as a factor k, equal to the number of linear axis units contained in one cycle of the logarithmic axis. The slope of the straight line will then equal $1/km$, when the logarithmic axis is horizontal as in *Fig. 1*. Here, $k = 32.6$, and it is seen that $m = 1/20$. Thus the slope (calculated in linear units each way) is equal to 20/32.6, or 0.615, and a straight line may be drawn through $S = 1$ at a slope of 0.615 as a preliminary construction.]

Fig. 1. Illustration of universal straight-line and circle diagram in semi-log coordinates for attenuation of single resonant circuit.



Coupled Resonant Circuits

We will consider the case where $Q_1 = Q_2$ (see *Fig. 2*):

The equation for attenuation for critical coupling is

$$U = \tfrac{1}{2}(S^4+4)^{1/2} \qquad (4)$$

Far away from resonance this equation becomes

$$U = \tfrac{1}{2}S^2 \qquad (5)$$

and the attenuation in db $= 20 \log \frac{1}{2}S^2$. The attenuation is then proportional to S^2, or an attenuation of 12 db/octave of S. From equation (5) the value of S for 0 attenuation is 1.414,

for $U = 1 \quad S = 1.414$

A straight line is drawn starting at this point with a slope of 12 db/octave of S. However, the actual attenuation for $S = 1.414$ is

$$U = \tfrac{1}{2}(1.414^4+4)^{1/2} = \tfrac{1}{2}(8) = 3 \text{ db}$$

The straight line is then modified, as in case 1, by swinging an arc at this point tangent to the straight line and the X axis.

As in case 1, the degree of accuracy for values of S smaller than 3 is less than ½ db.

For other values of coupling, the slope of the straight line is the same, 12 db/octave of S, but the starting point is different depending on the value of S for the cut-off point for 3 db attenuation.

Low-Pass and High-Pass Filters

We will consider a constant-K filter where the equation for attenuation for values of $Z_1/Z_2 > 100$ is (see *Fig. 3*):

$$U = Z_1/Z_2 \qquad (6)$$

The cut-off frequency f_c is where $\frac{1}{4} Z_1/Z_2$ is proportional to $(f/f_c)^2$, equation (6) in terms of f_c becomes

$$U = 4 \times \tfrac{1}{4} Z_1/Z_2 = 4(f/f_c)^2 \qquad (7)$$

and the attenuation in db $= 20 \log 4(f/f_c)^2 \qquad (8)$

The attenuation is then proportional to f^2 and is 12 db/octave, with the same

PLOTTING ATTENTUATION CURVES

Attenuation characteristics of many circuits plot as straight lines and circular arcs on semi-log paper, saving time for design engineers

slope as the coupled resonant circuit curve, case 2.

From equation (7) the value of f/f_c for 0 attenuation is 0.5

$$\text{for } U = 1(f/f_c) = 0.5$$

A straight line is drawn from this point with a slope of 12 db/octave.

For non-dissipative components the attenuation is zero at $f/f_c=1$. The curve is then modified by swinging an arc from this point tangent to the straight line at $f/f_c = 3$ where the curve starts to follow the straight line.

The degree of accuracy for f/f_c less than 3 is, as in the previous cases, less than ½ db.

All the curves shown are for one stage. For more than one stage the ordinates are multiplied by the number of stages at 2 points and a straight line drawn through those points will give the attenuation for the complete network.

We have shown here as an illustration 3 cases most widely used, but this method of plotting attenuation curves may be used for any other application by determining the slope and the origin of the straight line from the equation of the characteristic curve.

For example, the low- and high-frequency response of a resistance-coupled amplifier may be represented by a curve similar to *Fig. 1*, where the abscissa is f_c/f instead of S, where f_c is the frequency for $R/X = 1$.

The attenuation for a resistance-capacity network is

$$U = R/Z = R/(R^2 + X^2)^{1/2} \qquad (9)$$

For values of X/R larger than 3 the attenuation is

$$U = R/X \qquad (10)$$

The starting point for the straight line is where $R/X = 1$ or $f_c/f = 1$.

The actual attenuation for $R/X = 1$ from equation (9) is

$$U = \tfrac{1}{2}^{1/2} \text{ or } 3 \text{ db.}$$

The curve of a resistance-capacitance network is then the same as *Fig. 1*, except the abscissa is f_c/f.

Conclusion

In most attenuation circuits, no matter how complex the relationship may hold at frequencies close to resonance, far away from resonance the curves follow a straight line.

An attempt was made here to simplify the construction of these curves by reducing the formula of the circuit to the straight line function which holds true at frequencies far away from resonance.

The assumption made for constructing the curves at frequencies close to resonance give results that are fairly well within the limits of practical design work.

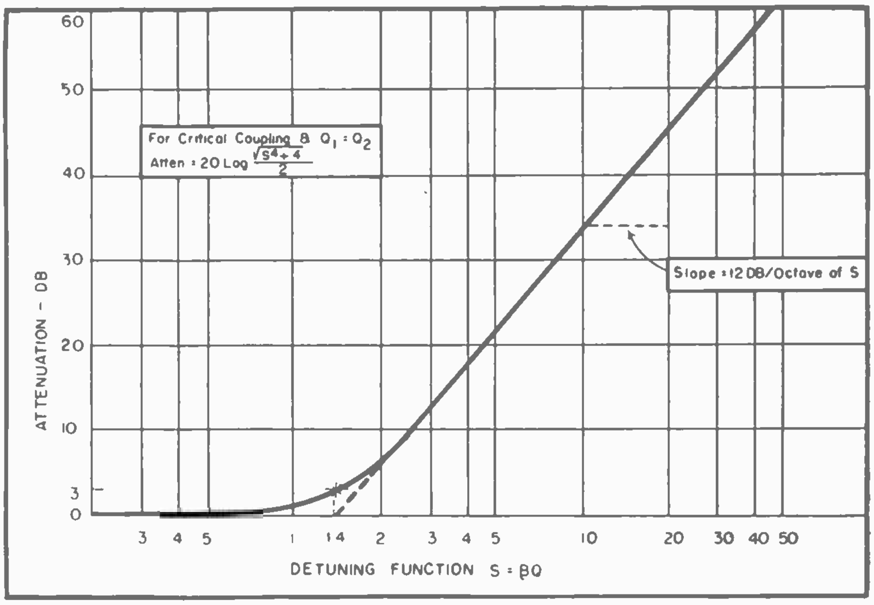
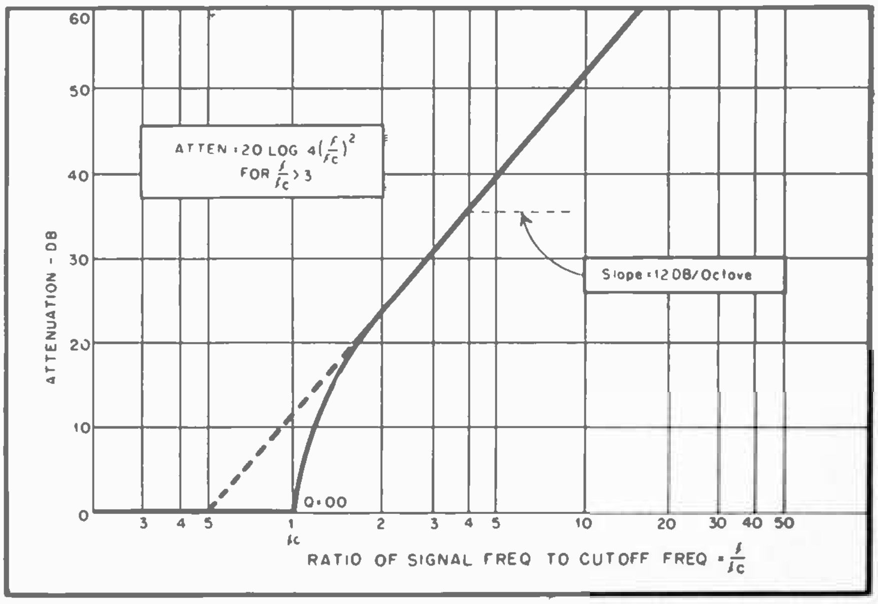


Fig. 2 (above). Construction similar to Fig. 1, but for coupled resonant circuit; maximum deviation is ½ db, as for single circuit. Fig. 3 (below). Constant-k filter attenuation may be represented on semi-log paper with straight-line and circle construction; maximum deviation is again ½ db.



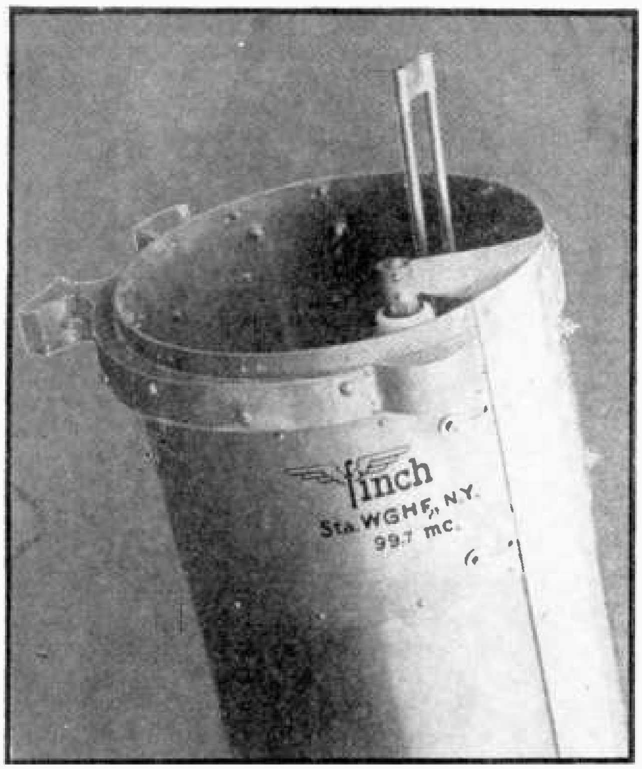


Fig. 1. End view of rocket antenna section: designed as a slotted cylinder, antenna is energized at edges of slot.

DUAL-ROCKET ANTENNA CHARACTERISTICS

GEORGE HENDRICKSON

Rocket antennas may be utilized in arrays, affording improved power gain over a single rocket

Resembling a rocket mounted 700 feet above sea level is a new type of antenna*, designed by Dr. Andrew Alford for fm and facsimile broadcasting.

The rocket antenna is essentially a long hollow metal cylinder with a metal bottom and an open top. It is cut longitudinally so that there is a straight narrow slot extending the full length of the cylinder from the bottom plate to the top. To exclude weather, the open top is covered with a molded fibreglass dome, and the slot is closed by a fibreglass strip.

A coaxial feeder is brought into the cylinder through the bottom plate and is continued along one side of the slot to the top of the antenna where it is terminated with an end seal insulator. The outer conductor is mentallically connected to the cylinder at the end seal and at several equally spaced points. The inner conductor is brought out through the end seal and is connected to the opposite edge of the slot. The potential between the inner and outer conductors is thus applied between the opposite edges of the slot as shown in *Fig. 1*.

The potential difference across the slot is distributed as is indicated by "6" in *Fig. 2 (d)*. This difference of potential produces a flow of circumferential currents around the cylinder. These circumferential currents, being very nearly in phase throughout the length of the cylinder, radiate a field which is similar to that which would be radiated by an array of a large number of small loops stacked one above another.

Radiation Patterns

The diameter of the cylinder is so chosen that the potential distribution shown in *Fig. 2 (d)* is obtained with the overall length of the cylinder equal to approximately one wavelength at the operating frequency. The voltage distribution is not sinusoidal, as it is along cylinders of large diameters, but comes closer to the ideal uniform distribution.

With a cylinder of this length the vertical radiation pattern is shown in comparison with the ideal *Fig. 3* (pattern 3 is the ideal, "X's" indicate points actually plotted. In the lower sketch, 3 and 4 indicate ideal and actual voltage distribution respectively.)

The radiation pattern in the plane at right angles to the axis is shown in

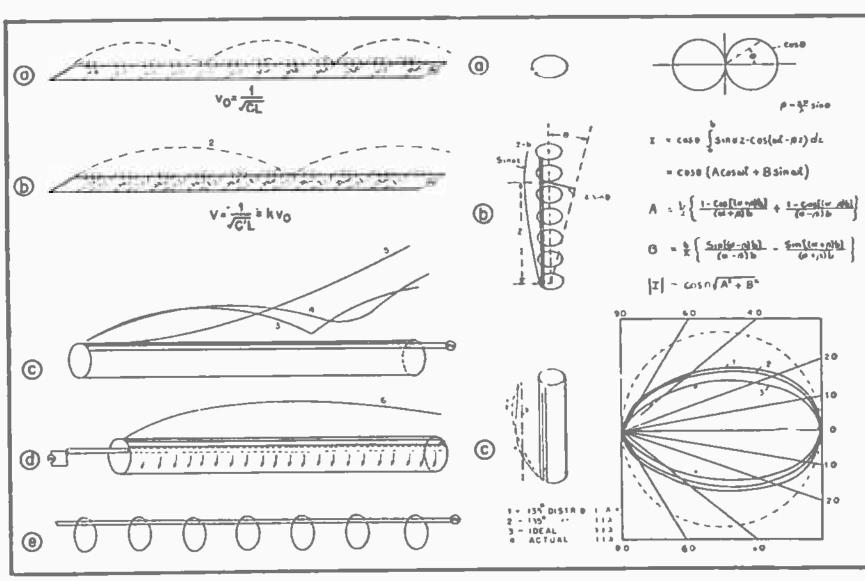


Fig. 2 (left). Equivalent lumped network of rocket antenna, and potential distributions with circumferential currents. Fig. 3 (right). Development of vertical radiation pattern, with experimenal values obtained.

*Radio, December 1945

Fig. 6. This is the horizontal pattern of the antenna.

Since the horizontal pattern is not perfectly circular the comparison between the gain of antenna and a standand half-wave antenna is made on the basis of the equivalent circular pattern. This equivalent pattern has a radius equal to 1/1.24 of the maximum of the actual pattern. On this basis the power gain of the single rocket antenna is 1.6. The power gain in the direction of maximum radiation is $1.6 \times (1.24)^2 = 2.46$. The power gain in the direction 180 degrees from maximum is $1.6/(1.07)^2 = 1.39$. In the direction of the minima the power gain is $1.6/(1.2)^2 = 1.11$. For convenience the horizontal radiation patterns in *Fig. 6* are plotted in terms of millivolts per meter. When calculated according to the Standards of Good Engineering Practice of the FCC, the variations from the circular indicated in *Fig. 6* almost disappear, and the patterns appear to be circular.

The effect of the supporting round metal mast may be seen in pattern *2* and 3, *Fig. 6*. There is a critical mast diameter beyond which the distortion of the horizontal pattern increases rapidly. At 100 mc, this diameter is around 22 inches with a recommended diameter of 16 inches.

The impedance of the antenna at the feed point is around 165 ohms with a negative reactive component. This impedance is transformed to the impedance of a standard 70 ohm or 51.5 ohm concentric transmission line by a line transformer incorporated into the feeder within the antenna. The voltage standing wave ratio along the 70 ohm feeder is to be held below 1.15.

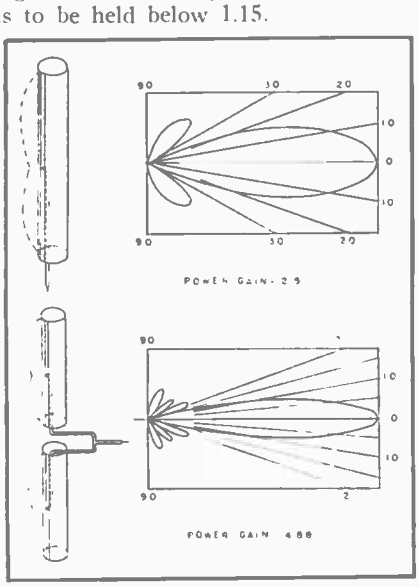


Fig. 4 (above). Vertical radiation pattern of dual-rocket antenna system. Horizontal pattern is the same as for a single unit. Fig. 5 (below). Array of two double-rocket antennas affords power gain of 7.5 in direction of maximum. 3.33 minimum. Horizontal pattern is unchanged.

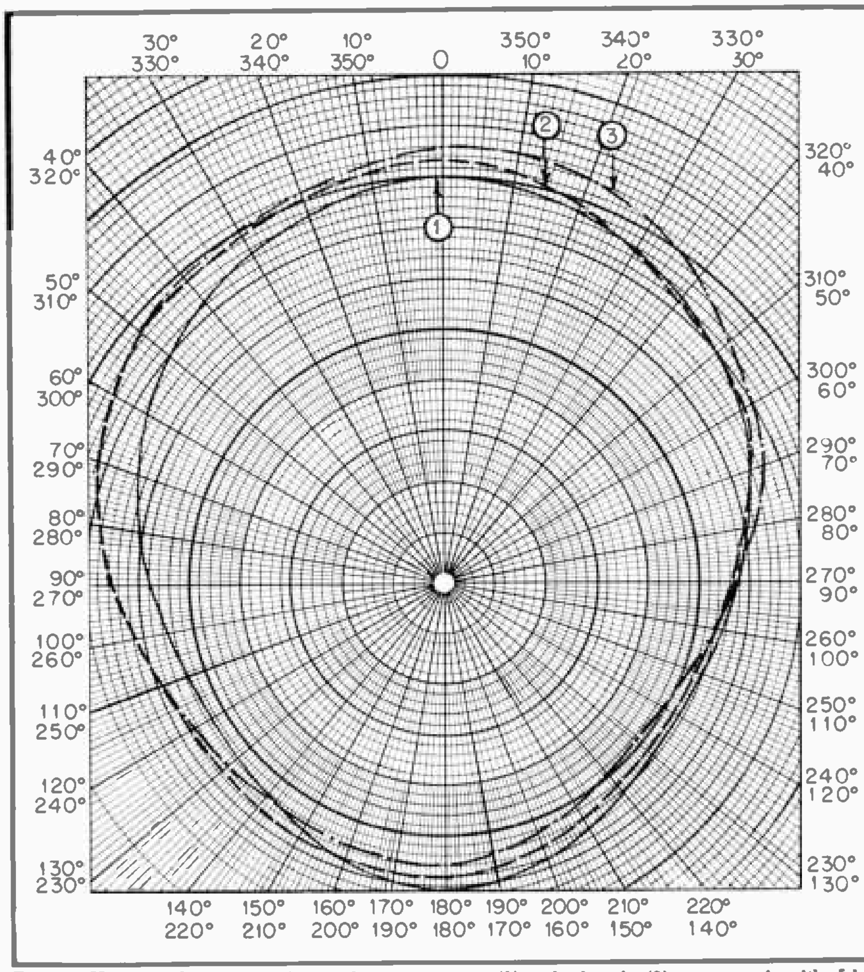


Fig. 6. Horizontal patterns for rocket antennas: (1) calculated; (2) measured with 5-in. diameter antenna on pole; (3) measured with 14.2" diameter antenna on pole. Notes: Slot is at 0°, pole at 180°; plot made in volts to give better picture as in μv/meter the patterns are close to circles.

Two-Rocket Array

Two such antennas can be used together and erected as a unit, with their open ends joined. A single concentric feeder entering the bottom and connected to the mid-point (corresponding to two open ends) serves the entire antenna. A metal cone seals the top. The vertical pattern of this antenna is shown in *Fig. 4*. The horizontal pattern is the same as for the single unit (see *Fig. 6*). This double unit is said to have a power gain of 2.5 on the basis of the equivalent circular pattern. The rated power gain in the direction of maximum is 3.85. The power gain 180 degrees from maximum is 2.18, and in the direction of the minima is 1.70.

The impedance of the antenna at the feed point is about 100 ohms with a negative reactive component. It is transformed to the impedance of a standard line in the same manner as is used in the single unit antenna.

In another type of antenna an array of two double rocket antennas is used and mounted one above the other and connected so that they are energized in the same phase. For convenience of making connections the lower antenna is turned upside down so that the feeders after making 90° turns may be brought together in a special four way junction fitting in which connection is made with the main feeder as indicated in *Fig. 5*.

The vertical pattern of the array is shown in *Fig. 5* with the horizontal pattern being the same as that of the other two types, as shown in *Fig. 6*. This array has a power gain of 4.88 on the basis of the equivalent circular pattern. The power gain in the direction of the maximum is 7.5, 180 degrees from the maximum it is 4.12, and, in the direction of minima, 3.33.

The transmission lines of the two antennas join at a special three way 90° junction box, from which a third line connects to a similar junction box at the top end of the main transmission line. The third line on this second junction box is a short circuited stub. A short section of the main feeder below the junction box contains a line transformer matching the impedances of the main line and the antenna array. This transformer is to be adjusted so that the voltage standing wave ratio on the main line feeder is below 1.15. Transformers can be furnished to match either 1⅝" or 2⅝".

RECENT RADIO INVENTIONS

These analyses of new patents in the radio and electronic fields describe the features of each idea and, where possible, show how they represent improvements over previous methods

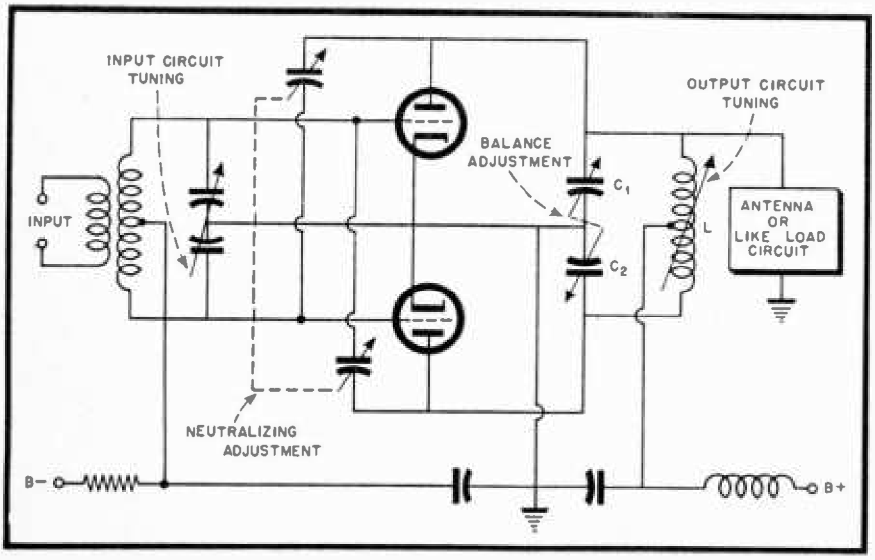
Balancing System

★ An apparatus for connecting a push-pull amplifier into a single-ended load and then quickly and conveniently tuning and balancing the system is the subject of a patent recently issued to Paul D. Andrews. The primary feature of the invention is embodied in a special two-gang variable condenser built so that the capacitance of the two sections when measured in series remains essentially constant even though the capacitance of the separate sections can be varied over the same range as the usual variable condenser. As the shaft is turned, whenever the capacitance of one section decreases the other increases so as to keep the sum of the reciprocal values constant. The use of such a device makes it possible to separate the adjustment needed for balancing and for tuning and hence greatly simplifies the adjustment of either control.

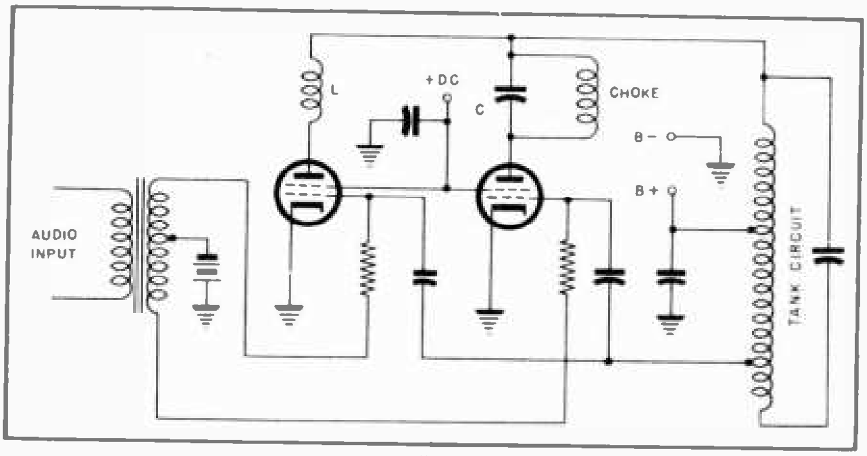
A circuit of one form of the invention is shown in the accompanying diagram. An ordinary push-pull amplifier stage is shown with a tunable input and output resonant circuit and adjustable neutralizing condensers installed in the usual way. The condenser in the output circuit, however, is of the special type just mentioned so that as far as the tuning of that circuit to resonance is concerned the capacitance may be considered as fixed and the adjustment made by appropriate change of the variable inductance without any regard to the condenser setting.

At the same time, however, adjustment of the special condenser will change the relative impedance seen by the plates of the two vacuum tubes and allow the circuit to be balanced to an even push-pull operation even though one side of the load is grounded.

The patent, number 2,380,389, is assigned to the General Electric Company.



Patent #2,380,389



Patent #2,388,098

Wave Length Modulation

★ A system in which an audio signal causes the wave length of an r-f oscillation to change in accord with the instantaneous amplitude of the audio voltage is described in a patent recently issued to George L. Usselman.

This type of modulation is essentially indistinguishable from phase or frequency modulation, and is basically a form of angular velocity modulation.

As is shown in the accompanying diagram, the invention consists of a Hartley oscillator which employs two vacuum tubes connected in parallel except that one vacuum tube has an inductance connected in series with its plate while the second includes a condenser at the corresponding point. The condenser is shunted with an r-f choke but that choke plays no role except to provide a d-c path to the plate. If the vacuum tube with the inductance in its plate circuit were the only one used, the phase of the energy fed to the plate circuit would be advanced over what it would be with the usual Hartley oscillator and the wave length of the resulting oscillation would in consequence be shortened.

This is essentially the situation which exists when the audio signal is such as to bias the second vacuum tube to a point near cut-off. Conversely, if the vacuum tube with the condenser in its plate circuit were the only one used, the phase of the energy supplied to the tank circuit would be retarded and the fre-

MOBILE RELAY BROADCASTING

HAROLD E. ENNES

Radio Station WIRE

Methods and apparatus employed in broadcasting from mobile units

THE SPECIAL EVENTS department of a radio broadcast station calls not only for remote control facilities entirely dependent upon wire-line links, but also upon facilities which may be used anywhere, anytime, without delays occurring from installation of wire lines. Indeed, many special events to be broadcast cannot be restricted by a wire-line broadcast loop due to the nature of their origin. Broadcasts of this type include pickups from airplanes, boats, trains, automobiles or other mobile conveyances. The special event may be a golf tournament, boat race, parade, or any other conceivable event of general interest to to the radio audience. In addition to these scheduled special events, the broadcast industry must be prepared in the interest of public service to cover adequately such emergencies as major fires, floods, and disasters. Some of the most colorful broadcasts in radio history have been made possible by the thought, preparation, and readiness of the engineers concerned with mobile unit and pack transmitter broadcasting.

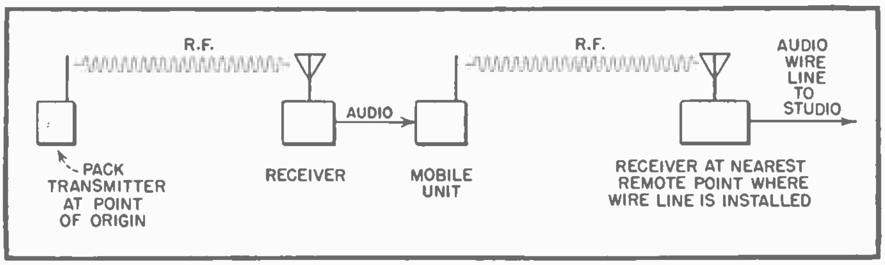


Fig. 1. Schematic of typical mobile relay broadcasting system.

General Set-Up

Regardless of the type of special event to be described, the basic method of achieving the final result is outlined in *Fig. 1.* The pack transmitter may be carried on the back of a person walking, or may be installed in a boat, airplane, etc., where necessary to cover the scene of action. This particular r-f link need not be required, of course, where the main mobile unit may be in position to cover the scene of action. For the sake of simplicity, this figure illustrates only the sending facilities for putting on the broadcast. In actual practice, it is necessary that additional receiving equipment be available to receive cues from the studio as to when to start the program, as well as to ascertain the success of the pickup prior to going on the air. In many installations, two-way communication is carried on between the studio and remote point of the main mobile unit, with another two-way link between the mobile unit and pack transmitter. Some pack transmitters have a built-in receiver with separate antenna for this purpose.

General Equipment Requirements

The problem of power supply and convenience of portability or mobile use set certain limits to the power rating of transmitters for this type service. The conveyance used to house and transport the mobile unit will range from a small car or station-wagon to elaborate tractor-trailer outfits. The available sources of power and their limitations are outlined as follows:

Dry batteries. Dry-cell batteries are the ideal power supply for receivers and low-powered transmitters due to the pure direct current and practically zero

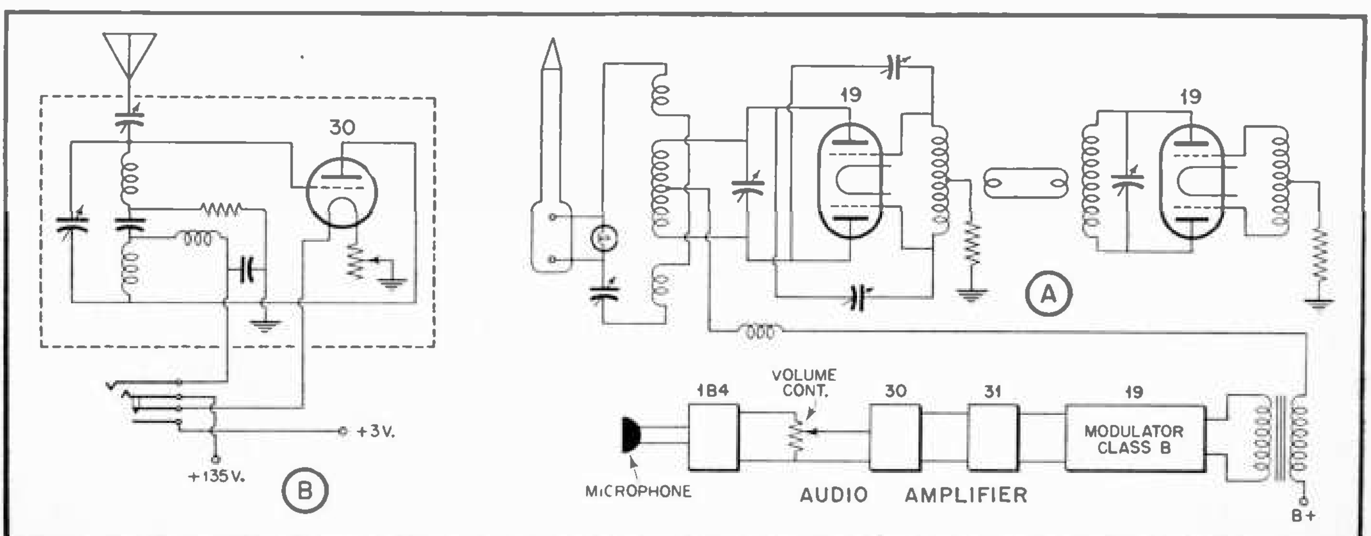
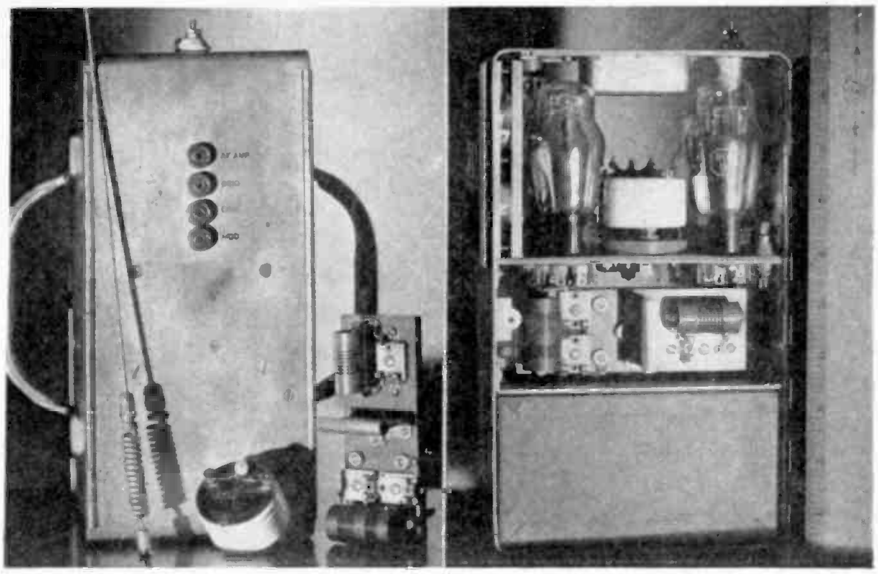


Fig. 3. (A) Typical pack transmitter with (B) monitor and cueing circuits.



Beer Mug handie-talkie, used by NBC. This is a completely self-contained unit. Coils, crystal, and loaded antenna at left. Pin jacks are for test purposes. Layout of components shown at right.

voltage regulation characteristics. This source of power is always used for small portable transmitters and pack transmitters. Their disadvantages are, of course, weight and low current capacity, which limits their use to the lowest powered equipment.

Storage batteries. This type battery is one of the most important and common source of power supply, due to its high initial capacity and recharge characteristics. A 6-volt storage battery is often used to supply the filaments directly, and to furnish plate voltages by means of a-c converters employing vibrators, dynamotors, or genemotors. The power drain may be around 20 amperes, which provides sufficient power for many mobile transmitters up to 30 watts of carrier power. Several of these batteries may be used in parallel to supply a transmitter up to 50 or 75 watts of carrier power, which is the limit of most mobile transmitters used in broadcasting service.

Vibrators. The usual vibrator-transformer power supply, operating from a storage battery, can furnish only about 400 volts at 200 ma. Thus, if a separate vibrator-transformer is used to supply the final amplifier alone, the carrier power will be limited to about 50 watts.

Genemotors. The genemotor has found wide accepance for mobile relay work, having good regulation, efficiency and low operating cost. A standard model is, in general, limited to about 500 volts at 10 ma. Series, parallel, and series-parallel operation is of course possible to supply any voltage-current requirements necessary for nearly any mobile unit installation.

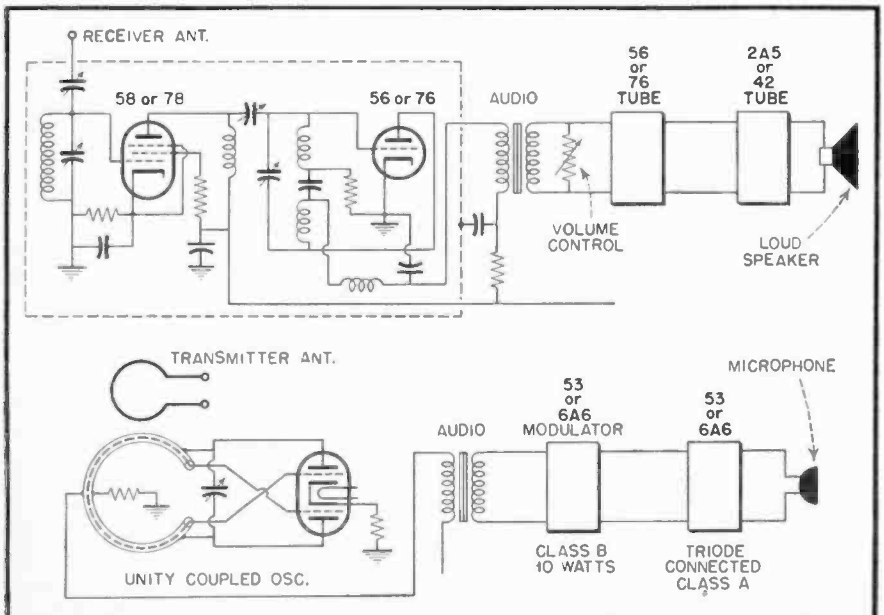


Fig. 4. Transmitter-receiver unit for mobile broadcasting.

Generators. The motor-generator set is a very common means of power supply for mobile units. This is particularly true for higher-powered mobile systems, and has the advantage of allowing standard a-c receivers and other equipment to be "plugged-in" to an outlet, in the truck with no changes or specially designed power wiring in the equipment. The 110 volt a-c motor-generator is available from 250 watts to two kilowatts rating.

Pack Transmitters

Fig. 2 illustrates one type of portable pack transmitter, shown in action at an NBC pick-up of the Normandie fire. These small transmitters are always powered by batteries. *Fig. 3* is a schematic of a typical pack transmitter, including a monitor and cueing circuit. Transmitters of this type have a very limited range, and are usually used to relay the signal to a truck housing the mobile transmitting and receiving equipment as sketched in *Fig. 1*. The actual range, of course, will depend upon the general topography of the land, and as long as line-of-sight is maintained between the pack transmitter and the receiving antenna, no difficulty need be expected. A small plate provided on the end of a wire for cueing purposes is carried in the pocket. The transmitting antenna rod is extended to ¼ wavelength.

Portable and Mobile Equipment

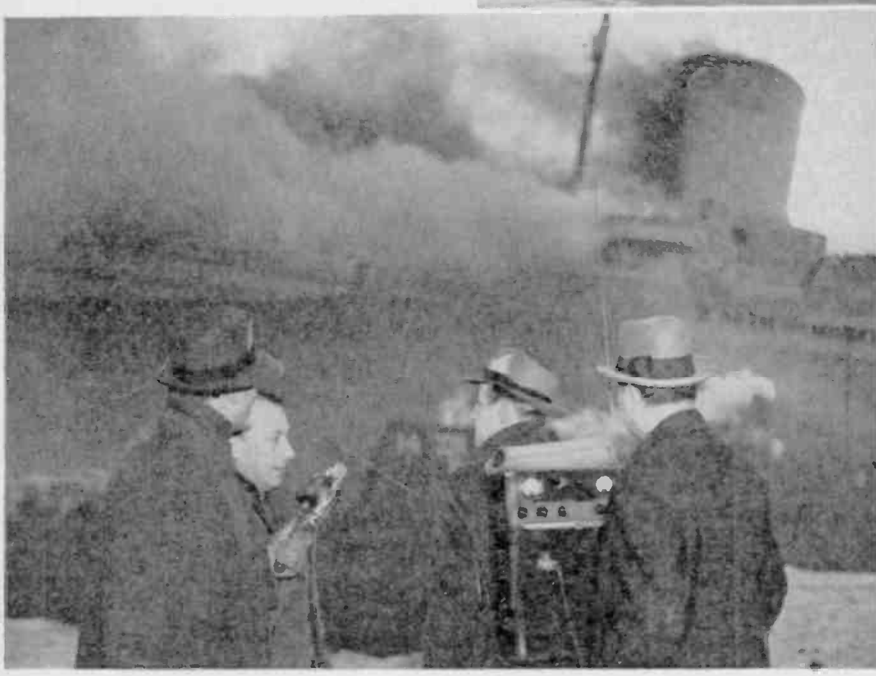
Fig. 4 is a schematic diagram of a duplex transmitter-receiver, combining a transmitter of 7-watt carrier and a 4-tube super-regenerative loudspeaker receiver. This transceiver provides a conveniently portable outfit that finds wide utility in relay work. Equipment of this type is not confined to automobiles; it may be set up out in open ground away from the absorptive effects of steel in vehicles, and an antenna system erected as elaborately as time and conditions will permit.

Higher power mobile transmitters, permanently installed in cars, are used in many cases. The range of transmission for satisfactory broadcast reception will depend, to a very great extent, upon the type of antenna system employed for both transmitting and receiving stations.

Antennas

The range of pack transmitters or portable or mobile transmitters operating in the u-h-f bands will depend entirely on the careful adjustment and type of antenna used. The distance covered by simple non-directional antenna systems is limited to about 20% in excess of the distance to the horizon as seen from the transmitter antenna, varying, of course, an amount dependent on the height of the receiving antenna. A non-

Fig. 6 (right). Relay broadcast pickup at a flood. Fig. 2 (below). Pack transmitter in use at the Normandie fire. *(NBC photos)*



directional antenna 100 feet high, for example, would be adequate for communication with a point at ground level 12 miles away. If this receiving antenna were also raised to 100 feet, the usable distance would be approximately 40 miles. A distance of 100 miles may often be achieved for reception of low-power signals from an airplane.

Satisfactory reception range has often been increased as much as 8 to 10 times by using directional antenna systems for both transmitting and receiving points. *Fig. 5* shows a mobile truck and transmitter pickup in operation, while the Army was taking over the Bendix Plant. The transmitter uses a highly directional antenna system. As an example of the effectiveness of directional systems, a comparison may be made with this type radiator to that of a non-directional antenna. For non-directional rods 50 feet above ground at each point, a maximum range of 15 miles may usually be expected. For a good directional array at either point and at the same height, a distance of 90 miles has been used with satisfactory results.

It is often possible, where the mobile truck may be set at a fixed point and not be required to be set in motion to follow a scene of action, to use a single long wire antenna stretched between two trees or other supporting structures. This procedure is often followed on mobile-relay transmitters operating on the lower frequencies assigned to mobile relay broadcasting. For actual mobile use, with the truck in motion, a rigid vertical radiator is usually used, loaded with the conventional coil and capacitor tuning unit. This is also satisfactory for use where only a limited range is required.

Fig. 5. Army at Bendix plant—showing directional antenna. *(NBC photo)*

Uses of Portable And Mobile Equipment

Many instances occur in broadcasting where regular "remote-control" pickups connected by leased telephone wires are aided by portable transmitting equipment. These are special features, differing in preparation from that necessary to cover emergencies and surprises. A great amount of planning and pre-broadcast preparation is necessary for adequate coverage of large conventions, Presidential inaugurations, openings of Congress, or elections. The coverage of the last national convention, for example, required the use of a specially

[*Continued on page* 30]

RADIO DESIGN WORKSHEET

NO. 50 – NOTE ON ANALYSIS OF PUSH-PULL AMPLIFIERS WITH NEGATIVE FEEDBACK

Making use of the feedback analysis involving recalibration of grid-voltage loci on the published plate family*, operation of the amplifier diagrammed in *Fig. 1* may be followed graphically. Composite characteristics are first set up without regard to voltage feedback from the two $R_2C_1R_1$ branches, according to established methods. The load R_L is reflected back as a plate-to-plate load R_L', and should the sum of R_2 and R_1 be sufficiently small that the value of R_L' is appreciably reduced, this fact should be taken into consideration when locating the load line on the composite characteristics.

The load line will then be drawn upon the back-to-back e_p-i_p coordinates through E_{bb}, the plate supply voltage (neglecting the small d-c resistance of the output transformer). The slope of the load line is the negative reciprocal of one-fourth of the effective plate-to-plate load resistance. The dotted lines shown in *Fig. 2* are obtained in the customary manner by averaging the plate currents. These particular characteristics present the *e-i* relation in the load for a 2/1 step-down output transformer; for other ratios the load voltage is modified accordingly.

Grid voltage e_c is defined in terms of e_i as $e_i = 2e_c$. The amplification of a single tube may be determined from the characteristics as $A = \Delta e_p/\Delta e_c$. It is evident that in general A will not be constant, since push-pull amplifiers may develop odd harmonics. Likewise, A varies symmetrically about the plate-supply voltage, since even-order harmonics are suppressed.

Next to be considered is the equilibrium attained between e_g and e_i with the feedback network closed. The term e_g is defined as the grid-cathode voltage resulting from the interaction of $\frac{1}{2}e_i$ and Fe_p, where F is the fraction of the output voltage returned to the grid by the voltage-dividing feedback mesh. The output voltage e_p is the plate-cathode swing along the abscissa corresponding to $\frac{1}{2}e_i$. But e_g is an actual grid-cathode voltage with an as yet unknown relationship to $\frac{1}{2}e_i$. When found, e_g will be used to recalibrate the e_c intervals of the plate family in terms of e_i.

The plate-cathode swing $e_p = Ae_g$, and e_g is composed of $\frac{1}{2}e_i$ plus the feedback component Fe_p, where $F = R_1/(R_1 + R_2)$. This assumes that the reactance of C_1 is very low. Or,

$$e_i = 2e_g(1 + FA)$$

This is the equation to be used for recalibration of e_c intervals, noting the proper values of A associated with successive e_c intervals. That is, each value of e_c is to be multiplied by the factor $2(1 + FA)$ and identified with this value of e_i.

Example of Analysis

In the circuit of *Fig. 1*, let the plate-to-plate load R_L' be 20,000 ohms, having taken into account if necessary the parallel feedback branches. This value of load is approximately twice R_p for a 6C5, and will afford maximum power output in Class A.

The slope of the load line is accordingly –0.0002, as shown in *Fig. 2*. The plate supply voltage E_{bb} is taken as 250 volts, and the static grid bias as –10 volts. The voltage amplification A of one tube is required, as plate-cathode voltage is used to energize the feedback network. A is seen to vary progressively with successive increments of e_c: 7.25, 7.5, 6.25, etc.

*Radio, March 1946, p. 23

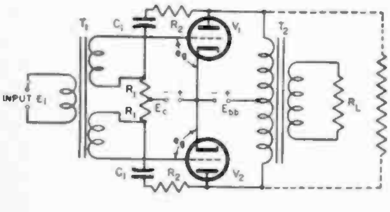


Figure 1

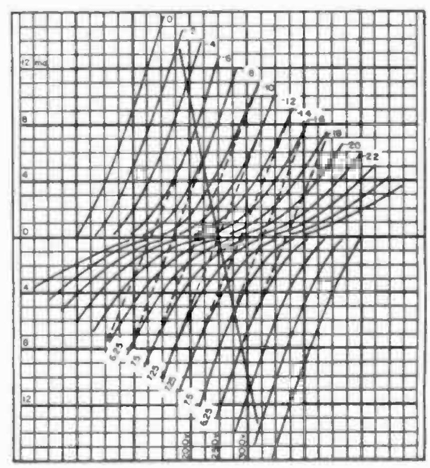


Figure 2

The final factor required is the ratio of R_1 to R_2. Assuming that 25% of e_p is fed back, the recalibration equation becomes

$$e_i = 2e_c(1 + .25A)$$

or, tabulating resulting values:

When $e_c = -10$ (0 volts with respect to -10), $e_i = 0$

When $e_c = -8$ (2 volts positive with respect to -10)
$e_i = 2(+2)(1+25 \cdot 7.25) = +11.25$

When $e_c = -12$ (2 volts negative with respect to -10) $e_i = -11.25$

When $e_c = -6$ (4 volts positive with respect to -10)
$e_i = 2(+4)(1+25 \cdot 7.5) = +23$

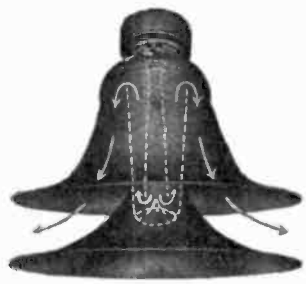
When $e_c = -14$ (4 volts negative with respect to -10), $e_i = -23$

These values may be noted above their associated grid-cathode voltages on the characteristics, if desired. For purposes of interpolation to obtain integral values of e_i, an e_c-e_i curve may be separately graphed on coordinate paper.

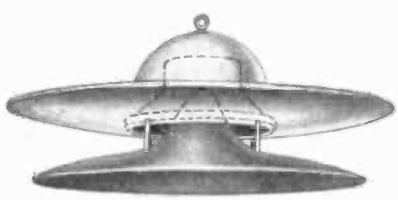
Making use of the foregoing technique, a complete graphical analysis of the transformer-coupled push-pull amplifier with negative feedback is made available. Distortion products may be evaluated by graphing the output waveform for sinusoidal input and making a schedule analysis in the conventional manner.

RACON SPEAKS FOR ITSELF

MARINE SPEAKER; approved by the U. S. Coast Guard, for all emergency loudspeaker systems on ships. Re-entrant type horn. Models up to 100 watts. May be used as both speaker and microphone.



RADIAL HORN SPEAKER; a 3½' re-entrant type horn. Projects sound over 360° area. Storm-proof. Made of RACON Acoustic Material to prevent resonant effects.



RADIAL CONE SPEAKER; projects sound over 360° area. Cone speaker driven. Will blend with ceiling architecture. RACON Acoustic Material prevents resonant effects.

AEROPLANE HORNS; super-powerful and efficient P.A. horns for extreme range projection. 9-4-2 single unit trumpets available.

Indoor — outdoor or on shipboard — RACON SPEAKERS, HORNS, and DRIVING UNITS are *designed* for every conceivable application.
Racon's precision manufacture assures maximum efficiency and high fidelity "true-tone" reproduction even at full power output. All-weather construction design makes Racon speakers impervious to any climatic condition, prevents resonant effects, assuring long, rugged, trouble-free service. Specify and use RACON! All types now available. Write us your requirements now — get our new catalog.

RACON

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52 EAST 19th ST. NEW YORK, N. Y.

This Month

FEDERAL PRODUCES FIRST TUBES FOR 50 KW FM TRANSMITTERS

The first FM broadcast tubes for 50 kw FM transmitters have been developed by the Federal Telephone and Radio Corporation, Newark, N. J. Two of these tubes, with a rated output each of 25 kw at 110 mc are shown in the photograph, with Norman E. Wunderlich, executive sales director (right), discussing them with F. X. Rettenmeyer, chief engineer.

S.L.U. GETS FM

St. Louis University, the first institution of higher learning to operate a radio station, will now be the first university to go on the air with frequency modulation, as the result of a contract for a 10 kw f-m transmitter and association equipment complete from microphone to antenna, with the Federal Telephone and Radio Corp., Newark, N. J. Announcement of the contract has been made by Nicholas Pagliara, general manager of the university radio station WEW, and N. E. Wunderlich, executive sales director of Federal.

Included in the equipment contracted for is a Federal 8-element Square Loop Antenna, with a gain of nine, which will give WEW an effective radio power of 90 kw—providing more power and more listening pleasure for the university's educational and religious programs, as well as its commercial broadcasts. An interesting feature of the antenna installation is that space will be left above the eight-loop array for the future installation of a 485-600 mc color television broadcast antenna.

RIPLEY EXPANDS

To provide additional plant facilities, Ripley Co., Inc., has purchased the former Pratt, Read & Co. plant at Deep River, Conn.

Louis R. Ripley, announcing the acquisition, stated that the new plant will begin production shortly of several new items while the company's plant at Torrington, Conn., will continue to be used primarily for research, design, and development operations.

The plant facilities at Deep River comprise eleven buildings, the largest being a five-story brick structure containing approximately 125,000 square feet of floor space, and completely equipped with a sprinkler system. A generating plant to supply power is included in the new property which covers approximately 3½ acres.

The Ripley Company, Inc., was organized recently to acquire the United Cinephone Corporation, the L-R Manufacturing Company, and The Ripley Company, all of whom were engaged in the electronics business in Torrington, Conn., for a number of years.

OSRD PAPERS TO LIBRARY OF CONGRESS

The largest scale dissemination of scientific information in history has just begun with the transfer of a mass of scientific documents by the Office of Scientific Research and Development to the Library of Congress for free distribution to universities and libraries throughout the United States.

These valuable documents, the results of the tremendous war-time research program of OSRD, were compiled by leading scientific minds of our country. The Navy's office of research and inventions, after collecting the first 100,000 research documents, suggested transfer of the total OSRD collection to the Library of Congress and lent its full support to this transfer project.

The OSRD, which is now in the process of liquidation, has transferred funds for this project to the Library of Congress. Had these funds not been made available, the distribution of surplus copies of OSRD reports would have been extremely limited, thus losing to American interests the results of a huge investment in research. Because of the foresight of the Bureau of the Budget and the Office of Scientific Reserch and Development in approving and transferring these funds, and the support given by ORI, this great mass of information soon will be made available to colleges, universities and libraries throughout the country at no cost whatsoever.

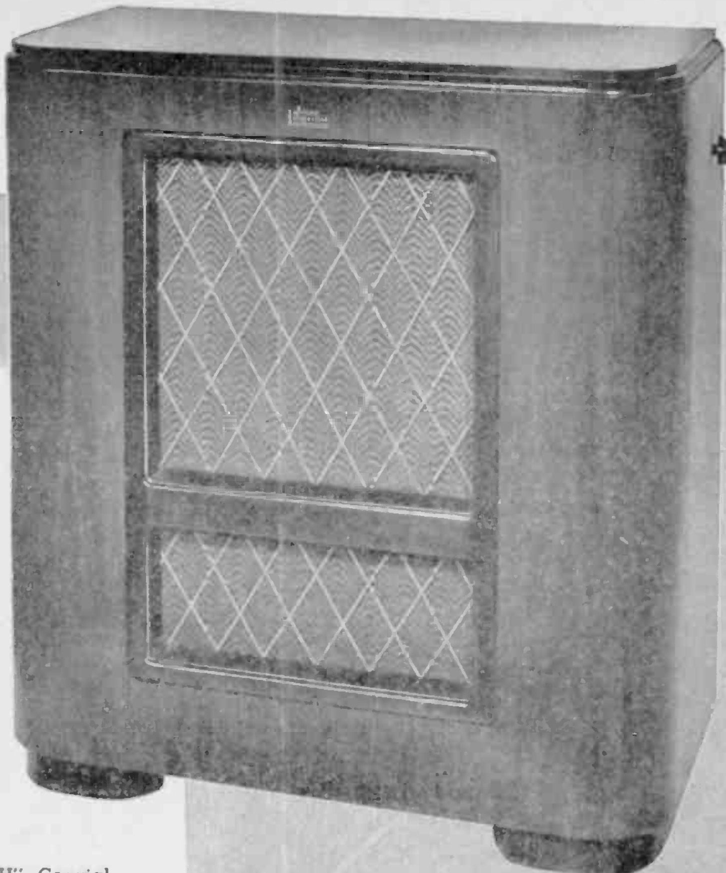
Titles of the reports cover a heterogeneous range from Microwave Radar Reflections (M.I.T. Laboratory, Dec., 1945) to Progress Report on Physical and Stress Corrosion Properties of Magnesium Alloy Sheet (Rensselaer Polytechnic Institute, March, 1945). These reports should be of interest and use to scientists, educators and industrialists in many fields.

COLOR TV BY BENDIX

CBS recently announced that it has licensed the Bendix Radio Corporation to manufacture color television receivers for home use as well as transmitter equipment, based on CBS' ultra-high frequency color television inventions.

Bendix thus becomes the third major firm licensed under Columbia's color television patents; the other two are the Westinghouse Electric Corporation and the Federal Telecommunication Laboratories, Inc. [*Continued on page* 28]

Dr. John R. Pierce of Bell Labs holds new amplifier tube with a power gain of 10,000 over a bandwidth of 800 mc. Tube is designed to operate in the 5000-mc region.



Jensen

TYPE "RD"

Reproducer

WITH THE NEW TYPE "H"

ARTICULATED *Coaxial*

This new Reproducer, combining the Type "H" Coaxial speaker with the new Jensen Type "D" Bass Reflex* cabinet, offers superior reproduction of your favorite program material and is unconditionally recommended for FM receivers, high quality phonograph reproduction, reviewing studios, monitoring, and home and public entertainment generally.

The cabinet is beautifully styled and fashioned of satin finish striped walnut. The harmonizing grille fabric is overlaid with a protecting pattern of flat, interlaced bronzed strips.

The Type "H" Coaxial, with all **ALNICO 5** design, employs a h-f horn and l-f (15-inch) cone which are electrically and acoustically coordinated to achieve brilliant and natural response throughout the entire useful frequency range. The frequency dividing network has variable control in the range above 4,000 cycles. Nominal input impedance to dividing network, 500 ohms; maximum power handling capacity 25 watts, in speech and music systems.

Model RD-151 Reproducer complete, approximate list price $180.

*Trade Mark Registered

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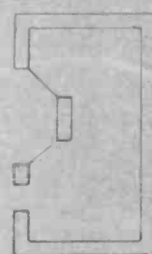
In Canada—Copper Wire Products, Ltd., 11 King Street, West, Toronto

JENSEN BASS REFLEX

Acoustically-correct Bass Reflex Cabinet gives smoothly extended low register. Better than an "infinite" baffle . . . efficiently uses back radiation too.



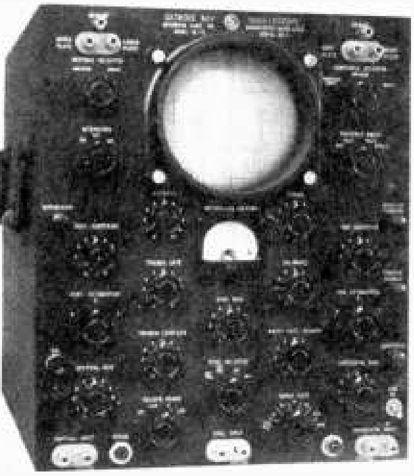
Jensen SPEAKERS WITH ALNICO 5

Specialists in Design and Manufacture of Fine Acoustic Equipment

New Products

GENERAL PURPOSE OSCILLOSCOPE

An omni-purpose 5-inch oscilloscope, Model 0L-15, is announced by Browning Laboratories, Inc., of Winchester, Mass.



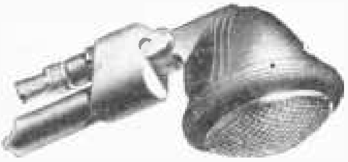
The instrument has been designed to be of the utmost usefulness to those requiring versatility of operation, dependability, minimum weight and bulk, and faithful presentation of high harmonic content waves.

Among the more salient features claimed is the response curve of the vertical amplifier which is linear and without positive slope from 10 cycles to well over 4 mc and having transient response such that a 100 kc square wave with rates of rise and fall in the order of 400 volts per microsecond is faithfully reproduced. The horizontal amplifier response extends linearly from 10 cycles to over 1 mc to accommodate any type of externally generated sweep voltage which one may wish to employ. The sawtooth sweep range is from 5 cycles to 500 kc with synchronizing sensitivity permitting synching and viewing 10-mc r-f sine waves.

Triggered sweeps of 1, 4, 20, and 200 microseconds per inch may be inaugurated by the internal trigger generator or by external pulses. Sweeps and internally generated trigger are phasable with respect to each other so that the sweeps may be adjusted to occur previous to or following the output triggers by varying degrees.

OUTDOOR MIKE

Among the new line of dynamic microphones now being manufactured by the St. Louis Microphone Company is an outdoor microphone.



Engineered to fit specific applications, it is a modern design, rugged in construction. With a range of 40-9000 cycles, it is built to take the toughest treatment under the worst operating and climatic conditions. Equipped with an Alnico-V magnet, the variable impedance output is adjustable to low, 200, 500 or high.

For further complete information, write St. Louis Microphone Co., 2726-28 Brentwood Blvd., St. Louis 17, Mo.

HOLE CUTTER

A new all-purpose adjustable hole-cutting tool is announced by Bruno Tools of Beverly Hills, California. This unique new tool cuts smooth large-size holes in wood, steel, brass, hard rubber, aluminum, fibre, plastics and problem materials which might necessitate use of torches or other expensive equipment. The Bruno Adjustable Circle Cutter cuts holes to any diameter from 1-7/8" to 8" through 1/4" thickness in steel or other tough metals and any thickness up to 1-1/2" in

plastics, fibre or wood. (Thickness capacities may be doubled if cut is taken from both sides of material). The tools are designed to operate in any standard drill-press, wood-worpking machine, or suitably mounted spindle machine.

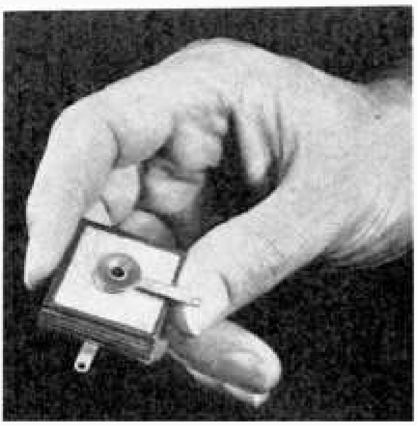
For prices and complete specifications, write to Bruno Tools, Beverly Hills, California.

FM BY FEDERAL

Containing block diagrams, schematics, photographs and technical descriptions, a new 32-page bulletin issued by the Federal Tel. & Radio Corp. presents much useful information concerning their 10 kw, 20 kw, and 50 kw f-m broadcasting transmitters. A comprehensive discussion of center-frequency control is included.

SELENIUM RECTIFIERS

Selenium rectifiers, now assuming enlarged scopes of application, are discussed in two new bulletins issued by Federal Tel. & Radio Corp. A useful four-page folder presents circuits for ac-dc radio rectifier application, with regulation curves for selenium units compared with tube rectifiers.



An 8-page bulletin titled Standard Selenium Rectifier Equipments presents photographs of various power supplies, battery chargers, and plating equipment, with technical specifications.

Both bulletins are printed in two colors; they are available on request to the manufacturer.

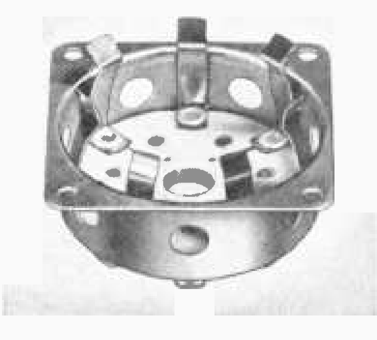
TRANSFORMERS

Describing both audio and power transformers, the new 12-page catalog entitled "Acme in Review" presents interesting production pictures as well as information concerning the transformers manufactured. The catalog is available from Acme Electric Co., Cuba, N. Y.

Other bulletins issued by the company are entitled Insulation Breakdown Tester, Voltrol, Stepdown and Voltage Adjuster, Neon Bulletin, Air-Cooled Transformers, Cold-Cathode Transformers, Radio Transmission, Cold Cathode Ballasts, Portable Power Transformers, Fluorescent Ballasts, Specification Transformers, Battery Chargers, Bell-Ringing Transformers, Control Transformers.

NEW SOCKET

E. F. Johnson Co., Waseca, Minn., announces an addition to their line of tube sockets, the 122-101. This socket is designed especially for top performances from 826, 829 and 832 transmitting tubes. It is a ceramic socket with an aluminum base shield, and is designed so that button mica by-pass capacitors may be mounted directly on the tube socket base, thus en-



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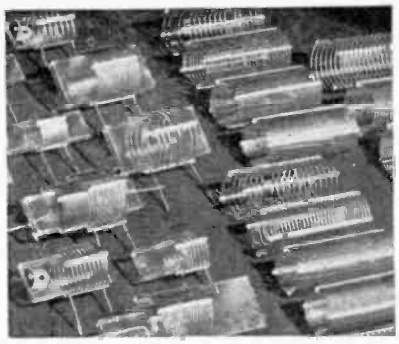
abling the tube to be used at its highest frequency.

Other features include grid terminals designed so that the connecting wires may be isolated from other circuits and especially constructed to permit small grid coils to be mounted directly on the terminal ends, thus eliminating connecting leads.

MINIATURE R-F COILS

"Miniductors", a peacetime adaptation of the wartime miniature r-f coils developed by Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa., are now being packaged in standard two and three inch lengths. They are supplied in diameters of ½", ⅝", ¾" and 1", and each diameter is available in four winding different pitches.



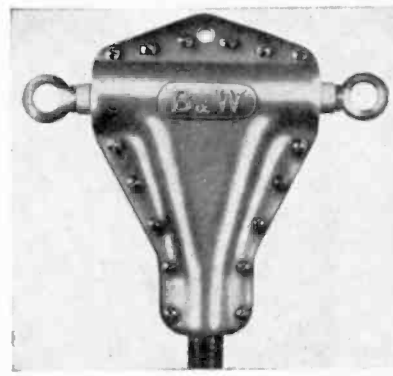
Although lengths have been standardized, the coils may be cut down to any desired size.

The compactness of these miniature coils, their high Q and wide variety of uses have made them a favorite for a wide variety of applications. These include use as tank circuit coils, r-f chokes, high frequency i-f transformers, loading coils and in many other ways. They can even be slit lengthwise and flattened to make Faraday shields.

NEW CABLE CONNECTOR

A new coaxial cable connector, CC-50, just introduced by Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa., provides both commercial stations and amateur operators with a means of making efficient, water-tight coaxial cable connections for antennas. It also serves as center insulator for a half-wave doublet.

The "CC-50" Connector is made of aluminum with steatite insulation and has two forged steel eyebolts that are

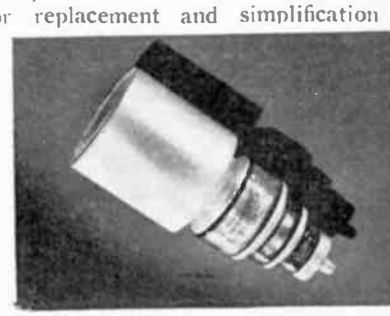


equipped with convenient soldering connections. A bottle of weatherproof cement and a piece of 5/8" outside diameter rubber tubing, plus the necessary assembly screws are supplied with each connector. The assembled connector weighs 12 ounces.

H-F FM TETRODE

A new screen-grid transmitting tube, Type GL-7D21, has been announced by the tube division of General Electric Company's electronics department.

Feature of the new h-f power tube for FM is ring-seal contacts (filament, grid and screen terminals are designed to permit plug-in methods of installation) which means fast tube installation or replacement and simplification of



equipment design, according to J. E. Nelson, sales manager of transmitting and industrial tubes for the division. Designed as a class C radio frequency amplifier with low driving power, the new tube will be useful for FM applications since the completeness of screen shielding between grid and anode minimizes problems of neutralization, he said.

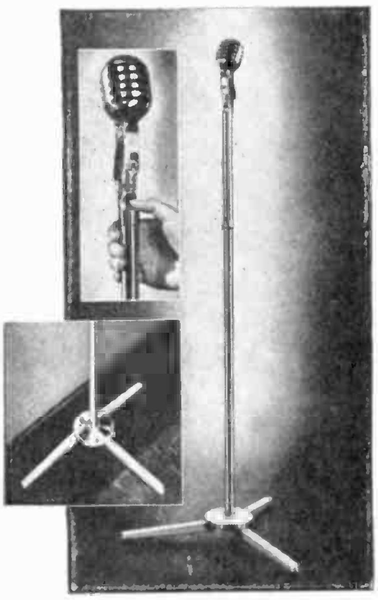
The new GL-7D21 is designed with

minimum internal inductance. There is complete internal shielding of the four electrodes, and provision for an r-f ground plane makes possible external shielding as well. The anode is forced air-cooled and is capable of dissipating 1200 watts. Maximum ratings apply up to a frequency of 110 megacycles.

The new tube has a plate rating sufficiently large that a pair will handle output for a 3-kw FM transmitter. A total driving power of less than 150 watts for two tubes is achieved.

MICROPHONE FLOOR STAND

A new unique microphone stand, designed strictly in conformity with its



function and operation, is offered by Electro-Voice, Inc., South Bend, Indiana.

The stand is modern, streamlined and finished in rich satin chrome. Height adjustment: from 37" to 66". Three-leg spread: 17". Net weight: 7½ lbs. For full details write to Electro-Voice, Inc., 1239 South Bend Ave., South Bend 24, Indiana.

NEW CAPACITOR CATALOG

Condenser Products Company, 1375 North Branch Street, Chicago, Ill., has their new two-color catalog off the press and available for distribution. It gives technical data on Plasticon and silicone filled capacitors, a-c and d-c capacitors, glassmikes and energy storage, photoflash and welding capacitors. Complete information on applications, specifications, prices, dimensions, etc., are listed in the catalog.

SQUARE-LOOP ANTENNA

Technical data, illustrations, performance curves and prices of the new f-m square-loop antenna are presented in a 16-page booklet issued by Federal Telephone and Radio Corp., 67 Broad St., New York City.

Various installation data and tower dimensions are indicated, and point-by-point comparisons with RMA specifications are made. Transmission-line details are shown, giving a bird's-eye view of the complete technical problem to be considered by the f-m station engineer.

The booklet is attractively printed in two colors.

KOVAR SEAL TRIODE

Machlett Laboratories, Inc., of Springdale, Connecticut, announce the addition of an improved type 889-A high frequency,

water-cooled triode to their line of high power transmitting tubes. This tube features the use of heavy sections of Kovar for the glass seals rather than the conventional type of feather-edge copper seals.

THIS MONTH

[*from page 22*]

In announcing the agreement for his firm, Charles Marcus, vice-president in charge of engineering for the Bendix Aviation Corp., said plans also call for the establishment of an experimental color television transmitter at the research and engineering laboratories of the main Bendix radio plant in Baltimore, Md.

Capt. W. H. G. Finch examining a facsimile "newspaper" at the first demonstration of airborne facsimile sponsored jointly by Finch Telecommunications, Inc., and Capital Airlines-PCA. This is expected to be a potential forerunner of radio-operated newspapers for air travelers.

James W. McRae

Dr. James W. McRae, electro-visual engineer for Bell Telephone Laboratories, has been appointed director of radio projects and television research for that organization, it was announced last night.

Dr. McRae became associated with the Laboratories in 1937 when he undertook research on transoceanic radio transmitters at the Laboratories Deal, N.J., location. In 1940, he turned to a study of microwave techniques, especially their use in radio relay systems, and, with the approach of war, to the construction of a microwave communications transmitter for the National Defense Research Committee. This was followed by a general study of radar possibilities and subsequent investigation of microwave radar components.

MOBILE RELAY

[*from page* 19]

designed master control board right in the convention hall where all the microphones and the various pickups were switched in and out of the main program channel, with provisions for cueing each announcer spotted throughout the convention hall. Quite a large number of microphones were necessary, some for the band, some to pick up the voting of each delegation, some for the speakers' platform, and others for the announcers at the various places in the hall. Added to this were several pack transmitters which enabled the announcers to roam about through the attendants at the convention to catch the "gossip" and lend "color" to the broadcast.

At one Presidential inauguration, a major network used a complete master-control board under the steps of the Capitol, a blimp in which was installed a short-wave transmitter and a "cue" transmitter atop the Washington Monument. This particular pickup, incidentally, required the services of 20 engineers, 2 commentators who could broadcast the description in French and Spanish, 18 other announcers, and approximately 30 microphones.

Although portable and mobile relay equipment is widely used in regular and scheduled special events, perhaps their most important function is the readiness with which the unpredictable occurrences may be brought before the waiting people via their radios. Just as with the press, speed is of prime importance in radio spot news. Equipment must be kept in readiness, fresh and spare batteries in place, and trucks ready to roll in short order.

The famous Louisville flood of 1937, when the Ohio river flooded a large portion of the city and disrupted power and telephone service saw portable and mobile equipment functioning in its most fitting manner. *Fig. 6* shows how a pack transmitter carried in a boat was the means by which a description was relayed to a mobile unit on land, where the signal was again relayed with higher power to a point where telephone lines were available.

The Squalus submarine sinking was an instance of a sudden tragedy that was brought by radio to the listening world awaiting eagerly the news of rescue attempts. A master-control and transmitter were set up in the Portsmouth navy yard. Another short-wave unit was installed on the destroyer Brooklyn, which was anchored at a point close to where the Squalus sank. A small launch was used to carry a third transmitter, and this launch cruised over the point of the sunken submarine. Some of the members of the Squalus were fortunate enough to have escaped death, and the dramatic rescue was broadcast "on the spot" by use of portable and mobile type broadcast equipment.

LOW NOISE DESIGN
[*from page* 11]

Equation (10) gives the solution for X_3

Equation (26) gives the required value of reactance necessary in parallel with the load R_2 to make it look like R_L. The series equivalent X_{ss}, which changes X_2 can be calculated from equation (25). X_2 has to be increased the amount of X_{ss} in order to keep the original conditions. It is interesting to note that the maximum value of X_{3s} results when X_3 is equal to R_2 of the pi network. Any increase or decrease of X_3 from this value results in a decrease of X_{3s}. Since the tuning of a pi network can be changed by any of the reactances it is quite obvious why the cut-and-try method is confusing. *Important to note is that if X_3 is increased, reducing R_2, the power transfer will increase to a point of over-coupling and low Q. As X_3 is further increased R_2 decreases more but X_2 starts to increase with the result of higher Q and under-coupling.*

One of the legs of the network must be of opposite reactance to the other two so that the result is a positive number and its square root a pure resistance. The image impedance in this case is resistive.

As mentioned in the first part of this article, $(R_1R_2 - X_2^2)^{1/2}$ must be real. In this case X_2 can take on a number of values if $X_2^2 < R_1R_2$. It is possible to get a match for different values of X_2 but the Q will change. Also X_2 can be negative or positive which would dictate that X_1 and X_3 would have to be of opposite signs. In the input circuit X_1 and X_3 would be selected to be negative in order to gain harmonic attenuation. X_2 in this case would be an inductance with X_1 and X_3 capacitance. X_2, also, should be as high as permitted. Theoretically, when $X_2^2 = R_1R_2$ the pi network takes on the form of a quarter wavelength section with minimum attenuation.

Known Conditions

The known conditions up to this point: i-f frequency 30 mc, crystal impedance 400 ohms (R_1), distributed capacitance across the crystal detector 30 $\mu\mu f$, bandwidth 15 mc and neutralized input load 752 ohms (R_2). The Q of the network will be approximately two. Below a Q of 9, where unity power factor and maximum impedance do not occur simultaneously, equation (19) does not hold as accurately but still provides a close result to use.

From equation (20)

[*Please turn to page 32*]

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$X_1 = X_2 = R_1/Q = 400/2 = 200$ ohms

From equation (21)

$R_L = X_2/Q = 200/2 = 100$ ohms

This indicates that a resistive load of 100 ohms will match 400 ohms when $X_1 = 200$ ohms and $X_2 = 200$ ohms.

To make the actual load of 725 ohms appear as 100 ohms, the load has to be shunted by a reactance. Equation (26) will yield this result.

$X_3 = -725[100/(725-100)]^{1/2} \cong 295$ ohms

$X_{3S} = -\{(725)^2(295)/[(725)^2+(295)^2]\} = 245$ ohms

The series equivalent is calculated from equation (25)

In this case X_2 would have to be increased 245 ohms to keep the original conditions. X_1 has been assumed to be 30 μμf, equal to approximately 180 ohms at 30 mc. The matched value of X_1 calculated is 200 ohms. In order to reduce X_1, X_2 will have to be reduced slightly

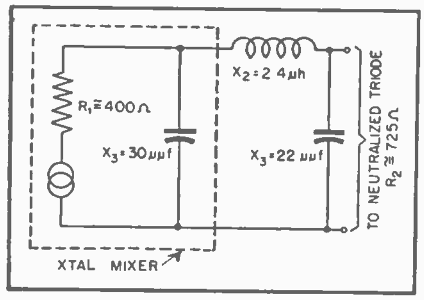

Fig. 6. Final design of pi filter for input to neutralized triode.

or X_{3S} increased. By watching a signal-to-noise ratio output meter the proper variable can be changed. *Fig. 6* shows the final results.

In *Fig. 6* the crystal distributed capacitance is used as X_1.

It might be well to mention also that the characteristic response can be "flattened out" by shunting X_2 with a pure resistance. The keep the cathode current of the 6J6 from flowing through the crystal a blocking condenser can be placed between the mixer and X_2. An r-f choke would then be placed across X_3 for the cathode return to ground. If an inductance is used in place of X_3 the r-f choke can be eliminated.

ADVERTISING INDEX

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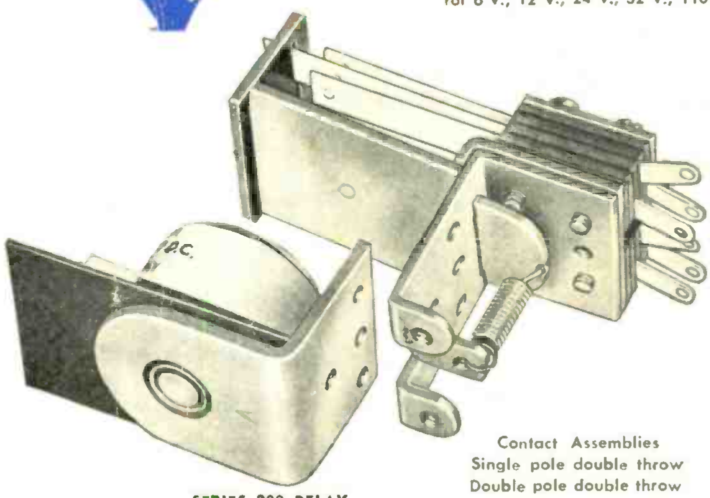

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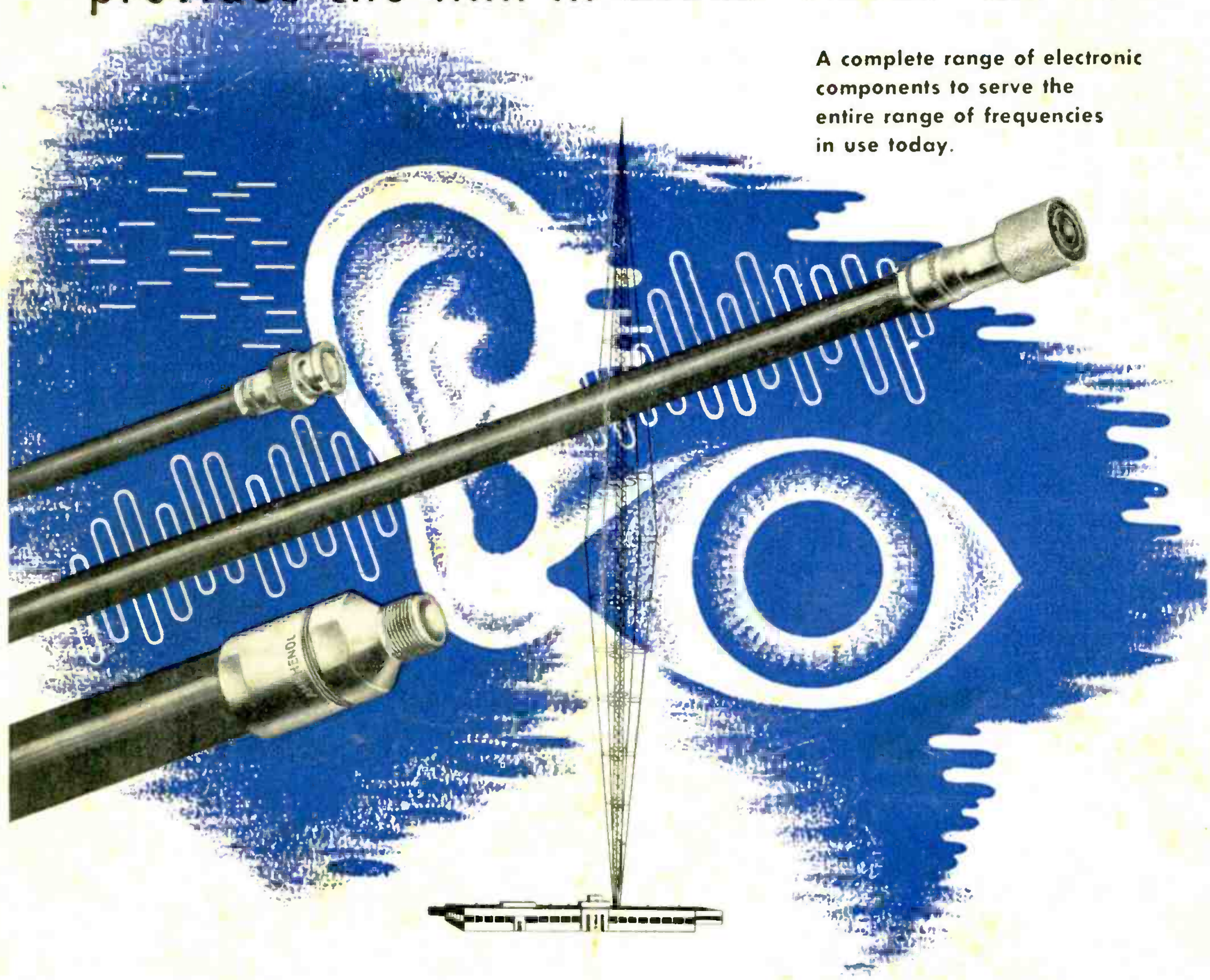

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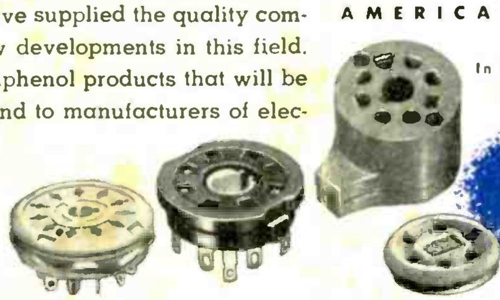

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