DECEMBER, 1934

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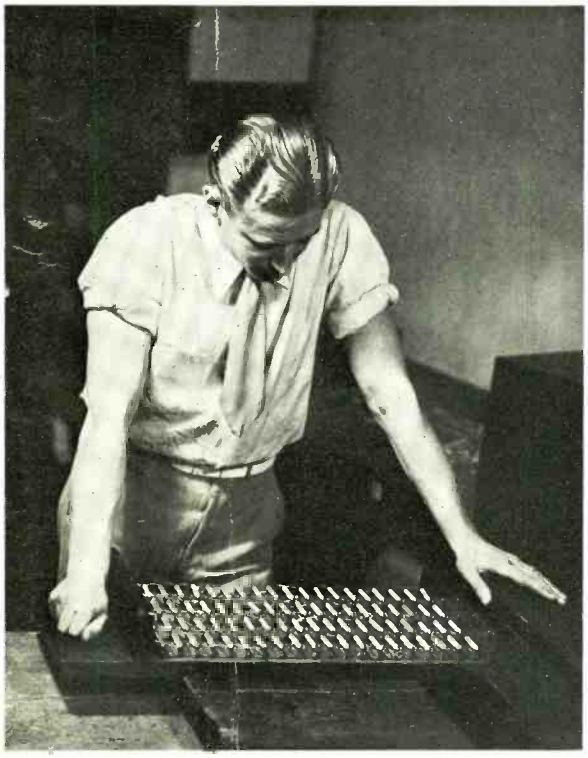

VOL. XIV NO. 12

The Journal of the Radio and Allied Industries

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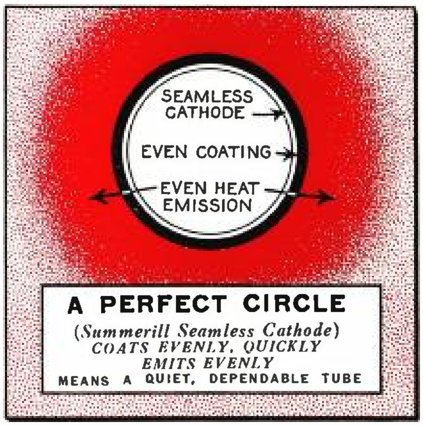
Why Trust Uneven Emission?



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EMITS EVENLY
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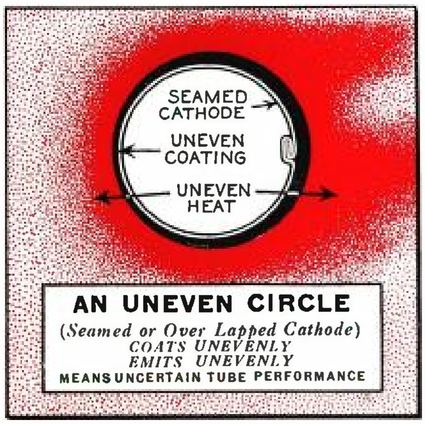

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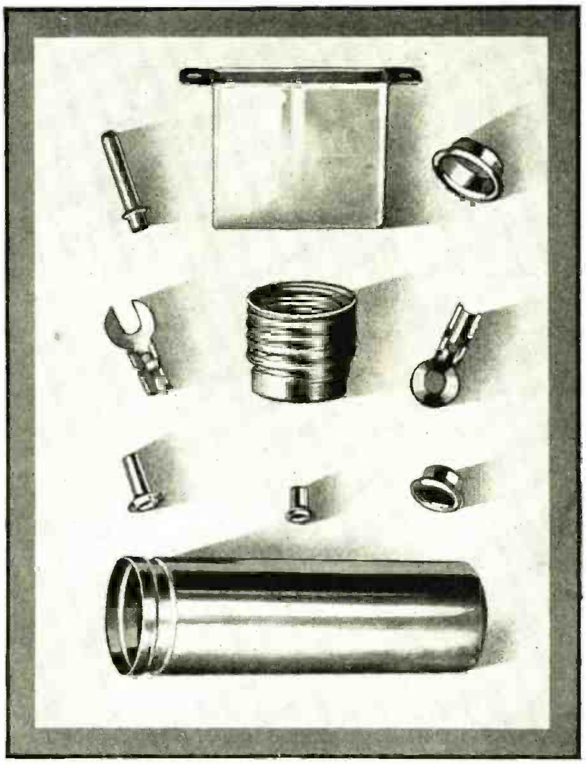

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EDITORIAL

ULTRA-SHORT-WAVES

THE RECENT PROGRESS in the field of ultra-short-waves should be of interest to both the receiver design engineer and the broadcast receiver manufacturer. If efforts to develop a listener audience in the vicinity of the five-meter region are successful, a new receiver market of large proportions will be opened up. There is a very good chance that this will happen—and possibly sooner than expected—which would suggest that it is not too early for the engineer and the manufacturer to undertake a survey of the field.

A sizeable number of ultra-short-wave transmitters, receivers and transceivers have already been sold to the amateurs and to the steadily increasing group of short-wave listeners who have been introduced to the higher frequency bands through the medium of the all-wave receiver. This phase of the business is on the increase and holds promise of reaching a stage where it may be profitable from a production basis.

Interest in the ultra-short-waves has been low due to the general belief that transmission is limited to very short distances. The amateurs have shown that this is not necessarily the case, as attested by the recent ultra-short-wave communication between the cities of Hartford and Boston. Distances as great as two hundred miles have been covered by the use of directional antenna systems and comparatively low power. With improved transmitters and receivers, and the use of directional antennas at both the transmitting and receiving points, the distances spanned may well be extended to four hundred miles or more.

It was at first believed that a signal having a wavelength in the region of five meters could not be received satisfactorily beyond the optical horizon. More recent researches indicate that a signal having a wavelength of three meters or below suffers the greatest degree of attenuation between the source and the optical horizon, whereas signals above three meters maintain comparatively large amplitudes up to a secondary or electrical horizon some distance beyond the optical. These findings, if correct, will not account for the reception of five-meter signals one hundred or more miles from the source and will account only for the possibility of more distant reception of signals above three meters.

The important point is that there is a usable signal beyond both the optical and electrical horizons and that this signal must follow the curvature of the earth. At wavelengths in the vicinity of five meters a signal received one hundred miles from the source can be attributed only to multiple reflections and refractions. Obviously, the signal obeys the square law, but at such relatively low levels as are encountered beyond the optical or electrical horizon, the actual attenuation over considerable distances expressed in power ratio, is decidedly small. So small as a matter of fact, that if shown graphically, the signal level beyond the horizon is found to be nearly a straight line.

This, then, is the signal the amateurs have used to advantage, a signal which at best is probably not above the noise level. The amateurs have raised this almost straight line above the noise level by increasing transmitter power and by beaming.

It is difficult to say just how far this matter may be carried but it appears that through the use of improved methods and equipment, and the employment of higher power than the amateurs are permitted to use, ultra-short-waves should be highly satisfactory for broadcasting over much greater distances than heretofore thought possible. In the light of these assumptions, it is not difficult to picture an entirely new field for the broadcast receiver manufacturer.

One thing is certain, however—before any progress is made in this direction, better ultra-short-wave receivers must be designed. Nothing short of a superheterodyne receiver will suffice. Moreover, improvement in the functioning of pre-selector and modulator stages is essential. Most of the present systems are inadequate at the higher frequencies.

RADIO ENGINEERING

FOR DECEMBER, 1934

TRANSFORMER DESIGN

By LEO A. KELLEY

INTRODUCTION:

THE IDEAL two-winding transformer has been described as one in which the primary and secondary inductances are infinitely large, there is no leakage flux and the resistances of the primary and secondary windings are zero. With such a transformer it is theoretically possible to achieve a perfect transformation of impedance level without attendant loss of energy at any point in a circuit where it is inserted.

THE IDEAL TRANSFORMER

Imagine, for example, a pair of wires connected to the terminals of a pure resistance of 100 ohms. Let us assume that if the impedance across the wires is measured at all frequencies from zero to infinity the result is always exactly 100 ohms. If an ideal transformer is inserted so that the 100-ohm resistance is connected across its secondary terminals and the pair of wires across its primary terminals, the primary inductance being ten times the secondary inductance, and the impedance is now measured across the pair of wires as before, the result will be exactly 1000 ohms at all frequencies from zero to infinity.

If the impedance connected across the wires is more complicated, say a network comprising resistances, inductances and capacitances, then the insertion of this ideal transformer has the effect, as far as the impedance measured across the wires connected to the primary is concerned, of replacing the network before insertion by an exactly similar network, except that all of the resistances and inductances are multiplied by a factor of ten and all the capacitances divided by ten. The ideal transformer is a self-effacing device which merely multiplies by a ratio the impedance connected to one pair of terminals as measured at the other pair of terminals without complicating the process by introducing peculiar characteristics of its own.

THE REAL TRANSFORMER

A real two-winding transformer is one in which the primary and secondary inductances are finite in magnitude, there is always some leakage flux and there is resistance in both primary and secondary windings. In contrast with the ideal transformer, the real one is by no means a self-effacing device. It approaches the performance of the ideal only approximately if at all for a limited range of frequencies. Nevertheless, it is probably the most useful single device at the disposal of the radio engineer, because by proper design the limited range of frequencies over which the transformer behaves most nearly like the corresponding ideal transformer may be made to coincide in that respect with the requirements of the circuit in which it is to be used. Of course, here, as in any other problem of design, there are limitations imposed by the physical properties of the materials used as well as cost. The order of difficulty increases in general as the useful range of frequencies is made wider, the loss in the transformer is made smaller and the ratio of transformation is made larger.

TRANSFORMER PARAMETERS

We are concerned here with only one aspect of the transformer problem, namely how the performance in a given circuit is affected by certain important parameters of the transformer. The transformer designer must be well acquainted with this aspect of the problem in order that his efforts be efficiently directed in meeting given requirements. The engineer whose function is to design circuits using transformers should also have some appreciation of this subject as a guide to the selection of available transformers for his purposes, or to prepare reasonable specifications for special designs. The author is fully aware that there is an abundance of literature dealing with this matter and hopes that these articles will provide a fresh point of view.

PART I

INPUT IMPEDANCE OF RESISTANCE-TERMINATED TRANSFORMER

Fig. 1 shows a transformer with a primary inductance of L_1 and a secondary inductance of L_2, coupled by a mutual inductance M. The terminals of the primary are 1-2 and of the secondary 3-4. Across the secondary

The subject of transformer design is to be presented in two parts: Part I deals with the transformers having resistance terminations, the transformers being assumed to have no distributed capacitance between turns; while Part II will deal with transformers whose function is voltage transformation, certain assumptions being made with respect to distributed capacitance between turns. All distorting effects caused by the iron core will be neglected.

terminals is connected a resistance R_2. The coefficient of coupling K is, of course, equal to $\frac{M}{\sqrt{L_1 L_2}}$.

In terms of these quantities the input impedance Z' is,

$$Z' = j\,\omega L_1 + \frac{\omega^2 M^2}{R_2 + j\,\omega L_2}$$

Rationalizing the denominator of the second term and grouping the real and imaginary terms,

$$Z' = \frac{\omega^2 M^2 R_2}{R_2^2 + \omega^2 L_2^2} + j\left(\omega L_1 - \frac{\omega^2 M^2 \omega L_2}{R_2^2 + \omega^2 L_2^2}\right)$$

Factoring out $\frac{R_2 L_1}{L_2}$,

$$Z' = R_2 \times \frac{L_1}{L_2}\left[\frac{\omega^2 M^2}{R_2^2 \frac{L_1}{L_2} + \omega^2 L_1 L_2} + j\left(\frac{\omega L_2}{R_2} - \frac{\frac{\omega^2 M^2 \omega L_2}{R_2}}{R_2^2 \frac{L_1}{L_2} + \omega^2 L_1 L_2}\right)\right]$$

Let $R_2 = \omega_1 L_2 = 2\pi f_1 L_2$. This simply means that with a given R_2 and L_2 there will always be some frequency at which the reactance of L_2 will be numerically equal to the resistance of R_2 and this frequency by the above relation is designated f_1. Then,

$$Z' = R_2 \frac{L_1}{L_2}\left[\frac{\omega^2 M^2}{\omega^2 L_1 L_2\left(\frac{f_1^2}{f^2} + 1\right)} + j\frac{f}{f_1}\left(1 - \frac{\omega^2 M^2}{\omega^2 L_1 L_2\left(\frac{f_1^2}{f^2} + 1\right)}\right)\right]$$

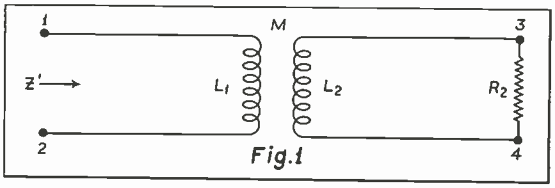
Since $K = \frac{M}{\sqrt{L_1 L_2}}$, the equation may now be written,

$$\frac{Z'}{R_2 \frac{L_1}{L_2}} = \frac{Z'}{R_1} = \frac{K^2}{\frac{f_1^2}{f^2} + 1} + j\frac{f}{f_1}\left(1 - \frac{K^2}{\frac{f_1^2}{f^2} + 1}\right), \quad (1)$$

where R_1 is put equal to $\frac{R_2 L_1}{L_2}$. R_1 is the input resistance if the transformer were ideal, having the same ratio of L_1/L_2. Let us examine this equation. The lefthand side expresses the ratio between the actual input impedance of the real transformer, terminated on the output side by the resistance R_2, and the input impedance of the corresponding ideal transformer, also terminated by the resistance R_2. The righthand side is a function of two variables K and the frequency ratio f/f_1, both of which are ratios and entirely independent of particular values of L_1, L_2, R_2 and M. This is advantageous because we can now plot a family of curves of general utility by assigning values to the two variables. It is convenient to make each curve correspond to a fixed value of the coefficient of coupling K and assign a series of values to the frequency ratio f/f_1 covering the desired range of this variable. By repeating this for several different values of K the effects of the two variables may be easily observed.

EQUATION ANALYSIS

It is instructive to analyze the component parts of equation (1). Since it expresses the ratio of the input resistance of the real transformer to that of the ideal transformer, we may conclude that the measure of equality between the real and ideal is unity. The righthand side of equation (1) is complex, however, so the measure of equality boils down to the first term being equal to unity and the second or j-term equal to zero. Obviously, the first term is a measure of the resistance component of the actual input impedance and the second term its reactance component.



A simple transformer circuit having a secondary resistance load equal to R_2.

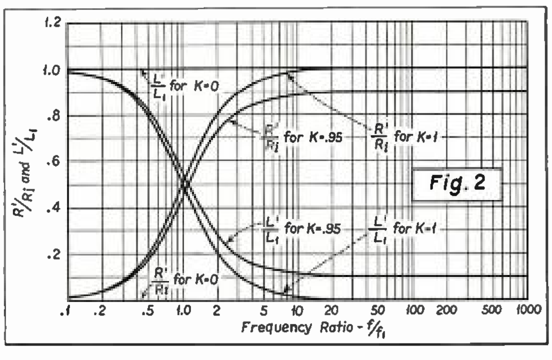
The curves of Fig. 2 are plotted for the first or resistance term of equation (1), K having values of unity, .95 and zero respectively. The frequency-ratio scale extends from .1 to 1000 and is logarithmic in accordance with the customary practice in showing transformer-frequency characteristics. Observing first the curve for unity coupling we note that for very small values of frequency ratio it approaches a value of zero, for a frequency ratio of one it equals .5 and for increasing values of frequency ratio it increases very rapidly so that by the time a frequency ratio of 5 is reached it has already attained over 95% of its final value which is one. Judging by the first term alone, the transformer with no resistance in its windings, perfect coupling and a resistance termination has the input impedance, at least very approximately, of an ideal transformer, providing the frequency at which it is measured exceeds a roughly defined minimum frequency. Since the frequency-ratio scale is converted to a frequency scale by multiplying by f_1, where $f_1 = R_2/2\pi L_2$, the roughly defined minimum frequency becomes smaller and smaller as L_2 is made larger and larger, the ratio L_1/L_2 remaining the same. If this is continued until L_2 is indefinitely great, f_1 approaches zero and all values of the frequency ratio f/f_1 become infinite. Consequently, the final value of one applies to all frequencies for the first term. Since one factor of the second or j-term equals one minus the first term, it will be equal to zero at all frequencies. That is, the transformer is now equal to the ideal in all respects. This is as it should be for we started out with a transformer which had all the attributes of an ideal transformer except that the inductances of its windings were finite.

We direct our attention next to the curve for a coefficient of coupling of .95, a value quite easily obtainable in an actual transformer. The curve represents the first term of equation (1) for this less than unity value of coupling and it will be seen that it is similar to the curve for $K = 1$. In fact, it may be derived by multiplying the ordinates of the curve for $K = 1$ by K^2 which is equal in this case to .9025. Additional curves for other values of K may be plotted in exactly the same manner. When K is equal to zero the result is merely a line along the horizontal axis. This also checks because when the coupling is zero the secondary circuit comprising L_2 and R_2 has no influence whatever on the input circuit. Since it was assumed that L_1 is free of resistance it is only natural that for zero coupling the resistance component should be zero at all frequencies.

REACTANCE CONSIDERATIONS

We have considered so far only the resistance term of equation (1) and on the basis of that might be led to certain conclusions. We might imagine that for practical purposes our real transformer with a fairly high coefficient of coupling may be made to have about the same input impedance as the ideal, providing we are satisfied with frequencies above a certain lower limit which can be made as low as desired by making the inductances L_1 and L_2 large enough. When we come to consider the second or reactance term of equation (1), however, we find that the input reactance of the real transformer is not zero as it must be for the ideal transformer, but may be very substantial in magnitude.

In order to indicate this more clearly, a group of curves is plotted in Fig. 3 showing the reactance term for several values of K including zero and unity. Fig. 3 employs the same scales as Fig. 2 so that one may be superimposed on the other. The boundary curves are $K = 0$ and $K = 1$. They practically coincide for low values of f/f_1, diverging slightly as the frequency ratio increases until at $f/f_1 = 1$ the curve for $K = 1$ is about to turn back toward the zero axis, while that for $K = 0$ continues to increase at a rapid rate. All the other curves lie in between. The $K = 0$ curve relates to the reactance of L_1 alone and is, therefore, only of academic interest. The $K = 1$ curve, on the other hand, is of considerable importance because it exhibits the limit approached in the practical design of two-winding transformers. With increasing frequency ratio this curve rises from zero to a maximum value of

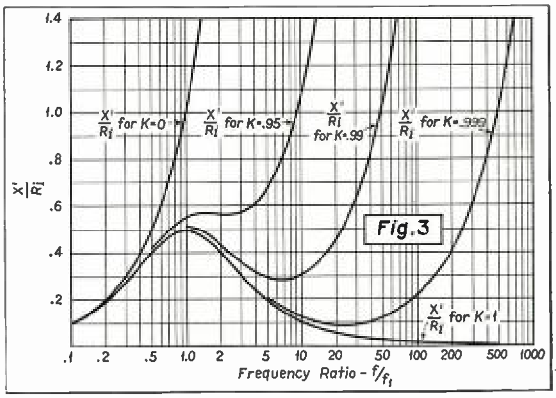


Curves plotted for the resistance term in equation (1), K having values of unity, .95 and zero.

.5 at $f/f_1 = 1$ and falls back rapidly approaching zero as the frequency ratio increases indefinitely. As previously explained in connection with Fig. 2, this maximum "hump" may be driven down the frequency scale toward zero by increasing proportionately both L_1 and L_2. Theoretically this process may be continued until the inductances become so large that the reactance is zero for all frequencies.

Our surmise to the effect that a real transformer is practically equivalent to an ideal one above a roughly defined lower limiting frequency is certainly true for unity or perfect coupling, because as we have observed the first, or resistance term, of equation (1) is very nearly equal to one and the second, or reactance term, is very nearly equal to zero in the case of the unity-coupled transformer for all frequencies except the lower range of frequencies.

Turning our attention to the reactance curves (Fig. 3)



Reactance curves for coefficients of coupling less than unity.

for slightly less than unity coupling we discover that they differ from that for unity coupling in one important respect. They are not asymptotic to the zero axis but rather with increasing values of frequency ratio they rise eventually to high values of reactance. They may be thought of as being controlled by two influences one of which makes them tend to follow the $K = 1$ curve and the other to follow the $K = 0$ curve. The first influence predominates for the lower values of frequency ratio and the latter makes itself felt only gradually at first as the frequency ratio increases until finally it predominates. This rising tendency is delayed, so to speak, until higher values of frequency ratio are reached as the values of K become more nearly equal to unity. The leakage reactance is responsible for this.

APPARENT INDUCTANCE

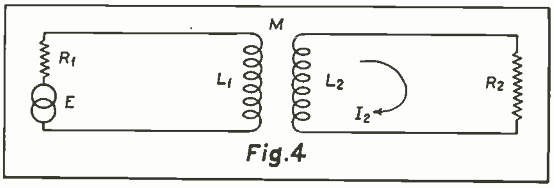
A clearer physical picture is obtained of the relationships involved if we examine the reactance term in the light of apparent inductance. Let L′ be the apparent inductance. Then,

$$\frac{\omega L'}{R_1} = \frac{\omega L'}{\omega_1 L_1} = \frac{f}{f_1}\cdot\frac{L'}{L_1} = \frac{f}{f_1}\left(1 - \frac{K^2}{\frac{f_1^2}{f^2}+1}\right),$$

whence

$$\frac{L'}{L_1} = 1 - \frac{K^2}{\frac{f_1^2}{f^2}+1}$$

Curves of L'/L_1 for $K = 1$ and $K = .95$ are shown in Fig. 2. For $K = 0$, the apparent inductance is, of course, L_1 for all frequencies. Therefore, for $K = 0$ the value of L'/L_1 equals one for all values of frequency ratio. For all other values of K, L'/L_1 starts with the value of one for a frequency ratio of zero and, as the frequency ratio is increased, falls to smaller and smaller values eventually flattening out to approach asymptotically some particular value. This particular value is equal to the expression $(1 - K^2)$ and relates



The simple transformer circuit of Fig. I to which has been added an oscillatory source, E, with an internal resistance of R_1.

to the input inductance of the transformer with R_2 short circuited. L'/L_1 approaches zero for $K = 1$ and .0975 for $K = .95$ and it will be clear that similar curves for $K = .99$ and $K = .999$ will lie in between and approach finite values. In passing we note that the L'/L_1 curves are derived from the R'/R_1 curves by subtracting the latter, for corresponding values of K, from one.

LIMITING FREQUENCIES

We may now analyze the reactance curves of Fig. 3 as the product of two factors, one of which falls with increasing frequency approaching a final value asymptotically, the other of which increases with increasing frequency. If carried to high enough frequencies, therefore, the reactance curve is bound to rise unless the final value is zero which, of course, it is for unity coupling. The rise is delayed as the coupling becomes more nearly unity.

Notice should be taken that these curves are all plotted on semi-logarithmic paper. It will be instructive for the reader to replot them for some low value of K, such as .5, on rectangular cross-section paper.

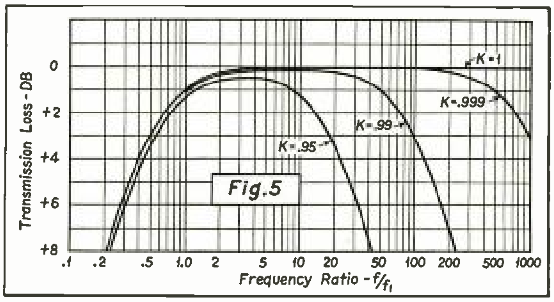
The net result of these considerations is that, whereas, when we had to deal with the resistance term alone of equation (1) we were restricted only by a lower limiting frequency. Now in investigating the reactance term we encounter what appears to be an upper limiting frequency as well. It is apparently disturbing to find that the reactance never falls below .55 for $K = .95$, .28 for $K = .99$ and .09 for $K = .999$ when to be equivalent to the ideal transformer for matching impedances it should be zero. Looking at the matter from a practical standpoint, however, we have achieved the desired result for a limited range of frequencies. After all, the reason we want to match impedances is to bring about efficient transfer of energy from a source of oscillations of a given impedance to a load of given impedance. When these impedances differ sufficiently we insert an impedance-matching transformer in order to reduce the excess loss caused by the mismatch of impedances.

Again we may have the problem of connecting portions of a circuit containing devices which function best at different impedance levels, in which case we would also use impedance-matching transformers. Even when there is no change in impedance level it may be desired to insulate one portion of a circuit from another by connecting the portions together by means of an impedance-matching transformer of unity ratio. It is interesting to learn how far the matching of impedances is accomplished, but we shall take up in the next section the transmission loss versus frequency characteristics of a real transformer showing that the impedance match is good enough for practical purposes over a frequency range comprised between the frequency ratio equal to one and the frequency ratios where the reactance curves of Fig. 3 cross the value of one.

Before passing on to the next section it should be noted that the curves of Figs. 2 and 3 with slight modification may be made to include the resistances of the primary and secondary windings which hitherto have been regarded negligible. The resistance of the secondary winding may be added to R_2 and the sum used in interpreting the frequency-ratio scale instead of R_2 alone. The resistance of the primary winding expressed as a fraction of R_1 should be added to the resistance curves of Fig. 2 thus raising them bodily by that amount.

TRANSMISSION LOSS VERSUS FREQUENCY OF RESISTANCE-TERMINATED TRANSFORMER

For the purpose of deriving the equation for plotting the transmission-loss versus frequency characteristic we refer to Fig. 4, which is the same as Fig. 1 except that a source of oscillations E with an internal resistance



Transmission loss-frequency ratio curves for various degrees of coupling. The equation for these characteristics was derived from Fig. 4.

R_1 is now connected to the input terminals of the transformer. It is assumed that the inductances L_1 and L_2 are proportioned to match the impedances R_1 and R_2, i.e., R_1 as previously defined is made equal to R_1. Consequently, R_1 is equal to $\frac{R_2 L_1}{L_2}$. E is an alternating emf of any frequency. The current flowing through the resistance R_2 is,

$$I_2 = \frac{E\, j\, \omega\, M}{(R_1 + j\,\omega\, L_1)\,(R_2 + j\,\omega\, L_2) + \omega^2 M^2}$$

Since $R_1 = R_2 L_1/L_2$ we may rewrite I_2 as follows,

$$I_2 = \frac{E\, j\, \omega\, M}{\frac{L_1}{L_2}\,(R_2 + j\,\omega\, L_2)^2 + \omega^2 M^2}$$

If an ideal transformer with the proper ratio is inserted to replace the real one, the current flowing through R_2 will be,

$$I_2\ (\text{ideal}) = \frac{E\sqrt{\dfrac{L_2}{L_1}}}{2\,R_2},$$

referring everything to the impedance level of the secondary circuit. The real transformer, of course, falls short of the ideal and to show how near ideal the real one is we express the relationship as the ratio (T) of the secondary current with the ideal transformer to the secondary current with the real one.

$$T = \frac{I_2\ (\text{ideal})}{I_2} = \frac{\dfrac{L_1}{L_2}(R_2 + j\,\omega\,L_2)^2 + \omega^2 M^2}{2\,R_2\,j\,\omega\,M}\ \sqrt{\frac{L_2}{L_1}}.$$

Remembering that $K = \dfrac{M}{\sqrt{L_1 L_2}}$ and $R_2 = 2\pi f_1 L_2$, the above expression may be simplified to,

$$T = \frac{1}{K} - j\frac{1}{2}\left[\frac{1}{K}\frac{f_1}{f} - \left(\frac{1}{K} - K\right)\frac{f}{f_1}\right] \qquad (2)$$

It will be observed that equation (2) is a function of the same two variables as equation (1), namely, the coefficient of coupling K and the frequency ratio f/f_1. It expresses the ratio of the current in R_2, with no loss, to the actual current in R_2. Following the customary practice in the communication art we put the loss in the form of decibels,

$$T\ (\text{db}) = 20\log_{10}\sqrt{\left(\frac{1}{K}\right)^2 + \left[\frac{1}{2K}\frac{f_1}{f} - \frac{1}{2}\left(\frac{1}{K} - K\right)\frac{f}{f_1}\right]^2} \qquad (3)$$

Curves of equation (3) are plotted in Fig. 5 covering a frequency-ratio range from .1 to 1000 for values of K equal to .95, .99, .999 and unity. These curves portray graphically the part played by the coefficient of coupling in its effect on the frequency range efficiently transmitted. We note that the loss is approximately one decibel or less for a range of frequency ratios from one to the frequency ratio where the reactance curves of Fig. 3 cross the value of unity. This upper frequency ratio is equal to 9 for K = .95, 50 for K = .99, 500 for K = .999 and infinity for K = 1. In other words, if we take 40 cps arbitrarily as the lower frequency limit, then the upper frequency limits will be 360, 2000, and 20,000 cycles per second for K equal to .95, .99 and .999 respectively. For K equal to one there would be no upper limit. Other factors may, of course, influence the upper portion of the frequency range but we are not considering them now.

UPPER FREQUENCY-LIMIT EQUATION

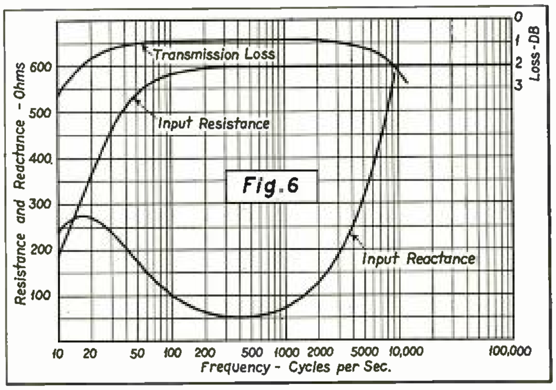
An equation may be derived for the upper frequency limit by placing the second term of equation (1) equal to one. When K is close to unity,

$$\frac{f_2}{f_1} = \frac{1}{2\,(1 - K)},$$

where f_2 is the upper and f_1 the lower limiting frequency. This means, for example, that every reduction of fifty percent in the leakage coefficient is equivalent to doubling the frequency range of the transformer.

RESISTANCE EFFECT

The effect of resistance in the primary and secondary windings is to add loss to the curves of Fig. 6 and



These curves were plotted to illustrate the specific example set up by the author.

change slightly the value of f_1. If we let r_1 be the primary winding resistance and r_2 that of the secondary, the added loss will be equal to,

$$20\log_{10}\frac{(R_1 + r_1)\dfrac{L_2}{L_1} + R_2 + r_2}{R_1\dfrac{L_2}{L_1} + R_2}.$$

If these resistances are fairly constant over the frequency range, the added loss will be flat over the entire range.

PHASE SHIFT

The phase shift referred to the emf impressed on the input circuit is equal to the angle whose tangent is the ratio of the second term of equation (2) to its first term. In each case it is about minus twenty-six degrees at f_1 passing through zero degrees in the middle of the transmitted range and about plus twenty-six degrees at f_2.

SUMMARY

For the sake of illustration and to summarize the foregoing, a set of curves is given in Fig. 6 for a specific example. The following constants are selected for these curves:

Primary inductance = 5 henries
Primary winding resistance = 50 ohms
Secondary inductance = 10 henries
Secondary-winding resistance = 100 ohms
Coefficient of coupling, K = .999
Internal resistance of primary source = 500 ohms
Resistance of secondary load circuit = 1000 ohms.

(To be continued)

THE DESIGN OF

By C. F. NORDICA

MUCH HAS BEEN written during the past few years on the design of resistance pads of various sorts. A number of involved formulae have been developed with the aid of hyperbolic trigonometry and transmission theory, which together with numerous graphs and charts can usually be made to yield the results required to fit any specific problem. However, it seems somewhat absurd to resort to any involved procedure to design so simple and common a structure as a resistance pad. It is proposed here to derive, with the aid of only simple algebra and the application of Kirchoff's laws, expressions for the constants of resistance pads . . . expressions which can be easily remembered and quickly solved.

IN THIS ARTICLE THE AUTHOR HAS MATHEMATICALLY DERIVED EQUATIONS THAT ARE READILY APPLICABLE TO THE DESIGN OF ALMOST ANY TYPE OF RESISTANCE PAD. AND, ACTUAL WORKING CURVES HAVE BEEN PLOTTED FROM THESE EQUATIONS. WHILE THE CURVES GIVEN HERE ARE FELT TO BE OF SUFFICIENT SIZE, AND HENCE ACCURACY, FOR THE ORDINARY DESIGN REQUIREMENTS, GREATER EASE OF READING AND ADDED DETAIL MAY BE GAINED BY REPLOTTING THEM TO A LARGER SCALE.

SIMPLE T-PAD CALCULATION

The resistance pad must, in general, fulfill two and only two conditions. They are: First, the pad must have a prescribed loss in db when inserted between a generator of impedance A and a terminating resistance B, and the pad must match the generator impedance A on its input and B on its output when working between these impedances. These conditions are illustrated in Fig. 1 in which A and B are resistances, since this represents the usual case. Applying Kirchoff's laws to this network, there results:

$$P\,(I_1 - I_2) = (N + B)\,I_2$$

$$\frac{I_2}{I_1} = \frac{P}{N + B + P} = R.$$

Whence,

$$P = \frac{R}{(1 - R)}\,(N + B).$$

But,

$$A = Z_1 = M + \frac{P\,(N + B)}{P + N + B} = M + R\,(N + B).$$

Therefore,

$$M = A - R\,(N + B)$$

and

$$B = Z_2 = N + \frac{P\,(M + A)}{P + M + A} = N + \frac{R\,(N + B)\,(M + A)}{R\,(N + B) + (1 - R)\,(M + A)}.$$

Solving for M, N and P, we have,

$$M = \frac{A^2 - 2\,RAB + R^2\,AB}{A - R^2\,B}$$

$$N = \frac{(1 - 2\,R)\,AB + R^2\,B^2}{A - R^2\,B}$$

$$P = \frac{2\,RAB}{A - R^2\,B}.$$

While the above values express M, N and P in terms of the terminal impedances and the ratio of output to input current, it is usually more convenient to have

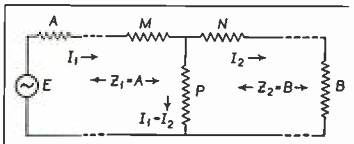


Fig. 1

The usual or T-type resistance pad which is designed to have a definite loss in db, and which matches the generator impedance on its input and the load impedance on its output.

them given in terms of the terminal impedances and the insertion loss of the pad. From the relations,

$$\lambda = \varepsilon^{-\alpha L}$$

and

$$L = 20\,\log \lambda^{-1}\ \text{db}$$

it may be shown for this case that

$$R = \lambda \sqrt{\frac{A}{B}} = \lambda \sqrt{\frac{Z_1}{Z_2}}.$$

Substitution for R gives,

$$M = \frac{2\,A - 2\,\lambda\,\sqrt{A\,B}}{1 - \lambda^2} - A \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$N = \frac{2\,A - 2\lambda\,\sqrt{A\,B}}{1 - \lambda^2} - B \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$P = \frac{2\,\lambda\,\sqrt{A\,B}}{1 - \lambda^2}. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

A COMMON PROBLEM

One of the most common problems is to design a pad, for impedance matching only, which will have minimum attenuation. For this case if A is greater than B, the

RESISTANCE PADS

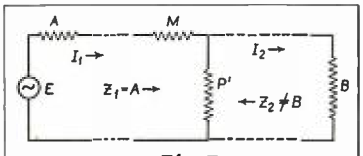


Fig. 3

This is an L-type pad designed for low loss. Here the impedances have been matched in only one direction, that of the higher impedance side.

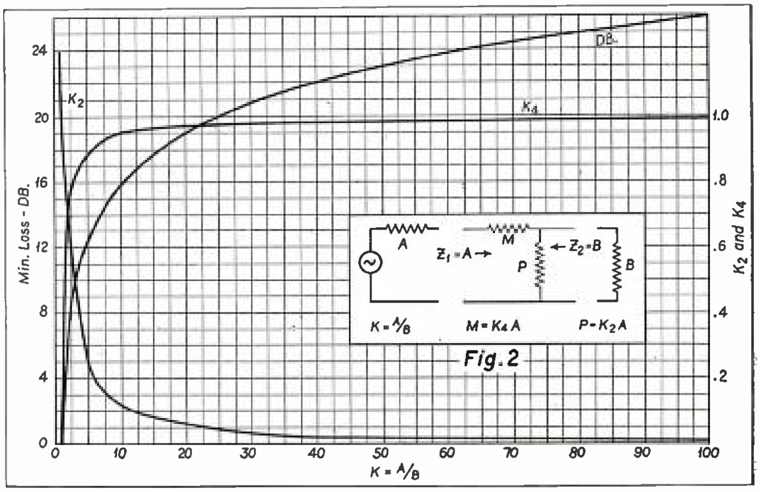


Fig. 2

Design curves of constants for L-type impedance-matching pad. The values of M and P have been expressed in terms of the generator impedance A.

condition of minimum attenuation will be reached when N vanishes. Whence,

$$B = \frac{2B - 2\lambda\sqrt{AB}}{1-\lambda^2}$$

and

$$\lambda = \frac{\sqrt{A} - \sqrt{A-B}}{\sqrt{B}}.$$

Let

$$A = KB.$$

Then

$$\lambda = \sqrt{K} - \sqrt{K-1} \qquad \dots\dots\dots\dots\dots\dots (4)$$

and the loss in db is

$$L = 20 \log \lambda^{-1}.$$

Hence

$$P = \frac{2\lambda\sqrt{K}}{1-\lambda^2} B = \frac{2\lambda}{\sqrt{K}(1-\lambda^2)} A$$

and

$$M = \left[\frac{2K - 2\lambda\sqrt{K}}{1-\lambda^2} - K\right] B = \left[\frac{2\sqrt{K} - 2\lambda}{\sqrt{K}(1-\lambda^2)} - 1\right] A.$$

Obviously both P and M may then be expressed as a function of either A or B and a constant which, in turn, is a function of K and λ. That is,

$$P = K_1 B = K_2 A$$

where

$$K_1 = \frac{2\lambda\sqrt{K}}{1-\lambda^2}$$

and

$$K_2 = \frac{2\lambda}{(1-\lambda^2)\sqrt{K}}.$$

Also

$$M = K_3 B = K_4 A$$

where

$$K_3 = \left(\frac{2K - 2\lambda\sqrt{K}}{1-\lambda^2} - K\right)$$

and

$$K_4 = \left(\frac{2\sqrt{K} - 2\lambda}{(1-\lambda^2)\sqrt{K}} - 1\right).$$

MINIMUM LOSS CONDITION

Needless to say the case of interest is that for the pad of minimum loss, so that λ is fixed by this condition for any value of K, as shown in formula (4). It immediately follows that curves for K_1, K_2, K_3 and K_4 may be plotted as a function of K, or the ratio of generator and terminal impedances. Fig. 2 indicates one set of curves in which M and P are expressed as functions of A. Naturally a similar set of curves may be drawn for K_1 and K_3.

In some cases the loss resulting from the insertion of an impedance-matching pad of the type shown in

These are curves of constants for symmetrical T-type impedance - matching pads.

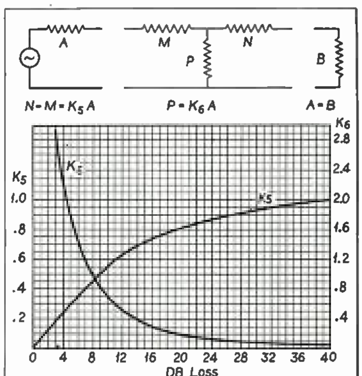


Fig. 4

Fig. 2 is greater than can be tolerated. In such cases it is customary to match impedances in only one direction, usually the higher impedance side, and to design the pad for this condition and the desired loss.

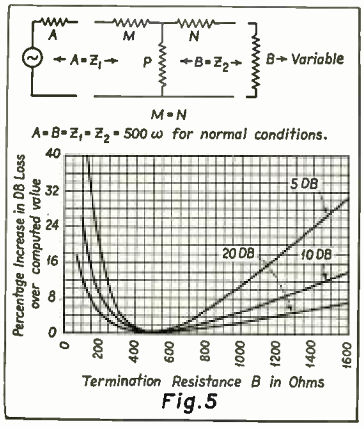


Fig. 5

The above curves show the error due to mismatch of a symmetrical T pad in percentage increase in db loss over computed values and for different values of the termination resistance B.

Such a pad is illustrated in Fig. 3. To arrive at the design formula for this case, let

$$R = \frac{I_2}{I_1} = \frac{P'}{P' + B} \text{ and } Z_2 = B\ .$$

But

$$P' = B \frac{R}{1 - R}$$

and

$$M = \frac{A\,(2R - 1) - RB}{1 - 2R}\ .$$

If

$$B = A$$

then

$$M = A\left(\frac{R - 1}{1 - 2R}\right) = A\,\frac{(1 - R)}{2R - 1}\ .$$

Now if

$$Z_2 \neq B$$

but

$$Z_1 = A$$

it follows that

$$M = A\,(1 - R)$$

and

$$P' = A\,\frac{R}{1 - R} = \frac{A^2 R}{M}\ .$$

EQUAL IMPEDANCE CASE

Formulae (1), (2) and (3) may, of course, be simplified for the case of equality between generator and terminating impedances. For that case these formulae reduce to

$$M = \left(\frac{1 - 2\lambda + \lambda^2}{1 - \lambda^2}\right) A = \left(\frac{1 - \lambda}{1 + \lambda}\right) A = K_5\,A \quad (5)$$

$$P = \frac{2\lambda}{1 - \lambda^2} A = K_6\,A \quad (6)$$

$$N = M = \frac{1 - \lambda}{1 + \lambda} A \quad (7)$$

Curves of constants for N, M and P are shown in Fig. 4.

MISMATCHING OF T PADS

Another case of interest is that for mismatching of a T-type pad. As long as the pad has a large loss and is terminated in a pure resistance it can produce no frequency distortion. However, the loss produced by the pad will be greater for the mismatched condition than the calculated loss. The computations involved in this case are identical with those used in setting up the initial equations for pad constants. The results for a 500-ohm symmetrical, T-type pad are shown in Fig. 5. The curve parameters in this case are the computed loss of the pad under conditions of impedance match.

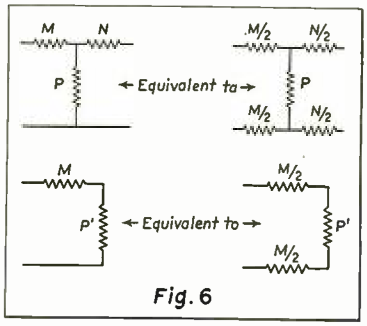


Fig. 6

The same line of reasoning used in the design of L- and T-type pads may also be used for the design of the H- and U-types, equivalent values for the arms being shown above.

It is assumed for this instance that the generator impedance is matched and the terminating impedance varied.

U- AND H-TYPE PADS

The above discussion has been confined to unbalanced or T- and L-type structures. Obviously the same reasoning applies to balanced or H- and U-type struc-

The output impedance in this circuit has both resistance and reactance, and the T-pad design formulae must be developed with this in mind.

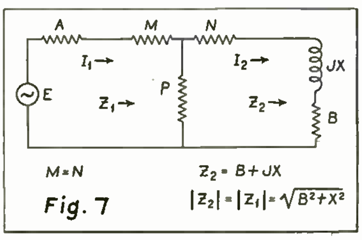


Fig. 7

These curves give the actual current ratio and percent reactance in the termination resistance of different values of db in the T pad.

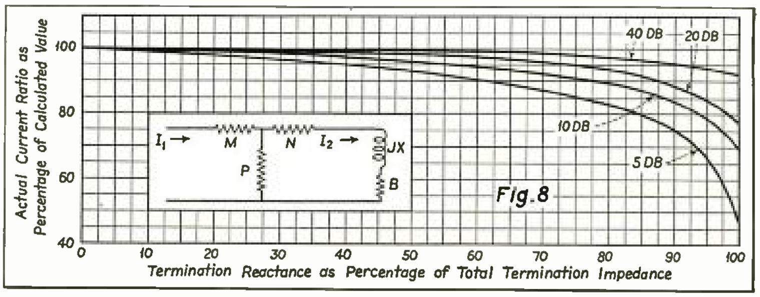


Fig. 8

tures. In the H-type structure, each series arm is half the value of the similar arm of the equivalent T-type pad. This is illustrated in Fig. 6. The shunt arm is, of course, unchanged in converting from the balanced to the unbalanced type of structure.

It is interesting to examine a pad terminated in a complex impedance. Limited space will preclude any extended discussion of this matter which is doubtless only of academic interest to the engineer. However, the case of a complex impedance equal to the termination impedance is a matter of some interest in high-frequency work. Since loss is normally expressed as a ratio of power delivered to a termination to power supplied, it becomes meaningless here . . . particularly for the limiting case of a wholly reactive termination. In instances of this nature current ratios, rather than power, are usually the quantity of interest.

In the circuit of Fig. 7, let,

$$R = \frac{I_2}{I_1}$$

Z_0 = input impedance of pad when it is terminated in a pure resistance equal to A or B.

Then

$$Z_1 = \frac{Z_0\,[(Z_2 + Z_0) + R^2 (Z_2 - Z_0)]}{(Z_0 + Z_2) + R^2 (Z_0 - Z_2)} = \frac{Z_0\,(\alpha + J\beta)}{\alpha' + J\beta'}$$

$$Z_1 = \frac{Z_0}{\alpha'^2 + \beta'^2}\,[(\alpha\alpha' + \beta\beta') + J(\alpha'\beta - \alpha\beta')].$$

Where

$$\alpha = (1 - R^2)\,Z_0 + (1 + R^2)\,B$$
$$\alpha' = (1 + R^2)\,Z_0 + (1 - R^2)\,B$$

and

$$\beta = (R^2 + 1)\,X$$
$$\beta' = (1 - R^2)\,X.$$

Let

$$\theta = \tan^{-1}\frac{\alpha'\beta - \alpha\beta'}{\alpha\alpha' + \beta\beta'}.$$

Now θ is maximum at

$$Z_2 = 0 + J\,X \text{ for a given R.}$$
$$|X| = Z_0.$$

If

$$R_1 = \frac{I_2}{I_1} \text{ for } Z_2 = \text{any impedance}$$

and

$$R = \frac{I_2}{I_1} \text{ for } Z_2 = Z_0$$

then

$$R_1 = \frac{P}{P + 2M + Z_2} = \frac{2 Z_0 R}{(Z_0 + Z_2) + R^2 (Z_0 - Z_2)}$$

$$= \frac{2 Z_0 R\,\alpha'}{\alpha'^2 + \beta'^2} - J\,\frac{2 Z_0 R\,\beta'}{\alpha'^2 + \beta'^2}$$

$$|R| = \frac{2 Z_0 R}{\sqrt{\alpha'^2 + \beta'^2}}.$$

Where

$$\alpha' = (1 - R^2)\,Z_0 + (1 - R^2)\,Z_2$$
$$\beta' = (1 - R^2)\,X.$$

Hence

$$P = \frac{2 Z_0 R}{1 - R^2}$$

$$M = \frac{Z_0}{2}\left(\frac{1 - R}{1 + R}\right).$$

The difference in current ratio when a pad is terminated in a complex impedance and in a pure resistance is illustrated graphically in Fig. 8. In this case the results hold for only a single frequency at which the termination impedance is equal to the nominal termination resistance. The parameters are calculated line losses in db assuming a pure resistance termination equal to the image impedance of the pad.

BOOK REVIEWS

HANDBOOK OF CHEMISTRY AND PHYSICS, nineteenth edition, edited by Charles D. Hodgman; published by the Chemical Rubber Publishing Co., Cleveland, Ohio; 4 x 6½ *inches; leatherette cover;* 1,934 *pages; price,* $6.00.

As the name implies, the handbook is a compilation of physical and chemical data of importance to the development engineer or research engineer. For convenience in reference, it is divided into five sections: 278 pages of mathematical tables, 485 pages of data on properties and physical constants, 391 pages of general chemical tables, 425 pages of heat and hygrometry, and 354 pages of quantities and units and miscellaneous.

The mathematical tables are exceptionally complete. Although the table of integrals is not as complete as one might find in a book devoted exclusively to this subject, the most important ones are included, as are many definite integrals used in engineering work. The formulas for the solution of certain cubic equations, trigonometric identities, permutations and combinations, probability tables, and logarithmic and trigonometric tables, are in handy form, close together, which makes them suitable for easy reference.

The second section of the handbook is devoted to the chemical elements and their characteristics. While this chapter is not very useful to the radio engineer, the data are valuable to those interested in the quantitative solution of certain photoelectric problems.

The sections on sound and light are of importance to the radio engineer. The velocity of sound in various media, the frequencies of the same notes for various musical scales, the absorption coefficients of different materials, the wavelength and specific inductive capacity of different materials, contact potentials, a complete table of resistivity of different materials, constants of iron, and numerous additional data make this one of the most useful tables for the engineer and physicist.

The last section of the handbook is devoted to numerous radio tables and data that are valuable to anyone in the radio field. A complete list of the characteristics of receiver, telephone, and transmitting tubes is included.

The usefulness of this book lies in the fact that the material most used by engineers is contained in a single volume, which obviates the necessity for extended research to obtain some constant that may be required at a moment's no-

(*Continued on page* 22)

Radio Broadcast Receivers*

A REVIEW OF THE DESIGN CONSIDERATIONS INVOLVED IN THE PRODUCTION OF BROADCAST RECEIVERS FOR EUROPEAN MARKETS.

By J. S. JAMMER[1] and L. M. CLEMENT[2]

IN THE OCTOBER, 1933, issue of *Electrical Communication,* the authors described the broadcast radio receiver program of the International System Group for last year. During the year, the companies in the International System Group manufactured and sold approximately a quarter of a million receivers. When it is realized that over eighty percent of this activity took place in a period of four months, one begins to appreciate the severe load thrown on the manufacturing facilities. At the peak period, the receivers were being produced at the rate of about one every twenty seconds.

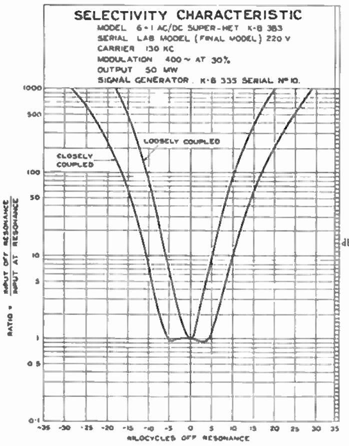


Fig. 1. Selectivity characteristic of variable selectivity receivers. Curves show effect on selectivity and band width of operating the selectivity control knob from most selective to highest fidelity positions.

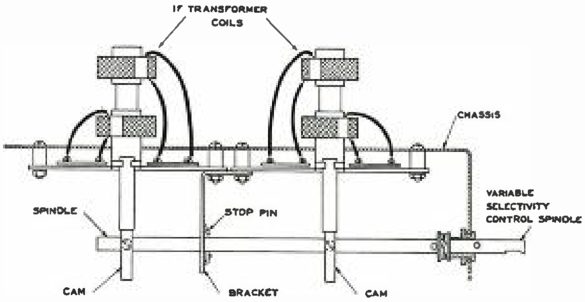


Fig. 2. Sketch showing the mechanics of the variable selectivity control in the i-f amplifier.

VARIABLE SELECTIVITY

Because of the very great number of high-power broadcast transmitters in Europe, it has been necessary, in the past, to design receivers with a very high degree of selectivity and consequent sacrifice of fidelity. The average purchaser, although extremely anxious to secure a very selective receiver at the time he acquires the instrument, subsequently finds that he is not particularly interested in the reception of distant stations but is more concerned with high-fidelity reception of nearby stations. Consequently, after owning the receiver for a short time, he feels that he prefers high-fidelity instead of high selectivity. This year, therefore, some of the receivers have been equipped with a very ingenious device which enables the owner to adjust the selectivity of the set at will to give any band width of reception he may require.

MECHANICAL BAND-WIDTH CONTROL

This variable selectivity is obtained by a mechanical change in the relative positions of the coils in the intermediate-frequency transformers. Each of these transformers has one stationary and one movable coil. The position of the movable coils is controlled by two cams in tandem bearing on the face of the brackets and actuated from the front of the receiver. With the coils spaced at the greatest distance, the intermediate-frequency transformer is just below the critical coupling, and this results in an extremely sharp selectivity characteristic, as shown in Fig. 1. When the coils are brought close together, the transformer is over-coupled and a broad bandpass characteristic results. Fig. 2 illustrates the mechanical arrangement of this feature.

With this variable selectivity feature, the overall fidelity characteristic of the receiver can be altered from a band of about 3,000 cycles, which is the normal for most receivers in Europe, to a band

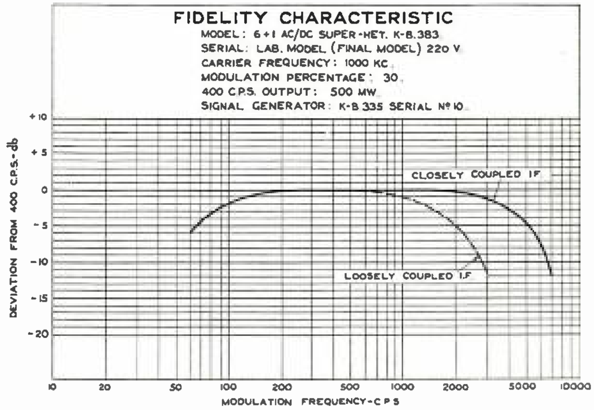


Fig. 3. Curves showing the effect on fidelity of varying the selectivity control on a K.B. 383 Receiver from maximum to minimum.

*From the October, 1934, issue of *Electrical Communication.*
[1]Assistant Vice-President, International Standard Electric Corp.
[2]Chief Engineer, Radio Broadcast Receivers, International Telephone and Telegraph Laboratories, Inc.

of about 7,000 cycles, thus enabling the set, under this latter condition, to reproduce faithfully many instruments of an orchestra, speech, and other sounds which ordinarily are not heard on the average broadcast receiver. Curves showing the effect of fidelity are given in Fig. 3.

MODERN DIALS

Most of the receivers this year include open face tuning dials, popularly called "aeroplane" or "clock" type. Delayed automatic volume control is used in some models to enable weak stations to be received with satisfactory volume. The International Group of companies last year was the first to introduce silent tuning and automatic tone compensation in Europe. These features are, of course, included again this year.

A great deal of attention has been paid to cabinet design and general appearance, not only to improve the mechanical construction, but to cater to the local tastes in each country.

NEW TUBES

In order to insure reliability and facilitate the interchange of tubes without disturbing the set performance, many of the receivers are designed to use so-called low-slope universal tubes. These receivers are also suitable for operation on either alternating or direct current. The System tube factory, in

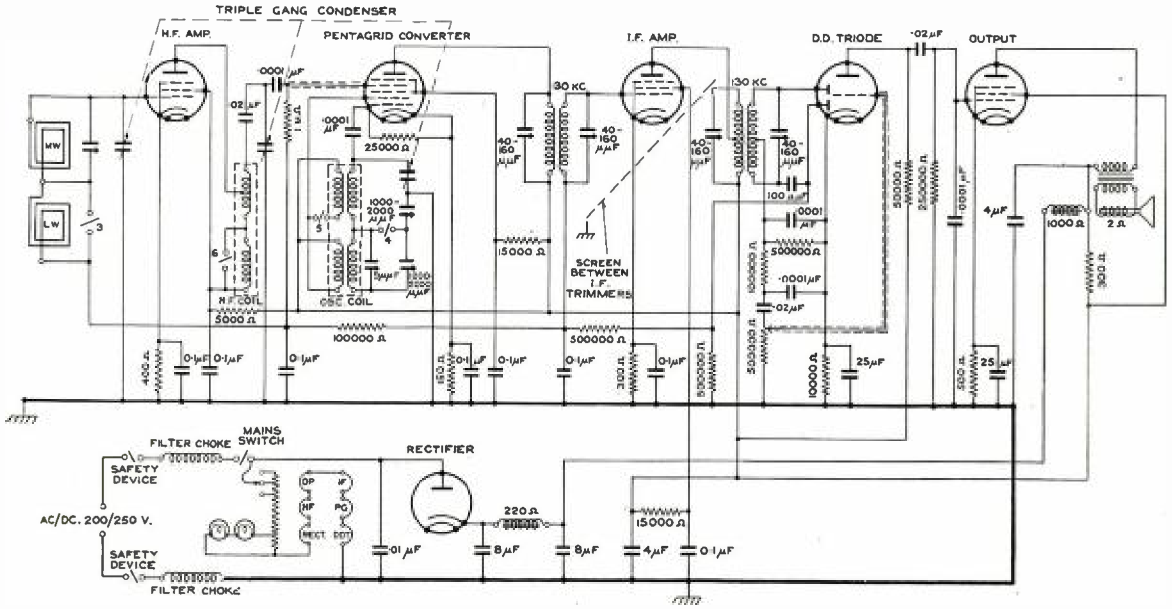
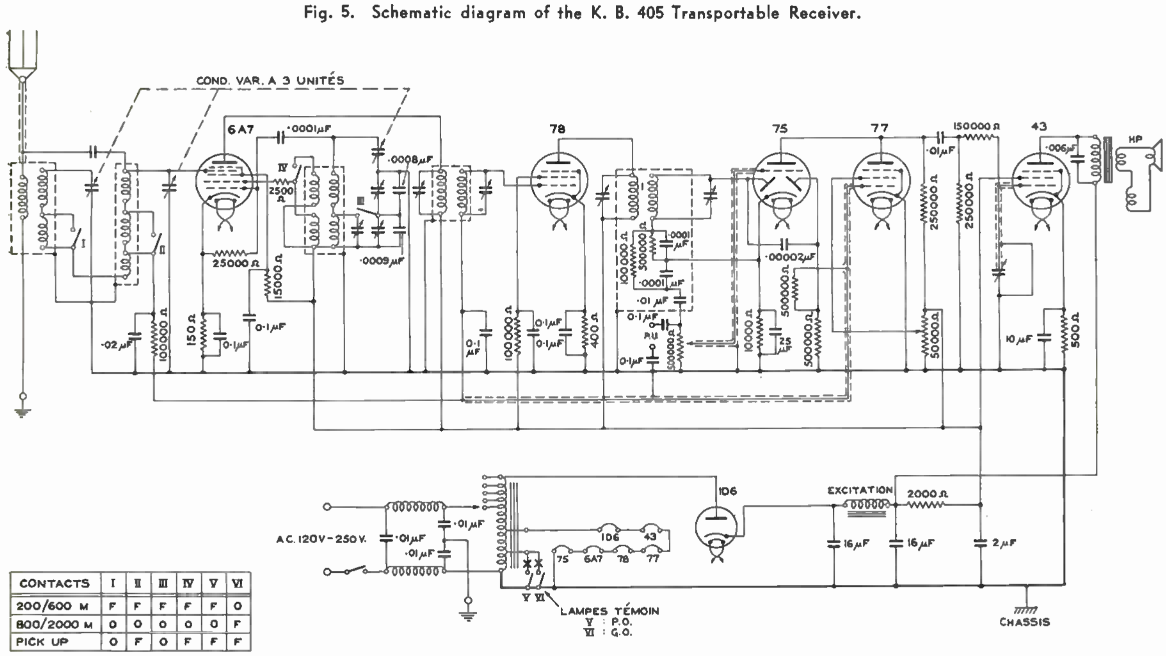


Fig. 5. Schematic diagram of the K. B. 405 Transportable Receiver.



CONTACTS	I	II	III	IV	V	VI
200/600 M	F	F	F	F	F	O
800/2000 M	O	O	O	O	O	F
PICK UP	O	F	O	F	F	F

Fig. 6. Diagram of the Bell Tel. Mfg. Co. "Bell 6" six-tube (5 + 1) ac receiver pictured in Fig. 12.

addition to the types made last year, is now producing five new types, as listed below and illustrated in Fig. 4, of these low-slope universal tubes.

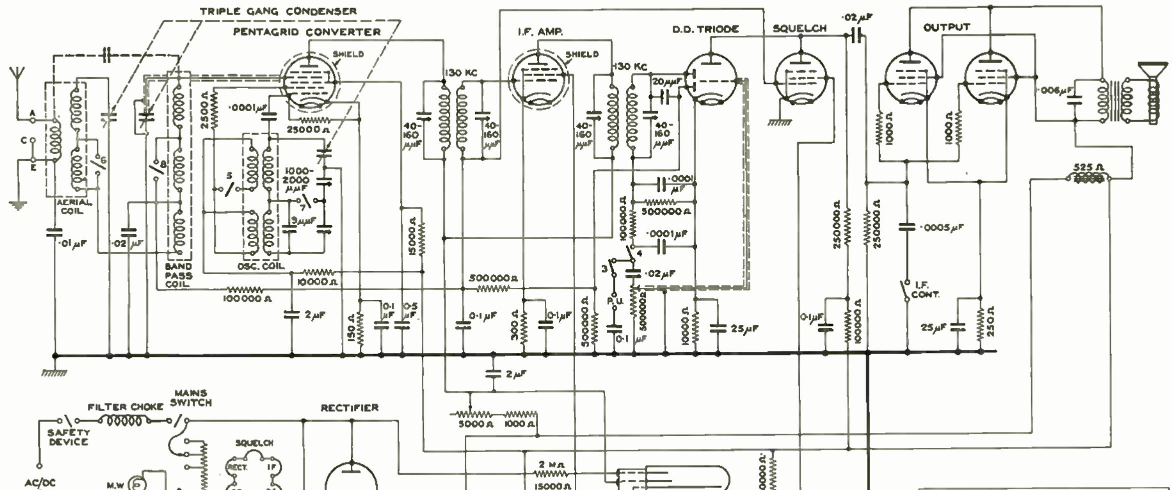
Description	*Type No.*
Pentagrid Converter.........	15-D-1
R-F Pentode................	9-D-2
Double Diode Triode........	11-D-3
Output Pentode.............	7-D-3
Rectifier	1-D-5

TYPICAL RECEIVER DESIGNS

There is still a considerable demand for battery sets, and a complete range of receivers to meet this requirement is included in this year's program. These range from an inexpensive 3-tube simple regenerative set to a deluxe 6-tube superheterodyne Class B, the latter incorporating all features hitherto available only in the ac-type receivers.

Figs. 5, 6, 7 and 8 show circuit diagrams of some of the new sets, and Figs. 9 to 13, inclusive, show completed models of various types. The sensitivity characteristics of a 6-tube receiver manufactured at Budapest are shown in Fig. 14.

In addition to this complete range of the normal form of domestic receivers,



POSITION OF SWITCH CONTACTS									
CONTACT Nº	1	2	3	4	5	6	7	8	9
M.W.	O	C	O	C	C	C	C	C	O
L.W.	C	O	O	C	O	O	O	O	O
GRAM	O	O	C	O	O	O	O	O	C

Fig. 7. Schematic of the K. B. 383 Variable Selectivity Radio Receiver pictured in Fig. 13.

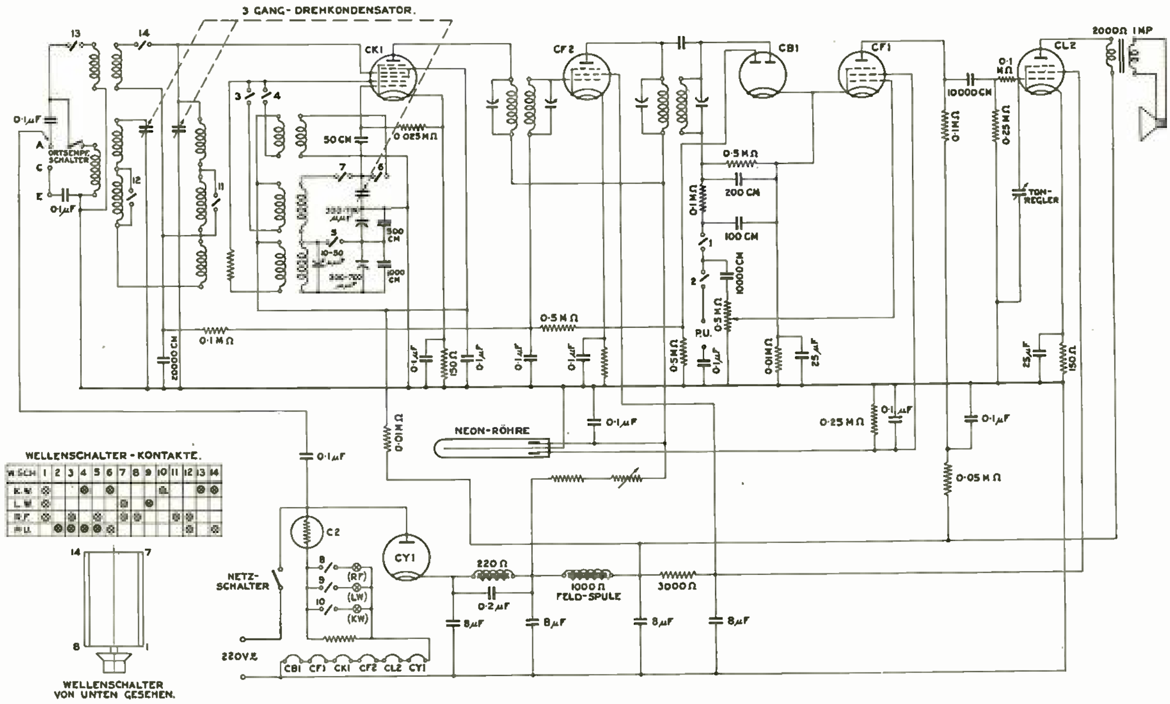


Fig. 8. Diagram of Vienna ac/dc Receiver pictured in Fig. 9.

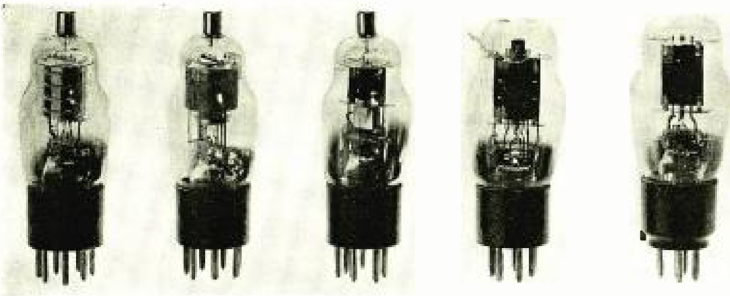


Fig. 4. Standard Universal Tubes. Reading from left to right, the type numbers are: 15-D-1, 9-D-2, 11-D-3, 7-D-3 and 1-D-5.

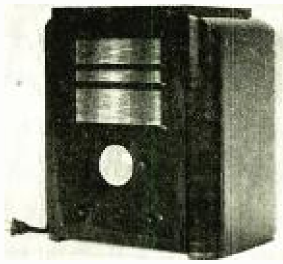


Fig. 9. Standard Vienna five-tube (4 + 1) ac receiver with protection scale and neon tuning beacon.

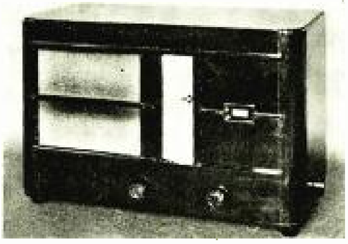


Fig. 10. Standard Budapest Super 35 six-tube (5 + 1) ac receiver with vertical drum full vision dial.

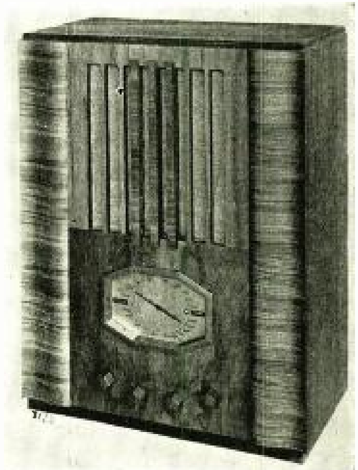


Fig. 12. Bell Tel. Mfg. Co. "6" ac and "6" ac/dc (5 + 1) receiver.

Fig. 11. Le Matériel Téléphonique (L. M. T. 43) five-tube (4 + 1) ac receiver with airplane type dial and station projection scales.

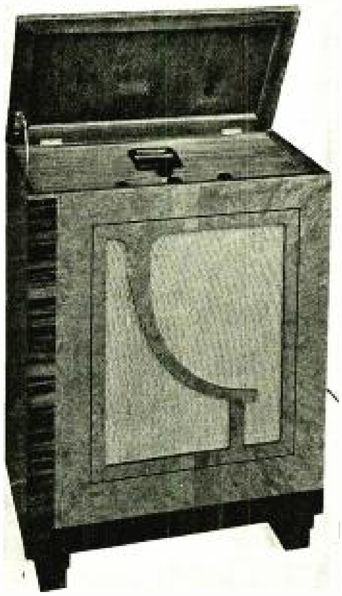


Fig. 13. K.B. 383 seven-tube (6 + 1) ac/dc receiver.

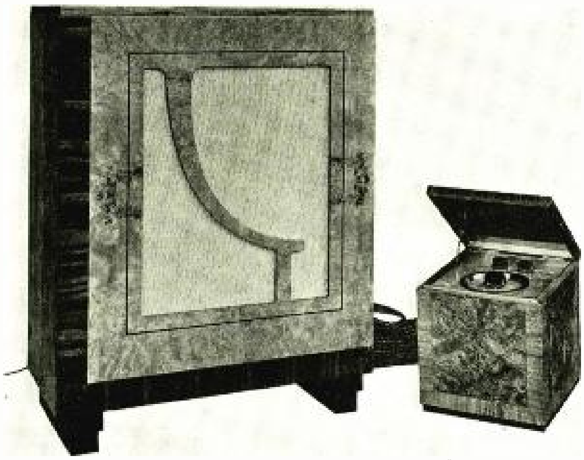


Fig. 15. Kolster Brandes Remote Control Radio Receiver showing remote tuning unit and power amplifier unit. This receiver has built-in "Rejectostat."

Factory	Name or No. of Tubes	Type	Wavelength Range	Cabinet Type	Features
Antwerp	Bell 5 a-c./d-c. Receiver 5 (4+1)	Superheterodyne 145 kc. intermediate frequency	200/600 800/2000	Horizontal Table type	Low Slope tubes; Airplane dial; a-c./d.c. 115-135 volts; Rejectostat; Tone Control.
	Bell 5 a-c. Receiver 5 (4+1)	Superheterodyne 145 kc. intermediate frequency	200/600 800/2000	Horizontal Table type	Low Slope tubes; 2 watts output; Airplane dial; a-c. 110-240 volts; Rejectostat; Tone Control.
	Bell 6 a-c./d-c. Receiver 6 (5+1)	Superheterodyne 145 kc. intermediate frequency	200/600 800/2000	Vertical Table type	Low Slope tubes; 1 watt output; Clock type dial, with illuminated station names; a-c./d-c. 115-135 volts; Rejectostat; Automatic Volume Control (AVC); Silent tuning (QAVC); Large dynamic speaker.
	Bell 6 a-c. Receiver 6 (5+1)	Superheterodyne 145 kc. intermediate frequency	200/600 800/2000	Vertical Table type	Low Slope tubes; 2 watts output; Clock type dial, with illuminated station names; a-c. 110-240 volts; Rejectostat; Tone Control; Automatic Volume Control (AVC); Silent tuning (QAVC); Large dynamic speaker.
	Bell 7 a-c. Receiver 7 (6+1)	Superheterodyne 145 kc. intermediate frequency	19/50:200/600: 800/2000	Console type	European type a-c. tubes; 6 watts output; Clock type dial with illuminated station names; a-c. 110-240 volts; Rejectostat; Variable selectivity—variable fidelity; Automatic Volume Control (AVC); Silent tuning (QAVC); Tone compensation; Tone Control; Push-pull triode (Three element tubes) output valves; Double speaker to cover range 50-7,000 cycles.
Budapest	Standard 2x a-c. Receiver 3 (2+1)	Regenerative T.R.F.	200/600:800/2000	Vertical Table type Cabinet	European a-c. tubes; 95-250 volt a-c. Trolitul variable condensers; Litz Coils; Wave trap; Full vision scale; Rejectostat.
	Standard Super X 4 (3+1)	Superheterodyne	20/50:200/600: 800/2000	Table type Cabinet	European a-c. tubes; 95-250 volt a-c.; Full vision scale calibrated for wavelength and stations; Local distant switch; Tone Control; Rejectostat.
	5 (4+1)	Superheterodyne	20/50:200/600: 800/2000	Table type Cabinet	Scale arrangement same as Standard Super X; Delayed automatic volume control; Visual shadow tuning; Local distance switch; Tone Control; Rejectostat.
	Super 35	Superheterodyne	20/50:200/600: 800/2000	Table type Cabinet	Delayed automatic volume control; Shadow tuning indicator; Local distance switch; Variable fidelity feature; Tone Control; Special vertical illuminated drum type scale, calibrated in metres and station names; Rejectostat.
London	KOLSTER BRANDES A-C. RECEIVERS				
	KB-397 3 (2+1)	Regenerative T.R.F.	200/600:800/2000	Vertical Table type	Clock type scale, calibrated in station names; a-c. tubes; 200-240 volt a-c.; Rejectostat.
	KB 444 4 (3+1)	Superheterodyne	200/600:800/2000	Horizontal Table type	a-c. operation; 200-240 volt; Dynamic speaker; Rejectostat.
	KB 666 6 (5+1)	Superheterodyne	200/600:800/2000	Horizontal Table type	a-c. operation; 200-240 volts; Automatic Volume Control (AVC); Tone Control; Tone compensation; Rejectostat.
	KB 888 8 (7+1)	Superheterodyne	200/600:800/2000	Console Cabinet	a-c. operation; 200-240 volts; Automatic Volume Control (AVC); Silent Tuning (QAVC); 5-watt output; 11-inch Dynamic speaker; Tone Control; Tone compensation; Rejectostat.
	KB 366 8 (7+1)	Superheterodyne	200/600:800/2000	Console Cabinet	Combined automatic record changing gramophone and radio set; Same features as KB 888 and two speakers.
	KOLSTER BRANDES BATTERY RECEIVERS				
	KB 362 3	Simple regenerative	200/600:800/2000	Vertical Table type	Dynamic speaker; Clock type dial; Station names; Rejectostat.
	KB-364 3	T.R. F.	200/600:800/2000	Table type	Dynamic speaker; Deluxe cabinet; Rejectostat.
	KB-393 3	T.R. F.	200/600:800/2000	Table type	Dynamic speaker; Rejectostat.
	KB-333A 3	T.R. F.	200/600:800/2000	Table type	Dynamic speaker; Rejectostat.

Factory	Name or No. of Tubes	Type	Wavelength Range	Cabinet Type	Features
London	KB-363 4	T.R.F.	200/600:800/2000	Table type	Dynamic speaker; Class B output; 2 watts output; Rejectostat.
	KB-398 6	Superheterodyne	200/600:800/2000	Table type	Variable selectivity; Dynamic speaker; Delayed automatic volume control; Tone control; 2 watts output; Rejectostat.
	KOLSTER BRANDES A-C./D.-C. RECEIVERS				
	KB-381 5 (4+1)	Superheterodyne	200/600:800/2000	Table type	200-240 volts; Delayed automatic volume control (DAVC); Full vision scale calibrated in station names and metres; Rejectostat.
	KB-383 Consolette 7 (6+1)	Superheterodyne	200/600:800/2000	Consolette	200-240 volts; Variable selectivity and fidelity; Delayed automatic volume control (DAVC); Silent tuning (QAVC); Neon tuning beacon; Calibrated in station names and metres; Rejectostat.
	KB-383 Console 7 (6+1)	Superheterodyne	200/600:800/2000	Console	Same features as 383 Consolette, with two loudspeakers.
	KB-405 Transportable 6 (5+1)	Superheterodyne	200/600:800/2000	Transportable	Loop antenna; Delayed automatic volume control; Full vision scale, calibrated in metres and station names.
	KB-387 Motor Car Rec. 5-tube	Superheterodyne	200/600:800/2000	Dashboard mounted or remote control from steering column	Car accumulator feeds motor gen. and supplies all H.T. voltages; Moving coil speaker; Delayed A.V.C.; Sensitivity 2 microvolts; Output 3 watts; Clock face dial.
	KB-385 7 (6+1) Remote Control	Superheterodyne	200/600:800/2000	Consolette	Same features as 383 Consolette, with remote control facilities.
Paris	Type 63 LMT 7 (6+1)	Superheterodyne 135 kc. Intermediate frequency	200/600:800/2000	Table	a-c. Receiver; 110-240 volts; Low slope tubes; Automatic volume control (AVC); Silent tuning (QAVC); Tone compensation; Tone Control; Neon Tuning Beacon; Calibrated dial-station names projected; Filtrostat.
	Type 253 LMT 6 (5+1)	Superheterodyne 135 kc. Intermediate frequency	200/600:800/2000	Table	a-c./d.c. Receiver; 100-125 volts; Low Slope Tubes; Automatic volume control (AVC); Silent tuning (QAVC); Open face, airplane dial; Filtrostat.
	Type 43 LMT 5 (4+1)	Superheterodyne 135 kc. Intermediate frequency	200/600:800/2000	Table	a-c. Receiver; 100-150 volts; Automatic volume control, 2 watts output; Open face airplane dial; Filtrostat.
	Type 163 LMT 6+1 Radio Gramophone	Superheterodyne 135 kc. Intermediate frequency	200/600:800/2000	Table	Same as LMT 6+1 Type 63
Vienna	4 WS 5 (4+1)	Superheterodyne	19/50:200/600: 800/2000	Table type	a-c. Receiver; European type a-c. tubes; Projection scale; Neon tuning indicator; Silent tuning; Automatic Volume Control (AVC); Mains antenna; Rejectostat.
	5 WS 6 (5+1)	Superheterodyne	19/50:200/600: 800/2000	Table type	a-c./d-c. Receiver; European type a-c./d-c. tubes; Ballast lamp; Same features as 4 WS.

including thirty different models, remote control receivers for special uses and motor-car receivers have been developed. They are illustrated in Figs. 15 and 16.

Due to the increasing number of short-wave broadcasters which have been erected throughout the world, there is a growing demand in Europe for domestic broadcast receivers capable of receiving these stations. Some of the standard models include this facility, and the basic design of all the models is such that short-wave features can be incorporated at little additional expense, if required.

The "Rejectostat" has proved to be

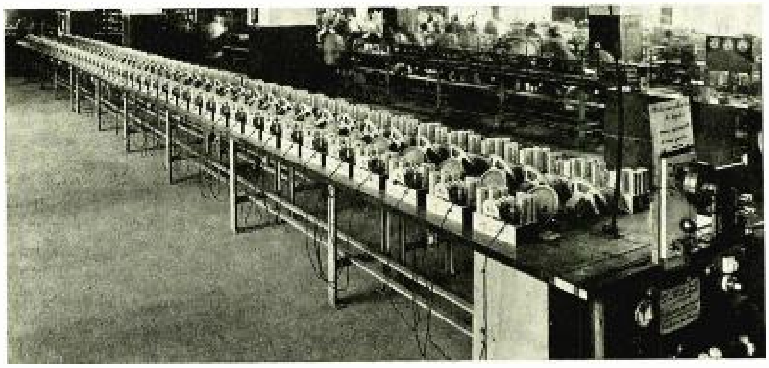


Fig. 17. Life test rack for 100 receivers, Boulogne factory.

a successful means of improving broadcast reception through the elimination of man-made static and, similar to last year, all of the new models are designed to work with the "Rejectostat." The public is showing an increasing interest in the use of this device.

As was the case last year, the receivers produced by the companies in the International Group are based on the same fundamental designs. They differ, however, in certain characteristics from one country to another in order to meet particular local conditions.

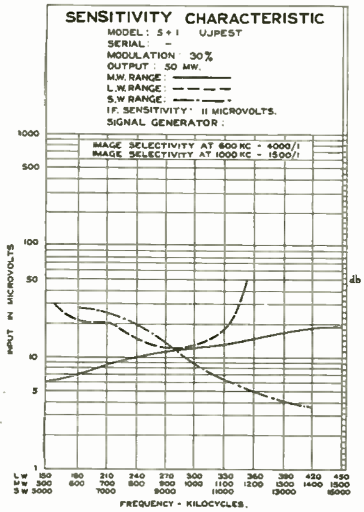


Fig. 14. Sensitivity characteristic of Standard Budapest 35 six-tube (5 + 1) receiver, the circuit for which is shown in Fig. 8.

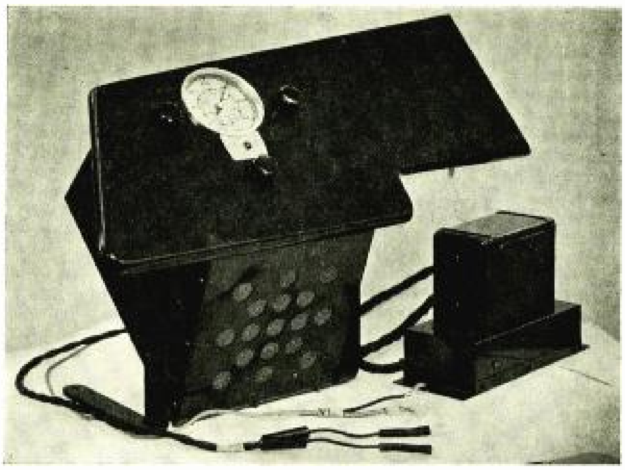


Fig. 16. K. B. 387 Motor-Car Receiver and dynamotor power supply unit for dash board mounting.

INSPECTION METHODS

Special attention is being paid this year to inspection methods, so as to reduce service troubles to the absolute minimum. To insure a high degree of reliability, the factories give all components—mechanical assembly, soldering and continuity—a one hundred per-cent inspection. Tubes are put through a severe shaking and aging test, and every receiver, of course, is given a severe final inspection. In addition, a percentage of each type of set is put on a life test and operated for hundreds of hours, so as to reveal any defects which may have passed through the severe inspection described above. Fig. 17 shows the life testing at Paris. Every receiver is operated for a number of hours before being shipped to the customer.

The following tables list the principal receivers being manufactured and sold this year, showing for each location the types, as well as the features and characteristics of the sets.

BOOK REVIEWS

(*Continued from page* 15)

tice. There are enough explanatory text books for the radio man available now, in the opinion of your reviewer; the handbook is a compilation of data without the explanations.

Those familiar with previous issues of the handbook will be interested to know that the present nineteenth edition has two hundred pages more than the previous edition, and that the material has been re-arranged for more handy reference, as outlined here. There should be room for this book on the desk, not in the bookcase.—*L. M.*

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BROADCAST-RECEIVER DESIGN, by G. S. Granger, 36 pages, paper covers, price 50 *cents.*
ALL-WAVE RECEIVER DESIGN, by G. S. Granger, 30 pages, paper covers, price 50 *cents.*
HIGH-FIDELITY RECEIVER DESIGN, by G. S. Granger, 32 pages, paper covers, price 50 *cents.*

Published by Manson Publishing Company, 521 Fifth Ave., New York, N. Y.

This set of three books on receiver design was written for the radio service man with the intention of assisting him in making independent analysis of receiver circuits. Complete explanations are given of modern circuit functions, with an occasional mathematical interpretation where it is deemed necessary.

Broadcast-Receiver Design opens with a chapter on antennae and antenna coupling circuits, with an interesting portrayal of subsequent engineering developments and the reasons for them. Later chapters, each handled in the same interesting manner, cover audio-amplifier systems, bandpass filters, image-suppression circuits, i-f amplifiers, coupling systems, oscillators and oscillator tracking, avc and qavc circuits, circuit noise, etc.

All-Wave Receiver Design deals with special antenna systems developed for wide frequency coverage, avc circuits as applied to all-wave receivers, beating oscillators, choice of intermediate frequency, oscillators and oscillator tracking, shielding, and waveband switching systems.

High-Fidelity Receiver Design opens with a chapter on acoustic considerations, and follows through with an explanation as to what constitutes an authentic high-fidelity receiver, special audio amplifiers, automatic tone control, bandpass filters, high-fidelity requirements, special i-f amplifiers and band-width control, oscillator problems, thermal noise, etc.

Though there are duplications of chapter heads in the three books, there is actually no duplication of material.

The data is well presented and parts appear decidely original. For this reason the books should be of interest to engineers as well as service men.

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AUTHORSHIP NOTICE

WE HAVE BEEN advised by Wireless Egert Engineering, Inc., that in submitting for publication the article, "Receiver Production Tests" (page 12, RADIO ENGINEERING, November, 1934), they inadvertently ascribed the work to S. Bagno and J. Sadowsky, whereas the credit should have gone to S. Bagno and M. Posner. Since Mr. Posner did a considerable amount of developmental work on the equipment described, it is felt that he should receive the acknowledgment due him.

The DB as a Unit of Receiver Sensitivity

By KEITH D. HUFF
Consultant, "General Graphics"

● **Using the decibel as a unit for measuring sensitivities permits rapid comparisons and determinations of stage gains by subtraction. This method was accepted as the standard but has not been as widely used as it should be.**

WHEN IT BECAME desirable to attach a figure of merit to radio receivers in comparing their sensitivities, a basic quantitative unit for this measurement had to be employed. The Microvolt-Per-Meter was widely used at first. The sensitivity of the receiver was given as the number of microvolts rms of modulated carrier per meter of effective antenna height excitation at the receiver's input required to register a standard output into the speaker. When antenna characteristics became standardized, the "Per Meter" function was dropped, and sensitivities are now given in microvolts rms absolute of 30% audio modulated carrier as delivered from the signal generator to the receiver through an artificial or dummy antenna having standardized lumped constants. The standard output for broadcast receivers is 50 milliwatts into a resistive load. Signal generators have their stepped attenuators and their slide wires or indicators calibrated directly in microvolts, thus permitting the practical measurement of receiver overall sensitivities.

As a unit for the general designation of receiver overall sensitivities, the microvolt serves very well, and its inverse relationship to sensitivity is understood not only by engineers and service men, but also by the members of the radio sales and distribution units as well.

With the radio development engineer, the juggling of circuit modifications, layouts, gains, and slopes form a major portion of the development job. He can employ the microvolt here as a quantitative unit in measuring and computing individual stage gains and slopes, but its use involves extensive operations in multiplication and division. Also, the microvolt being a linear designation, can mount into some unduly large figures on the data sheet when it is noted that an average radio receiver can build a received signal of one microvolt up to several million times that.

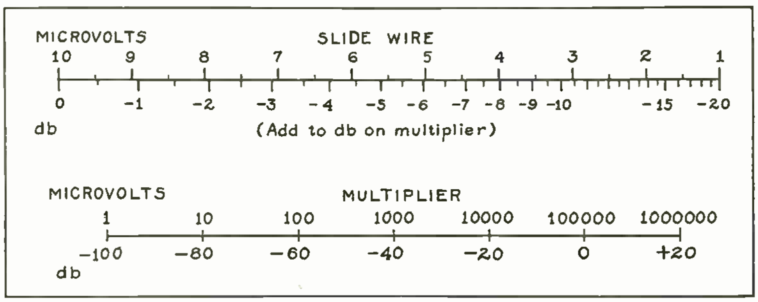
USE OF DECIBEL

A quantitative unit of sensitivity, the use of which somewhat simplifies the stage-to-stage data taking operations, is the decibel, or db. It can be used for designating radio-frequency voltage ratios as effectively as it has been used for some time in audio attenuation measurements. The db is a special case of the more general unit, the transmission unit or TU, the latter being the general designation for expressing the logarithmic ratios of voltages, currents, or powers as they appear in varying degrees of magnitude along a transmission system. The TU is also parent to the Naperian units, the neper and the decineper. The db, which will be discussed here, and which is the unit used widely in the United States, represents twenty times the logarithm (to the base 10) of the ratio of any two magnitudes of voltage or current. The db corresponding to the ratios of powers is given as ten times the logarithm (to the base 10) of the ratio of the two powers. The use of the db in expressing the measurements of stage gains and sensitivities, as against the use of the microvolt for this purpose, reduces multiplication to addition and substitutes subtraction for division, thus easing up considerably on the computations involved; nor do expressions in db ordinarily run into very large figures.

CONVERSION SCALE

Receiver sensitivity is read directly from the signal generator's microvolt-calibrated stepped attenuator and slide wire or microvolt meter scale. In order to use the db as a substitution unit here, conversion from microvolts to db must be made, and an auxiliary scale calibrated in db should be attached to the attenuators over the microvolt scales. Working from the definition of the db, conversion to it from microvolts is simple. Keeping in mind that db expresses primarily a ratio, there must be a reference level from which to work. This level is conveniently set as being one volt. As an example, consider a superheterodyne receiver which has a sensitivity of 300 microvolts at the modulator tube's grid, that is, the signal generator has to deliver 300 microvolts into this point in order to create an audio output of 50 milliwatts into the output load. Three hundred microvolts as a voltage ratio becomes $10^6/300$ or 3,333. Twenty times the $\log_{10}$ 3,333 then equals 70.5 db below one volt. Refer to the chart for graphical data to be used in constructing an auxiliary scale or scales for attaching to the signal generator. It can be seen that the term, microvolts, is in itself a ratio, being so

(Continued on page 26)



Graphical data for constructing supplementary signal-generator scales.

Design .. NOTES AND

I-F TRANSFORMER DESIGN

HIGH FIDELITY

HIGH FIDELITY requires that an i-f amplifier should have a wide, flat-nosed selectivity curve. The following discussion indicates a possible solution.

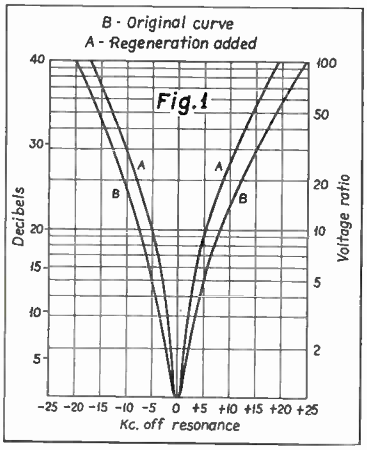
The expression for maximum stage gain has been given as

$$\omega M = \sqrt{r_p\, r_s}$$

where r_p = total resistance of the primary

r_s = total resistance of the secondary

when $\omega M > \sqrt{r_p\, r_s}$, the gain will drop at the frequency, f_o, to which the circuits are tuned and the selectivity curve



will exhibit a double hump. The frequencies at which these humps occur are given by

$$f' = \frac{f_o}{\sqrt{1+k}} \text{ and } f'' = \frac{f_o}{\sqrt{1-k}}, \text{ k as}$$

previously defined.

$$f'' - f' = \Delta f = f_o \frac{\sqrt{1+k} - \sqrt{1-k}}{\sqrt{1-k^2}},$$

Δf being the band width.

If k is small, $\Delta f = f_o\, k$

$$k = \frac{M}{\sqrt{L_s\, L_p}} = \frac{\sqrt{r_p\, r_s}}{\omega \sqrt{L_s\, L_p}} = \frac{r_p}{\omega L_p} \cdot \frac{r_s}{\omega L_p} = \frac{1}{\sqrt{Q_s\, Q_p}} \text{ and } \Delta f = \frac{f_o}{\sqrt{Q_s\, Q_p}}.$$

If $Q_s = Q_p = 100$, the critical coupling is found to be 0.01. Although any value of k beyond critical produces double-humps, the humps are almost indistinguishable until the coupling has been increased to 0.015. So for a flat-nosed response we may take:

$$k = \frac{1.5}{\sqrt{Q_s\, Q_p}} = \frac{\Delta f}{f_o}, \text{ and } \sqrt{Q_s\, Q_p} = \frac{1.5\, f_o}{\Delta f}.$$

We may thus compute the allowable values of Q for a given band width at any resonant frequency.

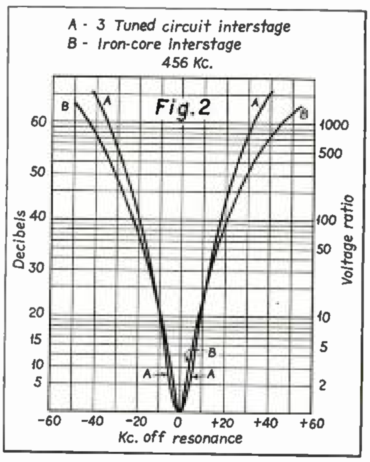
It appears that i-f transformers for high-fidelity requirements should use low-Q coils to obtain flat-nosed curves, but a large number of tuned circuits will be required to give sufficient rejection to signals on adjacent channels. An excellent overall i-f curve for broadcast reception would be ± 8 kc wide at the nose and be down 40 decibels at ± 10 kc.

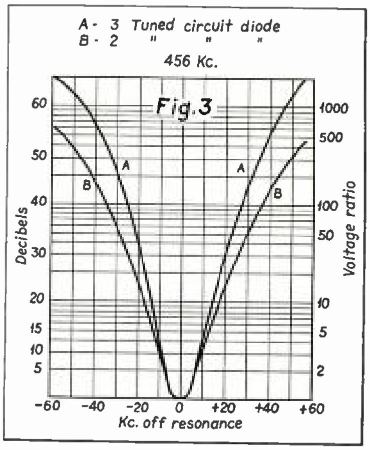
One vital effect on the overall i-f selectivity of a receiver is stray coupling. It may cause unsymmetrical curves or produce sharp responses, as regeneration tends to overcome circuit losses. The effect of added regeneration in an i-f amplifier is shown in Figure 1.

REPRESENTATIVE SELECTIVITY CURVES

Some i-f assemblies having three tuned circuits instead of the usual two have recently appeared on the market. Fig. 2 and Fig. 3 show comparisons of high-Q interstage and diode transformers with three tuned-circuit assemblies. The latter have steeper sides and broader noses.

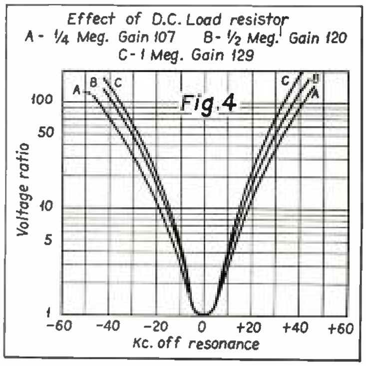
Fig. 4 shows the effect of dc load resistors on diode selectivity. The coupling of this transformer was readjusted for each changed condition.





The curve labeled "interstage" was fed from a 2A7 tube into a 58 and had a single-tuned transformer between the 58 and a 2A6. The "diode" curves were taken with the same single-tuned transformer between the 2A7 and the 58.

An inspection of Fig. 5 shows the improvement which may be realized in



overall i-f selectivity by utilization of two of the new three-circuit transformers, interstage and diode.

BAND-PASS FILTER DESIGN

An interesting approach to i-f transformer design is the consideration of a wave filter. For a filter to have negligible dissipation at intermediate frequencies, the Q of the coils should be in the order of 150 to 200. The input and output loads should be pure resistances and properly chosen to obtain the desired transmission characteristics. A transformer having two resonant circuits may be resolved into the "T" network shown in Fig. 6.

If $f_2 - f_1$ is the desired transmission

COMMENT . . *Production*

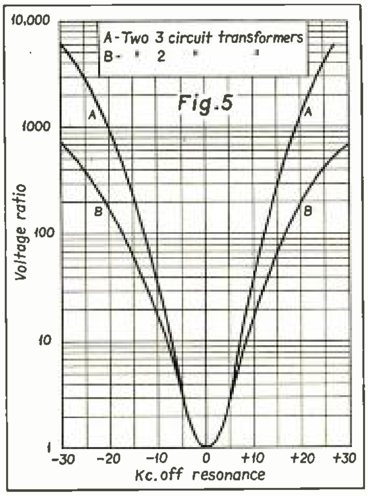
band, the relationship of C_1 and Z_{ab} is given by:

$$Z_{ab} = \frac{1}{2\pi(f_2 - f_1)C_1}.$$

Variation in tube and circuit capacities will not allow too small a value for C_1. 50$\mu\mu$f seems a reasonable lower limit for the present day r-f pentodes. It is advantageous to have:

$$Z_i = \frac{Z_{ab}}{0.8}.$$

Type 58 and 6D6 tubes have a normal plate resistance of 0.8 megohm. An increase in control-grid bias which results from automatic volume control action will increase the R_p to several megohms. As high fidelity is most important for local reception (high R_p), the input load will be Z_i. A non-

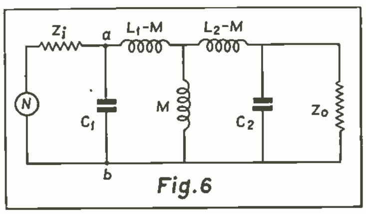


inductive resistor should be used for this purpose.

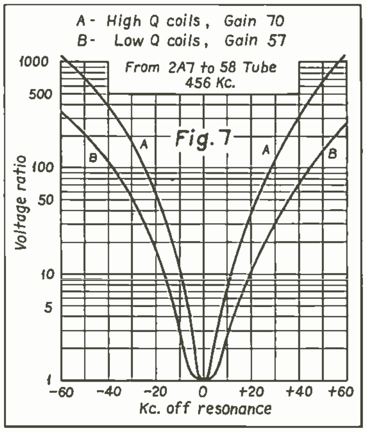
The Q of the coil may be chosen to provide an equivalent load at resonant frequency:

$$Q = \frac{Z_i}{\omega_0 (L_1 - M)}.$$

Such a load resistance will, however, depart from the "pure resistance" input requirement, as Z_i will then vary with frequency.



If $L_1 = L_2$, Z_o should equal Z_{ab}. Higher values of Z_o increase the transmission near cut-off and thus produce double-humps. Best efficiency for voltage amplification will be obtained by keeping the terminal resistance high.



The chosen value of Z_o will be a compromise between these two considerations.

$$k = \frac{f_2^2 - f_1^2}{f_2^2 + f_1^2}.$$

It is desirable that more than two sections be used in the filter so as to obtain sharper cut-off. The gain of the transformer described above will, of course, be less than that obtained by conventional design. Additional tubes will be required to increase the amplification.

Fig. 7 illustrates the improvement in i-f selectivity by using the three-pie winding for primary and secondary. Curve B is the ordinary single winding using 7/41 Litz. Curve A is the improved triple-pie coil using 7/41 Litz.

F. H. SCHEER,
Engineer,
F. W. Sickles Co.

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WAVE-BAND SWITCH DESIGN

MODERN RECEIVER designs covering high- and low-frequency bands have brought to the foreground many developments in wave-band switch construction which only a short while ago were of little importance. Today, wave-band switches should have the following electrical characteristics:

(1) Extremely low, non-variable contact resistance.

(2) Very low capacity between contacts.

(3) Negligible insulation losses.

In order to meet the first requirement it is first necessary to employ a contact metal having very low resistance. Silver meets the requirements very nicely and may be used economically as contact elements.

The development of an initial low resistance is not sufficient, however—means must be provided for the maintenance of low-resistance connections and for the prevention of any possible variables in the established low-resistance contact.

BRIDGING CONTACTS

These characteristics have been gained in one instance by the use of sterling silver for the contact elements and through the elimination of electrical connection to the rotating contact arm. A semi-spherical bridging contact stud is used on the rotor arm of the switch. All circuit connections are made to groups of stationary contacts on the stator in such a manner that connection may be made by bridging any two of the stator contacts with the rotating stud.

The stationary contacts are rounded to conform with the shape of the rotating stud with the result that large contact surfaces are obtained.

The bridge-contact stud is held in place by a conical spring. This spring acts as the driving member when rotating the switch from one position to another and also serves to maintain constant pressure between the rotor and stator contact surfaces. When the stud falls into place between two stator contacts, the spring provides a locking action. Moreover, the pressure exerted on the rounded surfaces is instrumental in cleaning and polishing the contacts with operation of the switch.

The second requirement—that of low capacity between contacts—is taken care of by the relatively large spacing between the paired stator contacts. Moreover, when in an open-circuit condition, there is a negligible amount of metal surface between contacts with the result that capacity is at a minimum.

Insulation losses may be kept to a minimum by the use of high-grade insulating materials. Wafers of insulation material are highly satisfactory and afford the necessary degree of mechanical strength.

Switches designed in the manner outlined have an average contact resistance of .0022 ohm and a maximum of .0026 ohm. The maximum metallic circuit resistance is .0010 ohm. The capacity between contacts may be kept at an aver-

(*Continued on page* 26)

THE DB AS A UNIT OF RECEIVER SENSITIVITY

(*Continued from page 23*)

many millionth parts of one volt; so the significant figures of the ratio become the reciprocal of the number of given microvolts. The conversion of the voltage ratios themselves can be made directly on the Log-Log scales of a slide rule. The index of scale C is set at the square root of 10 on scale LL3. Voltage ratios are then read on scales LL2 or LL3 with the significant figures of the corresponding db appearing opposite and above on scale C. Power ratios can be found in the same manner with the index of scale C set at 10 on scale LL3.

PRACTICAL ADVANTAGES

The practical advantages of using the db as a unit for measuring sensitivities lie in the fact that stage gains can be quickly determined by merely subtracting the sensitivities obtained with the signal generator feeding into any two points of stage sequence. Likewise the overall sensitivity of the receiver or any portion of it, as, say the i-f amplifier becomes merely the sum of the individual stage gains within it.

It must be noted that with the receiver delivering 50 milliwatts output (through 8,000 ohms load, equals 20 volts), the overall sensitivity of the signal generator reading in db does not correspond to the gain absolute in db. In this case, whereas the input is read in db below *one* volt, the output is actually 20 volts, giving rise to a discrepancy of 20/1 in the ratio between the input and the output reference levels. In order to determine the receiver's gain absolute in db, the db corresponding to the discrepancy ratio must be added to the input reading. As an example, a 10-microvolt receiver requires an input from the signal generator of 100 db below one volt to register 20 volts audio output. To this 100 db is added the db corresponding to the ratio of 20/1, or 26 db. This totals 126 db and represents the gain absolute of the receiver.

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RADIO INSTITUTE OF AUDIBLE ARTS

NOT TO REFORM radio but to stimulate public appreciation of the best that radio has to offer is the purpose of the Radio Institute of the Audible Arts, which was inaugurated on Thursday, November 22, at a luncheon for the leaders in music and education at the Waldorf-Astoria, New York, N. Y. The new organization will carry on a continuous drive to advance American appreciation of the audible arts—drama, music, opinion dissemination, and the like—and to encourage a greater recognition and more effective use of the best in radio.

ATTENDANCE

The luncheon was attended by many prominent figures in the fields of education, radio and music, and the ceremonies were broadcast through the facilities of the Columbia Broadcasting System.

Sayre M. Ramsdell, Vice President of the Philco Radio & Television Corporation, which is sponsoring the new organization, introduced Pitts Sanborn, Music Editor of the New York World-Telegram and Director of the Radio Institute of the Audible Arts, who spoke briefly and introduced the other speakers. They were P. W. Dykema, Professor of Music Education, Teachers College, Columbia University, New York, N. Y.; George S. Dickinson, Chairman of the Music Department, Vassar College, Poughkeepsie, N. Y.; Werner Janssen, noted Orchestra Conductor, who has just completed two weeks as guest conductor of the New York Philharmonic-Symphony Orchestra; and Boake Carter, well-known Radio News-Commentator.

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WAVE-BAND SWITCH DESIGN

(*Continued from page 25*)

age value of .04 mmfd, whereas the insulation resistance between contacts when using high-grade material is in the vicinity of 1.2×10^9 ohms, with a moisture absorption, after 24 hours immersion, of 0.7%.

CIRCUIT POSSIBILITIES

Switches following the general design outlined have innumerable circuit possibilities. A single-gang switch, with standard bridging-contact spacing, provides approximately 725 circuit combinations, and by changing the spacing of the bridging contacts, it is possible to increase the possible combinations many-fold.

Multi-throw combinations may be obtained by the addition of a simple jumper connection between common contacts. It is interesting to note that where single- and double-throw switching arrangements are used in combination with multi-throw arrangements, the single- or double-pole arrangement can be placed mechanically in any desired throw, or throws, of the multi-throw switch, with no electrical connection between circuits.

LEE L. MANLEY,
Production Engineer,
Hugh H. Eby, Inc.

"NEW VISTAS IN RADIO"

THE JANUARY ISSUE of *The Atlantic Monthly* carries an article titled "New Vistas in Radio," by Leopold Stokowski, the justly famous conductor of the Philadelphia Symphony Orchestra.

Mr. Stokowski makes a number of suggestions for new methods in radio broadcasting which should prove of interest to the broadcast receiver engineer and manufacturer. The suggestions offered cover technical improvements that have already reached a comparatively high stage of development.

Mr. Stokowski's wide interest in music and his understanding of the technical nature of both mechanical and electrical sound, may be assumed from the opening of his article, wherein he asks:

"Is there any difference between listening to music directly and by radio? I have tried to meet this question in two ways: first, personally and subjectively, as one who has devoted all his life from childhood to making music and trying to understand its true inner nature; and, secondly, objectively impersonally, trying to find the facts as registered, not by ear, but by instruments of precision."

Mr. Stokowski is of the opinion that the audio-frequency range of the broadcast transmitter and receiver should be 30 to 13,000 cycles, and adds:

"The first step toward making it possible to include the missing vibrations between 5,000 to 13,000 is, in my opinion, to widen the channels that were apportioned some years ago by the Radio Commission in Washington. . . . The first and the fundamental need is for Washington to revise its allotment of channels so that they can be broader."

In commenting on intensity range, Mr. Stokowski says:

"One of the greatest values of music—its power to evoke in us moods and states of feeling and of being—thus depends greatly upon dynamic contrast and graduation. . . . For the reception of operatic and symphonic music in the average home, a dynamic range of 85 decibels would not be necessary, but music needs a much greater variation of loudness and softness than is at present possible."

In summing up the subjects of frequency response, intensity range and auditory perspective, he says:

"When all the results outlined in (1) Frequency Range, (2) Intensity Range, (3) Auditory Perspective, are brought about, it will be more possible to find the answers to the two great questions of how the cost of radio can best be met and what ought to be the relation of government to radio. First of all we must see clearly what we *need* from radio socially and technically."

NEWS OF THE INDUSTRY

STRUTHERS DUNN BOOKLET

Struthers Dunn, Inc., 139 Juniper Street, Philadelphia, Pa., have a very interesting and useful booklet on Electric Heating Equipment, including Wax and Compound Pots, Solder Pots, and Ladles. Also included is a table listing the heats of fusion, melting points, heat of vaporization, weights, and the like, for a long list of solids, liquids, and gases and vapors. All items are well illustrated and have complete technical information included.

Another feature of this booklet is the full-page, Heat Absorption . Calculator. This Calculator has been compiled for rapidly estimating the heat absorption of various metals in terms of watt hours per degree Fahrenheit temperature rise. The results are within slide-rule accuracy, suitable for all commercial problems, if reasonable mechanical accuracy is exercised. Complete details on how to use this Calculator are also included.

CROSLEY RADIO SALES SET RECORD

Sales of 50,971 Crosley radios during October are announced by Powel Crosley, Jr., President, Crosley Radio Corporation, Cincinnati. This is the largest number of sales of radio sets since 1929, when the company sold 50,269 sets, and compares with 47,204 sets for October, 1933, and 22,742 for October, 1932, it is stated. In addition to the improvement in rural sections and business generally, a material factor in the increased sale of radios is the new all-wave American and Foreign receiving sets which are in great demand, Mr. Crosley stated.

PACK REJOINS DOEHLER

Mr. H. H. Doehler, President of the Doehler Die Casting Co., announces that Mr. Charles Pack has rejoined the Doehler organization in the position of Assistant to the President in charge of all research and development.

Mr. Pack is one of the outstanding technicians of the die-casting industry. For the last few years he acted as consulting engineer and metallurgist to the trade in general.

CHANGE OF ADDRESS

The New York City sales office of American Transformer Company has been moved from 11 E. 41st Street to 30 Rockefeller Plaza. The new telephone number is Columbus 5-4767.

In charge of AmerTran's audio transformer sales in New York City is Ivor B. Watts. Mr. Watts has been connected with American Transformer Company since 1927 and has been engaged in sales work for the past five years. Previous to February, 1934, Mr. Watts was employed at the Company's main office at 178 Emmet Street, Newark, N. J.

NEW BRUSH REPRESENTATIVE

Arthur H. Baier, Manufacturer's Representative, 2015 East 65th Street, Cleveland, Ohio, has been appointed Ohio Representative for the Brush Development Co., Cleveland, Ohio, whose line comprises Sound-Cell Microphones, Phonograph Pick-ups, Tweeters, Loudspeakers, and the like.

SAYRES BACK WITH LYNCH MFG.

Ralph A. Sayres, associated for many years with A. H. Grebe & Company, Lynch Manufacturing Company, and until recently in foreign fields for General Motors, has returned to the radio field.

Mr. Sayres has taken over the presidency and management of sales for the Lynch Manufacturing Co., Inc., 405 Lexington Ave., New York City, producers of a complete line of extruded and wire-wound resistors.

Mr. Sayres' many old friends will welcome him back to the fold.

AIR LINE ADOPTS W. E. EQUIPMENT

The latest air transport line to adopt Western Electric radiophone as standard equipment is Eastern Air Lines, which has equipped its five Douglas planes, recently put into service under the name of "Florida Flyers" on the speedy Miami route, with short-wave receivers and transmitters and beacon receivers.

Four more Douglas planes soon to be put in service by this line are being similarly equipped.

Radio ground stations of Eastern Air Lines are being adapted to operate with this equipment in the planes by the installation of special crystal units for the precise control of frequencies.

SPAULDING FOLDER

The Spaulding Fibre Company, Inc., Tonawanda, New York, have recently issued a folder entitled "An Improved Part for Radio." This folder is descriptive of a Spauldite Radio Coil Form, which, it is stated, is a newly developed and improved part for radio now being introduced to the trade.

GENERAL CABLE APPOINTMENTS

The General Cable Corporation on December 1 announced the appointment of Mr. George Sherry to the position of General Merchandise Manager. At the same time, Mr. H. B. Tompkins, formerly Manager of Supply Sales, General Electric Supply Corporation, took over the duties of General Sales Manager.

RCA VICTOR TO EXPAND CENTRALIZED SOUND ACTIVITIES

Preparatory to expanding the company's activities in the sound-reinforcement, centralized-radio and multiple-antenna systems field, Mr. G. K. Throckmorton, Executive Vice President of the RCA Victor Company, announced the appointment of Mr. W. L. Rothenberger as Manager of the Centralized Sound Department.

Mr. Rothenberger, who has been identified with the communications and house entertainment phases of radio for the past 14 years, was formerly the Atlanta, Ga., District Sales Manager of the Centralized Sound Department. Plans are being formulated for developing the sales potentialities in the many fields where centralized sound products are finding increasingly wider application. Particular attention is being given to the improvement of the distribution outlets through which the Company's products are to be merchandised, it is stated.

STROUD HAS SYLVANIA TERRITORY

The appointment of R. H. "Bob" Stroud as Sales Representative has been announced by Stanley N. Abbott, Sales Manager of Hygrade Sylvania Corporation. Mr. Stroud is very well known to the radio trade through his connection with Atwater Kent. As convention manager, he came in close personal contact with radio manufacturers and jobbers throughout the country. His sales work in Chicago, Cincinnati, Canada, and later a Divisional Sales Manager for the territory including southern Illinois, Missouri, Kansas, Oklahoma, Texas, Louisiana and Arkansas has given him a keen insight into the merchandising problems of the retail trade it is stated. He will handle Hygrade Sylvania sales in the Kansas City territory.

LEIPZIG FAIR DATES ANNOUNCED

The Leipzig Trade Fair will be held from March 3rd to 10th, maintaining the schedule followed for over 700 years. The great international market is the oldest going concern in the world and the most far-reaching in its influence. Indications of a general upturn in world trade are found in the advance bookings which are said to assure an attendance of 100,000 business men from seventy-two countries. More than 8,000 exhibits will be contributed by a score of the leading countries including the United States.

NEW QUARTERS FOR CURTIS

The Curtis Condenser Corp., of Cleveland, Ohio, manufacturers of Electrolytic Condensers, have moved their factory into larger quarters at 3088 W. 106th St. This move was necessitated by the fact that they were unable to increase production in their old plant to keep abreast of orders. The new plant will allow for much larger production which enables them to meet all requirements for Curtis Electrolytic Condensers.

MAGNAVOX APPOINTMENT

On December 1st the Magnavox Company, Ft. Wayne, Indiana, announced the appointment of Mr. J. I. Cornell to the position of Chief Engineer of their organization.

Mr. Cornell has had considerable experience in the application and use of radio components, having been in charge of the Receiver Power Supply Section of the RCA Victor Co., Camden, N. J., for a period of five years and previously with the General Electric Co., of Schenectady.

CORRECTION

On page 23, November, RADIO ENGINEERING there inadvertently appeared an item headed "Perfex Purchases Centralab." This head was *not* correct and should read, as the text indicates, Perfex Purchases Central Radio Corporation.

The Central Radio Laboratories (Centralab), 900 E. Keefe Ave., Milwaukee, Wis., are the well-known manufacturers of radio apparatus and feature resistors and controls.

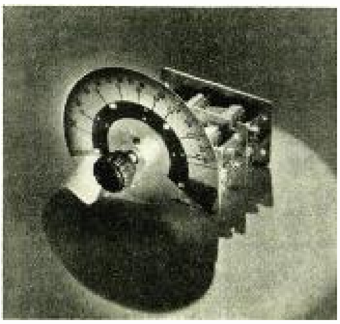
The Central Radio Corporation, who were purchased by the Perfex Controls Company, were manufacturers of automobile B-battery eliminators, radio tube sockets, range switches and the like.

NEW PRODUCTS

TRANSLUCENT RADIO DIALS

The Synthane Corporation of Oaks, Penna., has been able, through the use of its new Synthographic Process for printing of bakelite, to adapt translucent Synthane laminated bakelite to radio dials. It is stated that dials made of this material will not shrink or deteriorate with age, and are unaffected by variations of temperature and humidity. Also, illuminated Synthane gives off a soft amber light which can, by controlling the color of the resinoid, be varied to harmonize with the finish of the cabinet or mounting panel. A dial made of this material is shown in the accompanying illustration.

The new Synthographic Process is said



to produce durable printing on bakelite to the exacting fineness of dial markings. The designs and calibrations are clear-cut and can be applied in a variety of colors or color combinations, including gold, silver, bronze, black, red, green, and blue. The introduction of this new marking process now permits the use of this form of dial to the advantage of the industry, it is stated.

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NEW "UNIVERSAL" MIKES

Three different degrees of sensitiveness for microphones is even more necessary now than it was a few years ago, say officials of the Universal Microphone Co. at Inglewood, Cal. The three degrees for Universal instruments are: M for medium, S for sensitive and D for damped.

"M" is a happy medium between sensitive and highly damped, and is the more practical all-purpose microphone. It is particularly adapted for p-a systems where loudspeakers are at a distance from the microphone, or are pointed away from the instrument.

"D" is especially useful for the p-a systems where the loudspeakers are close to the microphone, such as sound trucks, platform speakers, interior call systems, or where p-a systems are used in small halls.

"S" is primarily intended for transmitting where the music or voice cannot get back into the microphone.

Microphones, point out Universal engineers, cannot be made to perform all functions perfectly, and so a mike cannot be made for use in a p-a system and then changed to studio or recording use and function properly in all cases.

The factory also produces a tone control for use with p-a systems where simple adjustments, varying with acoustical properties, are necessary.

TINY RESISTORS FOR HEAVY WORK

Although hardly larger than carbon resistors of low wattages, the tiny Pyrohm Junior wire-wound vitreous enamel resistors, developed by Aerovox engineers, are now available in 10, 15 and 20 watt ratings, and 100-30,000, 250-70,000, and 1000-100,000 ohms.

The units are wound on a porcelain tube with a high-grade resistance wire, the ends of which are brazed to copper bands, while the pigtail leads are soldered to the terminal bands. The entire unit is completely coated with a vitreous porcelain enamel, protecting the winding against moisture and mechanical injury. Proper design and conservative ratings insure adequate dissipation of heat. The units are being produced by the Aerovox Corporation, Brooklyn, N. Y.

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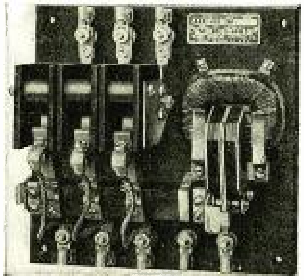
WARD LEONARD CONTACTORS

Ward Leonard Electric Company, Mount Vernon, N. Y., announces a line of dc. and ac. contactors that for several years have been used in their control assemblies and are now available as separate units.

They can be used as control contactors for motors, for disconnect purposes in conjunction with suitable auxiliary switches, for electric ovens, various other electric control applications and for special control panels.

High contact pressure with low operating and holding currents in the coils are



among the features claimed for these contactors.

Auxiliary silver-to-silver contacts are furnished as standard equipment for maintaining the coil circuit when momentary push-button control is used.

Additional normally open or normally closed auxiliary contacts can be furnished when required.

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NEW REMLER P-A AND REMOTE AMPLIFIERS

The unification of remote broadcasting and public-address amplification, made possible by the newly designed Remler High-Fidelity PAR-19 combination, shown in the accompanying illustration, is a convenience which measurably improves the quality of both p-a and broadcast performances, it is said.

The Remler PAR-19 consists of a public-address power amplifier and a remote amplifier housed in a single portable case designed to supply local public-address and remote broadcasts from the same microphone input. Three input channels are provided with main gain controls on both the p-a and the remote.

The public-address amplifier is a four-stage, push-pull resistance-coupled amplifier, using three type 6A6 tubes, two type 2A3 tubes, and one type 82 rectifier. The

remote amplifier consists of a three-stage, push-pull amplifier using type 6A6 tubes.

The new Remler PAR-19 weighs only 85 lbs. The unit is manufactured by the Remler Co., Ltd., 2101 Bryant St., San Francisco, Calif.

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BRUSH CRYSTAL TWEETER

The Brush Development Company, East 40th Street and Perkins Ave., Cleveland, Ohio, have developed two types of Piezo-electric High-Frequency Speakers particularly adaptable to high-fidelity receivers and special public-address use.

The primary use of the Type T-51 unit is in radio receivers, where it is intended to be connected across the primary of the low-frequency dynamic speaker transformer. Its reproduction begins at the point where the response of the dynamic speaker starts to fall off, it is said, and continues to 8,000 cycles.

As the speaker has a negative or capacitative reactance, no filter is required when used in combination with an inductive reproducer of the usual moving coil type. It is said that aside from supplying the desired upper register, thus permitting the dynamic speaker to be designed for maximum efficiency over a limited range, but also by its tendency to correct the power factor of the dynamic speaker gives a more efficient loading of the tube and circuit than would otherwise be obtained.

The Type T-51 has a face diameter of 4 15/16" and is 1 23/32" deep. No field excitation is required.

The Type T-51P is designed for public-address use and may be obtained with suitable transformer for 4, 8, 15 and 500-ohm input.

A special bulletin on these new crystal speakers may be obtained from the Brush Development Company.

JEFFERSON AIR-COOLED TRANSFORMERS

Jefferson lighting transformers are now designed in complete enclosing case with a separate compartment for the primary and secondary leads. This design permits complete protection of the connections, it is stated. Knock-out holes are provided for entrance of flexible or rigid conduit . . . or by use of porcelain bushing, open wiring may be brought in.

These transformers are used to supply 110- to 120-volt current to lamps, and various small motor-driven tools and heating

appliances. Their use puts this sort of load on the "lower rate" power circuits and in many cases saves expense in wiring installations, it is said. They are built to Underwriters' specifications and in various ratings and capacities up to 20,000 volt-amperes. The accompanying illustration shows a section of the cover removed to show new connection compartments. Jefferson Electric Company, Bellwood, Illinois, are the manufacturers.

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TACO NOISE REJECTOR

A further refinement in noiseless antenna systems for all-wave reception is offered in the variable impedance matching of downlead to receiver, which feature is made possible by a simple accessory applicable to any doublet antenna and receiver, it is stated. Known as the Taco Noise Rejector, the variable impedance-matching unit is a development of the Technical Appliance Corp., 27-26 Jackson Avenue, Long Island City, N. Y.

The unit is mounted alongside antenna and ground binding posts of the receiver by means of base lugs. Two short leads connect with the receiver, while two screw terminals take the twisted-pair downlead cable of the usual doublet antenna. With the set in operation, the Noise Rejector knob is adjusted for maximum transfer of signal energy from the downlead to the set, as well as for minimum background noise. This knob really brings about the balance between the antenna system and the receiver for sensitivity and signals, while reducing any remaining noises, it is said.

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NEW 5/8-INCH STANDARD DRILL

Announcement has been made of a new Skilsaw Drill of 5/8-inch capacity in steel. This new drill has a specially designed motor which delivers substantially more power under load for a drill of this size, it is stated. The motor used is of the universal type for operation on dc or ac, 60-cycle or less (all voltages) and the armature is statically and dynamically balanced to eliminate vibration. Field and armature windings are baked in bakelite and varnished to insure good insulation and long life.

The Skilsaw 5/8-inch Drill is housed in a die-cast aluminum-alloy body—a feature which means increased strength and lighter weight, greater accuracy, interchangeability of parts, a dense surface, and the like, it is stated.

This unit is also said to possess these other features: Free speed, 500 rpm; genuine Jacob Chucks; extra capacity (100% overload); bakelite-enclosed switch with patented Snuff-Arc construction; and motor cooling by means of a fan mounted on the armature shaft.

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DETECTIVE AGENCY EQUIPMENT

Sound Systems, Inc., Cleveland, Ohio, has developed amplifier equipment for Detective Agency Work. The same equipment is being used by industrial organizations, especially those whose business brings them in close contact with the public, it is stated.

The new crystal microphone is light and inconspicuous and its sensitivity is such that it can be hidden in a room and the conversation clearly understood on the headphones plugged into the small and light weight amplifier that accompanies the setup. The value of the equipment lies largely in the crystal microphone unit. This microphone is sturdy and can be used in any position, and being a self-energized unit, it is adaptable for remote work.

A contact microphone is also available with this equipment. In locations where access to a room cannot be gained, a detective may place the contact microphone against the outside of a door, for instance, and conversation in the room will be audible. Generally speaking, the surface to which the contact microphone is attached becomes the diaphragm and the driving pin on a spring shaft is connected by contact directly to the crystal element of the microphone.

Detective Agencies using this equipment find it more valuable in their work than anything heretofore available, it is said.

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NEW MIKE STANDS

The Eastern Coil Co. of 56 Christopher Ave., Brooklyn, N. Y., manufacturers of microphone stands and quartz crystal holders, announces the following new items of interest to broadcast stations.

Three section telescopic stands ideal for juvenile broadcasts. Allows microphone to be brought down to the level of the child performer. Available in varying weights of from 8 to 18 pounds.

A heavy floor stand with a 1/2-inch pipe thread especially designed for the new velocity and dynamic microphones. Base weight 23 pounds and total weight 32 pounds.

A simplified mounting for the 618 and 618A dynamic microphones allows the mike to be coupled to the regular type of microphone stand having the movable rod threaded for 5/8"-27 thread.

A microphone coupling device, ideal for remote control equipment, allows the microphone to be readily dismounted from the stand without the necessity of disconnecting any wires or the use of any tools.

Catalogued sheets upon request.

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NEW EBY MULTIPLE SWITCHES

Hugh H. Eby, Inc., 2066 Hunting Park Ave., Philadelphia, Pa., has introduced a new and improved line of multiple switches particularly adaptable as waveband switches for all-wave receivers.

Three of the new switches are shown in the accompanying illustration. The one to the left is a four-pole switch, the center one a six-pole unit and the one to the right an eight-pole switch.

This new type switch is of the bakelite wafer, and bridging contact style, designed for single-hole mounting and using the conventional 3/8"-32 mounting bushing, nut and lockwasher. All types have small physical dimensions.

The construction of the switch, although unique, is extremely simple, there being a minimum of parts used in the assembly. The circuit is completed between two adjacent stator contacts by a semi-spherical bridging contact of sterling silver. This bridge is held in place by a conical spring between a stud on the rotor plate and the bridging contact. This spring also acts as the driving member when rotating the switch from one position to another.

The stator is made up of copper alloy wire, .050 square heavily silver plated. The contact surface is coined to conform to the surface of the bridge, and gives as large a contact area as possible. The soldering lug end of this contact is hook shaped, as can be seen in the illustrations, for ease in connecting the switch in the circuit. The contacts are threaded in the stator plate and clamped in place.

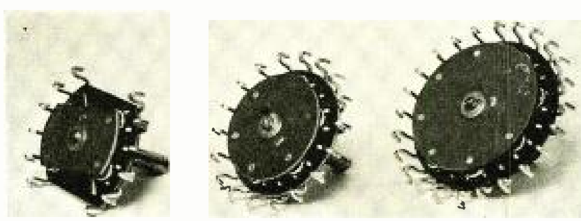
The rotor and stator plates are 1/16" extra high quality laminated bakelite, with a power factor (at 10^6 cycles) of 2.75% and a dielectric strength of 700 volts per mil. The steel shafts are rust proofed by cadmium plating.

The circuit possibilities in which this single gang switch can be used are practically unlimited. The standard bridging contact spacing provides approximately 725 circuit combinations and by changing the spacing of the bridging contacts it is possible to inrease this number of circuit combinations many-fold.

Multi-throw combinations are obtained by the addition of a simple jumper connection between common contacts. Where single- and double-throw switching arrangements are used in combination with multi-throw arrangements, the single or double-pole arrangement can be placed mechanically in any desired throw, or throws, of the multi-throw switch, with no electrical connection between circuits.

It is said that life tests on this switch have shown exceptional results. After 30,000 operations the contact resistance had not changed appreciably. The wear on the bridging contact and stator contact was slight.

NEW EBY MULTIPLE SWITCHES



PRECISION AUDIO TRANSFORMERS

A new and complete line of custom-built precision audio transformers with frequency characteristics uniform within plus or minus one-half db from 30 to 16,000 cycles is announced by American Transformer Company, Newark, N. J. According to the manufacturer, these units establish an entirely new standard of performance for a standard product and meet the most exacting requirements in broadcasting stations and recording studios.

In addition to the unusually extended straight-line frequency characteristics AmerTran's new Precision De Luxe line is said to be so designed that the slight rising or falling characteristic of one unit is compensated by the opposite characteristic in other units with which it would ordinarily be used in an amplifier. All types are also of a new construction which provides efficient electromagnetic and electrostatic shielding without the necessity of heavy-cast alloy cases. Tests made by the manufacturer indicate that these units without shielded cases are freer from hum pick-up than usual transformers in fully shielded mountings.

The Precision De Luxe line includes 38 designs which meet all requirements in broadcast and recording speech-input amplifiers. A new departure in transformer design is found in the line-to-grid units which are of two distinct types, one for use without any form of secondary loading resistor and the other for use when an attenuator or loading resistor is to be used, it is stated.

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NEW SHURE HAND-SETS, STANDS, CABLES

New items have been added to the Shure line of microphones and related equipment, information on which will be found in their Advance Catalog Sheet.

The new Transceiver Hand-Sets make available convenient, rugged, high-quality instruments for portable and mobile transmitters, it is stated. Five-meter transceivers, communicating systems and many other applications of the 6A and 6B Hand-Sets will occur to the reader.

A combination Floor Stand and Power Supply for condenser microphones is another development of the Shure Brothers Company, 215 West Huron Street, Chicago.

New Microphone Cables with heavy-duty rubber insulation, Desk and Combination Banquet and Floor Stands, as well as a Suspension Ring, are likewise described in their Advance Catalog Sheet which may be had on request.

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RCA VICTOR INDUCTOR MICROPHONE

The new RCA Victor Inductor Microphone is a high-quality unit specially designed for remote pick-ups, indoors or outdoors. This is a pressure-type unit differing, however, from previously designed pressure-operated microphones in that the faults common to this type of microphone have been reduced (in so far as remote pick-up requirements are concerned) to negligible proportions, it is stated. This results in the following qualities being claimed for the Type 50-A microphone: Insensitive to wind and mechanical vibration; unaffected by temperature and humidity; requires no external excitation or power supply; requires no closely-linked amplifier; is well suited for close talking; and is small, light, convenient, rugged and inexpensive.

The response characteristic of the Type 50-A unit is fairly uniform throughout its range of 60 to 10,000 cycles, the largest variation being 4 db.

The Inductor Microphone has been designed to have an output 8 to 10 db higher than that of the usual velocity microphone. This difference is sufficient to approximately balance the loss in mixers and therefore to offset the rise in background noise which would otherwise be caused by low-level mixing. The sensitivity is such that, for a sound pressure of 10 dynes, the output level across a 250-ohm line is —67 db, as compared to a zero level of 12.5 milliwatts.

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COMBINATION PICK-UP, RECORDER

The newest item in the production schedule of the Universal Microphone Co., Inglewood, Cal., is a combination pick-up and recorder of 400 ohms impedance.

The equipment is full annular ball bearing mounted, and this eliminates side wear of grooves, it is stated.

The spring adjustment is a special feature. It is so assembled that pressure can be adjusted well down on the needle groove.

This unit matches the input of standard microphone transformers. As a recording cutting head, it matches all standard line-to-line mixers, tube-to-line and line-to-line transformers.

The instrument permits playing on wax and all soft material, the arm being long enough to play up to 16-inch records.

The Universal combination recorder and pick-up is described by its makers as "A scientific instrument that insures clear, colorful recording and reproductions." It is said to be unusually sturdy, compact and long wearing.

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NEW LONG-STROKE DRAWING PRESS

The Hydraulic Press Manufacturing Company, Mount Gilead, Ohio, has developed a long-stroke press of the Hydro-Power Fastraverse class, equipped with their synchronized-pressure die cushion.

The die cushion added to the H-P-M Hydro-Power Press fits it for performing deeper draws in single press operations, it is stated. This cushion is actuated by a series of hydraulic cylinders which are hydraulically connected with the same source of pressure that operates the press itself. Thus the action of the die cushion is synchronized automatically with the press movements and pressure, the blank holding pressure being automatically proportioned to the drawing pressure.

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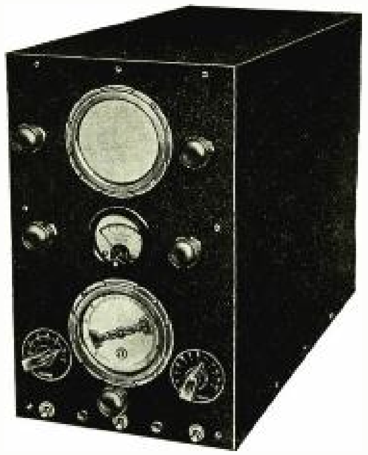
NEW CATHODE-RAY OSCILLOSCOPE

Wireless Egert Engineering, Inc., 179 Varick St., New York, N. Y., has placed on the market a completely self-contained combination Visual Resonance Indicator, using a Cathode-Ray Tube, and All-Wave Signal Generator.

This device provides direct reading resonance indications for all types of intermediate, broadcast and short-wave frequency alignment tests, and may also be used for visual indications of selectivity curves, adjacent channel selectivity, avc action, r-f signal distortion, presence of regeneration or oscillation in circuits, hum measurements, vibrator-transformer operation, a-f harmonic distortion, noisy circuits, and so on.

The Model 500 illustrated uses a type H72 cathode-ray tube for visual indications, a 6F7 as frequency modulated oscillator and buffer amplifier, a 75 as diode rectifier and a-f amplifier, a type 6A7 as all-wave oscillator and mixer tube. A type 84 tube serves as the rectifier supply-



ing voltage for the modulated oscillator, audio amplifier and all-wave oscillator. A type 143D tube is used as a rectifier for the cathode-ray tube voltages.

Focusing adjustments are provided on the front panel. Due to the circuit employed, the attenuation is said to be equally accurate on all frequencies.

The all-wave oscillator which is a part of the Model 500 unit, covers a range of 100 kc to 22,000 kc. The oscillator dial on the front panel can obtain accuracies to an absolute value of 1/10 of 1 per cent of the frequencies desired.

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HIGH PRESSURE CASTINGS

The successful employment of hydraulic pressure in die casting, as it is now being done by Pressure Castings, Inc., in Cleveland, indicates that this new method already is writing a new chapter in the art of die casting.

In the development of the hydraulic casting process, previous weaknesses characteristic of air pressure casting have been overcome. The pressure being hydraulically applied not only avoids the injection of air into the metal but permits such tremendous pressures as 3,000 to 17,000 pounds per square inch.

When the metal is inducted into the mold under such high pressures, the resultant casting becomes intensely dense, thoroughly and uniformly homogeneous from surface to surface, with an immense increase in tensile strength. In examining a cross section of such a casting, it is said that no porosity is apparent, the center having the same density as the outside surfaces.

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ULTRA-COMPACT ELECTROLYTICS

After countless tests on thousands of sample units, Aerovox engineers have finally released for production a new line of ultra-compact general-utility electrolytic condensers.

Known as Types PM5 and PM6, these units are the most compact electrolytics yet offered, it is stated. Each section is enclosed in two wax-impregnated cardboard boxes. The unit remains dry, and free from leakage or seepage or corrosion. It operates over wide ranges in temperature, for a long, economical life.

Type PM5 is rated at 525 volts surge peak, 450 volts dc working. Type PM6 is rated at 600 volts surge peak, 475 volts dc working. Both types are offered in single and dual capacities. These ultra-compact general-utility electrolytics are obtainable from the Aerovox Corporation, Brooklyn, N. Y.

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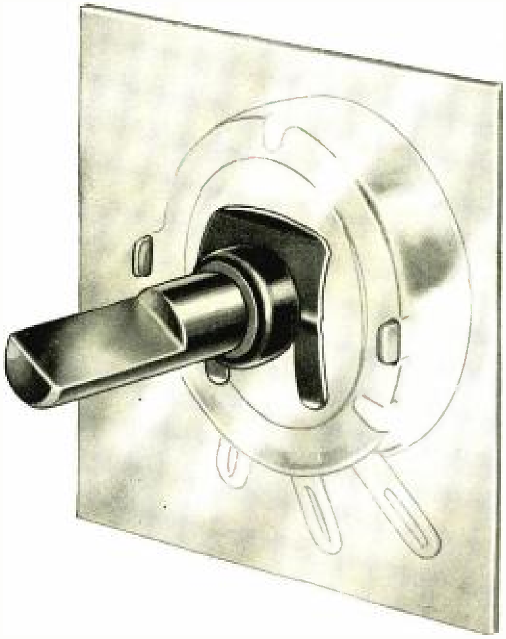
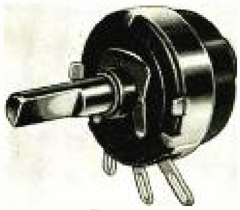
Type J Bradleyometer with cover removed to show contact mechanism and terminals.



Type J Bradleyometer — rear view—showing hot-solder-dipped terminals and cover.



Front view of Type JS Bradleyometer showing locking projections which prevent rotation on panel.

Type JS Bradleyometer showing unit with line switch in bakelite housing.

ULTRA-COMPACT!

The New Type J Bradleyometer

A SOLID MOLDED RESISTOR —NOT A FILM-TYPE UNIT

The Type J Bradleyometer outperforms film-type resistors, because hard service and climatic variations cannot alter its resistance-rotation curve. The solid molded resistor is of homogeneous cross-section. In longitudinal section, the material is varied to suit individual resistance specifications, but after molding, the unit cannot change. Practically any resistance-rotation curve shape can be provided, including straight logarithmic, modified logarithmic, or linear resistance-rotation curves.

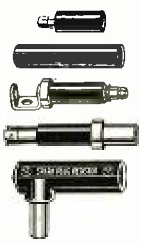
For volume control without tone compensation, the new Type J Bradleyometer possesses unusual advantages. The extreme compactness of the control has been achieved without sacrificing its electrical performance. The unique construction of the resistor unit makes possible practically any resistance-rotation curve. Long life and dependable performance are noteworthy qualities of the Type J Bradleyometer.

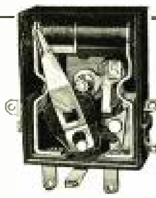
Such unusual mechanical features as snapping the control into place on the panel with the C-washer and the insulation of the shaft reduce receiver assembly costs. The Type J unit is interchangeable with others built to R. M. A. standards.

Send for Type J Bradleyometer data.

ALLEN-BRADLEY COMPANY
126 W. Greenfield Ave., Milwaukee, Wis

SPARK PLUG SUPPRESSORS
Allen-Bradley Spark Plug Suppressors are standard equipment on the nation's motor cars. They are made in five types for service in any auto-radio installation. The superiority of Allen-Bradley Suppressors is generally recognized. Performance curves will be submitted gladly upon request.





Type ATS Bradleyometer has never been surpassed for volume control with tone compensation.

FIXED RESISTORS
Fixed resistors of solid molded construction, used by the largest manufacturers of radio receivers, are made in four sizes, with or without leads. The production of these units represents years of research in the making of stable fixed resistors. They are color-coded to meet R. M. A. specifications.

ALLEN-BRADLEY RADIO RESISTORS