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Editorial.

Does a Vibrating Diaphragm Carry a Mass of Air With It?

IN calculations concerned with vibrating diaphragms such as those of loud speakers, an addition is usually made to the actual mass of the diaphragm to allow for the mass of the air which is moved with the diaphragm. The effective mass of the vibrating diaphragm which must be used in calculating resonant frequencies is thus greater than its actual mass. At first sight this seems obvious, but on second sight it becomes less obvious, and a close examination of the subject shows it to be a more interesting phenomenon than one might have anticipated. If one considers the case of a disc fastened to the end of a rod, which is then moved rapidly backward and forward, like the piston of an engine in the absence of the cylinder, it is natural to assume that it will carry some air with it and thus increase its effective mass, but will this still be the case if the disc or piston vibrates in a cylinder into which it fits? Or again, if we consider an ideal acoustic oscillator in the form of a spherical balloon which is caused to swell and contract in rapid succession, say, by connecting it to a reciprocating air pump without the usual non-return valve, can we regard the spherical surface as carrying a mass of air with it, on its outward and inward movements, and if so, how much? It was the consideration of this problem of the pulsating sphere that suggested this editorial note, for it is a fact that a certain mass must be added to the actual mass of the spherical diaphragm to obtain the total effective mass in calculating the forces and resonant frequencies. One might be tempted to say that since the sphere cannot expand without pushing the air before it, it is obvious that some account of this must be taken in determining the total effective mass of the diaphragm. This argument is entirely countered, however, by the fact that in our example of the piston in a long cylinder no addition has to be made, although it certainly pushes the air before it when it moves.

Lord Raleigh's Investigations.

The pulsating sphere was studied by Lord Rayleigh; it lends itself to accurate and relatively simple mathematical treatment, and supplies the answer to our question. In a plane wave, such as that in a very long cylinder, the air particles are moving most rapidly at the moment of their maximum compression or rarefaction. If the wave were being produced in the cylinder by forcing a piston to and fro, then if the piston itself had no mass, so that the forces acting on it were transmitted to the air, the force on the piston would be exactly in phase with its velocity. If the piston had a certain mass, then the total force would have to contain a component to overcome the inertia of the piston, and the velocity would now lag behind the applied force.

Divergent and Convergent Waves.

In the above we assumed a plane wave; if the sound wave is divergent then it is no longer strictly true that the velocity of an air particle reaches its maximum at the moment of maximum compression or rarefaction; the pressure and velocity are out of phase by an angle ϕ, where $\tan \phi = \lambda/2\pi R$, λ being the wavelength and R the distance from the centre from which the waves may be regarded as diverging. In a divergent wave the velocity of the air particles lags behind the pressure, whereas in a convergent wave the angle is given by the same formula, but the pressure lags behind the velocity. We are rarely concerned with the latter case and can limit our consideration to that of divergent sound waves.

Now the wave produced by any small area of the spherical surface will be a divergent beam and the pressure or force at the surface of the spherical diaphragm will therefore be out of phase with its velocity, just as if the diaphragm had a certain mass or as if a mass of air were attached to it. This mass is given by the formula

$$M = \frac{4\pi R^3 \rho}{1 + \left(\frac{2\pi R}{\lambda}\right)^2}$$

where ρ is the density of the air or other medium. When R is small compared with λ, this reduces to $M = 4\pi R^3 \rho$, which is three times the mass of the sphere if filled with air. The volume of air apparently moved with each square centimetre of the spherical surface is $\frac{R}{1 + \left(\frac{2\pi R}{\lambda}\right)^2}$, which decreases as R increases.

We thus see that the apparent attachment of a quantity of air to the diaphragm is a convenient fiction which is only necessary in the case of divergent sound waves, because such waves cause a phase displacement between pressure and velocity which can be simulated by an increase of the mass of the diaphragm.

G. W. O. H.

OBITUARY.

We publish in this number an article entitled "Output Characteristics of Thermionic Amplifiers." It is with very great regret that we have to announce that the author, Mr. B. C. Brain, B.Sc., has recently died of pneumonia after a short illness.

Mr. Brain, who had recently married, was a young man at the beginning of what promised to be a highly successful career. He was a member of the research staff of the British Thomson-Houston Company's works at Rugby, and a perusal of the article in this number will show with what ability and originality he handled the problems arising in the proper design of thermionic amplifiers. In publishing this article, we wish to extend our sympathy to his wife and to the other members of his family.

Output Characteristics of Thermionic Amplifiers.

By B. C. Brain, B.Sc. (Hons.), Engineering Laboratory, B.T.H. Co.

SUMMARY.—The improvements which have taken place in recent years in loud speaker design and the rapidly growing number of the radio public who desire a receiver giving faithful reproduction have resulted in the development of special large output power valves. For the design of these and their correct use, a knowledge of the factors which determine the output of a valve is essential.

The method that is commonly used at present is due to Warner and Loughren* and has been further dealt with by Green.† This method consists in drawing a series of plate voltage-plate current curves for various grid voltages and super-imposing upon these curves the load characteristic in such a way as to show the current and voltage at any instant. While it is probably true that this method will remain the most accurate means of determining the output of a valve, it has the disadvantage of requiring a considerable time to take the readings and plot the curves; also in some cases information may be required as to the capabilities of a valve before samples are available to hand.

It was with a view to overcoming these difficulties that the writer took up this investigation. It will be shown that all the data required to fix the operating conditions of a valve for maximum undistorted output can be obtained (by the aid of a slide rule and five minutes' work) from a knowledge of two valve constants. These constants are embodied in the information which usually accompanies commercially made valves.

A list of the symbols employed is given at the end of the article.

It is assumed that the reader is familiar with the general effect of a resistance load on the characteristics of a valve, which is dealt with in detail in the papers mentioned above.

Determination of the Optimum Load Resistance for Maximum Output.

IT has been shown graphically by Brown and other workers that the best load resistance is twice the A.C. resistance of the valve on the assumption that the plate volts/plate current characteristics are straight over the working range. This is a condition rarely obtained in practice, and we shall, therefore, deduce a perfectly general solution which holds whatever the shape of the plate voltage/plate current curves provided the plate current is sinusoidal.

Consider the elementary circuit in Fig. 1 (a).

A thermionic amplifier (which is drawn as a triode but which can equally well be a tetrode or pentode) has a purely resistive load R_x connected in its anode circuit. The anode current is supplied by a battery or other source having a negligible internal resistance and of voltage V_0.

The relation between the grid potential and the anode current is shown in Fig. 1 (b).

We shall suppose that the grid voltage is zero when the maximum current is flowing (*i.e.*, the grid is never positive), and that when the grid is most negative a small anode current still flows. These conditions are imposed to limit distortion.

When a signal voltage of constant frequency is applied to the grid the anode current will vary according to the curve in Fig. 1 (c).

Since the A.C. component of current in the anode circuit is assumed to be sinusoidal, the A.C. power dissipated in R_x will be proportional to

$$(I_{\text{max.}} - I_{\text{min.}})^2 R_x$$

$I_{\text{max.}}$ and $I_{\text{min.}}$ being the upper and lower limits of anode current respectively.

Let us assume that $I_{\text{min.}}$ is very small and is proportional to $I_{\text{max.}}$ Then the A.C. power is proportional to

$$I_{\text{max.}}{}^2 R_x.$$

Let us now consider the conditions *at zero bias* when

$$I_{\text{max.}} = (I_a)_{E_g = 0}$$

and the anode voltage is

$$(V_a)_{E_g = 0}.$$

For convenience in writing the subscript indicating $E_g = 0$ is omitted in the following work.

Applying Kirchhoff's law to the anode

* *Proceedings of the Institute of Radio Engineers*, December, 1926, p. 735.

† *E.W. & W.E.*, July, 1926, p. 402.

circuit

$$V_a - V_0 + R_x I_a = 0 \quad .. \quad (1)$$

or

$$\frac{V_a}{I_a} + R_x = \frac{V_0}{I_a}$$

V_a/I_a is the D.C. resistance of the valve (at $E_g = 0$) which we can call R, hence

$$I_a = \frac{V_0}{R + R_x} \quad .. \quad .. \quad (2)$$

For the A.C. power in the load to be a maximum or minimum R_x is given by

$$\frac{d}{dR_x}(I_a^2 R_x) = 0 \quad .. \quad .. \quad (2a)$$

or

$$I_a + 2R_x \frac{dI_a}{dR_x} = 0 \quad .. \quad .. \quad (3)$$

In order to find $\frac{dI_a}{dR_x}$ differentiate (2) with

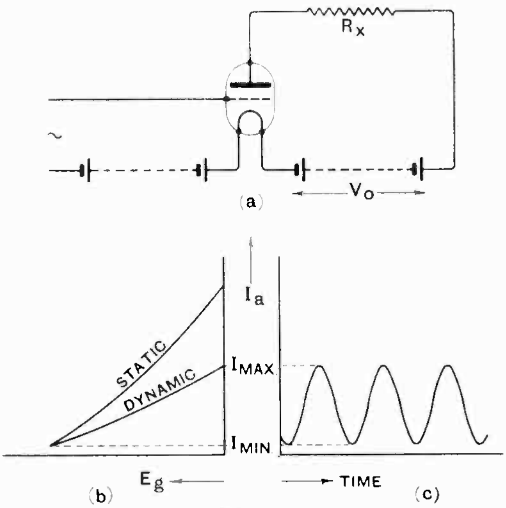


Fig. 1.

respect to R_x (I_a and R will both vary if the load resistance is varied)

$$\frac{dI_a}{dR_x} = -\frac{V_0}{(R + R_x)^2}\left(1 + \frac{dR}{dR_x}\right) \quad .. \quad (4)$$

Eliminating I_a and $\frac{dI_a}{dR_x}$ between (4), (2) and (3) we have

$$\frac{V_0}{R + R_x} - \frac{2R_x V_0}{(R + R_x)^2} \cdot \left(1 + \frac{dR}{dR_x}\right) = 0$$

or

$$R_x = \frac{R}{1 + 2\frac{dR}{dR_x}} \quad .. \quad .. \quad (5)$$

This result is of interest. If the valve obeys Ohm's Law, *i.e.*, R = constant, $dR/dR_x = 0$ and $R_x = R$. This is the well-known result for a battery or generator having an ohmic internal resistance R, the power in the circuit being a maximum when the external resistance is equal to the internal resistance of the battery.

A condition we have not yet made use of is

$$V_a = f(I_a) \quad .. \quad .. \quad (6)$$

which we can refer to as the law of the valve.

Hence $$R = \frac{V_a}{I_a} = \frac{f(I_a)}{I_a} \quad .. \quad .. \quad (7)$$

We now have four variables, R, R_x, V_a and I_a, connected by the three equations, (1), (6) and (7).

Hence R can be expressed as a function of R_x, and therefore these equations are sufficient to give us both R and $\frac{dR}{dR_x}$ in terms of R_x.

Differentiate (7) with respect to R_x

$$\frac{dR}{dR_x} = \frac{f'(I_a)}{I_a}\frac{dI_a}{dR_x} - \frac{f(I_a)}{I_a^2}\frac{dI_a}{dR_x}$$

$$= \frac{f'(I_a) - R}{I_a} \cdot \frac{dI_a}{dR_x} \quad .. \quad .. \quad (8)$$

$$\left(f'(I_a) \text{ denotes } \frac{d}{dI_a}f(I_a)\right)$$

re-writing equation (1) thus

$$f(I_a) - V_0 + R_x I_a = 0$$

and differentiating with respect to R_x

$$f'(I_a)\frac{dI_a}{dR_x} + R_x\frac{dI_a}{dR_x} + I_a = 0$$

or

$$\frac{dI_a}{dR_x} = -\frac{I_a}{R_x + f'(I_a)} \quad .. \quad (9)$$

putting this value in (8) we have

$$\frac{dR}{dR_x} = -\frac{f'(I_a) - R}{R_x + f'(I_a)}$$

but $$f'(I_a) = \frac{d}{dI_a}f(I_a) = \frac{d}{dI_a}(V_a) = R_a.$$

This is the differential or A.C. resistance of the valve under the operating conditions we are considering.

Hence $$\frac{dR}{dR_x} = \frac{R - R_a}{R_x + R_a} \quad .. \quad (10)$$

eliminating $\frac{dR}{dR_x}$ between (5) and (10) we get

$$R_x = \frac{R}{1 + 2\frac{R - R_a}{R_x + R_a}}$$

$$R_x^2 + R_x(R - R_a) - RR_a = 0$$

hence $\quad R_x = R_a$ *or* $-R \quad \ldots \quad \ldots \quad (11)$

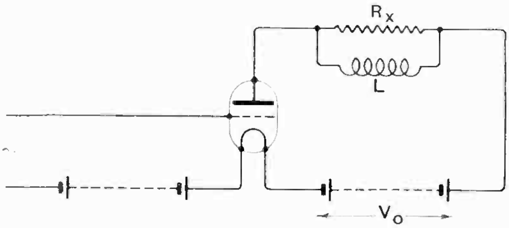


Fig. 2.

It is clear that maximum power is given by

$$R_x = R_a.$$

Thus when a resistive load is connected directly in the anode circuit of a valve as in Fig. 1 (a) the maximum power is developed in the resistance when its value is equal to the A.C. resistance of the valve *when the anode current is at its peak value*. We shall consider the significance of the clause in italics later.

The circuit shown in Fig. 1 (a) is rarely used because of the power wasted in the load resistance, owing to the D.C. component of anode current passing through it. The common arrangement is to use either a choke and condenser, or a transformer, to couple the valve to its load. Both these methods theoretically reduce to the circuit of Fig. 2. The choke L is supposed to have infinite inductance and negligible ohmic resistance, so that R_x only carries the sinusoidal output current while the steady anode current I_0 of the valve at its working bias (*i.e.*, without a signal input) flows through the choke. When a signal voltage is injected in the grid circuit A.C. power will be dissipated in R_x, while the steady current I_0 through the choke L is unaltered.

The equations we obtained in the previous case are now as follows:

Kirchhoff $\quad V_a - V_0 + R_x(I_a - I_0) = 0 \quad (12)$

Valve Law $\quad V = f(I_a).$

Condition for Max. Power

$$\frac{d}{dR_x}(I_{max.} - I_0)^2 R_x = 0 \quad \ldots \quad (13)$$

Since the current through R_x is assumed sinusoidal and $I_{min.}$ is very small and considered proportional to $I_{max.}$, we have

$$2I_0 = I_{max.} - I_{min.}$$

and $\quad (I_{max.} - I_0) = pI_{max.} \quad \ldots \quad (14)$

where $p = \frac{1}{2}\left(1 + \frac{I_{min.}}{I_{max.}}\right) =$ a constant.

Let us consider the conditions holding at the peak of the anode current swing, when the grid potential is zero. I_a and V_a will then be the instantaneous values of anode current and voltage at this point.

Combining (12) and (14), and (14) and (13) we get

$$V_a - V_0 + I_a pR_x = 0 \quad \ldots \quad (15)$$

$$p\frac{d}{dR_x}(I_a^2 \cdot pR_x) = 0 \quad \ldots \quad (16)$$

These equations are thus identical with (1) and (2*a*) obtained for the circuit of Fig. 1 (a), except that R_x is now replaced by pR_x. Thus by proceeding in exactly the same way as before we obtain for the circuit of Fig. 2.

$$\text{Optimum } R_x = \left(\frac{R_a}{p}\right)_{I_a = I_{max.}}$$

or $$-\left(\frac{R}{p}\right)_{I_a = I_{max.}} \quad \ldots \quad (17)$$

If we assume that $I_{min.}$ is negligible compared with $I_{max.}$ then $p = \frac{1}{2}$. Hence we obtain the following important result for choke or transformer coupled loads in thermionic amplifiers.

To obtain the maximum power output from a thermionic amplifier the load resistance should be twice the value of A.C. resistance of the amplifier when the anode current is at its peak value.

The assumption made by previous writers that the anode volts/anode current curves are straight and parallel means that the A.C. resistance of the triode is a constant and therefore they have not specified the conditions under which the R_a of the valve is to be measured. The result is that the practice has become common of making the load resistance equal to twice the A.C.

resistance of the triode at the working bias. It will be seen later that the error introduced by using this value is small in the case of triodes.

In the case of pentodes, however, the error is serious. The A.C. resistance of these under working conditions (and as published by manufacturers) is of the order of 50,000 ohms, but with the optimum load in circuit the A.C. resistance at the peak of the anode current swing is about 4,000 ohms.

Certain writers dealing with the design of loud speakers for use with pentodes have assumed that the A.C. resistance of the valve was 50,000 ohms for the purpose of their calculations and it seems to the writer that this assumption is open to criticism, and that in fact 4,000 ohms should be taken as the effective resistance. On this basis the optimum load resistance should be about 8,000 ohms and this has been verified by experiment. The writer hopes to deal with this branch of the subject in a later paper. For the present, attention will be given to the problem of calculating the optimum load resistance, etc., for triodes.

The R_a of the valve when $I_a = I_{\text{max.}}$ is impossible to determine without first knowing the load resistance, so that for equation (17) to be of any value to us we must translate

$$(R_a)^{I_a = I_{\text{max.}}}$$

into terms of some value which is easily found and which is independent of the value of R_x. The most convenient conditions are those when $I_a = I_0$. It is easily seen from equation (12) that the anode voltage at this point is equal to the voltage V_0 of the battery, and that the anode current is independent of R_x.

Let us assume that the performance of a triode is represented by the equation:

$$I_a = k\left(\frac{V_a}{m} - E_g\right)^{\frac{3}{2}} \quad \ldots \quad (18)$$

where E_g is the *negative* voltage on the grid of the valve.

"m" is the amplification factor and "k" is a constant which can be calculated given any set of simultaneous values of V_a, I_a, and E_g. Thus "k" can be calculated from values taken at a single point on the I_a/E_g characteristic which most makers supply with the valve.

No correction will be made here for the variation in potential along the length of the filament which is known to modify the form of equation (18). The error which is usually small will be compensated for later. The argument for the present, therefore, only applies to valves with equipotential cathodes, such as the indirectly A.C. heated type.

By differentiating (18) with respect to V_a we get

$$\frac{dI_a}{dV_a} = \frac{3}{2}\frac{k}{m}\left(\frac{V_a}{m} - E_g\right)^{\frac{1}{2}}$$

hence the A.C. resistance of the triode is given by

$$R_a = \frac{dV_a}{dI_a} = \frac{2}{3}\frac{m}{k}\left(\frac{V_a}{m} - E_g\right)^{-\frac{1}{2}} \quad (19)$$

When the anode current is at its maximum value, $E_g = 0$ and $I_a = I_{\text{max.}}$, and the anode voltage and A.C. resistance have their minimum values $V_{\text{min.}}$ and $R_{\text{min.}}$ respectively. Then from (18)

$$I_{\text{max.}} = k\left(\frac{V_{\text{min.}}}{m}\right)^{\frac{3}{2}} \quad \ldots \quad (20)$$

from (19)

$$R_{\text{min.}} = \frac{2}{3}\frac{m}{k}\left(\frac{V_{\text{min.}}}{m}\right)^{-\frac{1}{2}} \quad \ldots \quad (21)$$

from (12)

$$V_{\text{min.}} - V_0 + R_x(I_{\text{max.}} - I_0) = 0 \quad \ldots \quad (22)$$

When the anode current is at its steady value let

$$E_g = E_0,\ I_a = I_0,\ V_a = V_0,\ R_a = R_0$$

then from (18)

$$I_0 = k\left(\frac{V_0}{m} - E_0\right)^{\frac{3}{2}} \quad \ldots \quad (23)$$

from (19)

$$R_0 = \frac{2}{3}\frac{m}{k}\left(\frac{V_0}{m} - E_0\right)^{-\frac{1}{2}} \quad \ldots \quad (24)$$

when the grid is most negative $E_g = 2E_0$ and we have assumed that $I_a = I_{\text{min.}} = 0$; also $V_a = V_{\text{max.}}$

Then from (18)

$$I_{\text{min.}} = 0 = k\left(\frac{V_{\text{max.}}}{m} - 2E_0\right)^{\frac{3}{2}}$$

or

$$V_{\text{max.}} = 2mE_0 \quad \ldots \quad (25)$$

from (12)

$$V_{\text{max.}} - V_0 + R_x(0 - I_0) = 0 \quad \ldots \quad (26)$$

Having obtained these important relations, we can return to the problem of finding $R_{\text{min.}}$ in terms of R_0. We require this relation to interpret equation (17).

Since $I_{min.} = 0$ we have from equation (14)

$$I_{max.} = 2I_0$$

hence from (20) and (23)

$$\left(\frac{V_{min.}}{m}\right)^{\frac{3}{2}} = 2\left(\frac{V_0}{m} - E_0\right)^{\frac{3}{2}} \quad \ldots \quad (27)$$

but from (21) and (24)

$$R_{min.} = R_0 \frac{\left(\frac{V_0}{m} - E_0\right)^{\frac{1}{2}}}{\left(\frac{V_{min.}}{m}\right)^{\frac{1}{2}}}$$

hence from (27)

$$R_{min.} = \frac{1}{\sqrt[3]{2}} R_0 \quad \ldots \quad (28)$$

Returning to equation (17) we find that this gives

$$R_x = \left(\frac{2}{\sqrt[3]{2}}\right) R_0 \ldots \quad \ldots \quad (29)$$

Hence maximum power output from a triode with a resistive load (transformer or choke coupled to the anode circuit) is obtained by making the Load Resistance approximately 1.6 times the A.C. resistance of the valve at the working bias.

Calculation of Working Bias, Load Resistance, etc., in Terms of the Valve Constants.

It frequently happens that the mean anode current I_0 which flows when a valve is put in a circuit having the optimum load resistance is greater than the makers recommend. This anode current limitation is imposed in order to ensure that the power dissipated at the anode (and consequently the temperature of the anode) shall be kept within safe limits. In order to meet this further consideration the load resistance may have to be much greater than the optimum value.

The first problem is to find how n, the ratio of the external resistance to the A.C. resistance of the valve, is related to E_0.

From equations (25) and (26), eliminating $V_{max.}$ and putting $R_x = nR_0$

$$V_0 + nR_0 I_0 = 2mE_0$$

Putting the values of R_0 and I_0 from (23) and (24) in this equation

$$V_0 + nk\left(\frac{V_0}{m} - E_0\right)^{\frac{3}{2}} \frac{2}{3}\frac{m}{k}\left(\frac{V_0}{m} - E_0\right)^{-\frac{1}{2}} = 2mE_0$$

whence
$$n = \frac{3V_0 - 6mE_0}{2mE_0 - 2V_0} \ldots \quad \ldots \quad (30)$$

If we are given the safe limit of anode current at a battery voltage of V_0 we can calculate from (23) the value of E_0 which will just give this current. Putting in the value of E_0 in (29) we obtain the required ratio n.

We now have sufficient data to calculate all the required operating conditions to fit any circumstances, from the constants of the valve.

The method will be demonstrated on the

TABLE I.

$\frac{Rx}{R_0} = n$	Bias E_0	Anode Current I_0	Load Resis. R_x	Max. Current $I_{max.}$	Max. Plate Volts $V_{max.}$	Min. Plate Volts $V_{min.}$	Output W.
0.5	0.572	0.274	0.508	0.697	1.14	0.786	0.0308
1.0	0.625	0.230	1.09	0.538	1.25	0.662	0.0394
1.5	0.667	0.192	1.73	0.439	1.33	0.578	0.0415
2.0	0.700	0.164	2.43	0.368	1.40	0.511	0.0406
2.5	0.727	0.143	3.19	0.314	1.45	0.462	0.0393
3.0	0.750	0.125	4.00	0.269	1.50	0.418	0.0365
4.0	0.786	0.099	5.76	0.209	1.57	0.353	0.0317
5.0	0.813	0.081	7.70	0.171	1.63	0.308	0.0282
7.0	0.850	0.058	12.04	0.120	1.70	0.244	0.0218
10.0	0.885	0.039	19.60	0.080	1.77	0.185	0.0155
Symbol of Factor	B	A	C	D	—	F	H
	$B \cdot \frac{V_0}{m}$	$A \cdot k\left(\frac{V_0}{m}\right)^{\frac{3}{2}}$	$C \cdot \frac{m}{k}\left(\frac{V_0}{m}\right)^{-\frac{1}{2}}$	$D \cdot K\left(\frac{V_0}{m}\right)^{\frac{3}{2}}$	$2B \cdot V_0$	$F \cdot V_0$	$H \cdot Km\left(\frac{V_0}{m}\right)^{\frac{5}{2}}$

assumption that

$$R_x/R_0 = n = 3.$$

From (30)

$$E_g = \frac{3}{4}\frac{V_0}{m},$$

from (23)

$$I_0 = k\left(\frac{V_0}{m} - \frac{3}{4}\frac{V_0}{m}\right)^{\frac{3}{2}} = 1/8\, k\left(\frac{V_0}{m}\right)^{\frac{3}{2}},$$

from (24)

$$R_0 = \frac{2}{3}\frac{m}{k}\left(\frac{V_0}{m} - \frac{3}{4}\frac{V_0}{m}\right)^{-\frac{1}{2}} = \frac{4}{3}\frac{m}{k}\left(\frac{V_0}{m}\right)^{-\frac{1}{2}}.$$

Putting these values in (22) and solving the resultant cubic for $V_{min.}$ we get

$$V_{min.} = .418\, V_0,$$

hence from (20)

$$I_{max.} = k\left(\frac{.418 V_0}{m}\right)^{\frac{3}{2}} = .27\, k\left(\frac{V_0}{m}\right)^{\frac{3}{2}}$$

The power output is

$$1/8\, I_{max.}^2 R_x = 1/8\left[.27\, k\left(\frac{V_0}{m}\right)^{\frac{3}{2}}\right]^2 4\frac{m}{k}\left(\frac{V_0}{m}\right)^{-\frac{1}{2}}$$

$$= .0365\, km\left(\frac{V_0}{m}\right)^{\frac{5}{2}}$$

It will be observed that each of the quantities involves some or all of the factors m, k and V_0, and has a numerical coefficient which is clearly a function of n only. Thus as different values of n are used the value of $V_{min.}$, say, will always contain V_0, but the numerical coefficient will alter.

The results of giving n various values between 0 and 10 is shown in Table I.

The numbers tabulated are the numerical coefficients, and the whole of the expression is given at the bottom of each column. The capital letters A, B, C, D, etc., called "symbol of factor," are given to facilitate reference to the curve of Fig. 3.

All the important variables are here plotted against n. Once n is fixed, a vertical line drawn through this value gives all the coefficients A, B, C, D, etc., simultaneously. Alternatively, if n is unknown but one of the other variables, say, $V_{min.}$, is fixed, we write

$$V_{min.} = F \cdot V_0$$

from which the value of the numerical coefficient F is found. A vertical line through this value of F on the curve gives n and all the coefficients simultaneously.

The results given in Table I are for valves with equipotential cathodes. We shall now consider how these results can be modified to apply to valves having filaments directly heated by A.C. or D.C.* Owing to the

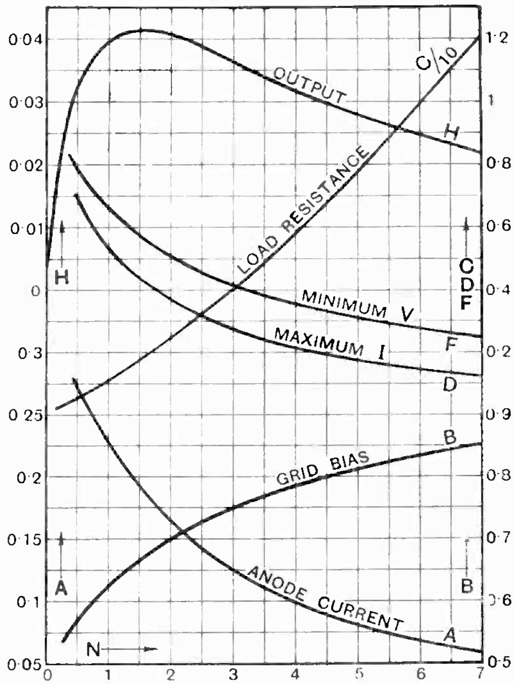


Fig. 3.

voltage drop along the length of a filament on D.C., the differences of potential between grid and filament, and anode and filament, are different at different parts of the filament. It can be shown that the mean effect of the biassing voltage due to this cause over the length of the filament is approximately the same as a decrease in anode voltage mz,

where $$z = \frac{E_f}{2}\left(1 + \frac{1}{m}\right) \quad .. \quad .. \quad (31)$$

E_f is the filament voltage.

Thus a valve having a 6-volt filament and an m of 4 will behave in approximately the same way as a valve of identical construction, but with the filament at a uniform

* NOTE.—It should be understood that this correction is a refinement of the method, and for the majority of purposes is hardly necessary. It is important to use the correction only when $\frac{V_0}{m}$ is small and/or the greatest accuracy is desired.

potential, having its anode voltage reduced by 15 volts.

By introducing the correction into equation (18) we can obtain the constant k of the valve. Having made use of the curve of Fig. 3 in the manner already described to find the coefficients A, B, C, D, etc., we can calculate the corresponding values of anode current, bias, etc., for a D.C. heated filament by replacing V_0 wherever it appears by $(V_0 - mz)$.

When A.C. is used for heating the filament the grid circuit should be always returned to the centre tap on the filament transformer. It will be seen that with this arrangement, so far as anode current is concerned, the result will be the same as if the filament were at a uniform potential. However, grid current can flow when $E_g = 0$ because, although the mean potential of the filament is zero, parts of it are negative with respect to the grid. In order to eliminate grid current, therefore, we must supply an *additional* bias to the grid of

$$z' = \sqrt{2}\,\frac{E_f}{2} \qquad \ldots (32)$$

where E_f is the R.M.S. filament voltage. The resulting characteristic is then the same as that of our ideal triode having its anode voltage reduced by m times *this additional* bias, *i.e.*, mz'.

To obtain the value of k, then, we apply no correction to the values of I_a, E_g and V_a measured with A.C. heated filaments, but in working out the operating conditions from the coefficients obtained from the curves of Fig. 3 we subtract the correction mz' from the value of V_0 wherever it appears.

The quantity E_0 calculated by this means is really the peak value of the signal voltage for maximum output, and differs from the grid bias by the quantity z'. To obtain the grid bias we must, therefore, add a voltage z' to the calculated E_0 for A.C. heated filaments.

The use of these corrections for A.C. and D.C. conditions appears at first sight complicated, but the following examples will show the ease of manipulation of the method.

Examples Showing Method of Calculating Operating Conditions.

A particular B.T.H. B.12 valve was found to have the following constants, taken with D.C. heating of the filament.

$$E_a = 375 \text{ volts}$$
$$E_g = 80 \text{ volts negative}$$
$$E_f = 7.5 \text{ volts}$$

Anode current $= 32\ mA$.

Amplification factor $m = 3.25$.

The correction for D.C. is thus

$$z = \frac{7.5}{2}\left(1 + \frac{1}{3.25}\right) = 4.9 \text{ volts,}$$

and for A.C. is

$$z' = \frac{\sqrt{2} \times 7.5}{2} = 5.3 \text{ volts}$$

also from (18) applying the correction for D.C.

$$32 = K\left(\frac{375}{3.25} - 80 - 4.9\right)^{\frac{3}{2}}$$

whence $K = \dfrac{32}{164} = .195$ milliamps/volt$^{\frac{3}{2}}$.

Example 1.—To find the Output and Operating Conditions with a battery voltage $V_0 = 425$ volts and the anode dissipation limited to 12 watts.

(*a*) Suppose the filament is to be heated by A.C.; the steady anode current $I_0 = \dfrac{12}{425} \times 1000 = 28.3$ milliamps; but Table I gives $I_0 = A \cdot K\left(\dfrac{V_0}{m}\right)^{\frac{3}{2}}$ for the ideal triode; on A.C. this becomes

$$I_0 = A \cdot K\left(\frac{V_0}{m} - z'\right)^{\frac{3}{2}} = 274\,A,$$

hence $$A = \frac{28.3}{274} = 0.103.$$

Drawing a vertical line on the curves of Fig. 3 through the point on the anode current coefficient curve corresponding to $A = .103$ we get the following values:

$n = 3.75$, $B = .775$, $C = 5.3$, $D = .22$, $F = .37$, $H = .033$.

Then $$E_0 = .775\left(\frac{425}{3.25} - 5.3\right) = 97 \text{ volts,}$$

and the grid bias for A.C. is $(E_0 + z') = 102.3$ *volts.*

Optimum load resistance

$$R_x = 5.3\frac{3.25}{.195}\left(\frac{425}{3.25} - 5.3\right)^{-\frac{1}{2}} = 7.9$$

(and since k is in milliamps) = 7,900 *ohms*

$$I_{max.} = .22 \times .195\left(\frac{425}{3.25} - 5.3\right)^{\frac{3}{2}} = 60 \textit{ milliamps.}$$

$$V_{min.} = .37\,(425 - 3.25 \times 5.3) = 151 \textit{ volts.}$$

Maximum Output $= .033 \times 3.25$

$$\times .195\left(\frac{425}{3.25} - 5.3\right)^{\frac{5}{2}} = 3.65 \textit{ watts.}$$

(*b*) Suppose the filament is to be heated on D.C. Proceeding as in (*a*) but replacing z' by $z = 4.9$ volts we get

$$I_0 = .195\left(\frac{425}{3.25} - 4.9\right)^{\frac{3}{2}} A = 275\,A,$$

hence $A = 0.103,$

which gives the same values for the coefficients as before.

Then,

$$E_0 = .775\left(\frac{425}{3.25} - 4.9\right) = 97.7 \text{ volts};$$

hence the grid bias on D.C. is 97.7 volts.

Similarly

Optimum load resistance = 7,900 *ohms*
$I_{max.}$ .. .. .. = 60.5 *milliamps.*
$V_{min.}$ .. .. .. = 151 *volts*
Maximum output .. = 3.7 *watts*

Example 2.—To find the Maximum Output when the Anode Battery Voltage is limited to 200 volts.

Since there is no limitation of anode current now, we can use the optimum value of load resistance, *i.e.*, $n = 1.6$. Drawing a vertical line on the curves through this point we get

$$A = .19,\ B = .67,\ C = 1.9,\ D = .43,$$
$$F = .56,\ H = .041.$$

For D.C. operation of filament

Anode current

$$I_0 = .19 \times .195\left(\frac{200}{3.25} - 4.9\right)^{\frac{3}{2}} = 15.7 \text{ mA.}$$

(negative) Grid Bias

$$E_0 = .67\left(\frac{200}{3.25} - 4.9\right) = 38 \text{ volts.}$$

Load Resistance

$$R_0 = 1.9\frac{3.25}{.195}\left(\frac{200}{3.25} - 4.9\right)^{-\frac{1}{2}} = 4{,}220 \text{ ohms.}$$

Power Output

$$= .041 \times 3.25 \times .195\left(\frac{200}{3.25} - 4.9\right)^{\frac{5}{2}} = .63 \text{ watt.}$$

Beside the value of this method as a simple means of determining the output conditions, we have discovered several interesting facts relating to the output of valves which are not obvious from graphical considerations.

(1) The maximum output from a valve is proportional to the 2.5 power of the anode voltage and to the constant K, defined previously.

(2) The output of valves of identical construction but with differing "*m*" values operating with the same anode voltage is inversely proportional to the 1.5 power of "*m*."

(3) The grid bias for maximum output is directly proportional to the anode voltage and inversely proportional to "*m*."

Throughout this work we have assumed that the valve follows the 3/2 power law. In order to get reliable results it is necessary to make sure that the valve under consideration is of sound design. For instance, a valve in which the filament projects above the grid so that a fraction of the electrons can reach the anode uncontrolled by the grid will have an unduly high value of K, and also, to avoid distortion due to the excessive curvature at the lower end of the characteristic, it will be necessary to make $I_{min.}$ fairly large; hence there may be a considerable discrepancy between the calculated results and those obtained in practice. In a paper by Hann, Sutherlin and Upp* it is pointed out that in valves with very open mesh grids a similar effect is produced, resulting in a lower undistorted output than would be expected from the constants. It is unlikely, however, that there are any commercial valves which show this failing to any marked extent.

List of symbols used in the preceding

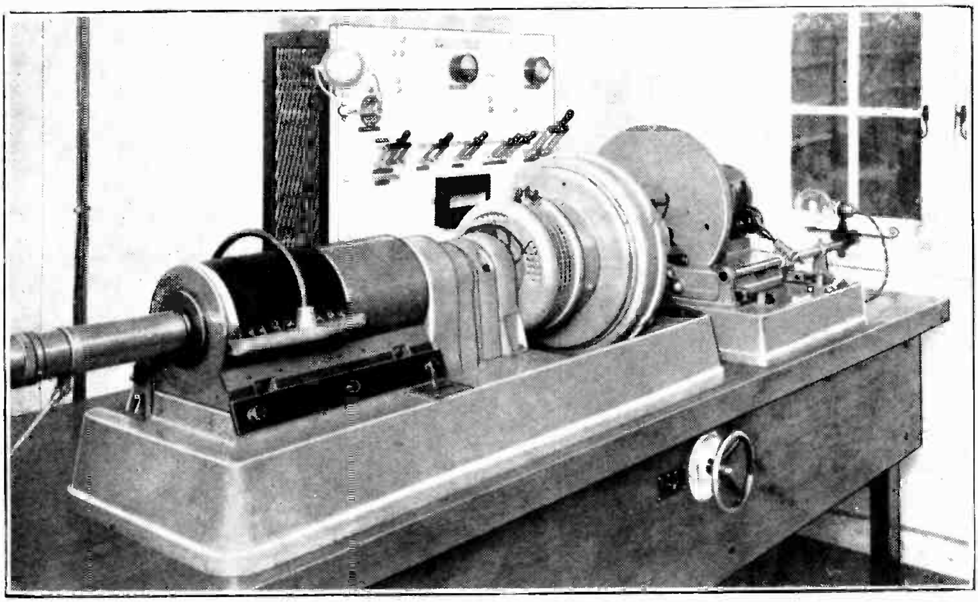
* *Proc. Inst. Rad. Engineers*, April, 1928.

calculations :—

I_a = Anode current.
V_a = Anode voltage.
E_g = Grid voltage.
R_a = A.C. resistance of valve.
R_e = Load resistance.
$I_{max.}$ = Maximum value of anode current under dynamic conditions.
$I_{min.}$ = Minimum value of anode current under dynamic conditions.
E_0 = The negative bias on the grid with no signal output.
I_0 = The steady anode current which flows when the grid voltage is at its steady value E_0.
R_0 = A.C. resistance of valve at working bias E_0 and anode voltage V_0.
$V_{min.}$ = Anode voltage when $I_a = I_{max.}$ and $E_g = 0$.
$V_{max.}$ = Anode voltage when $I_a = I_{min.}$ and $E_g = 2E_0$.
V_0 = The voltage of the anode battery.
k, m } = Constants of a triode defined by equation (18).
z = Correction to grid bias for valves with D.C. operated filaments.
n = Ratio of External load resistance to A.C. resistance R_0 of the valve.

I wish to acknowledge my indebtedness to Mr. C. G. Mayo for his co-operation in the theoretical investigation leading to equation (11) and to the British Thomson-Houston Co., Ltd., for permission to publish this work.

Marconi Facsimile Transmission System.



Picture transmitting equipment. The tube on the left carries the dispersed light from the image to the photoelectric cell.

This recently completed Marconi equipment is in operation over the Canadian beam service. Light from the lamp shown on the right passes through the aperture in the housing of a serrated disc for the purpose of introducing the audio carrier frequency. Passing down the hollow tube of the motor the pencil of light is swept across the face of the slowly traversing image. The dispersed light is conveyed to a photoelectric cell. Almost identical apparatus is used to recompose the image at the receiver a Kerr cell being used to control a source of light. Synchronous running is maintained by tuning forks and alternators. The tuning forks being kept at constant temperature.

On the Capacity of Dry Electrolytic Condensers.

By Philip R. Coursey, B.Sc., M.I.E.E.

THE development of large capacity condensers of the so-called electrolytic type which has taken place recently for use primarily in conjunction with battery eliminator apparatus for supplying the filament circuit of the valves of a radio receiver from electric light mains has raised the question as to the meaning of the statements of capacity attached to such condensers. With the majority of ordinary condensers using solid dielectrics such, for example, as paper, mica, etc., the statement of the capacity presents usually no ambiguity, since the capacity of such condensers does not vary very sensibly with either the frequency of the supply current or with the method of measurement. With the " dry electrolytic " condensers the same statement is not always true and it appears that the effective capacity of these condensers varies to some extent with the method of measurement, just as it also must vary with the frequency at which such measurements are carried out.

In most cases it has become customary to quote the results of ballistic methods of measurements of the capacity of these condensers, such methods involving the use of some form of ballistic galvanometer through which a discharge from the condenser is passed, the condenser having first been charged up from a source of small voltage, and the galvanometer usually being heavily shunted to allow for the rather heavy discharge currents which may arise from condensers of large capacity. The results obtained from such measurements do not, however, always appear to be as consistent as might generally be wished for, while some doubt may also arise as to whether the effective capacity of such condensers under working conditions bears any definite relationship to the results of such measurements.

As is now generally well known, these " dry electrolytic " condensers possess the feature of having a very large capacity in a very limited space, a condenser of this type having a capacity of over a thousand microfarads usually occupying no more space than a normal paper condenser of 4 or 5 microfarads capacity.

An ordinary type of condenser consists of sheets of metal and of dielectric interleaved with each other, or of strips of materials wound or rolled up together—the latter method being used with the more flexible dielectrics, such as paper. With these condensers the dielectric is highly insulating and the capacity of the condenser is determined by the area of the metal electrodes, the thickness of the dielectric separating them, and its dielectric constant. Liquid electrolytic condensers have been known for a long time in which the capacity effect was obtained by a chemically produced insulating film formed on the surface of a metal electrode immersed in an electrolyte. Aluminium plates readily form such films when placed in a solution of borax, or of ammonium borate or of similar materials, the action of a current flowing through such an electrolyte being to form a film of aluminium oxide on the surface of the metal. This film is very thin so that a large capacity can be obtained with metal plates of comparatively limited dimensions. The solution being electrically conducting serves in effect to bring the current flow from one metal electrode up to the surface of the insulating film formed on the other—so that the film becomes bounded on both sides by conducting materials.

In the recently produced so-called " dry-electrolytic " condensers a very similar arrangement is used, except that the large bulk of liquid electrolyte is dispensed with and replaced by a very limited amount of semi-fluid, but electrically conducting material kept in contact with the metal plate carrying the insulating film by means of a porous support which also holds the two metal plates apart. This porous support is commonly in the form of a layer of cloth or paper separating two strips of aluminium foil which form the main electrodes of the condenser, and on one of which the insulating film is formed.

In practice many different modes of constructing such condensers are used, but the results achieved with all are very similar. The electrolytic materials used differ as do also the precise forms in which they are used, but in all the real dielectric in the condenser is the thin chemically produced insulating film, while the electrolytic material with which the porous separator is soaked serves not only as a means of producing the insulating film but also as an electrically conducting medium to lead the current from one metal foil strip through the paper or separator to the surface of the dielectric film. This electrolytic material is thus in *series* with the dielectric film as indicated by Fig. 1. In this diagram M_1 and M_2 represent on a much enlarged scale, two metal sheets, separated by the porous separator P. On the surface of one plate M_1, the insulating film F is formed, so that this constitutes the dielectric of the condenser. The electrolyte carried by P, however, although covering a large area, and being only a thin layer, necessarily offers some resistance to the passage of current through it, so that the arrangement may be represented electrically as shown in Fig. 2, where M_1 and M_2 are the same metal plates as sketched in Fig. 1, and C represents the capacity of the insulating film F. The resistance of the electrolyte carried by P is represented by the resistance R shown in series with C in Fig. 2. The actual value of this resistance will necessarily depend upon the nature of the electrolyte used and the amount of it that is present in the interstices of the separator P (Fig. 1). In some of these condensers the value of R is apparently very small, while in others it is much larger and by no means negligible in its effect upon the condenser. The presence of the resistance in series with the true capacity portion of the condenser means that the power factor of the condenser is not good—the higher the resistance the poorer is the power factor.

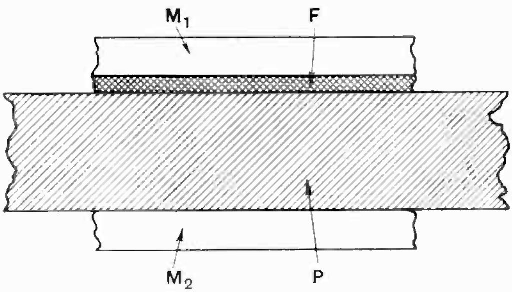


Fig. 1.

The effect of such a series resistance is not only to give rise to some energy dissipation in the condenser when it is subjected to the passage of alternating currents, but it is also to lower the effective capacity of the condenser to the passage of the alternating current. The effect may be seen by reference to the diagrams in Figs. 3 and 4. In Fig. 3 the vector OI is drawn to represent the current flowing through the condenser, while the vector OC which is perpendicular to it, represents the voltage drop across the true capacity portion of the condenser. The vector OR drawn in line with the current vector OI represents the voltage drop in the equivalent series resistance of the condenser, while the vector OV which is the resultant of OC and OR, therefore represents the total terminal voltage applied to the condenser when the current OI is flowing through it. If the resistance R were not present the current through the condenser for the same applied voltage would be larger and would be represented by the vector OC' which is obtained by striking an arc with centre O through the point V, so as to intercept the prolongation of the line OC. In the case drawn in Fig. 3, it will be seen that the length OC' is very little greater than the length OC, and since these lengths are proportional to the currents which would flow through the condensers under these conditions they may be taken to represent the equivalent capacities of the condenser. In Fig. 4 a similar diagram has been drawn with an arc drawn through the point C' so that the length of the vector OV is fixed and in the case drawn in this diagram the vector OR is much larger than it is in Fig. 3; or, in other words, the effective series resistance in the condenser has been assumed to be larger. The vector OV in these circumstances is therefore the resultant of the vector OR and the vector OC as before, but

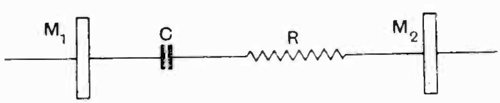


Fig. 2.

it will be seen at once by an inspection of the diagram that the length *OC* is now very considerably less than the length *OC′*. In other words, in this case with the same voltage applied to the condenser the effective capacity of this condenser is very considerably reduced.

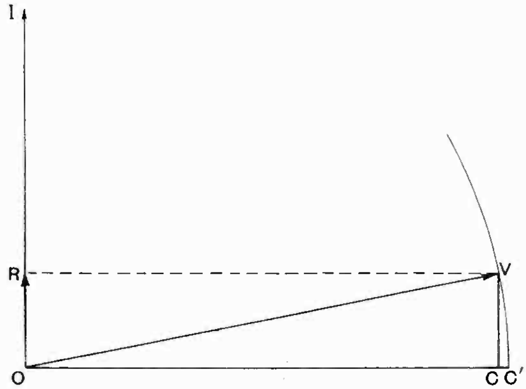


Fig. 3.

Since the voltage drop across the true capacity portion of the condenser is inversely proportional to the frequency of the current flowing through it, it will be obvious that the higher this frequency is made the more important will the series resistance effect become, or, in other words, at the higher frequencies the effect becomes more like that represented in Fig. 4 instead of like that represented in Fig. 3. The equivalent capacity of such condensers is therefore less for alternating current than it is for very low frequency or direct current.

It has already been pointed out that these dry electrolytic condensers must from their very nature possess some inherent series resistance hence their effective capacity value cannot be independent of the frequency at which they are used. Additional series resistance of not entirely inappreciable magnitude is also likely to occur in such condensers through the connections made between the terminals and the internal parts of the condensers. Such resistances should in well-designed condensers be only a small fraction of an ohm, but even such small fractions of an ohm may represent an appreciable fraction of the total impedance of the condenser. For example, a capacity of 3,000 microfarads has at a frequency of 50 cycles a reactance of only just over one ohm so that a series resistance even of a small fraction of an ohm will be quite appreciable.

Now the function of a condenser of this type is primarily to smooth out irregularities in a nominally steady direct current circuit. The effective capacity which such condensers offer to currents of the frequency of the irregularities in the direct current circuit is therefore the value which is really important in considering the action of such condensers. The voltage of direct current, as used, for example, for supplying the filaments of a valve receiver, when it is derived from a rectified alternating current source may be considered as a perfectly steady direct current voltage with a superimposed alternating ripple component. The smoothing action of the condenser is obtained from the effect of its capacity on this alternating ripple component, and the effective value of the condenser capacity at this frequency is the value which it is necessary to determine.

Measurements of the capacity of condensers of this class by direct current

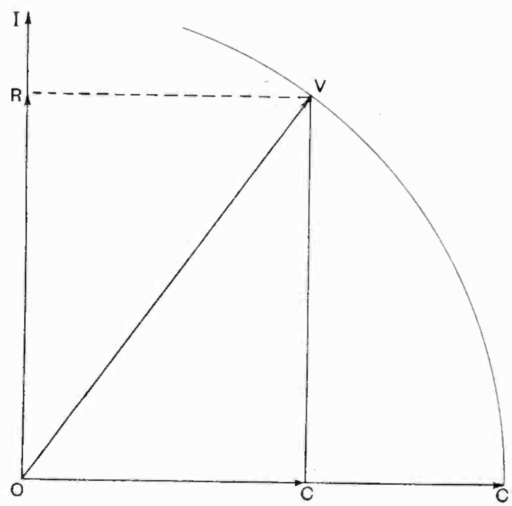


Fig. 4.

ballistic methods may therefore be of little value in determining the utility of any particular condenser when used in a filter circuit, since such measurements will usually be in error by an unknown amount. Usually the leakage resistance of condensers of this type is by no means excessively high so that a certain proportion of the charge in the condenser will leak away between the instant of disconnecting it from the charging battery and connecting it to the discharging circuit through the ballistic galvanometer. This leakage will imply that the ballistic reading obtained is less than the true ballistic reading, so that the capacity value calculated in this way will be correspondingly reduced and may therefore approach the lower alternating capacity value of the condenser. The error due to this leakage, however, is again an unknown amount which will depend upon the particular means employed for connecting the charging and discharging circuits, and will differ from one condenser to another due to differences in their leakage resistances. Taken all round, it would seem desirable that the capacity of these condensers should be measured, if possible, under conditions which more nearly resemble the conditions under which such condensers are used. Such a method for these measurements has recently been developed in the Laboratories of the Dubilier Condenser Company and can very easily be carried out with comparatively simple apparatus. The method in question is indicated in the diagram (Fig. 5), which is a circuit diagram of the connections used for these measurements.

In this diagram P represents a potentiometer resistance of the order of 200 to 250 ohms connected across the alternating current supply circuit at 240 volts 50 cycles. Between the slider and one end of this potentiometer the primary winding of the transformer T is connected, this transformer being wound to step down the voltage from 240 to 6 volts. The secondary winding of this transformer indicated in the diagram by the heavy lines forms part of the measuring circuit which also includes the battery B, the alternating current ammeter A, the short-circuiting switch S, and the condenser to be tested C. Across the terminals of the secondary winding of the transformer T the alternating current voltmeter V is connected, this instrument being an accurately calibrated low range meter capable of giving readings to an accuracy of approximately 1/100th of a volt. The function of the battery B is to maintain a direct current voltage between the terminals of the condenser C and thus to imitate the normal working conditions under which it operates with a direct current potential between its plates. The voltage from this battery also serves " to form " and to maintain "formed" the chemical dielectric layer on the surfaces of the metal plates in the condenser. The leakage current flowing from the battery B through the condenser C usually amounts at most to 1 or 2 milliamperes and so produces a negligible error in the reading of the ammeter A. For this ammeter a Weston thermojunction ammeter or similar instrument suitable for the measurement of alternating current up to about 1.5 amperes may conveniently be used. It should be connected across a substantial short-circuiting switch S so that the meter can easily be cut out of the circuit if the current proves excessive, whether derived from the transformer T or the battery B. In carrying out a measurement of the capacity C, the

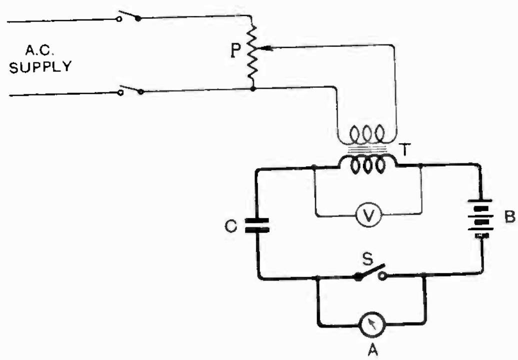


Fig. 5.

alternating current supply circuit is closed with the potentiometer P adjusted to the minimum position, and the voltage applied to the primary of the transformer T is then gradually raised while the readings of the meters V and A are observed. The potentiometer is conveniently adjusted until either the ammeter reaches a current of 1 ampere or the voltmeter reaches some definite voltage reading, such as 2 volts, whichever value is reached first. Knowing then the alternating current voltage at the terminals of the condenser and the current flowing through it the condenser capacity can be calculated from the usual formulæ, provided that the frequency of the supply is known. A correction must, however, be made before such a calculation can be carried out, since there will be a definite but small voltage drop in the battery B, in the resistance of the ammeter A, and in the connecting wires of the circuit. Since alternating current voltmeters suitable for the accurate reading of low values of the voltage of the secondary winding of the transformer T usually require an operating current which is an appreciable fraction of an ampere, such a meter cannot be connected directly across the terminals of the condenser C without giving rise to a rather considerable error and the arrangement sketched is probably the more accurate since the transformer T can easily furnish the current necessary for the operation of the voltmeter. The resistance of the circuit and the ammeter can fairly easily be obtained by direct current measurement since at low frequencies of the order of 50 cycles the alternating current resistance of the circuit will differ from the direct current value by an entirely negligible amount. Knowing then the current flowing through the circuit as obtained from the reading of an ammeter A, the voltage drop in the resistance of the circuit can easily be calculated and since the reactance of a condenser of a few thousand microfarads is at 50 cycles only of the order of an ohm, the correction for the voltage drop in the resistance of the circuit becomes quite appreciable, even although this resistance, including the ammeter, may only be a fraction of an ohm. Usually the ammeter contributes the major portion of this resistance and may be as much as 0.25 to 0.35 ohms for a meter of the range and type mentioned above. It should be borne in mind, however, that the voltage drop in this resistance and the voltage drop across the terminals of the condenser are vectorially perpendicular and must therefore be subtracted vectorially in order to arrive at a figure for the voltage drop across the terminals of the condenser from a knowledge of the reading of the applied voltage V. Such a calculation will give a figure for the voltage across the condenser terminals corresponding to the effective capacity of the condenser under these conditions of measurement. If V is the reading of the voltmeter V, and I is the current reading on the ammeter A, while R is the resistance of the circuit, it follows that

$$V^2 = R^2I^2 + I^2/\omega^2C^2$$

whence,

$$c = \frac{1}{\omega\sqrt{(V/I)^2 - R^2}} \text{ farads}$$

$$= \frac{10^6}{\omega\sqrt{(V/I)^2 - R^2}} \text{ microfarads.}$$

A check on the measured value of the resistance R can be obtained by taking readings on two condensers separately and connecting them together in parallel, then by solving the equations resulting from applications of the above formula to each set of readings a value for the total resistance R of the circuit can be calculated. This will usually be found to be very slightly in excess of the measured resistance of the ammeter A and the wires in the circuit, the difference being due to the internal resistance of the battery B.

As an example of the extent to which the effective capacities of condensers of this type measured under alternating current conditions in this way compare with the values measured by a ballistic method, the following figures measured in this way may be quoted.

Capacity by Ballistic Method.	Alternating Current Capacity.
1,500μF.	880μF.
4,400μF.	2,620μF.
4,000μF.	2,460μF.

The results expressed by the figures in this table should not be regarded as indicating the order of magnitude of the ratio of the two "capacities" which will always be obtained. As a matter of fact, the particular readings quoted represent an extreme case arising probably from a particular method of construction which led to high internal resistance and also to a not inappreciable inductance in the internal connections of the condensers. In general the ratio of the two readings will be found to be much more nearly unity, but some difference will usually be found even with the best constructed condensers. In view of the existence of such differences arising from the method of measurement, it is suggested that some such method as has herein been outlined should always be used in carrying out tests on these condensers. Only thus can their real utility as low voltage smoothing condensers be properly gauged.

Note on the Problem of Selectivity Without Reducing the Intensity of the Sidebands.

By W. B. Lewis.

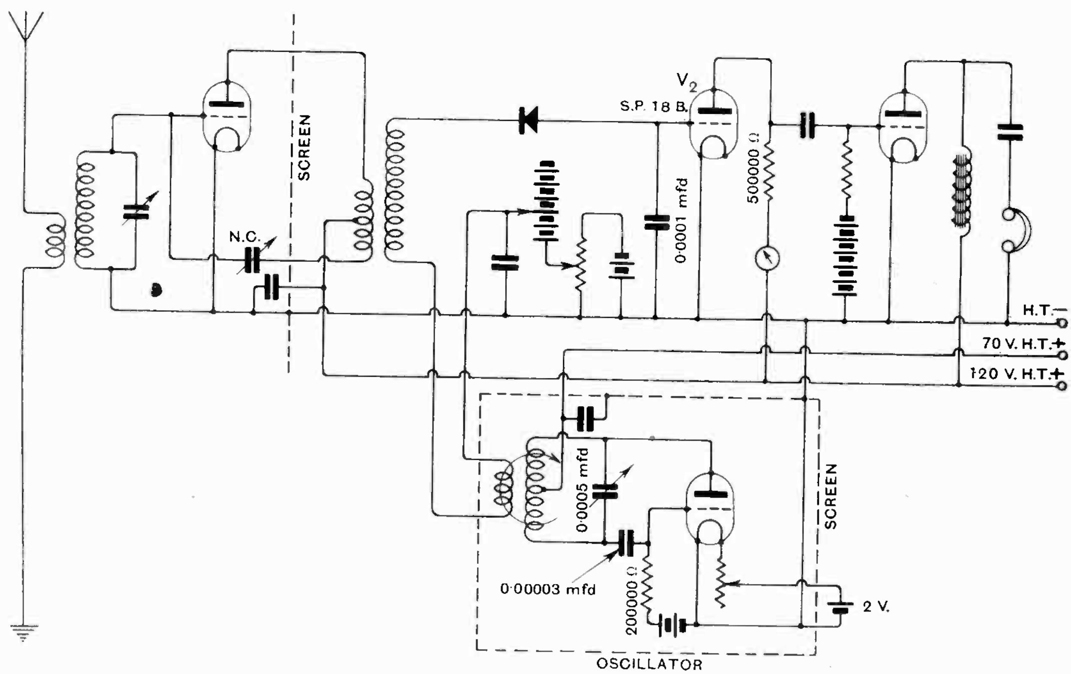
DR. BEATTY'S article in *E.W. & W.E.* for June 1928, suggests a solution of the above problem, which I have not seen mentioned. Briefly, signals are received on the Homodyne principle. The local oscillations are adjusted to be of sufficient intensity to wipe out any unwanted signals; and the H.F. amplifier is made practically aperiodic.

I may have put it too shortly to be intelligible. Suppose, for simplicity, we have an ordinary receiving set, fitted with an aperiodic H.F. amplifier, which is receiving strong but unwanted telephony (from the local station) and weak wanted telephony on a neighbouring wavelength. We couple an oscillator and tune it exactly to the carrier wavelength of the wanted station. The carrier and sidebands of the unwanted signal. The H.F. current supplied is made several times greater than that of the unwanted signal. After detection therefore the envelope of the H.F. current is the combination of beats mentioned above, of which only those of audio frequency will affect the ear even if others pass through the L.F. amplifier. The result is that we hear only the wanted telephony with no diminution of the higher frequencies if the amplifier is correctly designed.

The method should also be applicable to sideband telephony.

I made some experiments to test the method, and finally adopted the circuit shown in the figure.

Experiments were made on the 300–500-



oscillations supplied produce a beat of infinite period with the carrier wave of the wanted station, audio frequency beats with its sidebands, and supersonic beats with the metre broadcast band, and the circuit was arranged so that the feed back from the oscillator to the aerial was negligible. As few alterations as were necessary were made to the existing H.F.-Det.-L.F. set, since the experiments were only preliminary. The neutralised H.F. amplifier was left unaltered, the tuning condenser across the secondary of the H.F. transformer was removed, and the long-wave transformer (original *Wireless World* "All Wave Four" specification) plugged in. The set was made for alternative crystal or anode-bend detection. The galvanometer in the plate circuit of V_2 was used for setting the mean grid potential of V_2 to its normal value to avoid distortion. Leads were run out as shown to the oscillator, which was completely screened. The oscillation uses a 1923 D.E.R. !, + 3v. grid bias, 70v. H.T., 200,000-ohm grid leak, .00003 μF. grid-coupling condenser and .0005 μF. logarithmic tuning condenser with 4in. dial (a slow motion dial would be a great boon). The inductance is a simple solid wire, 3in. diameter, solenoid, inside which the coupling coil of about 15 turns rotates.

Anode-bend detection was abandoned as signals were not wiped out, unless the supplied oscillations overloaded the valve, even when using a P.M.4 as detector. With the crystal detector, signals were wiped out with the oscillator only very loosely coupled. Galena and zincite-tellurium seemed to answer equally well. Using a tuned H.F. transformer sufficient energy could not be supplied by the oscillator without coupling, so that the two circuits were not independent.

Results show that the principle is sound, but a rushing noise is heard in the phones which seems to originate in the crystal detector; this is not serious for loud signals. Quality is good with loud signals, but faint signals are horribly distorted; this seems partly, if not entirely, due to relative wobbling of the carrier and oscillator frequencies, As the volume is increased there seems to be a sudden transition from distortion to clarity.

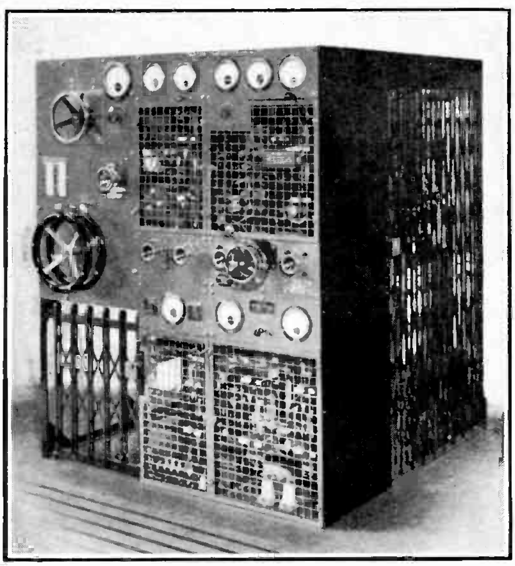
This may be serious, since 2LO at ten miles range is not completely wiped out when the aerial tuning condenser is set within three degrees of the correct setting for that station. Greater overall H.F. amplification would therefore result in an incomplete wipe out of 2LO, though avoiding distortion on a faint signal. If the local oscillations are amplified as well the rushing sound might be magnified in proportion. But no doubt improvements could be made in the linearity of the detector, the holding of the oscillator frequency, and the reduction of the rushing sound. I am writing this note at rather an early stage, as I shall be unable to continue experiments for the present.

New Commercial Apparatus.

We have received from Marconi's Wireless Telegraph Co., Ltd., description Leaflets Nos. 1087 to 1090. These give particulars of their new types of transmitter which, although designed specially to meet naval requirements, are equally suitable for use in land stations. The accompanying illustration is of Type TN1, having a nominal input of 5 kW. and an aerial rating of 2 kW. Type TN2 has an aerial rating of 1 kW.; TN4, TN5 and TN5*a* are smaller sets ranging from 350 watts to 75 watts respectively in the aerial circuit when used on I.C.W. telegraphy.

In the TN1 and TN2 transmitters I.C.W. signalling can be effected on any one of three selected note frequencies, thus allowing distinction notes to be used by different ships working on the same wavelength, and telephony transmission can be provided if required. The wave-range is from 400 to 3,000 metres.

Type TN4 is designed for fire control on destroyers, cruisers and battleships, and has a wave-range of 80 to 180 metres. Type TN5 has an effective range of about 50 nautical miles on wavelengths between 100 and 150 metres, and Type TN5*a*, intended for small craft, has a working range of about 10 nautical miles on wavelengths of 40 to 1,200 metres.



Marconi Type TN1 transmitter.

Effect of Anode-Grid Capacity in Anode-Bend Rectifiers.

By E. A. Biedermann, B.Sc., A.M.I.E.E.

(*Concluded from page* 76 *of February issue.*)

Effect of Anode-grid Capacity on Wave-form of Rectified Audio-frequency Current.

We have so far considered only the extent to which the feed-back affects the magnitude and phase shift of the individual side-bands of the grid-filament potential difference. The true criterion of the effect of the feed-back is, however, the extent of its effect on the wave-form of the rectified audio-frequency current in the anode circuit. A certain amount of distortion of the wave-form of this current is in any case produced, as is well known, by the imperfect functioning of the valve as a detector.

In the first place, a parasitic component of double the modulation frequency of the input potential difference is produced, and if the ratio of the external anode circuit impedance to the total impedance of the anode circuit, including the valve resistance, is not practically independent of the audio-frequency, a certain amount of distortion is inevitably introduced. These are inherent imperfections of a detector valve, and are in no way due to the anode-grid capacity of the valve. We are now concerned only to find to what extent, if any, additional distortion of the audio-frequency wave-form is caused by this capacity.

In order to determine this it is necessary to consider briefly the theory of the action of a valve as an anode-bend detector.

This subject has been dealt with in considerable detail in this journal by F. M. Colebrook,* but he discussed only the case of a modulated input potential difference of the form

$$e = (E_0 + E_1 \sin mt) \sin \omega t$$
$$= \{E_0 \sin wt - \tfrac{1}{2}E_1 \cos (\omega + m)t + \tfrac{1}{2}E_1 \cos (\omega - m)t\}$$

that is, the magnitudes of the positive and negative side-bands were equal and there was no phase shift relatively to the carrier-wave component. Actually, as we have seen, the positive and negative side-band components will not be quite equal, and are always out of phase with the carrier-wave component, and this to a slightly unequal extent. This is so even in the case of a valve having no appreciable anode-grid capacity.

If we take both these factors into account, we have an input potential difference of the form

$$e = \{E_0 \sin \omega t - \tfrac{1}{2}\lambda_1 E_1 \cos ((\omega + m)t + \phi_1) + \tfrac{1}{2}\lambda_2 E_1 \cos ((\omega - m)t + \phi_2)\} \quad .. \quad (28)$$

We have seen that the anode-grid capacity affects the magnitude of the carrier-wave component but produces no phase shift of it. E_0 is supposed to represent the actual magnitude of the carrier-wave component as modified by the increased resistance of the input circuit caused by the feed-back. Similarly E_1 denotes the actual magnitude which the modulation component would have at a very small audio-frequency. With this understanding, reference to (26) and (27) shows that the values of $\lambda_1, \lambda_2, \phi_1, \phi_2$ in the above expression are given by

$$\left.\begin{aligned} \lambda_1 &= \frac{\left(1 + B\frac{m}{\omega_c}\right)}{\sqrt{1 + \frac{4m^2L^2}{r_0^2}}}, \\ \lambda_2 &= \frac{\left(1 - B\frac{m}{\omega_c}\right)}{\sqrt{1 + \frac{4m^2L^2}{r_0^2}}} \\ \tan \phi_1 &= -\left(1 + \beta\frac{m}{\omega_c} + \gamma\frac{m^2}{\omega_c^2}\right)\frac{2mL}{r_0} \\ \tan \phi_2 &= \left(1 - \beta\frac{m}{\omega_c} + \gamma\frac{m^2}{\omega_c^2}\right)\frac{2mL}{r_0} \end{aligned}\right\} \quad .. (29)$$

* "The Rectification of Small Radio-Frequency Potential Differences by Means of Triode Valves," by F. M. Colebrook (*E.W. & W.E.*, Jan., 1926).

where m is now to be regarded as a positive quantity, so that $-m$ has been substituted for m in deriving the formulæ for λ_2 and $\tan\phi_2$, which have reference to the negative side-band.

Now if we examine, in the article referred to above, the analysis by which the value of the rectified current is derived, we find that it is determined by the equation

$$i + \frac{v}{r_a} = k\frac{1}{T}\int_0^T e^2 dt$$

where i denotes the total increase of anode circuit current due to the applied potential difference e, v the voltage drop in the anode circuit produced by this increment of current, T is the radio-frequency period, and k a constant depending only on the valve characteristics.

Evaluating the integral for a potential difference of the form (28), we obtain

$$i + \frac{v}{r_a} = k\Big\{\tfrac{1}{2}\{E_0^2 + \tfrac{1}{4}(\lambda_1^2 + \lambda_2^2)E_1^2\} + \tfrac{1}{2}\sqrt{\lambda_1^2 + \lambda_2^2 + 2\lambda_1\lambda_2\cos(\phi_1+\phi_2)}\,\sin(mt+\phi_0)E_0E_1 - \tfrac{1}{4}\lambda_1\lambda_2\cos(2mt+\phi_1-\phi_2)E_1^2\Big\}$$

where $\tan\phi_0 = \dfrac{(\lambda_1\sin\phi_1 - \lambda_2\sin\phi_2)}{(\lambda_1\cos\phi_1 + \lambda_2\cos\phi_2)}$

Hence, denoting by i_m, i_{2m}, v_m, v_{2m} the components of rectified current and voltage drop of frequencies $\dfrac{m}{2\pi}$ and $\dfrac{m}{\pi}$ respectively, we obtain

$$i_m + \frac{v_m}{r_a} = \tfrac{1}{2}k\sqrt{\lambda_1^2 + \lambda_2^2 + 2\lambda_1\lambda_2\cos(\phi_1+\phi_2)}\,\sin(mt+\phi_0)E_0E_1$$

$$i_{2m} + \frac{v_{2m}}{r_a} = -\tfrac{1}{4}k\lambda_1\lambda_2\cos(2mt+\phi_1-\phi_2)E_1^2$$

These expressions give the instantaneous values of current and voltage drop with reference to variations of audio-frequency. The corresponding maximum values of the current components are, therefore,

$$\left.\begin{aligned} I_m &= \frac{\tfrac{1}{2}kr_a}{\sqrt{(r_a+R_a)^2 + X_m^2}} \times \sqrt{\lambda_1^2 + \lambda_2^2 + 2\lambda_1\lambda_2\cos(\phi_1+\phi_2)}\,E_0E_1 \\ I_{2m} &= \frac{\tfrac{1}{4}kr_a}{\sqrt{(r_a+R_a)^2 + X_{2m}^2}}\lambda_1\lambda_2E_1^2 \end{aligned}\right\} \quad (30)$$

where X_m, X_{2m} denote the reactances of the external anode circuit for the frequencies $\dfrac{m}{2\pi}$, $\dfrac{m}{\pi}$, while the phase shift of the $\dfrac{m}{2\pi}$ frequency component is given by

$$\tan\phi_0 = \frac{(\lambda_1\sin\phi_1 - \lambda_2\sin\phi_2)}{(\lambda_1\cos\phi_1 + \lambda_2\cos\phi_2)} \quad .. \quad (31)$$

From (29) we have

$$\tan(\phi_1+\phi_2) = \frac{-4\beta\dfrac{m^2L}{\omega_c r_0}}{\left\{1 + \left(1 + (2\gamma-\beta^2)\dfrac{m^2}{\omega_c^2}\right)\dfrac{4m^2L^2}{r_0^2}\right\}}$$

Neglecting for the moment the effect of the small term $(2\gamma-\beta^2)\dfrac{m^2}{\omega_c^2}$, the maximum possible value of this expression with reference to $\dfrac{mL}{r_0}$ is $\beta\dfrac{m}{\omega_c}$. Since

$$\cos(\phi_1+\phi_2) = \{1 + \tan^2(\phi_1+\phi_2)\}^{-\frac{1}{2}},$$

we can therefore put

$$\cos(\phi_1+\phi_2) = \{1 - \tfrac{1}{2}\tan^2(\phi_1+\phi_2)\}$$

neglecting only quantities of the order $\beta^4\dfrac{m^4}{\omega_c^4}$, so that

$$\cos(\phi_1+\phi_2) = 1 - \frac{8\beta^2\left(\dfrac{mL}{r_0}\right)^2\dfrac{m^2}{\omega_c^2}}{\left\{1+\left(1+(2\gamma-\beta^2)\dfrac{m^2}{\omega_c^2}\right)\dfrac{4m^2L^2}{r_0^2}\right\}^2} = 1 - \frac{8\beta^2\left(\dfrac{mL}{r_0}\right)^2\dfrac{m^2}{\omega_c^2}}{\left(1+\dfrac{4m^2L^2}{r_0^2}\right)^2}$$

neglecting only quantities of the order $\beta^2(2\gamma-\beta^2)\dfrac{m^4}{\omega_c^4}$.

Hence, we have

$$\left.\begin{aligned} \cos(\phi_1+\phi_2) &= \left(1 - 2C\frac{m^2}{\omega_c^2}\right) \\ \text{where} \quad C &= \frac{\beta^2\left(\dfrac{2mL}{r_0}\right)^2}{\left(1+\dfrac{4m^2L^2}{r_0^2}\right)^2} \end{aligned}\right\} \quad .. \quad (32)$$

which is essentially less than $\frac{1}{4}\beta^2$.

From (29) we therefore find

$$\sqrt{\lambda_1^2 + \lambda_2^2 + 2\lambda_1\lambda_2 \cos(\phi_1 + \phi_2)}$$
$$= \frac{\sqrt{2+2B^2\frac{m^2}{\omega_c^2}+2\left(1-B^2\frac{m^2}{\omega_c^2}\right)\left(1-2C\frac{m^2}{\omega_c^2}\right)}}{\sqrt{1+\frac{4m^2L^2}{r_0^2}}}$$
$$= \frac{2}{\sqrt{1+\frac{4m^2L^2}{r_0^2}}}\left(1-\tfrac{1}{2}C\frac{m^2}{\omega_c^2}\right)$$

while

$$\lambda_1\lambda_2 = \frac{\left(1 - B^2\frac{m^2}{\omega_c^2}\right)}{\left(1+\frac{4m^2L^2}{r_0^2}\right)}.$$

Substituting these values in (30) we obtain

$$\left.\begin{aligned} I_m &= \frac{kr_a}{\sqrt{(r_a+R_a)^2+X_m^2}}\frac{\left(1-\frac{1}{2}C\frac{m^2}{\omega_c^2}\right)}{\sqrt{1+\frac{4m^2L^2}{r_0^2}}}E_0E_1 \\ I_{2m} &= \frac{\frac{1}{4}kr_a}{\sqrt{(r_a+R_a)^2+X_{2m}^2}}\frac{\left(1-B^2\frac{m^2}{\omega_c^2}\right)}{\left(1+\frac{4m^2L^2}{r_0^2}\right)}E_1^2 \end{aligned}\right\} \qquad (33).$$

Thus the small term involving the first power of $\frac{m}{\omega_c}$ which was present in the expression for the potential difference does not appear at all in the expressions for the rectified current components, and there remain only terms of the order $\frac{m^2}{\omega_c^2}$, which are negligibly small since the coefficients B and C will never much exceed unity.

Thus, so far as the magnitudes of these two current components are concerned, the effect of the anode-grid capacity of the valve is for all practical purposes solely that arising from the increase of the input circuit resistance which it causes.

The effect of this is clearly to cause a smaller variation in the values of I_m, I_{2m} with frequency than would occur if the valve had no appreciable anode-grid capacity.

The ratio of the parasitic current component I_{2m} to the modulation frequency component I_m is

$$\frac{I_{2m}}{I_m} = \frac{\sqrt{(r_a+R_a)^2+X_m^2}}{\sqrt{(r_a+R_a)^2+X_{2m}^2}} \cdot \frac{1}{4\sqrt{1+\frac{4m^2L^2}{r_0^2}}} \cdot \frac{E_1}{E_0} \qquad (34)$$

neglecting the small terms $B^2\frac{m^2}{\omega_c^2}$ and $\frac{1}{2}C\frac{m^2}{\omega_c^2}$.

Thus this ratio is greater than it would be in the case of a valve with negligible anode-grid capacity only to the extent that it is increased by the increase of resistance of the input circuit from r to r_0.

Lastly, to determine the extent of the phase shift of I_m, we have from (29) and (31)

$$\tan\phi_0 = -\frac{\left\{\lambda_1\left(1+\beta\frac{m}{\omega_c}+\gamma\frac{m^2}{\omega_c^2}\right)\cos\phi_1 + \lambda_2\left(1-\beta\frac{m}{\omega_c}+\gamma\frac{m^2}{\omega_c^2}\right)\cos\phi_2\right\}}{(\lambda_1\cos\phi_1+\lambda_2\cos\phi_2)}\frac{2mL}{r_0}$$
$$= -\left\{\left(1+\gamma\frac{m^2}{\omega_c^2}\right) + \frac{(\lambda_1\cos\phi_1-\lambda_2\cos\phi_2)\beta\frac{m}{\omega_c}}{(\lambda_1\cos\phi_1+\lambda_2\cos\phi_2)}\right\}\frac{2mL}{r_0}$$

In evaluating the coefficient of $\frac{m}{\omega_c}$ we need only retain the first power of $\frac{m}{\omega_c}$. Therefore

$$\cos\phi_1 = (1+\tan^2\phi_1)^{-\frac{1}{2}}$$
$$= \left\{1+\left(1+\beta\frac{m}{\omega_c}+\gamma\frac{m^2}{\omega_c^2}\right)^2\frac{4m^2L^2}{r_0^2}\right\}^{-\frac{1}{2}}$$
$$= \left\{\left(1+\frac{4m^2L^2}{r_0^2}\right)+\frac{4m^2L^2}{r_0^2}2\beta\frac{m}{\omega_c}\right\}^{-\frac{1}{2}}$$
$$= \left(1+\frac{4m^2L^2}{r_0^2}\right)^{-\frac{1}{2}}\left(1-b\beta\frac{m}{\omega_c}\right)$$

where

$$b = \frac{\frac{4m^2L^2}{r_0^2}}{\left(1+\frac{4m^2L^2}{r_0^2}\right)}.$$

Similarly

$$\cos\phi_2 = \left(1+\frac{4m^2L^2}{r_0^2}\right)^{-\frac{1}{2}}\left(1+b\beta\frac{m}{\omega_c}\right)$$

Hence

$$\frac{(\lambda_1 \cos \phi_1 - \lambda_2 \cos \phi_2)}{(\lambda_1 \cos \phi_1 + \lambda_2 \cos \phi_2)} =$$

$$\frac{\left\{\left(1+B\frac{m}{\omega_c}\right)\left(1-b\beta\frac{m}{\omega_c}\right)-\left(1-B\frac{m}{\omega_c}\right)\left(1+b\beta\frac{m}{\omega_c}\right)\right\}}{\left\{\left(1+B\frac{m}{\omega_c}\right)\left(1-b\beta\frac{m}{\omega_c}\right)+\left(1-B\frac{m}{\omega_c}\right)\left(1+b\beta\frac{m}{\omega_c}\right)\right\}}$$

$$= (B - b\beta)\frac{m}{\omega_c},$$

so that

$$\tan \phi_0 = -\left\{1 + \left((B - b\beta)\,\beta + \gamma\right)\frac{m^2}{\omega_c^2}\right\}\frac{2mL}{r_0}$$

Since B, b, β and γ are all comparable with unity, $\tan \phi_0$ only differs by a negligible amount from

$$\tan \phi_0 = -\frac{2mL}{r_0} \quad \ldots \quad \ldots \quad (35)$$

Thus as regards the phase shift of the modulation frequency component of the rectified current, also, the effect of the anode-grid capacity of the valve is solely that arising from the increase of the input circuit resistance which it causes, and this increase causes a decrease of phase shift.

In the whole of the above analysis we have neglected, compared with unity, only terms of the order $\frac{r_0^2}{\omega_c^2 L^2}$, $\left(\frac{r_0}{\omega_c L}\right)\frac{m^2}{\omega_c^2}$ and $\frac{m^3}{\omega_c^3}$, and the final conclusion we reach is that, except for a negligibly small effect of the order $\frac{m^2}{\omega_c^2}$ compared with unity, the sole effect of the anode-grid capacity is to increase the effective resistance of the input circuit, which results, not in an increase of distortion, but in all respects in a reduction of distortion, though possibly to a very slight extent. On the other hand, any such increase of resistance means reduced sensitivity and selectivity, and before concluding it will be of interest to find what degree of increase in the effective resistance is to be expected.

The Increase of Input Circuit Resistance due to Anode-grid Capacity.

The effective resistance r_0 of the input circuit as increased by the feed-back is given by

$$r_0 = (r + \phi(\omega_c)\omega_c^4 L^2 C_{ga})$$

$$= \left[r + \frac{r_a\left\{\mu C_a + \left(\mu + 1 + \frac{r_a}{R_a}\right)C_{ga}\right\}\omega_c^4 L^2 C_{ga}}{\left\{\left(1+\frac{r_a}{R_a}\right)^2 + r_a^2\omega_c^2(C_a + C_{ga})^2\right\}}\right] \quad \ldots \quad \ldots \quad (36)$$

where r is the inherent resistance of the input circuit. In general, $r_a^2\omega_c^2(C_a + C_{ga})^2$ will be much greater than $\left(1 + \frac{r_a}{R_a}\right)^2$. Since, also, C_{ga} will usually be small compared with C_a, we have—at least as a rough approximation—

$$r_0 = \left\{r + \mu\frac{\omega_c^2 L^2}{r_a}\left(\frac{C_{ga}}{C_a + C_{ga}}\right)\right\}$$

Thus the increase of resistance is independent of the inherent resistance of the circuit, and will be greater the greater the reactance $\omega_c L$ of the circuit. It will therefore be greater for circuits intended for long-wave reception than for those for short waves. Further, since $\frac{\omega_c L}{r}$ will be about the same in both cases, the percentage increase will also be greater in the case of the long-wave circuit, since

$$\frac{r_0}{r} = \left\{1 + \mu\left(\frac{\omega_c L}{r}\right)\left(\frac{\omega_c L}{r_a}\right)\left(\frac{C_{ga}}{C_a + C_{ga}}\right)\right\}$$

The increase of resistance is also roughly proportional to the amplification factor, and is inversely proportional to the A.C. anode resistance of the valve. While the former is relatively small, and the latter relatively large in the case of an anode-bend detector, the ratio $\frac{\mu}{r_a}$ will be much greater in the case of a grid-leak detector, so that in the latter case a very considerable resistance load may be imposed on the input circuit, in addition to that due to the grid current.

In the case of an anode-bend detector, however, the increase of resistance is not nearly as large as is deduced in Mr. Medlam's article. For a particular case where $C_{ga} = 5\mu\mu$F., $C_a = 50\mu\mu$F., $r_a = 10^5$, $\omega_c L = 1{,}500$ and frequency 800 kilocycles, he finds an increase of resistance of 100 per cent. for the very low value of $\mu = 0.15$. His formula does not involve the initial resistance of the input circuit, but if we take $r = 15$ ohms, which is quite a reasonable figure for a reactance of 1,500 ohms, we find from the accurate formula (36) (with $\frac{r_a}{R_a} = 0$), $\frac{r_0}{r} = 1.033$, *i.e.*, an increase of only some 3 per cent.

For a long-wave coil with $\omega_c L$, say, equal to 6,000 ohms and a proportionate increase of resistance, we should have $\frac{r_0}{r} = 1.132$, an increase of still only 13 per cent.

On the other hand, with a valve working as a grid-leak detector with an amplification factor of 10 and impedance of 20,000 ohms, and allowing for an initial increase of the resistance by 100 per cent. due to grid current, the resistance would be further increased four and a half times by the feed-back in the case of the short-wave circuit and about sixteen times in the case of the long-wave circuit.

The only means by which this increase of resistance can be reduced is to reduce the ratio $\left(\frac{C_{ga}}{C_a + C_{ga}}\right)$, *i.e.*, increase the ratio $\frac{C_a}{C_{ga}}$ as far as is compatible with other considerations. Thus, if we make $C_a = 300\mu\mu F.$ instead of $50\mu\mu F.$, the resistance would only be increased by about 60 per cent. in the one case and by 260 per cent. in the other.

In the case of the anode-bend detector, however, we can safely conclude that only a comparatively small percentage increase of resistance will be caused by the feed-back through the anode-grid capacity of the valve.

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 Transmitting Station actually sends out Waves of one Definite Frequency, but of Varying Amplitude.

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

SIR,—With reference to Mr. Aughtie's letter on the above subject in your December issue, the following may perhaps help to explain the "apparent fallacy" which he expounds. His argument is as follows: If a carrier wave of frequency, say, 1,000 kc., modulated with a 1 kc. note, is regarded as consisting of a combination of frequencies 999, 1,000 and 1,001, then when amplified by a non-linear amplifier, frequencies 1,998, 2,000, and 2,002 will, among others, be introduced, and consequently when a receiver is tuned to 2,000 kc., there should be heard a note of 2 kc., and, in general, all notes should be raised an octave, whereas experiment shows that a 1 kc. note is heard on all harmonics of the carrier-wave.

His conclusion is that when dealing with a valve it is not legitimate to regard a complex waveform as a sum of pure harmonics of constant amplitude. Thus if the complex waveform is represented by

$$e = E_0 \sin \omega t + E_1 \sin mt \sin \omega t$$

we must not express this in the equivalent form

$$e = E_0 \sin \omega t + \tfrac{1}{2}E_1 \cos (\omega - m)t - \tfrac{1}{2}E_1 \cos (\omega + m)t$$

when we wish to examine the effect of applying such a voltage to a valve.

In other words, the properties of a wireless valve are so peculiar as to render invalid an elementary trigonometrical transformation! The mere statement of Mr. Aughtie's conclusion in this form is sufficient, I think, to show that there certainly *is* a fallacy in his argument. It arises from the fact that he concentrates on consideration of certain frequencies which are produced under the assumed conditions to the entire exclusion of certain other frequencies which are also produced, and produced, moreover, with a much greater amplitude than the particular ones he considers.

The second harmonic of the carrier frequency produced by the assumed non-linear amplifier arises primarily from the introduction of a voltage component proportional to the square of the impressed voltage—*i.e.*, proportional to

$$\{E_0 \sin \omega t + \tfrac{1}{2}E_1 \cos (\omega - m)t - \tfrac{1}{2}E_1 \cos (\omega + m)t\}^2$$

$$\begin{aligned} = \{E_0^2 \sin^2 \omega t &+ \tfrac{1}{4}E_1^2 \cos^2 (\omega - m)t \\ &+ \tfrac{1}{4}E_1^2 \cos^2 (\omega + m)t \\ &- \tfrac{1}{2}E_1^2 \cos (\omega - m)t \cos (\omega + m)t \\ &+ E_0 E_1 \sin \omega t (\cos (\omega - m)t - \cos (\omega + m)t)\} \end{aligned}$$

$$\begin{aligned} = \{\tfrac{1}{2}E_0^2(1 - \cos 2\omega t) &+ \tfrac{1}{8}E_1^2 (1 + \cos 2(\omega - m)t) \\ &+ \tfrac{1}{8}E_1^2 (1 + \cos 2(\omega + m)t) - \tfrac{1}{4}E_1^2 (\cos 2\omega t \\ &+ \cos 2mt) + E_0 E_1 \sin mt (1 - \cos 2\omega t)\} \end{aligned}$$

The terms involving the second harmonic of the carrier frequency are

$$\begin{aligned} - \{\tfrac{1}{2}E_0^2 \cos 2\omega t &- \tfrac{1}{8}E_1^2 \cos 2(\omega - m)t \\ &- \tfrac{1}{8}E_1^2 \cos 2(\omega + m)t + \tfrac{1}{4}E_1^2 \cos 2\omega t \\ &+ E_0 E_1 \sin mt \cos 2\omega t\} \end{aligned}$$

In effect, what Mr. Aughtie has done in his argument is to take account of the components represented by the first four terms, but has entirely neglected the component represented by the term $E_0 E_1 \sin mt \cos 2\omega t$, which is the second harmonic of the carrier wave *modulated with the original note frequency* $\frac{m}{2\pi}$.

A valve detector rectifies primarily in virtue of the fact that it produces a current or voltage proportional to the *square* of the impressed voltage.

Writing the above expression in the form

$$-\{\tfrac{1}{2}(E_0^2 + \tfrac{1}{2}E_1^2) - \tfrac{1}{4}E_1^2 \cos 2mt + E_0E_1 \sin mt\}\cos 2\omega t$$

the rectified current or voltage will therefore be proportional to

$$\{\tfrac{1}{2}(E_0^2 + \tfrac{1}{2}E_1^2) - \tfrac{1}{4}E_1^2 \cos 2mt + E_0E_1 \sin mt\}^2$$
$$= \{\tfrac{1}{4}(E_0^2 + \tfrac{1}{2}E_1^2)^2 + \tfrac{1}{16}E_1^4 \cos^2 2mt + E_0^2E_1^2 \sin^2 mt - \tfrac{1}{4}(E_0^2 + \tfrac{1}{2}E_1^2)\,E_1^2 \cos 2mt + (E_0^2 + \tfrac{1}{2}E_1^2)\,E_0E_1 \sin mt - \tfrac{1}{2}E_0E_1^3 \sin mt \cos 2mt\}$$

On reducing this to a sum of harmonic frequencies, we find for the first and second harmonics

$$(E_0^2 + \tfrac{3}{4}E_1^2)\,E_0E_1 \sin mt$$

and

$$-(\tfrac{3}{4}E_0^2 + \tfrac{1}{8}E_1^2)E_1^2 \cos 2mt$$

This not only is the fundamental note frequency reproduced, as well as the second and higher harmonics, when receiving the second harmonic of the carrier wave, but the amplitude of the second harmonic of the note frequency is less than $\frac{3}{4}\frac{E_1}{E_0}$ of the amplitude of the fundamental note frequency.

The above analysis is, of course, only approximate, since we have taken account only of the terms depending on the square of the voltage impressed on the assumed non-linear amplifier, and only of that part of the rectified current or voltage depending on the square of the voltage (of double the carrier wave frequency) impressed on the detector valve. It is quite sufficient, however, to show that the main effect to be expected when listening to the second harmonic of the carrier wave frequency is a reproduction of the original note frequencies.

The analysis could have been considerably simplified by dealing with the voltage in the form

$$e = E_0 \sin \omega t + E_1 \sin mt \sin \omega t$$

with, of course, exactly the same result, but Mr. Aughtie would no doubt then have claimed that I was really only supporting his own conclusion.

E. A. BIEDERMANN.

Brighton.
January 1st, 1929.

Alignment Valve Characteristics.

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

SIR,—Referring to Mr. W. A. Barclay's letter in your February issue, I agree that the alignment chart in question could have been constructed more accurately from a knowledge of the observed data. The object of the above article, however, was to show how the valve characteristics could be obtained fairly approximately and easily, before the manufacture of the valve. The method employed makes use of the valve design data only, and enables the characteristics to be obtained without having to make tedious calculations consisting of repeated substitutions in a formula. In these circumstances, since the approximate shape of the characteristics is sufficient it was assumed that the Van de Bijl formula would give the necessary accuracy. The method of obtaining the constants for this formula were not given as it was thought that this part of the subject had been treated quite fully by other writers.

M. REED.

"The Allocation of Wavelengths to European Broadcasting Stations."

Mr. Siffer Lemoine has asked us to point out that in connection with his article on "The Allocation of Wavelengths to European Broadcasting Stations," published in our issue of July, 1928, the reference made in our editorial in our issue of January, 1929, is misleading, and is due to a mistranslation of his original text.

The translation of the sentence in question should have read :—

"The scheme worked out at Geneva by L'Union Internationale de Radiophonie, which came into operation in November, 1926, and to which most of the broadcasting organisations in Europe have given their adherence, has undoubtedly meant an important step forward, in spite of the deficiencies that mar it, and although the plan in question cannot be regarded as representing a definite solution."

Book Review.

DONNÉES NUMÉRIQUES DE RADIOÉLECTRICITÉ (T.S.F.). By R. Mesny. Extrait du Vol. VI des Tables Annuelles de Constantes (1923–1924) —1 Vol. in 4° de 26 pp. Price, 15 Fr. ; bound 30 Fr. Gauthier-Villars et Cie, 55, Quai des Grand-Augustins, Paris (vi°).

The international committee which controls the Tables Annuelles de Constantes has decided to publish in separate parts a certain number of the chapters contained in Vol. VI, and the section under review contains the constants and data dealing with radio telegraphy and telephony. It would have been a great convenience to have had this data in such a convenient form and at such a reasonable price, but it must be pointed out that the data is limited to that published during the two years 1923–1924, and is therefore not only very limited in its scope but in a subject developing so rapidly, it is now necessarily out of date. The material is divided into eight sections. The first entitled thermionic tubes gives characteristic curves of a number of valves, now five years old. The second section deals with the valve as a detector and the influence of alkali vapour on the characteristic ; then follows tables of permeability of iron and nickel at high frequencies. The fourth and fifth sections give the results of many measurements made on wave attenuation mainly with long waves five or six years ago. A section follows on direction finding and then a miscellaneous collection of data on various subjects which could not be classified. The final section contains tables for the calculation of inductance of coils of various shapes.

A set of volumes like this covering the last twenty years and brought right up to date would be very useful, but this one isolated volume only serves to remind us how far we have travelled since 1924.

The Development of the Oxide-coated Filament.

(Paper by Dr. B. Hodgson, O.B.E., and Messrs. L. S. Hartley, B.Sc., A.M.I.E.E., and O. S. Pratt, B.A., read before the Wireless Section, I.E.E., on 6th February, 1929.)

ABSTRACT.

IN the introductory portion, the paper traces the origin of the coated filament from the first lime-coated cathode of Wehnelt in 1904. Physical study led to the assumption that there were free electrons in a metallic conductor in a state of violent motion, like the molecules of a gas or liquid. This increases with temperature until the energy of these motions attains a value large enough to carry some of the electrons through the surface of the hot body. The electrons have to overcome forces acting at the boundary, as do the molecules of a vaporising solid or liquid.

Richardson gave his equation for emission in the well-known form

$$I = AT^2e^{-b/T}$$

where A is a constant, and $b = \phi\, e/k$, k being Boltzmann's constant, and ϕ the voltage level the energy of the electron must attain to break through the forces resisting its escape from the emitting surface.

The emission constants of the oxide-coated filament are then discussed, micropyrometric measurements showing an emissive improvement of a hundredfold or more by formation of the oxide coating.

TABLE II.

Material.	A	b	ϕ
	amps./cm²/deg. C.	deg. C.	volts.
Tungsten ..	60.12	52 560	4.53
	—	56 000	4.46
	100	53 100	4.57
Thorium ..	70	39 400	3.27
		34 100	2.94
Calcium oxide ..	—	21 400	1.77
		—	2.24
		—	2.4–2.5
Strontium oxide	—	15 300	1.27
		—	1.79
		—	2.15
Barium oxide ..	—	12 000	0.99
		—	1.59
		—	1.85
Mixture of barium and strontium oxides ..	0.001	12 100	1.04

Table II gives some values for different materials, showing the variation of A, b and ϕ, it being noted that A varies with the material, and does not keep the constant value (viz., of about 60) indicated by theory.

The Mechanism of Emission.

After discussing early theories of emission from the oxide-coated filament, the authors give the present theory. According to this, the barium oxide is decomposed electrolytically and oxygen is diffused into the vacuous space, while the alkaline earth metal remains at first where it was liberated, but subsequently diffuses to the surface where it forms small islands which are emission centres in the sense of Richardson's law (*i.e.*, thermionically). Everything that helps the building of these islands increases the emissivity of the filament. The emission thus becomes constant when equilibrium is reached between the evaporation of the metal and the building of new metal islands under the electrolysis set up by the emission current.

Various experiments and facts in support of this theory are mentioned. One (by Koller) was to take a filament with the maximum number of metallic islands and giving a work function of 1.04 volts. After glowing the filament at a high temperature and boiling off the barium (leaving a barium oxide filament), the work function had increased to 3.1 v., showing that the emission was due to metallic particles produced by electrolysis by the anode current.

Another is the known fact that a filament is partially de-activated if run for considerable periods without emission current, the supply of metallic particles due to electrolysis not being maintained. It can be re-activated by running with high anode voltage and large emission current, due to the re-electrolysis of the oxide and the re-formation of the metal.

One difficulty of the theory is why a volatile metal like barium remains on the surface after formation. (Barium melts at about 1120 deg. K., and vaporises at 1220 deg. K.). It is suggested that it may not be in the form of drops or separate particles, but perhaps in some adsorbed atomic condition which holds it fast to the surface. It is known that, with a tungsten filament in vapours of cæsium, rubidium and potassium, these metals adhere to the tungsten at temperatures higher than would be expected from the known vapour pressures of the metals. Experiments by the authors showed that valves with barium filaments lost their emission very quickly, while those with barium oxide filaments showed little change in thousands of hours. It thus appears that the oxide si essential as a support or carrier for the barium which would otherwise vaporise.

The Manufacture of the Barium Oxide Filament.

These filaments can be made in one of four ways :

(1) Melting or fusing of a barium compound to the core wire.

(2) Application to the wire of a resinous or paraffin paste containing a barium compound.

(3) Evaporation of a solution of a barium salt which is painted on the wire.

(4) Deposition on the filament of barium from vapour.

In the first method, the core wire of platinum or nickel is drawn through the fused salt bath. This gives a rough filament and a loosely adhering coating and is not now in much use.

In the second method, the prepared paste is applied to the heated filament, so that a portion of it adheres. The wire is then heated more strongly

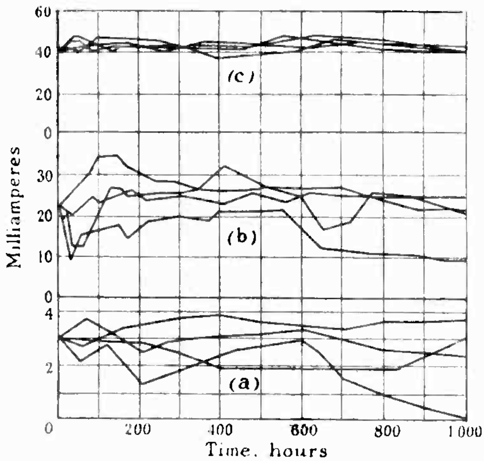


Fig. 2.—*Variation of saturation current from various oxide-coated cathodes with life.*

to evaporate the paraffin or resinous carrier. Finally, the core is heated to about 1,000 deg. C. to sinter the substance to the wire and convert the carbonate of the paste to oxide, this being repeated several times. A process of this nature is used by Standard Telephones and Cables. The resulting filaments are greyish and slightly rough in texture, but can be made regular along the length of the filament. The core metal is usually platinum or nickel. If too thick, the layer tends to crack. The filament must be protected, before pumping, from the action of carbon dioxide and water vapour.

In the third method the wire is dipped into the solution of barium salts, taken out and heated in carbon dioxide gas. This is repeated from fifty to one hundred times, and finally a layer of carbonate is formed. This layer is almost insoluble in water. The wire must be clean and the heating carefully carried out, or a "pearl-string" filament results. A filament made by this method is not vitiated by contact with the atmosphere.

The fourth method is done in vacuo. The core wire is oxidised before the evacuation of the bulb. On the side of the anode towards the filament a piece of barium metal is fixed. When a good vacuum is reached the anode is heated (usually by induction) and the metal evaporates. This vapour surrounds the filament, which is dull red, and tungstic oxide is reduced and barium oxide is formed. Barium azide solution can be painted on the anode instead of barium metal. The barium also acts as a getter after decomposition, although magnesium is usually employed as well.

With the first three methods pumping takes considerable time. The filament is heated to 900 deg. C. or 1,000 deg. C. without anode voltage and the anode heated. Activation commences as the vacuum improves and, as the filament improves in emissivity, it can be run cooler before sealing off. Ageing can then take place by heating the filament to its normal running temperature and applying an anode voltage. With the fourth method, the anode is heated in the same way, but the formation of the filament is more rapid and ageing is not always necessary.

If the coating is not uniform parts remote from the core are cooler than the more thinly coated parts, which give greater emission and produce "hot spots." This disadvantage is always present with this type of filament and is perhaps the reason why it has not been used with valves using very high anode voltages. Coatings of mixed oxides (*e.g.*, barium oxide and strontium oxide) and the use of thin coatings minimise this knot or pearl string formation.

With filaments made by the vapour process the thickness of the coating is under control, and measurements by the authors show it to be a few hundreds of molecules thick. Filaments by this process also show reasonably constant emission over long periods of life, and less variation from valve to valve. Fig. 2* shows this, the filaments "c" having been made by the vapour process,

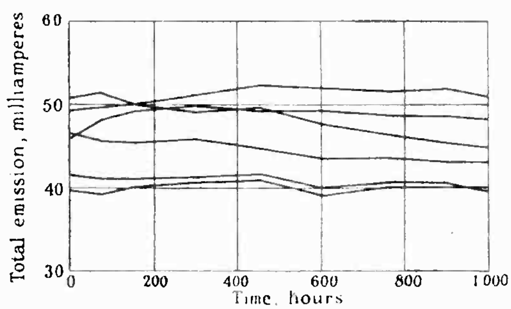


Fig 3.—*Variation of saturation current from an oxide-coated cathode made by the barium vapour process with life. Total emission of Mullard PM5 filament operated at 5.5 volts. Grid anode potential 80 volts. Grid connected to anode.*

while "a" and "b" were made by a paste process. Life curves of some valves made by the vapour process are shown in Fig. 3, while it is stated that the authors have not been able to detect any change in the amount of barium present in a filament after 1,000 hours' life.

Discussion.

In opening the lengthy discussion which followed the reading of the paper, Mr. G. Shearing said that

* The authors' original figure numbers are adhered to throughout this abstract.

the development of the oxide-coated filament was the most remarkable event of recent years in valve matters. Apart from their dull emitter properties, coated filaments had helped the study of the effects of gaseous content in the bulb. He suggested that the account given of the authors' own experimental work was too brief. As an example, he quoted the account of the use of barium and of barium-oxide filaments. What changes occurred in coated filaments if operated at excessive anode voltages, and was there any prospect of coated filament valves being available for greater power ? On the subject of the value A (Table II), Dushman had shown that this varied according to whether the atoms of the surface layer were electropositive or electronegative. Lastly, he suggested that the incorporation of a bibliography would be helpful.

Mr. M. Thompson said the authors had not given much information on the early history of the vapour process of filament coating. Table II showed the difficulties of studying oxide coatings. The work function ϕ for oxides displayed great discrepancies, showing the difficulty of measuring A. The value of 1 for ϕ with barium seemed to him unlikely. Caesium had a value of 1.4 and was more electropositive than barium, so he would expect barium to be higher. The theoretical value of 60.2 for A only applied to pure metals and had been proved for tungsten, molybdenum and thorium. He suggested the addition of the stroboscopic method of measuring small amounts of material in work on these filaments.

Mr. P. K. Turner asked several questions from the user's point of view. Could one express filament performance in terms of a ratio of mutual conductance to filament voltage for normal geometry of electrodes ? What were the effects of running the valves at low emissions ? As regards anode voltage were the working figures (given on valve boxes) based on specified limits in watts or were there higher safe limits to voltage ? Were the filaments damaged by excessive anode current ?

Mr. Hughes discussed the mechanism of emission. Only by knowledge of this subject would it be possible to build up a filament for higher powers. There was a need to know the mechanism of the separation of the barium.

Mr. Robinson also spoke of the mechanism of emission. He suggested that the barium formation was possibly due to bombardment of the cathode by gas, *e.g.*, hydrogen or CO_2. The latter reduced readily when ionised. Discussing the adhesion of barium to the filament he suggested that the barium had under it a layer of oxygen. It was difficult to reconcile the authors' results with directly applied coatings and those of the vapour process. He considered the presence of strontium oxide also necessary.

Mr. J. Bedford differed from the authors in their theory. He considered the statement of the effect of electrolysis misleading. Space current taken from the filament sets up a drift of ions due to dissociation. He did not agree with the authors' view of de-activation on running with no emission, but gave it as his experience that space current produced de-activation. The life curves given were interesting as differing from those obtainable with valves ordinarily purchased. He would be interested to know any reason. Why did the curves stop at 1,000 hours. He knew of coated filament valves going to 30,000 hours.

Prof. C. L. Fortescue thought that the position of thermionics was in a chaotic state. It had recently been stated that modern theories of wave mechanics could be used to explain thermionic theory, but he felt that physics had to go much further than at present to explain the actions involved.

Mr. McPherson asked if the life tests of Fig. 2 finished due to loss of activity. Coated filaments had been in use in valves of 300 watts dissipation at 1,600 v. and had been in existence for some time. At one broadcasting station such valves had given working lives of 3,000 hours.

The authors leaving the reply to the discussion to be communicated, the meeting terminated on a vote of thanks moved by the Chairman (Commander J. A. Slee, C.B.E.).

Abstracts and References.

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PROPAGATION OF WAVES.

RADIO ECHOES AND CONDITIONS FOR THEIR OCCURRENCE.—C. Störmer. (*Nature*, 5th January, 1929, V. 123, pp. 16-17.)

Since 24th October no more long-time echoes have been heard. It appears from this, and from the long silence in the spring and summer, that these echoes owe their occurrence to a series of favourable coincident circumstances. The mathematical theory shows that the chances of obtaining a well-defined toroidal space (January Abstracts) are good when the direction of the sun lies near the magnetic equatorial plane—confirmed by Birkeland's cathode ray and magnetised sphere experiment, a photograph of which is given showing the toroidal space. On the two occasions when the echoes were heard (October 11th and 24th) the sun was not far from this position. The writer suggests that the echoes will not be heard again till the middle of February, when this particular condition will be repeated.

ECHOS VON HERTZSCHEN WELLEN (Hertzian Wave Echoes).—K. W. Wagner. (*E.N.T.*, December, 1928, V. 5, p. 488.)

Discusses the Störmer-Hals echoes, and the short-time echoes of Taylor and Young, Hoag and Andrew (see recent Abstracts) and Quäck and Mögel (the observations of the last pair will appear shortly in *E.N.T.*). The short-time echoes, both American and German observers agree, come at intervals which are whole multiples of 0.010–0.011 sec., corresponding to path differences which are whole multiples of 3,000–3,300 km.

A VISUAL METHOD OF OBSERVING THE INFLUENCE OF ATMOSPHERIC CONDITIONS ON RADIO RECEPTION.—E. Merritt and W. E. Bostwick. (*Proc. Nat. Acad. Sci.*, November, 1928, V. 14, pp. 884–888.)

In studying fading and direction-shifts due to the combined effects of ground and sky waves, with a particular eye on the influence exerted by atmospheric conditions, it would be very desirable to find a method by which the effects of the sky wave (which is the more influenced by such conditions) could be measured by itself. The writers state that "thus far, no means of completely separating the two waves has been proposed. In fact, complete separation does not seem possible." They describe experiments in which a partial separation is effected by the use of two carefully balanced coil receivers, one (*a*) having its plane vertical and pointing towards the sending station, the other (*b*) with its plane vertical at right angles to this direction. (*a*) Responds to the resultant field due to ground wave and vertically polarised component of sky wave: (*b*) only responds to that component of the sky wave which is polarised with its electrical vector horizontal. It is not affected at all by the ground wave. The signals from (*a*) and (*b*) are heterodyned by one local oscillator: since the E.M.F. produced in the receiving circuit by this local oscillator is always greater than that due to either signal, the resulting amplitudes are proportional to those of the (*a*) and (*b*) signals. Moreover, the phase difference between the rectified beat-tones is the same as that between the original signals (U.S. Patent, No. 1,510,792, Merritt). These beat-notes, suitably magnified, are each brought to a pair of deflecting plates of a cathode ray oscillograph (*cf.* Friis, Abstracts, 1928, V. 5, p. 461), so that the vertical and horizontal movements of the spot of light correspond with the oscillations received on (*b*) and (*a*) respectively, both in amplitude and phase. So far the method has been used chiefly with different American broadcasting stations. The modulation (unless unusually strong) is rarely a source of disturbance. Tests with a similar short-wave apparatus, on American and European stations, show that code transmission gives no trouble, and that the absence of modulation gives particularly sharp and clear figures. The writers point out that as the arrangement gives only a partial separation of ground and sky waves, while there can be no vertical amplitude unless there is a sky wave, the absence of vertical amplitude does not necessarily mean that no sky wave is present, for it might be unsuitably polarised. The character of the figures produced is described: the changes as sunset approaches and the sky wave begins to appear: occasional continuous rotation shortly after sunset (as many as 20 complete turns, in the same sense, have been counted in a few minutes)—probably due to the rapid rise of the Heaviside layer producing a progressive change in phase and a progressive rotation of plane of polarisation. At night, both waves appear to be modulated equally, but when a strong sky wave is present in the day (*e.g.*, late afternoon) its modulation is much less marked than that of the ground wave. At night the movements of the figure are quite erratic: rotation, when it occurs, is sometimes in one sense and sometimes in the other: changes are in general more rapid than by day, but occasionally circular polarisation persists with unchanged amplitude for as long as two minutes. Observations during an auroral display are described: the figure showed violent and erratic changes so rapid that they could be followed with difficulty. This period of disturbance was preceded (about an hour earlier) by one of rapid changes and of rotations (some lasting two minutes) in both senses; but the time of beginning of the aurora is not known, and it is not quite clear whether these effects were more marked than usual. It is, however, mentioned that until they began, and for some days previously, "conditions for radio reception had been unfavourable," and only weak sky waves, and slow and not marked changes in figure, were observed.

SOME NOTES ON WIRELESS METHODS OF INVESTIGATING THE ELECTRICAL STRUCTURE OF THE UPPER ATMOSPHERE. Part I.—E. V. Appleton. (*Proc. Physical Soc.*, 15th December, 1928, V. 41, Part 1, pp. 43–59.)

This is the U.R.S.I. paper referred to in the abstract (February, 1929, p. 98) of an *E.W. & W.E.* editorial. In addition to the comparison of the three methods of determining the effective height of the layer, referred to in that abstract, the paper deals with methods of investigating the ionisation gradient (*a*) by height measurements on a number of mean frequencies at about the same time and under the same conditions of transmission distance, etc.; and (*b*) by simultaneous observations on the same mean frequency, at different distances; additional evidence being obtained by comparing results on different frequencies. (*Cf.* Schelling, February Abstracts.) In the subsequent discussion, Hollingworth states that his experience (on very long waves) suggests that for long distances of transmission the path is of a "flat-topped" form rather than triangular, and that the angle (with vertical) of incidence at the layer is definitely greater than 30 deg. (which point is welcomed by the author as an indication that the first method of finding the ionisation gradient may be carried out with some hope of success). Replying to Eccles, the author remarks that although the paper is based on the ionic refraction theory, it may turn out that the ionisation gradient is greater than commonly supposed and that we shall have to replace simple ionic refraction by some process intermediate between such refraction and true reflection. If, in such a case, the boundary of the layer had a certain degree of "roughness," we could possibly explain "skipped distances" as being regions in which only diffusely reflected radiation is received, the specularly reflected radiation being received at greater distances. [Contrast this with Ponte and Rocard, February Abstracts.] Such an explanation would give the correct relation between the wavelength and the magnitude of the skipped distance. Rankine points out the apparent close, but inverted, analogy between the travelling of wireless waves in a "flat-topped" path and the behaviour of seismic phenomena (natural earthquakes and artificial surface explosions), where the disturbances travel more rapidly in the deeper strata than in those near the surface. T. Smith, by optical reasoning, points out the difficulty of contriving experiments which really measure $\int \mu ds$; almost any procedure turns into one which deals with $\int ds/\mu$ rather than with $\int \mu ds$; for instance, a *signal* of any kind must give $\int ds/\mu$, for a signal is given by imposing a peculiarity of some kind on a train of waves, that is to say, it concerns group velocity, not phase velocity. In optics $\int \mu ds$ would probably be evaluated by an interference method, preferably one in which "white light fringes" were obtained. Perhaps a corresponding method, in which the time taken by an interfering wave to travel between source and receiver can be controlled and adjusted to give steady agreement of phase with the reflected beam for a range of wavelengths, would be possible in the wireless problem. He also points out that $\int ds/\mu$, besides being related to the length of hypothetical rectilinear paths observed from the ground (as the author showed), can be related to the area enclosed by the wave in its actual path.

ÜBER TELEGRAPHIE MIT KURZEN WELLEN (Short Wave Telegraphy).—H. Rukop. (*E.T.Z.*, 13th December, 1928, p. 1815.)

Abstract of lecture to the 1928 Hamburg Meeting of German scientists. A survey of our present knowledge as to the use of waves of 10–50 m. length. The limiting lengths, beyond which there is no return from the Heaviside layer, are by day 9–10 m. and 50–100 m.; by night the lower limit changes to about 18 m. Measurements by various methods allow us to place the height of the layer between 60 and 200 km. By a suitable choice of wavelength for each particular line of communication and for each time of day, a faultless commercial service can be obtained with piezo-electrically controlled valve transmitters giving up to 120 words per minute.

ÜBER DIE AUSBREITUNG KURZER ELEKTROMAGNETISCHER WELLEN IN DER HEAVISIDESCHICHT (Propagation of Short Waves in the Heaviside Layer).—K. Försterling. (*E.N.T.*, December, 1928, V. 5, pp. 530–542.)

Although this paper was only sent for publication in June, 1928, it is labelled as having been read at the Heinrich-Hertz Society in Berlin in September, 1927. The author accepts the arguments of Lassen (based on Lenard's tests) that the ultra-violet solar radiation is alone responsible for the ionisation of the atmosphere. He considers (1) refraction and absorption of waves in a layer containing free electrons or ions, and the effect of temperature; (2) propagation in a medium such as that of the layer: reflection; (3) reflection at a layer of finite thickness: improbability of a sharp border surface above or below: probability of the gradual change of condition of the atmosphere with increasing height, so that the refractive-index changes very little within the length of a wave; (4) propagation of light in an inhomogeneous medium, and the analogous behaviour of wireless waves: "at a medium of slowly changing dielectric constant there is either no reflection at all or total reflection. . . . Since within the layer the square of the refractive-index has a minimum, the condition (for total reflection) is fulfilled either not at all or twice": in the latter case there are two planes at which total reflection takes place, at a distance D ("effective thickness") dependent on the wavelength and on the earth-angle: the greater this thickness, the stronger the reflected wave. This section ends with a suggestion of the differing effects of a wave-front reflected and a wave-front bent by refraction: the relative positions of points on the front, on leaving and on returning to earth, are unchanged in the first case but reversed in the second: "the second case is impossible so long as the refractive-index depends on one co-ordinate and obeys the refraction law, since according to this parallel rays remain parallel the whole length of their path"; (5) the effect of the earth's magnetic field: "for very short waves the magnetic influence is very slight. . . . There is a critical frequency $\omega_0 = \frac{eH_0}{cm}$ near which the influence of the magnetic field becomes very marked. For free electrons this critical wavelength is about 210 m. For ions it is about 2,000 times greater." Although there may be relatively few free electrons compared with the mass of ions in the layer, it is likely that the propagation of waves in the neighbourhood of 210 m. is subject to certain peculiarities.

APPLICATION TO GEOPHYSICAL INVESTIGATIONS OF LEVI-CIVITÀ'S THEORY RELATING TO THE INFLUENCE OF A CONDUCTING SCREEN ON THE ELECTROMAGNETIC FIELD OF AN ALTERNATING CURRENT PARALLEL TO THE SCREEN. —A. Rostagni. (*Nature*, 29th December, 1928, V. 122, p. 1018.)

Title only of a paper read before the Royal Nat. Acad. Lincei, 17th June, 1928.

SUR LES PROPRIÉTÉS DES GAZ IONISÉS DANS LES CHAMPS DE HAUTE FRÉQUENCE (The Properties of Ionised Gases in H.F. Fields).—H. Gutton. (*Comptes Rendus*, 7th January, 1929, V. 188, pp. 156–157.)

The writer's previous work showed the existence of a natural period of oscillation for the ions; the present paper describes more experiments, to test how the elastic force varies with the conductivity of the gas. Measurements of the ionisation corresponding to resonance were made with four values of wavelength ranging from 1.324 m. to 4.830 m. Results showed that the product $\lambda^2 i^{0.75}$ was a constant (i being the current measuring the degree of conductivity); therefore, as the conductivity is proportional to the number of ions per c.c., the elastic force is proportional to the 0.75 power of this number.

NOTE SUR LES EXPÉRIENCES RELATIVES AUX PROPRIÉTÉS DIÉLECTRIQUES DES GAZ IONISÉS DE MM. GUTTON ET CLÉMENT (Note on Gutton and Clément's Experiments on the Dielectric Properties of Ionised Gases).—J. Rybner. (*L'Onde Élec.*, October 1928, pp. 428–436.)

Gutton and Clément have explained their results on the hypothesis that the ions are not free, their movements taking place under quasi-elastic forces (Abstracts, 1927, p. 572; 1928, p. 222, and above). The present writer explains the results on the classic idea of free ions; reconciles them approximately with Pedersen's formulæ, and suggests that with certain modifications the experiments would give a basis for exact calculations giving valuable information on the average speed of electrons in an ionised gas. His main point is to prove that large decrements are not necessary to explain the variations of the frequency of resonance; and that the contrary is even true.

THE MOBILITY OF IONS IN AIR. Parts IV and V. —A. M. Tyndall, L. H. Starr and C. F. Powell; A. M. Tyndall, G. C. Grindley and P. A. Sheppard. (*Proc. Roy. Soc.*, 1st November, 1928, V. 121 A., pp. 172–194.)

Two new methods of measuring the mobility, both of which have a high resolving power, are described. The apparatus can be made airtight, and the ions can be given any required age (from 1/65 to 2/3 sec.) before their mobility is measured. A third (air-blast) method is described which was used to check previous results. A number of conclusions are drawn from the experiments: among these may be mentioned the marked increase in the rate of transformation produced by a small quantity of ozone; at long ages the positive ions in air have mobilities distributed over a small range with a mean value of about 1.25, and this mobility is independent of the humidity of the air; there is no evidence of initial positive ions in very dry air or in pure nitrogen. If any are formed, they nearly all transform in less than 1/100 sec.

ON THE RATE AT WHICH PARTICLES TAKE UP RANDOM VELOCITIES FROM ENCOUNTERS ACCORDING TO THE INVERSE SQUARE LAW. —L. H. Thomas. (*Proc. Roy. Soc.*, 1st November, 1928, V. 121 A., pp. 464–475.)

Author's Summary:—The formulæ obtained—for low densities—lead to "effective mean free paths" shorter than might have been expected. It seems not impossible that the rapid rate at which beams of electrons moving through highly ionised gases have been observed by Langmuir to take up Maxwellian velocity distributions may be explained in this way.

DIAGRAMME DES CHAMPS ÉLECTRIQUES MESURÉS À MEUDON PENDANT LE DEUXIÈME SEMESTRE 1927 (Diagram of the Electric Fields measured at Meudon during the second half of 1927).—(*L'Onde Élec.*, October, 1928, pp. 458–460.)

These diagrams record the fields in microvolts per metre for Bordeaux, Nantes, Rocky Point and Leafield. References are given to 13 previous sets published in the same journal since 1922.

ÜBER DIE FORTPFLANZUNGSGESCHWINDIGKEIT ELEKTRISCHER WELLEN AN DÜNNEN DRÄHTEN VON VERSCHIEDENEM LEITVERMÖGEN (The Velocity of Propagation of Electric Waves along thin Wires of various Conductivities). —L. Bergmann and G. Holzlöhner. (*Ann. d. Physik*, 1st November, 1928, V. 87, No. 5, pp. 653–676.)

The variation with the radius and the conductivity is experimentally investigated, on wavelengths 172 and 400 cm., for copper, aluminium, manganese, etc. Diameters varied from 0.04 to 0.3 mm. Results agree well with the theory described at the beginning of the paper.

FIELD STRENGTHS OF EUROPEAN BROADCASTING STATIONS MEASURED AT BERLIN.—M. v. Ardenne. (*See under* "Measurements and Standards.")

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

ON THE ORIGIN OF THE AURORA POLARIS.—S. Chapman, with reply by E. O. Hulburt. (*Phys. Review*, December, 1928, V. 32, No. 6, pp. 993–996.)

Hulburt's new theory is criticised on the ground, principally, that free high-atmospheric ions in middle and low latitudes cannot travel far towards the poles along the earth's lines of magnetic force, because they must at the same time descend into the lower levels where their motion is interrupted by collisions. Upward moving ions will travel towards the equator. Hulburt replies that the ion spray caused by the sun's ultraviolet light may reach heights of (say) 30,000 km. above the equator, and may distil to within 20–30 deg. from the magnetic poles rapidly enough to supply the energy of the aurora. *Cf.* February Abstracts.

POTENTIAL GRADIENT AT GREAT HEIGHTS.—R. Idrac. (*Nature*, 29th December, 1928, V. 122, p. 1013.)

Summary of a publication by the French Meteorological Office, amplifying the 1926 paper by Idrac. A balloon carries the (valve) electrograph and the barothermograph. According to the afternoon averages, the gradient over Trappes at 2 km. is 43 V/m.; at 5 km. this falls off to 11, but at 7 km. it is 25 and at 9 km. it rises to 30. There is then a sudden drop, presumably on entering the stratosphere, to 2 V/m.; another rise begins at 12½ km. up to a max. of 16 V/m. at 14 km. "The diminution to practically zero gradient at 20 km. seems to be based on one record only." "If we may interpret the observations in the light of Coulomb's Law it appears that in the afternoon the air is positively charged up to 5 km., negatively between 5 and 9 km. There is a considerable positive charge just below the stratosphere. The stratification by night and in the morning is found to be somewhat simpler."

MESSUNGEN DER DURCH ELEKTRONENSTRAHLEN VERURSACHTEN IONISATION DER LUFT (Measurements of Air Ionisation by Electron rays).—W. Schmitz. (*Physik. Zeitschr.*, 15th November, 1928, pp. 846–849.)

For electron speeds of from 1,000–10,000 V., the mean volt-energy needed for the formation of an ion-pair keeps almost constant at about 42 V.

DIE MITTLERE LEBENSDAUER DER IONEN IN DER LUFT ÜBER DEM MEERE (The Mean Life of Ions in the Air over the Sea).—V. F. Hess. (*Physik. Zeitschr.*, 15th November, 1928, pp. 849–851.)

Results of recent tests in Heligoland. With a N. or N.N.W. wind, the light ion life is 200–300 sec. Condensation nuclei are only 500–1,500/c.c. With wind from the land (S.) these numbers may become about 30 sec. and 10.000/c.c. respectively.

THE EFFECT OF WATER VAPOUR ON THE MOBILITY OF GASEOUS IONS IN AIR.—H. A. Erikson. (*Phys. Review*, November, 1928, V. 32, pp. 791–794.)

Supplement to a 1927 paper. The H_2O molecule gives up an electron to the final positive air ion and thus forms an H_2O+ ion of a greater mobility. The reciprocal of the mobility bears a linear relation to the humidity.

ÜBER DEN EINFLUSS DER TEMPERATUR AUF DIE ZUSAMMENSETZUNG DER ATMOSPHÄRE IN DEN OBERSTEN SCHICHTEN (The Influence of Temperature on the Composition of the Highest Layers of the Atmosphere).—H. Petersen. (*Physik. Zeitschr.*, 1st December, 1928, pp. 879–884.)

Working on the assumption of a condition of equilibrium of flow instead of the usual static equilibrium of diffusion, the writer finds that the amount of helium in the atmosphere decreases with height far more rapidly than it would according to the latter idea; this fits in with the Northern Light spectrum. The possibility is also discussed—and shown to exist—of the destruction of the helium molecules by the corpuscular streams from the sun.

ERGEBNISSE MEINER UNTERSUCHUNGEN DER MESSUNGEN DES ERDPOTENTIALS (Results of my Investigations into the Measurements of Earth Potential).—R. Stoppel. (*Vortragshandbuch*, 90. *Versamm. d. Ges. deut. Natur. forsch.*, Hamburg, September, 1928.)

The summary contains the statement that the earth's charge is regarded as constant, but that this is not the case when limited areas of the earth's surface are dealt with. Preliminary results from the author's method of measuring these local variations show that at night the earth takes on a more negative charge, by day a more positive; and that the extremes of the curve fall at about midnight and midday.

TRIBO-ELECTRICITY AND FRICTION. IV.—ELECTRICITY DUE TO AIR BLOWN PARTICLES.—P. E. Shaw. (*Proc. Roy. Soc.*, 1st January, 1929, V. 122A, pp. 49–58.)

The impact of two unlike metals, of two like metals, or of sand on sand or ice on ice, is studied by driving wind-blown particles of these materials on to surfaces of one material only; the charges arising on the particles, surfaces and issuing air are separately measured. Results show that the Volta-effect plays a large, but not exclusive, part in the genesis of the charges; when the particles and surfaces are chemically identical, considerable charges arise. The results for sand and ice provide a key to the meteorological effects observed in electric sand-storms and snow-storms.

THE ELECTRIFICATION OF AIR BY FRICTION.—A. W. McDiarmid. (*Phil. Mag.*, December, 1928, V. 6, pp. 1132–1140.)

Experiments are described with the object of discovering whether or not electrification can result from the friction of dry, dust-free air with solid surfaces. They show that the passage of a rapid current of such air through a tube causes the current to carry with it charged particles of air and leaves the tube oppositely charged. It is thought that the need for a quick flow is due to secondary effects, *e.g.*, it may be necessary to prevent the charges on the air and on the tube from recombining and so masking the effect.

EVALUATION OF THE TRUE INFLUENCE OF THE ELECTRIC HYPER-ATMOSPHERE ON TERRESTRIAL MAGNETISM.—D. A. Grave. (*C.R., Academy of Sciences*, Leningrad, No. 22, 1928.)

The same number contains a paper by Kravetz on Magnetic Anomalies, in which he discusses a previous paper by D. A. Grave and says that his arguments are based on a misunderstanding.

PROPERTIES OF CIRCUITS.

ÉQUILIBRES INSTABLES ET RÉGIMES STATIQUES PARASITES DANS LES CIRCUITS ÉLECTRIQUES ASSOCIÉS AUX TRIODES (Conditions of unstable equilibrium and of parasitic disturbances in electric circuits associated with 3-electrode valves).—I. Podliasky. (*L'Onde Élec.*, November, 1928, pp. 475–487.)

Conclusion of the paper referred to in Abstracts, 1928, V. 5, p. 580. It begins by completing the first instalment's treatment of dynatrons and other valves used in such circuits that secondary emission is predominant: "the condition of parasitic disturbance is only possible if the internal characteristic possesses points of inversion of plate current: *i.e.*, if a value of plate voltage exists beyond which the secondary (plate) emission dominates the primary (filament) emission." Various ways of avoiding these—sometimes very destructive—disturbances are discussed; diminution of the external resistance below the critical value—not always possible; lowering the grid voltage; decrease of filament temperature—this will always suppress the points of inversion. (An increase, on the other hand, does not always have the opposite effect; some valves only allow parasitic conditions between two limits—often quite close—of filament temperature.) The paper then passes on to similar effects in ordinary triode circuits where the anode is positive to the mean grid voltage, and secondary emission from the plate does not occur. What can occur, however, is secondary emission from the grid, even where the grid is negatively polarised; and this can produce parasitic conditions analogous to the ones previously dealt with, and equally or more destructive. Their study is very difficult, for they start spontaneously and quickly destroy the valve. The condition is indicated by a high anode current, together with a small grid current in the reverse direction to normal. It is thus easily confused with the parasitic condition due to ionisation of the residual gas; but the difference can be made evident if the valve is robust enough to survive, for the electron disturbance is perfectly stable, whereas the ionic effect fluctuates. The latter is accompanied by blue glow; but the matter is complicated by the fact that in power valves (particularly water-cooled) the electron effect often starts by itself and then, by heating the electrodes, sets free occluded gases and starts the ionisation effect. These conditions of parasitic disturbance are particularly dangerous to thoriated filaments, which disintegrate rapidly during the period of reverse grid current. The paper then returns to methods of protection: choice of triodes with suitable grid characteristics; avoidance of surges by applying the anode voltage very gradually, short-circuiting meanwhile the grid resistances; or by introducing into the anode feed "anti-shock" coils (Bethenod suggests self-inductances shunted by high resistances). Filament regulation (previously referred to) is rarely possible, as it usually reduces the power too much; so does reduction of anode voltage. The writer advocates the use of a permanent magnetic field—taking advantage of the greater deflection of the (slower) secondary electrons. A suitable field completely removes the possibility of these disturbances, and appears even to increase the useful power of the valve—thanks to the greater constancy of the saturation current. In some high-power valves, the field created by the filament-current is enough to sweep away the secondary emission. Another plan (Philips Lamp Co.) introduces a diode in the grid circuit and thus prevents reversal of grid current; another (Shaposhnikow) neutralises the reverse grid current by a current through a diode shunted between grid and filament.

ÜBER ELEKTRISCHE SCHWINGUNGEN IN ZUSAMMENGESETZTEN KREISEN UND ÜBER DIE KAPAZITÄTSMESSUNG VON WIDERSTÄNDEN UND SPULEN NACH DER RESONANZMETHODE (Oscillations in compound Circuits, and the Capacity Measurement of Resistances and Coils by the Resonance Method).—M. Jezewski. (*Zeitschr. f. Phys.*, 5th April, 1928, V. 48, pp. 123–136.)

Earlier investigations (*ibid.*, V. 43, 1927, p. 442), of an oscillating circuit with resistance in parallel with the condenser, are here amplified; also, the oscillations in a circuit with a coil in parallel with the condenser are investigated. Formulæ for voltage and current are derived, and the procedure for the capacity-measurement of resistances and coils is described.

ÜBER MAXIMALLEISTUNGEN VON VERSTÄRKERRÖHREN (The Maximum Power Output of Amplifier Valves).—A. Forstmann and E. Schramm. (*Zeitschr. f. Hochf. Tech.*, December, 1928, V. 32, pp. 195–199.)

Paying attention to the straight line conditions, the optimum values are determined for the external load-resistance, to produce maximum power output for a given anode voltage. The conditions as to steepness of characteristic and the amplification constant (or its reciprocal) are also considered.

A GENERALISED ANALYSIS OF THE TRIODE VALVE EQUIVALENT NETWORK.—F. M. Colebrook. (*Journ. I.E.E.*, January. 1929, V. 67, pp. 157–169.)

Author's summary :—

The paper gives an analysis of the variation with the resultant anode circuit load of the input impedance and voltage magnification factor of a triode valve. A new mode of presentation is adopted which enables the total range of variation of these quantities to be represented as finite functions of a variable with a limited range of variation.

The most important conclusion is that at very high radio frequencies the voltage magnification factor may appreciably exceed the voltage factor of the valve, this condition being reached for a finite pure inductive load. Under the same conditions, however, the shunt input impedance is very low.

The most efficient means of associating a tuned circuit with a receiver of relatively low input impedance is considered in an Appendix.

ÉTABLISSEMENT DU COURANT DANS UNE SÉRIE DE CIRCUITS RÉSONNANTS COUPLÉS ENTRE EUX PAR L'INTERMÉDIAIRE DE LAMPES TRIODES (Calculation of the Current in a Series of Resonant Circuits coupled by 3-Electrode Valves).—G. Fayard. (*Bull. d.l. Soc. Fr. Rad.*, October, 1928, pp. 3–7.)

Derivation, by simple reasoning of the general expression for the amplitude in the p^{th}, namely :

$$1 - e^{-\frac{\pi}{s}.n}\left[1 + \frac{\pi}{s}.n + \left(\frac{\pi}{s}.n\right)^2.\frac{1}{2!} + \ldots\ldots\left(\frac{\pi}{s}.n\right)^{p-1}.\frac{1}{(p-1)!}\right].$$

REGENERATIVE COUPLING DEVICES IN AUDIO AMPLIFIERS.—J. K. Clapp. (*QST*, December, 1928, pp. 37–39.)

Applications : heterodyne reception of telegraphy : eliminating harmonic frequencies from a low power source, as used for bridge measurements : in various control problems, for selection of a desired operation.

HIGH FREQUENCY RESISTANCE : WHAT IT IS AND WHENCE IT COMES : LOSS OF ENERGY DUE TO DIELECTRIC.—A. L. M. Sowerby. (*Wireless World*, 19th and 26th December, 1928, V. 23, pp. 810–814 and 845–849.)

TRANSMISSION.

SUR LES OSCILLATEURS À ONDES TRÈS COURTES (Oscillators for Very Short Waves).—E. Pierret. (*Comptes Rendus*, 10th December, 1928, V. 187, pp. 1132–1134.)

An extension of the work referred to in Abstracts, 1928, V. 5, pp. 402 and 465. With the particular arrangement used, there is always a certain grid voltage below which only Barkhausen oscillations can be obtained, and another (higher) voltage above which only the much shorter waves appear, whatever the anode voltage may be : between these critical voltages, whether the Barkhausen or the short waves are obtained depends on the anode voltage. Various tuning effects are described, confirming the writer's former idea that whereas in the Barkhausen oscillations (in the region 40–70 cm.) the electrons oscillate between grid and plate, these very short waves (12–18 cm.) are caused by an oscillation of electrons from one part of the grid to another ; in the former case, the frequency of the oscillations produced in the antennæ is the same as that of the electronic oscillations, whereas in the latter case it is double that frequency. The writer's circuit consists of a horned valve, the grid and plate of which are attached each to one end of a copper rod on which a copper disc slides which reflects the waves and allows of tuning : the opposite ends being connected to the batteries of accumulators charging the electrodes.

SUR LES ONDES TRÈS COURTES (Very Short Waves).—G. A. Beauvais. (*Comptes Rendus*, 26th December, 1928, V. 187, pp. 1288–1289.)

Describes experiments with waves of 16–20 cm. length generated by Pierret's method (see above) and received by an arrangement similar but with lower grid voltage (about 100 v.) and a colder filament : a telephone being connected in the filament-plate circuit. The presence of stationary waves (by reflection at a metallic screen) is easily shown with this receiver. Reflection, by more than one mirror, was obtained according to optical laws. Telephony was worked successfully : the grid feed was through an iron-cored choke of some henries, and a three-electrode modulator valve (with the usual microphone transformer, etc.) had its anode connected to the grid of the oscillator. The receiver described above was improved by the use of super-regeneration : the grid of the valve was supplied with a D.C. voltage of 250 v. on which was superimposed the A.C. tension due to a H.F. oscillator : filament temperature was slightly raised, and a suitable negative voltage was supplied to polarise the anode. Range for the tonic train or I.C.W. waves used in the first experiments was increased " considerably " ; it is not clear whether the newer receiver was used for telephony, nor is the range given.

SHORT WAVE GENERATION WITH A QUARTZ OSCILLATOR.—(*French Patent No.* 642,969, Soc. Radiofrequenz and H. Eberhard, pub. 7th September, 1928.)

A three-electrode valve circuit is described in which the filament-anode circuit consists of the anode battery, a large inductance and a small inductance in series : at the point of junction of these two inductances a lead goes to a quartz oscillator and thence to the grid. When the natural frequency of the small inductance approaches that of the quartz oscillator, oscillations are set up, the wavelength being of the order of a few metres.

REICHWEITENVERSUCHE UND DÄMPFUNGSMESSUNGEN IM GEBIET SEHR KURZER WELLEN (Range Tests and Damping Measurements for Very Short Waves).—A. Esau. (*Summary in E.T.Z.*, 13th December, 1928, p. 1816.)

The decrement was measured on a wire loop whose ends were connected to two condenser plates of variable gap. A detector and galvanometer were connected to the point of symmetry. With $\lambda = 3$ m. and a loop of 240 cm.^{2} surface and 2.5 cm. condenser gap, the decrement was 0.032 and the radiation resistance 2.4 ohms. Increasing the condenser gap increased the radiation resistance. With these short waves the condenser itself radiates. The large condenser gaps will be useful for medical purposes. Waves down to $\frac{3}{4}$-metre were tested. Range is unaffected by atmospheric disturbances and fading. No difference in propagation could be noticed between 1.5 m. and 6 m. waves. Intensity fell off slowly but uniformly in all directions. No re-appearance from the Heaviside layer was noted. The use of such waves on trains is suggested, for communications between engine and rear of train: but there still remains the problem of the tunnel (*cf.* Ritz, these Abstracts). A transmitter on an aeroplane, using 0.1 W. (to aerial?), was heard at a height of 1,000 m. and at a distance of 35 km. at loud-speaker strength. Picture telegraphy is another suitable field.

ESSAIS SUR ONDES TRÈS COURTES (Trials on Very Short Waves).— —. Ritz. (*L'Onde Élec.*, November, 1928, pp. 488–499.)

Description of tests on portable tonic train sets, on a wavelength of 3.3 metres, made in mountainous country where the configuration of the ground enabled all kinds of conditions to be tried: with the idea of confirming and extending the results of Mesny (Abstracts, 1928, V. 5, p. 687). The sets are first described (Symmetrical Mesny transmitting-receiving circuit, 5-valve: transmitter feed about 15 mA. at 80 v.; total weight per set, including telescopic brass antenna and counterpoise, about 30 lb.). Results are summed up by the remark that the neighbourhood of earth is fatal to these waves; they will only fly into the distance if they can escape quickly and completely from its influence. Tests are described: (1) In a tunnel (circular absorption): one set 20 m. from the tunnel-mouth, the other moving into the tunnel; signals fall to R3 at 60 metres, and disappear at 75 m.; with both sets inside the tunnel, R3 at 100 m., zero at 125 m. (2) In a gorge (absorption on three sides): signals are extinguished by bends in the gorge. These and many other tests all confirm Mesny's results.

MODULATION DANS LE CIRCUIT DE PLAQUE (Anode-circuit Modulation).—J. Marcot. (*QST Franç.*, November, 1928, pp. 43–46.)

Of the various anode-circuit control methods, that of Heising has the advantage of giving very pure modulation even when the control is great. This article gives a mathematical analysis of the circuit.

MEASUREMENT OF MODULATION.—(*German Patent No.* 465,040, Schäffer, pub. 7th September, 1928.)

A glow discharge lamp is so coupled to the aerial that with a certain depth of modulation the voltage is enough to start the glow. But, once started, the glow extinguishes itself too slowly; according to the invention, the circuit containing the lamp is thrown in and out of tune (by a motor-driven rotating condenser) with a frequency low in comparison with the modulation frequencies; this ensures the periodic extinction of the glow.

ÜBER DEN EINFLUSS DES PHASENMASSES UND DER DÄMPFUNG BEI DER ÜBERTRAGUNG VON MODULIERTEN WELLEN (The Influence of Phase Relations and Damping on the Transmission of Modulated Waves).—H. Bartels. (*Wiss. Veroff. a.d. Siemens-Konz.*, No. 1, 1928, V. 7, pp. 260–272.)

Under certain conditions, interference between the two sidebands may make it better to use only the one. For carrier frequency telegraphy it is usually best to employ the two bands, for carrier frequency telephony it is often best to use only the one.

ADAPTING MEDIUM AND HIGH-POWERED SELF-EXCITED TRANSMITTERS FOR 1929 SERVICE.—R. A. Hull. (*QST*, September, 1928, V. 12, pp. 25–30.)

Two points particularly stressed are: Low or high values of grid excitation require extremely loose antenna coupling to give satisfactory frequency stability, whereas with grid excitation of a particular order, the normal coupling can be used and high efficiencies obtained; the amateur transmitter can be tuned about as successfully by watching the meters alone as an automobile can be driven in heavy traffic by exclusive observance of the ammeter and the oil gauge; tuning (and operation) ***must*** be controlled by listening on a check circuit (preferably crystal controlled).

THE OSCILLATOR-AMPLIFIER TRANSMITTER.—R. A. Hull. (*QST*, September, 1928, V. 12, pp. 9–14.)

Description of a master-oscillator-amplifier transmitter for wavelengths of about 42 m., to give very clean and steady signals; it can be left running with automatic keying for two hours on end without a serious frequency drift; plate voltage can be varied 10 per cent. with only just observable frequency change. As there is no crystal control, the required constancy can only be obtained if the input to the oscillator is at least one-sixth of the amplifier input and if the oscillator is run well below its rating.

A 28-MEGACYCLE CRYSTAL-CONTROLLED TRANSMITTER.—H. A. Chinn. (*QST*, November, 1928, V. 12, pp. 29–32.)

" Frequency was known to be 28 megacycles, within 0.1 of 1 per cent. This article, describing the transmitter used, is presented not because of any new or radically different features involved but rather to show the straightforward arrangement. ." The crystal has a fundamental frequency of 1.75 megacycles, so that four frequency doublers are necessary. The last stage contains two 2,000 v. valves in parallel; these originally formed the last stage of frequency doubling, but it was found that by using them as straight amplifiers (with neutralisation) and adding one more 200 v. valve as frequency doubler (the final doubler being a 500 v. valve), the output was increased many times with the same input. Valves used as frequency doublers are working less efficiently.

PUSH PULL TRANSMITTERS.—J. J. Lamb. (*QST*, December, 1928, pp. 13–16, 82 and 88.)

" . . . it is particularly recommended that those transmitters in which two tubes are being used in parallel may be converted to the push-pull circuit in one form or another to good advantage."

THE CONSTRUCTION AND OPERATION OF A 3,500-KC. CRYSTAL-CONTROLLED PHONE.—E. W. Springer. (*QST*, December, 1928, V. 12, pp. 9–12.)

Modulation is by the Heising constant current system, either the crystal oscillator or the amplifier being thus controlled. Tests for the adjustment of the set are described; when these had been fulfilled, reports from distant stations showed very good or perfect modulation; and when received on zero beat tuning, reception was practically as clear as when the receiver was not oscillating—showing great steadiness of frequency.

RECEPTION.

LE RÉGLAGE DES POSTES RÉCEPTEURS RADIOÉLECTRIQUES, ET LE NOUVEAU DISPOSITIF DE RÉGLAGE "VALUNDIA" (The Adjustment of Radioelectric Receivers, and the New "Valundia" Scheme of Adjustment).—J. L. Routin. (*Rev. Gén. d. l'Élec.*, 29th December, 1928, V. 24, pp. 987–989.)

A complete unit of calibrated adjustment much employed in French superheterodyne receivers is here described and illustrated. The indicating part includes two drums side by side, each rotated by its own geared button: each drum serves not only as a chart on which calibration curves are traced, but also as housing for the moving plates as a condenser. A fixed scale of wavelengths is situated in front of the two drums, and the complete adjustment is obtained by turning the two buttons so that each calibration curve cuts the scale at the required wavelength. A change-over switch is embodied in the unit which not only switches the apparatus from "long" to "short" waves, but at the same time rotates the fixed scale so that the appropriate graduations appear.

THE DIODE RECTIFIER.—H. L. Kirke. (*Wireless World*, 9th January, 1929, V. 24, pp. 32–35.)

The Editorial summary says: "This article, by the originator of the 'space charge neutralised' diode detector, explains the precautions that must be taken in order to obtain perfectly distortionless rectification. An interesting new B.B.C. long-range, high-quality receiver is also described." A history of the development of the circuit and its original particular object is first given; later, interesting points are: the use of a pentode as the preceding valve—on 100 v. H.T., it appears to work very well; a 3-electrode valve in this position would require careful neutralisation, while the ordinary type of screen-grid valve has insufficient linear power output: the advantage of the diode being independent of the high-tension supply (*cf.* H. F. Smith, Abstracts, February, 1929) should be used to the full (especially where mains units are employed) by making the output stage a push-pull one, in which the audio-frequency currents do not necessarily have to pass through the high-tension supply system: the disadvantage of the considerable current demanded from the grid polarising battery (20 mA. at 24 v. for large inputs)—high capacity electrolytic condensers withstanding a working potential round 40 v. will, when procurable, assist in the obtaining of grid-polarising potential from the mains, which at present offers certain difficulties: a low L/C value for the tuned circuit, though rather inconvenient, is more satisfactory than the tapped-down inductance suggested in the above-named article, probably because the former provides a low impedance path for the harmonics produced. There is an editorial, in the same issue, on the subject of diode detection; its conclusion is "it would hardly appear to be strictly necessary to include diode detection except in cases where no expense or trouble is spared to avoid distortion at each and every stage of the receiver." There is a letter (*ibid.*, 16th January) from the G.E.C., pointing out the drain put on a filament designed for a maximum anode current of say 5–6 mA. is used in this way to give perhaps 20–30 mA., so that the choice of a suitable valve should be made carefully: and also correcting any idea that "the normal grid bias battery, reversed, could always be employed for the diode detector circuit."

DIODE RECTIFIER.—P. G. Davidson. (*Wireless World*, 2nd January, 1929, V. 24, p. 23.)

A letter suggesting an arrangement of two "matched" valves, to give a performance superior to that of the diode recommended by Smith (February Abstracts): linear rectification for A.C. inputs between zero and a peak voltage equal to the grid bias: sensitivity comparable with that of an anode-bend rectifier having an anode resistance equal to that of the valve under rectifying conditions, *i.e.*, several times the normal valve resistance: applies no damping to the preceding tuned circuit.

UN RELAIS-AMPLIFICATEUR POUR ONDES COURTES (A Relay-Amplifier for Short Waves).—J. Vivié. (*QST Franç.*, November, 1928, pp. 21–24.)

The waves considered are from 100 m. down to 10 m. The circuit consists in a combination of a screen-grid H.F. amplifier valve and the so-called "Schnell" triode circuit with electrostatic reaction coupling.

THE PENTODE AND POWER AMPLIFICATION: SOME IMPORTANT CONSIDERATIONS REGARDING THE OUTPUT CIRCUIT: PRECAUTIONS NECESSARY TO AVOID EXCESSIVE PEAK VOLTAGES.—L. G. A. Sims. (*Wireless World*, 16th January, 1929, V. 24, pp. 60–64.)

One interesting point is that serious damage to the valve may result from the high voltages produced by injudicious manipulation, *e.g.*, if the loud speaker is disconnected from the pentode while the filament of the latter is alight.

LA TRIGRILLE À FONCTIONS MULTIPLES (The Five-Electrode Valve for Multiple Functions).—R. Barthélemy. (*T.S.F. Moderne*, July, 1928, V. 9, pp. 396–400.)

Description of a circuit (" trisodyne ") in which the 3-grid valve gives H.F. amplification and a frequency change: with reaction in the primary circuit and also in the beat-note circuit. A set using this circuit, with 4 three-electrode valves (one for medium frequency, one for detection and two for L.F.) gives results " comparable, if not superior " to those obtained with 7 or 8 valves with the usual frequency-changing circuits.

RECHERCHE DE LA QUALITÉ ACOUSTIQUE DANS LES RÉCEPTEURS SÉLECTIFS (Search for good quality in selective Receivers).—P. Borias. (*Bull. d.l. Soc. Fr. Rad.*, November, 1928, pp. 3–12.)

The particular object is to receive a distant station without interference from a nearer station and without loss of quality. A series of coupled L.F. circuits is recommended, a resultant tuning curve with a flat plateau from 0–4,000 being obtained by suitable shifts of the tuning of each circuit away from the mid-point.

SUR LE CALCUL DES AMPLIFICATEURS À MOYENNE FRÉQUENCE POUR SUPERHÉTÉRODYNE (The Calculation of Medium Frequency Amplifiers for Superheterodyne Reception).——. Boella. (*L'Onde Élec.*, November, 1928, pp. 500–508.)

Author's summary: It is shown how one can determine, in a stage with transformer with tuned secondary, the primary inductance to give maximum amplification, provided the constants of the secondary are known. From this are deduced the elements of a medium frequency amplifier for a superheterodyne, to receive telephony under good conditions of selectivity and fidelity. The example taken has 3 stages, plus detector, for a carrier wave of 200 kc./s., to give practically constant amplification for modulation frequencies 100–4,000 p.p.s.

BROADCAST RECEIVERS: LOEWE TYPE O.E. 333 WITH MULTI-ELECTRODE VALVE: A LOW-PRICED LOCAL STATION RECEIVER OF NOVEL DESIGN AND CONSTRUCTION.—(*Wireless World*, 16th January, 1929, V. 24, pp. 79–81.)

THE NEW EMPIRE RECEIVER: A STABLE SET COVERING ALL THE SHORT WAVELENGTHS.—H. F. Smith. (*Wireless World*, 26th December, 1928, V. 23, pp. 854–859.)

SCREEN GRID VOLTS: HINTS ON REGULATING AND MEASURING VOLTAGE.—" Radiophare." (*Wireless World*, 16th January, 1929, V. 24, pp. 70–71.)

AERIALS AND AERIAL SYSTEMS.

RADIO TRANSMITTING AERIALS.—P. P. Eckersley, T. L. Eckersley, and H. L. Kirke. (*Elec. Review*, 11th January, 1929, V. 104, pp. 84–85.)

Extracts from the I.E.E. paper on the Technical Aspect of the Design of Broadcast Radio-Telephone Radiating Aerials.

HIGH ANGLE RADIATION: THE EXPERIMENTAL 28,000 KC. (10-METRE) BEAM ANTENNA AT 1 CCZ.—P. S. Hendricks. (*QST.*, October, 1928, V. 12, pp. 31–32.)

Diagram and photographs of a rotatable aerial system (fundamental antenna, fed in the " Zeppelin " fashion, operating in conjunction with three reflector wires and two director wires arranged according to Uda and Yagi) set up with the idea of testing from America to Australia. An account of some tests is given in the January, 1929, issue (pp. 13–16) by R. A. Hull, in his article " The Status of 28,000-kc. Communication." Transmission from Cape Cod was received much the best, both in California and in New Zealand, when the beam was directed at an angle of 30 deg. to the horizontal; fading, which was severe at some angles, disappeared almost completely at this angle.

WHAT LENGTH ANTENNA?—J. J. Lamb. (*QST*, October, 1928, V. 12, pp. 49 and 76.)

Experiments on di-pole aerials having fundamental wavelengths of from 10–80 m., vertical or horizontal, high above ground or within a quarter wavelength, operated on fundamental or on harmonics, led to a universal value of 2.1 for the ratio fundamental wavelength/antenna length; agreeing with Englund's results for horizontal di-poles (5.36–6.34 m.) and Wilmotte's 4.2 for grounded aerials (15–800 m.).

THE ZEPP: FACTS AND FIGURES FOR THE DESIGN OF THE HERTZ ANTENNA WITH TWO-WIRE VOLTAGE FIELD.—J. J. Lamb. (*QST*, September, 1928, V. 12, pp. 33–36, 86 and 88.)

INFLUENCE OF ATMOSPHERIC POLLUTION ON PERFORMANCE OF LINE INSULATORS.—B. L. Goodlet and J. B. Mitford. (*Electrician*, 25th January, 1929, V. 102, pp. 91–95.)

A special investigation of troubles experienced in Britain—Performance of Fouled Insulators—Action of Coal Smoke—The Wind Factor—Points in Insulator Design.

SUSPENSION INSULATORS FOR H.T. TRANSMISSION LINES.—C. S. Garland. (*Electrician*, 25th January, 1929, V. 102, pp. 109–110.)

Overcoming difficulties due to expansion of cement—The "Spring Ring" Insulator—Increasing tensile strength—Employment of Steatite—New insulators for special purposes.

DEVELOPMENT OF GLASS INSULATORS FOR TRANSMISSION SCHEMES.—N. E. North. (*Electrician*, 25th January, 1929, V. 102, pp. 101–102.)

Some Advantages of Glass for Electrical Purposes—Examination under Polarised Light—Possible New Uses—The Proper Sealing Method.

AERIALS AND GALES.—(*Electrician*, 30th November, 1928, V. 101, p. 624.)

A paragraph mentioning the successful weathering of the November gales by the Marconi Beam aerial systems. The normally tightly strained wires are provided with safety devices which reduce the tension at the lower ends when a hurricane is tending to cause excessive strain.

ZUR MECHANISCHEN SICHERHEIT VON FREILEITUNGSEILEN (The Mechanical Safety of Open Line Cables).—A. Fuchs and H. Wiesthaler. (*E.T.Z.*, 22nd November, 1928, pp. 1705–1713.)

The writers show that the present V.D.E. regulations concerning the requirements of conducting materials for overhead lines no longer comply with present-day knowledge. New regulations are suggested which will embody the latest results of research (many curves representing which are given) and include the recently developed metals such as Aldrey, which in many cases is a good substitute for copper.

GRAPHICAL DETERMINATION OF STRESS AND SAG OF OVERHEAD LINES.—A. Thiry. (*Elektrot. u. Masch: bau.*, 6th May, 1928, V. 46, pp. 421–426.)

The problem is to determine the stress and sag of a given line at a given temperature when the values are known for another temperature.

WIND PRESSURES ON WIRES.—W. B. Woodhouse. (*Nature*, 1st December, 1928, V. 122, p. 859.)

Summary of a paper read before the I.E.E. on November 8th on the results of tests made at the National Physical Laboratory for the British Electrical Research Association. The theoretical relation, that the ratio of the pressure on a smooth cylinder to the product of the wind speed and the projected area should be a constant (provided that the product of the wind speed and the diameter of the wire remain the same), has been verified experimentally. The law does not apply to stranded cables. Tests on wooden poles show that the usual design could be greatly improved by modification. The wind pressure on a strut of circular cross section can be considerably reduced by the addition of a similar strut in its wake. Wind pressures on two struts of equal mechanical strength may be in the ratio of 6 to 1, depending on the shape of their sections. At certain speeds the pressure on a sphere can be reduced by roughening its surface.

VALVES AND THERMIONICS.

INTERACTION OF ELECTRON AND ION SPACE CHARGES IN CATHODE SHEATHS.—I. Langmuir. (*Abstract in Phys. Review*, 1928, V. 31, p. 1121.)

The usual space charge problem for electrons from a plane hot cathode to a parallel plane anode is modified by assuming positive ions emitted from the anode. Single ions emitted with negligible velocity allow $0.378\ (m_p/m)^{\frac{1}{2}}$ additional electrons to pass. An unlimited supply of ions gives an electron current 86.05 per cent. greater than with no ions, the field is symmetrically distributed between cathode and anode, and the electron current is $(m_p/m)^{\frac{1}{2}}$ times the ion current. These conditions apply to a cathode emitting a surplus of electrons surrounded by uniformly ionised gas. The cathode sheath is a double layer with an inner negative space charge and an equal outer positive charge, the field being zero at the cathode and at the sheath edge. The electron current is limited to $(m_p/m)^{\frac{1}{2}}$ times the rate at which ions diffuse to the sheath edge and is independent of voltage if the source of ions is constant. Experiments with oxide cathodes in mercury vapour agree with this theory, which has been extended to take into account initial velocities of ions and ultimate electrons, and also to deal with cylindrical sheaths.

IONIC OSCILLATIONS IN THE GLOW DISCHARGE.—L. A. Pardue and J. S. Webb. (*Phys. Review*, December, 1928, V. 32, No. 6, pp. 946–949.)

The first stage of an attempt to correlate Whiddington's work on moving striæ and Appleton's work on ionic oscillations from a striated discharge. In a hot cathode discharge tube, 26 cm. long, ionic oscillations from 15×10^4 to a few hundred cycles were obtained. Characteristic curves show an increase of frequency with filament current or with anode potential, and a decrease with pressure except at the lower pressures, where the frequency increases and passes through a maximum. With a varying pressure and without plates on the tube, oscillations do not occur when there are sharply defined striæ, but begin just as striæ begin to diffuse, decreasing in frequency and becoming audible when a uniform glow fills the tube.

EINFLUSS POSITIVER IONEN AUF DIE ELEKTRONEN-RAUMLADUNG INNERHALB EINES ZWEIPLATTEN-SYSTEMS (The Influence of Positive Ions on the Electronic Space Charge in a Two-plate System).—H. Cohn. (*Ann. der Physik*, No. 20, V. 87, pp. 543–569.)

In a brief reference to this article (Abstracts, 1929, V. 5, p. 44) the number of the journal was wrongly given as No. 4. Some results of the measurements are: the gas ions produced by the electrons tend to neutralise the space charge, by an amount directly proportional to the pressure of the gas and the mass of the gas atom, and inversely proportional to the absorption of the electrons by the gas molecules. For very small pressures, the voltage necessary for the neutralising effect is greater than the ionisation-voltage. It is dependent on the number of electrons flowing through the valve before neutralisation. The neutralisation effect is independent of the value of the saturation current of the cathode. In a particular arrangement used it was calculated that a positive ion-stream of 2 mA. would be necessary to neutralise completely the space charge. This could not be supplied by the filament: another source would be necessary.

MOTION OF ELECTRONS IN A VALVE GENERATING SHORT ELECTRIC WAVES OF THE BARKHAUSEN-KURZ TYPE.—N. Kapzov. (*Zeitschr. f. Phys.*, 1928, V. 49, No. 5/6.)

The motion of electrons in a variable field, due to potential variations of the grid and anode of a valve, is discussed theoretically and the conclusions applied to the process leading to the B-K oscillations.

THE THERMIONIC EMISSION CONSTANT A.—R. H. Fowler. (*Proc. Roy. Soc.*, 1st January, 1929, V. 122A, pp. 36–49.)

"The main object of this paper is to apply Nordheim's theory of the emission coefficient of electrons from metals so as to explain the remarkable relation between the constants A and χ of the thermionic emission formula, first recorded by O. W. Richardson and recently reformulated by DuBridge ($\log A = \xi + \eta\chi$, where $\eta > 0$, ξ and η being constants, η in particular depending on the type of surface dealt with). . . . Assuming the absolute values of A can be accounted for, the rest of the existing theory of thermionic emission is extremely satisfactory on account of the beautiful explanation which it gives of the general form of this relation."

THE THERMIONIC EMISSION FROM CLEAN PLATINUM.—L. DuBridge. (*Phys. Review*, December, 1928, V. 32, No. 6, pp. 961–966.)

The data confirm the previous announcement that A is 250 times greater than the theoretical value of 60.2 amp/cm.^{2} deg.^{2}. *Cf.* Abstracts, 1929, V. 6, p. 44.

ÜBER EIN VERFAHREN ZUR AUSLÖSUNG VON ELEKTRONEN UND DESSEN ANWENDUNG (A Method for Setting Free Electrons, and its Applications) *and* EXPERIMENTELLES ÜBER DEN ELEKTRON-AUSTRITT AUS METALLEN (Experimental Work on the Electron Emission from Metals).—F. Rother. (*Summaries in E.T.Z.*, 13th December, 1928, p. 1817.)

The first paper deals with experiments on the emission from cold electrodes in high fields, to check the results of Millikan and Eyring, which disagreed with the curves calculated by Schottky's theory. As causes for the discrepancies are suggested traces of gas in the anode cylinder and the destruction of the atomic thorium-layer on the wire, under the influence of the steep field gradient. The second summary gives details of experiments on cold wires, measurements being taken with all possible precautions. The cathode in one case was a wire of an alloy of thorium and molybdenum, 70 mm. long and 0.15 mm. in diameter, with a tantalum anode 40 mm. long and 20 mm. in diameter. Up to 6,000 v. no current greater than 10^{-11} A was found. At higher voltages the current increased quickly, its upper limit was given by the melting of the anode. With a pulsating D.C. field of the same mean value the emission was notably larger: at 6,000 v. the anode became bright red at once, the current being 3 mA.

THE EFFECT OF THE IMAGE FORCE ON THE EMISSION AND REFLECTION OF ELECTRONS BY METALS.—L. W. Nordheim. (*Proc. Roy. Soc.*, 3rd December, 1928, V. 121A, pp. 626–639.)

LES CAPACITÉS INTERNES DE LA LAMPE À PLUSIEURS ÉLECTRODES (Internal Capacities of the Multi-electrode Valve).—C. Rajski. (*L'Onde Élec.*, November, 1928, pp. 461–474.)

Author's summary: The author shows that the electro-static formula cannot be used for the calculation of the internal capacities of electronic valves. The correct calculation necessitates the study of the field around the valve electrodes; he carries out this calculation for the cases of flat and cylindrical electrodes. He deduces from it that in a triode, instead of the three capacities filament-grid, filament-plate, and grid-plate (which are the only ones to be considered in a valve out of action), four capacities must be reckoned with: self-capacity of grid $\left[\frac{\partial Q_g}{\partial V_g}\right]$, self-capacity of plate $\left[\frac{\partial Q_a}{\partial V_a}\right]$, grid-plate capacity $\left[\frac{\partial Q_a}{\partial V_g}\right]$, and plate-grid capacity $\left[\frac{\partial Q_g}{\partial V_a}\right]$.

In the course of the article, equations for all these quantities are obtained. The last capacity (C_{ag}) is a component of the input capacity (capacité d'entrée) thus:

$$C_{\text{input}} = C_g - C_{ag} \cdot \frac{K}{1 + \rho R},$$

and itself forms a coupling capacity between plate and grid—a direct cause of difficulties in H.F. amplifiers, and the provider of coupling in the Kühn-Huth oscillator. Its expression, given for plane electrodes as

$$C_{ag} = \frac{S}{4\pi(K+1)} \cdot \left(\frac{4}{3x_g} - \frac{K}{x_a - x_g}\right)$$

(though elsewhere—p. 469—a different expression is used which does not appear to be equivalent) indicates that theoretically it could be rendered zero by suitably dimensioning the valve. This could only be done in practice, however, for plane electrodes and small amplification constants. The author discusses the interpretation of the difference, in a functioning valve, between the capacities plate-grid and grid-plate.

PRODUCTION OF OXIDE-COATED CATHODES.—(*German Patent No.* 465,278, Philips Lamp Co., pub. 14th September, 1928.)

DIE NEUE PHILIPS-HOCHFREQUENZRÖHRE. A-442 MIT SCHIRMGITTER (The new Philips H.F. Valve A.442 with Screen Grid).—A. van Sluiters and C. J. van Loon. (*Suppt. to Elektrot. u. Masch : bau.* No. 10, 14th October, 1928, pp. 89–92.)

Designed chiefly for H.F. amplification with tuned-anode circuit, this valve has a grid-plate capacity of only 0.01 cm.

DIE TELEFUNKEN-RUNDFUNK-RÖHREN 1928 (Telefunken Broadcast Receiver Valves, 1928).—G. Jobst. (*Telefunken Zeit.*, October, 1928, No. 50, pp. 29–34.)

DIRECTIONAL WIRELESS.

THE REVERSIBILITY OF RADIO DIRECTION-FINDING AND LOCAL ERROR AT ROTATING-LOOP BEACONS.—R. L. Smith-Rose. (*Journ. I.E.E.*, January, 1929, V. 67, pp. 149–156.)

Author's summary : In this paper consideration is given to the applicability of the reciprocal theorem to the practice of radio direction-finding with either a rotating loop transmitter or a loop receiver. A description is given of some experiments carried out with the object of demonstrating that the permanent errors to which a rotating-loop beacon transmitter may be subject as a result of conditions local to its site are similar to those observed on a direction-finder erected on the same site. This similarity has materially assisted in locating the cause of the permanent error associated with the rotating beacon erected at Fort Monckton, near Gosport. From other experiments carried out under suitable conditions, it is shown that the occurrence of night errors is experienced on both systems of direction-finding to approximately the same extent. *Cf.* Abstracts, 1928, V. 5, pp. 36, 288 and 402.

WATER RIPPLES AND WIRELESS WAVES.—A. H. Davis. (*Wireless World*, 16th January, 1929, V. 24, pp. 56–59.)

"An interesting analogy explaining certain direction-finding phenomena." Photographs of ripples under various conditions illustrate not only the deflection of waves at a partially reflecting boundary (analogous to the Heaviside layer) but also effects analogous to the phenomena of coastal refraction and reflection also observed in direction finding.

ACOUSTICS AND AUDIO-FREQUENCIES.

EFFECT OF DIFFRACTION AROUND THE MICROPHONE IN SOUND MEASUREMENTS.—S. Ballantine. (*Phys. Review*, December, 1928, V. 32, No. 6, pp. 988–992.)

Proposed method of evaluating the pressure correction made necessary by diffraction : Theory of the diffraction of a sound wave by a rigid sphere (this second section is called for by the use of a spherical mounting proposed in the first section).

A PHOTOGRAPHIC METHOD OF MEASURING PITCH.—M. Metfessel. (*Science*, 2nd November, 1928, V. 68, pp. 430–432.)

The usual photographic methods (Phonodeik, phonelescope, Lapp Undulator, etc.) use a costly amount of film and require much time. The stroboscopic methods are often useful but do not give a continuous record. The present method is in a sense a combination of these two : the vibrating light passing through the equally spaced apertures of the numerous circular rows on the stroboscopic disc or drum, being photographed on film (stationary or moving) on the other side. If the film is stationary, the light passing through the particular row of holes which corresponds to the pitch will produce dots : through other rows it will form dashes.

ON THE VARIATION OF SOUND WITH DISTANCE.—L. A. Sokolov. (*Journ. Applied Phys.*, Moscow, No. 3/4, 1928, V. 5, pp. 235–245.)

Owing to the different sensitivities of the ear to sounds of different pitch, the tone-colour of a sound depends on the distance. If the fundamental is low, perception of the higher overtones improves if the distance is increased ; if it is high, it drowns the overtones at a distance.

A THEORETICAL STUDY OF THE ARTICULATION AND INTELLIGIBILITY OF A TELEPHONE CIRCUIT.—J. Collard. (Discussed in *Nature*, 5th January, 1929, V. 123, p. 24.)

From the subscriber's point of view, the efficiency of a telephone circuit should be judged by the relative time required to convey correctly a given number of ideas. Tests show that this is shortest for French, and then come English, German and Italian. The order for "intelligibility" (ratio of number of ideas correctly received to total number transmitted) is Italian, German, English and French. "It is quicker to speak a language of short words, even when some of the sentences have to be repeated owing to the low intelligibility, than to speak a language of long words which has a relatively high intelligibility." No consideration, however, is here apparently given to errors which are not perceived and therefore not corrected by repetition.

ZUR THEORIE DES HÖRENS : DIE SCHWINGUNGSFORM DER BASILARMEMBRAN (On the Theory of Hearing : The Nature of the Vibrations of the Basilar Membrane).—G. v. Békésy. (*Physik. Zeitschr.*, 15th November, 1928, pp. 793–810.)

THE IMPEDANCE OF A MOVING-COIL LOUD SPEAKER.—N. W. McLachlan. (*Wireless World*, 28th November, 1928, V. 23, pp. 729–732.)

"How the relative constants of the output stage and the moving coil affect the general character of reproduction." A previous paper (*Wireless World*, 1927, p. 372) is referred to and its results are extended so as to be free from the conditions under which they were obtained. Thus in the previous paper the coil was a high resistance one, so that any complication due to a transformer was avoided :

the diaphragm was free from resonances, whereas in practice it often has marked resonances: the inductance and resistance of the coil was assumed to be constant at all frequencies, whereas there is a variation. Among the various points developed, the importance is shown of designing so that the surround resonance-point is well below the working frequency range; in a quoted case, the influence of the surround resonance about doubled the loud-speaker impedance. If the higher frequencies are too strong, of the various remedies the one of increasing the turns on the moving coil has the advantage of augmenting the acoustic output.

ÜBER NEUERE AKUSTISCHE . . . (New Work on Acoustics . . .).—F. Trendelenburg. (*Zeitschr. f. Hochf. Tech.*, December, 1928, V. 32, pp. 202–206.)

Conclusion of the survey referred to in previous Abstracts. Curves are given showing the dependence of the amplitude-frequency curve of a condenser-microphone on the pressure of the air forming the air-cushion behind the membrane. Curves are also given for Riegger, ordinary telephone and the Gerlach band microphones. The ground-noise listener (Waetzmann), used for detecting mining operations in war, is illustrated. The rest of the paper deals with speech and hearing.

A NEW LOUD SPEAKER: THE USE OF GLOW-DISCHARGES TO CREATE SOUND-WAVES FROM VOLTAGE CHANGES. (*Wireless World*, 16th January, 1929, V. 24, p. 64.)

An article on the Brenzinger-Dessauer loud speaker referred to in Abstracts, 1928, V. 5, p. 645.

A.C. GRAMOPHONE AMPLIFIER.—N. P. Vincer-Minter. (*Wireless World*, 5th December, 1928, V. 23, pp. 755–760.)

THEORY OF VIBRATING SYSTEMS AND SOUND.—I. B. Crandall. (*Proc. Inst. Rad. Eng.*, November, 1928, V. 16, p. 1574.)

A short review, by A. Hund, of this book based on studies in the Bell Telephone Laboratories.

DISPERSION AND ABSORPTION OF HIGH FREQUENCY SOUND WAVES.—K. F. Herzfeld and F. O. Rice. (*Phys. Review*, April, 1928, V. 31, pp. 691–695.)

In addition to internal friction and heat conduction, the absorption and dispersion of sound waves is greatly influenced by the interchange of translational and intramolecular energy. Equations here developed (and applied to data on the velocity of high frequency sound waves) show that this energy exchange can be of great—in many cases preponderant—effect.

PHOTOTELEGRAPHY AND TELEVISION.

TELEVISION ABROAD.—A. G. Ingalls. (*Scient. American*, December, 1928, pp. 550–552.)

An article by an Associate Editor of the Journal, who is travelling in Europe. He deals only with his impressions of the Baird system; he was unable to see either the stereoscopic television or (it seems) the colour television, both of which he outlines; but he seems to have gained a fairly favourable impression of ordinary monochrome television. His final answer, after some hesitations, to the question whether it is "better" than some of the American systems is that "in general, the respective results seemed not so much better or poorer as quite different." He mentions elsewhere the more black-and-white effect produced by the Baird system as compared with the orange-red tone of the ordinary neon tube.

RUNDFUNK UND BILD (Broadcasting and Pictures).—F. Schröter. (*Telefunken Zeit.*, October, 1928, No. 50, pp. 7–16.)

A description of recent Telefunken progress in connection with picture telegraphy, synchronised cinematography (a half-way house between still-picture telegraphy and television or telecinematography) and these last two problems. The writer concludes that these, in spite of the latest brilliant results of Karolus (whose new apparatus is described and illustrated), still require development at the hands of inventors; whereas synchronised cinematography simply needs cheapening, mass production of narrow paper or cellophane films, etc. Karolus' latest apparatus for telecinematography uses 10,000 elements in place of the usual (Bell Laboratory and elsewhere) 2,500, special analysing discs being employed which "by the alternating action of *n* hole-spirals" produce *n* times the surface for a given number of elements or *n* times the elements for a given size of picture. On p. 54 is given a photograph of his large mirror-wheel used at the receiving end.

RADIOVISION. (*Science*, 16th November, 1928, V. 68, Supplement, p. xii.)

"The amateur radiovision enthusiast will soon have at least 21 stations broadcasting such programmes, located all the way from Lexington to Los Angeles. These are operated by eleven different broadcasters. Nine are now broadcasting, while two have their stations under construction." Radio Corporation has three bands allotted, of 100 kc. width; it is already using one. G.E.C. is regularly broadcasting on three different frequencies (10 kc. width) including 790 kc. (WGY). The Westinghouse Co. has been assigned two bands of 100 kc. width, at 63 and 150 m. Federal regulations and restrictions are mentioned; they appear generous at present, but there are to be further re-allocations of the radiovision bands. The "standard" 48-line, 15 picture p.s. has been adopted by four of the broadcasters only at present. Others are using fewer lines, or fewer pictures p.s., in an effort to get more varieties of light and shade in the limited (10 kc.) bands assigned. "With the 100 kc. band that will be used in the future" (in the re-allocation) "it will be possible to send considerable detail" with the standard arrangement.

Another paragraph (*ibid.*, 9th November) quotes Gray and Ives on the subject of outdoor television. The problem of full-length figures or groups of figures (the satisfactory television of which was prophesied to need a very much finer grained image) has been found to be greatly simplified by a psychological effect—it appears that when full length figures are observed, one's expectation of rendering of detail is automatically reduced. "With our 50-line (2,500-element) images, which are just sufficient for the transmission of clearly recognisable faces, the rendering of full length figures or even of two or three figures simultaneously is surprisingly satisfactory."

OPTICAL CONDITIONS FOR DIRECT SCANNING IN TELEVISION.—F. Gray and H. E. Ives. (*Journ. Opt. Soc. Am.*, December, 1928, V. 17, pp. 428–434.)

Direct scanning, by sunlight or flood-lighting on the object, originally gave too small photoelectric currents and was abandoned in favour of beam-scanning (Abstracts, 1928, V. 5, p. 410). Lately, however, good results with direct scanning have been obtained by increasing the dimensions of the scanning disc so that the disc holes are several times larger than usual, and by increasing the aperture of the lens to nearly its present limit of F/2. Greatly increased sensitiveness of a new type of cell (a description of which is promised later) has rendered it unnecessary to go to the largest practicable disc size (say 10 ft. diameter), and good results—with sunlight—have been obtained with a 3ft. disc and a lens aperture of F/2.5. The writers deal with the consideration of the defining power of the lens in relation to its size and to the size of the field it covers; also with the question of increasing the number of image elements, showing how, considering all things, doubling the number of image elements would demand a disc between 2 and 3 times the original diameter. They then describe the apparently psychological effect recently found, as to the good results of full length figure reproduction with only 2,500-element images (see above Abstract).

RADIOVISION.—T. P. Dewhirst. (*QST.*, September, 1928, V. 12, pp. 15–18.)

An American radio consultant's views on what may be expected at present and in the future. In its present state "it is merely a plaything for the amateur and experimenter." The use of present-day channels limits the number of lines drawn per picture to about 24; this means that the bust of a single person is about the limit of recognisable reproduction in half-tone work, or possibly two moving figures in silhouette. A 48-line picture sent 15 times per sec. will require about 20 kc's. for each side band—or about 4 present-day channels. For this work, receivers must differ considerably from those employed now for broadcast reception. One "stunt" is to use four channels, splitting the picture into 4 parts, each of which is handled by a separate transmitter and receiver. Various details of apparatus and methods are discussed, including special forms of disc.

TELEVISION.—C. R. Cosens. (*Wireless World*, 16th January, 1929, V. 24, pp. 81–82.)

A letter, the gist of which is that before television can become more than a scientific toy a very great speeding-up and increase in the number of elements of pictures that can be transmitted per second will be necessary; at present, to produce a picture one foot square with definition equal to that of the illustrations in *The Wireless World* would require a sideband of over 5,000 kilocycles—"the transmitter would require as much space in the ether as several hundred broadcasting stations." *Cf.* Korn, February Abstracts.

BILDÜBERTRAGUNG UND FERNSEHEN (Picture Telegraphy and Television).—R. Hiecke. (*Supplement to Elektrot. u. Masch. bau*, No. 10, 14th October, 1928, pp. 92–94.)

A continuation of the historical survey referred to in Abstracts, 1928, V. 5, p. 649. The present paper starts with 1921 and later deals at some length with Dauvillier's work from 1908 to 1925, particularly the later work on the "Telephot" in which, inspired by Campbell Swinton's researches, he used a cathode ray oscillograph at the receiving end. Zworykin's system (1925) of colour television is also mentioned, using the cathode ray with tri-coloured mosaic filters in front of the fluorescent screen.

The next instalment (No. 12, 9th December, 1928, pp. 107–112) is devoted to the great advance in America during 1927, indicated by the Bell Telephone Company's Washington–New York television demonstration. The apparatus is treated in considerable detail. The next step to be expected from these laboratories is the dividing up of the picture into several portions transmitted simultaneously.

AN HOUR WITH A PICTURE RECEIVER.—"Empiricist." (*Wireless World*, 5th December, 1928, V. 23, pp. 752–754.)

The writer has just secured one of the first batch of Fultograph machines, and describes and illustrates his first results on the transmissions from Königswusterhausen (and also from Paris; distortion was produced owing to Paris not transmitting on the Fultograph system). The set works well on signals too weak for loud-speaker reproduction; it requires only 3 mA. mean current. A good volume control is desirable, and the receiver must be selective. The chief trouble with the German signals was interference from 5XX, causing streaks.

BUILDING A PICTURE RECEIVER.—F. H. Haynes. (*Wireless World*, 2nd January, 1929, V. 24, pp. 2–6.)

UN NOUVEAU SYSTÈME DE TÉLÉVISION ET DE TÉLÉCINÉMATOGRAPHIE (A New System of Television and Telecinematography).—L. Thurm. (*QST Franç.*, November, 1928, pp. 40–42.)

A continuation of the article referred to in Abstracts, 1928, V. 5, p. 529. The author first describes the advantages of his plan (of slowing down the rate of actual wireless transmission and reception, so that this takes several times the length of time of the action itself) and then shows how it can be applied in practice to telecinematography—taking this as more simple for purposes of explanation than television itself. The camera would preferably use a film in uniform motion (instead of intermittent) with an opaque shield passing across its breadth, perforated with narrow rectangular slots at intervals equal to the breadth of the film, the length of these slots being in the direction of the length of the film and equal to its breadth. Thus the images take the form of a series of parallelograms slanting across the film, one below the other. The film thus made is used with a special scanning disc, and a photoelectric cell, to modulate the wireless transmitter. If only one wave channel is used, the whole film is passed through perhaps forty times, only two narrow longitudinal strips being scanned in each passage. The next instalment will deal with the reception and the frequency change necessary to reproduce the action at the proper speed.

FACSIMILE TELEGRAPHY.—(German Patent No. 464568, Siemens & Halske, pub. 21st August, 1928.)

To reduce the time of transmission, the white spaces are cut down as much as possible by having the writing on a tape or tapes wound on the picture drum. In the diagram, one tape is wound three times spirally round the drum, so that it looks not unlike the arrangement for "slanting line-jump scanning" (Schröter, February Abstracts).

SYNCHRONISM.—C. F. Jenkins. (*QST.*, September, 1928, V. 12, p. 38.)

It is here advocated that the motor should be run at the speed for which it is designed, as this will result in greater constancy. Regulation should be done by adjusting the position at which the rubber friction drive touches the disc.

SYNCHRONISATION.—(German Patent No. 464491, Karolus, published 21st August, 1928.)

To avoid the great amplification needed for the usual synchronisation by tuning forks, the apparatus is driven roughly in time by an asynchronous motor and the finishing touches are supplied by a small synchronous motor on the same axis, controlled by the tuning fork. In the diagram the synchronous motor takes the form of a round-toothed wheel (made up of iron laminæ) whose teeth pass close to the poles of an electromagnet.

NOUVEAU DISPOSITIF POUR L'ENREGISTREMENT SIMULTANÉ DE TROIS IMAGES SÉLECTIONNÉES POUR LA PRODUCTION D'IMAGES EN COULEURS (New Arrangement for the Simultaneous Blending of Three Selected Images for the Production of Images in Colour).—C. Nachet. (*Comptes Rendus*, 10th December, 1928, V. 187, pp. 1172–1174.)

CONTROL OF A KERR CELL.—(German Patent No. 464626, Telefunken, pub. 23rd August, 1928.)

The secondary winding of the transformer linking the Kerr cell to the amplifier should be very high to match the cell resistance, but a limit is put on it by the self-capacity of the primary and secondary windings. This capacity is here kept low by reducing the primary winding, by the use of a microphone in the primary circuit instead of a valve.

PHOTOELECTRIC RELAY.—(French Patent No. 644820, Siemens and Halske, published 15th October, 1928.)

The double refraction of glass or similar substance under the action of deformation stresses is here used without any employment of piezoelectric vibration, the deformation being produced by the electromagnetic attraction of an armature secured to one end of the glass, the other end being rigidly fixed.

LIQUID-FILLED PHOTO CELL.—(*Scient. American*, December, 1928, p. 552.)

Paragraph noting the production, by the Radiovision Corporation of New York City, of a photovoltaic cell resembling a "large radio vacuum tube filled with a greenish liquid." It is said to generate 1,000 times the current generated by the present-day photoelectric cell.

MARKING DEVICE FOR PICTURE TELEGRAPHY.—(German Patent No. 464954, Radio Corp., published 4th September, 1928.)

To avoid clogging of the ink at the pen-point when this is off the paper, the pen is kept all the time rubbing against the paper but is fed with ink at varying pressure.

PICTURE TELEGRAPHY.—(German Patent No. 464490, Hausmann, published 21st August, 1928.)

For every line of the picture a separate frequency is to be used, these frequencies being generated by a rotating siren disc. At the receiver a corresponding collection of resonators is to be used, consisting of a number of piezo crystals.

PREPARATION OF THE THALLIUM PHOTOELECTRIC CELL.—Q. Majorana and G. Todesco. (*Roy. Nat. Ac. Lincei*, abstracted in *Nature*, 5th January, 1929, V. 123, p. 34.)

A quick-acting cell, at least as sensitive as that of Case, may be prepared from thallium sulphide. *Cf.* next abstract, Dubois.

ÉTUDE DES PROPRIÉTÉS DES CELLULES PHOTO-ÉLECTRIQUES FOURNIER (The Properties of the Fournier Photoelectric Cells).—R. Dubois. (*Journ. d. Phys. et le Radium*, October, 1928, V. 9, pp. 310–336.)

These cells have a very thin crystalline deposit of metallic sulphide, the resistance of which decreases with illumination. Their properties differ from those of a selenium cell; they will follow light variations of very high (ultrasonic) frequencies, and their sensitivity extends into the visible and the nearer infra-red region ($\lambda = 0.5 - 1.3\mu$). On p. 322 the sensitivity of such a cell on 6 volts (not the maximum 45 v.) is given as 2,000 times as great as that of a potassium cell with 150 v. accelerating potential. Moreover, as the response of the Fournier cell varies with the square root of the illumination, instead of with the first power, it gains still more at weak illuminations. Full details of the behaviour of these cells, and a theory explaining it, are here given.

Atomic Layers of Rubidium.—Bell Telephone Laboratories. (*Science*, 2nd November, 1928, V. 68, Supplement, p. xii.)

A paragraph on Johnsrud's researches in connection with photoelectric cells. The rubidium was gradually deposited or (alternatively) a thick deposit was gradually thinned, and the photoelectric response measured during the process. Maximum response was obtained when the film was only one atom thick, as determined by polarised light.

Photo-electric Thresholds and Fatigue.—G. B. Welch. (*Phys. Review*, October, 1928, V. 32, No. 4, pp. 657–666.)

A linear relation was found between the logarithms of the photoelectric current and the logarithm of the time elapsed since polishing the surface. The rate of fatigue depends upon the element used, and—for a given substance—increases numerically as the threshold is approached. Increasing the gas pressure increases the rate of fatigue. The action of light has a negligible effect. The threshold wavelengths for various elements are given; with a high vacuum, fatigue produces no change in these at any rate over several hours. With lower vacua there is evidence of a shift towards shorter wavelengths. A "patch" theory, in which it is supposed that contamination takes place at discrete areas of the surface, is suggested to account for the experimental facts obtained.

Über die Sättigung des Lichtelektrischen Stromes (The Saturation of Photoelectric Current).—J. A. Becker. (*Naturwiss.*, 4th January, 1929, p. 12.)

Suhrmann has found that light of high frequency produces a current which gives a saturation effect, whereas light in the neighbourhood of the long wave border produces a current increasing regularly with an increase of potential. The writer explains this on thermionic and quantum principles.

Wave Mechanics of an Alkaline Atom in the Electric Field.—F. Rasetti. (*Nature*, 29th December, 1928, V. 122, p. 1018.)

Short abstract of a paper read before the Royal Nat. Acad. Lincei, 17th June, 1928. The theory (previously developed by the same worker) of the perturbation due to the effect of an external field on an atom of an alkali metal is applied to the case of lithium.

MEASUREMENTS AND STANDARDS.

Die Temperaturabhängigkeit der Frequenz des Quartzresonators (The Variation with Temperature of the Frequency of Quartz Oscillators).—F. Gerth and H. Rochow. (*E.N.T.*, December, 1928, V. 5, pp. 549–551.)

Previous results have differed quite seriously: in the tests here described, silvered quartz plates were used; thus the uncertain distance of the electrodes from the quartz—a frequent source of error—was avoided. The resulting value (60×10^{-6} per degree Centigrade) of temperature coefficient is considerably higher than those given by most workers, and leads to the conclusion that (for example) for a wavelength of 15 m. the temperature of the crystal must be kept constant to within 1/25th degree Centigrade in order to keep the frequency constant within 50 cycles per second. It is mentioned that Mason has given the temperature coefficient of a particular tuning fork as -4.7×10^{-6}, less than a tenth of the value here found for quartz.

Nouveau Mode de Développement d'Électricité par Torsion dans les Cristeaux de Quartz (New Method of Developing Electricity by Torsion in Quartz Crystals).—E. P. Tawil. (*Comptes Rendus*, 3rd December, 1928, V. 187, pp. 1042–1044.)

A cylinder of quartz cut with its axis parallel to the optical axis, when fixed at one end and subjected to torsion at the other, displays a disengagement of electricity on its surface which appears to be proportional to the variation of the effort of torsion; the polarity of the charge reverses when the direction of torsion reverses or if the torsion is removed. The respective polarities depend on the optical structure: positive electricity is developed whenever the torsion is in the direction of the optical rotation. A natural prism will show the effect: if long enough and not too big, sufficient twist can be applied by the two hands, without any mounting. Incidentally, the direction of optical rotation can easily be found in this way. If, in applying the torsion, the cylinder or crystal is subjected to bending, another liberation of electricity is produced which may interfere with the effects of the torsion. The writer concludes by remarking that the torsion effect is evidently distinct from the piezoelectric effect.

Erzeugung und Untersuchung Nichtkrystalliner Piezoelektrischer Stoffe (The Formation and Investigation of Non-crystalline Piezoelectric Materials).—A. Meissner. (*Zeitschr. f. Tech. Phys.*, November, 1928, pp. 430–434.)

These materials are obtained by powdering the natural substance (*e.g.*, quartz crystals) and binding it together—while under the action of a strong electric field—with some substance such as colophonium (a sulphurated zinc product), beeswax, Canada balsam or pitch. These artificial plates possess strong pyroelectric as well as piezoelectric qualities—the latter (for quartz) being from 50–70 times as great as for the natural crystal plate. Unluckily the piezoelectric moment does not remain constant, falling to half its value in times which vary (according to the binding material used) from a day or two to several months. The most successful plate from this point of view was one of asphalt and quartz, which remained constant for six months. At present such a plate is not suitable for valve frequency control: its coefficient of elasticity is too low and its damping too high, But it can be used for a piezoelectric microphone.

about which there will be a further communication. The first part of the present paper deals with the pyroelectric behaviour of loose powders of various degrees of fineness.

The Temperature Coefficient of Quartz Crystal Oscillators.—R. S. Strout. (*Phys. Review*, November, 1928, V. 32, pp. 829–831.)

The temperature coefficient of frequency of the plate used was found to decrease linearly from 22.7 parts per million per degree at 65 deg. C. to 1.6 parts per million per degree at − 189 deg. C.

Oscillation in Ultrasonic Generators and Velocity of Longitudinal Vibrations in Solids at High Frequencies.—R. W. Boyle and D. O. Sproule. (*Nature*, 5th January, 1928, V. 123, p. 13.)

The longitudinal, flectural and torsional oscillations of a quartz plate, with overtones of any or all of these, are further complicated when the plate is cemented to a metal rod or plate, as in ultrasonic generators. Examples are mentioned. Hence very cautious judgment must be exercised when determining a resonant frequency, particularly an overtone. However, with due caution the method may be used successfully to determine the velocity of sound in, and Young's modulus of, the rod at the frequencies of the fundamental note and lower overtones. The modulus for ice is easily determined by this method, whereas other methods appear to be unsatisfactory.

Frequency Stability by Magnetostriction Oscillators.—H. P. Westman. (*QST.*, November, 1928, V. 12, pp. 21–26.)

An article based on Pierce's paper in the *Proc. Am. Acad. Arts and Sciences*, V. 63, No. 1 (referred to in Abstracts, 1928, V. 5, p. 643).

A Portable Crystal-controlled Transmitter.—D. J. Angus. (*QST*, October, 1928, V. 12, pp. 33–36, 78 and 80.)

The Frequency Measurement Problem: Applications of the Monitor in Transmitter Setting and Signal Checking.—R. A. Hull. (*QST*, October, 1928, V. 12, pp. 9–19.)

See also the same writer, under "Transmission." In the wavemeters described, the series-gap condenser based on principles expounded by Griffiths (see February Abstracts) is employed.

Ein neuer Spannungswandler (A New Voltage-transformer).—A. Imhof. (*Bull. de l'Assoc. Suisse d. Élec.*, 7th December, 1928, pp. 741–750.)

For high tension measurements, the special non-inductive high resistance here discussed is used in place of the customary step-down voltage transformer, with economic advantages which grow rapidly for voltages above, say, 30 kV. The lower end is earthed through the primary of the Instrument current transformer.

A Sensitive Vacuum Tube Voltmeter.—C. B. Aiken. (*Journ. Opt. Soc. Am.*, December, 1928, V. 17, pp. 440–450.)

A new type of voltmeter making use of the heterodyne principle, for the measurement of steady, single frequency voltages in the audio and lower radio frequency ranges. It has a linear characteristic and is extremely sensitive: by using the best type of galvanometer it would probably give about one division per microvolt. Measurements can be made of weak signals accompanied by a relatively strong noise background.

A Useful Design of Tube-Voltmeter.—W. F. Powers and G. W. Alderman. (*Journ. Opt. Soc. Am.*, November, 1928, V. 17, pp. 379–380.)

A lay-out is shown which gives, with one arrangement of switching and connection, the "slide-back" thermionic voltmeter described by Kirke (*E.W. & W.E.*, Feb., 1927): with a second, the Van Der Bijl arrangement; and with a third, the Moullin voltmeter circuit.

Mesure des Fréquences (The Measurement of Frequencies).—F. Bedeau and J. de Mare. (*T.S.F. Moderne*, August, 1928, V. 9, pp. 469–485: Summary in *Rev. Gén. d. l'Élec.*, 8th December, 1928, V. 24, p. 198D.)

Description of a tuning fork of special steel, having a constant frequency in spite of temperature variations. The coil acting on one prong is in the grid circuit of the first valve of an L.F. amplifier; that acting on the other prong is in the plate circuit of the second valve: in this circuit there is also the primary of a transformer, the secondary going to the grid circuit of a separate valve, whose grid is negatively biased and whose plate is connected to an oscillating circuit linked to the rest of the apparatus by a dry battery. If the oscillating circuit is nearly tuned to a multiple of the fork frequency, it will emit waves of this harmonic. Using forks of frequency 800, 1,000, 1,200 and 1,500 p.p.s., the writers have obtained the 150th and 200th harmonics of these frequencies. The use of the apparatus is described for calibrating an instrument, by steps of 500 p.p.s., up to a frequency of 200 kc.; or for finding the fundamental frequency of a quartz oscillator. Also, by acting on the thickness of the crystal (maintained at a constant temperature) it is possible to make it oscillate at a frequency exactly corresponding to that of a known harmonic of the fork.

An Instrument for the Production of Known Small High-frequency Alternating Electromotive Forces.—B. S. Smith and F. D. Smith. (*Proc. Physical Soc.*, 15th December, 1928, V. 41, Part I, pp. 18–28.)

A portable instrument is described, giving E.M.F.'s of 10–50 kc. frequency and 0.0076–15,000 microvolts magnitude. It is intended for the calibration of amplifiers and the measurement of the strength of wireless signals of long wavelength. The valve oscillator (Hartley circuit) forms one screened unit, and its coupling coil is connected by 6ft. of screened cable to the second screened unit—

an artificial line of series and shunt resistance elements: each shunt element carries $1/\sqrt{2}$ times the current carried by the preceding element, so that the magnitude of the E.M.F. at the output of the artificial line depends upon the position of a rotating switch which makes connection with one or other of the sections. From this second unit another 6ft. screened cable goes to the third unit, a signalling key (specially designed to avoid abrupt changes in the constants of the circuit, which would produce noises in the telephones), the screening of all three units being connected together and earthed. The receiving circuit used with the set is a coil tuned by a condenser and a six-valve high and low frequency amplifier with heterodyne. It is sensitive to an E.M.F. of 0.01 μV. induced in the coil, and the valve oscillator must not affect it at a distance of 6ft.: the screening provisions, therefore, are aided by the use of toroidal coils in the oscillator; these coils are wound with a re-entrant turn of the conductor running along inside the winding, to neutralise the field due to the toroid behaving as a one-turn coil. The core of the toroid is of compressed iron dust. It was found useful to screen the secondary from the electric field of the primary by a braiding of fine copper wires. In the subsequent discussion, Wilmotte suggested the use of large condensers in place of resistances, in the artificial line, for high frequencies.

Über die Messung der Gitter-Anode-Capazität von Schirmgitterröhren (The Measurement of the Grid-Anode Capacity of Screen-grid Valves).—E. Klotz. (*Telefunken Zeit.*, October, 1928, No. 50, pp. 34–38.)

The method described will, with normal components and precautions, measure a capacity of 1/10th mm. with a maximum error of two or three per cent. By further precautions and the use of a micrometer-screw adjustment of the standard condenser, greater accuracy is obtained.

Die Messung von Kapazitäten mit dem Überlagerungsverfahren (Capacity Measurement by the Heterodyne Method).—W. Weihe. (*Zeitschr. f. Hochf. Tech.*, December, 1928, V. 32, pp. 185–194.)

A convenient and satisfactorily accurate method is described, depending on the phenomenon of "pulling into tune" between two oscillating circuits. Various methods of application are discussed with a view to the application of the simpler approximate formula $\Delta f = \frac{f}{2C} \cdot \Delta C$ in place of the more complex exact formula. In the case of the method depending on retuning the note circuit, where the approximate formula does not hold, another formula is obtained. For use with high frequencies (200–20 m. wavelength), which add so much to the value of the method, a condition is indicated under which the approximate formula can be applied, in spite of the effects of the self-inductance of the leads. Conditions for obtaining a good constancy of frequency are investigated. As an example of the method, the variation of the input capacity of a valve with the ohmic load of the output circuit and with the wavelength was measured, and the results shown to conform with theory. Frequency variations due to filament and anode voltage fluctuations were corrected by a suitable choice of reaction coupling and of the working voltages, and by the introduction of a capacity shunted by a resistance in the grid circuit. For the first hour or two of service, the valves showed a steady alteration of frequency, but after that the constancy was good; for a period of 15 minutes the alteration was only 1 Hertz for a wavelength of 204 m. For waves down to 20 m. the period over which such constancy could be obtained was considerably shorter, but was sufficient for the measurements by the process described.

Einige Messungen über die Hochfrequenzspannungen an der Eingangsseite von Empfängern (Some Measurements of H.F. Voltage at the Input End of Receivers).—M. v. Ardenne. (*Zeitschr. f. Hochf. Tech.*, December, 1928, V. 32, pp. 199–202.)

To determine what H.F. amplification is necessary to receive satisfactorily a given station on a given aerial it is necessary to know the voltage produced at the input end of the receiver. To measure this it is necessary first to amplify it with an H.F. amplifier whose magnification is known. After discussing the various difficulties, the writer describes his measurements of signals from various broadcasting stations, received on various aerials and frames; using a special aperiodic amplifier whose amplification performance was known (see his article, Abstracts, 1929, V. 6, p. 47) and his thermionic voltmeter (*ibid.*, 1928, V. 5, p. 405). Results on the local station, Berlin ($\lambda = 483.9$ m.), show the voltages measured on large and small aerials and on frames of different sizes. Results on distant stations are given, showing the variation with time of day, a five-minutes fading curve for Prague (290 km. distant) being particularly striking. The last diagram gives the measured voltages for about forty broadcasting stations, including English, Spanish and Italian, measured at Berlin: this table gives the mean value over six minutes, and the maximum and minimum values during the fading period: all these measurements being taken on the same evening, between 8 p.m. and midnight in October.

Ein Kurzwellenempfangsgerät zur Messung der Feldstärke (A Short-wave Receiving Apparatus for the Measurement of Field Strengths).—G. Leithäuser. (*Abstract in E.T.Z.*, 13th December, 1928, p. 1816.)

As in Ander's method, the deflection produced by the field is reproduced by a calibrated local sender on the same wave. Reception is on frames, with a perfectly symmetrical circuit of two valves for intermediate frequency amplification and valve voltmeter. The valves connected direct to the frame have shield grids and a particularly low "durchgriff" ($1/\mu$) of about 10 per cent.; in this way capacity reaction into the frames is avoided. The regulation of the local transmitter signals is done with a molybdenum-tube rectifier, acting as a resistance which can be varied between 5 and 10,000 ohms.

Smallest measurable field strengths are 6–7μV/m. On the roof of the G.P.O., Berlin, the field strengths of short-wave transmitters in England and Australia are about $150\mu V/m$.

RECEIVER CHARACTERISTICS AND THEIR MEASUREMENTS.—V. D. Landon. (*QST.*, October, 1928, V. 12, pp. 23–30.)

Deals with the work of the inter-company committee set up by the Radio Corporation, G.E.C., and Westinghouse Company, in standardising test methods and apparatus.

A QUICK AND SENSITIVE METHOD OF MEASURING CONDENSER LOSSES AT RADIO FREQUENCIES.—R. M. Wilmotte. (*Journ. Sci. Inst.*, December, 1928, V. 5, pp. 369–375.)

Author's Abstract: "The method is essentially a substitution method in which an air condenser is substituted for the condenser being measured, the current being brought to the same value in the two cases by inserting a resistance in series. The success of the method largely depends on the construction of a suitable continuously variable resistance, of which a description is given. With careful use the method will give the value of the difference of the equivalent series resistance between the standard condenser and that under test to within 0.01 ohm, or even less when the circuit conditions are very good.

A number of results of condenser measurements are given, and it is shown that the effective series resistance R of the variable air condensers measured can, within the limits of experimental error, be represented by the equation $R = r + \frac{1}{aC^2f}$, where f is the frequency, C the capacity, and r and a are constants of the condenser. r appears to be the resistance due to bad contacts and leads inside the condenser. Results tend to show that with aluminium plates the constant r is liable to be unexpectedly large, although in many cases it is very small. Also, with ebonite, the value of a appears to decrease with humidity.

The advantages claimed for the method are its rapidity, facility of working, possibility of working down to a wavelength of at least 50 metres, its comparatively high sensitivity, and most important, its freedom from errors due to reaction back on to the source." Later on it is stated that the method is only suitable for the measurement of screened apparatus and could not be used for the measurement of coils, for instance, which are not usually screened. But elsewhere the case of an unscreened condenser is mentioned, in which the capacity currents would render the measurement unreliable (unless the capacity were of such magnitude that its impedance could be neglected in comparison with the impedance of the capacity to earth): here the difficulty was overcome by measuring with the condenser inside a screened box.

CAPACITY IN THE DRYSDALE'S BRIDGE.—S. S. H. Nagir and P. N. Sharma. (*Journ. Sci. Inst.*, December, 1928, V. 5, p. 392.)

The distribution of stout copper pieces in this bridge (specially designed to minimise inductance) has been found to include capacities not negligible in comparison with the very small capacities to be measured in wireless circuits: they may be as much as $220\mu\mu F.$, and are not constant, being (in one case) more than halved after eight months' interval.

SUBSIDIARY APPARATUS AND MATERIALS.

EIN FÜR PRAKTISCHE VERWENDUNG GEEIGNETES VERFAHREN FÜR SPANNUNGSREGELUNG AN GENERATOREN MIT HILFE VON HOCHVAKUUMRÖHREN (A Practical Method of Generator Regulation by High Vacuum Tubes).—N. A. J. Voorhoeve. (*Arch. f. Elektrot.*, 7th December, 1928, V. 21, pp. 228–243.)

The writer considers three-electrode valve methods (*cf.* February Abstracts) too complicated for practical use, and describes a method, satisfactorily employed at the Philips Eindhoven Works, which uses two-electrode valves whose filament-temperature is controlled by the generator load, the consequent plate current variations regulating the generator field.

DIRECT-CURRENT GENERATORS OF VERY HIGH VOLTAGE.—S. R. Bergman. (*Gen. Elec. Review*, November, 1928, V. 31, pp. 596–599.)

The machines described are of one special type, built in ratings of from 5 to 150 kW. for voltages 7,500–15,000 v., specially for the anode supply of transmitting valves. The field is an open-slotted sheet-steel structure with two windings: a compensating winding completely neutralising the armature reaction, in series with the armature winding and distributed evenly around the armature so as to oppose the reaction at each point, and an exciting winding: the two windings being in quadrature. The field slots are closed by magnetic wedges made of soft iron, cotton-covered wire woven into a cloth, dipped in a resin solution, then shaped and cured. They halve the core loss and reduce the noise. With these machines, owing chiefly to the complete neutralisation of armature reaction, a treble overload does not cause commutator sparking. They will stand accidental short circuiting not only momentarily but for a sustained time without flashing. Ripple (caused chiefly by the slotted armature) is minimised by a squirrel-cage of copper strips in the bottom of the field-slots; this reduces the ripple to ¼ of 1 per cent. of total current; shunt condensers reduce it still further to 1/100 of 1 per cent. Above 10,000 v., two armature windings (in series), each with a separate commutator, are used.

A NEW TYPE OF LOW FREQUENCY LOW VOLTAGE DISCHARGE IN A NEON LAMP.—G. R. Paranjpe and K. Sheshadriengar. (*Nature*, 22nd December, 1928, V. 122, pp. 959–960.)

The periodic flashes here described differ from the usual type; no variable condenser is required in the circuit, the voltages used are lower, the discharges are very slow (0.57 to 9.04 seconds) and their period can be varied at will. The *actual* value of the potential of the cathode (in addition to its potential relative to the anode) and the earthing of the outside of the bulb appear to be important factors.

DER NEONGAS-SPANNUNGSANZEIGER (The Neon Tube Voltage Indicator).—(*Bull. d.l'Assoc. Suisse d.Élec.*, 22nd November, 1928, p. 740.)

The ordinary incandescent pilot lamp has the disadvantages that if the filament breaks the indication is false and that in any case it wastes current. The Philips Company has therefore produced a neon pilot lamp, for A.C. or D.C. With the latter, it also acts as a pole-indicator.

A NEW DEVICE FOR THERMOSTAT CONTROL.—H. F. T. Jarvis. (*Proc. Physical Soc.*, 15th December, 1928, V. 41, Part 1, p. 112.)

An arrangement is described which kept the temperature of a tank of water constant within 1/50 deg. centigrade for a fortnight. A large bulb full of toluol, immersed in the water, governs the level of a mercury column on which floats a glass cylinder controlling two alternative wire-mercury contacts, in circuit with solenoids which rock in opposite directions a relay switch controlling the heating circuit.

A SENSITIVE THERMO-REGULATOR.—D. H. Black. (*Journ. Sci. Inst.*, December, 1928, V. 5, pp. 376–377.)

A bi-metallic spiral-strip regulator, primarily designed for electrically heated air ovens; sensitivity is such that for a difference in temperature of 1 deg. C. the tip of the contact arm moves through about 1 cm. Constancy of temperature within 0.1 deg. C. is easily obtained: with special precautions this can be improved to 0.04 deg. C.

CATHODE RAYS AS A LABORATORY TOOL.—(*Science*, 9th November, 1928, V. 68, Suppt., pp. xii–xiii.)

A new form of tube is described due to Slack (Westinghouse Co.) in which the window of thin nickel is replaced by a bubble of glass, which may be one five thousandth of an inch thick and one inch in diameter. The method of formation is such that it automatically assumes its shape so that the air pressure afterwards is the same as that during its formation.

A PROPOS DE LA THÉORIE DES OSCILLOGRAPHES ET APPAREILS INDICATEURS (Concerning the Theory of Oscillographs and Indicating Instruments).—A. Blondel, and SUR LA THÉORIE MATHÉMATIQUE DES OSCILLOGRAPHES (The Mathematical Theory of Oscillographs).—N. Bogoliouboff and N. Kryloff. (*Comptes Rendus*, 19th November, 1928, V. 187, pp. 921–923 and 938–940.)

In the first paper, Blondel criticises the methods and conclusions of the second, which deals with his own theory and deduces from it certain conditions which should be observed in order to make the error of synchronisation as small as possible.

ON THE USE OF THE DUFOUR CATHODE RAY OSCILLOGRAPH.—Bekku, Narasaki and Miyamoto. (*Journ. I.E.E. Japan*, August, 1928, pp. 796–815.)

The results of a year's experience. In damp atmospheres there is an appreciable surface leakage from the cathode, resulting in unsteady focusing: a special chamber remedied this and also decreased the blackening of the cathode. It is concluded that the deflecting coils should be placed nearer to the cathode than the deflecting plates, to obtain better uniformity of the fields. A sweeping system (getting rid of the Dufour mercury contact) was devised.

CONSTANTS OF AN ELECTROMAGNETIC OSCILLOGRAPH.—A. E. Kennelly. (*Nature*, 29th December, 1928, V. 122, p. 1010.)

Summary of a paper in *Proc. Am. Phil. Soc.* When an oscillogram (taken by such instruments—including the electromagnetic type) is analysed into a series of Fourier components of different frequencies, a correction factor has to be applied to each, to eliminate the error due to inertia: the magnitudes of these corrections depending on the particular frequency. A new, quick method for determining these factors is described: the instrument constants whose measurement is required are the resonant frequency, the specific deflection (deflection per unit of testing current taken at some convenient reference-frequency, such as 60), and the "bluntness of resonance" (reciprocal of the sharpness).

EIN MESSKONDENSATOR FÜR HOCHSTSPANNUNGEN (A Test Condenser for Extra High Tensions).—R. Vieweg and H. Schering. (*Vortragshandbuch*, 90 Versamm. d. Ges. Deut. Nat. forsch., Hamburg, September, 1928.)

A compressed gas condenser in which the electrodes are built into an insulating case capable of withstanding the gas pressure: a leading-in insulator is thus dispensed with. A simple screening of the L.T. electrode gives freedom from loss and a constant capacity. The first of its kind has stood 350 kV. perfectly and has been used for measuring purposes up to 300 kV. The principle allows condensers to be made for much higher voltages still.

THE PHYSICAL SOCIETY'S ANNUAL EXHIBITION.—(*Wireless World*, 23rd January, 1929, V. 24, pp. 106–108.)

Among various exhibits of radio interest may be mentioned the McLachlan-Sullivan modulated C.W. wavemeter, in which a screened-grid valve working on the negative resistance part of the characteristic is connected with radio- and audio-frequency circuits so as to generate modulated H.F. without any reaction coupling: and an inductance for standard wavemeters wound on a former of such material that the diametrical and axial thermal expansions compensate in their effects.

AN IMPROVED ROSA CURVE TRACER.—H. E. Bonn. (*Journ. Opt. Soc. Am.*, September, 1928, V. 17, pp. 207–223.)

The improved form is smaller, simpler, and more accurate than the original type invented 30 years ago and relegated to the background by the various oscillographs. The instrument has the advantage, for the recording of the wave-form of A.C. generators, over moving coil or cathode-ray oscillographs in "greater sensitivity, remarkable accuracy and extreme simplicity." It will, for example, work in practically any circuit, of high or low impedance, where a voltage of 0.1 V. or even less is available: giving large records (examples are shown) with a very thin trace. It works by a personally operated point by point method, the galvanometer being brought to zero by a potentiometer adjustment and a "dot" formed on the record by pressing the "printing lever": the release of this lever moves on the cylinder by a desired amount. A complete wave-form takes a few minutes to plot.

Über ein hochempfindliches Messinstrument für Wärmestrahlung (A highly sensitive measuring instrument for heat radiation).—G. Hettner. (*Zeitschr. f. Phys.*, 6th March, 1928, V. 47, pp. 499–508.)

Describes a new design of radiometer greatly exceeding in sensitivity all previous types.

Device for Regulating a Physical Phenomenon according to a Curve determined in advance.—(French Patent No. 641,232, Arnoux Chauvin and Co., published 30th July, 1928.)

A rotating insulating cylinder covered with a conducting layer has the predetermined curve cut in this layer so as to divide it into two parts insulated from each other. A needle pressing on the cylinder controls, through relays, the physical process in question.

Über punktförmige Aufnahmen von Wechselstromkurven insbesondere bei höherer Frequenz (Point by Point Plotting of A.C. curves, especially at Higher Frequencies).—F. Eisner. (*Arch. f. Elektrot.*, 17th September, 1928, V. 20, pp. 473–502.)

The usual methods using the Joubert Disc fail at high frequencies. The writer, by the use of phase-changers and of valve circuits, has extended the same principle to frequencies of 8,000 cycles per sec., and is trying to reach 150,000.

A Portable Electric Harmonic Analyser.—(*Journ. Sci. Inst.*, October, 1928, V. 5, pp. 320–323.)

An instrument depending on the dynamometer principle that a steady deflection can only be produced by currents of the same frequency in the fixed and moving coils. A current related in some known way to the voltage or current to be analysed is passed through the moving coil, while through the fixed coil is passed a sinusoidal analysing current from a synchronously driven contact disc and a valve circuit.

Stromrelais mit geringem Eigenverbrauch (Current Relay with Small Consumption).—(*E.T.Z.*, 1st November, 1928, p. 1615.)

Illustration and brief description of a Siemens and Halske relay working on 0.1 volt-ampere, and controlling up to 10 VA. A special point is that by turning a knob the operating current can be doubled or halved and the relay adjustment will adapt itself to the new conditions.

Erfahrungen mit Aluminiumleitungen (Experience with Aluminium Conductors).—(*E.T.Z.*, 25th October, 1928, pp. 1581–1582).

Einfluss der Luftfeuchtigkeit auf den Überschlag von Isolatoren (Influence of atmospheric humidity on the Flash-over of Insulators).—W. Weicker. (*E.T.Z.*, 15th November, 1928, p. 1696–1697.)

A letter discussing the author's results and those of Littleton and Shaver in America, and of Schwaiger.

Magnet Cores.—(German Patent 460,645, Siemens and Halske, published 4th June, 1928.)

The use of spongy iron is specified, which for example is ground up, mixed with insulating material, and compressed.

Perfectionnement aux Rectificateurs Électriques à Contact (Improvements to Contact Rectifiers).—Westinghouse El. & Mfg. Co. (*Rev. Gén. de l'Élec.*, 24th November, 1928, V. 24, p. 186D.)

A summary of a patent recently published, describing the thermal processes used in the manufacture of these oxide rectifiers.

Megavox Eliminator: an H.T. Eliminator for A.C. Mains with Metal Oxide Rectifier of Universal Application to Receivers with Three and Four Valves. Part I.—W. I. G. Page. (*Wireless World*, 12th December, 1928, V. 23, pp. 787–791.)

"Motor-boating, distortion and hum are entirely absent and a generous output of 100 mA. at 200 v. is obtainable."

Surges in Eliminator Smoothing Circuits.—(*E.W. & W.E.*, December, 1928, V. 5, pp. 680–682.)

Correspondence on Warren's article (*ibid.*, November, 1928). It is suggested that in many cases matters are not so bad as the analysis might lead one to believe, and that simple safety devices, neon surge absorbers, etc., exist which remove such troubles as there may be. The author of the article replies.

STATIONS, DESIGN AND OPERATION.

Die Fernsprechverbindung zwischen Europa und Amerika (The Telephony Link between Europe and America).—E. Wollner. (*E.N.T.*, December, 1928, V. 5, pp. 489–522.)

A very full description of the London-New York system with photographs, diagrams of connections, curves (*e.g.*, of daily variations in interference and in the ratio signals to interference), lay-out of directional aerial systems, etc., etc.

Ein neuer Rüchkopplungssperrer (A New Reaction Suppressor).—W. Hahn and H. Warncke. (*E.N.T.*, December, 1928, V. 5, pp. 522–529.)

After describing the complications—reaction and echoes—which make their appearance when a wireless line of communication is extended to a land-line system, and explaining how the precautions which are satisfactory in 4-line telephone practice (artificial balancing lines, etc.) fail in such a case, the writers outline the methods of reaction-suppressing used in the England-America service; fundamentally similar in the two countries, though at the American end mechanical relays are used, while at the English end a shift of grid-potential is employed. They then describe the simpler methods which can be used where two different wavelengths are employed for the two directions: even in this case, the rather complex "double-actuated" arrangement (*i.e.*, actuated both by the transmitting and the receiving systems) must be used if the plan is adopted of leaving the receiving path open and the transmitting path closed during the state of rest. But if the receiving path is blocked and the transmitting path left open, a simpler circuit can be used ("singly actuated suppressor") which has the advantage, among others, that the listener hears no interference during the pauses of speech—with the subjective result that he gets the impression that there is no interference, and consequently hears better. The rest of the paper deals with the German Post Office's Magnetron-operated system working on this principle, and said to combine the advantages of the grid potential-shift and the mechanical relay systems. Three-electrode valves are used, connected for amplification, the degree of amplification being controlled by the magnetron-winding. Thus the control circuit is electrically disconnected from the controlled circuit: while the "relay" is inertialess as compared with a mechanical relay.

HÖRBARKEITSGRENZEN UND GÜNSTIGSTE VERKEHRSZEITEN BEI KURZWELLEN AUF DEN EINZELNEN ÜBERSEELINIEN (Limits of Audibility and Most Favourable Traffic Times for Short Waves over various Trans-oceanic Routes).—E. Quäck and H. Mögel. (*E.N.T.*, December, 1928, V. 5, pp. 542–549.)

A series of elaborate coloured tables is given (based on measurements made at Geltow) showing the most favourable times and the limits of audibility, in dependence on time of year and time of day, for the various short-wave routes from Berlin to New York, Buenos Aires, Rio de Janeiro, Mukden, Bandoeng, Manila, Sydney and Bangkok. Echoes (direct and reverse) are also indicated. Each route is dealt with descriptively in a separate section. The waveband 10–40 m. is divided into three channels—day waves 10–18 m., transition waves 19–24 m., night waves 25–40 m. In general, a day and a night wave is enough for a 24-hour service: for certain routes the intermediate wave is necessary. Various interesting points are discussed: in the Berlin-Sydney route during the daylight period of the direct route, transmission is best by the reverse route, which has 20,000 km. in darkness: directional aerials and screens would have therefore to be reversed.

ÜBER PROBLEME BEIM BAU MITTLERER UND KLEINER SENDESTELLEN (Problems connected with the Construction of medium and small Transmitters).—v. Behringer and Graf. (*Telefunken Zeit.*, October, 1928, No. 50, pp. 16–21.)

An article on the preliminary calculations connected with the design of transmitters; the particular case taken being a long wave overland telegraphy set of power of the order of 5 kW. Curves relating to distance, height of masts, etc., are given.

NAUEN TO BUENOS AIRES: A DESCRIPTION OF THE SHORT-WAVE BEAM TRANSMITTING STATIONS. —(*Wireless World*, 16th January, 1929, V. 24, pp. 73–74.)

"The telephony service on short waves was opened on December 10th last. Each transmitter has a power of 20 kW., while the wavelengths are 14.83 and 15.34 m." The article is based chiefly on papers from the Telefunken staff (*cf.* Abstracts, February, 1929, under "Aerials") read at the meeting of German scientific workers last year. Esau's opinion that hollow mirrors, especially if made with a continuous metal surface, would give better directional effect than the flat aerials used, was not supported by the Telefunken engineers, who maintained that the directional effect with the latter was so sharp that no improvement in this direction was necessary.

Runge's receiver (for telephony and high-speed telegraphy) for wavelengths down to 10 m. is mentioned: it has four neutralised H.F. stages giving an amplification of about 500, followed by intermediate-frequency amplification of some 20,000—giving a total H.F. amplification of about a million.

DIE NEUE FLUGHAFENSENDERANLAGE IN ASPERN (The new Air Station Transmitter at Aspern). —R. Linsmayer. (*Suppt. to Elektrot u. Masch: bau*, No. 11, 25th November, 1928, pp. 97–101.)

Description of the new installation near Vienna, for C.W. and tonic train telegraphy and for telephony: input to aerial 3 kW. on a long dash. Wave range 600–3,600 m.

POSTE À ONDES COURTES TYPE H.C.8 POUR HYDRAVIONS ET AVIONS (Short Wave Set Type H.C.8 for Seaplanes and Aeroplanes). —(*Bull. d. l. Soc. Fr. Rad.*, November, 1928, pp. 13–20.)

For C.W. and I.C.W. telegraphy. Wavelengths (transmission) 50–60 m.; (reception) 45–65 m. Power to aerial 50–75 W. Total weight including converter, batteries, and wiring about 95 lbs.

POSTE À ONDES COURTES, TYPE A.C.1 (Short Wave Set, Type A.C.1.).—(*Bull. d. l. Soc. Fr. Rad.*, October, 1928, pp. 8–17.)

Illustrated description of 15–60 m. transportable set (receiver 10–100 m.) giving 40–45 watts to the aerial. Telegraphy only is provided for. Weight of transmitter about 34 lbs., of receiver 11 lbs.

LES CODES MÉTÉOROLOGIQUES (The Meteorological Codes).—(*QST Franç.*, November, 1928, pp. 8–15.)

First part of an article dealing with the subject. Tables show names and positions of the principal transmissions of meteorological observations (Meteo-regional, Meteo-France, and the international Meteo-Europe and Meteo-America), their call numbers and hours, the nature of the information and the symbolic form in which it is given.

BROADCASTING IN CANADA.—(*Nature*, 29th December, 1928, V. 122, p. 1006.)

A "News and Views" paragraph on a paper in the *Canadian Magazine*, which says that broadcasting in Canada is almost in chaos: there is not a single station in the United States or Canada which exists purely for the purpose of entertaining the public: all have ulterior motives of self-interest. The possibilities of a new system are discussed: the English system would be inapplicable because of the great differences in time across Canada; the language difficulty also is a very real one. Two main stations, one in eastern and one in western Canada, each with a train of relay stations, are suggested. The main difficulty is the financial one, and the only solution appears to be a sound, businesslike development of the advertising field.

In connection with the above, a paragraph in *The Wireless World*, 19th December, is of interest. Members of a Royal Commission appointed in Ottawa are to tour Britain, France and the U.S.A. to gather data on the respective merits of State and privately owned Broadcasting. "It is believed that the Canadian Authorities favour a system designed on B.B.C. lines."

LES PROGRÈS DES COMMUNICATIONS TÉLÉGRAPHIQUES ET TÉLÉPHONIQUES EN ALLEMAGNE (Progress in telegraphic and telephonic communication in Germany).—(*Génie Civil*, 29th December, 1928, V. 93, pp. 637–639.)

This article includes a map giving the broadcasting stations, principal and secondary, with their lines of communications (cable or overhead line).

LA STATION DE LA TOUR EIFFEL (The Eiffel Tower Station).—G. Martin. (*QST. Franç*, November, 1928, pp. 25–36.)

DIE ENTWICKLUNG DES RUNDFUNKS IN ÖSTERREICH (Broadcast Development in Austria).—(*Suppt. to Elektrot u. Masch: bau*, No. 11, 25th November, 1928, pp. 103–104.)

WHO'S WHO IN THE ETHER.—J. G. Abrahams. (*Wireless World*, 2nd January, 1929, V. 24, pp. 7–12.)

"A guide to the identification of distant transmissions." Among other hints, the cuckoo call of Ljubljana and the musical-box nine-chord tune of Budapest are mentioned.

AMPLITUDENBEGRENZER FÜR PROGRAMMÜBERTRAGUNG (Amplitude Control for Transmission of Programmes).—H. F. Mayer. (*Summary in E.T.Z.*, 13th December, 1928, p. 1816.)

The upper limit is best done at the last stage of the main amplifier. Here the charge of a condenser shifts the grid-potential of the preceding valve, so that the condenser voltage cannot increase beyond the voltage of the lower bend of the characteristic. The final value of voltage is reached in about 0.01–0.02 sec., so that only for such a time can the last valve be over-controlled. The discharge time for the regulating condenser is about 2 minutes.

LAUTSTÄRKEREGELUNG (Volume Control).—H. Ziegler. (*Telefunken Zeit.*, October, 1928 No. 50, pp. 21–24.)

Automatic control methods (*e.g.*, in broadcast transmission, to avoid sudden over-modulation) have the weak point that they flatten down the transmission. The present paper deals quantitatively with non-automatic shunt controls, applied in front of the first amplifier valve; a non-inductively wound variable resistance across the primary of the input transformer is shown to be preferable to a variable resistance across the secondary winding.

GENERAL PHYSICAL ARTICLES.

THE UNIVERSE AND IRREVERSIBILITY.—(*Nature*, 24th November, 1928, V. 122, pp. 808–809.)

Correspondence on Jeans' lecture (January Abstracts). J. B. S. Haldane points out that if Jeans' premises are correct, it is consistent to deduce that there is no need to assume a break in the order of Nature to account for the beginning of the present universe: if the present universe melts away into radiation, another equally improbable one will develop in the course of $10^{10^{100}}$ years. But it is perhaps unlikely that even a single atom will be built up from radiation in inter-galactic space during the "life" of the present universe.

THE AVERAGE LIFE PERIOD OF AN ATOM.—J. H. J. Poole. (*Nature*, 22nd December, 1928, V. 122, p. 960.)

Referring to Jeans' hypothesis as to the ultimate fate of atoms, the writer refers to data on the observed energy flow from the earth's surface, and deduces that the complete life of a terrestrial atom must be at least 10^{21} years: so enormous compared with the estimated age of the universe that we should be justified in treating our atom as eternal. A following letter from Jeans agrees with the above conclusions and refers to similar statements in his own publications.

NEUE UNTERSUCHUNGEN ÜBER DIE DURCHDRINGENDE HESSCHE STRAHLUNG (New investigations of the penetrating Hess radiation).—E. Steinke. (*Zeitschr. f. Phys.*, 14th May, 1928, V. 48, pp. 647–689.)

NUCLEAR DISINTEGRATION.—Kirsch, Pettersson, Bothe and Fränz (*Nature*, 15th December, 1928, V. 122, p. 939.)

A paragraph on the argument between the first pair of workers (Vienna) and the second (Berlin) as to the interpretations which should be placed on their respective experiments on artificial disintegration.

MEASUREMENTS OF THE VELOCITY OF SOUND IN AIR, NITROGEN AND OXYGEN, WITH SPECIAL REFERENCE TO THE TEMPERATURE COEFFICIENTS OF THE MOLECULAR HEATS.—W. G. Shilling and J. R. Partington. (*Phil. Mag.*, November, 1928, V. 6, No. 38, pp. 920–939.)

The molecular heats of air, nitrogen and oxygen have been determined over a temperature range 0 deg. C. to 1,000 deg. C. by a method depending on the measurement of the velocity of sound in the chemically pure gases. Further measurements for air up to 1,300 deg. C. are added.

THE BALLISTIC METHOD OF IONISATION MEASUREMENT WITH A QUADRANT ELECTROMETER.—D. L. Webster and R. M. Yeatman. (*Journ. Op. Soc. Am.*, September, 1928, V. 17, pp. 248–253.)

AN APPARATUS FOR THE MEASUREMENT OF RADIATION INTENSITY OVER A WIDE RANGE OF WAVELENGTHS (0.02 – 3 Angstrom).—O. Glasser and V. B. Seitz. (*Journ. Opt. Soc. Am.*, September, 1928, V. 17, pp. 240–247.)

A condenser unit, with electrometer attached, is charged to a known potential, after which it is removed and placed with its ionisation chamber in the field of radiation for a specified time. A second electrometer-reading is then taken, and from the loss of charge the intensity of radiation is found.

RECOMBINATION OF IONS IN THE CHAMBER OF AN X-RAY SPECTROMETER.—D. L. Webster and R. M. Yeatman. (*Journ. Opt. Soc. Am.*, September, 1928, V. 17, pp. 254–259.)

ROTATION OF MOLECULES INDUCED BY LIGHT.—C. V. Raman and K. S. Krishnan. (*Nature*, 8th December, 1928, V. 122, p. 882.)

Compounds which have a strong optical anisotropy (*e.g.*, benzene) exhibit the "wings" or nebulosity (accompanying the original lines of the mercury arc after scattering) to a very much greater degree than compounds much more nearly isotropic (*e.g.*, alcohol). This supports the writers' earlier suggestion that these "wings" are the effect of those collisions of the incident light-quanta with the molecules which result in a change of their rotational state. It appears reasonable to suppose that the probability of a spin being set up should depend (among other factors) on the degree of optical anisotropy.

FREQUENCY CHANGE IN SCATTERED LIGHT.—F. A. Lindemann, T. C. Keeley and N. R. Hall. (*Nature*, 15th December, 1928, V. 122, p. 921.)

Preliminary results are announced of work on the Raman effect using a plane polarised beam. The results would be explained if it were assumed that a polarised quantum can only interact with a linear oscillator if the plane of polarisation is perpendicular to the line in which oscillation occurs, and that it is re-radiated polarised parallel to this line.

THE SCATTERING OF X-RAYS FROM GASES.—C. S. Barrett. (*Phys. Review*, June, 1928, V. 31, pp. 1119–1120.)

X-RADIATION FROM GASES.—A. Björkeson. (*Nature*, 7th July, 1928, V. 122.)

The writer has, after many failures, succeeded in obtaining X-rays from gases—by directing a beam of electrons on to sodium vapour and sulphur vapour.

ATOMIC MAGNETISM.—K. Honda. (*Nature*, 1st December, 1928, V. 122, p. 858.)

A summary of Honda's account of his theory of the origin of magnetism in the September issue of the *Science Reports of the University of Sendai*. He shows that it explains many facts not covered by previous theories. He considers the atom to consist of a number of orbital electrons equal to the atomic number of the element, and a nucleus containing additional electrons equal in number to the difference between the atomic weight and the atomic number. Just outside these latter electrons a number of protons revolve in the opposite direction. The outer electrons cannot be magnetised by an external field, but the processional motion produced gives rise to the diamagnetism of the atom. In ferromagnetic atoms the magnetic moment of the nuclear electrons and protons nearly cancel each other and the atom is easily turned by an external field. In paramagnetic atoms, neutralisation is less complete and the external field has less effect. In diamagnetic atoms the magnetic moment is large and the field produces no effect on it, the diamagnetism being due to the outer electrons.

ON THE MAGNETISATION OF SINGLE CRYSTALS OF IRON AT HIGH TEMPERATURES.—K. Honda, H. Masumoto and S. Kaya. (*Sc. Rep. Tôhoku Univ.*, No. 2, 1928, V. 17, pp. 111–130.)

THE UNDERSTANDING OF RELATIVITY. (*Nature*, 2nd November, 1928, V. 122, pp. 673–675.)

Nine years have passed since the historic meeting at the Royal Society when the British eclipse expedition announced the confirmation of Einstein's prediction, from the general theory of relativity, that starlight would be deflected by the gravitational field of the sun. The silent, matter-of-fact way in which relativity has since then been absorbed into the general scheme of physics is remarkable, but the attempt to express relativity in ordinary language so that the general public may absorb it represents the most conspicuous failure of modern scientific exposition. The present article points out some of the ways in which such attempts have failed, and suggests how future methods of exposition can be improved.

THE UNDERSTANDING OF RELATIVITY. (*Nature*, 24th November and 15th December, 1928, V. 122, pp. 808 and 925.)

Correspondence on the article referred to above, including a letter (p. 925) from L. Bolton, who (as the Editor remarks) was awarded the big "Scientific American" prize in 1921 for the clearest explanation for general readers. On p. 934 there is also a "News and Views" paragraph on the subject.

PRODUCTION AND PROPERTIES OF HIGH-FREQUENCY RADIATION.—E. Rutherford. (*Nature*, 8th December, 1928, V. 122, pp. 883–886.)

From the presidential address delivered at the anniversary meeting of the Royal Society. The gap in frequency between ordinary ultra-violet light and soft X-rays has been bridged in the last few years. There appears to be no limit to the frequency that can be obtained by the bombardment of matter with electrons—other than the practical difficulty of obtaining streams of the requisite high velocity electrons. About a million volts have been successfully applied for a short time to an X-ray tube. The X-rays obtained were of such intensity and penetrating power that they could easily be observed by the luminosity on a phosphorescent screen 100ft. away.

But no X-ray has yet been produced to equal the γ-rays in penetrating power. The Einstein equation $E = mc^2$ is then dealt with, in connection with the energy-emitting transformations of radioactive bodies; the loss of energy (27,000,000 electron-volts) in the process of building a helium nucleus from free protons and electrons, and that in building a mercury atom (1,400,000,000 electron-volts) suggest that the formation of the simple helium nucleus may be one of the sources of energy radiation from the stars: and that the heavy and complex nucleus of mercury, *e.g.*, is unlikely to be built up in one act. Jeans' supposition, that the protons and electrons themselves are not indestructible, but may be transformed into radiation, is discussed. If the proton and electron disappeared together, with the liberation of one single quantum of energy, we should expect to obtain a γ-radiation corresponding to about 940,000,000 volts.

After classifying such a hypothesis as of a very speculative nature and possibly very difficult of direct proof or disproof, the writer agrees that the long life of the hot stars seems to demand some such process where the liberation of energy is enormous compared with the mass involved. "It is thus of very great interest to examine whether any direct experimental evidence can be obtained of the existence of such extraordinarily energetic γ-rays." This leads to a discussion of the ultra-penetrating radiation first observed by Hess and Kolhörster. The absorption coefficient of the most penetrating type of this radiation, deduced by Millikan and Cameron, is in excellent accord with that to be expected on the Klein-Nishina theory for a quantum of energy 940,000,000 volts: but, "although this agreement is suggestive, our theories of absorption are at present too uncertain to place much weight upon it." Also it should be remembered that the ultra-penetrating radiation may not be high-frequency γ-rays, but high-energy electrons entering our atmosphere. The paper concludes by pointing out the need for further information before we can draw any but tentative conclusions. So far, experiments have been mainly confined to measuring the ionisation produced in a sealed electroscope: experiments are needed analogous to those of Skobelzyn (on the relative intensities of the main γ-rays from radium C), using a Wilson expansion chamber. The β-particles produced by the penetrating radiation could also be counted by a Geiger counter.

MISCELLANEOUS.

METHOD AND APPARATUS FOR THE MEASUREMENT OF DISTANCES BY THE USE OF ELECTROMAGNETIC WAVES.—(*British Patent No.* 288,233, Koulikoff and Chilowsky, acc. 6th September, 1928.)

To determine the distance between A and B, waves from A having a frequency of N_1 are received at B by a circuit tuned to N_1: they are amplified and may be rectified. The rectified current acts upon the grid of the oscillating circuit of a transmitter B' (close to B) and causes this transmitter to transmit waves of frequency N_2, which are received by a receiver A' (close to A) tuned to that frequency, and after amplification and perhaps rectification are used to act on the transmitter A. Thus a succession of trains of waves are obtained whose period (which can be measured by a wavemeter) gives the distance between A and B by the formula $d = \frac{c}{2N_m}$. Another variation of the method uses the same frequency at the two stations instead of the different frequencies N_1 and N_2.

RADIO ALTITUDE GAUGE. (*Science News Letter*, 24th November, 1928, V. 14, p. 317.)

Alexanderson described, before the Nat. Acad. Science (November 19th–21st, 1928), a method of using the reflection of radio waves back to an aeroplane from the ground as a method of measuring the height of the aeroplane: "by the effect of the returning wave on the actual transmitter: this effect is to change the wavelength of the transmitted wave, and so it affects the strength of the returning wave. Thus by measuring this strength of the returning wave and the number of changes in step, the distance is determined." He also suggested the use of two oscillators of slightly different frequency, which could be arranged to light a green lamp when the aeroplane was at 240 feet and a red lamp at 80 feet. *Cf.* Koulikoff and Chilowsky, above.

ALARM ALTIMETER.—(*Scient. American*, June, 1928, p. 551.)

Photograph of a device for use in ballooning: when the balloon approaches the ground too closely for safety, a light flashes and a buzzer sounds.

LES ONDES ULTRASONORES (Supersonic Waves).—S. Weil. (*Revue scientif.*, 13th October, 1928, V. 66, pp. 590–596).

An account of the work of Wood, Richard and Loomis on the generation of these waves and on their physical, chemical, thermal and physiological actions.

THE SOUND RANGERS.—G. E. Moore. (*Electrician*, 9th November, 1928, V. 101, p. 517.)

"Being memories of a little-known Technical Unit at the Front—Some Applications of Electricity in the Great War—Importance of the Hot-wire Microphone."

LA T.S.F. ET LA STRATÉGIE NAVALE BRITANNIQUE (Wireless and British Naval Strategy).—Commandant X —. (*QST. Franç.*, November, 1928, pp. 47–52.)

This article, based on the publication entitled "British Official Wireless Messages to Merchant Ships," begins by a lengthy analysis of Lord Jellicoe's "Naval Policy of the Empire" in the 1926 *Naval Annual*.

RAY OF DEATH—AND LIFE.—(*Daily Express*, 9th January, 1929.)

The Berlin correspondent reports an interview with Esau on the subject of his cigar-box-sized transmitter for wavelengths below 3m. "Flies and insects which pass across this field drop dead. Mice are killed in a few seconds. . . . If we succeed in perfecting our apparatus we shall be in a position without in any way injuring the tissue to kill disease-causing bacteria within the human body." *Cf.*, Abstracts, 1928, V. 5, p. 640.

BURGLAR ALARM, ETC., DEPENDING ON THE VARIATION OF AN OSCILLATING CIRCUIT.—(French Patent No. 644354, Laboureur and Briot, published 6th October, 1928.)

The action of the burglar upsets the tuning of the grid circuit of an oscillating triode, and thus causes a large change of plate current which works a relay.

ACOUSTIC MARINE SOUNDING.—(French Patent No. 641969, Marti, published 14th August, 1928.)

A fixed electromagnetic oscillograph actuated by one single microphone records the sound wave as it is emitted and as it returns after reflection; by a suitable arrangement of distances, the microphone retains its sensitivity after the first (large) impulse so that it can record the second even if this arrives a very short time later.

VACUUM TUBE SYNCHRONISING PROVES ADVANTAGEOUS.—(*Elec. World*, 17th November, 1928, V. 92, p. 996.)

A small coupling condenser with two stages of low frequency amplification has been used for synchronising, at an American hydro-electric plant, with great success for over a year. Maintenance cost has been practically zero, and the method dispenses with the high-voltage transformers, fuses, etc., usually needed for the operation of a synchroscope.

APPARATUS FOR THE GENERATION OF ELECTRICITY. M. E. L. M. Rolot. (French Patent No. 642771, published 4th September, 1928.)

Molecules of oxygen or of ozone, at pressures of the order of 100 kg/cm², finding themselves in the magnetic field of a magnet are put in motion and traverse one or more solenoids, in which they produce induced currents.

ÜBER EIN NEUES PRINZIP ZUR HERSTELLUNG HOHER SPANNUNGEN (A New Principle for the Production of High Voltages).—R. Wideröe. (*Arch. f. Elektrot.*, 17th December, 1928, V. 21, pp. 387–406.)

An investigation of the possibilities of using electrons or ions to generate very high voltages (*cf.* French Patent, above). Theoretically there are two methods, one in which the electrons are compelled to rotate in an electrical rotating field, the other in which they (or the ions) are accelerated in several potential fields one after the other. The former method is dismissed for the present as too difficult, but the latter is worked out in detail and actually tried on a small scale. Ions are more practicable than electrons owing to their lower speeds.

INCREASE IN CONDUCTIVITY OF GLASS UNDER ELECTRON BOMBARDMENT.—W. R. Ham, M. H. White and H. R. Kiehl. (*Phys. Review*, June, 1928, V. 31, p. 1128.)

NEUE STARKLICHTLAMPEN MIT WOLFRAM-EINKRISTALL (New High Candle-power Lamps with Single-crystal Tungsten Filaments).—— . Salmony. (Summary in *E.T.Z.*, 20th December, 1928, p. 1855.)

After describing the known processes for obtaining single-crystal filaments, the writer deals with a special form of tungsten filament (covered by German Patent No. 459651). Filaments of various shape can be used. With one form of filament, the consumption is 0.45W. per Hefner Candle (1 HK = 0.9 Candle). A spherical-spiral form gives a light density of 1700–1800 HK per cm². These filaments give reduced sputtering and consequent blackening.

RADIO-TELEGRAPHY AND RADIO-TELEPHONY: A REVIEW OF PROGRESS.—E. B. Moullin. (*Journ. I.E.E.*, January, 1929, V. 67, pp. 170–176.)

TALKING FILMS NO. 2. THE BRITISH ACOUSTIC FILM SYSTEM.—(*Wireless World*, 26th December, 1928, V. 23, pp. 842–844.)

LE V[e] SALON ANNUEL DE LA T.S.F. (The 5th Annual Wireless Exhibition).—(*Rev. Gén. de l'Élec.*, 1st and 8th December, 1928, V. 24, pp. 821–827 and 868–873.)

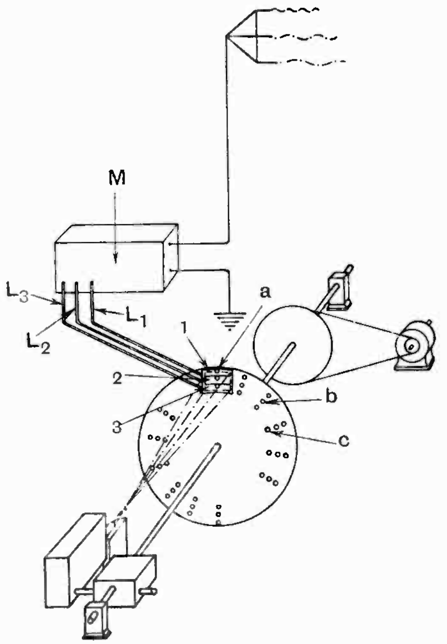
Some Recent Patents.

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 1s. each.

TELEVISION APPARATUS.

(*Application date, 8th June,* 1927. *No.* 298255.)

In order to reduce the speed of the rotating "scanning" discs used for transmitting and receiving animated visual effects, three or more



separate sets of spirally-staggered holes *a, b, c* are used to analyse simultaneously three distinct segments 1, 2, 3 of the object being televised. The elative setting of the spiral series of holes *a* is such that in each rotation of the disc they completely traverse the segment 1. Similarly the series *b* and *c* traverse the segments 2 and 3.

Separate frequencies are used for each segment and are fed along leads L_1, L_2, L_3 to the modulating apparatus *M*. A similar synthesising disc is used at the receiving station. Small light-sensitive cells may be fitted in each hole in the transmitter disc, each cell being connected to an insulated slip-ring from which the leads L_1, L_2, L_3 are fed through brushes. At the receiving end the spiral holes may be replaced by small neon lamps.

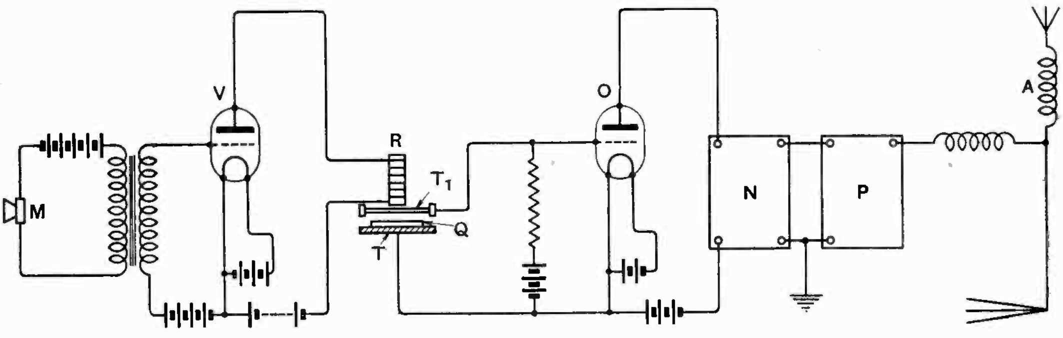
Patent issued to R. L. Aspden.

SIGNALLING BY FREQUENCY MODULATION.

(*Convention date* (*U.S.A.*), *17th March,* 1927. *No.* 287459.)

When transmitting music and speech on an ordinary or amplitude-modulated carrier, the attendant side-band frequencies usually extend over some 16,000 cycles. By utilising a system wherein the amplitude of the carrier is maintained constant, but its frequency is made to vary in sympathy with the applied low-frequency signals, the width of the side-bands is stated to be reduced to a few hundred cycles only, thus lessening the risk of overlap in areas where the available ether space is overcrowded.

The transmitting circuit is shown in the Figure. Signal current from the microphone *M* is applied to an amplifier *V*, in the plate circuit of which is an electromagnet *R*. A piezo-crystal *Q* is mounted between a fixed electrode *T*, and a movable electrode T_1 vibrated by the amplified currents passing through the electromagnet *R*. The piezo-crystal is located in the grid circuit of an oscillation-generator *O*, the output of which therefore varies in frequency according to the movements of the armature-electrode T_1. The frequency-modulated output from O is then passed through a frequency-multiplier *N*, and power-amplifier *P* to the transmitting aerial *A*. At the receiving end a highly resonant circuit is adjusted slightly off the mean carrier-frequency, and detection is effected by the travel



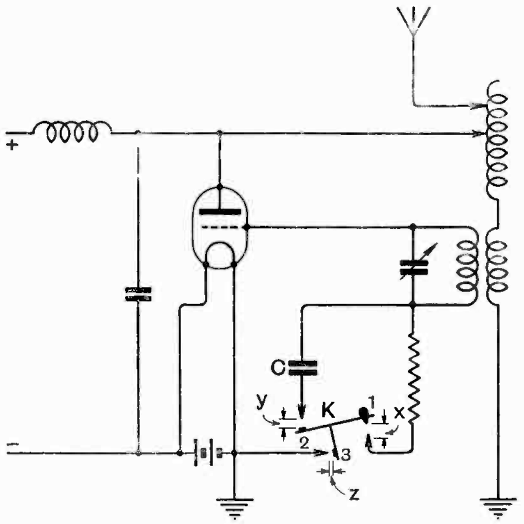
of the incoming signal-voltages along the slope of the resonance curve.

Patent issued to Westinghouse Electric and Manufacturing Co.

HIGH-POWER KEYING.

(*Application date, 8th September,* 1927. *No.* 299151.)

In order to prevent heavy sparking when keying high-power valves the grid circuit is made and



broken in a definite sequence. On breaking, the leak-resistance branch is opened first, and afterwards the branch containing a grid condenser; whilst in making, the condenser branch is closed first, to dispose of any residual charge, and then the resistance branch.

As shown in the Figure, the three contacts of the key *K* open in the order 1, 2, 3. The spark which would normally occur on the opening of 1 is absorbed by the condenser *C*, which can still discharge through contacts 2 and 3. If any residual charge is left in the condenser *C* when contact 2 opens, it can still discharge through contact 3 which is broken last. On "making," contacts 3 and 2 close in that order, so that any condenser charge flows to earth. Lastly, contact 1 closes to connect the leak-resistance to earth, so that the valve oscillations recommence smoothly and at once. The distance *x*, *y* and *z*, in diminishing order, are adjusted by means of screws.

Patent issued to Siemens Bros. & Co., Ltd.

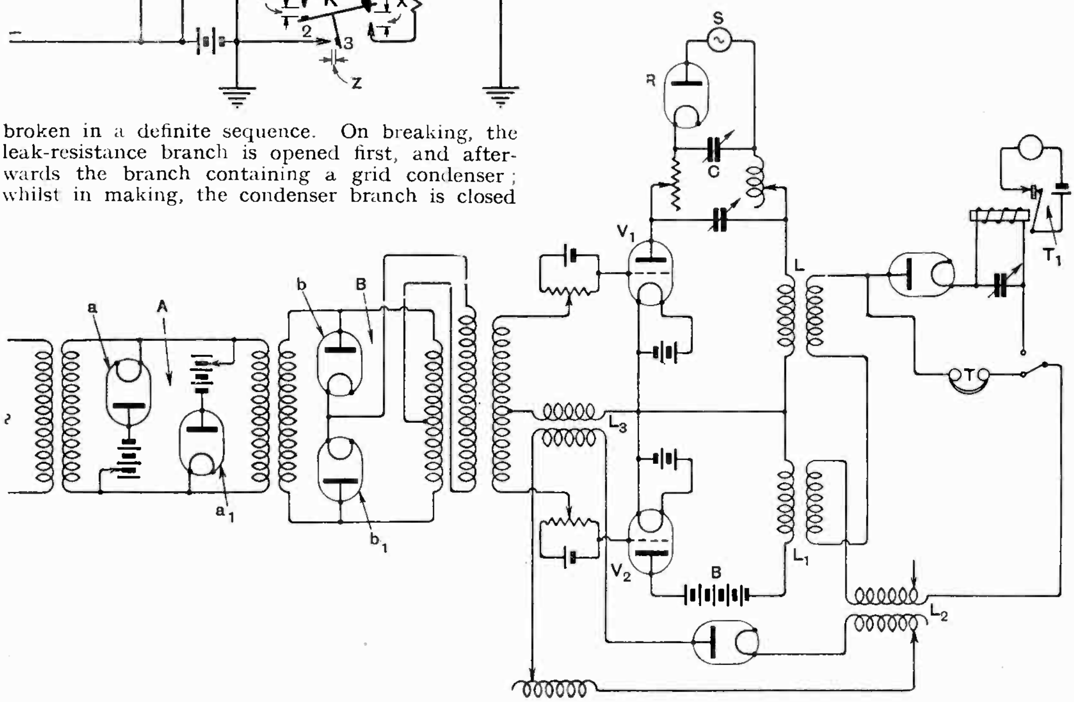
PREVENTING INTERFERENCE.

(*Application date, 25th June,* 1927. *No.* 297709.)

Relates to a method of eliminating atmospherics which depends upon the use of what is called a "fatigue" circuit in combination with a "constant" circuit. The two circuits are fed from a common input, but the outputs are opposed so that a sudden impulse which affects both the "fatigue" and constant circuits alike is balanced out, whereas a prolonged signal wears out the opposition of the "fatigue" circuit and so wins through to the telephones or recorder.

By a suitable initial setting of the two circuits the arrangement can be used to separate out a desired signal from an interfering signal of different frequency.

As shown in the Figure the incoming signals after suitable amplification are fed through an



intermediate circuit A comprising current-limiting devices a, a_1 to a circuit B fitted with full-wave rectifiers b, b_1. The rectified energy is then transferred to two thermionic amplifiers V_1, V_2 arranged in push-pull. The amplifier V_1 is fed with an adjustable supply of rectified high tension from a source S through a rectifier R, reservoir condenser C, and smoothing impedance. This forms the "fatigue" circuit because any prolonged signal applied to the grid of that valve will exhaust the H.T. supply, and so render the valve ineffective. The amplifier V_2 is supplied from a steady H.T. battery B. The output is reversed across the windings L, L_1, any resultant effect in the coil L_2 being back-coupled through a coil L_3 to the input circuit. The signals may operate a telegraphic relay T_1 or pass to a pair of telephones T.

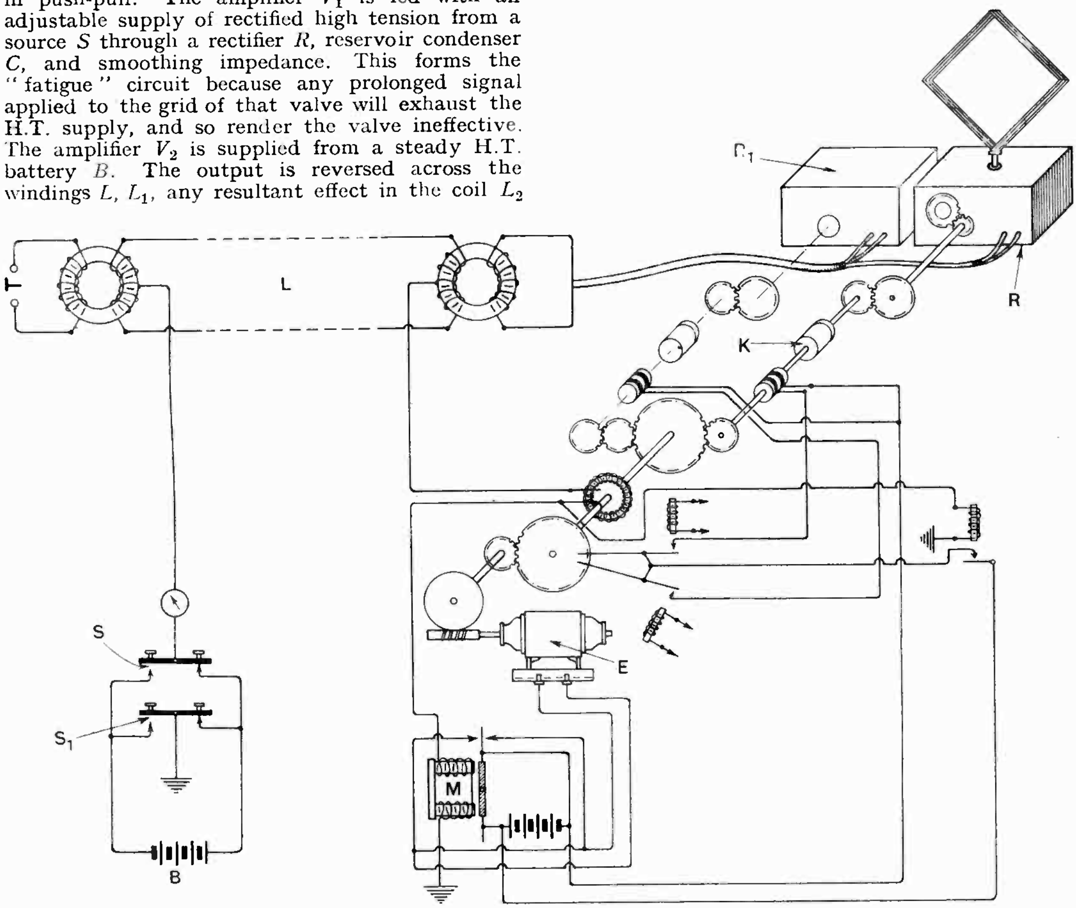
Patent issued to E. G. Gage.

REMOTE CONTROL OF RECEPTION.

(*Convention date* (*Germany*), *22nd February*, 1927. *No.* 285835.)

The invention contemplates the installation of a wireless broadcast service designed primarily for the distribution of urgent news, or for stock-exchange quotations and similar information of business value. In such a case the service must be available at any moment of the day, and the message must be absolutely clear and dependable. To meet these requirements the receiving aerial should preferably be located some distance outside the town so as to be clear of serious sources of interference.

In order to give a business house efficient control of the distant receiver, without the necessity of employing a special operator at the distant point, tuning to any desired wavelength is effected through local switches, the current necessary to operate the distant relays being carried by the low-frequency speech line. According as the switch contact S or S_1 is closed, the positive or negative pole of the battery B is connected to line L, and a distant relay M is thrown to one side or other to reverse the direction of rotation of a motor E. This in turn controls the setting of the tuning-condenser of the receiver R through the chain of gearing shown. The gearing includes (1) a magnetic clutch K which is released when the local contact S or S_1 is raised (as the required message is heard), and also (2) means to prevent over-running of the gear and possible displacement of the final condenser setting. A duplicate receiver R_1 can be switched into circuit should a valve burn out.

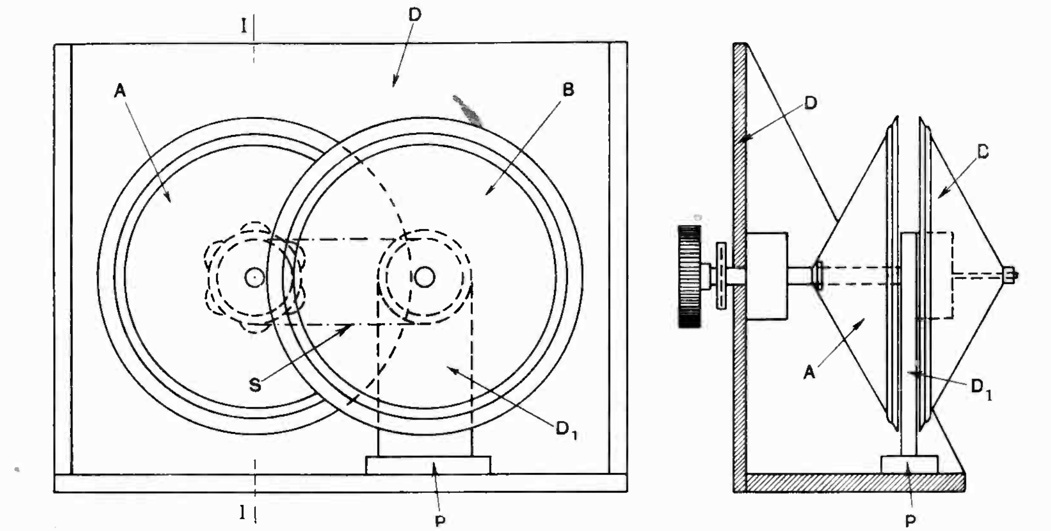


Patent issued to the C. Lorenz Co., Ltd.

DUPLEX LOUD SPEAKERS.

(*Convention date* (*Germany*), *27th January*, 1928. *No.* 300849.)

The capacity of a loud speaker to reproduce high and low notes depends to a large extent upon



the size of the resonating surfaces. In order to attain an equal overall response, covering a wide range of frequencies, two separate cone speakers *A*, *B* are used in combination, as shown. The diaphragm of the speaker *A* is mounted on a large resonant panel *D* of three-ply wood. It therefore tends to emphasise the lower notes. The diaphragm of the second speaker *B* is, by contrast, mounted on a rigid non-vibrating support D_1 secured at its lower end to a heavy base-plate *P*. It therefore reproduces at a higher pitch than the first. By mounting the two speakers so as to overlap, and by arranging the conical diaphragms face to face as shown, a correct balance between the high and low notes can be secured. At the same time, the resultant sounds appear to come from a single origin. A single control band *S* is used to adjust the air-gap in the magnetic drive of both speakers simultaneously.

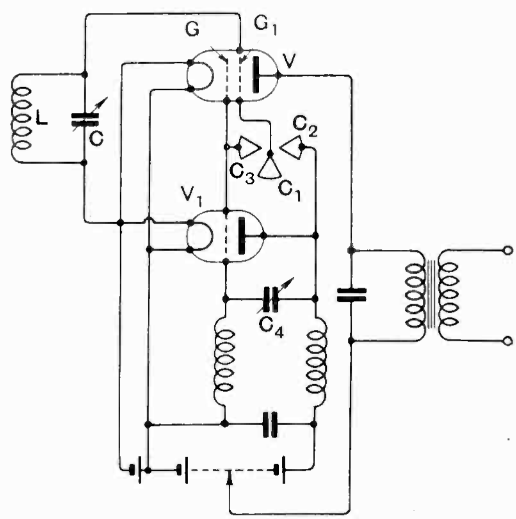
Patent issued to the Radiophon Co.

HETERODYNE RECEPTION.

(*Convention date* (*France*), 13th *July*, 1927. *No.* 293839.)

A two-fold heterodyne effect is secured from a four-electrode valve with the object of increasing or, under certain conditions reducing, the normal signal strength. The aerial input is applied from the tuned circuit *L*, *C* across the grid G_1 and filament of the tetrode *V*, and is combined in the plate circuit with oscillations of a slightly different frequency generated by the back-coupled triode V_1 and applied to the grid *G*.

A three-pole condenser C_1, C_2, C_3 couples the local oscillator V_1 to the grid G_1 of the tetrode *V*. As the plates C_2 and C_3 are across the condenser C_4 the momentary voltages at these points are in phase opposition. The two heterodyne effects therefore either reinforce or neutralise each other according as the plate C_1 overlaps the plate C_2 or C_3. If the signal wave-length is longer than the local oscillation, the two heterodynes add together in the plate circuit when the plate C_1 overlaps the plate C_2, whilst they neutralise each other if the coupling is between C_1 and C_3. On



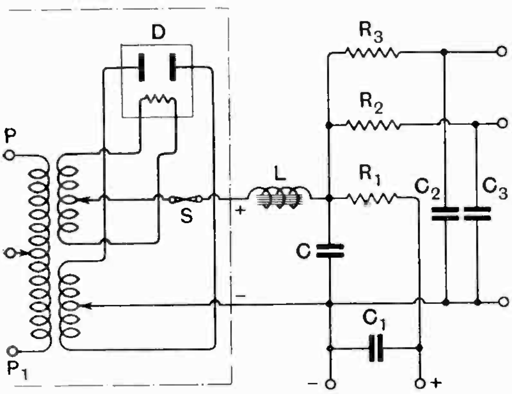
the other hand, if the incoming signal is shorter in wave-length than the local oscillations, these conditions will be reversed.

Patent issued to H. J. J. M. de R. de Bellescize.

MAINS SUPPLY UNITS.

(*Convention date (Germany), 4th August,* 1926. *No.* 275624.)

The use of choking-coils in the smoothing circuit of a main-eliminator unit is necessarily costly



where the circuit is designed to pass the considerable output required for power amplification. Resistance-capacity networks have been used as an alternative, the smoothing action in this case increasing as the product of the resistance and capacity elements in circuit. The latter method has, however, the drawback of introducing a large voltage drop, which, particularly in the first stage, varies according to the current consumption of the later or power amplifying stages.

In order to overcome this defect, a separate resistance-capacity filter cirucit is provided, in parallel, for each stage of valve amplification, the separate filter units being individually designed according to the output and the degree of smoothing required. As shown, the input supply across the points P, P_1 is fed to a rectifier D, the output circuit of which comprises a safety-fuse S, choke L, and blocking condenser C. From here the first filtering-circuit, comprising a resistance of R_1 of 60,000 ohms and a condenser C_1 of 2 mfds, feeds the first high-frequency valve, which is most sensitive to supply fluctuations, but consumes least current. A second circuit, containing a resistance R_2 of 25,000 ohms and a condenser C_2 of 2 mfds., feeds the detector valve, whilst a resistance R_3 of only 300 ohms, shunted by a condenser C_3 of 4 mfds., supplies the power valve, where an adequate output is of more importance than efficient smoothing.

Patent issued to Siemens & Halske Akt.

Important Patent Decision.

Reserved judgment has now been given in the action in which the Lektophone Corporation of Jersey City, U.S.A., sued Messrs. S. G. Brown, Ltd., of Willesden, N.W., for the sale of "Mascot" loud speakers in infringement of the former's patent rights.

The Lektophone Corporation are legal owners of Patent No. 16602 issued in 1914 to Marcus Clarence Hopkins, which claims "A sound regenerating machine—in which a tympanum of at least nine inches in diameter is provided, freely exposed to the air in which the sounds are to be propagated, the tympanum having a central conical portion surrounded by an annular portion which is supported in a rigid manner at its periphery."

Plaintiffs alleged that the "Mascot" loud speaker as sold by Messrs. S. G. Brown fell within this claim, which by inference covers any loud speaker of the same general type, *i.e.*, in which a large disc or cone with clamped edges radiates directly into the surrounding air, *i.e.*, without the intervention of a horn.

Defendants denied infringement, and counterclaimed for the revocation of the patent in question on the grounds of lack of novelty and subject matter, and of insufficiency of description.

During the course of the hearing, expert evidence was given on both sides by various eminent authorities. Dr. Eccles, F.R.S., in particular occupied the witness box for the best part of five days, and answered approximately 2,500 questions.

The main issue centred around the point as to whether a sound-reproducing diaphragm invented in 1914 for use with a gramophone could reasonably be held to apply to the modern loud speaker as used in combination with thermionic valve amplifiers for broadcast reception.

Defendants' Counsel contended that the Hopkins patent extended only to machines of the stylus-driven type in which the driving power is small by comparison with that delivered from a multi-valve receiver.

In delivering his considered judgment, Mr. Justice Tomlin accepted this view. He pointed out that at the time of the Hopkins patent the use of sound reproducers was practically limited to gramophones and similar stylus-driven machines. The thermionic valve amplifier as used in modern Broadcast reception was then unknown. His Lordship went on to say that he had seen a number of loud speakers said to have been constructed under licences issued by the Plaintiffs—the owners of the Hopkins patent. Many of them seemed to him to bear little resemblance to the Hopkins diaphragm, but he was not concerned to say more on this point. In his view the Mascot loud speaker did not infringe the Hopkins patent, and he gave judgment for the Defendants (Messrs. S. G. Brown) accordingly on the issue of infringement.

The Defendants' counterclaim had not however been sustained. His Lordship found the Hopkins patent valid as applied to a stylus-driven machine. On this point judgment would accordingly be in favour of the Lektophone Çorporation.

His Lordship divided the costs on the main issue, four-fifths to the Defendants, and one-fifth to the Plaintiffs. On the counterclaim costs followed the judgment.