THE

WIRELESS ENGINEER

AND

EXPERIMENTAL WIRELESS

NUMBER 119 VOLUME X AUGUST 1933

A JOURNAL OF

RADIO RESEARCH

AND

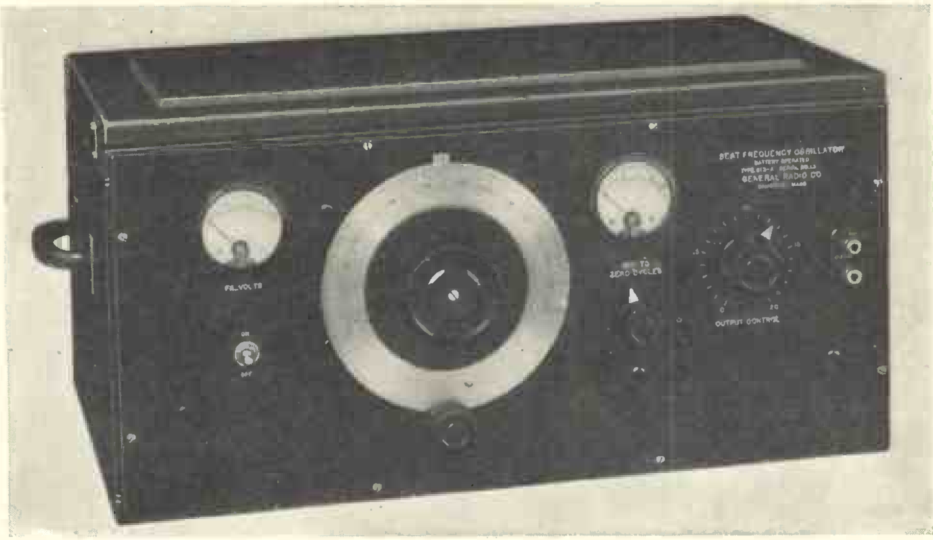
PROGRESS

2/6 NET

PUBLISHED BY

ILIFFE & SONS LTD.

DORSET HOUSE STAMFORD STREET LONDON S.E.1



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The

WIRELESS ENGINEER

and EXPERIMENTAL WIRELESS

A Journal of Radio Research & Progress

Editor
HUGH S. POCOCK

Technical Editor
Prof. G. W. O. HOWE D.Sc., M.I.E.E.

VOL. X. No. 119

AUGUST 1933

C O N T E N T S

Published Monthly on the first of each month
SUBSCRIPTIONS Home and Abroad : One Year, 32/-, 6 Months, 16/-. Single Copies, 2/8 post free

Editorial, Advertising and Publishing Offices
DORSET HOUSE, STAMFORD STREET, LONDON, S.E.1
Telegrams: "Experiwyr Watloo London" Telephone: Hop 3333 (50 lines)

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409

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Vol. X. AUGUST, 1933. No. 119

Editorial

Electromagnetic Induction

ALTHOUGH it is now over a hundred years since electromagnetic induction was discovered and systematically investigated by Faraday, and although the calculation of the electromotive force induced in any given case is now regarded as a suitable exercise for an elementary student, it is surprising how soon one gets into difficulties if one tries to get a clear conception of the phenomena involved in the simplest cases.

To appreciate this we need only consider the old question of the cylindrical bar magnet rotated about its axis. Does its magnetic field rotate with it or not? The magnetic condition of the space surrounding the magnet is undergoing no change whatever either in magnitude or direction, and there appears to be no justification for picturing the space as filled with concrete lines of magnetic induction fixed like bristles in some mysterious way to the magnet and forced to rotate with it. In the case of an air-cored solenoid such a conception appears even more far-fetched.

If one illuminates a table by means of a source of light, the candle-power of which is symmetrical about the vertical axis, will the illumination of the table rotate when the lamp is rotated? Or again, if one places a uniformly heated disc on the table, thus setting up a symmetrical temperature distribution, will this temperature distribution rotate when the disc is rotated? Neither the illumination nor the temperature at any point undergo the slightest change as the result of the rotation, and the question propounded appears meaningless. That these are scalar magnitudes whereas the magnetic induction is a vector does not affect the question; what we have said of temperature is equally true of the vector temperature-gradient.

If the source of light, or heat, or magnetism, is not uniform about the axis of rotation, the result of the rotation might be regarded by a superficial observer as an obvious proof of the rotation of the illumination, or temperature, or magnetic induction, but a closer consideration will show that these conditions are merely undergoing such changes at every point that their inequalities of distribution rotate. The illumination, or temperature, or magnetic induction at *A* may now be equal to what it was a moment ago at *B*, but it does not follow that the illumination, or temperature, or magnetic induction which now exists at A is actually that which was at B, and that it must necessarily have rotated ; in fact, such a statement appears meaningless.

We can see then no escape from the conclusion that the question whether the magnetic field rotates with the magnet or not can have no answer because it has no meaning. Were it otherwise the magnetic induction at a point would not be completely defined by the magnitude and direction of B.

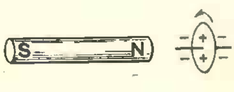


Fig. 1.

Let us assume in the first place that the bar magnet in Fig. 1 is at rest and that the metal disc is rotating in the direction shown. The electrons in the disc are moving through magnetised space and experience consequently an outward radial force crowding them towards the edge and charging it negatively, while leaving the central part charged positively. If now on rotating the magnet also in the same direction one finds that the charging of the edge of the disc is less than it was before one may be tempted to regard this as a proof that the disc and the magnetic field are now both rotating so that their relative speed is reduced, notwithstanding what we have said as to the meaninglessness of the statement.

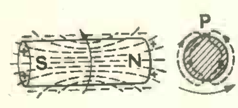
When the magnet rotates its free electrons rotate and they are also in a magnetic field. The electrons of the magnet now experience forces tending to remove them from some parts of the magnet and crowd them into others not only on the surface but throughout the material.

An Explanation

The magnet thus becomes charged as shown in Fig. 2 (*a*), and these charges produce an external electric field which tends to induce an electric distribution in the disc of opposite sign to that of Fig. 1. When the disc is at rest it is thus charged electrostatically by the rotating magnet, and when they both rotate in the same direction the electrostatic forces on the disc are more or less neutralised by the electromagnetic forces.

The phenomena can thus be explained by the movement of electrons in magnetised space without doing violence to one's powers of imagination by endowing with revolution a condition of space which undergoes no change.

Those who may have some misgivings about this explanation of what occurs when a cylindrical bar magnet is rotated about its axis may be somewhat reassured by regarding the phenomenon from the point of view of an observer situated on the surface of the magnet about midway between the poles. Let Fig. 2 (*b*) represent a cross section of the magnet looking towards the north pole and let the observer be at P at the moment. If this observer considers himself to be at rest, he will regard the magnet as revolving about him in the direction shown. Below him will be a magnetised space through which the material of the magnet is moving with a velocity proportional to its distance from himself causing the electrons to experience a force tending to move them away from him. He will also notice that the magnetic flux through some stationary close curves is increasing and that through others decreasing ; we show two closed curves and the directions of the electromotive forces induced in them by these changing fluxes. He will regard the final distribution of electrons as due to the resultant action of these two phenomena. (The electrons tend to move in the opposite direction to the induced E.M.F.).



(a) (b)

Fig. 2.

The explanation from this point of view is much more complicated than that given above where the axis of the magnet was taken as the axis of reference.

If the bar magnet is replaced by a solenoid we get an arrangement similar to that used in the Lorenz apparatus for the absolute determination of resistance, and the inductance of electromotive force can be explained in the same way by the radial force experienced by the electrons in the disc due to their rotational movement through magnetised space. If the solenoid were rotated it would also become charged as did the bar magnet and with the same result.

It would doubtless be possible to explain all these phenomena without the conception of a magnetic field, as they are all primarily due to the relative motion of electrons, but we do not propose to make such an attempt here.

If brushes are arranged to make contact with the spindle and edge of the disc, current can be maintained through an external circuit by this elementary form of homopolar dynamo, but it seems a very unnecessary and artificial procedure to attempt to explain this current, or the E.M.F. that produces it, as due to the magnetic flux through some fictitious circuit undergoing a continual change, as is sometimes done.

Blondel* replaced the disc in Fig. 1 by a drum of insulating material on which an ever increasing number of turns of insulated wire were wound as the drum rotated, the wire being unwound from another drum outside the magnetic field. By means of brushes rubbing on a slip ring on each drum, the "circuit" was completed through a galvanometer which, however, gave little or no indication of a current during the winding process, although the linkages of the "circuit" were being increased owing to the increasing number of turns on the drum in the magnetic field. The "circuit" here was fictitious; it consisted in part of a continually changing and arbitrary dotted line drawn on a slip ring, which made it impossible to apply the conception of linkages. Looked at from the point of view considered above there is nothing mysterious about the experiment; it is merely an unduly complicated and inefficient form of homopolar dynamo in which one of the brushes has been replaced by a flexible connection.

Conductor in a Changing Field

Up to the present we have confined ourselves to cases in which the conductor moves in an unchanging magnetic field. We shall now consider the more general case in which the conductor moves relatively to the magnet in such a way that it is situated in a changing field. The explanation given of the phenomena will depend on the observer. Whether in Fig. 3 (*a*) the magnet pole facing us be at rest and the conductor move across the front of it, or the conductor be at rest and the pole move across behind it, the result will be the same; the terms "moving" and "at rest" are only relative. To an observer situated on the pole it is at rest and the magnetic field is everywhere unchanging; he sees the conductor moving through this field and its electrons consequently experiencing an upward force tending to charge the conductor as shown, the magnitude of the force and charge depending on the strength of the field through which it is moving at the moment. If the conductor be replaced by a coil as in Fig. 3 (*b*) the electrons in the two sides will experience different forces, because they are moving through fields of different strength and a current will be set up due to this difference.

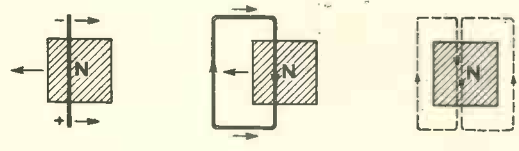


Fig. 3.

An observer situated on the conductor would probably explain matters differently; we say "probably" because he might be clever enough to see that a great simplification resulted by assuming that the magnet was at rest and that he himself was moving, in which case his explanation would be the same as that of the observer on the magnet. Failing this flash of genius he would regard himself as at rest but surrounded by a magnetic field which was changing from moment to moment so that the flux through any closed curve such as those shown in Fig. 3 (*c*) was either increasing or decreasing, thus inducing electromotive forces around these paths which cause the free electrons in the stationary conductor to crowd towards the top end. At first sight it might be expected that these electromotive forces would cause a similar upward movement of the free electrons of the magnet itself, but it must be remembered that to the observer on the stationary conductor the magnet is moving to the left through magnetised space—it is immaterial that the magnet is itself producing this magnetic field, and that its distribution in space is changing—and its electrons consequently experience a downward force which counterbalances the upward force. Both observers fortunately agree as to the facts, *i.e.*, the resultant movement of electrons, but their explanations are very different; to one of them the sur-

* *Comptes Rendus*, Vol. 159, p. 674.

rounding space contains an unchanging magnetic field but is devoid of electric fields, whereas to the other the magnetic field is undergoing great changes and is accompanied by an electric field.

In the case of a choking coil, induction coil, or transformer, there is no question of the movement of a conductor through magnetised space, since the observer would naturally be at rest relatively to all the windings, and would regard the electromotive forces as due entirely to variations in the magnetic induction.

To an observer on a pole of a smooth core dynamo or alternator the phenomenon appears simple ; the induced E.M.F. is due entirely to the movement of the conductors through magnetised space. When we are dealing with a rotating pole machine, the assumption by the observer that the pole on which he is situated is at rest involves the further assumption that the whole stator is moving bodily and that the opposite pole is moving at double its actual speed, but so long as he confines his attention to his own pole and the conductors under it he can ignore the rest of the machine and leave it to observers on the other poles to make their own assumptions. Strictly speaking, this is not quite correct, but we assume, as we did in considering Fig. 3, that the other poles are so far removed that any electric forces due to them may be neglected. The case of the toothed armature is much more complicated, but this is not the place to go into a detailed discussion of it. G.W.O.H.

The National Physical Laboratory

Wireless Interests at the Annual Visit

THE annual event of an invitation visit to the National Physical Laboratory took place on Tuesday, 27th June, and was largely attended. Matters of wireless interest were shown in several departments, particularly in the building of the newly formed Radio Department, including exhibits brought from the Radio Research Station at Slough, which, although now included in the Radio Department, continues its work at Slough.

Other exhibits comprised various apparatus for use in connection with ultra short waves, including apparatus for the generation of waves below 1 metre, a new type of diode for use as a short-wave electronic oscillator, and apparatus for the investigation of the electrical properties of the ground at these wavelengths. Soil properties were also represented by laboratory measurements of samples brought from various places. An exhibit in relation to circuital performance was one showing the use of two triodes as a tuned amplifier (instead of a single screened-grid valve), with advantages both as regards gain and linearity. Other measuring apparatus was for determination of total harmonic content (*e.g.*, of a l.f. output), and a differential wire-expansion radio frequency ammeter.

In the adjacent transmitting hut was exhibited a newly completed transmitting installation designed for various purposes of radio research, *e.g.*, pulse and frequency-change emissions, as well as for modulated or C.W. emissions for standard frequency tests, etc.

An exhibit from Slough was a portable direction-finder for use with either a closed-coil aerial or a rotating Adcock-type aerial, along with two cathode-ray oscillograph exhibits, in which the Slough station has specialised. One of these was an acoustical analogy of the method of echo-sounding for the determination of the height of the ionosphere. The other exhibit was a cathode-ray stroboscopic application for the detailed examination of a complicated pattern. In addition to these demonstrations there was also exhibited a film illustrating the work conducted at the Slough station. The film first showed a panoramic view of the station, followed by (*a*) the directional reception of atmospherics and the use of two-station intersections to locate thunderstorms ; (*b*) the reception of short-duration pulses, showing reflections from either or both regions of the ionosphere ; (*c*) determination of the polarisation of downcoming waves ; (*d*) measurement of downcoming angle of Transatlantic signals.

The Standards division of the Electricity Department had a number of typical exhibits relating to precision measurements. A new exhibit was the production of low frequencies (25 to 200 cycles) of high accuracy from the standard 1,000-cycle fork, this being demonstrated on a cathode-ray oscillograph. Another new and interesting article was a simple method of impedance measurement, using a pointer galvanometer as its detector and requiring no double adjustments.

The Physics Department had a number of exhibits of audio-frequency and acoustic interest. These included open-air acoustic measurements on loud speakers and the absolute measurement of sound intensities, the measurement and analysis of noise, and the delineation of audio-frequency response curves (*e.g.*, of microphones, etc.). The basement of the Physics building also had a number of acoustic exhibits, such as reverberation measurements of absorption coefficients, acoustic reflections illustrated by a ripple tank, and sound-pulse photography in relation to building acoustics.

Distortion Cancellation in Audio Amplifiers*

By W. Baggally

SUMMARY.—A method of amplification is described in which the input and output terminals of an amplifier are connected through a high resistance, the voltage existing between a point on this resistance and the earthy point being amplified and fed back to the input circuit.

It is shown that under suitable conditions all forms of distortion vanish from the output circuit.

The mathematical theory is first discussed, the conditions for distortionless working and for stability being derived.

Experimental results are quoted showing that the residual harmonic distortion in the output of an amplifier working at full power may be less than 25 parts in 10,000.

Practical details and circuit diagrams are given.

FIG. 1 shows an amplifier of any type, the upper input and output terminals being connected by resistances r and mr in series (m is an arbitrarily chosen numeric whose value is discussed below); r and mr are, for the sake of analytical simplification, assumed to be so large compared with the impedances in the input and output circuits that there is no appreciable feed-back of voltage; further, let the voltage w be assumed to be injected into the input circuit of a second amplifier (not shown, assumed to magnify a times without distortion, and hereinafter called the a amplifier), the output of which is injected into the input circuit of the main amplifier as shown, in series with the voltage v which it is desired to amplify without distortion.

It will be shown that distortion in the a amplifier appears in the main output circuit, but is multiplied by the distortion component of the main amplifier.

The resultant distortion in the output circuit is thus of the third order of magnitude and may usually be ignored.

If $\triangle$ signifies as usual a small change in the quantity to which it is prefixed, we have

$$\triangle E = \triangle e \,.\, dE/de = (\triangle v + a \triangle w)dE/de \quad .. \quad (1)$$

From circuit considerations we may easily prove that

$$w = (me + E)/(m + 1) \quad .. \quad (2)$$

$$\therefore \quad \triangle w = (m \triangle e + \triangle E)/(m + 1) \quad .. \quad (3)$$

From this and (1) we have

$$\triangle w = \triangle E(1 + m\,de/dE)/(m + 1) \quad (4)$$

and by substituting in the second form of (1) we get

$$\triangle E = \frac{dE}{de}\{\triangle v + a\triangle E(1 + m\,de/dE)/(m + 1)\} \quad .. \quad .. \quad (5)$$

$$\therefore \quad \triangle E\{1 - a(m + dE/de)/(m + 1)\} = \triangle v \,.\, dE/de \quad .. \quad (6)$$

$$\therefore \triangle E = \frac{dE/de}{1 - a(m + dE/de)/(m + 1)} \cdot \triangle v \quad (7)$$

$$\therefore \quad E = {}_0\!\int^v \frac{dE/de}{1 - a(m + dE/de)/(m + 1)} \,.\, dv \quad (8)$$

Now put

$$a = (m + 1)/m \quad .. \quad .. \quad .. \quad (9)$$

in (8), and if dE/de is not zero we have

$$E = -mv \quad .. \quad .. \quad .. \quad (10)$$

We thus have the interesting result that the output of the amplifier will not be distorted in any way, although the amplifier itself may be distorting, since (10) does not involve dE/de.

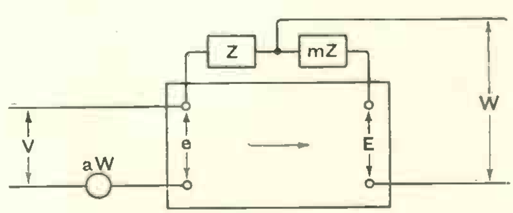


Fig. 1.

The physical explanation is, of course, that the amplifier distortion is rendered harmless by the input voltage being distorted in an equal and opposite manner, the two effects cancelling each other.

Equations (4) and (7) yield

$$\triangle w = \frac{m + dE/de}{m + 1 - a(m + dE/de)} \cdot \triangle v \,.. \quad (11)$$

* MS. received by the Editor, October, 1932.

$$\therefore\ w = {}_0\!\int^v \frac{m + dE/de}{m + 1 - a(m + dE/de)} \, . dv \quad .. \quad (12)$$

and putting in the distortionless condition (9) we have

$$w = {}_0\!\int^v \frac{-m(m + dE/de)}{(m + 1)dE/de} \, . dv \quad .. \quad (13)$$

The condition that the system, which is really a kind of retroactive amplifier, shall be stable, will now be investigated.

In equation (5) put $dE/de = c$ and $a(m + c)/(m + 1) = f$ and we have

$$\triangle E = c\triangle v + f(c\triangle v + f(c\triangle v + f(\,.\,.\,))) \quad (14)$$

$$\therefore\ \triangle E/c\triangle v = 1 + f + f^2 + f^3 + f^4 + \ldots \quad (15)$$

The condition for stability is that the series (15) shall converge; it does so if

$$|f| < 1 \quad .. \quad .. \quad .. \quad (16)$$

If we assume that v is sinusoidal, we can express phase shift in the amplifier by putting $dE/de = p + jq$ where $j = \sqrt{-1}$, and assuming m to be a real positive quantity we shall have from (16)

$$|\, a(m + p + jq)/(m + 1) \,| < 1 \quad .. \quad (17)$$

This is a scalar expression equivalent to

$$(m + p)^2 + q^2 < (m + 1)^2/a^2 \quad .. \quad (18)$$

If this were an equation, it would be that of a circle with centre at the point $(-m, O)$ and radius equal to $(m + 1)/a$, and since by (9), $a = (m + 1)/m$, the radius will be m; under these circumstances the origin will lie on the boundary of the circle.

These conditions are summed up in Fig. 2, in which the vector representing the amplification dE/de must lie completely within the shaded circle at all frequencies if the apparatus is to be stable.

In most systems of intervalve coupling, the amplification approaches zero at zero frequency and also at very high frequencies, so that to ensure stability it will be necessary to make a slightly less than $(m + 1)/m$ so that the origin may lie within the circle under all circumstances.

As an alternative, we may arrange the a amplifier so that the frequency band covered by it is the same or narrower than that of the main amplifier, so that as the vector dE/de gets smaller, the circle widens so as to keep the origin within its bounds at the extreme upper and lower frequencies.

In all cases it must be remembered, however, that the a amplifier will be called upon to deal with the harmonics of the input frequencies, so that its response must be level up to at least twice the highest frequency for which compensation is required, but that if there is no frequency distortion and phase distortion in the main amplifier and the a amplifier is separate from it (they may be combined as shown later), then the a amplifier may begin to cut off at a frequency one octave above the lowest note which it is desired to compensate, since under these conditions it is not called upon to deal with the fundamental frequencies, but only the harmonics.

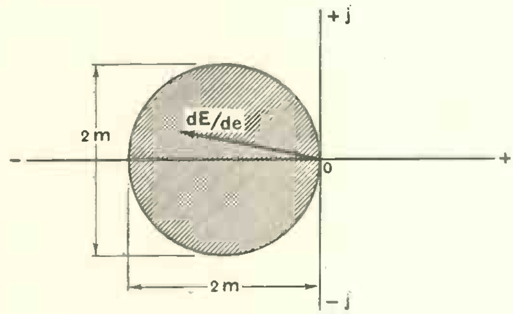


Fig. 2.

If the real part of dE/de is much greater numerically than the imaginary part (in a well-designed resistance amplifier this will always be so over the working range of frequency), it is convenient to make $m = -p$ at some mid-point in the frequency band; in this case w is very nearly zero for small amplitudes at this frequency, so that the a amplifier does not come into action until the main amplifier distorts; also the tip of the vector in Fig. 2 is brought to the centre of the circle, which gives maximum stability and allows of the widest variations in dE/de being compensated.

Under these conditions we may investigate the effect of distortion in the a amplifier as follows.

Suppose

$$dE/de = -m - g$$

and

$$a = h + (m + 1)/m,$$

where g and h are small quantities representing the distortion components and may be real or complex ; then from (8) we shall have

$$E = {}_0\int^v \frac{-m-g}{1-(h+(m+1)/m)(m-m-g)/(m+1)} \, . \, dv \quad .. \quad (19)$$

$$\therefore E = {}_0\int^v \frac{-m}{1+mgh/(m+1)(m+g)} \, . \, dv \quad (20)$$

$$\therefore E = {}_0\int^v -m(1-gh/(m+1)) \, . \, dv \quad .. \quad (21)$$

approximately.

Since g and h are both small quantities and $m + 1$ is always greater than 2, the term $gh/(m + 1)$ is extremely small and may be in general ignored.

It is of interest to compare this with the distortion introduced by a simple uncompensated amplifier under the same conditions ; it is readily seen that in this case

$$E = {}_0\int^v \frac{dE}{de} dv.$$

$$\therefore \quad E = {}_0\int^v -m(1+g/m) \, . \, dv \quad .. \quad (22)$$

since $e = v$ and $dE/de = -m-g$,

the distortion being more than $1/h$ times as great as in the compensated case.

When it is remembered that the a amplifier is only dealing with the second-order components in the output circuit of the main amplifier and only has to magnify them $(m + 1)/m$ times, the enormous advantage to be obtained from the cancellation becomes evident.

The actual amounts of distortion which can be successfully compensated are of considerable interest and may be determined in the following manner.

The permissible PHASE DISTORTION can be read off at once from Fig. 2 by striking an arc with centre at the origin and radius equal to $|dE/de|$ and measuring the angle subtended at the origin by the segment of arc lying within the circle ; in particular, if the real part of dE/de is equal to $-m$, the imaginary part may reach the same numerical value before instability sets in ; therefore the maximum phase displacement which can be compensated is $\phi = \pm \pi/4$.

The amplitude distortion which is capable of being compensated would be limited by the points at which $dE/de = 0$ if the a amplifier could deal with infinite amplitudes (see equation (13)) ; since it cannot, further investigation is necessary.

If the a amplifier can deliver a voltage u without serious distortion, but when u is exceeded the distortion becomes large, the limiting condition will be reached when

$$\left| {}_0\int^v \frac{(m + dE/de)}{dE/de} \, . \, dv \right| = u \quad .. \quad (23)$$

which is derived from (13).

From (7) it may be seen that

$$\triangle v = \frac{-dE/de}{m} \, . \, \triangle e \quad .. \quad .. \quad (24)$$

so that (23) may be written

$$\left| {}_0\int^y \frac{m + dE/de}{m} \, . \, de \right| = u \quad .. \quad (25)$$

where y is the value of e corresponding to an applied input voltage v.

It is now necessary to make some assumptions as to the form of the functional relationship of dE/de to e so as to be able to evaluate the integral (25).

The assumptions made should preferably conform fairly closely to reality and at the same time render (25) conveniently integrable.

For example, we can stipulate that $dE/de = -m$ from $e =$ minus infinity to $e = e_1$, then $dE/de = k(e - e_1) - m$ from $e = e_1$ until dE/de vanishes, after which we are not interested in its further exploits.

Integrating these and equating them when $e = e_1$ (since we are not permitting discontinuities in the output), we find that $E = -me$ from minus infinity to e_1, then $E = ke^2/2 - (ke_1 + m)e + ke_1^2/2$ from e_1 onwards.

It is a straight characteristic with a parabolic top which becomes saturated when $e = e_1 + m/k$.

This is probably sufficiently like real life over the working range for the present purpose ; inserting it in (25) we have

$$\left| {}_0\int^y \frac{k(e - e_1)}{m} \, . \, de \right| = u \quad .. \quad .. \quad (26)$$

since the first part of the integral is zero.

The result of the integration is

$$\left| \frac{k}{m} \left\{ \frac{y^2}{2} - e_1 y + \frac{e_1^2}{2} \right\} \right| = u \quad .. \quad (27)$$

or $\qquad y^2 - 2e_1 y + e_1^2 - 2mu/k = 0 \quad (28)$

The relevant solution of this quadratic is

$$y = e_1 + \sqrt{2mu/k} \quad .. \quad (29)$$

and finally we have the maximum undistorted output voltage

$$V = m(y - u) = m(e_1 + \sqrt{2mu/k} - u) \quad (30)$$

if $u < 2m/k$.

If $2m/k < u$, the analysis breaks down.

It is seen from the above that in FREQUENCY DISTORTION, dE/de may not rise to a greater value than $2m$ and may not fall below such a value that the output from the a amplifier exceeds u.

Using, as before, the notation $dE/de = c$, (23) may be at once integrated since c is now assumed constant with varying amplitude, thus

$$v(m + |c|) = |c|u \quad \ldots \quad \ldots \quad (31)$$

$$\therefore \quad |c| = mv/(u - v) \quad \ldots \quad \ldots \quad (32)$$

Therefore the apparatus will not distort or oscillate if

$$mv/(u - v) < |c| < 2m \quad \ldots \quad (33)$$

(c is, of course, negative).

The different kinds of distortion have been considered as occurring independently of each other, and the above analysis should suffice to give a good idea of the order of magnitude of the permissible distortions, but in practice all these effects will be occurring simultaneously and will all modify each other; the general case is probably too complicated to be worth a mathematical treatment, and the attempt will not be made here.

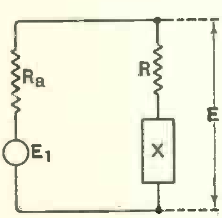


Fig. 3.

The question now arises: What is the greatest output voltage we can get without distortion? Since the amplifiers will presumably be designed with care, so as to reduce phase distortion and frequency distortion to very small values, the answer to this question is going to be given by equation (30) very nearly, but it must be noted that any departure of the phase characteristics and amplitude-frequency characteristics from the ideal of straight lines parallel to the axis of frequency, although not necessarily involving any direct distortion, will, nevertheless, cause some reduction in the maximum undistorted output and also some slight increase in the residual harmonic content at levels other than the maximum, due to the fact that the a amplifier will, under these conditions, be in action even at small amplitudes and will therefore contribute its quota of distortion as shown in equation (21).

The following question is, practically, of fundamental importance in the application of these methods to speech amplifiers, etc.

Suppose that the amplifiers are high-grade, resistance-coupled instruments, free from phase distortion and frequency distortion in themselves; what effect on the characteristics will be produced by a reactive load, such as a loud speaker, in the output circuit of the main amplifier?

From Fig. 3, which is the equivalent circuit of the output stage, we have at once

$$n = E/E_1 = (R + jX)/(R + R_a + jX) \quad (34)$$

$$|n| = \sqrt{(R^2 + X^2)/((R + R_a)^2 + X^2)} \quad (35)$$

$$\tan\phi = XR_a/(R(R + R_a) + X^2) \quad \ldots \quad (36)$$

where ϕ is the phase angle of n.

By differentiating (36) to X and equating to zero, we find that ϕ has a maximum when

$$X = \sqrt{R(R + R_a)} \quad \ldots \quad (37)$$

and substitution of this value back into (36) gives

$$\phi_{\max.} = \tan^{-1} R_a/2\sqrt{R(R + R_a)} \quad \ldots \quad (38)$$

which is the worst possible condition for phase distortion.

To get an idea of the way in which the quantities $|n|$ and ϕ vary with frequency, assume R fixed whilst X varies from zero to infinity.

Put $R_a = sR$; then when

$$X = 0 \qquad |n| = 1/(1 + s) \qquad \tan\phi = 0$$

$$X = R.\sqrt{1+s} \qquad |n| = 1/\sqrt{1+s} \qquad \tan\phi = s/2.\sqrt{1+s}$$

$$X = \text{inf.} \qquad |n| = 1 \qquad \tan\phi = 0$$

$$\ldots \quad \ldots \quad (39)$$

If X changes sign, so does ϕ, but remains the same numerically.

We can make these variations as small as we please by reducing the value of s, but if we go too far in this direction, the load in the output circuit will become far removed from the optimum and the output valve will not work efficiently.

If s is made about 0.3, the load will be only slightly greater than the optimum for most valves, $|n|$ only changes by $\pm$ 0.14 of the mean value and the maximum phase displacement will be $\pm$ 0.13 radian.

These changes are well within the capacity of the compensation, and will not be of very much consequence in practice, especially as X will not really reach zero or infinity in practical loads, so that the changes will be even smaller than the calculated figures.

It is worth noting in this connection that the compensation keeps the voltage across the load constant; that is to say, the amplifier behaves as if the A.C. resistance of the output valve were zero; this may or may not be advantageous, but it will have to be taken into account when considering the question of the response curve of a loud speaker.

Of course, a series resistance could be used to prevent anything drastic happening in the bass, with a condenser shunted across the resistance so as not to waste power in the treble; it will be noted that the problem is the opposite to that encountered when using pentodes, so that we shall have to use the opposite network to solve it.

When making up practical circuits using cancellation, the main thing to remember is that the input and output of the main amplifier must be in phase-opposition (*i.e.*, when the input terminal is positive with respect to the earthy point, the output terminal must be negative and vice versa), but that the input and output of the *a* amplifier must be in phase, which limits us to an odd number of valves in the main amplifier and an even number in the *a* amplifier; that is, if resistance amplifiers with common power supply to the valves are used.

If transformers are available which are sufficiently free from distortions of various kinds, these limitations do not arise, since we can get the necessary phase changes by reversing the connections to the transformers.

Of course, considerable liberties may be taken in this direction with the main amplifier, since the cancellation will correct all minor faults here, but the conditions to be fulfilled by the *a* amplifier are far more stringent and it is probably not practical to introduce any commercially existing types of intervalve transformer into this part of the circuit, although it seems probable that a low-ratio transformer following a low impedance valve and with a resistive load across the secondary could be designed to have the necessary characteristics; also the use of transformers in the main amplifier would allow the cancellation to be combined with the method of grid current compensation which was described in a previous paper by the present author in this journal, thus leading to further increases in the undistorted power output.

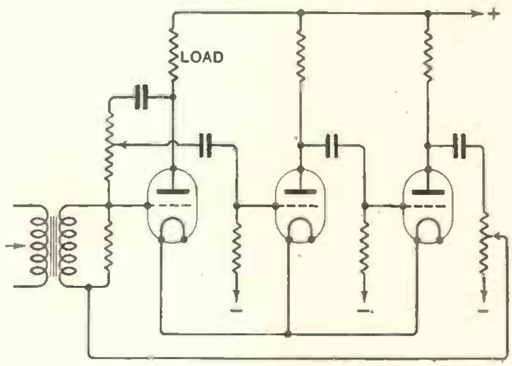


Fig. 4.

It is hoped to conduct further researches along these lines in the near future.

The simplest circuit of the resistance-coupled type is shown in Fig. 4, in which the output valve of a chain is compensated by a separate two-stage amplifier; it is useful for many purposes in the laboratory, but is hardly a proposition for a broadcast receiver.

However, it serves as an excellent experimental circuit with which to test the capabilities of distortion cancellation, and some results obtained with it are now given.

A Mazda P650 valve was used as the main amplifier, with about 200 volts on the anode and 42 volts grid bias, the anode current being 29 milliamps.

The load consisted of a non-inductive resistance of 4,500 ohms in series with the input circuit of the distortion meter, which was shunted with non-inductive resistance so as to have an impedance of 500 ohms, which is almost purely resistive; the total load was therefore equivalent to a pure resistance of 5,000 ohms to a sufficient degree of approximation for the present purpose.

The input consisted of carefully purified 1,000 cycle A.C. from a valve-maintained tuning fork, the harmonic distortion being less than one part in a million, the amplitude being adjusted just below the point at which grid current commenced to flow in the P650.

The amplifier adjustments are made as follows :—The output of the *a* amplifier is first disconnected from the main amplifier input circuit, the gap in the latter being bridged, and is connected to a pair of phones.

The grid-anode potentiometer tapping point is then adjusted for minimum sound when the input voltage is small ; from equation (12) we now know that under these conditions $m = -dE/de$ and that consequently the *a* amplifier will not come into action until the main amplifier distorts.

The output of the *a* amplifier is now reconnected to the input circuit and its gain adjusted until the harmonics in the output are at their minimum value, the input voltage having been first increased so as to give a good crop of harmonics before the gain adjustment is made.

If a harmonic measuring apparatus is not available, this adjustment can be made by connecting a potentiometer and phones as shown in Fig. 5 or in some other equivalent manner.

By adjustment of the slider of the potentiometer, the fundamental may be practically balanced out of the phones, when the harmonics will become audible and may be reduced to a minimum by the gain adjustment.

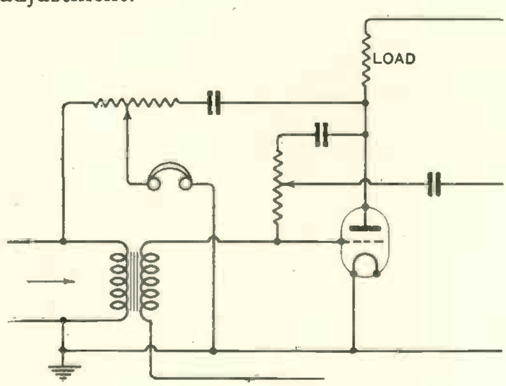


Fig. 5.

These adjustments having been made, the valve was found to be delivering one watt to the load, the total harmonic distortion being 0.25 per cent. ; when the gain of the *a* amplifier was reduced to zero, thus cutting out the cancellation without disturbing the other circuit conditions, the total harmonic distortion rose to 3.4 per cent. : thus the cancellation reduces the harmonics to less than 1/13th of the usual value.

When a small moving-coil loud speaker

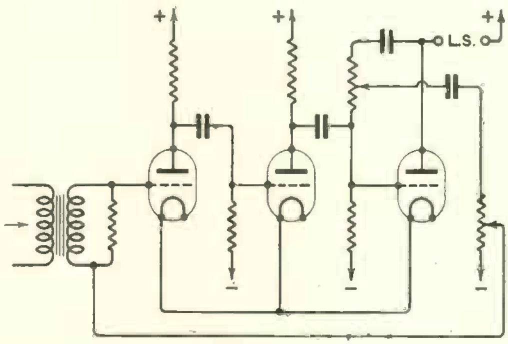


Fig. 6.

whose reactance and resistance at 1,000 cycles are 540 ohms and 2,440 ohms, respectively, was substituted for the 4,500 ohm resistance in the output circuit, the results were substantially the same as in the first experiment, thus confirming the conclusions arrived at theoretically in regard to the effect of reactive loads.

The percentage harmonic content measured by the distortion factor meter is the quantity

$$H = \sqrt{E_1 + E_2 + E_3 + \ldots} \times 100/E_0,$$

where E_0, E_1, E_2, etc., are the R.M.S. values of the total output, first harmonic, second harmonic, etc., respectively.

The meter consists of a high-pass filter which attenuates the 1,000 cycle fundamental about 110 db. but passes the harmonics with only about 0.5 db. attenuation, followed by a potential divider calibrated in percentages, the output of which goes into an amplifier with an A.C. voltmeter in the output circuit.

In taking a measurement the filter is put in and the voltage divider is set to 100 per cent., the gain of the amplifier being adjusted to give a convenient reading on the voltmeter.

The filter is then cut out and the potentiometer adjusted so as to give the same reading on the voltmeter.

The setting of the potentiometer then gives the percentage harmonic distortion as defined above, assuming there is no frequency or waveform error in the amplifier or voltmeter.

Reverting to the question of circuits for practical use, in the case of a multi-stage amplifier one may use the early stages to compensate the output stage; for example, in a three-stage amplifier the first two stages are used to amplify the incoming voltage in the usual way, the same two stages being used as the *a* amplifier for compensating the output stage, thereby securing the advantage of a compensated output stage without the use of extra valves.

The arrangement is shown in Fig. 6, the potentiometer on the extreme right controlling the amount of feed-back in the *a* amplifier without alteration of the total gain of the complete amplifier.

The resistance of the two potentiometers needs careful consideration in relation to the other circuit elements, since they constitute a high impedance in series with the input circuit; capacity effects are to be guarded against here.

In the case of a well-designed amplifier, however, the percentage harmonic distortion of the output stage will certainly be much greater than that introduced by all the other stages put together, and by eliminating the output stage distortion we shall be getting rid of the bulk of the total distortion introduced by the whole system.

The method of compensating a complete multi-stage amplifier by means of an independent *a* amplifier is shown in Fig. 7.

The only points of special interest here are, first, the *a* amplifier output is shown shunted across the main amplifier input circuit as an alternative arrangement to the series connection shown in Figs. 1, 4 and 6, which allows one input terminal to be at earth potential, which is useful in some arrangements, and secondly, the main amplifier output circuit is shunted with a high resistance which is tapped down as shown so as to only apply about 1/10th of the output voltage to the balancing potentiometer, the object of this arrangement being to avoid any appreciable feed-back from the output to the input of the main amplifier through the resistance of this potentiometer while keeping the resistance of the potentiometer within practical limits.

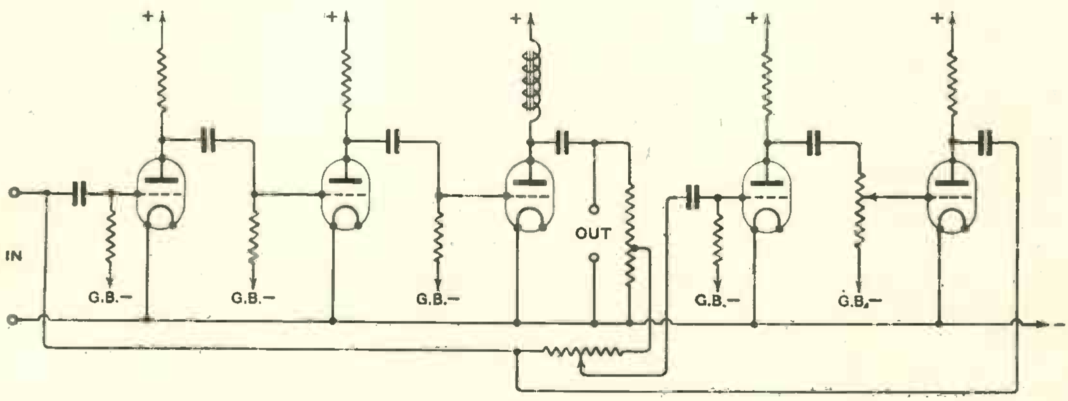


Fig. 7.

The theoretical limitation of this circuit is, of course, that it is only the output stage, not the whole amplifier, which is compensated, so that the distortion introduced by the first two stages remains without reduction.

The Acoustical Performance of a Cone-type Loudspeaker*

By D. A. Oliver, B.Sc.

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1. Introduction

IN acoustical engineering frequency response curves of various kinds are now widely used and they are being relied upon to an increasing extent. However, to justify the confidence which is being placed in them it is essential to know the exact conditions of test and to investigate the limitations on the interpretation of the results.

So far as the loudspeaker is concerned, the more important points which arise in testing under simplified acoustical conditions have already been discussed.[1] This paper is an extension of that discussion, but it attempts primarily to illustrate the recommendations already made and to furnish a series of precision measurements on one instrument of the inductor type,[2,3] when the boundary conditions are definite and the many variables kept under proper control.

2. Brief Description of Equipment

The laboratory in which the measurements about to be described were carried out consists of two adjacent rooms, the larger of which is 16ft. long by 8ft. high and 10ft. wide, covered first with two layers of cabot quilt, having behind the quilt at various places a small air space, and completely lined with six layers of gamgee tissue or medical cotton wool. The absorption of low frequency sound energy is believed to be due largely to the diaphragm action[4] of the brown paper confining the eel grass, the paper being elastically supported but well damped on either side. The loudspeaker is mounted on a stiff plywood baffle board 2ft. square and $\frac{5}{8}$in. in thickness integral with the partition wall separating the two rooms. The front of the cone radiates into the heavily damped room and the back would radiate into the smaller adjacent instrument room but for the fact that a very large tightly fitting box lined with absorbing material encloses the back of the loudspeaker and nearly absorbs all the sound energy radiated by the back of the vibrating paper diaphragm. It was checked at several frequencies between wide limits that the effect of this box did not influence the pressure measurement in the damped room by more than a few per cent., or a fraction of a decibel. The object of this box was to prevent the high sensitivity microphone amplifier from being affected by sound from the back of the diaphragm.

Elaborate precautions had previously been taken in the amplifier itself against microphonic troubles and adequate checks applied to verify that the microphone signals were not being invalidated by spurious e.m.f.s set up by other causes. In most of the tests a direct change-over was made from the calibrated condenser microphone to a standardising potentiometer immediately after each measurement, thereby eliminating any special reliance being placed on the amplifying and output recording system. The condenser microphone actually used for this work was a smaller and still further improved model[5] of proven reliability and had been calibrated against a Rayleigh disc in free air. A further check has recently been furnished by calculating its response on certain assumptions using its initially determined mechanical constants, and good agreement with the free air calibration has been obtained.

3. Experimental Results

In Fig. 1 are shown the principal dimensions of the inductor dynamic loudspeaker cone to which the following data apply. A more detailed account of the constructional features will be found elsewhere.[3] The paper was soft, untreated, and 0.023 cm. in thickness. The velocity of sound in this

* MS. received by the Editor, July, 1932.

paper ($\sqrt{E/\rho}$) was found to be 2.3×10^5 cm/sec.

(a) Axial Response

In Fig. 2 (*a*) is given the final corrected response curve for the loudspeaker when the sound pressure was measured on the axis at a distance of 60 cm. and the alternating current was kept constant at all frequencies. This curve plotted in decibels gives, at the measuring point, the true acoustical power variation above or below the power level at 1,000 cycles per second, as the driving point impedance of the medium in free space or a completely damped enclosure is resistive and constant at all frequencies. A further condition is that the radiations from the two sides of the vibrating diaphragm are separated by an infinite baffle and that no acoustical interference takes place between them.

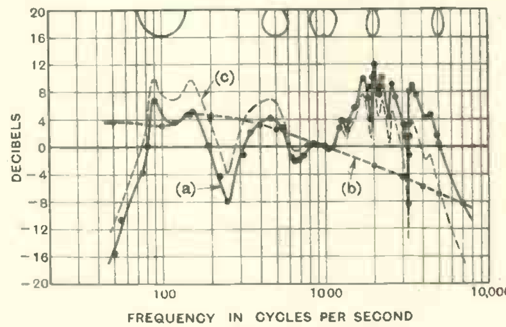

Fig. 2.

(a) *Axial response at constant current of* 5.0×10^{-3} *amp. Microphone distance* 60 *cm.* β *(dyne/cm²/amp) at* 0 *db* $= 1.1 \times 10^3$. $(\beta^2/\rho c) \times 10^{-7}$ *at* 60 *cm. at* 0 *db* $= 2.9 \times 10^{-3}$ *watt/cm²/amp.*

(b) *Current variation with P2 valve fully loaded.* 0 *db* $\equiv 8.2 \times 10^{-3}$ *amp.*

(c) *Axial response with P2 valve.* $(p^2/\rho c) \times 10^{-7}$ *at* 60 *cm. at* 0 *db* $= 1.9 \times 10^{-7}$ *watt/cm.²*

The constancy of the shape of Fig. 2 (*a*) when similar measurements are made at different values of constant alternating input current and at different axial distances from the plane of the baffle will be discussed later.

(b) Current Variation and Valve Coupling

When an e.m.f. constant at all frequencies is applied to the grid of the power valve the current through the loudspeaker is not necessarily constant with frequency, principally on account of the variation with frequency of the impedance of the loudspeaker. This variation can be calculated from the circuit constants but it has been found more convenient to measure the alternating current flowing through the loudspeaker under constant grid voltage conditions and to express the current ratios in decibels $20 \log_{10} (I_f/I_{1000})$. This gives a curve passing through zero at 1,000 cycles per second. This procedure does not give a curve of variation of input electrical power to the loudspeaker, as that would assume a constant loudspeaker input effective resistance at all frequencies, but rather one which, when added to the curve of true acoustical power variation measured at constant current, takes account of the actual acoustical power variation due to

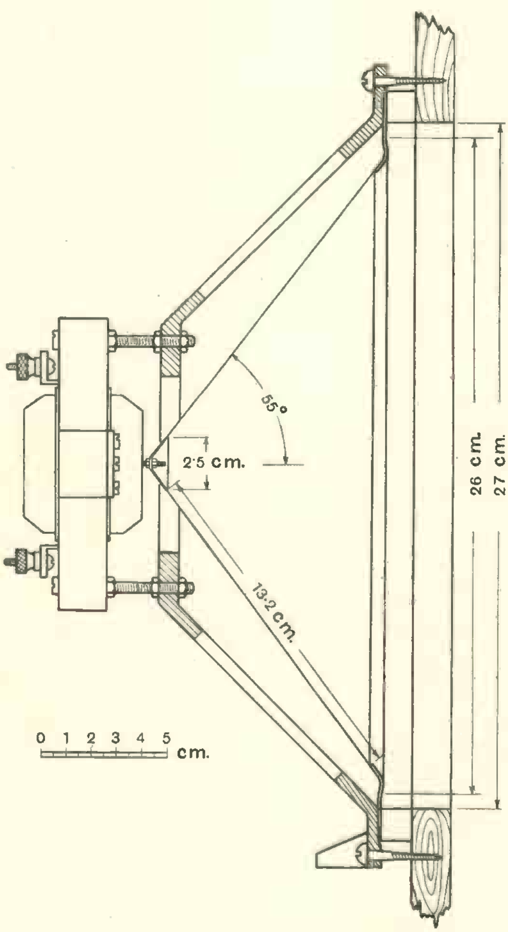

Fig. 1—*Section of Inductor Loudspeaker showing principal dimensions.*

the variation with frequency of the current through the loudspeaker when it is connected in the output circuit of the power valve to the grid of which a constant e.m.f. is applied. An underlying assumption is that the pressure in the sound field and the input current to the loudspeaker are connected by a linear relation, the validity of which can be checked experimentally in a given case.

A curve of current variation is given in Fig. 2 (*b*) and was obtained with an Osram P2 valve fully loaded and coupled to the loudspeaker by a 20 henry choke and 2 microfarad condenser, the circuit being similar to Fig. 9 of a previous paper.[1]

(c) Axial Response Curve at Constant A.C. Grid Voltage

The overall axial response curve Fig. 2 (*c*) is obtained by the sum of curves (*a*) and (*b*) Fig. 2, and curve (*c*) represents the variation in acoustical power at the measuring point per unit area of wave front for a constant applied voltage to the grid of the P2 power valve. This valve is not necessarily the most suitable for use with this loudspeaker, but as complete results with this valve have been obtained they are given here to illustrate the general method of applying the data.

(d) Polar Pressure Distribution

At the top of Fig. 2 an indication is given of the polar distribution of relative pressure round the source referred to the axial value. The actual experimental observations for the loudspeaker in question are shown in Fig. 3. Each point was referred to a potentiometer calibrating circuit similar in principle to that due to West,[6] thereby ensuring a degree of consistency difficult to attain in this type of measurement. To eliminate errors due to drift in frequency, a small monitoring source was supplied from the heterodyne oscillator, having filtered output, and continuous manual adjustment of frequency was carried out by maintaining slow beats with a series of standard tuning forks. It is seen that the polar pressure curves are fairly symmetrical and it was checked that repeating the measurements with the loudspeaker turned axially through 90 deg. gave further curves in close agreement with those quoted, thereby verifying that the polar distribution from the cone had axial symmetry to a high order of uniformity.

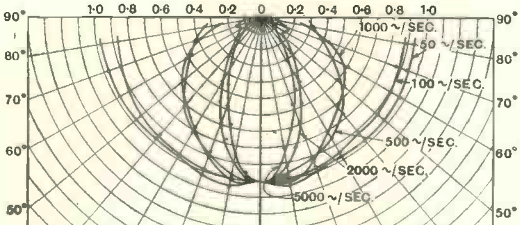

Fig. 3.—*Measured polar curves of relative pressures for cone at several frequencies.*

(e) Polar Factor

Under the test conditions already specified it has previously been shown[1] that the total acoustical power P_a radiated at a frequency f is given by

$$[P_a]_f = 0.150\, R^2 q^2 S \times 10^{-7} \text{ watts} \quad .. \quad (1)$$

where q is the actual axial pressure (dyne/cm^2) at radius R cm. measured from the centre of the front plane of the baffle and S is a polar factor obtained by applying the Rousseau construction to the square of the relative polar pressure diagram. For hemispherical radiation $S = 1$ and is less than unity when appreciable directivity is present. In deducing the various values of S from the inductor loudspeaker results in Fig. 3 the mean pressure-squared curve was found and then the Rousseau construction applied. Due to the high degree of symmetry in the polar distribution, these values of S were found to be in almost exact agreement with the same construction applied to the square of the mean pressure curve, which is considered a less accurate procedure.

(f) Total Power Response

From equation (1) it is seen that the variation of q has already been taken into account in the curves of axial pressure (*a*) and (*c*), Fig. 2, and therefore to convert these curves into curves of total radiated power at the front of the infinite baffle we have only to calculate $10 \log_{10} (S/S_{1000})$ to a base of frequency and add the new curve so obtained to Figs. 2 (*a*) and 2 (*c*) to obtain the total variation in acoustical power output for either constant input current or for constant input voltage to the grid of the power valve. The curve of $10 \log_{10} (S/S_{1000})$ might be called the "polar factor curve." The particular values obtained are shown plotted in Fig. 4 (*a*), where the general smooth curve connecting them has been drawn in by a chain line. It is realised that if further equally reliable measurements were carried

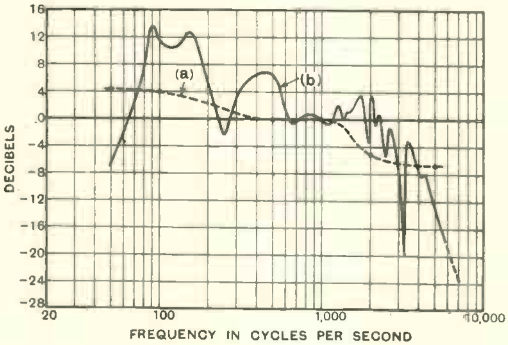

Fig. 4.
(a) *Polar factor in decibels. S at* 0 *db* = 0.34.
(b) *Total power response with P2 valve.* P_a *at* 0 *db* = $1.4_8 \times 10^{-3}$ *watt (fully loaded).*

at other frequencies, certain small fluctuations in the curve would probably be established due to the considerable changes that take place in the mode of vibration of the cone over the working frequency range, but from approximate additional polar curves taken at intermediate frequencies it is not expected that further lengthy and careful work would invalidate continuing the argument on the basis of Fig. 4 (*a*).

In Fig. 4 (*b*) is given the variation in total power output for the inductor loudspeaker coupled to the P2 output valve, and is the sum of Figs. 2 (*c*) and 4 (*a*). This curve only strictly applies to the specified conditions of test, of which the most important is the infinite baffle condition. The general method could doubtless be extended to cope with the case of a finite baffle, when polar curves of sound pressure would be required embracing the speaker or set cabinet and referred to different planes. The source would have to be centrally situated in absorbing surroundings, but these further conditions will not be elaborated here. However, the actual test conditions are not so artificial that they cannot be used when subjective aural tests are also desired.

(g) Combined Receiving Set and Loudspeaker Curves

It is convenient to point out at this stage that such curves as have already been obtained can be linked on directly with overall radio receiving set tests. In Fig. 5 (*a*) is given an actual curve for an all-mains receiving set showing the variation in decibels of the current into the loudspeaker. The high frequency tailing-off is rather severe for these particular conditions of test, which were not those of standard practice. If now this curve is added to the sum of Figs. 2 (*a*) and 4 (*a*), we obtain an overall curve of variation in total useful sound output power for an infinite baffle and constant radio-frequency dummy-aerial voltage input, and is primarily given as an example of the comprehensive flexibility of the general recommendations which have been put forward.

(h) Further Applications of Results

The next step correlating the acoustics of the loudspeaker and the room in which it is operated is by no means straightforward and has to be taken with caution.

Let us consider briefly some of the effects which take place when music is reproduced by a loudspeaker in an ordinary room in which both reflection and absorption are present. Standing waves are produced by progressive waves travelling simultaneously in opposite directions, these being set up in turn by multiple reflections from the boundaries of the enclosure. Some of these

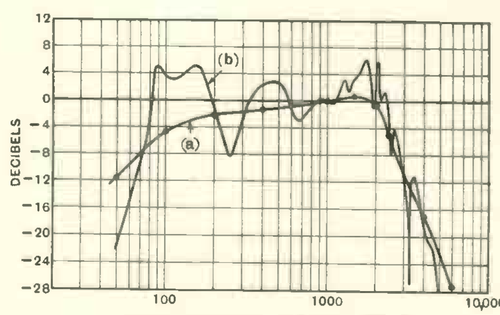

Fig. 5.
(a) *Three-valve receiver: loudspeaker current variation for constant input voltage to aerial.*
(b) *Total power response of receiver: (infinite baffle).*

standing wave effects are reinforced due to the many modes of resonant vibration[7] into which the volume of air in the room can be excited, and for a completely reflecting room these resonances are extremely sharp and numerous, but for ordinary rooms they are appreciably damped. The time required for these resonances to build up to their full amplitude even then is usually much longer than the brief period of sustained excitation. In practice, the standing wave pattern is changing continuously from moment to moment and measurements of the fine structure of the pressure variations can only be made conveniently when using a constant pure tone source. The effects mentioned above produce large local changes in intensity which are further enhanced by the presence of acoustical foci dependent upon the geometry of the room. However, as most forms of reproduction do not involve the sounding of long sustained notes, the deleterious local effects are not detected by ear as readily as might be expected, because the time intervals involved are usually too short for the individual forms of distortion to build up to their maxima. Moreover, with binaural listening an invaluable averaging effect is obtained. Subjective experience has, of course, approved the degree to which certain forms of reverberation and local wave distortion are tolerable or even desirable, but with such considerations we are not here concerned.

A further set of complications arises when the directional characteristics of the source itself are considered and the fact that the power radiated by the loudspeaker depends to some extent upon the magnitude of the reaction of the enclosure upon its diaphragm. This is due to the fact that the driving point impedance of the room experienced by the speaker diaphragm is different from the impedance imposed upon it in the equivalent infinite medium test condition, but Crandall[8] has pointed out that the effect of this is likely to be a minimum when the power is referred to a constant force basis, as in this case, rather than to a constant amplitude basis. The seriousness of this change in impedance is determined largely by the associated internal mechanical impedance of the driven diaphragm, being less serious the greater the mechanical impedance of the speaker. A correction for the effect is, however, expected to be small in most practical cases.

Some recent observations of the sound pressures in the field of a loudspeaker have been made by Barnes[9] and Ballantine,[10] first in a highly absorbing room and then in a reflecting one. If the fine structure and general level of the curves are ignored the trend of the pressure response in each case can be considered the same, although in the room having partially absorbing boundaries the variations in pressure from the mean are considerable.

There are two steady state cases which can be considered. Imagine first that the diaphragm of the loudspeaker is mounted in, and integral with, one wall of a completely absorbing room, and arranged so that the back of the diaphragm radiates freely into space or its equivalent. The conditions of use then conform to the conditions of test and the response curve of Fig. 2 (*c*) applies directly for all positions on the axis of the speaker, while the loss in response for positions away from the axis is readily obtained by converting the polar curves of relative pressure, Fig. 3, into loss in decibels from the axial value and applying the necessary corrections to Fig. 2 (*c*). If now we consider the loudspeaker similarly situated but working into a reflecting room an approximation to the state of affairs can be made in the following way. If E is the mean energy density in the room having an absorbing power a, and P_a' is the constant rate of supply of energy or actual power radiated to maintain the energy density E, and c is the velocity of sound in air, then [11]

$$E = \frac{4\,P_a'}{ac} \qquad \ldots \quad \ldots \quad (2)$$

or writing this equation in the standard decibel notation

$$10 \log_{10}\left(\frac{E_f}{E_{1000}}\right) = 10 \log_{10}\left\{\frac{(P_a')_f}{(P_a')_{1000}}\right\} - 10 \log_{10}\left(\frac{a_f}{a_{1000}}\right) \quad \ldots \quad (3)$$

As the values of P_a' are not expected to be very different from the values of P_a measured in absorbing surroundings an estimate of the variation of mean response can be made in the room. Thus Fig. 4 (*b*) from which the frequency curve of absorbing power of the room has been subtracted would give the approximate mean overall response in the room for that particular valve, coupling and speaker for a constant alternating voltage applied to the grid of the power valve. A conversion of the final characteristic into some scale of loudness units on the lines recently indicated[12] would complete the information. It is, of course, realised, that for a listener in front of the loudspeaker and close to it, the axial response curve will apply to a good degree of approximation even in a reflecting room as the direct energy is then large compared with the reflected energy. However, in general the effective response curve will lie between the axial response curve (*e.g.*, Fig. 2 (*c*)) and that curve corrected for the polar distribution of the speaker (*e.g.*, Fig. 4 (*b*)) and further modified by the frequency variation in decibels of the absorbing power of the room. That these various corrections are not very critical by ear is borne out by Capt. West's interesting experiments,[13] in which various forms of axial response curve, with presumably no allowance for polar distribution and room absorption, were judged for naturalness against the original, and the vote was definitely in favour of the most generally flat characteristic. It should be added in fairness that relatively large changes in response were being compared, but nevertheless the result was encouraging and makes more exact correlations worth attempting.

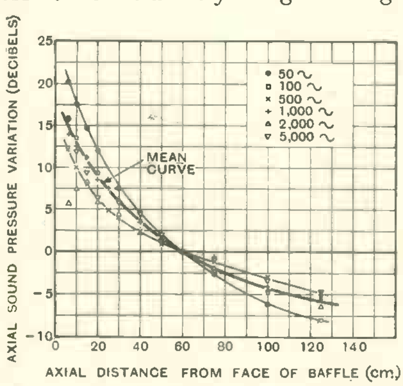

Fig. 6.—*Axial sound pressure variation with distance for constant loudspeaker current.*

4. Additional Experimental Results

(a) Variation of Axial Response with Distance

Previous experiments had shown that measurements of axial response at different distances were very similar, but, to obtain precise information, measurements were made at various frequencies checked continuously by tuning forks. These results are shown in Fig. 6, where $20 \log_{10} (p_r/p_{60})$ is plotted for various distances and frequencies. In general, the curves are smooth ones, showing that standing waves in the room and between the source and the condenser microphone are small. A mean curve lying between the various sets of results at different frequencies has been drawn in as well as the individual curves for the 50 and 500 cycle per second observations which happen to show the greatest divergencies.

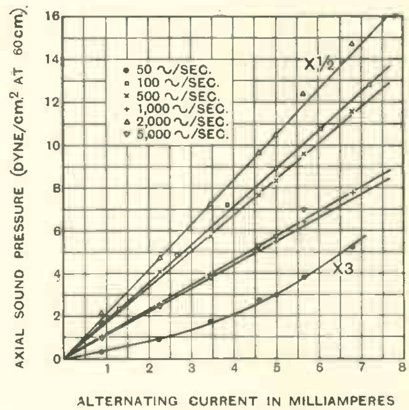

Fig. 7.—*Axial sound pressure variation at 60 cm. with alternating current to loudspeaker.*

An inspection of the spread from the mean curve in Fig. 6 indicates that for radial distances between the limits of 25 and 125 cm., the probable maximum uncertainty to be placed on Fig. 2 (*a*) and those derived from it, is not greater than $\pm$ 2 decibels.

(b) Relation between Axial Sound Pressure and Alternating Current Input

In any high class reproducer the relation between the excess pressure set up in the sound field, when reflected waves are absent, and the alternating current input, should be linear, otherwise the shape of the axial response curve will vary with the particular value of the constant testing input current.

Measurements were carried out to test the linearity of the inductor loudspeaker, and in Fig. 7 is given a series of curves for different frequencies relating the axial pressure at a distance of 60 cm. with the input alternating current. It is seen that within the limits of experimental error and for the somewhat limited range of the independent variable, the curves can be considered linear except for the results at 50 cycles per second which exhibit distinct non-linearity. However, at this frequency the loudspeaker is cutting off, the pressures involved are very small and the measurements are difficult to carry out and thus it is concluded that, for the majority of frequencies, the evidence furnished by Fig. 7 is sufficient to show that no serious amplitude distortion is present and that the shape of Fig. 2 (*a*) is independent of the input current.

Additional measurements were made with the loudspeaker connected by choke and condenser in the anode circuit of the P2 power valve, and the variation between the a.c. input current to the loudspeaker and the a.c. input grid voltage to the valve was examined. In this case the linearity was again checked, the plotted points being even more consistent among themselves than those shown in Fig. 7, and therefore it can be rightly concluded that the pressure set up in the sound field is proportional to the alternating voltage applied to the grid of the power stage, provided rectification and grid current are avoided.

(*c*) *Acoustical Efficiency*

The matter of efficiency has previously received attention[1] and at that time it was suggested that the efficiency of a loudspeaker alone might well be defined on orthodox lines as the ratio of the total useful acoustical output power (P_a) to the total input electrical power (P_e) at the same frequency. If now the radiation from the front only of the infinite baffle is regarded as the useful radiation, then the percentage acoustical efficiency is given by

$$[\eta_3]_f = \frac{P_a}{P_e} = \frac{0.150 R^2 \beta^2 S}{[Z \cos\theta]_f} \times 10^{-5} \quad \ldots \quad (4)$$

Where R = radius at which polar curve is measured.

β = dyne/cm²/ampere factor on axis at radius R.

S = polar factor.

$Z \cos\theta$ = effective resistance between input terminals at a frequency, f.

The efficiency defined in this way for the inductor loudspeaker has been determined at a few selected frequencies and the various quantities are given in Table I.

If we consider the combination of the loudspeaker and amplifier from the point of view of defining its effective attenuation in the electro-acoustical transmission system we can adopt Bostwick's[14] definition which has found favour,[15] and which is the ratio of the acoustical power radiated to the maximum electrical power the amplifier can deliver into a pure resistance load matching the output impedance of the amplifier.

To be more specific we will define the efficiency as

$$\eta_1 = \frac{P_a}{P_E} = \frac{4 R_a P_a}{m^2 e_g^2} \quad \ldots \quad \ldots \quad (5)$$

Where P_a = measured useful acoustical power radiated.

P_E = calculated maximum electrical output power.

R_a = internal resistance of power valve at mean bias voltage.

TABLE I.

EFFICIENCIES OF INDUCTOR LOUDSPEAKER.

Radial distance of microphone R = 60 cm.

Frequency cycles/second.	β dyne/cm²/amp.	S	$0.150 R^2\beta^2 S \times 10^{-7}$ watts/amp.	i for fully loaded P2 valve : amp.	$0.150 R^2\beta^2 S i^2 \times 10^{-7}$ watt.	$Z \cos\theta$.	η_3%	η_1%
50	0.20×10^3	0.94	2.0	12.3×10^{-3}	0.30×10^{-3}	940	0.22	0.11
100	$1.7_9 \times 10^3$	0.83	144	11.6×10^{-3}	$19._5 \times 10^{-3}$	980	$14._5$	$7._2$
500	$1.6_8 \times 10^3$	0.34	51	10.9×10^{-3}	6.1×10^{-3}	1,480	3.4	2.3
1,000	$1.1_0 \times 10^3$	0.34	22	8.2×10^{-3}	$1.4_8 \times 10^{-3}$	2,290	0.9_5	0.5_5
2,000	4.2×10^3	0.10_3	100	6.0×10^{-3}	3.6×10^{-3}	3,460	2.9	1.3
5,000	$1.1_5 \times 10^3$	0.07_1	4.9	3.7×10^{-3}	$0.6_7 \times 10^{-4}$	7,370	0.06_5	0.025

m = magnification of power valve.

e_g = maximum r.m.s. alternating grid voltage, taken to be the same for both loudspeaker and non-reactive load.

For the P2 valve actually used the measured constants yielded a value of

$$P_E = \frac{m^2 e_g^2}{4R_a} = 0.27_0 \text{ watt.} \quad \quad (6)$$

where $(e_g)_{\max.}$ was 7.0 volts for a steady bias voltage of — 10.2 and the corresponding current through the loudspeaker at 1,000 cycles per second was 8.2 milliamperes, when the valve was fully loaded and grid current was avoided. The calculated values of η_1 are given in the last column of Table I and are, of course, proportional to P_a.

It is seen that although the absolute values of η_1 are lower than those for the loudspeaker alone, they show less extreme variation. In fact, Fig. 5 (*b*) showing the variation of output acoustical power in decibels is really an efficiency (η_1) variation curve and it is necessary only to fix the absolute value of efficiency at 1,000 cycles per second. In practice the author has found this same curve with the level quoted in acoustical watts output for unit voltage on the grid of the power valve, with a statement of the maximum a.c. grid swing, to be the most useful curve as such a curve can then be linked on with the extended study of overall performance outlined in Section 3 (*h*).

It should be added that the values of efficiency given in Table I should approximately be doubled if it is assumed that the radiation from the back of the cone is equal to that from the front and that each can be separately utilised. The values of η_3 are chiefly of use in giving a concrete idea of the order of the individual efficiency of the inductor loudspeaker, when it is studied separately as a transducer converting electrical into acoustical power.

5. Theoretical Comparisons

It is of interest to compare the measured polar distribution (Fig. 3) with the calculated distribution for a vibrating rigid piston operating under similar acoustical conditions. It has been shown by Stenzel[16] and McLachlan[17] that, at a radius several times the diameter of the source, the polar distribution round a rigid piston working in an effectively infinite baffle is proportional to $J_1(x)/x$ where J_1 is Bessel's function of the first order, and x is equal to $kr \sin \alpha$ where

$k = \omega/c = 2\pi/\lambda$, λ = wavelength cm.

r = radius of piston cm.

α = angle between the normal to the piston through its centre and the point considered.

If we take $2J_1(x)/x$ the axial value becomes unity and the values of the function for different values of the angle α are then directly the relative pressures at those angles. The radius of the piston replacing the inductor cone has been taken to approximately midway between the edge of the paper cone and the clamped leather of the surround, and hence a value of r = 13.0 cm. has been adopted. The calculated curves of relative polar distribution are shown in Fig. 8 for the same frequencies as the measured curves in Fig. 3.

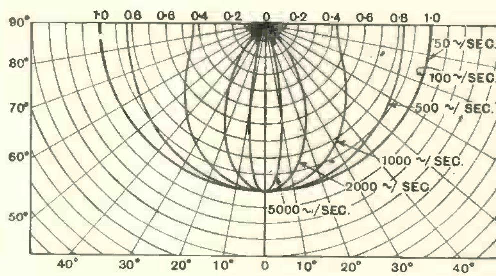

Fig. 8.—*Calculated polar curves of relative pressures for rigid piston* (D = 26 *cm.*) *at several frequencies.*

It is seen that while the agreement is close at low frequencies, the cone is definitely less directional at high frequencies and that on account of the more complicated nature of the vibration of the cone there is not the uniform sequence in the curves of relative polar pressure. Due to cone resonances, the polar factor and the axial sound pressures for the cone are, in general, greater than for the comparable piston case. Comparisons between the cone and the piston have previously been made by Cosens[18] and McLachlan and Sowter,[19] but it is believed that the data presented here are among the first[15] to give measured and calculated quantitative results, especially so far as the polar factors are concerned, which for the piston and cone are shown plotted together to logarithmic scales in Fig. 9.

In Fig. 9, while it is realised that each observed value of S is accurate within close limits, the general tendency of the points

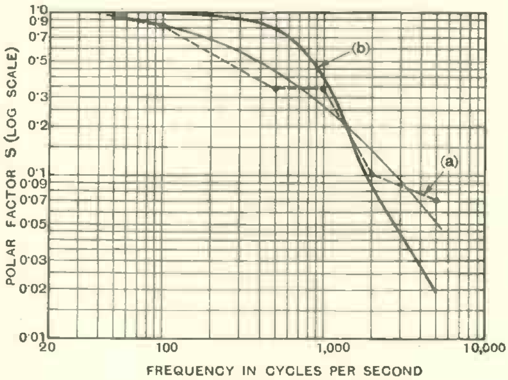

Fig. 9.—*Polar factor variation with frequency, showing* (a) *Measured values for the cone, and* (b) *Calculated values for the rigid piston.* (D = 26 *cm.*).

has been indicated by the mean line, and when further similar results are available for cones of comparable size it will be interesting to see within what limits a typical polar factor curve can be obtained for loudspeakers of the same general type and size. It may be mentioned that at no point in Fig. 9 does the mean curve differ from the observed points by more than 1.5 decibels.

6. Legitimacy of the Observations

A brief consideration shows that in the foregoing measurements observations have been made over a frequency range such that at low frequencies the diameter of the source is small compared with the wavelength of the sound radiated, while at high frequencies the reverse holds good. These points are brought out in Table II and it is seen that the ratio of the wavelength λ to the diameter of the source D varies by more than 100 : 1 over the working range of frequencies.

In the last column of Table II the distance R at which the greater number of observations was made, is expressed in terms of the wavelength λ. The ratio of the distance R to the diameter D is 2.3.

It is customary in the case of a piston to assume that the directional effect is negligible when the wavelength of the sound radiated is greater than about four or five times the diameter of the source, and thus we can regard the loudspeaker cone as approximating to a point source up to a frequency of a few hundred cycles per second. This statement is confirmed by the measured polar curves, Fig. 3.

Now it has been shown[1] that for a point source it is valid to regard the acoustical power as proportional to the square of the observed sound pressure even at distances small compared with the wavelength and, therefore, it is concluded that even when R/λ becomes less than 0.1 at low frequencies the acoustical power can still be taken to vary as the square of the pressure, or the response curve to be represented by $20 \log_{10} (p/p_{1000})$.

A further point arises at high frequencies when the wavelength is small compared with the diameter of the source. In the case of a piston there is a series of sound pressure maxima and minima on the axis, due to sound arriving from different parts of the disc, up to a distance [20] of approximately $D^2/4\lambda$ after which the pressure tends to vary inversely as the square of the distance, and accurately so at large distances. In our

TABLE II.

Frequency.	λ cm.	λ/D D = 26 cm.	R/λ R = 60 cm.
50	680	26.2	0.088
100	340	13.1	0.176
200	170	6.5	0.35
500	68	2.6	0.88
1,000	34	1.3	1.76
2,000	17	0.65	3.5
5,000	6.8	0.26	8.8
10,000	3.4	0.13	17.6

case $D^2/4\lambda$ becomes 50 cm. for r = 13 cm. and a wavelength corresponding to a maximum frequency of 10,000 cycles per second. The actual distance of 60 cm. is, therefore, sufficiently great to avoid these special interference effects even at the highest frequencies, although at smaller distances there is no real evidence in Fig. 6 of their presence in the case of the loudspeaker tested.

Finally, although the measured and calculated curves of polar distribution, Figs. 3 and 8, have been made as comparable as possible, it should be pointed out that the calculated curves derived from the formula $2J_1(x)/x$

only refer strictly to the case when the ratio of R/D is greater than about 5, but for the observations in Fig. 3 the ratio of R/D is 2.3.

To some extent the question of linearity has been dealt with in section 4 (*b*) but to cope with all the volume levels at which the loudspeaker might be expected to work in practice would make an examination of linearity desirable over ranges in the variables having considerably greater extreme ratios.

Closely connected with the general question of linearity is the further one of harmonic distortion. It was checked that for a pure electrical input the acoustical output was also pure by ear, and at certain frequencies attempts to measure the harmonic content were unsuccessful on account of the smallness of the quantities involved. Sufficient evidence was obtained, however, to confirm that the harmonic distortion was negligible by ear except at very low frequencies and that the measurements at one frequency were not affected by the integration of the overtones by the condenser microphone except in a small degree at frequencies below about 100 cycles per second.

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Correspondence

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

The Principles of Electromagnetism

To the Editor, Wireless Engineer

SIR,—Professor Fortescue's letter in your June issue suggests that he has not really grasped the nature of the difficulty that he has raised, and this view is supported by the absence of any answer to my questions.

May I put the matter to him in another way ? There are three experimental relationships which are fundamental in electromagnetics, namely :—

A. The inverse square law of mechanical force between like charges.

B. The inverse square law of mechanical force between like poles.

C. The law of mechanical force between a moving charge and a magnetic pole.

Each of these involves a factor of proportionality as between the mechanical force produced and the electrical or magnetic quantities involved. The factor in (A) is $1/\epsilon$, in (B) $1/\mu$, and in (C) we may call it k. Obviously these three are interdependent, the connection being that $k^2/\epsilon\mu = (\text{velocity})^2$.

All physicists and electrical engineers, except Professor Fortescue, agree in admitting that there is as yet no information available which will allow actual dimensions to be allotted to ϵ, μ and k. Pending such information, a convention must be adopted. Three such conventions are obviously possible, namely :—

1. To put $\epsilon = 1/v^2$
2. To put $\mu = 1/v^2$
3. To put $k = v$.

The first gives rise to the Electromagnetic Units, the second to the Electrostatic Units and the third to a system which I think is more rational than either, but, as this has never been adopted, it need not concern us here.

If we adopt (1), then B and H are quantities of the same kind, and one symbol will suffice.

If we adopt (2), then electric force and electric displacement are magnitudes of the same kind and one symbol only is necessary.

Professor Fortescue says definitely that " B and H are the same thing." It follows that the whole of the dimensions of all the electric and magnetic units are thus settled once and for all, and only one system of units is possible. This is splendid; but it is a matter of such paramount importance that we must be pardoned if, while admitting that Professor Fortescue may be right, we hesitate to accept his dictum until we have access to " those secrets of Nature not yet revealed to the rest of us "—upon which any such conclusion must inevitably be based.

WILLIAM CRAMP.
The University, Edgbaston, Birmingham.

The Use of the Cathode-ray Oscillograph at Ultra-high Frequencies*

By Dr. H. E. Hollmann

(*Heinrich-Hertz Institute for High-frequency Research, Berlin*)

Introduction

IN comparison with oscillographs with mechanical systems, the cathode-ray oscillograph can, of course, be regarded as free from inertia. But this freedom from inertia is not absolute, since the electrons which pass through the anode aperture and form the indicating or recording system of the oscillograph move with a finite velocity depending on the anode potential. Owing to this fact, the cathode-ray oscillograph has a certain inertia of its own, and this is obviously greater, the longer the path-time of the electrons compared with the duration of the process which is to be analysed. If, therefore, either the electron speed decreases or the process to be recorded occurs faster and faster, the inertia of the cathode-ray tube will show itself in altered sensitivity and in distortion of phase. With the usual commercial tubes working on some hundreds or thousands of volts on the anode, such departures from the normal behaviour make their appearance at wavelengths measured in decimetres, and require special measures for their suppression. These two problems, that of the "dynamic sensitivity" at very high frequencies and that of phase distortion, will now be dealt with in turn.

I. THE DYNAMIC SENSITIVITY OF THE CATHODE-RAY OSCILLOGRAPH

The deflection of the cathode ray in a Braun tube is generally produced by causing the ray to pass through an electric field, due to a voltage V, between two deflecting plates. In this way the ray is deflected from its original path in the manner shown in Fig. 1, according to the same law as that of the trajectory, where a horizontally projected body describes a parabolic path under the influence of gravity. There is one difference in the case of the Braun tube, namely, that the deflection only occurs during the passage between the deflecting plates; after leaving these, the ray proceeds again in a straight line, on a path inclined to the axis at the angle α, giving a deflection a on the fluorescent screen. We will define the Sensitivity (A) as the tangent of this deflection angle α, or in other words as the ratio v_y/v_0 of the velocity component v_y, perpendicular to the axis, to the velocity

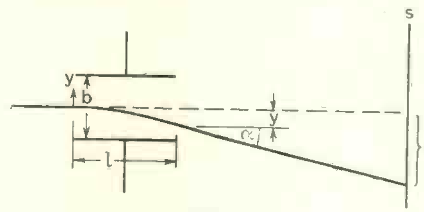

Fig. 1.

component v_0 in the axial direction. These values can be calculated by the simple adaptation of the horizontal trajectory law to the case of the cathode-ray tube: thus for the axial electron motion we have:

$$x = v_0 \cdot t \qquad (1)$$

where v_0 represents the electron speed corresponding to the anode potential ($v_0 = 6 \cdot 10^7\sqrt{E_a}$) and t is the time. In the y axis, the law of the falling body applies, namely:

$$y = \tfrac{1}{2}gt^2 \qquad (2)$$

where the "acceleration" is represented by:

$$g = e/m \cdot V/b.$$

Here e and m are the charge and mass of the electron, respectively, and V/b is the field strength given by the deflecting potential and the distance between the plates. From equations (1) and (2) we obtain the trajectory parabola:

$$y = \tfrac{1}{2}g \cdot x^2/v_0^2$$

* MS. received by the Editor, July, 1932.

and from this the static sensitivity:

$$A_0 = \tan \alpha = dy/dx = g \cdot x/v_0^2 \quad .. \quad (3)$$

From this we see that the static sensitivity is the greater, the longer the deflection plates (*i.e.*, the greater the value of x) and the smaller the anode potential (and consequently v_0); also, that A_0 and consequently the screen deflection a of a given tube are directly proportional to the "acceleration" g and therefore to the deflecting voltage. If, therefore, an a.c. voltage $V_0 \sin \omega t$ is applied to the plates, the deflection a will exactly reproduce the voltage curve.

The above results, however, only hold good so long as the deflecting field is constant while the electrons are between the deflecting plates. If, on the other hand, the periodic time of the deflecting voltage is comparable with the time necessary for the passage past the plates, the transverse accelerating field can no longer be regarded as quasi-stationary with respect to the electron beam. We will consider, by the example shown in Fig. 2, how the conditions alter in such a case: taking an electron which enters the space between the plates just at the moment when the instantaneous value of the deflecting potential is zero. During the passage of the electron, the deflecting potential passes first through a positive and then through a negative half-period, so that the potential distribution shown on the upper plate in Fig. 2 applies to this electron.

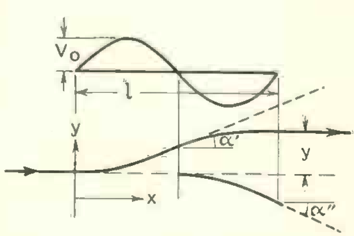

Fig. 2.

During the positive half-period the electron path is deflected through the angle α'. The negative half-period deflects the electron through an equal but opposite angle α'', so that in the complete period the effects of the two half-periods neutralise each other and the electron emerges from the plates once more in its original direction. The displacement y can be neglected in comparison with the screen deflection a. Another point which can be seen from Fig. 2 is that the deflection is greatest when the electron has just passed through a half-period: this, then, is the condition for maximum sensitivity of the tube, whereas when the passage-time is equal to the whole periodic time the sensitivity completely vanishes.

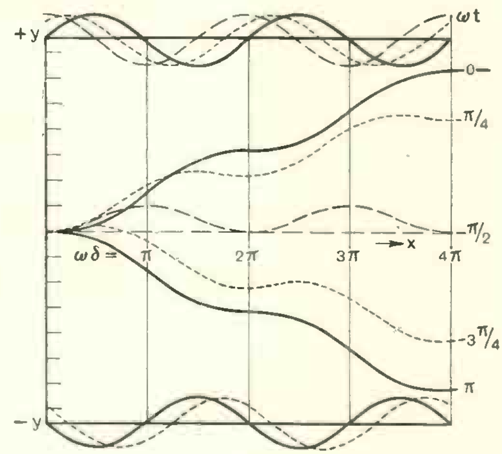

Fig. 3.

The above results can be represented mathematically by combining the temporal variation of the deflecting field (given by ωt) with the spatial variation of the electrons passing between the plates. If we take the deflecting potential at the moment when the electrons enter the plate-gap, *i.e.*, when $x = 0$, then the spatial distribution is to be defined by the electron path time $\delta = x/v_0$, or by the phase angle $\phi = \omega\delta$. Hence:

$$g = e/m \cdot V_0/b \cdot \sin(\omega t + \phi), \text{ or}$$

$$= g_0 \sin \omega (t + \delta) \quad .. \quad .. \quad (4)$$

From this, by double integration in the manner shown in (1) of the Appendix, we obtain as the equation for the electron motion:

$$y = g_0/\omega^2 \cdot \left(\omega\delta \cos \omega t - \sin \omega(t + \delta) + \sin \omega t\right) \quad .. \quad (5)$$

If we then plot y as a function of δ, or of $x = v_0 \cdot \delta$, with ωt as parameter, we obtain path curves of which examples are given in Fig. 3. These show that at the points where $\omega\delta$, or $\omega x/v_0$, $= \pi$ and 3π, the deflection angle displays maximum values, while for 2π and 4π it becomes zero.

It is shown in (2) of the Appendix that the "dynamic sensitivity" at a frequency ω is given by:

$$A_\omega = A_0 \sin(\omega t + \phi/2) \, . \sin\phi/2 / \phi/2 \quad \ldots \quad (6)$$

This equation shows that the dynamic sensitivity, and hence also the screen deflection a, is proportional to $\sin \omega t$; that is to say, the tube functions without distortion even at the highest frequencies. If we leave out of consideration the phase relation between the deflecting potential and the screen deflection a, we have, for $(\omega t + \phi/2) = \pi/2$, the maximum dynamic sensitivity $A_{\omega 0}$ given by:

$$A_{\omega 0} = A_0 \, . \sin\phi/2 / \phi/2 \quad \ldots \quad (7)$$

This sensitivity, corresponding to the peak voltage V_0, thus decreases gradually with increasing frequency. At definite points, where $\phi = 2n\pi$, it periodically becomes zero, and reaches at the intermediate points—where $\phi = (2n - 1)\pi$—ever-decreasing positive and negative maxima: here n represents the succession of whole numbers. For low frequencies and corresponding small phase angles, $A_{\omega 0}$ becomes equal to A_0.

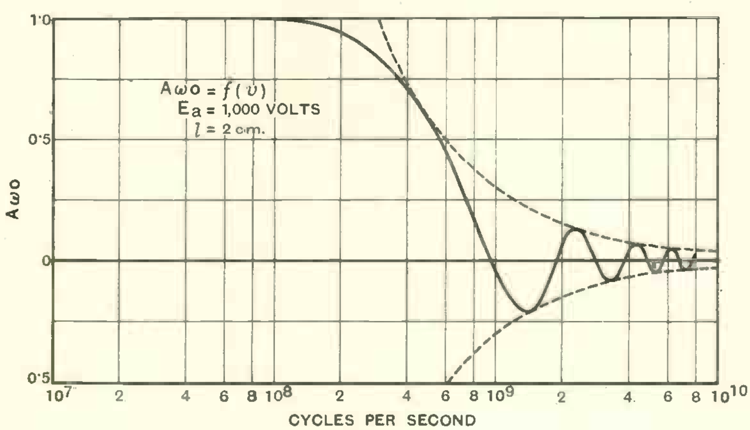

Fig. 4.

Fig. 4 shows the curve representing function (7) for an anode potential of 1 000 volts and a plate length of 2 cm, A_0 being taken as unity. The critical frequencies, at which the tube ceases to function, lie at $n \, . \, 9{\cdot}6 . 10^9$ cycles per second, corresponding to wavelengths $31{\cdot}6/n$ (in millimetres).

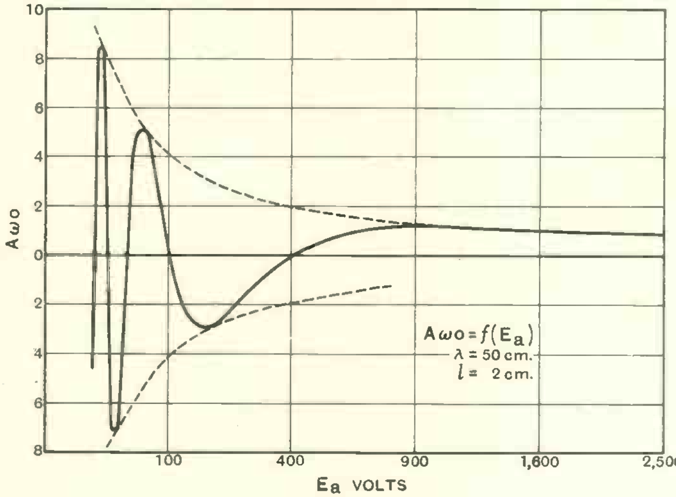

Fig. 5.

If we introduce into equation (7) the expression for A_0 given in equation (3), and for ϕ write $\omega x/v_0$, we obtain:

$$A_{\omega 0} = g_0 x/v_0{}^2 \, . \sin\omega x/2v_0 / \omega x/2v_0$$
$$= 2g_0/\omega v_0 \, . \sin\omega x/2v_0 \quad \ldots \quad \ldots \quad (8)$$

In this equation the plate length x only occurs in the argument of the sine function, so that for a given frequency and ray velocity the optimum plate length to give maximum dynamic sensitivity is given by:

$x_{opt} = \pi v_0/\omega$. Replacing π by the half-period $\omega T/2 = \omega\lambda/2c$, we have:

$$x_{opt} = v_0/c \, . \, \lambda/2 \quad \ldots \quad (9)$$

Thus the plate length giving maximum dynamic sensitivity corresponds to a half wavelength reduced in the ratio v_0/c, as has already been seen from a consideration of the electron paths in Figs. 2 and 3. An increase in the length of the plates beyond this value merely means a capacitive overloading of the deflecting potential. This relation also explains the falling off of dynamic sensitivity with increasing frequency, since it shows that as the waves grow shorter so also does the most efficient plate length decrease. For a given length of plate and a given frequency, the dynamic sensitivity presents itself as a function of the ray velocity or of the anode potential, and yields—according to equation (8)—the curve shown in Fig. 5. The curve displays a series of maxima with intermediate zero points. A practical result is that for any tube a maximum of sensitivity can be obtained by varying the anode volts. Nevertheless it is preferable to employ the higher voltages in spite of the lower static sensitivity consequent on their use; for as the example in Fig. 5 shows, above 1 000 volts a uniform sensitivity can be counted on, without the fear of encountering points of zero sensitivity.

APPENDIX

(1) Calculation of electron motion in an alternating accelerating field:

$$g = g_0 \sin \omega(t + \delta) \qquad (4)$$

The integration over $d\delta$ gives the deflection speed in the y-axis:

$$v_y = -g_0/\omega \cdot \cos \omega(t + \delta) + A \qquad (12)$$

At the moment of entry of the electrons between the plates, that is when x, and consequently also when δ, $= 0$, v_y must also equal 0:

$$v_y = g_0/\omega \cdot (\cos \omega t - \cos \omega(t + \delta)) \qquad (13)$$

By integrating again we obtain for the transverse motion:

$$y = g_0/\omega \cdot (\omega \cos \omega t - 1/\omega \cdot \sin \omega(t + \delta) + B) \qquad (14)$$

Since here again at the time $\delta = 0$ y must also equal 0, we obtain for the integration constant $B = 1/\omega \cdot \sin \omega t$, and hence:

$$y = g_0/\omega^2 \cdot (\omega\delta \cos \omega t - \sin \omega(t + \delta) + \sin \omega t) \qquad (5\text{: see p. 431})$$

(2) The dynamic sensitivity, from equation (13), is given by:

$$A_\omega = v_y/v_0 = g_0/\omega v_0 \cdot (\cos \omega t - \cos \omega(t + \delta)).$$

This can be written:

$$A_\omega = 2g_0/\omega v_0 \cdot \sin \omega(t + \delta/2) \sin \omega\delta/2 \qquad (15)$$

In order to introduce into this the static sensitivity A_0, we write (from equation 3):

$$g_0 = A_0 v_0^2/x = A_0 v_0/\delta,$$

and obtain:

$$A_\omega = A_0 \sin \omega(t + \delta/2) \cdot \sin \omega\delta/2 / \omega\delta/2 \qquad (6a)$$
$$= A_0 \sin(\omega t + \phi/2) \cdot \sin \phi/2 / \phi/2 \qquad (6\text{: see. p. 432})$$

(The second part of the paper, to be published next month, will deal with the problem of phase distortion and with gas-concentration at very high recording speeds.)

Book Review

Alternating Current Electrical Engineering

By Philip Kemp. 595 + xi pp. with 418 Figs. Macmillan and Co. 15s.

In the preface the author says that in preparing this fourth edition he has expanded the book to include many of the more important of the latest developments and that to keep the book within bounds he has had to do some careful pruning. We must say that what he has done has been done remarkably well, and the book is one that can be unreservedly recommended to every student of electrical engineering. The author has adhered to principles rather than described particular types of machinery, but the applications to practice are never lost sight of. On looking through the book we have queried two or three minor matters. The opening section of Chapter III is entitled "Back E.M.F. set up due to alternating current," but there is nothing in the section to suggest why it should be called a *back* E.M.F. It is stated correctly that the direction of the E.M.F. is such as to oppose the *change* of current, so that during the half cycle that the current is decreasing, the induced E.M.F. is in the same direction as the current.

It is only when one considers the induced E.M.F. in relation to the applied P.D. that one is justified in regarding it as a back E.M.F.

The regulation of alternators is treated very fully, but we cannot understand Fig. 234, which purports to show the variation of synchronous reactance with position. Synchronous reactance is obtained from the open-circuit and short-circuit characteristics, both of which are measured when the machine is running at its synchronous speed; it is a fictitious or equivalent reactance covering the combined effects of armature reaction and reactance. It is true that if the machine be stopped and the reactance of the armature measured by means of an A.C. supply, the result obtained will vary with the position of the armature with respect to the poles, but this is not the synchronous reactance. In future editions Fig. 234 might be entitled "variation of stationary reactance with position."

The third point refers to the simple circle diagram of the induction motor, where in Fig. 282 the author makes the common mistake of showing a constant magnetising current for all values of stator and rotor current. As a matter of fact, as the load increases the flux crossing the air-gap decreases until on short-circuit (locked-rotor) about half the flux crosses the gap and the magnetising ampere-turns are consequently about half of those required on open circuit. For this reason the author is wrong in saying that "I_m is constant in magnitude so long as Φ_s and E_s are constant." So long as the stator voltage E_s is constant the stator flux Φ_s will be constant, but the fraction of this which crosses the air-gap to the rotor will be reduced to about half, and with it I_m, as one moves round the circle. Fifty per cent. is not a negligible amount and it requires very little modification of the diagram. We commend this suggestion to the author for use in the fifth edition, which we feel sure will soon be required.

G. W. O. H.

Naval Direction-finding

The Meeting of the I.E.E. Wireless Section on 5th April was devoted to Two Papers on Naval Direction-finding by Members of the Staff of H.M. Signal School

The first paper was: "Errors in Direction-finding Calibrations of Steel Ships, due to the Shape and Orientation of the Aerial of the Transmitting Station," by Mr. J. F. Coales, B.A.

IN making calibrations of direction-finders on ships, in which a transmitting ship steams round the vessel to be calibrated, errors were suspected due to the orientation of the transmitting aerial. These were thought to arise from the horizontal electric intensity—with which is associated a vertical magnetic field—sent out by the horizontal portion of the transmitting aerial. The theory of the errors so produced is that in one case the vertical magnetic field H_2 produces in the effective loop of the ship (which loop in the presence of the horizontal magnetic field alone produces a quadrantal deviation) a current proportional to $\omega \frac{d}{dt} H_2$. This current gives rise to a magnetic field in the direction of propagation of the wave; which in turn causes an error ϵ in the observed bearing.

The paper then discusses the simple theory of the effect. It can be shown that if the normal to the effective loop of the ship makes an angle ψ with the vertical, and its projection on the horizontal plane makes an angle θ with the direction of propagation, then ϵ, the error in the absence of a vertical magnetic field H_2, is given by

$$\tan \epsilon = \frac{kA\omega \sin 2\theta \sin^2 \psi}{2(1 + kA\omega \sin^2 \psi \sin^2 \theta)} \text{ approximately}$$

where A is the effective area of the loop and k a constant depending on the position of the direction-finding aerial system.

In the case of a vertical magnetic field H_2 (Fig. 1)* being present as well as the horizontal field H_1 such that these are in phase and orientated as in Fig. 1(*a*), it is easily shown that ϵ_1, the error of the observed bearing in this case, is given by

$$\tan \epsilon_1 = \frac{Ak\omega \sin \psi \cos \theta (H_1 \sin \psi \sin \theta + H_2 \cos \psi)}{H_1 + Ak\omega \sin \psi \sin \theta (H_1 \sin \psi \sin \theta + H_2 \cos \psi)}$$

and in the case shown by Fig. 1(*b*), the direction of propagation being vertically upwards from the paper in both cases, the error ϵ_2 is given by

$$\tan \epsilon_2 = \frac{Ak\omega \sin \psi \cos \theta (H_1 \sin \psi \sin \theta - H_2 \cos \psi)}{H_1 + Ak\omega \sin \psi \sin \theta (H_1 \sin \psi \sin \theta - H_2 \cos \psi)}$$

In most ships the error when the transmitting station is right ahead is zero, in which case θ is always the relative bearing of the transmitting station. ψ is the angle the axis of the loop makes with the vertical and so is constant, and we get that calibrations in the two cases should be separated by an angle $(\epsilon_1 - \epsilon_2)$ with the normal calibration curve lying between them. The angle of separation $(\epsilon_1 - \epsilon_2)$ will depend on cos θ and so will be greatest right ahead and astern, and zero on the beams.

* The author's original figure-numbers are adhered to throughout these abstracts.

Since the second term of the denominator will usually be small compared with H_1, it is seen that the value of $(\epsilon_1 - \epsilon_2)$ will be approximately proportional to the frequency ω and to the intensity of the vertical magnetic field H_2, which latter is rapidly attenuated over sea since the corresponding electric field is horizontal. This gives a possible method of measuring the attenuation of the horizontal electric intensity over sea water.

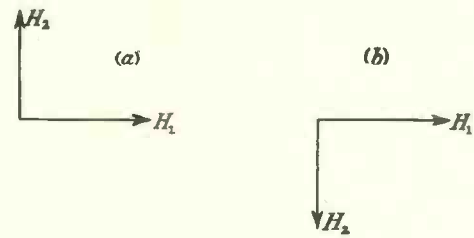

Fig. 1.

This was tested by a transmitting ship steaming round the receiving ship first in a clockwise and then in a counter-clockwise direction, the transmitting ship being a destroyer with L-shaped aerial, the vertical leg being 45 ft. and the roof 125 ft. long, the mean height of the roof being 50 ft. above the sea. The results show that if the receiving ship is not in line with the roof of the transmitting aerial, errors of 1° or 2° may arise if the roof is not symmetrical. The error, however, decreases rapidly with increasing distance from the transmitter and also with increasing frequency. The magnitude of the error depends on the shape and orientation of the transmitting aerial and the shape and orientation of the "effective loop" of the receiving ship.

The paper closes with a mathematical analysis from which it is concluded that in big ships these calibration errors will be very much more marked and that for such ships it is important that the transmitting aerial is of such a type that the emitted wave contains no horizontal component of electric force.

The second paper was: "A Radio Compass Developed in H.M. Signal School," by Messrs. C. E. Horton, M.A., and C. Crampton, B.Sc. This describes a wireless direction-finder free from ambiguity which has been developed for use in ships as well as on shore.

THE usual direction-finding practice is to take the bearing, using a figure-of-eight characteristic and to resolve the ambiguity by switching in an open aerial and obtaining a heart-shaped characteristic approximating sufficiently to a true cardioid to settle the sense of the bearing. This involves the provision of a separate "sense" pointer to allow for the displacement of 90° between the zero of the figure-of-eight and the zero of the cardioid. It also involves a loss of time, due to the need for two operations. The direction-finder described overcomes both of these disabilities by using what amounts to a distorted figure-of-eight having one sharp zero giving the true bearing and 180° from this a blurred zero giving the reciprocal bearing. This is achieved, as shown in Fig. 1, by taking a symmetrical figure-of-eight and superposing a small cardioid under conditions which ensure that the minimum of the cardioid coincides with one zero of the figure-of-eight, and that the cardioid e.m.f. is in quadrature with that of the figure-of-eight. The cardioid need only be very small in amplitude compared with the main figure-of-eight characteristic and need not therefore in itself be a perfect cardioid in order to blur the reciprocal bearing, while leaving the true bearing unaffected. Further, by ensuring that the cardioid is in quadrature with the figure-of-eight, it becomes impossible for the cardioid to produce an error of bearing, *i.e.*, the zero of the figure-of-eight cannot be shifted by the superposition of the cardioid.

If the figure-of-eight response is obtained from a rotating frame F (Fig. 2) the auxiliary cardioid can be obtained from a smaller frame F_2 (at right angles to and revolving with F_1), together with a stationary open aerial V. If the cardioid is imperfect because the response from F_2 is not exactly equal to that from V, then one zero of the figure-of-eight is blurred and the reciprocal bearing is more definitely blurred. There is, however, no error of bearing. On the other hand, if the cardioid is imperfect because of a defect of phasing, then possibility of an error of bearing arises. But by keeping the amplitude of the cardioid small compared with the amplitude of the figure-of-eight, the error produced in this way is a small quantity of the second order.

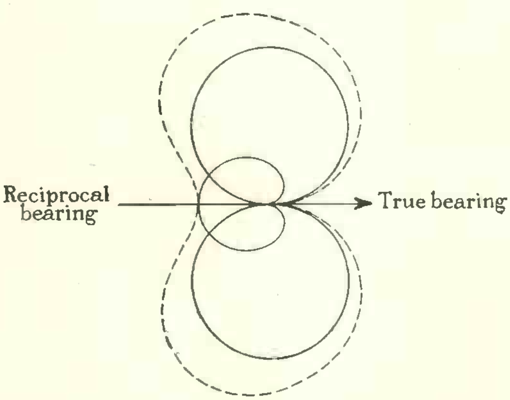

Fig. 1.—*Addition of a cardioid to a figure-of-eight quadrature.*

The paper then briefly discusses the components of e.m.f. active in a direction-finder on ship-board (as given in a previous paper by one of the authors*), and by numerical examples it is shown that the chief features of the new direction-finder can be summarised as follows:—(1) A perfect zero is obtainable without ambiguity of 180°. (2) The deviations (when installed on a ship) do not follow any very simple law, *e.g.*, quadrantal. (3) The amount of correction to be applied to observed bearings has to be determined by calibration, as with other types of direction-finder on ship-board. (4) The required values of the coupling M_2 (Fig. 2) all lie between two *positive* upper and lower limits.

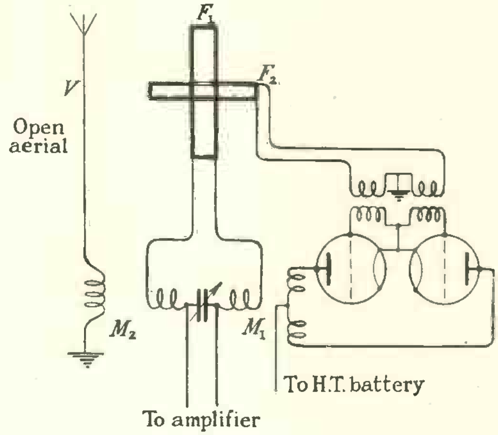

Fig. 2.

The instrument is thus capable of giving accurate bearings free from ambiguity, when allowance is made for deviation, as in ordinary ship-board practice. Electrical methods have been described in the previous paper by means of which deviation can be corrected on certain types of ordinary direction-finders. These can be further applied to cover deviations of the new system. Alternatively, with simple rotating-coil direction-finders a common practice is to read from a correction-curve, which can also be modified to include the deviations of the new system. Details of methods of correction are further discussed in the present paper, which then proceeds to describe a practical installation on the rotating coil system, illustrated in Fig. 4. The loop L is the corrector-loop, placed athwartships. F_2 is the main rotating frame coil, forming part of the inductance of the tuned receiving circuit. To obtain the e.m.f. induced by F_2 in the correct phase, this coil is left untuned, but its e.m.f. is amplified by coupling through the mutual inductance M_1 to a two-stage balanced-valve amplifier with resistance-capacity coupling. The output from the amplifier is coupled magnetically to the receiving circuit, as shown in Fig. 4. By careful construction of special valves and resistance-capacity elements in vacuo, it has been possible to obtain an amplifier giving appreciable gain over the whole range of frequency covered (the voltages after amplification being comparable in magnitude with those from F_1) and which changes the phase by only a small angle. The circuits employed with the corrector-loop L are similar to those of F_2, similar phasing being required. In this case, however, comparatively small e.m.f.s are

* *J.I.E.E.*, 1931, Vol. 69, p. 623. *E.W. & W.E.*, 1931, Vol. VIII, p. 195.

required and the resistance-capacity stage is omitted.

A description of sea trials of the new instrument and of methods of adjustment are lastly given. The sea trials were carried out in the vicinity of the Nab Tower in sight of Culver Wireless Telegraph Station, from which all the required transmissions were made. Correction curves to relative direction-finder bearings are shown in the paper for several different frequencies, their appearance being generally similar to those of quadrantal-error correction curves.

Discussion

The discussion which followed the reading of the papers was relatively short.

Mr. G. Shearing stated that the need for the analysis given in the first paper arose from the fact that a second calibration often gave different results from the first. In practice, it was important to get a short-distance calibration correct and in agreement with that of long-distance reception. The radio compass described in the paper had considerable advantages in practice. It was simple to adjust on land or on sea and very quick in operation. The trials described in the paper were made under more exacting conditions than those normal to mercantile marine working.

Dr. C. V. Drysdale also referred to the practical importance of naval direction-finding, and to the need for rapid operation. The papers showed the fundamental manner in which the problems had been tackled.

Mr. R. H. Barfield expressed surprise at the accuracy of the author's calibrations. He thought the field due to the horizontal roof should disappear more rapidly than the author suggested. As regards the radio compass, he referred to the small phase-change necessary to give an error of bearing, and to the difficulty of aural determination of the relative change of intensity corresponding to this phase-change.

Dr. Smith-Rose enquired as to the possibility of the radio compass device in application to a rotating beacon transmitter. This, on a fixed frequency, was the most favourable case for making optimum adjustments. Mr. Coales' analysis might be applied to the case of a flat-topped aerial used in the reception of the rotating beacon.

Mr. McPherson said the compass described was for manual operation on a " minimum " signal and enquired as to its operation on " maximum " observation with direct reading.

Mr. Bainbridge Bell asked why the " effective loop " of the ship was not vertical. As regards the radio compass, how was it ensured that no change of the sense indication ever occurred in subsequent service. Why not use a vertical aerial instead of one which necessitated the transmitting ship pointing to the receiver?

The authors briefly replied to the discussion. Mr. Horton pointed out that the cardioid system was untuned and that phase changes due to detune did not arise. The sense connections were not touched in subsequent operation after being corrected by the calibrating officer. The radio-compass principle could be applied to the rotating beacon, although this had not been done so far.

On the motion of the chairman, Col. A. S. Angwin, D.S.O., the authors were cordially thanked for their papers.

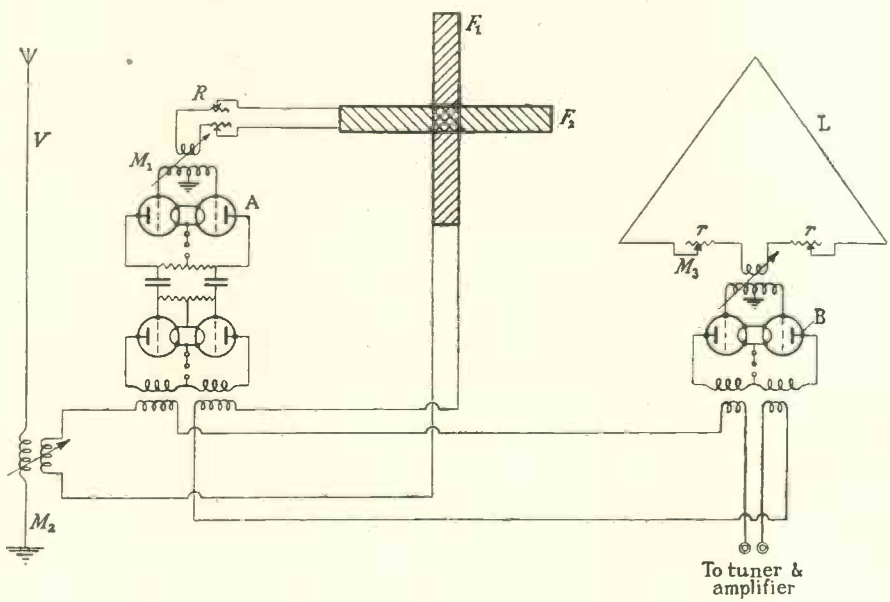

Fig. 4.—*Circuit diagram of radio compass.*

Abstracts and References

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PROPAGATION OF WAVES

INTERACTION BETWEEN RADIO-WAVES ?—B. D. H. Tellegen. (*Nature*, 10th June, 1933, Vol. 131, p. 840.)

This letter gives a short description of apparent interaction between waves from the Luxembourg high-power broadcasting station (wavelength 1 190 m) and from a series of other stations, observed at Eindhoven. A radio receiver tuned to the other stations shows the modulation of the Luxembourg station in the background. The phenomenon cannot be due to cross-modulation of the receivers. The stations with which it occurs all lie in the direction from Eindhoven to Luxembourg and further from Eindhoven than Luxembourg. This modulation has also been observed on other stations.

SUR LA VITESSE APPARENTE DES ONDES RADIOÉLECTRIQUES COURTES (The Apparent Velocity of Short Radioelectric Waves).—N. Stoyko and R. Jouaust. (*Comptes Rendus*, 1st May, 1933, Vol. 196, No. 18, pp. 1291–1292.)

Hitherto the apparent velocity of short waves has only been determined by comparison with the known apparent velocity of long waves; the result obtained was 272 700 ± 5 700 km/sec. The writers, by the reception, at Paris and Buenos Ayres simultaneously, of time signals from Pontoise (28.35 m) and Monte Grande (15.35 m), have now made direct measurements giving a value of 269 700 ± 4 400 km/sec. Assuming a true velocity equal to that of light, and an emission angle giving a minimum number of reflections (1931 Abstracts, p. 434) between earth and a layer at 300 km, this corresponds to 8 reflections between Paris and Buenos Ayres and an angle of 19°.8 between wave-direction and horizon.

By an identical method they have also measured the apparent velocity of long waves, with a resulting value of 245 000 km/sec. This difference between the apparent velocities of long and short waves may be explained by the long waves travelling, rather like a sound wave in a tube, between the ionised layer and the earth: owing to the different electrical resistances of the two conductors the wave front undergoes a spreading out, and the electric field at the receiver does not suddenly take up the value corresponding to the strength of the signal but builds up gradually until it is strong enough to act upon the receiver: this instant is taken to be the "arrival" of the signal.

ANOMALIES IN THE PROPAGATION OF SHORT RADIO-ELECTRIC WAVES [Abnormally Long Path Time for Annapolis Time Signals received in France].—N. Stoyko and R. Jouaust. (*Comptes Rendus*, 22nd May, 1933, Vol. 196, No. 21, pp. 1583–1585.)

The results of five months' observations on these 37.36 m signals indicate delays with two points of convergence, $\Delta_1 = 0.00676 \pm 0.00078$ sec. and $\Delta_2 = 0.02943 \pm 0.00107$ sec. The Annapolis beam is directed towards the west: owing to the earth's curvature it is possible for a ray to penetrate the ionised layer at such an angle that it suffers a strong diffusion which sends a part of the energy backwards (*cf.* Eckersley, Abstracts, 1929, p. 625, l-h col.). This diffusion may occur at the first contact with the ionosphere or after one or two normal reflections: Δ_1 would correspond to a first contact, Δ_2 to a diffusion after two normal reflections. Assuming for the angle between the direction of propagation and the horizon the value deduced as in the paper dealt with in the preceding abstract, the layer heights calculated from the observed delays are 400 ± 50 km for Δ_1, and 340 ± 15 km for Δ_2.

The distance of the first diffusion point from Annapolis, along the great circle, is about 900 km. *This is the region of the Great Lakes.* The second diffusion point is at a distance of 4 000 km from Annapolis, *corresponding to the coast of the Pacific Ocean.* "Can these anomalous dispersions perhaps be explained by the fact that above regions corresponding to discontinuities on the surface of the earth there exist distortions in the higher ionised layers? At any rate such results as these show that very serious errors may result, in certain cases, from the use of short waves for the determination of longitude."

THE REFLECTING LAYERS OF THE UPPER ATMOSPHERE [and Changes in Barometric Pressure].—R. C. Colwell and I. O. Myers. (*Phys. Review*, 1st May, 1933, Series 2, Vol. 43, No. 9, pp. 774–775: abstract only.)

See June Abstracts, p. 321, l-h column. The writers have made, at West Virginia University, simultaneous observations on short-wave propagation from W8XK (6 140 kc/s) and long-wave propagation from KDKA (980 kc/s), both of which stations are located at Saxonburg, Pa. They plotted the fading curves obtained from U.S. Weather Bureau maps and found at once that "the signal strength of the long waves varies after nightfall according to the change in barometric pressure." The short waves have the same characteristic curve whatever the weather. "The *F* (Appleton) layer covers the sky in a more or less uniform sheet, while the *E* (Kennelly-Heaviside) layer is concentrated in the regions of low pressure and is most active in the eastern half of the cyclone."

Der Einfluss des Wetters auf die Ausbreitung der Radiowellen (The Influence of the Weather on the Propagation of Radio Waves).—J. Fuchs. (*Funkmagazin*, June, 1933, Vol. 6, pp. 363–370.)

Further development of the work dealt with in 1930 Abstracts, p. 152, l-h col. As an exception to the statement that processes in the troposphere cannot directly affect the propagation of space waves, owing to the absence of sufficiently high ionisation, the writer cites the ionisation in the neighbourhood of a thunder-cloud just before the occurrence of a lightning flash: he mentions Stoye's observations of d.f. errors setting in just before a flash and disappearing the moment the flash occurred, and also the recent observations on the increase of cosmic-ray intensities below thunder-clouds (*e.g.*, Schonland and Viljoen, under "Atmospherics"). The ion densities produced by normal cold and warm fronts are comparatively seldom high enough to affect propagation: usually, when such fronts produce changes in signal strength, it is the ground wave which is affected as a result of conductivity changes due to rain, etc.

The latter part of the paper deals with the influence of the stratosphere, discussing whether changes occur there (besides the well-known daily and yearly periods, magnetic disturbances, etc.) which are related to the conditions in the troposphere. The formation of ozone at about 60 km and its descent to a height of from 20 to 30 km, and the fairly definite relation between the ozone content in this lower layer and the atmospheric pressure at the earth's surface, are quoted. Moreover, the writer showed in 1928 that the propagation of short waves over distances of the order of 7 000 km was connected with the atmospheric pressures at the surface along the path, although the active regions for the short waves are far above the ozone layer. The writer inclines to Exner's view of convective (vertical) and advective (horizontal) air currents in the intermediate regions, simultaneously producing pressure changes below, at the earth's surface, and risings and fallings of the air masses above; thus causing as secondary phenomena the variations in reflection and refraction which affect propagation. Such currents would be produced, for example, by the heating of the ozone layer at 20–30 km. The correlation between weather and propagation is likely to give inconsistent results owing to the effects varying according to the height at which the disturbing action occurs: if it occurs in the troposphere the relation is simple, a low-pressure system producing an increase, and a high-pressure system a decrease, of the skip zone. The writer's 1928 results were an example of this, the path lying over the N. Atlantic, where the troposphere is strongly disturbed under the influence of the Gulf Stream.

Double-Refraction Effects in the Kennelly-Heaviside Layers.—H. R. Mimno and P. H. Wang. (*Phys. Review*, 1st May, 1933, Series 2, Vol. 43, No. 9, pp. 769–770.)

A preliminary note on work on the continuous recording of echoes from the ionosphere on a frequency of 4 095 kc, with the receiver distant about 14 km to the south of the transmitter. Magneto-ionic split echoes have been observed in agreement with the results obtained by other workers (*cf.* Abstracts, 1932, pp. 275–276, Rukop and Wolf; May, p. 263, Wolf; Jan., pp. 29–30, Eckersley, and Appleton and Ratcliffe). During disturbed conditions the curves of effective height on the records are often found to intersect at an angle. The apparent presence of a *third* component in the first order reflection has been noted. A record of the effective height is given showing violently disturbed conditions. The writers have also noted strong multiple reflections from *E* layer occurring several hours before sunrise. They have already used and discarded the synchronised "grid-blocking" transmitter for sending short pulses described by Herd (May Abstracts, pp. 263–264).

Studies of the Ionosphere and Their Application to Radio Transmission [Measurements of Critical Frequencies: the *F* Region composed of Two Layers by Day: Skip Distances as Absorption, not Penetration, Phenomena].—S. S. Kirby, L. V. Berkner and D. M. Stuart. (*Proc. Inst. Rad. Eng.*, June, 1933, Vol. 21, No. 6, pp. 757–758: abstract of I.R.E. Convention paper.)

Bureau of Standards results using the pulse method on a number of wavelengths in quick succession (*see* next abstract). "It is found that the *E*-layer critical frequency [c.f.] shows a regular diurnal variation and a slight seasonal variation in noon maximum, indicating that the sun is the chief source of ionising forces in the day. The seasonal variation of ion content is about 25% of the maximum. In addition, sporadic increases of *E*-layer ionisation to abnormally high values occur at random, and most frequently at night from some ionising force apparently independent of direct radiation from the sun. Comparison of terrestrial magnetic data and electrical disturbances such as thunderstorms show no apparent relation to such irregularities so far observed.

"The *F* region is found to be composed of two definite strata or layers in the daytime as evidenced by a second critical frequency. This c.f. denoted as F_1 c.f. is approximately 1 000 kc higher than the *E* c.f., and is found to vary diurnally and seasonally in phase with the *E* c.f. Heights for the F_1 layer can only be estimated as 185–190 km and may be somewhat in error. The boundary between the F_1 (lower *F*) and F_2 (higher *F*) [layers] becomes indistinct in midwinter and at night. Certain changes near the F_1 c.f. are compared with terrestrial magnetic data.

"The F_2 region is found to be composed of one or more irregular and changing strata without regular seasonal or diurnal characteristics. The F_2 c.f. is found to have less regular characteristics than the E or F_1 c.f., but shows definite diurnal characteristics which change with season, the maximum occurring near noon in the winter and after sunset in the summer. The maximum value of this c.f. is higher during the winter noon than during the summer noon. This and other evidence shown indicates that the F_2 c.f. does not measure maximum F_2-layer ionisation but is limited by total absorption rather than penetration. . . . From the evidence it is indicated that daytime and possibly night skip distances are absorption phenomena, as suggested by T. L. Eckersley, rather than penetration phenomena. . . . An estimate of daytime ionisation . . . indicates an ion content in excess of 2×10^6 electrons/cc for the F_2 layer."

NOTE ON A MULTIFREQUENCY AUTOMATIC RECORDER OF KENNELLY-HEAVISIDE LAYER HEIGHT [and the Existence of Three Layers].—T. R. Gilliland. (*Ibid.*, pp. 759–760.)

See preceding abstract. The transmitter and receiver are automatically varied in frequency from 2 500 to 4 400 kc/s at a uniform rate of 200 kc per minute. The virtual height is recorded by an oscillographic recorder. "In the daytime during the period of these tests three strata were usually indicated. As a rule the E layer with a virtual height of about 120 km is found to return energy for frequencies below 300 kc. Between 3 000 and 3 600 kc reflections are likely to come from the F_1 region with a virtual height of about 200 to 240 km, while above 3 600 kc the F_2 region at 280 km and higher returns energy. These values vary considerably from day to day.

"Of particular interest is the character of the change observed when passing from one stratum to another as the frequency is increased. Although at times, when passing from E to F_1, reflections may drop out completely for a short interval, frequently the curve is continuous and the time retardation will reach a high value just before the appearance of the F_1 reflection. When passing from F_1 to F_2 the virtual height frequently reaches 800 or 900 km. As evening approaches, reflections no longer come from the E layer and the long retardation between F_1 and F_2 becomes less pronounced. By sunset the curve is almost straight and there is little change of height with frequency. Later at night the highest frequencies cease to be returned and long retardations again occur. The phenomenon of double refraction is in evidence at this time."

A BALANCED RECEIVING CIRCUIT FOR KENNELLY-HEAVISIDE LAYER OBSERVATIONS [Avoidance of Paralysis by Direct Radiation].—H. R. Mimno and P. H. Wang. (*Phys. Review*, 1st May, 1933, Series 2, Vol. 43, No. 9, p. 774: abstract only.)

In experiments on reflection from the ionosphere at vertical incidence, the direct radiation from the emitting aerial is likely to paralyse a sensitive receiving set. The writers have constructed the emitter and receiver as "a duplex r.f. network which can respond to the reflected wave without any interference from the direct radiation." Possible methods are the use of the emitting-set modulator to vary the receiving-set gain, or the balancing of the r.f. voltage induced in the receiving aerial by an equal and opposite voltage obtained directly from the emitter coils. The writers have used the second method and obtained successful results with the receiving apparatus about four metres from the emitter; several types of receiving aerials have been employed directly under the emitting aerial.

ATTENUATION OF OVER-LAND [and Over Land-and-Water Combinations] RADIO TRANSMISSION IN THE FREQUENCY RANGE 1.5 TO 3.5 MEGACYCLES PER SECOND.—C. N. Anderson. (*Proc. Inst. Rad. Eng.*, June, 1933, Vol. 21, No. 6, pp. 758–759: abstract of I.R.E. Convention paper.)

". . . It was not, however, until quite recently that it was generally appreciated that the effect of the ground per mile varies with distance from the transmitter, and that the effect is different for a given amount of land when the transmission is entirely over land, or when the land is adjacent to either the radio transmitter or receiver, or intermediate (non-adjacent). . . . It is the purpose of this paper to present various data in the 1.5- to 3.5-megacycle range which have been accumulated during the past few years chiefly in connection with various site surveys, and to show the relation of these data to a more generalised picture of over-land attenuation." The generalisations will be given chiefly in the form of curves, which will include some for entirely over-land transmission on other frequencies, especially in the broadcast band. "When plotted with distance on a logarithmic scale, the curves of apparent absorption are, in general, quite similar for the various frequencies, and beyond a critical distance, which varies approximately with the square of the frequency, the absorption per mile varies approximately inversely with its distance from the transmitter."

MESURES DE RAYONNEMENT ÉLECTROMAGNÉTIQUE DES ANTENNES (Measurements of the Electromagnetic Radiation from Aerials [Field-Strength Measuring Set for Motor-Car Transport: Charts of Poste-Parisien and Radio-Paris: Results over Sea, with Comparison of Austin Formula and Madrid Conference Curves: P. P. Eckersley's Indirect Night-Field Rule]).—P. David. (*Rev. Gén. de l'Elec.*, 13th May, 1933, Vol. 33, No. 19, pp. 623–630.)

ELECTROMAGNETIC FIELD AT A DISTANCE FROM A TRANSMITTER [General Discussion: Watson, Austin-Cohen, and Eckersley Formulae: Madrid Conference Sub-Committee Reports].—(*Journ. Télégraphique*, Dec., 1932, Vol. 56, pp. 344–348). *See* also Abstracts, February, pp. 113–114 (Eckersley) and June, p. 319, r-h column.

SUR LA DÉCHARGE À HAUTE FRÉQUENCE DANS LES GAZ (The High-Frequency Discharge in Gases [and the Effects of a Magnetic Field]).—Th. V. Jonescu and Irène Mihul. (*Comptes Rendus*, 1st May, 1933, Vol. 196, No. 18, pp. 1292–1294.)

"Researches on the h.f. discharge in gases have shown that the potential necessary to sustain the discharge passes through a minimum for frequencies of the order of 10^8 c/s and pressures of the order of 10^{-2} mm Hg. It may be smaller than the ionisation potential. This fact has not so far received a satisfactory explanation. It has been shown [Abstracts, February, p. 93, l-h col.] that the electrons of the ionised gases have a natural frequency of vibration of the order of 10^8 c/s. Electric fields of frequencies in this neighbourhood can communicate to these electrons an energy greater than that necessary to ionise the gas, and thus the discharge is sustained. Starting with these considerations we have begun to study the discharge in gases in a magnetic field."

Two régimes appear in these tests (where wavelengths of 4.7–8.7 m were used) according to the strength of the exciting h.f. field. In the first régime (weak field) it is quite clear that the magnetic field can diminish the potential necessary for the discharge, but the most interesting point is that as the magnetic field is increased from zero the luminosity first increases slowly, and then decreases sharply and disappears when $H = 22$ gauss ($\lambda = 4.7$ m) or 12 gauss ($\lambda = 8.7$ m) : these are the values for which the free electrons come into resonance with the external electrical field and describe spirals, increasing their energy at each turn. Like the high-velocity electrons in the cathode space of a Geissler tube, they do not excite the tube to luminescence. Even at the highest pressures of the total range from some thousandths to some tenths of a millimetre of mercury, the moment when the free electrons pass through resonance can be clearly observed.

On the other hand, in the second régime (stronger h.f. fields) no such variations are found : everything occurs as if no free electrons were present. This régime presents some analogy to that of metallic conductivity.

Propriétés des Gaz ionisés dans les Champs de haute Fréquence (Properties of Ionised Gases in High Frequency Fields).—C. Gutton. (*L'Onde Élec.*, Feb., 1933 [publication delayed], Vol. 12, No. 134, pp. 61–70.)

The object of this paper is to remark that the effect of the passage of electromagnetic waves through ionised gases can take very varied forms according to the boundary conditions imposed upon the gas. The writer considers the case of plane simple harmonic waves passing through an ionised gas ; the effects of collisional friction and of the external magnetic field are neglected. He starts from Maxwell's equations and finds the known formula $k' = k - 4\pi Ne^2/m\omega^2$ [usual notation] given by Eccles for the dielectric constant when the medium is unlimited and there is no ionisation by collision. When however the medium is confined between two parallel planes, normal to the direction of the electric vector and at a distance from one another small compared to the wavelength, the displacement of the electrons causes surface charges of opposite sign on the planes so that there is a mechanical force on the electrons and the dielectric constant assumes the form $k' = k + 4\pi Ne^2/(4\pi Ne^2 - m\omega^2)$. Eccles's formula is then only applicable if N is very small ; there is a resonance phenomenon for $4\pi Ne^2 - m\omega^2 = 0$. If the medium is contained in a sphere of radius small compared with the wavelength, the resonance frequency ω_1 is given by $4\pi Ne^2 - 3m\omega_1^2 = 0$. Such resonance frequencies have been observed by H. Gutton (Abstracts, 1930, p. 267, l-h column). If the ionised gas is contained in a long narrow tube, a disturbance in the electron distribution will be propagated along the tube with velocity $ae\sqrt{N/m}$, where a is a function of the diameter of the tube. This has been found experimentally by M. Chenot (1931, p. 261). The plasma-electron frequency of Tonks and Langmuir (1929, pp. 273, 512, 576 ; 1930, p. 175 ; 1931, pp. 374, 490 ; 1932, pp. 88, 600) is also cited. The writer remarks that in a non-uniformly ionised gas containing electron clouds, such as the upper atmosphere presumably is, it is difficult to know what will be the applicable form of the dielectric constant.

La Propagation des Ondes électromagnétiques —Exposé des Connaissances acquises ; Synthèse des Idées et des Théories (The Propagation of Electromagnetic Waves —Account of the Facts already Acquired ; Synthesis of Ideas and Theories).—P. Labbat. (Book Review by Mesny, in *L'Onde Élec.*, Feb., 1933 [publication delayed], Vol. 12, No. 134, p. 6A.)

Propagation of High-Frequency Currents along Overhead Power Lines affected by Short-Circuits or Faults in Insulation.—J. Fallou. (*Rev. Gén. de l'Élec.*, 8th April, 1933, Vol. 33, No. 14, pp. 449–450.)

The Damping of Surges on H.T. Lines [Higher Values than those calculated from Skin Effect, and their Causes].—E. Flegler and J. Röhrig. (*Archiv f. Elektrot.*, 1st June, 1933, Vol. 27, No. 6, pp. 413–422.)

Radiometer for Hertzian Waves, and its Application to the Study of Total Reflection.—G. A. Beauvais. (*Rev. Gén. de l'Élec.*, 29th April, 1933, Vol. 33, No. 17, p. 553.)

Summary of a French Physical Society's paper based on the work dealt with in Abstracts, 1932, pp. 474–475, and March, p. 150, l-h column.

Variations of Phase by Reflection at Very Thin Metallic Layers. — P. Rouard. (*Comptes Rendus*, 22nd May, 1933, Vol. 196, No. 21, pp. 1592–1594.)

Continuation of the work dealt with in April Abstracts, p. 208, l-h column.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

Sur la Variation rapide des Atmosphériques au Lever du Soleil (On the Rapid Variation of Atmospherics at Sunrise [and Lugeon's "Sounding" of the Upper Atmosphere]).— R. Bureau : Lugeon. (*Comptes Rendus*, 8th May 1933, Vol. 196, No. 19, pp. 1426–1428.)

" The rapid decrease of atmospherics observed at sunrise on waves of the order of 30 kc/s (10 000 m) is a consequence of the violent changes imposed by the solar radiation on the propagation of waves coming from distant sources. I have given an experimental proof of this by comparing the atmospherics curves of Paris, Tunis and Rabat, which are frequently identical during the night hours" [Abstracts, 1932, p. 518, r-h column]. Applying Lugeon's method to these curves [1931, pp. 493–494] the writer obtains 15 to 20 km as the height of the reflecting layer. This far too low estimate is due, he considers, to Lugeon imagining that the sudden change occurs when the first rays of the sun reach the layer at the zenith of the receiving station. There is no justification for this assumption; the critical point is more likely to be where reflection takes place, so that the moment at which the change occurs depends not only on the layer height but also on the position of the sources and the number of reflections between layer and earth.

An upper limit to the layer height may, however, be calculated on the assumption that the energy arrives horizontally, from directions ascertained by d.f. observations. "A number of heights thus calculated give reasonable results, a fact which would indicate that the energy of the atmospherics is localised to the neighbourhood of the horizontal plane." D.f. records at St. Cyr confirm his suggestion: at the end of the night the sources of atmospherics are often spread out from S to W, and the disappearance at sunrise takes place successively, beginning at the S and finishing, about 45 minutes later, at the W. "If the solar action took place at the zenith, the disappearances would be simultaneous. When the morning decrease occurs in successive steps, the reason should more often be sought in the simultaneous existence of sources in different azimuths than in the successive action of several ionised regions."

Noise Intensity due to Atmospherics, measured at Different Parts of the Broadcast Spectrum.—J. F. Byrne. (*Rad. Engineering*, March, 1933, Vol. 13, No. 3, p. 10.)

"The data show that the noise intensity at the low-frequency end of the broadcast spectrum is in the neighbourhood of 4 or 5 times as great as at the upper end of the spectrum in daylight hours, while the night-time ratio is approximately 2½ to 1. It is interesting to note that the noise energy received at night is about 2 500 times that received on the average quiet day. In addition local storms may cause an increase in noise intensity in a ratio as high as 100 000 to 1, in a period of a few hours." For other work by Byrne on the comparison of the different parts of the broadcast spectrum, *see* April Abstracts, p. 229.

Probability Ideas applied to Radio Communication: the Question of Atmospherics.—Deloraine. (*See* reference under "Transmission.")

A Recording Frequency Counter depending on the Time Constant of a Circuit [Counter for Atmospherics, Tachometer, etc.].—Lugeon and Gurtzman. (*See* under "Subsidiary Apparatus and Materials.")

Electrical Disturbances of Extraterrestrial Origin.—K. G. Jansky. (*Proc. Inst. Rad. Eng.*, June, 1933, Vol. 21, No. 6, p. 758: abstract of I.R.E. Convention paper.) On the Group 3 type of disturbance discussed in the writer's paper dealt with in April Abstracts, p. 208.

Versuch einer Theorie der Blitzsaüle (Attempt at a Theory of the Lightning Flash).—F. Ollendorff. (*Archiv f. Elektrot.*, 15th March, 1933, Vol. 27, No. 3, pp. 169–184.)

This paper is a preliminary attempt to develop a quantitative theory of an almost stationary lightning column, under various simplifying assumptions. Calculations are given of the temperature of the electrons, the current density and the current in the flash. The connection between the potential gradient and the current in the flash gives qualitative evidence as to the temporal course of the flash, and an explanation is found for partial discharges.

Zur Vorwachsgeschwindigkeit des Blitzes (On the Velocity of the Extension of a Lightning Flash).—H. Jehle. (*Zeitschr. f. Physik*, 1933, Vol. 82, No. 11/12, pp. 785–793.)

Author's summary:—This theoretical paper gives calculations for the velocity of extension of a lightning flash, (1) by calculating the velocity of the electrons or positive ions at a suitable place, (2) from electrostatic considerations. Two simple continuity conditions for the onset of lightning are derived, from which the current and charge distribution may be deduced and which give an explanation of ball lightning.

Influence of the Geological Composition of the Ground on the Ionisation of the Air and on the Incidence of Lightning.—C. Dauzère. (*Rev. Gén. de l'Élec.*, 11th March, 1933, Vol. 33, No. 10, pp. 297–298.) For previous papers *see* Abstracts, 1930, p. 503, r-h col., and 1931, p. 553, l-h col.

A Destructive Lightning Flash [Descriptive Account].—C. V. Boys. (*Nature*, 27th May, 1933, Vol. 131, pp. 765–766.)

Protection against Lightning by the "Distant Conductor."—B. Walter. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 14, 1933, p. 254.)

Dannmeyer and Will during the war worked out a similar method to that of the writer (May Abstracts, p. 268, r-h col.), in special connection with the protection of ammunition stores in the field.

Sur l'Intervalle de Temps entre les Phénomènes solaires et les Perturbations magnétiques terrestres (The Time Interval between Solar Phenomena and Terrestrial Magnetic Disturbances).—Ch. Maurain. (*Comptes Rendus*, 24th April, 1933, Vol. 196, No. 17, pp. 1182–1186.)

A survey of the writer's own work (by the statistical method for the years 1883–1923, and by the individual method for 1930–1932) and that of others. His statistical results showed that the maximum solar activity took place on the average

$2\frac{1}{2}$ days before the magnetic disturbances: for the years of minimum solar activity the average interval was about $3\frac{3}{4}$ days. His individual results gave an average interval of $2\frac{1}{2}$ days: certain particularly marked solar phenomena gave values of about 40 hours. He mentions, as a unique case, the 1872 observation of a "solar paroxysm" (near the edge of the sun) accompanied by *simultaneous* violent magnetic variations.

VARIATION OF THE HORIZONTAL COMPONENT AROUND DAYS OF MAGNETIC CALM.—L. Éblé. (*Comptes Rendus*, 8th May, 1933, Vol. 196, No. 19, pp. 1429–1431.)

Giving observations leading to the hypothesis that the currents of the upper atmosphere, whose sudden variations are the cause of disturbances, produce with unequal velocities two secondary effects: a certain magnetic agitation preceding the principal phase of the disturbance, and a rapid diminution of the horizontal component. It may be supposed that the first effect comes directly from the external currents, while the second results from an induction in the body of the earth.

ELEKTRONENBOMBARDEMENT ALS FAKTOR BEI ATMOSPHÄRISCHEN ERSCHEINUNGEN (Electronic Bombardment as a Factor in Atmospheric Phenomena [Blue Colour of Sky, Unpolarised Light from Night Sky Clouds, etc.]).—W. M. Cohn. (*Physik. Ber.*, 15th Feb., 1933, Vol. 14, No. 4, pp. 331–332.)

POLARISATION OF THE SOLAR CORONA DURING THE TOTAL ECLIPSE [Almost Constant for All Wavelengths: the Corona behaves as a Gas of Free Electrons].—J. Dufay and H. Grouiller. (*Comptes Rendus*, 22nd May, 1933, Vol. 196, No. 21, pp. 1575–1576.)

ELECTRICAL PROPERTIES OF THE ATMOSPHERE IN THE NEIGHBOURHOOD OF FLYING AIRCRAFT [Marked Stratification of Atmospheric Space Charge at and just above Cloud Level: Possibility of using Electrical Phenomena as an aid to Height Estimation in Blind Flying].—D. C. Rose. (*National Research Council, Canada*, Fifteenth Annual Report, 1931–1932, p. 52.)

MEASUREMENT OF THE ELECTRICAL CONDUCTIVITY OF THE AIR BY A NULL METHOD.—O. Thellier. (*Comptes Rendus*, 29th May, 1933, Vol. 196, No. 22, pp. 1684–1686.)

THE INFLUENCE OF THUNDER STORMS ON RADIO PROPAGATION.—Fuchs. (*See* abstract under "Propagation of Waves.")

ON A PENETRATING RADIATION FROM THUNDERCLOUDS.—B. F. J. Schonland and J. P. T. Viljoen. (*Proc. Roy. Soc.*, 3rd May, 1933, Vol. 140, No. A 841, pp. 314–333.)

For a letter on these experiments *see* January Abstracts, p. 33.

FLUCTUATIONS OF COSMIC-RAY IONISATION.—J. W. Broxon, G. T. Merideth and L. Strait. (*Phys. Review*, 1st May, 1933, Series 2, Vol. 43, No. 9, pp. 687–694.)

The writers have determined by a series of accurate measurements and corrections that a decrease of 2.1% in the cosmic-ray ionisation corresponds to an increase of 1 cm in the barometric column. No correlation was established with other atmospheric data.

COSMIC-RAY INTENSITIES IN THE STRATOSPHERE.—I. S. Bowen and R. A. Millikan. (*Phys. Review*, 1st May, 1933, Series 2, Vol. 43, No. 9, pp. 695–700.)

The writers have made flights corresponding to the barometric pressures 79 mm, 32 mm and 16 mm of mercury and obtain the same shape of ionisation–altitude curve, concave downward at the top, as was found by Regener and by Piccard (*see* January Abstracts, pp. 33 and 33–34).

POSITIVE AND NEGATIVE ELECTRONS APPARENTLY PRODUCED IN PAIRS [Support to Millikan's Photon Theory of Cosmic Rays].—R. M. Langer: Anderson. (*Sci. News Letter*, 27th May, 1933, Vol. 23, No. 633, p. 332.)

DIE ABSORPTIONSKURVE DER ULTRASTRAHLUNG UND IHRE DEUTUNG (The Absorption Curve of Cosmic Radiation and Its Meaning).—E. Regener. (*Physik. Zeitschr.*, 15th April, 1933, Vol. 34, No. 8, pp. 306–323.)

This paper describes measurements of the intensity of cosmic radiation in Lake Constance and in the stratosphere. The writer's final picture of cosmic radiation is as follows:—There are five different hard components with discrete absorption coefficients at intervals between 1 and 40. The hard components H_2 and H_1 are regarded as wave radiation, coming from the dissociation of helium and protons. The chief intensity of the soft components is in a component W_2, also of undular nature, corresponding to the formation of helium. There seems to be no reason for regarding these or the other components as corpuscular by nature. They may be accompanied by corpuscular secondary radiation. The variation with latitude (Clay, 1931 Abstracts, p. 264; April, p. 209; *also* Compton, February, p. 94) is not regarded as a proof of the corpuscular nature of the rays.

A POSITIVELY CHARGED COMPONENT OF COSMIC RAYS.—L. Alvarez and A. H. Compton. (*Phys. Review*, 15th May, 1933, Series 2, Vol. 43, No. 10, pp. 835–836.)

The writers find experimentally a preponderance of rays from the West which "seems necessarily to imply the existence of a positively charged component of the cosmic rays . . . the difference in counts in the East and West directions is of the order of magnitude to be expected due to the deflection of the particles by the earth's magnetic field." *See* also next abstract.

THE AZIMUTHAL ASYMMETRY OF THE COSMIC RADIATION.—T. H. Johnson. (*Phys. Review*, 15th May, 1933, Series 2, Vol. 43, No. 10, pp. 834–835.)

The results of the experiments shortly described here, in which the relative intensities of cosmic rays coming from the West and East directions respectively were measured, show that the West intensity is greater than that of the East at angles between 30° and 65° from the zenith. The results "accord with the Lemaitre-Vallarta theory [April Abstracts, p. 209, r-h col.] and show that the principal corpuscular component of the cosmic radiation is *positively* charged." *See* also Alvarez and Compton, above.

PROPERTIES OF CIRCUITS

TRANSFORMATOREN MIT VERÄNDERLICHER KOPPLUNG ([Air-Cored] Transformers with Variable Coupling).—E. Siegel. (*Hochf: tech. u. Elek: akus.*, May, 1933, Vol. 41, No. 5, pp. 167–176.)

Author's summary:—"It is shown that the behaviour of a transformer with capacities in primary and secondary circuits, under conditions of varying coupling, can be represented by a circle diagram. This diagram is investigated for certain important special cases [transformer with zero capacity in both circuits; with tuned secondary; with tuned primary and secondary; with tuned primary;] and formulae are developed for the most important working conditions.

"Further, the behaviour of the transformer with capacities in primary and secondary circuits, or with a capacity in either circuit, under conditions of varying coupling and of excitation by a varying frequency, is investigated, and the most important working conditions for these cases are set out analytically and graphically." The general theory shows that the efficiency of the transformer is independent of k (representing the tuning of the primary) being dependent only on p (that of the secondary) and on the coupling factor. To obtain the greatest efficiency the secondary tuning should be complete: when this is the case the efficiency increases with increasing tightness of coupling. If, together with the greatest efficiency, a power factor $\cos \phi = 1$ is required, the primary tuning also should be complete. Maximum energy transference occurs with $\cos \phi = 1$ and a primary copper loss of 50%; but in practice this involves too high losses.

Similar investigations of the conditions for maximum efficiency, etc., are given for the case of excitation by a varying frequency.

IDEAL TRANSFORMER, IDEAL SYNAPTER [dealing also with Phase] AND PERFECT TRANSDUCER.—P. C. Vandewiele. (*Rev. Gén. de l'Élec.*, 15th April, 1933, Vol. 33, No. 15, pp. 481–495.)

THE PRODUCTION OF NEGATIVE CONDUCTANCES BY MEANS OF RETROACTIVE COUPLINGS.—Kautter. (*See* under "Reception.")

THE REPRESENTATION OF [Single-Peak] RESONANCE CURVES BY "SELECTIVITY INDEXES."—Kafka. (*See* under "Reception.")

CRITICAL REVIEWS OF BOOKS AND PAPERS ON ELECTRIC FILTER CIRCUITS.—P. David: Cauer: Guillemin: Jaumann: Strutt: Beatty. (*L'Onde Élec.*, March, 1933, Vol 12, No. 135, pp. 12–14 A.)

The writer deals first with Cauer's book (Abstracts, 1932, pp. 50 and 537, r-h columns); then with Guillemin's paper (Jan., p. 52, l-h col.) which he describes as a good introduction to the study of Cauer's work; and then with Jaumann's paper on the multiple bridge filter (1932, pp. 595–596: *see* also April, p. 228, r-h col.) of which he remarks that while these filters may be considered as special cases of Cauer's filters, the simplicity of their construction and of their calculation justifies the direct study given by Jaumann. The last two papers dealt with are those of Strutt (1932, p. 402) and Beatty (February, p. 98, l-h column).

CONTRIBUTION A L'ÉTUDE DE LA STABILITÉ DES OSCILLATIONS DE COUPLAGE (Contribution to the Study of the Stability of Oscillations in Coupled Circuits [*e.g.* in Oscillating Circuit coupled to Wavemeter]).—J. Mercier. (*L'Onde Élec.*, Feb., 1933 [publication delayed], Vol. 12, No. 134, pp. 93–112.)

A theoretical and experimental investigation of the conditions under which zones of discontinuity, breaking-off of oscillation, etc., are liable to occur. Applied to the case of the wavemeter, the paper shows that the resonance and absorption methods are equivalent except for certain conveniences in the latter: that close coupling is fatal to accurate measurement: and that suitable conditions for accurate measurement are indicated when it is found that the result is not altered by a distinct increase in coupling.

THE MECHANISM OF THE PRODUCTION OF OSCILLATIONS.—Le Corbeiller. (*See* under "Transmission.")

SATZ VON DER GEGENSEITIGKEIT DER WIRKUNG VON VERÄNDERUNGEN (SPERRWIRKUNGEN) BEI LINEAREN SYSTEMEN (Law of Reciprocity for Changes involving the Removal of One Degree of Freedom in Linear Systems).—A. Bloch. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 14, 1933, pp. 234–239.)

THE RELATION BETWEEN THE DISTURBANCE CURRENT AND THE DEGREE OF ASYMMETRY IN LINES SUBJECT TO INDUCED NOISE.—K. Schotte. (*E.N.T.*, May, 1933, Vol. 10, No. 5, pp. 223–225.)

TRANSMISSION

ELEKTRONENSCHWINGUNGEN IM HOCHVAKUUM (Electronic Oscillations in a High Vacuum [Electron Flow equivalent to Negative Resistance for a Certain Frequency Band]).—J. Müller. (*Hochf: tech. u. Elek: akus.*, May, 1933, Vol. 41, No. 5, pp. 156–167.)

A theoretical investigation of the electron flow between two infinite parallel plane electrodes, taking into account the effect of space charge and limiting the treatment to those cases where at each point in the space only electrons of the same speed occur. It is shown, by considering the processes involved in the superposition of a small alternating voltage on the steady d.c. potential, that owing to the electron inertia such an electron stream acts as a negative resistance for frequencies within a certain band, and the question is examined whether this negative resistance is large enough to neutralise the damping of an oscillatory circuit.

In Fig. 10 a quasi-stationary oscillatory circuit is shown, consisting of a plane-electrode valve P and an inductance L; F is a blocking condenser acting as a short circuit for the r.f. oscillations and allowing the supply of anode potential through the choke coils D. The equivalent circuit is shown in Fig. 11. The conditions for the setting up of oscillations are found : the frequency is determined by the external circuit, the only effect of the electrons being the small change which their presence causes in the normal capacity of the valve. If C and R are the equivalent capacity and negative resistance of the valve, W the ohmic resistance of the external circuit, and η the circuit frequency, the condition for the setting up of oscillations is $W/\eta L < |\tan \beta|$. The maximum value for $\tan \beta$ lies in the space-charge region when the product of the path time τ and the circuit frequency η is $\eta\tau = 2.37\pi$; its value then is 0.074. In the saturation region its value is smaller.

The paper ends with an example of a circuit suitable for generating oscillations in this manner. Here two anodes, one on either side of the cathode, are connected by a circular loop : the d.c. supply goes to the cathode and to the middle point of this loop, so that the two anodes are at the same potential and the cathode lies at a potential node of the r.f. circuit. Numerical values are found for the various components in order to generate a 1-metre wave, and it is shown that the loss angle of the oscillatory circuit is 10 times smaller than the maximum possible value of $\tan \beta$ (*see* above). To obtain the optimum condition $\eta\tau = 2.37\,\pi$ for this 1-metre wave, τ must be 3.95×10^{-9} sec., and to obtain this an anode potential of 164 v is required. From energy considerations it is found that for the production of a given frequency the greatest amount of energy is obtained by the use of high current densities, while if the current density is limited the greatest energy is given by the use of longer waves.

Electron Conduction in Thermionic Valves [and the Generation of Ultra-High Frequencies in Diodes].—W. E. Benham : Potapenko. (*Elec. Communication*, April, 1933, Vol. 11, No. 4, pp. 223–225.)

"In a recent paper [1931 Abstracts, p. 212] the dielectric constant and conductance of an electron atmosphere between the parallel electrodes of a Langmuir diode were evaluated as functions of pT . . . . . Fig. 1 shows that the dielectric constant ϵ has a value less than unity for frequencies lying between 0 and $9/2\pi T$. Taking 10^{-9} sec. as a typical value for T, we see at once that the frequency range for which $\epsilon < 1$ embraces nearly all the frequencies so far obtained using thermionic valves (an angular frequency of nearly 10^{10} may be obtained under favourable conditions). Fig. 1 may also be read as the value for ϵ for different values of T, p being held constant. Read in this way it will be seen that as pT increases from zero up to about 1 or 2, the value of ϵ remains sensibly constant at the value 0.6, which means that in this case the value of ϵ is constant over the space included between the cathode ($T = 0$) to the anode ($T = T_d$). This surprising result that (for a range of frequencies of practical interest) the dielectric constant of all points in the inter-electrode space is 3/5 must constitute the first known case of a 'dielectric' which is distinctly non-homogeneous in constitution and yet homogeneous in respect of dielectric constant. Although on the above considerations ϵ is constant, the displacement current nevertheless varies from point to point. The space variation of displacement current and of potential combine to effect complete neutralisation of the space variation of dielectric constant in a Langmuir diode." The writer's tests and the work of Bergmann and Düring (Abstracts, 1929, p. 440) are mentioned.

By interpreting Fig. 2 (the relative change in conductance for values of pT between 0 and 22) in the same way, it is seen that the conductivity for exceedingly high frequencies is alternately positive and negative at a number of regions between the plates. If the anode lies in any one of these regions, the diode as a whole exhibits negative conductance : or for any given anode voltage there are ranges of frequency for which this occurs. Potapenko's experimental "normal" and "dwarf" waves (1932, p. 582, l-h col.) are discussed in this connection, and the fair constancy of the last column of Table I shows that these waves have frequencies whose relation to one another is not very different from the ratios determined by taking the minima of Fig. 2. "A significant feature of the theory, in contrast to previous conceptions, is that the generation of oscillations in an external circuit can take place with amplitudes of electron motion so small that if the motion in transit of the electrons under the influence of steady potentials could be followed with the eye, the superimposed oscillatory motion would escape notice altogether."

Resonance in Three-Electrode Valves.—E. W. B. Gill and R. H. Donaldson. (*Phil. Mag.*, June, 1933, Series 7, Vol. 15, No. 102, pp. 1177–1181.)

The writers have studied a three-electrode valve in which the grid was kept at a positive potential V and the anode at a slightly negative potential v with respect to the filament. A constant alternating e.m.f., whose periodic time was the same as that of the free oscillations of the electrons in the valve, was superposed on the space between filament and anode ; a resonance curve was found for observations of the direct current reaching the anode when the grid potential was varied ; a large valve was used and, with impressed e.m.f. of wavelength 10.01 metres, resonance was obtained for a grid voltage V of 24 volts. This was independent of filament emission : $\lambda^2 V$ was also found to be constant, within experimental error, λ being the wavelength of the oscillation at which resonance occurs. Since resonance is practically independent of filament emission, the experimental results are not in agreement with recent theories of Barkhausen-Kurz oscillation based on the consideration of the normal modes of free oscillation of the system of space-charges in the valve (*cf.* Rostagni, Abstracts, 1932, p. 282 ; *also* January, p. 37, l-h column).

The Use of Magnetic Fields for the Production of Ultra-Short Waves. Magnetron Transmitters.—M. Ponte. (*Journ. de Phys. et le Rad.*, No. 12, Vol. 3, 1932, pp. 183–184.) *See* also July Abstracts, p. 390, r-h col., Soc. Franç. Rad : élec. ; also *Rev. Gén. de l'Élec.*, 4th March, 1933, Vol. 33, No. 9, p. 278.

THE USE OF INSULATED REFLECTION PLATES, SLIDING ON PARALLEL-WIRE SUPPLY LEADS, IN PLACE OF CHOKING COILS IN ULTRA-SHORT-WAVE WORK.—(*Hochf:tech. u. Elek:akus.*, March, 1933, Vol. 41, No. 3, p. 111: German Pat. No. 540 338, pub. 14th Dec., 1932, Kohl.)

FREQUENCY MULTIPLICATION IN ULTRA-SHORT WAVES BY SUPERPOSITION ON RETARDING FIELD POTENTIAL. (*Hochf:tech. u. Elek:akus.*, May, 1933, Vol. 41, No. 5, p. 188: German Pat. No. 568 768, pub. 31st Jan., 1933, Gerhard.)

"Taking advantage of the relation between retarding-electrode current (and r.f. power) and retarding-electrode potential, shown in Fig. 5, a frequency multiplication can be obtained by superposing the a.c. potential to be multiplied on the retarding-electrode potential in such a way that both the rising and falling parts of the characteristic are worked on. The frequency-multiplied potential is taken from the grid circuit."

FREQUENCY MULTIPLICATION BY SUPERPOSITION OF TWO OSCILLATIONS EACH MODULATED AT THE OSCILLATING FREQUENCY, ONE IN PHASE AND THE OTHER IN OPPOSED PHASE. (*Hochf:tech. u. Elek:akus.*, Feb., 1933, Vol. 41, No. 2, p. 71: German Pat. No. 555 952, pub. 17th Aug., 1932, Wassermann.)

INDUCTIVE COUPLING ARRANGEMENT FOR SEVERAL ULTRA-SHORT-WAVE VALVES. (*Hochf:tech. u. Elek:akus.*, Feb., 1933, Vol. 41, No. 2, p. 71: German Pat. No. 560 129, pub. 28th Sept., 1932, Gerhard.)

See Fig. 4. Each anode has a radiator attached which is coupled to a half-wavelength portion of a zig-zag (Greek pattern) feeder.

GRADUATING TO OSCILLATOR-AMPLIFIER TRANSMITTERS ON 56 Mc [and the Prevention of Frequency Modulation and Drift in the Ultra-Short-Wave Band].—D. A. Griffin. (*QST*, May, 1933, Vol. 17, No. 5, pp. 21–22 and 68.)

L'OBTENTION DES OSCILLATIONS POLYPHASÉES À L'AIDE DES SYSTEMES DYNATRONIQUES (The Generation of Polyphase Oscillations with the aid of Dynatron Circuits).—J. Groszkowski. (*L'Onde Élec.*, Feb., 1933 [publication delayed], Vol. 12, No. 134, pp. 85–91.)

"The polyphase electrical oscillations first obtained by Mesny with the aid of triodes with reaction, and later treated theoretically by Arenberg [1931 Abstracts, pp. 438 and 497–498], can also be produced in dynatron systems. The latter, thanks to the absence of reaction, are simpler and also more interesting owing to the possibility of obtaining two modes of functioning. . . . The negative resistances of the dynatrons may be arranged in 'star' or in 'mesh' connection; moreover, the mutual combination of the system of circuits with the dynatron system may be star and star, mesh and mesh, or star and mesh. . . . In view of the ease of energy supply from a common source, and also of the simplicity of construction of the circuit elements, the star arrangements of circuits and of dynatrons are more convenient and more interesting. The mesh arrangements may in fact be reduced to a certain number of single-phase circuits joined among themselves at certain peaks; whereas in the star arrangements the circuits are mutually coupled, a fact which exerts an effect on the frequency of the system and on its condition for the maintenance of oscillation."

The writer therefore confines himself to dealing with the various types of star connection—inductances in star connection, capacities in star connection, and the case (usual in practice) where the inductances in star connection have self-capacities. The frequency equations and the limiting conditions are derived. He ends by giving some experimental results, using Philips triodes working as dynatrons. The wavelength was of the order of 2 000 metres.

LE MÉCANISME DE LA PRODUCTIONS DES OSCILLATIONS (The Mechanism of the Production of Oscillations).—Ph. Le Corbeiller. (*L'Onde Élec.*, March, 1933, Vol. 12, No. 135, pp. 116–148.)

Author's summary:—"Two general types of self-sustained oscillating systems are first studied. The first type consists of an irreversible relay whose output is coupled to the input through a passive quadripole. The second type is represented by a conductor whose characteristic presents a descending arc, connected to the supply source and to a passive bipole. Each of these two types can be set up in two different manners, corresponding to each other 'by duality' [*i.e.* according to the 'principle of duality' based on Maxwell's relation between electrostatic and electromagnetic energy: thus the series connection of L, C and R of the dipole in Fig. 9B, p. 132, corresponds 'by duality' with the parallel connection of the dipole in Fig. 9A, and the currents of the one are given by the same differential system as the potentials of the other]. A non-linear differential equation is derived corresponding to a variable electrical quantity of each of the two types. The differential equation of the second type is a particular case of that of the first type.

"The paper then deals with the simplest symmetrical oscillations obtained from electrical or mechanical self-sustained oscillators: the 'series' oscillations are given by the periodic solution of the equation $z'' - \epsilon(z' - z'^3/3) + z = 0$, and the 'shunt' oscillations by the periodic solution of the equation $y'' - \epsilon(1 - y^2)y' + y = 0$. They have opposed properties and correspond to each other 'by duality.'" The work of Liénard on closed integral curves, or "limiting cycles," of which use is made in the paper, is referred to in 1928 Abstracts, p. 469, r-h column.

MAGNETOELECTRIC RADIATIONS FROM RING-SHAPED OR SPIRAL OSCILLATORS.—K. F. Lindman. (*Physik. Ber.*, 15th April, 1933, Vol. 14, No. 8, p. 600.)

The writer gives the name "magnetoelectric" to the radiations produced in such oscillators by the lines of magnetic induction whose changes generate lines of electrical induction at right angles. Such radiations are less intense than those from a corresponding rod insulator, but can be detected at distances of some wavelengths. If, in a closed iron ring, sufficiently strong magnetic currents are generated by the rapid variation of a magnetic induction in the ring, Maxwell showed that an electrical field of the second type must be formed. The writer believes that he has demonstrated the existence of such a field in the space enclosed in a large iron ring, by the use of a sensitive thermo-electric detector. When the iron ring was replaced by one of copper, the effect was absent.

Graphische Behandlung von Modulationsproblemen (The Graphical Treatment of Modulation Problems [including Applications to the Transmission of Carrier and Side-Bands from Separate Aerials, and to Common-Wave Broadcasting]).—H. Roder. (*E.N.T.*, May, 1933, Vol. 10, No. 5, pp. 225–229.)

For papers in English on the author's graphical method *see* April Abstracts, pp. 210 (r-h col.) and 212–213. The present article deals separately with the two applications mentioned. Three alternative ways of transmitting the carrier and side-bands from separate aerials are shown in Fig. 4 ; of these, only the right-hand arrangement, in which the carrier is transmitted from the central aerial and one side-band from each of the outer aerials, is free both from linear and non-linear distortion, although its practical carrying out involves some difficulties.

Time Delay Effects in Synchronous [Common-Wave] Broadcasting.—Aiken. (*See* under "Stations, Design and Operation.")

Single Side-Band Telephony on Short Waves.—E. M. Deloraine : Reeves. (*Rev. Gén. de l'Élec.*, 15th April, 1933, Vol. 33, No. 15, pp. 476–477 : summary only.)

Arrangement for Single Side-Band Modulation.—(*Hochf:tech. u. Elek:akus.*, March, 1933, Vol. 41, No. 3, p. 110 : German Pat. No. 560 226, pub. 29th Sept., 1932, von Plebanski.)

The Balancing and Stabilising of High-Frequency Amplifiers, with Special Reference to Power Amplifiers for Radio Transmitters [particularly for Naval Ship Requirements].—W. Ure, E. J. Grainger, and H. R. Cantelo. (*Wireless Engineer*, May, 1933, Vol. 10, No. 116, pp. 259–261.)

Long abstract of an I.E.E. paper and Discussion. Among the points discussed are :—the fact that a valve with its associated circuits may be neutralised for the frequency at which it is designed to work is no guarantee that it cannot oscillate at a different frequency (even the push-pull circuit is capable of generating spurious oscillations) : "hot" and "cold" balance methods : naval ship requirements : design of coils for h.f. master-oscillator, to give constant inductance over temperature changes of about 40° C.

Elimination of Fading Compensating Devices by Choice of Modulation Curve of Transmitter, and Rectifying Curve of Receiver, as Identical Exponential Functions.—(*Hochf:tech. u. Elek:akus.*, Feb., 1933, Vol. 41, No. 2, p. 71 : German Pat. No. 560 227, pub. 29th Sept., 1932, Roosenstein.)

By this arrangement "the ratio of the maximum to the minimum amplitude of the rectified current is determined only by the degree of modulation, assumed to be constant, and is independent of fading."

Getting Quality Performance with Class B Modulation : Practical Design and Operating Data for Best Tube Combinations.—A. A. Collins. (*QST*, May, 1933, Vol. 17, No. 5, pp. 12–17 and 57.)

A Sensitive Tuning Indicator [Dry-Plate Rectifier Disc and Milliammeter shunted by Condenser].—J. D. Blitch. (*QST*, May, 1933, Vol. 17, No. 5, p. 20.)

RECEPTION

Empfangsversuche mit dem Kristalldetektor in China (Reception in China on a Crystal Detector [Nanking at 500 km by day : Manila at 2 500 km by night]).—F. Oster. (*Radio, B., F. für Alle*, May, 1933, p. 212.)

Cutting the Cost of Single-Signal Reception : Converting the T.R.F. Regenerative Receiver to an S.S. Superhet.—J. J. Lamb. (*QST*, April, 1933, Vol. 17, No. 4, pp. 8–12 and 58–66.)

A short summary of what is implied by "single-signal selectivity" is given on the last two pages. For previous papers *see* June Abstracts, p. 327, l-h column.

Second Channel Suppression.—R. I. Kinross. (*Wireless World*, 9th June, 1933, Vol. 32, pp. 416–417.)

There is a tendency at the present time to cut down the number of signal-frequency circuits in a superheterodyne, but unless special precautions are taken, second channel interference is likely to prove troublesome. The author describes a new input filter, combining the virtues of inductive and capacitive coupling, which satisfactorily minimises the effect of "image" frequencies.

The Introduction, into an Existing Receiver, of Exponential Valves in the place of ordinary Screen-Grid Valves.—(*Radio, B., F. für Alle*, May, 1933, pp. 215–219.)

The Two-Unit Portable.—H. F. Smith. (*Wireless World*, 23rd June, 1933, Vol. 32, pp. 440–443.)

A four-valve portable receiver for the amateur constructor, designed, for easy transport, in the form of two units which can be quickly connected together.

Checking the Performance of the Superheterodyne First Detector [and the Choice of Valve Types].—A. L. Chaney. (*QST*, May, 1933, Vol. 17, No. 5, pp. 34–35 and 70, 72.)

A Superheterodyne Receiver using the New "Fading Hexode" and "Mixing Hexode" Valves.—Wigand : Telefunken Company. (*See* abstract under "Valves and Thermionics.")

ULTRA-SHORT-WAVE TWO.—H. B. Dent. (*Wireless World*, 16th June, 1933, Vol. 32, pp. 422–424.)

A two-valve ultra-short-wave receiver for the amateur constructor. The waveband covered is from 5 to 7 metres. The super-regenerative principle is employed.

IMPROVING THE 56-MC RECEIVER : CONSTRUCTIONAL DETAILS OF TWO NEW SETS FOR THE ULTRA-HIGH FREQUENCIES.—C. F. Hadlock. (*QST*, May, 1933, Vol. 17, No. 5, pp. 23–26.)

AN INTER-CARRIER NOISE SUPPRESSION SYSTEM [using the Wunderlich Valve of a New Type, with Small Shielded Extra Anode].—N. E. Wunderlich. (*Rad. Engineering*, March, 1933, Vol. 13, No. 3, pp. 7–9 and 13.)

" A simplified and improved method for silent tuning. An exceptional 7-tube superhet with amplified AVC and noise suppression." *See* also a short article on p. 13 on the use of a standard Wunderlich " A " valve, in the absence of the new " B " type.

RADIO RECEIVER SITUATION FOR 1933 [including " Colour " Visual Indication of Noise, Tone and Volume Control].—(*Rad. Engineering*, May, 1933, Vol. 13, No. 5, pp. 12–13.)

CONTROLS FOR 1933 RECEIVERS [particularly Moulded Carbon Variable Resistances and Their Uses].—N. E. Wunderlich. (*Rad. Engineering*, May, 1933, Vol. 13, No. 5, pp. 17–19.)

AUTOMATIC VOLUME CONTROL FOR RADIO RECEIVERS [Survey of American Developments].—C. B. Fisher. (*Wireless Engineer*, May, 1933, Vol. 10, No. 116, pp. 248–254.)

CORRECTED AVC.—Cossor Laboratories. (*Wireless World*, 2nd June, 1933, Vol. 32, pp. 386–388.)

Although highly satisfactory results can be obtained by ordinary AVC systems in which the r.f. valves are controlled, theoretical perfection is impossible, for the controlling bias is dependent on the detector input. In the recently developed double-diode pentode valve, which has variable-mu characteristics, the AVC is taken both forwards and backwards to the a.f. and r.f. stages, respectively. As a result it is possible to obtain almost perfect AVC, since both pre- and post-detector volume control is obtained.

BACK TO QUALITY IN RADIO RECEIVERS ! [With Curves showing Wide Difference in Tone Fidelity between Large and Small Receivers].—(*Electronics*, April, 1933, Vol. 6, No. 4, pp. 106–107.)

RADIO AT THE LEIPZIG SPRING FAIR.—(*Radio, B., F. für Alle*, May, 1933, pp. 230–234.)

THE USE OF INSTRUMENTS IN RADIO RECEIVER MANUFACTURING.—J. H. Miller. (*Rad. Engineering*, May, 1933, Vol. 13, No. 5, pp. 20–21.)

RADIO RECEIVER DESIGN [The Equivalent Circuits Useful in Broadcast Receiver Design].—J. E. Smith. (*Rad. Engineering*, March, 1933, Vol. 13, No. 3, pp. 20–22.)

DIE HERSTELLUNG VON NEGATIVEN LEITWERTEN MIT HILFE VON RÜCKKOPPLUNGSSCHALTUNGEN. I. (The Production of Negative Conductances by means of Retroactive Couplings [and the Calculation of Retroactive Receiver Circuits]).—W. Kautter. (*E.N.T.*, May, 1933, Vol. 10, No. 5, pp. 199–214.)

" In a previous paper [1931 Abstracts, pp. 495–496] it was shown that, by the use of the current-source equivalent diagram of the aerial, the complete input circuit of an ordinary retroaction-less receiver can be represented by a parallel connection of positive and negative susceptances [imaginary components of admittances] and positive conductances, fed by the aerial with a certain practically constant current. The potential changes at the first grid due to adjustment of the tuning can be represented by the corresponding changes in the resultant admittance." The calculation of the selectivity and potential transformation (ratio of grid a.c. and aerial potentials) is unaffected, owing to the small frequency range involved, by the frequency dependence of the input current.

The object of the present paper is to extend the method to the case of a receiver with retroaction, by the introduction of a " negative conductance," which fortunately is easy to calculate and has practically no dependence on frequency. The retroaction is accompanied also by an unwanted, but unimportant, wattless component which shows itself in a slight de-tuning of the grid circuit. The variation with amplitude of the retroaction-equivalent " negative conductance " has a definite connection with the characteristic curves of the valves. After applying his method to capacitive and inductive retroactive couplings, the writer considers certain special circuits, such as retroaction methods which do not cause de-tuning, and retroaction over several stages.

INTERFERENCE WITH BROADCAST RECEPTION.—(*Rev. Gén. de l'Élec.*, 6th May, 1933, Vol. 33, No. 18, p. 143 D : summary of *National Electric Light Association Publication No.* 33, Jan., 1933, pp. 1–3.)

" This report has been issued by the Joint Committee created by the National Electric Light Association, the National Electrical Manufacturers Association and the Radio Manufacturers Association. . . . The recommendations given in the conclusions of this report are as follows : increase of the power of the transmitting stations ; the study of receivers in order to make them as insensitive as possible to parasitic fields without sacrificing their other qualities ; installation of receivers so that the coupling between aerial and the neighbouring circuits liable to create parasitic fields may be very loose ; the fitting, in special cases, of filters to apparatus producing well recognised interference."

INTERFERENCE WITH BROADCAST RECEPTION.—G.W.O.H. (*Wireless Engineer*, May, 1933, Vol. 10, No. 116, pp. 237–238.)

Editorial on the need for legislation ensuring that electrical apparatus should not be offered for sale if it cannot be operated without causing interference, and that the operation of apparatus in such a way as to produce interference should be an offence. A recent law promulgated in Roumania is discussed. The future need for the compulsory suppression of motor-car ignition interference, for the sake of ultra-short-wave services, is pointed out.

THE INSTALLATION OF AERIALS WITH SCREENED DOWN-LEADS.—Wigand. (*See* under "Aerials and Aerial Systems.")

ANTENNA TRANSMISSION LINE SYSTEMS FOR RADIO RECEPTION [Elimination of Man-Made Static by Suitable Location of Aerial and the Use of a Shielded Lead-In].—Brigham. (*Ibid.*)

NOISE INTENSITY IN RADIO RECEPTION.—Byrne. (*See* abstract under "Atmospherics and Atmospheric Electricity.")

DECOUPLING AND INSTABILITY [Production of Motor-Boating by Incorrect Design of Decoupling Circuits].—S. J. Preston. (*World Radio*, 9th June 1933, Vol. 16, No. 411, p. 772.)

WHY DOES THE LOW-FREQUENCY AMPLIFIER HOWL? TESTS ON THE STATIC SCREENING OF A.F. TRANSFORMERS.—H. Piesch. (*Radio, B., F. für Alle*, March, 1933, pp. 97–101.)

THE PROBLEM OF STABILITY [in Radio Receivers].—L. Chrétien. (*Rev. Gén. de l'Élec.*, 29th April, 1933, Vol. 33, No. 17, p. 132 D: summary only.)

TUNING DISCONTINUITIES OF A ROTATING VARIOMETER SMOOTHED OUT BY COMBINATION WITH A ROTATING CONDENSER WITH WAVE-FORM EDGES. — (*Hochf:tech. u. Elek:akus.*, Feb., 1933, Vol. 41, No. 2, p. 72: German Pat. No. 559 542, Telefunken.)

SUPPRESSION OF MAINS HUM: THE USE OF AN AUXILIARY VALVE IN OPPOSITION TO OUTPUT VALVE: OF A BRIDGE CIRCUIT: OF RECTIFIERS IN OPPOSITION ACROSS HEATING CIRCUIT.—(*Hochf:tech. u. Elek:akus.*, March, 1933, Vol. 41, No. 3, pp. 111–112: German Pat. Nos. 562 640, 562 305 and 562 304, pub. 27th, 24th and 24th Oct., 1932, Siemens-Schukert, Telephonfabrik Berliner, R.C.A.)

IMPROVED SMOOTHING IN MAINS RECEIVERS BY CONNECTING VALVES AS SERIES ELEMENTS OF ANODE-CURRENT FILTER CHAIN.—(*Hochf: tech. u. Elek:akus.*, Feb., 1933, Vol. 41, No. 2, p. 72: German Pat. No. 559 640, pub. 22nd Sept., 1932, Süddeutsche Tel. Kab. u. Drahtwerke.)

ÉTUDE DU CIRCUIT D'ENTRÉE D'UN POSTE RÉCEPTEUR RADIOPHONIQUE (Study of the Input Circuit of a Radiotelephonic Receiver [and the Predominant Importance of the H.F. Losses]).—Mezey. (*L'Onde Élec.*, March, 1933, Vol. 12, No. 135, pp. 149–160.)

A large number of receivers, particularly American, use a pre-selector circuit consisting of two inductively coupled tuned circuits, the two variable condensers being ganged. The coupling of the first circuit to the aerial circuit is sometimes inductive, sometimes capacitive, and is loose in either case. The writer deals with the inductively coupled type, and examines the forms of the resonance curves of such a band filter with a view to showing how they vary with the carrier wavelength and how to calculate the circuit constants to give the best results over a range such as 200–600 m. The first part of the paper gives the solution of the general equations in a simplified form; the second deals with a numerical example and shows the importance of the r.f. losses. The discussion of these losses is based on the writer's tests on duplicates of American coils: one of these had a resistance of 10 ohms at 400 m, which he considers too high to give any good result in a pre-selector circuit. The resistance was chiefly due to skin effect, and by using a wire of 30 insulated strands he reduced it to 5.8 ohms. He concludes that though many makers have abandoned the inductive coupling between the two circuits, in order to render the filter independent of frequency, and have adopted resistance and capacity couplings, the r.f. losses and their variation with frequency are of such predominant importance that improvements in this direction will furnish the true solution.

THE USE OF MULTI-WAVE CIRCUITS IN GRID AND ANODE CIRCUITS OF A RECEIVER WITH RETROACTION, TO GIVE RECTANGULAR RESONANCE CURVE.—(*Hochf:tech. u. Elek:akus.*, Feb., 1933, Vol. 41, No. 2, p. 72: German Pat. No. 558 300, pub. 6th Sept., 1932, Lorenz.)

DIE KENNZEICHNUNG VON RESONANZKURVEN DURCH SELEKTIVITÄTSZAHLEN (The Representation of [Single-Peak] Resonance Curves by "Selectivity Indexes"). — H. Kafka. (*Hochf:tech. u. Elek:akus.*, May, 1933, Vol. 41, No. 5, pp. 176–184.)

Taking first the case of a series connection of resistance r, inductance L, and capacity C, of which L is the variable component, and making use of a resonance curve in the form of a special circle diagram (Fig. 1), the writer examines how the value of $\tan\phi$ changes as the resonance point is passed through. Here ϕ represents the phase position of the vector OP: the relation of the special circle diagram to the ordinary resonance curve is shown by the fact that the latter is obtained if the length OP is plotted as ordinate along a horizontal L scale. The resonance is the sharper the larger ϕ is for a given change $\pm\Delta\lambda$ with respect to the resonance value $\lambda = 1$ (here λ is the ratio L/L_r of a value of the inductance L to its resonance value L_r). The relation between $\tan\phi$ and λ is $\tan\phi = \omega L_r/r\,.\,(1-\lambda)$, which can be represented by a straight line *whose slope is a measure of the size of ϕ corresponding to a given change $\pm\Delta\lambda$ with respect to $\lambda = 1$.*

On this basis, therefore, the writer suggests that a numerical measure of the selectivity with varying inductance is conveniently given by the absolute value S_L of the ordinate to the $\tan\phi$ straight line, corresponding to a change $\Delta\lambda = +1\%$ with respect to the resonance value $\lambda = 1$. Thus the formula for this "selectivity index" is $S_L = 0.01\,|\partial\tan\phi/\partial\lambda| = 0.01\,\omega L_r/r$.

Dealing next with the more practically important case of constant r and L and variable C, the writer shows that here the corresponding connection between tan ϕ and γ ($\gamma = C/C_r$) is not a straight line but a curve. This non-linear variation of tan ϕ has the result that the resonance curve for variable C is not strictly symmetrical as in the case of variable L. But to obtain a simple measure of selectivity the curve may be replaced, in the neighbourhood of its resonance point, by the tangent at that point. Then the selectivity index S_c is defined as the absolute value of the ordinate corresponding to a change $\Delta\gamma = +1\%$ drawn to the tangent to the tan ϕ curve at its resonance point $\gamma = 1$. In this case $S_c = 0.01\ \omega L/r$.

The very important case is then treated where r, L and C are all constant and the frequency f varies (r is taken as constant near a given resonance frequency, in spite of its general variation with high frequencies). Here again the connection between tan ϕ and η ($\eta = \omega/\omega_r = f/f_r$) is represented by a curve which must be replaced by its resonance-point tangent, giving a selectivity index $S_f = 0.01 \cdot 2\omega_r L/r$. Thus the selectivity index for variable frequency is twice as great as that for variable inductance or capacity. This point is discussed on p. 179, r-h column.

The writer applies his methods to a number of practical circuits, including frame aerials, a rejector circuit with series input resistance, and a series of two high-frequency stages with rejector-circuit coupling. He ends with a discussion of the selectivity relations in multi-circuit receivers for the broadcast range of wavelengths, where matters are complicated by the large variations with frequency of the r.f. resistance in the various coils. The case of resonance curves with *two* maxima will be dealt with in a later paper.

AERIALS AND AERIAL SYSTEMS

THE CONCENTRATOR ANTENNA [giving Decreased Space Wave and Increased Efficiency at the Shorter Broadcast Wavelengths].—Westinghouse Company. (*Rad. Engineering*, March, 1933, Vol. 13, No. 3, p. 10.)

The "exciter" is a copper rod 204 feet high; the "concentrator" is another copper rod about 150 feet high, about 250 feet from the "exciter" and adjusted to resonate with KYW's frequency of 1 020 kc/s. Under each rod is a buried earth of copper sheet with eight radial strips. "The concentrator tends to bend down the radio waves coming from the exciter, flattening them so that they are intensified over the useful area of the station."

FADING ELIMINATED BY HIGH AERIAL SUPPORTED BY BALLOON ["Blimp Antenna"]. (*Electronics*, April, 1933, Vol. 6, No. 4, p. 87: News item.)

"To eliminate troublesome fading, KDKA engineers obtain baby blimp to hold antenna aloft to a vertical height of 1 500 ft." *See* also *Rad. Engineering*, April, 1933, Vol. 13, No. 4, p. 14, where it is stated that these experiments "may have considerable effect upon the future efficiency of broadcasting stations . . . An experimental half-wave antenna, about 500 ft. long, now trails 1 500 ft. in the air. A light aluminium wire, serving as a combination guy and feed wire, serves the dual purpose of restraining the 'captive aerial' from free flight and 'feeds' it radio programmes."

INVESTIGATING THE DIRECTIVE PROPERTIES OF AN AMATEUR ANTENNA [Long L-Aerial for Short Waves].—S. L. Seaton. (*Physik. Ber.*, 1st April, 1933, Vol. 14, No. 7, pp. 514–515.)

Working on a frequency of 14 285 kc/s, this horizontal wire aerial had a length of 3λ and a height of $\lambda/2$. It showed a strong and sharply defined maximum in the usual direction, with 4 weak subsidiary maxima.

HORIZONTAL DIRECTIVE SHORT-WAVE ANTENNA.—(*Hochf: tech. u. Elek: akus.*, March, 1933, Vol. 41, No. 3, p. 112: German Pat. No. 562 306, pub. 24th Oct., 1932, U.S.S.R. Elektrot. Vereinigung.)

"A symmetrical dipole with two radiators of 0.6–0.65 λ gives in the main direction twice as much energy as a half-wave radiator."

JONCTION ENTRE DEUX LIGNES D'IMPÉDANCES CARACTÉRISTIQUES DIFFÉRENTES (The Joining of Two Lines of Different Characteristic Impedance [and the Calculation of the Dissymmetric Quadripole for Matching a Two-Wire and a Concentric Line]).—J. C. Pomey. (*Rev. Gén. de l'Élec.*, 18th March, 1933, Vol. 33, No. 11, pp. 331–335.)

REFLECTORS FOR ULTRA-SHORT WAVES.—(*Hochf: tech. u. Elek: akus.*, May, 1933, Vol. 41, No. 5, p. 188: German Pat. No. 568 015, pub. 12th Jan., 1933, Telefunken Company.)

See Fig. 4. The radiator *o* at the focus of a parabolic mirror has its direct radiation screened by the small spherical concave mirror *b*. According to the invention, a portion of the parabolic mirror around its vertex, about equal in aperture to the concave mirror, is removed and replaced by a spherical surface either inside or at the back of the parabolic mirror, in order to prevent the emission, in an incorrect direction, of rays reflected back from *b* on to that part of the parabolic mirror.

ANTENNA TRANSMISSION LINE SYSTEMS FOR RADIO RECEPTION [Elimination of Man-Made Static by Suitable Location of Aerial and the Use of a Shielded Lead-In].—C. E. Brigham. (*Rad. Engineering*, March and April, 1933, Vol. 13, Nos. 3 and 4, pp. 11–12 and 21–22.)

The Radio Club paper referred to in June Abstracts, p. 325, r-h column.

DER BAU VON ANTENNEN MIT ABGESCHIRMTER ZULEITUNG (The Installation of Aerials with Screened Down-Leads).—R. Wigand. (*Radio, B., F. für Alle*, May, 1933, pp. 193–198.)

Based on the use of the shielded "Kapa" cable, made by the Vacha Cable Works, with air insulation. The writer's remark that a lead of 15 m length would have a capacity of only about 400 cms calls for the editorial comment that the "only" seems rather out of place, since such a capacity is large for modern receivers.

VALVES AND THERMIONICS

Vacuum Tubes for use at Extremely High Frequencies [Very Small Triodes and S.G. Valves for Reception of Ultra-Short Waves down to 60 Centimetres with Conventional Circuits, or for Conventional Oscillator Circuit for 30 Centimetre Waves.].—B. J. Thompson and G. M. Rose, Jr. (*Proc. Inst. Rad. Eng.*, June, 1933, Vol. 21, No. 6, pp. 755–756 : abstract of I.R.E. Convention paper.)

Vacuum Tube Characteristics in the Positive Grid Region by an Oscillographic Method.—H. N. Kozanowski and I. E. Mouromtseff. (*Ibid.*, p. 756.)

Valves for Ultra-Short Waves : Reduction of Inductance of Grid Electrodes by Combination of Two or More Helices in Opposed Sense.—(*Hochf:tech. u. Elek:akus.*, May, 1933, Vol. 41, No. 5, p. 188 : German Pat. No. 567 560, pub. 5th Jan., 1933, Kohl.)

Valves for Ultra-Short Waves : Preventing Deformation of Grid Electrode by Insulating Strip made fast to Nodal Points of Spiral.—(*Ibid.*, p. 188 : German Pat. No. 567 903, pub. 11th Jan., 1933, Kohl.)

Electron Conduction in Thermionic Valves. —Benham. (*See* under " Transmission.")

The Hexode, a New German Valve.—R. Wigand: Telefunken Company. (*Radio, B., F. für Alle*, June, 1933, pp. 279–283.)

Two types are described, one with indirectly heated cathode, control grid, screen grid, second control grid, second screen grid, and anode ; the other with indirectly heated cathode, control grid, screen grid, perforated anode, second control grid, and anode. The first type is called a " fading hexode," the second a " mixing hexode." Of the former the writer says : " For a change of potential of grid 1, curves are obtained resembling those of the exponential valves. With the latter, however, the potential change necessary to produce a very large variation in amplification is itself very large (about 40 v)," whereas the hexode gives a regulation of at least 1:10 000 for potential changes of the order of 10–15 v.

In connection with the " mixing hexode " the writer points out the desirability of a mixing valve in which the straight part of the characteristic can be worked on, without rectification, and in which it is easy to make the oscillator portion free from harmonics. As an example of the use of the two types, the diagram (Fig. 337) is given of a 5-valve superheterodyne with a fading hexode V_1 regulated by the " binode " V_4 (combination of half-wave rectifier, from which the volume-control potential is taken, and l.f. amplifier leading to the output valve V_5), followed by a mixing hexode V_2 in the Numans connection, and a second fading hexode V_3 not connected to the AVC. " Contrary to other reports the hexodes are a purely German invention ; they will be put on the market by Telefunken and Valvo at this year's Radio Show and will then be obtainable from the shops."

The Hexode Tube [" Emission Valve Modulator"]. —Wheeler. (*Rad. Engineering*, March, 1933, Vol. 13, No. 3, p. 19.) *See* also next abstract, and Wigand, above.

The Hexode Vacuum Tube : Emission-Valve Mechanism makes practicable Oscillation, Modulation, High Amplification and Grid-Bias Control of Amplification. —H. A. Wheeler. (*Rad. Engineering*, April, 1933, Vol. 13, No. 4, pp. 12–14.) *See* also June Abstracts, p. 328, and above.

Considerations on Detector-Output Tube Systems [and the Possibilities of the Two-Valve Superheterodyne].—J. R. Nelson. (*Electronics*, April, 1933, Vol. 6, No. 4, pp. 94–95 and 98.)

The possible arrival of a two-valve superheterodyne receiver, using one of the recently announced oscillator-detector valves and a possible detector-output valve, was referred to in June Abstracts, p. 326, r-h col., and the present article deals with some of the possible types of combination valves for this latter service. The writer considers first the twin control-grid pentode ; an experimental valve was made up to see how much improvement of performance over an ordinary pentode could be obtained, and a considerable improvement was found, though the voltage sensitivity as a detector was rather poor and it was impossible to load up the output-valve section when the degree of modulation was low. The simplest arrangement, a combination diode and pentode amplifier, should have about the same sensitivity as that of the twin control-grid pentode. A combination triode and pentode amplifier would have considerably better voltage sensitivity, but the writer concludes that the only true solution as regards both output and sensitivity would be the diode, triode, pentode combination, whose complicated structure (with 8, or preferably 9, connections) would make it only problematically economical compared with two standard valves.

Still More Tubes [including " Pentagrid Converters " and " Duo-Diodes " with Pentodes in Output Portion].—(*QST*, May, 1933, Vol. 17, No. 5, pp. 30 and 68, 70.)

Detector Tube Performance Curves [Diode ; Conventional Detectors ; Duplex Diode-Triodes ; Types 75 and 2A6, with High-Mu Triode Section ; Duplex Triode-Pentodes].—J. R. Nelson. (*Rad. Engineering*, April 1933, Vol. 13, No. 4, pp. 15 and 23.)

The 77 as a [Self] Biased Detector with 100 Volts Plate Supply [for Small Universal A.C.–D.C. Receivers].—(*Rad. Engineering*, April, 1933, Vol. 13, No. 4, p. 18.)

New Tube Type Designations [Valve-Numbering System adopted by American Radio Manufacturers Association].—(*QST*, May, 1933, Vol. 17, No. 5, p. 28.)

VALVE DATA DIAGRAMS: CORRESPONDENCE.—F. P. Basto: I. Koga: G.W.O.H. (*Wireless Engineer*, May, 1933, Vol. 10, No. 116, pp. 257–258.)

Letters on the Editorials referred to in Abstracts, 1931, p. 441, r-h col., and March, p. 161, l-h col. Basto points out that the logarithmic diagram can be improved according to the following considerations: the maximum power output per peak volt squared is given by $P/E^2 = Q/8$, where Q is the "Güte" ($= \mu G_m$), so that the scale of Q may give an idea of the comparative sensitivity of identical power valves: if this power scale is plotted with the divisions proportional to log Q, there results a very useful scale in bels, or in db, easy to divide because it has equal divisions. Also, for the classification of h.f. valves, another scale, useful for determining the maximum voltage gain obtainable with a valve followed by a suitable transformer, may be plotted over the Q axis.

Koga describes, and illustrates by a specimen diagram, another method using ordinary rectangular ruled paper. This has the advantage of facilitating the interpolation of numerical values and the preparation of the diagram sheet, but the disadvantages that the "Güte" is not given conveniently and that the scale of the co-ordinates must be given in multiple to meet the large range of characteristic values.

TWO PROCESSES FOR THE FORMATION OF OXIDE-COATED CATHODES.—E. Bluhm: Tödt. (*E.T.Z.*, 18th May, 1933, Vol. 54, No. 20, pp. 477–478.)

SURFACES FROM WHICH COLD EMISSION CURRENTS APPEAR ONLY AT VERY HIGH FIELD GRADIENTS.—C. C. Chambers. (*Phys. Review*, 1st May, 1933, Series 2, Vol. 43, No. 9, pp. 768–769.)

The surfaces referred to were those of thoriated tungsten filaments after various heat treatments.

OUT-GASSING ELECTRODES BY MEANS OF A SHORT INDUCTION WINDING MOVED TO-AND-FRO IN AN AXIAL DIRECTION.—(*Hochf:tech. u. Elek:akus.*, May, 1933, Vol. 41, No. 5, p. 188: German Pat. No. 566 467, pub. 21st Dec., 1932, Telefunken Company.)

NEW TUBES: NEW TUBE MATERIALS [particularly Svea Metal].—(*Electronics*, April, 1933, Vol. 6, No. 4, p. 93.)

APPLICATION OF GRAPHITE AS AN ANODE MATERIAL TO HIGH-VACUUM TRANSMITTING TUBES.—E. E. Spitzer. (*Proc. Inst. Rad. Eng.*, June, 1933, Vol. 21, No. 6, pp. 756–757: abstract of I.R.E. Convention paper.)

THE RÔLE OF VACUUM TUBES IN A TUBE FACTORY [Measuring Low Mutual Conductances: Automatic Control of Cathode Spray Gun: Protective Circuits for Meters, etc.].—W. P. Koechel. (*Electronics*, May, 1933, Vol. 6, No. 5, pp. 121–123.)

DIRECTIONAL WIRELESS

THE AUTOMATIC COMMUNICATION TO A MOVING CRAFT OF ITS BEARINGS TAKEN BY TWO FIXED STATIONS.—(*Hochf:tech. u. Elek:akus.*, Feb., 1933, Vol. 41, No. 2, p. 73: German Pat. No. 557 257, pub. 20th Aug., 1932, Csejkovits and Dieckmann.)

"The signals from the craft are received by two automatic [direct-reading] direction finders at different points, each of which transmits the bearing by the simultaneous modulation, with two different audio-frequencies, of its own transmitter. This modulation takes place in such a way that the depth of modulation on the one frequency represents the angle between *zero of the indicating instrument and the actual indication*, while the depth of modulation on the second frequency represents the angle between *the indication and the scale maximum*. In the receiver on board the moving craft the two audio-frequencies are separated by filters and led to a quotient-showing instrument which controls the motion of a mechanical or optical pointer over a chart. The position is given by the intersection of two such pointers, each controlled by one of the two fixed transmitters, either through two separate receivers or by the alternate switching-over of a common receiver to the two transmitters."

THE "IRON RING QUOTIENT METER."—Geyger. *See* reference on p. 457, r-h column.

DISTANCE DETERMINATION BY ELECTROMAGNETIC WAVES. — (*Hochf:tech. u. Elek:akus.*, Feb., 1933, Vol. 41, No. 2, p. 73: German Pat. No. 545 168, pub. 30th Sept., 1932, Weigl.)

"A short-wave radiation modulated with a longer wave is received by a second station and simultaneously re-transmitted, being then received by the originating station and again re-transmitted, with the result that a resonance effect occurs when the length of the modulating wave is equal to the distance between the two stations or a multiple thereof." *Cf.* Koulikoff and Chilowsky, 1929 Abstracts, p. 168.

ULTRA-SHORT-WAVE BEACON [with Generating Circuit alternating between Positions on either Side of Focus of Parabolic Reflector]. — (*Hochf:tech. u. Elek:akus.*, May, 1933, Vol. 41, No. 5, p. 188: German Pat. No. 567 640, pub. 6th Jan., 1933, Telefunken Company and Ludenia.)

See Fig. 2. A receiver on the middle line *m* gets equally strong signals from the two positions; away from *m* the signal from one position preponderates.

RADIO SYSTEM FOR BLIND LANDING OF AIRCRAFT [Runway Localising Beacon on 300 kc/s, Two Marker Beacons on 10 Mc/s with Different Modulation Frequencies, and a Landing Beam on 100 Mc/s].—(*Bur. of Stds. Tech. News Bull.*, April, 1933, No. 192, pp. 39–40.)

ACOUSTICS AND AUDIO-FREQUENCIES

Electro-Mechanical Oscillator particularly applicable to Electrical Musical Instruments [Loud Speaker with "Preponderent Inertia" acting as Large Capacity variable by regulating Field Current or by switching-in Different Moving-Coil Windings].—(*Rev. Gén. de l'Élec.*, 29th April, 1933, Vol. 33, No. 17, pp. 134–135 D: French Pat. No. 742 079, pub. 27th Feb., 1933, Michaud.)

Back to Quality in Radio Receivers! [With Curves showing Wide Difference in Tone Fidelity between Large and Small Receivers].—(*Electronics*, April, 1933, Vol. 6, No. 4, pp. 106–107.)

Hornless Large-Surface Loud Speaker dispensing with Baffle and Cabinet, Outer Edge of Diaphragm carried back to Wall of Room.—(*Hochf:tech. u. Elek:akus.*, May, 1933, Vol. 41, No. 5, p. 188: German Pat. No. 568 088, pub. 14th Jan., 1933, Teuke.)

A New Cone Loud Speaker for High Fidelity Sound Reproduction [Uniform Response from 80 to 10 000 c/s by Voice Coil and Cylinder "segregated into Masses and Compliances" and connected to "Suitably Corrugated Cone"].—H. F. Olson. (*Proc. Inst. Rad. Eng.*, June, 1933, Vol. 21, No. 6, pp. 760–761: abstract of I.R.E. Convention paper.)

Cone Loud Speaker with Cone Space taken up by Independent Filler [*e.g.*, Wooden Cone] with Sound Channels leading to Flat Surface: to prevent Interference Effects due to Depth of Cone Diaphragm and to improve Frequency Characteristic.—(*Hochf:tech. u. Elek:akus.*, Feb., 1933, Vol. 41, No. 2, pp. 73–74: German Pat. Nos. 555 543 and 559 259, pub. 23rd July and 11th October, 1932, AEG and Stenzel.)

Arrangement for In-phase Transmission of Forces to Different parts of a Surface, particularly Loud Speaker Diaphragms [Use of Links of Materials with Different Propagation Velocities].—(*Ibid.*, p. 74: German Pat. No. 557 016, pub. 17th Aug., 1932, Telefunken and Hähnle.)

Reflection of a Sound Wave from a Circular Plate [Experimental and Theoretical].—M. Sasao. (*Sci. Abstracts, Sec. A*, Feb., 1933, Vol. 36, No. 422, p. 168.)

"Near the plate . . . the envelope of standing waves, if the wavelength is smaller than the radius of the plate, has a maximum and a minimum, and the interval between the maxima of standing waves is greater than half a wavelength. These facts were confirmed by theory."

Related [Vibration] Figures on Circular Plates.—R. C. Colwell. (*Phys. Review*, 1st May, 1933, Series 2, Vol. 43, No. 9, p. 782: abstract only.)

Vast Public Address System at Thirty-First International Eucharistic Congress, Dublin, June, 1932.—W. L. McPherson. (*Elec. Communication*, April, 1933, Vol. 11, No. 4, pp. 208–222.)

Analysis of the Wave Form in Sound-on-Film Recording by the Intensity Process.—O. Sandvik and V. C. Hall. (*Physik. Ber.*, 1st May, 1933, Vol. 14, No. 9, p. 675.)

Miniature Talkies.—B. R. Davies and E. A. Buckland. (*Wireless World*, 2nd June, 1933, Vol. 32, p. 389.)

A description is given of a 16–mm equipment using the sound-on-film process.

The Advantages of the Light-Weight Crystal Microphone for Sound Picture Recording [Carried on Fishing Rod].—(*Electronics*, April, 1933, Vol. 6, No. 4, p. 102: paragraph only.)

Akustiska Problem vid Studiolokaler för Rundradio (The Acoustic Problem in Broadcasting Studios [Convergent Walls, Stockholm and Malmö Studios, etc.]).—S. Lemoine. (*Teknisk Tidskr.*, June, 1933, Vol. 63, No. 22, pp. 81–87.)

Schall- und Schwingungsdämmung im Hochbau (The Deadening of Sound and Vibration in High Buildings).—W. Genest. (*Zeitschr. V.D.I.*, 22nd April, 1933, Vol. 77, No. 16, pp. 427–428.)

Transmit "Auditory Perspective" in Music: Bell Laboratories cooperate with Dr. Stokowski's Orchestra in 16 000–Cycle Fidelity at Ten-fold Volume.—(*Electronics*, May, 1933, Vol. 6, No. 5, pp. 118–120.) *See* also July Abstracts, pp. 396 and 396–397.

The Design of Filters for Carrier Programme Circuits [and the Use of Quartz Crystals in obtaining the Necessary Side-Band Suppression].—F. Ralph. (*Elec. Communication*, April, 1933, Vol. 11, No. 4, pp. 204–207.)

A New Criterion of Circuit Performance [New Performance "Unit" obtained by Dividing Interval between "No Performance" and "Perfect Performance" into 100 Equal Parts: Effects of any Particular Technique Eliminated].—J. Collard. (*Elec. Engineering*, April, 1933, Vol. 11, No. 4, pp. 226–233.)

The Advantages and Disadvantages of the Articulation, Intelligibility, and Repetition Rate Techniques.—Collard. (*See* preceding reference.)

Scales of Loudness.—B. G. Churcher and A. J. King. (*Nature*, 27th May, 1933, Vol. 131, p. 760.)

A preliminary letter giving a table of average figures for the relation between decibels above the threshold of audibility at 800 c/s and loudness deduced from 2 : 1 and 4 : 1 estimates of intensity made by 30 different individuals.

COSTRUZIONE E PROVE DI GENERATORI A FREQUENZA ACUSTICA (Construction and Tests of Audio-frequency Generators).—S. Rosani. (*L'Elettrotec.*, 15th Feb., 1933, Vol. 20, No. 5, pp. 102–104.)

AUDIO-FREQUENCY CONSTANTS OF CIRCUITS AND TELEPHONE LINES [by Mallett's Methods, for Frequencies 3–12 kc/s].—S. P. Chakravarti. (*Journ. I.E.E.*, May, 1933, Vol. 72, No. 437, pp. 416–422.)

EMPFINDLICHE RAYLEIGH-SCHEIBEN FÜR SCHALLMESSUNGEN (Sensitive Rayleigh Discs for Acoustic Measurements).—W. Grösser. (*Archiv f. Elektrot.*, 2nd May, 1933, Vol. 27, No. 5, pp. 329–334.)

Long rectangular discs are recommended instead of the circular ones hitherto used. The tuning moment exerted by sound waves on such a disc is calculated.

SUPERSONIC WAVES: EXPRESSIONS FOR ENERGY TRANSMISSION AND DECAY OF AMPLITUDE WITH DISTANCE DUE TO VISCOSITY AND HEAT CONDUCTION.—P. Biquard. (*Sci. Abstracts, Sec.A*, Jan., 1933, Vol. 36, No. 421, p. 78.)

APPLICATIONS OF SUPERSONICS, INCLUDING DEPTH SOUNDING AND SUBMARINE SIGNALLING.—C. Florisson and F. Vecchiacchi. (*Sci. Abstracts, Sec.B*, Jan., 1933, Vol. 36, No. 421, pp. 67–68: Internat. Elec. Congress Paper.)

UNSUCCESSFUL TESTS ON THE TRANSMISSION OF AN ULTRASONIC BEAM THROUGH AIR.—G. S. Field. (*National Research Council, Canada*, Fifteenth Annual Report, 1931–1932, p. 55.)

ÜBER EINIGE VERSUCHE ZUR BEUGUNG DES LICHTES AN ULTRASCHALLWELLEN (Some Experiments on the Diffraction of Light by Ultrasonic Waves [in Liquids]).—R. Bär and E. Meyer. (*Physik. Zeitschr.*, 15th May, 1933, Vol. 34, No. 10, pp. 393–396.) *See* also Debye, March Abstracts, p. 167, r-h column.

PHOTOTELEGRAPHY AND TELEVISION

PHOTOTELEGRAPHY OF HALF-TONE PICTURES BY MULTIPLE MODULATION OF A SHORT WAVE.—(*Hochf:tech. u. Elek:akus.*, March, 1933, Vol. 41, No. 3, p. 112: German Pat. No. 563 071, pub. 3rd Nov., 1932, Telefunken and Schröter.)

Each group of tone values has a modulation frequency allotted to it, which is set in action when the light spot of an oscillograph falls on the particular one of a row of photocells. The oscillograph deflection is controlled by the intensity of the light falling on the scanning photocell.

DIE ERSTEN UKW-FERNSEH-EMPFÄNGER AUF DEM MARKT (The First Ultra-Short-Wave Television Receiver on the Market [Te-Ka-De Receiver]).—F. Noack. (*Radio, B., F. für Alle*, March, 1933, pp. 101–103.)

THE ICONOSCOPE—A MODERN VERSION OF THE ELECTRIC EYE [Photo-Sensitive Surface scanned by Cathode-Ray Beam].—V. K. Zworykin. (*Proc. Inst. Rad. Eng.*, June, 1933, Vol. 21, No. 6, p. 755: abstract of I.R.E. Convention paper.)

DIE VERZERRUNGEN DURCH DIE RAUMLADUNG IN DER BRAUNSCHEN RÖHRE (Distortions caused by the Space Charge in Cathode-Ray Tubes [and the Use of a Bent Tube]).—E. Hudec. (*E.N.T.*, May, 1933, Vol. 10, No. 5, pp. 215–220.)

The movement of the light spot in cathode-ray television is controlled by two trip voltages, a rapid one for the "line" deflection and a slow one for the "picture" deflection. The return-stroke of the line deflection is invisible on account of its speed and the consequent feeble luminosity; the return-stroke of the "picture" deflection is rapid in comparison with its forward motion, but is slow enough to be of the same order as the forward motion of the quick "line" deflection, and if allowed to remain in the picture is conspicuous as a bright line down one edge. This can be avoided by taking it outside the frame by making the long synchronising impulse for the "picture" deflection act also on the trip potential for the "line" deflection.

After this preliminary discussion the writer goes on to describe the occurrence of a central "cross," brighter than the rest of the picture and stretching from side to side and from top to bottom, which becomes more and more prominent as the working ray current of a gas-filled tube increases from 0.05 to 0.2 mA (Fig. 3, *a* to *c*, where the current is varied by increasing the Wehnelt cylinder potential). The appearance of this "cross" is accompanied by an increase in the thickness of, and a decrease in the spacing between, the lines in the middle of the picture, so that apart from the defect of the cross itself the centre of the picture suffers distortion. Such distortion can also occur when the tube is used as an oscillograph, but the trouble is not so marked in this case because a less bright spot, and consequently a smaller ray current, can be used. The writer discusses the causes of the "cross" and the distortion: the changes in the line spacing and thickness are due to the space charge between the deflecting plates; the ions produce a subsidiary field which distorts the main field in the manner shown in Fig. 5. The greater the potentials causing the main field, the smaller the effect of the ion field: it is when the deflecting potentials are small that the thickening, etc. of the lines occur. This accounts for the formation of the central "cross" of Fig. 3, discussed above; for in the tube employed the ray was deflected *in both directions*, so that the deflecting potential was zero in the middle. To avoid these troubles, therefore, each deflection must be in one direction only, so that the zero potential is at the extreme edge of the picture: *this means that the position of rest of the spot must be at one corner of the picture.*

In order to obtain this result while still making full use of the screen area, the German Post Office have developed a bent container, the conical part of which is at a slight angle to the short cylindrical neck containing the electrode system. This arrangement brings the spot, in its central, "rest" position, close to the corner of the screen (Figs. 8, 9 and 10). Fig. 11 shows the good result obtained.

Another way of bringing the distortion to the edge of the picture is to employ a pair of auxiliary deflecting plates, at an angle to both the main pairs and carrying a constant d.c. potential which brings the ray from its central position S to a "corner" position S' (Fig. 12). But this plan has certain defects which decrease the sensitivity, and better results are obtained with *two* pairs of auxiliary plates. In Fig. 14, obtained with this arrangement, the return stroke of the slow trip potential is seen crossing the picture. This can be suppressed as in the previous records, but the simplest plan is to darken the picture at the transmitter during this instant.

THE THUN "LINE CONTROL" SYSTEM [Variable Speed Scanning].—(German Pat. No. 563 294, pub. 3rd Nov., 1932, Thun.) *See* 1932 Abstracts, pp. 44, r-h column; also January, pp. 46–47.)

SCANNING DISC WITH TWO-TURN SPIRAL, COMBINED WITH HALF-SPEED DISC WITH SPIRAL WINDOW: SMALL DIAMETERS WITHOUT LOSS OF BRIGHTNESS.—(*Rev. Gén. de l'Élec.*, 1st April, 1933, Vol. 33, No. 13, p. 101 D: French Pat. No. 739 644, pub. 14th Jan., 1933, Barthélemy.)

PHOTOCELL AND AMPLIFIER COMBINATION WITH VERY SHORT OR NO CONNECTING LEADS, BY USE OF VALVE WITH EXTERNAL CONTROL ELECTRODE.—(*Hochf: tech. u. Elek: akus.*, May, 1933, Vol. 41, No. 5, p. 188: German Pat. No. 568 093, pub. 14th Jan., 1933, Tonbild-Syndikat.)

PHOTOCELLS AND THEIR APPLICATIONS.—V. K. Zworykin and E. D. Wilson. (Book Review in *Review Scient. Instr.*, May, 1933, Vol. 4, No. 5, p. 316.)

THE [Constant Quantic] EFFICIENCY OF FLUORESCENCE OF SODIUM SALICYLATE [in connection with the Construction of a Photoelectric Cell for Ultra-Violet Light].—P. Dubouloz. (*Comptes Rendus*, 24th April, 1933, Vol. 196, No. 17, pp. 1221–1222.) *See* 1932 Abstracts, p. 422, r-h column.

THE USE OF COLOUR FILTERS, CONTROLLING PART ONLY OF SENSITIVE SURFACE, TO MAKE SPECTRAL SENSITIVITY OF PHOTOELECTRIC CELL SIMILAR TO THAT OF THE EYE.—A. Dresler. (*E.T.Z.*, 18th May, 1933, Vol. 54, No. 20, pp. 476–477: summary only.)

EXPERIMENTS ON THE SUITABILITY OF SOME RECTIFIER PHOTO CELLS FOR THE MEASUREMENT OF DAYLIGHT [Auger, Serpidox, Siemens and Halske, Westinghouse, Bergmann Selenium, etc.].—H. H. Poole and W. R. G. Atkins. (*Electrician*, 9th June, 1933, Vol. 110, No. 2871, pp. 737–738.)

NON-ADDITIVE EFFECT OF DIFFERENT RADIATIONS ON COPPER OXIDE PHOTOCELLS.—C. Lapique. (*Comptes Rendus*, 1st May, 1933, Vol. 196, No. 18, pp. 1301–1303.)

Leading from the researches on the sensitivity of these cells (1931 Abstracts, p. 621, r-h col.) the tests here described show that if a radiation of wavelength greater than 650 $m\mu$, acting alone, produces a current i_1, and another radiation of wavelength between 450 and 650 $m\mu$, also acting alone, produces a current i_2, the two radiations acting together produce a current greater than $i_2 + i_1$: there is a positive supplementary effect even if i_1 is negative (owing to the inverse photoelectric effect which occurs in that part of the spectrum). This supplementary sensitivity varies considerably in magnitude from one cell to another, but not in characteristic form nor in its position in the spectrum. In particular, it begins markedly at about 450 $m\mu$, just where the ordinary sensitivity curve always shows a bend which appears to indicate the superposition of two photoelectric effects, the one general and the other more selective. Apparently the more selective effect is amplified by the presence of the longer wave, while the other effect is not altered. The clearly selective character of the supplementary sensitivity shows that it cannot be attributed to a simple variation of the internal resistance of the cell.

ÜBER DAS VERHALTEN VON SPERRSCHICHT-PHOTOZELLEN BEI BELICHTUNG MIT RÖNTGENSTRAHLEN (The Behaviour of Barrier-Layer Photocells illuminated by X-Radiation).—K. Scharf and O. Weinbaum. (*Physik. Zeitschr.*, 1st April, 1933, Vol. 34, No. 7, p. 283.)

A note on experiments, the full paper on which has already been referred to in May Abstracts, pp. 277–278.

REVERSAL OF CURRENT IN RECTIFIER PHOTO-CELLS.—H. H. Poole and W. R. G. Atkins: Guild. (*Nature*, 15th April, 1933, Vol. 131, pp. 547–548.)

A reply to the letter by Guild dealt with in May Abstracts, p. 277, r-h column.

A NEW TYPE OF PHOTOELECTRIC EFFECT IN CUPROUS OXIDE IN A MAGNETIC FIELD.—I. Kikoin and M. Noskow. (*Nature*, 20th May, 1933, Vol. 131, pp. 725–726.)

A preliminary account of an effect of light incident perpendicularly on a plate immersed in liquid air, placed in a magnetic field parallel to its plane; an e.m.f. is produced in the plate perpendicular to the direction of the light and of the magnetic field. Its magnitude is proportional to the field strength, up to fields of about 2 500 gauss, and the direction of supposed flow of the negative electrons coincides with the direction of the light beam. The effect disappears completely when red light is used and is not found at room temperatures.

THE DISCONTINUITIES OF POTENTIAL AT THE CONTACT OF A SEMI-CONDUCTOR AND A METALLIC ELECTRODE.—G. Déchêne. (*Comptes Rendus*, 22nd May, 1933, Vol. 196, No. 21, pp. 1577–1579.)

THE RESPONSE OF BARRIER-LAYER PHOTO-CELLS TO X-RAYS.—P. R. Gleason. (*Phys. Review*, 1st May, 1933, Series 2, Vol. 43, No. 9, pp. 775–776: abstract only.)

PHOTOELECTRIC EFFECT IN CUPRITE SINGLE CRYSTALS.—R. Deaglio: Dember. (*Comptes Rendus*, 1st May, 1933, Vol. 196, No. 18, pp. 1303–1305.)

Experiments on the internal photoelectric effect ("crystal photoeffect": Dember, 1932 Abstracts, pp. 232 and 291, l-h columns) in crystals of cuprite, leading to the conclusion that Dember's interpretation on electronic lines is wrong and that the phenomenon is due to the property possessed by cuprite of acquiring an electrolytic conductivity on illumination.

ÜBER DEN PHOTOEFFEKT IN CUPRITKRISTALLEN (The Photoelectric Effect in Cuprite Crystals).—Anna Joffé and A. Joffé. (*Zeitschr. f. Physik*, 1933, Vol. 82, No. 11/12, pp. 754–758.)

In the experiments of which this is a preliminary description it was found that the potential distribution in an illuminated crystal does not agree with the diffusion theory; nor does the variation of photo-electromotive force agree with the intensity of the light. The phenomena can, however, all be explained on the assumption that the photoelectric current is carried by electrons of other energy levels than those forming the current in the absence of illumination.

ÜBER DEN LICHTELEKTRISCHEN EFFEKT IN BESONDERER AKTIVER SCHICHT DER KARBORUNDKRISTALLE (The Photoelectric Effect in a Particular Active Layer of the Carborundum Crystal).—O. W. Lossew. (*Physik. Zeitschr.*, 15th May, 1933, Vol. 34, No. 10, pp. 397–403.)

A continuation of work already referred to in 1932 Abstracts, p. 108, r-h column.

PAPERS ON PHOTOVOLTAIC CELLS OF SALTS OF COPPER.—R. Audubert. (*Comptes Rendus*, 8th and 22nd May, 1933, Vol. 196, Nos. 19 and 21, pp. 1386–1387 and 1588–1590.)

Researches giving quantitative confirmation of the writer's theory of photovoltaic actions (Abstracts, May, p. 278, l-h column; *also* 1932, p. 470, r-h column).

THE INTERNAL PHOTOELECTRIC EFFECT IN LIQUID DIELECTRICS.—G. Liandrat. (*Comptes Rendus*, 8th May, 1933, Vol. 196, No. 19, pp. 1385–1386.)

THE RÔLE OF COLOURING MATTER IN PHOTOVOLTAIC PHENOMENA.—C. Stora. (*Rev. Gén. de l'Élec.*, 27th May, 1933, Vol. 33, No. 21, p. 698: long summary.)

THE PHOTOELECTRIC SENSITIVITY OF MAGNESIUM.—R. J. Cashman and W. S Huxford. (*Phys. Review*, 15th May, 1933, Series 2, Vol. 43, No. 10, pp. 811–818.)

PHOTOELECTRIC PROPERTIES OF MAGNESIUM.—G. Déjardin and R. Schwégler. (*Comptes Rendus*, 22nd May, 1933, Vol. 196, No. 21, pp. 1585–1587.)

Including criticisms of the results of de Laszlo (1932 Abstracts, p. 470).

ELEKTRONENBEUGUNG UND LICHTELEKTRISCHE WIRKUNG AN ALKALIMETALLOBERFLÄCHEN (Electron Diffraction and Photoelectric Effect at Alkali Metal Surfaces).—W. Kluge and E. Rupp. (*Zeitschr. f. Physik*, 1933, Vol. 82, No. 9/10, pp. 568–583.) Continuation of work referred to in 1932 Abstracts, p. 649, l-h col. *See* also pp. 232–233.

VARIATION OF PHOTOELECTRIC EFFICIENCY WITH WORK FUNCTION IN THE EXTREME ULTRA-VIOLET.—C. Kenty. (*Phys. Review*, 1st May, 1933, Series 2, Vol. 43, No. 9, p. 776: abstract only.)

THEORY OF THE ENERGY DISTRIBUTION OF PHOTO-ELECTRONS.—L. A. Du Bridge. (*Phys. Review*, 1st May, 1933, Series 2, Vol. 43, No. 9, pp. 727–741.)

UNTERSUCHUNG ÜBER DEN INNEREN LICHTELEKTRISCHEN EFFEKT AN METALLEN (Investigations of the Internal Photoelectric Effect in Metals).—R. Schulze. (*Physik. Zeitschr.*, 1st May, 1933, Vol. 34, No. 9, pp. 381–385.)

The internal photoelectric effect for various metals in the thinnest possible film was measured; measurements with varying directions of incidence of light also gave increased current in the direction of the light.

EIN BEITRAG ZUR BESTIMMUNG DES REFLEXIONSVERMÖGENS VON METALLEN IM SICHTBAREN UND IM ULTRAVIOLETT (Contribution to the [Experimental] Determination of the Reflection Coefficients of Metals for Visible and Ultra-Violet Light [including Photoelectric Method for Ultra-Violet Light]).—K. von Fragstein. (*Ann. der Physik*, May, 1933, Series 5, Vol. 17, No. 1, pp. 1–21.)

ENERGY DISTRIBUTION OF PHOTOELECTRONS FROM ZINC SURFACES.—N. E. Bradbury. (*Phys. Review*, 15th March, 1933, Series 2, Vol. 43, No. 6, p. 502: abstract only.)

ÜBER DIE KLASSISCHE VERTEILUNG DER ELEKTRONEN IM PHOTOELEKTRISCHEN EFFEKT DER RÖNTGENSTRAHLEN (On the Classical Distribution of Electrons in the Photoelectric Effect of X-Rays [Theoretical Investigation]).—J. Kunz. (*Physik. Zeitschr.*, 1st March, 1933, Vol. 34, No. 5, pp. 219–220.)

ERHALTUNG DER ENERGIE UND DES IMPULSES IM PHOTOELEKTRISCHEN EFFEKT (Conservation of Energy and Impulse in the Photoelectric Effect [Theoretical Investigation]).—J. Kunz. (*Physik. Zeitschr.*, 1st March, 1933, Vol. 34, No. 5, pp. 218–219.)

LICHTELEKTRISCHE LEITUNG UND ABSORPTION DER LENARDPHOSPHORE IM ROTEN UND ULTRAROTEN SPEKTRALGEBIET (Photoelectric Conduction and Absorption in Lenard Phosphorescent Materials [*e.g.* CaSBi, CaS, ZnS with or without fluxes] in the Red and Infra-Red Regions of the Spectrum).—L. Weber. (*Ann. der Physik*, 1933, Series 5, Vol. 16, No. 7, pp. 821–843.)

DER EINFLUSS DER MATERIE AUF LANGSAMSTE ELEKTRONEN NACH LICHTELEKTRISCHEN UNTERSUCHUNGEN (The Influence of Matter on Very Slow Electrons, investigated Photoelectrically).—G. Lang. (*Ann. der Physik*, 1933, Series 5, Vol. 16, No. 7, pp. 781–792.)

MEASUREMENTS AND STANDARDS

ON SOME NEW FORMULAE FOR THE CALCULATION OF SELF AND MUTUAL INDUCTION OF COAXIAL CIRCULAR COILS IN TERMS OF ARITHMETICO-GEOMETRICAL SCALES.—L. V. King. (*Phil. Mag.*, June, 1933, Series 7, Vol. 15, No. 102, pp. 1097–1114.)

The writer uses well-known results from the theory of gravitational attractions to obtain highly convergent expressions for the self and mutual induction of various arrangements of coaxial circular coils and develops useful computational forms for direct accurate calculations without reference to tables of elliptic integrals.

ON THE USE OF ARITHMETICO-GEOMETRIC MEAN SERIES FOR THE CALCULATION OF ELLIPTIC INTEGRALS, WITH SPECIAL REFERENCE TO THE CALCULATION OF INDUCTION.—F. W. Grover. (*Phil. Mag.*, June, 1933, Series 7, Vol. 15, No. 102, pp. 1115–1133.)

This paper illustrates the use for numerical calculation of the formulae developed in the paper referred to above.

THE SELF AND MUTUAL INDUCTANCES OF LONG CONCENTRIC MULTI-LAYER SOLENOIDS.—P. Janet. (*Rev. Gén. de l'Élec.*, 13th May, 1933, Vol. 33, No. 19, pp. 619–623.)

"The expression given in a classic work and reproduced in a certain number of formulae for the self inductance of a long multi-layer solenoid being erroneous, I think it useful to give here the exact value": for this the writer derives the formula

$$L = 2/3 \,.\, \pi^2 n^2/l \,.\, (b^2 + 2ab + 3a^2),$$

where n is the total number of turns and a and b are the internal and external radii of the winding. Dealing similarly with the various cases of two concentric solenoids, he finds formulae for the mutual inductances, and shows that the erroneous self-inductance formula referred to above

$$(L = 4/3 \,.\, \pi^2 n^2/l \,.\, (b^2 + ab + a^2))$$

was due to its derivation from the mutual-inductance formula for concentric solenoids one inside the other, having no part in common; it should have been derived from the case where one winding encroaches on, or is entirely embedded in, the other winding.

INTERNATIONAL ACTION ON UNITS IN ELECTRICITY AND LIGHT.—Bureau of Standards. (*Journ. Franklin Inst.*, April, 1933, Vol. 215, No. 4, pp. 471–476.)

This note gives the formal recommendations on electrical units and standards and on photometry to be submitted to the International Committee on Weights and Measures.

DIMENSIONS OF FUNDAMENTAL UNITS.—F. M. Denton. (*Nature*, 22nd April, 1933, Vol. 131, p. 585.)

This letter answers various recent letters on the subject in the same journal, and gives arguments for regarding "magnetic pole" as a unit derived from "electric charge" rather than as an independent unit.

A NEW SYSTEM OF ELECTRIC AND MAGNETIC UNITS, AND THEIR DIMENSIONS.—H. Bucher. (*Rev. Gén. de l'Élec.*, 20th May, 1933, Vol. 33, No. 20, pp. 665–666.)

A NEW EXPOSITION OF ELECTROMAGNETIC PHENOMENA: THE USELESSNESS OF THE IDEA OF MAGNETIC MASS.—N. Vasilesco-Carpen. (*Rev. Gén. de l'Élec.*, 6th May, 1933, Vol. 33, No. 18, pp. 585–586.)

DUE CONFRONTI SIGNIFICATIVI SULL' USO DELLE UNITÀ ASSOLUTE M.K.S.Ω (Two Significant Comparisons of the Use of the Absolute Unit M.K.S.Ω [and of the orthodox C.G.S. Unit: Calculations of the Capacity of the Earth and the Inductance of a Coil]).—G. Giorgi. (*L'Elettrotec.*, 25th Feb., 1933, Vol. 20, No. 6, p. 125.)

THE SIMPLIFICATION OF ACCURATE MEASUREMENT OF RADIO-FREQUENCY.—W. H. F. Griffiths. (*Wireless Engineer*, May and June, 1933, Vol. 10, Nos. 116 and 117, pp. 239–247 and 299–306.)

The development of harmonic wavemeters: a variable frequency resonant circuit of great stability and calibration permanence (with thermal expansion compensation—1930 Abstracts, pp. 52–53 and 112): the development of a simple dynatron oscillating wavemeter: the selection of valves and operating conditions: the effect of the valve upon frequency, etc.

PRACTICAL MEASUREMENT OF ULTRA-SHORT WAVES.—C. C. Whitehead. (*World-Radio*, 2nd and 9th June, 1933, Vol. 16, Nos. 410 and 411, pp. 747 and 774–775: to be continued.)

A WAVEMETER WITH ALTERNATIVE CLOSE AND OPEN SCALES.—Radio Research Station, Slough. (*Wireless Engineer*, May, 1933, Vol. 10, No. 116, pp. 255–257.)

Authors' summary:—"An absorption wavemeter is described which can be used (*a*) with a wide frequency scale, (*b*) with a restricted range and correspondingly greater openness of scale. Observations are made on the calibration of such wavemeters, and their use in connection with receiving apparatus. The use of the principle in receiver tuning is noted." The normal, wide-range condition is "opened up" by the introduction of two fixed condensers, one in series with a tuning condenser and the other across the series of two thus formed, and therefore also across the fixed inductance. When a grid-current meter is not used, the "double beat" method is employed (Colebrook, 1932 Abstracts, p. 175, l-h column). *Cf.* and contrast Rohde and Schwarz, Jan. Abstracts, p. 49, r-h column.

CONTRIBUTION TO THE STUDY OF THE STABILITY OF OSCILLATIONS IN COUPLED CIRCUITS [*e.g.* in Oscillating Circuit coupled to Wavemeter].—Mercier. (*See* under "Properties of Circuits.")

NEW RADIO TEST OSCILLATOR [with High Frequency Stability due to "Electron-Coupled" Circuit].—(*Rad. Engineering*, May, 1933, Vol. 13, No. 5, p. 26.)

CRYSTAL-CONTROLLED CLOCK WITH QUARTZ VIBRATING AT SUCH A LOW RATE AS TO REQUIRE NO FREQUENCY REDUCTION.—Sollenberger. (*Sci. News Letter*, 27th May, 1933, Vol. 23, No. 633, p. 325.)

A STANDARD OF RADIO FREQUENCY [Quartz-Driven Clock: the Necessity of devising a Ball Thrust Bearing to replace the Jewel Bearing].—W. A. Steel. (*National Research Council, Canada*, Fifteenth Annual Report, 1931–1932, p. 42.)

"The accuracy of the frequency of the crystal has at all times been better than one part per million and has been held to within 3 parts in 10 million for periods of a month at a time."

POSSIBLE ERRORS IN LONGITUDE DETERMINATIONS DEPENDING ON THE APPARENT PROPAGATION VELOCITY OF SHORT WAVES.—Stoyko and Jouaust. (*See* abstracts under "Propagation of Waves.")

A MULTIPLE INTERFEROMETER FOR ANALYSING THE VIBRATIONS OF A QUARTZ PLATE.—H. Osterberg. (*Phys. Review*, 15th May, 1933, Series 2, Vol. 43, No. 10, pp. 819–829.)

"This interferometer combines in a convenient form six interferometers for measuring the relative motion of any two plane surfaces of the vibrating plate."

HIGH-FREQUENCY MEASUREMENTS.—A. Hund. (Book Review in *Review Scient. Instr.*, May, 1933, Vol. 4, No. 5, pp. 316–317.)

FIELD-STRENGTH MEASURING SET FOR MOTOR-CAR TRANSPORT, AND RESULTS OBTAINED.—David. (*See* reference under "Propagation of Waves.")

THE MEASUREMENT OF THE POWER FACTOR AND CAPACITANCE OF A CONDENSER BY COMPARISON WITH A MUTUAL INDUCTANCE [using 1 000 c/s Mains and giving Great Accuracy].—A. W. Smith. (*Review Scient. Instr.*, May, 1933, Vol. 4, No. 5, pp. 280–284.)

The secondary of the mutual inductance is in the telephone bridge circuit and carries zero current. A Wagner ground circuit gives complete silence at the balance point. The final balance is obtained by adjusting a small variable self-inductance in series with the primary of the mutual inductance: for a given capacitance and frequency the value of this self-inductance is directly proportional to the power factor of the condenser.

SOME IMPORTANT APPLICATIONS OF THE A.C. POTENTIOMETER WITH CAPACITIVE POTENTIAL DIVISION [and the Measurement of the Loss Angles of Dielectrics at High Voltages].—A. M. Angelini. (*L'Elettrotec.*, 5th Feb., 1933, Vol. 20, No. 4, pp. 77–81.)

A METHOD OF AUTOMATIC COMPENSATION OF POTENTIALS AND ITS APPLICATION TO DETERMINING THE POTENTIAL DISTRIBUTION IN L.F. ELECTRIC FIELDS.—S. Dunikowski. (*Rev. Gén. de l'Élec.*, 3rd June, 1933, Vol. 33, No. 22, pp. 719–727.)

DEGREE OF MODULATION MEASURED BY TWO-VALVE VOLTMETERS, ONE WITH PARABOLIC CHARACTERISTIC AND THE OTHER ACTING AS LINEAR RECTIFIER.—(*Hochf:tech. u. Elek: akus.*, March, 1933, Vol. 41, No. 3, pp. 110–111: German Pat. No. 561 190, pub. 11th Oct., 1932, Wigge.)

DETERMINATION OF THE CHEMICAL COMPOSITION OF LIQUIDS BY ELECTRICAL RESISTANCE MEASUREMENTS [Using the Geyger "Iron Ring Quotient Meter"].—W. Geyger. (*Zeitschr. V.D.I.*, 13th May, 1933, Vol. 77, No. 19, pp. 507–508.

TEILWEISE AUFHEBUNG DER MITTELWERTBILDUNG BEI MESSINSTRUMENTEN (The Partial Elimination of the Averaging Effect ["Smoothing" due to Inertia] of Measuring Instruments).—E. Gschwind and W. Lohmann. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 14, 1933, pp. 169–172.)

ASTATIC PRECISION METERS FOR CURRENT, VOLTAGE AND POWER.—Siemens & Halske. (*E.T.Z.*, 18th May, 1933, Vol. 54, No. 20, pp. 475–476.)

SUBSIDIARY APPARATUS AND MATERIALS

UN FRÉQUENCEMÈTRE ENREGISTREUR À CONSTANTE DE TEMPS (A Recording Frequency Counter depending on the Time Constant of a Circuit [Counter for Atmospherics, Tachometer, etc.])—J. Lugeon and J. Gurtzman. (*L'Onde Élec.*, Feb., 1933 [publication delayed], Vol. 12, No. 134, pp. 71–83.)

The process whose frequency is to be measured is made to work a relay with front and back contacts.

With the armature in repose the back contact connects a condenser C_1 to a source of d.c. potential V; the arrival of an impulse first breaks this contact and then makes the front contact, which connects the charged condenser across a second, much larger, condenser C_2, shunted by a recording milliammeter of resistance R. The values for the components of an equipment for recording the average number of atmospherics per minute are as follows :—

$$V = 10\text{ v}, C_1 = 50\,\mu\text{F}, C_2 = 40\,000\,\mu\text{F}, R = 900\text{ ohms}.$$

The bulk of the paper is taken up with the mathematical proof that the milliammeter reading is a simple function of the frequency of the relay movements. A specimen record of atmospherics is given, below a simultaneous record taken on the more complex "atmoradiograph" with Richard cinemograph, previously used (1930 Abstracts, pp. 502–503.)

HIGH-SPEED CATHODE-RAY OSCILLOGRAPHIC RECORDING ON COMMERCIAL PHOTOGRAPHIC PAPER.—I. Stekolnikoff: Förster. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 14, 1933, p. 254.)

Referring to Förster's paper dealt with in 1932 Abstracts, p. 596, l-h col., the writer points out that with his oscillograph described in *Westnik Elektrotechniki*, 1931, p. 43 [*see* also 1932 Abstracts, p. 277, l-h column] he obtained recording speeds up to 5 000 km/sec. on commercial photographic paper.

EIN KATHODENSTRAHLOSZILLOGRAPH ZUR UNMITTELBAREN AUFNAHME SEHR HOHER GLEICH- UND WECHSEL-SPANNUNGEN (A Cathode-Ray Oscillograph for Direct Photography of Very High Direct and Alternating Voltages [of the order of 100 kv]).—M. Messner. (*Archiv f. Elektrot.*, 2nd May, 1933, Vol. 27, No. 5, pp. 335–340.)

A new deflecting system, contained in a special high-voltage chamber, is described.

RECENT DEVELOPMENTS IN CATHODE-RAY TUBES AND ASSOCIATED APPARATUS [including Cathautograph and Cathode-Ray Compass].—A. B. Du Mont. (*Rad. Engineering*, March and April, 1933, Vol. 13, Nos. 3 and 4, pp. 15–19 and 19–20 and 23.)

NEW CATHODE-RAY TUBE SCREEN MATERIAL.—Du Mont Laboratories. (*Electronics*, April, 1933, Vol. 6, No. 4, p. 113.)

". . . produces a spot intensity five times as brilliant as any screen previously used . . . A unique feature . . . is the ability to retain for well over a minute any wave or figure applied to it when used in a darkened room or hood. This feature, however, in no way affects the use of the tube for ordinary oscillograph use or photographic recording, because of the large difference between the spot intensity and the after-glow." No details are given.

LIAISON BETWEEN THE TWO GENERAL METHODS OF PREPARING PHOSPHORESCENT ZINC SULPHIDE.—R. Coustal. (*Comptes Rendus*, 1st May, 1933, Vol. 196, No. 18, pp. 1306–1307.)

THE LUMINESCENCE OF ALKALINE EARTH TUNGSTATES CONTAINING LEAD.—F. E. Swindells. (*Journ. Opt. Soc. Am.*, April, 1933, Vol. 23, No. 4, pp. 129–132.)

THE PREPARATION OF METALLIC TUNGSTATES [and the Advantage of the Presence of an Alkaline Chloride].—A. Karl. (*Comptes Rendus*, 8th May, 1933, Vol. 196, No. 19, pp. 1403–1404.)

THE EFFICIENCY OF FLUORESCENCE OF SODIUM SALICYLATE.—P. Doubouloz. (*Comptes Rendus*, 24th April, 1933, Vol. 196, No. 17, pp. 1221–1222.)

ZUR THEORIE DER GASKONZENTRATION VON ELEKTRONENSTRAHLEN (Theory of the Gas Concentration of Electron Beams).—O. Scherzer. (*Zeitschr. f. Physik.*, 1933, Vol. 82, No. 11/12, pp. 697–708.)

Author's summary :—This paper contains a mathematical investigation of stationary conditions of gas-concentrated electron beams under simplifying assumptions. It is found that, if the distribution of electrons over the cross-section of the beam is given, the density distribution of the ions which concentrate the beam is also given. In the special case of the beam with nodes, the electron and ion densities are constant over the whole cross-section; the equation connecting them is given. The distance between two nodes is found to be always greater than $\pi/\epsilon p \cdot \sqrt{m_-/m_+}$ where ϵp is the probability of ionisation and m_-/m_+ the ratio electron mass/ion mass. It is shown how a layer of positive charge in a plasma surrounds itself with a region of negative space-charge.

DISTORTIONS DUE TO SPACE CHARGE IN CATHODE-RAY TUBES.—Hudec. (*See* under "Phototelegraphy and Television.")

ÜBER DIE OPTIK DER BRAUNSCHEN NIEDERSPANNUNGSRÖHRE (The Optics of the Braun Low-Voltage [Cathode-Ray] Tube).—E. Brüche. (*Archiv f. Elektrot.*, 10th April, 1933, Vol. 27, No. 4, pp. 266–274.)

Author's summary :—The electrode system of a low voltage oscillograph, working with gas concentration, must be regarded as an arrangement similar to the electron microscope. The enlarged image of the cathode produced by this system on the fluorescent screen is diminished to an illuminated point by the effect of the optics of gas concentration. This way of regarding a Braun low-voltage tube is demonstrated by experiments with an A.E.G. oscillograph, and a number of conclusions are drawn which may be experimentally confirmed and are of interest in the construction of oscillographs.

ZUR THEORIE DER ELEKTRONENOPTIK (On the Theory of Electron Optics).—J. Picht: Scherzer. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 14, 1933, pp. 239–241.)

Showing that the writer's formula for the focal length of an "electrical lens" (Abstracts, April, p. 224, r-h col.) is identical with that found independently by Scherzer (*ibid.*, same col.). Both formulae are second approximations, and the writer now derives a closer approximation for focal length and for the position of the principal points.

ELECTRON OPTICS: ON ELECTRON BEAMS IN HIGH VACUUM.—C. J. Davisson: V. K. Zworykin. (*Phys. Review*, 1st May, 1933, Series 2, Vol. 43, No. 9, pp. 777 and 778–779: abstracts only of Surveys.)

SYMPOSIUM ON ELECTRON OPTICS.—Davisson, Farnsworth, Swann and Danforth, Zworykin. (*Journ. Opt. Soc. Am.*, May, 1933, Vol. 23, No. 5, pp. 190–192: summaries only.)

THE EFFECTIVENESS OF PHOTOGRAPHIC LAYERS IN SPECTROGRAPHY OF ALL WAVELENTHS [including Cathode Rays: a Survey].—J. Eggert. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 14, 1933, pp. 177–186.)

VAPOUR PRESSURE OF VACUUM CEMENTS.—R. M. Zabel. (*Review Scient. Instr.*, April, 1933, Vol. 4, No. 4, pp. 233–234.)

NOTES ON THE MANUFACTURE OF MERCURY VAPOUR RECTIFIER TUBES.—P. G. Weiller. (*Electronics*, April, 1933, Vol. 6, No. 4, pp. 99–101.)

The coating process: use of netting as filament base: relation between gas pressure and life: " long life, the reward of many items."

THE IMPORTANCE OF TEMPERATURE REGULATION IN THE USE OF MERCURY VAPOUR RECTIFIERS, AND A DEVICE FOR THIS PURPOSE.—C. Stansbury and G. C. Brown. (*Electronics*, April, 1933, Vol. 6, No. 4, p. 104.)

THE SINGLE-TUBE THYRATRON INVERTER [and Its Applications, particularly as Generator of Saw-Tooth Voltage for Linear Time Base or Spot-Welding Control].—O. W. Livingston and H. W. Lord. (*Electronics*, April, 1933, Vol. 6, No. 4, pp. 96–98.)

CALCULATIONS ON THYRATRONS [on Basis of Richardson Equation: Desirable Relations Found].—J. Frenkel. (*Sci. Abstracts, Sec. B*, March, 1933, Vol. 36, No. 423, p. 200.)

THE TEMPORAL COURSE OF THE IGNITION OF IONIC VALVES [Thyratrons].—Klemperer. (*Archiv f. Elektrot.*, 2nd May, 1933, Vol. 27, pp. 322–328.)

DIE STROM- UND SPANNUNGSVERHÄLTNISSE DER GITTERGESTEUERTEN GLEICHRICHTER (The Current and Voltage Ratios of the Grid-Controlled Rectifiers).—K. Müller-Lübeck and E. Uhlmann. (*Archiv f. Elektrot.*, 2nd May, 1933, Vol. 27, pp. 347–373.)

GAS AND VAPOUR TUBE MULTIPLIERS FOR INDICATOR USE [The Use of Grid-Controlled Rectifiers for Amplification of Small D.C. Voltages, as from Thermocouple Pyrometers].—P. G. Weiller. (*Rad. Engineering*, April, 1933, Vol. 13, No. 4, pp. 16–17.)

THREE-PHASE TRANSFORMER CONNECTIONS AND THEIR APPLICATION TO HIGH-VOLTAGE RECTIFYING CIRCUITS.—J. B. Epperson. (*Rad. Engineering*, May, 1933, Vol. 13, No. 5, pp. 14–16.)

TESTS ON THE NEW ARC-IN-AIR RECTIFIER FOR VERY HIGH VOLTAGES AND POWERS.—E. Marx. (*E.T.Z.*, 27th April, 1933, Vol. 54, No. 17, pp. 396–397.)

Highly successful tests of a large rectifier constructed on the principles outlined in Marx's paper (1932 Abstracts, p. 597, r-h column).

SUR UN NOUVEAU DÉTECTEUR (A New Detector [Insensitive Galena Crystal treated with Sulphur, with Copper Electrode]).—J. Cayrel. (*Comptes Rendus*, 24th April, 1933, Vol. 196, No. 17, pp. 1216–1218.)

The so-called " insensitive " galena crystals give rectification in the opposite sense to the " sensitive " crystals. If covered with quasi-colloidal sulphur (by electrolysis of sulphuretted hydrogen) and used with a noble metal as electrode, they give about the same order of rectification as before the sulphur treatment, but with much greater stability: with oxidisable electrodes they behave practically as they did before the treatment: but with copper electrodes (which give poor results with the untreated crystals) the rectification is so much improved that it surpasses, for small amplitudes, the results given by the most sensitive galena detectors. The effect is due to the formation, at the contact, of copper sulphide. This cold sulphur treatment is quite different from Florisson's sulphur vapour treatment, which converts " insensitive " into " sensitive " galena and thus changes the sense of rectification.

DYNAMOS FOR RADIO TRANSMITTING STATIONS.—H. Hutt: Brown-Boveri Company. (*Rev. Gén. de l'Élec.*, 15th April, 1933, Vol. 33, No. 15, p. 119 D: summary only.)

AN IMPORTANT IMPROVEMENT IN THE CONSTRUCTION OF THE LEAD ACCUMULATOR [the Féry-Carbone Non-Sulphating Cell].—Ch. Féry. (*Rev. Gén. de l'Élec.*, 11th March, 1933, Vol. 33, No. 10, pp. 313–318.) *See* 1931 Abstracts, p. 453, r-h column.

IODIDE CELLS—AN INVESTIGATION OF CADMIUM IODIDE AND ZINC IODIDE TYPES.—A. E. Salazar. (*Electrician*, 19th May, 1933, Vol. 110, No. 2868, p. 650.)

H.T. FOR THE CAR SET.—A. Dinsdale. (*Wireless World*, 19th May, 1933, Vol. 32, pp. 352–353.)

The tuned vibratory transformer used during the war to obtain a high voltage from an l.t. accumulator is well known. This article describes a greatly improved version of this device which has been developed in the U.S.A. for supplying h.t. to a radio receiver installed in a car, using the existing car accumulator as the source of l.t.

THE DEVELOPMENT OF A SOUND-ISOLATING BASE FOR MOTORS.—E. H. Hull. (*Gen. Elec. Review*, May, 1933, Vol. 36, No. 5, pp. 223–227.)

The Use of Two-Grid Valves for the Amplification of Continuous Currents.—P. Donzelot and J. Divoux. (*Comptes Rendus*, 22nd May, 1933, Vol. 196, No. 21, pp. 1579–1581.)

Instability due to variations of the anode battery voltage has already been dealt with (Feb. Abstracts, p. 113, l-h col.). The writers now show how the use of two-grid valves overcomes the instability due to variations in the filament and grid batteries.

The Automatic Transmission by Radiotelegraphy of the Reading of an Instrument by Two Audio-frequency Modulations of Varying Depth.—Csejkovits and Dieckmann. (*See* abstract under "Directional Wireless.")

Special Design of H.F. Coils [for Master-Oscillator] to give Constant Inductance over Temperature Range of 40° C.—Ure, Grainger and Cantelo. (*See* abstract under "Transmission.")

[Air-Cored] Transformers with Variable Coupling [Theoretical Investigation].—Siegel. (*See* under "Properties of Circuits.")

Controls for 1933 Receivers [particularly Moulded Carbon Variable Resistances and Their Uses].—N. E. Wunderlich. (*Rad. Engineering*, May, 1933, Vol. 13, No. 5, pp. 17–19.)

VDE Regulations for Condensers for Broadcast Receivers and Interference Prevention.—Verband Deutscher Elektrotechniker. (*E.T.Z.*, 18th May, 1933, Vol. 54, No. 20, pp. 484–485.)

Recent Developments in Mica Condensers.—A. E. Thiessen. (*General Radio Experimenter*, Jan., 1933, Vol. 7, pp. 1–4.)

Über einen Plattenkondensator mit negativer Kapazität (A Plate Condenser with Negative Capacity).—H. Benndorf. (*Zeitschr. f. Physik*, 1933, Vol. 82, No. 5/6, pp. 397–403.)

The writer has defined electrostatic capacity as $C = de/dV$, where V is the potential difference and e the charge on the plates; he finds that it can become negative when the plates of a condenser are in elastic connection with one another.

A New Compressed Insulating Material [Synthetic Resin and Linen Aggregate].—H. Römmler Company. (*E.T.Z.*, 18th May, 1933, Vol. 54, No. 20, pp. 478–479.)

"Calit" and "Calan," Two New Ceramic Insulating Materials. (*Zeitschr. V.D.I.*, 6th May, 1933, Vol. 77, No. 18, pp. 483–484.) *See* also July Abstracts, p. 402, r-h column.

On the Permeability of Iron at Ultra-Radio Frequencies.—W. Arkadiew. (*Phys. Review*, 15th April, 1933, Series 2, Vol. 43, No. 8, pp. 671–672.)

This note compares results due to Hoag and Jones (April Abstracts, p. 226, r-h col.) with previous work of the writer. The frequencies used are above 3×10^8 c/s.

Dauermagnete (Permanent Magnets).—W. Elenbaas. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 14, 1933, pp. 191–197.)

From the Philips' Company laboratories: a new treatment leading to simpler formulae than those usually given. The demagnetisation curve is replaced by an ellipse.

VDE Rules for Design and Testing of Small and Low-Voltage Transformers.—Verband Deutscher Elektrotechniker. (*E.T.Z.*, 23rd March, 1933, Vol. 54, No. 12, pp. 293–294.) Continued: *see* June Abstracts, p. 340, l-h column.

Critical Reviews of Books and Papers on Electric Filters.—P. David. (*See* under "Properties of Circuits.")

The Nevson Tangraph Rule.—(*Journ. Scient. Instr.*, April, 1933, Vol. 10, No. 4, pp. 119–120.)

A Round Chart Indicating Recorder.—Leeds and Northrup Company. (*Ibid.*, p. 119.)

A Drawing Instrument for Large Radius Arcs.—E. Simeon. (*Journ. Scient. Instr.*, May, 1933, Vol. 10, No. 5, pp. 157–158.)

An Electrical Calculating Machine.—R. R. M. Mallock. (*Proc. Roy. Soc.*, May, 1933, Vol. 140, No. A 841, pp. 457–483.)

This machine was devised for solving sets of linear algebraic simultaneous equations involving a large number of unknowns; it consists of a set of a.c. transformers each with a number of windings. The unknowns are proportional to the fluxes in the transformers and the coefficients to the numbers of turns in the windings. The present model can deal with 10 equations and the errors in the roots have been reduced to less than 0.1% of the largest root.

STATIONS, DESIGN AND OPERATION

The International Radiotelegraphic and Telegraphic Conference in Madrid, 1932.—J. Reyval. (*Rev. Gén. de l'Élec.*, 20th May, 1933, Vol. 33, No. 20, pp. 667–673.)

The International Organisation of Radio Communications: Organisations, Conventions and International Regulations.—M. Adam. (*Rev. Gén. de l'Élec.*, 3rd June, 1933, Vol. 33, No. 22, pp. 733–741.)

Six Months of Empire Broadcasting.—N. Ashbridge. (*World-Radio*, 19th May, 1933, Vol. 16, No. 408, pp. 677–678 and 680.)

La T.S.F. dans l'Aéronautique (Radio Communication in Aviation [a Survey]).—P. Brenot. (*Rev. Gén. de l'Élec.*, 27th May, 1933, Vol. 33, No. 21, pp. 704–710.)

Time Delay Effects in Synchronous [Common-Wave] Broadcasting.—C. B. Aiken. (*Electronics*, May, 1933, Vol. 6, No. 5, pp. 124–126.)

A short mathematical treatment followed by an account of experimental investigations, the first of which was to confirm that when $M = m$ and $\beta = 0$ there is no distortion but only variations in intensity of the resultant signal as K or γ is varied (*cf.* July Abstracts, p. 392); the other experiments yielded curves showing the "tolerable carrier ratio" as a function of γ and as a function of the time delay when γ is maintained within $\pm$ 1% of 180°. At this value of γ (*i.e.*, carriers in phase opposition) the distortion is of a very unpleasant non-linear character, while when γ is near 0° the distortion is largely a matter of impaired fidelity and is not nearly so unpleasant. Other conclusions, in agreement with theory, are reached by these tests. Thus a relative time delay of only 50 microseconds (ether path difference of 9.8 miles) between two otherwise identical transmissions will produce a distortion, when the carriers are out of phase, of sufficient magnitude to require a carrier ratio of about 6 db for its elimination.

Field-Strength Charts of Poste-Parisien and Radio-Paris.—David. (*See* reference under "Propagation of Waves.")

Five Metre Work for Amateurs.—H. L. O'Heffernan and S. G. Morgan. (*Wireless World*, 26th May, 1933, Vol. 32, pp. 368–369.)

GENERAL PHYSICAL ARTICLES

Electrical Conductivity of Ionised Gas in the Presence of a Magnetic Field.—T. C. Cowling. (*Sci. Abstracts, Sec.A*, March 1933, Vol. 36, No. 423, p. 289.)

The Field Distortion of a Plane Spark Gap, crossed at Constant Voltage by an Ionising Electron Layer [Theoretical Investigation].—J. J. Sämmer. (*Zeitschr. f. Physik*, 1933, Vol. 81, No. 7/8, pp. 440–444.)

On the Mobility of Electrical Charge Carriers under the Simultaneous Influence of Strong Electric and Magnetic Fields [Theoretical Investigation].—G. A. Kugler, F. Ollendorff and A. Roggendorf. (*Zeitschr. f. Physik*, 1933, Vol. 81, No. 11/12, pp. 733–744.)

High-Frequency Electric Discharge in Gases.—J. C. Wilson. (*Nature*, 15th April, 1933, Vol. 131, pp. 546–547.)

This letter describes curious streamer-like discharges obtained with a range of frequency from 11.1 to 21.4 Mc/s in the capacitive electrodeless discharge.

Movement of Charged Particles in a Field of Suddenly Changing Potential.—E. Persico. (*Sci. Abstracts, Sec.A*, March, 1933, Vol. 36, No. 423, p. 300.)

Observation with the Eye of a Schrot Effect for Photons.—R. R. Barnes and M. Czerny. (*Sci. Abstracts, Sec.A*, March, 1933, Vol. 36, No. 423, p. 273.)

Electron Theory of Metals [Mathematical Paper on Present State: including Thermionic and "Cold" Emission].—R. Peierls. (*Sci. Abstracts, Sec.A*, Feb., 1933, Vol. 36, No. 422, p. 177.)

The Quantum Theory of Semi-Conductors [a Survey].—E. L. Hill. (*Review Scient. Instr.*, April, 1933, Vol. 4, No. 4, pp. 186–188.)

On the [Quantum Mechanics] Theory of Electronic Semi-Conductors.—M. Bronstein. (*Physik. Zeitschr. der Sowjetunion*, No. 1, Vol. 2, 1932, pp. 28–45.)

Course of Current and Voltage in Insulating Materials with One or Several Movable Thin Layers of Charge.—W. O. Schumann. (*Archiv f. Elektrot.*, 15th March and 10th April, 1933, Vol. 27, Nos. 3 and 4, pp. 155–168 and 241–253.) *See* also May Abstracts, p. 282, l-h column, 3 references.

Positive and Negative Electrons Apparently Produced in Pairs [Support to Millikan's Photon Theory of Cosmic Rays].—R. M. Langer: Anderson. (*Sci. News Letter*, 27th May, 1933, Vol. 23, No. 633, p. 332.)

The Interaction of Charges in Dirac's Theory [Interaction of Two Electrons in Three Dimensions].—K. Nikolsky. (*Ibid.*, No. 6, Vol. 2, 1932, pp. 447–452.)

MISCELLANEOUS

Lamé, Mathieu and Related Functions in Physics and Engineering [including Propagation of Electromagnetic and Acoustic Waves].—M. J. O. Strutt. (Book Review in *L'Onde Élec.*, Feb., 1933 [publication delayed], Vol. 12, No. 134, p. 6a.)

Tangential Polar Coordinates or Polar Coordinates, and Their Applications [to Problems of Vibratory Motion in Acoustics, Electricity, etc.].—M. Jacob. (*Rev. Gén. de l'Élec.*, 1st April, 1933, Vol. 33, No. 13, pp. 403–411.)

Successive Approximations [to the Solution of Linear Differential Equations] by the Rayleigh-Ritz Variation Method.—J. K. L. MacDonald. (*Phys. Review*, 15th May, 1933, Series 2, Vol. 43, No. 10, pp. 830–833.)

A Simple Method for the Numerical Solution of Differential Equations: Note on Error and its Avoidance.—W. G. Bickley. (*Phil. Mag.*, June, 1933, Series 7, Vol. 15, No. 102, pp. 1174–1177.)

Kurventafel zum Auswerten von Messungen komplexer Grössen (Curve Sheet for Working out Measurements of Complex Quantities).—P. C. Hermann. (*Archiv f. Elektrot.*, 10th April, 1933, Vol. 27, No. 4, pp. 283–286.)

The sheet of curves given enables the sine or cosine of the angle between two vectors to be read if their components are given.

Electro-Physics [Review of Progress].—N. R. Campbell. (*Journ. I.E.E.*, Feb., 1933, Vol. 72, No. 434, pp. 153–159.)

High-speed particles: thermionic amplifiers:

photoelectric cells: electron microscope: quantum theory (and the return of intuitive reasoning, as in Gurney's application to the phenomena at an electrolytic cathode, using only the simplest mathematics): electron theory of conduction: thermionics and photoelectricity: radioactivity: discharge through gases (" the conception of positive ions causing the emission of electrons from the cathode 'by impact' has become meaningless "): penetrating rays (" the possibility of a terrestrial source, once almost abandoned, is now being reconsidered. It is at least certain that the far-reaching speculations on cosmology and the origin of matter, to which one phase of the study of these rays gave rise, are quite unfounded.")

THE PRINCIPLES OF ELECTROMAGNETISM.—E. B. Moullin: G.W.O.H. (Book Review in *Wireless Engineer*, Feb., 1933, Vol. 10, No. 113, pp. 61–64.) See also *ibid.*, March, 1933, pp. 146–147, for a letter from Fortescue, and April, pp. 179–182 and 202–204, for replies.

ON WRITING TECHNICAL ARTICLES.—J. Williamson. (*British Radio Annual*, 1932, pp. 64–74.)

In the section on " the English " of an article, the writer says: " For accuracy, continually be trying to read wrong meanings, even foolish or pig-headed ones, out of everything you write; and change the wording or the sentence structure until those are rooted out. . . . Recognise *punctuation* as a necessary part of sentence structure, rather alike to the bracketing of an algebraic expression. It depends less on breath-taking than on logic."

RADIO AND ELECTRICAL NOMENCLATURE [a Plea for a General " Cleaning Up "].—M. G. Scroggie. (*Wireless Engineer*, March, 1933, Vol. 10, No. 114, pp. 145–146.)

RADIO ENGINEERING HANDBOOK.—Edited by K. Henney. (Book Review in *Electronics*, March, 1933, p. 77.)

THE PRODUCTION OF 4 800 000 VOLT HYDROGEN IONS.—M. S. Livingston and E. O. Lawrence. (*Phys. Review*, 1st Feb., 1933, Series 2, Vol. 43, No. 3, p. 212.)

THE ELECTROSTATIC PRODUCTION OF HIGH VOLTAGE FOR NUCLEAR INVESTIGATIONS.—R. J. Van de Graaff, K. T. Compton and L. C. Van Atta. (*Phys. Review*, 1st Feb., 1933, Series 2, Vol. 43, No. 3, pp. 149–157.)

REMOTE INDICATION AND CONTROL DEVICES.—G. F. Tagg. (*Journ. Scient. Instr.*, March, 1933, Vol. 10, pp. 65–71.)

THE MEASUREMENT OF TELEGRAPH DISTORTION.—V. J. Terry. (*Elec. Communication*, April, 1933, Vol. 11, No. 4, pp. 197–203.)

DETERMINING THE TRANSMISSION EFFICIENCY OF TELEGRAPH CIRCUITS.—E. H. Jolley. (*P.O. Elec. Eng. Journ.*, April, 1933, Vol. 26, Part 1, pp. 1–7.)

MUTUAL IMPEDANCE OF GROUNDED WIRES FOR HORIZONTALLY STRATIFIED TWO-LAYER EARTH.—J. Riordan and E. D. Sunde. (*Bell S. Tech. Journ.*, April, 1933, Vol. 12, No. 2, pp. 162–177.)

The full paper, a preliminary account of which was referred to in 1931 Abstracts, p. 457, r-h column.

MUTUAL INDUCTION BETWEEN POWER AND TELEPHONE LINES UNDER TRANSIENT CONDITIONS.—W. G. Radley and H. J. Josephs. (*Journ. I.E.E.*, March, 1933, Vol. 72, No. 435, pp. 259–264.)

CONTROL OF WOOD-PULP COOKING BY PHOTOCELL.—Navarre Paper Mills. (*Electronics*, March, 1933, p. 75.)

THE MEASUREMENT OF VERY WEAK LUMINOUS FLUX BY MEANS OF A PHOTOELECTRIC CELL [Increased Sensitivity by using a Vacuum Tube with Filament and Two Highly Insulated Electrodes as a Variable High Resistance].—E. Gambetta. (*Comptes Rendus*, 27th March, 1933, Vol. 196, No. 13, pp. 906–908.)

THE LIMITING MAGNITUDE OBSERVABLE WITH A PHOTOELECTRIC STELLAR PHOTOMETER. THE APPLICATION OF A THERMIONIC AMPLIFIER TO THE PHOTOMETRY OF STARS.—Sinclair Smith: A. E. Whitford. (Summaries in *Review Scient. Instr.*, April, 1933, Vol. 4, No. 4, p. 240.)

A NEW SYNCHRONISING EQUIPMENT FOR HAND OR AUTOMATIC CONTROL [for H.T. Networks: the Synchronoscope, using a Photoelectric Cell].—H. Heyne. (*E.T.Z.*, 6th April, 1933, Vol. 54, No. 14, pp. 321–324.)

THE EXACT MEASUREMENT OF PHOTOGRAPHIC DENSITIES [by Photoelectric Methods].—P. Fleury and G. A. Boutry. (*Comptes Rendus*, 3rd April, 1933, Vol. 196, No. 14, pp. 1013–1015.)

A PRECISION DENSITOMETER USING A PHOTOELECTRIC CELL.—G. A. Boutry. (*Ibid.*, 10th April, 1933, Vol. 196, No. 15, pp. 1101–1102.)

A PHOTOELECTRIC INSTRUMENT FOR COMPARING THE STRENGTHS OF COLOURED SOLUTIONS.—E. W. H. Selwyn: Kodak Company. (*Journ. Scient. Instr.*, April, 1933, Vol. 10, No. 4, pp. 116–118.)

A SONIC NEPHELOMETER [for Comparison of Light transmitted by Translucent Materials, Photocell and Loud Speaker being used to detect " Flicker "].—J. S. Wilson. (*Journ. Scient. Instr.*, April, 1933, Vol. 10, No. 4, pp. 97–101.)

A PRACTICAL PHOTOELECTRIC REFLECTION METER [using the Bergmann Selenium Barrier-Layer Photocell].—L. Bergmann. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 14, 1933, pp. 157–158.)

PHOTOELECTRIC PHOTOMETER TESTS AIR PURITY.—(*Electronics*, Feb., 1933, p. 45.)

PHOTOCELL SIGNALS WHEN COFFEE IS ROASTED TO CORRECT SHADE.—(*Ibid.*, p. 45.)

ROTATIONS OF FRICTIONLESS STEAM OR GAS METER COUNTED BY PHOTOELECTRIC CELL.—(*Electronics*, Feb., 1933, p. 44.)

PHOTOELECTRIC CONTROL OF PAPER CUTTER FOR PAPER BAG MAKING.—D. R. Shoults. (*Elec. World*, 22nd October, 1932, Vol. 100, pp. 562–563.)

PHOTO-ELECTRIC CELLS: THEIR PROPERTIES AND USES. II. SOME APPLICATIONS.—L. G. Stoodley. (*World Power*, May, 1933, Vol. 19, No. 133, pp. 287–292.) *See* June Abstracts, p. 344, r-h column, for Part I.

REPRODUCTION OF PRINT FOR THE BLIND [Five Points of Light reflected successively on to Photocell and actuating Solenoids controlling Five Points touching the Finger].—F. Allen. (*National Research Council, Canada*, Fifteenth Annual Report, 1931–1932, p. 129.)

OPTICAL TELEPHONY TO A SHIP BELOW THE HORIZON.—(*Electronics*, April, 1933, Vol. 6, No. 4, p. 87: News item.)

"A great Atlantic liner talks with a ship below the horizon, by means of a modulated light-beam playing on a distant cloud-bank."

LOUD SPEAKERS SUMMON PHYSICIANS IN THE NEW YORK HOSPITAL ["Doctors' Paging Service"].—(*Bell Lab. Record*, April, 1933, Vol. 11, No. 8, pp. 241–243.)

AN ELECTRICAL CALCULATING MACHINE [for solving Sets of Linear Simultaneous Equations involving a Large Number of Unknowns].—Mallock. (*See* under "Subsidiary Apparatus and Materials.")

SUGGESTED UNIT OF VIBRATION AMPLITUDE [the "Pal," corresponding to the Phon in Acoustics].—W. Zeller. (*Zeitschr. V.D.I.*, 25th March, 1933, Vol. 77, No. 12, p. 323.)

OPTICAL MANOGRAPH WITH LOW INERTIA [for Study of Internal Combustion Motors].—M. Serruys. (*Comptes Rendus*, 10th April, 1933, Vol. 196, No. 15, pp. 1083–1085.)

[Variation of] CONDUCTIVITY OF NACL CRYSTALS UNDER PRESSURE.—Z. Gyulai. (*Sci. Abstracts, Sec. A*, Feb., 1933, Vol. 36, No. 422, p. 178.)

AN AMPLIFYING LEVER FOR THE MEASUREMENT OF SMALL DISPLACEMENTS [such as the Deformations of Piezoelectric Plates].—G. A. Fink and G. W. Fox. (*Review Scient. Instr.*, May, 1933, Vol. 4, No. 5, pp. 276–279.)

PIEZOELECTRIC MEASUREMENT OF PRESSURES [*e.g* in Large Guns, or Very Low Pressures usually measured by McLeod Gauge] AND WEIGHTS [Deflections of One Millionth of an Inch easily Measured].—H. C. Weber. (*Electronics*, April, 1933, Vol. 6, No. 4, p. 103.)

SHORT-WAVE TREATMENT OF NERVOUS PARALYSIS.—D. Kellner. (*World-Radio*, 21st April, 1933, Vol. 16, No. 404, p. 539.)

EXPERIMENTAL RESEARCHES ON THE EFFECTS OF ULTRA-SHORT WAVES ON THE FUNCTIONING OF THE CEREBELLUM.—P. A. Gemelli. (*La Ricerca Scient.*, 31st March, 1933, pp. 373–374.)

MEASUREMENTS OF THE TEMPERATURE IN THE INTERIOR OF AN EGG IN THE ELECTRIC FIELD OF ULTRA-SHORT WAVES [Support of Theory of Specific Action as opposed to Purely Thermal].—A. Jellinek. (*Comptes Rendus*, 10th April, 1933, Vol. 196, No. 15, pp. 1149–1150.) Continuation of the work referred to in 1931 Abstracts, p. 169, r-h column.

KILLING WEEVILS IN WHEAT BY [Ultra-] SHORT WAVE.—Westinghouse Company. (*Electronics*, March, 1933, p. 75.) *See* also February Abstracts, p. 117, left-hand column, and below.

[Ultra-Short] RADIO WAVES KILL INSECT PESTS [in Wheat, Seeds, Tobacco, Vegetables, etc.].—J. H. Davis. (*Scientific American*, May, 1933, Vol. 148, No. 5, pp. 272–273.)

Using 20 kw 6-metre waves, an exposure of 6 seconds was sufficient to exterminate eggs, larvae and adult insects in wheat, with no damage to the wheat itself. "The plant has been in operation for a year and many kinds of infested materials have been successfully treated . . ." *See* also preceding abstract.

RADIOACTIVE PHENOMENA OF THE SECOND ORDER AND OF ARTIFICIAL ORIGIN [Highly Absorbable Radiations from "Resistance Cells." Wavelengths between Some Dozens and Some Hundreds of Angstrom Units: Electrons of the Peripheral Orbits of the Atom involved].—G. Reboul. (*Journ. de Phys. et le Rad.*, Feb., 1933, Vol. 4, Series 7, No. 2, pp. 73–89.) Continuation of the work referred to in 1932 Abstracts, p. 541, r-h column.

ON THE PROBABLE EMISSION OF A RADIATION OF SMALL PENETRATING POWER FROM CERTAIN METALS.—J. Reboul. (*Comptes Rendus*, 22nd May, 1933, Vol. 196, No. 21, pp. 1596–1598.)

THE E.M.FS DEVELOPED BY MAN IN CONTACT WITH A METALLIC CONDUCTOR [and Their Diurnal Variation].—F. Vlès and others (*Comptes Rendus*, 27th March, 1933, Vol. 196, No. 13, pp. 965–967.) For another paper by Vlès on an allied subject, *see* March Abstracts, p. 174, r-h column.

Some Recent Patents

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

COLOUR TELEVISION

Convention date (Germany), 30th May, 1931.
No. 387206

The viewing-screen of a cathode-ray tube is coated with three differently-coloured fluorescent salts, for instance red, blue, and green in the manner of a lineated grid, one fundamental colour being allotted to each line in succession. The scanning ray may be kept horizontal and made to travel three times faster than is normally necessary, or it may be applied transversely to the grid and the intensity-variation trebled.

Patent issued to Siemens Schuckertwerke A.G.

AERIALS

Application date, 9th June, 1932. No. 387215.

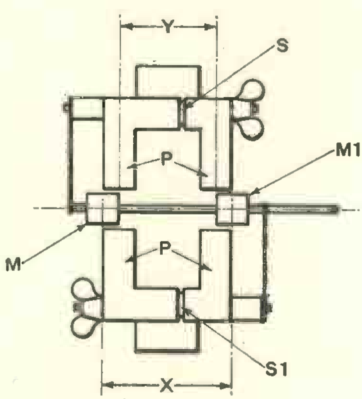
An indoor aerial is made by enclosing a metal wire or ribbon between two strips of insulating material, the combination being coated on one side with a non-drying adhesive, so that it can be applied to the wall of a room. The other side of the strip is suitably coloured or decorated to simulate the effect of a dado. Tags or eyelets are provided to take the connecting-lead to the wireless set.

Patent issued to C. S. Garland.

LOUD SPEAKERS

Application date, 20th May, 1931. No. 385603

The resonance frequency of the movement of a loud speaker is varied by adjusting the geometrical relations of the magnetic circuit. For instance in



No. 385603.

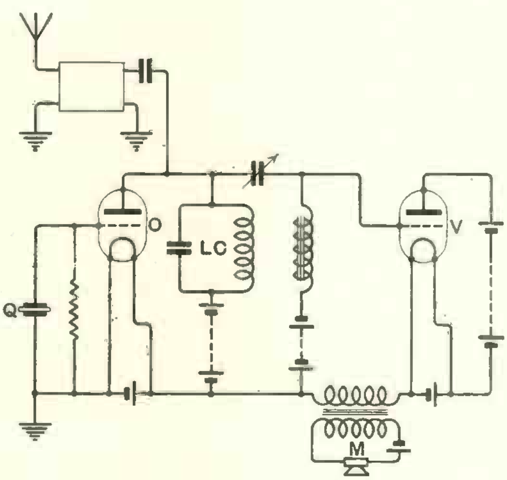
an "inductor" type of instrument the pole-pieces *P* are split as at *S* and *S1* so that the distance *Y* between their centres can be varied. Similarly the distance *X* between the masses *M*, *M1* is changed by sliding them along the armature bar. This also alters the effective gap between the opposed poles.

Patent issued to The General Electric Co., Ltd.

SIGNALLING SYSTEMS

Convention date (U.S.A.), 2nd September, 1930.
No. 386356

The invention utilises the fact that when a negatively charged electrode is placed in a strongly ionised gas at low pressure it becomes covered with



No. 386356.

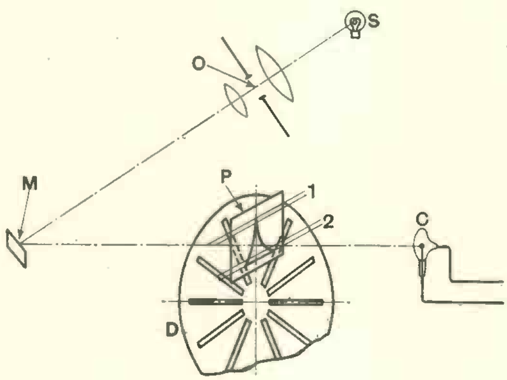
a sheath of positive ions. The electrode and sheath in effect form a condenser the capacity value of which is, however, independent of the relative position of the opposed "plates," though it can be controlled by varying either the degree of ionisation of the gas, or the potential of the electrode with respect to the gas. As shown the valve *V* is filled with mercury vapour, and the grid is negatively biased, so that it acquires a sheath of positive ions in the manner described. The valve is inserted in shunt with the main oscillatory circuit *LC* of a constant-frequency generator *O* stabilised by a quartz crystal *Q*. Modulating signals from a microphone *M* are applied between the grid and filament of the valve *V*, and alter the effective capacity of the sheath by varying the voltage across it. This in turn causes a frequency-modulation of the outgoing carrier wave from the generator *O*.

Patent issued to British Thomson Houston Co., Ltd.

PICTURE-TRANSMISSION SYSTEMS

Convention date (France), 30th June, 1931. No. 385536

Relates to systems of the kind in which the different light-and-shade values of the picture are first translated into signals of constant intensity



No. 385536.

which vary in length so that the time factor controls the intensity of light reproduced at the receiving end. Any "fading" that may occur in transit does not then produce "differential" effects in reception. As shown, light from a constant source *S* passes through an optical system *O* on to a mirror *M*, which is vibrated by a current depending upon the light-and-shade values of the picture. This throws the transmitted ray up and down relatively to a screen *P* having a flared aperture and an associated disc *D* with radial slots. When the ray follows the upper lateral track marked 1 only a short impulse reaches the photo-electric cell *C*, whereas when it follows the lower track 2 the impulse is more prolonged.

Patent issued to Etablissements E. Belin.

GRAMOPHONE PICK-UPS

Convention date (Switzerland), 22nd April, 1931. No. 384531

In order to secure accurate tracking along the whole face of the record, the axis of rotation of the needle is inclined at an angle instead of being perpendicular to the plane of the magnetic flux. Instead of inclining the whole of the pick-up, the air-gap is cut at an angle with the pole-pieces, and the armature (which is of square section) is fitted inside and packed with rubber. The arrangement allows the pick-up to be conveniently replaced by a sound-box without requiring any modification of the usual opening in the sound-arm.

Patent issued to E. Paillard et Cie Soc. Anon.

Application date, 4th November, 1931. No. 385702

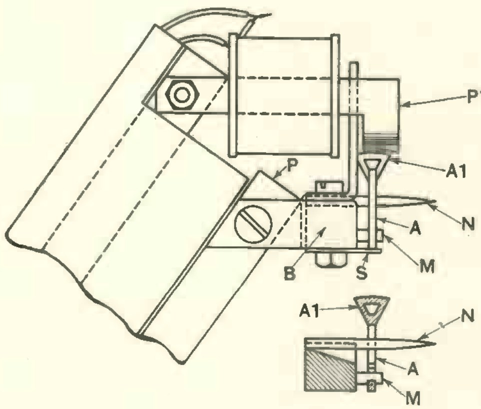
To minimise distortion arising from (*a*) mechanical inertia, (*b*) the electric "lag" due to the coil, and (*c*) the uneven magnetic distribution from the pole-pieces, the upper end of the pick-up needle does not carry the usual winding but extends inside a closed vessel containing a conducting fluid. Here it vibrates between two adjacent electrodes so as to alter the effective resistance of a circuit in accordance with the sound-track variations on the record.

Patent issued to A. M. Low.

Application date, 4th May, 1932. No. 386507

The needle *N* is mounted in a block *B* on the lower pole-piece *P*, and the armature *A* is in the form of a light, stiff lever extending at right-angles and having an end-piece *A*1 which vibrates between the bifurcated parts of the upper pole-piece *P*1 to vary the flux passing between them. The armature is pivoted at *M*, a spring *S* giving the required restoring force. When in use the needle is held in position by the normal pressure from the record, no clamping-screw being necessary. When the pick-up is lifted off the record, the needle is still retained *in situ* by magnetic attraction. The armature is so light that its natural frequency lies above the useful audible range.

Patent issued to The General Electric Co., Ltd., and F. H. Brittain.



No. 386507.

TELEVISION SYSTEMS

Convention date (U.S.A.), 24th April, 1931. No. 386183

The incoming signals are recorded by means of a spark discharge which etches a permanent image on the prepared surface of a photographic film. After the film has been suitably fixed, it is passed before a projector in the ordinary way and reproduced on a large screen. The method of recording removes some of the present limitations as regards illumination and therefore enlarges the size of televised scenes. Means are provided for compensating for the "lag" introduced by the necessary treatment of the film, so as to allow "sound" effects to be accurately synchronised.

Patent issued to American Television Laboratories Inc.

CATHODE-RAY TUBES

Convention date (Germany), August 21st, 1931. No. 386706

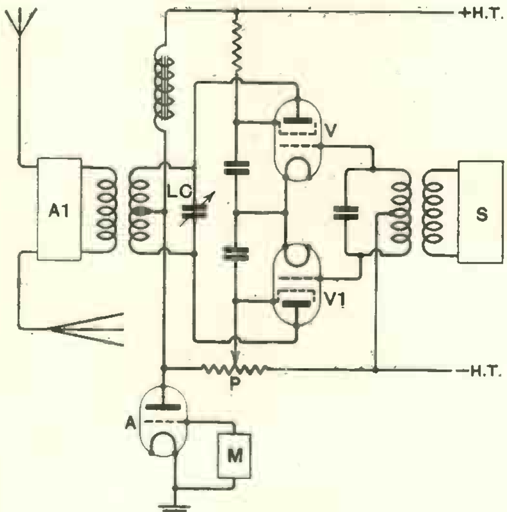
The filament of a cathode-ray tube, when heated directly by alternating current, creates a magnetic field which tends to deflect the ray out of the straight. To prevent this the filament is twisted into the shape of a figure eight, open at the bottom; or it may be formed as two co-axial coils oppositely wound; the object in both cases being to reduce the resultant field to zero.

Patent issued to Lignose Hörfilm System Breusing G.m.b.h.

THERMIONIC AMPLIFIERS

Convention date (U.S.A.), 21st May, 1931. No. 386500

When an amplifier is operated so that the output is more than say 50% of its commercial rating, it develops a "drooping" characteristic (caused chiefly by the falling-off in effective resistance due to grid rectification) and a consequent tendency to distortion. According to the invention an auxiliary valve is used to feed additional energy to the common output circuit, as and when required to restore a strictly straight-line response. The Figure shows the arrangement applied to a transmitting arrangement comprising a high-frequency source *S* feeding two S.G. amplifiers *V*, *V1*. Modulating signals are applied from a microphone *M* through an amplifier *A*. The screening grid of the compensating valve *V1* is biased through a potentiometer *P*, so that it does not come into operation



No. 386500.

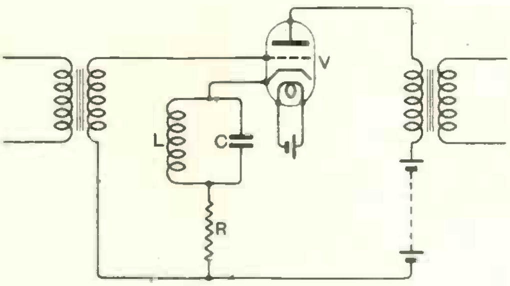
until the output from the valve *V* commences to "droop," whereupon it contributes the required extra energy to the common output circuit *LC* feeding the power amplifier *A1*.

Patent issued to Marconis Wireless Telegraph Co., Ltd.

REDUCING INTERFERENCE.

Application date, 21st October, 1931. No. 387050

In order to cut out a definite disturbing frequency, such as an interfering station on the high-frequency side, or the audio-frequency of a Morse



No. 387050.

transmitter or a heterodyne whistle on the low-frequency side, a rejector circuit *L*, *C* is inserted in the cathode lead of an indirectly-heated valve *V*, shown in the Figure as a low-frequency amplifier. A resistance *R* supplies grid bias.

Patent issued to W. T. Sanderson and R. Blackburn.

CATHODE-RAY TELEVISION

Convention date (Germany), 27th March, 1931. No. 387536

For scanning, two "tilting" or quick-return oscillations of constant amplitude are applied to the deflecting plates of a cathode-ray tube. The viewing screen at the end of the tube is formed by a coating of potassium silicate, or water-glass, sprayed evenly with cadmium tungstate. This is stated to give a point intensity of illumination of from 2 to 4 candle power, with practically no "time-lag." In transmission the luminous area produced on the fluorescent screen is concentrated by a lens system on the object to be televised, the reflected ray (or the transmitted ray in the case of a photographic film) being directed on to a number of photo-electric cells.

Patent issued to M. von Ardenne.

BROADCAST RELAY SYSTEMS

Application date, 3rd December, 1931. No. 386764

Relates to wired-wireless relays for redistributing Broadcast programmes in low-frequency form. In order to shut out extraneous disturbances, due to electric trolley buses, etc., chokes are inserted in series in the distributing network. Each choke consists of a pair of tightly coupled coils, preferably wound together of bifilar wire, so that the flux is practically neutralised for signal currents which flow through the coils in series; the chokes however offer a high impedance to disturbing currents since these are usually induced in parallel.

Patent issued to Siemens Bros. & Co., Ltd.

Printed for the Publishers, ILIFFE & SONS LTD., Dorset House, Stamford Street, London, S.E.1,
by The Cornwall Press Ltd., 1-6, Paris Garden, Stamford Street, London, S.E.1.
Sole Agents for Australasia—Gordon & Gotch (Australasia), Ltd.
Sole Agents for South Africa—Central News Agency, Ltd.