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Editorial.

Percentage Harmonic Distortion.

WE publish in this issue a letter from Mr. M. G. Scroggie in which he alleges, and seeks to prove, that the formula which is commonly used for estimating the second harmonic distortion from the characteristic curve of an output valve is wrong and gives results only half as great as his correct formula. He concludes his letter with a challenge to any protagonist of the formula in question to come forward and show him where his reasoning is incorrect. This we propose to do. It is an important point, and the error into which Mr. Scroggie has fallen is one which might easily be overlooked.

If we assume that the characteristic curve obeys a simple square law so that $I = aV^2$, and that the voltage varies sinusoidally, then

$$I = aV^2 = a(V_0 + \hat{v} \sin \omega t)^2$$
$$= a(V_0^2 + 2\hat{v}V_0 \sin \omega t + \hat{v}^2 \sin^2 \omega t)$$

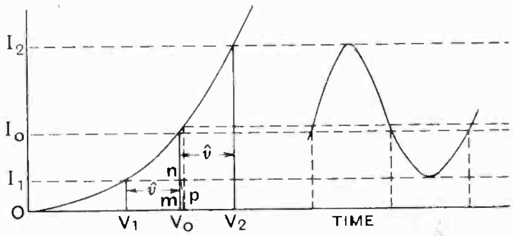
which, if we put

$$\sin^2 \omega t = \frac{1 - \cos 2\omega t}{2}$$

becomes

$$I = a\left(V_0^2 + \frac{\hat{v}^2}{2}\right) + 2a\hat{v}V_0 \sin \omega t - \frac{a\hat{v}^2}{2} \cos 2\omega t$$

The first term represents the steady component, the second term the fundamental, and the last term the second harmonic.



The important point to notice is that *the steady current upon which the fundamental and harmonic are superposed is not I_0 but* $a\left(V_0^2 + \frac{\hat{v}^2}{2}\right)$. If one makes *mn* equal to $\hat{v}/\sqrt{2}$, and with centre *o*, draws the arc *np*, then $Op = \sqrt{\left(V_0^2 + \frac{\hat{v}^2}{2}\right)}$ and the ordinate at P will give the steady component current on which the harmonics are superposed. Hence $I_2 - I_0$ is not the sum of the fundamental and second harmonic, nor is $I_0 - I_1$ their difference.

The distortion, being defined as the ratio of the amplitudes of the second harmonic and fundamental, is equal to $\frac{a\hat{v}^2}{2}\Big/2a\hat{v}V_0$ that is, to $\hat{v}/4V_0$.

Now

$$I_2 = a(V_0 + \hat{v})^2 = aV_0^2 + a\hat{v}^2 + 2a\hat{v}V_0$$

$$I_1 = a(V_0 - \hat{v})^2 = aV_0^2 + a\hat{v}^2 - 2a\hat{v}V_0$$

and $I_0 = aV_0^2$.

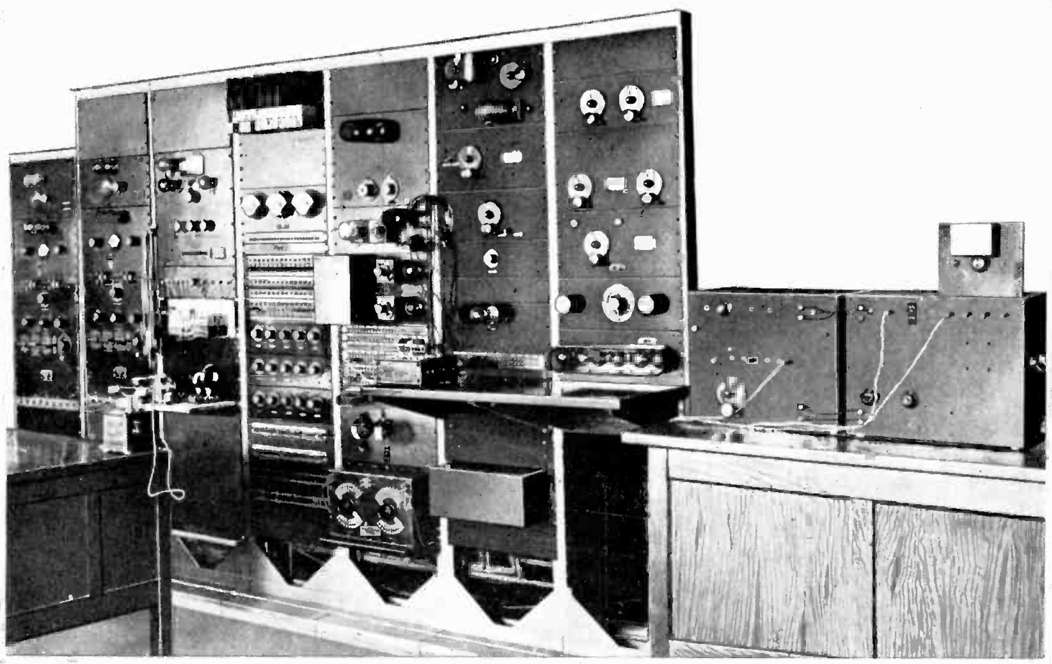
Therefore Mr. Scroggie's formula for the distortion, viz., $\frac{I_1 + I_2 - 2I_0}{I_2 - I_1}$ is equal to $\frac{2a\hat{v}^2}{4a\hat{v}V_0}$, *i.e.*, to $\frac{\hat{v}}{2V_0}$, which is double the correct value. The ordinary formula, viz., $\frac{I_1 + I_2 - 2I_0}{2(I_2 - I_0)}$ is therefore, happily, quite correct.

Our correspondent points out that his result agrees with that of Mr. P. K. Turner on p. 371 of the July number, 1930. This is true, but it will be seen that the explanation is the same in both cases.

G. W. O. H.

Short-wave Single Sideband Telephony.

A DEMONSTRATION was given recently at Trappes, near Paris, by engineers of the Laboratories of the Matériel Téléphonique in co-operation with engineers of the International Telephone and Telegraph Company, of the application of the single sideband system to duplex telephony on wavelengths of the order of 15 metres.



In place of attempting to synchronise between the suppressed carrier at the transmitter and the local oscillator at the receiver by means of quartz crystal control or similar methods which had proved to be insufficiently constant for satisfactory results, a new system has been developed which consists in the transmission of a continuous radio-frequency "pilot wave" in addition to the speech sideband. This "pilot" is used at the receiver to synchronise the frequency of the local oscillator automatically, using purely electrical methods.

A number of important advantages are claimed for the system and in the practical demonstration which was given excellent speech quality was obtained.

The photograph shows the equipment at Trappes which was used for communication with Madrid.

The Design of High-frequency Transformers.*

By M. Reed, M.Sc., A.C.G.I., D.I.C.

IN Radio Receiver design, the high-frequency transformer is employed to couple the antenna to the receiver, and also to couple the valves which provide the high-frequency amplification. This article shows that the same considerations govern the design of transformers for either of these purposes, and it also gives an analysis of the factors which influence the design of high-frequency transformers.

The bibliography shows that many papers have already been published on this subject, but it is hoped that this attempt to co-ordinate two sections, which have previously been treated separately, will justify yet another.

General Equation.

Consider two circuits whose currents, voltages, and impedances are as indicated in Fig. 1, and which are coupled by a mutual inductance whose value is M.

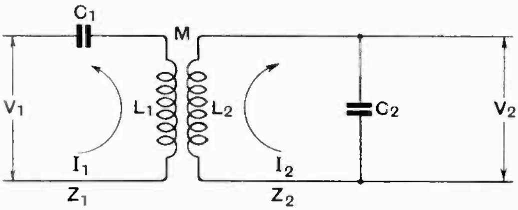


Fig. 1.

Applying Kirchoff's law to this circuit, we obtain

$$V_1 = Z_1I_1 + j\omega MI_2 \quad \ldots \quad (1)$$

$$0 = Z_2I_2 + j\omega MI_1 \quad \ldots \quad (2)$$

From equation (2) $I_2 = -\frac{j\omega M}{Z_2} . I_1 \ldots \quad (3)$

Substituting equation (3) in (1), we have

$$V_1 = Z_1I_1 + \frac{\omega^2M^2}{Z_2} I_1$$

Therefore effective input impedance

$$Z_1 = \frac{V_1}{I_1} = Z_1 + \frac{\omega^2M^2}{Z_2} \quad \ldots \quad (4)$$

Also from equations (3) and (4), we have for the ratio of input voltage to secondary current

$$Z_{12} = \frac{V_1}{I_2} = \frac{Z_1Z_2 + \omega^2M^2}{-j\omega M} \quad \ldots \quad (5)$$

Now $V_2 = -\frac{jI_2}{\omega C_2} = -\frac{M}{C_2Z_2} . I_1$

from equation (3).

Therefore

$$\frac{V_2}{V_1} = N = -\frac{MZ_2}{C_2Z_2(Z_1Z_2 + \omega^2M^2)}$$

$$= -\frac{1}{C_2}\left[\frac{M}{Z_1Z_2 + \omega^2M^2}\right] \quad \ldots \quad \ldots \quad (6)$$

Let ω_1 = natural frequency of the primary circuit $= \frac{1}{\sqrt{L_1C_1}}$,

ω_2 = natural frequency of the secondary circuit $= \frac{1}{\sqrt{L_2C_2}}$,

f = frequency of the received voltage, so that $\omega = 2\pi f$,

$$x_1 = \frac{\omega_1}{\omega}, \qquad x_2 = \frac{\omega_2}{\omega},$$

$$d_1 = \frac{R_1}{\omega L_1}, \qquad d_2 = \frac{R_2}{\omega L_2},$$

where R_1 and R_2 are the resistances of the primary and secondary circuits, respectively.

Then $Z_1 = R_1 + j\left(\omega L_1 - \frac{1}{\omega C_1}\right)$

$$= \omega L_1[d_1 + j(1 - x_1^2)]$$

and $Z_2 = R_2 + j\left(\omega L_2 - \frac{1}{\omega C_2}\right)$

$$= \omega L_2[d_2 + j(1 - x_2^2)]$$

Hence

$$Z_1Z_2 = \omega^2L_1L_2[\{(d_1d_2 - (1 - x_1^2)(1 - x_2^2)\} + j\{d_1(1 - x_2^2) + d_2(1 - x_1^2)\}]$$

$$= \omega^2L_1L_2(a + jb) \quad \ldots \quad \ldots \quad (7)$$

Where $a = d_1d_2 - (1 - x_1^2)(1 - x_2^2)$ (8)

and $b = d_1(1 - x_2^2) + d_2(1 - x_1^2)$ (9)

Therefore from equation (6) we obtain

$$N = -\frac{1}{C_2}\left[\frac{M}{\omega^2L_1L_2(a + jb) + \omega^2M^2}\right]$$

* MS. received by Editor, August, 1930.

Now $\omega_2^2 = \frac{1}{L_2C_2}$

Therefore $\frac{1}{C_2} = \omega_2^2L_2 = \omega^2x_2^2L_2$

also $M = \kappa\sqrt{L_1L_2}$ where κ = coupling factor.

Hence $$N = -\frac{x_2^2\kappa\sqrt{\frac{L_2}{L_1}}}{(\kappa^2 + a) + jb} \quad \ldots \quad (10)$$

The absolute magnitude of N is therefore given by

$$|N| = \frac{x_2^2\kappa\sqrt{\frac{L_2}{L_1}}}{\sqrt{(\kappa^2 + a)^2 + b^2}} \quad \ldots \quad (11)$$

Further from equation (5) we deduce that

$$Z_{12} = j\left[\frac{\omega^2L_1L_2(a + jb) + \omega^2M^2}{\omega M}\right]$$

$$= \frac{1}{\omega M}[-b\omega^2L_1L_2 + j(\omega^2M^2 + a\omega^2L_1L_2)]$$

The absolute magnitude of this impedance is therefore given by

$$|Z_{12}^2| = \frac{\omega^2L_1^2L_2^2(a^2 + b^2)}{M^2} + 2a\omega^2L_1L_2 + \omega^2M^2 \quad \ldots \quad \ldots \quad (12)$$

Now for given circuit conditions and a given input voltage, the value of N will be a maximum when the value of I_2 is a maximum, that is when the value of Z_{12} is a minimum.

To determine the conditions under which the value of N is a maximum, we must consider the following cases :—

Case 1.—The value of the mutual inductance is the only variable in the circuit.

By differentiating equation (12) and evaluating $\frac{dZ_{12}}{dM} = 0$, we have that $|Z_{12}|$ is a minimum when $\omega^2M^2 = \omega^2L_1L_2\sqrt{a^2 + b^2}$

Now from equation (7) we have that

$$|Z_1Z_2| = \omega^2L_1L_2\sqrt{a^2 + b^2}$$

Hence N is a maximum when

$$\omega^2M^2 = |Z_1Z_2| \quad \ldots \quad (13)$$

We have also from equations (8) and (9) that the value of the coupling factor which gives a maximum value for N is obtained from

$$\kappa^2_{\text{max.}} = \sqrt{\{d_1^2 + (1 - x_1^2)^2\}\{d_2^2 + (1 - x_2^2)^2\}} \quad \ldots \quad \ldots \quad (14)$$

Case 2.—The value of the natural frequency of the secondary circuit is the only variable. In this case x_2 is the variable. From equation (12) we have that $|Z_{12}|$ is a minimum when

$$\omega^2L_1L_2\frac{da}{dx_2} + \frac{\omega^2L_1^2L_2^2}{M^2}\left[a \cdot \frac{da}{dx_2} + b \cdot \frac{db}{dx_2}\right] = 0.$$

Evaluating for a and b from equations (8) and (9), respectively, and putting $M^2 = \kappa^2L_1L_2$, we obtain as the necessary condition

$$(1 - x_2^2) = \frac{\kappa^2(1 - x_1^2)}{d_1^2 + (1 - x_1^2)^2} \quad \ldots \quad (15)$$

Case 3.—The value of both M and x_2 is varied. In this case both M and x_2 are adjusted to obtain a maximum value for N. If we substitute the value obtained for κ from equation (14) in equation (15), the condition for a maximum in this case is given by

$$\frac{d_1^2}{d_2^2} = \frac{(1 - x_1^2)^2}{(1 - x_2^2)^2}$$

or $$\frac{d_1}{d_2} = \frac{1 - x_1^2}{1 - x_2^2} \quad \ldots \quad \ldots \quad (16)$$

In practice, in order to obtain a maximum value for I_2, the value of x_2 is made the variable, generally by changing the value of C_2. In some cases the value of M is also adjusted at the same time.

Having obtained the above general equations, it is now necessary to apply them to the design of H.F. transformers which are used in the following cases :—

(*a*) To couple a tuned antenna to the receiver proper.

(*b*) To couple an aperiodic antenna to the receiver proper.

(*c*) As an inter-valve transformer.

Amplification.

We shall first consider the above three cases from the point of view of amplification. For this purpose the value of V_2/V_1 will be regarded as the amplification for a given value of the coupling between the primary and secondary circuits. The ratio of the value of the amplification for a given value of the coupling and the value of the amplification for the optimum value of the coupling will be called the amplification factor.

$$\text{That is, amplification} = \frac{V_2}{V_1} = N.$$

$$\text{Amplification factor} = \frac{N}{N_{max.}}$$

1. The Tuned Antenna.

In this case the primary circuit has a natural frequency which is the same as that of the received signal.

Hence $\qquad x_1 = 1$

We have, therefore, from equation (15) that in order that I_2 may be a maximum, the value of x_2 must be unity.

Putting $x_1 = 1$ and $x_2 = 1$ in equations (8) and (9), respectively, we obtain

$$a = d_1 d_2 \quad \ldots \quad \ldots \quad (17)$$

and

$$b = 0 \quad \ldots \quad \ldots \quad (17a)$$

If the coupling is also varied in order to obtain a maximum, then from equation (14) we have that

$$\kappa^2_{opt.} = d_1 d_2$$

The optimum value for the coupling is therefore given by

$$\kappa_{opt.} = \sqrt{d_1 d_2} \quad \ldots \quad \ldots \quad (18)$$

From equations (11), (17), (17a) and (18) we have that the maximum value for $|N|$ under these conditions is given by

$$|N_{max.}| = \frac{1}{2\sqrt{d_1 d_2}} \cdot \sqrt{\frac{L_2}{L_1}}$$

$$= \frac{1}{2d_2} \cdot \sqrt{\frac{R_2}{R_1}} \quad \ldots \quad \ldots \quad (19)$$

If we do not adjust the coupling but keep it fixed at same value κ, then let

$$\frac{\kappa}{\kappa_{opt.}} = A_1 \text{ so that } \kappa = A_1 \kappa_{opt.}$$

$$= A_1 \sqrt{d_1 d_2}$$

Then from equations (11), (17) and (17a) we have that in this case the value for $|N|$ is given by

$$|N| = \frac{\kappa\sqrt{\frac{L_2}{L_1}}}{\kappa^2 + d_1 d_2} = \frac{A_1}{1 + A_1^2}\sqrt{\frac{L_2}{L_1 d_1 d_2}}$$

$$= \frac{A_1}{1 + A_1^2} \cdot \frac{1}{d_2}\sqrt{\frac{R_2}{R_1}} \quad \ldots \quad \ldots \quad (20)$$

$$\text{Therefore} \quad \left|\frac{N}{N_{max.}}\right| = \frac{2A_1}{1 + A_1^2} \quad \ldots \quad (21)$$

2. The Aperiodic Antenna.

In this case it is assumed that the antenna is sufficiently distuned, from the received signal, to make its resistance small compared with the value of its reactance.

Hence $\qquad d_1^2 \ll (1 - x_1^2)^2$

We have therefore from equation (15) that

$$1 - x_2^2 = \frac{\kappa^2}{1 - x_1^2} \quad \ldots \quad \ldots \quad (22)$$

or

$$x_2^2 = 1 - \frac{\kappa^2}{1 - x_1^2} \quad \ldots \quad \ldots \quad (22a)$$

If the coupling is also adjusted to give a maximum value for N, then we have from equation (16) that

$$(1 - x_2^2) = \frac{d_2}{d_1}(1 - x_1^2) \quad \ldots \quad (22b)$$

We have also from equation (14) that

$$\kappa^2_{opt.} = \sqrt{d_1^2 d_2^2 + d_1^2(1 - x_2^2) + d_2^2(1 - x_1^2) + (1 - x_1^2)(1 - x_2^2)}$$

$$\text{Hence} \quad \kappa^2_{opt.} = d_2\left[d_1 + \frac{(1 - x_1^2)^2}{d_1}\right]$$

by substitution from equation (22b).

Now $\qquad d_1 \ll (1 - x_1^2)$

$$\text{Hence} \quad \kappa^2_{opt.} = \frac{d_2}{d_1} \cdot (1 - x_1^2)^2$$

or

$$\kappa_{opt.} = (1 - x_1^2)\sqrt{\frac{d_2}{d_1}} \quad \ldots \quad (23)$$

From equations (9) and (16) we obtain

$$b = 2d_2(1 - x_1^2) \quad \ldots \quad (24)$$

and from equations (8) and (16) we have

$$a = d_1 d_2 - \frac{d_2}{d_1} \cdot (1 - x_1^2) \quad \ldots \quad (25)$$

Therefore from equations (11), (23), (24), and (25) we deduce that

$$|N_{max.}| = \frac{x_2^2(1 - x_1^2)\sqrt{\frac{L_2}{L_1}}}{\sqrt{d_1 d_2\{d_1^2 + 4(1 - x_1^2)^2\}}}$$

As $\qquad d_1^2 \ll (1 - x_1^2)^2$

$$\text{Hence} \quad |N_{max.}| = \frac{1}{2}\sqrt{\frac{L_2}{L_1}} \cdot \frac{x_2^2}{\sqrt{d_1 d_2}}$$

$$= \frac{x_2^2}{2d_2}\sqrt{\frac{R_2}{R_1}} \quad \ldots \quad \ldots \quad (26)$$

Equation (22*a*) shows that the coupling between the antenna and the secondary circuit causes resonance to take place at a point which differs from the natural frequency of the secondary circuit, *i.e.*, when $x_2 = 1$.

If this coupling is small, so that $\kappa^2 \ll (1 - x_1^2)$, then we have from equation (22*a*) that $x_2 = 1$. For this condition, from equation (26) we deduce that

$$|N_{\text{max.}}| = \frac{1}{2d_2}\sqrt{\frac{R_2}{R_1}} \quad \cdots \quad \cdots \quad (27)$$

It is seen that this value is the same as that given by equation (19), hence, for this case, there would be no advantage in tuning the antenna.

If the coupling is not fixed at the optimum value, then let the ratio of the value of the coupling at any instant to that of the optimum coupling be given by

$$\frac{\kappa}{\kappa_{\text{opt.}}} = A_2 \text{ so that } \kappa = A_2\kappa_{\text{opt.}} \quad \cdots \quad (28)$$

From equation (22) we have

$$\kappa^2 = (1 - x_1^2)(1 - x_2^2) \quad \cdots \quad (29)$$

and from (23) we have

$$\kappa^2_{\text{opt.}} = (1 - x_1^2)\frac{d_2}{d_1} \quad \cdots \quad \cdots \quad (30)$$

Therefore from (28), (29), and (30) we deduce that

$$\frac{1 - x_1^2}{1 - x_2^2} = \frac{d_1}{d_2}\frac{1}{A_2^2} \quad \cdots \quad \cdots \quad (31)$$

From equations (9) and (31) we obtain

$$b = d_2(1 - x_2^2)(A_2^2 + 1) \quad \cdots \quad (32)$$

and from (8) and (29) we have

$$a = d_1d_2 - \kappa^2 \quad \cdots \quad (33)$$

Substituting for κ, a and b, from (29), (33) and (32), respectively, in equation (11) we obtain

$$|N| = \frac{x_2^2A_2(1 - x_1^2)\sqrt{\frac{d_2}{d_1}\cdot\frac{L_2}{L_1}}}{d_2\sqrt{d_1^2 + (1 - x_1^2)^2(A_2^2 + 1)^2}}$$

Now we have that $d_1^2 \ll (1 - x_1^2)^2$

Therefore the last equation reduces to

$$|N| = \frac{x_2^2A_2\sqrt{\frac{L_2}{L_1}}}{(A_2^2 + 1)\sqrt{d_1d_2}}$$

$$= \frac{A_2}{A_2^2 + 1}\cdot\frac{x_2^2}{d_2}\sqrt{\frac{R_2}{R_1}} \quad \cdots \quad (34)$$

Comparing this equation with (26) we see that

$$\left|\frac{N}{N_{\text{max.}}}\right| = \frac{2A_2}{A_2^2 + 1} \quad \cdots \quad \cdots \quad (35)$$

3. The Inter-valve Transformer.

In this case the primary circuit can be regarded as consisting solely of the inductance of the primary winding and the resistance of the valve.

We can therefore assume that

$$C_1 = \infty \text{ and } R_1 \gg \omega L_1,$$

except at very high frequencies.

From the first condition we have that $x_1 = 0$.

In practice the value of the secondary condenser is adjusted until the value of the secondary current is a maximum. Therefore from equation (16) we have that

$$\frac{d_1}{d_2} = \frac{1 - x_1^2}{1 - x_2^2}$$

Now $x_1 = 0$ and $d_1 \gg d_2$, hence the above equation shows that x_2 does not differ appreciably from unity.

We have therefore from equation (14) that

$$\kappa^2_{\text{opt.}} = d_2\sqrt{d_1^2 + 1}$$

$$= d_1d_2 \text{ . since } d_1 \gg 1$$

Hence $\kappa_{\text{opt.}} = \sqrt{d_1d_2}$. $\quad \cdots \quad \cdots \quad (36)$

Because $x_1 = 0$ and $x_2 = 1$.

We have from equation (8) that $a = d_1d_2$ and from equation (9) that $b = d_2$.

Hence from equation (11) we obtain that

$$|N_{\text{max.}}| = \frac{d_1d_2\sqrt{\frac{L_2}{L_1}}}{\sqrt{4d_1^2d_2^2 + d_2^2}}$$

$$= \frac{\sqrt{d_1d_2\cdot\frac{L_2}{L_1}}}{d_2\sqrt{4d_1^2 + 1}}$$

$$= \tfrac{1}{2}\sqrt{\frac{L_2}{L_1}\cdot\frac{1}{d_1d_2}} \text{ . since } d_1^2 \gg 1.$$

which can be expressed as

$$|N_{\text{max.}}| = \frac{1}{2d_2}\sqrt{\frac{R_2}{R_1}}$$

If V_g is the voltage applied to the grid of the valve, m is the amplification factor of the valve and R_p is the resistance of the valve, then $V_1 = mV_g$ and $R_1 = R_p$.

Therefore $N_{max.} = \frac{V_2}{V_g} = \frac{m}{2d_2}\sqrt{\frac{R_2}{R_p}}$ .. (37)

So far we have assumed that the mutual inductance has been varied at the same time as the value of the secondary condenser, in order to obtain the optimum condition. If the value of the condenser is the only variable, then we obtain from equation (15) that

$$1 - x_2^2 = \frac{\kappa^2(1 - x_1^2)}{d_1^2 + (1 - x_1^2)^2}$$

If we put $x_1 = 0$ and neglect κ^2 with respect to $(d_1^2 + 1)$ in the above equation, we see that in this case, also, x_2 does not differ appreciably from unity.

We have therefore as before that

$$a = d_1 d_2 \text{ and } b = d_2.$$

If $\frac{\kappa}{\kappa_{opt.}} = A_3$ so that $\kappa = A_3\kappa_{opt.} = A_3\sqrt{d_1 d_2}$

Then from equation (11) we obtain

$$|N| = \frac{A_3\sqrt{d_1 d_2 \cdot \frac{L_2}{L_1}}}{\sqrt{d_1^2 d_2^2(A_3^2 + 1)^2 + d_2^2}}$$

$$= \frac{A_3}{(A_3^2 + 1)} \cdot \frac{1}{d_2}\sqrt{\frac{R_2}{R_1}} \quad .. \quad (38)$$

after assuming that $d_1^2(A_3^2 + 1)^2 \gg 1$

Making the substitutions as above, we have that in the case of a valve

$$|N| = \frac{A_3}{(A_3^2 + 1)}\frac{m}{d_2}\sqrt{\frac{R_2}{R_p}} \quad .. \quad (39)$$

Comparing equations (37) and (39), we see that

$$\left|\frac{N}{N_{max.}}\right| = \frac{2A_3}{(A_3^2 + 1)} \quad .. \quad (40)$$

Reference to equations (21), (35) and (40) shows that the amplification factor of a transformer for the tuned antenna, the aperiodic antenna, and also for the inter-valve transformer, can be expressed by an equation of the form

$$\frac{N}{N_{max.}} = \frac{2A}{(A^2 + 1)} \quad .. \quad (41)$$

where $\frac{N}{N_{max.}}$ denotes the amplification factor for a given value of the coupling, and A denotes the ratio of the value of that coupling and the value of the optimum coupling. The value of the optimum coupling for the above transformers is given by equations (18), (23) and (36), respectively.

It is, therefore, seen that as far as amplification is concerned, equation (41) can be used as a basis for the design of the three types of radio-frequency transformers.

Selectivity.

We have next to consider the three cases from the point of view of selectivity. For a given value of the coupling the selectivity will be taken as the ratio of the value of the amplification at resonance and the value of the amplification when the circuit is distuned by a certain amount. The selectivity factor will be taken as the ratio of the value of the selectivity for a given value of the coupling and the maximum value of the selectivity. It is not necessary to specify the amount by which the circuit is distuned; it is only necessary to assume that the same value of the distuning will be used throughout, and that it will be of the order of 10 per cent.

1. Tuned Antenna.

Assume that both circuits are distuned by the same amount, so that $x_1 = x_2 = x$.

Assume also that the distuning is of the order of 10 per cent., so that $(1 - x^2) \gg d$. Therefore from equation (8) we have

$$a = d_1 d_2 - (1 - x^2)^2$$

and from equation (9) we have

$$b = (d_1 + d_2)(1 - x^2).$$

Therefore from equation (10) we deduce that

$$N_x = -\frac{x^2\kappa\sqrt{\frac{L_2}{L_1}}}{\kappa^2 + \{d_1 + j(1 - x^2)\}\{d_2 + j(1 - x^2)\}}$$

Since $d \ll (1 - x^2)$, therefore

$$N_x = -\frac{x^2\kappa\sqrt{\frac{L_2}{L_1}}}{\kappa^2 - (1 - x^2)^2}$$

Now we have seen that the value of κ is of the order of $\sqrt{d_1 d_2}$, hence it is small compared with the value of $(1 - x^2)$, therefore κ^2 can be discarded with reference to $(1 - x^2)$ in the above equation.

Hence $$|N_x| = \frac{x^2\kappa\sqrt{\frac{L_2}{L_1}}}{(1 - x^2)^2} \quad .. \quad (42)$$

From equation (20) we have that at resonance

$$|N_{res.}| = \frac{\kappa\sqrt{\frac{L_2}{L_1}}}{d_1 d_2 + \kappa^2}$$

Therefore the selectivity

$$S_x = \left|\frac{N_{res.}}{N_x}\right| = \frac{(1 - x^2)^2}{(d_1 d_2 + \kappa^2)x^2}$$

$$= \frac{(1 - x^2)^2}{d_1 d_2(1 - A_1^2)x^2}, \text{ where } A_1 = \frac{\kappa}{\kappa_{opt.}}$$

From the above equation it is seen that for a given value of x the selectivity is a maximum when $A = 0$, *i.e.*, when the coupling is zero. We have therefore that

$$S_{max.} = \frac{1 - x^2}{d_1 d_2 x^2}$$

Therefore the selectivity factor

$$S = \frac{S_x}{S_{max.}} = \frac{1}{1 + A_1^2} \quad .. \quad (43)$$

2. Aperiodic Antenna.

In this case it is necessary to have the coupling sufficiently loose, and the secondary circuit sufficiently distuned, to enable us to assume that

$$\frac{\kappa^2}{1 - x_1^2} \ll (1 - x_2^2)$$

i.e., $\kappa^2 \ll (1 - x_1^2)(1 - x_2^2)$.

We also assume that the distuning of the secondary circuit is sufficient to make $d_2 \ll (1 - x_2^2)$ and for the primary circuit we assume, as before, that $d_1 \ll (1 - x_1^2)$.

We have therefore from equations (8), (9) and (10) that

$$N_x = -\frac{x_2^2\kappa\sqrt{\frac{L_2}{L_1}}}{\kappa^2 - (1 - x_1^2)(1 - x_2^2)}$$

Since $\kappa^2 \ll (1 - x_1^2)(1 - x_2^2)$, the above equation can be reduced to

$$|N_x| = \frac{x_2^2\kappa\sqrt{\frac{L_2}{L_1}}}{(1 - x_1^2)(1 - x_2^2)} \quad .. \quad (44)$$

Now from the fact that $\kappa = A_2\kappa_{opt.}$ and from equation (23), we deduce that

$$\kappa = A_2(1 - x_1^2)\sqrt{\frac{d_2}{d_1}}$$

Substituting this value for κ in equation (44), we obtain

$$|N_x| = A_2\sqrt{\frac{L_2}{L_1}\cdot\frac{d_2}{d_1}}\,\frac{x_2^2}{1 - x_2^2}$$

From equation (34) we have that at resonance

$$|N_{res.}| = \frac{A_2}{A_2^2 + 1}\sqrt{\frac{L_2}{L_1}}\cdot\frac{1}{d_1 d_2}\cdot x_2^2$$

Hence

$$S_x = \left|\frac{N_{res.}}{N_x}\right| = \frac{1}{d_2(A_2^2 + 1)}\cdot(1 - x_2^2)$$

For a given value of x_2, this is a maximum when $A_2 = 0$, hence

$$S_{max.} = \frac{(1 - x_2^2)}{d_2}$$

Therefore

$$S = \frac{S_x}{S_{max.}} = \frac{1}{1 + A_2^2} \quad .. \quad (45)$$

3. Inter-valve Transformer.

As in the previous cases, we assume that conditions are such that $d_2 \ll (1 - x_2^2)$.

The primary circuit has no capacity, hence $x_1 = 0$.

From equations (8), (9) and (10), we have therefore that

$$N_x = -\frac{x_2^2\kappa\sqrt{\frac{L_2}{L_1}}}{\kappa^2 + j\,(d_1 + j)(1 - x_2^2)}$$

Now $d_1 = \frac{R_1}{\omega L_1}$ where R_1 = valve resistance, hence we can assume that $d_1 \gg 1$, except at very high frequencies.

Hence $$N_x = -\frac{x_2^2\kappa\sqrt{\frac{L_2}{L_1}}}{\kappa^2 + jd_1(1 - x_2^2)}$$

Therefore

$$|N_x| = \frac{x_2^2\kappa\sqrt{\frac{L_2}{L_1}}}{\sqrt{\kappa^2 + d_1^2(1 - x_2^2)^2}}$$

From page 353 we have that

$$\kappa = A_3\kappa_{opt.}$$
$$= A_3\sqrt{d_1 d_2}$$

Hence

$$|N_x| = \frac{x_2^2 A_3\sqrt{\frac{L_2}{L_1}}\cdot d_1 d_2}{\sqrt{d_1^2\{A_3^2 d_2^2 + (1 - x_2^2)^2\}}}$$

We have already assumed that

$$d_2 \ll (1 - x_2^2)$$

Hence

$$|N_x| = \frac{x_2^2 A_3 \sqrt{\frac{L_2}{L_1}} \cdot d_1 d_2}{d_1(1 - x_2^2)}$$

$$= \frac{x_2^2}{(1 - x_2^2)} \cdot A_3 \sqrt{\frac{L_2}{L_1}} \cdot \frac{d_2}{d_1} \qquad \ldots \ldots (46)$$

From equation (38) we have that at resonance

$$|N_{res.}| = \frac{A_3}{(A_3^2 + 1)} \cdot \frac{1}{d_2} \sqrt{\frac{R_2}{R_1}}$$

Hence

$$S_x = \left|\frac{N_{res.}}{N_x}\right| = \frac{1 - x_2^2}{x_2^2} \cdot \frac{1}{d_2(A_3^2 + 1)}$$

For a given value of x_2, this is a maximum when $A_3 = 0$.

Hence $S_{max.} = \frac{1 - x_2^2}{x_2^2} \frac{1}{d_2}$

Therefore

$$S = \frac{S_x}{S_{max.}} = \frac{1}{1 + A_3^2} \qquad \ldots (47)$$

From equations (43), (45) and (47), respectively, it is seen that, so far as selectivity is concerned, the selectivity factor for the three types of high-frequency transformer can be expressed by the following equation

$$S = \frac{S_x}{S_{max.}} = \frac{1}{1 + A^2} \qquad \ldots (48)$$

where A has the same significance as that given on page 353.

In the case of the aperiodic antenna, the above result is subject to the conditions given on page 354.

General Conclusions.

Fig. 2 shows the amplification factor $N/N_{max.}$ and the selectivity factor $S_x/S_{max.}$ plotted for different values of A.

From these curves it is seen that when designing an H.F. transformer we have to effect a compromise between these two factors. For values of A below 0.5 we have good selectivity but poor amplification, for values of A between 0.5 and 1.0 we have good amplification but poor selectivity, and for values of A greater than 1.0 we have both poor amplification and selectivity. It seems, therefore, that a suitable value for A would be in the neighbourhood of 0.5. That is to say, that the value of the best coupling to employ would be about one-half the value of the optimum coupling. For each type of transformer the value of the optimum

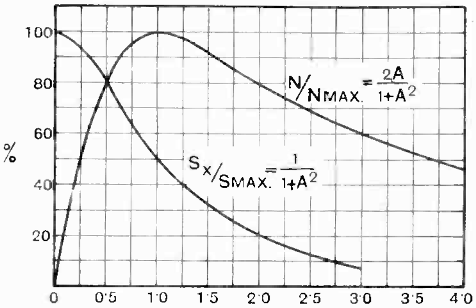


Fig. 2.

coupling can be calculated from the respective formulae given above.

It is thus seen that from the point of view of amplification and selectivity the three types of H.F. transformers can be treated together, and that their design is governed by the same general formulae.

The complete design of these transformers is not gone into here, because this matter has already been treated quite fully elsewhere (*see* references 2, 3, 4 and 8).

REFERENCES.

1 "Radio Frequency Transformers as Applied to Screen Grid Valves." *E.W. & W.E.*, June, 1929.

2. "The Inductively Coupled Antenna." *Telefunken Zeitung*, p. 62, May, 1929.

3. "Analysis of the Screen Grid Tube." *Proc. Inst. of Radio Engineers*, Feb., 1929.

4. "The Tuned High Frequency Amplifier." *Telefunken Zeitung*, p. 50, Oct., 1927.

5. "Mathematical Study of Radio Frequency Amplification." *Proc. of Inst. of Radio Engineers*, June, 1927.

6. "Measurement of Radio Frequency Amplification." *Proc. of Inst. of Radio Engineers*, July, 1927.

7. "Selectivity of Tuned Radio Sets." *Proc. of Inst. of Radio Engineers*, May, 1927.

8. "Antenna Coupling Questions." *Telefunken Zeitung*, p. 79, Dec., 1926.

9. "Radio Frequency Transformers." *Proc. of Inst. of Radio Engineers*, Dec., 1925.

Thermo-junctions at High Radio-frequencies.*

An Investigation of Mutual Consistency by Comparison with a Specially Designed Valve Milliammeter.

By F. M. Colebrook, B.Sc., D.I.C., A.C.G.I.

(*Wireless Division, National Physical Laboratory.*)

SUMMARY.—The object of the investigation was to obtain information about the frequency variation of thermo-junction milliammeters. A valve rectifier milliammeter was specially designed for the purpose of inter-comparison of the thermo-junctions investigated and the valve instrument itself. A method of calibrating the valve rectifier milliammeter by direct current is described. The calibration so obtained was found to agree with a low-frequency calibration by thermo-junction to better than two parts in a thousand. The calibrations of the valve milliammeter and of three thermo-junction milliammeters were compared at frequencies from zero up to 10^7 cycles per second. The maximum mutual discrepancy was about 5 per cent. with one of the thermo-junctions and about 2½ per cent. with the other two, most of the variation occurring over the range 10^6 to 10^7 cycles per second.

1. Object and Method of the Investigation.

THE object of the investigation was to obtain information as to the nature and magnitude of the variation with frequency of the calibrations of thermo-junctions of the kind used for the measurement of small currents at radio-frequencies.

In the absence of any absolute and independent standard of radio-frequency current measurement, the most that can be done is to investigate the mutual consistency of a group of instruments of such different characteristics as to make it improbable that their frequency variations will be identical. If one of the instruments is of variable range and the others of various fixed ranges, the mutual comparison can clearly be made through the medium of the variable range instrument. A valve rectifier milliammeter of variable range was, therefore, constructed for this purpose. A brief description of this instrument, and of its calibration by direct current, is given in the next section.

2. A Valve Rectifier Radio-frequency Milliammeter, Calibrated by Direct Current.

The application of the triode valve, used as a rectifier, to the measurement of radio-frequency currents and potential differences has long been known, and has been developed to a high degree of practical usefulness and convenience by E. B. Moullin. The valve rectifier arrangement described below has a sensitivity as a milliammeter comparable with that of the non-contact thermo-junctions now obtainable commercially.

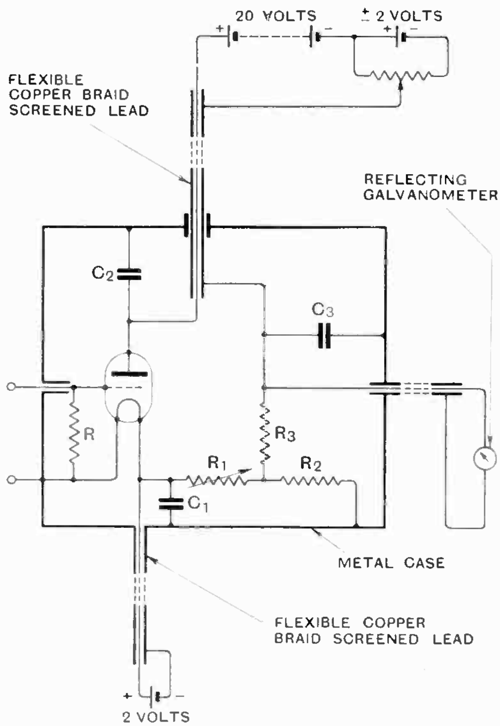


Fig. 1.

The circuit is shown in Fig. 1. The valve actually used was a *DEH*, but any other of comparable characteristics would probably

* MS. received by the Editor June, 1930.

do as well. The resistances R_1, R_2 and R_3 are for the purpose of balancing out the anode current in the galvanometer (R_1, 20 ohms continuously variable ; R_2, 16 ohms fixed ; R_3, 70,000 ohms fixed, Loewe type). Condensers C_1, C_2 and C_3 are 0.05 μF. mica. (Paper condensers could be used if of sufficiently high insulation resistance). To minimise the input capacity and also for convenience of construction and operation, the valve was mounted pins uppermost, without a holder, inside the metal case in the position shown in the diagram. The galvanometer used was a reflecting instrument with a sensitivity of about 2×10^{-9} amperes per millimetre deflection at a scale distance of about 2 metres. Flexible copper-braided leads were used for connection to the batteries and galvanometer, as shown in the diagram, to avoid undesirable inductive loops. The anode voltage was 20, with a 2-volt potentiometer arrangement for the purpose of maintaining the initial anode current at a constant value during any set of measurements. (In some earlier measurements failure to maintain this constancy gave rise to errors of a few per cent.).

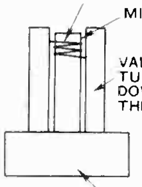


Fig. 2.

The various resistances (R in Fig. 1) for obtaining the desired ranges as a milliammeter were of values from 2 to about 100 ohms, and were constructed as shown in Fig. 2. No. 47 gauge Eureka wire was used for the lower values, and an even finer wire for the higher.

Details of the "skin-effect," capacity, and inductance corrections required in connection with these resistances are given below.

3. Discussion of the Operation of the Rectifier.

In the conditions in which the valve is used the rectification is square law in character to a few parts in a thousand. This implies a rectification characteristic in which powers of the grid voltage higher than the third are negligible, *i.e.*, if i_a and v_g be *changes* in anode current and grid voltage, then, assuming constant anode voltage

$$i_a = av_g + bv_g^2 + cv_g^3.$$

(Under the actual conditions of operation the changes in anode voltage can safely be neglected).

For the above characteristic, if v_g be an alternating voltage $E_m \sin \omega t$ (R.M.S. value E), then i_c, the mean value of i_a over a period, is given by

$$i_c = bE^2$$

This defines the rectification performance of the valve.

The coefficient b can be determined very simply by direct current measurements as follows.

One of the prepared resistances R is plugged on to the grid-filament terminals, and a measured current i is passed through it. The change in anode current is given by

$$i_a = a(Ri) + b(Ri)^2 + c(Ri)^3$$

On reversing i (and of course the galvanometer) we have

$$-i_a' = -a(Ri) + b(Ri)^2 - c(Ri)^3$$

Adding these results

$$(i_a - i_a') = \delta i_a = 2b(Ri)^2$$

or
$$\frac{\delta i_a}{2R^2} = bi^2$$

Thus, if $\delta i_a/2 R^2$ is plotted against i^2 the result is a straight line of slope b. This is illustrated in Fig. 3. The value of b so determined was 5.794×10^{-5}. A subsequent comparison with a thermo-junction at a fairly low frequency (about 20 kilocycles) gave the measured value of b from the rectification characteristic $i_c = b\ E^2$ as 5.785×10^{-5}. Thus the measured and predicted values are in agreement to about fifteen in ten thousand.

In determining b by d.c. measurements, the maximum applied grid-voltage change should be made about equal to the maximum value of the alternating voltage corresponding to full scale deflection in the rectifier. This will involve a reduction of the galvanometer sensitivity in the d.c. calibration to about 1/10th of its normal value, by means of a shunt.

The fact that the valve rectifier can be calibrated accurately by direct-current measurements does not necessarily imply that this is the simplest way of calibrating it. Comparison with a thermo-junction at a fairly low frequency will probably be simpler in most cases. The d.c. calibration was carried out in the present instance because of its theoretical interest in connection with the problem under investigation.

Sensitivity.—Used as a rectifier the arrangement described gave full scale deflection (*i.e.*, about 80 cms. at a 2-metre scale distance) for a R.M.S. voltage of 0.18 volt. As a milliammeter it can be used over a very wide range of sensitivities by a suitable choice of shunt resistance. Thus, with $R = 100$ ohms full scale will correspond

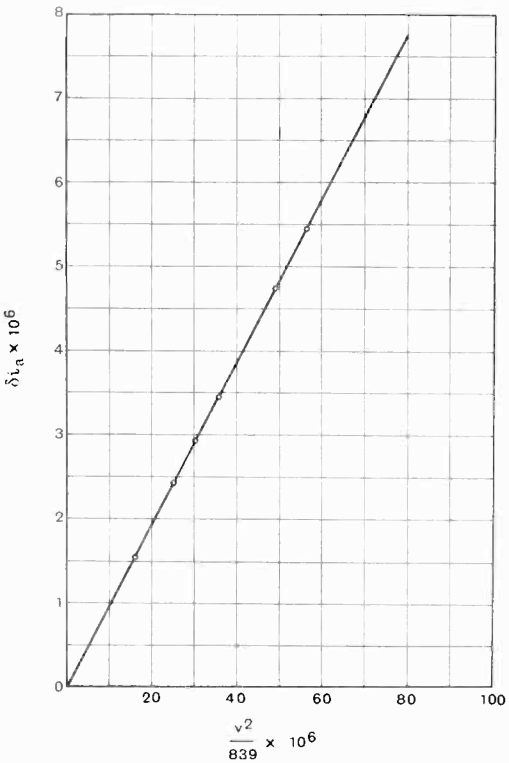


Fig. 3.

to 1.8 m.a., and with $R = 2$ to 90 m.a. This sensitivity is comparable with but somewhat less than that given by the latest type of non-contact vacuum thermo-junction with the same galvanometer. It has, of course, a number of disadvantages when compared with a non-contact thermo-junction, in particular the array of auxiliary apparatus required and the necessary care in adjustment. On the other hand, its elasticity of range is an advantage, as is also the fact that the resistance elements are easily replaced if they are burnt out by accident.

It should be noted that the resistance of the grid-filament path, which will certainly be higher than 10^4 ohms, and possibly of the order 10^5, will not play any part in the performance of the instrument as a milliammeter.

Frequency Corrections.—The two factors which will limit the reliability of the calibration at very high frequencies are the residual inductance of the resistance elements and the input capacity. Measurement of the latter showed it to be less than micro-microfarads. Taking ten as an outside figure the frequency error due to this cause can easily be estimated. It will change the radio-frequency impedance from R to $R/\sqrt{1 + \omega^2 C^2 R^2}$. The error will be less than one in a thousand as long as $f \times R$ is less than 7×10^8. Thus, with $R = 10$ ohms, the error will only be one in a thousand at 70,000 kilocycles (about 4 metres).

The inductance correction is more important, though even this does not amount to very much except with the lowest resistances at the highest frequencies. It was arrived at as follows. At the conclusion of each set of comparison measurements the resistance shunt of the valve milliammeter was replaced by a short circuiting copper strip of approximately the same geometrical form—that is, enclosing about the same space with the filament and grid leads. The valve milliammeter deflections given by the same currents as before were then determined. It was found that these deflections were very approximately proportional to the square of the current and the square of the frequency, indicating a potential difference proportional to current and frequency. Thus these deflections could reasonably be assigned to an inductive reactance. The actual inductance, determined from the formula:

$$L = \frac{V}{\omega i}$$

gave values as follows :—

Frequency.	Wavelength.	Inductance in Microhenrys.
5×10^6	60 metres	0.0091
7.5×10^6	40 ,,	0.0087
10×10^6	30 ,,	0.0081

Each resistance was then corrected for this inductance plus an additional term due to the actual length of very small diameter resistance wire, this term being determined by calculation. For the 2-ohm resistance, for example, the additional term was 0.012 μH. Actually it was only in the case of the lowest resistance (the 2 ohms) at frequencies higher than 10^6 that the inductance correction was at all important.

The only other factor which can be taken into account is the increase in resistance due to "skin-effect." Calculation showed, however, that this was entirely negligible over the range of frequencies concerned.

4.—Comparison of Three Thermo-junction Instruments with the Valve Milliammeter, up to 10^7 cycles per second.

The actual experimental procedure was to assume the calibration of the valve milliammeter and use it to determine the apparent calibration of the other instruments, at various frequencies from zero to ten million. The actual disposition of apparatus was as shown in Fig. 4.

Three thermo-junction instruments were compared in this way.

No. 1.—A non-contact thermo-junction of N.P.L. construction of the pattern described in *E.W. & W.E.*, Vol 5 (1928), pp. 565–571, used in conjunction with a Campbell bifilar galvanometer. The heater resistance was 4.86 ohms, and the range about 85 m.a.

No. 2.—A non-contact vacuum thermo-junction of commercial make, of nominal heater resistance 29.4 ohms, measured value 29.40 ohms: used in conjunction with the same galvanometer as No. 1, gave a range of about 7 m.a.

No. 3.—A self-contained non-contact vacuum thermo-junction milliammeter of commercial make: nominal heater resistance 115.7 ohms at 20° C. The resistance measured with direct current varied from 105 to about 116 ohms, depending on the current. Range 10 m.a.

Each instrument was calibrated over its full range at each frequency—21 calibrations in all. As was to be expected, there were no appreciable variations in the general shape and character of the calibrations with frequency, which were approximately

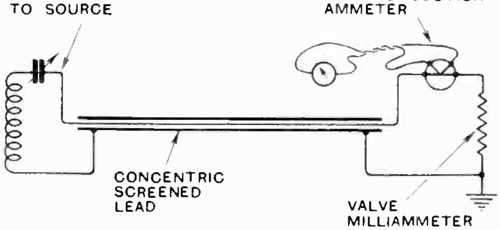


Fig. 4.

"square law" in every case. After the first series of measurements the apparatus was dismantled. It was reassembled about a fortnight later for the purpose of checking the measurements. The check confirmed the mutual calibrations of the thermal instruments but indicated that the valve calibration had changed by 2 per cent. in the interval. It would probably be necessary to age the valve a little to ensure time constancy of calibration.

The comparison is illustrated in Fig. 5 on which are plotted the currents corresponding to some convenient fixed deflection (about full scale) for each instrument, the the corresponding direct current being taken as 100 in arbitrary units.

As already pointed out, the curves can only be regarded as an indication of mutual consistency and there is, therefore, little to be gained by any elaborate analysis of the results. The following points can be noted however :—

(*a*) The shape of curves 2 and 3 suggests that at least two factors of opposite significance are involved in the variations. Such factors might be (*i*) the heating of the thermo-junctions by eddy currents induced by the field of the heater ; (*ii*) the leakage of current from the heater to earth through the mutual capacity between heater and junction. The first would give a downward displacement of the curve and the second an upward displacement. It is notable that the case in which the downward displacement is most marked is that in which there are ten strip-form junctions in series, in close proximity to a heater wire about 2 cms. long, an arrangement which might well give rise to appreciable eddy-current heating at very high frequencies.

(*b*) The other noticeable feature is that the mutual consistency of the three instruments and the valve is unexpectedly good. The worst case shows only about 5 per cent. discrepancy at 10^7 cycles/second, and the other two only about $2\frac{1}{2}$ per cent. There is admittedly no proof of absolute accuracy to these limits, but the fact that the valve and the thermo-junctions depend on totally different electrical effects gives some little additional value to the comparison.

(*c*) The third point relates to the question of the apparent constancy of the valve characteristics. It can be stated that the rectification performance of the valve as deduced from measurements of its continuous current characteristics appears to be consistent with thermo-junction measurements to about $2\frac{1}{2}$ per cent. up to 10^7 cycles per second. There is, of course, considerable probability that the actual frequency constancy of the valve is much better than this, but no more definite statement than the above can be made in view of the conditions of measurement. A further note on this subject is given in the next section.

(*d*) The curves for instrument No. 3 in Fig. 5 show that the fact that a calibration at approximately 10^7 cycles per second agrees with that taken with direct current, does not preclude the possibility of some error occurring at intervening frequencies.

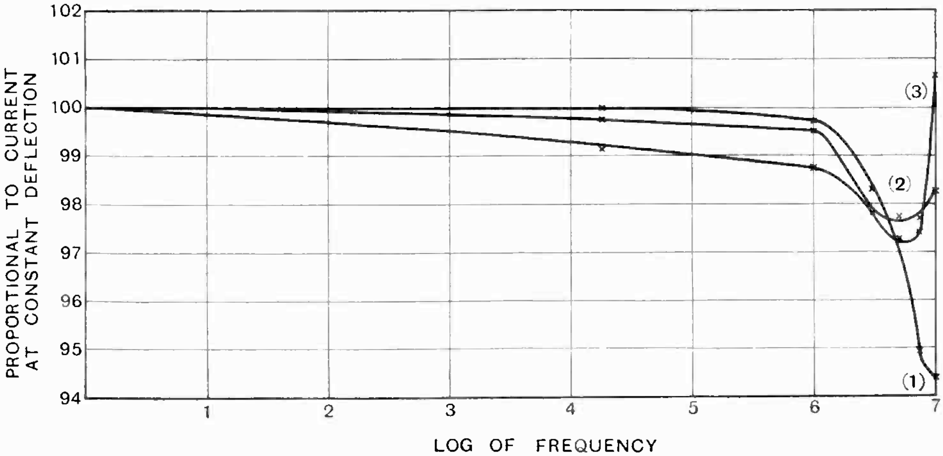


Fig. 5.

5. A Note on the Frequency Constancy of Valve Characteristics.

As already pointed out, it is impossible in the absence of any absolutely reliable means of measuring currents of very high frequency (above 10^7) to make any direct investigation of the frequency variation of valve characteristics, though there may possibly be indirect methods of doing this. At least two direct investigations have actually been carried out ("Detection by valve": P. David, *Onde Elect.*, Vol. 7, 1928, pp. 313–361, and "A study of the rectification efficiency of thermionic valves at moderately high frequencies," W. E. Benham: *Phil Mag.*, Vol. 5, 1928, pp. 323–324). Divergent conclusions were arrived at in these two cases. In the first, however, the method employed was hardly of sufficient accuracy to give very exact information; and in the second, there would appear to be no certainty that the variations observed could not be attributed to the comparison instrument employed (an electrostatic voltmeter). It is to be hoped that the matter will be more thoroughly investigated as soon as current measuring methods of sufficient accuracy are available. In the meantime it will be well to emphasise the necessity for caution in making assumptions in this matter. In default of a clear physical picture of what is actually occurring in the inter-electrode space when an alternating electro-motive-force is superimposed on a steady electro-motive-force, it is difficult to estimate the significance of the various factors involved—such as the inertia of the individual electron, the time of transit of an individual electron from filament to anode (which has been estimated at 10^{-9} seconds*), the distribution of electric intensity, the variation of dielectric properties due to the space charge, and so on. It is a question of considerable theoretical and practical interest which has not yet been sufficiently explored. It is submitted that in the absence of the necessary theoretical and experimental work on the subject, there is no justification for assuming the frequency constancy of the valve characteristics, at least at frequencies higher than 10^7.

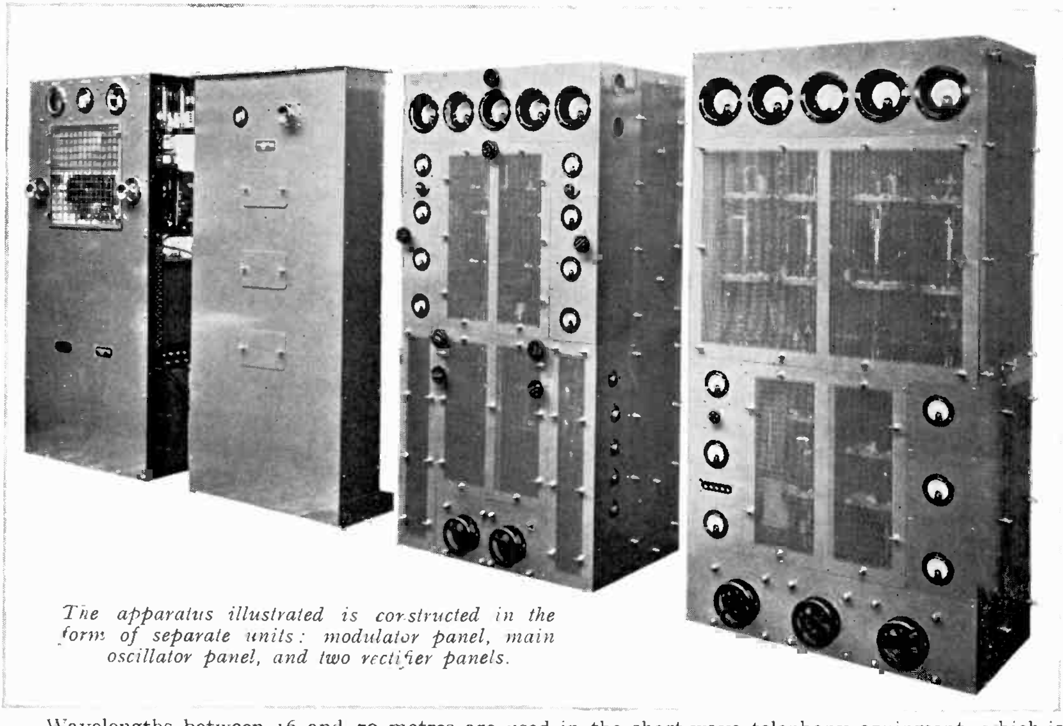
This work was carried out as part of the programme of the Radio Research Board, and is published by permission of the Department of Scientific and Industrial Research.

In conclusion the writer wishes to thank Dr. L. Hartshorn, of the Electrical Measurements Division of the National Physical Laboratory, for advice and assistance in connection with the measurements of residual inductance, and also his assistant, Mr. A. C. Gordon-Smith, for thoroughness and accuracy in the measurements and calculations.

* R. L. Smith-Rose and J. S. McPetrie: "Experimental transmitting and receiving apparatus for ultra-short waves."—*E.W. & W.E.*, 1929, Vol. 6, pp. 605-619.

"Empress of Britain."

The Largest Marine Telephone Equipment Installed.



The apparatus illustrated is constructed in the form of separate units: modulator panel, main oscillator panel, and two rectifier panels.

Wavelengths between 16 and 70 metres are used in the short-wave telephony equipment, which is a part of the general Marconi radio installation on the "Empress of Britain."

The telephony service is carried out in conjunction with the British Post Office and with the International Telephone and Telegraph Company in the United States, both of these organisations having land stations erected for short-wave telephony services.

The Variation of Magnification with Pitch in Resistance-capacity Coupled Amplifiers.*

By W. A. Barclay, M.A.

IT is now a commonplace that the resistance-capacity coupled amplifier, at one time generally held to be the only perfect means of obtaining linear L.F. magnification over a wide range of frequencies, does not by any means justify such extravagant claims. The reason is that such an amplifier necessarily introduces note-loss at either end of the audio-frequency scale; the low notes failing to receive their proper amplification owing to losses due to the coupling condenser, while the high notes tend to disappear mainly owing to the action of the valve capacities associated with the circuit. The resistance-capacity amplifier is, however, one which lends itself unusually well to theoretical analysis, and for this reason its behaviour is capable of more scientific study than is possible with other types.

It is the usual practice in dealing with this subject to consider high-note loss and low-note loss as quite separate entities. For the purpose of estimating high-note losses, the amplifier is assumed to work without loss at low frequencies, and a formula for the percentage losses at the higher frequencies is evolved on this assumption. Again, in the estimation of low-note losses, the hypothesis is expressly made that the amplifier is "perfect" over the higher frequencies. Neither of these assumptions is, of course, strictly correct. The truth of the matter is that there is a certain middle frequency at which the amplification obtainable is optimum; on either side of this frequency the note-losses progressively increase. To show that this "middle" frequency is readily calculable, and that the losses entailed on other frequencies no less easily ascertainable, is one of the chief objectives of this article.

It may be instructive here to compare the treatment of these points given by previous writers on the subject. In his illuminating exposition of the effects of stray capacities on amplification,† Mr. Hartshorn is more con-

* MS. received by the Editor, April, 1930.

† "Inter-Electrode Capacities and Resistance Amplification," L. Hartshorn, *E.W. & W.E.*, August, 1928.

Symbolism Employed.

$R_a = \frac{1}{G_a}$ = Anode A.C. resistance of valve.

R = External anode resistance.

C_x = Capacity across anode resistance.

Z = Impedance of R and C_x in parallel at frequency f.

R_0 = Resistance of R and R_a in parallel.

Z_0 = Impedance of Z and R_a in parallel.

$R_1 = \frac{1}{G_1}$ = Grid leak.

$G_g = \frac{1}{R_g}$ = Grid conductance of following valve.

C_g = Grid-filament capacity of following valve.

$A_g = \frac{1}{Z_g} = G_1 + G_g + j\omega C_g$ = Admittance of following grid circuit.

C = Grid coupling condenser.

μ_0 = Magnification factor of valve.

μ = Actual magnification attained at frequency f.

μ_m = Maximum magnification attained.

$f_m = \frac{\omega_m}{2\pi}$ = Frequency for which magnification is maximum.

$f = \frac{\omega}{2\pi}$ = Any other frequency.

$\rho = f/f_m$.

cerned with high-note than with low-note losses. He assumes (*loc. cit.*, p. 426) a value of 0.001μF. or 0.002μF. for the coupling condenser, whose reactance at the higher audio-frequencies may conveniently be disregarded. Again, Mr. Colebrook, dealing with the problem of ascertaining the best value for this coupling condenser,* expressly neglects the effects of stray capacities, which at the lower frequencies need not be taken into account (*loc. cit.*, p. 203).

It is not intended to recapitulate here the theory of the resistance amplifier. The treatment now to be given derives from the analysis given by Mr. Hartshorn in the paper above cited, and to which readers are referred. It will therefore only be necessary to recall the symbolism employed, and give the general equation for the theoretical amplification which was arrived at in that article, in order to make this the basis of subsequent development.

General Equation for Resistance Amplification.

The simplified circuit being as shown in Fig. 1, the general expression for the voltage

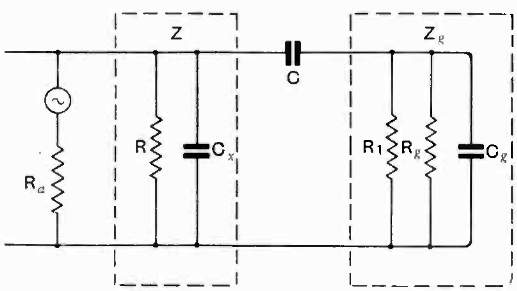


Fig. 1.—*Simplified equivalent network for two-stage amplifier.*

amplification obtainable from the assemblage is given by Mr. Hartshorn as

$$\mu = \mu_0 \cdot \frac{Z}{Z + R_a} \times \frac{Z_g}{Z_g + \frac{1}{j\omega C} + Z_0} \quad \ldots \quad (1)$$

to the neglect of a coupling factor whose value is negligible over all working frequencies. In his subsequent evaluation of this formula in its application to high-note losses, Mr. Hartshorn omitted the term $\frac{1}{j\omega C}$ as of no importance at the higher frequencies. As it stands, however, equation (1) is applicable to all audio frequencies, and in general, therefore, the retention of this term in the formula when dealing with the complete frequency range is essential. We can then proceed to find a general expression for the relative amplification at various frequencies as follows:

$$\mu = \frac{\mu_0 Z_0}{R_a} \cdot \frac{1}{1 + A_g\left(\frac{1}{j\omega C} + Z_0\right)}$$

$$= \frac{\mu_0}{R_a} \cdot \frac{1}{\frac{1}{Z_0} + (G_1 + G_g + j\omega C_g)\left(\frac{1}{j\omega C Z_0} + 1\right)}$$

$$= \frac{\mu_0}{R_a} \cdot \frac{1}{\frac{1}{Z_0}\left(1 + \frac{C_g}{C}\right) + G_1 + G_g + j\left\{\omega C_g - \frac{G_1 + G_g}{\omega C Z_0}\right\}} \quad \ldots \quad \ldots \quad (2)$$

Neglecting the ratio $\frac{C_g}{C}$ in comparison with unity, and substituting for $\frac{1}{Z_0}$ its equivalent, $G_a + G + j\omega C_x$, we obtain

$$\mu = \frac{\mu_0}{R_a} \cdot \frac{1}{G_a + G + G_1 + G_g + j\left\{\omega(C_g + C_x) - \frac{(G_1 + G_g)}{\omega C} \cdot (G_a + G + j\omega C_x)\right\}}$$

Collecting terms, and neglecting the ratio $\frac{C_x}{C}$ in comparison with unity, this becomes

$$\mu = \frac{\mu_0}{R_a} \cdot \frac{1}{G_a + G + G_1 + G_g + j\left\{\omega(C_g + C_x) - \frac{(G_1 + G_g)(G_a + G)}{\omega C}\right\}} \quad (3)$$

It is obvious that for some value of ω the coefficient of j in the above expression becomes zero. If f_m denote this frequency, the corresponding value of μ attains its absolute maximum, which we may denote by μ_m.

* "A New Development in Resistance Amplification," F. M. Colebrook, *E.W. & W.E.*, April, 1927.

Therefore,

$$\mu_m = \frac{\mu_0}{R_a} \cdot \frac{1}{G_a + G + G_1 + G_g} \quad \cdots \quad (4)$$

in G_1, we have approximately

$$\omega_m{}^2 = \frac{1}{R_1 R_\theta C(C_g + C_x)} \quad \cdots \quad (5)$$

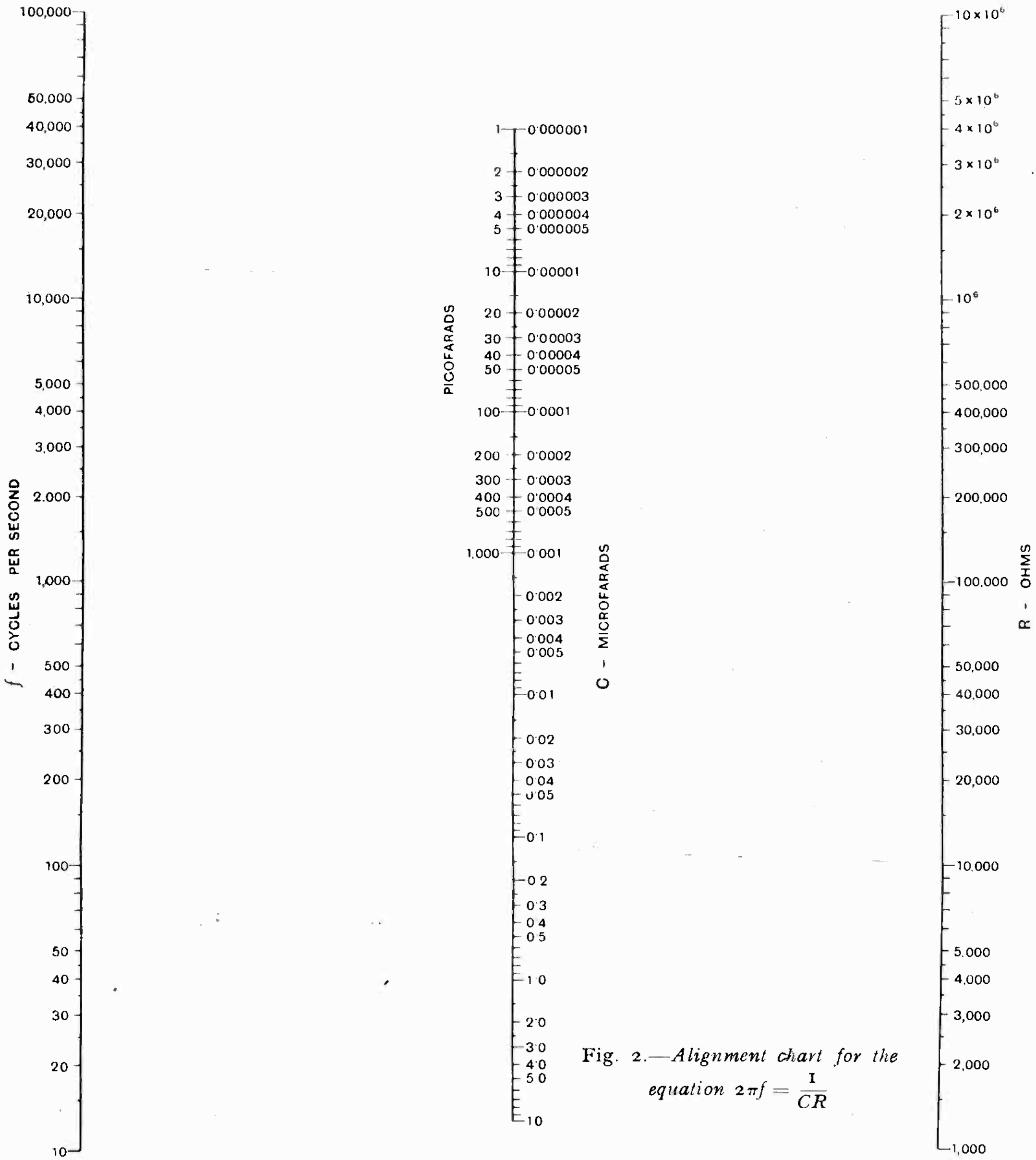


Fig. 2.—*Alignment chart for the equation* $2\pi f = \frac{1}{CR}$

The value of f_m is evidently found by

$$\omega_m (C_g + C_x) = \frac{(G_1 + G_g)(G_a + G)}{\omega_m C}$$

If, now, we regard the symbol G_g as included

In order conveniently to compute the value of the optimum frequency f_m, we may use the alignment chart of Fig. 2 which relates the three variables, frequency, capacity and resistance, according to the following equations (6) and (7). Let us obtain the values of two frequencies, f_1 and f_2 from this chart, defined by the equations

$$2\pi f_1 = \frac{1}{CR_1} \quad \ldots \quad \ldots \quad (6)$$

and

$$2\pi f_2 = \frac{1}{(C_g + C_x)R_0} \quad \ldots \quad (7)$$

Then we shall have simply,

$$f_m = \sqrt{f_1 f_2} \quad \ldots \quad \ldots \quad (8)$$

An Example.

We shall illustrate these remarks by an amplifier having the following values:

$R_a =$ 60,000 ohms
$R =$ 120,000 ohms
$R_1 =$ 2 megohms
$C =$ 0.005μF.
$C_g + C_x =$ 200μμF.

Then, $R_0 =$ 40,000 ohms.

From Fig. 2, using equation (6),

$f_1 =$ 16 cycles per sec. (approx.).

Similarly, using equation (7),

$f_2 =$ 20,000 cycles per sec. (approx.).

Whence, $f_m =$ 566 cycles per sec. (approx.).

Relative Amplification.

The equation (3) above gives a vectorial expression for the total magnification attainable at any frequency f. In practice, however, we are more concerned with the *relative* magnification sustained by notes of various pitch as compared with that at some standard frequency. The frequency f_m being that for optimum magnification, is obviously suitable for this standard. The fraction $\frac{\mu}{\mu_m}$ when μ is calculated for any other frequency f will then represent the "relative" magnification of f as compared with f_m, and may be expressed as a percentage of the latter. It will be convenient, moreover, to express f itself as a fraction or multiple of f_m; we shall thus write

$$\rho = f/f_m = \omega/\omega_m$$

If, as before, we assume the symbol G_1 to include G_g, we have from equations (3) and (4),

$$\frac{\mu}{\mu_m} = \frac{1}{1 + j \cdot \left\{ \dfrac{\rho\omega_m(C_g + C_x) - \dfrac{G_1(G_a + G)}{\rho\omega_m C}}{G_a + G + G_1} \right\}}$$

$$= \frac{1}{1 + j\left\{ \dfrac{G_1(G_a + G)(\rho - 1/\rho)}{\omega_m C(G_a + G + G_1)} \right\}}$$

which becomes after simplification,

$$\frac{\mu}{\mu_m} = \frac{1}{1 + j \cdot \left\{ \dfrac{(\rho - 1/\rho)}{\omega_m C(R_1 + R_0)} \right\}} \quad \ldots \quad \ldots \quad (9)$$

Equation (9) is in vector form; to obtain the absolute value of $\frac{\mu}{\mu_m}$, which we may denote by $\left|\frac{\mu}{\mu_m}\right|$, we shall have

$$\left|\frac{\mu}{\mu_m}\right| = \frac{1}{\sqrt{1 + \dfrac{(\rho - 1/\rho)^2}{\omega_m^2 C^2 (R_1 + R_0)^2}}} \quad \ldots \quad (10)$$

This equation is of such fundamental importance in the theory of resistance amplification that its numerical interpretation by alignment will, it is hoped, be of some assistance to those who wish for a rapid means of estimating the performance of such amplifiers. For this purpose we may simplify (10) still further by introducing a new variable T, defined as

$$T = 40 \times \frac{f_m}{f_1} = 40 \times \frac{\omega_m}{\omega_1} \quad \ldots \quad (11)$$

Then we have, since $\omega_1 = \frac{1}{CR_1}$,

$$T = 40\omega_m CR_1 \quad \ldots \quad \ldots \quad (12)$$

Thus, if we neglect R_0 in comparison with R_1, we may rewrite (10) as

$$\left|\frac{\mu}{\mu_m}\right| = \frac{1}{\sqrt{1 + \dfrac{1600(\rho - 1/\rho)^2}{T^2}}} \quad \ldots \quad (13)$$

The chart of Fig. 3 has been designed to facilitate the solution of this equation. Having found T from the defining equation (11), we seek on the left-hand scale of Fig. 3 the point of value ρ corresponding to the particular frequency considered. (Values of ρ less than unity are seen to occupy the same positions on this scale as their reciprocals).

The value of $\left|\frac{\mu}{\mu_m}\right|$ is then read off upon the right-hand scale in alignment with the values shown for ρ and T. In passing, it may be noted that the neglect of R_0 in arriving at equation (13) will not in general lead to an error of more than 5 per cent. in the value of T. From the chart it will be readily seen that such an error in T cannot cause so great a percentage variation from the true value of $\left|\frac{\mu}{\mu_m}\right|$. That this is so may, indeed, be proved by differentiation of equation (13). The approximation is thus amply justified.

To illustrate the ease with which this chart may be used to show the relative effect of pitch variation on magnification, the same values of amplifier constants as were taken in the previous section were employed to trace the effect on $\left|\frac{\mu}{\mu_m}\right|$ of the variation in frequency above and below the central value of 566 cycles previously obtained for f_m. The results are plotted to a logarithmic base for

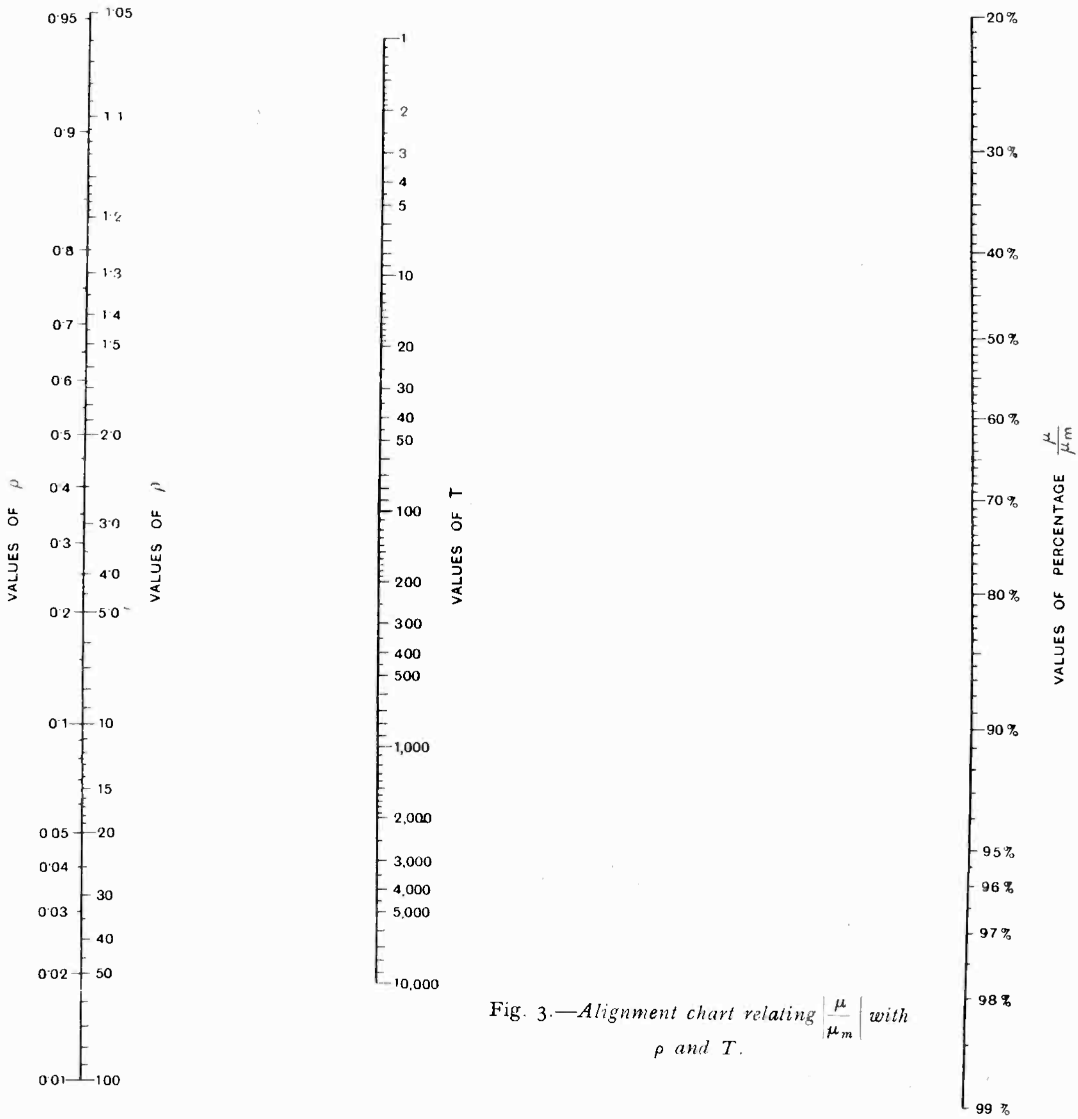


Fig. 3.—*Alignment chart relating* $\left|\frac{\mu}{\mu_m}\right|$ *with* ρ *and* T.

values of ρ, and show, as was to be anticipated from equation (10) the symmetrical nature of the magnification about the central frequency $f_m = 566$. The value of T is readily found from (11) to be a little under 1420, and the percentage magnification curve is that shown by the full line in Fig. 4.

Pitch Loss Factor.

We have thus a ready means of determining the nature of the falling-off in magnification as ρ is varied, and can, moreover, estimate how much the amount of this falling-off depends on the value of T. Indeed, it is obvious from equation (13) that the quantity T may be regarded as an index of this loss of magnification, and it may, therefore, be referred to as the " pitch-loss " factor of the circuit. For low values of the pitch-loss factor the falling off in magnification at both ends of the pitch scale may be very pronounced ; for large values of T the effect is smaller, and the relative amplification tends to become uniform over the entire range. These considerations are illustrated by the broken curves for the values $T = 710$ and $T = 2840$ which are shown for comparison on Fig. 4 about the same maximum ordinate $f_m = 566$ cycles per second.

Grid Leak and Condenser Variation.

We shall now examine the effect upon the response curve obtained above ($f_m = 566$, $T = 1420$) of altering some of the various constants of the amplifier. Let us suppose, first, that the grid leak is reduced to one-half of its former value, *i.e.*, it will now be 1 megohm, all the other constants remaining as before. This will double the value of f_1, and hence the new optimum frequency f_m will have $\sqrt{2}$ times its former value, or 800 cycles per second. At the same time, the value of T is decreased to 1000. By using the chart of Fig. 3 the new response curve will easily be found to be as shown by curve (b) of Fig. 5, the curve for the original amplifier being reproduced for convenience of comparison as curve (a) in the same diagram. It will be seen that the effect of reducing the grid leak is to cause a marked deterioriation in the magnification at low frequencies, leaving the relative magnification at the upper frequencies unchanged. Indeed, the two curves (a) and (b) are indistinguishable over the upper frequency band within the limits of accuracy imposed by the diagram of Fig. 3. The reason for this will appear later.

It is to be noted that an exactly similar effect could have been obtained if, keeping the value of the leak fixed at 2 megohms, we had substituted a grid condenser of one-half of the value originally used, or $0.0025\mu F$. It is easy to see that the curve (b) of Fig. 5 would also represent the performance of this combination. The above analysis thus goes to show that the relative magnification of an amplifier is theoretically unchanged (within the limits of the approximation specified) when R_1 and C are varied so as to preserve

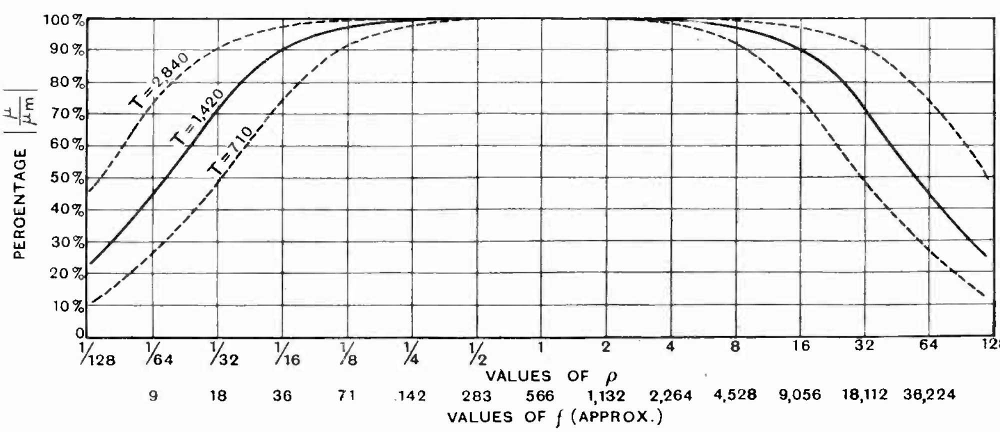


Fig. 4.—*Curves of relative amplification for optimum frequency $f_m = 566$.*

their product R_1C and hence the frequency f_1 unchanged. For if f_1 is unchanged, so also will be f_m and T (since the values of all the other symbols are, *ex hypothesi*, fixed).

Effect of Anode Resistance Variation.

When we come to examine the effect of altering the anode resistance, it is convenient to consider the variable as R_0, since if the A.C. resistance R_a of the valve is supposed to be constant, any change in R is reflected in a change in the value of R_0. (In strictness it should be remembered that the symbol R_a represents throughout the working value of the A.C. resistance, and not the maker's value, from which it usually differs more or less according to working conditions. In fact, the value of R_a is itself essentially dependent on that of R, a circumstance that may easily be lost sight of in dealing with this subject.)

Let us suppose, then, that the value of R_0 is decreased. This will result in an increase of f_2, and hence an increase in f_m. If, *e.g.*, R_0 have one-half the value previously assigned to it, if, that is to say, R_0 be now 20,000 ohms, the value of f_2 will now be 40,000 cycles per sec., so that f_m will once more be 800 cycles per sec. The value of T will, however, be greater than before, *i.e.*, in this case it will be 2000. The response curve will now be found to assume the form shown by Fig. 5 (c). This curve, which is indistinguishable from curve (a) over the lower frequencies, gives a marked improvement in the relative magnification at the higher frequencies. This, of course, is practically discounted by the lower actual magnification which is obtained due to the decrease in R.

The above curves are, of course, mere numerical illustrations of equation (10), and it is by no means intended to suggest that such ideal curves are practically realisable. Usually the value of R_a will be much higher than we have assumed above, and it may be interesting to show how large a decrease in relative magnification is to be expected at the higher frequencies when the working value of R_a assumes the comparatively large figure of 600,000 ohms. Taking then an anode resistance of twice this value, or 1.2 megohm, we have $R_0 = 400{,}000$ ohms, or ten times the original value assigned to it.

Assuming as before $C = 0.005\mu F$, $R_1 = 2M\Omega$, $C_x + C_g = 200\mu\mu F$, we have $f_1 = 16$, $f_2 = 2000$. Whence, $f_m = 179$ and $T = 448$. The resulting curve is that shown in Fig. 5 (d). It will be noticed that the relative pitch loss in the higher frequencies is here much more pronounced, while as before the curve is indistinguishable from that of (a) over the lower frequency region.

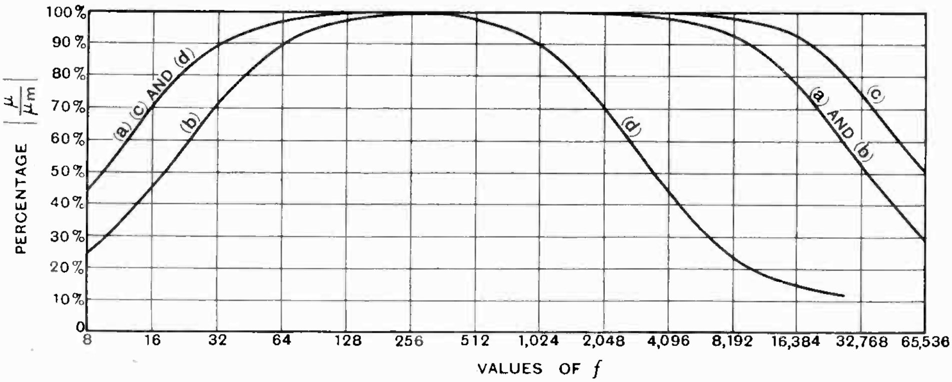


Fig. 5.—*Relative amplification curves for various amplifiers.*

Variation of Stray Capacity.

Enough has been said to demonstrate the facility with which the response curves of Fig. 5 may be set out with the aid of the alignment diagram of Fig. 3, and it will not be necessary to trace the similar effect on these curves of varying the capacity $C_x + C_g$. Mention should here be made, however, of one of the peculiar advantages of the alignment process which renders it of particular service in the present connection. This is the virtual segregation of the variables dealt with into distinct and different elements in a geometrical figure, so that the effect of varying each in turn may be conveniently studied. In the present case, the capacity C_g is itself known to vary with the anode resistance in the circuit.* If, therefore, we can assign approximate values for C_g as R is varied, we can compute the values of f_2 from equation (7) by means of Fig. 2 precisely as before. Similarly it would be possible to allow for the effect of the anode load on the input conductance, inasmuch as the foregoing analysis has in fact assumed the inclusion of G_g in the symbol G_1.

Partial Identity of Response Curves.

It is natural to inquire if the coincidence of the curves (a), (c) and (d) over the low-frequency band in Fig. 5 and of curves (a) and (b) over the high-frequency band is merely accidental or otherwise. That it is not fortuitous is easily seen by substituting for T and ρ their respective values in equation (13). This becomes,

$$\left|\frac{\mu}{\mu_m}\right| = \frac{1}{\sqrt{1 + \{f/f_2 - f_1/f\}^2}} \quad .. \quad (14)$$

For very low frequencies, f/f_2 is negligible, and we have

$$\left|\frac{\mu}{\mu_m}\right| = \frac{f}{\sqrt{f^2 + f_1^2}} \text{ (approximately) } .. \quad (15)$$

For very high frequencies, f_1/f may be neglected, and we have

$$\left|\frac{\mu}{\mu_m}\right| = \frac{f_2}{\sqrt{f^2 + f_2^2}} \text{ (approximately) } \quad (16)$$

For these extreme frequencies, equations (15) and (16) may therefore be employed. In practice, their numerical interpretation is much simplified by the "N"-Diagrams described by the writer in *The Wireless World*.* With regard to the curves shown in Fig. 5, it is readily seen that the cases (a), (c) and (d) each have the same value for f_1. Hence, by equation (15) their response over the lower frequency band is identical. Again, the curves (a) and (b) in the same figure are plotted from the same value of f_2; hence by equation (16) they should coincide over the higher frequencies.

Conclusion.

In conclusion, the writer may be pardoned a personal note. While no one could be more fully alive than himself to the deficiencies of a purely theoretical paper, none regrets more sincerely his inability at present to undertake the experimental work which would give a practical content to the analysis. In the present case, however, it is hoped that the synthesis which is here achieved between high and low note losses in resistance amplification will point the way for further experimental work in this field of research.

* *See* Hartshorn, *loc. cit.* p. 423.

* *See The Wireless World*, 9th and 16th April, 1930.

Books Received.

KENNRUFE DER RUNDFUNKSENDER.

A list of 183 European Broadcasting Stations, arranged in alphabetical order and giving the geographical position, wavelength, opening, interval and closing signals of each. Pp. 192. Published by Rothgiesser and Diesing A.G., Berlin, price R.M.2.

HIGH FREQUENCY ALTERNATING CURRENTS. By Knox McIlwain and J. G. Brainerd.

A text-book for advanced students comprising the theory and calculations relating to Resonance Phenomena, Coupled Circuits, Valves, Amplification, Modulation, Detection, Filters and other problems connected with Transmission and Reception. Pp. 510+xiii, with 226 diagrams and illustrations. Published by John Wiley & Sons, Inc., New York, and Chapman & Hall, Ltd., London, price 30s. net.

RADIO TUBE DATA.

Compiled by J. D. Reid and containing useful data concerning typical American valves, with very complete characteristic curves. Pp. 32. Published by Lefax Inc., Philadelphia, Pa., U.S.A. price $1.

Calibrating Ultra-short Wave Receivers Employing Super-regeneration.*

Note on a Simple and Accurate Method.

By C. Whitehead.

THE Lecher-wire method of calibrating ultra-short wave power oscillators is well known, but the writer has not yet seen any published description of a simple and *direct* method of calibrating a *receiver* for use on ultra-short waves. The purpose of this note is to describe a method used by the writer, recently, to calibrate a receiver designed for use on wavelengths between two and three metres. This method is only suitable for receivers employing super-regeneration, but as practically *all* successful ultra-short wave receivers do, and presumably will, employ this, the method about to be described should prove generally useful.

There are three obvious methods of calibrating a receiver of this type :—

(*a*) By means of a power oscillator, previously calibrated by the Lecher-wire method. (Constancy of calibration of the oscillator may be doubtful.)

(*b*) Simultaneous calibration of power oscillator and receiver by means of the Lecher wires. (This is probably the most rigorously accurate method.)

(*c*) Calibration of an " absorption " wave-meter by method (*b*), this, in turn, being used to calibrate the receiver. (This is undoubtedly the best method where a number of receivers, each covering the same wave-band, are to be calibrated.)

Methods (*a*) and (*b*) are inconvenient, expensive and laborious, and so is (*c*), unless a large number of receivers are to be calibrated.

These methods, however, have the advantage of being suitable for receivers not employing super-regeneration.

(*d*) The method used by the writer makes use of the fact that (under suitable conditions) the load imposed upon an oscillating

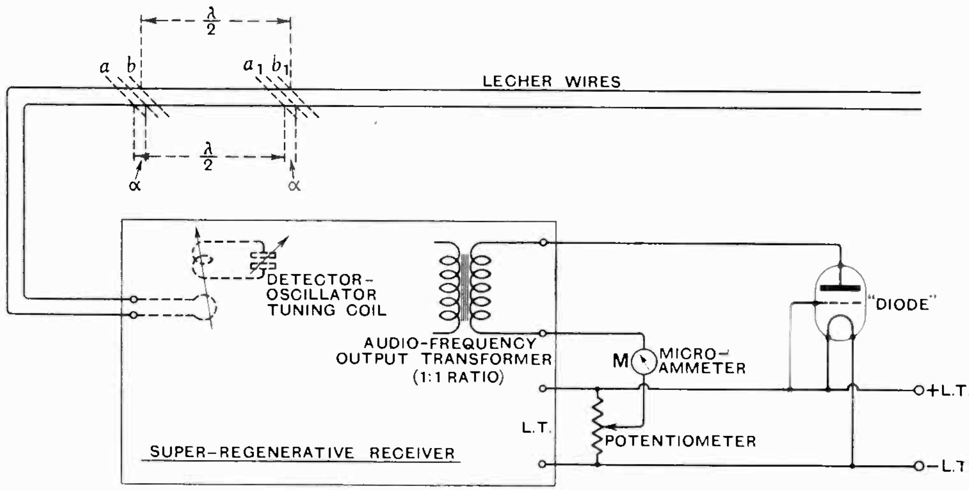


Fig. 1.—*Positions of short-circuiting wires for equal readings on M are shown at a a_1, and b b_1.*

* MS. received by the Editor July, 1929.

valve circuit of this type is a simple sine function of the position of the short-circuiting "bridge" along the length of a Lecher wire suitably coupled to it.

The *modus operandi* is shown by Fig. 1. The super-regenerative receiver is provided with a suitable "signal-strength" measuring device, such as that shown at M in the figure. (Consisting, in this case, of a diode rectifier and micro-ammeter.)

If the "quench" (super-regeneration) is now put into operation, a reading will be observed upon the meter M. This is due to the "mush" caused by the "quench." When a load is imposed upon the oscillating detector circuit, the noise of this "mush," and consequently the reading on "M," will decrease. This reading will be inversely proportional to the load.

A Lecher-wire system of suitable dimensions is then coupled to the oscillating detector circuit, and a short-circuiting wire adjusted along the length of the Lecher wires until a maximum reading is obtained on "M." By means of the adjustment just mentioned, and manipulation of the receiver quench and reaction controls, this reading can be adjusted so as to be near the full-scale reading of "M." Then, calling this position of the short-circuiting wire zero, and successive positions, with reference to this, "θ"

$$R = r \cos \theta.$$

Where r = reading noted above. (=R_{max}, Fig 2 (a).)
R reading at any point of the short-circuiting wire, as defined above.

Since $\lambda = 2\pi$

$$R = r \cos \frac{\lambda}{2},$$

and, under the conditions shown in Fig. 2 (a), R_{max} or R_{min}, recurs at distances apart (of successive positions of the short-circuit) equal to half a wavelength. (Any other value of R recurs *twice* in this distance.)

The conditions shown in Fig. 2 (a) are not always easy or convenient to obtain in practice, the usual conditions being as shown in (*b*) or (*c*).

As this is the most usual and convenient state of affairs, we choose a convenient value (R_1) of the reading on "M" (usually near R_{max})* so as to obtain "pairs" of readings R_1, so that

$$R_1 = r \cos \left(\frac{\lambda}{2} \pm \alpha\right) \qquad \text{(See Figs.)}$$

and each *alternate* recurrence of R takes place at distances apart of short-circuiting positions of $\lambda/2$.

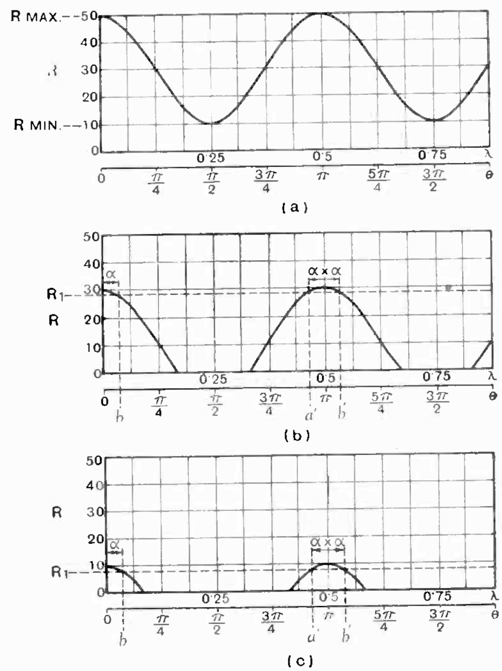


Fig. 2.—*Representing* (*a*) *very loose coupling;* (*b*) *usual conditions;* (*c*) *coupling too tight.*

Though the method takes a considerable time to describe in detail, it is quickly and easily carried out in practice, and the necessary preliminary adjustments are not critical.

Checked by means of the methods mentioned earlier, (*a*) to (*c*), this latter method proved quite accurate if used with due care.

One might say that in this method the "quench mush" is used as an aperiodic artificial "signal."

* The values of R shown in Fig. 2 are *virtual* values, the signal-strength meter (a valve voltmeter) used by the writer having been calibrated in R.M.S. values. The values shown are arbitrary values (approximately, valve voltmeter readings × 10). As the calibration of most forms of H.F. meters follows a "square law," it is obviously better to choose a value of R_1 near the maximum, as this is more easily read with accuracy.

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.

The Resistance Capacity Coupled Transformer.

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

SIR,—I have read with interest the article by F. Aughtie and W. F. Cope, on the Resistance Capacity Coupled Transformer, which appeared in the issue of April, 1931, also the letter by A. D. Hodgson in the June issue on the same subject.

The considerable advantage and high note response obtained by using high permeability alloy cores has been known for some time past, and the Research Department of Radio Instruments have been experimenting with nickel alloys of higher permeability than those previously employed in Intervalve Transformers.

As a result of this research, the "Parafeed" Transformer has been produced, the high note response of which is mainly due to the use of a very low volume of core; the total weight is only 3½ ozs., and the Transformer normally gives a flat response of from 25 up to about 8,000 cycles.

As pointed out by Mr. A. D. Hodgson, the high permeability and low iron volume operate jointly to enable leakage inductance to be considerably reduced, thereby ensuring flat high note response.

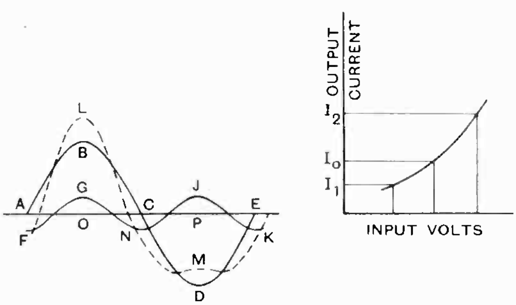
A number of curves have been taken on this Transformer by the National Physical Laboratory, and these appear in a small publication which is available on request to any of your readers interested in the subject.

J. JOSEPH, M.I.E.E.,
Managing Director,
Radio Instruments, Ltd.

Percentage Harmonic Distortion.

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

SIR,—There appears to be some ambiguity in connection with the estimation of percentage harmonic distortion in the output of power valves, as methods have been published which disagree among themselves in the ratio of 2 : 1.



I arrive at a formula for 2nd harmonic distortion due to curvature of valve characteristics, making the usual assumptions, thus :—

ABCDE represents a sine fundamental and *FGHJK* a 2nd harmonic which when combined result in the dotted curve *FLMK*. If the load is non-reactive and a pure input waveform is assumed, each half-cycle is symmetrical as shown. The distortion is assumed to be the ratio of the amplitudes of harmonic and fundamental, and is therefore equal to $\frac{GO}{BO}$ which it is easy to show is equal to $\frac{LO - PM}{LO + PM}$. Translating this into terms of the output currents $LO = I_2 - I_0$ and $PM = I_0 - I_1$ hence the distortion $= \frac{I_1 + I_2 - 2I_0}{I_2 - I_1}$.

This result is in agreement with Mr. P. K. Turner on p. 371 of *E.W. & W.E.*, July, 1930, dealing with rectification. On the other hand, the formula which has been published and which is commonly used is $\frac{\frac{1}{2}(I_1 + I_2) - I_0}{I_2 - I_1}$ giving values half as great. Scales for rapid estimation of the maximum output conditions have also been produced based on this formula. As the advertised output figures of power valves depend upon the assumed permissible distortion, which is generally agreed upon as 5%, it is obviously important to make certain that this is not found in fact to be on a 10% basis in some cases.

Perhaps some protagonist of the latter formula will come forward and show where the preceding reasoning is incorrect.

M. G. SCROGGIE.

Book Review.

National Physical Laboratory.

Collected Researches. Vol. XXII, 1930. Pp. iv + 417. H.M. Stationery Office. £1.

This is a collection of twenty-one electrical papers, reprinted from various journals. The first six deal with aerials and their field distribution and are by Colebrook, Wilmotte and McPetrie. The seventh on amplifiers is by H. A. Thomas. The eighth and tenth by Dye are on high frequency measurements, the ninth on a high frequency inductive resistance and the eleventh on the measurement of condenser losses are both by Wilmotte. The following six papers are not connected with radio telegraphy, but deal with the current-rating of cables and other matters. Then follows a paper on the dielectric constant of liquids by Hartshorn and Oliver, and one on thermionic valve measurements by Hartshorn. The concluding two papers by Vigoureux deal with quartz oscillators.

We should point out that several of these papers were published as long ago as 1924–1925. Why they should be reprinted now it is difficult to see; why not wait until 1949 and make a jubilee volume of it ?

G. W. O. H.

Abstracts and References.

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PROPAGATION OF WAVES.

EEN STATISTISCHE THEORIE OVER SNELLE FADING. I (A Statistical Theory of Rapid Fading. I).—H. J. de Boer. (*Tijdschr. Nederl. Radiogenootschap*, Jan., 1931, Vol. 5, No. 1, pp. 1–18.)

The author defines as a measure of fading the "percentage scattering" [100] $\frac{\overline{v^2} - \bar{v}^2}{\overline{v^2}}$, where v denotes the deflection from zero position at any instant, $\bar{v}$ its mean value with respect to time and $\overline{v^2}$ the mean value of v^2. Experimental curves taken on wavelengths of about 16 m. with a vertical antenna 9 m. long and a superheterodyne receiver gave percentage scatterings of 44.5 % and 43.5 % respectively.

The percentage scattering is calculated from probability considerations for one antenna and different numbers, phases and amplitudes of interfering rays. For variation of phase alone, the amplitudes of the rays considered being equal and constant, 2, 3, 4 and m ($\gg 1$) interfering rays give percentage scatterings of 19.1 %, 22.21 %, 21.32 % and 21.5 % respectively. For variation of phase and amplitude, the mean values of the amplitudes being the same, 2, 3, 4 and m ($\gg 1$) interfering rays give percentage scatterings of 38.6 %, 44.3 %, 41 % and 41 %. 21.5 % is the value found for any number of rays for phase and amplitude variation with different mean amplitudes.

To explain the huge fading percentage actually found it must be assumed that one bundle of incident rays is present or that, if several are present, one bundle is much stronger than the others. Several bundles of comparable intensity give 21.5 %.

The phase variation of more than one antenna is then discussed; the percentage scattering found for two rays with two antennae is 10.5 %, with n antennae $1/(1 + 4.28\,n)$. For m rays, two antennae give 12 %, and n antennae $1/(1 + 3.66\,n)$. For a large number of antennae whose e.m.f.s are statistically independent, the rapid fading due to phase variation alone is inversely proportional to the number of antennae. In the case of phase and amplitude variation of more than one antenna and m rays, 2 antennae give 24.6 %, and n antennae

$$\frac{3 + 20\,n}{3 + 20\,n + 33\,n^2}$$

Thus the fading for a large number of independent antennae is much decreased.

EEN STATISTISCHE THEORIE OVER SNELLE FADING. II (A Statistical Theory of Rapid Fading. II).—H. J. de Boer. (*Tijdschr. Nederl. Radiogenootschap*, Feb., 1931, Vol. 5, No. 2, pp. 57–67.)

A continuation of the article referred to in the previous abstract. The effect of rotation of the plane of polarisation is considered in addition to those of phase and amplitude variation, and it is found that it has little effect on depth of fading. One ray with rotating plane of polarisation gives a percentage scattering of 19 %; two rays of the same amplitude, phase variation also being considered, give 19.1 % and m ($\gg 1$) rays 21.5 %. When amplitude variation also is taken into account, the percentage scatterings for one, two and m ($\gg 1$) rays are respectively 38.6 %, 39.2 % and 41 %. If the amplitudes no longer have the same mean value, the resulting integral for the percentage scattering has not been solved but would probably give a value about 22 %.

Measurements were made on stations using wavelengths varying from 17 to 20 m. with a vertical receiving antenna 8 m. long and a superheterodyne receiver. The audio-frequency output was measured with a detector of as nearly linear a law as possible and a self-registering milliammeter in the anode circuit. Details are given of the measured signal strength of various stations at Eindhoven; the percentage scatterings found grouped themselves either in the neighbourhood of 45 % *or* in that of 23 %. Thus either one *or* two or more bundles of incident rays must have been present at the receiving station.

DAS REZIPROZITÄTS-THEOREM DER DRAHTLOSEN TELEGRAFIE (The Reciprocity Theorem of Wireless Telegraphy).—A. Sommerfeld. (*Zeitschr. f. hochf. Tech.*, April, 1931, Vol. 37, pp. 167–169.)

The writer's earlier paper under this title (*ibid.*, Vol. 26, 1925, p. 93) contained a miscalculation which is here rectified. The statement of the theorem remains unchanged.

OVER REFLECTIE VAN ELECTROMAGNETISCHE GOLVEN (On Reflection of Electromagnetic Waves).—G. J. Elias. (*Tijdschr. Nederl. Radiogenootschap*, Jan., 1931, Vol. 5, No. 1, pp. 19–37.)

See next abstract.

ON REFLECTION OF ELECTROMAGNETIC WAVES AT IONISED MEDIA WITH VARIABLE CONDUCTIVITY AND DIELECTRIC CONSTANT.—G. J. Elias. (*Proc. Inst. Rad. Eng.*, May, 1931, Vol. 19, pp. 891–907.)

Substantially the same paper as that referred to in the preceding abstract. Deductions are made from the calculations given in previous papers (*cf.* 1930 Abstracts, p. 330), in which a horizontally stratified conducting medium with an exponential law of variation of conductivity and dielectric constant with depth of medium is assumed and the relative amplitudes of incident and reflected waves are obtained by approximations to the Hankel functions. Former calculations of the ionisation of the upper atmosphere under the influence of the ultra-violet light of the sun are also used; first the assumption is made that the upper atmosphere consists of nitrogen and conclusions are drawn about the reflection of electromagnetic waves. For short waves, if ω is the angular frequency, ϕ the angle between the direction of propagation and the vertical, and h_1 the height where reflection chiefly takes place, the values 70, 75 and 80 km. for h_1 give values 2.6×10^6, 1.3×10^7, 2.8×10^7 respectively for $\omega \cos \phi$. The limiting frequency for reflection in long distance propagation is $\omega = 2.8 \times 10^8$ ($\lambda \approx 7$ m.).

For the usual long waves, the value of h_1 is nearly 65 km., and this increases with decreasing frequency. There must thus be an intermediate frequency with a minimum height of reflection.

If the upper atmosphere does not consist only of nitrogen but contains hydrogen in appreciable amount, the maximum ion density is reached at a much greater height. Using Wegener's assumptions as to the constitution of the atmosphere, the reflected amplitude would be found to be much smaller than for nitrogen gas only, in fact too small to explain propagation to great distances.

A calculation is then made of the time necessary for the reflection of a signal consisting of a train of waves of varying amplitude. Under various assumptions, times are found of the order of 5×10^{-4} sec., which is quite different from that of the long period echoes. These can thus not be explained with the type of ionisation assumption made in this paper. The author is of the opinion that, if reflection is assumed to take place at a finite height and the reflected amplitude is finite, the possibility of an infinite reflection time has not yet been rigorously proved.

RADIO TELEPHONY DISTORTION [ON SHORT WAVES: PARTIAL DISAPPEARANCE OF MODULATION WITH RETENTION OF CARRIER].—T. L. Eckersley. (*Marconi Review*, March–April, 1931, pp. 12–18.)

In certain conditions the carrier of a telephone station is strongly received but with very little or no trace of modulation: the effect is most marked within the skip distance. The writer shows how the phenomenon can be explained as the result of the presence of echoes from scattering centres in the Heaviside layer; the side waves being, as a result, random phased with respect to the carrier. His explanation brings to light the fact that single side band transmission with suppressed carrier will eliminate this effect. "Improvements in frequency stability of transmitters will probably enable such methods to be used [on short waves, where at present they have met with great difficulties], and will eliminate not only the effect discussed, but also the more normal type of fading dependent on the product of the carrier and side band intensity" [*cf.* April Abstracts, p. 204; and for a demonstration of suppressed carrier working on short waves, *see* these Abstracts, under "Transmission"].

THE CYLINDRICAL IONISED FIELD AND THE PATH TIME OF THE IONS.—Pauthenier and Moreau-Hanot. (*See* under "General Physical Articles.")

HIGH FREQUENCY BEHAVIOUR OF A PLASMA.—L. Tonks. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, p. 1020.)

An extension of the work referred to in 1929 Abstracts, p. 273. Abstract only:—Earlier work on spontaneous short-wave oscillations in a low-pressure mercury arc plasma has been extended to forced oscillations by experiments similar to those of H. Gutton [1930 Abstracts, pp. 207–208 and 267]. Theory gives $K = 1 - \nu_e^2/\nu^2$ where ν is the impressed, ν_e ($= 8980\,(N_e)^{\frac{1}{2}}$) the plasma-electron frequency, for the specific inductive capacity of a plasma. The unit cube thus behaves like a tuned shunt circuit $C = 1/4\pi$, $L = m_e/N_e e^2$. This disagrees with Gutton's conclusion. A modified Mossotti theory requires that a cylindrical plasma between plane condenser plates show shunt resonance when $\nu_e = (2)^{\frac{1}{2}}\nu$. With a constant impressed frequency, the positive column of a Hg arc always resonated at two values of arc current (ionization density) and sometimes at three, due possibly to the non-uniformity of the plasma cross-section. The two main resonance densities were roughly in the ratio 2 to 5 and lay above and below the theoretical value. The variation with frequency was $\nu_e \propto \nu^{1.1}$ cf. $\nu^{1.0}$ theoretically. Above resonance ($\nu_e > (2)^{\frac{1}{2}}\nu$) the variation of K with ν_e as given above was confirmed.

ZUR FRAGE NACH DER NATUR DER LANGZEITECHOS (On the Question of the Nature of the Long-Delay Echoes).—G. Joos. (*Zeitschr. f. hochf. Tech.*, April, 1931, Vol. 37, p. 136.)

Van der Pol's explanation is based on a largely decreased group velocity in the ionised layers. The writer considers that sufficient attention has not been given to the fact that such a decreased group velocity would be accompanied by a very marked dispersion. Taking the case of a 30-metre wave, and assuming the group velocity to be reduced to one hundredth of the vacuum velocity of light, he arrives at the fact that if the wave were modulated at 1,000 c.p.s. the one side band would have a group velocity twice that of the carrier, while the other side band would have zero group velocity. He admits that this calculation is not correct, since other terms of the Taylor series should have been considered; but it shows qualitatively that the dispersion would be so great that a modulated signal of 1 second's duration could not be reproduced as a long-time echo. He therefore suggests that a test with alternately modulated and unmodulated waves would decide between van der Pol's interpretation and the toroidal space theory of Störmer.

VERSAGEN DER KURZEN WELLEN AUF DER LINIE EUROPA-NORDAMERIKA IN DER ZEIT VOM 8. BIS 12. AUGUST 1930 (Short Wave Failure on the Europe—N.America Service, 8th to 12th August, 1930 [and a Possible Connection with Meteoric Showers].—E. Quäck: Nagaoka. (*E.N.T.*, January, 1931, Vol 8, pp. 46–48.)

The writer refers to the correlation between magnetic disturbances and fading, worked out by Mögel in the paper dealt with in March Abstracts,

p. 144. On certain days, however, the magnetic disturbances were slight and the fading marked; this applies particularly to the period mentioned in the title, and the writer looks about for an additional cause for the strong fading. "A clue is furnished by a paper published by H. Nagaoka in the Tokio '*Institute of Physical & Chemical Research*' under the title 'The Possibility of the Disturbance of Radio Communication by Meteorite Showers'" (*see* also 1930 Abstracts, p. 270).

He then reproduces this paper of Nagaoka's, which develops the idea mentioned in the above abstract and mentions that data provided by Nakagami indicate a correlation between disturbances in the Transoceanic service during the past 3 years and certain meteoric showers; the observations of Yokoyama (1930 Abstracts, p. 563) are also referred to.

Quäck then announces that he will be publishing the results of an enquiry, in collaboration with Hoffmeister of the Sonnenberg Observatory, as to such correlation on the Europe—N. America service. Meanwhile, he gives details of the conditions on that service during the particular period mentioned. He calls attention to the fact that other short wave services, to all parts of the world, suffered from disturbance on those days, if not to the same extent; whereas the long wave services (13–18 km.) were able to maintain communication, although with decreased speed.

Effects of Sun Spots and Terrestrial Magnetism on Long-distance Reception of Low-frequency Waves.—E. Yokoyama and T. Nakai. (*Proc. Inst. Rad. Eng.*, May, 1931, Vol. 19, pp. 882–890.)

A companion paper to that dealt with in 1930 Abstracts, p. 562. Authors' summary:—Daily average variations of sun spots and field intensity are not simply related. What mostly occurs are the effects which vary as the period of the sun's rotation and one-half thereof. Phase relations are generally found in about 180 degrees and 90 degrees. There is no indication of different effects between daylight and darkness waves.

The relation between their monthly average variations is, in general, not obvious. However, direct relation is observed on some stations in summer, whereas inverse relation is noted in winter in several cases, the relation being less clear in the latter season.

Daily average variations of terrestrial magnetism and field intensity are also not simply related. However, field intensity usually reaches its maximum from two to four days before the day of occurrence of magnetic disturbance and then gradually decreases until it reaches its minimum from two to four days after that day. There is also no indication of different effects between daylight and darkness waves. The relation is not clearly found for monthly average variations.

Influence of the Moon on Radio Reception.—H. T. Stetson: Breckel. (*Sci. News Letter*, 2nd May, 1931, p. 278.)

See also the next abstract. A further note on the unfavourable influence of the moon on reception (*see* June Abstracts, p. 317). Stetson found that the average strength of signals for the last few years between Chicago and Boston was about 100 % better when the moon was below the horizon. It is suggested that the effect is due to a negative electrical charge on the moon causing a "pushing down" of the Heaviside layer. "The unfavourable influence of the moon on the reception of radio waves of 4,000 kilocycles has also been independently established by Lieut. H. F. Breckel of the U.S. Navy Department . . . ." For Pickard's criticism of Paulson's report on a lunar effect on propagation, *see* 1928 Abstracts, p. 637.

On the Correlation of Radio Reception with the Position of the Moon in the Observer's Sky.—H. T. Stetson. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, p. 1021.)

See also preceding abstract. Summary only:—Observations of the intensities of radio reception at the Perkins Observatory and elsewhere have been utilized for a study of correlation of signal strengths with cosmic phenomena. Papers already published by the writer and by Greenleaf W. Pickard call attention to apparent change in the altitude of the Kennelly-Heaviside layer with the change in solar activity. The same data have now been utilized in an investigation of the possible relation between the intensity of signal strength and the position of the moon with respect to the observer, on the assumption that the moon is at a different electrical potential from that of the earth. The result of the observations indicates that the height of the Kennelly-Heaviside layer is substantially decreased by the presence of the moon above the horizon, and elevated as the moon passes underneath the observer. A plausible explanation follows on the assumption that the moon is negatively charged with respect to the earth. The form of the curve showing correlation between the moon's altitude and the intensity of radio reception suggests an electronic tide which follows a hypothetical equipotential surface in the electrostatic field of the earth-moon system.

Über die Ausbreitung elektromagnetischer Wellen (The Propagation of Electromagnetic Waves).—B. van der Pol. (*Zeitschr. f. hochf. Tech.*, April, 1931, Vol. 37, pp. 152–156.)

Covering the same ground as the Dutch paper dealt with in 1930 Abstracts, pp. 560–561.

Short-Distance Observations on Long-Wave Phenomena.—R. Naismith. (*E.W. & W.E.*, May, 1931, Vol. 8, pp. 254–255.)

Long abstract of an I.E.E. (Wireless Section) paper describing experiments which show that, contrary to the usual assumption, reflection from the ionized layer plays a part in the propagation of long waves even to relatively short distances (100 to 400 km.). Rugby (18,700 m.) gave surprisingly large variations of intensity at Slough, 111 km. away, over a period of six months. Simultaneous measurements of Rugby at Tadworth, Surrey, and at Manchester—points about equidistant—gave 18.6 mv/m. at the former and only

11.4 mv/m. at the latter, though polar curve tests round Rugby at 35–45 km., where no downcoming wave effect was found, showed that there was no direction of maximum radiation. Again, tests on Northolt (6,950 m.) at Manchester and Exeter gave an average intensity at the former about twice that at the latter; since the distances were almost equal, the indirect wave received at Manchester must have been much greater. To Manchester, the wave travelled approximately in the plane of the magnetic meridian, and to Exeter, more nearly at right angles to it. The writer suggests that at short distances more energy is returned in the S.-N. direction than in the E.-W., and that therefore less energy is left to travel to greater distances in the former than in the latter direction—thus fitting in with the Marconi Company's cruise results where no long-distance signals were received from New York when the great circle between the vessel and New York was over or near the N. and S. poles. Other results discussed deal with magnetic storms, sunset effects, and the large apparent rotation of the plane of polarisation.

Field-Strength Measurements on Daventry 5XX.—R. Naismith: Reyner. (*E.W. & W.E.*, May, 1931, Vol. 8, pp. 253–254.)

Abstract of an I.E.E. (Wireless Section) paper, on tests undertaken to elucidate Reyner's Cornwall results (1930 Abstracts, pp. 208–209), which he interpreted as due to a radio shadow thrown by the Bodmin beam station. The present writer finds no evidence of such shadows, and attributes the peculiarly shaped contours plotted in Cornwall, and the rapid attenuation west of Launceston, to the influence of the large, irregularly shaped moor rising to the hill "Brown Willy." A discussion is summarised on pp. 255–256. For a paper on the effects of hills, mountain ranges, etc., *see* next abstract (Ollendorff).

Die Beugung elektromagnetischer Wellen an kapazitiv erregten Sekundärstrahlern (The Bending of Electromagnetic Waves at Capacitively Excited Secondary Radiators).—F. Ollendorff. (*E.N.T.*, April, 1931, Vol. 8, pp. 147–161.)

The radiators thus defined are obstacles in the path of electromagnetic waves whose re-radiated fields near at hand are pre-eminently electrostatic; the electrodynamic dimensions of such an obstacle must therefore be small compared with the wave-length, since otherwise the distinct path-length differences within the obstacle would prevent this condition being fulfilled. The treatment is on the lines of Rayleigh's treatment of optical diffraction. The secondary radiation is determined by potential theory methods for a number of technically important cases. If the obstacle possesses rotational symmetry it can be replaced, with sufficient accuracy, by a single Hertz dipole. This already-known result is put on a quantitative basis by the introduction of the idea of a "transit capacity": the charging current of this capacity in an incident wave field, multiplied by the height of the obstacle, gives that dipole moment of the secondary radiator on which the excitation of the scattered secondary waves depends.

The value of the transit capacity is found for several frequently met-with obstacles:—for a hemisphere, representing a house; for a flattened ellipsoid of rotation representing a flattened structure, flat topped hillock, etc.; for a high, narrow ellipsoid of rotation, as a model for a high building or a tower; and finally for an elliptic cylinder as a model for a mountain range. Since the secondary waves interfere with the primary, a diffraction zone is formed around the obstacle, within which the resultant field is markedly different from the field of the primary waves. The size of this diffraction zone is calculated for each of the examples taken. It is found that high buildings such as are met with in cities are quite enough to upset the propagation of waves in the broadcast band. Particularly marked is the effect of long mountain ranges; here the diffraction wave takes the form of a cylindrical wave whose intensity decreases only slowly, with the square root of the reciprocal of the distance, so that an especially large area of diffraction zone results. It is suggested that this phenomenon should be of use in warning aircraft of their approach to mountains; the interference between the direct and the bent waves being indicated by abnormal fluctuations in the strength of signals received.

In the above it is assumed that the incident wave arrives in a direction at right angles to the mountain range: a later paper will deal with oblique incidence and its results, which are of importance—for example—in connection with errors in direction finding.

Twenty-four-hour Receiving Measurements of Low-frequency Radio Stations—Bolinas, Bordeaux, Kahuku, Malabar and Saigon.—E. Yokoyama and I. Tanimura. (*Res. Electrot. Lab., Tokio*, January, 1931, No. 297, 110 pp.)

Pfeiftöne aus der Erde (Whistling Tones from the Earth).—H. Barkhausen. (*Zeitschr. f. hochf. Tech.*, April, 1931, Vol. 37, pp. 123–125.)

See 1930 Abstracts, pp. 622–623. In the present paper the writer goes rather more thoroughly into his *second* suggested explanation. He urges further research on the subject to decide whether the source is a distant lightning flash or whether T. L. Eckersley's belief in the dependence of the "whistlers" on magnetic storms is correct.

A Photoelectric Spectrophotometer for Measuring the Amount of Atmospheric Ozone.—G. M. B. Dobson. (*Proc. Physical Soc.*, 1st May, 1931, Vol. 43, Part 3, pp. 324–339.)

Ozongehalt der unteren Atmosphärenschichten (Ozone Content of the Lower Layers of the Atmosphere).—F. W. P. Götz and R. Ladenburg. (*Naturwiss.*, 1st May, 1931, Vol. 19, No. 18, pp. 373–374.)

The results of optical experiments on the transparency of the lower atmospheric layers in the frequency region of the ozone bands, made in the spring of 1930, show that these layers contain a noticeable quantity of ozone. *Cf.* Chalonge and Dubois, June Abstracts, p. 317.

OZONE IN THE UPPER ATMOSPHERE AND ITS RELATION TO METEOROLOGY.—G. M. B. Dobson. (*Nature*, 2nd May, 1931, Vol. 127, pp. 668–672.)

A general account of the present state of knowledge of atmospheric ozone.

THE ELECTRICAL LAYERS OF THE ATMOSPHERE.—W. C. Reynolds. (*Nature*, 9th May, 1931, Vol. 127, p. 704.)

A letter pointing out causes for considering the existence of a dividing layer in the atmosphere at a height (in Central Europe) of from 7 to 12 km.

THE INSTRUMENTAL PHASE-DIFFERENCE OF SEISMOGRAPH RECORDS; AN ILLUSTRATION OF THE PROPERTIES OF DAMPED OSCILLATORY SYSTEMS.—F. J. Scrase. (*Proc. Physical Soc.*, 1st May, 1931, Vol. 43, Part 3, pp. 259–274.)

APPLICATION OF SPINOR ANALYSIS TO THE MAXWELL AND DIRAC EQUATIONS.—O. Laporte and G. E. Uhlenbeck. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, p. 1022.)

Abstract only.

THE PRESENT POSITION IN THE DEVELOPMENT OF THE ULTRA-SHORT WAVES, WITH REGARD TO THEIR PRACTICAL POSSIBILITIES FOR BROADCASTING. — Gerth. (*See* under "Stations, Design and Operation.")

ULTRA-SHORT-WAVE BROADCASTING.—Schwandt. (*See* under "Stations, Design and Operation.")

RADIO TRANSMISSIONS ON ULTRA-SHORT WAVES OF THE ORDER OF 17 CENTIMETRES.—Ferrié. (*See* abstract under "Transmission.")

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

LOW ALTITUDE AURORA.—G. C. Simpson. (*Nature*, 2nd May, 1931, Vol. 127, p. 663.)

A. Corlin has described (*cf.* June Abstracts, p. 319) an observation which convinced him that the aurora can appear under the clouds; in this letter the author describes a similar phenomenon in circumstances which convinced him that the whole effect was an illusion and that the aurora was above and not below the clouds.

ÜBER DEN URSPRUNG DER DURCHDRINGENDEN KORPUSKULARSTRAHLUNG DER ATMOSPHÄRE (On the Origin of the Penetrating Corpuscular Radiation of the Atmosphere).—B. Rossi. (*Zeitschr. f. Phys.*, 1931, Vol. 68, No. 1/2, pp. 64–84.)

ORIGIN OF COSMIC PENETRATING RADIATION.—A. K. Das. (*Naturwiss.*, 3rd April, 1931, Vol. 19, No. 14, pp. 305–306

ULTRA-PENETRATING RAYS.—H. Geiger. (*Nature*, 23rd May, 1931, Vol. 127, pp. 785–787.)

The opening paper of a discussion at the Royal Society; a short account of the methods and results of the various experiments on ultra-penetrating rays, particularly of the secondary radiation experiments. The conclusion reached is that these experiments can only be interpreted "by regarding the ultra-radiation as made up of material particles such as protons with the energy of an ultra-quantum."

AN ATTEMPT TO MEASURE THE ENERGY OF THE COSMIC ELECTRONS BY MAGNETIC DEFLECTION.—L. M. Mott-Smith. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, pp. 1001–1003.)

DER STOSS-DURCHSCHLAG DER LUFT NACH UNTERSUCHUNGEN MIT DEM KATHODENOSZILLOGRAPHEN (Impulsive Breakdown of the Air, Investigated with the Cathode Ray Oscillograph).—H. Viehmann. (*Archiv f. Elektrot.*, 15th April, 1931, Vol. 25, No. 4, pp. 253–266.)

DURCHSCHLAG UND ÜBERSCHLAG IN LUFT BEI DRUCKEN VON 1 BIS 30 AT. (Breakdown and Spark-over in Air at Pressures from 1 to 30 atmos.).—C. Reher. (*Archiv f. Elektrot.*, 15th April, 1931, Vol. 25, No. 4, pp. 277–298.)

OBSERVATIONS SUR LES DÉTONATIONS ATMOSPHÉRIQUES PRÉCÉDANT LES PERTURBATIONS SOLAIRES ET TERRESTRES (Observations on Atmospheric Detonations preceding Solar and Terrestrial Disturbances).—A. Nodon. (*Comptes Rendus*, 27th April, 1931, Vol. 192, pp. 1047–1049.)

Followed by remarks by E. Esclangon.

ZUR VERGLEICHBARKEIT METEOROLOGISCHEN STRAHLUNGSMESSUNGEN (On the Comparability of Meteorological Radiation Measurements).—W. Mörikofer and F. Levi. (*Naturwiss.*, 8th May, 1931, Vol. 19, No. 19, p. 309.)

A note on a method of calibrating the photoelectric cadmium cells used to measure the intensity of ultra-violet solar radiation, to compensate for the varying distribution in the ultra-violet spectrum at equal heights of the sun.

[ATMOSPHERIC] INTERFERENCE IN OCEAN CABLE TELEGRAPHY. — J. W. Milnor. (*Elec. Engineering*, April, 1931, Vol. 50, pp. 281–283.)

WHISTLING TONES FROM THE EARTH.—Barkhausen. (*See* under "Propagation of Waves.")

PROPERTIES OF CIRCUITS.

ZUR THEORIE DER RÜCKKOPPLUNG BEI HOCHFREQUENZEMPFÄNGERN (On the Theory of Retroaction in High Frequency Receivers).—R. Feldtkeller and W. Kautter. (*E.N.T.*, March, 1931, Vol 8, pp. 93–103.)

The writers set out to obtain, in as general a form as possible, the fundamental equations of an amplifier stage with retroaction; they refer to Watanabe's treatment of the amplification of a narrow radio-frequency band (1928 Abstracts, p. 685) but consider that his circuit is of only slight interest as an input circuit for a modern receiver. They set themselves to obtain the complete solution of one of the possible complex systems—the admittance system; when this is found, the calculation of other properties of the circuit presents no theoretical difficulties although the working-out may be laborious.

They give the generalised retroaction circuit and show how it may be represented by six separate quadripoles with their input and output terminals connected in parallel. From this equivalent circuit they obtain, in their most general form, the fundamental equations (equation 22, p. 96) and from these they derive the expression for the total input admittance (equation 36, p. 97). They then apply these results to the simplified case of a purely inductive retroaction, and obtain equation 40. In section 5 they obtain approximate solutions for the amplification and selectivity of the retroactive circuit, yielding the equation 71,

$$im\sqrt{e^{2\Delta b}-1}=\frac{2\Delta\omega}{L_1C_A\omega^3},$$

where m is the ratio aerial e.m.f. to a.c. grid potentail. If $\sqrt{e^{2\Delta b}-1}$ is called the "selectivity" of the circuit, it is seen that the product of the selectivity and m is inversely proportional to the cube of the frequency, provided the aerial capacity C_A and the primary winding inductance L_1 are both kept constant. *If both the quantities, selectivity and amplification, are to remain independently constant,* either the aerial capacity or the primary inductance, or both, must be considerably reduced with increase of frequency.

The final section deals in detail with the values of the components of a receiver with constant primary inductance.

THEORY AND OPERATION OF TUNED RADIO-FREQUENCY COUPLING SYSTEMS.—H. A. Wheeler and W. A. MacDonald. (*Proc. Inst. Rad. Eng.*, May, 1931, Vol. 19, pp. 738–805.)

Author's summary:—The subject is the tuned r-f coupling systems commonly used in broadcast receivers, to couple the antenna to the grid of the first tube, and to couple the plate of each r-f amplifier tube to the grid of the following tube. The simple tuned r-f transformer used in the 1923 neutrodyne receiver has been improved by the co-operation of different kinds of impedances in the primary circuit. The "equivalent mutual inductance" is thereby caused to vary with frequency in a predetermined manner, without the use of any moving elements except the tuning condenser; this is also referred to as a varying "effective turns ratio." The gain of an amplifier can be held uniform or made to vary with frequency in any desired manner consistent with the amplifying ability of the tube and the tuned secondary circuit, and without appreciable loss of selectivity. A large variety of these improved coupling circuits are shown and classified in terms of the fixed and varying components of the equivalent mutual inductance. A large number of these coupling systems from commercial broadcast receivers are described in terms of coil structure, electrical constants, and performance. These include antenna and amplifier circuits dating from 1924 to date, and used in unneutralised, neutralised, and screen-grid receivers. Special attention is paid to antenna circuits for unicontrol receivers, whose tuning is substantially independent of antenna capacitance and of the adjustment of a shunt rheostat sometimes used as a volume control. The problems involved are treated mathematically with the aid of general theorems and specific examples.

ZUR THEORIE ZWEIER GEKOPPELTER SCHWINGUNGSKREISE. II. (On the Theory of Two Coupled Oscillatory Circuits. Part II.)—V. Petržilka. (*E.N.T.*, March, 1931, Vol. 8, pp. 122–131.)

In the first part of this paper (1930 Abstracts, p. 625) the writer found the general expressions for the total energy applied to two coupled circuits, and the expressions for the partial energies of the primary and secondary circuits in dependence on the dampings, coupling and de-tuning; further, he applied these results to the special case (*a*) where ω is varied while ω_1 and ω_2 (the natural frequencies of the two circuits) are equal and constant.

In the present part, the remaining cases are similarly dealt with, namely where (*b*) $\omega_1 \neq \omega_2$ but both remain constant while ω, as before, is varied; (*c*) ω is kept constant while either ω_1 or ω_2 varies; and (*d*) all three frequencies vary, but maintain a relation represented by the so-called "frequency equation" of the intermediate circuit transmitter circuit already dealt with by Heegner, Pauli, Albersheim and others.

ZUR DEMONSTRATION VON KOPPELUNGSSCHWINGUNGEN (A Demonstration of the Oscillations of Coupled Systems).—W. Kossel. (*Zeitschr. f. hochf. Tech.*, April, 1931, Vol. 37, pp. 139–141.)

A simple demonstration apparatus consisting of two rigid pendulums, each of continuously variable period, which can be variably coupled together by a weak spiral spring. Perhaps the most important point demonstrated is that in order to obtain resonance phenomena the frequencies which must be adjusted to equality are *not* the natural frequencies of the separate pendulums *but the frequencies which each displays as a component of the whole system.* The writer considers this result mathematically and examines its implications as regards electrical oscillatory circuits (*cf.* May Abstracts, p. 265). In such circuits "exactly the same relations . . . are found provided the coupling is carried out by the addition of special coupling organs (coils, condensers). But it is quite otherwise when, without adding new organs, the circuits are linked together by the lines of force of already existing inductances."

SELECTIVITY, A SIMPLIFIED MATHEMATICAL TREATMENT.—B. de F. Bayly. (*Proc. Inst. Rad. Eng.*, May, 1931, Vol. 19, pp. 873–881.)

Author's summary:—This paper gives a simple formula for finding the voltage gain of a resonant circuit at different frequencies in terms of that at resonance. Tables and curves are given in decibels below the resonant value so that calculations are quickly made.

Means of converting the ordinary radio-frequency circuit into an equivalent simple resonant circuit are given so that a close approximation of its behaviour may be obtained, especially in cascaded circuits of diverse tuning.

The criteria for maximum gain, etc., are discussed by means of the equivalent circuit. A new expression for selectivity is proposed in terms of decibels below resonance. The principle of diverse tuning of cascading circuits to obtain band-pass effects is discussed.

BAND-PASS FILTERING BY DIVERSE TUNING OF CASCADING CIRCUITS.—Bayly. (*See* preceding abstract.)

THE SELECTIVITY OF THE SUPERHETERODYNE.—Cocking. (*See* under " Reception.")

BAND-PASS AMPLIFIER STAGES.—Couillard. (*See* under " Reception.")

BAND-PASS FILTERS IN RADIO RECEIVERS.—G.W.O.H. (*See* under " Reception.")

A SYSTEM FOR SUPPRESSING HUM BY A NEW FILTER ARRANGEMENT.—P. H. Craig. (*See* under " Subsidiary Apparatus.")

THE AMPLIFICATION OF A LOW-FREQUENCY TRANSFORMER-COUPLED STAGE AS A FUNCTION OF FREQUENCY AND AMPLITUDE.—R. Watrin. (*L'Onde Élec.*, March, 1931, Vol. 10, pp. 121–130.)

Second and final part of the paper dealt with in June Abstracts, p. 321.

BERECHNUNG DER VERSTÄRKUNG DES ZWISCHENFREQUENZ-GLEICHRICHTERS (Calculation of the Amplification of the Intermediate Circuit Detector).—P. Hermannspann. (*Zeitschr. f. hochf. Tech.*, April, 1931, Vol. 37, pp. 134–135.)

Ballantine, in his paper on detection at high signal voltages (1929 Abstracts, p. 570), abandons the usual d.c. characteristics and starts with the experimentally determined rectification characteristic of the valve, building up a new theory in a series of powers, not of E_0, but of mE_0, and the various differential parameters of the rectification characteristic. In this series the first order term gives the rectifying effect (Ballantine calls the parameter $P_1 = \partial I_p/\partial E_g$ the "transrectification factor," analogous to the mutual conductance of the amplifier theorem). The present writer reproduces this part of Ballantine's paper and makes use of it for the calculation of the amplification of an intermediate circuit detector (ratio of the intermediate frequency voltage in the anode circuit of the detector to the received voltage acting on its grid). It is found that the optimum amplification is half as large as the optimum high-frequency amplification of the same valve.

ZUR THEORIE EINES GLEICHRICHTERS MIT FALLENDER, HYPERBELFÖRMIGER KENNLINIE (The Theory of a Rectifier with Falling Characteristic of Hyperbolic Form).—O. Stierstadt. (*E.N.T.*, Jan., 1931, Vol. 8, pp. 31–38.)

The method of working of such a rectifier is examined theoretically. It is shown that the most important working data, for any particular load, can be read off a diagram—the " rectification characteristic "—obtained by selecting various working points on the characteristic for a fixed a.c. potential $e = \epsilon \sin \omega t$, keeping the d.c. bias always greater than ϵ, measuring off the mean current for each point, and plotting these mean currents against the d.c. bias.

In particular, the rectification characteristics for constant a.c. power output and for constant a.c. potential are derived and discussed. The criteria for stability are considered, and from these the limiting working conditions are obtained. Maximum rectified output is given by the rule of matched resistances.

NEGATIVE CIRCUIT CONSTANTS.—L. C. Verman. (*Proc. Inst. Rad. Eng.*, April, 1931, Vol. 19, pp. 676–681.)

" . . . It is clear, therefore, that a good deal of work could be done in the development of stable negative resistances that would stay constant over long periods and at the same time be applicable to a.c. circuits. It seems that the progress in this direction has been rather slow, chiefly owing to the fact that convenient alternative means are available for accomplishing the chief purposes for which the negative resistance might be used; for example, oscillators, voltage and current amplifiers, etc. The number of possible applications, however, has been considerably increased by the suggestion of negative inductance and negative capacitance [Bartlett, *J.I.E.E.*, 1927: van der Pol, 1930 Abstracts, p. 272], so that now we have at our disposal, at least theoretically, all the three fundamental circuit constants with negative as well as positive values. It is the purpose of this paper to discuss some new possible applications of these negative impedances to accomplish novel results."

New names are suggested—nesistance, ninductance and napacitance. It is shown that for transient states the ninductance and napacitance respond as would be expected of true negative circuit constants. External circuits are suggested to vary the nesistance of a given valve system. A system of circuits is described by means of which it is possible to obtain impedances proportional to $\pm (j\omega)^n$, where n is any positive or negative integer.

THE THEORY OF THE DYNATRON.—Ito. (*See* under " Valves and Thermionics.")

UN NOUVEAU TUBE AMPLIFICATEUR DE PUISSANCE AVEC TENSION DE GRILLE POSITIVE (A New Power Amplifier Stage with Positive Grid).—B. Decaux: L. Thompson. (*L'Onde Élec.*, March, 1931, Vol. 10, p. 26A.)

Summary of an *Electronics* article. In order to use valves with high amplification factor, and thus with large internal resistance, it is necessary to use positive grid potentials, which lead to distortion due to the grid current. Thompson suggests reducing this distortion by connecting two valves in opposition, the filament of one connected to the grid of the other. In this way the input transformer works in perfect symmetry. In order that the combination may behave as a uniform resistance, the grid characteristic must be rectilinear; this is obtained by the secondary grid emission which compensates the too rapid rise of the normal grid current; the filament temperature is also reduced for the same purpose. Decaux doubts whether the additional gain (about 3 times) is worth the complication.

OUTPUT NETWORKS FOR RADIO-FREQUENCY POWER AMPLIFIERS.—W. L. Everitt. (*Proc. Inst. Rad. Eng.*, May, 1931, Vol. 19, pp. 725–737.)

Author's summary:—At high frequencies a transformer consisting of primary, secondary, and mutual inductances cannot be constructed to match a generator effectively to a resistive load. By introducing capacitative elements, such a match can be obtained.

The design of reactance networks to connect a resistive load efficiently to a source of power can be carried out most conveniently by the theory of image impedances. Such reactance networks can provide not only for high efficiency but can also attenuate undesired harmonics.

A variety of configurations can be designed to accomplish the desired result. The network can also be arranged to provide extremely high attenuation at designated frequencies.

The most efficient network is one designed for critical coupling, assuming a constant Q for the inductances. The efficiency also depends on the impedance ratio.

OSCILLATIONS IN THE CIRCUIT OF A STRONGLY DAMPED TRIODE.—F. Vecchiacci. (*Proc. Inst. Rad. Eng.*, May, 1931, Vol. 19, pp. 856–872.)

Translation of the Italian article referred to in 1930 Abstracts, p. 625. Author's summary:—The following is a study of the particular action produced by a triode oscillator when the relation of the inductance to the capacity, L/C, is greater than the square of the internal resistance, ρ^2, and when the reactive coupling between plate and grid is greater than the limit required for starting oscillation. The shape of the oscillation curve is clearly other than sinusoidal, the frequency is much lower than that usual in the LC circuit, and is determined essentially from the constants of the triode and from the current.

OVER DE TRILLINGEN VAN REGULATEURS EN VAN TRIODELAMPEN (On the Oscillations of Regulators and of Triodes). — Ph. le Corbeiller. (*Tijdschr. Nederl. Radiogenootschap*, Feb., 1931, Vol. 5, No. 2, pp. 39–56.)

A theoretical study of the analogy between oscillations in an engine regulator and in triode oscillators; the case of a thermostat is also considered and the extension of the theory to relaxation oscillations is indicated.

ÜBERSETZUNGSVERHÄLTNIS BEI KAPAZITIVER SPANNUNGSTRANSFORMATION (Transformation Ratio in Capacitive Voltage Transformation).—E. Zakarias. (*E.N.T.*, Jan., 1931, Vol. 8, pp. 42–45.)

GROUP THEORY AND THE ELECTRIC CIRCUIT.—N. Howitt. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, p. 1015.)

Abstract only. "The paper shows that electrical networks consisting of inductances, resistances and capacitances form a group with the impedance function as an absolute invariant."

EINSCHALTVORGANG DER KAPAZITIV BELASTETEN ENDLICHEN LEITUNG BEI ENDLICHER STIRNSTEILHEIT DER SCHALTWELLE NACH DER OPERATORENRECHNUNG (Transient Phenomena in the Capacity Loaded, Finite Cable with Finite Initial Steepness of the Transient Wave, on the Operational Calculus).—W. Schilling. (*Archiv f. Elektrot.*, 15th April, 1931, Vol. 25, No. 4, pp. 241–252.)

AUSGLEICHSSTRÖME BEI PARALLELEN EINZELLEITUNGEN, VON DENEN DIE EINE IN DER ERDE LIEGT UND UNENDLICH LANG IST (Compensating Currents in Separate Parallel Lines, One of Which is Buried and of Infinite Length).—J. Riordan. (*E.N.T.*, March, 1931, Vol. 8, pp. 134–136.)

A supplement to Ollendorff's work (March Abstracts, p. 169.)

CALCULATION OF MAXIMUM ELECTRICAL STRESS BETWEEN TWO WIRE CONDUCTORS, ARRANGED IN DIFFERENT WAYS WITH AIR AS THE DIELECTRIC.—G. Yoganandam. (*Electrician*, 8th May, 1931, Vol. 106, pp. 686–687.)

The capacity and maximum electrical stress between two wire conductors are determined for the following arrangements: parallel wires, crossed wires, parallel rings and linked rings. It is found that the parallel arrangement of rings gives the least capacity and least electrical stress, while the linked rings give the greatest voltage-gradient. "Such knowledge is of great importance in the design of high-voltage circuits."

DIE FRAGE DER FREQUENZ BEI DER INDUKTIVEN ERWÄRMUNG (The Part Played by Frequency in the Heating produced by Induction).—W. Fischer. (*Zeitschr. f. hochf. Tech.*, April, 1931, Vol. 37, pp. 127–133.)

Author's summary:—In analogy with the skin-effect in straight wires, the skin-effect in an axial field is calculated. From the functions thus found, conclusions are drawn for the dimensioning (*a*) of induction furnaces utilising the inductive heating, and (*b*) of component parts in which such heating is to be avoided.

TRANSMISSION.

TRANSMISSIONS RADIOTÉLÉGRAPHIQUES OU RADIOTÉLÉPHONIQUES SUR ONDES TRÈS COURTES (Radiotelegraphic or Radiotelephonic Transmissions on Ultra-Short Waves [of the order of 17 Centimetres]).—G. Ferrié. (*Ann. des P.T.T.*, April, 1931, Vol. 20, pp. 253–258.)

A paper on the ultra-short wave researches at the Nancy Laboratory of Physics and the Paris National Laboratory of Radioelectricity. It deals first with the Pierret generating circuits (*see* Abstracts, 1928, pp. 402 and 465; 1929, p. 149—two—and 448—Beauvais; 1930, p. 43—left-hand column) the "most practical" of which he describes as follows:—"To the 'horn' which is connected to the grid, a copper wire a few centimetres long is fixed, constituting the antenna. At the point on this wire where the potential remains constant in spite of the oscillations, the antenna is connected to the positive pole of an accumulator battery, or dynamo, of e.m.f. 250 to 300 v. The negative pole is connected to the filament. The anode is raised to a lower positive potential by a dry battery of about 40 v. In these conditions, a suitable adjustment of grid and plate voltages, antenna length and contact point on the antenna, will give rise to sustained oscillations in the grid-antenna combination. When these take place, a current forms in the plate circuit; its intensity is a fraction of a milliampère and it passes through the plate battery in a direction opposing the e.m.f. of the latter." The electrons in the valve oscillate *on both sides* of the grid, producing a frequency twice that of their motion.

The writer describes briefly how these oscillations are detected and measured by a Lecher wire system and thermo-junction. "A valve of type Métal T M C gives a wavelength of about 17 cms" (1930 Abstracts, p. 628, Gutton and Pierret). The value of the thermo-junction resonance current enables one to find the transmitter adjustments (voltages and contact-point) which give maximum strength of oscillation. He then goes on to describe the use of reflectors (1929 Abstracts, Beauvais, pp. 149 and 326; Pierret, p. 565). Beauvais, for ease of construction, used fine metal gauze: "on account of the bad contacts between the copper wires, it is better to employ a continuous metal surface."

The Pierret receiver (1930 Abstracts, p. 43, right-hand column; also Beauvais, *loc. cit.*) similar to the transmitter but with a grid voltage of only 120 v., is then referred to. Super-reaction greatly increases the sensitivity, and is provided by introducing into the grid circuit an oscillatory circuit of wavelength between 15 and 30 m., and coupling this to a coil in the plate circuit. The correct adjustment is obtained by varying the coupling and the potentiometer (across the filament, its contact leading to the telephone, or input winding of l.f. amplifier, in the grid circuit).

The range results of Beauvais (Abstracts, 1931, p. 39) and of Gutton and Pierret (Abstracts, 1930, p. 628), Mlle. Husson's work on the mechanical action of the waves (1930, p. 502), Sonada's determination of the radiation resistance of very small half-wave aerials (1930, p. 570; 1931, p. 97), and Gutton and Beauvais' researches, after Garbasso, on the reflection by resonators (1931, p. 143), are all briefly referred to.

For the I.T. and T. England-France demonstration on 18 cms., *see* June Abstracts, p. 339.

SINGLE SIDE-BAND TELEPHONY ON SHORT WAVES.—Le Matériel Téléphonique, Paris: A. H. Reeves. (*The Times*, 22nd May, 1931, p. 13.)

Description of a recent demonstration given near Paris, when speech was received from Madrid which was clear, intelligible, and of good and constant volume. The wavelength is not actually stated, but it is mentioned that "on a wavelength of 15 metres a difference of no more than one-millionth is admissible" (in the accuracy of synchronisation between the transmitter and the local oscillator replacing the carrier at the receiving end). This is obtained by the use of "a high-frequency pilot signal which, transmitted simultaneously with the main wave and requiring very little power, automatically controls the receiving oscillator and keeps it within the required limits." For a full description of the methods employed, by a witness of the demonstration in question, *see Wireless World*, 3rd June, Vol. 28, pp. 590–593.

MODULATION AND ITS SUPPRESSION.—V. V. Gunsolley. (*Rad. Engineering*, April, 1931, Vol. 11, pp. 46, 48 and 50.)

"The purpose of this article is to show the equivalence between the two methods [lag in rise and fall of resonance, and side bands] and to show that the side-band theory, while perfectly valid, is nevertheless based on an imaginary conception having no part in the actual physical phenomena of broadcasting."

REISSDIAGRAMME BEI BARKHAUSENSCHWINGUNGEN UND IHRE THEORIE ("Break-off" Diagrams of Barkhausen Oscillations, and Their Theory).—H. G. Möller and W. Hinsch. (*Zeitschr. f. hochf. Tech.*, April, 1931, Vol. 37, pp. 145–149.)

In an ordinary reaction receiver the reaction-adjustment at the oscillating threshold is sometimes smooth and sometimes harsh, according to the shape of the dynamic characteristic, as affected—for instance—by the filament temperature. The sensitivity of the receiver is greatest when the adjustment is just at the border between smooth and harsh; a "jumping" oscillation threshold, such as occurs when the heating current is reduced too far, is impossible to work with.

Similar effects occur in the case of Barkhausen oscillations, and are of equal importance for short-wave receivers using these oscillations. The writers, therefore, develop the theory of these "jump" phenomena far enough to give a *qualitative* knowledge of the effects of filament heating, anode and grid potentials, and the damping of the Lecher wire system on the steepness of the threshold; they check the theory by experiment. The whole is based on the first writer's papers (Feb. Abstracts, p. 95) in which he develops the principle of amplitude and phase balance; and definitions and nomenclature are taken from this former work. The following results are obtained and confirmed experimentally :—(1) Increase of excitation factor increases the *height* of the " jump." (2) If a jump is present, the oscillations also display a " break off." (3) The *width* of the jump is greatest for medium excitation factors and decreases both for an increase and for a decrease of the factor. For very small and very large factors, the jump disappears. " This result is very remarkable." (4) At the onset of oscillation the phase displacement is about 90°, the frequency is 1.5 times the natural frequency of the electron swings, and the wavelength sinks to 0.67 of that for a purely unreal Lecher wire system resistance. " The exceeding of a phase displacement of 90° is again a very noteworthy result, which would not be expected by analogy with reaction-coupling oscillations." The paper ends with a number of curves showing the relation between amplitude and excitation factor, first for various anode and grid voltages and then for various filament currents.

NEW LONG WAVE COMMERCIAL RADIO TELEPHONE-TELEGRAPH TRANSMITTERS.—D. B. Mirk and S. G. Knight. (*Elec. Communication*, No. 3, Vol. 9, 1931, pp. 189–195.)

From the International Telephone and Telegraph Laboratories. Two master-oscillator type transmitters are described, one for 1.5 kw. aerial power, the other for 3.5 kw. ; both operating on wavelengths from 600 to 3,600 metres.

MODERN QUARTZ-CONTROLLED COMMON-WAVE BROADCASTING TRANSMITTERS.—Gerth and Hahnemann.

(*See* under " Stations, Design and Operation ".)

PORTABLE ULTRA-SHORT-WAVE DIRECTIVE TRANSMITTER, USING MECHANICAL INTERRUPTER. —(Brit. Pat. 344620, J. J. V. Armstrong, 5th Feb., 1930.)

Resembling the Telefunken-Ludenia patent dealt with in March Abstracts, p. 150.

MULTIPLE-GRID VALVE IN IMPROVED [MORE CONSTANT FREQUENCY] NUMANS-ROOSENSTEIN CIRCUIT.—Wolf.

(*See* abstract under " Measurements and Standards ".)

RECEPTION.

AMPLIFICATEURS À BANDE DE FRÉQUENCES (Band-Pass Amplifier Stages). — L. Couillard. (*L'Onde Élec.*, April, 1931, Vol. 10, pp. 171–188.)

A description of several different amplifier stages with overall characteristics similar to that of a band-pass filter. The principle underlying them is as follows :—two identical triodes have their plates connected in parallel, and work on the straight part of their characteristics : the total plate current is then proportional to the algebraic sum of the grid potentials u_1 and u_2. If these grids are connected to two suitably chosen points in a system of impedances in the anode circuit of an amplifier triode, and if the impedances are so chosen that u_1 and u_2 are in phase for all currents of frequencies between the band limits f_1 and f_2, and in opposition for all currents of frequencies outside these limits, then the amplification will be high and practically uniform between f_1 and f_2, and will drop rapidly outside the band.

In another variation the two identical triodes, each working on the straight part of the characteristic, are replaced by one double-grid valve in which the two grids are identical (" bigrille Métal GM," for example). To avoid having to use such a special valve, two other circuits have been devised using one triode only per stage (Figs. 3 and 5, pp. 178 and 180). All these circuits are most suitable for fairly wide bands ; it would, for example, be difficult, with commercial types of valve, to obtain an intermediate frequency amplifier (for a superheterodyne) with a mean frequency of 50 kc. and a pass band of 10 kc. But a final circuit (Fig. 8) is particularly suitable for such a narrow band. It is also of special interest because it lends itself readily to the use of screen grid valves.

THEORY AND OPERATION OF TUNED RADIO-FREQUENCY COUPLING SYSTEMS.—Wheeler and MacDonald. (*See* under " Properties of Circuits.")

DIVERSITY RECEIVING SYSTEM OF R.C.A. COMMUNICATIONS, INC., FOR RADIOTELEGRAPHY. —Beverage and Peterson. (*See* under " Aerials and Aerial Systems.")

DIVERSITY TELEPHONE RECEIVING SYSTEM OF R.C.A. COMMUNICATIONS, INC.—H. O. Peterson, H. H. Beverage and J. B. Moore. (*Proc. Inst. Rad. Eng.*, April, 1931, Vol. 19, pp. 562–584.)

The problem of bringing together the outputs of several aerials in such a manner as to be independent of phase is more difficult in the case of telephony than in the case of telegraphy (*see* preceding abstract) because of the higher modulation frequencies involved. The simple mixing of the outputs (each with automatic volume control) was found to be unsatisfactory. In an attempt to dissociate more completely the phase relationships of the various components of the several receivers, two receivers on spaced aerials were connected to two loud speakers in a room having considerable reflection from the walls, and a microphone received the combined output. The output level was considerably stabilised but the quality was somewhat deficient owing to the echoes in the combining chamber.

The method finally adopted at the Riverhead station for re-broadcasting gives what is practically equivalent to the automatic switching of the output circuit to the aerial and receiver having the highest carrier level, by a system involving no mechanical relays. If the signal on one aerial is twice as strong as on another, its receiver will contribute four times as much to the combined output as will the other. The switching action can function very rapidly and will at times improve even the fastest types of fading (" flutter fading "). The method is as follows :—the signal outputs from each aerial pass through separate superheterodyne receivers to the grids of individual second detectors, the plate circuits of which are energised by a common battery feeding current through a common load resistance. The audio-frequency output is taken from across this resistance, and the voltage drop across it is applied, through a time-constant circuit, to the control grid bias of the r.f. amplifier valves of all the sets. Automatic volume control of all the receivers simultaneously is therefore obtained, and a strong signal output from any one receiver reduces the gain of all three, thus preventing the contribution of noise output by the other two.

The equipment is described and over-all characteristics are given. In addition to its use for international re-broadcasting, this type of installation will be employed at the Hawaiian end of the San Francisco-Honolulu telephone circuit.

EXPERIMENTS WITH A QUARTZ CRYSTAL RECEIVER [STENODE RADIOSTAT CIRCUIT].—A. Palmgren. (*E.W. & W.E.*, May, 1931, Vol. 8, pp. 250–252.)

The circuit used in the writer's tests, from which he draws certain conclusions as to the Stenode Radiostat, is a 5-valve superheterodyne circuit in which the intermediate frequency is transferred to the second detector through a crystal bridge circuit. His conclusions, as regards broadcast reception, are that (i) the better the bridge circuit is balanced, the less will be the sensitivity of the receiver; (ii) the set is 100 times more critical to tune than an ordinary superheterodyne; and (iii) the power of all side-band frequencies of a received modulated wave is only a small fraction of the power obtainable with a corresponding superheterodyne without crystal.

"As far as I can see, the system is enormously uneconomical when used for broadcast reception, but it cannot be denied that it may give excellent results in other fields where no modulated waves are used." (*Cf.* June Abstracts, p. 323.)

ADJUSTING THE SUPERHETERODYNE FOR MAXIMUM SENSITIVITY.—R. J. Knouf. (*Rad. Engineering*, April, 1931, Vol. 11, p. 42.)

Description of the apparatus and procedure.

SIDE-BAND SMOKE SCREEN [AND THE STENODE RADIOSTAT]. (*Electronics*, April, 1931, p. 600.)

A quartz crystal "is a band-pass filter, and if properly used at 175 kc. (the frequency employed in most present-day superheterodynes) will produce an attenuation of about 22 decibels at 3,500 cycles off resonance and about 40 decibels at 5,000 cycles. If, as in the Stenode receiver, an audio amplifier can be built which goes up at the same rate that the crystal circuit cuts down the higher audio frequencies, and if this amplifier reproduces nothing at all beyond 5,000 cycles, and if this crystal stage can be produced as cheaply as sufficient tuned stages to produce equivalent selectivity, it might be that a very compact, exceedingly selective receiver could be built, in which the crystal furnishes the selectivity, and direct-coupled screen-grid tubes furnish the gain. All of this has nothing to do with the side-band theory, and does not involve questions of 'crowding stations closer together.'"

BAND-PASS FILTERS IN RADIO RECEIVERS.—G. W. O. H. (*E.W. & W.E.*, May, 1931, Vol. 8, pp. 233–237.)

An editorial in which a discussion of inductive and capacity couplings leads up to an examination of the theory of the mixed coupling filter, giving an approximation to constant peak separation, described by Page (May Abstracts, p. 268). "In all these considerations we have neglected the resistance of the circuits and the effects of the aerial and valve which are connected to or coupled to the filter. . . . The whole chain of circuits from aerial to detector constitutes a filter, and it is the resultant response curve of the whole chain that determines the selectivity and quality of the receiver. There is room for more research in the direction."

FREQUENCY CHANGERS.—W. T. Cocking. (*Wireless World*, 6th May, 1931, Vol. 28, pp. 473–476.)

"It is not too much to say that the frequency changer spells the success or failure of the superheterodyne." The article describes the effect of different methods on selectivity and quality.

The SELECTIVITY OF THE SUPERHETERODYNE.—PART I.—W. T. Cocking. (*Wireless World*, 13th May, 1931, Vol. 28, pp. 498–501; PART II, 20th May, 1931, pp. 547–549.)

The causes and prevention of interference. An intermediate frequency of about 110 kc. is considered the most generally satisfactory for use in Great Britain. Suitable band-pass filters can easily be constructed for an intermediate frequency of this order and very high selectivity and amplification are readily obtainable with first-class quality. In Part II attention is given to the elimination of harmonics.

RADIATING RECEIVERS AGAIN.—(*Electronics*, April, 1931, pp. 600–601.)

A paragraph on the subject of "new unshielded radiating superheterodynes made by skimping manufacturers, or those guilty of inadequate engineering design."

TWENTY-FOUR-HOUR RECEIVING MEASUREMENTS OF LOW-FREQUENCY RADIO STATIONS—BOLINAS, BORDEAUX, KAHUKU, MALABAR AND SAIGON.—E. Yokoyama and I. Tanimura. (*Res. Electrot. Lab., Tokyo*, Jan., 1931, No. 297, 110 pp.)

AVOIDING DETECTOR DISTORTION.—F. M. Colebrook. (*Wireless World*, 20th May, 1931, Vol. 28, pp. 529–532.)

A description of a circuit arrangement whereby the grid condenser can be reduced to a much smaller value than would normally be used, without any loss of rectification efficiency and with a corresponding reduction in the loss of output at the higher modulation frequencies.

The circuit differs from the usual system in the substitution of a so-called "acceptor" circuit—that is, an inductance and variable condenser in series—for the fixed by-pass condenser. By suitable design of the inductance the series tuning capacity can be kept to a very small value—it should not be allowed to exceed about 50 micro-microfarads at the longest wavelength. The audio-frequency shunt effect of the system with associated loss of the higher audio-frequencies will obviously be considerably less than that of any fixed by-pass condenser satisfying the radio-frequency condition.

SUR UNE MÉTHODE DE RÉCEPTION DES ONDES COURTES ENTRETENUES (A [SUPER-REGENERATIVE] METHOD OF RECEIVING C.W. TELEGRAPHY ON SHORT WAVES).—E. Petrasco: David: Mesny. (*L'Onde Élec.*, April, 1931, Vol. 10, pp. 141–170.)

Author's summary :—"The transmission of short waves has reached a high state of perfection quite rapidly, but their reception gives rise to certain questions not yet solved. The super-regenerative receiver, which had almost been abandoned for 200–600 metre waves because of the complexity of its adjustment, has been made suitable for short-wave work by the circuit due to P. David [1928 Abstracts, p. 519]. The super-regenerative receiver, as originally designed, only worked on modulated waves. In his work on the classification of the various types of super-regeneration, David succeeded in using the method, under certain conditions, fo rthe reception of pure c.w. Mesny used a combination of David's circuit with a separate heterodyne, for the same purpose [and it is this version of the super-regenerative receiver on which the present writer concentrates].

"The writer has verified experimentally Mesny's hypothesis [*cf.* David, *loc. cit.*] that the reception of the signals is due to a stroboscopic phenomenon between the beats and the frequency produced by the modulating valve of the super-regenerative circuit. He has shown that (as occurs in autodyne reception) the system possesses a maximum sensitivity under certain conditions; and has established the anti-parasitic character of the reception with regard to disturbances of every kind—a property possessed by no [other ?] system of reception in itself."

A PSEUDO-SYMMETRICAL (PUSH-PULL) RECEIVING CIRCUIT USING ONE FOUR-ELECTRODE VALVE.—C. Krulisz. (*Wiadomości i Prace, Inst. Radjotech, Warsaw*, No. 6, Vol. 2, pp. 209–237.)

In Polish. A simplified theory is given. The anode and inner grid work in opposite phases on the output circuit. By the use of the static characteristics of a Philips A–141 valve, the usefulness of the circuit for low-frequency amplification is shown, and certain discrepancies between theory and practical results are explained.

ATTACHMENT FOR ULTRA-SHORT WAVE RECEPTION.—(*Die Sendung*, 1st May, 1931, Vol. 8, p. 315.)

Amplification, and corrections, of the constructional article referred to in June Abstracts, p. 325.

RECEPTION OF ULTRA-SHORT WAVES OF THE ORDER OF 17 CENTIMETRES.—Ferrié.

(*See* abstract under "Transmission.")

STATISTICS OF TYPES OF BROADCAST RECEIVERS USED IN GERMANY.—(*Rad., B., F. f. Alle*, May, 1931, p. 193.)

A census in which 75 % of licence-holders took part shows that 16 % still use crystal detectors. Of the valve sets, 53 % are battery-driven, 35 % are driven off a.c. mains and 12 % off d.c. mains. 53 % of all the valve sets are 3-valve receivers.

COMBATING THE "SWAMP" EFFECT OF HIGH POWER TRANSMITTERS.—McMichael, Ltd. (*Elec. Industries*, 20th May, 1931, p. 848.)

Tests on a standard 4-valve portable receiver at 2 miles from the North Regional Station showed that the high power programme could be cut right out 15 metres above and below the transmitting wavelength of 479 m. Further tests a few yards from the masts showed that even here the "swamp area" of the transmitter was only 25 metres above and below, a number of foreign programmes being received at full loud-speaker strength.

INFLUENCE OF THE MOON ON RADIO RECEPTION.—Stetson. (*See* two abstracts under "Propagation of Waves".)

EFFECTS OF SUN SPOTS AND TERRESTRIAL MAGNETISM ON LONG-DISTANCE RECEPTION OF LOW-FREQUENCY WAVES.—Yokoyama and Nakai. (*See* under "Propagation of Waves.")

TEST PROCEDURE FOR DETECTORS WITH RESISTANCE COUPLED OUTPUT.—Robinson. (*See* under "Measurements and Standards.")

A TESTING EQUIPMENT FOR BROADCAST RECEIVERS.—Troeltsch. (*See* under "Measurements and Standards.")

L'ÉLIMINATION DES PERTURBATIONS RADIOÉLECTRIQUES (The Elimination of Interference with Radio Reception).—M. Adam. (*Rev. Gén. de l'Élec.*, 11th and 18th April, 1931, Vol. 29, pp. 591–602 and 635–643.)

An exhaustive treatment of the subject dealt with by Leduc (June Abstracts, p. 324). A large number of connection diagrams illustrate the methods adopted to cope with the various sources of trouble.

"ELIMINATION OF RADIO INTERFERENCE."—Philips Lamps, Ltd. (*Electrician*, 15th May, 1931, Vol. 106, p. 733.)

The material for this booklet has been collected from various sources (Union Internationale de Radiophonie; Larsen; Rahbek and Jorgensen; also the experiences of the Philips Laboratory); it deals with forms of interference other than telegraphic and offers suggestions for its elimination to manufacturers of electrical motors, vacuum cleaners, etc., and to railway and tramway companies.

LOW-FREQUENCY INDUCTION: NOISE-FREQUENCY INDUCTION.—Conwell and Warren: Wills and Blackwell. (*Elec. Engineering*, April, 1931, Vol. 50, pp. 276–279: 279–281.)

AERIALS AND AERIAL SYSTEMS.

DIVERSITY RECEIVING SYSTEM OF R.C.A. COMMUNICATIONS, INC., FOR RADIOTELEGRAPHY.—H. H. Beverage and H. O. Peterson. (*Proc. Inst. Rad. Eng.*, April, 1931, Vol. 19, pp. 531–561.)

The most outstanding method of counteracting fading is the diversity principle. The various forms of this method are described, and reasons developed for the choice of the particular form now in common use, in which the d.c. outputs of the separate receivers are combined in a common resistor, the drop in which is used to actuate means for controlling a locally generated tone which may be transferred to the operator over a wire circuit. The apparatus is described in detail.

An aperiodic form of directive receiving array [H. O. Peterson] is described. The original Beverage wave-antenna, when adapted to waves shorter than 100 m., had to be reduced in its physical length, and its effective height was thus decreased so that the non-directive effective height of the down-leads became greater in proportion. The Peterson modification overcomes this difficulty; it consists of a two-wire transmission line along the great circle path, its near end terminating in a damping impedance equal to its surge impedance, while its end furthest from the transmitting station goes to the receiver. At regular intervals along its length the line is loaded with un-tuned horizontal elements, at right angles to the direction of propagation, coupled through small condensers to the line; these capacities are designed so as to keep the phase velocity above 90 % of the velocity of light.

Polar diagrams (taken with the help of an aeroplane) showing the directivity of this array, and of its broadside combinations, are given. A series of measurements indicate a gain in signal-to-noise ratio of the order of 32 db for the European circuits, as compared with a horizontal doublet. The effects of echo and cosmic disturbances are briefly discussed in the final pages.

HORIZONTALE STRAHLUNGSKENNLINIE EINER KURZWELLEN-RICHTANTENNE MIT GESPEISTEM REFLEKTOR (The Horizontal Radiation Characteristic of a Short-Wave Beam Aerial System with Directly-Excited Reflector).—K. Krüger and H. Plendl. (*Zeitschr. f. hochf. Tech.*, April, 1931, Vol. 37, pp. 142–145.)

The writers' former ground and aeroplane tests on the Nauen aerials (1930 Abstracts, p. 631; and next abstract) referred to a 64-element system with a reflector *radiatively* excited (provisional aerial for Japan service). The present paper deals with aeroplane tests on the Nauen aerial for N. America (DFA), which has 192 dipoles with a reflector *directly* excited from the transmitter.

The observed diagram is first compared with the calculated diagram, good agreement being found, and then with the former diagram of the Japan aerial. Here the great difference lies in the proportion of backward and forward radiation; with the Japan aerial this was 1 : 7 (reckoned in field strengths), while with the N. America aerial it was less than 1 : 20.

RADIATION MEASUREMENTS OF A SHORT-WAVE DIRECTIVE ANTENNA AT THE NAUEN HIGH POWER RADIO STATION.—M. Bäumler, K. Krüger, H. Plendl, and W. Pfitzer. (*Proc. Inst. Rad. Eng.*, May, 1931, Vol. 19, pp. 812–838.)

English version of the German paper dealt with in 1930 Abstracts, p. 631.

THE DIRECTIVE SHARPNESS OF THE ARTIFICIAL CHARACTERISTIC OF ANY ARRANGEMENT OF RADIATORS IN SPACE.—Fischer. (*See* under "Acoustics.")

DIE WIRKSAME HÖHE KURZER LINEARANTENNEN (The Effective Height of Short Linear Aerials).—M. Dieckmann. (*Zeitschr. f. hochf. Tech.*, April, 1931, Vol. 37, pp. 126–127.)

In plotting the strengths of radiation fields it is common practice to use, as an exploring aerial, a frame aerial the effective height of which is very simply derived from the formula $h_f = \frac{2\pi AN}{\lambda}$ metres, where A is the area of the frame in sq. metres and N the number of turns. The writer shows that a small dipole aerial, each half of length l metres (very small compared with λ) with its central tuning coil (or coil and condenser) and associated receiving circuit carefully screened against the external field, has an effective height given by a similar simple formula $h_a = \frac{2\pi l^2}{\lambda}$ metres. Thus a frame aerial and a short dipole have the same effective height if l, the half dipole, is equal to the square root of the frame area multiplied by the square root of the number of turns.

NOTE SUR LES DÉFORMATIONS DU DIAGRAMME D'UN CADRE ÉMETTEUR (Note on the Deformations of the Diagram of a Transmitting Frame Aerial).—C. Bourgonnier. (*L'Onde Élec.*, March, 1931, Vol. 10, pp. 136–140.)

The difference between the theoretical and practical polar diagrams of a frame aerial is due to the antenna effect which is so difficult to avoid entirely. The writer shows that in calculating the behaviour of such a frame the respective phases of the antenna- and frame-effects must be considered. This can be done by calculation or by a simple graphical construction.

THE SAIC "SOUND-FILTER SPHERE ANTENNA."—(*Rad., B., F.f. Alle*, April and May, 1931, pp. 150–151 and 193–194.)

Reports in another journal, quoted here, state that the results in the heart of Berlin were not merely surprising but astounding. A well-known two-valve receiver could receive nothing but

Witzleben and Konigswusterhausen, either on an outdoor or on an indoor aerial; while on the Saic device the receiver gave 30 stations in turn on the loud speaker. According to the present editorial, the device appears to consist of a very thin copper wire round which is wound, well insulated from it, another very thin wire of silvered copper. The combined wire is then coiled into a number of turns to form a sphere. One end of the silvered wire is connected to the receiver, the other is left free; one end of the copper core-wire is earthed, the other may either be earthed also or connected to an outside aerial. In the commercial form two tuning condensers make their appearance, forming with the "sphere coil" a filter circuit "which enormously increases the selectivity of a receiver and yet gives good reproduction even of the high notes."

The original inspiration of Saic's work seems to be the reduction of high-frequency resistance by decreasing the amount of surface which is subject to the skin effect, and thus reducing the losses.

KDKA'S AERIAL WITH CONTROLLABLE ANGLE OF ELEVATION.—Dinsdale. (*See* under "Stations, Design and Operation.")

VALVES AND THERMIONICS.

ZUR THEORIE DES DYNATRONS (The Theory of the Dynatron).—Y. Ito. (*E.N.T.*, Jan., 1931, Vol. 8, pp. 23–30.)

In the ordinary ["anode"-] dynatron the negative resistance is assumed to be between cathode and anode. On this assumption the behaviour of the dynatron is readily explained so long as the grid potential remains constant. But when this alters (as it does, for example, in the generation of short waves) the phenomena are much more complex. The same thing applies to the "grid"- dynatron (Feb. Abstracts, p. 98) where a second oscillatory circuit is connected to the anode. Here, a change in the anode potential corresponds to a change in the grid potential of the "anode"-dynatron. In cases where changes occur in the grid potential of an "anode"-dynatron, or in the anode potential of a "grid"-dynatron, it is desirable to separate the anode current in the former case, or the grid current in the latter, into its physical components the primary and secondary emissions.

The writer attacks in this way the problem of the "grid"-dynatron, investigating first the distribution of the internal resistances (cathode-grid, grid-anode and cathode-anode) and then working out the theory of the equivalent circuit. This theory explains all the phenomena of the "grid"-dynatron, including the "ziehen" [pulling-into-tune] effect and the generation of short waves [Baranowski circuit: oscillatory circuit between grid and anode, which are both separated by choking coils from the cathode]. Finally, the theory is extended to apply to the ordinary "anode" (Hull) dynatron.

ELECTRON TUBES IN INDUSTRIAL SERVICE.—W. R. G. Baker, A. S. Fitzgerald and C. F. Whitney. (*Electronics*, April, 1931, pp. 581–583.)

(i) Various "inverter" circuits for giving a.c. from a d.c. supply, including one circuit in which the supply of a.c. is started and stopped by push-button control, no switching of the d.c. being necessary. (ii) Two Thyratrons as a frequency indicator—furnishing a direct current proportional to the frequency of the voltage applied to the grids, and (within limits) independent of the grid voltage. (iii) Screen-grid valve and Thyratron combination as a time delay device over a time range of 30 minutes. (iv) Telemetering.

GRID CURRENT REQUIRED BY HOT-CATHODE, GRID CONTROLLED MERCURY ARCS ["THYRATRONS"] BEFORE DISCHARGE.—W. B. Nottingham. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, p. 1019.)

Abstract only.

THE NEW VARIABLE-MU VACUUM TUBES.—A. G. Campbell. (*Rad. Engineering*, April, 1931, Vol. 11, pp. 21–24.)

A paper, from the Arcturus Laboratories, on the tetrode valves referred to in March Abstracts, p. 156 and elsewhere. The important advantages of the Type 551 valve are summed up as follows:—(i) Increase of maximum allowable input voltage for distortionless operation by a factor of about 20. (ii) Extension of the range of automatic volume control by a factor of 20. (iii) Reduction of cross-talk by a factor of several hundred times. (iv) Improvement in uniformity of control over the entire range of volume control. (v) Reduction of "hum on carrier" (modulation of carrier in r.f. valves) due to incomplete power pack filtering. (vi) Reduction in receiver noise. This is brought about indirectly. In receivers employing double pre-selectors (two tuned circuits between aerial and first valve) for the purpose of reducing cross-talk, the gain in voltage between aerial and first grid is comparatively low, with the result that the "hiss" noise is high compared with the signal. The new valves permit the replacement of the double pre-selector by a single tuned circuit, with an increase in gain between aerial and first grid which reduces the noise.

Several types of variable-mu structures are discussed and illustrated: some of the other structural embodiments of the principle which have been contemplated and tested are shown: and the article ends with a table of data for the old screen-grid tetrode Type 24 and the new Types 550 and 551, and a table showing the tentative rating and normal characteristics of the Arcturus 551, the De Forest 451, and the RCA Radiotron 235.

[A NEW METHOD OF] MEASUREMENT OF VACUUM IN RADIO TUBES. A NEW TUBE CONSTANT—THE IONISATION FACTOR.—M. D. Sarbey. (*Electronics*, April, 1931, pp. 594–595.)

With very high vacua, the usual methods of "gas current" [inverse grid current] measurement demand very delicate apparatus. The procedure here described obviates this, currents of the order of 3 thousandths of a microampère being readily measured by a timing method. The writer ends by pointing out that the statement of a certain gas current is meaningless unless the exact conditions of measurement are given, and even then valves of the same type but with different plate currents will show different gas currents though their vacua are identical. "Much indefiniteness would be obviated if, instead of gas current, the 'ionisation factor' [ratio of grid to plate current] were used to define vacuum."

DESIGN PROBLEMS OF POWER PENTODES FOR RADIO RECEIVERS.—B. V. K. French. (*Electronics*, April, 1931, pp. 576–577 and 614.)

Advantages and limitations: design of the output coupling device: effect of loud-speaker impedance/frequency characteristic: tone control in the pentode output circuit: auto-bias *versus* fixed bias.

SOME VIEWPOINTS OF TUBE MANUFACTURING EXECUTIVES ON THE VACUUM TUBE INDUSTRY. *Also* A SURVEY OF THE VACUUM TUBE INDUSTRY. (*Rad. Engineering*, April, 1931, Vol. 11, pp. 25 and 26–28.)

"PERMANENT" VALVES. (*Electronics*, April, 1931, p. 575.)

In an article entitled "The New Tubes—A rush of new ideas and new designs for 1931," the writer refers to the disappointment felt in the replacement market in the U.S.A. at the excessively long lives reached, irregularly, by the modern valve (up to and over 5,000 hours). One result of this is that certain manufacturers are contemplating improving their valves so that a life of 3 to 5 years may uniformly be obtained, and building them into the set as integral parts thereof, like the transformers or condensers: the average life of a receiver being apparently estimated at this number of years.

BEOBACHTUNGEN ÜBER DEN EINFLUSS DER BELICHTUNG AUF DIE ARBEIT VON ELEKTRONENROHREN (Observations on the Effect of Illumination on the Behaviour of Valves).—L. Pungs and K. Schulze. (*Zeitschr. f. hochf. Tech.*, April, 1931, Vol. 37, pp. 157–159.)

In the course of some quartz oscillator experiments, the writers found that the frequency of a reaction-coupled auxiliary valve generator varied according to the amount of light falling on the valve (ordinary space-charge-grid receiving valve with oxide-coated filament). On investigation, a photo-effect was found in two forms:—in an oscillating circuit, illumination by a 1,000 w. incandescent lamp (heat being cut off by a water filter) produced a frequency change of about 250 cycles in 3 megacycles; in a non-oscillating circuit it produced an anode current change of the order of 2.3×10^{-5} ampère. *The effect was only found in valves with a getter deposit*, and is attributed to changes in the field due to alteration of the charge of this deposit. This explanation is confirmed by tests on a special Te-Ka-De valve in which the getter layer is provided with an external contact. It is suggested that the phenomenon may be of some importance in the measurement of short waves.

TIME CHANGES IN OXIDE-COATED FILAMENTS.—E. F. Lowry and W. T. Millis. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, p. 1019.)

Abstract only.

AN ESTIMATION OF PATCH SIZES ON A THORIATED TUNGSTEN FILAMENT.—L. B. Linford. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, p. 1018.)

Abstract only.

SOME THERMIONIC PROPERTIES OF BARIUM FILMS ABSORBED ON TUNGSTEN.—H. Nelson. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, pp. 1018–1019.)

Abstract only.

THE ALLEGED PRODUCTION OF ADSORBED FILMS ON TUNGSTEN BY ACTIVE NITROGEN.—I. Langmuir. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, p. 1006.)

Recent experiments show that the film produced on tungsten by active nitrogen is an *oxygen* film. "With great care to avoid oxygen and with the bulb cooled in liquid air, active nitrogen does not produce any adsorbed film which alters the electron emission or the accommodation coefficient, but instead it is able to remove any oxygen film already present."

FERMI-DIRAC STATISTICS APPLIED TO THE PROBLEM OF SPACE CHARGE IN THERMIONIC EMISSION.—R. S. Bartlett. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, pp. 959–969.)

Author's abstract:—This paper develops mathematically the state of an electron gas in equilibrium with a plane electrode when the electron gas obeys the Fermi-Dirac rather than the classical distribution law. For a part of the range of integration graphical methods were found necessary, but fortunately a change of variable leads to a solution, shown graphically, which is independent of the temperature and of the nature of the emitting electrode. Thus the single graphical integration can be applied to any emitting surface at any temperature, giving the density, electric intensity, and potential at any desired distance from the surface. A simple extension of the theory makes possible the calculation of the thermionic current between plane electrodes. Numerical examples are given, and the validity of the assumptions is discussed briefly.

POSITIVE ION EMISSION FROM THIN PLATINUM FILMS ON GLASS.—R. A. Nelson. (*Rev. Scient. Instr.*, March, 1931, Vol. 2, pp. 173–179.)

GIBT ES EINE ANODENZERSTÄUBUNG? (Does Anode Sputtering Exist?)—M. Bareiss. (*Zeitschr. f. Phys.*, 1931, Vol. 68, No. 9/10, pp. 585–590.)

No anode sputtering was detectable in delicate experiments on the impact of 220 volt and 800 volt electrons on gold.

THERMIONIC EMISSION.—S. Dushman. (*Rev. Modern Phys.*, No. 4, Vol. 2, pp. 381–476.)

A comprehensive survey.

STUDY OF VALVE MODELS WITH ZELENY [OSCILLATING-LEAF] ELECTROSCOPE.—Barton. (*See* under "Subsidiary Apparatus.")

DIRECTIONAL WIRELESS.

WIRELESS DIRECTION FINDING SYSTEMS FOR MARINE NAVIGATION [COMPARISON OF].—(*Marconi Review*, March–April, 1931, pp. 1–11.)

A comparison between the Marconi-Bellini-Tosi System and the Rotating Frame method exploited by S.F.R., Telefunken, and R.C.A.

DEFORMATIONS IN THE LOOP AERIAL DIAGRAM.—Bourgonnier. (*See* abstract under "Aerials and Aerial Systems.")

THE COLLABORATION BETWEEN WIRELESS AND AVIATION.—Martz. (*See* under "Stations, Design and Operation.")

DIE ENTWICKLUNG DES FERNKOMPASSES UND SEINE BEDEUTUNG FÜR DIE AUTOMATISCHE STEUERUNG (The Development of the Distant-Indicating Compass, and Its Importance for Automatic Control).—W. Möller: Askania Works. (Long Abstract in *Physik. Berichte*, 15th March, 1931, Vol. 12, pp. 584–585.)

The writer considers that neither the selenium nor the earth-inductor compass is at present satisfactory, and devotes himself to the new Askania development of a pneumatic transmission, which he reports as giving excellent results.

AIRCRAFT COMPASS ACCELERATION ERRORS AND THEIR COMPENSATION.—J. D. Tear and E. J. Lawton. (*Gen. Elec. Review*, April, 1931, Vol. 34, pp. 265–268.)

"In conclusion we may say that the magneto compass [1929 Abstracts, p. 347, Rhea] plus the turn compensator described above has proved, in exhaustive flight tests, to constitute a thoroughly reliable and satisfactory direction system for aircraft."

DER ELEKTRONENSTRAHLKOMPASS (The Cathode Ray Compass).—W. Bermbach. (*Helios*, Vol. 37, 1931, p. 25.)

MECHANICAL EYE FOR AIRCRAFT IN FOG.—W. F. Westerndop: G.E.C. (*Southern Daily Echo*, 22nd May, 1931.)

Paragraph on an apparatus for fixing on the tail of an aeroplane. It sights an airway light through the fog and reproduces a "synthetic beacon" on the dashboard. In ground tests it has worked successfully through two miles of fog.

ACOUSTICS AND AUDIO-FREQUENCIES.

ÜBER DIE PEILSCHÄRFE DER KÜNSTLICHEN CHARAKTERISTIK EINER BELIEBIGEN ANORDNUNG VON STRAHLERN IM RAUME (The Directive Sharpness of the Artificial Characteristic of Any Arrangement of Radiators in Space).—F. A. Fischer. (*E.N.T.*, Feb., 1931, Vol. 8, pp. 89–91.)

An extension of the writer's work on the artificial characteristic of non-directive point radiators disposed over a spherical surface (January Abstracts, p. 45) to the case where the shape of the group is not limited to the spherical. Each radiator is represented by a point-mass proportional to the intensity of radiation, and it is shown that the directive sharpness is *inversely* proportional to the square of the wavelength, and *directly* proportional to the moment of inertia of the system formed by the projections of the radiators on the plane containing the direction of radiation and the compensation direction, about an axis formed by the radiation direction passing through the centre of gravity.

If this moment is represented by $T(r, r')$, the general formula arrived at by the writer, from which the above relations are seen, is

$$R = 1 - \frac{2\pi^2}{\lambda^2} T(r, r')\epsilon^2 + \ldots \ldots \quad (15)$$

If the radiators lie all in one plane, and the compensation direction is perpendicular to that plane, formula (15) becomes that obtained by Stenzel for the natural characteristic: *i.e.*, for a plane radiator system compensated normally to the plane, the artificial and natural characteristics are the same.

ON THE AMPLITUDE OF DRIVEN LOUD SPEAKER CONES.—M. J. O. Strutt. (*E.W. & W.E.*, May, 1931, Vol. 8, pp. 238–243; *Proc. Inst. Rad. Eng.*, May, 1931, Vol. 19, pp. 839–850.)

Author's summary:—Bragg's method for measuring small amplitudes of vibration [1929 Abstracts, p. 519; micrometer adjustment of chattering contact] was developed technically for the measurement of driven loud speaker cones. It is shown that amplitudes of 1 micron at 500 cycles may easily be measured within a few per cent. Nodes of symmetrical cones may be diametral or circular. It is shown that diametral nodes do not influence the effective sound radiative area and the effective mass. Circular nodes do so, and for different cones, at different frequencies, a quantity η is calculated from experimental data, to which both effective mass and effective area are proportional.

"It is shown that circular nodes exist already at 500 cycles in most of the paper cones measured, except specially stiff ones, which up to 2,200 cycles did not show any circular node. Effective mass and effective area of most cones diminish rapidly with increasing frequency so as to become very small for, say, 1,000 cycles. Here again, specially stiff cones are a favourable exception. Different loud speaker systems were tested for proportionality of amplitude to a.c. strength."

LOW NOTE RESPONSE OF MUSICAL INSTRUMENTS AND LOUD SPEAKERS.—J. M. Schmierer. (Summary in *Electronics*, April, 1931, p. 604.)

THE LOWER REGISTER IN MOVING COIL LOUD SPEAKERS.—N. W. McLachlan. (*Wireless World*, 6th and 13th May, 1931, Vol. 28, pp. 479–481 and 514–516.)

An examination of the experimental results from (1) using a rubber or other adequately flexible surround to mount the diaphragm at its periphery, the resonance of the diaphragm as a whole in the surround being below 20 cycles per second; and (2) using a surround of leather or similar material and of such tautness that the diaphragm (moving as a whole) resonates upon it at some frequency between 50 and 100 cycles.

The conclusions are summarised as follows:—

1. When the edge of a conical diaphragm is quite free, so that it can bend readily, sharp resonances lasting only a few cycles occur from 50 cycles up to 200 cycles, after which they are relatively unimportant. These resonances correspond to modes of vibration of the diaphragm caused by its bending and assuming certain shapes. At the lowest resonance the mouth of the cone is oval and there are four nodes.

2. When the edge is reinforced it cannot bend easily and the radial modes disappear. The low-frequency output is considerably reduced and weak compared with the upper register.

3. Addition of a rubber annulus or surround gives a much greater low-frequency output than either a free or a reinforced edge. This is due to the surround acting as an auxiliary resonant diaphragm. When the area and tension of the surround are properly adjusted, the overall response of the loud speaker is better balanced than with either a free or a reinforced edge.

4. When the surround is very taut, or is made of a material like leather, the lower register is given by resonance of the diaphragm vibrating as a whole thereon. The resonant frequency usually lies below 100 cycles, and the bass is centred round this point. The radiation resistance—as referred to the valve circuit—reaches thousands of ohms. Being greater than the resistance of a power triode, it is adequate to cause a "crevasse" in the current-frequency curve. When the diaphragm is impulsed, the magnetic field is inadequate to stop oscillations. This method of producing "bass" is very objectionable.

ÜBER HOCHLEISTUNGSBLATTHALLER (High Power [Riegger] "Blatthaller" Loud Speakers).—H. Neumann and F. Trendelenburg. (*Zeitschr. f. hochf. Tech.*, April, 1931, Vol. 37, pp. 149–151.)

Cf. Abstracts, 1930, p. 163, and 1931, p. 158.

THE OSCILLOPLANE, A VOGT ELECTROSTATIC LOUD SPEAKER.—(*Radioélec. et QST franç.*, January, 1931, Vol. 12, pp. 70–71.)

LOUD SPEAKER LISTENING TESTS.—R. P. Glover. (*Rad. Engineering*, April, 1931, Vol. 11, pp. 35–37.)

"Description of actual switching arrangement and circuits employed in examining the merits of various commercial loud speakers."

ALL A.C. RADIO-GRAMOPHONE FOR THE MOVING COIL LOUD SPEAKER.—F. H. Haynes. (*Wireless World*, 13th and 20th May, 1931, Vol. 28, pp. 502–506 and 533–536.)

A local station alternative programme receiver for the home constructor, specially designed for quality reproduction. Pre-set two-range tuning on the broadcast band is provided for with arrangements for gramophone reproduction. Undistorted a.c. power output up to 5 watts over a frequency range of 40 to 10,000 cycles.

DEVELOPMENTS IN AUTOMATIC RECORD CHANGERS FOR GRAMOPHONES.—F. S. Irby. (*Electronics*, April, 1931, pp. 584–586 and 612.)

AN ELECTRIC PICK-UP GIVING INCREASED FIDELITY, REDUCED COST, AND SEMI-AUTOMATIC NEEDLE CHANGE.—(French Pat. 694947, MacClatchie, pub. 9th Dec., 1930).

For summary and diagram *see Rev. Gén. de l'Élec.*, 28th Feb., 1931, Vol. 29, pp. 78D–79D.

POINTS IN THE DESIGN OF THE GRAMOPHONE MOTOR.—(*Wireless World*, 25th March, 1931, Vol. 28, pp. 321–325.)

Enumerating the respective capabilities of the various types—spring and electric—now on the market. Speed variation tests with a stroboscope are recommended.

Practically the only disadvantage of the clockwork motor is the necessity for winding. On the other hand, its price is half that of the electric type, its running costs are nil, it is more silent than the best electric and needs less frequent attention. Nevertheless, in the higher-priced instruments the supersession of the spring motor is already complete.

ÜBER KOHLEMIKROPHONE (Carbon Microphones. [I.—Production of a Sound Field Constant in Amplitude over the Audible Scale, for Testing Microphones: II.—The Non-linear Distortion of Telephone Transmitters]).—M. Grützmacher and P. Just. (*E.N.T.*, March, 1931, Vol. 8, pp. 104–114.)

Part I describes an arrangement for producing a sound field which is constant in amplitude throughout the whole audible scale. A loud speaker excited by a heterodyne note-generator directs its sound on to a condenser microphone provided with a perforated auxiliary electrode in front of its diaphragm. This special microphone acts, through an amplifier and rectifier, on the note-generator valve, controlling the working point on the characteristic of the latter and thus maintaining the sound-field intensity at a constant intensity. The writer then describes the use of such an arrangement for obtaining the frequency characteristics of other microphones, and gives automatically registered photographic records obtained with a number of types of carbon transmitters in general use, including the English "solid-back" type.

Part II deals with tests on similar carbon transmitters as regards their non-linear distortion. Meyer's "exploring note" method of analysis is used (1929 Abstracts, p. 46). To obtain both summation- and difference-tones, two pure notes were impressed on the microphones under test, and from the records the distortion ("klirr"-) factors were obtained from the relation

$$K = \sqrt{\frac{D^2 + S^2}{F_1^2 + F_2^2}},$$

S and D representing the summation- and difference-tones and F_1 and F_2 the two fundamentals. Particularly noteworthy is the very marked non-linear distortion of all the types investigated. Another result is that the distortion factor reaches a maximum at quite small sound pressures and does not increase beyond that.

LOW-FREQUENCY AMPLIFICATION BY A PUSH-PULL CIRCUIT USING ONE FOUR-ELECTRODE VALVE.—Krulisz. (*See* abstract under "Reception.")

THE VELOCITY OF SOUND-WAVES IN A TUBE.—G. G. Sherratt and J. H. Awbery. (*Proc. Physical Soc.*, 1st May, 1931, Vol. 43, Part 3, pp. 242–253.)

Authors' abstract:—The apparent velocity of sound in a tube of diameter 2 cm. has been measured at temperatures up to 400° C. and with frequencies of from 3,000 to 14,000 ~. The reduction in velocity below the free-air value is discussed, and the suggestion is put forward that this reduction, for a single tube and gas, depends on the wavelength rather than on the frequency. The theoretical expression found by Helmholtz and Kirchhoff for the reduction in velocity does not appear to be valid, at any rate for the conditions obtaining in these experiments. The method used by Dixon and by Partington and Shilling for correcting for the influence of the tube receives support from the present results.

The experiments reveal the complication which ensures when the wavelength falls below a certain multiple of the tube diameter.

THE TUBE EFFECT IN SOUND-VELOCITY MEASUREMENTS.—P. S. H. Henry. (*Proc. Physical Soc.*, 1st May, 1931, Vol. 43, Part 3, pp. 340–362.)

PHENOMENA IN A SOUNDING TUBE.—H. S. Patterson and W. Cawood. (*Nature*, 2nd May, 1931, Vol. 127, p. 667.)

LES NOUVEAUTÉS DU CINÉMA SONORE (New Developments in Sound Films).—Lipoug. (*Radioélec. et QST franç.*, March, 1931, Vol. 12, pp. 20–25.)

Including a quotation from a lecture by Gaumont describing the "rational" film system in which two superimposed films are used, one carrying the pictures and the other the sound (using the whole width of the film); the combined film is transparent to visible rays but the component carrying the sound record is made opaque to ultra-violet (or to infra-red) rays.

UNIFICATION IN SOUND PICTURES.—Winckel: Mihaly. (*Funk*, Berlin, March, 1931; summary in *Electronics*, April, 1931, p. 605.)

In Mihaly's system the photoelectric cell is placed beside the screen, and the sound-modulated beam projected with the picture beam. It is claimed, among other advantages, that any type of film can thus be used. Mention is also made of apparatus for home use; photographs are given.

EFFECTS OF OPTICAL SLITS IN VARIABLE AREA SOUND RECORDING.—J. P. Livadary. (*Electronics*, April, 1931, pp. 587–589.)

SUR UNE MÉTHODE D'INSCRIPTION MÉCANIQUE APPLICABLE À L'ENREGISTREMENT ET À LA REPRODUCTION DES SONS. (A Method of Mechanical Inscription applicable to the Recording and Reproducing of Sound).—E. Huguenard. (*Comptes Rendus*, 4th May, 1931, Vol. 192, pp. 1084–1085.)

A method depending on engraving, with a kind of chisel, a groove of constant width but varying depth on a supple band of celluloid or cellulose acetate.

A.C. MEASURING INSTRUMENTS AS DISCRIMINATORS AGAINST HARMONICS.—Wolff. (*See* under "Measurements and Standards.")

A DIRECT-READING THERMIONIC FREQUENCY METER FOR 20 TO 10,000 CYCLES PER SECOND.—Guarnaschelli and Vecchiacchi. (*See* under "Measurements and Standards.")

THE EFFECT OF A DIRECT CURRENT ON THE FREQUENCY OF A SONOMETER WIRE.—R. Schaffert. (*Review Scient. Instr.*, April, 1931, Vol. 2, pp. 231–233.)

Explanation of the results of Gogate and Naik, who found that a vibrating sonometer wire undergoes a lowering in frequency when placed in a d.c. circuit.

PHOTOTELEGRAPHY AND TELEVISION.

IMPROVED SCANNING METHODS FOR TELEVISION AND TELECINEMA.—(French Pat. 697932, Barthélémy and Le Duc, pub. 23rd Jan., 1931.)

A more stationary image is claimed to be produced by a new way of carrying out the framing motion: during half the framing period the motion is in one direction and leaves alternate bands unscanned, during the other half these bands are filled in by motion in the reverse direction. Methods are described for carrying out this plan.

CATHODE RAYS IN TELEVISION.—H. R. Wright. (*Rad. Engineering*, April, 1931, Vol. 11, pp. 29–30.)

General outlines, as developed in the Westinghouse Laboratories.

IMPROVEMENT OF THIN FILM CAESIUM PHOTOELECTRIC TUBES.—S. Asao and M. Suzuki. (*Proc. Inst. Rad. Eng.*, April, 1931, Vol. 19, pp. 655–658.)

Authors' summary:—The photoelectric sensitivity of thin films of caesium deposited on silver oxide with silver as a base metal was studied by L. R. Koller. Photoelectric tubes with sensitive surfaces made in this manner have a maximum sensitivity in the short-wave range and also a second maximum in the red, with the long wavelength limit moving out into the infra-red. We have found that if a thin film of silver or gold is deposited on the above sensitive cathode surface and afterwards baked, it becomes very much more sensitive and shows displacements of the long wavelength limit still further in the infra-red. By this new method, which will be described below, sensitivities as high as 40 and even 48 microampères per lumen have been obtained. This is several times better than for the caesium on silver oxide tubes and about thirty times better than potassium hydride tubes. The new sensitive surface or cathode thus formed may be considered to have a thin film of caesium, over which is deposited, as a final layer, a thin film of silver. The sensitivity as reported was measured with a gas-filled tungsten lamp operating at 2,700 deg. K.

EINE ELEKTROLYTISCHE DARSTELLUNGSMETHODE VON ALKALIMETALLEN IN ENTLADUNGSRÖHREN (An Electrolytic Method of Depositing Alkali Metals in Discharge Tubes).—Magdalene Forró and E. Patai. (*Zeitschr. f. tech. Phys.*, May, 1931, Vol. 12, pp. 256–262.)

Since the first application of the electrolysis of glass to the formation of sodium films, many efforts have unsuccessfully been made to extend the method to other metals, in particular potassium. The present paper deals with an exhaustive investigation of such extension, resulting in the successful deposition of potassium, rubidium and caesium coatings without the glass fracturing and even (as tests with polarised light showed) without putting the latter into any appreciable state of strain.

The successful method evolved depends on *a preliminary electrolytic process by which the inner surface of the soda glass is converted, to a certain depth, into potash glass;* the bulb is filled with KNO_3 and immersed in $NaNO_3$, the latter being connected to the negative pole of the battery. When this process is complete, the bulb is evacuated in the usual way and the electrolytic procedure (already described by the writers—1930 Abstracts, p. 572) is applied, by which the sodium ions migrate from the outer surface inwards and the potassium ions on the inner surface are set free, are neutralised by collisions with electrons, and are deposited as potassium atoms on the cooled wall of the bulb.

NEUERE FORMEN LICHTELEKTRISCHER ZELLEN (New Forms of Photoelectric Cell).—F. Schröter. (*Zeitschr. f. tech. Phys.*, April, 1931, Vol. 12, pp. 193–200.)

The full lecture, a summary of which was dealt with in May Abstracts, p. 275. Among other new developments dealt with are the Telefunken "wall-charge" cell (after the principle of their "peg" valve), Zworykin's screen-grid cell and his cell with light-sensitive control grid (somewhat resembling the older "luminotron" of Nakken), and the new American combination of a gas-filled cell and glow-discharge relay (a kind of photoelectric thyratron).

Finally, a short section deals with photoelectric "contact detectors": although these have been known for some time, and were used by Bose for optical telephony, a great deal is unknown on the physical side; the molybdenite detector shows that the effect is not always concentrated at the point of contact, since the light may be directed on a spot as much as 1 cm. from the contact without decreasing the effect (a result which must be taken into account when using such a cell for scanning purposes). Grützmacher's new progress in this direction is referred to (*see* next abstract).

THE "GRUMA" PHOTOELECTRIC CELL OR CELL "P" [GRÜTZMACHER CRYSTAL DETECTOR PHOTOELECTRIC CELL].—(*Radioélec. et QST franç.*, January, 1931, Vol 12, pp. 72–73.)

No description of the cell is given, but it is presumably of the type referred to in February Abstracts, p. 103. According to the present writer, it will revolutionise television, the talking film, and above all the gramophone. It requires no excitation, no costly optical system and slit, etc.; it is contained in a glass tube 1 cm. in diameter and 8 cms. long. It responds without inertia to all frequencies between 0 and 30,000; in television it allows the number of elements, hitherto never more than 20,000, to be increased to 100,000. It will make sound-on-film gramophones for the home an instant success.

CONCERNING THE GRID LEAK OF A GRID-PHOTOELECTRIC CELL.—T. Asada and K. Hagita. (*Journ. I.E.E. Japan*, Feb., 1931, Vol. 51, No. 2, pp. 17–19.)

More on the subject of the 3-electrode cell dealt with in June Abstracts, p. 332. It is here reported that the connection of the grid with the filament, through a high resistance which is similar to the grid leak of a triode, is very important; without this connection the sensitivity is not constant and the cell is subject to self-oscillation. Test curves illustrating these effects are shown: they also demonstrate how the frequency response curve of the grid cell, with the necessary leak, resembles that of a vacuum caesium hydride cell.

RECENT RESEARCHES ON THE COPPER-OXIDE RECTIFIER AND PHOTOELECTRIC CELL.—Bates. (*See* under "Subsidiary Apparatus.")

ÜBER DIE VERSTÄRKUNG VON PHOTOZELLENSTRÖMEN (The Amplification of Photoelectric Cell Currents).—H. Simon. (*E.T.Z.*, 26th Feb., 1931, Vol. 52, pp. 264–266.)

Including an illustration of a special amplifier valve (double grid, for use in the space-charge grid connection to allow the low anode potential of 6 v. to be used when the photoelectric cell is connected as a grid leak) with a very highly insulated grid; designed by Hausser, Jäger and Vahle, of the Siemens Company.

PHOTOELECTRIC PROPERTIES OF COMPOSITE SURFACES AT VARIOUS TEMPERATURES AND PRESSURES.—D. Ramadanoff. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, pp. 884–896.)

Cf. June Abstracts, p. 332 (2). Author's abstract :—Experiments designed to determine the variation of photoelectric current with temperature and plate potential for barium photoelectric cells are described. The technique used in making the cells is also given. A new method, employing interrupted illumination, a transformer coupled amplifier and a cathode ray oscillograph, is developed for measuring the photoelectric current. In this way the thermionic current and currents of slow response are completely eliminated and only the a.c. component of the photo-current is amplified.

Experimental results. With constant plate voltage the photoelectric current increases gradually with temperature and at about 600°C. is nearly twice as large as the current at room temperature. As the temperature however is raised from 600°C. to 750°C. the increase in photoelectric current for steady illumination is 100-fold while for interrupted illumination it is only 17-fold. The smaller increase in the latter case may be explained in view of the elimination of all sluggish currents produced by light in some secondary way. While the two curves for steady and interrupted illumination are similar in appearance, the latter has a maximum at 560°C. which resembles very much a resonance peak.

The increase or decrease in photoelectric sensitivity with temperature for composite surfaces consisting of barium and oxygen on platinum may be explained by the diffusion of barium or oxygen on the surface. The increase in saturation voltage of the potential-current curves with temperatures may likewise be explained by an increase in the contact potential brought about by a change in the work function.

ZUR THEORIE DES PHOTOEFFEKTES AN METALLEN (On the Theory of the Photoelectric Effect at Metallic Surfaces).—Ig. Tamm and S. Schubin. (*Zeitschr. f. Phys.*, 1931, Vol. 68, No. 1/2, pp. 97–113.)

ÜBER DIE LICHTABSORPTION IN EINFACHEN IONENGITTERN UND DEN ELEKTRISCHEN NACHWEIS DES LATENTEN BILDES (On the Absorption of Light in Simple Ionic Lattices and the Electrical Demonstration of the Latent Image).—R. Hilsch and R. W. Pohl. (*Zeitschr. f. Phys.*, 1931, Vol. 68, No. 11/12, pp. 721–734.)

THE OPTICAL PROPERTIES OF A LIQUID IN A MAGNETIC FIELD AND TRAVERSED BY A POLARISED BEAM IN ANY DIRECTION.—Cotton. (*See* under "General Physical Articles.")

MEASUREMENTS AND STANDARDS.

ZEIGERFREQUENZMESSER (A Pointer Frequency Meter).—E. Mittelmann and M. Wald. (*Zeitschr. f. hochf. Tech.*, May, 1931, Vol. 37, pp. 187–191.)

Authors' summary :—" In the theoretical part of the paper the principle is developed of a new meter which indicates by its pointer the amount and sense of the deviation of the applied frequency from a fixed value. It is shown that the readings of the instrument are independent of the amplitude, and also of the absolute value of the frequency ; and, further, that its sensitivity can be increased at will without making it dependent on the amplitude.

In principle the instrument consists of an astatic dynamometer system, to whose moving coil circuit a short-circuiting circuit tuned to the fixed frequency is connected in parallel. The sensitivity of the instrument is only dependent on the ratio between the inductance of the short-circuiting circuit to the inductance of the field coil of the dynamometer system. In the experimental part of the paper [*see* following abstract] it is shown that the theoretical expectations can be largely realised. Frequency changes of the order of 1.4×10^{-6} [there is a misprint here in the original] can be kept watch on by direct pointer deflection."

If ω_r is the resonance frequency corresponding to the mid-scale reading, and $\omega_{max.}$ and $\omega_{min.}$ the frequencies corresponding to the ends of the scale, the ratios $\frac{\omega_r}{\omega_{min.}}$ and $\frac{\omega_r}{\omega_{max.}}$ can be chosen to suit one of two types of application. If these ratios are very close to unity, the instrument will be suitable for keeping a watch on the very smallest variations in a very constantly controlled frequency ; *e.g.*, for the continuous control of the constancy of frequency of a telegraph or broadcasting transmitter. By a suitable design of the tuned circuit and the rest of the instrument, the standard frequency can be in any part of the spectrum, including note frequencies. If, on the other hand, the ratios are very far removed from unity, the instrument may be used as a direct-reading meter over a wide range of frequencies.

MESSUNG GERINGER FREQUENZABWEICHUNGEN MIT DIREKTER ANZEIGE (The Measurement of Slight Frequency Variations by a Direct Reading Instrument).—E. Mittelmann and Rose Mittelmann. (*Zeitschr. f. hochf. Tech.*, May, 1931, Vol. 37, pp. 191–199.)

Supplement to the above paper. It is shown that with the normal instrument therein described, frequency variations of the order of 10^{-5} can be directly indicated ; but that if the paralleled tuned circuit is so designed that the frequency under measurement is near the natural frequency of the inductance of that circuit, the sensitivity is greatly increased and in an actual instrument has reached 1.4×10^{-6}.

DIRECT-READING [THERMIONIC] FREQUENCY METER.—F. Guarnaschelli and F. Vecchiacchi. (*Proc. Inst. Rad. Eng.*, April, 1931, Vol. 19, pp. 659–663.)

The arrangement referred to in 1930 Abstracts, p. 463. Authors' summary :—The frequency meter described functions over the whole scale of acoustic frequencies from 20 to 10,000 cycles per second, and in addition constitutes a static equivalent of the vibrating reed apparatus used for precise comparisons of a capacity with a resistance and a time.

A condenser is charged at a given voltage E_0 across a triode in a half period and discharged across another triode in the successive half period; for this two grid circuits are controlled by opposite phases of the periodic voltage variations obtained from the two secondaries of a single transformer whose primary is supplied with the frequency to be measured. If the continuous voltage supply E_0 is kept constant, the frequency may be read directly on the calibrated scale of a milliammeter. It is possible to attain an almost complete independence of the triode characteristics and of the form and value of the voltage of the applied oscillation, within very wide limits.

The frequency meter may also serve for the measurement of very small capacities.

MISURE ASSOLUTE DI FREQUENZA ALLA RICEZIONE (Absolute Measurement of Frequency on Signals Received from a Distance).—U. Ruelle. (*L'Elettrotec.*, 25th March, 1931, Vol. 18, pp. 202–203.)

Description of measurements carried out by the Italian Naval Institute in collaboration with the Paris National Laboratory. Eiffel Tower signals were received at Livorno and the radio frequency and an audio-frequency measured. The direct-reading frequency meter dealt with in the preceding abstract was used successfully. The carrier wave measured at Livorno gave four successive values ranging from 207,356.4 to 207,374.5 p.p.s., while almost simultaneous readings at the Paris Laboratory gave values from 207,355 to 207,361 p.p.s.

TEST PROCEDURE FOR DETECTORS WITH RESISTANCE COUPLED OUTPUT.—G. D. Robinson. (*Proc. Inst. Rad. Eng.*, May, 1931, Vol. 19, pp. 806–811.)

Author's summary:—This paper presents a simple circuit for use primarily in determining the response, to modulation, of a detector with resistance coupled output. Only d-c, 60 cycle a-c, and the corresponding meters are used. The theory of operation of the circuit is briefly explained: this theory neglects the effects of capacity reactances at modulation frequencies but not at carrier frequencies. Sample curves obtained by this method show marked differences between the positive and negative peak values of the audio output of the detector with high percentage modulation of the carrier.

EINE MESSEINRICHTUNG ZUR UNTERSUCHUNG VON RUNDFUNKEMPFÄNGERN (A Testing Equipment for Broadcast Receivers).—F. Troeltsch. (*E.N.T.*, April, 1931, Vol. 8, pp. 137–146.)

Author's summary:—The inadequacy of the subjective judging of broadcast receivers by the use of signals from distant stations has led to the design of a testing equipment which fulfils very completely the practical requirements as to simplicity and quickness. The necessary components—such as transmitter, coupling arrangements, artificial aerial, and output-measuring instruments—are described, their calibration and use discussed, and the various test processes treated briefly. As an example, the comparison is described of an old five-valve receiver with a modern four-valve screen-grid instrument.

EINE SPANNUNGSMESSMETHODE FÜR FREQUENZEN BIS ZU 1.5×10^8 HERTZ (A Method of Voltage Measurement for Frequencies up to 150 Megacycles/Sec.).—L. Rohde. (*Zeitschr. f. tech. Phys.*, May, 1931, Vol. 12, pp. 263–265.)

The writer first refers to the high-frequency valve voltmeters of Moullin (Abstracts, 1930, pp. 580–581) and King (same, p. 640), the Kerr cell method of Pungs and Vogler (same, pp. 460–461) reliable up to 10 megacycles, and the cathode-ray method of Kirchner (*Ann. d. Physik*, 1925, p. 287) applicable up to 35 megacycles. He himself has designed arrangements of triodes which are useful up to 10 megacycles, but at higher frequencies these are subject to serious errors due to self-inductance and capacity inside the valves.

The present method, which works with an error of about 1 % (2 % gross error at 100 megacycles, reduced by a frequency correction formula to about 1 %), can be applied to voltages above 1 v. up to 700 v., for the particular special diode employed. It is a compensation method, the a.c. voltage to be measured and a compensating d.c. voltage being applied to the anode and cathode of this diode. So long as current arrives at the anode (as shown by a meter with a sensitivity of 3×10^{-7} A.) the peak voltage is greater than the compensating voltage. At the moment of zero current the two voltages are equal. Calculation shows that for this particular diode the electron transit time does not interfere so long as the potential is as much as 1 v. The minimum voltage measurable thus depends on the design of the diode, particularly on the gap between anode and cathode. This cannot be made too small on account of the bending of the filament and because of the internal capacity, which must be as small as possible—in the actual valve designed by the writer it is 0.45 cm.

As an example of the use of the method, the discharge potentials of commercial neon tubes, filled with various gases, are given for a 4.32-metre wave.

A THERMIONIC VOLTMETER OF HIGH SENSITIVITY: DISCUSSION.—Benecke: Schulze and Zickner. (*Zeitschr. f. tech. Phys.*, April, 1931, Vol. 12, pp. 225–226.)

Referring to Benecke's linear calibration voltmeter with auxiliary a.c. bias voltage (1930 Abstracts, p. 639) Schulze and Zickner compare it with their previously announced device (March Abstracts, p. 169, penult. abstract) which uses a rectifying circuit in place of Benecke's amplifying circuit. They claim that in their method the potential under measurement is automatically brought into phase with the auxiliary voltage by the fact that the input bridge circuit is thrown out of balance by a definite amount, whereas Benecke's use of a transformer does not ensure similarity of phase. Benecke replies.

ALTERNATING-CURRENT MEASURING INSTRUMENTS AS DISCRIMINATORS AGAINST HARMONICS.—Irving Wolff. (*Proc. Inst. Rad. Eng.*, April, 1931, Vol. 19, pp. 647–654.)

Author's summary:—Alternating-current measuring instruments are classified and a brief description of a method for obtaining each one of them is given. They are then discussed from the standpoint of the increase in reading which can be caused by harmonics added to the pure tones. It is shown that, under certain conditions, the linear detector may be superior to other forms of alternating-current instruments in that the increase due to harmonics is the smallest, whereas the full-wave square-law detector or energy measuring device has the unique superiority of having an increase which is independent of the phase relations between the fundamental and the harmonics and between the harmonics themselves.

SCHLEIFDRAHT-MESSEINRICHTUNGEN MIT ERHÖHTER EINSTELLGENAUIGKEIT (Slide Wire Measuring Apparatus with Increased Accuracy of Adjustment).—O. Zwierina. (*Elektrot. u. Masch: bau*, 8th March, 1931, Vol. 49, pp. 181–185.)

ON THE USE OF THE SCHERING HIGH VOLTAGE BRIDGE FOR THE MEASUREMENT OF LARGE CAPACITIES.—G. Zickner and G. Pfestorf. (*Zeitschr. f. tech. Phys.*, April, 1931, Vol. 12, pp. 210–213.)

CHAIN OF STATIC DEMULTIPLIERS FOR THE MEASUREMENT OF FREQUENCIES FROM 10^2 TO 10^8 CYCLES PER SECOND.—F. Vecchiacchi. (*L'Onde Élec.*, March, 1931, Vol. 10. p. 18A.)

French summary of the Italian paper referred to in January Abstracts, p. 49.

DETERMINATION OF FREQUENCY AND DAMPING OF RESONATING CIRCUITS [INCLUDING AERIALS].—Tykocinski-Tykociner. (*See* June Abstracts, p. 322.)

MULTIPLE-GRID VALVE WAVE-METERS FOR SHORT WAVES.— –. Wolf. (*Funk, Berlin*, 27th Feb., 1931; summary in *Electronics*, April, 1931, p. 606.)

Descriptions of the Numans-Roosenstein circuit and of an improved form said to be far less dependent on anode and filament voltages than the original circuit.

QUARTZ CONTROLLED WAVEMETER FOR SHORT AND ULTRA-SHORT WAVES.—J. Groszkowski. (*Wiadomości i Prace, Inst. Radjotech., Warsaw*, No. 6, Vol. 2, pp. 197–208.)

In Polish. The principle is described of a wavemeter covering a range of from 5 to 85 metres with an error of less than 0.1 %, suitable for calibrating amateurs' wavemeters for which the admissible error is 0.5 %. The current from a quartz-controlled generator, of a constant known frequency, is modulated by the current from a heterodyne generator of variable frequency. The range is covered by making use of the quartz-controlled harmonics.

PERFECTIONNEMENTS AUX STABILISATEURS DE FRÉQUENCE (Improvements in Frequency Stabilising Arrangements [including the Mounting of Quartz Plates]).—C. Florisson. (*L'Onde Élec.*, March, 1931, Vol. 10, pp. 131–135.)

The writer considers that many of the troubles encountered with piezoelectric and similar stabilisers are due to faulty methods of mounting the quartz plates, metal reeds, etc. He then deals with the method of mounting covered by his patent (1930 Abstracts, pp. 462–463) and goes on to consider how the reaction of the neighbouring walls (in the case of quartz plates, the electrodes) can be avoided. In the presence of a gas to carry the ultrasonic waves which cause the reaction, the walls should be several centimetres away from the vibrating faces, so that the waves are absorbed by the gas. If the walls have to be close, *they should be rendered diffusing to the waves—e.g.*, by granulations of dimensions comparable to the wavelengths—so as to avoid the formation of standing waves. If no gas is present, there is no trouble with reaction.

INFLUENZA DEL DECREMENTO DEL QUARZO SULLA FREQUENZA DI OSCILLAZIONE DEI PIEZO-OSCILLATORI (Influence of the Quartz Decrement on the Frequency of a Piezo-Oscillator).—M. Boella. (*L'Elettrotec.*, No. 32, Vol. 17, pp. 734–736.)

A quantitative investigation of the effect of the crystal decrement. The writer finds that the values of the two frequencies for which the excitation of the quartz is a maximum and a minimum are only slightly affected by the variations in decrement. He arrives at a particular circuit by the use of which he makes the quartz resonate to the "maximum" frequency with a variation, as a function of the decrement, only about one-tenth of that obtained with the Pierce circuit. This special circuit should be useful for obtaining a very stable frequency.

THE RESONANCE CURVES OF PIEZOELECTRIC RESONATORS.—G. Angrisano. (*L'Elettrotec.*, 15th Oct., 1930, Vol. 17, pp. 678–679.)

Including a "particularly stable" circuit for quartz resonators.

MEASUREMENTS OF TEMPERATURE COEFFICIENT AND PRESSURE COEFFICIENT OF QUARTZ CRYSTAL OSCILLATORS.—S. Leroy Brown and S. Harris. (*Review Scient. Instr.*, March, 1931, Vol. 2, pp. 180–183.)

Authors' abstract:—A method of measurement is used whereby variation in frequency of a high-frequency oscillator can be measured easily to a fraction of a part in a million. The audible difference tone produced by a harmonic of a constant, high-frequency oscillator and a harmonic of a second oscillator is compared to the tone of a variable, calibrated audio-frequency oscillator. Any change of the frequency of the second high-frequency oscillator is measured to a fraction of a cycle per second. This method of measurement is used to determine the effects of temperature and pressure on the frequency of a piezo-electric oscillator. The temperature effect is of the order of 20 parts per million per degree centigrade, while the pressure effect is of the order of only 6 parts per million per atmosphere.

SUR L'ORIENTATION DES CRISTAUX ET SPÉCIALEMENT DU QUARTZ À L'AIDE DES FIGURES DE CORROSION (The Orientation of Crystals, particularly Quartz, with the Aid of Corrosion Figures).—C. Gaudefroy. (*Comptes Rendus*, 4th May, 1931, Vol. 192, pp. 1113–1116.)

The corrosion figures produced on the face of a quartz fragment by means of hydrofluoric acid can be used to orientate the fragment, of whatever shape it may be, even if it has preserved not a single crystalline face; to find the direction of the optical axis, the direction and sense of the piezo-electric axes, etc. This possibility depends on the fact that each corrosion figure possesses facets in definite planes and the combined systems of facets can be studied by goniometric methods as if they were the natural faces of the crystal.

SUBSIDIARY APPARATUS AND MATERIALS.

ÜBER HOCHFREQUENZWIDERSTÄNDE (Resistances for High Frequencies).—M. Wien. (*Zeitschr. f. hochf. Tech.*, April, 1931, Vol. 37, pp. 169–172.)

By special methods of winding (*e.g.*, of Wagner and Wertheimer) the capacitive and inductive effects of ordinary wire resistances can be reduced so as to make such resistances serviceable up to frequencies of the order of 10^5 p.p.s., though small resistances of thick wire are troubled also by skin effects. As the frequency increases, errors due to all these causes increase, and for frequencies in the range 10^7 to 10^8 p.p.s. the need arises for quite special resistances. Such resistances the writer has already discussed (Jan. Abstracts, p. 48); in the present paper he deals with them in greater detail. As regards wire resistances, short straight pieces of resistance-wire (down to 0.03 mm. diam. for manganin, giving 10 ohms for a length of about 1.7 cm., with an inductance of about 23 cm.) are satisfactory when suitably mounted, if the current does not over-heat them. For continuous loading, they may be embedded in paraffin wax, and will then carry up to 0.5 A. for several minutes. For impulses, the paraffin is useless, since the heating is adiabatic. In measuring operations where the resistance has to be cut in and out, it is best to replace it with a dummy of copper wire whose resistance may be calculated by the Zenneck formula and tables.

The Siemens "Karbowid" resistances (carbon layer on non-conducting cylinder) have very little inductance and can be made down to about 30 ohms; they show very little skin effect up to 10^8 p.p.s., but have a rather high temperature coefficient; for a longish passage of current this may be counteracted by suspending the resistance in oil, but here again large currents of short duration cause adiabatic heating. This type would be far the best if only it could be made of still lower resistance and without appreciable temperature coefficient.

Electrolytic resistances have the advantage that they can be varied by changing their concentration. But at high frequencies it must be remembered that the capacity current will make itself felt; moreover, measurements by the Kohlrausch method are upset by electrode polarisation. This last difficulty can be overcome by measuring by the barretter method (*loc. cit.*) which will measure such resistances accurately down to 0.1 ohm. An example of a liquid resistance for high frequencies is sketched; the bulb is only about 1.5 cm. in diameter, the electrode plates being correspondingly small to reduce the capacity effect.

The paper ends by giving the quantitative results of tests on various commercial resistances of the several types.

A SYSTEM FOR SUPPRESSING HUM BY A NEW FILTER ARRANGEMENT.—P. H. Craig. (*Proc. Inst. Rad. Eng.*, April, 1931, Vol. 19, pp. 664–675.)

The system described was designed to produce better smoothing of current from rectifier or commutator-generator sources than that given by existing types of filter, for the same amount of inductance and capacity; or alternatively to produce equal smoothing with less inductance and capacity. It depends on the principle that if, on a current given by a full wave rectifier, a similar and equal current is superposed which is 180° displaced in phase (as regards the ripple frequency; 90° as regards the input a.c.) then the resulting output has a ripple with double the frequency of either full-wave rectified current, and the amplitude of the a.c. component is greatly reduced.

Practical ways of using this principle, by the employment of filter circuits, are discussed; actual hum measurements in a particular case are given, showing that the phase-shifting arrangement reduced the hum to 0.162 v., whereas the standard filter, embodying larger inductances and capacities, reduced it to 0.23 v. The method is also applicable to frequency doubling.

ZUR FRAGE DES WIRKUNGSGRADES UND DER NUTZLEISTUNG VON FREQUENZTRANSFORMATOREN (On the Efficiency and Useful Output of Frequency Changers).—F. Sammer. (*Zeitschr. f. hochf. Tech.*, April, 1931, Vol. 37, pp. 159–161.)

The present paper does not concern itself with the choice of a suitable type of iron in order to reduce losses, but deals with methods of connection and dimensioning which can produce the same desirable result (*cf.* 1930 Abstracts, p. 113).

A special (Telefunken) circuit is described in which the several harmonics of a magnetic frequency changer are made use of for the production of the one required frequency; thus while the 15th harmonic, say, of the first transformer frequency is used as part of the output, the fifth harmonic is also dealt with in a second transformer, stepped up 3 times and added to the output. In its simplified form this multiple frequency-multiplying circuit can be modified so as to resemble the known "auxiliary circuit and parallel capacity" arrangement; the use of an auxiliary circuit, in order to increase the *di/dt* at the beginning of the demagnetisation, is discussed and compared with the Telefunken plan of cutting down the amount of iron and correspondingly increasing the primary ampère-turns; the auxiliary circuit method is more complex and has no advantages over the arrangement thus obtained, except in cases where the copper losses are of the same order as the iron losses; in this event the smaller copper losses in the auxiliary circuit method give it an advantage.

ELEKTROPHOTOGRAPHIE VON ISOLIERSTOFFEN (Electro-photography of Insulating Materials).—A. Gemant. (*Zeitschr. f. tech. Phys.*, May, 1931, Vol. 12, pp. 250–256.)

Photographic paper placed in a uniform field between plate electrodes shows blackening due to glow-discharges in the air. The writer uses this effect for the investigation, by what he names electro-photography, of insulating materials. The test material lies in direct contact with the sensitised layer. The main blackening is produced by glow discharges in the air enclosed in the pores and bubbles of the material, so that a picture is obtained of the distribution of the minutest pores and crevices. Examples are given, ranging from the very porous filter paper to the micro-porous cellophanes, bakelites, etc. A measure of the *size* of the pores is given by the voltage at which blackening first appears, while their *distribution* is evident from the pictures themselves. These are best taken by the use of alternating, not direct, current.

In the case of materials completely free from pores and flaws (*e.g.*, cable paper soaked in oil), blackening still occurs as a result of ionisation by collision. Electro-photography here throws light on the breakdown processes.

ÜBER SCHALTANORDNUNGEN BEI KATHODENSTRAHL-OSZILLOGRAPHEN ZUR AUFNAHME VON PERIODISCH UND APERIODISCH VERLAUFENDEN VORGÄNGEN IM RECHTWINKLIGEN KOORDINATENSYSTEM ([Survey of] Circuit Arrangements for C.-R. Oscillographs for Recording Periodic and Aperiodic Processes in a Rectangular Co-ordinate System).—W. Krug. (*Elektrot. u. Masch: bau*, 29th March, 1931, Vol. 49, pp. 233–239.)

EIN BEITRAG ZUR ENTWICKLUNG DES KATHODENOSZILLOGRAPHEN MIT KALTER KATHODE (Contribution to the Development of the Cathode Ray Oscillograph with Cold Cathode).—K. Beyerle. (*Archiv f. Elektrot.*, 15th April, 1931, Vol. 25, No. 4, pp. 267–276.)

A PERIODIC CONTACTOR OPERATED BY A NEON-TUBE OSCILLATOR.—H. J. Reich. (*Review Scient. Instr.*, March and April, 1931, Vol. 2, pp. 164–170 and 234–236.)

Among the several uses mentioned, the device has been used for periodically switching from one circuit to another in simultaneously studying two voltage waves with a cathode-ray oscillograph. It may also be used as a source of saw-tooth voltage of frequency up to about 5,000 cycles/sec.

A SIMPLE OSCILLOGRAPH.—Tabard: Sprenger. (*Radioélec. et QST franç.*, May, 1931, Vol. 12, pp. 13–15.)

Suitable for frequencies up to 3,000 p.p.s., this equipment consists essentially of a telephone movement, carrying a very light mirror, and a rotating mirror-drum.

PAPERS ON THE APPLICATION OF A C.-R. OSCILLOGRAPH TO PIEZO-ELECTRIC MEASUREMENTS.—Watanabe. (*See* abstracts under "Miscellaneous.")

APPAREIL ENREGISTREUR POUR TOUS DISPOSITIFS À SPOT (Recording Apparatus for "Spot of Light" Instruments).—M. Prot. (*Journ. de Phys. et le Rad.*, Series 7, Vol. 1, No. 3, p. 35.)

For simultaneous watching and recording. The photographic plate can make its complete transit in times ranging from 10 sec. to several days: its speed is controlled by a flow of oil through a regulated aperture, and is shown on the plate by indications made by a lamp controlled by an electric pendulum.

A BALLISTIC RECORDER FOR SMALL ELECTRIC CURRENTS.—E. B. Moss. (*Proc. Physical Soc.*, 1st May, 1931, Vol. 43, Part 3, pp. 254–258.)

A modification of the standard thread recorder of the Cambridge Instrument Company is described, whereby it records ballistic throws in place of the usual steady deflection. The current-sensitivity may thus be increased at least 25 times, so that the instrument is made to record currents of the order of 10^{-7} ampère.

POLYPHASE RECTIFICATION SPECIAL CONNECTIONS.—R. W. Armstrong. (*Proc. Inst. Rad. Eng.*, April, 1931, Vol. 19, p. 682.)

A number of corrections to the paper dealt with in May Abstracts, pp. 279–280.

THE THEORY OF A RECTIFIER WITH FALLING CHARACTERISTIC OF HYPERBOLIC FORM.—Stierstadt. (*See* under "Properties of Circuits.")

GLÜHKATHODEN-GLEICHRICHTER FÜR HOCHSPANNUNG, INSBESONDERE FÜR RUNDFUNKSENDER (Hot-Cathode Rectifiers for High Voltages, particularly for Broadcasting Transmitters).—A. Glaser: A.E.G. (*E.T.Z.*, 26th Feb., 1931, Vol. 52, pp. 277–278.)

A FULL-WAVE MERCURY-VAPOUR RECTIFIER TUBE: A NEW RECTIFIER FOR LOW-POWER SUPPLIES.—P. Schwerin. (*QST*, May, 1931, Vol. 15, pp. 22–24 and 44.)

NEW DESIGN OF MERCURY VAPOUR RECTIFIER.—(French Pat. 699041, Oerlikon Company, pub. 9th Feb., 1931.)

For summary and diagram, *see Rev. Gén. de l'Élec.*, 25th April, 1931, Vol. 29, p. 152D. The new design is based largely on the disproof of the idea that the chief site of the evaporation was the cathodic spot, and on the advantage of keeping the vapour away from the anodes.

RADDRIZZATORI ELETTRONICI (Electronic Rectifiers).—(*L'Elettrotec.*, 5th April, 1931, Vol. 18, pp. 233–234.)

An article on the Italian rectifiers type ARWO made by a Turin firm.

RECENT RESEARCHES ON THE COPPER-OXIDE RECTIFIER AND PHOTOELECTRIC CELL.—L. F. Bates. (*Science Progress*, April, 1931, Vol. 25, pp. 570–571.)

A useful summary of recent researches on the copper oxide cell, with references.

SOME NEW EXPERIMENTS WITH THE ZELENY [OSCILLATING-LEAF] ELECTROSCOPE.—R. Barton. (*Review Scient. Instr.*, April, 1931, Vol. 2, pp. 217–225.)

Experimental study of three-electrode valve models: experiments with photoelectricity: with beta rays: comparison of insulation resistances: absolute measurement of high resistances.

STATIONS, DESIGN AND OPERATION.

DER DERZEITIGE STAND DER ENTWICKLUNG DER ULTRA-KURZEN WELLEN UNTER BERÜCKSICHTIGUNG IHRER VERWENDUNGSMÖGLICHKEITEN FÜR RUNDFUNKZWECKE (The Present Position in the Development of the Ultra-Short Waves, with regard to their Practical Possibilities for Broadcasting).—F. Gerth. (*E.N.T.*, Jan., 1931, Vol. 8, pp. 39–42.)

The writer begins with a short history of the ultra-short-wave development work carried out since 1925 by Esau, Gresky, the Lorenz Company, Fassbender and Kurlbaum (*see* past Abstracts). Although the 1930 Berlin tests on 1 kw. power on a 7-metre wave showed the practicability of such waves for broadcasting purposes (ranges of 10 km. being obtained to the W. and S.W., and of about 7 km. to the E., N.E. and N., for a transmitter height of 30–50 m.) they made it clear that intensive work on certain points was necessary. The received field strengths were only comparatively small, and to obtain serviceable signals the damping of the receiver circuits had to be decreased by a strong reaction coupling. Improved modulation was essential: self-excited transmitters controlled by the choke control method were subject to very marked frequency modulation, and therefore the Lorenz Company developed their separately-excited quartz-controlled set and modulated it by their grid-voltage system.

The writer then refers to experiments carried out by the Lorenz Company in 1929 on the double modulation of a 3 m. wave, the ultra-short wave being modulated by a 300 m. (later 1,600 m.) wave which was itself modulated at audio-frequencies (*cf.* von Ardenne, Jan. Abstracts, p. 52). He mentions certain objections to this plan: the distance of the intermediate-frequency side-bands from the carrier, too great for the resonance curve of an audion with strong retroaction: super-regeneration, which had proved itself so valuable for note-modulated c.w., and which would give a considerably wider resonance curve, was found to be unsatisfactory for telephony on the ground of noise. The pros and cons of double modulation require very careful consideration; the Lorenz 7-metre transmitter at RPZ, Berlin, is equipped with the system, and research is continuing.

ULTRA - SHORT - WAVE BROADCASTING.—E. Schwandt. (*Wireless World*, 20th May, 1931, Vol. 28, pp. 526–528.)

An account of the experiments conducted in Berlin since October, 1930, by the German Post Office and the Telefunken Company in broadcasting on wavelengths of 6.75 and 7.05 metres. The object is to provide relays of distant transmissions over a limited zone of about 40 kilometres radius, and amateurs within the zone (*i.e.*, Berlin) are encouraged to build ultra-short-wave adaptors for addition to their ordinary receivers.

MODERNE QUARTZGESTEUERTE GLEICHWELLENSENDER (Modern Quartz-controlled Common-Wave Broadcasting Transmitters).—F. Gerth and W. Hahnemann. (*E.N.T.*, March, 1931, Vol. 8, pp. 131–134.)

From the Lorenz Laboratory. The design is due chiefly to Schumacher and Jacobs. The practice in other countries of employing tuning-fork control was rejected on account of the very great high-frequency multiplication necessary (about 1 : 500) and the consequent expense and elaboration. By the use of quartz control, a comparatively simple arrangement is obtained, and by a special design of the quartz oscillator and thermostat a constancy of frequency better than 1×10^{-6} was arrived at. With the equipment working at a frequency of 1,320 kc/sec., an anode-voltage change of $\pm$ 20% gave a frequency change of less than 1 cycle, a grid-bias change of $\pm$ 10 % gave the same, while a $\pm$ 15 % change of filament voltage gave a variation of about 1 cycle.

A prolonged test on two equipments with an interference note of 50 cycles/sec. was made, and throughout the test the reed frequency-meter never showed a change of as much as 1 cycle. This was without any adjustment to either set during the test.

The quartz plates were cut with their faces parallel to the crystal faces, and had a natural frequency of the order of 7 megacycles/sec. Electrode-gap effects were eliminated by silvering the quartz and by holding it and making connection to it by light spring contacts. A special thermostat, about which a separate paper will be published, was designed to give a constancy of better than $\frac{1}{8}$°C., and actually gave one of not more than $\frac{1}{500}$°C., the thermostat itself being exposed to the air. In practice this thermostat was itself enclosed in a second thermostat maintaining a temperature within $\pm$ 1°, so that the actual constancy attained was even greater. Special precautions were taken to design the circuit so that the quartz underwent as small oscillations as possible, in order to keep down the internal generation of heat. A special circuit (also to be described later) was employed to minimise the reaction effect of the oscillatory circuits on the frequency of the quartz. Many components, whose variation might affect the constancy of frequency, were themselves enclosed in the outer thermostat. Reactions of various kinds were guarded against by careful screening, by the introduction of an isolating stage, by neutralisation, etc. Thus the switching in or out of the last amplifier stages had no noticeable effect whatever on the frequency.

SYNCHRONISM OF BROADCAST STATIONS.—*Rad. Engineering*, April, 1931, Vol. 11, p. 41.)

Concerning the synchronisation of the Hartford and Baltimore stations (WTIC and WBAL). "We finally solved the last obstacle to practical synchronisation" [variation of phase] by means of a "stabiliser" which automatically operates the station and is itself governed by the frequency control which comes over the line from the central point. "The stabiliser disregards line variations in voltage, momentary changes in frequency and other disturbing factors, and for all practical purposes maintains the phase relationship in an ideal way." *Cf.* May Abstracts, p. 283.

R.C.A. DIVERSITY RECEIVING SYSTEM FOR RE-BROADCASTING.—Peterson, Beverage and Moore. (*See* abstract under "Reception.")

LA COLLABORATION DE LA T.S.F. ET DE L'AVIATION (The Collaboration between Wireless and Aviation).—P. Marty. (*L'Onde Élec.*, March, 1931, Vol. 10, pp. 97–120.)

After a short review of early days, the writer gives a detailed description of the Type A.V.L. 10 equipment of the S.F.R. He then deals with this Company's automatic "distress" transmitter which enables an untrained person to send out the distress signal together with his call signal and position. The rest of the paper deals with direction finders and beacons, especially the installation at Abbeville.

KDKA'S NEW 400 KW. TRANSMITTER.—A. Dinsdale. (*Wireless World*, 6th May, 1931, Vol. 28, pp. 470–472.)

A description of the two experimental transmitters of the Westinghouse Electric and Manufacturing Co., at Saxonburg, Pa., used for relaying KDKA—one on the normal broadcast frequency and the other on the higher frequencies.

To control the angle of elevation of the transmitted waves, eight poles, round a circle 700 ft. in diameter, are used to support the aerial, which has a vertical down lead to each pole. A cage top links up each pole to form a complete circle. By varying the phase relation of the currents in the feeder lines the radiated energy can be directed at any required angle of elevation.

The main 900-kw. rectifier, the largest unit of its kind ever used for broadcasting, employs six 190-KVA. single-phase transformers to provide the proper voltage and phase relations for rectification into the desired direct current energy. The rectifier is further remarkable for its use of the recently developed mercury vapour rectifier tubes.

FIELD STRENGTH MEASUREMENTS ON DAVENTRY 5XX.—Naismith. (*See* under "Propagation of Waves.")

GENERAL PHYSICAL ARTICLES.

SUR LA MÉCANIQUE QUANTIQUE DES CHOCS ATOMIQUES (The Quantum Mechanics of Atomic Collisions).—L. Goldstein. (*Comptes Rendus*, 27th April, 1931, Vol. 192, pp. 1022–1024.)

"The object of the present note is to show how one can calculate in quantum mechanics the probabilities of excitation of discrete or continuous atomic levels by collisions of neutral atoms or of *rapid* positive ions, without entering into the details of the calculation, which will be reserved for later publication."

SUR LE CHAMP CYLINDRIQUE IONISÉ ET LA DURÉE DE PARCOURS DES IONS (The Cylindrical Ionised Field and the Path Time of the Ions).—M. Pauthenier and M. Moreau-Hanot. (*Comptes Rendus*, 4th May, 1931, Vol. 192, pp. 1086–1087.)

In a uniform field, an ion of mobility k travels a distance l in a time $t_0 = \frac{l^2}{kV}$ where V represents the difference of potential between the points of departure and arrival. The writers show that if the field $E = -\frac{dV}{dl}$ varies in the space considered, the path time $t = \frac{1}{k}\int_0^l \frac{dl}{E}$ is in all cases greater than t_0.

In the case of a cylindrical field such as that in a condenser formed by a wire stretched along the axis of a cylinder, the field is strongly modified by the presence of ions due to corona effect. Pauthenier and Mallard (1930 Abstracts, p. 175) have shown that this field is constant except near the wire. The curve representing the variation of potential is much less concave than in the classic case of a cylindrical condenser without ionisation, and approaches a straight line more and more as the corona is more intense. It might be deduced that with this increase of corona the displacement of an ion from one armature to the other would become more and more rapid. This is confirmed by numerical examples: in the classic field, without ionisation, the path time worked out at $t_0 \times 3.6$; with a faint corona effect, it became $t_0 \times 1.47$, and with a very intense corona it was reduced to $t_0 \times 1.04$. In normal conditions of temperature and pressure, therefore, a corona effect can be obtained which is strong enough to reduce the path time between the armatures *practically to its minimum value* t_0.

Certain workers have reported on the one hand an increase of mobility in intense fields (of several thousand volts per cm.) and on the other a diminution of mobility a very short time after the formation of the ions (of the order of 1/100 sec.). These conditions of field or of time are satisfied in the straight portions of the writers' curves, and these reported irregularities are, so far as they are concerned, smaller than the experimental errors.

CORRECTED VALUES FOR THE COEFFICIENT OF RECOMBINATION OF GASEOUS IONS.—O. Luhr and N. E. Bradbury. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, pp. 998–1,000).

Authors' abstract :—Previously published values [O. Luhr, Feb. Abstracts, p. 112, and 1930 Abstracts, p. 585] of the coefficient of recombination are found to be 12 per cent. too high because of the distortion of the field between the plates of the ionisation chamber. Corrected values which may be used for the purpose of calculation are given as follows : Air, $(1.23 \pm 0.1) \times 10^{-6}$; O_2, $(1.32 \pm 0.1) \times 10^{-6}$; N_2 and A, $(1.06 \pm 0.1) \times 10^{-6}$; H_2, $(0.28 \pm 0.05) \times 10^{-6}$.

LES LOIS DE VARIATION, AVEC LE MILIEU, DE LA CHARGE MASSIQUE DE L'ÉLECTRON ET DE L'INTENSITÉ D'UN COURANT ÉLECTRIQUE (The Laws of Variation, with the Medium, of the Mass Charge of the Electron and of the Intensity of an Electric Current).—L. Genillon. (*Journ. de Phys. et le Rad.*, Series 7, Vol. 1, No. 12, pp. 135–137.)

Calculations on the assumption that the electric charge Q depends on the properties of the medium, as the electric forces do.

SUR LES PROPRIÉTÉS OPTIQUES D'UN LIQUIDE PLACÉ DANS UN CHAMP MAGNÉTIQUE ET TRAVERSÉ PAR UN FAISCEAU POLARISÉ DE DIRECTION QUELCONQUE (The Optical Properties of a Liquid in a Magnetic Field and Traversed by a Polarised Beam in Any Direction).—A. Cotton. (*Comptes Rendus*, 4th May, 1931, Vol. 192, pp. 1065–1069.)

THE KERR ELECTRO-OPTICAL EFFECT IN GASES.—E. C. Stevenson and J. W. Beams. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, p. 1021.)

Abstract only.

PROPERTIES OF DIELECTRICS IN ELECTRIC FIELDS.—G. L. Addenbrooke. (*Nature*, 9th May, 1931, Vol. 127, pp. 703–704.)

A reply to a previous letter on the same subject (*cf.* April Abstracts, p. 227).

MISCELLANEOUS.

A NEW DESIGN OF C.-R. OSCILLOGRAPH AND ITS APPLICATIONS TO PIEZO-ELECTRIC MEASUREMENTS : STUDY ON IMPACT TEST BY MEANS OF PIEZO-ELECTRICITY AND C.-R. OSCILLOGRAPH.—S. Watanabe. (*Scient. Papers Inst. Phys. and Chem. Res.*, Nos. 212 and 213, Vol. 12, pp. 82–98 and 99–112.)

ANALYTISCHE AUSWERTUNG EMPIRISCHER KURVEN (The Analytical Treatment of Empirical Curves).—W. Holzer. (*Bull. d. l'Assoc. suisse d. Élec.*, 20th March, 1931, Vol. 22, No. 6, pp. 147–150.)

SUMMARY OF THE WORK OF THE GERMAN AIRCRAFT RESEARCH ESTABLISHMENT (WIRELESS DIVISION) FOR 1929/30.—(*Zeitschr. V.D.I.*, No. 52, Vol. 74, p. 1771.)

Giving a series of references to papers already dealt with in past Abstracts.

DIE WIRKUNG DES MAGNETISCHEN FELDES AUF DIE LANGWELLIGE STRAHLUNG DES ELEKTRISCHEN FUNKENS (The Effect of a Magnetic Field on the Long-wave Radiation of the Electric Spark [when passing through a mixture of Canada Balsam and Molybdenum Granules]).—N. A. Lewitsky. (*Physik. Zeitschr.*, 15th March, 1931, Vol. 32, No. 6, pp. 252–255.)

THE DIELECTRIC CONSTANT OF COMPLEX COLLOIDAL SYSTEMS.—C. Marie and N. Marinesco. (*Journ. de Chimie-Phys.*, 25th November, 1930, pp. 455–470.)

One result obtained was that in some cases (*e.g.*, carbon-gelatine) the two constituents, taken separately, *increased* the dielectric constant of the water to which they were added, while the mixture of the two *decreased* it.

ELECTRON TUBES IN INDUSTRIAL SERVICE.—(*See* under "Valves and Thermionics.")

PHOTOELECTRIC CELLS IN INDUSTRIAL PROCESSES.—C. A. Styer and E. H. Vedder. (*Indust. and Eng. Chem.*, Oct., 1930, Vol. 22, pp. 1062–1069.)

Present and prospective uses in various manufactures are dealt with.

A PRELIMINARY REPORT OF THE APPLICATION OF THE PHOTOELECTRIC CELL TO THE READING OF MINIMA IN A MAGNETO-OPTIC METHOD OF ANALYSIS [OF CHEMICAL COMPOUNDS IN SOLUTION].—F. Allison, J. H. Christensen and G. V. Waldo. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, pp. 1003–1004.)

THE USE OF FILTERS WITH PHOTOELECTRIC TUBES [IN MEASURING CONCENTRATION OF SOLUTIONS].—L. R. Koller. (*Review Scient. Instr.*, March, 1931, Vol. 2, pp. 195–197.)

THE ELIMINATION OF MAN-MADE INTERFERENCE WITH RADIO RECEPTION.—(*See* abstracts under "Reception.")

SOVIET RUSSIA'S "FIVE-YEAR PLAN" FOR RADIO.—M. Codel. (*Electronics*, March, 1931, pp. 548–549 and 572.)

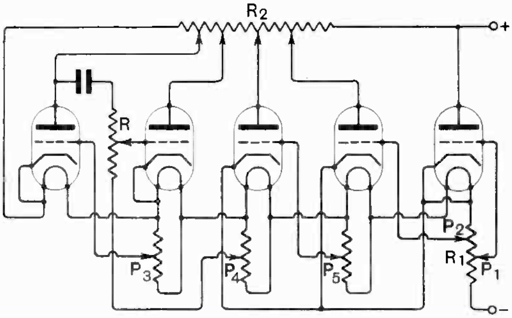
Some Recent Patents.

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.

ELIMINATING MAINS HUM.

Application dates: 9th December, 1929, 2nd January and 28th January, 1930. No. 340399.

In a multivalve set driven from D.C. mains, or from rectified A.C., the anode of the first valve comprises a resistance R, from which a variable tapping is taken to the grid of the second valve.



No. 340399.

Hum is eliminated by suitably adjusting the position of this tapping point. A resistance R_1 inserted in the negative main provides grid-bias for the last two valves through taps P_1, P_2, whilst bias for the first three stages is derived from potentiometers P_3, P_4, P_5 as shown. The cathodes of the last three valves are connected together and to the negative main. A resistance R_2 in the positive lead provides variable anode tappings.

Patent issued to O. D. Lucas.

REMOTE CONTROL SYSTEMS.

Application date, 23rd September, 1929. No. 340259.

The ganged tuning-condensers are coupled through a belt-drive to the shaft of a "shaded-pole" induction motor, which is energized for forward or reverse rotation by means of two keys on the remote-control board. A variable resistance in series with a measuring-instrument on the control board serves to indicate the position of the distant tuning-condensers at any time. The plate voltage of certain of the valves is also adjustable from the control panel.

Patent issued to Kolster-Brandes, Ltd.

HIGH-EMISSION FILAMENTS.

Convention date (Germany), 30th June, 1928. No. 314551.

Alkaline-earth metals of a specific gravity of 3.8 or less (or their alkyl compounds such as barium dimethyl with one group of carbon atoms) and barium diethyl with two groups of carbon atoms, are vaporized in a valve bulb which has previously been pumped and degasified. The barium separates out, first as carbide, and then as the oxide, which is precipitated on to a tungsten-wire cathode. The preparation of the barium alkyl compounds is described in the Specification.

Patent issued to B. Loewe.

ELECTROSTATIC LOUD SPEAKERS.

Convention date (U.S.A.), 14th January, 1929. No. 339391.

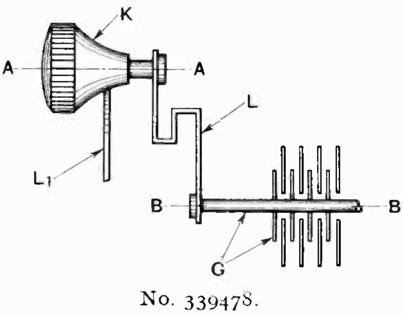
The reactance of the ordinary condenser type of speaker falls off at the higher frequencies, so that the lower tones are unduly emphasised. According to the invention an electrostatic speaker is built up from a number of condenser units which can be connected together either in series or parallel with each other and with auxiliary reactances, either capacitative or inductive, so that the overall impedance of the "network" can be adjusted to match any type of amplifier. The units may also be connected in parallel with respect to the polarising voltage, and in series with respect to the amplified signal voltage.

Patents issued to United Reproducers Patents Corporation.

COARSE AND FINE ADJUSTMENTS.

Application date, 28th November. No. 339478.

An S-shaped spring lever L connects the spindle of a condenser C directly to the shaft of a control knob K. The periphery of a circular disc L_1, mounted concentric with the condenser axis, B, B, normally makes contact with the tapered portion of the knob K as shown. For rapid adjustment,



No. 339478.

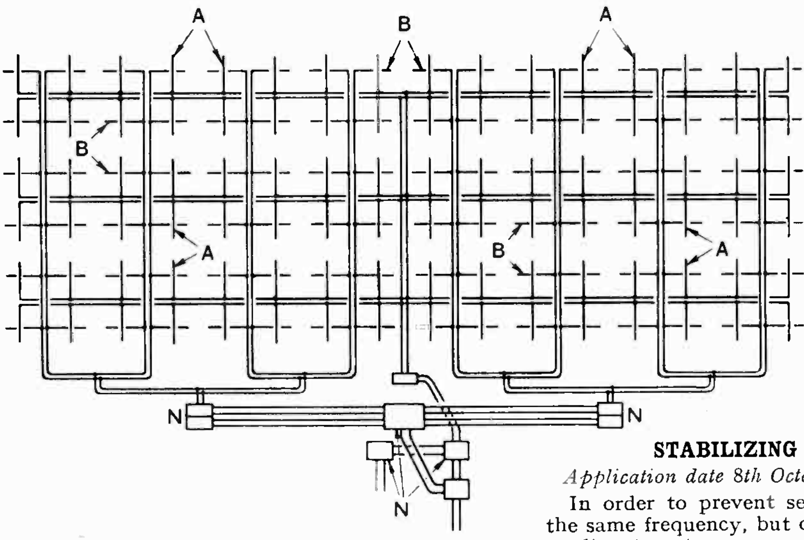
the knob K is pulled out of contact with the disc L_1, and is swung bodily about the condenser axis B, B. For fine adjustment the knob is rotated about its own axis AA whilst in frictional contact with the slow-motion disc L_1.

Patent issued to Gramophone Co. Ltd., and A. G. D. West.

PREVENTING FADING.

Convention date (Germany), 19th February, 1929.
No. 342060.

To reduce fading the radiation from a short-wave aerial of the beam type is circularly polarized.



No. 342060.

The radiating system comprises a series of vertical oscillators *A* co-operating with horizontal oscillators *B*, all arranged in parallel planes and energized with a phase-difference of 90 degrees. The necessary phase-regulation is secured by inserting impedance networks in the feed lines. A reflector-array, similar in construction to the radiating aerial, is arranged a quarter wavelength behind it.

Patent issued to Telefunken Gesell. für Drahtlose Telegraphie m.b.H.

FREQUENCY-MODULATED SYSTEMS.

Application date, 23rd October, 1929. No. 343538.

The signals are transmitted as frequency-modulated waves of constant amplitude, and in reception are heterodyned to a predetermined frequency range. The various frequency components within this range are first amplified equally, and the amplitudes are then limited to a definite value. At this stage they are passed through an amplifier having a variable-frequency characteristic, which converts the frequency modulation into a corresponding amplitude modulation. This is then rectified in the ordinary way. The system is applicable to telephony, picture transmission, or television.

Patent issued to J. H. Hammond, Jnr.

PIEZO-ELECTRIC OSCILLATORS.

Convention date (U.S.A.), 20th June, 1929.
No. 340918.

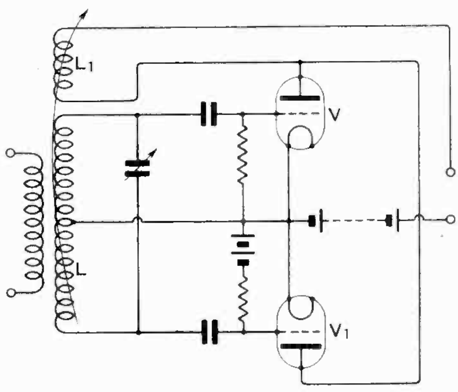
The fundamental frequency of oscillation of a piezo-crystal is varied, within limits, by changing the pressure of a medium in contact with it. For instance, one face of the crystal is exposed, inside a horn or flared tube, to a column of air of such length that it has a natural period of vibration slightly different from that of the crystal. Under these conditions the crystal tends to oscillate at an intermediate frequency, but by varying the pressure of the air, the crystal oscillations are caused to fluctuate in frequency. The resulting vibrations may be used to "wobble" the carrier-wave of a wireless transmitter, either to produce a frequency - modulated signal, or as a means for reducing fading-effects in long-distance working.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

STABILIZING AMPLIFIERS.

Application date 8th October, 1929. No. 341082.

In order to prevent self-oscillation, impulses of the same frequency, but of opposite phase to those tending to set up regeneration, are automatically applied to the valve when the energy in the system reaches a critical point. The back-coupled valve *V* shown in the figure may be one of the stages in a wireless receiver. An auxiliary valve V_1 is connected across a part of the input coil *L* as shown, so that the voltage applied to the grid is in phase-opposition to that on the grid of the valve *V*. The output is fed through the reaction coil L_1.



No. 341082.

The applied grid bias is normally sufficient to allow any current to pass through the valve V_1, but when a signal of unusual strength is received, out-of-phase currents pass to the coil L_1, and by reducing the effective back-coupling prevent the valve from breaking into oscillation.

Patent issued to J. Robinson.

TELEVISION RECEIVERS.

Convention date (U.S.A.), 21st December, 1928. No. 340612.

The incoming signals are fed simultaneously to a number of different light-valves, one of which is supplied as a viewing-appliance to each of the audience in a theatre, so that each observer sees the built-up image independently on the proscenium screen. Each light valve controls the passage of the rays from one common arc lamp to the eyes of each observer. By using this system, instead of applying the received signals directly to a single Kerr cell controlling the source of light, greater illumination is attained without injury to the light-sensitive apparatus.

The arc lamp may be replaced by a cathode-ray tube in which the electron stream is traversed across a fluorescent viewing-screen.

Patent issued to Electrical Research Products Inc.

TELEVISION SYSTEMS.

Convention date (U.S.A.), 18th August, 1928. No. 317475.

The picture to be transmitted is first scanned by one or more rotating-mirror drums so arranged as to spread out successive sections of the picture into one dimension, thus forming a continuous-line image. This is thrown on to a light-cell containing a sensitive electrode of coiled wire, the effective inductance of which varies according to the incidence of the light-ray. In this way each element of the image is transmitted at a different frequency, though the range of frequencies is constant over each line image. At the receiving end the incoming signals are fed to an inductance coil, and create nodes of current, which change in position with variations in wavelength. These changes are then utilised to produce corresponding changes in the position and intensity of a scanning light beam.

Patent issued to E. L. Peterson.

VOLUME CONTROL.

Convention date (U.S.A.), 3rd October, 1929. No. 343999.

Signal volume is regulated by applying the incoming energy in parallel to the grids of two amplifiers, the output circuits of which are arranged in push-pull or phase-opposition. The grids of the valves are separately biased so as to give different degrees of amplification, the net output being determined by the difference of current in the two plate circuits. For this reason any modulation distortion on strong signals is automatically eliminated, whilst a linear response is secured even with an input of several volts. The stage gain is reduced when the difference in grid-bias on the two valves is small.

Patent issued to Radio Frequency Laboratories Inc.

AERIALS.

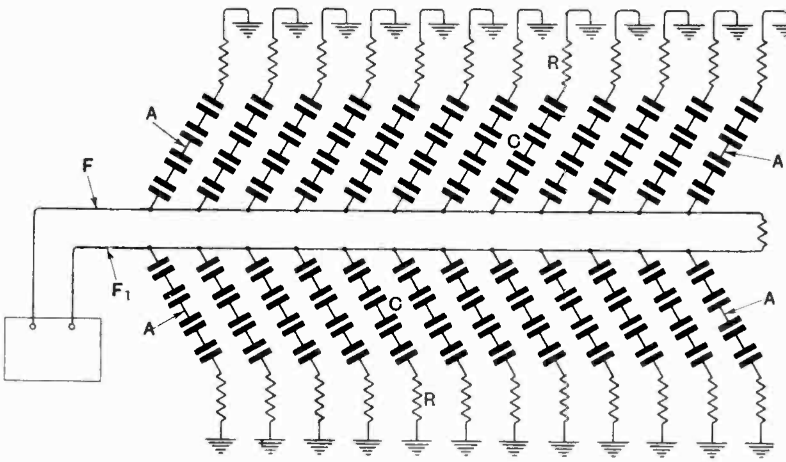
Application date, 7th October, 1929. No. 339714.

When tuning half-wave aerials, rapid changes of resistance and reactance occur as the frequency is altered which, in turn, tend to introduce asymmetrical characteristics on the upper and lower side bands of a modulated wave. In order to prevent distortion due to this cause, the aerial is loaded with a non-radiating element, comprising an inductance coil and an associated capacity which serves to increase the distributed self-capacity of the coil. The inductance and capacity per unit length of the loading element is greater, though the ratio of these factors is the same as that of the open coil aerial.

Patent issued to H. L. Kirke.

Convention date (U.S.A.), 29th March, 1929. No. 340892.

A directional aerial comprises a pair of closely spaced feeder lines F, F_1, to which are coupled a number of diverging antennae A grounded through surge impedances R. Each antenna is fed with current having a relative phase-displacement in step with that of the wave in space as it travels along the feed-lines. Also the rate of energy flow along the antennae, resolved in the direction of propagation, must be equal to the velocity of the space-wave in that direction. These conditions are ensured by the insertion of coupling and loading condensers C as shown.



No. 340892.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

GRAMOPHONE PICK-UPS.

Convention date (U.S.A.), 12th June, 1929. No. 342635.

The mechanical vibrations of the needle are converted into equivalent current-variations through the changes in electrical resistance of a layer of cuprous oxide with which an electrode carried by the needle makes contact. The contact electrode consists of a coating of deflocculated graphite upon a rubber block. The electrode may be so mounted that movement in one direction increases the contact resistance at one end of the electrode and decreases it at the other end, thus giving a push-pull effect.

Patent issued to Vega Manufacturing Corporation.

Application date 14th September, 1929. No. 339949.

The permanent magnet is in the form of a bar mounted at one end on a pivot-piece and carrying the winding-spool at the other. Saw-cuts are made in the top and bottom flanges of the spool to form housings for a pole-piece and a pole-plate. The pivot-piece is a horizontal rod supported at each end by axial pins carried by a swing-arm moving over the record. The arrangement lessens the weight of the needle, particularly by avoiding any mass situated directly over the needle. Most of the effective mass is disposed as nearly as possible in the line of the needle reaction, thus providing an inertia "anchorage" which prevents the pick-up as a whole from being set into vibration. The magnetic circuit is an open one, the return path of the lines of force being through the surrounding air.

Patent issued to F. W. Lanchester.

MEASURING DISTANCES BY RADIO.

Application date, 27th September, 1929. No. 340531.

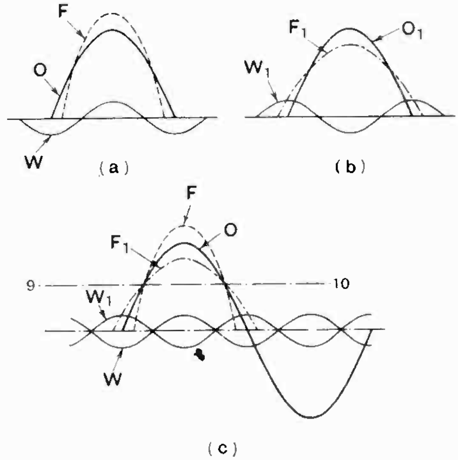
In order to ascertain the height of an aeroplane above ground, or the depth of a submarine in the sea, or, in general, the distance of any observer from a reflecting surface, a steady stream of oscillations is radiated and advantage is taken of the resultant "stationary-wave" formation set up between the outgoing waves and that fraction of the energy which is re-radiated back from the distant reflector. The distance between successive nodes or loops depends upon the wavelength radiated, whilst the amplitude varies as the distance from the reflecting surface. In the case of aeroplanes, the landing field at the aerodrome may be provided with a network of buried wires to increase the reflection.

Patent issued to A. A. Thornton.

HETERODYNE RECEIVERS.

Convention date (U.S.A.), 6th February, 1929. No. 340569.

Instead of combining the incoming signal wave with one of nearly the same frequency, the local oscillations are made approximately one-half the signal frequency, and the grid of the rectifying valve is so biased that current flows only during intervals corresponding to the "peaks" of the local oscillations. The advantage obtained is a comparative increase in the amplitude of the resultant "beat" or intermediate-frequency oscillation. For instance, in Fig. (*a*) the local oscillation O is shown in phase with the signal wave W, giving a "maximum" beat frequency F; whilst in Fig. (*b*) the two



No. 340569.

are out of phase giving a "minimum" resultant F_1. Fig. (*c*) shows Figs. (*a*) and (*b*) superposed. Now if the grid bias on the detector valve is adjusted to the level represented by the line 9, 10, the portion of the curves F, F_1, O below that line became ineffective. Since a greater portion of the "minimum" curve F_1 is cut out as compared with the "maximum" curve F, owing to the greater base-line of the former, a net gain is secured in the average amplitude of the resultant intermediate-frequency wave O.

Patent issued to Standard Telephones and Cables, Ltd.

DIRECTION-FINDERS.

Convention date (U.S.A.), 8th March, 1929. No. 340182.

When using a frame aerial to ascertain the direction of a distant transmitter, the accuracy of the reading depends upon the rate of change in the field-flux as the frame moves past the critical position.

In order to increase the sensitivity of the frame in either the maximum or minimum positions, the pick-up voltage is first amplified at radio frequency, and is then passed through one or more frequency-doublers before reaching the headphones or indicating device. The output from the frequency-doubling stages, being substantially proportional to the square of the input voltage, gives a correspondingly pronounced indication of any slight deviation of the frame from the true setting.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

STEREOPHONIC REPRODUCTION.

Application date 1st November, 1929. No. 341999.

Two pick-up microphones are located at different positions relative to the orchestra, etc., and are connected to a common recording apparatus, such as a single gramophone disc on which two separate impressions are recorded on tracks running side by side. In reproduction, the loud-speakers operated from the double track record are located at different points relatively to the audience so as to ensure a stereophonic effect.

Patent issued to H. A. Rogers and H. Germain.

MULTIPLEX SIGNALLING.

Convention date (U.S.A.), 31st May, 1929. No. 343392.

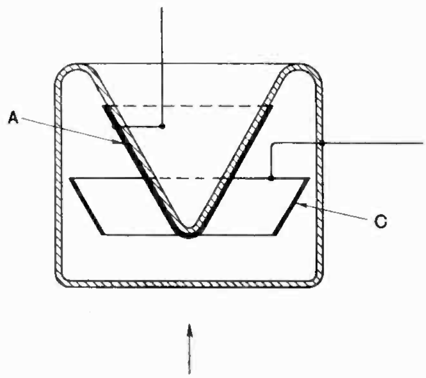
A number of different signals are superposed so as to form a composite wave, and transmission from the aerial takes place intermittently, sometimes at constant frequency and sometimes at constant amplitude, for periods which bear a definite relation to the amplitude of the complex wave. At the receiving end the incoming energy is rectified and separated into its constituent signals.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

LIGHT-SENSITIVE CELLS.

Application date, 29th August, 1929. No. 340527.

In order to increase the output from a given size of cell, the anode *A* consists of a coating of sensitized material laid on the conical inner surface of a re-entrant part of the bulb. The cathode *C* is in the form of an annular truncated cone, so as to throw no shadow on the anode. The direction of



No. 340527.

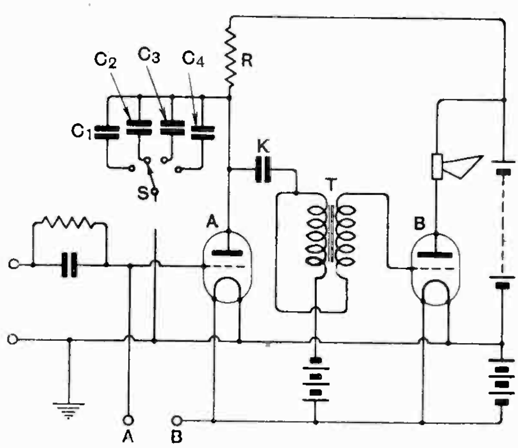
the incident light-ray is shown by the arrow. Alternatively the glass bulb is made conical in shape and the cathode is mounted on the inner surface of the glass to co-operate with a conical anode which is suspended centrally.

Patent issued to L. Kecskemeti-Kaye and British Talking Pictures, Ltd.

TONE CONTROL.

Application date, 4th October, 1929. No. 340615.

The first amplifier *A* is coupled to the next stage *B* through a combined resistance-capacity coupling *R*, *K* and a transformer *T*. A bank of



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condensers C_1, C_2, C_3, C_4 is arranged in the anode circuit, so that any selected one can be connected across to the filament circuit by means of a switch *S*. The input from a gramophone pick-up is applied across the points *A.B.* A similar system is described in connection with a back-coupled valve for wireless reception. The arrangement is stated to improve the quality of reproduction, and to reduce needle-scratch or atmospherics.

Patent issued to M. E. Elliott.

MAGNETRON DETECTORS.

Convention date (U.S.A.), 19th April, 1929. No. 340456.

The split-anode magnetron is a highly-evacuated tube having a hot cathode mounted between two anodes in a strong magnetic field flowing parallel to the axis of the anodes. The device has already been used to generate oscillations of a frequency higher than is normally possible with an ordinary triode valve.

According to the present invention it is employed to receive ultra short-wave signals (below 1 metre wavelength) by a heterodyne method. A tuned oscillatory circuit is connected across the two anodes, and is coupled to the receiving aerial so as to produce a beat frequency. This is fed to the primary winding of a transformer inserted between a mid-point tapping on the coil of the oscillatory circuit and the cathode of the magnetron. The secondary winding of the transformer is in series with a pair of headphones.

Patent issued to The British Thomson-Houston Co., Ltd.