EXPERIMENTAL WIRELESS & The WIRELESS ENGINEER

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Editorials.

Radio Transmission and the Upper Atmosphere.

FOR many years after Heaviside and Kennelly first suggested that the upper atmosphere played an important part in long-distance radio telegraphy our ideas as to the exact role played by the ionised layer were very vague. If the layer were conducting it would act as an upper guide just as the earth acted as a lower guide and the waves would spread out in the thin atmospheric spherical shell between them, thus causing much less attenuation over large distances than would have been the case had the waves been free to radiate into space. All long-distance communication was at that time carried out with very long waves and this simple explanation seemed to fit in fairly well with the observed phenomena. The very long ranges sometimes obtained with shorter waves could hardly be explained by reflection at the surface of a layer, but Dr. Eccles' theory that the waves entered the layer and were refracted in it owing to their velocity being greater in the ionised medium than in the un-ionised atmosphere offered an alternative explanation which has proved very fruitful in its further development. That was in 1912, and although little progress in our knowledge of the subject was made during the War, the last few years have seen phenomenal strides in what might be called the technique of the wireless investigation of the upper atmosphere.

Different methods have been used by different investigators and it was questionable to what extent these various methods might be expected to give concordant results. Did the so-called equivalent height of the ionised layer as determined by one method mean exactly the same thing as the equivalent height as determined by another method? This question has been investigated very thoroughly by Prof. E. V. Appleton, who communicated a paper on the subject at the Brussels meeting of the Union Radio Scientifique Internationale in September and again recently at a meeting of the Physical Society. The investigation is necessarily highly mathematical but the results can be explained fairly simply.

Three Comparative Methods.

Three methods are compared, viz., the wavelength change method, the angle of incidence method, and the group-retardation method.

The first method was proposed and developed by Appleton and Barnett. The carrier wave of a transmitting station reaches a distant receiving station by two paths, one along the ground and the other via the upper atmosphere; if these two rays arrive in phase the signals have a maximum intensity, if they arrive in opposition the signals have a minimum intensity. If now the transmitting station gradually increases or decreases its wavelength, the received signal passes through successive maxima and minima and the change of wavelength necessary to pass from one maximum to the next enables one to calculate the difference of path of the two rays and thus, on certain assumptions, to deduce the height of the ionised layer.

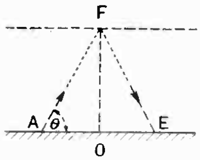


Fig. 1

The second method—a fairly obvious one—also proposed by Appleton and Barnett, and used both by them and by Smith-Rose and Barfield, consists in determining the angle at which the downcoming wave arrives at the receiving station. Assuming reflection at an upper horizontal surface, this suffices to fix the height of the surface.

The third method was proposed and used in the United States by Breit and Tuve. They sent out very short pulses and measured the interval elapsing between the arrival of the pulse by the ground path and the atmospheric path.

What the Different Methods Revealed.

If the atmospheric ray travelled with a constant velocity until it met the lower surface of an ionised layer and were there reflected as shown in Fig. 1, all three methods would necessarily give the same result for the height OF, unless the reflection introduced a change of phase which varied with the wavelength. If, however, the ray enters the ionised layer, and, due to the increasing ionisation and consequent increasing velocity with increased height, is refracted along such a curved path as BCH in Fig. 2, it is by no means evident that the three methods should give the same result, in fact, at first sight, it looks rather improbable. It is interesting, therefore, to know that a complete theoretical investigation shows that all three methods should lead to the same value of the equivalent height of the layer, so that, if Fig. 1 be drawn to give the path difference $AFE - AOE$ calculated from the observations of the first or last method, not only should they both give the same equivalent height OF, but the angle θ should be the same as the angle θ_1 (Fig. 2) observed by the second method, and the point F_1 should coincide with the point F.

When a train or group of waves enters the ionised medium we must be quite clear in our minds as to the meaning to be attached to the velocity of the waves. In an article on "Phase and Group Velocities in an Ionised Medium" (Vol. 4, p. 259, May, 1927) we explained that if one earmarks any hill or dale in the wave, one finds that it is moving with a higher velocity than it did in un-ionised air, that is, with a velocity greater than C, the velocity of light. It is due to this that the ray is refracted downwards and emerges again from the ionised layer. If, however, one regards a group of waves as a whole, one finds that the head or tail of the group is moving with a velocity less than the velocity of light. If the refractive index of the ionised medium be called μ—something a little less than unity—the phase velocity will be c/μ, and the group velocity $c\mu$. The refractive index gradually decreases as one penetrates the ionised layer.

As the ray follows the path BCH in Fig. 2 its phase velocity is greater than c, and on emerging at H its phase will correspond to some path less than BCH, that is to say, its optical path is less than its actual path. In mathematical language its real path is $\int ds$, whereas its phase on emerging at H corresponds to a path $\int \mu ds$. How then can the first method, which depends on the phase of the wave arriving at E, give a result indicating an effective height OF_1, for the path BF_1H is obviously longer than BCH? The answer to this is that the first method does not depend on the phase of the arriving wave, but on the change of its phase when the wavelength is changed—a very important distinction. The refractive index of the ionised medium depends on the wavelength and therefore when the wavelength is changed, the ray changes its path and the integral $\int \mu ds$ gives a different value. Analysis shows that this apparent complexity leads to the surprisingly simple and satisfactory result that the equivalent height as usually calculated by the first method, neglecting the change of path, gives the value OF_1 obtained from the angle of the downcoming wave.

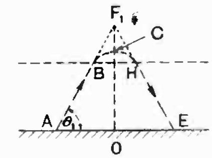


Fig. 2

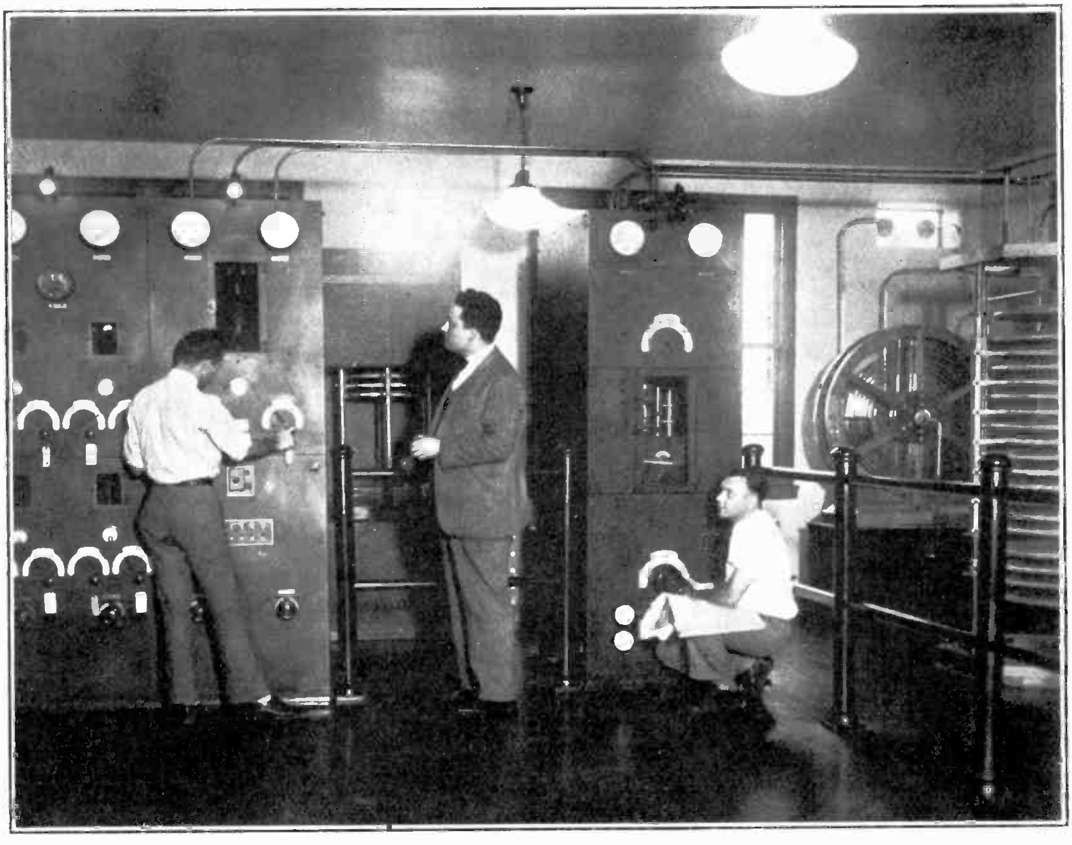
The third method takes no account of the phase of the wave arriving from the atmosphere, but depends only on the time of arrival of the group of waves constituting the pulse. Now this depends on the group velocity which, as we have seen, is decreased in the ionised medium so that the time elapsing between the ray entering the ionised layer at B and leaving it at H corresponds to a path longer than the actual path BCH; the actual path is $\int ds$, whereas the equivalent path is $\int \frac{ds}{\mu}$. Here again analysis shows that the method leads to the same result as the other two methods, because this slowing down makes the time taken along the path BCH exactly the same as it would have been along the path BFH at the velocity of light.

Hence, neglecting any effect that the earth's magnetic field may have on the problem, all three methods should give the same value OF_1 for the equivalent height of the ionised layer, but this is a greater height than the refracted ray ever reaches.

G. W. O. H.

Completion of the Volume.

The present issue completes the year's volume of *Experimental Wireless* and readers will see that we have made arrangements which have enabled us to include the index to the volume and the special index to the year's abstracts in this number instead of waiting for the January issue before incorporating this information, as was done in the case of the last volume. This obviates the necessity of detaching the index from the January number for binding purposes.



WEAF, which has recently changed its wavelength from 491.5 to 454.3 metres. The station is crystal controlled and the wavelength change took place without interruption in the service.

The Graphical Estimation of Low-frequency Choke Amplifier Performance.

By W. A. Barclay, M.A.

Of the different kinds of valve characteristic graphs now in common use, the plate voltage-plate current type is perhaps the most generally serviceable to the experimenter. This form of valve characteristic has already been fully described in the pages of this journal (see *i.a.*, the articles by Mr. E. Green of July-Aug. 1926 and Aug. 1927), while in a recent note on "Calculations for Resistance Amplifiers," Mr. A. L. M. Sowerby utilised this characteristic to derive the best values of resistance, etc., suitable for given conditions of amplification. It is natural to inquire if by means of an analogous procedure similar optimum values might be obtained for the case of choke-coupled L.F. amplification. Unfortunately, any direct solution of this problem is rendered impossible by reason of the increased number of variables of which we have to take account. Whereas in the case of a resistance amplifier (neglecting coupling capacity) all frequencies are theoretically amplified in the same proportion, the same does not hold true for a choke. In addition, the constants of the choke itself are two, an inductance and a resistance, so that we have now three variables to consider instead of one.

We must, then, fall back on some indirect means of ascertaining which values of our components are likely to give best results, and for this purpose there is nothing for it but to take several arbitrary values of the choke constants and frequency, deducing from them and the characteristics of the valve the best conditions of operation which will give good amplification without distortion. Normally, the amount of arithmetical labour entailed in doing this work is entirely prohibitive, and, however regrettable it may be, the sad fact remains that the ultimate selection of choke, valve and voltage values to be used is usually made without due regard to securing the greatest possible efficiency. To provide a rapid means of estimating and comparing amplifier performance for selected values of voltage, frequency and choke is the object of the present article.

The subject-matter which follows arranges itself naturally into three parts. The first of these is devoted to a statement of the problem to be solved, the true nature of which is not always appreciated by the experimenter. The second describes a simple graphical construction which has been devised by the writer to solve the problem. The last section contains a mathematical analysis of the problem and proof of the construction.

1. The Problem Stated.

On the plate voltage-plate current diagram, the individual values of grid potential appear as curves which are approximately linear over a considerable portion of their length. Within this linear field the characteristics may be represented by the equation

$$i_a = \frac{e_a - E_o + \mu_o e_g}{R_o}$$

where the symbols have their usual significance. In particular, E_o is that value of voltage in which the straight portion of the characteristic $e_g = 0$, if produced, would meet the voltage axis (a result equivalent to putting $e_g = 0$ and $i_a = 0$ in the above equation). Further, let $I_{min.}$ denote that value of anode current below which the characteristics are curved, and above which, consequently, is situated the linear field of the diagram. Then the conditions for distortionless amplification are expressed by saying that the working point of the diagram must confine its excursions to the linear field above $I_{min.}$, and that no grid current must be allowed to pass. This second condition is secured in practice by confining the movements of the point to the right of the curve for $e_g = 0$, *i.e.*, by ensuring that the grid voltage e_g is always negative. For choke-coupled amplification the working point will describe an ellipse the position and dimensions of which depend on various factors, such as signal strength, H.T. voltage, the choke constants, and the frequency (see Fig. 1). At any particular frequency the working point describes the corresponding ellipse once in every cycle of oscillation,

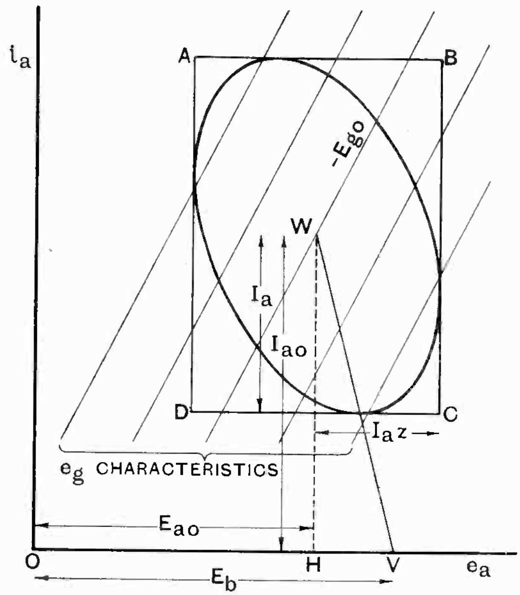


Fig. 1.—*Showing the elliptical locus of the working point on the i_a-e_a diagram of L.F. choke amplifier.*

and in its progress relates pictorially the values of plate voltage, e_a, anode current, i_a, and grid voltage, e_g, which obtain at every instant of the cycle. It is proved in the subsequent analysis that, subject to the two conditions before-mentioned, the variation of all three of these quantities is uniformly sinusoidal, so that a true amplification of signals at that frequency is obtained.

If L and R denote the inductance and resistance of the choke, and f the frequency, we may write for the ohmic value of the choke impedance $z = \sqrt{R^2 + \omega^2 L^2}$, where ω as usual denotes $2\pi f$. Then, if a rectangle $ABCD$ be described about the working ellipse of Fig. 1 with sides parallel to the axes, it will be shown later that the ratio of the voltage represented by AB to the current represented by AD is a measure of z; *i.e.*, the slope of the diagonal BD is proportional to $1/z$. The actual size of the ellipse, of course, is determined by the signal strength; when this is zero, *i.e.*, when no signals are passing, the ellipse collapses to its central point W. This point represents the initial or steady values of the quantities, which may be denoted by the symbols E_{ao}, I_{ao}, and E_{go}. When no signals pass, the steady current I_{ao} through the choke will cause a potential drop across it of RI_{ao}, and if E_b denote the H.T. battery voltage we have immediately

$$RI_{ao} = E_b - E_{ao} \qquad \ldots \quad (1)$$

If the points H and V represent the values of E_{ao} and E_b respectively on the voltage axis, we shall have

$$\frac{HW}{HV} = \frac{1}{R}.$$

We see, therefore, that if through V a line of slope $-\frac{1}{R}$ be drawn, the centre W of the ellipse will lie somewhere on this line, its precise situation being dependent on the value of grid bias in use, as represented by the particular negative E_{go} line chosen to intersect it. We have, then, to seek for some means of obtaining the most suitable value of grid bias for the given conditions of operation.

It is clear that the number of possible rectangles with inscribed ellipses that may be drawn is infinite, and that without more data to go on the choice of a particular curve must be entirely arbitrary. Now, the size of the ellipse depends on the amplitude of the signal, and as in all cases we wish the signal to be the maximum possible, we shall assume in what follows that the ellipse found is that for the greatest available amplitude without overload. At this point we call to mind the two limiting conditions—*viz.*, the maintenance of negative grid potential and the maintenance of the anode current at a value greater than $I_{\min.}$

The problem is, then, to find the centre and dimensions of the ellipse for greatest signal strength which will represent without distortion at a given frequency the working locus of a given choke and using a given H.T. voltage, the curve being constructed to touch but not pass the grid curve $e_g = 0$, and to touch but not pass the anode current line $i_a = I_{\min.}$ The centre when found will indicate the necessary grid bias to apply for the distortionless amplification of signals of the given strength and frequency.

It should be remarked that this curve and the values obtained from it are not necessarily those which provide the maximum possible voltage amplification for a given signal input. As already remarked, this is a further problem which can only be solved by a comparison of the data which it is the object of this article to ascertain rapidly and conveniently.

2. The Graphical Solution.

The following graphical solution will be found extraordinarily simple, considering the complexities of the problem. Let axes be prepared as in Fig. 2, where values of resistance are taken to any suitable scale on

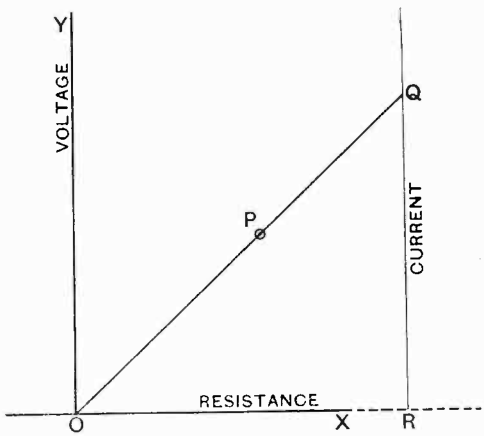


Fig. 2.—*The gradient of OP is a measure of current.*

OX, and values of voltage to any desired unit on OY. Then current values will be represented by the gradients of lines drawn through the origin; *e.g.*, the current flowing through a resistance R due to an impressed voltage v will be shown by the gradient of the line OP, where P is the point whose co-ordinates are (R, v). The values of current are most easily set out as graduations on a vertical line RQ, drawn perpendicular to OX beyond the usual limits of the diagram. Thus the current value of the line OP is simply read by extending it to meet this line at Q. It will be found convenient to assign such a position to the vertical line RQ of Fig. 2 that the graduations upon it will be set out to the same scale as the values of i_a in the $i_a - e_a$ diagram. This latter diagram may then be placed beside it as in Fig. 3, so that the two scales of i_a are in juxtaposition. If, further, the scale of voltage upon OY has been chosen the same as that of the voltage axis of the $i_a - e_a$ diagram, the range of values shown by the two diagrams will be identical.

Let us now define the symbol Z as numerically equal to $\sqrt{(R + R_0)^2 + \omega^2 L^2}$, R_0 being, of course, the internal A.C. resistance of the valve over the "straight" portion of the characteristic. We then proceed as follows (see Fig. 3):

Set out downwards from O on OY' a distance equal to ωL ohms measured in terms of the resistance scale. From this point set out parallel to OX distances equal to R and R_0 respectively as shown. The diagonal lines from O will then measure z and Z ohms.

From O on $X'X$ take $OH = -Z$, $ON = z$, $OM = R + R_0$.

Draw the slope line OA for $I_{min.}$, and take A on it of abscissa $(R + R_0)$.

Next, find B, the point of co-ordinates $(-Z, E_b - E_0)$, so that HB is equal to the distance VE_0 on the $i_a - e_a$ diagram.

Through C, the intersection of AB and OY, draw KD parallel to XX' to meet HB in K and MA in D. Then the slope of OD represents I_{a_0}.

Thus, on the $i_a - e_a$ diagram the centre W of the ellipse is found on the line VW by means of its intersection with the dotted line through I_{a_0}.

Further, if NFG be drawn through N parallel to OY to meet the slope lines in F and G, the distance FG will represent to scale the maximum peak variation of anode voltage from its mean value, *i.e.*, FG will be one-half the base measurement of the required rectangle. This may now readily be drawn in about W as centre and standing on the $I_{min.}$ line as base. The curve itself may also now be inscribed as shown in Appendix I, and will be tangential to the characteristic $e_g = 0$. The value of necessary grid bias for this particular signal is given by $-E_{g_0}$, the value of the characteristic passing through W.

As a check on the work, the voltage measured by BK should be found equal to $\mu_0 \times E_{g_0}$, where μ_0 is the amplification factor of the valve.

By this means, using a given choke,

frequency, and H.T. voltage, the ellipse corresponding to the maximum possible signal strength capable of amplification without distortion is quickly obtained. If

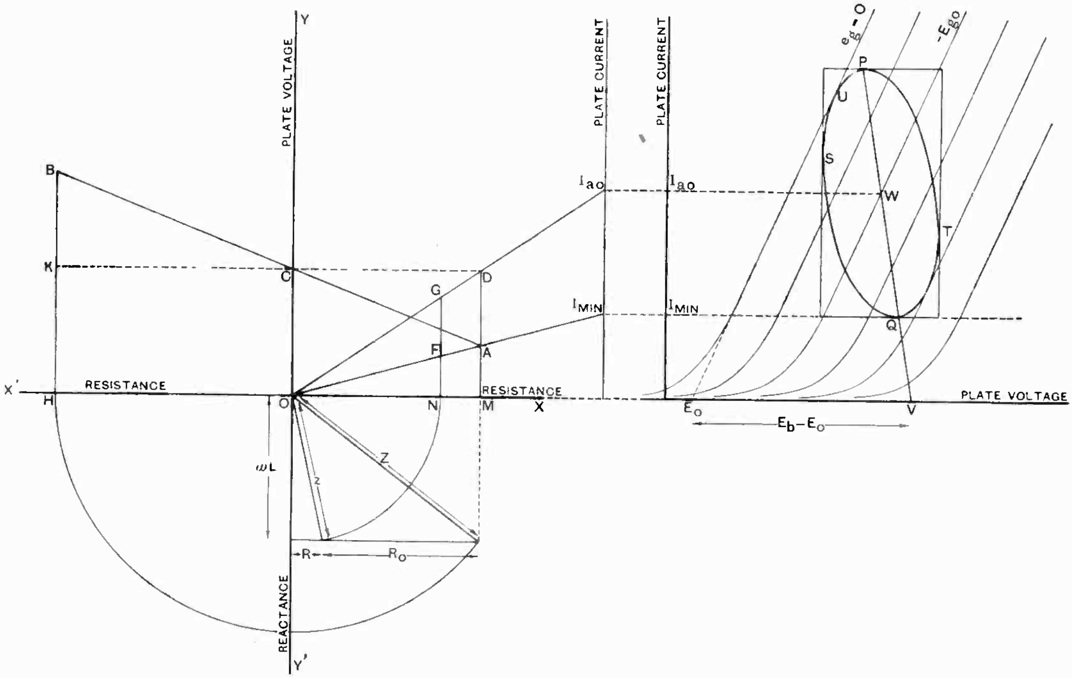


Fig. 3.—*Method of construction of the working ellipse.*

(*N.B.—It is important to notice that the reactance* ωL *is set out along* OY' *for convenience only, and to avoid the necessity of a separate diagram to determine* z *and* Z.)

any factor, *e.g.*, frequency, is varied, the corresponding changes in the elliptical path may be ascertained with surprising rapidity. The fact that the characteristic $e_g = 0$ is always tangential to the curves makes this method one of particular utility in the study of amplifier performance. The ellipse need not, of course, be drawn in. The position of the centre W having been found, the grid bias to be applied is read off, while the length of FG is also noted. Comparison of various conditions will soon indicate the best values for use.

3. Mathematical Analysis.

We now proceed to an analytical derivation of the above construction. It is known that if an alternating current $i = I \sin \omega t$ pass through a choke of inductance L and resistance R, the P.D. across its ends at any instant is given by the formula

$$e = Iz \sin (\omega t + \phi),$$

where $z = \sqrt{R^2 + \omega^2 L^2}$ and $\phi = \tan^{-1} \dfrac{\omega L}{R}$.

Hence, if a current represented by

$$i_a = I_{a0} + I_a \sin \omega t \qquad \text{.. (2)}$$

pass through the anode circuit of Fig. 4, E_b being the applied H.T., we may write for the instantaneous voltage on the anode,

$$e_a = E_b - I_{a0}R - I_a z \sin (\omega t + \phi) \qquad \text{.. (3)}$$

The equation of the Working Locus.

This is obtained by eliminating t between (2) and (3) as follows:

$$(e_a - E_b + I_{a0}R + I_a z \cos \phi \sin \omega t)^2$$
$$= I_a^2 z^2 \sin^2 \phi \, (1 - \sin^2 \omega t)$$

i.e., $$(e_a - E_b + I_{a0}R + (i_a - I_{a0}) z \cos \phi)^2$$
$$= z^2 \sin^2 \phi \, \{I_a^2 - (i_a - I_{a0})^2\}$$

Transferring the origin to the centre, $(E_b - I_{a0}R, I_{a0})$, the equation becomes

$$(e_a + i_a z \cos \phi)^2 = z^2 \sin^2 \phi \, (I_a^2 - i_a^2) \qquad (4)$$

which is an ellipse centred at the origin.

Dimensions of the Circumscribing Rectangle.

By differentiation of equation (4),

$$\frac{di_a}{de_a} = -\frac{e_a + i_a z \cos\phi}{z^2 i_a + e_a z \cos\phi}.$$

Then it may be shown that

$$\frac{di_a}{de_a} = 0 \text{ when } i_a = \pm I_a$$

$$\frac{di_a}{de_a} = \infty \text{ when } e_a = \pm I_a z.$$

Hence the sides of the circumscribing rectangle are $2I_a$ and $2I_a z$, while the gradient of the diagonal is $\frac{1}{z}$.

Derivation of Mean Anode Current.

The equations of the straight portions of the grid voltage characteristics may be written

$$i_a = \frac{e_a - E_0 + \mu_0 e_g}{R_0}$$

or $$\mu_0 e_g = i_a R_0 - e_a + E_0 \qquad .. \quad (5)$$

Substituting in (5) the values of i_a and e_a given by (2) and (3), we obtain for the value of grid voltage e_g at instant t:

$$\mu_0 e_g = R_0(I_{ao} + I_a \sin \omega t) - E_b + I_{ao}R + I_a z \sin(\omega t + \phi) + E_0 \quad .. \quad (6)$$

$$= \{I_{ao}R_0 - E_b + I_{ao}R + E_0\} + \{I_a R_0 + I_a z \cos\phi\} \sin \omega t + \{I_a z \sin\phi\} \cos \omega t$$

$$= \mu_0 E_{go} + \mu_0 E_g \sin(\omega t + \psi) \qquad .. \quad (7)$$

where

$$-\mu_0 E_{go} = (E_b - E_0) - I_{ao}(R + R_0) \quad .. \quad (8)$$

$$\mu_0 E_g = I_a \sqrt{R_0^2 + 2R_0 z \cos\phi + z^2}$$

$$= I_a \sqrt{R_0^2 + 2R_0 R + R^2 + \omega^2 L^2}$$

$$= I_a Z \quad .. \quad .. \quad .. \quad .. \quad (9)$$

and $$\psi = \tan^{-1} \frac{z \sin\phi}{R_0 + z \cos\phi}$$

$$= \tan^{-1} \frac{\omega L}{R_0 + R} \qquad .. \quad (10)$$

where $-E_{go}$ represents the steady component of voltage on the grid, and E_g the amplitude of grid voltage variation. Thus the variation of all three quantities, i_a, e_a, and e_g takes place in simple harmonic manner.

Now, I_a, the amplitude of the varying component of plate current should never exceed the difference between the steady component I_{ao} and $I_{min.}$. For greatest I_a, therefore,

$$I_a = I_{ao} - I_{min.}.$$

Again, the numerical value of E_g, the amplitude of the varying component of grid voltage should never exceed the difference between the steady value $-E_{go}$ and zero. Hence we can write, for maximum permissible grid swing,

$$-E_{go} = E_g$$

i.e., from equations (8) and (9),

$$(E_b - E_0) - I_{ao}(R + R_0) = I_a . Z$$

$$= (I_{ao} - I_{min.}) . Z$$

$$\therefore \quad I_{ao}\{Z + R + R_0\} = I_{min.} Z + E_b - E_0$$

$$\therefore \quad I_{ao} = \frac{I_{min.} Z + (E_b - E_0)}{Z + (R + R_0)} \qquad .. \quad (11)$$

Proof of Graphical Construction.

Referring to the diagram of Fig. 3, we had

$$HO = \sqrt{(R + R_0)^2 + \omega^2 L^2} = Z$$

$$HB = E_b - E_0$$

$$OM = R + R_0$$

$$MA = I_{min.}(R + R_0)$$

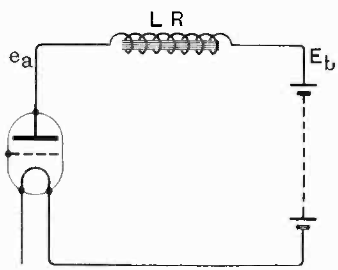


Fig. 4.—*Anode circuit of L.F. choke amplifier.*

From the properties of similar triangles,

$$\frac{AD}{CD} = \frac{HB - MA}{HM}$$

$$\therefore (MD - MA) . HM = (HB - MA) . CD$$

$$\therefore MD\ HM = MA(HM - CD) + HB . CD$$

$$= MA . HO + HB . OM$$

$$\therefore \quad \frac{MD}{OM} = \frac{\frac{MA . HO}{OM} + HB}{HM}$$

$$= \frac{I_{min.} Z + (E_b - E_0)}{Z + (R + R_0)}$$

Therefore, from equation (11), $\frac{MD}{OM}$ must represent I_{ao}, and hence the line OD represents I_{ao}.

Whence, again, since $I_{ao} - I_{\text{min.}} = I_a$,

$$AD = MD - MA = I_a(R + R_0)$$

and further

$$GF = \frac{ON}{OM} \cdot AD = \frac{z}{R + R_0} \cdot AD$$
$$= I_a z,$$

thus proving the construction.

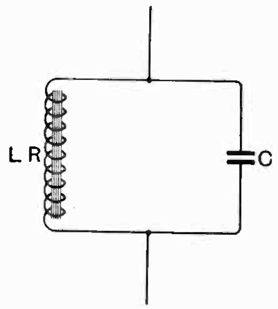


Fig. 5.

Finally, since $\frac{BK}{HO} = \frac{AD}{OM} = \frac{GF}{ON}$,

$$\therefore \quad BK = \frac{ZI_a z}{z}$$
$$= \mu_0 E_g \text{ by equation (9).}$$
$$= -\mu_0 E_{g0}.$$

It may be interesting to note that, if L be put equal to zero in equation (11), the expression reduces to the equivalent for a resistance amplifier, for which case, since Z reduces to $R + R_0$,

$$I_{ao} = \frac{I_{\text{min.}}(R + R_0) + (E_b - E_0)}{2(R + R_0)}$$
$$= \tfrac{1}{2}\left\{\frac{E_b - E_0}{R + R_0} + I_{\text{min.}}\right\}$$

or, since $I_a = I_{ao} - I_{\text{min.}}$,

$$I_a = \tfrac{1}{2}\left\{\frac{E_b - E_0}{R + R_0} - I_{\text{min.}}\right\}.$$

In conclusion, it should be pointed out that the above analysis for a simple choke is capable of considerable extension to include more complex circuits. If, for example, we have to take account of a shunting capacity, C, as in Fig. 5, we may substitute throughout for z the quantity z', where

$$z' = \frac{z}{\sqrt{1 - 2\omega^2 CL + \omega^2 C^2 z^2}}$$

while ϕ will now represent the angle $\tan^{-1}\frac{\omega L - \omega C z^2}{R}$. z' is, of course, the ohmic impedance of the combination of Fig. 5 to the given frequency, and a convenient graphical method of obtaining its value has already been described in a former issue of this journal* It is therefore possible to substitute for ωL and R in the lower portion of Fig. 3 the equivalent series values of reactance and resistance for the combination, which may be rapidly ascertained from the Impedance Diagrams referred to. The subsequent procedure and analysis are unaltered, provided the new significance of ωL and R is kept in view.

The gradient of the slope line VW will, of course, still be that corresponding to the D.C. resistance of the coil, and not the "equivalent" resistance of the combination.

APPENDIX I.

To Inscribe the Ellipse in the Given Rectangle

It will be sufficient to find the four points P, Q, S, T at which the ellipse touches the circumscribed rectangle (Fig. 3).

When $\frac{di_a}{de_a} = 0$, *i.e.*, when $i_a = \pm I_a$, we have from equation (4)

$$(e_a \pm I_a z \cos \phi)^2 = 0$$

i.e., $$e_a = \mp I_a z \cos \phi = \mp I_a R.$$

If P and Q be the two points where $\frac{di_a}{de_a} = 0$, the gradient of PQ is $-\frac{I_a}{I_a R} = -\frac{1}{R}$. Also W lies on PQ.

Hence the line VW of gradient $-\frac{1}{R}$ meets the upper and lower sides in P and Q.

Again, when $\frac{di_a}{de_a} = \infty$, *i.e.*, when $e_a = \pm I_a z$, we have from equation (4)

$$(\pm I_a z + i_a z \cos \phi)^2 = z^2 \sin^2 \phi \, (I_a^2 - i_a^2)$$

i.e., $$I_a^2 \cos^2 \phi \pm 2 i_a I_a \cos \phi + i_a^2 = 0$$

i.e., $$i_a = \mp I_a \cos \phi.$$

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* See W. A. Barclay: "Some New Coil Impedance Diagrams," *E.W. & W.E.*, Feb., 1927.

If S be the point $(-I_a z, I_a \cos\phi)$, since P is $(-I_a R, I_a)$

$$\text{Gradient of } PS = \frac{I_a - I_a \cos\phi}{-I_a R + I_a z} = \frac{I_a - I_a \cos\phi}{-I_a z \cos\phi + I_a z}$$

$$= \frac{1}{z}, \text{ the gradient of the diagonal.}$$

Also, Gradient of $QT = \frac{1}{z}$.

Therefore, the points S and T are found by drawing through P and Q parallels to a diagonal to meet the vertical sides.

By using these four points of contact, and the fact that the characteristic $e_g = 0$ provides an additional tangent, the ellipse may be rapidly sketched in.

APPENDIX II.

Symbols Employed.

e_a = instantaneous voltage on anode.
e_g = instantaneous voltage on grid.
i_a = instantaneous anode current.
E_a = amplitude of varying component of e_a.
E_g = amplitude of varying component of e_g.
I_a = amplitude of varying component of i_a.
E_{ao} = steady or normal component of e_a.
E_{go} = steady or normal component of e_g.
I_{ao} = steady or normal component of i_a.
E_b = H.T. battery voltage.
$I_{min.}$ = minimum permissible value of i_a for valve.
μ_0 = amplification factor of valve.
E_0 = "space charge voltage effect" of valve.
R_0 = anode A.C. resistance of valve.
R = resistance of choke.
L = inductance of choke.
z = impedance of choke at frequency $\frac{\omega}{2\pi}$.
Z = impedance of choke and valve at frequency $\frac{\omega}{2\pi}$.
z' = impedance of choke and shunt capacity C at frequency $\frac{\omega}{2\pi}$.
$\phi = \tan^{-1}\frac{\omega L}{R}$.

The Washington International Radiotelegraphic Convention of 1927.

I. E. E. Wireless Section Chairman's Inaugural Address.

Abstract.

The opening meeting for the session of the Wireless Section of the Institution of Electrical Engineers was held on Wednesday, 7th November, when the chair was taken by the Institution President, Col. K. Edgcumbe.

On the motion of Capt. P. P. Eckersley, seconded by Capt. Kennedy-Purvis, a vote of thanks to the retiring chairman (Lt.-Col. A. G. Lee, O.B.E., M.C.) was carried with acclamation.

The new Section Chairman, Commander J. A. Slee, then delivered his inaugural address, which was on the subject of the 1927 International Radiotelegraphic Convention of Washington.

Historical.

The new chairman opened his address by tracing the history leading up to the 1927 Convention.

In the infancy of wireless there were practically no rules—national or international. The Government did not assume control of wireless until 1904 The development of marine work had, however shown the necessity for some international agreement, especially with regard to questions of the safety of life at sea. As a result, a meeting was summoned in Berlin in 1903, the main work of which was to prepare proposals for a subsequent assembly, which was the International Radiotelegraphic Conference of Berlin, held in 1906. Perhaps the most striking decision reached was the abolition of the "no-intercommunication" principle, thus acknowledging wireless to be a universal, as opposed to a private, means of communication between the inhabitants of the world.

The meeting of 1906 was followed by the Conference of 1912 in London, at which was produced the document known as the Radiotelegraphic Convention of London, 1912. This continued the work of the 1906 meeting, and was concerned almost exclusively with ship work and with "spark signalling." With the exception of Poldhu very little progress had been made in long-distance communication or in point-to-point working. The arrangements then made have formed the basis on which all ship work is still carried out. The original object of installing wireless in ships was to earn a revenue, and the methods then fixed of conducting the truly international accounts—for ships and coast stations of all nations take part in this service—remain almost without alteration to this day.

It was then decided also that conferences should be held at five-year intervals, and that the next meeting should be at Washington in 1917. This was, of course, prevented by the war, and wireless arrangements could only exist between allies.

During the war the technical development of wireless was remarkable, the advent of the three-electrode valve revolutionising both transmission and reception. The effect of these enormous strides was felt in the warlike organisation of the time, and elaborate inter-allied agreements were worked out and made use of during hostilities.

After the war, in addition to the difficulties of rearranging the old Convention so as to bring it into line with the vast technical improvements made in the interval, there remained the diplomatic problem of getting the nations to meet in friendly discussion on so thorny a subject. Technical improvements had given stations a world-wide range and world-wide powers of interference, so that there was every prospect of acute differences arising between rival claimants for the wavelengths necessary to carry on the wireless communications of the world.

In 1923 an inter-allied commission met at Washington to work out some document which could be circulated to the world as a basis of truly international discussion. This meeting used the old wartime interallied agreement as a foundation, and in due course circulated the result of its labours with an invitation to all nations to attend an International Conference as soon as it could be arranged.

National rejoinders were forwarded to Washington with all the remarks, counter proposals and explanations of the 74 States likely to be represented. These were printed together, and circulated for further discussion. During this time the complexity of the subject had been added to by the rapid growth of broadcasting and the enormous weight of public opinion which it carried. The old professional wireless services—Naval, Military, Air Force, Post Office, and Commercial—found themselves being elbowed out of the ether by the demands of this vigorous new claimant for a share in the available wavelengths.

As a final complication came the reintroduction of short waves and the beam system which only proved itself to be a practical proposition a few months before the Washington Conference assembled.

The Washington Meeting of 1927.

The Conference, as finally assembled at Washington in 1927, consisted of some 400 delegates from 74 Governments, speaking 52 languages. The subject to be discussed had changed out of all recognition since the last fully international meeting, while the administrative side of the proposals opened up a wide cleavage of view due to the differences between the constitutional powers of the U.S.A. and the powers of most European states.

The Conference, consisting only of official delegates from the various countries, met and drew up rules of working, dividing the work into sections under eleven committees. The representatives of wireless companies and other wireless interests, who had been invited to be present, could attend the main and committee meetings, and address the meetings by permission of the chairman, but had no voting powers.

The great changes which had taken place in the subject made the distribution of work difficult. This was frequently solved either by handing over parts of the work from one committee to another, or by joint meetings of two or more committees. These formal committees split up into less formal sub-committees which were in many cases further divided. This fine distribution of work made it necessary for each of the maritime countries to be represented simultaneously in several different rooms, and the daily working hours of all members of the delegates became very long.

The language difficulty was settled as follows: Volunteers from among the delegates and the representatives of private companies were appointed as " Rapporteurs " to the various committees and sub-committees, to act as secretary and interpreter. The official language was French, and any delegate who so wished might ask for a translation into English, while any speech made in English was translated into French as a matter of routine. The drafts of all minutes were agreed at the next meeting and handed by the " Rapporteur " to the Drafting Committee. In the smaller and less formal meetings, the chairman usually did any necessary interpreting.

Work was carried out in this way for about six weeks, when began the period of sub-committees reporting to committees and of committees reporting to plenary sessions. Progress at this period was rapid, as the discussions had all taken place outside and agreement had already been reached. The only details requiring careful scrutiny were the exact draftings of paragraphs which embodied the work of two or more committees. Special care was necessary in the wording of administrative regulations, so that the largest possible number should be acceptable as they stood to the U.S. and other countries whose constitutional position differed from that of most European states. A very small portion of such regulations was left in an appendix which a few governments were unable to sign, due to legal inability to undertake the enforcement of regulations which were outside their constitutional powers.

Throughout all the preliminary discussions and during the Conference itself, the Government officials had at their disposal the services of the commercial representatives; indeed, in some cases, nations had to delegate temporarily the national voice to a commercial representative in order that enough people might be available to attend the large number of simultaneous sub-committees.

The 1927 Convention.

The Convention itself consists of 24 Articles, couched in the broadest terms, in which the governments concerned bind themselves to work together to enforce the regulations and to repress illicit work. It also sets up the principle of arbitration in case of disagreement and re-states the former principles of priority for distress messages from ships and of general intercommunication between ships.

Then follow the regulations which are enforced under the Convention—34 in all as now printed.

The technical side of the regulations is based on the idea that there are certain services carried out by stations distinguished by the corresponding name and that types of emission shall be classified and their uses controlled according to this classification. The wireless services are "Fixed," "Mobile," "Broadcasting," and "Special," which includes Time Signals, Direction Finding, Standard Waves, etc. A generous allocation of the shorter waves is also made to amateurs for experimental purposes.

Waves are divided into four classes—A1, A2, A3, and B, which may be interpreted as Continuous Waves, Interrupted Continuous Waves, Telephony and Spark. The article on this subject (article 5) lays down the wavelengths to be used for the various services and goes as far as possible in the direction of discouraging the use of spark. All of the different interests gladly accepted this article as a workable basis on which the wireless work of the world could be carried out, providing a certain amount of flexibility so that future contingencies might be met without summoning a special conference.

The Convention agreed to the introduction of the practice of designating waves by their frequencies in kilocycles per second, but no very great progress has yet been made in this direction. The distribution of waves among the different services was a matter of difficulty, but by the time the proposals reached the Technical Committee there was not a single dissentient voice.

As regards fixed services, the position is simple. As a general principle, one wave is allotted to one station. The Administration is responsible that suitable waves are allotted, and once a station is granted a licence to work on a certain wave the station is free to make the best use it can of the privilege.

With mobile stations the case is different. There are about 12,000 ships, which must be able to get into touch with one another or with land. The operators must be up to a high standard of competence and apparatus must be kept up to a definite state of efficiency. There must be an international code of signalling and procedure and accounts to be rendered in many languages and using many currencies, must be standardised in form. The ship service must be regulated so as to provide the best touch between ship-and-ship, and ship-and-shore, both for safety of life at sea and for the commercial convenience of the great liners. All the regulations governing these complex matters must be truly international in character, clear, binding and yet flexible enough to permit of unforeseen contingencies being encountered and satisfactorily dealt with.

The regulations for aircraft are similar in principle to those for the control of ship working. So far there is no regular exploitation of commercial communications to and from aircraft, but no doubt these will come into being when long-distance flights become frequent.

After the regulations proper appear numerous appendices which support the regulations in a more detailed fashion, including the list of authorised abbreviations now well known over the seven seas.

Finally, the book is completed by the additional regulations (seven in number) dealing with details of accountancy, which, as already mentioned, certain states were unable to sign.

Conclusion.

Taking a broad view of the whole Convention, it should have the effect of regularising existing practices without fixing them so firmly that progress will be impeded. So far as possible progress will be accelerated in the direction of the reduction of the interference caused by ships. There will be a general reduction in interference due to the more scientific use of the means of communication now available. Above all, the foundations have now been firmly laid for a series of similar international meetings at which there will be less to be done at one blow and fewer conflicting requirements to be satisfied, and from which real improvements in the international wireless arrangements can be looked for with confidence.

At the conclusion of his address, a vote of thanks to the new chairman was carried with acclamation on the motion of the Institution President.

A Double Super-heterodyne.

A Description of a Receiver built by the Author.

By J. F. Ramsay.

THE merits of supersonic amplification for particular purposes are well established. As a means of obtaining extreme sensitivity the super-heterodyne is unsurpassed. It is strikingly successful in overcoming the difficulties of amplifying the higher radio frequencies. The benefits of having a local oscillating valve, the output of which can be controlled, are made good use of. Opprobrium has been cast, and to some extent justifiably, on the quality of reproduction of the super-heterodyne. Here we are concerned with policy. So much emphasis has been given to the "distance-getting" properties of the super-heterodyne that manufacturers feel it incumbent upon them to secure a maximum gain per stage; they use sharply tuned couplings and high *m* valves. Quality is not a feature of such an arrangement. The conditions for (1) maximum voltage amplification and (2) maximum distortionless A.C. output are wholly different —valves have yet to be made which give both of those requirements together. At present we can only effect a compromise.

The super-heterodyne is not popular in this country—ask any wireless salesman—but the precise psychological reasons for this are beyond us. The evil reputation associated with "quality" may have something to do with it; it need not. Moreover, we are well supplied with broadcast stations and, being as a nation conservative, we accede to the cry of the B.B.C. to cultivate the local station, and are satisfied. He who shouts convinces. This is most regrettable, as it has prevented a wider appreciation of a most excellent receiver.

Many articles have appeared on super-heterodynes, but we have not seen any practical details of that extension of the system which may be called "multiple heterodyning." This is an old idea and may be outlined as follows: If a valve oscillator is coupled to a circuit which is tuned to a particular signal frequency, "beating" is obtained, the nature of the beats being determined by the initial conditions—*i.e.*, the frequency of the local oscillation and the relative amplitudes of the interfering oscillations. (We here propose to talk of "frequency" and "amplitude" of a beat, although rigorously, this is erroneous). The frequency of the beat, for the purposes we are concerned with, is

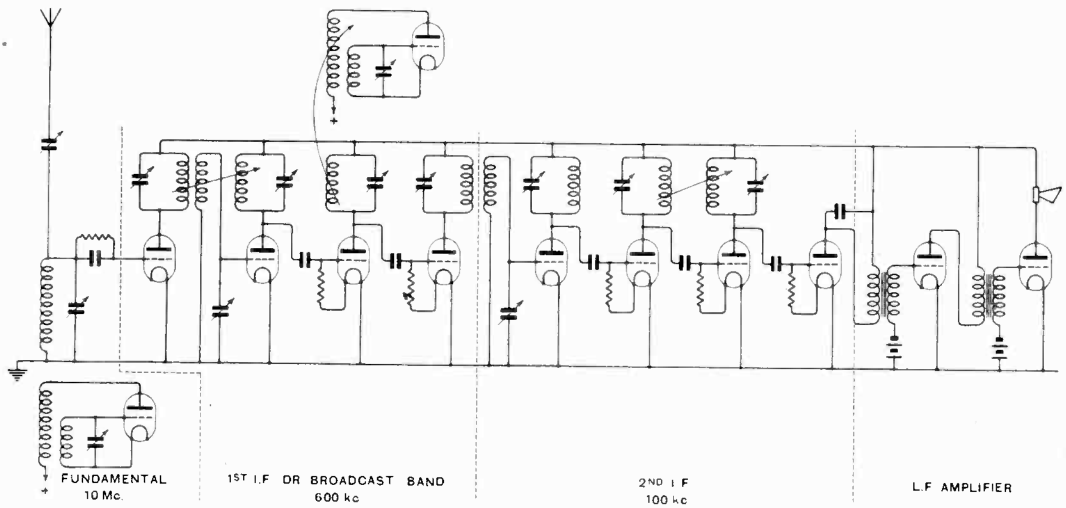

Fig. 1.—*Circuit of the double super-heterodyne.*

equal to the difference in frequency between the signal and local oscillatory currents. The success of the super-heterodyne is due to the fact that the beat frequency is such that it lies in the range 10-300 kilocycles. Amplifiers operating in this band can be designed to give a reasonable efficiency. Cascading may be resorted to with more or less impunity. Having amplified the beat we can now introduce a second local oscillation such that it beats with the first beat. Hence we obtain a second beat of still lower frequency. This may now be amplified successfully.

A third local oscillation is then introduced, and further amplification undertaken ; and so on.

However, in the set shown in the accompanying photographs, heterodyning is only carried out twice. Although the technical difficulties may seem formidable, in actual practice comparatively little trouble is experienced ; some care has to be taken with the preliminary adjustments and the strength of the local oscillations.

The receiver comprises fundamental, two heterodynes and, correspondingly, two supersonic amplifiers, these amplifiers operating on different frequencies.

Circuit Details.

The input E.M.F. (the signal) is applied to grid and filament of a "frequency changer," to which is coupled an oscillator giving a beat of about 600 kc. This is amplified by two valves, tuned-anode-coupled, and the magnified E.M.F. applied to a second frequency changer, to which a local oscillator is coupled, and a beat of about 150 kc. obtained. This is passed through a three-stage radio-frequency amplifier (tuned anode), rectified and amplified by a two-stage low-frequency amplifier.

Fig. 2 is the front view, showing controls and switches. For short-wave reception (using the entire apparatus) only the two large vernier dials on the left are used. In the case of short-wave C.W., the second intermediate frequency amplifier is made to

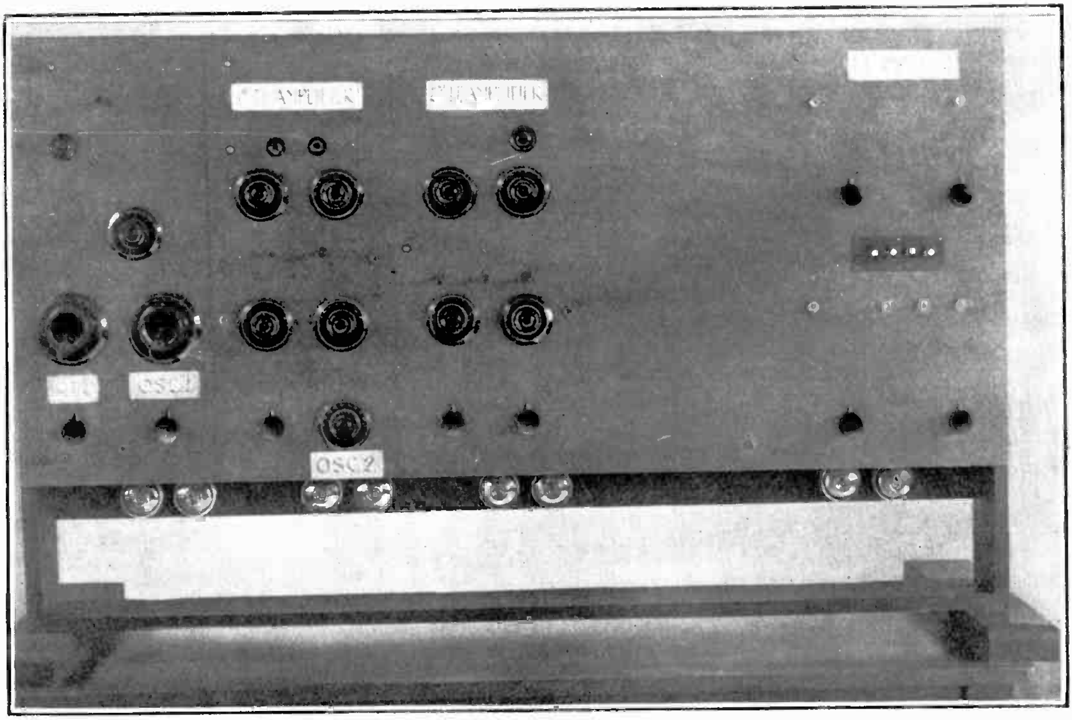

Fig. 2.—*Tuning controls and switches.*

oscillate by increasing the coupling between the last two tuned-anode coils.

Fig. 3 is a complete back-of-panel view, including coils and valves.

Fig. 4 shows the fundamental "detector," local oscillator, 1st I.F. amplifier, and 2nd oscillator.

Fig. 5 shows the first I.F. amplifier, second oscillator, and second I.F. amplifier.

Fig. 6 shows the L.F. amplifier, two-stage transformer-coupled. Above this amplifier is an auxiliary two-valve resistance-coupled amplifier; this is a freak amplifier and makes use of the secondary emission effect of a screened-grid valve.

Amplifiers to operate on a single frequency were not favoured since (1) it is a distinct advantage to be able to change the supersonic frequency, and (2) it was desired to use the amplifiers as straight receivers covering specific bands of frequencies. The stages had therefore to be tuned.

The frequency ranges of the amplifiers were governed by the following considerations. The first amplifier was intended to be used as a straight broadcast receiver (500-1,000 kc.), the output being either put into the L.F. amplifier, or into the second I.F. amplifier; in the latter case an oscillator is of course switched on. This arrangement

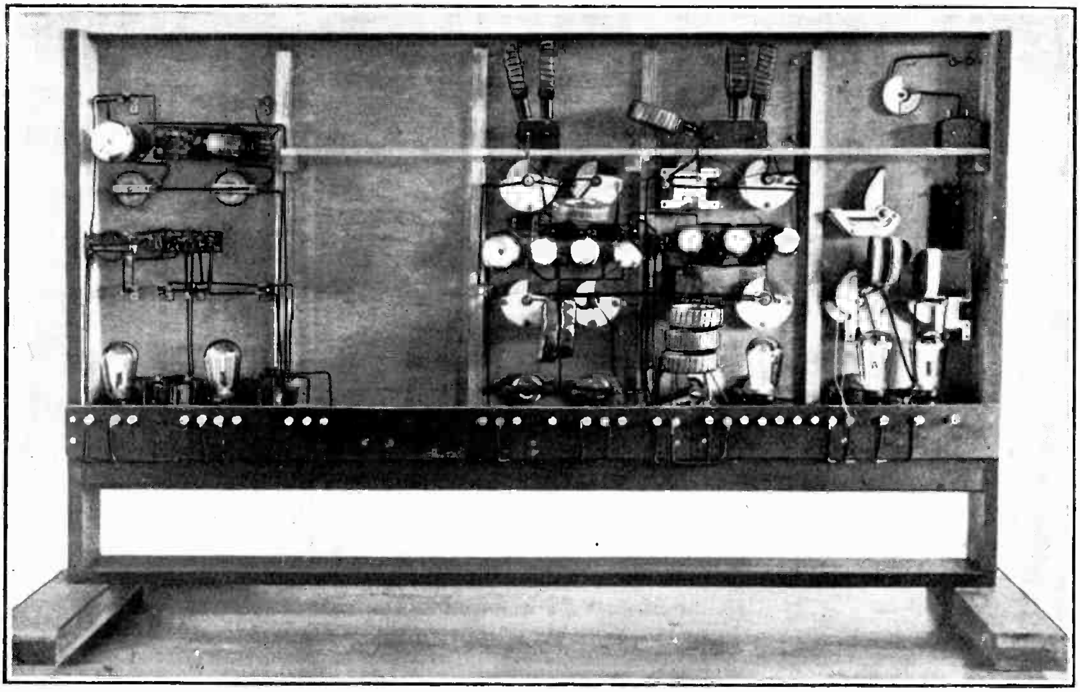

Fig. 3.—*Complete back-of-panel view.*

(a single oscillator super-heterodyne) constitutes an exceedingly powerful broadcast receiver and embodies ten valves.

It will be seen that no attempt at screening has been undertaken. Although an advantage, it has been found to be unnecessary; the apparatus is sufficiently stable, and if beating between the oscillators does occur the intermediate frequencies may be altered.

The justification for a set of this nature is interesting. First, it was desired to have a maximum sensitivity, necessitating the use of a fair number of valves.

Secondly, the receiver was to be useful over as large a frequency range as possible.

Again, the second I.F. amplifier was for use as a straight receiver on the longer broadcast wavelengths; the frequency range is therefore 100-300 kc.

The fundamental panel comprises simply a detector (or frequency changer) and an oscillator, the tuning range being approximately 30-50 m.

Thus we start, say, with a signal on 45

metres, change to about 500 metres, and change again to about 2,000 metres.

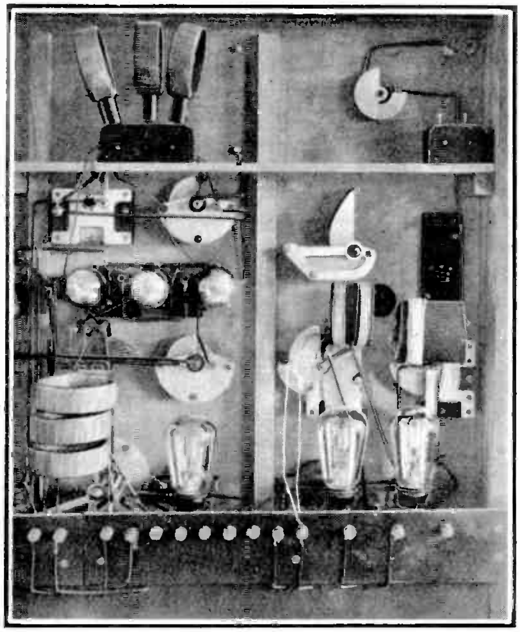

Fig. 4.—*Fundamental and 1st I.F. panels.*

As would be expected, remarkable results are obtainable. Using the single-stage super-heterodyne (ten valves) broadcast from all over Europe can be put on the loud speaker without the use of an aerial. With an aerial continental broadcast is received at excellent strength on the loud speaker, using only one L.F. stage, the quality being exceedingly satisfactory.

The double super-heterodyne is even more sensitive. It is possible to tune in low-power amateur C.W. by its ripple alone; amateur telephony can be picked up without preliminary oscillation. Broadcast from Schenectady, New York, can be made to overload the loud speaker; it has been received without an aerial, but was barely intelligible.

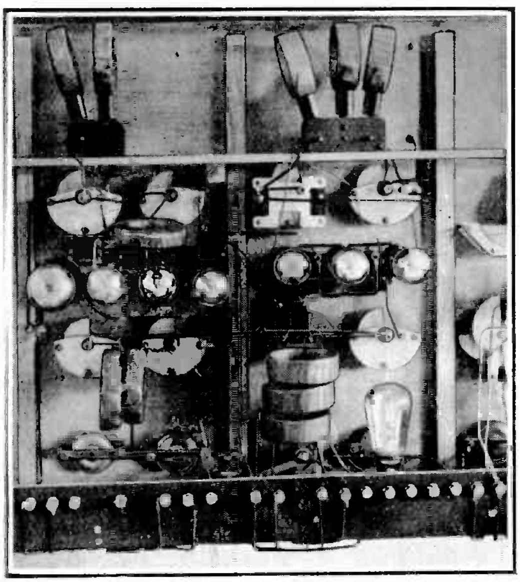

Fig. 5.—*1st I.F. amplifier, 2nd oscillator, 2nd I.F. amplifier.*

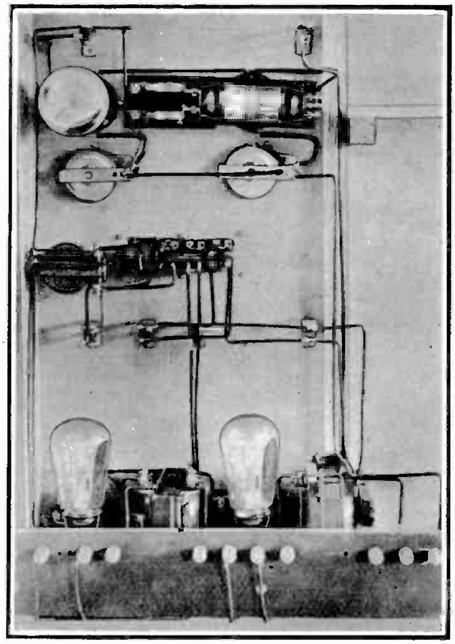

Fig. 6.—*L.F. amplifiers.*

As far as the set itself is concerned, the great number of variables certainly conduce to complexity but considerably enhance the experimental elasticity, which is sufficient justification. To one initiated operating is indeed delightful by virtue of the control of amplification, and by the fact that new features are continually revealing themselves. In effect, in the opinion of the writer, it may be said with some justification that such a receiver is a close approximation to the ideal.

A Note on Some Interfering Oscillations Experienced in a Supersonic-Heterodyne Receiver.

By R. L. Smith-Rose, D.Sc., Ph.D., A.M.I.E.E.

A TYPICAL arrangement of a supersonic-heterodyne receiver for the reception of continuous-wave signals is shown in the schematic diagram, Fig. 1. The arriving waves produce oscillations of a frequency f_1 in the aerial receiving circuit. By adding to these oscillations of a frequency f_2 obtained from the first local oscillator and rectifying the combination, a set of oscillations having a frequency $f_3 = f_1 \sim f_2$ is obtained. The value of f_3 may be in the suitably low radio-frequency band within which large magnification may be obtained in the intermediate-frequency amplifier. During the course of this amplification another set of oscillations of frequency f_4 is introduced from the second local oscillator. The output from the second detector will then consist of oscillations of a frequency $f_5 = f_3 \sim f_4$. If f_5 is within the audio-frequency range, these oscillations will thus produce a response in a pair of telephone receivers, either before or after passage through a suitable audio-frequency amplifier. In this manner the incoming continuous-wave signals at a frequency f_1 may be made to produce a response in the telephone receivers or to operate a suitable recorder from the audio-frequency currents finally obtained.

In practical operation the frequency f_3 will naturally be chosen to suit the intermediate-frequency amplifier, which may be made highly selective and very efficient at this frequency. The frequency of the first oscillator will therefore be determined by the frequency of the incoming signals to satisfy the equation $f_3 = f_1 \sim f_2$. The second local oscillator is obviously required to work at a frequency in the neighbourhood of that of the intermediate-frequency f_3, since f_3 and f_4 only differ by an audible frequency. Incidentally, it is thus seen that the pitch of the note heard in the telephones is easily adjustable to the best value by altering the second local oscillator. Once the best adjustment of this oscillator is obtained, no alteration is required with change of wavelength of the incoming signals, since the intermediate-frequency oscillations are obtained by adjusting only the receiving circuit and the first oscillator. It is this simplicity of control which comprises one of the greatest advantages of the supersonic-heterodyne type of receiver. Although the intermediate-frequency amplifier may contain several stages of sharply-tuned circuits, the resulting high selectivity is available for use over a large range of received wavelengths merely by tuning the receiving circuit * and the first oscillator.

The processes described above will perhaps become clearer if some typical figures are allocated to the various frequencies. Suppose that the arriving signals are on a wavelength of 100 metres, corresponding to a frequency of 3,000,000 cycles per second. Then by setting the first oscillator to a frequency of 2,900,000 cycles per second, an intermediate-frequency of 100,000 is obtained, i.e., corresponding to a wavelength of 3,000 metres. If now the second local oscillator is set to a frequency of 99,000 cycles per second, a steady note of pitch 1,000 cycles per second will be produced in the telephones. If the wavelength of the signals is changed to 150 metres, i.e., a frequency of 2,000,000, then by altering the first oscillator frequency to 1,900,000 the same intermediate frequency of 100,000 cycles per second will result, and the signals will be heard at the same pitch in the telephones without any alteration of the second oscillator.

During the development of a highly sensitive supersonic-heterodyne amplifier for the reception of continuous-wave signals, the writer has had cause to trace out the source of various interfering oscillations arising in the receiver. It is thought that a brief description of the nature of these oscillations and the methods of eliminating them may be of interest.

* In some cases for the reception of very short wave signals, even this tuning adjustment may be dispensed with.

In the first place, either of the two local oscillators employed in the receiver may not be producing continuous oscillations. It is well known that a valve oscillator containing a grid leak and condenser combination may produce an interrupted type of oscillation. The process of interruption, which has become commonly known among wireless engineers as "squegging," is due to the accumulation of a negative charge on the grid of the valve during oscillation. On reaching a sufficiently high value this negative charge on the grid decreases the anode current below the point necessary for the maintenance of oscillation. The presence of the grid leak permits the charge to leak away slowly to the point at which the oscillations are restarted, and the process is then repeated. The period of the interruption is evidently determined by the magnitude of the grid condenser and leak, and by the valve constants. If the first oscillator valve is "squegging" at an audible frequency the interruption will be superimposed upon the intermediate-frequency oscillations upon the arrival of signals which will thus become audible after passing the second detector without the aid of the second oscillator. This may prove to be a convenient method of receiving continuous-wave signals, but it is usually desirable to put a stop to the "squegging" process. The desirability of this will be the more appreciated when it is pointed out that the frequency of interruption may be above the audible range, and may for example be within the working range of the intermediate frequency amplifier. In this case its presence will be indicated by switching on the second oscillator when a steady howl is produced in the telephones at a pitch which is independent of the adjustments of the receiving circuit and first oscillator. By a suitable choice of the values of the components used in the construction of the valve oscillators, it is not difficult to secure steady oscillations free from the interruption described above. From a limited experience with different types of superheterodyne receiver it appears that the liability to "squegging" is greater when one valve is made to serve the dual purpose of first oscillator and first detector, a practice which is adopted in some manufactured types of receiver, but which has little to recommend it save the doubtful point of valve economy.

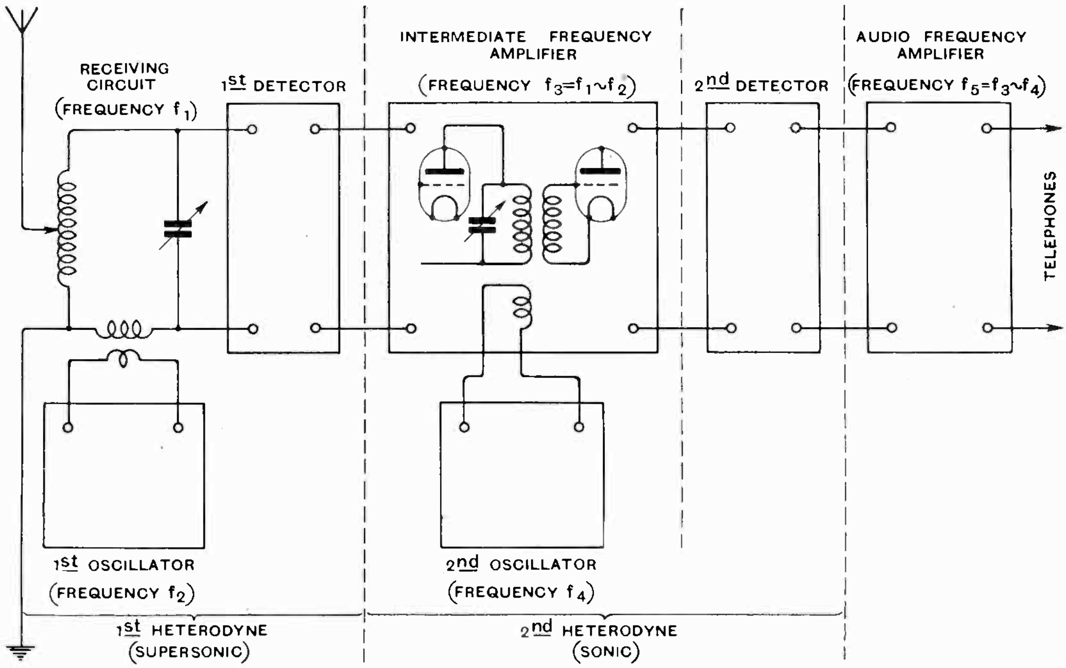

Fig. 1.—*Typical superheterodyne circuit for reception of C.W. signals.*

The second source of disturbance in a receiver of the type under discussion arises from the self-oscillation of the intermediate frequency amplifier either as a whole or in individual stages. Since this amplifier is intentionally made very selective, as it is required to operate over only a narrow band of frequencies, the oscillations will take place at a frequency in the neighbourhood of f_3 (see Fig. 1). They will thus be suitable for heterodyning the incoming signals, which will immediately become audible on tuning the first oscillator, with the second oscillator shut off or disconnected from the circuit. Alternatively, with the first oscillator shut off so that incoming signals do not produce any currents at the intermediate frequency, these oscillations may be detected by switching on and adjusting the second oscillator when a steady audible beat note will be obtained. In some cases, particularly as an emergency measure, this use of the intermediate frequency amplifier in the oscillating condition renders the reception of short-wave C.W. signals possible without the necessary provision of a second oscillator. But since little or no control is obtained over the amplifier when it is oscillating, the optimum heterodyne condition cannot be obtained by adjusting the amplitude of the local oscillations, and an oscillating receiver is liable to become very noisy. For the highest efficiency it is desirable to stop the generation of oscillations in the intermediate frequency amplifier, either by the use of positive grid bias or by a neutrodyne or other anti-reaction control.

The third cause of interfering oscillations in a superheterodyne receiver is a little more elusive than the two just dealt with, since its presence only becomes evident when the whole of the receiver is in operation. This disturbance is encountered as a steady musical beat note, the strength and pitch of which depends upon the adjustments of both oscillators and also on the tuning of the receiving circuit. In brief, this spurious oscillation has every appearance of being due to a steady incoming continuous wave signal such as the carrier wave of a broadcasting station. The scheme of connections of the receiver in which this was discovered is shown in Fig. 2. A frame aerial was employed in the primary receiving circuit, which was completed through the coupling inductance coil L_1 and the variable tuning condenser C_1. The first set of local oscillations was introduced into the secondary circuit L_2C_2, which was connected to the first detector and the intermediate-frequency amplifier at a suitable point, of which the second set of local oscil-

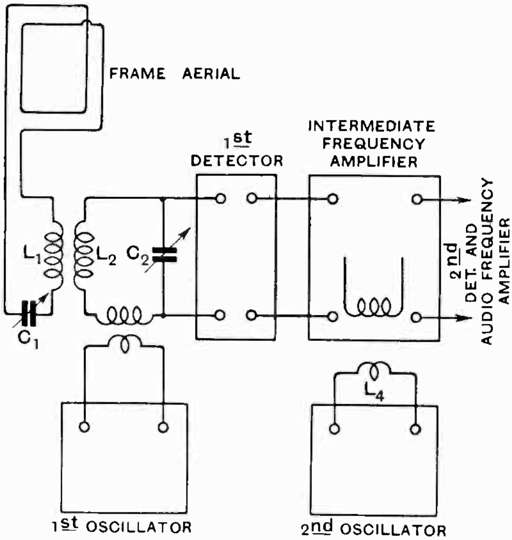

Fig. 2.—*Scheme of connections in circuit employed.*

lations was introduced. For the reception of modulated signals, such as broadcasting transmissions, the second oscillator is not required, and may be switched off. In this condition the set was found to give perfectly satisfactory reception on all wavelengths. By adjustment of the control provided on the intermediate-frequency amplifier this could be made to oscillate or not as desired, and it was found to be quite sensitive and satisfactory in the non-oscillating condition. When, however, the second oscillator was switched on for the reception of continuous wave signals, the existence of a steady oscillation became apparent on certain wavelength adjustments. The strength of the resulting signal heard in the telephones was found to be independent of the orientation of the frame coil, so that it was apparent that the oscillation was generated inside the receiver, and was not due to incoming waves. As a first explanation it was thought that the intermediate-frequency amplifier was being forced into oscillation by the second local oscillator; but this possibility was disposed of by making these local oscillations very weak and by increasing the stability of the amplifier itself. It is also to be remembered that the interference was only experienced on certain wavelength adjustments of the primary and secondary receiving circuits.

The cause of the interference was brought to light by the discovery that two successive wavelengths upon which the disturbance was experienced bore a simple ratio to one another, and that the integers forming this ratio, when multiplied by their respective wavelengths, gave the same number, which was very approximately the wavelength at which the intermediate-frequency amplifier and the second oscillator were in operation. For instance, with the intermediate frequency corresponding to a wavelength of about 2,800 metres, interference was experienced at 467 and 400 metres, which are respectively the sixth and seventh harmonics of 2,800 metres. It would appear from this that the oscillations given by the second local oscillator were not pure, and that there was sufficient mutual inductance between its coupling coil L_4 and either the primary or secondary receiving circuit, or both, for a harmonic of these oscillations to be induced in these receiving circuits. When the two receiving circuits were set to the wavelength of this harmonic, a steady signal corresponding to it was transferred to the intermediate-frequency amplifier, and was subsequently made audible by being heterodyned by the fundamental oscillation of its own source—the second oscillator. Expressed in the nomenclature of Fig. 1, it will be evident that the condition for this interference to exist is that $f_1 = \frac{f_4}{N}$, where N is an integer indicating the order of the harmonic of the oscillation f_4, which caused the disturbance. Such an oscillation would have all the characteristics of an incoming signal, and could be sharply tuned on the primary and secondary receiving circuits. In the set in question, the whole of the receiver was carefully screened, so that the harmonic oscillation would not be induced into the frame coil. The strength of the resulting signal would not, therefore, vary with the rotation of this coil, and it was this fact alone which distinguished the disturbance from an incoming signal.

The validity of the above explanation was established by two very simple tests. First, by altering the adjustments of the intermediate frequency oscillator to give either a slightly higher or slightly lower frequency, the two wavelengths upon which the disturbance was experienced were shifted in the same sense, while their ratio remained constant. The second confirmation was obtained by searching for the positions of successive disturbing oscillations over the whole wavelength range of the receiver. In the upward direction this range was limited to about 600 metres, so that it was not possible to identify harmonics of a lower order than the fifth, which was located at about 560 metres. In the direction of shorter wavelengths the disturbing signals were picked out by careful search and accurate tuning down to 155 metres, which corresponds to the 18th harmonic of the second local oscillator. Over the range of the receiver—150 to 600 metres—there were thus fourteen different wavelengths upon which the harmonics of this oscillator caused a disturbance. The magnitude of the disturbance varied according to the strength of the particular harmonic concerned, but on most of the wavelengths it was found to interfere very seriously with all but the strongest incoming signals.

Having located the cause of the trouble, its removal or avoidance is a comparatively simple matter. As a temporary expedient in an emergency, it suffices to alter the wavelength of the second local oscillator so that its harmonic is removed from the working wavelength of the incoming signals. The most satisfactory plan, however, is to improve the quality of the oscillations concerned by fitting a suitable filter circuit to the second oscillator between its valve circuits and the output coil L_4. Alternatively, or as an additional precaution, the primary and secondary circuits of the receiver may be separately screened so that there is no mutual coupling between them and either the coil L_4 or the intermediate frequency amplifier.

The Effect of Frequency on the Value of High Resistances of the Grid Leak Type.

By W. Jackson, M.Sc.

THE usual type of grid leak or anode resistance may be regarded as consisting of a pure resistance R shunted by a small condenser C_0 representing the inherent self-capacity. The result of this small self-capacity is to produce a reduction in the effective resistance of the leak as the frequency increases, the effective resistance at a frequency $\omega/2\pi$ being given by the expression

$$R' = \frac{R}{1 + R^2C_0{}^2\omega^2}.$$

While C_0 will seldom exceed a few micro-microfarads, this reduction is very pronounced at frequencies approaching 10^6 cycles per second and explains the unsatisfactory voltage amplification of resistance-capacity-coupled amplifiers at high frequency.

It is of interest—if not of great importance for general purposes—to investigate whether there occurs any marked variation in the actual resistance R as the frequency changes, quite independent of the change in effective resistance R' due to self-capacity. The results of a series of measurements on several types of grid leak and anode resistance have served to show that such a variation in the value of R does actually occur and in some cases to a greater extent than would have been expected.

Method of Measurement.

The method of measurement consisted in an arrangement whereby the resistance under test could be connected across the terminals of a variable air condenser, which, along with an inductance, formed a simple tuned circuit loosely coupled to a valve oscillator capable of providing a wide range of frequency, and in measuring the resistance of the circuit with and without the leak connected. The connection of the leak across the condenser affects the circuit in two ways, namely, it produces a slight alteration in the required value of tuning capacity and a variation in the apparent high-frequency resistance. The self-capacity C_0 may be regarded as added directly to the main tuning capacity C and throughout the tests C was arranged to be sufficiently large to render C_0 negligible in comparison. The resistance R in parallel with C (Fig. 1) can be replaced so far as its effect on the circuit LC is concerned by an equivalent series resistance r, where $\sim$ is given by the expression

$$r = \frac{1}{RC^2\omega^2}*.$$

Measurement of this change in circuit resistance on connecting the leak across the condenser C enabled the value of R to be

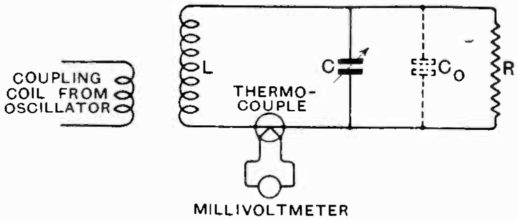

Fig. 1.

determined over a considerable range of frequency. Any variation of R with frequency measured in this way will be quite independent of the shunting effect of its self-capacity C_0.

The resistance variation method, employing a thermocouple as current-measuring device, was adopted in determining the circuit resistance. Especial care was taken to retune the circuit by the small amount necessary on connecting the leak resistance across the variable condenser C. In order that at all frequencies the change in circuit resistance r produced by this connection was sufficiently large—compared with the resistance of the rest of the circuit—to ensure accuracy in its determination, it was necessary to employ in the tuned circuit,

* See Appendix.

in turn, a number of coils of different inductance. The lower the frequency the larger the inductance of the coil used. The approximate inductances of the coils were: (*a*) 101 microhenrys, (*b*) 388 μH., (*c*) 2,133 μH., (*d*) 3,460 μH., (*e*) 5,099 μH., (*f*) 14,680 μH.

The self-capacity of the resistance *R* and holder was measured by noting the change in tuning capacity *C* on connecting *R* across the circuit. In all cases this was found to be about 2.0 micro-microfarads, for which the holder was mainly responsible.

The resistances tested were as follows:— 0.25-megohm Dubilier; 0.25-megohm McMichael; 0.25-megohm Mullard; 0.1-megohm Mullard and a Lissen variable grid leak. The setting of the latter was, however, found to be unreliable, and a satisfactory set of readings was not obtainable. The direct-current resistance was measured by comparison with a standard resistance under applied pressures of from 4 to 20 volts, but little variation with voltage was noticeable.

Readings on 0.25-megohm Dubilier Grid Leak Resistance.

The usual type of Dubilier leak consists of a strip of compressed material impregnated with a black varnish and surrounded by a layer of wax, the whole being enclosed in a cylindrical casing of compressed paper. The type tested was of different pattern, the strip being surrounded merely by a glass enclosure.

Wave-length. (metres.)	Frequency in cycles per sec.	Circuit resistance without grid leak connected. (ohms.)	Circuit resistance with grid leak connected. (ohms.)	Change in circuit resistance. (ohms.)	Tuning capacity. ($\mu\mu$F.)	Resistance of grid leak.
6,890	$.435 \times 10^5$	77.50	145.20	67.70	910	.239 megohm.
4,320	$.694 \times 10^5$	50.15	71.20	21.05	1,029	.237 ,,
2,464	1.217×10^5	39.70	50.80	11.10	804	.238 ,,
1,120	2.680×10^5	8.31	9.73	1.42	1,022	.238 ,,
968	3.100×10^5	8.92	10.91	1.99	747	.238 ,,
806	3.720×10^5	9.73	12.70	2.97	502	.244 ,,
604	4.960×10^5	11.36	17.12	5.76	271	.243 ,,
532	5.640×10^5	4.19	4.70	0.51	810	.238 ,,
441	6.810×10^5	4.37	5.13	0.76	554	.235 ,,
399	7.520×10^5	4.61	5.49	0.88	448	.251 ,,
355	8.460×10^5	4.71	5.85	1.14	354	.248 ,,
304	9.870×10^5	4.99	6.45	1.46	260	.263 ,,

Self-capacity of grid leak and holder = 1.60$\mu\mu$F.

D.C. RESISTANCE.

Voltage applied.	4	8	12	16	20	Mean Resistance = .242 megohm.
Resistance.	.242	.243	.243	.242	.242	

Wheatstone's Bridge gave .247 megohm.

Readings on 0.25-megohm McMichael Grid Leak Resistance.

This resistance consisted of a short rod ($\frac{1}{8}$ inch diameter) of slate-coloured material, enclosed in an ebonite casing. Metal caps screwed into the ends of the casing made contact with the rod and formed the terminals of the resistance.

Similar readings were taken on the Mullard resistances which appeared essentially similar in construction to the usual type of Dubilier resistance except that instead of wax an air space separated the strip of resistance material and the outer paper casing.

The complete results are shown plotted in Fig. 2. The curves bring out two peculiar

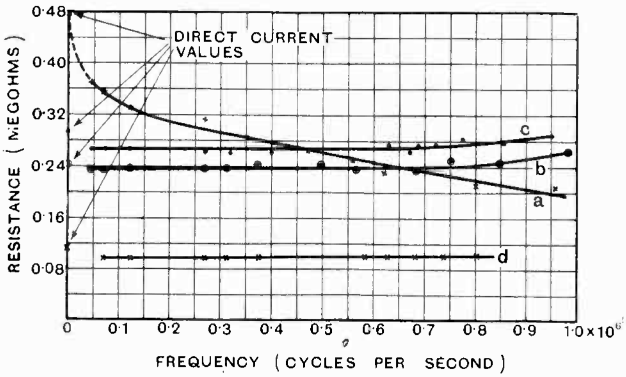

Fig. 2.—*a. McMichael,* 0.25-*megohm. b. Dubilier,* 0.25-*megohm. c. Mullard,* 0.25-*megohm. d. Mullard,* 0.1-*megohm.*

effects which may be stated as follows :—

(1) The whole of the leak resistances tested appear, with decreasing frequency, to tend to a direct-current value lower than that given by the direct-current measurement. This is most marked in the case of the McMichael leak and is least noticeable with the glass-enclosed Dubilier.*

(2) While the Mullard and Dubilier leaks increase in resistance with frequency, the McMichael and Lissen variable leaks decrease, the McMichael falling very rapidly with increasing frequency. The Mullard and Dubilier leaks remain fairly constant until the frequency approaches 10^6 cycles per second.

* We do not think that the results as shown in Fig. 2 justify this conclusion.—EDITOR.

Appendix.

$$\frac{1}{z} = \frac{1}{R} + \frac{1}{-j/C\omega} = \frac{1}{R} + jC\omega$$

$$= \frac{1 + jRC\omega}{R}$$

where z is the symbolic impedance of R and C in parallel.

$$z = \frac{R(1 - jRC\omega)}{1 + R^2C^2\omega^2} = \frac{R}{1 + R^2C^2\omega^2} - \frac{jR^2C\omega}{1 + R^2C^2\omega^2}$$

Since $R^2C^2\omega^2$ throughout the previous measurements is large compared with unity

$$z = \frac{1}{RC^2\omega^2} - \frac{j}{C\omega}$$

giving an equivalent series resistance

$$r = \frac{1}{RC^2\omega^2}$$

Wave-length. (metres).	Frequency in cycles per sec.	Circuit resistance without grid leak connected. (ohms.)	Circuit resistance with grid leak connected. (ohms.)	Change in circuit resistance. (ohms.)	Tuning capacity. ($\mu\mu$F.)	Resistance of grid leak.
6,890	$.435 \times 10^5$	78.00	122.00	44.00	910	.368 megohm.
4,320	$.694 \times 10^5$	49.85	64.00	14.15	1,029	.352 ,,
2,464	1.217×10^5	39.70	47.70	8.00	804	.330 ,,
1,122	2.670×10^5	9.37	8.28	1.09	1,022	.314 ,,
845	3.550×10^5	9.64	11.91	2.27	296	.284 ,,
635	4.730×10^5	11.07	15.94	4.85	296	.266 ,,
535	5.610×10^5	4.34	4.82	0.48	822	.249 ,,
483	6.200×10^5	4.41	5.03	0.62	667	.232 ,,
376	7.980×10^5	4.64	5.81	1.17	400	.213 ,,
314	9.550×10^5	5.04	6.79	1.75	275	.208 ,,

Self-capacity of leak and holder = 1.90$\mu\mu$F.

D.C. RESISTANCE.

Volts applied.	4	8	12	16	20	Mean Resistance.
Resistance.	·479	·479	·477	·475	·475	= ·477 megohm.

Wheatstone's Bridge gave .477 megohm.

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.

Television.

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

SIR,—On page 239 of your issue of April, 1927, you published a contribution from M. Denes von Mihaly, wherein some exceedingly pertinent questions were asked as to the Baird system of "television."

I was recently favoured, at the Radio Exhibition, with a demonstration of this system, and those questions were brought back to my mind. As far as I can ascertain, Mr. Baird has never put forward any answer to M. Mihaly's statements, and it seems certain that some sort of reply is now more than ever imperative.

DUNCAN SINCLAIR.

Haynes Church End,
Bedfordshire.

Surges in Eliminator Smoothing Circuits.

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

SIR,—I have read with much interest Mr. A. G. Warren's article in the November number of *E.W. & W.E.* on "Surges in Eliminator Smoothing Circuits," but I would suggest that in many cases matters are not quite so bad as the analysis might lead one to believe, and that simple safety devices exist.

(*a*) The analysis given leaves out of account the resistance of the smoothing chokes; for small smoothing circuits (capable of supplying less than, say, 100 watts), the resistance of the choke is in practice rather large compared with the inductance; rough calculations on some figures given by manufacturers of commercial chokes show that the resistance has the effect of considerably reducing the maximum surge voltages occurring.

(*b*) Where the smoothing circuit follows a valve rectifier operating from A.C., two causes tend to reduce the surge voltage; first the rectifying valves will only pass a limited maximum current, which cause is always operative; and secondly, the rectifying valve filaments are usually substantial (*e.g.*, a B.T.H. "RH.1" takes 1½ amp. at 7½ volts), and therefore do not heat up instantaneously, hence for the first few thousandths of a second or so at least, the emission of the rectifier is low, and we get the effect of a gradual application of rectified D.C. voltage to the smoothing filter input, but this cause, which in practice seems to reduce surge voltages to very small amounts at switching on, would not be operative in the case of mains disturbance such as feeder switching causing a momentary interruption in supply.

(*c*) I am using B.T.H. B.12 output valves with filaments lighted from the same transformer which supplies the rectifier for H.T., the transformer primary being switched by relay from a distance; surge at break is not serious, due apparently to the output valves having thick filaments which do not become cold for an appreciable time, so that the valves remain conducting for long enough to prevent serious rise of voltage. I keep a "Ferranti" voltmeter with additional series resistance (making ½ megohm in all) connected permanently across the smoothing output condenser; on switching off the transformer primary, as described above, there is no visible upward movement of the pointer, it flicks *down* from, say, 425 to 350 or so in about ¼ to ⅓ second, and then drops at a much slower and, of course, gradually decreasing rate as the condensers discharge through the voltmeter resistance.

(*d*) *Safety devices.* It appears desirable to keep a high resistance of about ½ megohm always connected across smoothing circuit output, so as to discharge the condensers on switching off, otherwise well-insulated condensers will hold their charge for a long time, and there is risk of shock when making adjustments within even a minute or so after switching off. The voltmeter mentioned in (*c*) above performs this duty satisfactorily and indicates how soon it is safe to open the screening box and make adjustments (say when the reading has dropped to 100 or 50 volts, according to the operator's taste).

(*e*) *Surge Absorber.* There is a very simple safety device which does not seem to be sufficiently well known, and which is very simple and cheap to apply to any smoothing circuit dealing with less than, say, 100 watts. I refer to the Neon lamp. The "beehive" type, obtainable from the G.E.C. without any internal resistance, has an ignition voltage of about 149 volts, a sufficient number of these connected in series are bridged across the smoothing output, the ignition voltage of the series will be about 140 times the number used, and this should be rather more than the working voltage. (I find three in series light up at about 430 to 450 volts). The current taken by these lamps increases very rapidly indeed after the ignition voltage is passed, and this current discharges the condensers more rapidly than they can be recharged through the choke, so that the condenser P.D. soon drops below the extinction voltage and the lamps go out, thus smoothing off the voltage surge. I may say that although the ignition voltage of my arrangement is only some twenty volts above the working voltage, I have only once seen them light up and then only for an instant when the supply co-bungled a switching operation (for demonstration purposes I dim the output valve filaments with series resistance). This would seem to show that with normal operation voltage surges are negligible with A.C. rectified for H.T. supply, and the output valves lighted off the same transformer. There seems no reason why the neon lamp arrangements should not be adopted for D.C. smoothing circuits.

It may be noted that reversing the lamps in the holders varies the ignition voltage, and I understand that some of the "letter" lamps have quite large variations from the 140 volts suggested, so that it would probably be possible by judicious selection and choice of polarity to make a neon lamp surge absorber to operate at any desired voltage, within as close limits as would be required in practice.

(*f*) I cannot agree with Mr. Warren's statement that the use of a large condenser to reduce the voltage drop with A.C. is "unnecessary, since any voltage can be obtained with a transformer." The whole object of a large smoothing condenser is to minimise the voltage variation *during a cycle*, and putting up the transformer voltage will not help here. The argument put forward, namely, that we may increase the transformer voltage, would apply to a suggestion that resistance in smoothing chokes is not detrimental; but even this is only true within limits, as even with the Ferranti anode feed resistance scheme, it is possible to get motor boating with a multi-stage amplifier if the filter chokes have very high D.C. resistance (high compared to the anode feed resistances). I have even found it worth while to use specially low resistance chokes and to design the transformer to have as good voltage regulation from no load to full load as is practically possible with so small a piece of apparatus as a 100-watt transformer.

(*g*) I can recommend a two-stage filter rather than a single stage as cheaper for a given smoothing effect than a single stage.

(*h*) As additional proof that surges are not in fact as large as might be feared, I had an old smoothing circuit for 150 volts D.C. using the ordinary T.C.C. "300-volt-test" condensers, which are not recommended by the makers for eliminator use at all. When putting up the output power to 400 volts 60 milliamps., I could not obtain high voltage condensers at the moment, and I thought of trying the old ones "until they burnt out." They have not done so yet, although they ran for three months before being replaced by "600-volt-test," and several are still in use with anode feed resistances in earlier stages than the last.

I do not know what the final breakdown voltage of a common, green tin-cased condenser may be, but evidently for three months no surge voltage ever reached it, which tends to show that surge is not very troublesome in practice, (and also that the old tin-cased condenser with a compo top had an enormous factor of safety).

(*i*) Of course, rectifier transformers should be fused on both poles, 47 S.W.G. Eureka in removable clips is satisfactory.

C. R. COSENS.

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

SIR,—I thank Mr. Cosens for his letter. My comments on his criticisms follow.

(*a*) The resistance of the smoothing chokes was neglected for the sake of simplicity; it is easy to take it into account. With standard chokes, which may have a resistance of about five ohms per henry, the reduction in the surge voltage due to resistance is only about 5 per cent. With low-resistance chokes, designed to ease the smoothing, the reduction in the surge potential is less.

(*b*) I suggested on p. 606 that when working on rectified A.C. the surge at make is often limited by the rectifying system. This applies particularly when hot cathode valves are used as rectifiers.

(*c*) A voltmeter is of no value as a surge indicator. It only indicates the average voltage, which falls steadily to zero (see Fig. 7, p. 605). An oscillograph is required to indicate the instantaneous values, which may be quite high.

(*d*) A high resistance connected across the output condenser is useful if the set is switched off at the same time as the eliminator, though the set itself acts effectively as a discharger if the eliminator is switched off first. A high resistance has little effect upon the surge voltage.

(*e*) Surge absorbers are an added complication. It is clear that if they are necessary, one must be connected across each condenser; it is not sufficient to protect only the output condenser C_1 (ee Figs. 7, p. 605). My experience of neon lamps is limited, but it has been sufficient to convince me of their unreliability.

(*f* and *g*) Several points are involved here. Working on D.C. the only resistance to be considered is that of the choke, which behaves very much as the internal resistance of a high tension battery. If great, it may tend to motor boating. When working on A.C. there is nothing which directly corresponds; to talk of resistance of the smoothing circuit is almost meaningless. Back-coupling is induced chiefly through the impedance of the output condenser; in some cases it may actually be assisted by the by-pass condensers introducing a semi-resonant reaction into the L.F. amplifier. Choke resistance militates against smoothing and it is desirable to keep it low for this reason. From the point of view of *regulation* there is no particular virtue in a very low resistance. Even if the ohmic resistance were zero, the effective resistance of the smoothing circuit—condenser, choke, condenser—amounts to several hundred ohms. I agree that large condensers must give a smoother output, but I find it quite unnecessary to use higher values than those I have already suggested. I believe it is desirable to use a separate eliminator for the early valves, which require only a few milliamperes. Motor boating is thereby practically eliminated and a very smooth voltage is obtained for the detector valve. Using a single stage filter, having an L.C. product of 200 microfarad-henrys, on the output valve I find, even with half-wave rectification, no appreciable hum with a M.C. speaker. If a hum occurs its cause must be sought elsewhere than in the smoothing circuit (see last paragraph of article, p. 606). Good smoothing is required for the detector valve; it is surprising how little smoothing is necessary elsewhere. I think two eliminators a cheaper and more satisfactory solution than one.

(*h*) I agree that condensers may often have an enormous factor of safety. From experience I know that waxed paper prepared and used under the best conditions rivals the best mica. The difficulty is to ensure such conditions in a factory routine. It is unsafe to depend upon much more than the maker's recommended voltages, though many condensers will stand much higher potentials. Mr. Cosens has been lucky, and so have I (as well as careful). But I have known of several less fortunate individuals.

(*i*) Fuses are of course desirable, but they will not save a condenser. A safety gap is better.

In conclusion, it may be emphasised that in the article not only was the nature of eliminator surges discussed, but it was also pointed out that proper design could eliminate over-voltage. It is true that various safety devices (when fitted) may mitigate the effects of over-voltage. With the Irish I agree, however, that prevention is the surest remedy.

A. G. WARREN.

The Transmitting Station Actually Sends Out Waves of One Definite Frequency, but of Varying Amplitude.

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

SIR,—In connection with the correspondence under the above heading in the November issue of *E.W. & W.E.* and Prof. Howe's reply, the following may be of interest as confirming the latter's views.

Suppose we have a telephony transmitter in which a modulated oscillator (or amplifier) is followed by a stage of high-frequency amplification which feeds the aerial. Let the carrier frequency be 1,000 kc. and suppose this to be modulated with a 1 kc. note. The output from the modulated oscillator will comprise frequencies of 999, 1,000 and 1,001 kc. The succeeding amplifier will not be working wholly on the linear portion of its characteristic and in its output there will be the usual series of harmonics. Of these, consider only the second. We are led to the conclusion that its output will include frequencies of 1,998, 2,000 and 2,002 kc. This is, of course, equivalent to a carrier frequency of 2,000 kc. modulated at 2 kc. Thus when listening to the second harmonic of such a transmitter all the notes should be raised an octave.

Experiment shows that no such effect is observed, a 1 kc. note is heard on the fundamental and on all harmonics.

My explanation is, that while it is legitimate, and even correct to view a modulated wave as a spectrum from the point of view of the tuning circuits, this course is not justified when dealing with a valve. The valve output is a definite function of the input to it, and hence, when dealing with it, it is necessary to consider the input as a complex waveform and not as a sum of pure frequencies of constant amplitude. The valve itself is quite aperiodic (over the frequency range involved) and is incapable of any harmonic analysis.

The conclusion is that both methods of viewing the modulated wave are of service but that one must not use them indiscriminately.

I shall be interested to hear if any of your readers can suggest any alternative and more acceptable explanation. The apparent fallacy was published in a letter to *The Wireless World* about two years ago, but no suggestions were offered by any of its readers.

FRANK AUGHTIE.

Teddington.
7th November, 1928.

BOOK REVIEW.

HANDBUCH DER EXPERIMENTAL PHYSIK (WIEN-HARMS), XIII. 2 Teil. Glühelektroden und Technische Elektronenröhren [Technical electronic valves and heated filaments.], pp. 492. Akademische Verlagsgesellschaft, Leipzig, 1928.

The first half of this book deals with thermionics. the scientific phenomena which underlie the behaviour of heated filaments; a general discussion of the thermodynamics of uncharged systems, electrically charged systems, and systems in electro-chemical equilibrium, clears the way for a comprehension of the facts of the emission of electrons by hot bodies. It is shown that an atmosphere of electron vapour may be considered as a perfect gas provided that the mean free path is sufficiently long; this condition demands that, as is practically always the case, the current density should not exceed a few amperes per cm.^{2}.

The equation for the emission of electrons in terms of the temperature of the source, first worked out by O. W. Richardson, is examined in detail, and the subsequent work of Langmuir and others on the emission from tungsten in the presence of vapours of alkali metals; thoriated tungsten and oxide covered filaments are included and a large number of curves and tables are reproduced; facts and theories of the shot and flicker effects terminate the first part of the book.

Sixty pages are then devoted to the production of wires of tungsten, molybdenum, and tantalum; several microphotographs show the crystalline state of these metals during drawing and recrystallising operations. The technique of oxide coating is gone into thoroughly and curves are given showing the decrease of emission with time for surfaces prepared by different methods. Methods of evacuating and outgassing valves are set out and a section is given to the various "getters" which are in use.

The remainder of the book, containing 130 pages, treats of the theory and practice of modern transmitters and receivers. The discussion is naturally severely condensed, but the recent advances, such as piezo-electric control, screened grids, and valve rectifying systems, are adequately dealt with. It is regrettable that the term "Durchgriff" should still be retained when its reciprocal, the voltage amplification factor, is now used by the whole world outside Germany.

The book should appeal to any serious student of wireless problems, to the mathematical physicist in search of interesting problems, and to the valve designer.

R. T. BEATTY.

Abstracts and References.

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PROPAGATION OF WAVES.

LONG-WAVE RADIO RECEIVING MEASUREMENTS AT THE BUREAU OF STANDARDS IN 1927.—L. W. Austin. (*Proc. Inst. Rad. Eng.*, September, 1928, V. 16, pp. 1252–1257.)

Illustrated by tables showing monthly averages of daylight signal intensities of a number of stations, European and American, and the strength of atmospherics. Although from January to May the intensities of the distant stations fell for the most part below the 1926 values, the averages (except for Bordeaux) were above those for 1926. Atmospheric disturbances have been very weak.

THE MEASUREMENTS OF THE FIELD INTENSITIES OF SOME HIGH POWER LONG DISTANCE RADIO STATIONS. Part I. Bolinas and Bordeaux.—E. Yokoyama and T. Nakai. (*Researches of Electrot. Lab.*, Tokio, No. 229, June, 1928, 70 pages).

Field intensities were measured by the substitution method used by Beverage and Peterson, slightly modified. Intensities of "grinders" were measured by the method employed by Austin and Judson, also slightly modified.

THE DAILY TERRESTRIAL MAGNETIC VARIATIONS AND THE SUN'S MAGNETIC FIELD.—S. Chapman. (*Nature*, 13th October, 1928, V. 122, p. 572.)

Referring to Gunn's suggestion (see October Abstracts) that the daily variation of the earth's magnetic field is due to the diamagnetism of the outermost layer of the atmosphere, the writer says that the magnetic effect is far outweighed by that of a drift acquired by the charges under the joint action of the magnetic field, gravity, and the vertical electrostatic field which prevents the light electrons from spreading upwards much farther than the heavier ions. He goes on to discuss briefly the effects of this drift, and mentions the possibility of its playing a part in the magnetic field of sunspots.

THE INFLUENCE OF THE EARTH'S MAGNETIC FIELD ON WIRELESS TRANSMISSION.—E. V. Appleton. (*International Union of Scientific Radio Telegraphy—U.R.S.I.*—July, 1928, V. 1, Fascicule 1, pp. 2–3, English, or Fasc. 1 *bis*, pp. 2–3, French.)

A summary of the paper read at the Washington Assembly, 1927. The magneto-ionic theory, previously developed, of the propagation of wireless waves in an ionised medium is here extended to the general case of propagation in any direction with regard to the magnetic field. The formula shows that only when the ionisation is small should critical effects occur for one of the two waves generally propagated, at about 200 metres: also, that under certain conditions, even vertical incidence on the layer may give reflection.

A NOTE ON THE SHORT WAVE LONG DISTANCE TRANSMISSION.—T. Minohara and K. Tani. Also DIURNAL VARIATION IN SIGNAL STRENGTHS OF SHORT WAVES, and SEASONAL VARIATION IN SIGNAL STRENGTHS OF THE 20-METRE WAVE FROM NAUEN IN JAPAN.—T. Nakagami and T. Ono. (*U.R.S.I.*, July, 1928, V. 1, Fascicule 1—English, or Fasc. 1 *bis*.—French; pp. 44–51 or 37–44.)

The first paper gives some daily runs taken near Tokio on Buenos Ayres, Schenectady and Nauen, plotted in correlation with the width of the intervening "dark path." The titles of the other papers explain themselves.

EFFECTIVE HEIGHTS OF THE KENNELLY-HEAVISIDE LAYER IN DECEMBER, 1927, AND JANUARY, 1928.—Breit, Tuve, and Dahl. (*Proc. Inst. Rad. Eng.*, September, 1928, V. 16, pp. 1236–1239.)

Results obtained by the echo-method with the improved transmission giving short widely-spaced peaks (see September Abstracts). Wavelength was about 75 m. Sometimes triple reflections were observed, corresponding to heights in the ratio 1, 2 and 4 (in a particular case, during a period of severe short-distance fading, 67, 140 and 280 miles). Heights (1st reflection) vary from 132 to 145 miles, though a 65–75 mile value recurs at the times of triple reflection, particularly in January. A table gives the daily measured effective heights and also rough estimates of the intensities of the waves recorded.

THE EFFECT OF OZONE ON THE TEMPERATURE OF THE UPPER ATMOSPHERE.—E. H. Gowan. (*Proc. Roy. Soc.*, 1st October, 1928, V. 120A, pp. 655–669.)

From material provided by other workers (*e.g.*, Abbot's curve of distribution of energy in solar spectrum: data as to total average amount of ozone, etc.), the writer considers the radiative equilibrium of the upper part of the atmosphere, taking into account the effects, with selective absorption, of water-vapour and ozone. The resulting curves indicate, among other things, a region of high temperature in the neighbourhood of, and above, 60 km. This agrees with deductions made from meteor observations and from acoustic observations on big explosions.

ON THE DIFFRACTION OF THE MAGNETIC ELECTRON.—C. G. Darwin. (*See* under "General Physical Articles.")

LONG WAVE RADIO RECEPTION AND ATMOSPHERIC OZONE.—K. Sreenivasan. (*Nature*, 27th October, 1928, V. 122, pp. 646–647.)

The weekly averages of signal field strength at Madras from Bangalore, on a 4,000 m. wave, for

26 weeks from 1st March, 1927, are plotted in comparison with the corresponding weekly averages of ozone content measured in N.W. Europe. In spite of the 8,000 km. difference of locality, the curves show such a marked agreement that the writer deduces (a) that changes in the ozone values partake of the nature of a world phenomenon, and (b) that long wave field intensity is proportional to the ozone value of the air even when the averages are taken over such short periods as a week. It would appear likely that the reverse would be true with very high frequency waves, say below 100 m. wavelength. The diagrams also show the corresponding curves of sunspot numbers and of the mean magnetic character of day. Correlation of signals with the former are considered by the writer to be fairly definite: with the latter, no tangible connection is suggested.

GERMANS OVERCOME RADIO FADING.—(*Science News Letter*, 29th September, 1928, V. 14, p. 197.)

According to this report, Dr. Rukop announced at the recent meeting of the German Association corresponding to the "British Association" that fading on short waves can now be overcome by the use of two aerials at the receiving station, spaced perhaps 50 to 100 yards apart. No details, nor mention of any limitations, are given here.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

ZUR FRAGE NACH DER NATUR DER KUGELBLITZE (The Nature of Globular Lightning).—K. F. Bottlinger. (*Naturwiss.*, No. 13, 1928, p. 220.)

The nucleus is suggested to be temporarily radio-active matter produced by the breaking up of atoms by the enormous potential differences.

OBSERVATION, ENREGISTREMENT ET PRÉVISION DES ORAGES AU MOYEN DES ONDES ÉLECTRIQUES (Observation, recording and forecasting of Storms by Electric Waves).—A. Turpain. (*Rev. Gen. de l'Élec.*, 20th October, 1928, V. 24, pp. 584–587.)

The apparatus described and illustrated is based on a coherer of seven gilt needles. One modification records the energy of the discharge registered, by a bolometric circuit. The Turkish Government has installed over 30 of these instruments, including four of the bolometric type.

THE DIRECTIONAL OBSERVATIONS ON ATMOSPHERICS IN JAPAN.—E. Yokoyama and T. Nakai. (*U.R.S.I.*, July, 1928, V. 1, Fascicule 1—English, or 1^{bis} — French, pp. 74–78 or 69–74.)

Results of observations at Isohama from February-July, 1927, on atmospherics interfering with long wave reception, chiefly 10,000 and 20,000 m. Among the conclusions drawn are: that not only is the direction of origin of "clicks" different from that of "grinders," but that the former come from less distant places than the latter; that the direction of "clicks" shifted from nearly south towards west as the season advanced from winter to summer, while that of the "grinders" remained unchanged; and, finally, that the "clicks" originate in the mountain regions of Japan, while the "grinders" probably come always from a tropical region such as the East Indies.

ELEKTRISCHE LEITFÄHIGKEIT DER ATMOSPHÄRE UND KONDENSATIONS-KERNZAHL (Electrical Conductivity of the Atmosphere and Condensation Nucleus Numbers).—J. Scholz. (*Naturwiss.*, 5th October, 1928, pp. 760–761.)

Further evidence of the correlation of these two properties, observed at the Meteorological-Magnetic Observatory at Potsdam.

RELATIONS ENTRE LES PARASITES ATMOSPHÉRIQUES ET LES PHÉNOMÈNES MÉTÉOROLOGIQUES (Relation between atmospherics and meteorological phenomena).—R. Bureau. (*U.R.S.I.*, July, 1928, V. 1, Fascicule 1, pp. 6–16.)

An exposition of the author's theory according to which he divides atmospherics into three classes: nocturnal (which he links up with meteorological anti-cyclonic conditions); irregular, appearing at any hour of day or night (linked to air-currents due to perturbations of the polar front); and afternoon, starting sharply about mid-day and decreasing at about 9 p.m. (linked to storm disturbances independent of the polar front). By "polar front" is meant the surface of encounter of masses of air from the polar regions with masses of air from tropical regions: this surface of encounter forms itself all round the earth at moderate latitudes. There are also the "pseudo-polar fronts," the most important one (for W. Europe) being born on the S.E. face of the Azores anti-cyclone by the meeting of Sahara and Atlantic airs. By means of records taken, some at sea in the N. Atlantic but most at Paris, the author correlates the observed atmospherics with the meteorological records of such "cold fronts"; and concludes that while in Europe the distance of the origin may lie between 50 and 150 km., in French W. Africa it may be as great as 300 km. Greater distances are only admitted as exceptional events caused by "particularly intense" cold fronts accompanied in general by violent storms.

THE POLARITY OF THUNDERCLOUDS AND THE INTERCHANGE OF ELECTRICITY BETWEEN THUNDERCLOUDS AND THE EARTH.—B. F. J. Schonland. (*Proc. Roy. Soc.*, 1st March, 1928, V. 118A, pp. 233–262.)

THE PRESENT STATE OF OUR KNOWLEDGE ON ATMOSPHERICS.—R. A. Watson Watt. (*Engineering*, 19th October, 1928, V. 126, p. 496.)

Summary of a paper read at the recent British Association meeting. Among other interesting points may be mentioned the fact that most of the many thousands of atmospherics whose shapes and magnitudes were discussed (observed in England, Khartoum and Australia) were of aperiodic form, and no reversal of voltage reaching 4 millivolts per metre could be measured. The mechanism by which these aperiodic forms are produced, whether by wide separation in time of the periods of acceleration and deceleration in the original discharge or by selective dissipation, is not yet understood: incidents in the propagation, rather than peculiarities at the source, may be responsible. At Aboukir the predominant stream of atmospherics arrives about noon from nearly due south, then swings round through west in the afternoon, and by 5 p.m. begins to come from the north-east. The sources of atmospherics seem to lie chiefly in the mountain areas; none are produced over the Pacific. Russian work has resulted in the location of thunderstorms 3,000 to 5,000 km. distant, the 10 kilocycle intensity component of the atmospherics observed being found to vary with the distance according to the inverse square law.

THE MECHANISM OF THUNDERSTORMS.—(*Engineering*, 19th October, 1928, V. 126, pp. 495–496.)

Summary of the British Association discussion opened by G. C. Simpson and continued by C. T. R. Wilson, E. V. Appleton, B. F. J. Schonland, R. A. Watson Watt and J. J. Nolan.

MAGNETIC STORMS.—A. H. R. Goldie. (*Engineering*, 19th October, 1928, V. 126, p. 496.)

Summary of a paper read at the recent British Association meeting, dealing with conclusions drawn from observations at Lerwick, Eskdalemuir and Abinger.

SUN-SPOT NUMBERS AND ANNUAL RAINFALL IN NEW ZEALAND.—E. Kidson. (*N.Z. Journ. Sci. and Tech.*, July, 1928, V. 10, pp. 90–97).

THE VALUE OF MAGNETIC INVESTIGATIONS IN NEW ZEALAND AND SAMOA.—C. Chree. (*N.Z. Journ. Sci. and Tech.*, July, 1928, V. 10, pp. 97–100.)

PRESENT STATE OF KNOWLEDGE OF ATMOSPHERICS.—R. A. Watson Watt. (*E.W. & W.E.*, November, 1928, V. 5, pp. 629–632.)

PROPERTIES OF CIRCUITS.

DIE SELBSTERREGUNGSBEDINGUNGEN BEI RÜCKKOPPLUNGS-RÖHRENSENDERN FÜR SEHR KURZE WELLEN (Conditions for self-excitation in reactively-coupled valve transmitters for very short waves).—W. Pfitzer. (*E.N.T.*, September, 1928, V. 5, pp. 348–369.)

A long paper on work under the auspices of Prof. Barkhausen. Waves under 10 metres are considered, down to about 1.75 m. The theoretical conclusions of the first part are confirmed by experimental work with various types of circuit, all derived from the voltage-dividing connection, though externally not recognisable as such. Current measurements were made by a small incandescent lamp with thermopile, in a movable circuit which could be coupled to any desired part of the oscillating circuit. Excitation laws for waves 100 times longer, in similar circuits, were found to apply to these very short waves, except that below 2.5 m. small discrepancies appeared, due to the influence of the electron time of transit.

QUANTITAVES ZUR AUDIONGLEICHRICHTUNG (Quantitative Measurements on Audion-rectification).—M. v. Ardenne. (*Rad. f. Alle.*, October, 1928, pp. 433–436.)

Illustrated by curves taken with Telefunken-type valves on 400 m. wavelength.

ÜBER DIE EINEM EMPFÄNGER DURCH ERDUNG ZUGEFÜHRTE ENERGIE (The Energy introduced into a Receiver by Earthing).—A. Székely. (*Zeitschr. f. Hochf. Tech.*, September, 1928, V. 32, pp. 83–86.)

The writer concludes that the supplementary current produced by earthing is due less to the earth than to the effect of the vertical part of the earth-lead; and that the effect is only marked on short waves.

NOTE ON RADIO FREQUENCY TRANSFORMER THEORY.—Diamond & Stowell. (*Proc. Inst. Rad. Eng.*, September, 1928, V. 16, pp. 1194–1202.)

The writers state that computations based on hitherto accepted equations often fail to be in entire agreement with test results, and attribute this chiefly to the existence of a capacitive coupling whose effect is considered negligible in the usual analysis. They develop new equations which include this effect and which yield a closer agreement with experimental data. The variation with frequency of the equivalent transformer primary impedance is also affected by this distributed capacitive coupling.

ÜBER DEN RÜCKGEKOPPELTEN VERSTÄRKER (Amplifiers with Reaction coupling).—Y. Watanabe. (*Zeitschr. f. Hochf. Tech.*, September, 1928, V. 32, pp. 77–83.)

For various types of reactively-coupled amplifier, the equations are given for amplification factor, limits of amplification without oscillation, and coupling coefficient. A new reaction-circuit is mentioned which increases many times the amplification factor of the distortionless L.F. reactance amplifier. A method of solution is given for an amplifier with coupled resonance-circuit.

ON THE PREDETERMINATION OF OSCILLATING AMPLITUDES AND CIRCUIT CONSTANTS L, C AND M UNDER THE CONDITIONS OF MAXIMUM OUTPUT OF TRIODE OSCILLATORS.—K. Kurokawa and H. Hayakawa. (*Journ. I.E.E. of Japan*, August, 1928, pp. 796–815.)

The static characteristic surfaces of the plate current as a function of plate and grid voltages are assumed to be represented by parts of four planes mutually intersecting. The current and voltage amplitudes of the oscillating circuit are calculated from the conditions of equality of mean power supplied to the oscillating circuit by the source and the valve, and that consumed in the oscillating circuit (neglecting the grid circuit loss). Values for L, C and M giving the maximum output for a specified frequency are calculated.

EIN EXPERIMENTELLER BEITRAG ZUM SPULENPROBLEM (An experimental contribution to the coil problem).—R. Rücklin. (*Arch. f. Elektrot.*, 17th September, 1928, V. 20, pp. 507–532.)

The problem of current and voltage distribution for high frequency in a single-layer cylindrical coil leads to different solutions by different workers, some saying that the distribution is sinusoidal for all frequencies, others that there is a critical frequency at which it changes to hyperbolic. These tests tend to show that there is such a change at a critical frequency.

ZWEI VERSTÄRKER MIT OHMSCHER RÜCKKOPPLUNG IN THEORETISCHE BEHANDLUNG (Two Amplifiers with Resistance Reaction, treated theoretically).—F. Schierl. (*Arch. f. Elektrot.*, 11th August, 1928, V. 20, pp. 346–370.)

Theoretical results are confirmed experimentally. The two amplifiers are the 2-valve circuit known as the kallirotron of Turner, and a somewhat similar circuit but using 2-grid valves, due to Jäger and Scheffers. With each of these, increase of back-coupling resistance causes increase in the characteristic steepness, which may become infinite—when instability and "flaws" appear in the plotting. Finally, the practical application of these two amplifiers to the measurement of small A.C. currents is dealt with. The effect of inductance in the anode circuit on the amplification is discussed.

UNTERSUCHUNGEN AN DER DOPPELGITTERRÖHRE IN RAUMLADUNGSNETZSCHALTUNG (Investigation of double-grid valves in space-charge-net connection).—J. Dantscher. (*Arch. f. Elektrot.*, 11th August, 1928, V. 20, pp. 333–345.)

The functioning of the 2-grid valve in this connection, in the region of saturation, is studied by means of static characteristic curves. A series of current-voltage curves are given. A number of conclusions are drawn, for which the paper must be consulted. Mention can be made here of two: as a result of the non-rectilinear slope of the grid characteristic, for full control the amplification is not completely free from distortion; and the value of "durchgriff" is even more dependent on conditions of employment than in the case of a single-grid valve.

EINIGE ERGÄNZUNGEN UND BERICHTIGUNGEN ZUM PROBLEM DER KIPPSCHWINGUNGEN (Some Amplifications and Corrections on the Problem of Relaxation Oscillations).—E. Friedlander. (*Arch. f. Elektrot.*, 7th June, 1928, V. 20, pp. 158–161.)

Refers to previous papers by the same writer (see Abstracts 1927, p. 51) and to van der Pol's work (see there and also various recent Abstracts). Goes on to give a provisional table showing the production of harmonic, relaxation, and combined har. and relax. oscillations according to the number of frequency-determining, energy-storing elements present in the circuit; with examples of each class. Thus in the class of 2 elements, for Relax. osc. alone is given the Abraham-Bloch Multivibrator circuit; in the 3 element class, for mixed har. and relax. osc., the Flewelling circuit is given. Finally, various cases of relaxation oscillations in everyday life are mentioned, including water-hammer effects in water systems, and effects in A.C. arcs.

AN EXPERIMENTAL INVESTIGATION OF FORCED VIBRATIONS.—L. W. Blau. (*Journ. Franklin Inst.*, October, 1928, V. 206, p. 502.)

Corrections to the paper under this title (November Abstracts).

LE BATTEMENT DU CŒUR CONSIDÉRÉ COMME OSCILLATION DE RELAXATION, ET UN MODÈLE ÉLECTRIQUE DU CŒUR (Heart-beat as an Oscillation of Relaxation, and an Electric Model of the Heart).—B. van der Pol and J. van der Mark. (*L'Onde Élec.*, September, 1928, pp. 365–392.)

The first part of this paper shows how the equation which for certain conditions of resistance, inductance and capacity leads to the ordinary sinusoidal damped waves leads also, for other conditions, to the production of the totally dissimilar oscillations of relaxation; discusses the properties of these, in particular their property of putting themselves in synchronism with an external periodic phenomenon acting on them; and some of the processes in which they occur (*e.g.*, in the production of sound by a flute). It then goes on to establish the analogy between the processes of these oscillations and the beating of the heart; not insisting that any electric excitation causes or precedes the contractions of the heart, but considering the two processes as parallel examples of the same mathematical behaviour. Thus the knowledge recently obtained regarding the electrical oscillations allows the cardiac rhythm to be considered from a new point of view; for example, well-known irregularities of the heart can be predicted and in addition some which so far are unknown as regards the human heart. The whole of the rest of the paper is devoted to an actual electrical circuit representing the heart, and to electro-cardiograms taken from it.

TRANSMISSION.

VACUUM TUBES AS OSCILLATOR GENERATORS.—D. C. Prince and F. B. Vogdes. (*G.E. Review*, October, 1928, V. 31, pp. 546–554.)

Part VI of this series deals with secondary grid-coupled circuits: power-amplifier and master-controlled circuits.

CONSIDERATIONS AFFECTING THE LICENSING OF HIGH-FREQUENCY STATIONS.—S. C. Hooper. (*Proc. Inst. Rad. Eng.*, September, 1928, V. 16, pp. 1240–1251.)

The writer deals with frequencies between 6 and 23 megacycles, which he considers must generally be considered as interfering around the world. The article includes a suggested table of priority among applicants in the fixed service bands; and the writer points out that places must be found in the spectrum for other uses of radio:

for instance, channels between 80 and 500 kc. will be required for television. See also Espenschied, September Abstracts.

NOTE AU SUJET DES ONDES DE QUELQUES MÈTRES (Note on Waves of a few metres length).—R. Mesny. (*U.R.S.I.*, July, 1928, V.1, Fascicule 1—French, or 1 *bis*—English, pp. 42–44 or 35–37.)

Wavelength was from 2 to 4 m.; power from 2–200 W. Reception was by super-regenerative circuits. Propagation between raised positions within sight of each other was excellent; in the Alps between two peaks 100 km. apart, reliable duplex telephony needed only 3 W. input; as might indeed be expected, since the formula gives at this distance for this wavelength (assuming a transmitter isolated in space, and no damping) a field-strength of 67 microvolts per metre for every watt of energy radiated.

The effect of a screen was tested by interposing a chain of hills about 25 km. away. In all cases, the signals vanished somewhat abruptly when the line joining the receiver and the edge of the screen made an angle of 1° to 1.5° with the line passing directly to the transmitter. Propagation near the ground presented very different phenomena. With transmitter and receiver a few metres above flat open ground, the same 3 W. input gave communication vanishing between 2 and 3 km. Even if the transmitter remained high (*e.g.*, at the top of the Eiffel Tower) the signals disappeared at some 20 km. if the receiver was on a plateau a few hundred metres from the near edge; though if it was moved to that edge, the signals again became strong. This is interpreted as a case of reflection of plane waves at a plane, which by calculation would cause a field nearly 25 times weaker at the interior of the plateau than at the edge, where reflection does not come in. With the transmitter at the top of the Eiffel Tower, powers of 150 W. gave no result at distances of 600 and 900 km., where the sphericity of the earth constitutes a screen 7 km. high. Only ionic refraction could permit such communication, and apparently this is insufficient to bring back, even at greater distances, waves lower than about 10 metres. The uses of such short waves are discussed. Atmospherics were absolutely imperceptible (as was also found by Esau). Cf. the latter's paper, November Abstracts, for points of agreement and of contrast.

RECEPTION.

RADIO RECEIVER VOLUME CONTROL.—A. B. Whittaker. (*Elec. Review*, 26th October, 1928, V. 103, pp. 703–704.)

Comments on the various applications of variable resistance as a means of control.

L'EVOLUTION ET L'AVENIR DES HAUT-PARLEURS (The Evolution and Future of Loud Speakers).—P. Toulon. (*L'Onde Élec.*, September, 1928, pp. 393–409.)

The writer evidently places great faith in the future of the electrostatic loud-speaker, a present form of which he describes and illustrates. Field voltage used is about 2,400 V.

RESONANCE IN MOVING-COIL LOUD SPEAKERS, THE IMPORTANT INFLUENCE OF THE DIAPHRAGM SURROUND, AND ITS QUANTITATIVE ANALYSIS.—N. W. McLachlan. (*Wireless World*, 10th and 17th October, 1928, V. 23, pp. 497–499 and 539–542.)

THE KILO-MAG FOUR: A SCREENED GRID SET WITH A THOUSAND-FOLD H.F. AMPLIFICATION.—H. F. Smith. (*Wireless World*, 24th October, 1928, V. 23, pp. 550–554.)

FURTHER NOTES ON THE "MEGAVOX THREE."—N. W. McLachlan. (*Wireless World*, 3rd October, 1928, V. 23, pp. 458–460.)

The numerical treatment of signal voltages is first dealt with, on the foundation provided by the Barfield field strength contour map of 2LO, which is reproduced. The question of smooth volume control is then considered.

FADING AND THE DETECTOR: ADVANTAGES OF LEAKY GRID DETECTION IN MINIMISING EFFECTS OF FADING.—(*Wireless World*, 3rd October, 1928, V. 23, p. 485).

VALVES AND THERMIONICS.

ELEKTRONENSTRÖME UND RAUMLADUNG IN DICHTEN GASEN (Electron-currents and Space-charge in dense gases).—F. Skaupy and W. Daudt. (*Phys. Zeitschr.*, 1st May, 1927, pp. 313–315.)

Skaupy showed in 1918 that amplifier valves with Nitrogen, or Argon plus Nitrogen, at pressures of the order of ⅜ atmosphere, showed the same effects (if weaker) as vacuum valves. The present paper develops the experiments still further; characteristic curves are shown, one diagram, for instance, giving curves for various pressures of N_2; a second, for various anode voltages from 100 to 220 V. at a constant pressure of 300 mm. of N_2; and a third, for the effects of various impurities in the gas.

SCREENED-GRID VALVE AS A DETECTOR: SOME INTERESTING DATA BASED ON ACTUAL MEASUREMENT.—A. P. Castellain. (*Wireless World*, 10th October, 1928, V. 23, pp. 492–494.)

OSCILLATIONS IN IONISED GASES.—I. Langmuir. (*Proc. Nat. Acad. Sci.*, August, 1928, V. 14, pp. 627–637.)

A theoretical analysis, with experimental confirmation, of various possible modes of vibration of a "plasma"—a highly ionised gaseous medium at low pressure containing positive ions and electrons normally in about equal numbers, so that the resultant space charge is very small.

Oscillations of small amplitude with frequencies up to 1.2×10^9 have been observed, explained by the theory as being low-velocity electron waves with zero group velocity and therefore incapable of transmitting energy. Other vibrations, electrical analogues of sound waves, with frequencies ranging from 1 to 240 kilocycles, are due to ionic oscillation. Oscillations in a beam of electrons, having different frequencies according to the direction from which they are observed, have frequencies ranging from 10^7 to 10^8.

Recherches et Essais sur les Lampes de T.S.F. (Research and tests on Wireless Valves).—A. Kiriloff. (*Q.S.T. Fran.*, October, 1928, pp. 7–18.)

The first of a series of articles. The present part deals with the installation of the laboratory, transformer and rectifier room, and machine room.

Graphs for the Design of Bright-emitting Tungsten Filaments.—N. Kato. (*Electrot. Lab. Tokyo*, Circ. No. 50, February, 1928, pp. 1–14.)

Empirical Formulæ for Dependence of Tungsten Resistance on Temperature.—N. D. Morgulis. (*Teleg. i Telef. b.p., Nichny-Novgorod*, August, 1928, V. 9, pp. 485–486.)

DIRECTIONAL WIRELESS.

Radio Beacons for Transpacific Flights.—C. C. Shangraw. (*Proc. Inst. Rad. Eng.*, September, 1928, V. 16, pp. 1203–1235.)

Deals with the "equi-signal zone" system (*cf.* various recent Abstracts) in particular connection with various recent long-distance flights. The width of the zone appears to be about 8 miles at a distance of about 1,200 miles. Reception on the aeroplane would seem to be the weakest part of the system. Even with the best transmitting and receiving apparatus, adequate training of personnel is necessary.

Experiences in Radio Compass Calibration.—F. A. Kolster. (*U.R.S.I.*, July, 1928, V. 1 Fasc. 1—English, or 1 *bis*—French, pp. 40 or 33.)

Abstract of paper read at the Washington Assembly, 1927.

MEASUREMENTS AND STANDARDS.

A Frequency Standard.—W. A. Marrison. (*Nature*, 6th October, 1928, V. 122, p. 552.)

Summary of an article in the Bell Lab. Record for August. Engineering physicists are beginning to question whether the accuracy of the rate of the earth's rotation round its axis is sufficient for their measurements. If the length of the day alters by about one second in ten years, this would soon cause an appreciable discrepancy between reference standards. Marrison points out that in electrical communication we have to work with frequencies ranging from less than unity to a hundred million or more per second. It seems now possible to maintain frequencies constant to one part in ten million, for several seconds. In fact, in successful television this is done. He goes on to describe the Bell Company's new form of quartz-controlled reference standard and the clock-equipment used to determine the frequency. The crystal temperature is controlled to within about one-hundredth of a degree centigrade. The clock, controlled by the crystal oscillator, keeps time with a maximum inaccuracy of less than one-tenth of a second per day.

Limits of Accuracy in Physical Measurements.—A. E. Ruark. (*Proc. Nat. Acad. Sci.*, April, 1928, V. 14, pp. 322–328.)

Methoden der Vakuumbestimmung an Fertigen Glühlampen (Methods of determining the vacuum of a completed incandescent lamp).—P. Selenyi. (*E.T.Z.*, 27th September, 1928, p. 1443.)

Zur Berechnung der Schallenergie (The calculation of Sound Energy).—V. Weisskopf. (*Phys. Zeitschr.*, No. 10, 1928, V. 29, pp. 302–304.)

The writer points out that it has hitherto been the custom to neglect variations of the second order of magnitude in pressure and volume-changes, but that this is inadmissible as the factors thus neglected can have a harmonic-producing effect.

The Use of a Wente Condenser Transmitter to Measure Sound Pressures in Absolute Terms.—A. J. Aldridge. (*P.O. Elec. Eng. Journ.*, October, 1928, V. 21, pp. 223–225.)

Unless suitable corrections are made, certain errors—here indicated—may be involved.

Appareil de Tableau Permettant de Mesurer par Lecture Directe les Différents Éléments d'un Circuit Complexe sous Courant Alternatif (Measuring instrument reading directly the various elements of a complex A.C. circuit).—S. S. Held. (*Rev. Gén. de l'Élec.*, 29th September, 1928, V. 24, pp. 465–471.)

Description of the "Henrymeter" and the ways of connection enabling it to read direct values of L, C and R, independent of voltage and frequency within industrial limits.

The Standardisation of Stationary Secondary Cells in the British Post Office.—H. C. Jones. (*P.O. Elec. Eng. Journ.*, October, 1928, V. 21, pp. 227–235.)

Subsidiary points of interest are the use of the "Electrode Cadmium" as a means of detecting trouble in individual cells: and the employment of anti-spray oil film.

Über neuere akustische und insbesondere elektroakustische Arbeiten (Latest work on acoustics, and in particular electro-acoustics).—F. Trendelenburg. (*Zeitschr. f. Hochf. Tech.*, September, 1928, V. 32, pp. 94–99.)

Second part of the long survey referred to in October Abstracts. This part deals with sound-field processes and the acoustics of rooms, both theoretically and experimentally. Sabine's researches on small scale models are mentioned, and illustrated by photographic representations of a vertical section of a theatre showing the course of a sound wave and the formation of reflection waves, particularly from the dome: showing also the improvements resulting from changes made in the model. Oscillograms also are given of echo-duration measurements on different frequencies of test-note. Reference is made to the treatment of broadcasting studios.

HOCHVAKUUM-MESSEINRICHTUNG FÜR GROSSGLEICHRICHTERS (High Vacuum Indicator for large Rectifiers.)—W. Menger. (*E.T.Z.*, 11th October, 1928, pp. 1512–1513.)

An appliance (by which an eye can be kept on the state of the vacuum) depending on the fact that the heating of a wire traversed by a constant current depends on the vacuum surrounding it.

MESSUNG VON MAGNETISCHEN FELDERN UND FELDÄNDERUNGEN MIT DEM MAGNETRON (Measurement of Magnetic Fields and Field-changes by the Magnetron.)—M. Rössiger. (*E.T.Z.*, 11th October, 1928, p. 1513: summarised from *Zeitschr. f. Phys.*)

The writer uses a Hull Magnetron for determining the total intensity and the variations of the earth's magnetic field. A sensitivity of 10^{-5} Gauss is obtainable.

MESURES ET ESSAIS EFFECTUÉS AVEC L'ANTENNE PROJECTEUR S.F.R.—C.M. (Measurements and Tests on the Soc. Fran. Radioélec. Chireix-Mesny Beam Aerial).—(*Bull. d.l. Soc. Fran. Rad. Él.*, June, 1928, pp. 22–27.)

MEASUREMENT OF RADIO FIELD INTENSITY.—V. I. Bashenoff. (*Teleg. i. Telef. b.p., Nichny-Novgorod*, August, 1928, V. 9, pp. 385–410.)

GENERAL METHOD FOR PLOTTING MODULATION CHARACTERISTICS OF RADIO TELEPHONE TRANSMITTERS.—N. D. Smirnov. (*Teleg. i. Telef. b.p., Nichny-Novgorod*, August, 1928, V. 9, pp. 478–484.)

MESURES ÉLECTROMÉTRIQUES DE TRÈS FAIBLES DIFFÉRENCES DE POTENTIEL ALTERNATIVES (Electrometer Measurements of very small A.C. Potential Differences).—Gutton and Laville. (*Phys. Berichte*, 1st July, 1928, p. 1174. from Comptes Rendus, 1924.)

The moving system weighed only 15 mg., and 1 volt gave a spot deflection of 100 mm.

DIELEKTRISCHE MESSUNGEN AN EINEM CELLON-KONDENSATOR BEI MITTLEREN FREQUENZEN UND NIEDERSPANNUNG (Dielectric Measurements on a "Cellon" Condenser at Medium Frequencies and Low Voltages).—W. Hubmann. (*Arch. f. Elektrot.*, 11th August, 1928, V. 20, pp. 371–373.)

NEW PRECISION IN COSMIC RAY MEASUREMENTS, YIELDING EXTENSION OF SPECTRUM AND INDICATIONS OF BANDS.—R. A. Millikan and G. H. Cameron. (*Phys. Review*, June, 1928, V. 31, pp. 921–930.)

A method is described which leads to greatly increased precision in the measurement of capacities of the order of one E-S. unit—giving results accurate to about 1 in 1,000. With the new electroscopes and methods, more penetrating cosmic rays have been detected and measured than the hardest hitherto found.

A METHOD OF CALIBRATING A LOW FREQUENCY VALVE GENERATOR WITH A SINGLE FREQUENCY STANDARD SOURCE.—T. S. Rangachari. (*E.W. & W.E.*, November, 1928, V. 5, pp. 633–634.)

SCIENTIFIC INSTRUMENTS AT OLYMPIA.—(*E.W. & W.E.*, November, 1928, V. 5, pp. 620–628.)

SUBSIDIARY APPARATUS AND MATERIALS.

THE ELEMENT OF TIME IN THE PHOTOELECTRIC EFFECT.—E. O. Lawrence and J. W. Beams. (*Phys. Review*, September, 1928, V. 32, pp. 478–485.)

Experiments are described on the time-variation of the photoelectric emission from a metal surface illuminated by light flashes of 10^{-8} sec. duration. They have yielded information as to the speed of operation of the Kerr cell electro-optical shutter (August Abstracts) and have made possible for the first time the observation of the steepness of wave fronts (resulting from spark discharges) travelling along wires.

L'EMPLOI DE CELLULES PHOTOÉLECTRIQUES, ASSOCIÉES À DES LAMPES À PLUSIEURS ÉLECTRODES, À LA SOLUTION DE DIVERS PROBLÈMES CONCERNANT LA MESURE DU TEMPS (The Use of Photoelectric Cells associated with multi-electrode Valves, for the solution of various Time-measuring Problems).—G. Ferrié and R. Jouaust. (*U.R.S.I.*, July, 1928, V. 1, Fascicule 1—French—or 1 *bis*—English; pp. 21–28 or 12–19.)

The self-maintained photoelectric pendulum finally evolved would keep time to within $\frac{1}{100}$ sec. or less after 24 hours if the supply voltage were kept constant during that time.

PHOTO-ELECTRIC THRESHOLDS AND FATIGUE.—G. B. Welch; and THE POTENTIAL OF PHOTO-ACTIVE CELLS CONTAINING FLUORESCENT ELECTROLYTES.—H. W. Russell. (*Phys. Review*, October, 1928, V. 32, pp. 657–666, 667–675.)

ÜBER EINEN KATHODENOSZILLOGRAPHEN HOHER SPANNUNGSEMPFINDLICHKEIT (A Cathode-ray Oscillograph of High Voltage-sensitivity).—E. Sommerfeld. (*Arch. f. Elektrot.*, 17th September, 1928, V. 20, pp. 607–618.)

A hot cathode instrument using low voltages (round 1,000 V). For obtaining as small a surface of emission as possible, the point and hood arrangement described by Rogowski and Grosser is used, modified slightly. It was found that for the low voltages employed, the vacuum had to be very high—less than 10^{-6}mm. Internal photography is used; an accelerating grid close to the screen, and with a voltage between it and the screen, speeds up the electrons. Greatest sensitivity so far is 0.1 cm./volt.

EMPFINDLICHER GLÜHKATHODENOSCILLOGRAPH FÜR INNENAUFNAHMEN IN EINEN VORVAKUUM (A sensitive Hot Cathode Oscillograph for Internal Photography in an ante-vacuum).—W. Rogowski, E. Sommerfeld and W. Wolman. (*Arch. f. Elektrot.*, 17th September, 1928, V. 20, pp. 619–624.)

Discusses Sommerfeld's above-described apparatus, and points out the practical difficulties due to the high vacuum. Improvements are mentioned—*e.g.*, a method of avoiding having to renew the high vacuum each time the photographic plate is removed, by substituting a thin fluorescent plate (a fixed part of the main tube) and allowing the fluorescence of this to mark the photographic plate. To prevent this thin plate from being forced in by atmospheric pressure, an "ante-vacuum" is used in the container for the photographic plate; this vacuum has to be renewed each time, but need not be high—1 mm. is enough. Many photographic records thus taken are shown.

NEUERE UNTERSUCHUNGEN AN KOHLEMIKROPHONEN (New Investigation of Carbon Microphones).—C. A. Hartmann. (*E.N.T.*, September, 1928, V. 5, pp. 344–347.)

The writer refers to a previous paper in which he pointed out that not only the frequency-dependence, but also the non-linear property of a microphone affects transmission, the latter cause producing overtones and a displacement of the amplitude of the partial tones. "Amplitude curves" of a microphone illustrate this and give a measure of the effect. The present tests were chiefly on a high-grade microphone, and show that for medium sound-pressures the non-linearity is reasonable, but that for small pressures, near the threshold point, there is great room for improvement.

MORE POWERFUL CATHODE RAYS.—(*Journ. Am. I.E.E.*, October, 1928, V. 47, p. 756.)

A paragraph referring to improvements in the Coolidge tube due to Plauson in Germany: consisting in the use of beryllium instead of nickel for the window, and of a rotating magnetic field for controlling the electron stream. Great intensification of ionic activity is said to result. Somewhat sensational claims appear to be made.

AVERTISSEUR AUTO-ALARME SYSTÈME S.F.R.-CHAUVEAU (Automatic Distress Call System S.F.R.-Chauveau).—(*Bull. d.l. Soc. Fran. Rad. Él.*, July-August, 1928, pp. 3–17.)

Description, with test results over distances up to 200 miles, of the S.F.R. ship call apparatus working on the standard minute call of 12 four-second dashes spaced by 1 sec. intervals. To provide the latitude necessary in view of incomplete and hand-sent calls, the apparatus will respond to three consecutive dashes between 3 and 5 seconds each and spaced by intervals below 2 seconds.

GLEICHSTROM - HOCHSPANNUNGSMASCHINEN ALS ANODENGENERATOREN (D.C. High-tension machines for anode supply).—H. Schulthess. (*E.T.Z.*, 18th October, 1928, pp. 1542–1543.)

Results with dynamos giving 12,000 V lead to the hope that similar success will be obtained with machines for 20,000 V. 20 kW. appears to be the smallest economical size.

EIN GLEICHSTROM-WECHSELSTROM-UMFORMER FÜR JENE, DIE EIN GLEICHSTROM-LICHTNETZ IN IHRER WOHNUNG HABEN (a D.C.-A.C. Converter for use on D.C. Power Supply).—F. Gabriel. (*Rad. f. Alle*, October, 1928, pp. 437–448.)

Illustrated description of a complete "home" unit designed round a 160 W. D.C. motor driving to 70 W. A.C. generator. The article is followed by two pages on the subject "Are D.C. Mains-adapters dangerous?" by Dr. Göttinger.

ON THE ACTION OF THE GEIGER COUNTER.—L. F. Curtiss. (*Phys. Review*, June, 1928, V. 31, pp. 1060–1071.)

A PORTABLE OSCILLOGRAPH EQUIPMENT FOR THE OBSERVATION OF TRANSIENT ELECTRICAL PHENOMENA.—P. R. Coursey. (*E.W. & W.E.*, November, 1928, V. 5, pp. 616–619.)

SURGES IN ELIMINATOR SMOOTHING CIRCUITS.—A. G. Warren. (*E.W. & W.E.*, November, 1928, V. 5, 601–606.)

STATIONS, DESIGN AND OPERATION.

THE USE OF RADIO FIELD INTENSITIES AS A MEANS OF RATING THE OUTPUTS OF RADIO TRANSMITTERS.—S. W. Edwards and J. E. Brown. (*Proc. Inst. Rad. Eng.*, September, 1928, V. 16, pp. 1173–1193.)

A method is described, with examples based on field strength surveys and other tests on five broadcasting stations, by which the outputs of transmitters could be regulated by the authorities in terms of field intensities instead of watts power in the transmitter or aerial circuits. The writers consider that stations should be so licensed that the largest possible number of listeners should receive signals of 5 to 30,000 microvolts per metre, while signals above the 30,000 should be considered as of interfering strength.

TECHNISCHES NACHRICHTENWESEN IN DER REICHSWEHR (Communication-technique in the National Army).—Pleger. (*E.T.Z.*, 11th October, 1928, pp. 1519–1522.)

A semi-popular lecture before a branch of the Elektrotechnischer Verein.

RÉGULATEUR AUTOMATIQUE DE FRÉQUENCE POUR POSTES ÉMETTEURS À ONDES COURTES (Automatic Frequency Regulator for Short Wave Transmitting Stations).—(*Bull. d.l. Soc. Fran. Rad. Él.*, January, 1928, pp. 3–13.)

Description of the S.F.R. system of frequency stabilisation, depending on the formation of beats between the transmitter oscillations and those of a standard low-power oscillator; the rectification and amplification of these beats in such a way that the final output is proportional to the frequency of the beat-note; and the action of this output in the saturation-winding of a specially designed iron core choke whose H.F. winding is coupled to the main transmitter circuit. In this way small rapid variations of frequency are compensated for, while slow variations of greater magnitude are attended to by a variable air condenser electromagnetically controlled by the same regulating current.

GENERAL PHYSICAL ARTICLES.

INFLUENCE OF TEMPERATURE ON THE RAMAN EFFECT.—K. S. Krishnan. (*Nature*, 27th October, 1928, V. 122, p. 650.)

The new lines in the spectrum of the scattered light are due to the result of inelastic collisions of the light quanta with the molecules of the medium (giving a frequency-shift towards a longer wavelength) or of super-elastic collisions (giving a shift towards a shorter wavelength). As the temperature rises, the number of molecules in a position to communicate energy to the light quantum should increase, so that the proportion of super-elastic to inelastic collisions should increase. The writer brings experimental proof that such actually happens, the shorter wavelength lines increasing in intensity with rise of temperature, and the longer decreasing.

THE RAMAN EFFECT IN HIGHLY VISCOUS LIQUIDS, S. Venkateswaren; and WAVELENGTH SHIFTS IN SCATTERED LIGHT, W. H. Martin. (*Nature*, 6th October, 1928, V. 122, pp. 506–507.)

New results and deductions on the subject of Raman's new type of secondary radiation.

DÉPOLARISATION DES RADIATIONS SECONDAIRES DANS LA LUMIÈRE COMPLEXE QUI RÉSULTE DE LA DIFFUSION MOLÉCULAIRE D'UNE RADIATION MONOCHROMATIQUE (Depolarisation of Secondary Radiations in Complex Light, resulting from Molecular Diffusion of a Monochromatic Radiation).—J. Cabannes. (*Comptes Rendus*, 15th October, 1928, V. 187, pp. 654–656.)

The writer's measurements of the depolarisations of the Raman secondary radiations lead to the conclusion that the action of the light on the molecule depends on the orientation of the latter. The writer suggests that it would be interesting to study from this point of view crystals in which the molecules are oriented according to a few known directions.

THE ABNORMAL SPECIFIC HEAT OF A RAREFIED GAS AT A LOW TEMPERATURE: AND THE COSMIC RADIATION.—R. D. KLEEMAN. (*Summary in Physik. Berichte*, 1st October, 1928, p. 1825.)

The conditions in interstellar space and at the border of the earth's atmosphere are explained to be such that the highly energised gamma rays are endowed with the penetrating properties found in the "cosmic" radiation.

EXPERIMENTAL PROOF OF "NEGATIVE DISPERSION."—Kopfermann and Ladenburg. (*Nature*, 22nd September, 1928, V. 122, pp. 438–439.)

AVAILABLE ENERGY.—R. A. Millikan. (*Nature*, 6th October, 1928, V. 122, pp. 555–556.)

A summary of a Messel memorial address. The two chief problems dealt with are: (1) where in the universe do the atom-building processes proceed?; and (2) why have not the primordial positive and negative electrons, which go to build up the common elements, been used up long ago?

THE ORIGIN OF THE COSMIC RAYS.—R. A. Millikan and G. H. Cameron. (*Phys. Review*, October, 1928, V. 32, pp. 533–557.)

A short abstract is impossible. One point may be mentioned: the observed properties of the rays, indicating that the creation of the common elements occurs only in interstellar or intergalactic space, and *not* in the stars, suggests the possibility of avoiding the "Wärme-tod" (the ultimate disappearance of all available energy, necessary according to Jeans' theory that atoms and molecules are everywhere convertible into radiant energy but that the process is nowhere reversible; and apparently also according to the opposed theory of Stern, Tolman and others, that the foregoing processes are all everywhere reversible) and of regarding the universe as already in "the steady state."

THE MAGNETIC MOMENT OF THE ELECTRON.—G. Breit. (*Nature*, 27th October, 1928, V. 122, p. 649.)

ON THE MAGNETIC MOMENT OF THE ELECTRON.—C. G. Darwin. (*Proc. Roy. Soc.*, 1st October, 1928, V. 120A, pp. 621–631.)

There are certain problems in which it is convenient to attribute part of the magnetic field of a moving electron to an electric convection current and part to its intrinsic magnetisation; *e.g.*, in discussing the Stern-Gerlach effect for free electrons. The present paper effects this separation, the formulæ being worked out first for slow motions and then generalised for high speeds by relativity principles.

ON THE DIFFRACTION OF THE MAGNETIC ELECTRON.—C. G. Darwin. (*Proc. Roy. Soc.*, 1st October, 1928, V. 120A, pp. 631–642.)

Author's summary: The problem is solved of the diffraction of an electron wave by a line-grating exerting periodic electric or magnetic forces; this represents the essential features of diffraction by a crystal. The incident wave is supposed to be magnetised in a definite direction, and it is shown that when the grating exerts only electric forces, the effect is to rotate the direction of magnetisation through a definite angle about an axis perpendicular to the incident and diffracted rays, and no polarisation can be produced by the diffraction. For some magnetic forces a similar rotation occurs, but in general the simultaneous action of electric and magnetic forces may produce a partial polarisation, though the case is too remote from experiment to be worth treating in detail.

ÜBER DIE WINKELVERTEILUNG LANGSAMER ELEKTRONEN BEIM DURCHGANG DURCH METALLHAÜTE (The Angular Dispersion of Slow Electrons on Passage through Metal Films).—E. Rupp. (*Ann. d. Physik*, No. 8, 1928, V. 85, pp. 981–1012.)

DE DISPERSO-ELECTRICITEIT ("Disperso-electricity").—H. G. Bos. (*Summary in Physik. Berichte*, 1st October, 1928, pp. 1767–1768.)

Deals with the electricity produced by the dispersion of a liquid in a gas. Previous results have been inconsistent and irregular, and the writer has set up a "dispersometer" to clear up the phenomenon.

THE REVOLUTION IN PHYSICS.—Oliver Lodge. (*Journ. I.E.E.*, October, 1928, V. 66, pp. 1005–1020.)

The nineteenth Kelvin Lecture, with four Supplements.

UNTERSUCHUNGEN ÜBER DEN ELEKTRISCHEN DURCHSCHLAG UND ÜBERSCHLAG IN UNHOMOGENEN FELDE (Investigations of Electrical Breakdown and Flashover in a Field which is not Homogeneous).—E. Marx. (*Arch. f. Elektrot.*, 17th September, 1928, V. 20, pp. 589–606.)

In connection with point and plate discharges, through solids, liquids and gases, particular stress is here laid on the influence of polarity and of the duration of the voltage impulse. Some specially beautiful photographs are shown.

INTERFERENZERSCHEINUNGEN BEI KORPUSKULARSTRAHLEN (Interference Phenomena in Corpuscular Radiation).—W. Elsasser. (*Naturwiss.*, 14th September, 1928, pp. 720–725.)

A review of the methods and results of the various workers in this field, including Davisson and Germer, G. P. Thomson, E. Rupp and E. G. Dymond.

STOSSSPANNUNGEN UND FUNKENBILDER (Shock-voltages and Spark-pictures).—W. Rogowski and R. Tamm. (*Arch. f. Elektrot.*, 17th September, 1928, V. 20, pp. 625–634.)

New experimental records to support still further the authors' previous exposition of the difficulties in interpreting the shock breakdown of gases according to Townsend's theories (*cf* September Abstracts).

DIE ERSTE AUSSENAUFNAHME EINER WANDERWELLE (The First External Record of a Wave-surge).—W. Rogowski and E. Flegler. (*Arch. f. Elektrot.*, 17th September, 1928, V. 20, pp. 635–636.)

The first oscillograms of a surge were published by the writers in 1925. They now show the progress made in the technique by giving photographs of such waves (taken by the external method) of 1/10,000th, 1/250,000th and about 1 millionth sec., finishing with one of about 0.4×10^{-6} sec., involving a recording speed of about 2,000 km./sec.

A DETERMINATION OF A LIMIT OF THE NUMBER OF FREE ELECTRONS IN A METAL.—F. E. Colpitts. (*Journ. Franklin Inst.*, October, 1928, V. 206, pp. 489–501.)

The lower limit of the number of free electrons in gold is found to be of the order of 2×10^{17} c.c., in tungsten 9×10^{15} c.c.

AN ATTEMPT TO DETECT A MAGNETIC FIELD AS THE RESULT OF THE ROTATION OF A COPPER SPHERE AT HIGH SPEED.—W. F. G. Swann and A. Longacre. (*Journ. Franklin Inst.*, October, 1928, V. 206, pp. 421–434.)

Final report on the experiment mentioned in August Abstracts. So far as accounting for the earth's magnetic field is concerned, results were negative: but it is pointed out that a comparatively small change in the equation worked to would cause the value to come below the limit of sensitivity of the measuring apparatus, whereas it would be negligible in the case of the earth.

THÉORIE MOLÉCULAIRE DE LA DIFFUSION DE LA LUMIÈRE PAR LES FLUIDES (Molecular Theory of the Diffusion of Light by Fluids).—Y. Rocard. (*Ann. de Physique*, July-August, 1928, V. 10, pp. 116–179.)

The first thirty pages are occupied by a historical bibliography formed chiefly of abstracts with a running commentary. The rest of the paper develops the purely molecular theory, neglecting for the moment the inter-molecular field. In the following number (September-October, pp. 181–231) this field is taken into consideration.

WAVE MECHANICS AND RADIOACTIVE DISINTEGRATION.—Gurney and Condon. (*Nature*, 22nd September, 1928, V. 122, p. 439.)

It has hitherto been necessary to postulate some special arbitrary "instability" of the nucleus of a disintegrating atom; but here it is pointed out that disintegration is a natural consequence of the laws of quantum mechanics without any special hypothesis. A recent and puzzling experimental result is explained by the same reasoning.

THE PHOTO-ELECTRIC PROPERTIES OF THIN FILMS OF THE ALKALI METALS.—N. R. Campbell. (*Phil. Mag.*, October, 1928, V. 6, pp. 633–648.)

The observations—mainly on thin films produced by depositing an alkali metal on some other material, driving it off by heat, and subjecting the remaining film to a discharge in hydrogen—would seem to have an important bearing upon attempts to correlate thermionic and photo-electric emission.

MERCURY LAMP AND RADIUM AS IONISERS.—Rogowski and Tamm. (*Science Abstracts*, 25th September, 1928, V. 31A, p. 721.)

The mercury lamp produced the same result as 7 mgm. of radium at the same distance, as regards the effect on the potential required to produce a spark between metal electrodes in air.

CALCUL DU CHAMP INTERNE DE POLARISATION (Calculation of the Internal Field of Polarisation).—de Malleman. (*Comptes Rendus*, 24th September, 1928, V. 187, pp. 536–538.)

The writer describes a direct molecular method, applicable to any assemblage of molecules, in solid or fluid, isotropic or anisotropic, which avoids the difficulties and contradictions encountered when Lorentz' method (" Method of Cavities ") is applied to the calculation of electro-optical properties.

ELECTRON REFLECTION.—S. Szczeniewski. (*Comptes Rendus*, 9th July, 1928, V. 187, pp. 106–109.)

The writer has set out to amplify the results of G. P. Thomson and Davisson and Germer by experiments on a more direct method, which measured the reflection of a Cathode ray by a cleavage-surface of a bismuth crystal, for three different values of accelerating potential and for different angles of incidence. Curves were plotted showing clearly the maxima corresponding to the different orders of reflection: the wavelengths calculated from the positions of these maxima agreed with those given by the formula of wave-mechanics.

THE CHARACTER OF THE DISCHARGE IN AN AIR GAP SUBMITTED TO A STEEP-FRONTED POTENTIAL WAVE.—Mochizuki and Murakami. (*Journ. I.E.E., Japan*, June, 1928, No. 479, pp. 652–661.)

The effect of ultra-violet light in the case of various forms of electrode is studied.

THE SCATTERING OF POSITIVE IONS FROM A PLATINUM SURFACE.—R. W. Gurney. (*Phys. Review*, September, 1928, V. 32, pp. 467–477.)

The scattering from solid surfaces of particles of small momentum has been investigated by Davisson with Kunsman and Germer, who studied electrons; and by Ellett and Olson, who examined the slow atoms of cadmium, sodium and hydrogen. Here, the scattering of particles of comparatively high momentum is studied. The source used was an oxide catalyst emitting potassium, cæsium or lithium ions.

TEMPERATURE OF THE CATHODE AS A FACTOR IN THE SPUTTERING PROCESS.—L. R. Ingersoll and L. O. Sordahl. (*Phys. Review*, October, 1928, V. 32, pp. 649–656.)

THE DISTRIBUTION OF ELECTRONS IN A METAL.—J. E. Lennard-Jones and H. J. Woods. (*Proc. Roy. Soc.*, 1st October, 1928, V. 120A, pp. 727–735.)

The writers regard the metal as a whole, and find the average distribution of electrons in the same way that Thomas and Fermi have done for isolated atoms.

SUR L'ÉTAT DIT " SAMA-ZUSTAND " (The Condition called " Sama-condition ").—E. A. Holm. (*Comptes Rendus*, 24th September, 1928, V. 187, pp. 531–534.)

The writer produces experimental evidence of the existence of this phenomenon, which was foretold on theoretical grounds by Dallwitz-Wegner, namely, that gravity can produce, in the heart of a solid, liquid or gaseous body, an ascending thermal gradient.

THE HISTORY AND RECENT PROGRESS OF THE THEORY OF ELECTRONS.—T. Shimizu. (*Journ. Jap. I.E.E.*, July, 1928, pp. 691–699.)

In this general survey the writer lays special stress on the relations between luminous waves and the mechanical oscillations of the electrons.

MOTION OF ELECTRONS IN GASES.—J. S. Townsend. (*Proc. Roy. Soc.*, 1st October, 1928, V. 120A, pp. 511–523.)

A detailed reply to Atkinson's criticisms of the author's previous results and conclusions (*see* September Abstracts).

THE " ACTION " OF AN ELECTROMAGNETIC FIELD.—S. R. Milner. (*Proc. Roy. Soc.*, 1st October, 1928, V. 120A, pp. 483–502.)

Advanced mathematical treatment leading to expressions for the Hamiltonian and Eulerian " actions " of the field which form strict equivalents to those for the actions of a dynamical system.

MISCELLANEOUS.

THE BEHAVIOUR OF OVERHEAD TRANSMISSION LINES IN HIGH WINDS.—E. H. Lamb. (*Journ. I.E.E.*, October, 1928, V. 66, pp. 1079–1085.)

HARMONIC PRODUCTION IN FERROMAGNETIC MATERIALS AT LOW FREQUENCIES AND LOW FLUX DENSITIES.—E. Peterson. (*Bell Tech. Journ.*, October, 1928, V. 7, pp. 762–796.)

It has been established experimentally, as a confirmation of theoretical speculations, that the third harmonic E.M.F. generated by a sinusoidal wave of magnetising force may serve as an index of the distortion with a complex wave: this paper is devoted to an investigation of the third harmonic production in its dependence upon the properties of hysteresis loops.

STUDIEN ÜBER SCHWINGUNGEN VON KREISPLATTEN UND RINGEN (The Vibration of Discs and Rings).—W. Hort and M. Koenig. (*Zeitschr. f. Tech. Phys.*, October, 1928, pp. 373–382.)

Theoretical treatment confirmed by experimental tests, of which photographic records are shown: mostly of discs with central aperture.

THE EFFECT OF CHEMICAL COMPOSITION ON THE SENSITIVITY OF GALENA AS A RADIODETECTOR: AND THE COLD EMISSION FROM CRYSTALS.—W. Ogawa, C. Nemoto, and S. Kaneko. (*Researches of Electrot. Lab., Tokio*, No. 230, June, 1928, 28 pages.)

THE " FULTOGRAPH ": FIRST COMPLETE DESCRIPTION OF THE PICTURE RECEIVING MACHINE.—F. H. Haynes. (*Wireless World*, 24th October, 1928, V. 23, pp. 555–560.)

VI KONGRESS DER ASSOZIATION DER RUSSISCHEN PHYSIKER (VI Congress of the Assoc. of Russian Physicists).—M. Born. (*Naturwiss*, 28th September, 1928, pp. 741–743.)

A summary of the recent congress at Moscow.

HIGH ANGULAR VELOCITIES OBTAINED BY ROTORS HAVING NO SOLID AXIS.—E. Henriot and E. Huguenard. (*Journ. Franklin Inst.*, October, 1928, V. 206, pp. 561–562.)

Summary of a French article. Rotors supported by sheets of gas attained speeds of 11,000 r.p.s. (for diameter of 11.7 mm.), giving a peripheral speed of 404 m/sec. Small mirrors reduced the speed (by air-churning) to about 5,500 r.p.s., but even so the arrangement enables tests on the velocity of light to be made over distances as small as one metre. For further development see Lawrence, Beams and Garman, *Phys. Review*, No. 6, 1928. These workers obtain speeds of 5,000 to 6,000 r.p.s. for a diameter of 16 mm.

USE OF MEGGER CIRCUIT IN GEOPHYSICAL PROSPECTING. (*Journ. Franklin Inst.*, October 1928, V. 206, pp. 547–548.)

EXPERIMENTS IN UNDERGROUND COMMUNICATION THROUGH EARTH STRATA.—Ilsley, Freeman and Zellers. (*Science Abstracts*, *B*, 25th September, 1928, V. 31, p. 522.)

Summary of a paper from the Bureau of Mines on experiments to devise, if possible, practical means of communication with entombed miners.

LA NOUVELLE MÉTHODE LORENZ-KORN POUR LA TRANSMISSION DES IMAGES PAR LA T.S.F. (The new Lorenz-Korn method of Picture Telegraphy by Wireless).—(*Génie Civil*, 22nd September, 1928, V. 93, p. 290.)

A short paragraph based on Noack's article in *Zeitschr. des Vereines deutscher Ingenieure*, 14th April.

CONTRACTIONS FOR TITLES OF PERIODICALS.—Allan Gomme. (*Nature*, 22nd September, 1928, V. 122, p. 441.)

This reply to a letter (October Abstracts) defends the " World List " and its abbreviations.

WHAT DO THEY KNOW OF RADIO . . . ?—D'Orsay Bell. (*Wireless World*, 3rd October, 1928, V. 23, pp. 477–480.)

In the course of an article directing attention to various researches on parts of the Frequency Spectrum other than " radio," the author suggests that ultra-audible sound waves might have an effect—destructive, repulsive, or perhaps even attractive—on small insects such as mosquitoes.

HIGH FREQUENCY SOUND RADIATION FROM A DIAPHRAGM.—R. B. Lindsay. (*Phys. Review*, September, 1928, V. 32, pp. 515–519.)

By a hydrodynamical-acoustical method, a calculation is made of the intensity of the H.F. sound radiation from a circular piston-like oscillator, at a distance from the oscillator greater than twice the radius.

PROBLEMS IN POWER-LINE CARRIER TELEPHONY.—W. B. Wolfe and J. D. Sarros. (*Journ. Am. I.E.E.*, October, 1928, V. 47, pp. 727–731.)

The advantages of a new single-frequency, single side-band, carrier-suppressed system are described, together with an outline of this system. A discussion containing interesting points is summarised on p. 764.

POWER LINE CARRIER TELEPHONY.—L. F. Fuller and W. A. Tolson. (*Journ. Am. I.E.E.*, October, 1928, V. 47, pp. 711–715.)

Gives an outline of modern communication requirements in this field, the problems involved, and the different types of equipment now available. A discussion containing interesting points is summarised on p. 764.

AUSTRALIAN CARRIER SYSTEMS.—R. N. Partington. (*P.O. Elec. Eng. Journ.*, October, 1928, V. 21, pp. 215–223.)

PICTURE TELEGRAPHY.—(*P.O. Elec. Eng. Journ.*, October, 1928, V. 21, pp. 191–199.)

Deals with the Bell, Siemens-Carolus, and Belin systems: gives the Transmission Line Requirements for successful working, and describes certain difficulties encountered in trials of the Siemens system between London and Berlin, and the means of overcoming them.

DIE BERLINER FUNKSCHAU 1928 (The Berlin Radio Exhibition 1928).—H. Kröncke. (*Rad. f. Alle*, October, 1928, pp. 450–456.)

The writer picks out a few miscellaneous exhibits of special interest. These include a Loewe-v. Ardenne receiver in which three double valves are said to give a H.F. amplification of 5,000; a patented smoothing choke coil for rectified filament current, in which the energy of the fluctuations is almost entirely absorbed by a subsidiary winding short-circuited by a small incandescent lamp; a receiver in which loud-speaker or telephones are replaced by a small wooden rod intended to be held between the teeth to enable deaf people to enjoy broadcasting; and (with a certain reservation) a cylindrical " earth-antenna " said to give good summer and winter reception of the " pure ground wave " when buried only 75 centimetres deep.

BILDFUNK UND FERNSEHEN AUF DER 5 DEUTSCHEN FUNKSCHAU (Picture Wireless and Television at the 5th German Radio Exhibition.)—H. Kröncke. (*Rad. f. Alle*, October, 1928, p. 463–464.)

A brief survey of the exhibits, and the conclusions drawn by the writer.

UNE NOUVELLE APPLICATION DES COURANTS DE HAUTE FRÉQUENCE (A new Application of H.F. Currents).—Bordier. (*Comptes Rendus*, 15th October, 1928, V. 187, pp. 687–688.)

A new form of d'Arsonvalisation (the medical use of H.F. currents) by which medicinal substances such as cocaine, iodine, or aconite are caused to be absorbed by the skin or mucous membrane. Such absorption has been obtained before by constant current, but in this case decomposition of the molecule takes place and there is moreover the danger of ultra-violet radiation. Both these factors are removed by the use of H.F. combined with a special electrode without any metallic point.

AUS DER GROSSEN DEUTSCHEN FUNKAUSSTELLUNG (From the great German Radio Exhibition).—W. Burstyn. (*E.T.Z.*, 11th October, 1928, pp. 1504–1507.)

ACOUSTICS.—A. G. Huntley. (*Journ. R.S. of Arts*, 12th October, 1928, V. 76, pp. 1146–1158.)

Cantor Lecture of 16th April, on the acoustics of buildings.

DAS PROBLEM DER PHOTO-TELEPHONIE (The Problem of Telephony by Light-Rays).—K. Zickler. (*Elektrot. u. Masch. bau.*, No. 29, 1928, V. 46, pp. 769–775.)

A new and effective method is described and the whole problem placed on a quantitative basis.

ÜBER EIN OPTISCHE INTERFERENZMETHODE ZUR UNTERSUCHUNG VON MEMBRANEN (An optical interference method of investigating diaphragms).—P. Paasche. (*Zeitschr. f. Tech. Phys.*, October, 1928, pp. 411–414.)

Description of a stroboscopic interferometer method for measuring the deflections of electrically excited vibrating diaphragms. Records are shown of resonance and time-amplitude curves.

ÜBER NEUERE AKUSTISCHE UND INSBESONDERE ELEKTROAKUSTISCHE ARBEITEN (Latest work on Acoustics, and in particular Electro-acoustics).—F. Trendelenburg. (*See* under "Measurements and Standards.")

SOME FUNDAMENTAL DEFINITIONS.—R. A. Wilmotte. (*E.W. & W.E.*, November, 1928, V. 5, pp. 607–615.)

ON THE COMPUTATION OF INDUCED VOLTAGE IN A COMMUNICATION LINE CAUSED BY OCCASIONAL GROUNDING OF A NEIGHBOURING POWER LINE.—K. Kanaya. (*Journ. I.E.E. of Japan*, August 1928, pp. 856–867.)

CHAUFFAGE PAR INDUCTION (Heating by Induction).—P. Bunet. (*Bull. d.l. Soc. Fran. d. Élec.*, September, 1928, V. 8, pp. 940–992.)

An important paper on the theory of induction furnaces (condenser discharge or alternator) and its application in practice. A preceding paper by Dufour (pp. 929–939) discusses various forms of spark dischargers for such furnaces.

MITTEILUNG ZUM DETEKTORPROBLEM: DER ELEKTROLYTISCHE DETEKTOR (The Detector Problem: the electrolytic detector).—G. G Reissaus. (*Phys. Zeitschr.*, 15th September 1928, pp. 655–658.)

Esperanto Section.

Abstracts of the Technical Articles in Our Last Issue.

Esperanto-Sekcio.

Resumoj de la Teknikaj Artikoloj en Nia Lasta Numero.

ATMOSFERAĴOJ.

NUNA STATO DE SCIO PRI ATMOSFERAĴOJ.

Resumo de prelego de S-ro. R. A. Watson Watt, B.Sc., F.Inst.P., A.M.I.E.E., legita antaŭ Sekcio A, de la Brita Asocia Kunveno ĉe Glasgow, Septembro, 1928a.

La prelego konsideras la temon laŭ vidpunkto de donitaĵoj koncernantaj la atmosferaĵojn mem. La aŭtoro priskribas la rezultojn de laboro pri l'ondoformo de atmosferaĵoj (kiel determinitaj de observadoj pri la katodradia oscilografo); numera incideco de atmosferaĵoj; direktaj observadoj—kaj ĉe mezaj fluoj kiel determinitaj de rotacianta radia anteno kaj pluma registrilo, kaj ĉe individuaj atmosferaĵoj, kiel ekzamenitaj de l'katodradia direktotrova sistemo; la intenseco de l'perturbo, kaj la amplekso de atmosferaĵoj, kiel determinitaj de vasta brodkasta ekzperimento.

Bilda tabelo montras la ĉefajn formojn de atmosferaĵoj viditajn en Anglujo, dum komparoj estas ankaŭ donitaj pri la ĉefaj formoj observitaj en Anglujo, Khartoum, kaj Okcidenta Aŭstralio.

La direktaj observadoj ŝajnas esti de konsiderinda meteorologia intereso, kaj donas multe da informo pri la distribuado de fulmotondra aktiveco.

PROPRECOJ DE CIRKVITOJ.

METODO POR KALIBRI MALALTFREKVENCAN VALVAN GENERATORON PER UNUOBLA FREKVENCA NORMA FONTO.—T. S. Rangachari.

La metodo konsistas laŭjene; kunigi unue la konatan kaj poste la nekonatan fonton trans cirkvito de variebla rezisteco R laŭserie kun indukteco de konata rezisteco R_L. La norma fonto estas aplikita kaj R alĝustigita al valoro R_1, kiam la voltkvanto trans ĝi egalas tiun trans la indukteco (mezurita per termiona voltmetro). La nekonata fonto estas poste anstataŭigita kaj R alĝustigita al nova valoro R_2 por simila egaligo kiam

$$f_2 = f_1 \times \frac{R_2^2 - R_1^2}{R_1^2 - R_L^2}$$

Notoj estas donitaj pri praktikaj punktoj en la metodo, kaj rezultoj estas montritaj en tabelo kaj kurvoj.

ŜVELADOJ EN ELIMINILAJ GLATIGAJ CIRKVITOJ.—A. G. Warren.

La aŭtoro diskutas la ŝveladojn, kiuj emas okazi kiam ia ŝanĝo okazas en la altatensia voltkvanto aplikita al ricevilo pere de glatiga cirkvito. Ĉi tiuj ŝveladoj povas esti multe pli ol normala potencialo kaj kaŭzi riskon de paneo.

La ŝveladoj estas pli seriozaj je enŝalto aŭ malŝalto, aparte se la valvoj ne brulas.

Por sufiĉa glatigo, LC'a (Indukteco-Kondensatora) produto de ĉirkaŭ 200 mikrofaradoj-henrioj estas dezirinda. Oni montras, ke glatiga cirkvito, kiu povas esti perfekta ĉe unu instrumento, povas naski malbonajn ŝveladojn ĉe alia. Por instrumento, kiu bezonas definitivan anodan kurenton, oni montras, ke malpliigante la grandecon de la kondensatoroj kaj pliigante la valoron de l'ŝokbobeno, malpliigas la ŝveladon je enŝalto, sed pliigas la ŝveladon je malŝalto, kaj inverse. Estas do optimumaj valoroj por ĉi tiuj komponeroj, kaj oni citas regulojn por ebligi, ke kondensatoroj kaj ŝokbobeno estu dimensiigitaj laŭ la ŝarĝo, tiel ke la normala funkcia voltkvanto ne estas superita, aŭ je enŝalto aŭ malŝalto.

HELPA APARATO.

PORTEBLA OSCILOGRAFA EKIPAĴO POR LA OBSERVADO DE EFEMERA ELEKTRA FENOMENARO.—P. R. Coursey.

La aparato priskribita estas la plej lasta modelo de la tri-elementa oscilografo de la *Cambridge Instrument Company*, kun modifaĵoj je la kunmeto por la aparta celo skizita. La ĝenerala aranĝo de la instrumento estas unue priskribita, inkluzive la metodo por ekspozi fotografan filmon por registro de l'onda formo.

La normalaj aranĝoj ne estas bone adaptitaj por la registrigo de efemeraĵo, kies ĝusta tempo de okazo estas preter la kontrolo de l'funkciisto, kaj la modifaĵoj priskribitaj estas desegnitaj por faciligi ĉi tion. La kamera cilindro estas rotaciata senĉese, kaj la obturatoro malfermita dum antaŭdeterminita tempo, por enhavi la efemeraĵon registritan. Nebuliĝo de l'filmo estas malhelpita de vertikala vergo, kiu obstrukcias la nedefleksitan radion for de la vibrila spegulo. Detaloj de l'modifaĵoj por ĉi tiu celo estas donitaj, kaj de l'metodo de tempo-registrado. La tuta aparato estas kunmetita sur rulportilo pro portebleco, kaj sistemo de rektifikatoroj estas provizita por funkciigi la kontinukurentan motoron per alternkurenta provizo.

La artikolo estas ilustrita de fotografaĵoj de l'kunmetado kaj diagramoj de ŝuntaj aranĝoj, rektifikatoroj, k.t.p.

GENERALAJ FIZIKAJ ARTIKOLOJ.

KELKAJ FUNDAMENTAJ DIFINOJ.—R. M. Wilmotte.

Ĉi tiu artikolo diskutas redakciajn artikolojn (en marta kaj aprila numeroj) pri la malfacilaĵoj kuŝantaj sub la ordinaraj signifoj de P.D. (potenciala diferenco) kaj E.M.F. (elektromova forto) en alternkurentaj cirkvitoj, kaj poste diskutas ĉi tiujn iomlonge kaj laŭ iomete malsama vidpunkto. La difinoj tiel obtenitaj estas poste etenditaj al aliaj kvantoj.

Ellaborante la rezonadon de l'originalaj redakciaj artikoloj, la aŭtoro difinas skalajn kaj vektorajn potencialojn; poste pasas al elektra intenseco kaj al difinoj kaj distingoj de P.D. kaj E.M.F., kun la ilustraĵo de l'fermita kadro. La rezonado estas poste etendita al la konsiderado pri impedanco, uzante la difinon de reaktanco kiel bazon por la plua ekzameno de indukteco kaj kapacito. La ekzemploj de mem-indukteco kaj de komuna indukteco estas pritraktitaj; poste la aŭtoro pasas al kondukeco kaj delokigaj kurentoj, kondukante al difino de kapacito. Distribuitaj indukteco kaj kapacito estas laste konsideritaj.

La rezonado tratute estas laŭ matematika bazo, kaj oni donas esprimojn por la diversaj difinoj atingitaj.

Redakcia artikolo diskutas la rezonadon de S-ro. Wilmotte.

DIVERSAĴOJ.

RESUMOJ KAJ ALUDOJ.

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

LIBRO-RECENZOJ.

Recenzoj estas donitaj pri la jenaj verkoj :—

LETTERS PATENT FOR INVENTION (Patentaj Dokumentoj por Inventado), de A. W. Griffiths, B.Sc., Advokato.

EXPERIMENTAL RADIO (Eksperimenta Radio), de R. R. Ramsay, Ph.D. (tria eldono).

SCIENCAJ INSTRUMENTOJ ĈE OLYMPIA. Revuo pri kelkaj aparatoj interesaj laŭ laboreja vidpunkto ĉe la lastatempa Radio-Ekspozicio (Londono).

La Ekspozicio estis ĉefe de brodkasta intereso kun kompare malmulto interesa laŭ laboreja vidpunkto pri altfrekvencaj kurentoj. Raporto estas donita en ĉi tiu artikolo pri diversaj mezuraj instrumentoj, ondometroj, k.t.p.

Kontinukurentaj instrumentoj pritraktitaj enhavas tiujn de Ernest Turner, S-roj. Ferranti Ltd., la " Avometer " de l'Aŭtomatic Coil Winder Company, S-roj. A. H. Hunt, kaj S-roj. Siemens Brothers. Alternkurentaj kaj alternfrekvencaj instrumentoj de Ernest Turner kaj S-roj. Ferranti estas ankaŭ pritraktitaj, la ĉi-lasta enhavanta alternkurentan instrumenton konsistantan el ordinara kontinukurenta funkcimetodo, kune kun ponto de kvar kuproksidaj rektifikatoroj.

La ondometroj revuitaj enhavas modelojn de S-roj. Burndept, S-roj. Bowyer-Lowe, la Igranic Company, kaj S-roj. Dubilier, kiuj ankaŭ montris grandan aron da normaj kondensatoroj por laboreja laborado, kaj instrumenton kondensatore-ŝuntitan por grandaj radio-frekvencaj kurentoj.

Instrumentoj por provi valvojn de S-roj. Ferranti kaj de S-roj. R. I. kaj Varley estas ankaŭ priskribitaj, dum la fako pri aliaj elmontraĵoj traktas pri novaj transformatoroj, valvoj, kaj la nova Aŭtomata Alarma Ekipaĵo de S-roj. Siemens Brothers.

La artikolo estas bone ilustrita per fotografaĵoj de multaj elmontraĵoj priskribitaj.

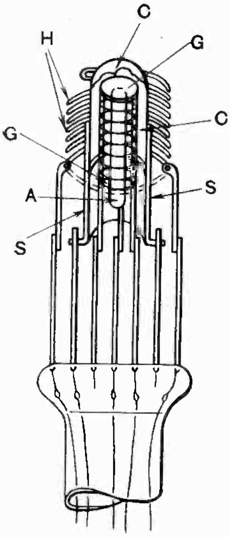
Some Recent Patents.

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.

INDIRECTLY-HEATED VALVES.

(*Application date 23rd June, 1927. No.* 297495.)

Relates to valves of the kind in which an electron-emitting filament is heated by radiation from a special heating element fed directly from the electric-light mains. According to the invention, the normal arrangement of the several valve electrodes is inverted. For instance, a central anode *A*, in the form of a thin metal tube, is surrounded by a special grid *G*, outside which comes a tubular cathode *C*, and finally an external winding *H* of carbon or tungsten wire which serves as the heating element.



The tubular cathode *C* is coated with alkaline-earth oxides and is closed at the upper end. At the lower end it extends downwards to form a screen *S*, which shields the grid and anode from the heat of the windings *H*. The top of the grid is also closed in. As the heating element *H* is connected directly to the mains, it must be of considerable length in order to have a resistance adequate to the normal domestic supply voltages. By locating it outside the other electrodes a more robust and compact arrangement than usual is ensured.

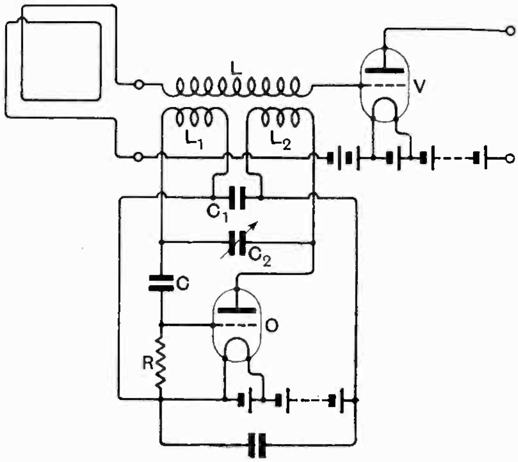
Patent issued to The M.-O. Valve Co., Ltd.

SUPERSONIC RECEIVERS.

(*Application date, 24th June, 1927. No.* 297507.)

In general the voltage induced into the coupling coil *L* from the local oscillator *O* of a supersonic set is not uniform over a wide range of frequencies, but increases for the higher and diminishes at the lower frequencies. This gives rise to excessive noise in the one case and to ineffective detection in the other, after the beat note has passed through the first detector *V* and the signal components have been finally separated.

To remove this defect the local oscillator *O* is provided with a grid condenser *C* of 0.005 mfd. and a resistance *R* of approximately 12,000 ohms. The oscillator coils L_1, L_2 are separated by a blocking condenser C_1, whilst the circuit as a whole is tuned to the operating frequency by a condenser C_2. The effect of the grid leak and condenser *R*, *C* is to damp the main oscillatory circuit *C* to a greater extent at high frequencies than at low, thus counterbalancing the effect of the variable coupling previously mentioned, and maintaining



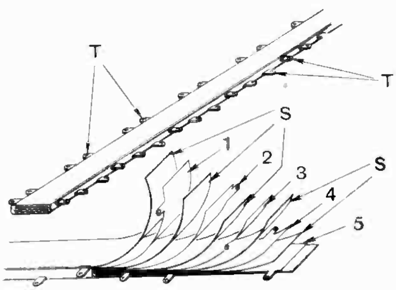
a constant energy-transfer from the oscillator *O* to the first detector *V* at all settings of the tuning condenser C_2.

Patent issued to Standard Telephones and Cables, Ltd.

WIRING SYSTEMS.

(*Convention date* (*U.S.A.*), *10th August*, 1926, *No.* 275938.)

A multiple wiring element is built up of a number of flat metal conductors 1 . . . 5 interleaved with strips *S* of insulating material. Metal tabs *T* are attached to each conductor at intervals, and project outwards to facilitate connection to the



various circuit components when wiring-up the set. The insulating strips, in combination with the conductors, form a condenser system which is utilised to replace the ordinary fixed by-pass condensers for shunting high-frequency currents across the batteries or other impedances on the low-frequency side of the receiver. Also the outer metal strips serve to screen the inner conductors and so prevent undesirable feed-back and pick-up effects.

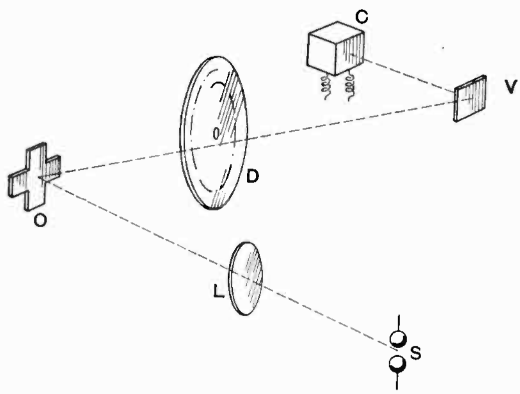
Patent issued to E. T. Flewelling.

TELEVISION SYSTEMS.

(*Application date* 10*th March*, 1927. *No.* 297014.)

In his early experiments with ether waves, Hertz showed that such waves could be detected by the sparks induced between two or more conductors separated by a very small gap. The present invention proposes to utilise this effect for the purpose of transmitting a visible image of a normally invisible object. The object, shown in the form of a cross *O*, is first explored by a stream of short-wave energy generated at *S*.

The generated energy is stated to be of the same order as the infra-red part of the spectrum, but of slightly longer wavelength than the infra-red rays. This "invisible light" is focussed on the object *O* by means of a lens *L* of sulphur or bitumen. The reflected rays are passed through a rotary "scanning disc" *D* and are then thrown on to a viewing screen *V*. This operates on the principle of the Hertzian detector mentioned above, its



surface being composed of separated conducting particles, such as a sprinkling of metal powder on a plate of non-conducting material. Instead of viewing the image so produced directly, the resultant "sparks" may be thrown upon a light-sensitive cell *C*, which in combination with known mechanism serves to reproduce the image at a distance.

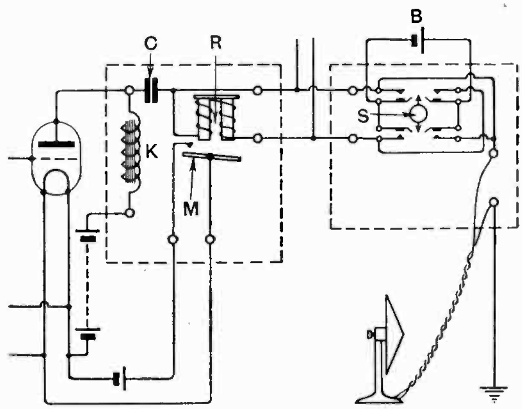
Patent issued to Television Ltd., and J. L. Baird.

REMOTE CONTROL SYSTEMS.

(*Application date, 2nd August*, 1927. *No.* 297918.)

A receiving set *S* is switched on or off by means of a polarised relay *R* controlled from the distant point by a switch *S*. A choke *K* diverts the steady current from the connecting leads, so that musical frequencies alone flow through the loud speaker, which is earthed as shown. A blocking condenser *C* keeps the H.T. voltage off the leads. The moving arms of the double-pole reversing switch *S* are bridged by a single dry-cell battery *B*, which is normally kept out of circuit and only comes into operation momentarily.

When the switch *S* is thrown upwards, a pulse of current from the battery B flows in one direction through the relay *R*, to close the contact *M* and



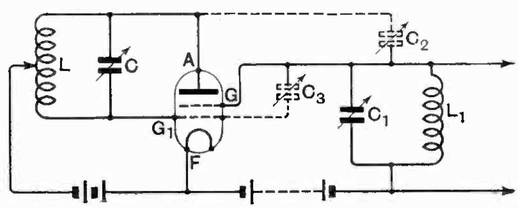
so light the valve filaments. Throwing the switch downwards will reverse the direction of the momentary flow of current from the battery *B* through the relay *R*, and thus trip the polarised armature to break the filament circuit.

Patent issued to F. S. Angel.

A STABILISED TETRODE CIRCUIT.

(*Application date 8th June*, 1927. *No.* 296806.)

Inter-electrode capacity is neutralised in a four-electrode valve amplifier by connecting the input circuit *L*, *C* across the anode *A* and inner grid G_1, with a variable tapping to the filament, whilst the output circuit L_1, C_1 is connected between the outer grid *G* and the filament as shown. Any capacity coupling between the anode *A* and the outer grid *G* is effectively offset by the coupling between the outer and inner grids *G*, G_1. For slight departures from complete neutralisation, the amplifier can be brought to the desired condition by adjustment of the filament current. If neces-



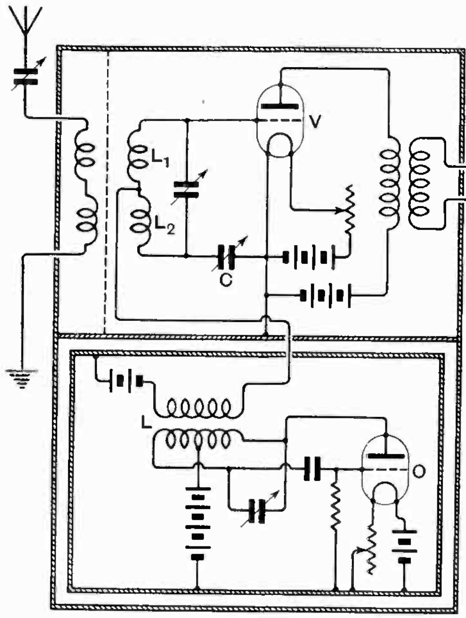
sary a small external condenser is connected in parallel with the lesser inter-electrode capacity, as at C_2 or C_3. In the latter case the tapping point on the input coil *L* may be moved farther towards the top so as to throw a larger proportion of the input voltage on the inner grid G_1, thus increasing the efficiency of the amplifier.

Patent issued to E. W. B. Gill and R. H. Donaldson.

PREVENTING RE-RADIATION.

(*Convention date* (*U.S.A.*), *23rd May*, 1927. *No.* 291012.)

In a heterodyne or supersonic receiver, the energy from the local source of oscillation is liable to be communicated to the aerial, and so cause local disturbance by re-radiation. In order to prevent this effect the current from the local oscillator O is applied through a coupling L to the mid-point of the input circuit of the detector valve V so that it divides and flows equally in opposite directions through the coils L_1, L_2. No transfer to the aerial can therefore occur.



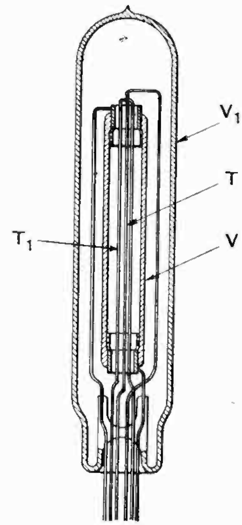
Signal energy transferred from the aerial flows through the coils L_1, L_2 in series so that the full potential fluctuations are applied across the grid and filament. A condenser C equal to the inherent grid-to-filament capacity is inserted in the filament lead, as shown, so that its reactance upsets the balance of the virtual Wheatstone-bridge arrangement sufficiently to enable the effect of the local oscillations from O to reach the grid. Here they combine with the incoming signals to form the desired beat frequency. The oscillator O is housed inside a double copper shield. In the case of supersonic reception, the intermediate frequencies are further amplified at A.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

PHOTO-ELECTRIC CELLS.

(*Convention date* (*U.S.A.*), *8th June*, 1927. *No.* 291763.)

It is usual to deposit a thin film of light-sensitive material, such as alkali metal, on the inside of an evacuated glass vessel, leaving a transparent window through which the activating beam of light can be admitted. In course of time, however, the alkali coating tends to volatilise, and to be redeposited over the transparent area, so as to obscure the window aperture and thus lessen the sensitivity of the cell as a whole.



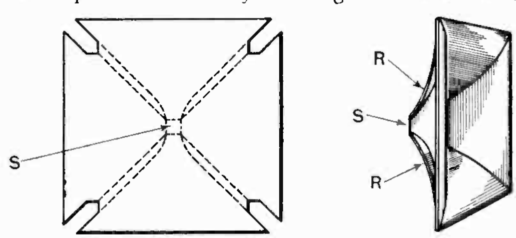
In order to remove this effect the light-sensitive coating is made of a composite layer. For instance, a coating of tungsten or molybdenum having a low vapour pressure is first deposited, upon which a photo-sensitive coating of alkali is superposed, the double layer being so thin that it is transparent to light. In manufacture a filament T of tungsten and another T_1 of platinum coated with an alkali metal salt are mounted inside an inner tube V, and the whole is then enclosed in an outer tube V_1. Each filament is heated in turn to a temperature sufficient to vaporise first the tungsten and then the alkali, and so to deposit layers of the required thickness on the inside walls of the tube V.

Patent issued to Westinghouse Electric and Manufacturing Co., Ltd.

LOUD SPEAKER DIAPHRAGMS.

(*Application date 14th May*, 1927. *No.* 297131.)

A single piece of homogeneous material is cut and creased so as to form a number of curved surfaces of approximately pyramidal formation, and so that no additional material is required to make the joints air-tight. In operation the various flexed surfaces vibrate in unison along transverse straight lines, transmitting the sound energy to the surrounding air in the form of concentric polygons. Bodily or piston-like vibration is minimised, since the joints between the various flexed portions are only semi-rigid. The absence



(a) (b)

of stiffening or other extraneous material at the joints prevents damping and increases the overall efficiency of response.

The square piece of material is first cut at the corners and is then creased or scored diagonally as shown in dotted lines in Figure (a). When the blank is folded along the straight crease-lines, flexed backwards, and then folded along the curved crease-lines, with the material between the crease-lines overlapped upon the plain quadrants, the diaphragm assumes the pyramidal form shown in Figure (b) with four strengthening ribs *R* radiating from the central squares to which the vibrations from the magnetic movement are applied.

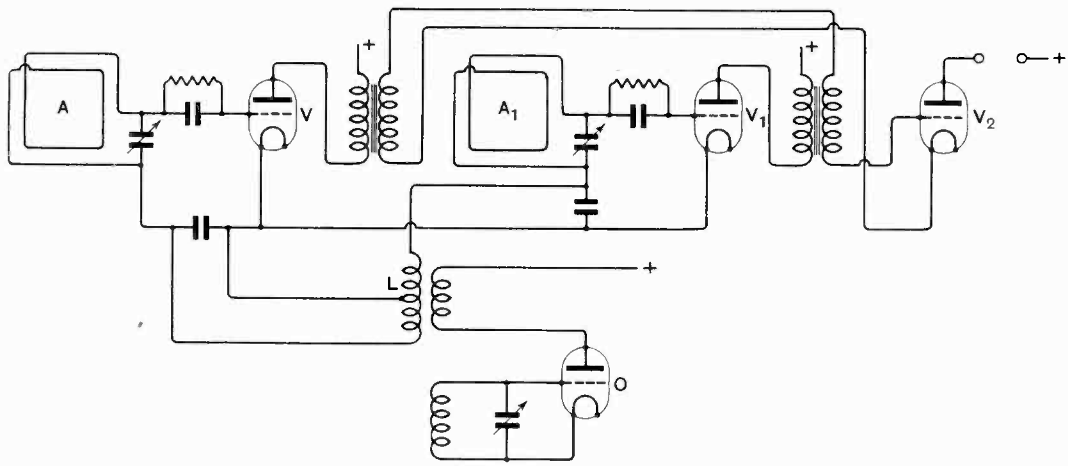
Patent issued to B. F. Waddell.

PREVENTING FADING EFFECTS.

(*Application date 12th April*, 1927. *No.* 297015.)

Signal waves are usually radiated from a transmitting station with the electric and magnetic vectors located in well-defined directions, *i.e.*, in definite planes of polarisation. Owing, however, to variable atmospheric and like conditions, the waves usually arrive at the receiving station polarised in different and conflicting planes. In such circumstances signals received on an ordinary aerial system will fluctuate in strength.

Accordingly, the receiving station is fitted with two or more aerials or loops, located in different planes, and means are provided for combining each aerial with the receiving apparatus in rapid succession, each alternation lasting for a very small interval of time, with the object of ensuring a



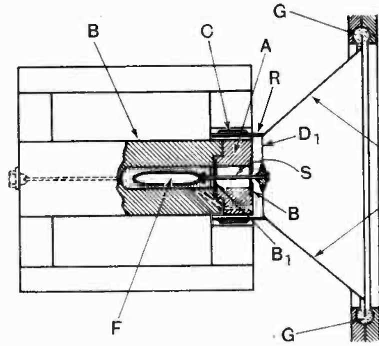
constant overall signal strength. As shown in the Figure, the two aerials A, A_1 are set at right angles, and are coupled to valves V and V_1 respectively, the output circuit of both valves feeding a common amplifier V_2. A local oscillator valve O is tuned to any frequency from 50 to 100,000, and induces voltages into a coil L so that the grid potentials on the valves V, V_1 are varied in opposite senses at that frequency. The valves are thereby thrown alternately in and out of action, and thus connect the aerials A, A_1 in rapid succession to the receiving apparatus.

Patent issued to J. Robinson.

LOUD SPEAKERS.

(*Application date, 21st July*, 1927. *No.* 297183.)

In a moving-coil or other loud speaker certain of the moving parts of the magnetic driving-means are supported in a fluid, such as machine oil.



The core of the pot-magnet is made in two parts, an upper portion A and a lower B, both being bored out centrally to form a chamber for the fluid as shown. Bearing-discs B, B_1, say of vulcanised fibre, are fitted on the upper and lower ends of the part A, and have a central hole to guide the moving spindle S.

The conical diaphragm D is closed at the lower end by a disc D_1 to which is fixed a supporting ring R for the moving coil C. The outer edges of the diaphragm are housed in a groove G formed in the sounding-board. The groove is preferably filled with cotton-wool or velvet which, whilst having no appreciable effect on the diaphragm movement, prevents the air waves passing from one side of the diaphragm to the other. The spindle S is secured to a boss on the disc D_1, and carries at its lower end a float F, which is immersed in the liquid. In assembling the speaker machine oil is poured into the central chamber until the float F raises the lower end of the diaphragm clear of the part A, when the upper edge of the diaphragm will lie centrally in the groove G.

Patent issued to The British Thomson-Houston Co., Ltd., and G. R. Searle.