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Editorial.

The Equivalent Inductance and Capacity of an Aerial with Inserted Tuning Coil or Condenser.

IN an editorial note in the June issue we drew attention to the fact that the treatment of this subject in Dr. Palmer's recently published "Wireless Principles and Practice" led to results at variance with those which we published in 1917; we also pointed out what it was that caused this difference and showed that the two different methods of solving the problem, if correctly applied, both led to the same correct result.

We might have mentioned that the values which we obtained in 1917 have since been generally accepted and derived in various ways by other writers.*

We refer to the matter again, because the subject is of considerable interest, and as Dr. Palmer attempts in a letter, which we publish in this issue, to justify his result with the aid of some arguments with which we do not agree.

An aerial without any tuning coil or condenser is equivalent to a simple circuit with inductance L_0 and capacity C_0, but since the equivalent values of inductance and capacity change when inductance or capacity is inserted at the foot of the aerial, the values corresponding to the aerial alone can only be determined by adding infinitely small reactances—*i.e.*, either very small inductances or very large capacities. In other words, since the change we make to determine the equivalent values alters the values which we wish to determine, we must only make a very small change if we wish to obtain an accurate result; otherwise we obtain a result which is dependent on the magnitude of the change. This is a case in which the result can be obtained quite simply and accurately by means of the differential calculus, as we showed in our editorial. Of course, one obtains a result by inserting a large inductance, or small capacity, but the result so obtained lies somewhere between the correct result for the aerial when earthed and the correct result for the aerial when loaded with the added inductance or capacity.

Dr. Palmer's statement that we ascribe his erroneous result to his neglecting a certain term is not correct; what he neglects is the fact that this term, "which is by no means negligible, varies as the square of the frequency." It is true that he says that his result is only an approximation. We shall show later how the approximation fits in with the facts.

The equivalent inductance of the aerial

* See, for example, J. M. Miller, *Proc. of Inst. of Radio Eng.*, Vol. 7, p. 312, 1919 (equation 17); also August Hund, *loc. cit.*, Vol. 8, p. 426, 1920. The former refers to our 1917 article.

when no tuning coil is inserted is $\frac{hL}{2}$, and as an inductance inserted between it and the earth is increased its equivalent inductance decreases until when a very large inductance is inserted the equivalent inductance of the aerial itself is $\frac{hL}{3}$. If the wavelength is shortened by inserting a condenser the equivalent inductance of the aerial is increased. We shall now set ourselves this question: for what value of the tuning coil or condenser will the equivalent inductance of the aerial be equal to $\frac{hL}{2\cdot 46}$, the approximate value obtained by Dr. Palmer?

Wavelength Increased by Inserting an Inductance.

Let L_1 and C_1 be the equivalent inductance and capacity of the aerial when an inductance L_x is inserted between it and the earth; then the reactance of the whole equivalent circuit will be given by the formula:—

$$X = \omega\ (L_1 + L_x) - \frac{1}{\omega C_1} \quad .. \quad (1)$$

If $\omega_1/2\pi$ is the resonant frequency, then

$$\frac{1}{C_1} = \omega^2{}_1\ (L_1 + L_x)$$

and
$$X = \omega_1\ (L_1 + L_x)\ \left(\frac{\omega^2 - \omega^2{}_1}{\omega\omega_1}\right) .. \quad (2)$$

For the rate of change of X with ω we have

$$\frac{dX}{d\omega} = (L_1 + L_x)\ (1 + \frac{\omega^2{}_1}{\omega^2}) \quad .. \quad (3)$$

Near resonance $\omega = \omega_1$ and

$$\frac{dX}{d\omega} = 2(L_1 + L_x) \quad .. \quad (4)$$

Turning now to the actual aerial with its tuning coil, we have the reactance of the aerial $-\sqrt{\frac{L}{C}}$ cotan $\omega h\sqrt{LC}$ in series with the reactance ωL_x of the tuning coil—that is, a total reactance of

$$X = \omega L_x - \sqrt{\frac{L}{C}} \text{cotan}\ \omega h\sqrt{LC} \quad .. \quad (5)$$

Differentiating this we have

$$\frac{dX}{d\omega} = L_x + \sqrt{\frac{L}{C}} h\sqrt{LC}\ \frac{1}{\sin^2 \omega h\sqrt{LC}} \quad (6)$$

At resonance $\omega = \omega_1$; we shall assume that the value of L_x is such that $\omega_1 = a\omega_0$ where $\omega_0/2\pi$ is the resonant frequency of the aerial alone, *i.e.*, when $L_x = 0$.

Since $\omega_0 h\sqrt{LC} = \pi/2$, we have at resonance

$$\frac{dX}{d\omega} = L_x + \frac{hL}{\sin^2 a\pi/2} \quad .. \quad .. \quad (7)$$

Equating this to the value found above for the equivalent circuit we have

$$2(L_1 + L_x) = L_x + \frac{hL}{\sin^2 a\pi/2},$$

therefore

$$L_1 = \frac{hL}{2 \sin^2 a\pi/2} - \frac{L_x}{2} \quad .. \quad (8)$$

but since at resonance the total reactance (equation 5) must be zero

$$L_x = \frac{1}{a\omega_0}\sqrt{\frac{L}{C}} \text{cotan}\ a\omega_0 h\sqrt{LC}$$
$$= \frac{hL}{a\pi/2} \text{cotan}\ a\pi/2 \quad .. \quad .. \quad (9)$$

and on substituting this value for L_x in (8) we have

$$L_1 = \frac{hL}{2}\left(\frac{1}{\sin^2 a\pi/2} - \frac{\text{cotan}\ a\pi/2}{a\pi/2}\right) \quad (10)$$

This gives the equivalent inductance of the aerial for any value of a, where a is the ratio of the frequency with the tuning coil L_x to that without the tuning coil, and L is the inductance per unit length of the aerial.

If $a = 1$ we have $L_1 = \frac{hL}{2}$ for the equivalent inductance of the plain aerial without any inserted inductance. This is what we have called L_0.

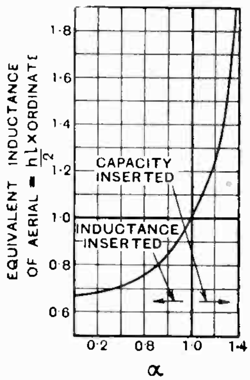
As a approaches zero, the quantity in brackets approaches $\frac{2}{3}$*, so that $L_1 = \frac{hL}{3}$ if a very large inductance is inserted, always assuming that the aerial may be regarded as a transmission line with a fixed value of inductance and capacity per unit length—a very doubtful assumption.

* We are indebted to Dr. B. Hague for evaluating this limit.

For other values of α the quantity in brackets has been calculated and the values are as follows :—

$\alpha =$	1.0	0.9	0.8	$\frac{2}{3}$	0.5	$\frac{1}{3}$	0
	1.0	0.913	0.847	0.782	0.727	0.694	0.667

These are plotted in the accompanying graph.



$$\alpha = \frac{\text{frequency with tuning coil or condenser}}{\text{fundamental frequency}}.$$

Wavelength Reduced by Inserting a Condenser.

If the natural frequency of the aerial be increased by inserting a condenser C_x between it and the earth, the reactance of the equivalent circuit will be given by the formula

$$X = \omega L_1 - \frac{1}{\omega \cdot \frac{C_1 C_x}{C_1 + C_x}} \quad .. \quad (11)$$

If $\omega_1/2\pi$ is the resonant frequency, then $L_1 = \frac{1}{\omega_1{}^2 C'}$, where C' is put for the resultant capacity $\frac{C_1 C_x}{C_1 + C_x}$;

$$\therefore \quad X = \frac{1}{\omega_1 C'}\left(\frac{\omega^2 - \omega_1{}^2}{\omega\,\omega_1}\right) \quad .. \quad (12)$$

and

$$\frac{dX}{d\omega} = \frac{1}{\omega_1{}^2 C'}\left(1 + \frac{\omega_1{}^2}{\omega^2}\right) \quad .. \quad (13)$$

Near resonance

$$\omega = \omega_1 \text{ and } \frac{dX}{d\omega} = \frac{2}{\omega_1{}^2 C'} = 2L_1 \quad (14)$$

For the reactance of the actual aerial with the condenser inserted between it and the earth we have

$$X = -\frac{1}{\omega C_x} - \sqrt{\frac{L}{C}}\cot\text{an}\, \omega h\sqrt{LC} \quad (15)$$

and therefore

$$\frac{dX}{d\omega} = \frac{1}{\omega^2 C_x} + \sqrt{\frac{L}{C}}\, h\sqrt{LC}\, \frac{1}{\sin^2 \omega h\sqrt{LC}} \quad (16)$$

At resonance $\omega = \omega_1 = \alpha\omega_0$, where

$$\omega_0 h\sqrt{LC} = \pi/2.$$

Hence at resonance

$$\frac{dX}{d\omega} = \frac{1}{\omega_1{}^2 C_x} + \frac{hL}{\sin^2 \alpha\pi/2} \quad .. \quad (17)$$

but since at resonance equation (15) must be zero,

$$\frac{1}{\omega_1 C_x} = -\sqrt{\frac{L}{C}}\,.\, \cot\text{an}\, \alpha\pi/2$$

and

$$\frac{dX}{d\omega} = hL\left(\frac{1}{\sin^2 \alpha\pi/2}\right) - \frac{\cot\text{an}\, \alpha\pi/2}{\alpha\pi/2} \quad (18)$$

Comparing this with equation (14) for the equivalent circuit, we find that

$$L_1 = \frac{hL}{2}\left(\frac{1}{\sin^2 \alpha\pi/2} - \frac{\cot\text{an}\, \alpha\pi/2}{\alpha\pi/2}\right) \quad (19)$$

which is, of course, identically the same as the expression found for the case of inserted inductance. α is in this case greater than unity. The quantity in brackets has the following values :

$\alpha =$	1.0	1.2	4/3	1.5
	1.0	1.223	1.608	2.424

These are also plotted on the right-hand side of the graph.

We can now answer the question which we set ourselves, and the answer is as follows : The aerial has an equivalent inductance of $\frac{hL}{2.46}$ when α=0.73 ; that is, when a tuning coil with such an inductance that the frequency of the aerial is reduced to 73 per cent. of its fundamental value is inserted between the aerial and earth, and only then.

When one speaks of the natural frequency of an aerial or of its equivalent inductance and capacity, it is generally assumed that the values referred to are those for the aerial alone, *i.e.*, without inserted inductance and capacity.

It will be obvious that the value $\frac{hL}{2.46}$ has no special merit as an approximation beyond the fact that the corresponding value of the equivalent capacity is simply hC. When $a=0.73$ it will be quite accurate and for other values of a it will be a close enough approximation for most practical purposes when a tuning coil is connected in series with the aerial. It has the advantage in this case of lying roughly halfway between the limiting values $hL/2$ and $hL/3$.

Dr. Palmer's mathematical treatment overlooks the change of the equivalent inductance of the aerial as inductance or capacity is inserted in series with it, and his graph is made to favour his result by confining it to the case of added inductance.

We do not suggest that Dr. Palmer should have gone into the matter in his book in such detail as we have done here, for equation (10) and the accompanying graph have been specially evolved for the purposes of this note and, so far as we know, have not been previously published.

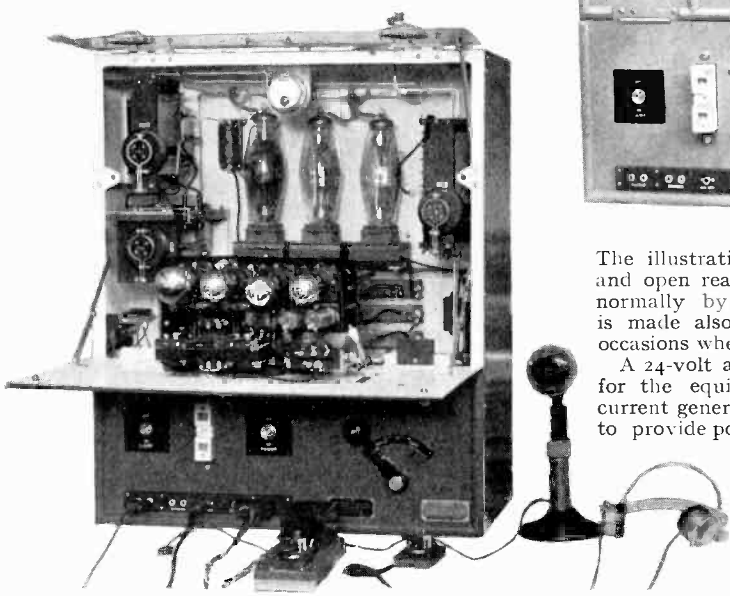
G. W. O. H.

An Interesting New 100 Watt Set.

The Marconi Company has recently produced a new 100 watt fixed wavelength telephone set, which is self-contained and designed for use under the roughest conditions by unskilled persons.

The set operates on a single wavelength, which is chosen to suit the particular service it is intended to give, and the set is also adaptable for morse working. The set is particularly suitable for use on small vessels, lighthouses, and on other occasions where a skilled operator is not available. The wavelength can be set between the limits of 150 and 400 metres and the wavelength is fixed at the time of installation.

The set is known as the Marconi Type XMB 1, and it employs the new DET.1.SW valves as oscillator and modulators. The total weight of the equipment is 180 lbs. and the dimensions 2ft. $7\frac{1}{2}$in. high by 2ft. 1in. in width and 1ft. 3in. in depth.



The illustrations show the equipment closed and open ready for operation. Reception is normally by loud speaker but provision is made also for 'phones to be used for occasions when they may be preferred.

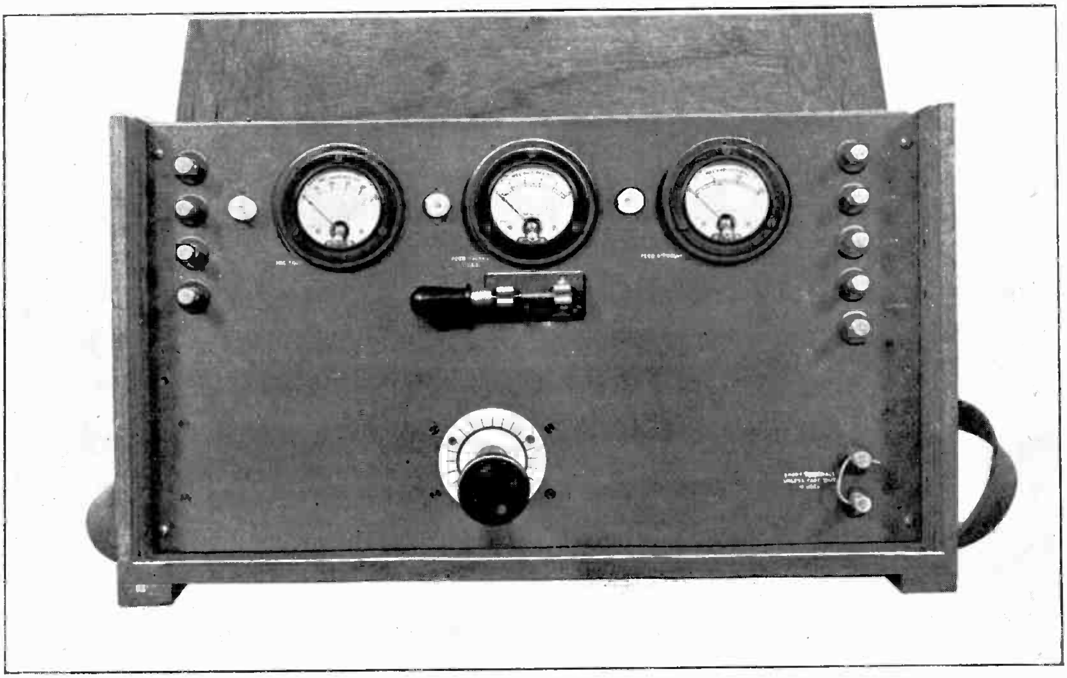
A 24-volt accumulator supplies the power for the equipment, a high-tension direct current generator being run from this battery to provide power for the plate circuits of the transmitting valves. The plate circuits of the 4-valve receiver are supplied from a 120-volt dry cell battery and the filaments are fed in series from the 24-volt accumulator through a resistance.

Microphone Amplifiers and Transformers.

By H. L. Kirke.

INTRODUCTION.

THE energy delivered by a microphone in a Broadcast Transmitting System is usually very small, lying between 10^{-12} and 10^{-9} watts, according to the type of microphone ; this small amount of energy has to be magnified up to the power necessary to modulate the actual transmitter. The most powerful Broadcasting Transmitter yet built uses about 50 kilowatts in the aerial. The amplifying system may conveniently be divided into three portions, a low-power amplifier, a medium-power amplifier, and a high-power amplifier.



Outside Broadcast Amplifier type 6 for local lines.

The low-power amplifier is usually situated close to the microphone. The medium-power amplifier is placed in some central room where all switching operations are carried out. This is called the Control Room. The volume of the electrical impulses supplied from the microphone is usually controlled at this stage before passing on to the transmitter.

The third, or power stage, is usually situated at the transmitting station, which may be situated anywhere within reasonable distance from the control room and is connected thereto by land line. The design of the power amplifying stages will be dealt with later.

Development of Progress.

Before the advent of broadcasting little attention had been paid to accurate reproduction of speech ; understandable speech was the sole requirement of the commercial telephone. In this case only the frequencies between 500 and 2,000 were seriously considered. It has been lately realised that even in commercial telephony greater efficiency can be achieved by introducing greater intelligibility, *i.e.* by the use of a wider band of frequencies.

In broadcasting, the ideal must be to reproduce (especially for music) the full audible gamut without distortion of any sort. The chief discouragement to those engaged upon the design of "straightline" amplifiers has been the fact that, in general, loud-speakers seldom produce frequencies below 300 p.p.s. or above 3,000 to 4,000. This state of affairs is at the time of writing rapidly improving.

Frequency Range of Musical Instruments.

The piano has an unusually wide range of notes, the lowest note being of the order of 26 vibrations per second, the highest of the order of 3,500 vibrations per second. The organ is more remarkable, having a range of from 8 to 6,656 p.p.s. The frequency of the various piano octaves is A_3-26, A_2-52, A_1-104, A_0-208, A^1-416, A^2-832, A^3-1,664, A^4-3,328. The violin has a normal frequency range of 212 p.p.s. to 2,560 p.p.s., and when bowed to produce overtones only, up to 3,320 p.p.s. The cello has a range of 64 to 1,540 p.p.s. The bass-fiddle has a range of 64 to 230 p.p.s., and for bowed overtones up to 560 p.p.s. The highest note of a piccolo is 4,112 p.p.s.

All of these notes have overtones (multiples of the fundamental frequency), which give to a note its characteristic tone or timbre. It is only by the degree in which the various overtones are present that we can distinguish the various instruments. It is important, therefore, to reproduce the overtones. In the reproduction of music the low frequencies give colour, fullness and vigour and can almost be considered as foundation stones upon which the remainder is built, while the high frequencies give character and detail. The human voice uses frequencies between 50 and 15,000, but for practical purposes we need consider only those between 100 and 6,000.

The pitch or tone of the voice is determined by a fundamental frequency which lies between 50 and 500 p.p.s. The degree in which the frequencies between 500 and 3,000 are present characterises the vowel sounds, and the frequencies above 3,000 determine the sibilants and hence the intelligibility.

A reproduction of the frequency range 100 to 5,000 will give almost perfect naturalness and intelligibility for human speech while the reproduction of the range of from 50 to 10,000 will give an extremely adequate picture of any musical rendering. "Cut off" of bass tones will produce lack of "warmth" in music, and cut off of the higher tones takes away brilliancy.

The chief points governing the design of microphone amplifiers are :—

(1) Accuracy of reproduction required.
(2) Overall magnification required.
(3) Amount of output power required.

Accuracy of Reproduction.

By accuracy of reproduction is meant the degree of faithfulness with which the output wave-form is a copy of the input wave-form.

It is convenient to use a unit which might be called the reproduction factor and may be termed the ratio of magnification at any given frequency to that at, say, 600 cycles per second (this frequency is purely arbitrary, 600 cycles being roughly the geometric mean of 35 and 10,000 cycles).

Consider a system consisting of, say, 5 units in cascade: let us call the reproduction factors at a certain frequency of the various units r_1, r_2, r_3, r_4, r_5, etc., then the overall reproduction is $R = r_1 \times r_2 \times r_3 \times r_4 \times r_5$, etc.; if the reproduction factor of each unit is the same, then $R = r_1^5$ or $r_1 = R^{1/5}$.

If the reproduction factor of each unit is 0.8 at a certain frequency the overall reproduction factor will be $.8^5 = 0.328$. This shows that if the overall distortion is to be kept small the distortion in each unit must be kept extremely small. The overall desirable reproduction performance is, of course, 100 per cent.; 90 per cent. would be considered extremely good, and 80 per cent. unusually good.

Distortion may be divided into two classes :—

(1) Distortion of the frequency-magnification characteristic.

(2) Distortion of the amplitude-magnification characteristic.

Distortion of the frequency-magnification characteristic, which will be referred to as the frequency characteristic, may be described as the failure of a piece of apparatus to amplify equally at all frequencies within the required frequency range.

Distortion of the amplitude-magnification characteristic—or briefly, the amplitude characteristic—may be described as the failure to amplify equally at all intensities over the required frequency range. It is possible to correct for distortion of frequency characteristic, but not for distortion of amplitude characteristic.

The various causes of distortion and how they may be avoided will now be considered.

Distortion of the Frequency Characteristic.

This may be due to bad design of transformers, too small coupling condensers in resistance-capacity-coupled amplifiers, too low a value of inductance in anode choke, if used, feed back or reaction effects, and badly designed volume-controlling apparatus.

The Transformer.*

In considering the general design of amplifiers it is preferable to consider firstly the design of transformers, as most of the distortion of the frequency characteristic in an amplifying system is due to this cause.

In all microphone amplifiers it is necessary to have both an input and an output transformer since the input is fed from a microphone the impedance of which is usually low (300 ohms or less), whereas the grid-filament impedance of the first valve is very high. The output is usually connected to a land line the impedance of which is too low to be connected directly to a valve. Proposals have been made, notably with the push-pull method of amplification, to avoid the use of an output transformer, but the transformer presents a more practical solution.

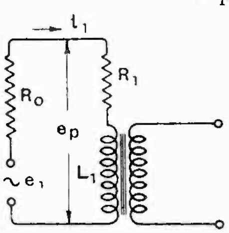


Fig. 1.

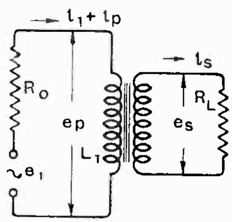


Fig. 2.

* The reader is referred to papers by D. W. Dye, *E.W. & W.E.*, 1924, Vol. I, p. 691; P. W. Willans, M.A., before the I.E.E., 1926; and by C. H. Naylor, *Electrical Review*, 10th and 17th April, 1925.

Intervalve transformers, while transformers remain imperfect, should never be used, since resistance or choke coupling gives sufficient amplification and can be made to give a sensibly linear characteristic.

Transformers are of two classes—input and output. Intervalve transformers can be considered as input transformers. The input transformer secondary has appreciable self-capacity and is not necessarily loaded, while the output transformer is loaded and has very little self-capacity. The load on an output transformer may change with frequency—notably in the case of a transmission line.

In considering transformer design we are confronted by two problems, one concerned with the high and the other with the low frequencies. For low frequencies all that matters is the primary inductance in relation to the total primary impedance. For high frequencies the transformation ratio, magnetic leakage and secondary self-capacity are the important factors.

Consider first the low frequency problem. It is required to determine the ratio of voltage transformation at some low frequency to that at some medium frequency. Fig. 1 shows a transformer with its secondary unloaded and its primary fed from an E.M.F. e_1 of frequency f_1, with which is associated an internal resistance R_0. R_1 and L_1 are the D.C. resistance and inductance of the primary winding respectively. Then, if e_p is the voltage across the primary winding,

$$e_p = R_1 i_1 + L_1 \frac{di_1}{dt}$$

where i_1 is the primary current.

If i_1 is a sine wave this may be written :—

$$e_p = R_1 i_1 + j\omega_1 L_1 i_1 \text{ (where } \omega_1 = 2\pi f_1\text{)}.$$

In most practical cases R_1 is very small compared with $\omega_1 L_1$, so that the expression may be written $e_p = j\omega_1 L_1 i_1$ or $i_1 = \dfrac{e_p}{j\omega_1 L_1}$.

i_1 is the primary magnetising current and lags 90 degrees behind the impressed voltage e_p. There is also a small current flowing in the primary to supply the iron losses (eddy current and hysteresis); this can be represented as a current flowing through a resistance shunted across L_1, but in practice the iron losses are very small so that this effective shunt resistance is very high and can be neglected.

Now consider the transformer with its secondary loaded with a resistance R_L, as shown in Fig. 2. Then, if " n " be the ratio of secondary turns to primary turns, the secondary voltage $e_s = ne_p$ and the secondary load current $i_s = \frac{1}{n} . i_p$, where i_p is the primary load current. This load current i_p flows in the primary winding in addition to

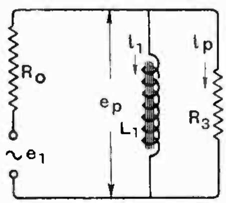


Fig. 3.

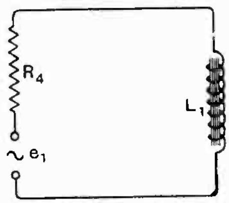


Fig. 4.

the magnetising current i_1, which remains unchanged as long as e_p is unchanged, neglecting the small voltage drop in R_1. (The D.C. resistances R_1 and R_2 have been omitted from Fig. 2 for simplification, since they are very small.)

Fig. 2 may be redrawn as far as the primary is concerned, as in Fig. 3, where the secondary load R_L of Fig. 2 has been transferred to the primary side, where it has the value $R_3 = \frac{R_L}{n^2}$. That this is so is easily seen, since

$$R_3 = \frac{e_p}{i_p} = \frac{e_s}{n} . \frac{1}{n . i_s} = \frac{1}{n^2} . \frac{e_s}{i_s} = \frac{R_L}{n^2}$$

Now the ratio $\frac{e_p}{e_1}$ will be the ratio that the impedance Z_p of L_1 and R_3 in parallel bears to the total impedance Z_t of the whole circuit considered from e_1. The ratio $\frac{e_s}{e_p}$ being a constant and equal to n, $\frac{e_s}{e_1}$ will therefore depend upon the ratio $\frac{e_p}{e_1}$. It will be seen that at low frequencies the numerical value of Z_p is less than R_3, and that it approaches the value R_3 as the frequency increases. To obtain the reproduction factor at some low frequency it is necessary to determine the value of $\frac{Z_p}{Z_t}$ at that frequency and at some medium frequency, say 600 p.p.s., at which ωL_1 has become so large that its shunting effect is negligible, so that Z_p equals R_3.

Let $a = \frac{Z_p}{Z_t}$ at a low frequency f_1.

$b = \frac{Z_p}{Z_t}$ at a medium frequency f_2

(at which $\omega_2 L_1$ is very large compared with R_3).

$$\text{Then } a = \frac{R_3 j\omega_1 L_1}{R_3 + j\omega_1 L_1} \div \left(R_0 + \frac{R_3 . j\omega_1 L_1}{R_3 + j\omega_1 L_1}\right)$$

$$= \frac{1}{1 + \frac{R_0(R_3 + j\omega_1 L_1)}{R_3 j\omega_1 L_1}}$$

$$\text{and } \quad b = \frac{R_3}{R_0 + R_3}.$$

$$\text{Now } r = \frac{a}{b} = \frac{1}{1 + \frac{R_0 R_3}{(R_0 + R_3) j\omega_1 L_1}}$$

$$\text{Numerically } r = \frac{1}{\sqrt{1 + \left[\frac{R_0 R_3}{\omega_1 L_1 (R_0 + R_3)}\right]^2}}$$

Now if a circuit be drawn as in Fig. 4 the ratio of the reactance $\omega_1 L_1$ to the total impedance from e_1 is

$$\frac{j\omega_1 L_1}{R_4 + j\omega_1 L_1} = \frac{1}{1 + \frac{R_4}{j\omega_1 L_1}}$$

$$= \frac{1}{\sqrt{1 + \left[\frac{R_4}{\omega_1 L_1}\right]^2}} \quad .. \quad (1)$$

numerically.

This expression is identical with the one just obtained for r if $R_4 = \frac{R_0 \times R_3}{R_0 + R_3}$ (*i.e.*, the total resistance of R_0 and R_3 in parallel). For the purpose of determining r, therefore, the two resistances may be conveniently considered as in parallel.

Fig. 5 shows a curve in which the cut-down r is plotted against $\frac{\omega_1 L_1}{R_4}$ where $R_4 = \frac{R_0 . R_3}{R_0 + R_3}$ in Fig. 3.

The value of L affects the cut-down and shows how necessary it is to have a high primary inductance if a good frequency characteristic is to be obtained. The above applies to all types of transformers, but special effects in output transformers will be dealt with later.

As an illustration, reference to Fig. 5 shows that for a cut-down to $r=.95$, the ratio $\frac{\omega_1 L_1}{R_4} = 3$ approx. Therefore, if the value of R_4 be 500Ω, L_1 would have to be 1.20 henries for a cut-down of .95 at 200 p.p.s., 2.4 henries for this cut-down at 100 p.p.s., and 4.8 henries for 50 p.p.s.

The inductance of a coil with a closed iron core varies inversely as the length of magnetic path and directly as the permeability, cross-sectional area, and as the square of the turns, and is given by $L=\frac{4\pi A T^2 \mu}{l} \times 10^{-9}$ where A is the cross-sectional area in cms, T the total number of turns, μ the permeability, and l the length of magnetic path.

The value of μ for Stalloy varies with flux density from a minimum of between 200 to 250 to a maximum of the order of 3,000 for a flux density of about 5,000 lines per square centimetre. Hence for small flux densities the permeability will be of the order of 200 to 250. Transformers for use

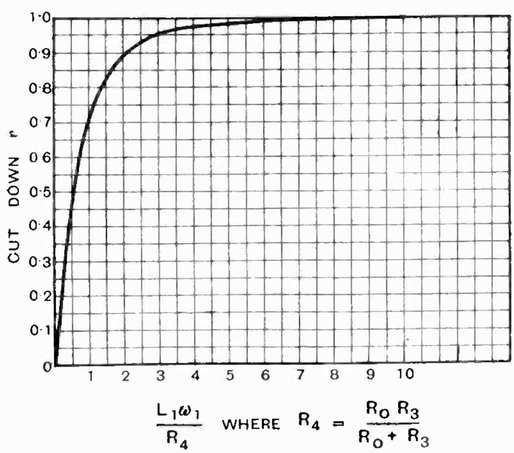


Fig. 5.

over a very wide range of flux densities should therefore be designed on a basis of the lowest permeability likely to be met with.

The ratio of transformation obtainable depends upon the magnetic leakage, self-capacity, and secondary load in an input transformer.

At the high-frequency end of the scale the design of an input transformer must be dealt with differently from that of an output transformer, due to the effect of secondary self-capacity in the case of the former. The case of the output transformer will be considered first.

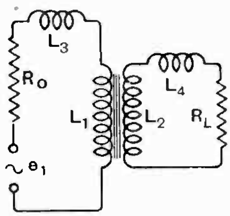


Fig. 6.

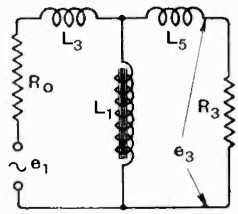


Fig. 7.

All transformers suffer from the effect of magnetic leakage. The coefficient of leakage is a function of the coupling between primary and secondary, the tighter the coupling the less the leakage. The coefficient of coupling is given by $K = \frac{M}{\sqrt{L_1 \times L_2}}$ where L_1, L_2 are the inductances of the primary and secondary windings and M is the mutual inductance between the two windings. The coefficient of leakage is given by $\lambda=1-K^2$. Leakage acts in the same way as an inductance in series with the load. The effective value of this leakage inductance bears a definite relationship to the self-inductance of the winding for a given core and type of winding, *i.e.*, $L_3=L_1(1-K^2)$, where L_3 is the effective series inductance due to leakage.

Its effect can best be understood by reference to Figs. 6 and 7. In Fig. 6, R_0 is the internal resistance associated with the source of E.M.F. e_1, L_1 and L_2, the respective primary and secondary inductances, L_3 and L_4, the respective primary and secondary leakage inductances, and R_L, the resistance load on the secondary. In Fig. 7 the impedance across the secondary winding has been referred to the primary winding, as in the case of Fig. 3, the leakage inductance L_5 having the value $\frac{L_4}{n^2}$, and R_3 having the value $\frac{R_L}{n^2}$, where n is the ratio of turns. At high frequencies the reactance ωL_1 is very large compared with the impedance of L_5 and R_3 in series, and its shunting effect can be neglected. The circuit can therefore be considered for the purposes of the frequency characteristic as consisting of R_0, $L_3+L_5=L_6$, and R_3 in series. The ratio $\frac{e_3}{e_1}$, which is representative of the frequency characteristic, will be given by :—

$$\frac{e_3}{e_1}=\frac{R_3}{R_0+R_3+j\omega_3 L_6} = a$$

where $\omega_3 = 2\pi f_3$, f_3 being a high frequency for which the reproduction factor is required.

At a medium frequency f_2, at which $\omega_2 L_6$ is small compared with $R_3 + R_0$,

$$\frac{e_3}{e_1}=\frac{R_3}{R_0+R_3}=b.$$

Now the reproduction factor or cut-down is given by $r=\frac{a}{b}=\frac{1}{1+\frac{j\omega_3 L_6}{R_0+R_3}}$

Numerically, $r=\frac{1}{\sqrt{1+\left(\frac{\omega_3 L_6}{R_0+R_3}\right)^2}}$

$$\therefore \qquad \frac{\omega_3 L_6}{R_0+R_3}=\sqrt{\frac{1}{r^2}-1}$$

As an example, if the value of r is to be 0.95 at 5,000 p.p.s. and $R_0=R_3=1{,}000$ ohms, then L_6 must be .0210 henries, or, if the same cut-down is required at 10,000 p.p.s., L_6 must be only .0105 henries.

For a Stalloy core having a cross-sectional area of 5.5 sq. cms. approximately and a length of magnetic path of 18 cms., the leakage coefficient $\frac{L_6}{L_1}$ varies between .005 and .02 according to spacing between the windings and the method of winding. Taking a mean value of .01, then, for a cut-down to 0.95 at 10,000 p.p.s., since L_6 must be .0105 henries, L_1 will be 1.05 henries. Now from Fig. 5 it is known that for a cut-down to 0.95 at a low frequency f_1, $\frac{\omega_1 . L_1}{R_4}=3$, therefore in this case $\omega_1 L_1 = 3 \times 500 = 1{,}500$ ohms.

$$\therefore \qquad \omega_1=\frac{1500}{1.05}=1{,}430$$

$$\therefore \qquad f_1=\frac{1410}{2\pi}=228 \text{ p.p.s.}$$

The cut-down at 50 p.p.s. would be .555.

As previously explained, an overall cut-down to 0.95 would be good, but a cut-down to .95 in each transformer in a case where there were five transformers in the chain would be an overall cut-down of $0.95^5 = .77$ at 228 p.p.s., and a cut-down of $.555^5 = .053$ at 50 p.p.s., which would be very bad.

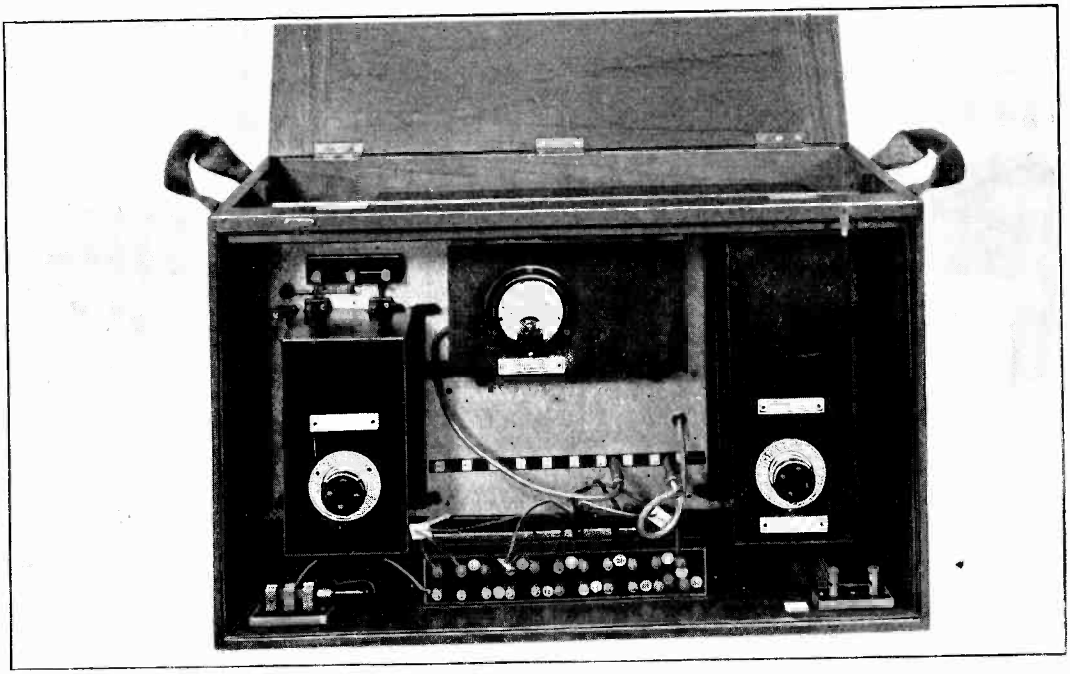
For the value of r of 0.95 at 5,000 p.p.s. the leakage inductance of the winding must be .0210 henries. With a leakage coefficient of .01 this fixes the primary inductance as 2.10 henries, which gives a value of $r = 0.95$ at 114.0 p.p.s. and gives $r = 0.80$ at 50 p.p.s. It should be observed that the frequency band-width, $\frac{f_3}{f_1}$ is the same as in the previous case, the loss of high frequencies being compensated for by a gain of low frequencies. Now if the leakage coefficient can be halved, then for the same value of primary inductance the leakage inductance will be reduced to .0105 henries, which gives a value of $r = 0.95$ at 10,000 p.p.s. Hence by halving the leakage coefficient the frequency band-width $\frac{f_3}{f_1}$ for a given cut-down can be doubled. The advantage of halving the leakage coefficient may be used to improve the low frequencies instead of the high frequencies by doubling the primary inductance (*i.e.*, by increasing the primary turns in the ratio $\sqrt{2}/1$), in which case the value of $r = 0.95$ is obtained at the frequencies 57 p.p.s. and 5,000 p.p.s., the frequency band-width being doubled as before. These two examples illustrate the general principle that the frequency band-width obtainable for a given cut-down r is inversely proportional to the leakage coefficient, whether the reduction of leakage coefficient be utilised to improve the high frequencies, the low frequencies, or both.

The foregoing examples illustrate the difficulty of designing an output transformer to operate with a matched impedance load, that is for the condition $R_3 = R_0$. Good reproduction at the low frequencies demands a high primary inductance; but as the inductance is increased the leakage inductance is proportionately increased (for a given type of core and winding), and therefore the term $\omega_3 L_6$ is increased compared with $(R_3 + R_0)$, so increasing the cut-down at high frequencies. The simplest method of reducing the effect of leakage is to increase the value of R_3 (Fig. 7) by increasing the ratio of turns. This, of course, reduces the efficiency and also, when R_0 represents a valve impedance, reduces the maximum output obtainable from the valve.

Consider a transformer as in Fig. 6 loaded with a resistance R_L of 500 ohms, operating from a valve for which $R_0 = 1{,}000$ ohms. Then for matched impedance the turns ratio would be $\sqrt{2}$, so that R_3 (Fig. 7) $= 1{,}000$ ohms. Now if the ratio of turns be increased from $\sqrt{2}$ to $\sqrt{2} \times \sqrt{5}$*, R_3 becomes $500 \times 10 = 5{,}000$ ohms. Then, if r is to be 0.95 at 5,000 p.p.s., $L_6 = \dfrac{\sqrt{\dfrac{1}{r^2} - 1}\,(R_0 + R_3)}{\omega_3} =$ .0630 hys. Therefore, for a leakage coefficient of .01, L_1 will be 6.30 henries. Then at 50 p.p.s. ω_1, L_1 will be 1,980 ohms, and $R_4 = \dfrac{R_0 \times R_3}{R_0 + R_3} = 834$ ohms. $\therefore \dfrac{\omega_1 L_1}{R_4} = \dfrac{1980}{834} = 2.38$, and therefore from Fig. 5 $r = 0.925$. The reproduction factor at 50 p.p.s. has thus been improved by this means from 0.80 to 0.92. The value $r = 0.95$ is obtained at the frequency of 64 p.p.s. The band-width has thus been improved from 5,000/114 to 5,000/64, *i.e.* 78 per cent.

The loss of efficiency due to this may be calculated as follows :—

For the matched impedance condition—*i.e.*, when $R_3 = R_0$, at medium frequencies $e_3 = \dfrac{e_1}{2}$ and $e_s = \dfrac{e_3}{\sqrt{2}} = \dfrac{e_1}{2\sqrt{2}}$. Output power p_1 is therefore $\dfrac{e_1^2}{8} \cdot \dfrac{1}{500} = .25\ e_1^2$ milliwatts (if e_1 is expressed in volts). For the condition when $R_3 = 5{,}000$ ohms, $e_3 = \dfrac{5}{6}\ e_1$ and $e_s = \dfrac{e_3}{\sqrt{10}} = \dfrac{5}{6\sqrt{10}}\ e_1$. Therefore output power



Outside Broadcast Amplifier type 5 for long lines.

* A value chosen empirically.

p_2 is $\frac{25}{360} e_1^2 \times \frac{1}{500} = .139\, e_1^2$ milliwatts. The ratio of efficiencies is therefore $\frac{p_2}{p_1} = \frac{.139}{.25} = 0.55$, so that the loss of efficiency is 45 per cent.

The leakage coefficient can only be decreased for a given type of core by decreasing the spacing between sections, and this cannot usually be done owing to the increase of capacity which must result.

If the transformer is wound in several sections and the sections packed closely (*i.e.*, no spacing between them) and the primary and secondary interleaved, the leakage coefficient may be reduced to about .005, at the expense of increased interwinding capacity. With a leakage coefficient of .005 a transformer having matched impedance windings can be designed so that its performance factor is $r = .95$ at 50 and 4,400 p.p.s. or at 100 and 8,800 p.p.s.

For a transformer having an increased ratio to reduce the leakage effect, as explained above, then for an increased ratio of $\frac{1}{\sqrt{5}}$ $r = .95$ at 50 and 7,850 p.p.s.

So far the design of an output transformer has only been considered for a load of equal impedance at all frequencies. In a transmission line, however, the impedance and phase angle vary with frequency, particularly for unloaded lines, and in consequence the output transformer must be designed to meet all loads at all frequencies in the same way that a commercial power transformer must have a good regulation factor for varying loads at one frequency. If the impedance of the transmission line varies with frequency, then the voltage and current, and therefore power, in the line will also vary with frequency. If the transformer is designed to take the load of the mean impedance, the voltage and current at the sending end will vary with frequency. If the transformer is designed so that R_0 (Fig. 3) is high compared with R_3 (*i.e.*, its output impedance being high in relation to the load), then the load current will be nearly equal at all frequencies (constant current condition). If R_3 is made high compared with R_0 at all frequencies, then the voltage across the load will be nearly constant at all frequencies (constant voltage condition). All this is assuming constant E.M.F. e_1. In practice it is found preferable to aim at constant voltage, because for any line the ratio of received to transmitted current varies more with frequency than the ratio of received to transmitted volts.

In order to obtain the constant voltage condition it is necessary to make the effective primary impedance (when the secondary is loaded) high compared with R_0; that is to say, the effective impedance of the output circuit, looked at from the line, must be low compared with that of the line at any frequency. This is the same as saying that the voltage regulation for all loads must be good. It has been found that for the average line, if the output impedance is made 100 ohms actual, the frequency characteristic $\frac{\text{line volts}}{\text{grid volts}}$ will be practically straight.

Input Transformers.

The essential difference, as has been said before, between an input and an output transformer is that the secondary of an input transformer has self-capacity, and that the secondary winding need not necessarily be loaded.

An input transformer is usually designed so that its primary has a certain impedance which matches the mean impedance of the input circuit.

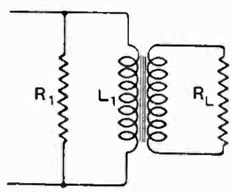


Fig. 8.

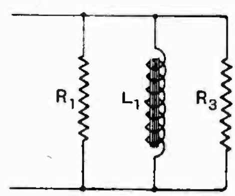


Fig. 9.

For a microphone this impedance is usually between 100 and 300 ohms, depending on the type of microphone. When the input transformer has to work from a line it is usual to design the effective impedance between 200 and 1,000 ohms, according to the type of line. A value of 500 ohms has been found convenient. This impedance may be made up of primary load, secondary load, or a combination of both. Reference to Figs. 8 and 9 will show this clearly. The secondary load R_L (Fig. 8) has been referred to the primary side in Fig. 9, where it has the value $R_3 = \frac{R_L}{n^2}$. The total input impedance, for all except very low frequencies, is $Z = \frac{R_3 . R_1}{R_3 + R_1}$, ωL_1 being high compared with Z.

The actual values of R_1 and R_L will depend upon the frequency characteristic

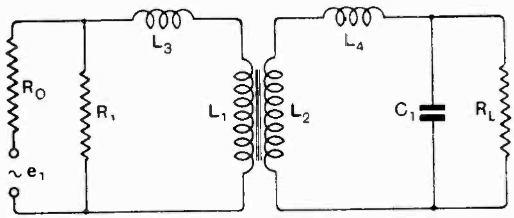


Fig. 10.

required, the secondary leakage and capacity, and partly upon the ratio of transformation.

Fig. 10 shows a transformer having primary and secondary loads R_1 and R_L, primary and secondary leakages L_3 and L_4 and capacity C_1. Fig. 11 shows the same transformer viewed from the primary side, in which

$$L_5 = \frac{L_4}{n^2} \text{ and } C_2 = n^2 C_1$$

$$\left(n \text{ being } \frac{\text{Secondary turns}}{\text{Primary turns}}\right).$$

At high frequencies the reactance of L_1 is very large and its shunting effect is negligible. Then, if there were no primary and secondary loads the circuit would consist of R_0, $L_3 + L_5 = L_6$, and C_2 in series. Actually there would be very slight damping across C_2 representing iron losses. This is essentially a resonant circuit, and the shape of the frequency characteristic of such a transformer would depend largely upon the value of R_0. The effect of R_3 is to flatten the curve and make it independent of R_0. The ratio $\frac{L_6}{C_2}$ can be varied by altering the spacing between the sections, this varying the damping of the circuit. The product L_6C_2 can be varied by altering the secondary turns ; this determines the frequency of the resonance peak, which when correctly damped by R_3 will be the point at which the high frequency cut-off begins. The effect of R_3 in damping the circuit is shown in the curves of Fig. 12. Curve (*a*) is obtained with the secondary open-circuited, curve (*b*) for one value of R_3, and curve (*c*) for a smaller value. (In these curves the amplitude has in each case been brought to 1 for 500 p.p.s. for purposes of comparison.)

Therefore, in designing an input transformer it is first necessary to choose such a value of secondary turns that the leakage inductance cum self-capacity resonant frequency is not lower than the highest frequency it is desired to transmit. The next step is to choose the ratio $\frac{L_6}{C_2}$ together with the value of R_3 such that the curve (*a*) of Fig. 12 is reduced to curve (*b*) with any value of R_0 (the resonant peak will be more prominent the lower R_0).

The primary turns are then determined by the amount of cut-down allowable at some definite low frequency according to equation (1), where the R_4 of equation (1) is the total resistance of R_3, R_1, and R_0 in parallel (Fig. 11).

In practice it has been found that a transformer for 500 ohms input impedance, having a value of r of not less than .95 at 50 and 9,000 p.p.s., may have the following dimensions :—

Core area 5.5 sq. cms. } Stalloy.
Core length 18 cms. }

Primary turns, 2,040 in 4 sections. } Sections interleaved.
Secondary turns, 11,250 in 5 sections. }

Secondary load resistance, 70,000 to 100,000 ohms.

Primary load resistance, 640.

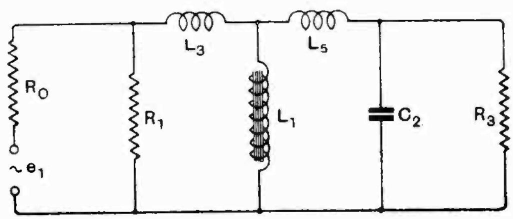


Fig. 11.

The above transformer has the advantage that the input phase angle is small for all frequencies from 50 to 9,000.

It is possible to improve the overall

performance of transformers very considerably by the use of iron of higher initial permeability than that of Stalloy, the initial permeability being the permeability of the iron for very low values of flux density (values between 0 and 50 lines /sq. cm.).

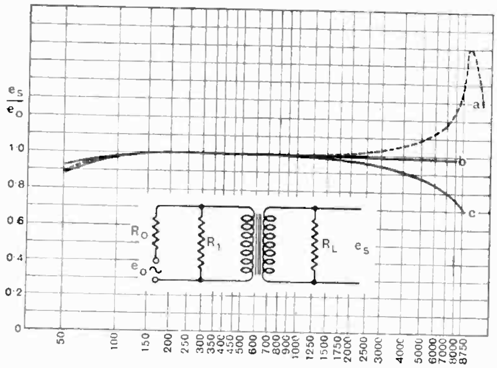
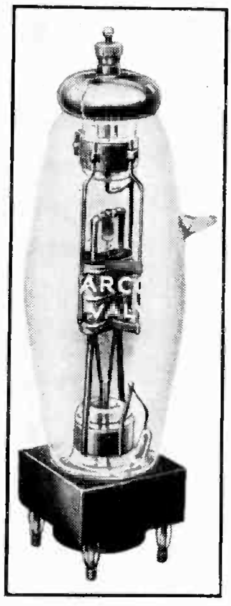


Fig. 12. *Curves show effect of altering secondary low resistance R_L.*

One kind of iron suitable for this purpose is an alloy of iron and nickel called nickel-iron, which has an initial permeability of about 600 compared with the value of 250 for Stalloy. As the flux density is increased the permeability increases, but this increase is much greater in the case of Stalloy than in the case of nickel iron, so that at a flux density of about 100 lines/sq. cm. the μ for Stalloy is equal to that for nickel iron, and at higher flux densities the former exceeds the latter. The use of nickel-iron is therefore only advantageous in transformers where the working flux density is normally low; this is the case in both input and output transformers of microphone amplifiers, although in the output transformer the flux density may sometimes rise to 200 lines/sq. cm. The reason for the improvement in overall performance is that the leakage coefficient is inversely proportional to the permeability of the iron, since with a given number of turns on a given size of core, if the permeability be increased "n" times, the primary inductance will be increased "n" times, whereas the leakage inductance remains unaltered since the leakage flux is wholly in the air space outside the core. The reduction of leakage coefficient by using nickel iron is therefore $\frac{250}{600}$, and the frequency band for a given value of r is correspondingly increased as previously explained. Nickel iron is a robust material and retains its magnetic properties as well as Stalloy. Another material of high initial permeability is an alloy of iron, nickel and copper called Mumetal, the value of initial permeability being about 3,000. The magnetic properties of this alloy are obtained by heat treatment, and it must not be subjected to mechanical shock or excessive heating. Using this alloy it has been possible to obtain a leakage coefficient as low as .0003, and transformers can be designed with it having a frequency band of 50 to 8,000 for an r value of 0.98.

(To be concluded.)

Short-wave Transmitting Valve.



THE well-known Marconi D.E.T.1. valve is now produced in a special form for short-wave work and is available for amateur use under the designation D.E.T.1.SW. Originally developed for use with the Beam system the new valve is of the double-ended type and is suitable for wavelengths down to 10 metres. The filament consumption is 2 amps. at 6 volts, the amplification factor and impedance are 8.5 and 5,000 respectively, and the valve is rated at 30 watts.

Supplies are now available and the price is £7 5s. 0d.

Reactance and Admittance Curves.

Applied to Tuned Circuits With and Without Resistance.

By L. T. Bird.

(*Concluded from page* 334 *of June issue.*)

Resistance in a Resonant Circuit.

It is now possible to study the general case of a resonant circuit in which the resistance of the coil and the leakance of the condenser are both taken into account. Consider first the series resonant circuit shown in Fig. 9a. The two portions of which this circuit is made up have already

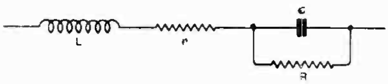


Fig. 9a.

been considered separately, and it is now only necessary to see how they combine. The two portions being in series, assume unit current to flow through the circuit. It is then merely necessary to discover how the voltages across the two portions combine to obtain an impedance curve of the complete circuit. For this purpose the vector diagrams provide invaluable aid. The diagrams of the separate portions are shown in Figs. 7a and 8c.

The connecting link between the two diagrams is the vector representing the constant current of one ampere. In Fig. 7a this is OD and in Fig. 8c it is OQ. These being identical the diagrams may be combined as in Fig. 9b, and the phase relationship between the voltage OC across the inductance and the voltage OS across the capacity becomes apparent. The vector sum of these two voltages is the required total voltage and is shown as OX.

It is interesting to note how the appearance of this diagram alters with the frequency. When the frequency is low, S will be high on the semi-circle and C will be near A. Thus OS will be greater than OC and the resultant voltage vector will be on the right of OA. As the frequency increases, the point C moves further along to the left on the line AC and S moves downwards on the semi-circle. Thus OS gets shorter and OC longer, and OX approaches the line OT. At a certain frequency OX becomes vertical and the total voltage is in phase with the current. As the frequency is still further increased OX moves over to the left of OT and increases in length again. When the values of resistance, inductance and capacity are such as obtain in normal radio circuits the length of OX is a minimum at the same time as it comes into phase with OA.

This diagram is the basis of the following method of drawing the complete impedance curve of such a circuit. Draw as before the reactance curve of the inductance and the impedance curve of the combination of condenser and resistance in parallel (Fig. 9c). Draw AA' parallel to OO' at a height equal (on the scale of the diagram) to the value r of the resistance in series with the inductance. Mark off OT equal to R, the resistance across the condenser, and describe a semi-circle thereon, select a frequency (say at F, Fig. 9c) and erect ordinates FG and FH to the reactance and impedance curves. Mark off along AA' a length AC equal to FG. With centre O and radius FH describe an arc cutting the semi-circle in S. The line CS will be a measure of the impedance of the circuit at the frequency considered, and if erected at F as an ordinate will give a point on the impedance curve.

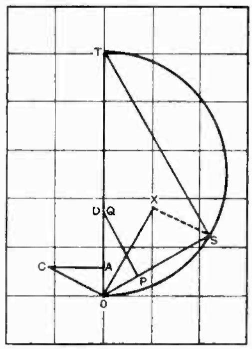


Fig. 9b.

The connection between this construction and the vector diagram of Fig. 9b will become more apparent from 9e and 9f, where the essential part of the construction is compared with the vector diagram as normally drawn. Fig. 9d is an intermediate step between the two, where OA is drawn downwards from O and AC to the right from A. This has the effect of reversing the direction of OC. Since SX and OC are equal and parallel, figure $OXSC$ is a parallelogram; therefore OX and SC are equal and parallel. Hence CS is equal to OX. Since OX represents the value of the total voltage for unit current, CS is a measure of the impedance of the circuit; and since $\widehat{XOT} = \widehat{SCV}$ the inclination of CS to the vertical is the angle of phase difference between current and voltage at the frequency considered.

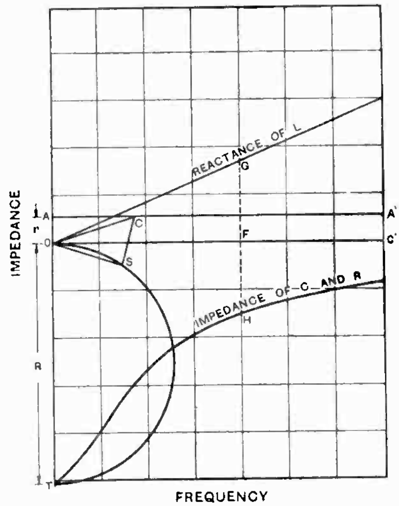


Fig. 9c.

Fig. 9e is identical with Fig. 9d, except that it is drawn, upside down as it were, for comparison with Fig. 9c. A repetition of this construction for several frequencies will yield a series of points through which the impedance curve may be drawn. Preserving the convention that leading currents and lagging voltages are plotted as negative quantities, the impedance diagram appears as in Fig. 9f, where it is drawn for a concrete case. By plotting the inverse of a series of values of the impedance the admittance curve may be drawn therefrom. Both these curves show a marked difference from those obtained by neglecting the effect of resistance. The impedance is never actually zero, but has a minimum value at " tune point," where the total voltage is in phase with the current. Similarly, the admittance does not rise to infinity, but to a definite maximum at the same point. Very often at this stage the convention relating to leading voltages

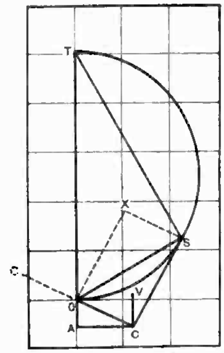


Fig. 9d.

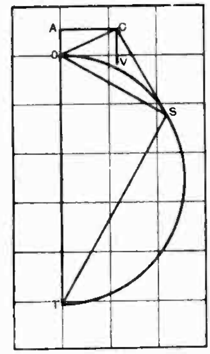


Fig. 9e.

and lagging currents is dropped and all values are shown as positive. This is then referred to as a resonance curve.

The case of the parallel resonance curve is very similar. Consider unit voltage to be applied across the circuit of Fig. 10a. The two parts of the circuit will behave as if separate, but the currents to each part will combine in the common lead. The voltage

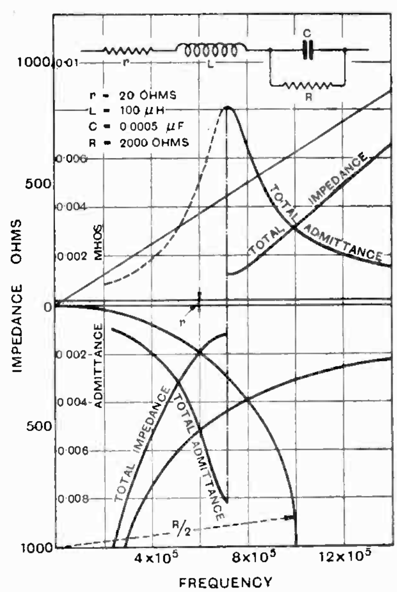


Fig. 9f.

vector is the connecting link between the respective diagrams. The combined figure

(10a) is similar to that for the series case, and hence no detailed explanation need be given.

The construction for drawing the admittance curve of the circuit may be given thus. Draw the admittance curve of L and r in series, and the admittance curve of C (Fig. 10b), also a line parallel with the axis, at a distance equal on the scale of the diagram to the leakance of the condenser in mhos. Mark off OE equal to $1/r$ and describe a semi-circle thereon; select a frequency and erect ordinates to the admittance curves already drawn. From O mark off the admittance of L and r as a chord OD of the semi-circle, and from P the admittance PQ of C along PP'. The line joining the two points D and Q so obtained gives on the scale of the diagram the total admittance at this frequency, together with the angle of phase difference between supply current and voltage. In Fig. 10c this construction has been followed for the same values of L, r, C and R as in the series case.

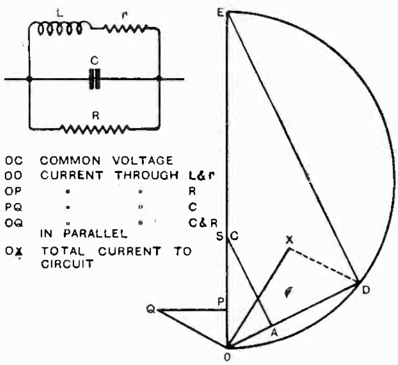


Fig. 10a.

It may have been remarked that in the concrete case worked out the values of the resistances chosen are somewhat heavy, and are such as would be obtained only by deliberately damping the circuit. A second case is shown worked out in Fig. 10d, where the resistance of the coil is taken as 8 ohms and the insulation resistance of the condenser as 10,000 ohms.

Observe the effect on the diagrams. The maximum value of total impedance has increased considerably (the scale has been reduced to get the curve on to the paper) and the peak of the curve has become much sharper, *i.e.* the interesting part of the diagram covers a smaller range of frequencies. In addition to this the actual construction for finding the impedance of the circuit around resonant frequency occupies a more confined space, shown by the dotted rectangles (Figs. 10c and 10d). It is within this rectangle that all such points as SC (Fig. 10a) fall for frequencies around resonance.

If r is still smaller and R bigger, the resonance peak becomes yet sharper and the space containing the essential work more and more confined.

Some modification of the construction is therefore necessary to make the method practical for lightly damped circuits. The scale must be magnified considerably and the diagram restricted to frequencies around resonance. This is readily achieved in practice by reason of the fact that, when r is small and R large, certain approximations become justifiable.

Consider the parallel circuit.

(1) If r is small in comparison with $L\omega$ at resonance, the arc of the semi-circle upon which the essential part of the construction is made may be drawn as the curve of $\frac{r}{L^2\omega^2}$, and this curve is indistinguishable from a straight line parallel with the frequency axis ($\frac{r}{L^2\omega^2}$ being sensibly constant over the range considered).

(2) Instead of marking off along the semi-circle a chord whose length represents the admittance of L and r, it is equally accurate to mark off along the frequency axis a length equal to $1/L\omega$ and erect an ordinate to the arc of the semi-circle (now drawn as a straight line).

(3) If the resonance curve occupies only a narrow band of frequencies, the portion of the curve of $1/L\omega$ which comes into the construction will be found to be for all practical purposes a straight line.

These approximations may be rendered more acceptable by considering a concrete example.

Let $L = 100\ \mu$H. and $C = .0005\ \mu$F as before. Let r be .05 ohms and R be 5 megohms. Referring to Fig. 10b, OD is the admittance of L and r in series.

$$\therefore \qquad OD = \frac{1}{\sqrt{r^2 + L^2\omega^2}}$$

Now, since ODE and OJD are similar triangles,

$$JD/OD = OD/OE$$

$$\therefore \quad JD = OD^2/OE$$

$$= \frac{\dfrac{1}{r^2 + L^2\omega^2}}{1/r}$$

$$= \frac{r}{r^2 + L^2\omega^2}$$

$$= \frac{1}{r + \dfrac{L^2\omega^2}{r}}$$

For the values under consideration it will be found that r is negligible in comparison with $\dfrac{L^2\omega^2}{r}$. At resonance $\dfrac{L^2\omega^2}{r} = \dfrac{440^2}{.05} = 4 \times 10^6$ approx., whilst $r = .05$. Hence JD may be taken as $\dfrac{r}{L^2\omega^2}$, *i.e.* the curve of $\dfrac{r}{L^2\omega^2}$ near resonance is a very close approximation

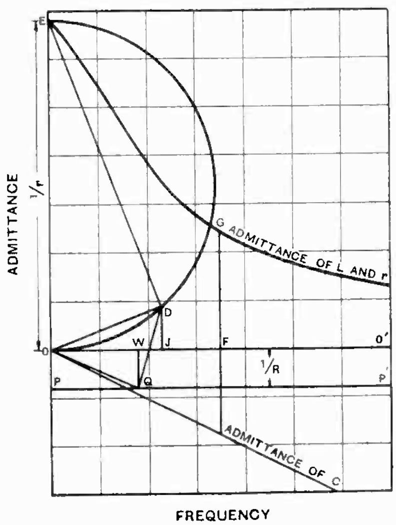


Fig. 10b.

of that part of the semi-circle made use of in the construction.

Now for the values of r and R considered, the essential part of the resonance curve covers a band of frequencies from about 711,000 to 712,500, *i.e.* ω varies from about 4,467,000 to 4,477,000.

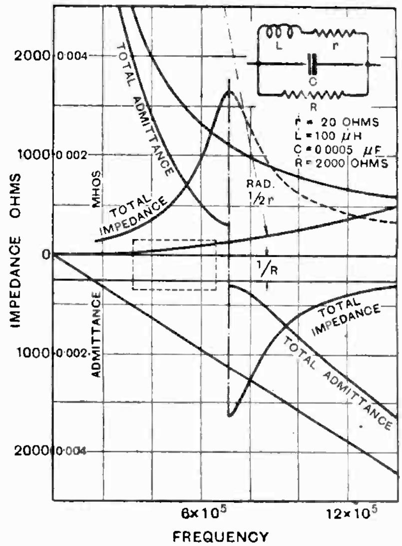


Fig. 10c.

When $\omega = 4,467,000$

$$\frac{r}{L^2\omega^2} = .2506 \times 10^{-6}.$$

When $\omega = 4,477,000$

$$\frac{r}{L^2\omega^2} = .2495 \times 10^{-6}.$$

On the scale of the diagram there is no appreciable difference between these two quantities. Hence for all practical purposes the essential arc of the semi-circle may be drawn as a straight line parallel with the axis and distant from it $r/L^2\omega^2$ on the scale of mhos. (Approximation No. 1.)

Now consider the line OJ.

Since OED and OJD are similar triangles,

$$OJ/OD = ED/EO.$$

$$\therefore \quad OJ = \frac{OD \, . \, ED}{EO}$$

Now $ED = \sqrt{OE^2 - OD^2}$

$$= \sqrt{\frac{1}{r^2} - \frac{1}{r^2 + L^2\omega^2}}$$

$$= \sqrt{\frac{L^2\omega^2}{r^2\,(r^2 + L^2\omega^2)}}$$

$$= \frac{L\omega}{r\sqrt{r^2 + L^2\omega^2}}$$

$$\therefore \quad OJ = \frac{\dfrac{1}{\sqrt{r^2 + L^2\omega^2}} \quad \dfrac{L\omega}{r\sqrt{r^2 + L^2\omega^2}}}{1/r}$$

$$= \frac{L\omega}{r^2 + L^2\omega^2}$$

$$= \frac{1}{r^2/L\omega + L\omega}$$

As previously stated throughout the range considered, ω varies from 4,467,000 to 4,477,000.

$$\therefore \quad r^2/L\omega = \frac{.0025}{447} = .000006 \text{ approx.}$$

which is a minutely small quantity compared with 447, the value of $L\omega$. Thus $r^2/L\omega$ may be neglected in comparison with $L\omega$, and without serious error the length of OJ be taken as $\frac{1}{L\omega.}$ Instead, therefore, of marking off as a chord of the semi-circle the value of the admittance of L and r, it is equally accurate, when r is small compared with $L\omega$, to mark off along OO^1 a distance OJ equal to $\frac{1}{L\omega}$ and erect at J an ordinate cutting the semi-circle in D (approximation No. 2).

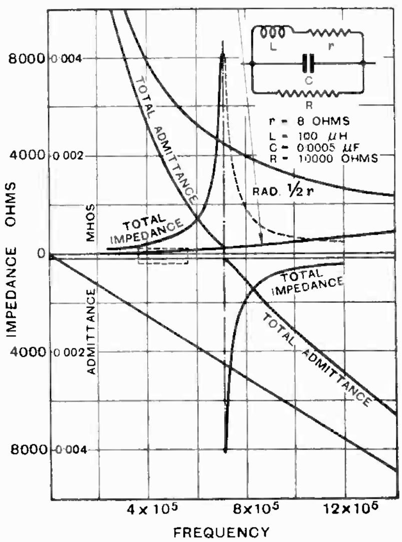


Fig. 10d.

It has already been shown that $r/L^2\omega^2$ is appreciably constant over the peak of the resonance curve. Now r and L are themselves constant quantities, hence the expression $-\frac{1}{L\omega^2}$ will also be appreciably constant. This is the measure of the slope of the curve

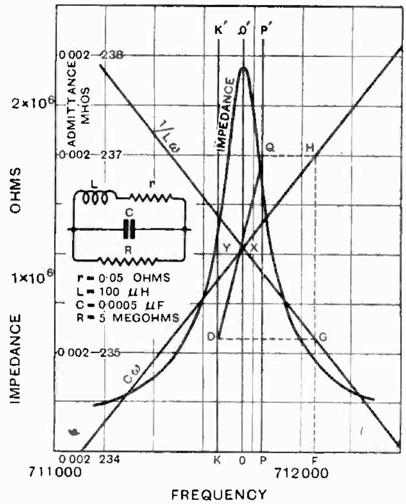


Fig. 11.

of $1/L\omega$ for any value of ω. If this be constant the curve of $1/L\omega$ is a straight line (approximation No. 3).

All that remains, therefore, is to enlarge the scale of the diagram by restricting the frequencies to those around resonance, and to rearrange the construction to make it more readily workable.

Thus (Fig. 11) lay out a horizontal axis of frequency and plot vertically as positive quantities the values of $C\omega$ and $1/L\omega$. These will both appear as straight lines and will intersect at a point X. Through this point draw a vertical line OO' (O will be the resonant frequency). On the left of this line erect a parallel line KK' distant $r/L^2\omega^2$ on the scale of mhos already adopted. On the right of it erect a third parallel line PP' distant from it $1/R$ on the same scale. To find the total admittance at a given frequency (say at F) erect a perpendicular cutting the $C\omega$ and $1/L\omega$ curves in H and G respectively. From H draw HQ horizontally cutting PP' in Q. From G draw GD horizontally cutting KK' in D. DQ will be a measure of the total admittance of the circuit at the frequency considered. The inverse of this value will be the impedance of the circuit. (This is shown worked out for the last mentioned values of L, r, C and R.)

This construction may be identified with the previous figure as follows. The curve of $1/L\omega$ corresponds with the admittance curve of L and r, except that the scale of admittance has been moved. The curve of $C\omega$ is the same as before except that the values are now shown as positive. KK' represents a portion of the semi-circle and PP' the line PP' of Fig. 10b. These lines have been drawn vertical instead of horizontal to make the marking off of $1/L\omega$ along KK' and $C\omega$ along PP' more of an automatic process.

Since the curves of $1/L\omega$ and $C\omega$ are in effect straight lines the expression connecting such lengths as KD and PQ with the frequency will be a linear one, and it would be possible to plot as a linear scale along KK' a series of points such as D and to label them with the frequencies to which they correspond. This would give along KK' a frequency scale $\frac{1}{2\pi C}$ times the admittance scale, and as the slopes of these curves are equal and opposite

(N.B.—Slope of curve $\frac{1}{2\pi fL} = -\frac{1}{2\pi f^2 L}$.

Slope of curve $2\pi fC = 2\pi C$

and near resonance $f^2 = \frac{1}{4\pi^2 LC}$

i.e., $2\pi C = \frac{1}{2\pi f^2 L}$)

all such lines as DQ will intersect at a point Y, which falls midway between KK' and PP' and immediately opposite point X. Having found the position of Y, to find the admittance of the circuit join Y to the point on the scale corresponding to the chosen frequency and double its length.

This suggests a further modification eliminating quite a deal of labour and making it possible to obtain the impedance curve directly by graphical methods.

Lay out along a line ZZ' (Fig. 12) a scale of frequency so that f_0, the resonant frequency, occurs at the centre point Y $\left(f_0 = \frac{1}{2\pi\sqrt{LC}}\right)$.

At Y erect YY' perpendicular to ZZ'. Lay out along YY' a scale of admittance $4\pi C$ times the scale of frequency (or what is the same thing $\frac{1}{\pi f_0^2 L}$ times the scale of frequency). This scale will be in mhos. Mark off along YY' a length YW, so that $YW = \frac{r}{L^2\omega^2} + \frac{1}{R}$ on the admittance scale (N.B.—To make a reasonable figure the scale of frequency must be so chosen that ZZ' is of the order of twenty times the length of YW). Through W draw KK' parallel to ZZ'. Lay off also along YY' a convenient impedance scale and make YV on this scale equal to $\frac{1}{r/L^2\omega_0^2 + 1/R}$, *i.e.* $1/YW$. With centre Y and radius YV describe a semi-circle on ZZ'.

To find for a given frequency:

(1) The impedance of the circuit.

(2) The admittance of the circuit.

(3) The angle of phase difference between supply voltage and current.

At the selected frequency, F, draw FH perpendicular to ZZ', cutting KK' in D and the semi-circle in H. Join YD and produce so as to cut the semi-circle in M. Draw MN parallel to ZZ', cutting FH in N.

Then

(1) FN on the impedance scale is the impedance of the circuit (*i.e.*, N is a point on the impedance curve).

(2) YD on the admittance scale is the admittance of the circuit.

(3) $\widehat{DYY'}$ is the angle of phase difference.

Comparing this with Fig. 11, KK' corresponds with KK' and the point Y with point Y. The factor connecting the scales of frequency and admittance has, however, been doubled so as to make such lengths as YD show the admittance direct instead of half that quantity as in Fig. 11.

The fact that FN is a measure of the impedance of the circuit may be demonstrated thus:

Draw MJ perpendicular to ZZ'. MJY and DFY are similar triangles.

Hence $MJ/MY = DF/DY$.

Now $DF = YW$, $MY = YV$ and $MJ = FN$

$\therefore \quad FN/YV = YW/DY$

$$\therefore \quad FN = \frac{YW \cdot YV}{DY}.$$

But the scales are so chosen that

$$YV = 1/YW \quad \because \quad YV \cdot YW = 1$$

$$\therefore \quad FN = 1/DY.$$

But DY represents the admittance of the circuit; therefore FN represents on the impedance scale the impedance of the circuit.

On plotting such points as N for various frequencies, the resonance curve for the given circuit may be drawn. A concrete example has been worked out in Fig. 12.

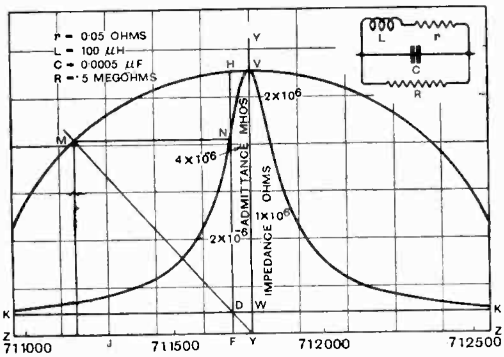


Fig. 12.

Although the development of this construction may seem a trifle involved, it should be noted that the use of it in practice should be quite a simple matter requiring the calculation of three quantities and the drawing of two parallel straight lines and a semi-circle. Thenceforward the construction is an automatic process. The three quantities required are:

(1) f_0 the resonant frequency $= \dfrac{1}{2\pi\sqrt{LC}}$

(2) The quantity $\dfrac{r}{L^2\omega_0^2} + \dfrac{1}{R}$ and

(3) Its inverse.

It should be noted that (2) is the admittance of the circuit at resonance. And since at resonance

$$\omega_0^2 = \frac{1}{LC}$$

$$\frac{r}{L^2\omega_0^2} = \frac{r}{L_2\left(\dfrac{1}{LC}\right)} = \frac{r}{L/C} = \frac{Cr}{L}$$

This is an easy quantity to calculate.

Also (3) is the impedance at resonance. If $1/R$ is small enough to be negligible in comparison with $\dfrac{Cr}{L}$ the impedance at resonance becomes $\dfrac{L}{Cr}$ ohms. This is a useful quantity to memorise.

A similar construction may be developed in like manner for the admittance of a series circuit. Here the quantities required are:

(1) f_0 as before.

(2) The quantity $\dfrac{L}{CR} + r$.

(3) Its inverse,

and the scale of impedance is $4\pi L$ times the frequency scale; when R is so large as to make $\dfrac{L}{CR}$ negligibly small, the impedance at resonance reduces to r ohms.

Book Review.

THE DISCOVERY AND FORMULATION OF A NEW THEORY OF THE GENERATION AND PROPAGATION OF WIRELESS WAVES IN SPACE. By H. R. Khan, pp. vi+95, with 27 Plates. Published by Thacker, Spink & Co., Simla. 7s. 6d.

We find great difficulty in reviewing this book. The author is an enthusiast who has devoted much time and thought to the subject, but who describes the phenomena of electricity and magnetism in a language of his own, which makes it difficult to decide to what extent his ideas are new and to what extent they are the conventional ideas expressed in a different terminology. After trying to follow some parts of his argument we were reminded that "East is East and West is West and never the twain shall meet." His experiments have led him to the discovery "that the *taproot* of wireless phenomena is an *entity* which Providence in His great wisdom has provided for the manifold benefits of mankind. It is this entity which I have termed the 'magneto-electric molecule' which forms one of the several invisible constituents of the atmosphere filling the empty space surrounding the earth." We are also told "that water and moisture render the atmosphere of precisely the correct humidity, thereby making the magneto-electric molecules healthy and vigorous." Living in Glasgow we were specially interested in this statement. There is no doubt that our mental picture of magneto-electrical phenomena is largely conventional, but we doubt very much whether we should gain in any way by substituting Mr. Khan's conventions for those with which we are more familiar.

G. W. O. H.

System for Combating Effects of Static.

By E. A. Tubbs.

THE Federal Telegraph Co. of San Francisco, California, maintains a commercial system of wireless telegraphy between the principal cities on the Pacific coast. This service is in direct competition with the Western Union and the Postal telegraphic companies, the two main telegraph systems in the United States. Because of the strong competition it is absolutely necessary that a fast, accurate and reliable service should be available to the public.

For this purpose the company's receiving stations are equipped with some very novel devices; one of the most interesting of which is a system for reducing the effects of static and other undesirable disturbances.[1]

The principle of this static eliminator is shown schematically in Fig. 1. This circuit will be recognised as that of the Carson balanced modulator, which is extensively used in carrier current systems (wired wireless) and in the transatlantic telephone.

In the figure, V represents some form of an adjustable oscillator, such as an oscillating valve. Let us first see what will happen if we disconnect this oscillator and then tune the antenna circuit A to some desired signal. This incoming signal will be transferred to the inductance S, which is tuned to it by the condenser C_2. Therefore, the grids of the two valves 1 and 2 will receive this signal E.M.F. in the same phase and the currents in the two anode circuits will also be in phase. That is to say that if at any given instant the signal current in the anode circuit of valve 1 is flowing from the H.T. battery up through the primary P_1 to the anode A_1, the signal current in the anode circuit of valve 2 will be flowing from the H.T. battery down through the primary P_2 to the anode A_2. Thus it will be seen that the signal current in P_1 and P_2 will neutralise one another and there will be no signal current introduced in the secondary S_1.

Now if we connect the oscillator V we will see that it will place a negative potential on the grid of one valve at the same instant that it places a positive potential on the grid of the other valve. This will unbalance the system, because it will let more signal current flow in one of the primaries, P_1 or P_2, than in the other, and when this happens it will be seen that P_1 and P_2 will no longer neutralise one another and signal energy will be transferred to the secondary S_1. Consequently if we adjust the oscillator V so that it differs from the frequency of the incoming signal by, say, 1,000 cycles, we will obtain a beat note of 1,000 cycles in S_1, which will be modulated in accordance with the received signal. If the received signal be telephony, then V should be adjusted to produce beats of an inaudible frequency, say, for example, 45 kilocycles, in which case the system could be used as the first detector of a superheterodyne receiver.

Now it is a known fact that in heterodyne reception, if the amplitude of the local oscillator is less than that of the incoming

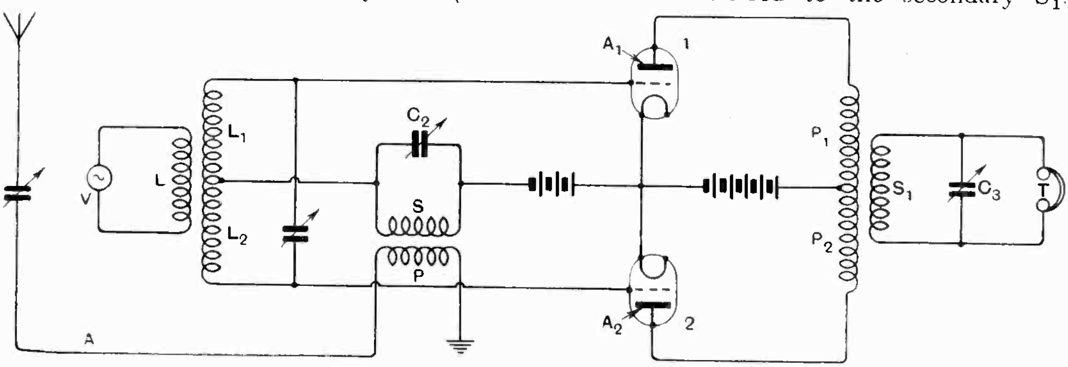


Fig. 1.

[1] U.S. Patent No. 1,459,306 issued to Dr. McCaa.

signal, the amplitude of the resultant beat note will be more or less proportional to the local oscillator. Therefore, by adjusting the coupling between L and the two secondaries L_1 and L_2, an adjustment can be found where any interference that is introduced into S_1 will never be louder than the desired signal.

Those of us who have hastened the appearance of grey hairs by the hours on end that we have spent trying to read signals during periods of heavy static, know that static does not really become very troublesome in aural reception until it is a number of times stronger than the signal. Consequently, although the static is only reduced to the same strength as the signal, one gets the impression that it has been relegated into the background and the signal seems to stand out free from interference.

In actual practice this form of static eliminator has proven much more effective in dealing with the crash and click forms of static than with the grinder type.

Appendix.

Let us assume that the current and voltage relations of a three-element tube are expressed by the following simplified tube equation:

$$I_A=K[(E_A+\mu E_c)^2+2(E_A+\mu E_c)\mu e+\mu^2e^2] \quad .. \quad (1)$$

where:

- I_A =Output or anode current.
- K =a constant depending on the tube structure.
- E_A =H.T. battery voltage.
- μ =Amplification factor of valve.
- E_c =C battery or grid bias voltage.
- e =any external input potential.

If now we assume that K, E_A, μ, and E_c are held constant, during the operation of the valve, then the first term, $(E_A+\mu E_c)^2$, will represent a steady direct current in the valves output, which will be suppressed by the transformer, P_1, P_2 and S_1. Therefore we may write:

$$I_A=K[2(E_A+\mu E_c)\mu e+\mu^2e^2] \quad .. \quad (2)$$

For purposes of simplification let:

$$2K(E_A+\mu E_c)\mu=D$$

and

$$K\mu^2=C.$$

Then we will have:

$$I_A=De+Ce^2 \quad .. \quad .. \quad (3)$$

Now let us represent the potential, due to the local oscillator, across L_1 by: $+V\sin\omega t$, and across L_2 by: $-V\sin\omega t$, where $V=$ maximum amplitude and $\omega=2\pi$ times the frequency. And similarly let: $S\sin qt$ represent the signal potential across the circuit S, C_2, q being equal to 2π times the signal frequency. The potential applied to the valve 1 will be:

$$e=S\sin qt+V\sin\omega t \quad .. \quad (4)$$

And to the grid of valve 2:

$$e=S\sin qt-V\sin\omega t \quad .. \quad (5)$$

Now substituting (4) and (5) into our tube equation (3) and expanding, we find that the current in the anode circuit of valve 1 will be:

$$I_A=+DV\sin\omega t+DS\sin qt-\frac{CV^2}{2}\cos 2\omega t-\frac{CS^2}{2}\cos 2qt+\frac{CV^2}{2}+\frac{CS^2}{2}+CVS\cos(q-\omega)t-CVS\cos(q+\omega)t \quad .. \quad (6)$$

And similarly for valve 2:

$$I_A=-DV\sin\omega t+DS\sin qt-\frac{CV^2}{2}\cos 2\omega t-\frac{CS^2}{2}\cos 2qt+\frac{CV^2}{2}+\frac{CS^2}{2}-CVS\cos(q-\omega)t+CVS\cos(q+\omega)t \quad .. \quad (7)$$

Because of the fact that the two primaries P_1 and P_2 are opposing each other, we must subtract (6) and (7) in order to obtain the resultant current induced into S_1. Therefore:

$$I_{S_1}=\underbrace{2DV\sin\omega t}_{\text{1st term.}}+\underbrace{2CVS\cos(q-\omega)t}_{\text{2nd term.}}\underbrace{-2CVS\cos(q+\omega)t}_{\text{3rd term.}} \quad .. \quad (8)$$

The first term will be seen to represent an amplification of the oscillator frequency. The second term represents a beat note which is equal to the incoming signal frequency minus the oscillator frequency. This is the frequency which will be heard in the telephones T. The third term represents the sum of the incoming signal frequency and the oscillator frequency, and is obviously of such a high frequency that it can be neglected.

The Use of Alternating Current for Heating Valve Filaments.

By C. W. Oatley, B.A.

Introduction.

DURING the past year great interest has been aroused in this country by the introduction of valves with indirectly heated cathodes for use with A.C. filament supply. It is, therefore, of interest to enquire why such valves should be necessary; in other words, to ask why A.C. cannot be used to heat the filaments of ordinary valves in which the filament is also the cathode. It is well known that when an attempt is made to do this, an audio-frequency note, due to the A.C. mains, is produced in the loud-speaker. There are four ways in which this note might be produced, viz. :—

(1) By direct coupling between leads carrying the alternating filament current with leads connected to grid and anode circuits.

(2) By coupling inside the valve.

(3) By reason of the fluctuations of filament temperature and therefore of filament emission due to the alternations of the current.

(4) By reason of the fact that, since for any one valve the grid circuit can only be connected to the filament at one point, the potential of the grid with respect to other points of the filament varies with time, the magnitude of this variation being equal to twice the amplitude of the filament voltage drop from the point considered to the point at which the filament is connected to the grid circuit.

Of these four effects (1) and (2) will not be considered here, since (1) can be made negligibly small by careful design, while (2) is present in "indirectly heated cathode" valves as well as in ordinary valves. We proceed, therefore, to a more detailed consideration of (3) and (4).

Variation of Filament Temperature.

Let the filament be heated by a current $I \cos \omega t$ and let its absolute temperature at any instant t be θ. Further, let θ_s be the correct running temperature for the filament in question—*i.e.*, the temperature at which it would be run if heated by direct current.

We make the following assumptions :—

(*a*) That the radiation of heat from the surface of the filament obeys Stefan's Law. This assumption is not really necessary, since the final result will be practically the same so long as the rate of loss of heat is proportional to $a\theta^{\psi}$ where a and ψ are constants and ψ is approximately equal to 4.

(*b*) That the variation of temperature is small. This assumption is justified by the fact that we are trying to find the conditions which will make the variation small, since a large variation would render the valve unsuitable for use in a wireless set.

(*c*) That the resistance R of the filament remains constant. This follows from (*b*).

Then rate of supply of heat to the filament

$$= I^2R \cos^2 \omega t \text{ watts}$$

$$= \frac{I^2R}{J} \cos^2 \omega t \text{ calories per sec.,}$$

where J is Joule's equivalent (4.18 Joules per calorie).

This heat is expended in two ways, viz. :—

(1) By raising the temperature of the filament.

(2) By radiation.

If a quantity of heat dQ causes a rise of temperature $d\theta$, we have

$$dQ = c\, d\theta$$

where c is the thermal capacity of the filament.

$$\therefore \quad \frac{dQ}{dt} = c\,\frac{d\theta}{dt}$$

= rate at which heat is being absorbed to increase the temperature of the filament.

If ρ is the rate of loss of heat by radiation, we have by Stefan's Law

$$\rho = \alpha\,(\theta^4 - \theta_0^4)$$

where θ_0 is the temperature of the enclosure surrounding the filament and α is a constant. Since θ_0^4 will be negligible compared with θ^4 we may write

$$\rho = \alpha\theta^4$$

$$\therefore \quad \delta\rho = 4\alpha\theta^3 . \delta\theta$$

Since θ is never very different from θ_s we may write

$$\rho = \alpha\theta_s^4 + 4\alpha\theta_s^3(\theta - \theta_s)$$
$$= 4\alpha\theta_s^3\theta - 3\alpha\theta_s^4$$

Equating the rates of gain and loss of heat :

$$c\frac{d\theta}{dt} + 4\alpha\theta_s^3\theta - 3\alpha\theta_s^4 = \frac{I^2R\cos^2\omega t}{J}.$$

This may be written :

$$c\frac{d\theta}{dt} + 4\alpha\theta_s^3\theta = 3\alpha\theta_s^4 + \tfrac{1}{2}\frac{I^2R}{J} + \tfrac{1}{2}\frac{I^2R}{J}\cos 2\omega t.$$

Let

$$\frac{4\alpha\theta_s^3}{c} = A, \quad \frac{3\alpha\theta_s^4}{c} = B, \quad \frac{\tfrac{1}{2}I^2R}{cJ} = D.$$

Multiply through by ϵ^{At} and integrate

$$\theta\epsilon^{At} = \frac{B+D}{A}\epsilon^{At} + \epsilon^{At}D\left[\frac{2\omega\sin 2\omega t + A\cos 2\omega t}{4\omega^2 + A^2}\right] + \kappa,$$

where κ is the constant of integration.

Rewriting :

$$\theta = \frac{B+D}{A} + \frac{D}{\sqrt{4\omega^2 + A^2}} . \sin(2\omega t + \phi) + \kappa\epsilon^{-At},$$

where

$$\tan\phi = \frac{A}{2\omega}.$$

The term in κ will decrease with time and will be negligible when the filament has reached the steady state—in practice a few seconds after switching on the current.

Thus finally

$$\theta = \frac{B+D}{A} + \frac{D}{\sqrt{4\omega^2 + A^2}}\sin(2\omega t + \phi) \quad .. \quad (1)$$

The mean temperature $\frac{B+D}{A}$ may be equated to θ_s, so that

$$\frac{3\alpha\theta_s^4 + \tfrac{1}{2}\frac{I^2R}{J}}{4\alpha\theta_s^3} = \theta_s,$$

whence

$$\alpha = \frac{I^2R}{2\theta_s^4 J}.$$

If i is the R.M.S. value of I, we have

$$\alpha = \frac{i^2R}{\theta_s^4 J} \quad .. \quad .. \quad (2)$$

as is otherwise obvious.

The magnitude of the maximum variation of temperature from the mean value θ_s is

$$\frac{D}{\sqrt{4\omega^2 + A^2}} \quad .. \quad .. \quad (3)$$

It will be shown later that A^2 is, in general, negligible compared with $4\omega^2$, so that (3) reduces to

$$\frac{D}{2\omega} \quad .. \quad .. \quad .. \quad (4)$$

From (2)

$$D = \frac{\alpha\theta_s^4}{c} \quad .. \quad .. \quad (5)$$

Thus for a given frequency the temperature variations are proportional to the fourth power of the mean temperature and inversely proportional to the thermal capacity of the filament.

For given values of c *and* θ_s *the variations are inversely proportional to the frequency of the heating current.*

Numerical Data.

The following numerical data refer to a thoriated tungsten filament. The first five columns of the table give the filament current (in amps.), voltage (in volts), power (in watts), length (in cms.), and radius (in cms.), respectively. The values are obtained from typical valves of this type, except that, in the case of the filament length a small estimated allowance has been made for the cooling of the filament by the support wires. Assuming the specific gravity of the filament to be 18.8 and its specific heat .033, we can calculate its thermal capacity c from its known dimensions. To calculate A we note from (5) that $D = \frac{a\theta_s^4}{c}$, while $A = \frac{4a\theta_s^3}{c}$.

$$\therefore \qquad A = \frac{4D}{\theta_s}.$$

In the present case we take $\theta_s = 1750°$ K. If we further assume that the frequency of the A.C. supply is 50 cycles per second, we have $\omega = 2\pi f = 314$. Whence we see in all cases that A^2 is negligible compared with $4\omega^2$.

Thus the amplitude of the temperature fluctuation is $\frac{D}{2\omega}$, and values of this quantity are given in the last column of the table.

In Fig. 1 the values of $\frac{D}{2\omega}$ are shown plotted against i_f. Here it is seen that, from the point of view of temperature fluctuation, nothing much is to be gained by using filaments taking more than half an ampere. There is, however, another point to be considered. Under normal working conditions the plate current of a valve is limited by space charge and is only a fraction of the total emission current of which the filament is capable. Therefore, unless the magnitude of the plate current approaches that of the emission current, the former will be almost independent of the latter. The use of large filaments is therefore advantageous in that these have greater emission than small filaments and therefore less tendency to saturate. This is especially true of power valves where the plate current is much greater than in other valves.

element of the filament considered alone is of the same form as the characteristic for the whole filament. If we are dealing with a curved portion of the characteristic the mathematical expression for the curve will not be quite the same in the two cases, but the actual curves will appear very similar. We will define the infinitesimal

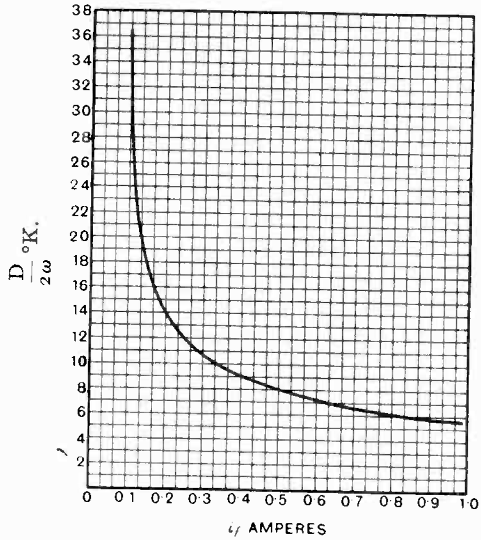


Fig. 1.

characteristic to be that curve which is represented by the equation

$$di_a = f(v_a + \mu_1 v_g) \, . \, dx,$$

where di_a is the plate current due to an element dx of the filament, v_a and v_g are the anode and grid potentials with respect to the element considered, and μ_1 is the infinitesimal amplification constant which need not necessarily have the same value as the ordinary amplification constant. Our assumption is that μ_1 and the function f are the same for all elements of the filament. If we know the form of the function f we can obtain the equation of the ordinary

TABLE 1.

i_f amps.	v_f volts.	i_f, v_f watts.	l cms.	r cms.	c gm. cals.	D	A	$\frac{D}{2\omega}$ °K.
.1	3	·3	1.6	.001	3.16×10^{-6}	23×10^3	52	34
.12	5	.6	3.5	.0012	10.0	14	33	23
.25	5	1.25	4.8	.002	38.0	7.9	18	12
·4	6	2.4	6.5	.0028	101.0	5.7	13	9.1
·95	6	5.7	7.5	.005	371.0	3.7	8.4	5.7

Variation of Effective Grid Potential.

In order to calculate the consequences of this effect, we make the assumption that the characteristic curve for an infinitesimal characteristic by integration over the whole filament. In general, f is not a simple function, and we shall consider only two special cases.

Case (*a*). When we are working on a straight portion of the infinitesimal characteristic we may write

$$di_a = \frac{v_a + \mu_1 v_g + \kappa}{\rho_1} \cdot dx,$$

where ρ_1 is the infinitesimal slope resistance.

Let us suppose that the filament is of length l, and that the voltage applied to it is $E \sin \omega t$. Also that the grid and anode circuit returns are connected to the filament at a point distant b from one end. Then if v_{a_0} and v_{g_0} are the anode and grid potentials with respect to this point, we have for any element of the filament distant x from the end which we are taking as origin

$$di_a = \frac{1}{\rho_1}\left[(v_{a_0} + \mu_1 v_{g_0} + \kappa) + \frac{E \sin \omega t}{l}(1 + \mu_1)(x - b)\right] dx.$$

Integrating with respect to x

$$i_a = \frac{1}{\rho_1}\left[(v_{a_0} + \mu_1 v_{g_0} + \kappa)\, l + \frac{(1 + \mu_1)}{l} E \sin \omega t \cdot \left(\frac{l^2}{2} - bl\right)\right].$$

Therefore, in general, there will be an alternating component in the plate current, but this component will disappear if $b = \frac{l}{2}$, *i.e.*, if we connect the grid and anode returns to the centre of the filament. In practice, of course, the same result is achieved by placing a potentiometer across the filament and connecting to the mid-point of this. It should thus be possible to eliminate hum when A.C. is used on the filament if the valve is used on a straight portion of the characteristic; that is, if it is used as an amplifier.

There is, however, another effect which must be considered in this case. Suppose that the infinitesimal characteristic is linear and without grid current only from $v_g = p$ to $v_g = q$. Then, if the filament is heated by a direct current of voltage V, the permissible grid swing on the complete characteristic will be $(p - q) - V$ (assuming $p > q$). If, however, the filament is heated by A.C., the R.M.S. voltage of which is V, then with the centre-tapped potentiometer arrangement the permissible grid swing will be $(p - q) - \sqrt{2} \cdot V$. The use of A.C. thus tends to reduce the permissible grid swing. This reduction would probably not be serious in the case of a power valve, but might be so in the case of a resistance coupled amplifier where the available grid swing is already small owing to the fall of H.T. voltage in the anode resistance.

Case (*b*). When we are not working on a linear portion of the infinitesimal characteristic. This case covers the operation of detector valves. A complete theory would be complicated, but the chief results can be obtained by a consideration of an anode bend detector for which the infinitesimal characteristic is parabolic in form. With the previous notation

$$\begin{aligned} di_a &= \frac{dx}{\rho_1}(v_a + \mu_1 v_g + \kappa)^2 \\ &= \frac{dx}{\rho_1}\left[(v_{a_0} + \mu_1 v_{g_0} + \kappa) + \frac{E \sin \omega t}{l}(1 + \mu_1)(x - b)\right]^2 \\ &= \frac{dx}{\rho_1}\left[(v_{a_0} + \mu_1 v_{g_0} + \kappa)^2 + 2(v_{a_0} + \mu_1 v_{g_0} + \kappa)\frac{E \sin \omega t\,(1 + \mu_1)(x - b)}{l} + \frac{E^2 \sin^2 \omega t}{l^2}(1 + \mu_1)^2 (x - b)^2\right] \end{aligned}$$

Integrating with respect to x

$$i_a = \frac{l}{\rho_1}\left[(v_{a_0} + \mu_1 v_{g_0} + \kappa)^2 + 2\frac{E \sin \omega t}{l}(v_{a_0} + \mu_1 v_{g_0} + \kappa)(1 + \mu_1)\left(\frac{l}{2} - b\right) + \frac{E^2 \sin^2 \omega t}{l^2}(1 + \mu_1)^2\left(\frac{l^2}{3} - bl + b^2\right)\right].$$

The expression for the plate current thus contains two alternating components, one having the same frequency as the filament supply, and the other double this frequency. (This follows from the fact that $2 \sin^2 \omega t = 1 - \cos 2\omega t$). It is possible to find a value of b (real or imaginary) for which either of these terms will vanish, but both will not vanish for the same value of b.

In general, when the infinitesimal characteristic is of a less simple form, the plate current will contain a fundamental A.C. component and a series of harmonics, and it will not be possible to find a value of b for which more than one of these terms vanishes at the same time. Thus A.C. is not suitable for heating the filaments of detector valves when anode bend rectification is employed. The case of grid rectification has not been worked out, but it is reasonable to assume that similar results would be obtained. The fact that A.C. has sometimes been used to heat detector valve filaments without producing noticeable hum in the loud-speaker is probably due to low frequency cut-off in the loud-speaker.

Conclusions.

From the foregoing it appears that indirectly heated cathode valves have a definite place in the detector stage, but it is not obvious that they possess any advantages over ordinary valves as amplifiers. The fact that ordinary valves have not been more extensively used with A.C. in the filament is probably due to (*a*) the high price of suitable valves, and (*b*) the much better mutual conductance of indirectly heated cathode valves.

The high price of valves with heavy filaments, *e.g.*, valves of the L.S.5 type, is not due to any difficulty in introducing heavy filaments into the valve, but to the fact that, being designed to withstand high plate voltages, they must be "bombarded." There is no reason why "gettered" valves of the same dimensions should be any more costly than the smaller receiving valves.

The superiority of indirectly heated cathode valves over ordinary valves in the matter of mutual conductance is chiefly due to the much greater filament power consumption of the former. It may be thought that this statement is not borne out by the characteristics of valves of the L.S.5 type, but it must be remembered that since these valves are designed to withstand high plate voltages, their electrode clearance distances are greater than would otherwise be necessary. It seems probable that a 6 volt 1 amp. coated filament valve could be designed to withstand not more than 150 volts plate voltage and to have a mutual conductance as high as an indirectly heated cathode valve with an equal filament power consumption.

The foregoing remarks, of course, do not take into account the ease with which the two types of valve may be introduced into an existing receiver which was not specially designed to use A.C. for filament heating.

Correspondence.

Letters of interest to experimenters are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

On the Equivalent Inductance and Capacity of an Aerial.

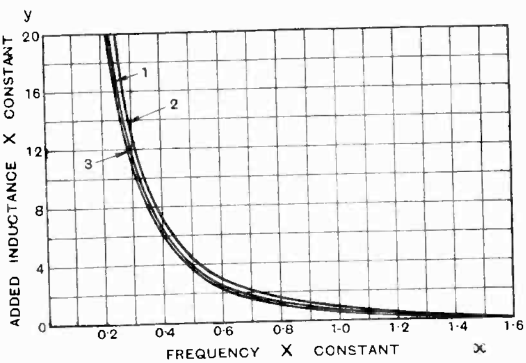
To the Editor, E.W. & W.E.

Sir,—Professor Howe very kindly allowed me to see an advance copy of his editorial for June in which he advocates different values for the equivalent inductance and capacity of an aerial from those which I have given on p. 55 of "Wireless Principles and Practice." As Professor Howe very rightly points out, the equivalent inductance L_0 and capacity C_0 must be such that the square root of their product leads to the same frequency as the natural frequency of the aerial, and also that the "stiffness" of the equivalent circuit must be the same as that of the aerial. A circuit may be considered as equivalent to an aerial circuit when the insertion of an inductance into the equivalent circuit produces the same change in frequency as it does when inserted into the aerial circuit. This is the practical test advocated by Professor Howe in the first paragraph of his editorial.

Professor Howe's values for L_0 and C_0 are $\frac{hL}{2}$ and $\frac{8hC}{\pi^2}$ respectively, where L and C represent the inductance and capacity per unit length of the aerial of height h. The values of L_0 and C_0 on p. 55 of "Wireless Principles and Practice" are (using the present nomenclature) $\frac{hL}{2.46}$ and hC. Thus the two suggested equivalent circuits agree in their natural frequencies since the two sets of values have the same product, but the circuits differ in "stiffness" because the quotients of the two sets of values differ. Taking the "stiffness" to be proportional to $\sqrt{L_0/C_0}$, Professor Howe's equivalent circuit has a "stiffness" proportional to $\sqrt{\frac{hL}{2}\Big/\frac{8hC}{\pi^2}}$ or to $0.786\sqrt{L/C}$, whilst my result leads to a "stiffness" proportional to $\sqrt{\frac{hL}{2.46}\Big/hC}$ or to $0.638\sqrt{L/C}$.

The method by which Professor Howe obtained his result involves the assumption that the added inductance is *very small* compared with the aerial self inductance, and consequently the resulting change in frequency is correspondingly small compared with the natural frequency. The values of L_0 and C_0 so obtained cannot, therefore, be expected to yield reliable frequency values when the resulting equivalent circuit has a *large* inductance added to it. In the test of equivalence outlined at the beginning of the editorial (p. 297, line 16), and in the first paragraph of this note, no statement occurs to the effect that the added inductance must be very small. Furthermore, in practice, it may be many, many times larger than the self inductance itself. It is shown in the accompanying graph that, as a consequence of the assumption made by Professor Howe, his equivalent circuit fails when tested as advocated above. In fact, the values of L_0 and C_0 which he gives can only be considered as equivalent for the very limited range when the added inductance is practically negligibly small compared with the aerial self-inductance or with the ordinary loading inductances usually employed for tuning aerial circuits.

Turning now to Professor Howe's criticism of my values, he states that the approximation by which



Curve 1.—Theoretical Formula.
Curve 2.—Howe's Formula.
Curve 3.—Palmer's Formula.

I obtain an "erroneous" result is in neglecting the terms $\left(\frac{\omega^2 h^2 LC}{15} + \text{etc.}\right)$ in the expansion of $\cot(\omega h\sqrt{LC})$. As a matter of fact, I neglect none of these terms. Had they been neglected, the equivalent inductance L_0 would have been equal to $hL/3$ and not $hL/2.46$. The approximation involved, however, lies, not in neglecting the terms, but in including them all as part of the *inductance*, when actually they contain capacity reactance components. Nevertheless, this procedure is fully justified because the resulting equivalent circuit is found, when tested by the method of adding inductance, to give frequency values which differ from the theoretical values by negligibly small amounts for all magnitudes of added inductance up to, at least, twenty times as big as the aerial self-inductance.

Curve *I* shows the resonant frequency resulting when a given inductance L_x is added as a loading coil in the aerial circuit itself. The curve is calculated from the reactance formula:

$$\omega L_x - \sqrt{L/C}\cot\omega h\sqrt{LC}$$

which equals zero for the resonant frequency, with the result

$$\frac{L_x}{hL} = \frac{\cot\omega h\sqrt{LC}}{\omega h\sqrt{LC}}$$

$$\text{or}\quad y = \frac{1}{x\,.\tan x} \qquad \ldots \quad (1)$$

where y is proportional to the added inductance and x is proportional to the frequency.

When the same inductance is added to Professor Howe's equivalent circuit, we get:

$$\omega = 1/\sqrt{(hL/2 + L_x)8hC/\pi^2}$$

$$\text{or } y = \frac{1.233}{x^2} - 0.5 \qquad \ldots \quad (2)$$

From the equivalent circuit given in "Wireless Principles and Practice":

$$\omega = 1/\sqrt{hL/2.46 + L_x)hC}$$

$$\text{or } y = \frac{1}{x^2} - 0.406 \qquad \ldots \quad (3)$$

Equations (1), (2), and (3) are plotted in curves 1, 2 and 3, respectively, for values of L_x from 0 to 20 times as big as hL. From the fact that curves 1 and 3 practically coincide, it is obvious that formula (3) and the value $L_0 = hL/2.46$, $C_0 = hC$ are not erroneous. On the contrary, these values of L_0 and C_0, when tested as outlined by Professor Howe, are found to approximate very closely to the true equivalent values for the aerial self-inductance and self-capacity, respectively.

L. S. PALMER.

[With reference to the concluding sentence of this letter we would point out that the method outlined by us specified that the inserted inductance or capacity should be small (see p. 298, line 7), but the reader is referred to the editorial note on p. 357 of this issue, where the matter is discussed in further detail.—ED.]

Retro-action in Amplifiers.

To the Editor, E.W & W.E.

SIR,—I have read with much interest the article by Mr. H. A. Thomas, M.Sc., on Retro-action in Amplifiers, which appeared in the May issue. It might appear, however, from this article that in a radio receiver the maximum gain, due to reaction, is given by

$$E_{max} = \frac{E_0}{\sin\theta},$$

and that with a given circuit arrangement no further gain can be obtained.

While this is perfectly true if θ is kept arbitrarily constant, it is not a case very likely to occur in practice. In any set at least one tuning control is provided and this can be, and is, employed to vary θ. In fact, the set will not, in general, appear to be tuned to the transmitting station unless θ is zero, when maximum signal strength will be obtained. This will not, of course, be infinite, but the limiting factor would not appear to be the finite value of θ, unless the amplifier is used in a detuned condition.

W. S. PERCIVAL.

Dagenham, Essex.

Allocation of European Broadcast Wavelengths —Some New Points of View.

By Siffer Lemoine,

Chief Engineer Swedish Telegraph Administration, Member Technical Committee of L'Union Internationale de Radiophonie.

THE problem of the allocation of wavelengths for the broadcasting stations of Europe has for some considerable time proved a constant source of discussion and the question is, perhaps, more acute than ever at the present time.

The scheme devised at Geneva by *L'Union Internationale de Radiophonie*, which came into operation in November, 1926, and to which most of the broadcasting organisations of Europe have given their adherence, has undoubtedly proved a step in the right direction but, in spite of its defects, it cannot be regarded as representing a final solution to the problem.

Many widely divergent difficulties have hindered the successful execution of the proposals. There are countries and broadcasting organisations who have not conformed to the "Geneva Scheme" and whose stations have been continually changing their wavelengths. These have constituted what might be termed a party of "freebooters of the ether" interfering now with one and now with another of the orthodox stations with results that have naturally been of little service either to themselves or to those affected. Further confusion was also caused by the fact that a number of stations were equipped with old-fashioned installations which were unable to maintain the high degree of accuracy now deemed essential in the maintenance of a constant radio frequency and, indeed, unable to maintain even approximately the wavelengths allotted under the scheme, a difficulty which it is hoped will gradually disappear but of which the effect is at present somewhat annoying. When accurate distribution of wavelengths was first attempted this, more than any other factor, proved the greatest stumbling block, but now it can, to a certain extent, be remedied by fitting one of the wavemeters that have been constructed to meet the requirements of the Union. The need for absolute constancy of radio frequency is incontestable and should be insisted on more than has hitherto been the case either in connection with the reconstruction of old installations or in the erection of new stations.

During the past twelve months it may be said that this phase in the development of broadcasting has mainly been characterised if not by stagnation at least by a reduction in its progress as compared with former years, due to a certain doubt as to the principles on which its future is to rest and an uncertainty as to what is likely to be permissible or practicable as time goes on. Even where the Geneva plan has been accepted it has been, in many cases, with a realisation of its imperfection in its present state and in the hope of a revision in the future.

True, some countries have, within the scope of the agreements now in force and without waiting for forthcoming international regulations, managed to increase the power of their stations, but most countries have adopted a cautious attitude, both as regards extending their power and erecting new installations, having in mind especially the question of the principles that might be laid down on this point by the International Radio Conference held at Washington last autumn.

The Resolutions passed by the Washington Conference, and their significance.

The resolutions passed by the Washington Conference are now known, although there has not yet been time to ratify them. Various wireless services have had their different wavebands allotted — including broadcasting—while the particularly vital question (from the European point of view) of wavelength rights for every country and other principles governing the use of the broadcasting bands has been left open for the present.

It may be said that the result, as far as broadcasting is concerned, has been poorer than had generally been anticipated. Those zones that have now been assigned for the purpose have been extended in so niggardly a fashion that not only has the growth of the number of stations been stunted but a restriction has been practically laid on those that were previously functioning.

Thus, above 1,000 metres, permission has been granted in Europe to use the zone from 1,875 to 1,550 metres, corresponding to 160-194 kilocycles per second, exclusively for broadcasting and from 1,550 to 1,340 metres (194-224 kc/sec), jointly with the air services, but with the proviso that no increase in power may take place so long as disturbances with other traffic may be caused thereby. Below 1,000 metres the limit upwards has been reduced from the present maximum of 600 metres down to 545 metres, while the lower limit has been maintained at 200 metres—corresponding to the kilocycle numbers 550 to 1,500—with the exception of 220 metres (1,365 kc/sec.), which has been allotted exclusively for maritime requirements.

An examination into the significance of these proposals shows that in a way broadcasting finds itself in a more embarrassed situation than before. From having previously been comparatively free from control it has now been confined within a zone amounting in all to no more than 1,014 kilocycles, and this too without taking account of the 220 metres wavelength allotted to shipping as mentioned above, which will in practice not mean a fixed frequency but a band of considerable breadth. The frequency zones that broadcasting has been granted in addition, comprising lower wavelengths from 50 metres downwards, are at present of no very great importance for the development of normal broadcasting in Europe and in this connection are therefore disregarded.

On the other hand, the resolutions passed in Washington imply a distinct gain, in so far as we are now actually able to say what lines are to be followed. From the point of view of principle, this is more or less of secondary importance, as all countries have conformed to the regulations in question and thus one and all have to come in line with the new order. The resolutions will come into force on the 1st January 1929, except those affecting the higher wavelength zone for broadcasting, for the enforcement of which a further respite of one year has been granted.

The wavelength distribution for which the Geneva plan has been worked out comprises only the zone from 200 to 600 metres, whereas stations working on other wavelengths have had to rely on their right of priority, which in fact has as a rule been respected. This might have been satisfactory enough at a time when there were no restrictions as to wavelength either upwards or downwards, but as soon as the Washington resolutions come into force, matters will be very different. It is obviously no longer either reasonable or fair to regard the two bands as separate, so that a few privileged countries, actually not more than seven, solely on grounds of priority, may lay claim to the higher wavelengths, while the lower band is allotted on a basis that is independent of the former and to which all are alike entitled. When the allocation is made all frequencies should be included and the question regarded as a whole.

Area and population as principles governing the distribution of wavelengths.

Before proceeding further, mention should be made of the principles laid before the Technical Committee of the Union Internationale by the author at the time—principles which, with certain modifications, formed the basis of the distribution now in force. The first of these contentions was that the number of wavelengths which a country is entitled to possess should be in a fixed proportion to the area of the country. The second proposed that consideration should be given to the size or density of the population.

As regards the first of these principles, it must still be considered to have full force, It may be assumed with approximate accuracy that a broadcasting station of a certain power and with normal equipment has the same range, regardless of the country in which it is erected—there are certainly some exceptions to this, such countries as, for instance, Norway and Switzerland, and part of Sweden, with very mountainous and wooded terrain, are at a disadvantage, whereas on the other hand, the conditions in Holland and Denmark are more favourable than the average. If we take as our basis the idea that every individual, to whatever country he belongs, shall be equally privileged as regards the possibilities of listening-in, the problem of wavelength would be solved simply enough—viz., allotted in proportion to the area of each country. For reasons which will be more closely dealt with later on, however, the time has apparently not yet arrived when we can accept this simply and solely as the basis of distribution; if we are not to lose continuity in the development, we must also give consideration to other factors.

As to the principle of population, the argument produced at the time in favour of this was that the more densely populated areas were better entitled to be supplied with more convenient means of "receiving" than sparsely populated districts, and in consequence certain countries should be allotted a greater number of wavelengths. It may be remembered in this connection that these proposals were made in 1925, that is to say, at a period when the size of the biggest commercial transmitters existing on the market was at the most $1\frac{1}{2}$ kilowatts. This way of looking at the subject might have been justified at the time by the difficulty of building stations of sufficient power, but nowadays that point of view can hardly be considered tenable, seeing that transmitters of as much as 50 kilowatts and more are now standardised and may be procured at a reasonable price. In certain cases better results and increased efficiency are obtained by the removal of the station to a more suitable locality.

In this connection I venture to quote from the minutes of the meetings of the Union's Technical Committee, held at later dates, a recommendation mentioned in several places and reading as follows: "Fewer stations, greater power"—a principle which is fundamentally quite true and the truth of which, as such, is worthy of being emphasised. It goes without saying that it is in densely populated areas that an outlay of capital for higher-powered transmission will pay best, besides giving the listeners-in within the service area better possibilities of reception, and bringing to the business an increased income from new licence-holders.

Observations on the Question of Modifying the Primary Basis of Distribution.

The question of wavelength distribution must not, however, be viewed merely against a theoretical background; account must also be taken of the position of the present stage of development. The author does not mean by this that the population principle should at once be entirely eliminated, as in certain countries this would involve too sudden a reversal of conditions. A gradual modification is a matter of minor importance and would not seriously inconvenience the broadcasting organisations affected, but enable them to effect the change gradually and without too much friction.

The primary principle that, according to the author's proposal, should be made the basis of a revised allocation of wavelengths is as follows:—

Every country would obtain the right to a number of wavelengths as corresponding to a function of the country's area and population expressed in percentage, calculated on the basis of area plus one-half the population.

In Table I a summary has been made according to the latest available official statistics on the areas and populations of the countries of Europe, with the exception of Russia and Turkey in Europe. The total area amounts to 5,329,500 sq. kilometres and the population to 36.15 millions. In the last column have been worked out for each country comparative numbers according to the formula $a + \frac{b}{2}$, where a denotes the area and b the population, both expressed in percentage of the total figures.

If we compare the comparative numbers deduced according to this formula with those obtained if the *same* value were given both to area and population, we find that only a few unimportant modifications take place slightly to the disadvantage of small and densely populated countries, while corresponding advantages accrue to states with a large area but comparatively small density of population. I would emphasise the fact that the table may obviously be adapted to admit of such modifications as may be rendered necessary by special requirements, such as, in particular, unfavourable geographical conditions, polylingual nations, etc., and that, conversely, it may be possible to make certain limitations wherever theoretical deductions have produced abnormally high comparative numbers.

and the telegraph in each country, it was resolved that a distribution should be made among the different countries in accordance with Table II :—

This table relates only to the exclusive wavelengths, and Russia has here been

TABLE I.

COMPARATIVE NUMBERS FOR WAVELENGTH DISTRIBUTION IN PROPORTION TO SUPERFICIAL CONTENT AREA AND POPULATION.

Country.	Superficial Content (a).		Population (b).		Comparative Numbers.	
	100 sq. Kms.	%.	Mill.	%.	$a + b/2$.	%.
Albania	275	0.52	0.83	0.23	0.635	0.42
Austria	838	1.57	6.58	1.83	2.485	1.66
Belgium	304	0.57	7.87	2.19	1.665	1.11
Bulgaria	1,031	1.94	5.48	1.52	2.700	1.80
Czecho-Slovakia	1,404	2.63	14.24	3.95	4,605	3.07
Denmark	429	0.81	3.42	0.95	1.285	0.86
England	2,448	4.59	45.21	12.55	10.865	7.24
Esthonia	475	0.89	1.12	0.31	1.045	0.70
Finland	3,885	7.29	3.29	0.91	7.745	5.16
France	5,510	10.34	40.74	11.31	15.995	10.66
Germany	4,704	8.82	62.54	17.37	17.505	11.67
Greece	1,270	2.38	6.20	1.72	3.240	2.16
Holland	408	0.77	7.52	2.09	1.815	1.21
Hungary	929	1.74	8.37	2.32	2.900	1.93
Iceland	1,028	1.93	0.10	0.03	1.945	1.30
Ireland	698	1.31	2.97	0.85	1.735	1.16
Italy	3,097	5.81	40.55	11.26	11.440	7.63
Lettland	658	1.23	1.86	0.52	1.490	0.99
Lithuania	561	1.05	2.23	0.62	1.360	0.91
Luxemburg	26	0.05	0.27	0.07	0.085	0.06
Norway	3,238	6.08	2.77	0.77	6.465	4.31
Poland	3,883	7.29	29.25	8.12	11.350	7.57
Portugal	887	1.66	5.62	1.56	2.440	1.63
Roumania	2,942	5.52	16.98	4.71	7.875	5.25
Spain	4,979	9.34	21.62	6.00	12.340	8.23
Sweden	4,485	8.42	6.07	1.69	9.265	6.18
Switzerland	413	0.78	3.94	1.09	1.325	0.88
Yugoslavia	2,490	4.67	12.49	3,47	6.405	4.27

Wavelength Allocation according to the Geneva Plan.

For the sake of comparison with the calculation, worked out in Table I, of the new figures proposed as a basis for a revised wavelength distribution, there is given in Table II, as a supplement to the above table, a comprehensive table of the Plan now in force. After the introduction of a third factor, borrowed from the official statistical information drawn up by the League of Nations regarding the use of the telephone

excluded from the list, that country not having been represented at the Washington Conference and its attitude towards the question being still unknown. If we examine Table II side by side with Table I, we find agreement in the main, but in certain cases there are considerable differences. Thus, some countries have been allotted, on the Geneva Plan, the same number of wavelengths as others whose area is ten times greater. From a purely technical point of view every one must, of course, admit that the situation of the country that has received a less favourable allotment is fairly hopeless as regards the possibility of carrying on effective broadcasting and that, in such cases, justice and equity demand that a change should be made.

TABLE II.

WAVELENGTH DISTRIBUTION ACCORDING TO THE GENEVA PLAN.

Country.	No. of Exclusive Wave-lengths.	Country.	No. of Exclusive Wave-lengths.
Albania ..	1	Italy ..	5
Austria ..	2	Lettland	1
Belgium ..	2	Lithuania	1
Bulgaria..	1	Luxemburg ..	1
Czecho-Slovakia	3	Norway..	3
Denmark	1	Poland ..	4
England ..	9	Portugal	1
Esthonia..	1	Roumania	2
Finland ..	2	Spain ..	5
France ..	9	Sweden ..	5
Germany*	12	Switzerland ..	1
Greece ..	1	Yugoslavia..	1
Holland ..	2		
Hungary..	1		
Iceland ..	—		
Ireland ..	1		

* To be taken 5 in each section.

The Principles for the Mutual Location of the Wavelengths.

The second question of at least equal importance to that of the allocation of the *number* of wavelengths to each country is that of the *mutual location* of stations within the 200–600 metre zone. The number of wavelengths has been based on the principle of a frequency difference between each of 10,000 cycles per sec. Proposals have been brought forward to reduce this difference in order to make room for more stations; it would seem, however, that the time for this has not yet arrived and the present basis of distribution must be maintained for some time longer.

The principles applied in placing the stations have been, in the first place, the so-called polygon procedure, consisting in two stations whose frequencies are of about the same order, being placed at the greatest possible geographical distance apart, as a rule at distances of about 1,000 to 2,000 kms. and, secondly, the acknowledgment of a certain prior right to a previously utilised wavelength. With regard to the polygon method, I shall revert thereto later on in another connection. As to the principle of priority, which should without doubt be given the same value as before, I propose to quote what I wrote on the matter in an earlier report, as follows: "It may be considered reasonable that a station that has for years past been working on one and the same wavelength should be allowed to continue to retain it wherever possible, or, if a change must be made, that this should be done only within such a zone that existing receiving sets within the normal radius of the station need not be altered."

The consequence of this has naturally been that the "better" zone between 300 to 600 metres has been the most sought after and been the first to be utilised, while frequencies below 250 metres have, to a considerable extent, been held as a kind of reserve for future requirements. It may also be regarded as a logical result that countries whose broadcasting has been organised at a later date must in that case be content to use wavelengths within a band that has not previously been occupied.

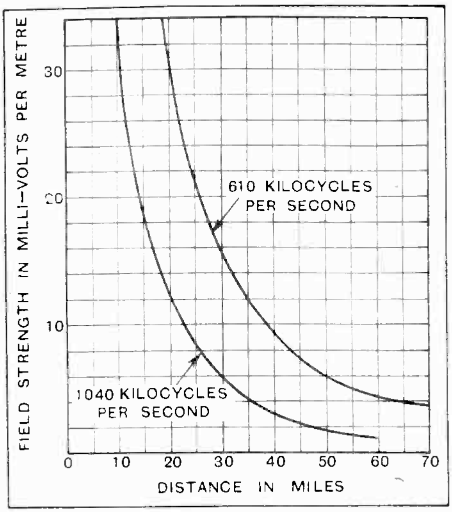


Fig. 1.

Proposal for the Introduction of So-called Wavelength Equivalents.

On the other hand, in the author's opinion, an incorrect method has been employed when, in allotting wavelengths, attention has been paid exclusively to the *number* of wavelengths apart from the question of where they are to be found within the frequency zone, and no consideration has been given to the question of their different service-value. As is well known, a wavelength of 200 metres is, as regards its efficiency, not so desirable as one of 500, wherefore they cannot be compared with one another *qua* wavelengths.

values is still less justified than before. On the other hand, since it is desirable that the basis of any allocation of wavelengths should be equally applicable to the higher and the lower wavelength zone, the question is whether an acceptable formula can be found for allotting a value to the different frequencies in relation to one another.

Here we have several points of departure to choose from. It is possible to gauge the field-strength at various distances from a

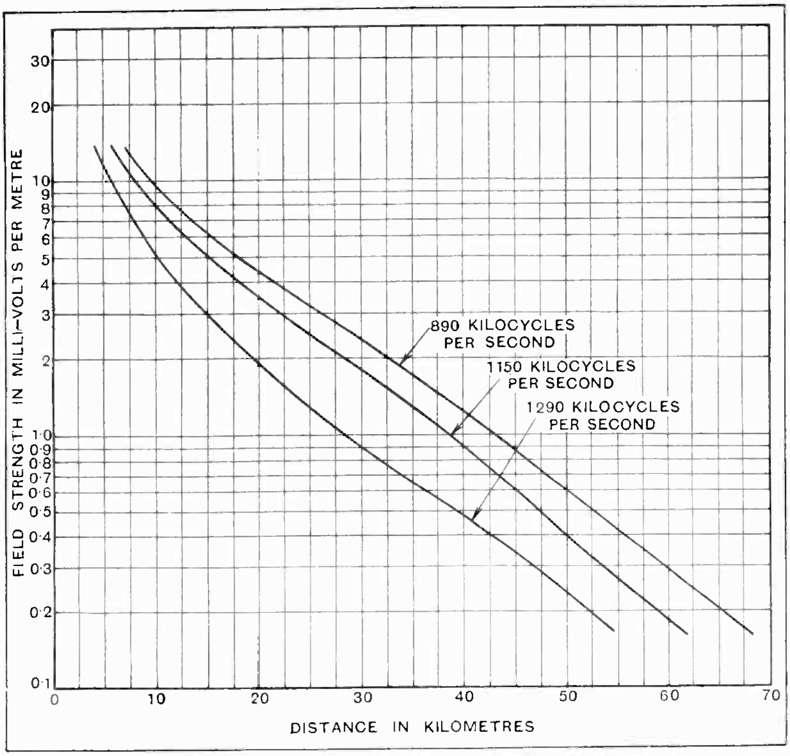


Fig. 2.

A comparative valuation of different frequencies is justified for two reasons: first, the higher the frequency the greater is the attenuation of a radiated wave; and, secondly, a higher wavelength permits the use of higher masts for the same radiation resistance and consequently gives a greater number of metre-amps. for the same primary power. In consequence of the resolutions passed by the Washington Conference, and since the possibility of a choice of wavelength outside the fixed frequency bands is almost entirely eliminated, the standpoint of equal

given station at different frequencies and when using the same power. Such curves have been published, *inter alia*, by *P. P. Eckersley* in a recent paper read before *The Institution of Electrical Engineers*, from which the illustration (Fig. 1) has been reproduced. Similar results have been obtained in a comparison between measurements of the field-strength from broadcasting stations in Sweden, thus Fig. 2 shows field intensity curves from one and the same station; Fig. 3 similar curves from two different stations, in both cases with approximately the same aerial output. As the measurements in the latter case were taken over land of varying character—actually more favourable to the short-wave station—no direct comparison can be made, but the example shows clearly that there is no small difference in the efficiency of the wavelengths in question.

The object of reproducing these curves is mainly to show that it is not possible by means of measuring to secure a simple and generally applicable expression for the comparative service value of the wavelengths, chiefly owing to the fact that the field intensity as a rule is dependent on the nature of the ground in each particular case. It seems to be equally improbable to be able to deduce the desired formula on a basis of purely theoretical speculation.

Disregarding therefore the investigations made by the author into the possibilities of using strictly mathematical calculations in the derivation of a suitable formula, the following proposal is submitted: *The service value of one arbitrary wavelength in relation to another within the broadcasting band is calculated as the cube root of the ratio between the inverse values of their frequencies,* this value being hereinafter called the *wavelength equivalent.*

If for this purpose we choose 300 metres, corresponding to 1,000 kc/sec., as a standard, the desired wavelength equivalent equals the cube root of the quotient between 1,000 and the respective kilocycle number and the calculations will then be easy to work out. In Table III are given the wavelength equivalents, first for the band between 160 and 224 kc/sec. for every 10th kilocycle, secondly for the upper frequency-band for every 100th kilocycle, and in Fig. 4 they are further shown graphically as a function of kc/sec.

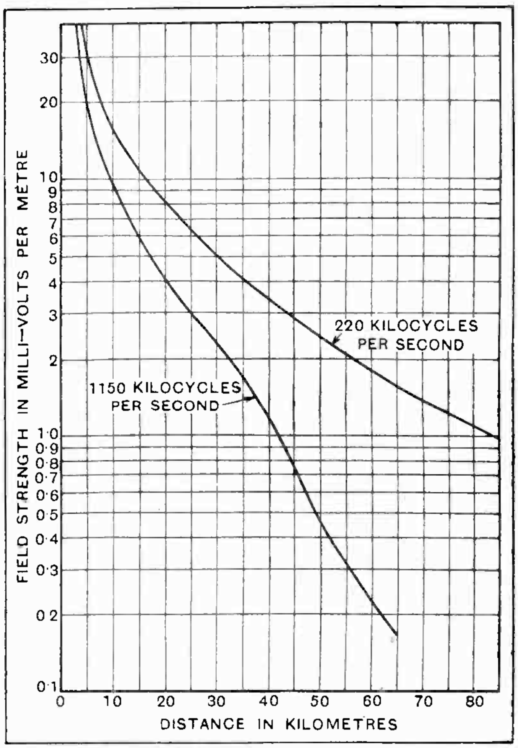


Fig. 3.

This valuation of higher or lower frequency implies that, for instance, a wavelength between 550 and 500 metres would be regarded as having about 40 per cent. greater efficiency than a wavelength of about

TABLE III.

Wavelength Equivalents for Different Frequencies.

Frequency in Kc/sec.	Wavelength in Metres.	Wavelength Equivalent.	Frequency in in Kc/sec.	Wavelength in Metres.	Wavelength Equivalent.
162	1,852	1.84	700	428.6	1.13
172	1,744	1.80	800	375.0	1.08
182	1,648	1.76	900	333.3	1.04
192	1,563	1.73	1000	300.0	1.00
202	1,485	1.70			
212	1,415	1.68	1,100	272.7	0.97
222	1,351	1.65	1,200	250.0	0.94
			1,300	230.8	0.92
550	545.6	1.22	1,400	214.0	0.89
600	500.0	1.19	1,500	200.0	0.87

200 metres, and further that the wavelengths within the higher band are calculated, on an average, to be 50 to 60 per cent. more effective than those between 300 and 550 metres.

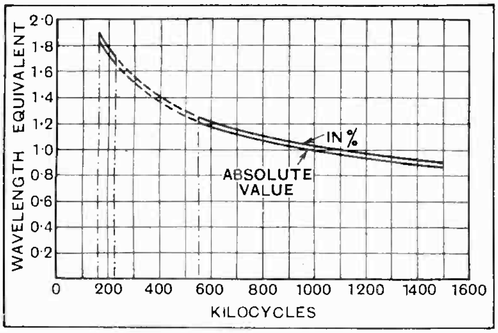


Fig. 4.

If we compare the values of the Table with results obtained by taking measurements, we find that they are throughout a little unfavourable to short-wave stations. It is the view of the author that, to a certain extent, this must actually be the case. The main argument against the introduction of frequency equivalents is that by increasing the power of stations working on lower wavelengths it is possible to counteract the greater attenuation and to obtain an equally long range. This reasoning is correct only within certain limitations. To obtain parity in range between a wavelength of 200 and one of, say, 1,500 metres, would require a power amounting to several hundred kilowatts, with correspondingly heavier establishment and greater running costs. On the other hand, the mathematically less exact agreement and the advantage which the formula gives to the lower frequencies can be compensated without much sacrifice by a smaller increase in the power or often even merely by adopting more suitable arrangements in order to get a better efficiency.

Exclusive and shared wavelengths.

When the above-mentioned allocation of frequencies between 200 and 600 metres was fixed at Geneva, it was decided that the number of so-called exclusive wavelengths should be 83 and the shared waves 16. It seems in this connection that the question of this distribution should also be taken up for renewed discussion.

The reason for the existence of the shared wavelengths was the need in certain countries for utilising a smaller number of transmitting stations with only a local range. This system has for the present been adopted in most countries. In view of the present establishment the shared wavelengths cannot on that account be removed at once without further notice, but there exist strong reasons for restricting the number, say, from 16 to 12, which in all probability could be done without much inconvenience.

The shared wavelengths have been allocated fairly evenly, being distributed over the entire wavelength band, starting at 588 metres, then at 500, 400, 300 metres, and so on, downwards. An alteration in this arrangement might now profitably be made. Since it was originally the intention that those stations working on shared waves were supposed only to possess a local range and consequently to be equipped with transmitters of comparatively small power—this might be put at approximately not more than 200 watts aerial energy or about 100 metre-amps.—there is no reason why one should set apart for this purpose higher wavelengths that are more serviceable for exclusive use; on the contrary, lower wavelengths are even better adapted for that purpose.

A proposal for a new allocation of the common frequencies is made in Table IV in which the scheme now in force is also given for comparison purpose. All the 12 shared wavelengths proposed are placed below 300 metres, viz., three up to each one of the frequencies 1,100, 1,200, 1,350 and 1,500 kilocycles/sec.

By the adoption of this reduction in the number and re-allocating the shared wavelengths: First, restrictions on the zone 500 to 550 kc/sec. are compensated for; the Washington Conference prohibits the use of this zone for broadcasting, certain countries, however, being at liberty, wherever possible, to allocate thereto stations of low power, provided that no interference is caused to commercial services. Moreover, the wavelengths of 500, 400 and 300 metres, which have actually proved not very good for joint use, are released as exclusive.

Finally, the frequencies around 220 metres, which have at the same time been allotted to marine wireless traffic, might perhaps conveniently be used by stations having common wavelengths, in cases where the interference from either side may be expected to be negligible.

TABLE IV.

LIST OF THE PRESENT AND A PROPOSAL FOR NEW SHARED WAVELENGTHS.

Present Wavelengths.		Proposed Wavelengths.	
Frequency in Kc/sec.	Wavelength in Metres.	Frequency in Kc/sec.	Wavelength in Metres.
510	588.2	1,090	275.2
520	577.0	1,100	272.7
530	566.0	1,110	270.3
600	500.0		
		1,190	252.1
750	400.0	1,200	250.0
1,010	297.0	1,210	247.9
1,020	294.1		
1,080	277.8	1,350	222.2
		1,360	220.6
1,090	275.2	1,370	219.0
1,100	272.7		
1,180	254.2	1,480	202.7
1,190	252.1	1,490	201.3
		1,500	200.0
1,200	250.0		
1,470	204.1		
1,480	202.7		
1,490	201.3		

Application of the Principle of Wavelength Equivalents.

To return to the discussion on the exclusive wavelengths, it has previously been mentioned that the total range of frequencies available for broadcasting amount in all to 1,014 kc/sec., which, allowing for a difference of 10 kilocycles between stations, corresponds to 103 usable frequencies. After deducting the proposed 12 shared wavelengths there thus remain a total of 91 for distribution amongst all the countries of Europe.

It is proposed that the distribution of these should be carried out on the following principle: *Each country to be allotted that number of frequencies of which the sum of the wavelength equivalents, expressed in percentages, corresponds to the respective comparative numbers given in Table I.*

If we work out the total wavelength equivalents for all frequencies, we obtain, after deducting the shared wavelengths, the number 98.45. From this we must further deduct 1.7 for the big station in Moscow working on about 1,450 metres, which we must take into account for the purposes of this calculation. On wavelengths below 600 metres, on the other hand, there are in Russia at present only a couple of installations of minor importance. The final result will then be 96.75. If, further, we convert the absolute value of each wavelength equivalent in Fig. 4 and express it as a percentage of the total, then the sum of the percentage equivalents of the wavelengths each country is entitled to use will equal the comparative numbers calculated in Table I.

The gist of this is perhaps best explained by means of examples. In the case of most countries the new principle of distribution results in no change. For Great Britain the application of the formula would entail a certain reduction of the wavelengths now provided. Thus, England has, according to Table I, the comparative number 7.24, and with the 10 wavelengths, including Daventry, which are now in use, she would receive an absolute equivalent of 11.27, corresponding in percentage to 11.65. A strict application of the principle would therefore involve a surrender of one or two of the existing lower exclusive wavelengths. The application of the formula would likewise prove disadvantageous to Sweden and Germany, compared with the present arrangement, while on the other hand, Finland, Italy, Norway, Poland, Spain and Hungary, *inter alia*, would find their position improved. (For possible modifications when the formula is brought into effect, see under final observations.)

Group Allocation of Wavelengths instead of the Polygon Method.

As regards the determination of the frequencies that the various stations must use, the author's view is, as already pointed out, that the principle of priority should still be adhered to as far as is feasible when the distribution is made; concerning the application of the polygon method, however, this system might usefully be made the subject of discussion.

As is well known, the radiation from a transmitting station is of two kinds, viz., ground-radiation and space-radiation, of which the former represents the radiation of service to listeners within the normal radius, while the latter as a rule is useful for listeners at very great distances. Experience further goes to show that the space-radiation in the case of the frequencies used in broadcasting returns by reflection to the earth's surface with a maximum of strength at distances of about 1,000 to 2,000 kms., which, when the polygon method is employed, is about equivalent to the distance between two stations of closely related frequencies.

The consequence of this is—and a great many complaints from different quarters testify to the fact—that listeners not infrequently experience great difficulty in distinguishing between the programme of their own station and that of the foreign station next to it in frequency, although it may be remote in point of distance. It is not intended to try in any way to depreciate or disregard the demand for selectivity in receiving sets, but the fact remains that great inconvenience is caused by the present system. There are, for instance, continental stations which, owing to their high power and powerful ether radiation, after nightfall can be heard splendidly in neighbouring countries within the crystal-range of their own local stations, and even on crystal sets employed for the reception of local stations. Moreover, it may be supposed that these interferences will be felt in proportion as the number of higher power stations increases.

One way in which the author considers it possible, at least in part, to eliminate this trouble, is to substitute for the polygon method what may most suitably be termed the "group-allocation" of the wavelengths, which would mean that, *if a country possesses the right to several frequencies, these frequencies should be allotted in groups of three or four adjacent bands.*

In this there are at least two advantages to be gained: first, the broadcasting organisation in each country will itself become responsible for the frequencies within each band being kept constant, which would be quite easy when the stations are subordinate to one and the same authority—at the same time the work of the international wavelength control would be lessened—and if they fail in their efforts, their own listeners and not, as is now the case, listeners outside the country, who have nothing to do with the matter, will be the sufferers. Secondly, many of the disturbing effects of the space-radiation would be eliminated, since they would come within a considerably broader frequency-band, and thus listeners to their own local stations will not be troubled by it to such an extent as at present. And a third advantage is that owners of sufficiently selective sets will be afforded at least as good, if not better, chances of picking up stations over greater distances. Two stations adjacent in frequency already exist in England, namely, Aberdeen and Daventry Experimental (5GB). Whether or not these disturb one another in England I do not know, but that they produce interference on the Continent is an acknowledged fact.

It may be added that, as matters stand to-day, the demand for increased transmitting power is often quite as fully justified by the plea of international competition as by the desire of the station to increase its own range. The former way of viewing the matter, which, of course, does not tend to a sound development of broadcasting, would, if the group-allocation of wavelengths were introduced, have less grounds for justification.

Summary.

The views submitted above regarding a revision of the system now in force for allocating the wavelengths of the European broadcasting stations may be summarised as follows :—

(1) That every country shall have the right to such number of frequencies as corresponds to a function of the country's area and population, expressed as a percentage, for which purpose the first factor is taken as the whole, and the latter as half, the numerical value.

(2) That such right shall involve the necessity, before a certain date to be fixed by the Union or other International Conference, of taking into actual use the frequencies allotted, and if this is not done, then, by agreement, such frequencies may be disposed of in some other way, until the International Radio Conference of 1932 determines otherwise.

(3) That all wavelengths that are available within the frequency-bands fixed by the Washington Conference shall be distributed on a common basis.

(4) That the valuation of different frequencies shall be made by the intro-

duction of so-called "wavelength equivalents" on the basis of the formula here drawn up by the author, calculated, in the manner suggested, as the cube-root of the ratio between the inverse values of their frequencies.

(5) That the number of shared frequencies be reduced, to consist of 12 wavelengths instead of the present 16.

(6) That in the allotment of frequencies to various stations and in the application of the principle of priority investigations be made into the possibility of introducing a certain "group-allocation" instead of the polygon method.

(7) That such deviations from the principles outlined above may be made as special circumstances require.

Final Observations.

Before closing this article I would like to make a few final remarks and observations. First, then, it may be pointed out that the proposals and views submitted above have not been offered with the idea of procuring for my own or any other country greater advantages than those they have previously enjoyed or may be expected to enjoy in the future, but they represent an attempt to deal with relative questions from an international angle. The object, therefore, is primarily that the views here submitted shall form a basis for a comprehensive enquiry and for further discussion of these problems, and contribute towards giving permanent shape to the international system the foundations of which have been laid by the Geneva Union, and thereby conduce to the continued development of broadcasting.

It may also be emphasised that it is not, in the author's opinion, either possible or expedient to bring these proposals into immediate effect on the strict basis of his theoretical deductions, but, on the contrary, common principles of application are inevitably necessary, exceptions, however, being made in cases where they are deemed to be justified.

Broadcasting has not developed uniformly in all countries, nor, of course, is it likely to do so in the future. The suppression of what has once been created in favour of newly arisen demands cannot perhaps be avoided in a number of cases, but, on the other hand, it must be admitted that this cannot be done all in a moment ; we must keep pace with the discovery of fresh means for solving the problems that arise. Nor can broadcasting afford to let employable frequencies be kept in reserve for an indefinite period ; they must be utilised as and when required (point 2 in the summary). At the same time, it is the author's intention, in this article, to give a comprehensive idea of the prevailing conditions and of the difficulties with which broadcasting, regarded internationally, has at present to contend, and also that any claims that may arise must be considered by everyone in their proper light and adjusted accordingly.

At the meeting of the Technical Committee of the International Union, held in Prague last February, the desire was expressed in several quarters for a revision of the present system with a view to its being brought into line with the resolutions of the Washington Conference.

In submitting this article, with the views on the various problems expressed therein and proposals for their solution, the author ventures to express the lively hope that, as these questions may shortly be expected to be taken up for international discussion, his recommendations may happily serve their purpose.

Abstracts and References.

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PROPAGATION OF WAVES.

MEASUREMENT OF FADING.—(*Bureau of Standards, Washington,* "Scientific Paper" No. 561).

A record of tests carried out by stations in the United States and Canada, and the conclusions drawn.

THE POLARISATION AND FADING OF SHORT WIRELESS WAVES.—T. L. Eckersley. (Letter to *Nature*, 5 May, 1928, Vol. 121, p. 707).

The effect of the earth's magnetic field in altering the plane of polarisation and producing circular polarisation in a transmitted wireless ray has been fairly fully discussed recently by Nicholls and Shelling and by Appleton. Examples of this effect have been observed at night time when the ray from a vertically symmetrical aerial gives a received ray either partially or wholly horizontally polarised, and consequently an erroneous bearing. The letter describes two sets of experiments carried out in the daytime in which rather more definite indications of these effects were observed on very short waves (from 14 to 50 metres) using a unidirectional receiving aerial consisting of a vertical aerial coupled to a closed loop rotating about a vertical axis. Experiments in April, 1927, with this arrangement showed that on certain occasions, relatively rare but quite definitely established, the received ray was circularly or elliptically polarised. The effect has not been observed on long-distance stations, and appears to be most marked on stations just outside the skip-distance. Five stations giving the effect are mentioned, three being (relatively to the observer) in the sector E. to S.E., the other two being W.S.W. and W. nearly. The first three always showed polarisation in a clockwise direction, the latter two in a counter-clockwise. Unfortunately there were no stations to the N. on which to test.

The writer continues: "The explanation is obviously connected with the double refraction suffered by two circularly polarised components of the plane polarised wave emitted; one of the components being more bent than the other, the two will be separated near the edge of the skip-distance where the effect is observed.

"It has not been possible yet to trace the two rays which must pass through a medium of variable electronic density, partly along and partly across the earth's magnetic field, in sufficient detail to account for the difference in direction of rotation of the rays according as they travel eastward or westward. But it might be surmised that at greater distances, that is, well outside the skip-distance, both the rays into which the original plane polarised wave is split will reach the receiver, where they will combine to produce a plane polarised ray, the direction of which will depend on the distance traversed by the ray through the medium and the strength of the magnetic field.

"This resultant direction will vary momentarily with slight changes in the path and the earth's magnetic field (as suggested by Breit), with the result that the vertical field will vary from time to time and produce fading. But fadings from this cause, which is due to a bodily rotation of the electric vector, will produce opposite effects on a vertical and horizontal aerial perpendicular to the ray. In fact the fading on one will be the inverse of the fading on the other, for when the vertical electric force is a maximum, the horizontal force is zero and *vice versa*. Experiments made recently confirm this view, at least in certain cases. In Fig. 1 (not abstracted) simultaneous fading records taken on a horizontal and vertical aerial are shown, and it is clear at a glance that these are opposite in phase.

"The observations were made on *PQW*, a beam station at Lisbon, and many more records showing the same characteristics have been taken. Apart from the theoretical interest, these results have great practical value in devising systems which will eliminate, or at least reduce, fading.

"Whether all short wave fading is of this type remains to be seen, but further experiments seem to show that this is not the only type of fading."

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

EINIGE UNTERSUCHUNGEN ÜBER DEN BLITZ (Some investigations into Lightning-flashes).—L. Binder. (*E.T.Z.*, 29 March, 1928, V.49, pp. 503-507.)

From thermal effects the current-strength of very powerful flashes is reckoned at $9{,}500 : \sqrt{t}$ (for example, if $t = 1/100$ sec., $I = 95{,}000$ amperes). The duration and course of flashes have been measured by Cathode ray oscillograph and "Klydonograph." Latest results suggest that the time course of the potential-rise in conductors is very much influenced by the distance away of the flash, and that results on the surface of the earth do not give a representation true to time of the processes in the course of the flash.

ANFANGSPANNUNGEN FÜR MEHRFACH ELEKTRODEN IN LUFT (Initial sparking voltages for multiple-electrodes in air).—(*E.T.Z.*, 5 April, 1928, V.49, pp. 549-551.)

An investigation doing for multiple-electrodes what has already been done thoroughly for single electrodes, and thus giving information useful in connection with protective devices used on wireless receivers.

IONISATION OF THE UPPER ATMOSPHERE.—E. O. Hulbert. (*Journ. Washington Ac. Sci.*, April, 1928, V.18, p. 227.)

Author's abstract of a paper in which the form of the electron bank in the high atmosphere is calculated, using laws either known or based on easonable assumptions. For a summer day (N. Temperate Zone) the max. density is about 3×10^5 electrons per c.c., at a height of about 200 km.: the corresponding values for a winter day are about 2×10^5 and 150 km., and for a summer or winter night about 8×10^4 and 100–150 km. There is an ion bank below the electron bank, whose max. density is probably less than 10^8 ions per c.c.

(Abstractor's note: No details as to the basis of the laws assumed are given in the Journal.)

PROPERTIES OF CIRCUITS.

Analyse einer Elektrischen Schaltung für das Kondensatormikrophon (Analysis of an electrical circuit for the Condenser-Microphone).—A. J. Jakowleff. (*Zeitschr. f. Hochf. Tech.*, March, 1928, V. 31, pp. 85–87.)

An analytical expression is derived for the current strength in a condenser-microphone circuit. The evaluation of the current shows that this circuit produces practically no distortion.

Zur Niederfrequenzverstärkung mit Drosselspulenkopplung (Low frequency amplification with choking-coil coupling).—H. Kafka. (*Zeitschr. f. Hochf. Tech.*, March, 1928, V. 31, pp. 87–90.)

A low-frequency amplifier due to E. E. Hiler, using two choking-coils and one condenser for the coupling of each step, is here dealt with. The relation of this coupling-method to the frequency is investigated. This dependence on frequency can be controlled within wide limits by variations of the inductance of the coils, so that practically uniform amplification can be obtained over a wide frequency-range. On the other hand it is possible to favour one chosen frequency-zone.

The adaptability of the method of coupling is strongly praised by the writer in comparison with transformer or resistance-couplings, which in their frequency-dependence show a rigidly un-uniform behaviour.

Applications Nouvelles des Lampes à Quatre Électrodes (New applications for four-electrode valves).—Decaux. (*Bulletin de la Soc. Franc. des Elec.*, February, 1928, V. 7, pp. 126–130.)

An article based on the work done during the past two years, in the Army radio-research laboratories, on double-grid valves. The Society's bronze medal was awarded to M. Decaux for his work on this subject. There are four subdivisions: (1) dealing with the use of the interior grid to allow a reduction of plate-voltage (with the advantage, *inter alia*, of small batteries: useful not only for portable or military receivers, but also for multi-stage H.F. amplifiers—since it facilitates the screening of each stage by allowing the inclusion of the battery), leading to experiments where the plate-voltage is supplied by the signals themselves. When a double-grid valve oscillates the power set free is very weak, so that parts of the apparatus can be brought nearer to each other without causing interference from the radiation from autodynes, etc. A new two-grid valve for low-frequency power-amplifiers has recently appeared which shows interesting properties. (2) Multiple-function valves: by using the interior grid as a second plate, double amplification (high and low frequency) is attained. A circuit is shown which gives particular stability. The principal use of the second grid is, perhaps, for the production of two different frequencies in the same valve, *e.g.*, for modulating. It also serves to provide, in an autodyne detector, a supplementary reaction free from loss of efficiency due to de-tuning. A four-valve h.f. amplifier for frames, very satisfactory for sensitivity and syntony, has been made on these lines for waves from 3,000 to 20,000 m. (3) Circuits for reaction by resistance or impedance coupling, made possible by the fact that the characteristic of the interior grid is in the reverse sense to that of the plate. Van der Pol and others have pointed out how these circuits can be used for the production of oscillations of "relaxation," *i.e.*, the periodic discharge of a condenser through a resistance, analogous to the results produced by neon tubes and multivibrators. The author has first employed them in connection with a cathode-ray oscillograph. Higher frequencies, with much lower voltages, are obtained than with neon tubes. The circuits have also been useful as a source of harmonics of known and constant frequency, useful for the precise measurement of wavelengths. By synchronising the circuit by a source of a sub-multiple frequency, a time-divider controlled by an astronomical pendulum has been made.

The circuit can be adjusted so as to act as an amplifier-relay of great sensitiveness (Siemens and Halske patent). By another modification, a notable anti-atmospheric effect by limitation is obtained.

(4) Future work outlined: in particular, a receiver with reaction for very short waves, in which tuning is practically independent of reaction; and a multi-stage receiver for waves of moderate length.

Determination of the Voltage-Amplification-Coeffient of H.F. Amplifiers with Resistances.—Witorsky and Konaschinisky (*Vestnik Elektrotech., Moscow*, February, 1928, pp. 77–80.)

The measuring is done by a thermionic-voltmeter connected not in the anode circuit (as is usual) but in the grid-circuit: greater accuracy is thus claimed.

Kettenleiter, (1) Drossel-und Kondensatorketten. (2) Siebketten. (Wave-filters, (1) Choking-coil-and condenser filters. (2) Wave-band filters).—H. Bock. (*Radio f. Alle*, April, 1928, pp. 157–162; May, 1928, pp. 196–200.)

and

Uber das Verhalten Symmetrischer, Verlustfreier Kettenleiter zwischen Ohmschen Widerständen (The behaviour of symmetrical, loss-free Wave-filters between ohmic Resistances).—R. Feldtkeller. (*Elek. Nachr. Tech.*, April, 1928, V. 5, pp. 145–159.)

Both these papers treat the subject mathematically.

TRANSMISSION.

PRODUCTION OF INTENSE EXTRA-SHORT ELECTROMAGNETIC WAVES BY "SPLIT-ANODE MAGNETRON."—K. Okabe. (*Journ. Inst. E.E. Japan*, March, 1928, pp. 284-290.)

Undamped waves from 20—30 cms. in wavelength are produced in a vacuum-tube containing a straight filament and a cylindrical anode split into two or more segments by narrow splits parallel to its axis; each segment having a separate lead-out which joins the others at a desired spot outside the tube. At this spot the anode-leads are brought near the cathode-lead, the distance being adjustable and having an effect of tuning. The anode segments and their separate leads form a resonant circuit. The tube is placed in a magnetic field which must be stronger than the "critical voltage" of the magnetron. An anode voltage of 320-950 volts is employed.

50 WATT AUS 220 VOLT! EIN EINFACHER UND LEISTUNGSFÄHIGER KURZWELLENSENDER (A simple and efficient short-wave transmitter). —W. Nestel. (*Radio f. Alle*, April, 1928, pp. 190-192.)

A description of a small 6-valve transmitter using the Meissner circuit.

TRANSMITTING AERIALS FOR BEAM STATIONS.—S. I. Turlyghin. (*Vestnik Elektrotech*, Moscow, Feb., 1928, pp. 69-77.)

A mathematical treatment of the subject.

RECEPTION.

UN SUPER-VALISE (A Super-" suit-case "-receiver). —G. Chaillon. (*Q.S.T. Francais*, April, 1928, No. 49, pp. 51-52.)

A description, with blue print, of a six-valve portable receiver using one double-grid valve.

NEW APPARATUS.—(*Electrician*, May 11, 1928, V.100, p. 539.)

A paragraph dealing with new receivers developed by the Marconi Company, including a number for naval and military use. By means of a new H.F. amplifier system it has been possible to produce a receiver operating over the large wave-range 300-22,000 metres.

A NEW METHOD OF PUSH-PULL (Advantages to be gained by Employing Tapped Loud-speaker Windings).—L. E. T. Branch. (*Wireless World*, 23 May, 1928, V.22, pp. 547-550.)

EINDVERSTERKERPROBLEMEN (Problems of the final stage of amplification).—B. D. H. Tellagen. (*Tijdschr. v.h.Ned. Rad.*, April 1928, V.3, pp. 141-160.)

The action of the loud-speaker valve is considered as regards quality, amplification, quantity and economy. Quality and amplification demand a valve whose internal resistance is high in comparison with the impedance of the loud-speaker. This can be reconciled with large quantity by putting a positive screen-grid between control-grid and plate. To prevent secondary emission a third grid between screen-grid and plate is necessary which can be connected directly to the filament.

CASCADE H.F. AMPLIFIERS (A Super-sensitive Receiver " by instalments.")—H. F. Smith. (*Wireless World*, 9 May, 1928, V.22, pp. 484-488.)

Description of a receiver in which each valve with its associated apparatus forms a separate screened unit.

AMPLIFICATION AND HIGH QUALITY (Permissible Gain per Stage for Good Reproduction).—N. W. McLachlan. (*Wireless World*, 2 May, 1928, pp. 463-466.)

EIN NETZANSCHLUSSEMPFÄNGER FÜR 220-VOLT GLEICHSTROM (A " mains-fed " receiver for 220 volts D.C. supply).—A. Leunig. (*Radio f. Alle*, May, 1928, pp. 209-213.)

A description of a 3-valve receiver completely supplied by the D.C. mains.

DIE ANWENDUNG DER RAHMENANTENNE (The use of frame-aerials).—E. Schwandt. (*Radio f Alle*, May, 1928, pp. 224-227.)

Right and wrong methods for the use of frame aerials with various types of receiver.

WERT UND WIRKSAMKEIT DES TONVEREDLERS (The value and efficiency of the " tone-improver ".)—E. Schwandt, with reply by H. Kröncke. (*Radio f. Alle*, May, 1928, pp. 204-206.)

A discussion on the desirability of the use of a " tone-improver "—an external filter-circuit between receiver and loud-speaker. Dr. Kröncke's view is that such a device is useful only for poor receivers and poor loud-speakers.

WEITERES ÜBER DIE SCHIRMGITTERRÖHRE (More about the Screened-grid Valve).—H. Kröncke.

and

EIN EMPFÄNGER MIT SCHIRMGITTERRÖHRE (A receiver with screened-grid valve).—O. A. Klotz. (*Radio f. Alle*, May, 1928, pp. 213-215.)

Short articles on the subjects indicated. The first writer refers to the work of J. Harmon, recently published in the *Wireless World*, and mentions that with the Marconi Company's valve an amplification of 80 times can be obtained without oscillation. The valve specified in the second article is the Philips " Miniwatt."

DIE VERWENDUNG VON WECHSELSTROMRÖHREN (The use of alternating current valves).—R. Wigand. (*Radio f. Alle*, May, 1928, pp. 206-208).

The use of special short-filamented valves directly heated by A.C. is satisfactory for near reception, but when much use of reaction is made for distant reception, indirect heating of the audion-valve by an auxiliary filament is advisable.

EIN FÜNFRÖHREN - INTERFLEX - EMPFÄNGER MIT ABSTIMMBARER ABSCHIRMUNG (A 5-valve-interflex-receiver with adjustable screening).—H. Günther. (*Radio f. Alle*, April, 1928, pp. 170-175.)

EIN REISE-EMPFÄNGER MIT EINER VIERFACHRÖHRE (A portable receiver with one four-anode valve).—N. Werner. (*Radio f. Alle*, May, 1928, pp. 194-195.)

EIN EINFACHER KURZWELLEN-EMPFÄNGER MIT ZWEIFACHRÖHRE (A simple short-wave receiver with double-anode valve).—W. Nestel. (*Radio f. Alle*, May, 1928, pp. 222-223.)

These three articles deal with special receivers. The four-anode valve used in the second receiver is so connected as to be equivalent to an audion plus three stages of low-frequency amplification.

DER BETRIEB EINES HOCHLEISTUNGS-TROPADYNEMPFÄNGERS (The working of a high-efficiency Tropadyne receiver).—E. Schwandt. (*Radio f. Alle*, April, 1928, pp. 149-157.)

An improved heterodyne receiver with filter and balanced-out first valve (differential neutrodon).

EUROPA-EMPFANG IM LAUTSPRECHER MIT 2 BIS 3 RÖHREN (Reception of European stations on loud-speaker with 2 to 3 valves).—C. Riedel. (*Radio f. Alle*, April, 1928, pp. 147-149.)

The writer considers that in the average broadcast receiver too many valves are employed, and bearing in mind that such a receiver only reaches as far as its first valve can reach, and that two stages of L.F. amplification is enough for ordinary purposes, he bases his 2-3-valve receiver on (*a*) freeing the signals from interference in the most efficient circuit possible before they reach the first valve, and (*b*) working this valve in the most efficient way.

L'AMPLIFICATION À HAUTE FRÉQUENCE PAR TRANSFORMATEUR À SECONDAIRE ACCORDÉ (High-frequency amplification by transformer with tuned secondary).—G. H. d'Ailly. (*Q.S.T. Francais*, May, 1928, pp. 30-33.)

The conditions for maximum efficiency are treated mathematically.

HARMONIQUES ET SUPER-RÉACTION.—L. La Porte. (*Q.S.T. Francais*, May, 1928, pp. 34-38.)

The use of the advantages of super-regeneration without prejudicing the reproduction of essential quality or "timbre."

VALVE CRYSTAL RECEIVER: A NON-RADIATING SUPER-SENSITIVE ONE-VALVE LOUD-SPEAKER SET.—P. W. Willans. (*Wireless World*, 23rd May, 1928, V.22, pp. 553-556, and 30th May, pp. 573-577.)

VALVES AND THERMIONICS.

DIE STROMVERTEILUNG IN DREIELEKTRODENRÖHREN UND IHRE BEDEUTUNG FÜR DIE MESSUNG DE VOLTASPANNUNGEN (Current-distribution in three-electrode Valves and its importance for the measurement of Contact-potentials).—H. Lange. (*Zeitschr. f. Hochf. Tech.*, April, 1928, V. 31, pp. 105-109.)

The first instalment of a series whose scope is indicated by a table of contents comprising about twenty headings. The present paper deals with six :—

A. Theory of Current Distribution.

B. Experimental checking and discussion of Sources of Error. (1) The electric and magnetic field of the heating-current; (2) Space charges; (3) Secondary radiation, true reflection and back-diffusion; (4) Initial velocity distribution; (5) Contact-potentials.

It is concluded that the discrepancies between the theory and the experimental results cannot be explained by these five sources of error. A further source is suggested, namely, the thickness of the grid, any variation of which has an extreme influence on the current-distribution. The grounds for this become obvious when one considers the electron-paths. These therefore are dealt with in the next article.

ÜBER DEN EINFLUSS HOHER OHMSCHER ANODENWIDERSTÄNDE AUF DEN GITTERWIDERSTAND VON VERSTÄRKERRÖHREN (The influence of high ohmic Anode-resistances on the Grid-resistance of Amplifier-valves).—E. Döring. (*Zeitschr. f. Hochf. Tech.*, April, 1928, V. 31, pp. 116-120.)

A description of experimental work which resulted in agreement with Barkhausen's estimate. The high ohmic resistances work as if the vacuum of the valve were improved. For certain special purposes, where very high grid-resistance is desired, the use of valves with not very good vacuum is indicated, together with high anode resistances.

ELECTRON EMISSION IN INTENSE ELECTRIC FIELDS.—R. H. Fowler and L. Nordheim. (*Proc. Royal Society*, May, 1928, No. A.781, pp. 173-181.)

Experimental data, on the phenomenon of the extraction of electrons from cold metals by intense electric fields, have been much improved recently by Millikan and his associates Eyring and Lauritsen. They seem to have established quite definitely the laws of dependence of the emission on the field strength F, showing that a plot of log I, where I is the current, against $1/F$ yields a good straight line whenever the experimental conditions are sufficiently stable. At ordinary temperatures these currents are completely independent of the temperature, but as the higher temperatures, at which ordinary thermionic emission begins, are approached, the strong field emission does become sensitive to temperature, and finally blends into the thermionic. On the strength of these facts they suggest that perhaps there may exist a general formula for the current

$$I = A\ (T + cF)^2 e^{-b/(T + cF)},$$

valid over wide ranges of T and F. The writers of the present paper, however, extend the results of Nordheim to include the effect of an external field, using the same methods and the same underlying picture of the metal (Sommerfeld's). They fail to find any theoretical justification for the above formula, though some justification may exist (it is true, of course, for large T and small F and for small T and large F; but for intermediate strengths it does not appear to have been tested quantitatively and awaits experimental and theoretical investigation). But they show that Sommerfeld's picture of a metal yields the formula both for strong fields and for thermionic emission, and that a single set of free or conduction electrons distributed according to the Fermi-Dirac statistics suffices for both purposes. They therefore strongly deprecate another deduction of Millikan and Lauritsen, namely, that a distinction should be drawn between the electrons which can function as thermions and the ordinary conduction electrons which yield the emission at great field strengths and are absolutely independent of the temperature.

On the Cause of the Loss of Thermionic Activity of Thoriated Tungsten Filaments under certain Voltage Conditions.—A. C. Davies and R. N. Moss. (*Phil. Mag.*, May, 1928, V. 5, No. 31, pp. 989-1010.)

This work was carried out as part of the programme of the Radio Research Board. The writers sum up their results by stating that there does not appear to be any necessity for attributing any appreciable part of the observed de-activation to any factor other than bombardment of the filament by positive ions, which originate in their turn from the electron bombardment of the grid and plate.

Space-charge Effects.—E. W. B. Gill. (*Phil. Mag.*, May, 1928, V. 5, No. 31, pp. 859-865.)

The writer refers to his former experiments with a gas-free three-electrode valve, in which the current from the filament to the plate was investigated, the plate being kept at a few volts, and the grid at from 20 to 30 volts, positive to the filament. It was found that the space-charge between grid and plate had a considerable effect on the electric field in that region, and when the current was sufficiently increased discontinuous changes took place in the field. The theory which was given has recently been extended by Tonks.

The present investigation comprises a further extension of the experiments to the case in which the plate is a little negative to the filament.

Results were obtained which could only result from disturbances of the field, proving that the emission from a filament, though very steady, is not steady enough to prevent such changes.

Über die Gleichzeitige Erregung Zweier Schwingungen in einer Dreielektrodenröhre (The Simultaneous Excitation of Two Oscillations in One Three-electrode Valve).—Hans Mögel. (*Zeitschr. f. Hochf. Tech.*, Feb., 1928, V. 31, pp. 33-39; March, 1928, V. 31, pp. 72-84 and plates.)

The normal overtones existing in a valve simultaneously with the fundamental oscillation, and due substantially to the departure of the anode-current from the sinusoidal form, are neglected in this paper, which deals with the simultaneous existence of two oscillations whose frequencies are entirely independent of each other.

In the first part is considered an oscillation of frequency f_2 which can be formed in the presence of a back-coupled oscillation f_1, but is itself not produced by back-coupling.

In the second part the author deals with the simultaneous production of two back-coupled stable oscillations, and discusses some practical applications of his results in connection both with transmission and reception. He concludes that the deliberate excitation of two simultaneous oscillations in a single valve is not likely to have much practical value even in multiple-tone telegraphy or for test-room purposes; two valves being more practicable than one valve plus the filter circuits which would be necessary.

He then considers the use of the second oscillation as a modulator of the first, and refers to the self-excited "tone-sender" of Mauz and Zenneck; deals with the case of stray oscillations, such as endanger the life of large valves; Armstrong's "super-regenerative" circuit; and the reflex-connections of tropadyne receivers.

The papers are profusely illustrated.

A propos de la Recherche de la Démodulation Parfaite (The search after perfect demodulation).—G. E. Petit. (*Rev. Gén. de l'Electricité*, 7th April, 1928, V. 23, pp. 607-608.)

The author briefly recalls the principle of demodulation and the ideal conditions for the functioning of a detector for electric waves. In practice, these conditions are not as a rule realised, from the fact that the acute angle of the characteristic is replaced by a parabolic arc more or less bent. The author shows that this bend is entirely due to the fall of heating voltage along the filament constituting the cathode. It disappears or, at any rate, is much reduced, by the use of equipotential cathodes. Great progress has recently been made on these lines by decreasing the heating voltage from 4 volts to 0.5 volt and by the use of oxide-coated filaments in parallel.

Détermination de la Condition d'Entretien et de la Période d'Oscillation d'un Oscillateur à Triode (Determination of the condition for the maintenance of oscillation and of the period of the oscillation, in a three-electrode valve oscillator). — L. Abélès. (*Rev. Gén. de l'E.*, 21st April, 1928, V. 23, pp. 696-701.)

The work of Blondel and Lavandry and of Gutton is mentioned, the method of the latter being considered too complex in the case of valves characterised by a differential equation of more than the second order. The author's method is more simple in its application to such problems. It shows that the resolution of the equations which determine the conditions for the maintenance of oscillations can be brought down to the study of a quadripole constituted by the impedances of the grid and plate circuits and by the couplings between these circuits. The method is therefore elementary and the resolutions are done by means of determinants. The author applies it to nine types of oscillators corresponding to more or less complex systems of linking between the electrodes.

ÜBER DIE KOMPENSATION DER SCHÄDLICHEN KAPAZITÄTEN UND IHRER RÜCKWIRKUNGEN BEI ELEKTRONENRÖHREN (The compensation for undesired capacities and their effects in valves). — V. Ardenne and W. Stoff. (*Zeitschr. f. Hochf. Tech.*, April, 1928, V. 31, pp. 122-128.)

The first part of a long paper which brings together under mathematical treatment the various methods of other workers. This first part comprises —A. Introduction, showing the bad influence of these capacity effects in cascade amplifiers ; B. The nature of the effects ; C. Their compensation : (1) valve-circuits with sharply tuned couplings : (*a*) abolition of tendency to oscillate, by complete neutralisation (circuits of Loftin and Young White, Hazeltine, Barber and others) ; (*b*) neutralisation arrangements with regeneration (Leithäuser, Scott-Taggart, Reinartz and others) ; and (*c*) combination methods.

SUR UN NOUVEAU MODE D'ENTRETIEN D'OSCILLATIONS DANS LES LAMPES TRIODES (A new manner of producing oscillations in three-electrode valves).—E. Pierret. (*Comptes Rendus*, 7th May, 1928, V. 186, pp. 1284-1286.)

The author obtains waves of 14 to 18 cm. length, very stable, and of an intensity at least equal to that obtained by Barkhausen at 45 to 50 cm. He states that the latter worker only obtained stable waves down to about 30 cm., and that the two methods are very different ; *e.g.*, the author's method, using two valves, is such that the electrons from the filament never reach the plate, whereas the Barkhausen oscillations are only produced if the electrons reach the plate. The author suggests that the oscillations obtained irregularly by Scheibe were of the same nature as (though longer than) the ones now obtained in a stable form.

DIRECTIONAL WIRELESS.

DIRECTIONAL WIRELESS AND MARINE NAVIGATION : THE ROTATING-LOOP BEACON.—R. L. Smith-Rose. (*Nature*, 12th May, 1928, V. 121, p. 745.)

The rotating beacon system of directional wireless transmission has been developed to a high degree in Great Britain by the Royal Air Force, as providing a method of navigating aircraft without necessity of carrying additional and elaborate apparatus in the machine itself. In a previous latter to *Nature* the writer mentioned that the application of the method to marine navigation was under investigation. In his present letter he states that the results of these experiments show that the method will prove of great importance in the future application of directional wireless to marine working, gives a description of the method, and summarises the main results arrived at.

Among these might be mentioned that bearings by the beacon system at distances over 60 miles oversea are subject to night effects similar to those experienced in wireless direction-finding. He sums up thus : "From a scientific point of view, it thus appears that while there is little to choose in direction-finding between the rotating-loop transmitter and the rotating-loop receiver, the former may have a slight advantage for navigation purposes. It must remain for the mariner himself to become familiar with the operation and performance of each system and to determine the sphere of their application as scientific aids to modern navigation."

CONSTRUCTION RAPIDE, SUR LA CARTE, DES LIGNES DE RELÈVEMENTS CONSTANTS POUR UTILISER LES RELÈVEMENTS RADIOGONIOMÉTRIQUES PRIS DU BORD (Quick construction on the chart of "lines of constant bearing," to utilise the D.F. bearings taken on board ship).—D. Gernez. (*Comptes Rendus*, 7th May, 1928, V. 186, pp. 127-1280.)

Direction-finding bearings on a land-station taken on board ship cannot be transferred directly to the chart, being great circle arcs. By drawing, however, on the chart the "lines of constant bearing" (*i.e.*, the loci of the positions at which the bearing of the station is n°) the D.F. bearings can be used directly. The method of plotting these "lines of constant bearing" is described.

MEASUREMENTS AND STANDARDS.

VERFAHREN ZUR ERMITTLUNG DER WIRKSAMEN HÖHE VON ANTENNEN UND DES EMPFANGS WERTES EINER ANLAGE UNTER MITBENUTZUNG DES BIOT-SAVARTSCHEN FELDES IN UNMITTELBARER ANTENNENNÄHE (A method of ascertaining the effective height of Aerials and the receptive value of an installation by the aid of the Biot-Savart Field in the immediate neighbourhood of the aerial).—Max Dieckmann. (*Zeitschr. f. Hochf. Tech.*, March, 1928, V. 31, pp. 65-72.)

This method, particularly for receiving aerials, is based on the comparison between the field strength produced at the receiving points by the distant transmitter, and the Biot-Savart Field caused by the current in the receiving aerial.

The comparison is accomplished by means of a frame receiver, which is oriented, first, so that it receives only from the distant sender ; and, secondly, so that it is excited only by the aerial under examination.

INTERNATIONAL COMPARISON OF RADIO-FREQUENCY STANDARDS : TESTING AND ADJUSTING PIEZO OSCILLATORS.—(*Bureau of Standards, Technical News Bulletin*, February, 1928, No. 130, pp. 13-15.)

The increase in power of many United States and foreign radio stations, making them international in their effects, raised the question as to whether or not the national standards of radio-frequency of the various governments are in agreement. Since 1924 the bureau has made several comparisons of frequency standards with the national laboratories of other countries. These showed satisfactory agreement to the accuracy then required. During the past year, however, it became important to know such agreement much more accurately, and the development of the temperature-controlled Piezo oscillator offered a means of doing this. As a result, the bureau found the average departures from the mean to be 3 parts in 100,000, the countries being the U.S.A., England, France, Italy, and Germany. The bureau considers this agreement to be surprisingly good, representing, as it does, an average difference of only 0.03 kilocycle at 1,000 kilocycles (300 metres), which is much smaller, for instance, than the variation 0.5 kilocycle allowed to broadcasting stations in the U.S.A. The second article deals with the use of Piezo oscillators, particularly by broadcast stations in America, to enable them to comply with the regulations as to a 0.5 kilocycle variation. It mentions the publication by the bureau of specifications for a portable Piezo oscillator for this purpose, and the "rush" which the bureau has experienced for its services in testing and adjusting oscillators destined for this use.

EVALUATION OF THE CAPACITY OF FLAT CONDENSERS IN THE CASE OF UNPARALLEL PLATES.—Florensky and Popoff. (*Vestnik Elecktrotech, Moscow*, Feb. 1928, pp. 41-45.)

The authors derive formulæ for the above calculations for plates of various shapes.

LEISTUNGS- UND STRAHLUNGS-MESSUNGEN AN FLUGZEUG- UND BODENSTATIONEN (Power- and radiation-measurements in aeroplane- and land-stations).—Eisner, Fassbender and Kurlbaum. (*Zeitschr. f. Hochf. Tech.*, April, 1928, V. 31, pp. 109-116.)

The first part of a long paper on work undertaken to bring clarity on the power and radiation of aeroplane aerials. The work showed that existing publications gave unsatisfactory information on the same questions as regards land-stations, so that it had to be extended to these. The present instalment deals with I. Power-measurements on aerials. (1) Theoretical basis for power measurements by the means of added resistances and use of high frequency; (2) Description of the methods employed in the present experiments; (3) Experimental results in power-measurement on Aeroplane- and Land-stations.

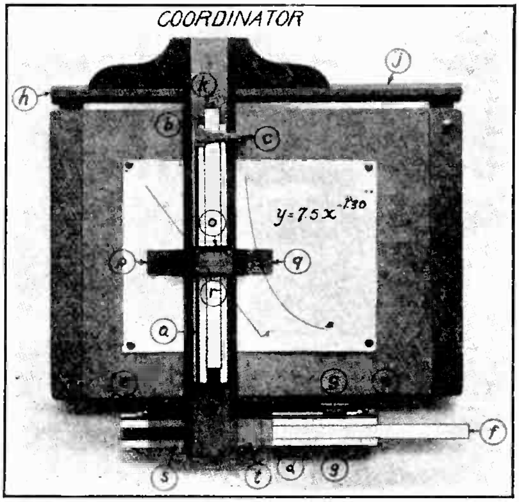
EINE NEUE METHODE ZUR EXPERIMENTELLEN AUFNAHME DER RICHTKENNLINIE EINER ANTENNE (A new method for the experimental plotting of the directional-characteristic-curve of an aerial).—F. A. Fischer. (*Zeitschr. f. Hochf. Tech.*, April, 1928, V. 31, pp. 121-122.)

Previous methods involved either touring round the aerial with a transmitter and measuring the received energy, or exciting the aerial and exploring round it with a receiver which measured the radiated energy. Both methods involved the intensity of the radiated energy, and both therefore were liable to errors due to absorption in the surrounding (and not uniform) earth. The present method is free from this defect as it does not involve the intensity. A tour is made round the aerial with a transmitter, and near the aerial a directional-receiver is employed to measure the apparent deflections of the waves from the transmitter, due to the re-radiated field from the aerial.

SUBSIDIARY APPARATUS AND MATERIALS.

AN IMPROVED CO-ORDINATOR.—R. A. Castleman, Jnr. (*Journ. Opt. Soc. America*, April, 1928, V. 16, pp. 287-292.)

A plotting and computing device, assembled from a T-square, a drawing-board, two slide-rules and certain machined accessories. It is adapted for use as a log, semi-log and uniform co-ordinator,



and among other things is particularly adapted to the *complete* treatment of equations of the form

$$y = x \cdot u^n,\ y = b \cdot 10^{mx},$$
$$y = b_1 e^{m_1 x},\ y = c \cdot \sin^n x, \text{ etc., etc.}$$

A NEW TYPE OF SELENIUM CELL.—R. E. Martin. (*Journ. Opt. Soc. America*, April, 1928, V. 16, pp. 279-281.)

A cell of high sensitivity in which the conducting part is cylindrical, this shape offering certain advantages, *e.g.*, the current density at any point is easy to calculate for D.C. and A.C.; the electrodes can be changed easily; the electrodes can be kept in the dark while the central parts of the selenium are exposed. Resistance was of the order of 5×10^5 ohms in the dark, and light sensitivity was from 40 per cent. to 75 per cent. The process of annealing is described.

AN OPTICAL METHOD OF MEASURING SMALL VIBRATIONS.—H. A. Thomas and G. W. Warren. (*Phil. Mag.*, May, 1928, V. 5, No. 32, pp. 1125-1130.)

An interferometer method of measuring small mechanical vibrations, such as those encountered in telephone diaphragms and structures, is described.

DAS OSZILLOSKOP (The Oscilloscope).—Bedell and Reich. (*E.T.Z.*, 3rd May, 1928, V. 49, p. 689.)

Disadvantages of the Cathode-ray Oscillograph include: (1) the non-linearity of the time-axis, and (2) the impossibility of superimposing several curves, as can be done with multi-looped oscillographs. The methods here described avoid both of these disadvantages, the first by the use of a rotating commutator, and the second by an application of the fact that a condenser uniformly charged through a resistance shows an increasing voltage linear with the time.

REDRESSEUR "OXYMÉTAL" POUR COURANT ALTERNATIF, À RONDELLES DE CUIVRE OXYDÉ ("Oxymetal" Rectifier, for alternating current, comprising washers of oxidised copper).—C. Chouquet. (*Génie Civil*, 14th April, 1928, V. 92, pp. 364-365.)

A description of a rectifier involving neither liquids nor moving parts, and suitable either for charging accumulators or—in certain cases—for dispensing with the use of these by supplying current direct to apparatus requiring continuous current. The rectifier is composed of a number of copper washers, each oxidised on one face, separated by washers of soft metal, such as lead, and clamped firmly together. Cooling fins of copper are provided. The rectifying action is due to the considerable difference between the resistance opposed to the passage of the current in the direction copper-oxide and that in the direction oxide-copper. After the passage of the current no change, chemical or physical, can be noticed.

Explanations of the phenomenon are discussed.

SUR L'ADAPTATION DES OSCILLOGRAPHES BIFILAIRES À L'ÉTUDE DES LAMPES TRIODES (The adaptation of bifilar Oscillographs to the study of three-electrode valves).—André Blondel. (*Comptes Rendus*, 16th April, 1928, V. 186, pp. 1034-1036.)

The bifilar oscillograph of 1893 was improved to meet the demands of greater sensitiveness and higher frequency by various changes in design, but even so it was not satisfactory for the study of three-electrode valves. To this fact the writer attributes the increasing use of what he calls "telephonic oscillographs," *i.e.*, instruments based on the construction of certain refined forms of telephone such as those of Brown or Baldwin.

He considers the use of these as a retrograde step, liable to introduce errors caused by their high self-induction and also by their methods of damping; and recommends a return to the bifilar oscillograph, which can be rendered satisfactory for valve-work by the use of a suitable transformer (somewhat like those used in the low-frequency stages of a valve-amplifier) transforming down to a bifilar loop of low resistance (.5 to 1 ohm).

A NEW QUICK-TUNING VIBRATION GALVANOMETER WITH CALIBRATED TUNING.—D. C. Gall. (*Journ. of Scientific Instruments*, April, 1928, V. 5, pp. 134-135.)

An illustrated description of a modified form of a standard moving-coil vibration galvanometer intended for use in the duplexing of submarine cables, where it is desirable to tune immediately to a required frequency without any process of tuning by trial. The tuning is carried out by the simultaneous adjustment of the position of the bridge pieces, between which the suspended coil vibrates, and the tension of the suspension strip itself; a large milled disc being turned until the desired frequency is opposite the index. Three different suspension pieces cover the total range of 3 to 300 cycles.

L'ALIMENTATION DES POSTES RÉCEPTEURS (The supply of electricity to receiving sets).—J. Granier. (*Q.S.T. Français*, April, 1928, No. 49, pp. 46-50.)

A short practical article dealing with the charging of accumulators from D.C. mains; from A.C. mains by means of various forms of rectifiers—vibrating, rotating, electrolytic and thermionic; the abolition of accumulators and high tension batteries by the use of mains both for filament and plate ("when extreme sensitiveness is not required, *i.e.*, for local or powerful stations"); precautions and refinements necessary.

SUR L'EFFET DE SOUPAPE PRÉSENTÉ PAR LES ÉLECTRODES EN SILICIUM (Rectifying effect of silicon electrodes).—M. Aubert. (*Recherches et Inventions*, March, 1928, quoted in *Rev. Gen. de l'Elec.*, 12th May, 1928, V. 23, p. 824.)

Deals with a rectifier using an electrode of silicon (or derivative) associated with one of iron, platinum, carbon or lead, in an acid or basic electrolyte. Practical advantages over other electrolytic rectifiers are said to be (1) no forming-current needed; (2) the electrolyte can rise nearly to boiling point without seriously upsetting the working; (3) the silicon electrode is not attacked either in working or in rest; (4) rectification is excellent and the efficiency can, under certain conditions, reach the theoretical maximum.

PROTECTION OF . . . . . LINES AGAINST OVER-VOLTAGE.—E. Beck. (*Journ. A.I.E.E.*, May, 1928, V. 47, pp. 332-336.)

At the end of this article is described a special protection to relieve lightning voltages. The breakdown voltage is 350 to 500 v., and the protector will handle many times discharges of 50 ampères of two seconds duration. It will take care of heavier discharges up to hundreds of ampères, but at a sacrifice of length of life. The gap is enclosed in argon at reduced pressure.

SAFEGUARDING BATTERIES AND VALVES: HOW TO USE PROTECTIVE FUSES. (*Wireless World*, 23rd May, 1928, V. 22, p. 551.)

BRIDGE FOR MEASURING SMALL TIME INTERVALS.—J. Herman. (*Bell Tech. Journal*, April, 1928, V. 7, pp. 343-349.)

In the form described, this method is applied to measuring the time elapsing between the opening or closing of one set of contacts and the opening or closing of another set. Intervals from about 1/10,000th sec. to several seconds can be measured with fair accuracy, and can be read off directly. The method depends on the charging of a condenser through a resistance.

EIN EMPFINDLICHES RÖHRENVOLTMETER FÜR HOCHFREQUENZ (A sensitive Valve-voltmeter for High Frequency).—M. von Ardenne. (*E.T.Z.*, 12th April, 1928, V. 49, pp. 565-567.)

This instrument has a capacity of only 7.4 cms. and can be used to measure peak-voltages down to 0.03 v. or with anode-current compensation down to 0.003 v.

EIN WECHSELSTROM-NETZANSCHLUSSGERÄT ZUR GLEICHZEITIGEN ENTNAHME DER HEIZ UND DER ANODENSPANNUNG (An arrangement for obtaining heating- and Anode-voltage simultaneously from the public A.C. supply). —J. Schad. (*Radio f. Alle*, April, 1928, pp. 162-165.)

A description, with diagrams, of a method using a glow-discharge rectifier valve (Raytheon valve), a two-anode valve working at 250 v. and giving 350 milliampères.

DIE TROCKENPLATTEN-GLEICHRICHTER (The dry-plate rectifiers).—H. Fröhlich. (*Radio f. Alle*, April, 1928, pp. 165-170.)

A survey of the various dry-plate rectifiers recently developed, *e.g.*, the copper-oxide, vanadium-pentoxide-wolfram, and other combinations.

DU FONCTIONNEMENT ET DE L'ENTRETIEN DES ACCUMULATEURS (The Working and Maintenance of Accumulators).—M. Devauchelle. (*Q.S.T. Français*, May, 1928, pp. 20-29.)

A practical article, the last part of which deals with the various forms of rectifier for charging from A.C. mains.

L'ACCUMULATEUR LÉGER (The Light-weight Accumulator).—J. Granier. (*Q.S.T. Français*, May, 1928, pp. 12-14.)

Discussing the light-weight " Almeida " accumulator using a carbon positive electrode, a zinc negative, and an electrolyte of chloride or bromide of zinc. The writer considers that this accumulator cannot at present compete with the lead type, but that it is capable of improvement.

L'ALIMENTATION DES POSTES DE T.S.F. (The supply of electricity to Radio-stations).—P. Olinet. (*Q.S.T. Français*, April, 1928, No. 49, pp. 37-45.)

A previous article (*Q.S.T. Franc.*, No. 48) dealt with rectifiers: the present deals with the question of the filtering necessary to make the rectified current suitable from the point of view of quality. The question is studied in considerable detail by means of curves and simple mathematics.

CONSTANT SPEED MECHANISM FOR AN ACCURACY OF 1 IN 10,000. (*See* Miscellaneous, " Picture Reception.")

STATIONS, DESIGN AND OPERATION.

LA RADIOTÉLÉPHONIE PAR ONDES COURTES PROJETÉES: LES PREMIÈRES COMMUNICATIONS ENTRE PARIS ET ALGER (Radiotelephony by short-wave beam: the first communications between Paris and Algiers).—R. Nöel. (*Génie Civil*, 21st April, 1928, V. 92, pp. 373-379.)

The work of the Administration of Posts and Telegraphs, in collaboration with the French radio electric industry, in linking-up the French and North-African telephone systems, has shown that a public radio-telephone system no longer presents technical difficulties. Last March, one-way communication was established from Paris to Algiers, and only the absence of a transmitting plant at Algiers prevented normal two-way communication.

The writer first mentions the esential differences between radio-broadcast (already arrived at a remarkable degree of perfection) and radio-telephony proper, of which only one example in regular service exists (England—United States, with extensions to Cuba and Canada, France and Belgium). Unlike radio-broadcast, radio-telephony should provide communication similar to that of the ordinary telephone, independent of hours or seasons, across seas and frontiers, with enough secrecy for commercial use, by the employment of the same instruments and with the same reliability as in the case of a good telephone system. It has, therefore, two problems: the satisfactory linking-up of the telephone subscribers to the transmitting and receiving stations and the establishment of a permanent and reliable radio-electric liaison.

After dealing briefly with the first problem, and mentioning in passing one of the various methods of obtaining the requisite secrecy (transposing the frequency of modulation at its entry to the modulating organs of the transmitter), the writer criticises the England-America system of long-wave transmission on the grounds of interference by atmospherics and of high cost, and points to short-wave beam telephony as the only real solution, economically providing, as it does, a reserve strength of signal for passing out to the landlines, even under the worst conditions of propagation.

After detailing various advantages of short waves, he outlines the method (due to Franklin) adopted by the Marconi Company for realising beam transmission. This also he criticises as only partially effective, complicated and costly, and claims considerable advantages for the aerial-system Chireix-Mesny (used in the Paris-Algiers tests) adopted by the Société française Radio-électrique. He deals at some length with the theory and practice of this aerial system, aided by pictures and diagrams, including one diagram of the energy radiated from a single-bay C.M. aerial. He passes on to the consideration of the transmitting plant (where the wave-frequency is stabilised by piezo-electric means) and of the receiving plant, where the stability of reception is assured by the total absence of reaction, by a great reserve of amplification, and by an automatic "fading-compensator."

DER NEUE DEUTSCHLAND-SENDER BEI KÖNIGSWUSTERHAUSEN (The new "Germany transmitter at . . . .).—W. Kummerer. (*E.T.Z.*, 17th May, 1928, pp. 741–745.)

A description, with illustrations, connection diagrams, modulation curve, etc., of the transmitter put in commission at the end of 1927. Power in aerial is 30 kW. at rest (corresponding to 75 kW. rating for broadcasting stations), six times as great as the former set. For telegraphy the aerial power is 120 kW.

TRANSATLANTIC TELEPHONY—THE TECHNICAL PROBLEM.—O. B. Blackwell. (*Bell Tech. Journ.*, April, 1928, V. 7, pp. 168–186.)

The paper read as a preface to the Joint Meeting (by wireless telephone) of the English and American I.E.E. It describes in a non-technical way the engineering problems involved in developing the transatlantic radio trunk by means of which the American telephone system of some 18,000,000 telephones can communicate with the English system of about 1,500,000 telephones, and also with the systems of other European countries. Among the many interesting points may be mentioned the following. Two plots, on a logarithmic scale, one of the radio spectrum and the other of general frequencies ranging from Donati's comet (period 2,000 years) to cosmic rays (Millikan) of frequency about 10^{22}; on the radio spectrum, one frequency near the lower end and one near the upper end appear to be most suitable for transoceanic transmission (about 60,000 and 10,000,000 to 20,000,000 frequencies). Photographs of transmitting and receiving aerials for the long-wave transmission, and also for the short-wave system held in reserve (at present only eastwards) as an emergency routing and used in the summer of 1927 during the severe static season. Refinements in transmission methods for greater economy in power: single side-band carrier-suppression method, double frequency transformation. Long-wave curve and corresponding short-wave curve of received field strength showing variations over 24 hours; the advantage in employing a number of separate wave-lengths for choice at any time. Great circle routes for long and short-wave circuits; reception from a northerly direction, static coming chiefly from the opposite direction. Location and directional characteristics of the receiving aerials equivalent to a transmitted power increase of 5,000 times. Linking to the land-systems; dangers of echo and building-up of oscillation; voice-actuated relays. For American-Europe communication, long-waves cannot (so far as can be seen) be replaced by short. Privacy: new method probably in experimental use shortly.

THE DESIGN AND DISTRIBUTION OF WIRELESS BROADCASTING STATIONS FOR A NATIONAL SERVICE.—P. P. Eckersley. (*Journal of I.E.E.*, May, 1928, V. 66, pp. 501–528.)

This gives the paper read before the Wireless Section on 1st February, 1928, and the subsequent discussion. In his summary, the author says that his paper attempts to be comprehensive and therefore cannot in a manageable length fail to be more qualitative than quantitative. The comprehensiveness is indeed best indicated by giving the sub-headings and an occasional extension, thus: Part I. (1) Historical (in Britain); (2) Service Area (division into four areas, from "wipe-out area" where field strength is > 30 millivolts per metre, to "C" area in which it is > 2.5; nature of service in each area); prediction of Service Area, depending on wave-lengths, type of ground, design of transmitting aerial; use of medium waves (800–600 k cycles); advantages and disadvantages of long waves (200 k cycles). This portion includes curves showing alteration of field strengths with distance, for various powers. (3) Limitation of wave-lengths; required separation of fundamental frequencies; theoretical considerations; the "Plan de Genève." (4) Provision of Alternative Programmes. (5) Linking together of Stations (*a*) in same country, (*b*) from country to country; short waves most likely to provide the required link? fading; equalising intensity of received signals; spaced aerials? reflectors? (6) Single wave-length working—same programme on same wave-length from two or many stations; synchronisation by master-drive; not yet satisfactory. (7) Distribution of Stations for a National Scheme. Part II. (1) Design of Transmitters; types; choke-modulation, high-power and low-power modulation systems; comparison between these two systems; Valve point discharge; anode power supply from economic view point. (2) Conclusion. The illustrations include circuit diagram of 5 GB, illustrating the general principle of low-power modulation with subsequent amplification at high frequencies.

WIRELESS MASTS AND SCREENING. (1. The Aerial Support and its Effect on Signal Strength; and 2. Some Considerations in Erecting a Broadcast Receiving Aerial).—R. L. Smith-Rose. (*Wireless World*, 2nd May and 9th May, 1928, V. 22, pp. 460–462 and 497–498.)

DIE STÖRBEFREIUNG IN DER DRAHTLOSEN TELEGRAPHIE NACH DEM VERFAHREN "BAUDOT-VERDAN" (The prevention of interference in Wireless Telegraphy by the "Baudot-Verdan" system).—(*E.T.Z.*, 19th April, 1928, V. 49, pp. 623–625.)

A description of the system already used in France with success, based on the repetition of each letter of each word either once or twice, the repetitions not following directly on the first sending of the letter but being separated by (*e.g.*) four other letters. It has been calculated that for a given number of short interferences, which would on the ordinary Baudot system spoil every fourth word, the Verdan modification with one repetition would lose one word in 272 or with double repetition only one word in 5,820.

GENERAL PHYSICAL ARTICLES.

A Suggested Arrangement for the Determination of the Velocity of Light.—N. Deisch. (*Journ. Opt. Soc. America*, April, 1928, V., 16, pp. 272-275.)

A method using, as modulator, electro-optic cells supplied with H.F. oscillating potential. The pulsating beam can have its frequency rigorously controlled by a calibrated piezo-electric resonator. Thus the limitations inherent in the use of mechanical devices such as a rotating multi-sectored disc or multi-faced mirror are avoided, and, moreover, very much higher frequencies can be used than with mechanical modulation methods.

The Shadowgraph Method as Applied to a Study of the Electric Spark.—H. A. Zinszer. (*Phil. Mag.*, May,1 928, V. 5, No. 32, pp. 1098-1103.)

The apparatus and methods described are essentially the same as that devised by Foley and Souder for photographing sound-waves.

Un Nouveau Phénomène d'Optique (A new phenomenon in Optics).—J. Cabannes. *Comptes Rendus*, 30th April, 1928, V. 186, pp. 1201-1202.)

Raman has just discovered that the spectrum of the light diffused by a perfectly pure liquid contains not only the incident radiations, but also new radiations whose place in the spectrum depends jointly on the incident light and on the chemical constitution of the liquid. These new radiations are much less intense than those diffused without change of wavelength, but they are distinguished from ordinary fluorescence by their strong polarisation. Raman, to explain this remarkable phenomenon, considers it an effect analogous to the Compton effect. The writer, however, sees in it the phenomenon of "optical beats" (entirely analogous to the ordinary acoustic beats) which he predicted in 1924, but looked for in vain in gases. The derivation of these beats is shown mathematically.

Polarisation Rotatoire—Calcul du pouvoir rotatoire du quartz (Rotatory Polarisation —Calculation of the rotating power of quartz).—de Mallemann. (*Comptes Rendus*, 16th April, 1928, V. 186, pp. 1046-1048.)

A previous paper outlined a theory on the electrical properties of quartz considered as an effect of orientation of the polar anisotropic molecules, and this is a further development based on the experimental results of Ny Tsé Zé.

Les idées nouvelles sur la structure de l'éther (The new ideas on the structure of the ether).—G. Giorgi. (*Rev. Gen. de l'Elec.*, 14th April, 1928, V. 23, pp. 643-653.)

Professor Giorgi shows the evolution of ideas from Newton, Huygens and Descartes through the epoch of the first discussions on the drift of the ether and the theories of Cauchy, Stokes and Fresnel. He reviews the hypotheses of Maxwell and Lorenz, and then deals with the origins of the Relativity theories, formulating the conceptions of the ether led to by these theories. He shows how the Quanta theory can be reconciled with the conception of the ether and how this last view imposes itself on the new undulatory physics of de Broglie and Schrödinger. He ends with an exposition of his personal views.

A bibliography of 49 references is appended, ranging from Newton to Einstein, Millikan, de Broglie and Schrödinger.

Au sujet de la relativité et de Lorentz (Concerning Relativity and Lorentz).—Général Cartier. *Q.S.T. Français*, April, 1928, No. 49, pp. 2-4.)

An instalment of a series of articles by this writer under the heading "Radiotelephony and the phenomena of propagation." In the present article he defends himself against a number of correspondents who attack his anti-Einstein views. One correspondent, assuming that the author could only have read bad translations of Einstein's work, recommended him to read one translated into French by Mlle. Rouvière, entitled "The Theory of Relativity restrained and generalised." The author did as he was told, and strongly commends the book to those who wish to know, without formulæ, the essential ideas of Einstein. He then proceeds to contest point after point in it.

The High-frequency Electric Discharge at Low Pressures.—J. Taylor and W. Taylor. (*Proc. Cambridge Phil. Soc.*, April, 1928, V. 24, pp. 259-267.)

A paper dealing with further studies of electrical discharges through gases under the influence of H.F. oscillations of the order of 10^7 cycles per sec. Even at the highest degree of exhaustion, faintly luminous discharges could be obtained. The absence of luminosity and the difficulty of maintaining uni-directional or low-frequency discharges at very low pressures may arise from (1) the infrequency of collisions between gas atoms or molecules and electrons, preventing cumulative ionisation by collision; (2) the loss of electrical charges to the metal electrodes, and (3) the separation of the positives and negatives under the influence of the field.

In the high-frequency discharge, those inherent difficulties may be overcome. Experiments were made regarding the condensation of the luminosity along the tube and round corners: the electrical effects due to the wall were studied, also the effect of adding an extra quota of electrons, the effects of magnetic fields, and spectra observations.

Remarques sur la Théorie de la Lumière, Énergie, Cohérence et Franges Supplementaires (Remarks on the theory of Light, Energy, coherence and supplementary fringes).—F. Wolfers. (*Comptes Rendus*, 30th April, 1928, V.186, pp. 1198-1201.)

The writer concludes that in the phenomenon of supplementary fringes an effect is met with, for the first time, which it is impossible to explain by an undulatory theory only or by a "quanta theory" only. A more general theory, at present non-existing, is necessary.

UNTERSUCHUNG UND THEORIE DER PYROELEKTRIZITÄT (Investigation and theory of Pyroelectricity).—Meissner and Bechmann. (*Zeitschr. f. Tech. Phys.*, May, 1928, pp. 175-186.)

Quantitative experiments on the pyroelectric behaviour of tourmaline and of quartz are described, and an interpretation of pyroelectricity is deduced from the structure of the latter. According to these views, it is unnecessary to assume a distinction between true and false pyroelectricity—*i.e.*, to assume that heat first produces special mechanical tensions and deformations, which by way of piezoelectrical action produces pyroelectricity. This view is supported by experiments on piezoelectric crystals in powder-form, which show pyroelectric effects as great as or greater than those shown by plates of the same material. The paper ends with full calculations of the pyroelectric constants, which agree satisfactorily with experimental results.

QUELQUES DIFFICULTÉS EXPÉRIMENTALES DE LA THÉORIE ÉLECTROMAGNÉTIQUE DU RAYONNEMENT DE LA LUMIÈRE (Some experimental difficulties in connection with the electromagnetic theory of Light).—A. H. Compton. (*Journ. Franklin Inst.*, February, 1928, pp. 155-178.)

The writer concludes that there is no doubt that radiations are constituted of separate quanta of energy—*i.e.*, of photons, and that the energy and the quantity of movement conserve themselves in the course of mutual actions between these photons and the electrons or atoms. This does not mean, however, that there is no truth in the wave theory, but that energy is not transmitted by the waves. The difficult problem to solve is whether the waves serve as a guide to the photons, or if there is some other relation, at present unknown, between them.

DISAPPEARANCE AND REVERSAL OF THE KERR EFFECT.—C. V. Raman and S. C. Sirkar. (*Nature*, 19th May, 1928, V. 121, p. 794.)

The writers announce that a beautiful confirmation of recent theories of the electric birefringence in liquids (Raman and Krishnan, *Phil. Mag.*, April, 1927) is furnished by observations of the phenomenon in electric fields oscillating with radio-frequency. Observations with octyl alcohol show that the Kerr Effect disappears at a frequency corresponding to 32 metres and re-appears at still shorter wavelengths, exactly as could be prophesied from the theories mentioned.

THE ELECTRODELESS DISCHARGE THROUGH GASES.—J. J. Thomson. (*Proc. Phys. Soc.*, April, 1928, V. 40, pp. 79-89.)

The discharge is first defined, as a ring discharge in gas at low pressure, in which the currents form closed circuits; the method of production is given, and the theory of the discharge mathematically worked out (showing a certain analogy to the spark discharge). The author mentions that when large discharges of this kind pass through a gas, a state of the medium is obtained similar to that of the Heaviside layer. The electrodeless discharge is a convenient method for investigating experimentally the properties of such a medium; examples of such treatment are given: thus in one experiment, the number of electrons are found to be comparable with the number of molecules in the same volume. The effect of light on the discharge (due to the absorption of ultra-violet light) is studied: the effect of impurities in the gas: and finally, the effect of the discharge on chemical combination.

MISCELLANEOUS.

DIE ARBEITEN DES AUSSCHUSSES FÜR SCHALTSBILDER DES VERBANDES DEUTSCHER ELEKTROTECHNIKER (The work of the Committee for Circuit- and Wiring-diagrams of the V.D.E.).—W. Heym. (*E.T.Z.*, 10th May, 1928, V. 49, pp. 715-722.)

This article illustrates fully the standard signs and symbols (ranging from the sign for a continuous current to that for "a power-meter for three-phase current unequally loaded with current- and voltage-transformer") arrived at by the above Committee. It also compares these standards with the work of the International Electrotechnical Commission, indicating certain differences and the reasons for them.

DRAHTLOSE RANGIERBEFEHLSÜBERMITTLUNG (Wireless shunting-control at goods stations).—K. Steinner. (*E.T.Z.*, 10th May, 1928, V. 49, pp. 722-723.)

Shunting at large goods stations is usually regulated by visual signalling, which in adverse weather conditions is unreliable and has often led to accidents. The paper outlines the wireless system already installed at a few stations in Germany.

THE (ELECTRICAL) INDUSTRY AS RELATED TO BROADCASTING AND THE GRAMOPHONE.—F. C. Topham. (*Electrician*, 11th May, 1928, V. 100, pp. 517-518.)

Among other interesting points, the author remarks that if an examination is made of the various pieces of "mains apparatus" (*i.e.*, subsidiary apparatus, for connection to the mains, for use in broadcasting reception) one is struck by the absence of "electrical design"—except in certain well-known products. Fuses are seldom provided, terminals are often close together, poorly insulated and inadequately protected against short-circuit. In the case of A.C., high secondary voltages may be employed without adequate safeguards.

ÜBER EINE METHODE ZUR ERGEUGUNG VON SEHR KURZEN ELEKTRISCHEN WELLEN MITTELS HOCHFREQUENZFUNKEN (A method of generating very short electric waves by high-frequency spark).—E. Busse. (*Zeitschr. f. Hochf. Tech.*, April, 1928, V. 31, pp. 97-105.)

Wavelengths of the order of 30 cms. are useful in the investigation of a number of problems in theoretical and applied physics, and also lend themselves to concentration by lenses and mirrors for medical purposes. The production by valve methods presenting difficulties, other methods are being sought. The method here described uses a variation of the quenched-spark system, the primary H.F. current being supplied by a ½ kW. valve working on 960 metres. The quenched gap is included in a closed shock-circuit to which a dipole oscillator is coupled. At least 50 watts of energy can be radiated at wavelengths of the order of 30 cms.

LES ONDES COURTES ET LES TRAVERSÉES TRANSATLANTIQUES (Short Waves and Transatlantic Flights).—*Q.S.T. Français*, April, 1928, No. 49, pp. 53-56.)

A review of the radio equipment or lack of equipment of the various machines hitherto involved in these flights, and what happened to each. The writer concludes that radio-equipment was generally provided, but in the wrong form for the purpose. He advocates the use of short waves as the only ones serviceable.

LES ONDES COURTES ET LA TÉLÉGRAPHIE SANS FIL SOUTERRAIN (Short Waves and subterranean Telegraphy).—J. M. Sacazes. (*Q.S.T. Français*, April, 1928, No. 49, pp. 57-59).

A note on the work of J. H. Rogers on buried aerials ("Undergrounds,") using powers from 5 to 1,500 watts and wavelengths between 100 and 200 metres, with the object of obtaining greater range with relatively feeble powers and without fluctuations in reception by day or night.

MARINE ET T.S.F. (The Navies and "Wireless.")—Major X. (*Q.S.T. Français*, April, 1928, No. 49, pp. 32-36.)

The principal contents are :—

Wireless and the British Navy : the use of short waves : the British Admiralty and the Washington Conference : short-wave communication between Admiralty and Hong Kong, etc. during the China troubles : typhoon-warnings by short waves in the China seas : iceberg-warnings by radio.

RADIODIFFUSION (Radio-broadcasting).—E. Girardeau. (*Q.S.T. Français*, April, 1928, No. 49, pp. 11-15.)

A manifesto by the president of the French Syndicate of Radio-electrical Industries, against the absorption of broadcasting by the State. Broadcasting should be watched over by the State just as traffic in the streets is watched over by policemen—to prevent confusion and accident. Otherwise it should be free. The State should possess its own broadcasting stations for its own purposes.

LES GRANDES HEURES DE LA T.S.F. (The great hours of "Wireless.")—Major X——. (*Q.S.T. Français*, April, 1928, No. 49, pp. 24-26).

The first part deals with interception of messages during the War, and cites as a fresh example of the "treason" of wireless the victories of Ludendorff on the eastern front, which he attributes to the interception of Russian army wireless. The second part deals with the service of wireless to humanity in the saving of life.

LES ONDES ULTRASONORES (Sound waves of ultra-audible frequency).—P. Langevin. (*Rev. Gén. de l'Elec.*, 7th April, 1928, V. 23, pp. 626-634.)

A long extract from a paper read in Paris in March, 1928. In this paper M. Langevin first defined the waves in question and pointed out the properties which give them a superiority, for certain applications, over ordinary sound waves : especially their directivity (both in transmission and in reception)—particularly useful for marine sounding, submarine detection and ship-to-ship and ship-to-shore communication. Various suggested and attempted methods of production are touched on, notably those of Richardson (who, following the "Titanic" disaster, advocated the use of these waves to detect icebergs and proposed to use aquatic organ pipes) and of Sir C. Parsons. The true solution of the problem appears to lie in the use of the piezo-electrical phenomenon to convert the easily obtained electrical oscillations of the desired frequencies into mechanical energy in the form of pressure-waves. Already, frequencies up to 160,000 p.s. have been obtained up to 1 kW., and an installation is now in preparation which will develop a power of several kilowatts. The paper goes into the application of piezo-electricity to the transmission and reception of ultra-audible waves, and then deals with certain applications, namely, marine sounding, the determination by ships of an obstacle by the method of echo : the guiding of ships in fog, and submarine communication telegraphic and even telephonic. Finally, the author refers briefly to certain applications in physiology (in regard to the destructive effect on bacteria) and in physics (as a tool for the investigation of the constitution of matter).

TÉLÉGRAPHIE OPTIQUE À ÉCOULEMENT RAPIDE DES SIGNAUX (Light-ray Telegraphy, high-speed).—F. Fournier. (*Bulletin d.L. Soc. Franc. des Elec.*, Feb., 1928, V. 7, pp. 131-135.)

A description of the author's work in evolving a simple apparatus to obtain speeds equal to those of radio-telegraphy, for day or night use, which will neither interfere with nor be interfered by other means of communication (telegraphy or telephony with or without wires). Rapid Morse signalling is produced by the two line-screens or grids, one fixed and the other vibrating, through which the light-ray has to pass. Reception is normally by telephones, a special form of selenium cell being the detector.

APPAREILS POUR LA REMISE À L'HEURE AUTOMATIQUE DES PENDULES PAR T.S.F. (Clock-setting, etc., by wireless).—M. Lavet. (*Bulletin d.L. Soc. Franc. des Elec.*, Feb., 1928, V. 7, pp. 162-177.)

The writer mentions that electric clocks can be made very cheaply which possess such accuracy that they require setting only once every six months in order to keep within one minute of exact time ; these would seem to remove the need for automatic radio-telegraphic adjustment involving perhaps a special 4-valve receiver and its adjuncts. He goes on to mention, however, cases where the need still exists, and, further, he extends the use of the apparatus described to the radio-control of vehicles, ships, aeroplanes, etc., and for distress signals and explosion of mines. The scheme depends on the combination of a microphone-relay and a pendulum or balance-wheel-relay actuated by rhythmical signals. (c.f. *Wireless World*, June, 1914).

DIE NEUESTEN FORTSCHRITTE DES BILDTELEGRAPHIE-SYSTEMS TELEFUNKEN-KAROLUS-SIEMENS (The latest progress of the Picture-telegraphy - system Telefunken - Karolus-Siemens).—F. Schröter. (*Telefunken-Zeitung*, Jan., 1928, No. 48-49, pp. 5-10.)

The writer begins by stating that Facsimile Telegraphy, once it reaches the word-capacity of high-speed telegraphy, is superior to Morse or "impulse" telegraphy by its avoidance of errors such as those liable to occur in tape-punching or at the receiving end. The system Telefunken-Karolus-Siemens has demonstrated its practicability in distance tests from Nauen to Ostia and Rio de Janeiro, on waves 25 m. to 60 m. Even on longer waves (800 m. between Berlin and Leipzig and 1,250 m. between Berlin and Vienna) rates between 200 and 500 w.p.m. were reached. Similar speeds were attained over open lines. On cables, the simplicity and mechanical robustness of the Karolus light relays and the abolition of relays with moving parts was found to be of especial advantage. The Telefunken photo-electric cell at the transmitter has been brought practically to perfection. Specimens of handwriting and of pictures sent by the system are included, and various details of the system are given.

THE DISTURBANCE OF RADIOCOMMUNICATION BY TRAMWAYS AND ITS REMEDIES. Clausing and Muller. (*Elektrotech. Zeitschr.*, 21st February, 1928, V. 49, pp. 178–180.)

Interference caused by sparks between collector and line can make themselves felt at a distance of 4 km. The paper recalls previous remedial work in Germany and describes the most recent researches. The use of a material which gives an arc and not a spark even at the lowest voltages met with, for the current-collector, is recommended. Carbon is indicated as the suitable material.

ENKELE PHYSISCHE BESCHOUWINGEN OVER ULTRA-KORTE GOLVEN, MEDE IN VERBAND MET DE UITZENDINGEN VAN HET PHILIPS' RADIO-LABORATORIUM (Some physical considerations on ultra-short waves based on transmissions from the Philips' Radio Laboratory). —B. Van der Pol. (*Tijdschr. v. h. Ned. Rad.*, April, 1928, V. 3, pp. 161–184.)

The author deals with the history of ultra-short wave development, and passes on to a consideration of various points inherent in the use of these waves: *e.g.*, skin effect and the need for maintaining constancy of wave length (by piezo-electric or other methods). The propagation of the waves is then considered, and the work of Breit and Tuve in Washington ("echo" effect), Appleton and others is referred to. The waves in question are of the order 12 to 30 metres. The author mentions that an example of the other kind of "echo" effect (dependent not on the difference in paths of the direct and reflected rays, but on the circumnavigation of the earth) was produced when a metronome beating seconds was placed before the microphone of the Philips' Laboratory transmitter, and the receiving station heard not merely double but treble beats, showing a double circling of the earth.

AIR SERVICE AND AMATEUR CO-OPERATION (The American Coast-to-Coast Air Route Described.)—H. de A. Donisthorpe. (*Wireless World*, 9th May, 1928, V. 22, pp. 491–492.)

JOINT MEETING OF THE INSTITUTION OF ELECTRICAL ENGINEERS AND THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—(*Bell Tech. Journ.*, April, 1928, V. 7, pp. 161–167.)

A verbatim report of the joint meeting of these two Institutes, by transatlantic wireless telephone, on February 16th, 1928—the first of its kind.

THE USE OF A MOVING BEAM OF LIGHT TO SCAN A SCENE FOR TELEVISION.—F. Gray. (*Journ. Opt. Soc. Amer.*, March, 1928, V. 16, pp. 177–190.)

A description of this portion of the system of television developed recently by the Bell Telephone Laboratories. The paper, however, begins by a brief survey of the former systems (in which what is "scanned" is an image of the subject formed by a lens) and of the Bell System (in which the subject itself is scanned by a moving beam) and compares the two systems: the latter presenting two very large gains in the amount of light that can be collected to produce photo-electric currents—the transient nature of the illumination permits it to be very intense without causing inconvenience to the subject, and the optical efficiency of the system is not limited by the aperture of a lens, but can be increased by using large photo-electric cells and more than one in parallel.

LES STATIONS DE SIGNAUX HORAIRES. (Time-Signal Stations.)—De la Forge. (*Q. S. T. Français*, May, 1928, V. 50, pp. 5–11.)

The present instalment deals very fully with the twelve European stations and their various methods. A complete table is given.

DYNAMO UNIPOLAIRE POIRSON.—(*Rev. Gen. de l'Elec.*, 28th April, 1928, V. 23, p. 730.)

The French National Office for Scientific and Industrial Research includes, among the various inventions in which it is interested, the construction of a large unipolar dynamo (for D.C. without commutator) to give 10,000 ampères at 10 volts.

LES REPRODUCTEURS ÉLECTRIQUES DE PHONOGRAPHIE (Electric "Pick-Ups" for gramophones, etc.).—A. Cremailh. (*Q.S.T. Français*, May, 1928, pp. 48–56.)

Among other interesting points in this article may be mentioned an outline of an electrical process for record-making depending on an oscillograph-record combined with pantograph-magnification; a suggestion that electric reproducers cause less wear on the record because less work has to be done by the disc; and a suggestion that an electro-static pick-up (in which the part moving with the needle forms one plate of a condenser) can eliminate needle-scratching noises more than the usual electromagnetic pick-up.

Esperanto Section.

Abstracts of the Technical Articles in Our Last Issue.

Esperanto-Sekcio.

Resumoj de la Teknikaj Artikoloj en Nia Lasta Numero.

PROPRECOJ DE CIRKVITOJ.

La Ekvivalenta Indukteco kaj Kapacito de Anteno.

Redakcia artikolo diskutanta esprimojn por la indukteco kaj kapacito de anteno. Oni aludas al esprimoj por ĉitiuj kvantoj donitaj en la " Jarlibro de Senfadena Telegrafio " 1917a kaj al esprimoj donitaj en lastatempa verko " Senfadenaj Principoj kaj Praktikado " de D-ro. L. S. Palmer.

La esprimoj estas derivitaj el unuaj principoj kaj la kialo estas montrita por la erara rezulto obtenita de D-ro. Palmer.

Reaktancaj kaj Admitancaj Kurvoj Aplikitaj al Agorditaj Cirkvitoj Kun Kaj Sen Rezisteco.—L. T. Bird.

En la unua parto de l'artikolo la aŭtoro diskutas la ekzemplon de cirkvitoj sen rezisteco, kaj donas kurvojn de la reaktanco kaj la admitanco de kapacito kaj indukteco. Kombinoj de indukteco kaj kapacito estas poste simile konsideritaj, kiam ĉi tiuj estas konektitaj simple serie, simple paralele, kaj ankaŭ en pli komplikitaj cirkvitoj, k.e., cirkvitoj kun branĉoj, miksitaj seriaj kaj paralelaj, k.t.p.

La dua parto de l'artikolo diskutas resonancajn cirkvitojn kun rezisteco, traktante unue pri l'ekzemplo de kurento restanta konstanta, dum la frekvenco varias, kaj poste de tensio restanta konstanta dum la frekvenco varias. La ekzemplo de rezisteco paralele kun kondensatoro estas poste konsiderita kiam la tuto de kurento kaj tensio respektive restas konstantaj.

La artikolo estas bone ilustrita per grafikaĵoj kaj vektoraj diagramoj, kaj estas finota en la venonta numero.

Pri Aroj da Paralele-aranĝitaj Valvoj Provizantaj Rezistivajn Ŝarĝojn Sen Distordo de la Onda Formo.—W. Baggally.

La aŭtoro traktas longe la kondiĉojn plenumotajn de aro da valvoj provizantaj potencon sen distordo de onda formo, ĉi tiu parto de la prelego estante pure matematika kaj ne permesante resumiĝon.

La rezonado estas poste aplikita al kelkaj praktikaj ekzemploj, kiel ekzemple, la potenco havebla ĉe iuj difinitaj konstantoj ; la valoro de ŝarĝa rezisteco por maksimuma potenco ; la nombro da valvoj bezonitaj por provizi difinitan potencon, k.t.p.

Amortizo Kaŭze de Krada Kurento Rilate al Valva Oscilatoro.—M. Reed.

La artikolo konsideras kuplitan oscilatoron kun la anoda cirkvito agordita, kaj montras la kalkuladon de l'amortizo enkondukita en la oscilan cirkviton kaŭze de krada kurento.

La rilatoj inter anoda alternkurento kaj krada tensio estas konsideritaj, kaj la efekto de krada kurento montrita grafike. La kalkulado estas poste farita pri aparta okazo, kiam la potenco absorbita en la krada cirkvito estis 0.1233 vato, ĉi tio estante la ekvivalento de efektiva rezisteco de 44 omoj enkondukita en la anodan cirkviton.

Mallongondaj Antenaj Sistemoj. Elementa Teorio pri la Sendado de Altfrekvenca Energio laŭlonge de la Alkondukiloj.—E. Green.

La aŭtoro unue konsideras la ekzemplon de ebena elektromagneta ondo en spaco inter du paralelaj kaj perfekte kondukantaj ebenoj je iu ajn distanco apartaj, kaj montras, ke la ekzemplo de senlime longa alkondukilo de nekonsiderinda rezisteco kaj elfluo donas analogajn rezultojn.

Li poste diskutas la rilatojn de kurento, tensio, kaj energio, en la onda lameno en la alkondukilo kun sinusa elektromova forto aplikita al la enmetaj bornoj, kaj kun diversaj bornaj ŝarĝoj egalaj kaj malegalaj je la ondega impedanco de l'alkondukilo. La kondiĉoj en la ŝarĝo kaj ĉe punktoj en la alkondukilo estas ekzamenitaj kaj ilustritaj per vektoraj kaj grafikaj diagramoj, kaj la efekto de mallonga cirkvito aŭ de malferma cirkvito ĉe l'elmetaj bornoj estas diskutita. Laste konsiderita estas la efekto de maldensiĝo.

RICEVADO.

Valvoj kun Skrenitaj Kradoj.

Resumo de neformala diskutado ĉe kunveno de la Senfadena Sekcio de la Institucio de Elektraj Inĝenieroj, Londono, je 2a Majo, 1928a.

La diskutado estis malfermita de S-ro. M. G. Scroggie, kiu pritraktis la evoluiĝon de la valvo kun skrenita krado, kaj ĝian aplikadon, precipe al altfrekvenca amplifado.

La diskutado estis daŭrigita de D-ro. J. Robinson, S-ro. C. F. Phillips, Leŭt.-Kol. K. Edgeworth, Kap. P. P. Eckersley, S-ro. E. H. Shaugnessy, Leŭt.-Kol. Fuller, kaj aliaj, kaj S-ro. Scroggie respondis al kelkaj el la punktoj levitaj de la aliaj parolantoj.

La Ŝajna Malmodulo de Malforta Stacio per Pliforta Stacio.—R. T. Beatty.

La aŭtoro unue konsideras la fortecon de portondo ricevita el agordita signalo dezirita kaj el nedezirita signalo malagordita ĝis, ekzemple, 50 k.c. Li konkludas, ke la elimino de ĉi tiu lasta estas kaŭze de interago inter la signaloj, kiun oni ne enkalkulas je simpla cirkvita teorio. Li poste ekzamenas la supersonajn batojn naskitajn inter la du portondoj, kaj montras, ke ili estas ankoraŭ modulitaj per la modulo de la dezirita signalo. Li plue montras, ke per perfekta detektoro, la nedezirita signalo povus esti tute malmodulita de la pliforta dezirita stacio, sed, ke per neperfekta detektoro, iometa modulado, pro la plimalforta nedezirita signalo, estus ricevita. La efektoj estas analogaj al supersona ricevado, kiam la aŭda komponero estas portita sur nova supersona portondo kaj estas izolebla nur per trapasigo tra dua detektoro.

Li konkludas, ke ĉe praktikado, la nedezirita stacio povas esti silentigita se ĝia portondo ne superas dekonon de la nedezirita stacio, laŭ mezuro ĉe la krado de l'detektora valvo.

HELPA APARATO.

PUNKTO-KUNFORĜITAJ TERMO-KUNIĜOJ.

Mallonga priskribo kun fotografaĵoj estas donita pri modelo de vakua termo-kuplilo de fero-konstantano punkto-kunforĝita al la varmiga fadenó de nikromo, plateno, aŭ konstantano.

Per ĉi tiu speco de kuniĝo estas malpli da ŝanco, ke la kuplilo enhavos malgrandan longon de l'varmiga fadeno, dum ĝi estas malpli impresebla je domaĝo pro troŝarĝado.

La kuniĝoj estas fabrikitaj de S-roj. Collier kaj Stephenson, Hornsey, Londono.

SUB-NORMA ONDÒMETRA DESEGNADO.—W. H. F. Griffiths.

Krom precizeco de normigado, la aŭtoro emfazigas la bezonon por *konservi* ĉi tiun precizecon kaj urĝas la utiligon de altaj valoroj de kapacito.

Li poste diskutas la desegnon de mallongonda ondometro, kun skalo malsupreniranta ĝis 10 metroj, kiu utiligas ne malpli ol 240 $\mu\mu$F. Precizeca variebla aerkondensatoro estas uzita kun du tre kompaktaj fiksaj aerkondensatoroj. Rigida mem-subtenanta bobeno kun unu turno de kupra tubo estas uzita kiel la induktanco malsupreniranta ĝis 16 metroj. Por utiligo malsupren ĝis 10 metroj, bobeno de noveca desegno estas uzita, konsistante el nombro da maldikfadenaj cirkvitoj konektitaj paralele per du pezaj koncentraj rondaj ĉef-fadenoj. La konstrumetodo de l'bobeno estas ilustrita.

DIVERSAĴOJ.

RESUMOJ KAJ ALUDOJ.

Kompilita de la *Radio Research Board* (Radio-Esplorada Komitato), kaj publikigita laŭ aranĝo kun la Brita Registara Fako de Scienca kaj Industria Esplorado.

GRAFIKA KALKULADO.—M. H. Ashworth.

La aŭtoro diskutas grafikajn metodojn por fari la normigadon de Moullin'a (anodkurva) voltmetro laŭ la kontinukurentaj karakterizoj de la valvo. Volto-tempaj kurvoj estas aldonitaj al la karakterizo, laj la grafika derivado de la kurento-tempaj kurvoj montritaj. Grafika metodo por trovi la areon de ĉi tiuj kurvoj estas poste klarigita, kaj oni montras, ke bona interkonsento estas obtenita kun la rezultoj, kiel mezuritaj de planimetro.

Aliaj aplikadoj de la metodo estas cititaj.

LIBRO-RECENZOJ.

Recenzoj estas donitaj de la jenaj verkoj :—

PITMAN'S TECHNICAL DICTIONARY (Teknika Vortaro) en Sep Lingvoj.

WIRELESS PRINCIPLES AND PRACTICE (Senfadenaj Principoj kaj Praktikado), de L. S. Palmer, M.Sc., Ph.D.

THE INSTRUMENT WORLD (La Instrumenta Mondo), nova ĵurnalo por desegnistoj, k.t.p.

INTERMEDIATE ELECTRICITY AND MAGNETISM (Mezgrada Elektro kaj Magnetismo), de R. A. Houston, M.A., D.Sc.

Some Recent Patents.

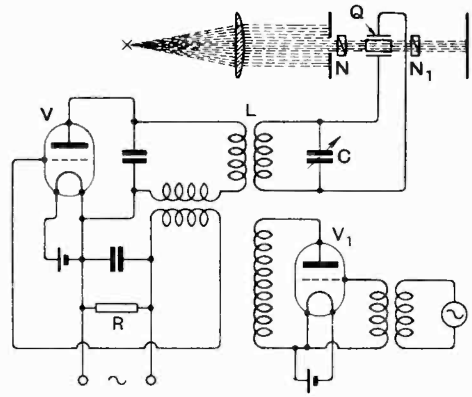
The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.

TRANSMITTING PICTURES.

(*Convention date* (*Germany*), *1st March*, 1926. *No.* 266753.)

When rays of light are passed through a doubly refracting crystal, they are subject to variations as regards the condition of polarisation and direction of propagation, so that for a given type of crystal and light employed an extinction of rays of a given wavelength may be secured. In this way the intensity or colour of light passing through the system may be controlled.

The invention consists in utilising such variations in the optical qualities of a quartz oscillator, in combination with its normal piezo-electric property of mechanical vibration at definite frequencies. As shown in the figure, a ray of light from a source *S*, the intensity of which is to be controlled, for example, by the incoming currents from a picture-transmission system, is passed through an optical system comprising crossed Nichols N, N_1 and a piezo-electric oscillator *Q* of quartz, Tourmaline, or Rochelle salt. The crystal is set into



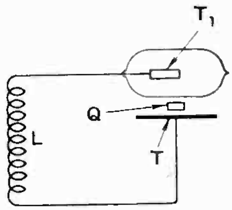
vibration at its fundamental frequency, or an harmonic thereof, by means of a tuned circuit *L*, *C*, connected across its terminals and energised by an oscillating valve *V*. The incoming signals to be converted into corresponding light-effects may be applied either across a resistance *R* in the grid circuit of the oscillator *R*, or alternatively to the grid circuit of a separate amplifier V_1.

Patent issued to The Telefunken Co.

LUMINOUS CRYSTAL OSCILLATORS.

(*Convention date* (*Germany*), *2nd September*, 1926. *No.* 277002.)

It is known that when a piezo-crystal is oscillating at a fundamental frequency, small sparks may be caused to appear on the surface of the crystal when situated in a strong magnetic field. Usually, however, the crystal breaks up when the sparks exceed a certain length, or the applied tension grows too high. The effect can be more favourably observed if the crystal is mounted inside an evacuated tube, but this method is inconvenient in practice.



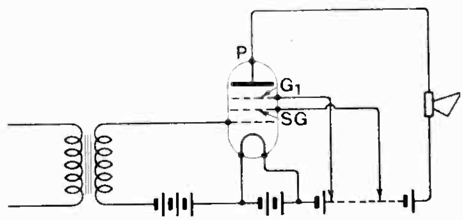
The inventor has discovered that the desired luminous effect can be obtained simply by mounting the crystal in close proximity to a tube filled with helium, neon, or argon gas. As shown in the figure, the crystal *Q* is located between an external electrode *T* and a second electrode T_1 mounted inside the tube. When a frequency to which the crystal is resonant is applied across the coil *L*, luminous effects appear. The phenomenon can be utilised either as a convenient method of determining the frequency of a crystal under test or, conversely, to measure the frequency of a given source of oscillations.

Patent issued to H. Eberhard.

SCREENED GRID AMPLIFIERS.

(*Application date*, *24th December*, 1926. *No.* 287958.)

When using a screened grid valve for power amplification, owing to the considerable fluctuations of anode potential created by large current-variations in the output circuit, it may happen that the effective voltage of the anode will drop below the normal positive bias applied to the screening grid.



In these circumstances secondary emission is liable to occur between the two electrodes in question, together with temporary reversals in the normal direction of the electron stream, both of which factors tend to diminish the overall efficiency of the valve.

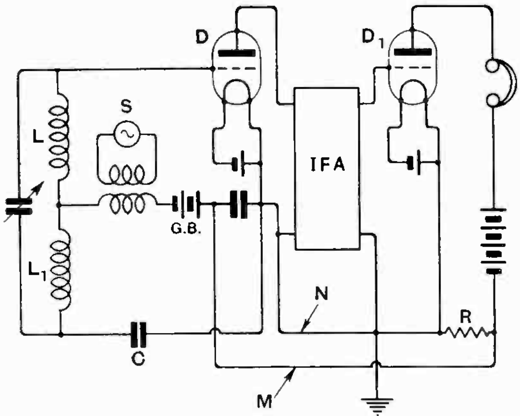
In order to overcome this tendency a second auxiliary grid G_1 is inserted, as shown, between the usual screening grid SG and the anode A, and is supplied with a biasing voltage well below that of the screening grid. Under these circumstances the instantaneous voltage of the anode can never fall materially below the level at which "reversal" tends to set it.

Patent issued to N. V. Philips Gloeilampenfabrieken.

AUTOMATIC VOLUME CONTROL.

(*Application dates, 1st and 3rd January,* 1927. *No.* 287972.)

The figure shows in schematic form a superheterodyne receiver comprising a frame aerial L, L_1, a source S of local oscillations, a first detector D, and an intermediate-frequency amplifier IFA followed by a second detector. Input signals are applied from the upper half L of the centrally-earthed frame aerial, the lower winding L_1 and condenser C functioning to stabilise the system.



A resistance R, serving to apply an automatic control of signal strength, is inserted in the output circuit of the last valve D_1, and also in the direct-current connection between the filament and grid of the first valve D, through leads M, N.

The value of resistance R and grid bias GB are adjusted so that (1) the detector D operates on the point of greatest curvature of its characteristic curve and (2) the peak voltage from the heterodyne source S will be such as to raise the operating characteristic to saturation point.

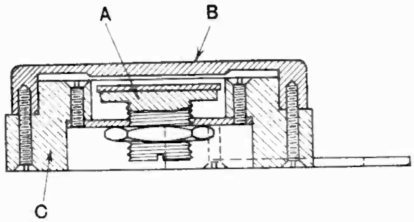
Under these circumstances a decrease in the incoming signal strength—due, for instance, to fading, lowers the plate current from the valve D_1 and hence the voltage drop across the resistance R. This in turn shifts the operating point of the first valve D to a more sensitive part of the curve, and also causes an increase in the effective heterodyne voltage, thus tending automatically to restore signal strength. Should the signal voltage increase above normal, the action of the resistance R is reversed.

Patent issued to Standard Telephones and Cables.

MOUNTING PIEZO CRYSTALS.

(*Convention date (U.S.A.), 13th September,* 1926. *No.* 277330.)

A crystal holder, specially adapted for mounting piezo oscillators, comprises an adjustable screw-controlled electrode A, protected by an outer



cup-shaped electrode B firmly screwed on to a baseplate C of suitable insulating material. The quartz or other crystal is mounted on the central electrode A.

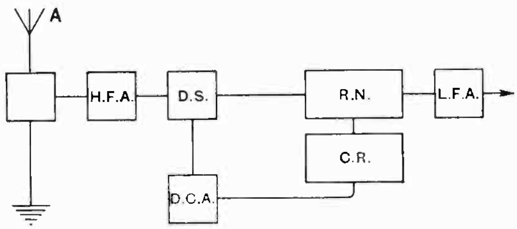
A long leakage path is maintained between the two electrodes, whilst metals having a low coefficient of expansion are used for the conducting parts. The holder protects the crystal from dust and dirt, whilst the effect of temperature variations is minimised, as far as possible, so as not appreciably to alter the electrode spacing and consequently the effective capacity value of the unit in operation.

Patent issued to Westinghouse Electric Co.

COMBINED LAND-LINE AND RADIO SYSTEMS.

(*Application date, 7th January,* 1927. *No.* 288,371.)

When wireless signals are relayed from the aerial for some distance over a land line, varying attenuation in the ether (due to fading and similar causes) is liable to give rise to considerable fluctuation in the effective strength of the signals as received at the terminal recording station. For instance, the amplitude of the low-frequency component of speech signals at the output of the first amplifier may vary between 1 and 50 milliamps,



so that the repeater valves used on the land line may be over-loaded, or other causes of distortion may arise.

In order to prevent this an automatic limiting or regulating device is inserted between the receiving aerial and the land line which operates as follows. The incoming signals are fed from the aerial A to a high-frequency amplifier HFA and then to a detector DS, where the low-frequency signal current is separated from the direct-current component. The former is passed through an attenuation network RN comprising a number of resistance units arranged in chain form, the number of units in series being controlled by means of switches actuated by means of a master relay CR.

The relay CR is controlled in turn by the direct-current component derived from the detector DS and amplified at DCA. The strength of the control current supplied to the relay CR will be proportional to the amplitude of the received carrier wave, and assuming that this bears a constant relation to the signal strength, the operation of the relay CR can readily be arranged to maintain a constant overall input to the land-line amplifier LFA, irrespective of fluctuations in the aerial voltage due to fading and similar causes.

Patent issued to G. A. Mathieu.

AUTOMATIC DIRECTION-FINDING.

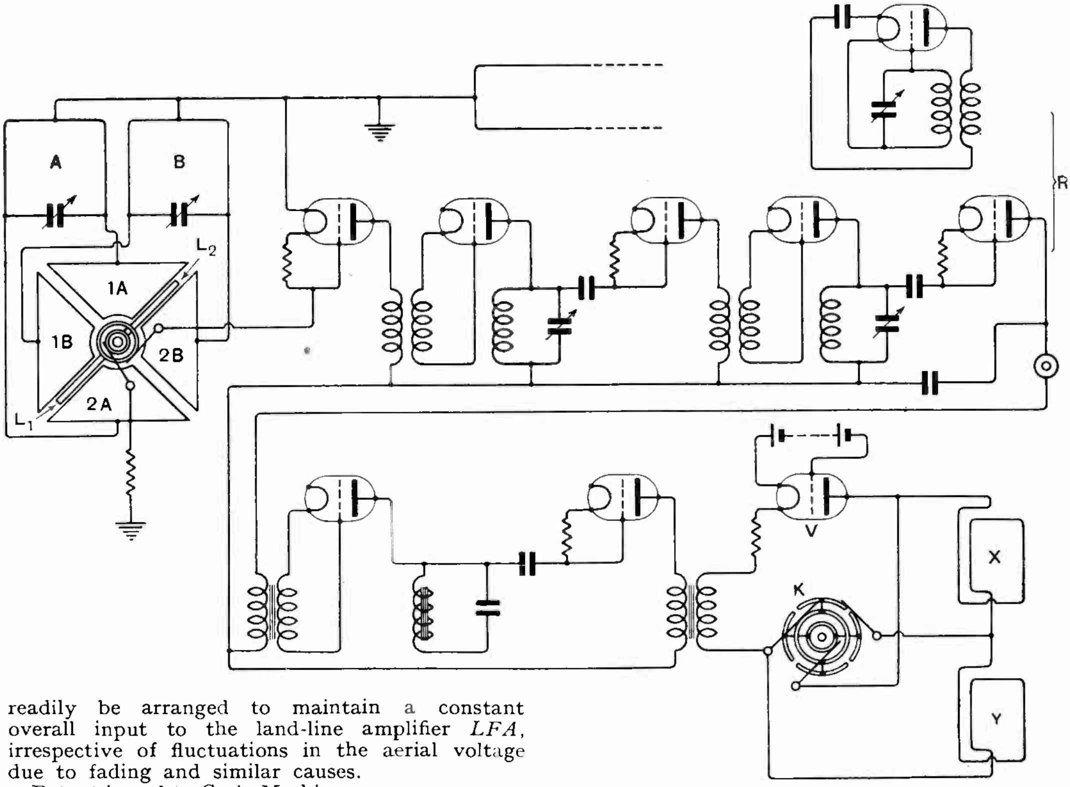
(*Application date*, 25*th January*, 1927. *No.* 286840.)

The arrangement is adapted to give an automatic indication of the direction of an incoming signal. Two frame aerials A, B are mounted at right angles to each other in the ordinary way, the output terminals being taken to opposite pairs of a series of four fixed plates marked 1A, 2A, 1B, 2B respectively. The midpoints of the aerials are earthed as shown.

Between the fixed plates are mounted two series of continuously rotating plates L_1, L_2. The plate L_1 forms a capacity coupling between the aerials A amd B and the input of a superheterodyne receiver R. The plate L_2 merely completes the symmetry of the frame circuits through a resistance R_1 to earth.

The automatic indicator consists of a moving needle (not shown) controlled by the current flowing through two coils x, y. By means of a commutator device k, which is driven from the same shaft as the rotating plates L_1, L_2, the coils X, Y are coupled intermittently to the last amplifier V of the set, and are thus fed with direct current proportional at all times to the " pick-up " of the loop aerials A, B, so that the moving needle automatically registers the direction of the received signals.

Patent issued to H. Busignies.

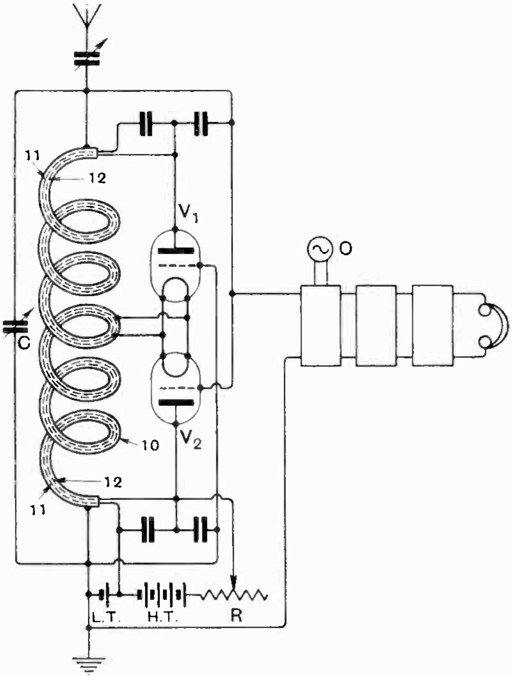


PUSH-PULL H.F. AMPLIFICATION.

(*Application date*, 10*th January*, 1927. *No.* 288,379.)

For short-wave reception, a coil 10 of copper tubing shunted by a tuning condenser C, forms the aerial inductance. The tubular coil 10 encloses insulated wires 11 and 12, the outer ends of the latter being connected to the plates of two valves V_1, V_2, through a high-tension battery HT, and a resistance R, which serves to regulate the degree of reaction.

The upper and lower ends of the coil 10 are connected to the respective grids of the valves V_1, V_2, whilst the centre point is tapped as shown to the common filament. The other side of the filament is connected to the wire 11, this and the coil 10 serving to supply filament current from the battery *LT*. The upper half of the coil 10 applies the incoming signal voltages across the grid and filament of valve V_1, whilst the valve V_2 is similarly fed from the lower half of the same coil so that the valves operate as push-pull amplifiers in a regenerative circuit of the Hartley type. The amplified signals are then combined with a local



oscillator *O* forming part of a standard super-heterodyne receiver.

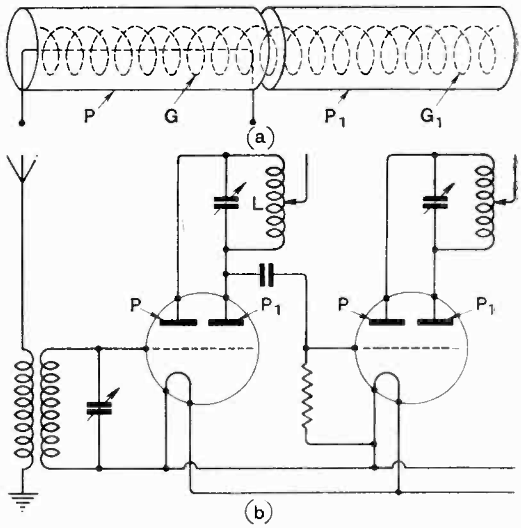
Patent issued to Standard Telephones and Cables, Ltd.

MULTI-ELECTRODE VALVES.

(*Application date*, 30*th November*, 1926. *No*.288,663.)

In order to balance-out inter-electrode capacity effects, a valve amplifier is provided with extra plate or grid elements so disposed as to lie outside the normal electron stream and to function merely as a condenser coupling between the plate and grid circuits. In the construction shown in Fig. A, the normal assembly of filament *F*, grid *G*, and cylindrical plate *P* is supplemented by a symmetrical plate P_1, placed close to but insulated from the plate *P* and surrounding an extension G_1 of the spiral grid, which lies outside the path of the electron-stream from the filament *F*.

Fig. B shows the circuit arrangement of a two-stage high-frequency amplifier using balanced valves of this type. The divided plate *P*, P_1 is shunted by a tuned circuit *LC*, the high-tension supply being tapped to the centre of the coil *L*.



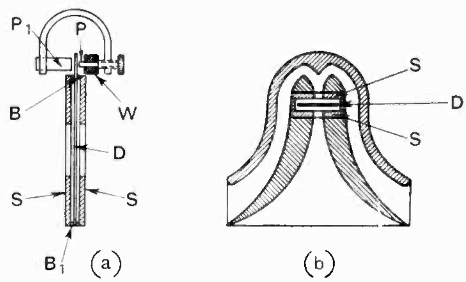
The undesired capacity-coupling existing between the "active" grid and plate *P* is now counter-balanced by the condenser of identical value formed by the symmetrical counterpart P_1, G_1.

Patent issued to J. Robinson.

LOUD-SPEAKERS.

(*Application date*, 19*th January*, 1927. *No*. 288,386.)

A band-shaped diaphragm *D*, Fig. A, is supported inside a slotted sound-box *S* by a fixed bearing at *B* and by a lower bearing B_1 arranged to permit of a slight longitudinal movement. Between these



points the diaphragm is unrestrained. A part of the diaphragm extends freely beyond the upper bearing *B* and passes between the two polepieces of the actuating electromagnet. One polepiece *P* is thinner than the other P_1 and carries the speech coil *W* as shown. The slot in the sound box *S* may be arranged inside a double-horn, as shown in Fig. B.

Patent issued to H. Sachs.