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THE
WIRELESS ENGINEER
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VOL. IX. SEPTEMBER, 1932. No. 108

Editorial.

Coupling and Coupling Coefficients.

IS it possible to give a simple, succinct definition—or, indeed, any definition—of the coupling between two circuits? We do not mean a definition of the method of calculating a numerical coefficient, but a definition of the physical conception which the word "coupling" is intended to convey. To be satisfactory the definition should be quite general and apply to the interaction between any two circuits, however constituted and however coupled. It is only when one tries to draw up such a definition that one realises how vague and elusive the underlying conception really is. In text-books and handbooks of radio-telegraphy one finds many formulae—some right and some wrong—for calculating coupling coefficients for a number of special cases, but in no case, so far as we are aware, is any attempt made to explain the exact physical significance of the coupling between two circuits. One is merely given the general impression that it is a measure of the interaction between two circuits.

Some years ago, in the days of spark transmitters, a system was devised for which it was claimed that the coupling could be made much tighter than in the ordinary system without introducing the double frequency which in the ordinary system necessitated the use of very loose coupling. The system, which was patented by a French concern, was known as the system "à onde unique." It soon transpired, however, that the real novelty lay not in the system but in the method of calculating the coupling which was in reality no tighter than usual if calculated correctly. As a matter of fact, in the case of coupled oscillatory circuits, tuned to the same frequency, the difference between the two resultant resonant frequencies is undoubtedly the best criterion of the coupling and provides a ready method of calculating the effective coupling coefficient in many cases of mixed coupling.

In the Pocket Book of Wireless Telegraphy and Telephony, edited by Dr. F. Banneitz—a German work of 1,250 pages and 1,190 figures—it is stated that a measure of the coupling is given by the coupling coefficients. which are $\sqrt{\frac{L_{12}L_{21}}{L_1L_2}}$ for magnetic or inductive coupling, $\sqrt{\frac{C_1C_2}{C_{12}C_{21}}}$ for electric or capacitive coupling and $\sqrt{\frac{R_{12}R_{21}}{R_1R_2}}$ for resistance or galvanic coupling. Similar formulae are to be found in other publications. The first two are the well-known formulae for the cases in which the coupling is purely inductive or purely capacitive, but the formula for resistance coupling appears to have little real significance, for if two oscillatory circuits are entirely free from coupling except that due to a small common resistance R which is the only resistance in either circuit, the formula gives a coupling coefficient of unity, although the two circuits are in reality very loosely coupled. No formula for a coupling coefficient can neglect the storage of energy in the circuits, since the basic conception concerns not merely the rate of transfer of energy from one circuit to the other, but the ratio of this rate of transfer to the energy stored in the circuits. Moreover, the effect of any resistance, other than a resistance common to both circuits and causing consequently a transfer of energy, is of a secondary nature and cannot be regarded as having any direct effect on the coupling. In the ordinary simple case of inductive coupling the shape of the resonance curve depends on two factors, the coupling and the damping, and it is preferable to regard these as two independent factors and not to attempt to include the latter in any definition of the former.

If an alternating current of 1 ampere be assumed to flow in the primary circuit of two inductively coupled oscillatory circuits, the maximum energy W_1 stored in its magnetic field is $0.5\ L_1\hat{i}_1^2 = L_1I_1^2 = L_1$ joules. Every quarter of a cycle this energy is transferred from the magnetic to the electric field. The electromotive force E_{12} induced in the secondary circuit is $\omega MI_1 = \omega M$ volts. This may be regarded as a measure of the capability of the primary circuit of transferring energy to the secondary; the actual transfer of energy will depend on the conditions in the secondary circuit. If multiplied by unit current it would represent power in watts. Now the ratio of this mutually induced e.m.f. E_{12} to the maximum energy W_1 stored in the circuit for a current of 1 ampere is $\omega M/L_1$; similarly for a current of 1 ampere in the secondary the ratio of the mutually induced e.m.f. E_{21} to the maximum energy W_2 stored in the secondary circuit is $\omega M/L_2$.

Hence $$\frac{E_{12}}{W_1}\cdot\frac{E_{21}}{W_2} = \omega^2\frac{M^2}{L_1L_2}$$

and the coupling coefficient

$$k = \sqrt{\frac{M^2}{L_1L_2}} = \frac{1}{\omega}\sqrt{\frac{E_{12}}{W_1}\cdot\frac{E_{21}}{W_2}}$$

This gives a logical basis for the definition and determination of the coupling coefficient in the case of two oscillatory circuits tuned to the same frequency, in which case ω would be taken as 2π times this frequency. If the circuits have different resonant frequencies ω_1 and ω_2 we have

$$E_{12} = \omega_1 M \text{ and } E_{21} = \omega_2 M$$

and $$k = \frac{1}{\sqrt{\omega_1\omega_2}}\sqrt{\frac{E_{12}}{W_1}\cdot\frac{E_{21}}{W_2}}$$

The same method can be applied to two coupled oscillatory circuits however complicated the coupling may be.

From this point of view, the coupling between two circuits may be defined as the relation between the possible rate of transfer of energy and the stored energy of the circuits. By the possible rate is meant the rate of energy transfer in the absence of all resistance other than that utilised for coupling, since, however closely two circuits are coupled, the transfer of energy can be reduced to a very small value by increasing the resistance, and can be reduced to zero by increasing the resistance of one of the circuits to infinity, that is, by opening the circuit. The numerical value of the coupling is then $1/\omega$ or $1/\sqrt{\omega_1\omega_2}$ of the geometric mean of the ratios of the mutually induced e.m.f. to the maximum stored energy when unit current flows at the resonant frequency, first in one circuit and then in the other.

When the coupling between two oscillatory circuits is of a complex character the ordinary coupling coefficients quoted above are of little help, but the method we have outlined can always be applied. In the case of non-oscillatory circuits it is questionable whether a coupling coefficient should be employed; it certainly loses much of its significance.

G. W. O. H.

The Detector.*

By W. B. Lewis.

THE detector is distinguished from the other parts of a receiver in that it is essentially non-linear. This means that components of the current in the detector circuit are not independent. It follows that it is incorrect to think of the radio-frequency component, modulation frequency and direct current as if they were independent. To think of the carrier-frequency component, sidebands and interfering signal separately is even more dangerous.

Moreover, it is impossible to assign characteristic impedances to a detector circuit, for such impedances are not characteristic of the detector itself, but of the detector together with its input. Anyone who has attempted to consider the "demodulation effect" as a modification of the detector characteristics will appreciate this point, and realise into what difficulties and complications it leads. The proper function of the perfect detector is to produce an electrical output which is a faultless reproduction of the variations of the amplitude envelope of the radio-frequency input. A method is developed in this article from which the performance in this respect of certain simple detector circuits employing straight-line rectifiers may be estimated.

To illustrate the application of this knowledge consider the demodulation effect. Following the treatment suggested in this article the complex modulated envelope of the radio-frequency input must first be derived,† then, as detailed below, the possibility of the perfect reproduction of this envelope by the detector must be considered. As far as the writer is aware no treatment of this subject yet published (May, 1932) has gone further.

The consideration of the detector presented here is simply a development of the explanation usually adopted in the most elementary accounts of the principle of detection. The method will be found very useful when faced with the problem of a detector working under any unusual conditions.

* MS. received by the Editor, Feb., 1931.

† For this see Editorial, *Wireless Engineer*, August, 1931, by G. W. O. Howe.

(2) Equations of the Simple Circuit.

The relation between the output potential V across the condenser C in the circuit of Fig. 1 (*b*) and the input E.M.F. E will be determined. Let the resistances R, R_a and the currents i, i_c be as marked and let $\pm q$ be the charges on the plates of the condenser C.

By Kirchoff's laws

$$E = (i + i_c)R_a + iR \quad .. \quad (1)$$

Also $iR = \frac{q}{c} \quad \therefore i_c = \frac{dq}{dt} = CR\frac{di}{dt}.$

Substituting for i_c in (1) we have

$$CRR_a\frac{di}{dt} + (R + R_a)i = E \quad .. \quad (2)$$

Writing for brevity $A = \frac{R + R_a}{CRR_a}$, $\Big(\frac{1}{A}$ is the

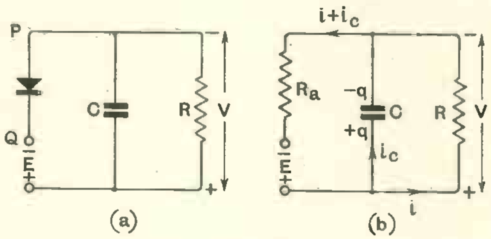

Fig. 1.

"time constant" of the circuit$\Big)$ equation (2) is solved by multiplying both sides by e^{At} and integrating, giving

$$CRR_a ie^{At} = \int_{t=0}^{t=t} Ee^{At}dt + \text{const.}$$

or writing V_t = P.D. across the condenser at time t

$$V_t = V_0e^{-At} + \frac{e^{-At}}{CR_a}\int_{t=0}^{t=t} Ee^{At}dt \quad .. \quad (3)$$

If we assume E to be of the form

$$E = E_0 + E_s \sin(pt + a)$$

where E_0, E_s, p and a are constants, since

$$\int_{t=0}^{t=t} E_s \sin(pt + a)e^{At}dt = \frac{E_s}{A^2 + p^2}$$
$$\{[A \sin(pt + a) - p \cos(pt + a)]e^{At} - [A \sin a - p \cos a]\}$$
$$= \frac{E_s}{\sqrt{A^2 + p^2}}\{\sin(pt + a - \theta)e^{At} - \sin(a - \theta)\}$$

where $\tan\theta = p/A$

and $\int_{t=0}^{t=t} E_0 e^{At}dt = \frac{E_0}{A}(e^{At} - 1)$

equation (3) becomes

$$V_t = V_0 e^{-At} + \frac{E_0 R}{R + R_a}(1 - e^{-At}) + \frac{E_s R}{R + R_a}\frac{1}{\sqrt{1 + p^2/A^2}} \{\sin(pt + \alpha - \theta) - \sin(\alpha - \theta)e^{-At}\} \quad (4)$$

This equation shows that after sufficient time, when the terms involving e^{-At} become negligible, the potential across the condenser alternates about the mean value $\frac{E_0 R}{R + R_a}$. Moreover, the alternating component lags behind the alternations of the input E.M.F. by a phase angle θ, which we may note lies between 0 and $\frac{\pi}{2}$.

(3) Detector Circuit with an Ideal Straight-line Rectifier.

Let the rectifier of Fig. 1 (*a*) be such that, when the potential across it is zero or nega-

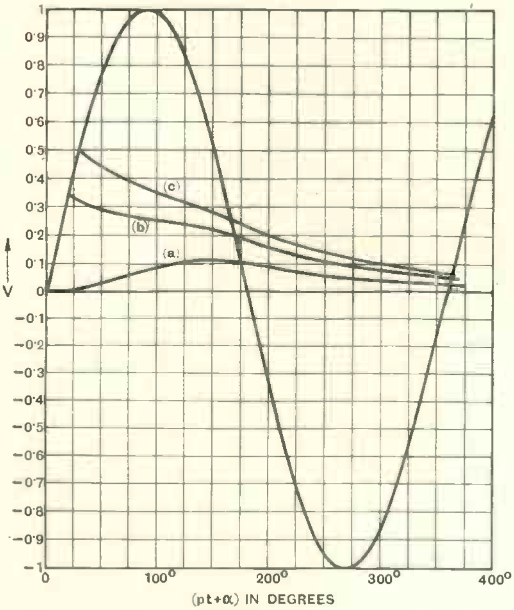

Fig. 2.—*Simple Detector* $p/A = 2$, $4R = R_a$.

tive, *i.e.*, the point P more negative than Q, its resistance is infinite, but when the potential is positive its resistance has the constant value R_a.

Positive values of E and V are shown in Fig. 1 (*a*), so when $E > V$ the rectifier has resistance R_a.

When the rectifier is required to rectify very small inputs, E_0 is made zero.

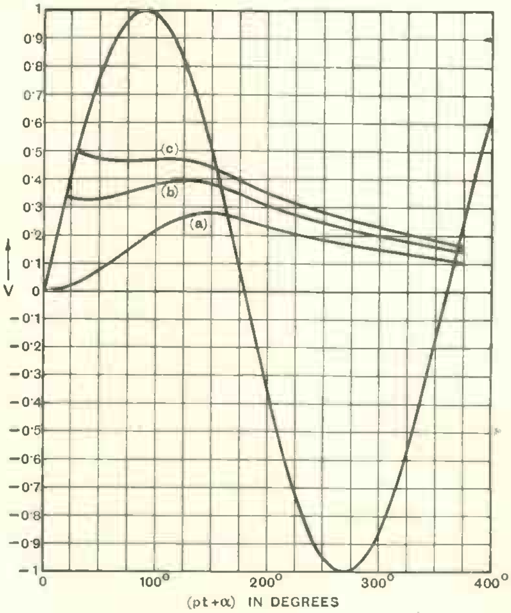

Fig. 3.—*Simple Detector* $p/A = 2$, $R = R_a$.

Then, during the part of the cycle of the signal E.M.F. E_s, for which the instantaneous value $E_s \sin(pt + \alpha)$ is greater than V, V will be given by equation (4), where V_0 is the value of V at the instant when E becomes greater than V. If this is taken as the zero of time, we have $V_0 = E_s \sin\alpha$.

Equation (4) becomes

$$V_t = E_s\left\{\left[\sin\alpha - \frac{R}{R + R_a}\frac{\sin(\alpha - \theta)}{\sqrt{1 + p^2/A^2}}\right]e^{-A/p \cdot pt} + \frac{R}{R + R_a}\frac{1}{\sqrt{1 + p^2/A^2}} \cdot \sin(pt + \alpha - \theta)\right\} \quad \ldots \quad \ldots \quad (5)$$

When $E_s \sin(pt + \alpha) < V$, the condenser C simply discharges through the resistance R, so that $V_t = V_{t'} e^{-(t-t')/CR}$, where t' is given by $E_s \sin(pt' + \alpha) = V_{t'}$, combined with equation (5).

(4) Graphical Representation.

Consider how the action of the circuit may be graphically represented. We wish to follow the variation of V, the potential across the output load resistance, with time, when the input is a radio-frequency E.M.F. which may be of varying amplitude. Equation (5) shows that the form of the curve will depend on the ratio R/R_a, different sets of curves are therefore plotted for selected values of R/R_a. The ratio p/A is taken as a second independent variable; this ratio represents the time constant of the circuit expressed as a multiple of $\frac{1}{2\pi}$ of the radio-frequency period. In order to plot a number of curves on the same figure, and to make the curves as general as possible, V is plotted as a function of the input amplitude E_s, and $pt + \alpha$ is plotted to represent the time scale. The sine curve representing the input E.M.F., $E_s \sin (pt + \alpha)$, therefore appears the same in all the figures. Figs. 2

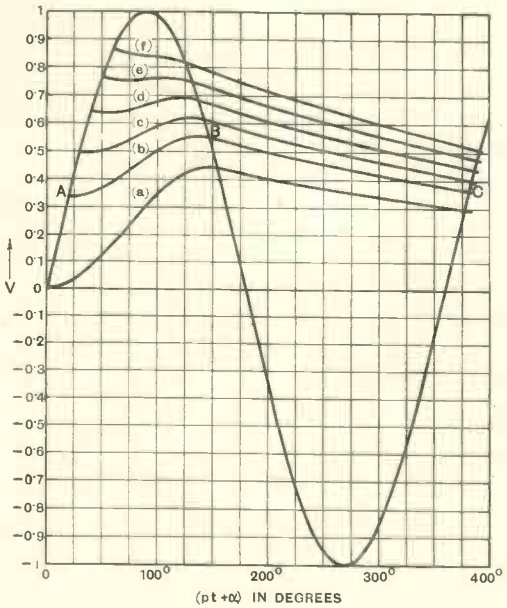

Fig. 4.—*Simple Detector* $p/A = 2$, $R = 4R_a$.

to 6 are plotted in this way for some of the three cases $4R = R_a$, $R = R_a$, $R = 4R_a$ and for values of p/A of 2 and 10. In any one figure, that is to say given the values of R/R_a and p/A, the curve for V depends on its initial value, a series of curves (*a*), (*b*), (*c*), etc., are therefore drawn for different initial values of V. Following the convention adopted in deducing equation (5), the origin

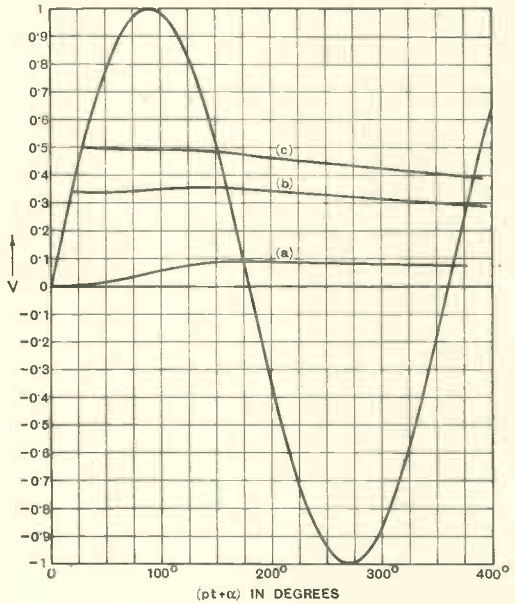

Fig. 5.—*Simple Detector* $p/A = 10$, $R = R_a$.

of time is taken at the instant when V equals the input E.M.F., which is then equal to $E_s \sin \alpha$. Curves plotted for different values of α are therefore equivalent to curves for different initial values of V.

As an example take the case represented in Fig. 4; suppose that V is initially zero and a sinusoidal input E.M.F. $E_s \sin (pt + \alpha)$ is started. During the first cycle V is represented by the curve (*a*), and it is seen that the initial value of V for the next cycle is $0.296\ E_s$; during this second cycle V will therefore follow a curve which lies slightly under curve (*b*). The initial value for the third cycle will be $0.355\ E_s$, so that during this cycle V will follow a curve slightly above curve (*b*). Finally, after a number of cycles, the initial value for V for each cycle is constant and equals $0.371\ E_s$. The curve followed during each cycle would lie only slightly above curve (*b*).

(5) Modulated Input.

When the input is modulated it will be supposed that it may be represented with sufficient accuracy by a succession of single cycles of true sine form, but of differing amplitudes.

Continuing the example just considered, suppose that the input amplitude (E_{s1}) after a number of cycles is suddenly dropped to half value (E_{s2}); the initial value of V for the first cycle with the reduced amplitude will be approximately $0.371\ E_{s1} = 0.742\ E_{s2}$, V will therefore follow a curve just below curve (*e*) during this cycle. The initial values of V, (V_0) for successive cycles will then decrease progressively to the final value $0.371\ E_{s2}$. The total change of V_0 due to the reduction of the input amplitude is therefore $0.371\ (E_{s1} - E_{s2})$, but this response is spread over a number of cycles. The fraction of this total response, or change of V_0, which takes place in the first cycle will be called the response factor.

If the output V is to be a perfect reproduction of the modulation of the input, the full response must take place in one cycle so that the response factor is unity. If, for this ideal case, the change of V_0 between one cycle and the next is plotted against the initial value of V_0, as in Fig. 8 (*a*) and (*b*), a straight line would be obtained making angles of 45° with the axes. The slope of this line, unity in this case, is a measure of the response factor. The lines drawn in Fig. 8, corresponding to actual detector circuits employing a straight-line rectifier, are derived from the curves of Figs. 2 to 7, etc. It will be noticed that the lines are not quite straight; this means that the response factor is not a constant, but varies slightly with V_0. The response factor for any value of V_0 is the slope of the line joining the point on the curve concerned (in Fig. 8), which corresponds to this value of V_0, to the point at which the curve cuts the zero change line. This latter point gives the constant value of V_0 for a steady maintained input, and the slope of the curve at this point is a measure of the response factor for small or slow changes of input amplitude.

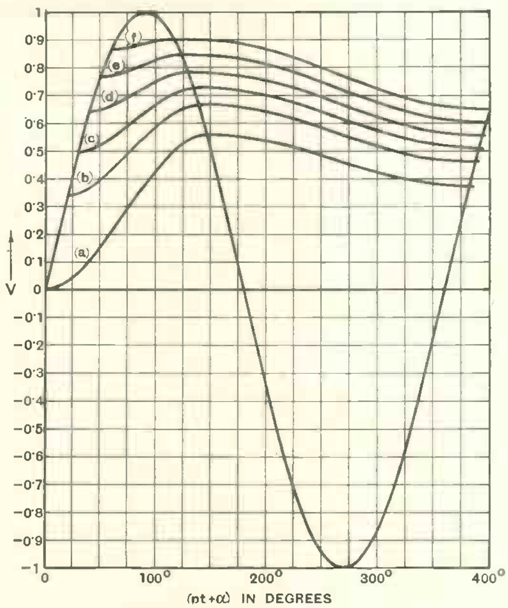

Fig. 7.—*Detector with infinite load resistance.* $p/A = 2$, $R = \infty$. *Back resistance of rectifier* $= 10R_a$.

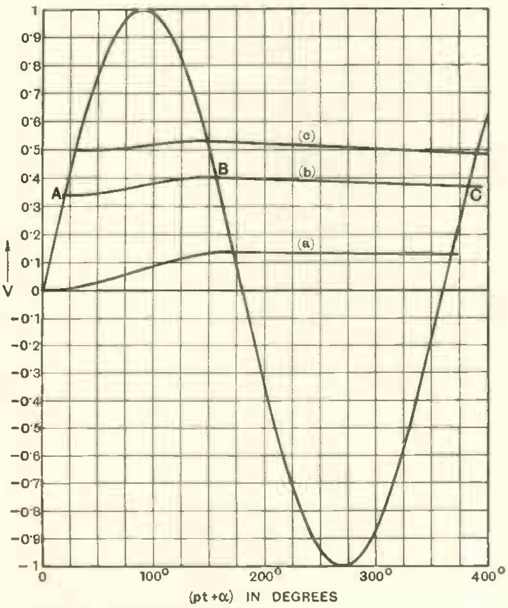

Fig. 6.—*Simple Detector* $p/A = 10$, $R = 4R_a$.

Since the curves in Fig. 8 (*a*) and (*b*) are very nearly straight the variation of the response factor in these cases is very small. The response factor is slightly greater for small values of V_0 than for large values. This means that the response factor is slightly greater when the amplitude of the input is rapidly increasing than when it is decreasing. It has been suggested that the response factor for increasing input amplitude is markedly greater than for decreasing amplitude (*see* footnote * on next page), but the curves of Fig. 8 show that this is only true in special cases (as in Fig. 8 (*c*)). These cases are discussed in § 7.

Certain features of the curves of Figs. 2 to 7, etc., should be noted. It has been explained how they are used to form a picture of the variation of V corresponding to a modulated input.* The slope of the curve for V does not change at the points where it is cut by the sine curve, for the current through the rectifier is then zero. The curve is continuous and smooth. Looking at the curves (b) and (c) in Figs. 4 and 6 we see that curve (b) cuts the succeeding cycle of the sine curve at a higher point than the first, whilst the curve (c) cuts it at a lower. Some curve between these will cut the successive cycles at the same level. This curve is the curve for V_t, after the input has been maintained at constant amplitude for many cycles. The curves of Fig. 8 derived by plotting the difference between the initial and final values of V over the cycle shown in the figures, against the initial value of V_0,

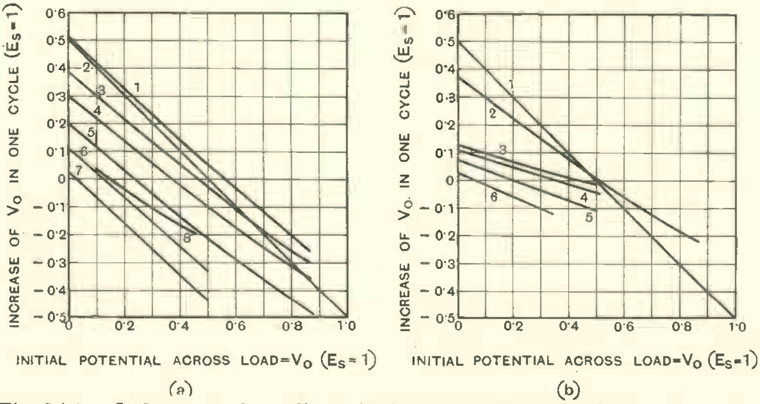

Fig. 8 (a).—*Index to numbered lines.* (1) *Push-Pull Detector* $p/A = 2, R = 4R_a$. (2) *An ideal line.* (3) *Capacity across rectifier equals C.* $p/A = 2, R = 4R_a$. (4) *Simple Detector* $p/A = 2, R = 4R_a$. (5) *Same as* (4) *but with back resistance of rectifier* $= 10R_a$. (6) *Simple Detector* $p/A = 2, R = R_a$. (7) *Simple Detector* $p/A = 2, 4R = R_a$. (8) *Biased rectifier* $E_0 = \frac{1}{2}E_s$, $p/A = 2$, $R = 4R_a$.
(b) *Index to numbered lines.* (1) *An ideal line.* (2) *Detector with infinite load resistance.* $p/A = 2$, $R = \infty$. *Back resistance of rectifier* $= 10R_a$. (3) *Simple Detector* $p/A = 10, R = 4R_a$. (4) *Same as* (3) *but with back resistance of rectifier* $= 10R_a$. (5) *Simple Detector* $p/A = 10$, $R = R_a$. (6) *Simple Detector* $p/A = 10$, $4R = R_a$.

may be used to determine the value of V_0, for this steady state as already explained.

(6) Efficiency.

For the discussion of efficiency it is assumed in this article that the function of the detector is to derive from a modu-

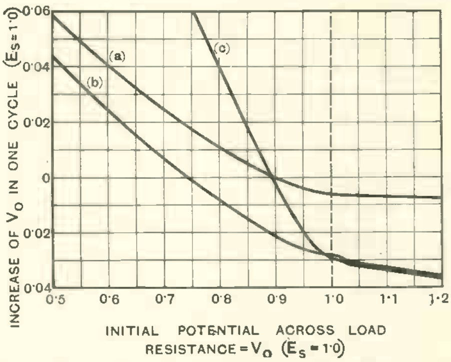

Fig. 8 (c).—*Simple Detectors with high output load resistances.* (a) $p/A = 10$, $R = 100R_a$. (b) $p/A = 10$. $R = 20R_a$. (c) $p/A = 2$, $R = 100R_a$.

lated input E.M.F. an output potential of the modulation frequencies only. Power and other efficiencies have also been dealt with from another and more suitable standpoint, by F. M. Colebrook,† and are not considered here. The ratio of the mean output potential to the input peak potential for an input of constant amplitude, is termed the D.C. efficiency. If at any modulation frequency $\frac{\omega}{2\pi}$, the percentage modulation of the input is $100m$, the modulation efficiency for the frequency $\frac{\omega}{2\pi}$ is defined as $\frac{V_s}{mE_s}$, where V_s is the output peak potential of frequency $\frac{\omega}{2\pi}$, and E_s, as before, is the mean radio-frequency input peak potential.

There is also another efficiency to be considered, the ratio of the mean output potential to the radio-frequency peak potential also present in the output, which may be termed

* Inexact curves of a similar nature have been given by Medlam and Oschwald, *Journ. Inst. Wir. Technology*, Vol. I, No. 4, 1928. These have been quoted by W. I. G. Page, *Wireless World*, March 13th and 27th, 1929; and C. D. Hall, *Wireless Engineer*, Dec., 1930. These curves neglect the phase angle θ, *i.e.*, neglect CR_a in comparison with $1/p$.

† F. M. Colebrook, "The Theory of the Straight Line Rectifier," *Wireless Engineer*, Nov., 1930.

the radio-frequency filtering efficiency. This efficiency has been derived from the curves of Figs. 2 to 7, etc., for each case considered, and is given in the collected table of results.

Consider first the D.C. efficiency. The mean value of V_t for a given ratio $R : R_a$ does not vary very greatly with A, *i.e.*, with C. If $C = 0$ the mean value of V_t

$$V_{tm} = \frac{1}{\pi}\frac{E_sR}{R + R_a} = 0.318\frac{E_sR}{R + R_a}$$

For $p/A = 2$ from Fig. 4 we see that approximately

$$V_{tm} = 0.468\,E_s = 0.585\frac{E_sR}{R + R_a}$$

This estimate, derived as explained in the footnote to the table, is slightly too high.

For $C = \infty$ it is not difficult to show that for $R = 4R_a$

$$V_{tm} = 0.473E_s = 0.591\frac{E_sR}{R + R_a}\ *$$

To sum up, for $R < 4R_a$, the equilibrium mean value of V_t lies between $0.318\dfrac{E_sR}{R + R_a}$ and $0.591\dfrac{E_sR}{R + R_a}$ for all values of C. But as $R/R_a \to \infty$, $V_{tm} \to E_s$ for large values of C. So that, on these considerations unless $R >> R_a$, the value of C has little effect on the D.C. efficiency. This point is emphasised, because in practice when an anode bend detector is fed from a tuned circuit of small decrement; the output is greatly increased by increasing the capacity across the load ; this effect is due to the reduction of the feed-back from the anode circuit via the anode-grid capacity, and has been discussed by Medlam† and by Biedermann. The large output may be maintained even when the capacity across the load is small, by a neutralising scheme as suggested by Medlam (*loc. cit.*). Another cause of inefficiency produced by too small a capacity across the load is discussed below.

The ratio V_{tm}/E_s represents the modulation efficiency only for low modulation frequencies. For high frequencies the response factor and the ratio of modulation to carrier frequency must be taken into consideration. Assuming that the response factor is constant for all changes of amplitude, we may draw an analogy with the circuit of Fig. 9. If E is a steady potential applied at time $t = 0$ we have

$$V_t = E(1 - e^{-t/CR}) + V_0 e^{-t/CR}$$

i.e.
$$E - V_0 = \frac{V_t - V_0}{1 - e^{-t/CR}}$$

Now $\dfrac{V_t - V_0}{E - V_0}$ is, by definition, the response factor, if t is a standard interval of time. So that if t is one radio-frequency period, the response factor

$$S = 1 - e^{-2\pi/pCR}$$
$$= 1 - e^{-2\pi/pT} \quad (6)$$

where $T = CR =$ time constant of the circuit of Fig. 9.

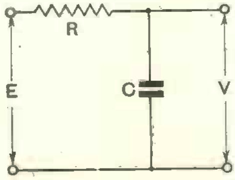

Fig. 9.—*Equivalent filter circuit.*

If $E = E_x \sin \omega t$, then

$$V = \frac{E_x}{\sqrt{1 + \omega^2T^2}} \sin (\omega t - \theta) \quad (6(a)),$$

where $\tan \theta = \omega T$. (This equation may be obtained by comparison with equation (4) or otherwise). T is related to the response factor by equation (6), so that a relation has been established between the quantity termed the response factor and the alternating potential output. The circuit of Fig. 9 has been introduced in order to deduce the relation in a simple manner, but the relation could be deduced without its aid. The relation depends on the assumption that the response factor is a constant. If this condition is fulfilled the analogy between the detector circuit, and the linear circuit of Fig. 9 may be drawn, so that in this matter we may consider the modulation components to be independent in the detector output, just as in a linear circuit. Moreover the modulation efficiency for one component is not affected by the presence of other modulation components. If the response factor is not a constant this is not strictly true, for the one modulation component may give rise to variations in the output potential so large that the response factor varies appreciably, thereby affecting the modulation efficiency for a second modulation component.

The lines of Fig. 8 (*a*) and (*b*) are

* *See*, for instance, F. M. Colebrook, *loc. cit.*, *Wireless Engineer*, Nov., 1930. Fig. 5 (*a*) of that article shows $\pi R_a/R$ plotted against V_{tm}/E_s in the notation of this article, for C very large.

† W. B. Medlam, *Wireless Engineer*, 1928. E. A. Biedermann, *Wireless Engineer*, Feb. and March, 1929.

sufficiently straight to justify the assumption of a constant response factor. For such cases, therefore, from the analogy with the circuit of Fig. 9, the result follows, that the efficiency of the detector for a modulation frequency $\frac{\omega}{2\pi}$ is equal to the D.C. efficiency multiplied by the factor $\frac{1}{\sqrt{1+\omega^2T^2}}$, where T is given by the equation

$$pT = 2\pi\left\{\frac{-1}{\log_e(1-S)}\right\}$$

from equation (6), S being determined from the appropriate line on Fig. 8.

The factor $\frac{1}{\sqrt{1+\omega^2T^2}}$, for usual values of ω/p and the response factor S may be read from the graph, Fig. 10. As explained below, the value of pT for a given value of S may first be read from one of the two lower curves, then $\frac{1}{\sqrt{1+\omega^2T^2}}$ is obtained from the upper curve for most reasonable values of ω/p. For example, suppose we have a response factor of 0.5. From the lowest curve we find $\omega T = 0.09$ so that $pT = 9$, since for this curve $pT = 100\,\omega T$; for this case the value of pT may be obtained more accurately from the curve for $p = 10\,\omega$, from this we find $\omega T = 0.905$, so that $pT = 9.05$. Now suppose that we wish to find the output for a modulation frequency of 10,000 cycles per sec. imposed on a carrier of frequency 500 kilocycles per sec. ($\lambda = 600$ metres). We have $\omega/p = \frac{10}{500} = .02$, so that $\omega T = .02 \times pT = .181$. For this value of ωT we read off from the top curve the value 0.984 for $\frac{1}{\sqrt{1+\omega^2T^2}}$. The efficiency of the detector for this modulation frequency is therefore 98.4 % of the efficiency for low modulation frequencies. Similarly it may be found that for the same modulation as considered above, but for a response factor of 0.1 the modulation efficiency is 64.3 % of the D.C. efficiency.

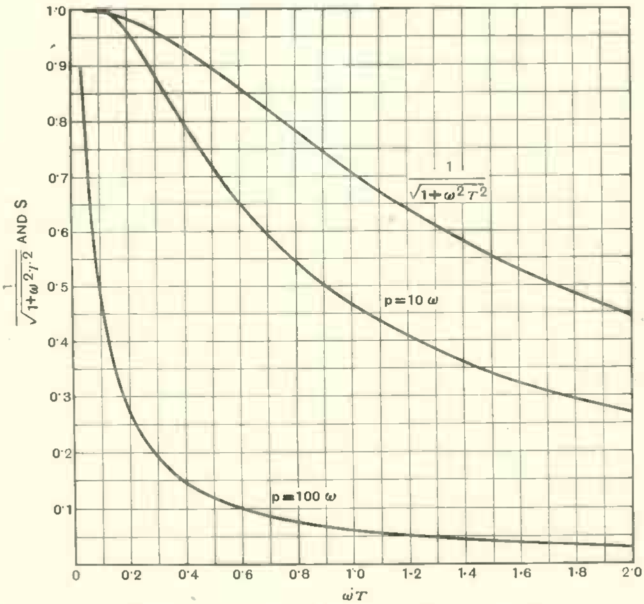

Fig. 10.—*Curves showing relation between Response Factor and Modulation frequency output.*

It may be noted that pT may be compared with p/A and pCR or p/B (where $B = \frac{1}{CR}$ except in certain cases discussed below). It is found for the calculated examples that pT is roughly equal to $p/\sqrt{AB}$, as may be seen from the values given in the collected table of results. By this empirical rule the value of T is approximately the geometric mean of the " time constants " of the circuit when the rectifier is conducting and when non-conducting.

(7) Very High Load Resistance.

When the load resistance is very great so that $R >> R_a$, the constant value of V_0 for a steady maintained input may be over 0.9 E_s. These conditions may arise with grid rectification as the grid leak may have a resistance of the order of 100 times the grid-filament resistance R_a. With such a detector, when the input is modulated so that its amplitude decreases rapidly a value of V_0 may occur which is greater than E_s. The curves of Fig. 8 (*c*) show that when this happens the response factor is appreciably reduced. The effect is that, for deep modulation especially at high modulation frequencies, the response to positive and negative half-cycles of the modulation is unequal. This results, in the first place, in an increase in the output of the component of twice the modulation frequency. Also it has been pointed out that, when the response factor is not constant, the modulation components are not independent, with the result that combination tones between the modulation components are produced, and distortion results.

It is instructive to consider in detail the examples for which the curves of Fig. 8 (*c*) have been derived. Curve (*a*) is for $p/A = 10$, $R = 100\,R_a$. Suppose the carrier wavelength is 377 metres for which $p = 5 \times 10^6$ sec.$^{-1}$, and suppose $R_a = 20{,}000\ \omega$, so that $R = 2$ megohms, then for $p/A = 10$ $C = 0.0001\ \mu$F. Curve (*b*) is for $p/A = 10$, $R = 20\,R_a$, these values may be obtained approximately from the numerical constants suggested for curve (*a*) but with R reduced to 400,000 ω. Similarly the conditions for curve (*c*), $p/A = 2$, $R = 100\,R_a$, may be obtained by keeping R at 2 megohms, but reducing C to 1/5th of its previous value, that is to say to 20 $\mu\mu$F. For these three cases an approximate answer to each of the following questions will be derived. (1) For 80 % modulation by a single pure note, above what frequency does the proportion of second harmonic in the output begin to increase rapidly? (2) Suppose there is an interfering modulated signal on a neighbouring wavelength of amplitude m relative to the carrier of the main signal. If m is sufficiently small the modulation of the interfering signal will not appear in the detector output, owing to the demodulation effect first discussed by Beatty (*E.W. & W.E.*, June, 1928). As m increases the beat note between the interfering carrier and the main carrier increases in amplitude. When this modulation of the main carrier becomes so great that there is an appreciable change of the response factor over the modulation (beat note) cycle, the different modulation components will cease to be independent and combination tones will result. The modulation of the interfering signal will then become an appreciable component in the output, and will increase rapidly with further increase of m. Approximate answers will be derived to the two questions; above what value of m does this increase of modulation interference occur when the frequency difference between the two carriers is (*a*) 9 kilocycles, (*b*) 18 kilocycles?

By equation 6 (*a*) we may write

$$V_0 = fE_s + \frac{mfE_s \sin(\omega t - \theta)}{\sqrt{1 + \omega^2 T^2}}$$

where fE_s is the constant value of V_0 for a steadily maintained input and

$$E_s(1 + m \sin \omega t) \sin(pt + a)$$

is the modulated input. If during the modulation cycle a value of V_0 occurs which is equal to $E_s(1 + m \sin \omega t)$, any further increase in m or ω will result in a marked increase in distortion. The condition $V_0 = E_s(1 + m \sin \omega t)$ at one point of the modulation cycle is therefore assumed as the critical condition. From the expression for V_0 given just above, this is equivalent to

$$1 + m \sin \omega t = f + \frac{mf}{\sqrt{1 + \omega^2 T^2}} \sin(\omega t - \theta),$$

which may be written

$$-(1 + \omega^2 T^2)(1 - f)$$
$$= m\sqrt{(1 + \omega^2 T^2 - f)^2 + f^2\omega^2 T^2} \sin(\omega t + \phi)$$

where $\tan \phi = \dfrac{f\omega T}{1 + \omega^2 T^2 - f}$, this equation is satisfied for the smallest values of m and ωT when $\sin(\omega t + \phi) = -1$. Then

$$(1 + \omega^2 T^2)(1 - f)$$
$$= m\sqrt{(1 + \omega^2 T^2 - f)^2 + f^2\omega^2 T^2}.$$

It may be verified by substitution in this equation that, for $m = 0.8$ and $p = 5 \times 10^6$ and the values of f and pT determined from the curves of Fig. 8 (*c*) and Fig. 10, the corresponding critical values of ω are 850, 4,300, and 5,000 cycles per sec. for cases (*a*), (*b*) and (*c*) of Fig. 8 (*c*), respectively. Also when there is an interfering signal the critical relative amplitudes m are, 0.16, 0.57, and 0.59, for cases (*a*), (*b*) and (*c*), respectively, when the frequency difference between the main and interfering signals is 9 kc., and 0.15, 0.38 and 0.36, for a frequency difference of 18 kc.

It must not be supposed that the critical condition is sharply defined, the curves of Fig. 8 (*c*) have a marked curvature before the critical condition is reached. Measurements of the proportion of second harmonic in the output for certain detectors have been made by Terman and Morgan,* who also

* F. E. Terman and N. R. Morgan, *Proc. Inst. Rad. Eng.*, Dec., 1930, Vol. 18, p. 2160.

derive an expression for the critical condition which may be criticised on the grounds that f does not appear in it. Their measurements show that the critical condition is not sharply defined, and the two results they publish are in reasonable agreement with the conclusions reached above concerning the critical condition.

It is concluded that when R is much greater than R_a, though the response factor may be large, so that the high note loss is small, yet, to prevent distortion for large amplitudes of modulation, the product CR must be kept small. The minimum value of C may be determined by other considerations discussed below, when this is so R must not be too great. These conclusions are in no way new, but it is hoped that the consequences of departing from the best conditions have been made clearer.

(8) Back Resistance of the Rectifier Finite.

If the back resistance of the rectifier is not infinite, when $E_s \sin(pt + a) < V_t$, V_t will be given by an equation of the same form as equation (4). The altered value of A during this portion of the cycle is denoted by B. Two cases for $R = 4R_a$ and $p/A = 2$ and 10 have been worked out assuming the back resistance of the rectifier $= 10R_a$. The curves for V_t are not much altered by this and they are not shown; the characteristics of these two circuits are given in the table below.

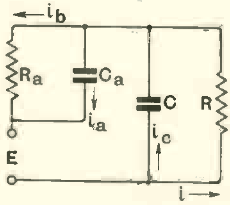

Fig. 11.—*Detector circuit with appreciable capacity across rectifier.*

If R is infinite, but the back resistance of the rectifier is finite, the behaviour of the detector will be fairly normal. Equation (4) becomes

$$V_t = E_s\left\{\left[\sin a - \frac{1}{\sqrt{1 + p^2/A^2}}\sin(a - \theta)\right]e^{-t/CR_a} + \frac{1}{\sqrt{1 + p^2/A^2}}\sin(pt + a - \theta)\right\} \quad .. \quad (7)$$

and $A = \frac{1}{CR_a}$. If therefore C is small p/A will be large, and a change of R_a will make little effect in the formula for V_t (equation (7)), so that rectification efficiency is small. This was not the case, when R_a was of the same magnitude or $> R$ for the cut-off part of the cycle, owing to the change in the factor $\frac{R}{R + R_a}$.

For normal values of C, the detector with $R = \infty$ will be very efficient, as the results for the example worked out show. For the example, $p/A = 2$, and the back resistance of the rectifier $= 10R_a$. The curves of Fig. 7 show that the whole of the radio-frequency variations in the output contributes towards increasing the response factor, since the curves for V_t are horizontal where they intersect the sine curve.

(9) Appreciable Capacity across the Rectifier.

Up to this point it has been assumed that the stray capacity across the rectifier is negligible compared with C. In practice this is seldom the case, and the behaviour of the detector may consequently be very different.

Equation (4) no longer holds, but a similar equation may be deduced for the circuit of Fig. 11.

By Kirchoff's laws we have

$$i + i_c = i_a + i_b \quad .. \quad .. \quad (8)$$

$$E = i_b R_a + iR \quad .. \quad .. \quad (9)$$

As before we have $i_c = CR\frac{di}{dt}$, and similarly

$$i_a = C_a R_a \frac{di_b}{dt}$$

Substituting in (8) and multiplying by R_a, we get

$$R_a i + CRR_a\frac{di}{dt} = C_a R_a \frac{d(i_b R_a)}{dt} + i_b R_a$$

Substituting for $i_b R_a$ from (9) and rearranging gives

$$CRR_a\frac{di}{dt} + C_a RR_a\frac{di}{dt} - C_a R_a\frac{dE}{dt} + i(R + R_a) = E$$

or

$$(C + C_a)RR_a\frac{d}{dt}\left(i - \frac{C_a}{C + C_a}\cdot\frac{E}{R}\right) + (R + R_a)\left(i - \frac{C_a}{C + C_a}\frac{E}{R}\right) = E\left(1 - \frac{R + R_a}{R}\cdot\frac{C_a}{C + C_a}\right) \quad (10)$$

If we write

$$A = \frac{R + R_a}{(C + C_a)RR_a} \text{ and } i_x = i - \frac{E}{R}\frac{C_a}{C + C_a},$$

this equation (10) reduces to the same form as equation (2). Corresponding to equation

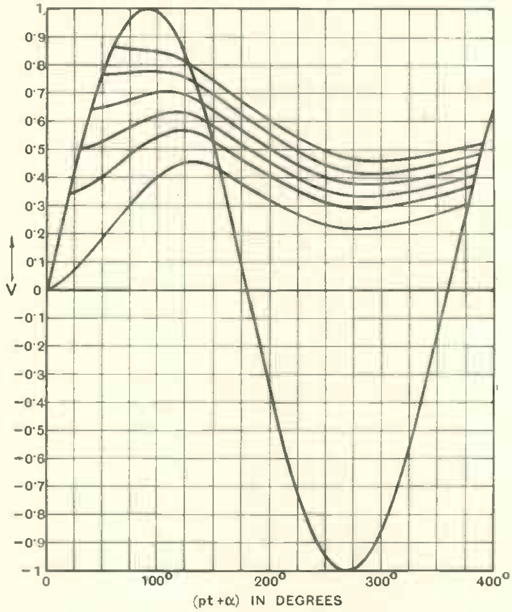

Fig. 12.—*Detector with appreciable capacity across rectifier.* $p/A = 2$, $R = 4R_a$, $C = 9C_a$, $\left[A = \frac{R + R_a}{(C + C_a)RR_a}\right]$

(4) we then have

$$i_xR = (i_xR)_{t=0}e^{-At} + \frac{E_sR}{R + R_a}$$
$$\left(1 - \frac{R + R_a}{R}\frac{C_a}{C + C_a}\right)\frac{1}{\sqrt{1 + p^2/A^2}}$$
$$\{\sin(pt + a - \theta) - \sin(a - \theta)e^{-At}\}$$

Substituting for i_x from the defining equation, and arranging in the form of equation (5), this becomes

$$V_t = E_s\left\{\left[\frac{C}{C + C_a}\sin a - \frac{1}{\sqrt{1 + p^2/A^2}}\left(\frac{R}{R + R_a} - \frac{C_a}{C + C_a}\right)\sin(a - \theta)\right]e^{-At} + \frac{C_a}{C + C_a}\sin(pt + a) + \frac{1}{\sqrt{1 + p^2/A^2}}\cdot\left[\frac{R}{R + R_a} - \frac{C_a}{C + C_a}\right]\sin(pt + a - \theta)\right\} \quad \text{(11)}$$

Like equation (5) this equation is valid when $E > V_t$, when $E < V_t$, the valid equation is obtained by putting $R_a = \infty$; then A becomes $\frac{1}{(C + C_a)R} = B$ say, and we get

$$V_t = E_s\left\{\left[\frac{C}{C + C_a}\sin\beta - \frac{1}{\sqrt{1 + p^2/B^2}}\frac{C_a}{C + C_a}\sin(\beta - \psi)\right]e^{-Bt} + \frac{C_a}{C + C_a}\sin(pt + \beta) - \frac{1}{\sqrt{1 + p^2/B^2}}\frac{C_a}{C + C_a}\sin(pt + \beta - \psi)\right\} \quad \text{(12)}$$

Where $E_s \sin\beta = V_0$ at $t = 0$, the instant when E becomes $< V_t$; and $\tan\psi = p/B$.

Two cases have been worked out in detail. For both $p/A = 2$ and $R = 4R_a$, in the first case $C = 9C_a$, in the second $C = C_a$. The curves for these cases are shown in Figs. 12 and 13, respectively. These curves and the figures obtained from them show that, to preserve efficiency, C must be much greater than C_a, a point worth remembering in short wave work. The effect of C_a may however be balanced out, as will appear in the next section.

(10) Push-Pull Detector.

The symmetrical circuit of Fig. 14 (*a*) will be considered. Let resistances, con-

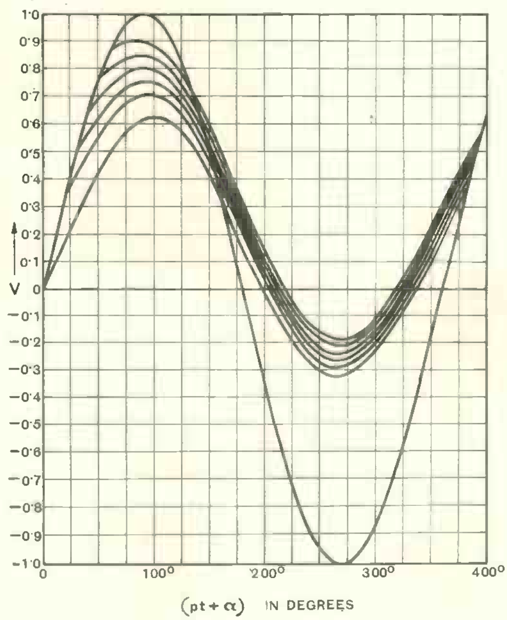

Fig. 13.—*Detector with capacity across the rectifier equal to the capacity across the output load resistance.*

$p/A = 2$; $R = 4R_a$, $A = \frac{R + R_a}{(C + C_a)RR_a}$

densers, currents and potentials have the values marked in the figure. The rectifiers, as before, are supposed to have infinite resistance for negative applied potentials.

When $E > V$, we have for the upper half of the circuit

$$E = i_1 R_a + (i_1 + i_{1c} + i_{2c})R \quad .. \quad (13)$$

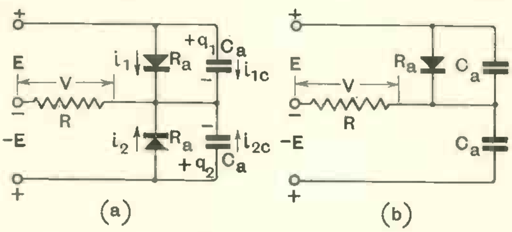

Fig. 14.—(*a*) *Push-Pull Detector Circuit.* (*b*) *Neutralised Detector Circuit.*

and for the lower half

$$-E = \frac{q_2}{C_a} + (i_1 + i_{1c} + i_{2c})R \quad .. \quad (14)$$

Also $i_1 R_a = \frac{q_1}{C_a}$, $\therefore i_{1c} = \frac{dq_1}{dt} = C_a R_a \frac{di_1}{dt}$

And $\qquad i_{2c} = \frac{dq_2}{dt}$

Eliminating i_{2c} between (13) and (14) by subtracting gives $2E = i_1 R_a - \frac{q_2}{C_a}$

Differentiating this

$$\frac{dq_2}{dt} = C_a R_a \frac{di_1}{dt} - 2C_a \frac{dE}{dt}$$

Substituting in (13) gives

$$E = i_1(R + R_a) + 2C_a R\left(R_a \frac{di_1}{dt} - \frac{dE}{dt}\right)$$

$$\text{i.e. } 2C_a R \frac{d}{dt}(R_a i_1 - E) + \frac{R + R_a}{R_a}(R_a i_1 - E) = -E\frac{R}{R_a}$$

But $\qquad E - R_a i_1 = V.$

$$\therefore \text{ we have } \frac{dV}{dt} + \frac{R + R_a}{2C_a R R_a} V = \frac{E}{2C_a R_a}$$

The solution of which is

$$V_t = V_0 e^{-At} + \frac{e^{-At}}{2C_a R_a}\int_0^t E e^{At} dt$$

Where $A = \frac{R + R_a}{2C_a R R_a}$. This is identical with equation (3), if $2C_a$ is written for C.

Hence with this modification equations (4) and (5) also apply to this case.

When $E < V$ and $-E < V$, both rectifiers have infinite resistance, so the solution for V (obtained by putting $R_a = \infty$ in equation (5)), becomes $V_t = V_0 e^{-Bt}$ where $B = \frac{1}{2C_a R}$. V therefore decays by the discharge of the condensers, as in the case of the single rectifier.

When $-E > V$, the second rectifier has resistance R_a, and the first has infinite resistance. Hence by symmetry the solution for V is the same as before, with $-E$ replacing E. But since E is negative the curve is of the form shown in Fig. 15. Fig. 15 is worked out for $R = 4R_a$, $p/A = 2$. The numerical results derived are included in the table below. These show that the push-pull detector can be more efficient in all ways, than a single rectifier circuit. It must be noted, however, that the input

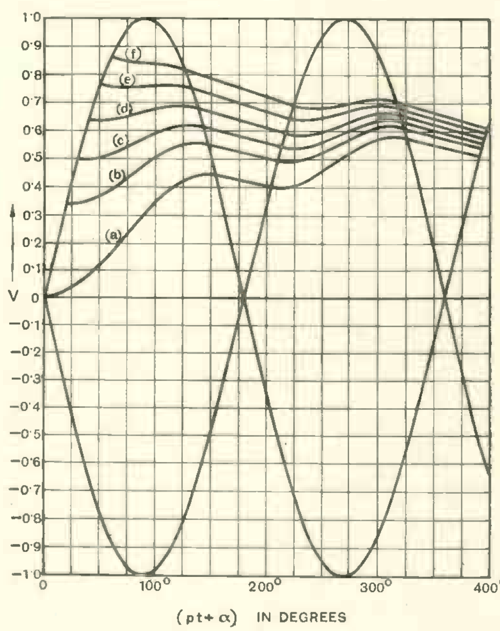

Fig. 15.—*Push-Pull Detector.* $p/A = 2$, $R = 4R_a$.

considered is $2E_s \sin(pt + \alpha)$. The main radio-frequency component in the output is of twice the signal frequency, other components being of higher frequency.

It is of interest to note that even if the second rectifier had been omitted in the above circuit (leaving the circuit of Fig. 14 (*b*)) the equations would still have been those of the simple circuit in which any capacity across the rectifier was neglected. The circuit of Fig. 14 (*b*) is therefore a circuit which uses only a single rectifier, and in which the effects of stray capacity across the rectifier are neutralised.

(11) Biased Rectifier.

It may happen that the characteristic of the rectifier is more nearly represented by an infinite resistance for an applied potential less than a critical value E_0, and a "slope" resistance R_a for greater applied potentials. This is equivalent to applying a negative bias E_0. V is then given by equation (4), which may be written

$$V_t - E_0\frac{R}{R+R_a} = \left(V_0 - E_0\frac{R}{R+R_a}\right)e^{-At} + \frac{E_sR}{R+R_a}\,\frac{1}{\sqrt{1+p^2/A^2}}\{\sin(pt+a-\theta) - \sin(a-\theta)e^{-At}\} \quad .. \quad (13)$$

The curves shown in Fig. 16 illustrate this, and it will be observed that the curves are derived from those of Fig. 4, by displacing the zero for V upwards by an amount $E_0\frac{R}{R+R_a}$ and by placing the zero for E_s, at E_0 below the zero for V. The exponential fall when $V > E_s + E_0$ (E_0 is negative), is towards zero V.

Two examples have been worked out for $p/A = 2$, $R = 4R_a$: in the first (illustrated in Fig. 16, E_s is considered reduced by modulation to $2E_0$, and in the second to $1.25\ E_0$. The results, shown in the table, show that the response factor is reduced. In consequence a component of twice the modulation frequency will be introduced into the output. In addition the maintained output V_{tm} is not exactly proportional to $E_s - E_0$, but the departure from linearity is small if E_s is never less than about $1.25\ E_0$.

It may be worth noting that it is impossible to bias the rectifier by applying a steady potential E_0, as above, if R is infinite.

TABLE OF RESULTS.

Circuit.		p/A	R	Efficiency V_{tm}/E_s	V_{tm}/H.F. Amplitude	Response Factor	pCR	pT	$\frac{p}{\sqrt{AB}}$	Remarks.
Simple Detector, Fig. 1 (*a*)	Fig. 2	2	.25 R_a	.072	1.5	0.94	2.5	2.2	2.2	
,, ,, ,, ...	Fig. 3	2	R_a	.217	2.1	0.88	4	2.9	2.8	
,, ,, ,, ...	Fig. 4	2	4 R_a	.468	4.7	0.80	10	3.9	4.5	
,, ,, ,, ...		10	.25 R_a	.076	6.9	0.43	12.5	11	11.2	
,, ,, ,, ...	Fig. 5	10	R_a	.225	9.4	0.36	20	14.1	14.1	
,, ,, ,, ...	Fig. 6	10	4 R_a	.470	21.4	0.27	50	20.0	22	
,, ,, ,,		10	100 R_a	.905	370	0.088	1010	66.6	100.5	
,, ,, ,,		10	20 R_a	.752	84	0.156	210	37.1	45.8	
,, ,, ,,		2	100 R_a	.905	38	0.39	202	12.8	20.1	
Ditto, with back resistance		2	4 R_a	.370	2.6	0.82	10	3.7	3.8	$p/B =$ 7.15
of rectifier = 10 R_a		10	4 R_a	.375	12.7	0.30	50	17.5	18.9	$p/B = 35.7$
	Fig. 7	2	∞	.620	5.7	0.68	∞	5.6	6.3	$p/B = 20$
With appreciable Stray Capacity across the rectifier, $C = 9\ C_a$	Fig. 12	2	4 R_a	.442	3.1	0.79	10	4.0	4.5	
$C = C_a$	Fig. 13	2	4 R_a	.253	0.52	0.79	10	4.0	4.5	
Simple Detector, Fig. 1 (*a*) with biased rectifier, $E_0 = \frac{1}{2}E_s$	Fig. 16	2	4 R_a	(.195)	4.2	0.76	10	4.4	4.5	$V_{tm}/(E_s - E_0) = 0.39$
$E_0 = 0.8E_s$		2	4 R_a	(.068)	3.0	0.64	10	6.1	4.5	$V_{tm}/(E_s - E_0) = 0.34$
Push-Pull Circuit, Fig. 14 (*a*) ..	Fig. 15	2	4 R_a	.604	13	0.88	10	3.0	4.5	H.F. $= p/\pi$

NOTE.—The mean value V_{tm} given in the table is the arithmetic mean between the maximum and minimum values which V_t assumes for a steady maintained input.

The H.F. amplitude is half the difference between the same maximum and minimum values of V_t.

By way of example, for $R_a = 25{,}000\ \omega$, $R = 100{,}000\ \omega$ and $C = .0001\ \mu$F, then $A = 500{,}000$, so for $p = 10^6$, *i.e.*, a wavelength $\lambda = 1885$ metres, the curves for $p/A = 2$ Fig. 4 apply. Or for $p = 5 \times 10^6$, *i.e.*, $\lambda = 377$ metres the curves for $p/A = 10$, Fig. 6 apply. Or for the same wavelength 377 metres if $C = 20\ \mu\mu$F, the curves of Fig. 4 again apply.

A bias may be applied through a resistance connected in parallel with the rectifier, in which case the back resistance of the rectifier is in effect reduced as well.

(12) Limitations.

It has been assumed that the input is maintained in spite of the load imposed by the detector. This in general is not the case, and the modulation response may be greatly

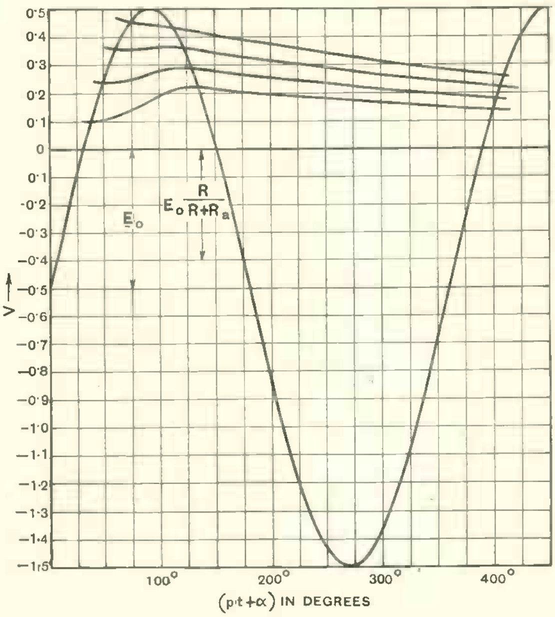

Fig. 16.—*Detector with Biased Rectifier.* $E_0 = \frac{1}{2}E_s$, $p/A = 2$, $R = 4R_a$.

altered, if the detector is fed from a tuned circuit for example. Unfortunately, I have not been able to calculate this effect by an extension of the method, as it involves complicated cubic equations. Similar remarks apply to the case where the output load is fed through a frequency filter. The reason is that impedance considerations alone are insufficient, for though only linear equations are involved, the complementary function in the solution is always important owing to the transitions. Alternatively, if the complementary function is discarded, simple oscillations must be replaced by complicated Fourier integrals.

(13) Summary.

The usual elementary pictorial treatment of the action of a detector employing a straight line rectifier, has been extended so that numerical calculations may be made for selected examples.

Illustrative curves are given showing the relation between simultaneous values of input and output potentials for simple detector circuits with different constants.

For a steady maintained input it is pointed out that the efficiency

$$\frac{\text{(mean output potential)}}{\text{(input peak potential)}}$$

does not vary greatly with the capacity across the load resistance, provided this is large compared with the capacity across the rectifier. Efficiency may be maintained when this is not the case, by a neutralising arrangement, or by the use of a push-pull detector circuit.

The efficiency of the detector for the modulation frequencies is somewhat less, being reduced by a factor, which may be compared with the transmission efficiency of a single stage resistance capacity filter. The time constant of this filter stage may be taken, by an empirical rule, as roughly the geometric mean of the time constants of the detector circuit when the rectifier is conducting and non-conducting. The time constant is, however, rather less for a push-pull detector.

The distortion which may arise when the output load resistance is very great, is discussed.

The case of infinite load resistance, but finite back resistance of the rectifier is considered, and shown to be quite normal.

It is shown that the slight distortion will be increased with a biased rectifier.

It has had to be assumed throughout that the input potential is maintained despite the load imposed by the detector.

The Generation of "Centimetre" Waves.*

By F. W. Chapman, M.Sc. (King's College, London).

IN the course of some experiments on the electrical properties of ionised gases for high-frequency electromotive forces, it was necessary to produce continuous waves with frequencies of the order of 10^9 cycles per second. In the experimental work carried out to this end a variety of circuits was tried and experience gained as to their relative practicability. It is possible that a description of the oscillators constructed for this purpose, which have proved most useful and satisfactory in operation, together with an account of the experience obtained in their manipulation, might be of interest to other workers interested in the same subject.

In what follows an essentially practical account is given of the production of high-frequency waves of wavelengths down to 40 cms. Further, a brief account is given of a simple method of detecting and measuring the wavelength of these oscillations.

In the generation of short electric waves by means of regenerative arrangements there is a lower limit occasioned by the fact that the time of transit of the electrons within the valve can no longer be ignored as compared with the wave period, and consequently the ordinary regenerative coupling conditions,

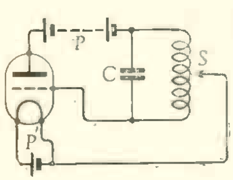

Fig. 1.

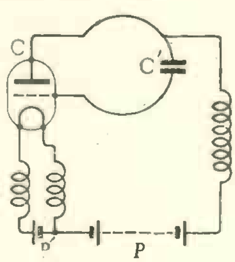

Fig. 2.

as far as they concern the phase relations of the grid and anode potential changes, are no longer sufficient. Such considerations have led to the Barkhausen-Kurz method of generating very short waves.[1]

For wavelengths of the order of a metre the method of maintenance is the same as that of longer waves by means of regenerative arrangements, but several modifications are made in reducing the values of inductance and capacity of the oscillatory circuits.

Much work on this subject has been done by Hartley, who developed the circuit shown in Fig. 1. The coupling is maintained by the two parts of the coil interposed between the two circuits of the grid and plate. From this circuit very short wavelengths have been produced. The capacity

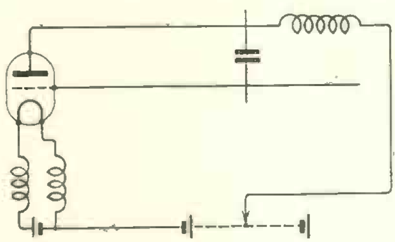

Fig. 3.

between the plate and grid is in parallel with the condenser *C*. This circuit, however, was modified by C. Gutton and M. Touly.

The coil *S* is replaced by a single loop of wire connecting the grid and plate (Fig. 2). The battery *P*, which would be in the oscillatory circuit, is modified, for this circuit is coupled to the filament by a condenser of 0.001 μF. capacity, which is great compared with the capacity of the valve.

Its presence does not modify sensibly the oscillation condition of the circuit. The chokes are employed to minimise the disturbing effects of the leads. With such an arrangement, a wavelength of 2 metres was obtained by C. Gutton and M. Touly. The existence of oscillations is indicated by the sudden increase in the plate current.

We have made a further modification of this circuit by using instead of a loop two parallel copper wires coupled directly to the grid and anode leads of the valve and shunted by a sliding bridge consisting of a 0.0003 μF. fixed condenser (Fig. 3). This arrangement, which is very similar to that adopted by Gill and Donaldson,[2] made it convenient to pass over to Barkhausen-Kurz oscillations by using the same apparatus. Before giving details of our first experiments with this, it may be mentioned that preliminary work was done with the circuit

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

developed by M. Mesny[3] (Fig. 4), but it was found impossible to attain wavelengths of less than five metres with this, whereas this was possible with the above method.

The structural details of the apparatus constructed according to Fig. 3 are shown in Fig. 5. The valve is supported on an ebonite frame and the Lecher Wires, of 16 S.W.G. gauge copper wire, 100 cms. long and 8 cms. apart, are attached to the grid and plate electrodes of the valve. These wires were amalgamated with mercury to ensure good contact with the short-circuiting condenser bridge. The wire chokes were employed to minimise the disturbing effects of the leads on the high-frequency circuits.

For the suitable plate voltage applied to the valve, the bridge was adjusted until the resonance position was obtained, when oscillations commenced, as was indicated by the change in the anode current. The wavelength of the oscillations was determined on a Lecher Wire System.

To produce wavelengths of the order of a few centimetres, we have developed the methods of Barkhausen and Kurz. In contrast with the ordinary method of operating the three-electrode valve the grid potential is highly positive and the plate potential is negative generally with respect to the filament. Because of the distribution of electric force inside the valve, there is a to-and-fro movement of the electrons about the grid, since those with high velocity that have passed through the meshes of the grid are reversed by the retarding field of the anode and are driven back to the grid. This point has been criticised recently by W. E. Benham[4] who gives another theory.

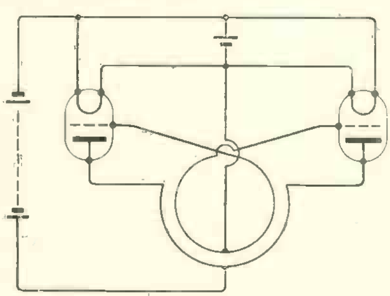

Fig. 4.

A confirmation of the views of Barkhausen and Kurz is found in the fact that the wavelengths produced are determined by the dimensions of the valve and the applied potentials.

The modifications necessary to our apparatus are shown in Fig. 6, and the structural details are still as shown in Fig. 5.

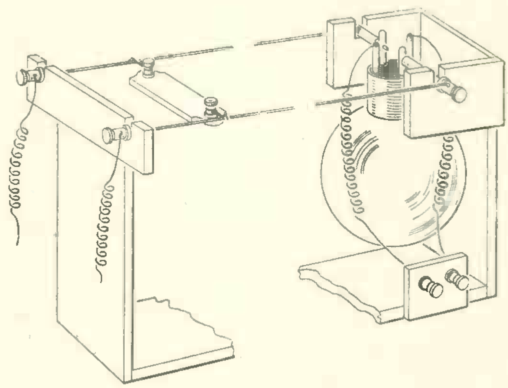

Fig. 5.

The suitable valves available were of the bright emitter type, having a symmetrical cylindrical electrode system. The valves used were the low power "army transmitter" type, A.T.40. The anode was approximately 1.4 cms. in diameter and length 2.2 cms., with a close spiral grid of about 0.5 cm. in diameter. These valves approached most to the types used previously and the specifications given by R. Mesny and Pierret, who used the French T.M.C. valve, which was not available for our first experiments. It may here be mentioned that the production of Barkhausen-Kurz oscillations depends on the design and dimensions of the valve, and it has been found that valves of the same dimensions and manufacture, placed in identical circumstances, do not oscillate with the same facility.

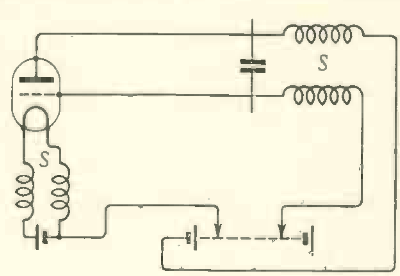

Fig. 6.

Details of the valve type used, voltages applied to the grid and the plate, and the resulting wavelength obtained are given in the Table below, but the experimental procedure is as follows :—

In all cases it was found that valves would

Valve : Low Power " Army Transmitter," A.T.40.
Filament Voltage : 7 volts.
Filament Current : 1.5 amps.

Circuit Fig. Ref.	Grid Voltage +ve.	Anode Voltage.	Wave-length. cms.
6	150	0	89
6	270	−2.5	60
8 or 9	300	−16	54
9	270	−90	44
9	360	−90	40

not oscillate until a certain filament brilliancy was reached, and on cooling the oscillations ceased. It was observed that for fixed voltages the wavelength emitted could be varied slightly by adjusting the filament brilliancy. A milliameter was placed in the plate circuit lead, for when oscillations commenced a current was indicated in this circuit. The maximum intensity of oscillations coincided generally with the maximum plate current, although, as observed previously,[5] this was not always the case.

The best results were found to be obtained by using a 0.0003 μF. short-circuiting condenser across the Lecher Wires. Various negative anode voltages were applied, and by continual variation of the grid voltage positive to the filament, and the bridge

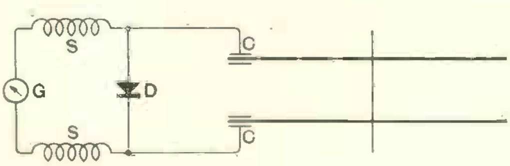

Fig. 7.

condenser position, it was found possible to detect the optimum value of the voltage and the bridge position for oscillations to commence. It was further observed that the wavelength is not always determined by the applied voltages as defined by the method of Barkhausen and Kurz, but depends also on the external oscillation system. The Lecher Wires connected with the grid and anode directly effect the wavelength, since the resonance maxima were found not to be fixed, but to " slide along " as the bridge was shifted.

This effect was first observed by Gill and

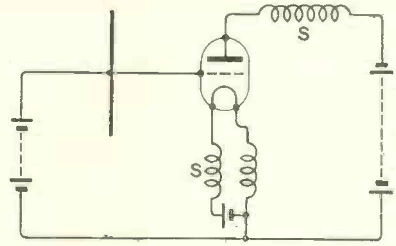

Fig. 8.

Morrel,[6] and the existence of these oscillations and the true Barkhausen-Kurz oscillations at the same time—giving rise to two frequencies—was observed on several occasions. However, monochromatic radiation was obtained by the more intense Gill-Morrel oscillations by suitable adjustment of the bridge.

Thus it was found that the wavelength λ could be controlled to some extent by the position of the bridge. In some cases two positions for maximum oscillation were observed, and the difference in distance between them was found to be $\lambda/2$ as determined on a Lecher Wire system in the vicinity.

The circuit of this arrangement is shown in Fig. 7. The parallel copper wires, of 16 S.W.G. copper wire, were 5 cms. apart and 200 cms. in length. At first a short-circuiting metal bar was used and its position adjusted until stationary standing waves were obtained. When this is the case a maximum E.M.F. is developed across the free ends of the wires and detected by the condensers *CC* consisting of short brass tubes, which were insulated from the wires by a thin glass tube, and the crystal detector circuit. A maximum deflection produced by a dead-beat moving-coil galvanometer indicates resonance points of the bridge, and the distance between such points is $\lambda/2$. Unfortunately, end effects made this procedure doubtful ; however, following the method of Mesny,[3] by using a metal disc of convenient size, 30 cms. × 30 cms., and at right angles to the wires by which it was made to slide by a long ebonite rod, end effects were found to be entirely eliminated and the tuning for resonance points sharper.

A typical curve for this, showing galvanometer deflections for different positions of the disc along the Lecher Wires, is shown in

Fig. 11, which indicates a radiation of wavelength 89 cms.

In order to obtain still shorter wavelengths we have followed the experiments of Pierret.[7] It is found that by increasing the grid potential to voltages of the order of 300 v. and decreasing the plate voltage to between 40–90 volts negative that weak oscillations of much shorter wavelength are detected on the detector Lecher Wire system, although no plate current is indicated. Pierret has explained these oscillations and we have constructed apparatus from his circuit shown in Fig. 8. A single wire 60 cms. long was attached to the grid along which a copper disc perpendicular to the wire could slide. The wire passes through the centre of the disc, of diameter about $\lambda/2$, *i.e.*, 20 cms.

For a convenient position of this disc oscillations are maintained along the wire, but, contrary to the previous circuits, they are not found along the wire joining the plate, which may consequently be connected by a choke to the battery. Increased intensity of

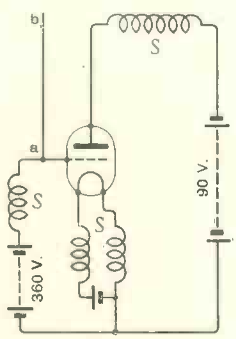

Fig. 9.

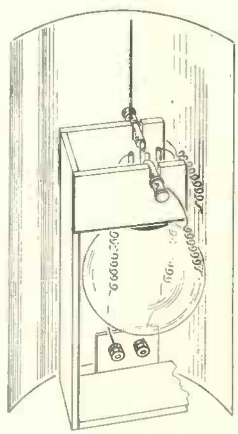

Fig. 10.

radiation is given from this system, although the feeble oscillations are present in the valve, irrespective of the external circuit as was found by connecting four chokes to the valve electrodes.

A series of positions of the disc are found for maximum oscillation intensity separated by a distance of $\lambda/2$ as before, but λ is not determined by the external circuit and depends alone on the valve and applied voltages.

The oscillator can be used to radiate energy by using a little rectilinear aerial. The arrangement in Fig. 9 is used, and the length of the copper wire *ab* is determined experimentally such that the conductor which it forms with the grid is that required to give maximum radiation. This is found to be approximately $\lambda/4$. The plate was 90 volts negative and the grid 360 volts positive to the filament, and with our valves a wave-

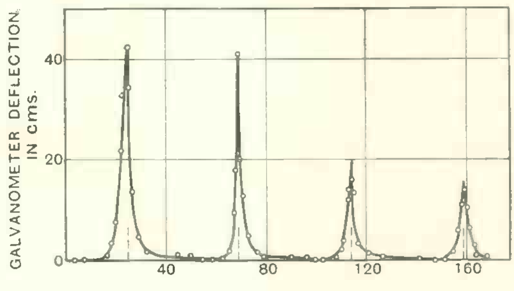

Fig. 11.

length of 40 cms. was obtained, whereas Pierret, using the French T.M.C. valve, maintained waves of wavelength 12 cms.

Much increased radiation was obtained by this system, shown in Fig. 10, and it was found that almost all the energy could be concentrated in one direction by using a copper cylindrical reflector.

The absence of high-frequency oscillations in the wire connected to the plate shows that the electron movements are produced in the vicinity of the grid. The reduction of the wavelength is explained by Pierret by the fact that the effective electronic movements are no longer between the grid and plate, but on either side of the grid.

In conclusion, the author would like to acknowledge his indebtedness to Professor E. V. Appleton for his very generous provision of apparatus and helpful discussion during the progress of the work.

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Resistance in Band Pass Filters.*

By George H. Buffery.

WHILE investigating the possibility of improving the general performance of a wireless receiver over the whole of the broadcast bands, it became necessary for the author to examine the theoretical performance of a Band Pass Filter, as a preselector before the first H.F. valve, at several points in each band, and under two sets of conditions. As was recently pointed out by Professor G. W. O. Howe in *The Wireless Engineer*, any estimation of such performance which leaves out of account the influence of the resistance of the circuit, is likely to be extremely misleading. Further, the position is complicated by the fact that in the perfectly general case, no definite allowance can be made for the effective resistance introduced into the primary member by the aerial re-radiation, etc., nor into the secondary member by the load impedance of the amplifier. Within certain limits, however, it is possible to assign values to these quantities, based upon specific measurements in definite cases, and assuming that such values hold approximately for the case under consideration. Thus in what follows the resistance in each filter member is assumed to be known at all frequencies.

A convenient classification of coupled circuits is that used by L. S. Palmer ("Wireless Principles and Practice," p. 81), who divides them into three classes:

(*a*) Coupling reactance not common to both members.

(*b*) Coupling reactance common to both members.

(*c*) Coupling through a mutual field.

Generalised diagrams of these types are shown in Fig. 1. Under certain conditions, two or more couplings can be combined giving a resultant which is approximately the algebraic sum of the separate couplings. Couplings of classes (*a*) and (*b*) will be dealt with in this article. Couplings of class (*c*) have been extensively used for many years and the considerations governing their use are well known. The coupling reactances in the two former types are either inductive or capacitive, but for practical reasons capacity coupling is more generally used. In the "mixed" filter capacity coupling is combined with negative mutual inductance. These two filters are shown in Fig. 2 (*a*) and (*b*), which also give the notation which will be employed subsequently. It will be noticed that the inductance and capacity in primary and secondary members respectively are sensibly equal. This is in accordance with current practice and, in fact, this equality is the feature to which the name "Band Pass Filter" is now given. For convenience, therefore, it will be assumed that the resistances and reactances of primary and secondary members are equal, so that the symbols *R*, *L*, *C*, *X*, *Z*, are common to both members.

Referring to Fig. 2 (*a*) it is seen that if i is the current flowing in the secondary member due to the e.m.f. e, where $e = E_{max.}$

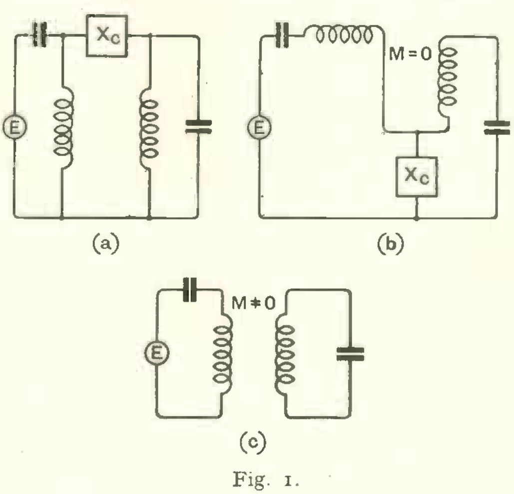

Fig. 1.

$\sin \omega t$, then the voltage applied to the grid of the first valve is $\frac{i}{j\omega C}$. Further, these instantaneous values can easily be converted into R.M.S. values, and therefore i', the virtual current, can be calculated for a series

* MS. received by the Editor, November, 1931.

of values of ω (which is $2\pi f$) and a curve plotted showing the "pass characteristic" of the filter, i' against ω, or the applied grid voltage, v' against ω.

Taking then the circuit of Fig. 2 (*a*) let currents be assumed to flow as shown by the direction of the arrows. Maxwell's rule may now be applied to the network, giving the following equations :

$$\left.\begin{aligned} ZI - jx_c i &= e \; (a) \\ -jx_c I + Zi &= 0 \; (b) \end{aligned}\right\} \quad \ldots \quad \ldots \quad (1)$$

From (*b*) $I = \dfrac{Z}{jx_c} i$, and inserting this value in (*a*)

$$e = \left[\frac{Z^2}{jx_c} - jx_c\right] i$$

$$i = \frac{jx_c e}{Z^2 + x_c^2} \quad \ldots \quad \ldots \quad (2)$$

Now in this filter $x_c = -\dfrac{1}{\omega C_0}$, and

$$Z = R + j\omega L + \frac{1}{j\omega C} + jx_c$$

$$= R + j\omega L + \frac{1}{j\omega C} + \frac{1}{j\omega C_0}$$

$$= R + j\omega L + \frac{C + C_0}{j\omega C C_0} \quad \ldots \quad (3)$$

but, by the usual definition of a coupling coefficient κ

$$\kappa = \frac{C}{C + C_0} \text{ (for this type of filter)}$$

and therefore eq. (3) can be written

$$Z = R + j\left(\omega L - \frac{x}{\kappa}\right) \quad \ldots \quad (3a)$$

$$Z^2 = R^2 + 2Rj\left(\omega L - \frac{x}{\kappa}\right) - \left(\omega L - \frac{x}{\kappa}\right)^2 \quad (3b)$$

(where x is written for $-x_c$ or $\dfrac{1}{\omega C_0}$) and from eq. (2)

$$-i = \frac{jxe}{R^2 + x^2 - \left(\omega L - \frac{x}{\kappa}\right)^2 + 2Rj\left(\omega L - \frac{x}{\kappa}\right)}$$

It is now permissible to write

$$i' = \frac{xE'}{\left[\left\{R^2 + x^2 - \left(\omega L - \frac{x}{\kappa}\right)^2\right\}^2 + 4R^2\left(\omega L - \frac{x}{\kappa}\right)^2\right]^{\frac{1}{2}}} \quad \ldots \quad \ldots \quad (4)$$

since the R.M.S. value only of i is required.

$$\therefore \quad i' = \frac{xE'}{Z_f^2}$$

where $$x = \frac{1}{\omega C_0}$$

$$Z_f^4 = (R^2 + x^2 - P^2)^2 + 4R^2P^2$$

$$P = \omega L - \frac{x}{\kappa}$$

$$E' = \frac{E}{\sqrt{2}}$$

By allotting numerical values to the constants in this expression, it is possible to draw the pass characteristic of the filter over any desired range of pulsatance. The chief difficulty is with the term $\left(\omega L - \dfrac{x}{\kappa}\right)$ since each separate computation is usually required over only a small range of pulsatance, *e.g.*, 7.4×10^6 to 7.6×10^6 or approximately 30,000 cycles. In such circumstances computations of ωL and $\dfrac{x}{\kappa}$ made by slide rule for small differences of ω are very inaccurate, while the evaluation for, say, 12 values of ω only 15,000 apart is

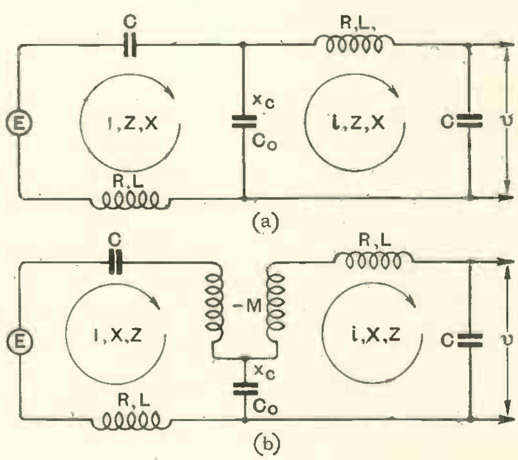

Fig. 2.

apt to become a tedious business. A few computations of this nature showed, however, as might have been expected, that the term $\left(\omega L - \dfrac{x}{\kappa}\right)$ is practically linear over the range required in any one investigation, and if this term were made the independent variable instead of ω in a semi-graphical method of computation, an accurate picture of Z_f^2 could be obtained with little labour, while the curves brought out several points not immediately apparent in the algebraic

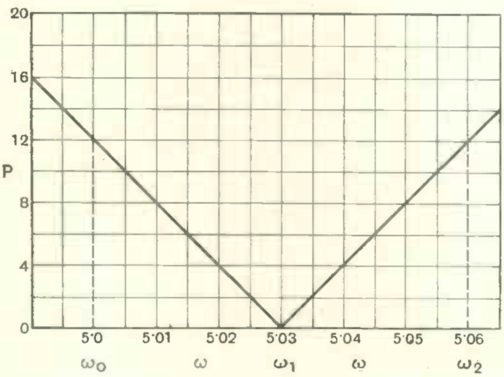

Fig. 3.

form, and enabled a clearer insight into the "mechanism" of the filter to be obtained. From the Z_f^2 curve, the Pass characteristic can be obtained by slide rule with sufficient accuracy.

From equation 3*a* and the circuit diagram, Fig. 2 (*a*), it is seen that $\left(\omega L - \frac{x}{\kappa}\right)$ is the reactance of either the primary or secondary member of the filter taken alone, but including the coupling condenser in series with the tuning condenser. Now when the "Pass region" of the filter is approached, for any given setting of the tuning condenser, from the lower end of the frequency spectrum, *i.e.*, from the direction in which $\frac{x}{\kappa} > \omega L$, a point ω_0 is reached at which

$$\frac{1}{\omega_0 C} - \omega_0 L = 0, \text{ or } \omega_0^2 = \frac{1}{LC}$$

$$\frac{x}{\kappa} - \omega_0 L = \frac{1}{\omega_0 C_0} \quad \ldots \quad \ldots (5a)$$

Proceeding along the spectrum we reach the point ω_1, at which

$$\omega_1 L = \frac{x}{\kappa}$$

$$\omega_1 L = \frac{1}{\omega_1 C} + \frac{1}{\omega_1 C_0}$$

$$\omega_1^2 = \frac{1}{LC}\left(\frac{C_0 + C}{C_0}\right), \text{ or } \omega_0^2 \frac{C_0 + C}{C_0} \quad \ldots (5b)$$

Finally, on reaching the point ω_2, where

$$\omega_2 L - \frac{x}{\kappa} = \frac{1}{\omega_2 C_0}$$

$$\omega_2 L - \frac{1}{\omega_2 C} = \frac{2}{\omega_2 C_0}$$

$$\omega_2^2 = \omega_0^2 \frac{2C + C_0}{C_0} \quad \ldots (5c)$$

In the ordinary course of events, *when the resistance is negligible*, one "peak" of the filter current occurs at ω_0 and the other at ω_2, while at ω_1 the filter impedance passes through a maximum and the current is therefore a minimum. Thus if $\left|\omega L - \frac{x}{\kappa}\right|$ is plotted against the pulsatance, the graph shown in Fig. 3 is obtained. In order to give point to the curves, a concrete example has been taken. Hence, Fig. 3 relates to a filter having the following values in each member:

$L = 200$ μH., $C = 200$ μμF., $R = 5$ ohms, $C_0 = 0.0167$ μF (actually 15,000 cms.).

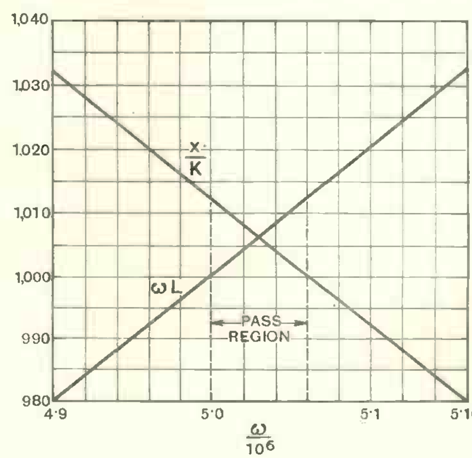

Fig. 3a.—*Linear variation of ωL and $\frac{x}{\kappa}$ over small (but sufficient) range of ω.*

From this data and eq's. 5*a*, *b* and *c*, it will be found that $\omega_0 = 5 \times 10^6$, $\omega_1 = 5.03 \times 10^6$ and $\omega_2 = 5.06 \times 10^5$. The "theoretical" peak separation, neglecting the effect of resistance, is thus $\frac{60{,}000}{2\pi}$ or approximately 9,500 cycles.

The ordinate $\left|\omega L - \frac{x}{\kappa}\right|$ has been designated " P." It will be seen that $P = B\delta\omega$, where $\delta\omega$ is the amount the pulsatance differs from ω_1 (where $P = 0$) and B is a constant. The fact that P is a linear function of ω over this range of pulsatance enables us to draw graphs of the various component terms of Z_f^2 against P as abscissa.

Thus in Fig. 4 are shown P^2, x^2, $R^2 + x^2$, and $R^2 - x^2$ against P. It must be here pointed out that in most practical cases it will be found that x^2 is practically constant over the pass region immediately under

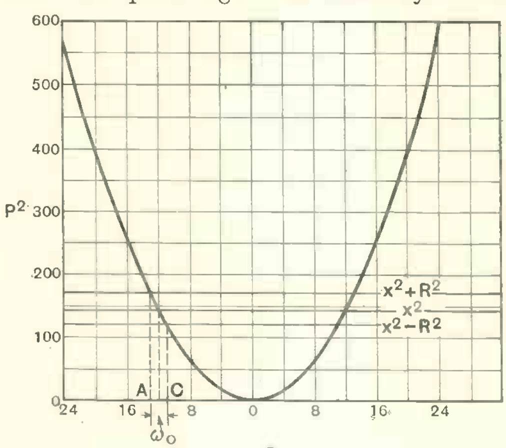

Fig. 4.

investigation, and as a first approximation we may consider this to be the case.*

A simple consideration then shows that the whole of the first component of Z_f^2 can be shown by a simple graphical subtraction, as in Fig. 5. A convenient method of performing this subtraction is to plot $y = P^2$ on a separate sheet and cut out the area contained by the curve and its axis. Such a curve can then be used for all computations on the same geometrical scale. It is now an easy matter to derive the graphical equivalent of $Y^2 = \{R^2 + x^2 - P^2\}^2$ (Fig. 6). $X = 2RP$ (Fig. 5) and $X^2 = 4R^2P^2$ (Fig. 6) are also obtained in a similar manner. Fig. 6 shows Y^2 and X^2 against P, and by graphical addition Z_f^4 is obtained. From this it is an easy matter to obtain Z_f^2, which is plotted on the same scale (and sheet) as X and Y. Finally the expression $i' = \frac{xE'}{Z_f^2}$ can be evaluated by slide rule with sufficient accuracy for any ordinary purpose, and the expression plotted to abscissa ω if required by means of the relation $P = B\delta\omega$.

Inspection of these curves brings out several points which are not immediately obvious in the algebraic form. Thus it is seen that if $R = 0$, $Z_f = 0$ at ω_0 and at ω_2, giving the two peaks in the positions usually obtained. With the condition $R > 0$, however, these " potential " peaks are moved outward to an extent depending upon the resistance, while since at the points where Z_f^2 is a minimum, X is not zero (although Y is), $Z_f^2 = X$ instead of 0. Consequently i' can be immediately computed for these points, being $\frac{xE'}{X}$ or $\frac{xE'}{2RP}$. The intersections of the curves of X and Y give another easily computed point, for here

$$i' = \frac{xE'}{\sqrt{X^2 + Y^2}} = \frac{xE'}{\sqrt{2}X}$$

Again, at ω_1 $Z_f^2 = Y$ and $i' = \frac{xE'}{Y}$, but at this point $Y = x^2 + R^2$.

$$\therefore \quad i' = \frac{xE'}{x^2 + R^2} \quad \ldots \quad \ldots \quad (6)$$

These points, with one to be mentioned later, will often be enough to draw the curve of Z_f^2 without computing any intermediate values.

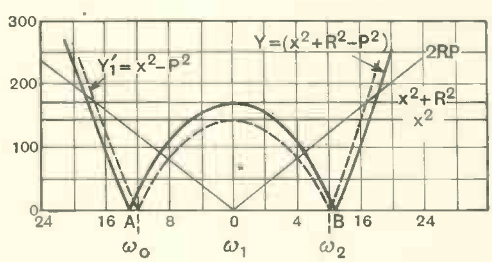

Fig. 5.

The chief merit of this method is the ease with which the effect of any variation of resistance can be studied. As has been already shown, the first, or what may be called the " non-reactive," effect of R is to displace the peaks outward from their rudimentary positions ω_0 and ω_2 to A and B

* For " constant peak separation " x would be constant over the whole range of the tuning dial.

(Fig. 5). The effect of the "reactive" component X, however, is to displace the peak inward, for an increase in R increases the slope of X, and therefore tends to move

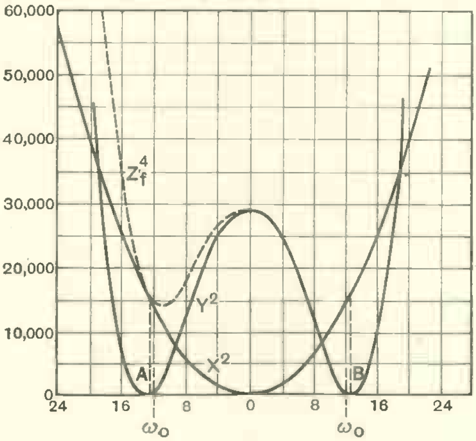

Fig. 6.

its intersection of the inverse parabola inward toward the origin of P. The actual combined effect of the two components is certainly seen most clearly with the aid of analysis. Therefore, writing

$$Z_f^4 = \{R^2 + x^2 - P^2\}^2 + 4R^2P^2 \quad .. \quad (7)$$

Expanding,

$$Z_f^4 = R^4 + 2R^2x^2 + x^4 + 2P^2(R^2 - x^2) + P^4$$

deriving with respect to P and equating to zero

$$(R^2 - x^2) + P^2 = 0$$

$$P = \sqrt{x^2 - R^2} \quad .. \quad .. \quad (8)$$

This is a minimum if P is real and gives the position of the peak value of i'. Substituting this value for P in eq. 6, $Z_f^2 = 2Rx$

and $$i' = \frac{xE'}{2Rx} = \frac{E}{2R} \quad .. \quad .. \quad (9)$$

giving the peak value of i'. It will be observed that the peak is non-existent if $R > x$, in which case P in eq. 8 becomes imaginary. In such cases the current never reaches the value $\frac{E'}{2R}$. This point can now be added to those already referred to. Fig. 4 shows that the position of the actual peak is given graphically by the intersection of the lines $y = P^2$ and $y_1 = x^2 - R^2$, *i.e.*, at C.

Consideration of the foregoing principles will be of assistance in determining whether in any particular case it is possible to design a filter having certain definite characteristics. Two cases commonly arise in practice.

In the first instance, with given coils and condensers, whose total equivalent series resistance is known, it is desired to know the maximum ratio of i_p, the current at "peak" frequency to i, the current at ω_1, *i.e.*, at the centre of the pass region.

N. R. Bligh and W. T. Cocking have already given an expression which can be used for this case, which can be written

$$\delta\omega_p = \frac{\sqrt{x^2 - R^2}}{2L} \quad .. \quad .. \quad (10)$$

Example.

A pair of coils of 200 μH. and 12 ohms resistance each, tuned by variable condensers, and coupled by a fixed condenser, are to be tuned as a filter to $\frac{5 \times 10^6}{2\pi}$ cycles/sec. (This is the coil examined by A. L. M. Sowerby, *W.W.*, 14.10.31.)

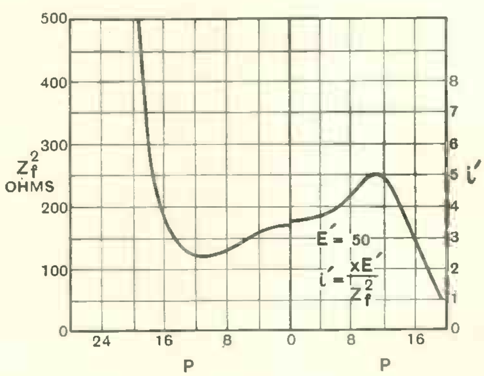

Fig. 6a.

The desired frequency breadth is $\frac{3 \times 10^4}{2\pi}$ *on either side* of the midpoint. Inserting values in eq. 10,

$$3 \times 10^4 = \frac{\sqrt{x^2 - 144}}{400/10^6}$$

$$3 \times 10^4 \times 400 = \sqrt{x^2 - 144} \times 10^6$$

$$(12)^2 = x^2 - 144$$

$$x^2 = 2 \times 144$$

$$x = 12\sqrt{2} = 17 \text{ ohms.}$$

i.e., $$\frac{1}{5 \times 10^6 C_0} = 17$$

$$C_0 = \frac{1}{5 \times 10^6 \times 17} \times 10^6 \mu\text{F}.$$
$$= .01175\ \mu\text{F}.$$

The ratio of i_p to i_1 is given by

$$\frac{E}{2R} \div \frac{xE}{x^2 + R^2}$$

$$= \frac{x^2 + R^2}{2Rx} = \frac{289 + 144}{2 \times 12 \times 17} = \underline{\underline{1.06}}$$

A second type of calculation arises when it is desired that the ratio $\frac{i_p}{i_1}$ shall have some definite ratio at a particular frequency. In this case it is necessary that the damping factor $\frac{R}{2L}$ of the circuit (that is, of each member of the filter) should be known. Then from eq's. 6 and 9,

$$i_p = \frac{E}{2R}, \quad i_1 = \frac{xE}{x^2 + R^2}$$

and if $\frac{i_p}{i_1} = n$,

$$\frac{1}{2R} = \frac{nx}{x^2 + R^2}$$

or $$x^2 - 2Rnx + R^2 = 0$$

$$x = R\{n + \sqrt{n^2 - 1}\}$$

remembering that n is assumed positive and > 1, also that $x > R$ for a peak to occur.

Let P_p = value of P at ω_p where peak current occurs.

P_0 = value of P at $\omega_0 = \frac{1}{LC}$

$\delta\omega_p$ = interval of pulsatance, $P = P_p$ to $P = 0$.

$A = n + \sqrt{n^2 - 1}$.

Then $$P_p = \sqrt{x^2 - R^2}$$
$$= \sqrt{A^2R^2 - R^2}$$
$$= R\sqrt{A^2 - 1}$$
$$P_0 = x = AR$$
$$\frac{P_0}{P_p} = \frac{AR}{R\sqrt{A^2 - 1}} = \frac{A}{\sqrt{A^2 - 1}}$$

From eq. 10, $P_p = 2L\delta\omega_p$

$$P_0 = AR = \frac{A}{\sqrt{A^2 - 1}} P_p$$

$$\therefore \quad AR = \frac{A}{\sqrt{A^2 - 1}} \times 2L\delta\omega_p$$

or $$\frac{R}{2L} = \frac{\delta\omega_p}{\sqrt{A^2 - 1}} \quad \ldots \quad \ldots (11)$$

Thus the pass region and the ratio i_p/i_1 both depend upon the circuit-damping factor. It appears that if an experimentally obtained resonance curve is available, the damping factor can be easily determined, the requirements being

(1) The pulsatance difference between "centre" and "peak" of curve ($\delta\omega_p$).

(2) The *ratio* i_p/i_1.

Reverting to the case where $\delta\omega_p$ and A are given, it is seen that the problem becomes one in coil and condenser design, in order to achieve the desired damping factor.

The Mixed Filter.

If the equations for Fig. 2 (*b*) are fully developed, eq. 4 becomes

$$i' = \frac{\left(\omega M + \frac{1}{\omega C_0}\right)E'}{\left[\left\{R^2 + \left(\omega M + \frac{1}{\omega C_0}\right)^2 - \left(\omega L - \frac{x}{\kappa}\right)^2\right\}^2 + 4R^2\left(\omega L - \frac{x}{\kappa}\right)^2\right]^{\frac{1}{2}}} \quad \ldots (4a)$$

which is identical with eq. 4 if x be written for $\left(\omega M + \frac{1}{\omega C_0}\right)$. It follows that all the foregoing applies to this arrangement exactly as for the simple filter. Note that M in this expression is a positive quantity, although electrically M is — ve. If M is + ve electrically, M in the above expression is — ve, and the filter is a type of "band stop" arrangement.* The advantage of the mixed filter is seen by an examination of eq. 4*a*, since it will be found that by a suitable choice of values x can be made practically constant over a wide range of variation of ω.

The "Link" Filter.

Fig. 7 (*a*) shows the circuit to which this name is usually given. Although from the point of view of analysis this is a three-mesh

* W. H. Nottage, "Calculation of Inductance and Capacity," quotes A. Campbell, *Proc. Phys. Soc.*, xxiv, p. 107 (1912), for the origin of this device.

network, an expression for i' can be obtained which is similar to that already obtained for the simple filter. In fact, for the circuit of Fig. 7

$$i' = \frac{\left(\omega L\kappa_L^2 + \frac{1}{\omega C_0}\right)E'}{\left[\left\{R^2 + \left(\omega L\kappa_L^2 + \frac{1}{\omega C_0}\right)^2 - P^2\right\}^2 + 4R^2P^2\right]^{\frac{1}{2}}}$$

where P is now equal to

$$\omega L(1 - \kappa_L^2) - \frac{x}{\kappa_c}$$

Here κ_L is the coefficient of coupling between the tuning inductance proper and the

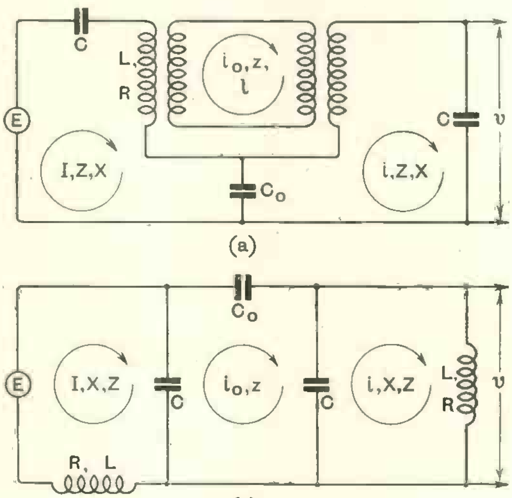

Fig. 7.

link circuit. κ_L^2 is approximately the coefficient of coupling between the primary and secondary members. Obviously x can be written for $\omega L\kappa_L^2 + \frac{1}{\omega C_0}$ and the expression then becomes identical with eq. 4.

In passing, it may be remarked that the link circuit, either "single" or "mixed," behaves as a coupled circuit with one stationary peak, at $\omega^2 = \frac{1}{LC}$. This is because current can exist in the "link circuit" independently of either separate coupling.

The physical interpretation of this phenomenon was first given by Professor G. W. O. Howe.*

Three-mesh Circuits.

The fact that the three-mesh network of the link circuit is capable of such manipulation as to give an equation of the same form as the simple filter is rather surprising. It suggests that similar expressions may be obtained for the three-mesh network shown in Fig. 7 (*b*). Analysis gives the secondary current in this case as identical with eq. 4, if the following relations are conceded :—

$$x = \frac{C_0}{\omega C(2C_0 + C)}$$

$$P = \omega L - \frac{1}{\omega C}\left(1 - \frac{C_0}{2C_0 + C}\right)$$

The positions of the peaks and centre of filter are

"Peak" at $\omega_0^2 = \frac{1}{LC}$, *i.e.*, $\frac{1}{LC}\,\frac{2C_0 + C}{2C_0 + C}$

Centre at $\omega_1^2 = \omega_0^2\,\frac{C_0 + C}{2C_0 + C}$

Peak at $\omega_2^2 = \omega_0^2\,\frac{C}{2C_0 + C}$

Resistance of Separate Circuits.

Examination of eq's. 3 *et seq.* shows that if the resistances in the two members are unequal, the above equations still hold if R_1R_2 is written for R^2 and $R_1 + R_2$ for $2R$.

Conclusion.

This paper was originally intended to deal with the capacity coupled filter in such a manner as to render it amenable to computation. The possibility of reducing other forms of filter-current equations to a similar form caused it to become a general dissertation upon filter circuits ; nevertheless, it is hoped that the simple treatment given herein will be found useful by wireless engineers.

Appendix.

Equation for the Link Circuit :

$$ZI - j\omega Mi_0 - \frac{i}{j\omega C_0} = E$$

$$-j\omega MI + zi_0 - j\omega m = 0$$

$$-\frac{I}{j\omega C_0} - j\omega mi_0 + Zi = 0$$

* "Analysis of Frequency in Oscillatory Circuits," *Elec. World*, N.Y., vol. 68, 1916.

i can be obtained from the determinant

$$\frac{\begin{vmatrix} Z, & -j\omega M, & E \\ -j\omega M, & z, & 0 \\ \frac{j}{\omega C_0}, & -j\omega m, & 0 \end{vmatrix}}{\begin{vmatrix} Z, & -j\omega M, & \frac{j}{\omega C_0} \\ -j\omega M, & z, & -j\omega m \\ \frac{j}{\omega C_0}, & -j\omega m, & Z \end{vmatrix}}$$

From which

$$i = \frac{-\omega^2 MmE - \frac{jz}{\omega C_0}E}{Z^2 z - \frac{j}{\omega C_0} \times 2\omega^2 Mm + \omega^2 M^2 Z + \omega^2 m^2 Z + \frac{z}{\omega^2 C_0^2}}$$

The resistance of z can be neglected so that $z = j\omega l$. Also $m = -M$.

$$i = \frac{\left\{\omega^2 M^2 + \frac{\omega l}{\omega C_0}\right\}E}{\left\{Z^2 j\omega l + \frac{2j\omega^2 M^2}{\omega C_0} + \frac{j\omega l}{\omega^2 C_0^2} + 2Z\omega^2 M^2\right\}}$$

$$= \frac{-j\left\{\frac{\omega M^2}{l} + \frac{1}{\omega C_0}\right\}E}{\left\{Z^2 + \frac{2\omega M^2}{l} \times \frac{1}{\omega C_0} + \frac{1}{\omega^2 C_0^2} - j\frac{\omega M^2}{l} \times 2Z\right\}}$$

Consider the denominator only ; $\frac{M^2}{Ll} = \kappa_L^2$

$$\therefore \quad \frac{\omega M^2}{l} = \omega L\kappa_L^2; \text{ also } \frac{1}{\omega C_0} = x$$

$$D = Z^2 + 2\omega L\kappa_L^2 x + x^2 - j2\omega L\kappa_L^2 Z$$

$$= R^2 - \left(\omega L - \frac{x}{\kappa_c}\right)^2 + 2Rj\left(\omega L - \frac{x}{\kappa_c}\right) + 2\omega L\kappa_L^2 x$$
$$+ x^2 - 2j\omega L\kappa_L^2 R + 2\omega L\kappa_L^2\left(\omega L - \frac{x}{\kappa_c}\right)$$

$$= R^2 - \omega^2 L^2 + \frac{2\omega Lx}{\kappa_c} - \frac{x^2}{\kappa_c^2} + 2\omega^2 L^2\kappa_L^2$$
$$- 2\omega L\kappa_L^2\frac{x}{\kappa_c} + 2\omega L\kappa_L^2 x + x^2$$
$$+ 2Rj\left\{\omega L(1 - \kappa_L^2) - \frac{x}{\kappa_c}\right\}$$

and by adding to this $[\omega^2 L^2\kappa_L^4 - \omega^2 L^2\kappa_L^4]$ and rearranging

$$D = R^2 - \omega^2 L^2 + 2\omega^2 L^2\kappa_L^2 - \omega^2 L^2\kappa_L^4$$
$$- \frac{2\omega Lx}{\kappa_c} - \frac{2\omega L\kappa_L^2 x}{\kappa_c} - \frac{x^2}{\kappa_c^2} + \omega^2 L^2\kappa_L^4$$
$$+ 2\omega L\kappa_L^2 x + x^2 + 2Rj\left\{\omega L(1 - \kappa_L^2) - \frac{x}{\kappa_c}\right\}$$

$$= R^2 - \left\{\omega L(1 - \kappa_L^2) - \frac{x}{\kappa_c}\right\}^2$$
$$+ \{\omega L\kappa_L^2 + x\}^2 + 2Rj\left\{\omega L(1 - \kappa_L^2) - \frac{x}{\kappa_c}\right\}$$

$$= R^2 - P^2 + x^2 + 2RjP$$

where P, x, now have the values assigned in the text.

The equation for the three-mesh capacity coupled circuit is derived in a similar manner.

Books Received.

G.P.O. Handbook for Wireless Telegraph Operators. 1932 edition.

Revised in accordance with the Radiotelegraph Convention of Washington, 1927, and including the use of the Automatic Alarm Signal. With appendices giving the International Morse Code, List of authorised abbreviations and "Q" code, Scale of Signal Strengths, Service Advices, Necessary Qualifications for Candidates for Operators' Certificates, and International Radiotelephone Procedure. Published by H.M. Stationery Office, Price 9d. Postage extra.

Admiralty Handbook of Wireless Telegraphy 1931.

A standard work prepared at H.M. Signal School and superseding the previous Handbook dated 1925. Containing practical information on Electricity and Magnetism as applicable to Wireless Telegraphy. Transmissions by spark, arc and valve ; reception, radio telephony, direction-finding, etc., with appendices on the elementary principles of W/T, mathematics, mechanics, physical and mathematical tables, etc. Pp. 1012+viii, with 567 diagrams and illustrations. Published by H.M. Stationery Office, 1932, price 7s. 6d. net.

Testing Radio Sets.

By J. H. Reyner, B.Sc. 2nd Edition, revised and enlarged especially with regard to Superheterodyne receivers, Laboratory Tests and Component testing. Pp. 207+viii with 95 illustrations and diagrams. Published by Chapman & Hall, Ltd., London, 1932. Price 10s. 6d.

Thermionic Emission.

A survey of existing knowledge with reference to the filaments of Radio Valves, compiled by W. S. Stiles, Ph.D. (Radio Research Board, Special Report No. 11). Pp. 116, including bibliography of all the important papers on the subject published up to December 1930. Issued by the Department of Scientific and Industrial Research, and published by H.M. Stationery Office. Price 2s. 6d. net.

Simplifying the Practical Use of the Starr Impedance Measuring Set.*

By James Steffensen, B.Sc.

WITH reference to the most interesting paper by Mr. A. T. Starr in the June, 1932, number of *W.E. & E.W.*, the following suggestions may be found of value.

If $Z = R + jX$, then $R = Z \cos \phi$ and $X = Z \sin \phi$.

Since $\cos \phi = 2 \cos^2 \frac{\phi}{2} - 1$ and

$$\sin \phi = 2 \cos \frac{\phi}{2}\sqrt{1 - \cos^2 \frac{\phi}{2}}$$

then

$$\cos \phi = \frac{k^2}{2} - 1 \text{ and } \sin \phi = k\sqrt{1 - \frac{k^2}{4}}$$

where $$k = 2 \cos \frac{\phi}{2} = \frac{R_1}{R_2}$$

In the accompanying table will be found $\cos \phi$, $\sin \phi$, and ϕ as functions of $k = \frac{R_1}{R_2}$

As we have $Z = R_1$, then

$$Z = R_1 \cos \phi + jR_1 \sin \phi,$$

it being only necessary to determine k and find $\cos \phi$ and $\sin \phi$ from the table.

If, in addition, the switching arrangement shown in Fig. 1 is employed in conjunction with two decade resistance boxes, an exceed-

* MS. received by the Editor, 30th June, 1932.

k	$\cos \phi$	$\pm \sin \phi$	$\pm \phi°$	k	$\cos \phi$	$\pm \sin \phi$	$\pm \phi°$
1.414	0.0000	1.0000	90.0	1.71	0.4621	0.8868	62.5
1.42	0.0082	1.0000	89.5	1.72	0.4792	0.8777	61.4
1.43	0.0225	0.9997	88.7	1.73	0.4965	0.8681	60.2
1.44	0.0368	0.9993	87.9	1.74	0.5138	0.8579	59.1
1.45	0.0513	0.9987	87.0	1.75	0.5313	0.8471	57.9
1.46	0.0658	0.9978	86.2	1.76	0.5488	0.8359	56.7
1.47	0.0805	0.9968	85.4	1.77	0.5665	0.8240	55.5
1.48	0.0952	0.9955	84.5	1.78	0.5842	0.8116	54.3
1.49	0.1101	0.9939	83.6	1.79	0.6021	0.7984	53.0
1.50	0.1250	0.9922	82.8	1.80	0.6200	0.7846	51.7
1.51	0.1401	0.9901	82.0	1.81	0.6381	0.7700	50.4
1.52	0.1552	0.9879	81.1	1.82	0.6562	0.7546	49.0
1.53	0.1705	0.9854	80.2	1.83	0.6745	0.7383	47.6
1.54	0.1858	0.9826	79.3	1.84	0.6928	0.7211	46.1
1.55	0.2013	0.9795	78.4	1.85	0.7113	0.7029	44.6
1.56	0.2168	0.9762	77.5	1.86	0.7298	0.6836	43.1
1.57	0.2325	0.9726	76.5	1.87	0.7485	0.6631	41.5
1.58	0.2482	0.9687	75.6	1.88	0.7672	0.6414	39.9
1.59	0.2641	0.9645	74.7	1.89	0.7861	0.6181	38.2
1.60	0.2800	0.9600	73.7	1.90	0.8050	0.5933	36.4
1.61	0.2961	0.9552	72.8	1.91	0.8241	0.5664	34.5
1.62	0.3122	0.9500	71.8	1.92	0.8432	0.5376	32.5
1.63	0.3285	0.9445	70.8	1.93	0.8625	0.5061	30.4
1.64	0.3448	0.9387	69.8	1.94	0.8818	0.4716	28.1
1.65	0.3613	0.9324	68.8	1.95	0.9013	0.4332	25.7
1.66	0.3778	0.9259	67.8	1.96	0.9208	0.3901	23.0
1.67	0.3945	0.9189	66.8	1.97	0.9405	0.3398	19.9
1.68	0.4112	0.9115	65.7	1.98	0.9602	0.2792	16.2
1.69	0.4281	0.9037	64.6	1.99	0.9801	0.1987	11.5
1.70	0.4450	0.8955	63.6	2.00	1.0000	0.0000	0.0

$k = \frac{R_1}{R_2}$. $\cos \phi = \frac{k^2}{2} - 1$. $\sin \phi = k\sqrt{1 - \frac{k^2}{4}}$. $Z = R + jX$. $Z = R_1$. $R = Z \cos \phi = R_1 \cos \phi$. $X = \pm Z \sin \phi = \pm R_1 \sin \phi$.

ingly handy laboratory instrument results, especially when compared to the hitherto usual "complex compensators," which certainly are rather aptly named!

It should be noted that the determination of X becomes somewhat uncertain when k approaches the value 2 (*i.e.*, when Z is a nearly pure resistance); this is also obvious from Mr. Starr's vector diagram (Fig. 4 of his paper).

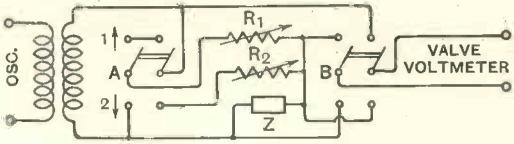

Fig. 1.—*Positions 1 and 2 of switch A correspond to Fig. 1 a and b in Mr. Starr's paper.*

The maximum value of R_2 need only be $1/\sqrt{2}$ times that of R_1.

Present Knowledge of the Upper Atmosphere.

THE final meeting for the season of the I.E.E. Wireless Section was held on 25th May, when the lecturer was Prof. E. V. Appleton, F.R.S.

In his opening remarks, the speaker said that the discussion was confined entirely to work at short distances, since long-distance measurements gave considerable difficulty of interpretation. With short-distance transmissions the ground ray was present as a reference for all the reflected rays.

In such work two things could be measured; these were (*a*) the angle of incidence of the down-coming ray, (*b*) the time of the journey occupied by the returned ray.

The first of these was difficult to measure, but the second was convenient, and could be determined by two methods, viz., by variation of either the frequency or the amplitude of the signal. The lecturer then described what is usually called the "frequency-change" method, where a known change of mean frequency is effected at the transmitter in a known time, giving at the receiver an "interference" pattern as the returned rays go into phase and dephase with the ground ray. A slide was shown illustrating a received record of this type, while another slide showed rhythmic fading in addition to the interference variations. The amplitude-variation method consists of sending out very short pulses of signal so that the ground ray has been received and recorded at the receiver before the first returned ray is recorded. If all the received pulses are recorded, *e.g.*, on an oscillograph, the time-separation between the ground ray and subsequent echoes permits calculation of the height from which the echoes have been returned. Slides were shown illustrating this type of reception, one slide showing reflection from the E or Kennelly-Heaviside layer (at approximately 100 km.) and the other showing up to five reflections from the F or higher layer (over 200 km.). A cinema film was displayed showing the appearance of the oscillograph screen and illustrating the variations that occur in the amplitude of the received echoes.

A further slide showed a case when an echo returned from the upper (F) layer had been split into two parts, due to the effect of the earth's magnetic field. It was shown that the first of these had right-hand polarisation and the second left-hand polarisation. This was explained by the fact that the ionised medium was in the magnetic field of the earth. The electrons under the influence of the impinging wave virtually became a current and received a twist. A corresponding twist was therefore given to the radiation from the electrons. Theory showed the tendency for this to produce two returned rays from an incident linearly polarised wave, one right-hand and one left-hand polarised. The lecturer suggested that it would be interesting to send out a wave circularly polarised and check if there was less absorption and better signal than from a wave linearly polarised. An interesting fact in confirmation of theory was quoted, that the polarisation in England and Australia had been found to be of opposite sign, as would be expected from the reversal of the earth's magnetic field as between the Northern and Southern hemispheres.

Prof. Appleton then turned to discuss the critical frequency at which the Kennelly-Heaviside layer fails to return incident waves. It was shown that for waves below 100 metres the upper (F) region was the more important, the lower region being insufficiently ionised. A slide showed the ionisation of the atmosphere over 24 hours, from noon to noon, with a decrease at sunset and an increase at sunrise. The summer-to-winter ratio for the Kennelly-Heaviside layer was of about the mean value of 2.5, while the upper (F) layer was about 4 or 5 times the density of the E layer, but showed less change as between day and night.

The lecturer lastly discussed the agencies producing the two regions of the ionosphere. The upper (F) layer was attributed by Prof. S. Chapman to the effect of ultra-violet radiation, while the E layer was attributed to particles or corpuscles of solar origin. In this connection it was pointed out that in the case of a solar eclipse there was considerable difference in time between the obscuring effect on these two agencies. In the case of an eclipse to occur in August next, it was shown that the corpuscular eclipse would occur about two hours before the optical eclipse, and that while the latter would be chiefly confined to a band in Canada, the former would be much more widespread and would therefore provide opportunity for testing these conclusions.

The meeting closed with a vote of thanks to the lecturer, moved by Col. A. G. Lee and seconded by Mr. L. B. Turner.

Abstracts and References.

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PROPAGATION OF WAVES.

RADIO TRANSMISSION PROBLEMS TREATED BY PHASE INTEGRAL METHODS.—T. L. Eckersley. (*Proc. Roy. Soc.*, 1st June, 1932, Vol. 136, No. A 830, pp. 499–527.)

This paper gives illustrations of the applications of the phase integral method recently described by the author (1931 Abstracts, p. 548) to the solution of transmission problems in radiotelegraphy. The analysis is applied to transmission between plane stratified layers, and the following illustrative problems are discussed:—(1) A radially symmetrical transmitter between two perfectly conducting parallel planes. When the distance between the planes is less than half a wavelength, the solution is found to be a cylindrical wave spreading out uniformly in the space between the two layers, and the writer states that "there is no high-angle radiation, or rather, all the high-angle radiation cancels out," in contrast with the ray theory, which requires the presence of all the high-angle rays. If the distance between the planes is greater than half a wavelength, a finite number of high-angle rays are found. These results are deduced using the method of images as well as the phase integral method.

(2) A radially symmetrical transmitter between two parallel planes of which one is imperfectly conducting. "The method of investigation . . . is based on Sommerfeld's analysis of the transmission of electric waves over the surface of the earth." The transmitter is assumed to be situated on a perfectly conducting earth. The characteristic equation determining the proper values of the propagation constant is found both by Sommerfeld's method and that of the phase integrals. A table of attenuation coefficients for various cases is given.

(3) Here the imperfectly conducting but sharply defined layer is replaced by one of graded ionic refraction where the electrons are substantially free. The density is assumed to vary in proportion to the square of the distance from the lower layer. It is found again "that if λ is great enough there are no high-angle rays or proper values, and with smaller wavelengths there are only a finite number." The ray theory is found to be inadequate for long wavelengths.

(4) Finally, the diffraction of waves round the earth's surface is considered and the effect of the earth's resistivity taken into account. The field strengths predicted by theory are compared with those measured at Chelmsford for transmissions from a broadcast station at Warsaw (wavelength 1 410 m) and good agreement is found if the earth's conductivity is taken as 10^{-12} e.m.u.

THE PROPAGATION ALONG THE EARTH OF RADIO WAVES ON A WAVELENGTH OF 1.6 METRES.—R. L. Smith-Rose and J. S. McPetrie. (*Proc. Physical Soc.*, 1st July, 1932, Vol. 44, Part 4, No. 244, pp. 500–508: Discussion, pp. 508–510.)

Authors' abstract:—A previous paper (Jan. Abstracts, p. 29) described an investigation of the attenuation of ultra-short radio waves when transmitted directly along the earth's surface. The present paper reports the progress made in the continuation of this research, the particular wavelength to which attention has recently been given being 1.6 metres. A brief description is given of the simple, but efficient, transmitting and receiving apparatus which has been employed for the experiments on this wavelength.

Measurements of the field-intensity at different distances from the transmitter have been carried out for various heights of the apparatus above the ground level. When both transmitter and receiver are used very close to the ground, the attenuation curve obtained is similar to that encountered at longer wavelengths. When, however, the apparatus is elevated by an amount comparable with, or greater than, the wavelength, the field-intensity/distance curves have maximum and minimum values, the positions of which depend upon the actual heights employed. These maxima and minima are due to interference between waves transmitted directly from the transmitter to the receiver, and those which arrive at the receiver after reflection from the earth's surface.

Theoretical curves having the same characteristics have been calculated from a consideration of the reflection coefficient of the earth's surface, account being taken of the electrical properties of the earth. By a comparison of such theoretical curves with the experimental results, the effective conductivity of the earth appears to be about 95×10^8 e.s.u. (resistivity 95 ohm-cm) at the very high frequency of 190 megacycles per second employed. This is higher than the values of 5×10^8 to 30×10^8 e.s.u. previously obtained at frequencies of 30 to 60 megacycles per second, and these in turn were higher than the values obtained in earlier work, at a frequency of 1 megacycle per second. Owing to this considerable increase in the value of the conductivity as the frequency is raised, the experimental method does not enable the dielectric constant of the earth to be ascertained with any great accuracy, although a value of 10 gives suitable agreement between the theoretical and experimental results in the present case. At the same time this consideration indicates that, from the point of view of practical communications, the value of the dielectric constant of the earth is not a controlling factor in determining the propagation of waves over the earth's surface on either long or short wavelengths, except in situations where the conductivity of the ground is abnormally low.

CONDUCTIVITY OF THE GROUND FOR AN 8.65 METRE WAVE.—Palmer. (*See* abstract under "Aerials and Aerial Systems.")

THE ATTENUATION OF SHORT WIRELESS WAVES AT THE SURFACE OF THE EARTH.—G. H. Munro. (*Journ. I.E.E.*, June, 1932, Vol. 71, No. 426, pp. 135–143.)

Author's summary:—An apparatus is described for measuring relative field intensities of wireless waves of the order of 20 metres, and the results of a series of measurements taken with it on wavelengths of approximately 25 metres, for distances of from 200 ft to 60 miles from the transmitter, are shown as "Intensity/Distance" curves. For distances greater than 2 miles the decrease of intensity is found to be approximately proportional to the inverse square of the distance, as predicted by the theory of Sommerfeld. For shorter distances, however, the curves are much straighter than predicted by theory. This is attributed to penetration of the waves to layers of higher conductivity below the surface. This is supported by the increase in the variations in attenuation with change of surface observed on a wavelength of 18 metres, and by measurements on the "tilt" of the electric vector of the wave-front.

In all cases, marked changes in intensity and attenuation were found to occur with apparently slight changes of surface and slope of the ground.

FIELD-INTENSITY MEASUREMENTS AT FREQUENCIES FROM 285 TO 5 400 KILOCYCLES PER SECOND [AT DISTANCES FROM A FEW WAVELENGTHS TO 400 KILOMETRES: DETERMINATION OF ELECTRICAL CONSTANTS OF THE GROUND].—S. S. Kirby and K. A. Norton. (*Bur. of Stds. Journ. of Res.*, April, 1932, Vol. 8, pp. 463–479: *Proc. Inst. Rad. Eng.*, May, 1932, Vol. 20, pp. 841–862.)

Authors' abstract:—"Radio field intensities were measured at distances of only a few wavelengths from a transmitting station on a wide range of frequencies, including the broadcast band, in order to determine the distance at which ground absorption became appreciable. At a distance of 2.4 km, there was no appreciable absorption for frequencies below about 1 000 kc; above this frequency, the absorption became appreciable and increased as the frequency was increased. Daylight measurements, made at greater distances on broadcast transmissions, airways phones and airways beacons show that field intensities fall off to 1 per cent of what the inverse distance law with no absorption would give at distances from 100 to 400 km, depending on the frequency and the nature of the ground. The experimental data were compared with Rolf's attenuation graphs in order to determine the electrical constants of the land east and west of the Allegheny Mountains. East of and including the mountains (Maryland, Pennsylvania, and New Jersey) the conductivity and dielectric constant were found to be 3.35×10^{-14} e.m.u. and 13, respectively; west of the mountains (near Chicago) they were found to be 1.07×10^{-13} e.m.u. and 13, respectively. Using these constants, theoretical values of field intensity were graphed for these two types of ground and for broadcasting frequencies.

"The experimental data were also compared with results given by the Austin-Cohen transmission formula. It was found that for overland transmission in the range of frequencies observed this formula did not satisfactorily give the variations in field intensity as the distance was changed or as the frequency was changed."

MEASUREMENTS OF THE HEIGHT OF THE KENNELLY-HEAVISIDE LAYER IN JAPAN [USING WAVELENGTHS OF THE ORDER OF 100 METRES].—T. Minohara and Y. Ito. (*Rep. of Rad. Res. and Works in Japan*, March, 1932, Vol. 2, No. 1, pp. 15–22.)

By the Appleton frequency-change method, over a fixed base of 49 km. The apparent height ranged from 80 to 210 km, being 80–110 km by day and 180–210 km by night. In unstable conditions of the layer sudden changes in apparent height took place, but always within the 80–210 km range. The appearance of higher harmonics suggests that both by day and by night two space waves travelling by different paths may reach the receiver: the heights calculated from these higher harmonics are all nearly 150 km by day and about 400 km by night (thus by day the height *is somewhat less than* twice the ordinary height): "It is difficult to discuss, from only this experiment [on three or four separate days], whether this phenomenon is due to the multi-reflection or refraction of the waves, or to some other causes."

WEITERE MITTEILUNGEN ÜBER NAHECHOS (Further Communications on Near Echoes [Delay Times of the Order of 0.01–0.02 Sec.]).—H. Mögel. (*Telefunken-Zeit.*, No. 60, Vol. 13, 1932, pp. 29–32.)

The first part of this paper is taken from the *E.N.T.* note dealt with in May Abstracts, p. 276, but a number of new results are then discussed and illustrated by records and a diagram. The latter shows a 24-hours' run from Nauen received at Geltow, giving the reflection heights of the first, second and third near echoes; the day wave was 15.6 and the night wave 30 metres. Near sunset only the first near echo is in evidence, and directly afterwards the reflection height for this increases sharply and, like the skip distance, becomes infinitely great. This, of course, is for the day wave: for the night wave, on the other hand, the ionisation is sufficient to give strong reflection at the comparatively low height of about 2 000 km (and a smaller, lower group of echoes at about 1 000 km). The effects of solar disturbances (of the two types dealt with in Mögel's earlier paper—1931 Abstracts, pp. 144–145) on the near echoes, on the Heaviside layer echoes, and on atmospherics, are discussed at the end of the paper.

KURZWELLENEMPFANG UND SONNENTÄTIGKEIT (Short-wave Reception and Solar Activity [Increased Wavelength of Optimum Waves near Sunspot Minimum]).—H. Mögel: Plendl. (*Telefunken-Zeit.*, No. 60, Vol. 13, 1932, pp. 32–34.)

Supplement to the writer's paper dealt with in 1931 Abstracts, pp. 144–145: *see* also May Abstracts, p. 276, where most of the "Transradio" results discussed in the present paper are mentioned. It is concluded from these (particularly from the effect of distance of path from pole) that the displacement of the optimum waves is due to a decrease not in the non-deflectable ultra-violet radiation but in the electron emission—supporting the theories of Birkeland and Störmer, and relegating magnetic disturbances to a subordinate rôle.

The belief that the day waves suffer less displacement to the lower frequencies than the night waves is fairly consistently confirmed by all observations. The result is that during the period of minimum solar activity more waves are needed for a 24-hours' service, the favourable time for each frequency being greatly narrowed. Whereas during a sunspot maximum period (*e.g.* 1927/29) on some lines two waves were enough to give a safe 24-hours' service, to-day from four to eight waves are necessary. The writer ends by stressing the difference between amateur results and the requirements of a commercial service : for at least 60% of the time the latter demands very considerable power, and even so—on certain lines—no communication is possible for about 1% of the time. It seems from experience up to the present that in the case of "long" disturbances short-wave telegraphic communication can be maintained by the use of great efforts, but during "short" type disturbances no means exist for maintaining such communication (*see* the first of the two abstracts above mentioned). The one diagram given shows that the New York 20-metre wave, which in 1928 gave communication of a sort during the whole 24 hours, in 1931 was quite useless except between noon and midnight.

POLARLICHT UND HEAVISIDESCHICHT (Aurora Borealis and the Heaviside Layer).—E. Brüche. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 13, 1932, pp. 336–341.)

Försterling and Lassen, the writer recalls, deduce the existence of an ionised hydrogen layer with its maximum ionisation at 400 km, above an ionised nitrogen layer with its maximum at 120 km (Abstracts, February and April, pp. 87 and 217). "Although Goubau and Zenneck have shown that for long waves (530 m) all the observed echo times can be accounted for by only one layer at about 100 km (Feb., p. 87), the latest measurements of Rukop and Wolf with short waves (84 m : May, pp. 275–276) leave practically no doubts as to the existence of other reflecting layers affecting short waves." He then points out that the observation of the corpuscular rays attacking the layers from the far side affords another and more direct method of exploring the layers and their distribution, since this method requires none of the assumptions and calculations involved in the exploration by radio waves. He therefore surveys, with this particular object in view, our present knowledge of auroral phenomena, especially the sun-lit rays. The chief discrepancy between the results of the two methods is that no indication of an ionised layer ("the hypothetical hydrogen layer") at 400 km is given by the auroral observations.

POLAR ECHO OF HIGH-FREQUENCY RADIO WAVES [ECHO PECULIAR TO WAVES PASSING THROUGH POLAR REGION OR AURORA ZONE].—S. Namba. (*Rep. of Rad. Res. and Works in Japan*, March, 1932, Vol. 2, No. 1, pp. 23–25.)

The particular phenomenon which the writer labels "polar echo" is characterised by a continuous fluctuation of the carrier frequency and a blurring and "hoarse" effect on Morse signals (yielding what operators call "New York signals," since it is met with mainly on New York signals received in Japan). It is more marked on waves above 30 m than on those below 25 m. Both the Doppler effect and the blurring effect are doubtless closely associated with polar ionisation, which is considered to be due chiefly to solar corpuscles and is thus more liable to be disturbed than that of non-polar regions, where the main ionising agency is ultra-violet radiation. "Many interesting results may be expected on the ionisation in the north and south magnetic polar regions, if the phenomenon be investigated together with the observation of the direction and the sense of the incoming waves."

LONG DISTANCE RECEIVING MEASUREMENTS OF BROADCAST WAVES ACROSS THE PACIFIC [SEASONAL VARIATION, DEPENDENCE ON SOLAR CONDITIONS, ETC.].—S. Namba and D. Hiraga. (*Rep. of Rad. Res. and Works in Japan*, March, 1932, Vol. 2, No. 1, pp. 9–14.)

It is generally known that broadcast waves between 100 and 500 m are very unsuitable for long-distance communication, but very few actual propagation data are available, although these waves, lying as they do between high and low frequencies, should furnish valuable information. The present paper gives results on trans-Pacific reception, chiefly from U.S.A. stations : results from Australian, New Zealand and European stations are mentioned briefly. The observations on the American stations show that while reception is worst in summer, as would be expected, it is best in autumn, not in winter. A comparison with certain 1924 summer data indicates that conditions then were much better than during the summer of 1930.

SOLAR AND RADIO PERIODICITIES.—C. G. Abbot : Austin. (*Science*, 10th June, 1932, Vol. 75, p. 607.)

In a recent paper by Abbot and Mrs. Bond, the writers describe seven periodicities in the variation of solar constant values—of 7, 8, 11, 21, 25, 45 and 68 months (*cf.* Abbot, March Abstracts, p. 160). They have now examined Austin's long-wave radio transmission data for 1922–1930 (July Abstracts, p. 398) with the aid of their periodometer (*loc. cit.*) *and find the seven periodicities above mentioned, and one other of 18 months, all well indicated.* The 18-month cycle, though not found in solar variations, is conspicuous in terrestrial temperatures, as was pointed out in the writers' paper. Details of the investigation are promised later.

THE RECOMBINATION OF IONS IN AIR AT LOW PRESSURES.—Lenz. (*See* under "Atmospherics and Atmospheric Electricity.")

EFFECT OF METEORS ON RADIO TRANSMISSION.—H. Nagaoka. (*Rep. of Rad. Res. and Works in Japan*, March, 1932, Vol. 2, No. 1, pp. 49–53.)

In view of Skellett's publication of his ideas on the above subject (March Abstracts, p. 156) Nagaoka here reprints his own paper (1930 Abstracts, p. 270, and 1931, pp. 374–375—Quäck) with a short addition: "as the mean height of meteors is nearly coincident with the K.-H. layer, electric waves which are reflected at it are not much affected, so that the influence of meteors on long waves is not so great as for short waves, the trajectories of which have apices above the layer. Considering that the formation of ions is so great that the number of electrons formed during the passage is comparable with those already existing, the wave is doubly affected, in going up and in coming down. The disturbance is consequently felt at the receiving station, especially when the course of the meteors is nearly coincident with the incoming wave. . . . It is also possible that the intrusion of meteors is felt as atmospherics, which are of a character somewhat different from those usually experienced. . . . I venture to suggest that a small portion of atmospherics, which are frequently observed during summer months, may be traced to meteors invading the upper atmosphere during this period. . . ."

THE ACTION OF THE APPLETON LAYER IN THE PROPAGATION OF WAVES OF 30 KC/SEC. FREQUENCY.—Bureau. (*See* abstract under "Atmospherics and Atmospheric Electricity.")

BEITRAG ZUR THEORIE DER STÖRZONEN BEI GLEICHWELLENSENDERN (Contribution to the Theory of Interference Zones in Common-Wave Transmission).—W. Hübner. (*Archiv f. Elektrot.*, 17th June, 1932, Vol. 26, No. 6, pp. 381–396.)

Author's summary:—The curves and zones of the interference minima due to transmitters of equal wavelength are determined graphically and analytically. The regions within which the interference minima can give rise to disturbed reception are also found graphically and analytically. The investigations refer to two transmitters with and without modulation, and to three unmodulated transmitters [and neglect absorption. The distant zone of the ground waves only is considered, with amplitude modulation, synchronised transmitters of equal modulation and phase, and only vertical polarisation. It is shown to be distinctly less advantageous to use three transmitters than two. The best distribution is found with two transmitters of different power].

ÜBER DIE ABSORPTION KURZER ELEKTRISCHER WELLEN IN IONISIERTEN GASEN, EIN VERSUCH ZUM NACHWEIS LANGWELLIGER ÜBERGÄNGE IM SPEKTRUM DES WASSERSTOFFATOMS (On the Absorption of Short Electric Waves in Ionised Gases, an Attempt at the Demonstration of Long-Wave Transitions in the Spectrum of the Hydrogen Atom).—H. Klumb. (*Physik. Zeitschr.*, 1st June, 1932, Vol. 33, No. 11, pp. 445–447.)

It has been calculated that in the hydrogen atom transitions between energy levels are possible which would give rise to wavelengths of 2.74, 9.25 and 24.75 cm respectively. If these transitions really exist, there should occur, in the absorption spectrum of excited atomic hydrogen, places of selective absorption corresponding to these transitions. The writer is investigating this experimentally and has found in hydrogen strong maxima of selective absorption at 3, 9 and 28 cm wavelength. In oxygen and nitrogen the absorption was continuous. This preliminary note sketches the idea of the experiments and describes some precautions essential to success.

DIRAC'S WAVE EQUATION OF THE ELECTRON AND GEOMETRICAL OPTICS.—W. Pauli. (*Helvet. Phys. Acta*, Vol. 5, 1932, Fasc. 3, pp. 179–199.)

DIELECTRIC CONSTANT, RESISTANCE AND PHASE ANGLE OF ICE.—H. Wintsch. (*Helvet. Phys. Acta*, Vol. 5, 1932, Fasc. 2, pp. 126–144.)

DEMONSTRATION STEHENDER ELEKTRISCHER WELLEN MIT HILFE EINES EINFACHEN EMPFÄNGERS (Demonstration of Standing Electric Waves Using a Simple Receiver).—R. Ramshorn. (*Physik. Zeitschr.*, 1st June, 1932, Vol. 33, No. 11, pp. 457–453.)

This note describes a lecture demonstration of standing Hertzian waves in which the intensity distribution is shown by a linear resonator enclosed in a neon atmosphere which glows with intensity proportional to the voltage distribution along the resonator.

UNTERSUCHUNG DER WIRKUNG MECHANISCHER UND ELEKTRISCHER KRAFTFELDER AUF DIE DOPPELBRECHUNG DES QUARZES (Investigation of the Effect of Mechanical and Electrical Fields of Force on the Double Refraction of Quartz).—N. Günther. (*Ann. der Physik*, 1932, Series 5, Vol. 13, No. 7, pp. 783–801.)

ON THE PENETRATION OF DAYLIGHT INTO THE SEA [OBSERVATIONS TO DEPTHS OF OVER 1 400 FEET, AND THEIR INTERPRETATION].—E. O. Hulburt: Beebe. (*Journ. Opt. Soc. Am.*, July, 1932, Vol. 22, pp. 408–417.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

ESSAIS CONCERNANT LA DISTRIBUTION DANS L'ESPACE DES PARASITES EN T.S.F. (Tests on the Distribution in Space of Atmospherics [Application of Verdan Principle to Space instead of to Time]).—E. Montoriol and R. Subra: Lillo. (*Ann. des P.T.T.*, June, 1932, Vol. 21, pp. 525–532.)

The Verdan system of repeated messages makes use of the irregularity of the distribution *in time* of atmospherics: Lillo has suggested that a similar irregularity *in space* might also be utilised, if for instance two or three receivers some hundreds of kilometres apart proved to be differently affected at any given instant. Preliminary tests have been carried out, transmissions from Bordeaux being received simultaneously at Rabat, Oran, Algiers and Tunis, during 28 programmes of 25 to 30 minutes each. Out of a total of 62 500 letters, the four stations gave a total of 3 300 errors due to atmospherics. On the average, each station thus had a percentage error of 1.32. If three (for example) receptions had been combined, by retransmission by line and some manual or automatic sorting process, *the proportion of errors would have been only* 0.0005%.

The next point to decide is whether such metallic liaison and automatic comparison can be accomplished satisfactorily. Tests are to be carried out from Bordeaux, the receiving stations being probably Brest, Le Havre and Strasbourg. The Baudot system will be employed.

Recherches goniométriques sur les Atmosphériques (Direction-Finding Researches on Atmospherics).—R. Bureau. (*Comptes Rendus*, 6th June, 1932, Vol. 194, pp. 2073–2074.)

Continuation of the work dealt with in Abstracts, 1931, pp. 213–214; *see* also July, p. 401. The writer has now applied to his goniometer the principle of the "narrow sector" developed by Watson Watt, in which the action of an insensitive receiver connected to an aerial is paralysed by that of a sensitive receiver connected to a frame, in such a way that the former receiver only gives an output when the source of the atmospheric lies in the direction of the minimum of the frame. By suitably choosing the thresholds of the relays used in applying this principle to his apparatus, the writer is able to record simultaneously the position of sources in different azimuths and to mark the hours of the appearance and disappearance of each.

Working on 27 kc/s, he finds during the night two principal sources, one nearly *NS*, the other nearly *EW* (with variations reaching $\pm 30°$). The *NS* sources predominate in general from sunset to midnight, the *EW* sources from midnight to sunrise; the two sources are often simultaneous for several hours. Moreover, quite a large number of sources move progressively from the *NS* to the *EW* direction during the night. These phenomena are reproduced night after night (in the spring) with remarkable regularity. One night differs from another in the relative number of atmospherics of each of the three types (*NS*, *EW*, and rotating); this proportion may vary very considerably. Afternoon atmospherics on the other hand may appear in any direction: they often present themselves in several simultaneous directions.

These results agree with the springtime results of Schindelhauer, working on about 15 kc/s (May Abstracts, p. 277); the only discrepancies are in connection with the day atmospherics and may well be due to the difference in wavelength—on 27 kc/s the day atmospherics come from shorter distances than those on 15 kc/s. But the writer does not agree with Schindelhauer's *explanation* of this remarkable regularity of the diurnal variation of direction, placing the sources in the ionised layers. On the contrary, he considers that the results agree with a meteorological origin of the sources, the regularity of the diurnal variation being largely due, certainly, to the ionised layers, but through the action of these on the propagation; while the fixed relation of the two night directions is the result of the action of two continents in developing sources, the African continent being responsible for the *NS* sources and the American for the *EW* sources.

"This regularity, moreover, may be expected to decrease in summer when the *ensemble* of the sources gets closer together. The nocturnal rotation of some of the sources is the consequence of their diurnal variation, the time of the maximum being that of the maximum of convection, namely, 15 h or 16 h local time."

Du Rôle des Phénomènes de Propagation dans les Enregistrements d'Atmosphériques (The Part Played by Propagation Phenomena in the Recording of Atmospherics [and the Action of the Appleton Layer on Waves of 30 kc/sec. Frequency]).—R. Bureau. (*Comptes Rendus*, 4th July, 1932, Vol. 195, pp. 69–71.)

Atmospheric recorders at Tunis and Rabat, similar to the Paris recorder but tuned to waves round 30 kc/s instead of 27.5 kc/s, give curves showing the same characteristics as the Paris curves (*cf.* July Abstracts, p. 401). In particular, the African and Paris curves show a remarkable agreement during the hours of night common to all three recorders: thus bearing witness to the almost complete absence of local sources and to the existence of very distant sources affecting all three receivers simultaneously. The agreement ceases as soon as daybreak reaches one of the receivers, the characteristic changes in the curves occurring in succession at each station.

These effects are propagation phenomena, and the writer therefore compares the results with the sunrise layer-height results given by Appleton and Builder (March Abstracts, p. 155). From this comparison he concludes that the night propagation to a distance of waves round 30 kc/s is accomplished by the action of the upper, F, layer. The curves of waves round 12 and 90 kc/s no longer show the same aspect, from which he deduces that the propagation of these frequencies does not depend only, or even chiefly, on the properties of the F layer. "The recording of atmospherics on 30 kc/s is thus specially adapted to furnish regular information on the electrical condition and on the variations of height of the F layer." The last paragraph of the Note deals briefly with the effects of certain atmospheric phenomena (squally showers, etc.) on the curve of atmospherics.

For previous papers by the same writer *see* 1931 Abstracts, p. 436.

Die Blitzentladungen als Ursache atmosphärischer Rundfunkstörungen (Lightning Discharges as Sources of Atmospherics causing Interference with Broadcast Reception).—H. Norinder. (*E.N.T.*, June, 1932, Vol. 9, pp. 195–201.)

Author's summary:—Direct observations show that lightning discharges cause chacteristic disturbances in broadcast receivers. These disturbances are due to certain rapid field-strength variations which are superposed on the often relatively slow lightning discharges. The author has experimentally investigated these field-strength variations, by means of specially constructed cathode-ray oscillographs connected to aerial circuits. A number of original oscillograms of lightning discharges are reproduced. The measurements show not only aperiodic field-strength variations lasting only a few microseconds [and less than one microsecond], but also variations lasting several hundred [up to 1 200] microseconds. Individual potential rises of 30 volt/metre/microsecond were observed.

EFFECT OF METEORS ON RADIO TRANSMISSION [AND THE PRODUCTION OF ATMOSPHERICS].—Nagaoka. (*See* under "Propagation of Waves.")

THE RELATION OF BRANCHING OF LIGHTNING DISCHARGES TO CHANGES IN THE ELECTRICAL FIELD OF THUNDERSTORMS.—J. C. Jensen. (*Phys. Review*, 15th June, 1932, Series 2, Vol. 40, No. 6, pp. 1013–1014.)

In twelve night storms, within the Schonland reversal distance, the author has photographed 366 lightning flashes, for 185 of which the field change deflections were observed. "Of these, 77 show downward branching in discharges which reached the ground and the accompanying galvanometer deflections indicated positive field changes, requiring the lower pole of the cloud to be negative." These observations show that there can be branching downward from a negative cloud and this agrees with the work of Schonland and Allibone (February Abstracts, p. 91) . . . "Simpson's criterion for determining the polarity of a thundercloud by the direction of branching can no longer be accepted."

ERGEBNISSE DER GEWITTERMESSUNGEN IM JAHRE 1931 (Results of Lightning Measurements in 1931 [on a Swiss H.T. Power Line, with Two Cathode-Ray Oscillographs]).—K. Berger. (*Bull. Assoc. suisse d. Élec.*, No. 12, Vol. 23, 1932, pp. 289–302.)

Among other things, the tests show that the surge is heavily damped and that its disturbing effect perpendicular to the line is strictly limited.

ON THE CHARACTERISTICS OF THE CURRENTS IN A DISCHARGE IN AIR AT LOW PRESSURE [CATHODE-RAY OSCILLOGRAPH INVESTIGATION].—R. Anthouard. (*Comptes Rendus*, 4th July, 1932, Vol. 195, pp. 35–36.)

LES ÉCLAIRS GLOBULAIRES ET ASCENDANTS DANS LES MONTAGNES ET LES PLATEAUX ÉLEVÉS (Globular and Ascending Lightning in Mountains and Elevated Plateaus).—E. Mathias. (*Comptes Rendus*, 27th June, 1932, Vol. 194, pp. 2257–2260.)

IMPULSE TESTING TECHNIQUE.—Foust, Kuehni and Rohats. (*Gen. Elec. Review*, July, 1932, Vol. 35, pp. 358–366.)

DIE WIEDERVEREINIGUNG VON IONEN IN LUFT BEI NIEDEREN DRUCKEN (The Recombination of Ions in Air at Low Pressures).—E. Lenz. (*Zeitschr. f. Phys.*, Vol. 76, No. 9/10, pp. 660–678.)

Author's summary :—The variation with pressure of the coefficient of recombination of ions in air is determined in the pressure range 20–760 mm Hg. The coefficient is found to be strictly proportional to the pressure with a normal value of $(1.7 \pm 0.1) . 10^{-6}$ $cm^3 \, sec^{-1}$ at 760 mm Hg and 18° C. The distribution in space of the ions is measured and taken into account. The contradictions in the measurements hitherto made are explained, as far as diffusion processes are concerned, by neglect of the inhomogeneous distribution of ions in space.

ON THE VALUE OF THE ELECTRICAL FIELD OF THE ATMOSPHERE AT HIGH LATITUDES [EXPLANATION OF ANDRÉE'S LOW AVERAGE VALUE OF 12 VOLTS].—E. Salles. (*Comptes Rendus*, 4th July, 1932, Vol. 195, pp. 68–69.)

SOLAR RADIATION AS A METEOROLOGICAL FACTOR.—H. H. Kimball. (*Reviews of Modern Physics*, April, 1932, Vol. 4, No. 2, pp. 259–277.)

COSMIC RAY INTENSITY VARIES WITH CHANGE IN LATITUDE.—A. H. Compton. (*Sci. News Letter*, 16th July, 1932, p. 32.)

Compton's first report from the extensive survey now being carried out (April Abstracts, p. 219) states that so far the measurements of cosmic ray intensity indicate a "uniform variation with latitude, showing a minimum at or near the equator and increasing intensity towards the north and south poles." At sea level, the difference between intensities at latitude 45° and 0° is roughly 16 %, whilst at 9 000 ft. it is about 23 %. "With Dr. Compton's report this theory [Millikan's heavy elements' 'birth cry' theory, based on his findings that cosmic radiation bombards the earth equally from all directions] is likely to lose support."

THE INTENSITY OF THE COSMIC RADIATION AT 16 000 METRES ALTITUDE.—A. Piccard, E. Stahel and P. Kipfer. (*Comptes Rendus*, 4th July, 1932, Vol. 195, pp. 71–72.)

PROPERTIES OF CIRCUITS.

WIRK-, BLIND- UND SCHEINLEISTUNG IN ELEKTRISCHEN STROMKREISEN MIT NICHTSINUSFÖRMIGEN VERLAUF VON STROM UND SPANNUNG (Real, Wattless and Apparent Power in Electrical Circuits with Non-sinusoidal Current and Voltage [New Definitions rendering valid the Formulae holding for Sinusoidal Currents]).—S. Fryze. (*E.T.Z.*, 23rd and 30th June, 1932, Vol. 53, pp. 596–599 and 625–627 : to be concluded.)

THE FALL OF POTENTIAL IN A CHARGED INSULATED CABLE.—D. K. McLeery. (*Proc. Physical Soc.*, 1st July, 1932, Vol. 44, Part 4, No. 244, pp. 494–499.)

REMARKS ON BAERWALD'S PAPER "THE RANGE OF VALIDITY OF THE STRECKER-FELDTKELLER MATRIX EQUATIONS FOR QUADRIPOLE SYSTEMS."—O. Brune : Baerwald. (*E.N.T.*, June, 1932, Vol. 9, p. 234.)

A letter suggesting a simpler and more general form for the conditions arrived at in the paper referred to in April Abstracts, p. 221. Baerwald replies on the same page.

A MECHANICAL ANALOGY FOR COUPLED ELECTRICAL CIRCUITS [NEW SYSTEM OF MECHANICALLY COUPLED PENDULUMS].—H. J. Reich. (*Review Scient. Instr.*, June, 1932, Vol. 3, pp. 287–293.)

NEW THEORY AND DESIGN OF WAVE FILTERS.—Cauer. (*See* under "Subsidiary Apparatus and materials.")

CALCULATION OF THE BUILDING-UP TIME OF BAND-PASS FILTERS.—Labus. (*See* under "Subsidiary Apparatus and Materials.")

THE CALCULATION OF DETECTOR PERFORMANCE FOR LARGE SIGNALS.—Woods. (*See* under "Reception.")

THE DETECTION BY A STRAIGHT LINE RECTIFIER OF MODULATED AND HETERODYNE SIGNALS.—Moullin. (*See* under "Reception.")

TRANSMISSION.

A CATHODE-RAY FREQUENCY MULTIPLIER [FOR OBTAINING ULTRA-HIGH FREQUENCIES].—N. C. Jamison. (*Physics*, April, 1932, Vol. 2, pp. 217–224.)

"At the present time there seems to be no method available for the production of intense, sustained electric oscillations in the frequency range above 2×10^9 c/s." The writer describes a special tube having a filament and slit arrangement for producing a sheet of electrons, one pair of deflecting plates, and a receiving plate composed of a series of rectangular insulated conductors connected alternately into two sets. By deflecting the beam by an a.c. potential across the deflecting plates, currents from the two sets of conductors should pulsate with frequencies which are multiples of the applied frequency. Tests gave "very definite indications" of receiving-plate currents of 2, 4 and 6 times the frequency of the applied field. The highest frequency obtained was round 2.6 megacycles/sec., but a tube of improved design is being constructed with which it is hoped to produce intense oscillations above 2 000 megacycles/sec.

INVESTIGATIONS IN THE FIELD OF THE ULTRA-SHORT ELECTROMAGNETIC WAVES: III. ELECTRONIC OSCILLATIONS IN VACUUM TUBES AND THE CAUSES OF THE GENERATION OF THE DWARF WAVES.—G. Potapenko. (*Phys. Review*, 15th June, 1932, Series 2, Vol. 40, No. 6, pp. 988–1001.)

From the author's summary :—An investigation was made of the motion of the electrons in tubes generating ultra-short waves. The motion of the electrons was investigated graphically by means of special diagrams which simultaneously represented the trajectories of the electrons and the alternating potentials at the electrodes of the tube. In this manner it was shown that the reason a vacuum tube can generate dwarf waves is because the tube can transmit energy into the oscillating circuit coupled with it and transmit it periodically with a period equal to the natural period of the circuit, not only when this period T is equal to the period of the electronic oscillations τ (normal waves) but also when $T = \frac{1}{2}\tau$, $T = \frac{1}{3}\tau$, $T = \frac{1}{4}\tau$, . . . (dwarf waves). This property of the tube depends on the fact that, in all the cases described, a periodic division of the electrons into two groups is possible. According to the theory of E. Gill and J. Morrell, this division determines the transmission of energy into the oscillating circuit. The above property of the tube means also that the dynamic resistance of the tube is negative under these conditions. The diagrams of the trajectories and the velocities of the electrons, constructed on the basis of the computations [by the Runge-Kutta method] of G. Kreutzer, confirmed the above deductions.

ON THE ULTRA-HIGH-FREQUENCY OSCILLATION OF THE MAGNETOSTATIC VACUUM TUBE.—W. Dehlinger. (*Physics*, June, 1932, Vol. 2, pp. 432–442.)

The full paper, an abstract of which was dealt with in July Abstracts, p. 404.

A NEW METHOD OF MODULATION [CHIREIX DEPHASING SYSTEM].—G.W.O.H. : Chireix. (*Wireless Engineer*, July, 1932, Vol. 9, No. 106, pp. 367–368.)

Editorial on Staut's article on "Radio-Paris" (May Abstracts, p. 299), pointing out that the explanation of the dephasing system given in the article is based on a misunderstanding, and giving the true explanation and a discussion of the system. See also Feb. Abstracts, p. 94, for Chireix's paper on the system.

PHASE SHIFT IN RADIO TRANSMITTERS [CAUSES AND EFFECTS: CATHODE-RAY OSCILLOGRAPHIC INVESTIGATION AND MATHEMATICAL TREATMENT].—W. A. Fitch. (*Proc. Inst. Rad. Eng.*, May, 1932, Vol. 20, pp. 863–883.)

The most serious result of phase shift is shown to be the creation of adjacent channel interference. The amplitude of the second order side band is roughly one per cent. of the first order side band per degree of phase shift.

DISCUSSION ON "AMPLITUDE, PHASE, AND FREQUENCY MODULATION."—D. G. C. Luck : Roder. (*Proc. Inst. Rad. Eng.*, May, 1932, Vol. 20, pp. 884–887.)

Discussion on Roder's paper dealt with in March Abstracts, p. 162. Luck states that Roder's method of attack on sinusoidal "phase" modulation is incorrect. The correct method shows the phenomenon to be merely "frequency" modulation with the frequency variation range increasing linearly with modulation frequency, thereby explaining the pernicious effects of "phase" modulation as regards interference production. Roder replies.

THE RECEPTION OF FREQUENCY-MODULATED RADIO SIGNALS.—Andrew. (*See* under "Reception.")

NOTE RELATIVE TO HECHT'S PAPER ON "MODULATION AND SIDE BANDS."—J. B. Pomey : Hecht. (*L'Onde Élec.*, May, 1932, Vol. 11, No. 125, p. 224.)

A note showing the derivation of a formula in this paper dealt with in June Abstracts, p. 341.

A Defect in Transmissions : Frequency Modulation as a Little Known Source of Interference. (*See* under " Reception.")

Application of Quartz Plates to [Broadcasting and Aircraft] Radio Transmitters.—O. M. Hovgaard. (*Proc. Inst. Rad. Eng.*, May, 1932, Vol. 20, pp. 767–782.)

Author's summary :—This paper discusses the disturbing elements encountered in the application of quartz plates to broadcast and aircraft radio transmitters. A general procedure for minimizing such effects is considered from a circuit standpoint as well as in the light of practical experience. The degree to which maintenance may affect performance and the necessity for automatic equipment are shown by data obtained in the field. Apparatus and systems which enable the operating staff to meet modern frequency stability requirements by monitoring the emitted carrier are also described.

A Study of Class B and C Amplifier Tank Circuits.—P. H. Osborn. (*Proc. Inst. Rad. Eng.*, May, 1932, Vol. 20, pp. 813–834.)

Author's summary :—An investigation was made of the relations between the constants L, C, and R of a power amplifier output tank circuit. Experimental data were taken on an amplifier excited at a frequency of 480 cycles per second. An indication of the harmonic content of the output was obtained by means of a cathode ray oscillograph.

The results of the experimental data show that the output power and voltage and the efficiency depend only on the output circuit impedance and are independent of the L/C ratio. However, for a given output, the second harmonic in the output voltage increases with the L/C ratio.

It is shown both experimentally and theoretically that the per cent of second harmonic in the output is a function of the volt-ampere-to-watt ratio existing in the circuit. With a very large value of this ratio, the tank circuit will have a large flywheel effect so that the current amplitude will not follow the modulation closely at the higher modulating frequencies. A formula for calculating this effect is developed.

It is demonstrated that for class B and C amplifiers the tube cannot be considered as a generator having a fixed internal resistance and generated voltage with any degree of exactness.

Über den Störton von Sendern (Background Hum in Radio Transmitters [Definitions of Objective and Subjective Ripple : its Measurement and Frequency Analysis]).—H. Brückmann. (*T.F.T.*, May, 1932, Vol. 21, pp. 135–141.)

The Mode of Action of Screen-Grid Transmitting Valves [based on the Philips' Company's Valves].—de la Sablonière. (*See* under " Valves and Thermionics.")

RECEPTION.

La Réception synchrone (" Synchronous " Reception).—H. de Bellescize. (*L'Onde Élec.*, May, 1932, Vol. 11, No. 125, pp. 209–224.)

In a long introduction the writer, prompted particularly by Reeves' use of " asynchronous " reception (*see* below) in single-side-band short-wave reception, recalls his own pioneer work on protection against atmospherics based on an appreciation of the spectrum difference between these and the desired signals. He sums up the advantages of Reeves' methods as :—(i) almost complete suppression of the carrier (or pilot) wave, rendered possible by the fact that even when reduced in strength it is sufficiently stable to control the frequency of a local oscillation created at the receiver : hence the possibility of doubling, at the transmitter, the amplitude of the signal side bands. (ii) Suppression of one of the two side bands, thus reducing by a half the time constant of the receiver, giving protection against interference equivalent to multiplying the signal amplitude by $\sqrt{2}$. (iii) Parasitic disturbances reduced by a half. (iv) Detection rendered exactly linear and of invariable sensitivity, thanks to the constancy of the local oscillation : giving better quality and above all a great reduction of fading. (v) Suppression of distortion due to sudden propagation changes, and (vi) Suppression of distortion due to lack of symmetry between the two side bands, independent of propagation effects.

" Thus asynchronous reception of signals consisting of a single side band and a weakened carrier (or pilot) represents a quite remarkable sum of progress. In this particular application, *synchronous* reception enjoys exactly the same advantages, and realises them so simply that *nothing could be easier than to allow the broadcast listener to benefit by them* . . . eighteen months of experiment have shown me that most European stations are at present stable enough to be received in this way. But it is in telegraphy that synchronous reception will bring the greatest improvement ; the action of the mechanism of accumulation [of the regular signal waves], protecting the signal against atmospherics, there reaches its maximum." The writer thinks it is impossible to forecast the changes which synchronous reception may bring about in various domains : one may be a reversion to medium and long waves for services now employing short waves.

The whole difference between what the writer calls " synchronous " and " asynchronous " reception lies in the fact that in the latter system (as used by Reeves) the local oscillations are merely kept as closely as possible to the same *frequency* as the suppressed carrier, whereas in " synchronous " reception they are maintained with *a constant phase difference with regard to the carrier* (*see* p. 218, equations 1, 2 and 3). The writer's object is to show how to improve the single side band system by the application of synchronous reception, then to extend its use as far as possible to signals with two side bands, and finally to indicate new lines of progress rendered possible only by this system of reception. The paper is to be continued.

Les Amplificateurs pour Bandes de Fréquences (Amplifiers for Bands of Frequencies [for Frequency-Changing Receivers]).—P. Drouin. (*L'Onde Élec.*, May, 1932, Vol. 11, No. 125, Supp. pp. 1–32.)

First instalment of a lengthy study specially arranged for detaching from the journal so as to form finally a complete booklet. "Most authors who have calculated the effects of amplifying and selective arrangements for the modulation band have made use of filter theory—which involves, in general, the necessity for studying first of all circuits with negligible resistances and then introducing corrections intended to take the actual resistances into account. This method . . . has the fault that it only allows for the resistances in a manner which is often inadequate, especially when the circuits in question are to be used in connection with very high internal resistances, as in the case of screen-grid valves."

The writer therefore examines the problem of band amplification without any reference to filter theory and taking into account, from the very start, the effects of the ohmic resistances. He does not deal with a few particular arrangements but studies the problem as a whole, so as to obtain a general procedure for calculation, precise lines indicating the results which may be obtained with a given number of stages, means for the direct determination of the most favourable distortion and selectivity obtainable with an amplifier of given type, and groups of curves for the rapid calculation of the components for an amplifier to satisfy given conditions. "Finally, an important part of the work is devoted to a study of amplifiers compensating the distortion of the tuning system. This compensation, nearly always neglected, gives remarkable results and constitutes, especially for the reception of waves of medium length, a real improvement over non-compensated amplifiers."

BANDFILTER (BAND PASS FILTERS [FOR BROADCAST RECEIVERS]).—H. Brykczynski. (*Funk-Magazin*, June, 1932, Vol. 5, pp. 471–478.)

Discussing filters with inductive coupling, Vreeland filter with inductive circuit coupling and with capacitive circuit coupling, filters with constant band breadth, and filters with continuously variable band breadth.

RESISTANCE AND TRANSFORMER COUPLING FOR AMPLIFIERS: A COMPARISON.—A. Forstmann. (Summary in *L'Onde Élec.*, May, 1932, Vol. 11, No. 125, pp. 19–20A.)

Resistance coupling is not necessarily more faithful than transformer coupling. On the contrary, the proper use of the two transformer resonances enables one to obtain an output either completely uniform, or favouring one or the other end of the band if this is desired to correct a distortion; moreover, the amplification falls very rapidly outside the band, which is an advantage. Perhaps the best method is to alternate a resistance stage with a transformer stage.

THE RECEPTION OF FREQUENCY-MODULATED RADIO SIGNALS.—V. J. Andrew. (*Proc. Inst. Rad. Eng.*, May, 1932, Vol. 20, pp. 834–840.)

Author's summary:—The reception of frequency modulated signals by means of various adjustments of a tuned circuit is discussed non-mathematically. The simplest method consists in analysing the signal into a carrier and side bands, and calculating the response of the tuned circuit to each component. The maximum power response is found to be 0.09 of the response with an amplitude modulated transmitter of the same power. There is an inherent discrimination in the receiver against the lower modulation frequencies which just balances a similar discrimination in the transmitter against the higher modulation frequencies.

A DEFECT IN TRANSMISSIONS: FREQUENCY MODULATION AS A LITTLE KNOWN SOURCE OF INTERFERENCE. (*Wireless World*, 22nd July, 1932, Vol. 31, pp. 52–53.)

An article discussing aspects of mutual interference of adjacent stations which have only become apparent since the introduction of highly selective receivers. Tests on the reception of Mühlacker in London lead to the conclusion that the harsh, "tearing" sound so often heard in this reception was due, at any rate in this particular case, to frequency modulation in the London Regional transmission. Incidentally, the trouble was at its worst during the reading of the London news bulletin, "at which time it is well known that deep modulation is used." For an editorial comment, *see* p. 51.

THE SELECTIVITY OF BROADCAST RECEIVERS [INTRODUCTION TO DISCUSSION].—C. L. Fortescue. (*Journ. I.E.E.*, June, 1932, Vol. 71, No. 426, pp. 102–103.)

In the subsequent discussion (pp. 103–113) many interesting points of view are expressed by a number of speakers, and finally Fortescue sums up. A *Wireless Engineer* summary was referred to in July Abstracts, p. 405; *see* also Kirke, Aug. Abstracts, p. 460.

INCREASING SELECTIVITY BY CRYSTAL IN INTERMEDIATE CIRCUIT OF SUPERHETERODYNE.—(French Pat. 698 769: summary in *Electronics*, June, 1932, p. 205.)

In one arrangement two intermediate circuits are used in opposition, one only having a crystal across it: all frequencies except that to which the crystal is tuned (which is suppressed by the crystal circuit) cancel out. A second arrangement uses direct coupling but is otherwise similar.

THE DETECTION BY A STRAIGHT LINE RECTIFIER OF MODULATED AND HETERODYNE SIGNALS.—E. B. Moullin. (*Wireless Engineer*, July, 1932, Vol. 9, No. 106, pp. 378–383.)

The new view-point from which the writer examines the problem is indicated by the following quotation from his introductory section:—"The interfering programme should become the side bands of the difference frequency as carrier, and we should expect this to sound very unlike the original. . . . Every low note of the interfering station should be reproduced as a high note, and *vice versa*. But experience shows that the interfering programme is in general recognisable, and we wish to understand why it should be. The problem to me is to understand why the interfering programme gets through in the presence of the strong signal, and not to understand why the strong signal appears to reduce or 'demodulate' the weak. The strong signal has in fact very little power to demodulate the weak, but it has the power of transferring the interfering programme to a modulation of the frequency difference between the two carriers. . . ."

The final section deals with the case where by means of a quartz crystal or by valve retroaction the value of the circuit power factor is made of the order of 1/2 000.

"DEMODULATION."—F. M. Colebrook. (*Wireless Engineer*, July, 1932, Vol. 9, No. 106, p. 394.)

A letter denouncing the above name as applied to the phenomenon in question (*cf.* Mallet, Aug. Abstracts, p. 460) and then pointing out that "the new fact which seems to be emerging . . . is the part played by the carrier beat frequency in relation to the time constant of the detector load . . . First, it was thought necessary that the carrier beat frequency should be supersonic (relative to the load); then later, that it need not be; and finally, that it must not be. It is an interesting object lesson in the necessity for a close scrutiny of analytical processes."

THE MUTUAL INTERFERENCE OF SIGNALS IN SIMULTANEOUS DETECTION.—E. V. Appleton. (*Wireless Engineer*, July, 1932, Vol. 9, No. 106, pp. 394–395.)

Supplement to the letter dealt with in July Abstracts, pp. 405–406. In view of Colebrook's somewhat different conclusions (*ibid.*, pp. 402–403) the question has been examined again in a wider series of experiments, very definitely confirming the results of the earlier experiments. The table shows that good agreement with theory is only obtained when the time constant of the grid circuit is sufficiently low, and that the effect of the suppression of the acoustic output due to the weaker signal becomes smaller as this time constant is increased.

A CARRIER INTERFERENCE ELIMINATOR.—W. Baggally. (*Wireless Engineer*, July, 1932, Vol. 9, No. 106, pp. 388–390.)

A paper on the design and use of a Campbell sifter circuit with choice of constants and adjustable construction making it very satisfactory for this particular purpose.

THE CALCULATION OF DETECTION PERFORMANCE FOR LARGE SIGNALS.—J. P. Woods. (*Physics*, April, 1932, Vol. 2, pp. 225–241.)

Author's abstract:—It is mathematically proven that a detector tube which has a broken straight line for its plate current/grid voltage static characteristic will detect the standard radio signal without distortion, regardless of signal strength. The plate detection performance of a tube having a given curve for its static characteristic can be calculated from the extended power series which represents the characteristic. The power series analysis of the curve is obtained from a Fourier series analysis by a method [de la Vallée Poussin] which saves labour and is more accurate than the method of simultaneous equations. Thus, by using twelve or fifteen terms of the power series instead of only the first two or three, and by setting up special formulae, detection performance can be calculated for any signal strength and any modulation. The method is applicable to the tube alone, to a circuit containing the tube and external resistances, and may be applied to any similar non-linear receiving system.

DAS RAUSCHEN VON EMPFÄNGERN (Background Noise in [Aircraft] Receivers).—W. Brintzinger and H. Viehmann. (*Hochf:tech. u. Elek:akus.*, June, 1932, Vol. 39, pp. 199–207.)

The background rustle here investigated is due to four causes:—(i) current fluctuations due to chemical processes in the batteries: (ii) imperfect contacts: (iii) temperature effect—the pulsation of current in conductors resulting from molecular oscillations: (iv) Schrot (small-shot) effect, and the action of secondary electrons and ions (Llewellyn, 1930 Abstracts, pp. 279–280). The first two causes are here dismissed as elementary, and the investigation deals with (iii) and (iv). Previous papers by other workers are discussed, and the writers then deal with recent researches by the D.V.L. on various types of valve and on aircraft receivers, particularly for short waves.

The following conclusions are reached:—For wavelengths between 15 and 1 000 m, the noise is independent of frequency, for a given amplifier band-breadth. To obtain the least possible noise in proportion to the amplification of the receiver, the following points should be observed:—(i) the efficiency of the input circuit and the amplification of the first stage should be as high as possible, in order to obtain a favourable ratio input-voltage/noise-voltage: (ii) selectivity should be high without loss of amplification or increase of number of stages: (iii) the leaky grid circuit should be properly designed; for a certain value of grid leak (of the order of 1 megohm) the noise reaches a maximum (Fig. 13); this effect can be decreased by a parallel condenser, and a sufficiently large condenser renders the noise independent of the value of the resistance and brings it down to about the minimum for the particular valve. This phenomenon requires to be taken into account in all designs of audion and resistance-capacity amplifier circuits.

(iv) Commercial German valves work in the region of minimum noise when fully heated. With lower heating (even in the "normal" voltage range 3.8–4 v) the noise increases to a marked extent. Different types of valve, otherwise equally good, give different amounts of noise: a diminution of noise level can be attained by careful choice of valve, especially for the input stage: (v) valves with low vacuum, or near the end of their life, must be avoided: (vi) anode direct current should be kept down, since the noise increases with its value: (vii) with ordinary valves, negative grid bias causes no appreciable increase in noise, and under certain conditions may even decrease it by reducing the anode d.c.

The paper includes (p. 204) an outline of the DVL "audimeter" used in determining the frequency characteristic of the noise.

UN RÉCEPTEUR MODERNE POUR LE TRAFIC TÉLÉGRAPHIQUE SUR ONDES MOYENNES (A Modern Receiver for Telegraphic Traffic on "Medium" Waves [3 000 to 21 000 Metres: the Noiseau Station Equipment]).—G. Espinasse. (*Ann. des P.T.T.*, April, 1932, Vol. 21, pp. 299–314.)

In a final section the writer considers future improvements possible in such receivers: they are not of great importance—possibly the r.f. selectivity may be somewhat improved, since increased selectivity and the use of band-pass filters have been shown to be the best way of protection against aperiodic disturbances. He urges that the C.C.I.R. tolerance of $\pm$ 0.1 % for the frequency constancy of transmitters is much too great: fixed stations should be given at most a 0.02 % tolerance.

REDUCING ERRORS DUE TO ATMOSPHERICS BY UTILISING THEIR IRREGULARITY IN SPACE.—Montoriol and Subra. (*See* abstract under "Atmospherics.")

THE BEELITZ OVERSEAS RECEIVING STATION.—Mögel. (*See* under "Stations," Design and Operation.")

THE MODERN BAND FILTER SUPERHETERODYNE WITH FADING COMPENSATOR, FOR AMATEUR CONSTRUCTION: INTRODUCTORY.—E. Rossmann. (*Die Sendung*, 6th May, 1932, Vol. 9, No. 19, pp. 399–400.)

Continued in subsequent numbers up to 10th June.

NEW PENTODE OUTPUT CIRCUIT.—L. G. A. Sims. (*Wireless World*, 29th June, 1932, Vol. 30, pp. 677–681.)

The writer shows that a very considerable improvement in bass response can be effected by the use of quite a small capacity in the choke filter output circuit of a pentode. A condenser of about one-eighth of the usual capacity is made to resonate with the output choke at low frequencies, and a circuit very similar to that of the parallel-fed l.f. transformer results. The resonance is damped out by the low impedance of a triode but remains almost unaltered by the high pentode impedance. Many practical examples of the arrangement are outlined.

EIN DREIKREIS-VIERRÖHREN-EMPFÄNGER MIT EXPONENTIALRÖHRE (A Three-Circuit Four-Valve Receiver with Exponential Valve).—(*Rad., B., F. f. Alle*, July, 1932, pp. 303–307.)

THE AUTOTONE PORTABLE.—F. L. Devereux. (*Wireless World*, 8th July, 1932, Vol. 31, pp. 2–5.)

A three-valve portable receiver for the amateur constructor. The principal feature is the use of tone correction to restore the upper audio-frequencies lost by the use of critical retroaction.

THE APPLICATION OF PERMEABILITY TUNING TO BROADCAST RECEIVERS [AND THE USE OF POLYIRON].—R. H. Langley. (Summary in *Proc. Inst. Rad. Eng.*, June, 1932, Vol. 20, p. 914.)

HET METEN VAN RADIOSTORINGEN (The Measurement of Radio Interference [High Frequency Spectra of Disturbances from Motors, Rectifiers, etc.]).—J. W. Alexander. (*Tijdschr. Nederl. Radiogenoot.*, June, 1932, Vol. 5, pp. 155–170.)

The method investigated is in principle as follows:—the disturbance is made to act as e.m.f. in a circuit containing L, C and R. The condenser potential of this circuit is taken, in series with a variable source of similar potential, to the grid of an amplifier triode, the positive pole of the source being connected to the cathode. The value of the variable potential is adjusted so that the anode current is a minimum. The disturbance is then replaced by a sinusoidal e.m.f. of the same frequency as the natural frequency of the circuit, this e.m.f. being adjusted so that the same anode current flows.

The maximum potential caused by the disturbance is then compared with that caused by the sinusoidal e.m.f. The relation between the two maxima is worked out by Fourier analysis and also by the operational method. By changing the natural frequency of the L, C and R circuit a frequency spectrum of the disturbance can be obtained. The necessary apparatus is described and examples of its work are given, interference spectra due to motors and rectifiers being shown: they differ very greatly.

RUNDFUNKSTÖRUNGEN UND DEREN BESEITIGUNG BEI HEIZKISSEN-TEMPERATURREGLERN (Eliminating Interference from Thermostatically Controlled Electric Cushions).—A. C. Wiese. (*Elektrot. u. Masch:bau*, 3rd July, 1932, Vol. 50, No. 27, pp. 384–385.)

MAN-MADE STATIC AND THE BEST AERIAL FOR ITS SUPPRESSION.—Leithäuser: Zerlett. (Summaries in *L'Onde Elec.*, May, 1932, Vol. 11, No. 125, pp. 20–21 A.)

Frames and indoor aerials are particularly exposed to such interference, surrounded as they are by the lighting and power system leads which conduct the disturbances. The outside aerial is much more favourably situated, and a screened lower portion is all that is necessary to protect it against trouble, even in the immediate neighbourhood of the worst offenders (medical apparatus, for instance).

THE TESTING OF BROADCAST RECEIVERS [AT THE RADIO INSTITUTE, WARSAW].—S. Dierewianko. (*Wiadomości i Prace Inst. Radjot., Warsaw*, No. 5, Vol. 3, pp. 66–74: in Polish.)

DEVELOPMENTS IN THE TESTING OF RADIO RECEIVERS.—H. A. Thomas. (*Journ. I.E.E.*, June, 1932, Vol. 71, No. 426, pp. 114–125: Discussion, pp. 125–133.)

The full paper, a *Wireless Engineer* summary of which was referred to in August Abstracts, p. 460.

ON THE ACTION OF TUNED RECTANGULAR FRAME AERIALS WHEN RECEIVING SHORT WAVES.—Palmer. (*See* under "Aerials and Aerial Systems.")

NUMBER OF BROADCAST LISTENERS AT 1ST JANUARY, 1932, IN VARIOUS COUNTRIES.—(*E.N.T.*, June, 1932, Vol. 9, p. 233.)

Ranging from 73 (Madagascar) to 951 321 (Japan).

THE OSCILLATING [CRYSTAL] DETECTOR.—Noack: Habann. (*See* under "Subsidiary Apparatus and Materials.")

RADIO IN CANADA—TRADE CONDITIONS IN 1931.—(*Electrician*, 3rd June, 1932, Vol. 108, p. 769.)

The increased sale of mains receivers more than compensated for the drop in radio-gramophones and battery sets, making a total sales increase of over 25 % on the previous years.

LA POLICE MUNICIPALE ET LA RADIOELECTRICITÉ (Municipal Police and Radio).—A. Mestre. (*Génie Civil*, 6th June, 1932, Vol. 100, No. 23, pp. 569–570.)

Deals with the question of protecting radio listeners from interference caused by electric installations such as trams and distribution networks. In some municipalities police authority is used to deal with owners of such installations. Such procedure is based on a law giving authority to the police to deal with acts liable to disturb the public peace. The writer considers that radio listeners do not constitute the public, but are merely a limited number of people using a public service: the power of dealing with owners of interfering apparatus should rest rather with the state authorities who organise the radio transmission and who should ensure that it is functioning efficiently.

AERIALS AND AERIAL SYSTEMS.

DIE WIRKUNGSWEISE VON VOLLMETALL- UND GITTERREFLEKTOREN BEI ULTRAKURZEN WELLEN (The Action of Sheet Metal and Grid Reflectors for Ultra-Short Waves [Experimental Investigation]).—W. Köhler. (*Hochf:tech. u. Elek:akus.*, June, 1932, Vol. 39, pp. 207–219.)

Tests on 16.8 cm waves. The transmitter emitted practically only vertically polarised waves; owing to the internal valve construction a weak horizontally polarised component existed, but this decreased rapidly with distance. No change of the plane of polarisation by plane or parabolic reflectors was observed, nor was any alteration of wavelength noticeable. The reflectors were made of copper, aluminium, zinc and brass sheet of various thicknesses: no measurable variation of the reflecting action with these different materials could be found—the most important quality of the materials as regards reflection, their conductivity, being all of the same order of magnitude.

Plane reflectors were first investigated. The use of large plane reflectors is limited by the occurrence of interference phenomena, the limit being already reached for an aperture (distance apart of the edges of the reflector) equal to 2λ. For every reflection maximum (optimum positions of reflector behind aerial) there is a corresponding aperture with optimum gain and sharpness of directivity. The best results were obtained, both at transmitter and receiver, with an aperture of 2λ at the third reflection maximum. At the receiver, a reflector only produces 42% of the gain it yields at the transmitter. The use of reflectors at transmitter and receiver gives a total gain which on the average is equal to the *sum* of the separate gains at the two ends.

Dealing next with cylindrical parabolic reflectors, quite different results are found as regards aperture: gain and sharpness of directivity both increase with aperture, no interference making its appearance to spoil the results. With "square" (*i.e.*, aperture = height) reflectors of this type they reach constant values for an aperture of 10λ. The most favourable reflection maximum for large reflectors of this type is the third, at a distance λ (0.27 + 1) cm from the aerial. Of the three classes of reflector in this category, namely (1) "square" parabolic metal-sheet, (2) tuned parabolic metal-sheet, and (3) parabolic grid reflectors, tuned or un-tuned, the first gives the best performance as regards gain and sharpness (but see later). The second, with a height of 2.5λ and placed at the second reflection maximum, gives a gain up to 56% better than that given by (1), up to an aperture of 6λ, but has the disadvantage of a slightly increased back-radiation. Of (3), the untuned grid type with aperture 5λ, for which the second maximum is the best, gives nearly as good gain and sharpness as type (1) with aperture 10λ, but with worse back-radiation and subsidiary maxima: the tuned grid type is inferior in all ways to the other types.

Tables 2 and 3 show the very great superiority of the parabolic over the plane reflector. For practical purposes, the untuned grid type of parabolic reflector is recommended, since its gain for a 5λ aperture is only 10% less than that given by the metal-sheet 10λ aperture parabolic reflector. For parabolic reflectors the use at receiver as well as at transmitter yields a gain equal to the *product* of the individual gains; but with these as with the plane reflectors, the average gain at the receiver is only about 42% of that at the transmitter.

The paper ends with a comparison of the experimental results with the results calculated by Ollendorff's formula.

APPLICATION OF THE PRINCIPLE OF HUYGHENS TO THE CALCULATION OF REFLECTORS FOR ULTRA-SHORT WAVES.—R. Darbord. (*Journ. de Phys. et le Rad.*, March, 1932, Vol. 3, Series 7, pp. 105–115.)

Author's summary:—"The combination of the general form of the Huyghens principle and of the principle of the conservation of energy allows the following problem to be solved:—If an electromagnetic wave falls obliquely on a reflecting screen, what is the electromagnetic field diffracted to a distance by an element of this screen in the direction corresponding to reflection according to the laws of geometrical optics? The elementary law thus obtained allows the efficiency of parabolic reflectors for ultra-short waves to be calculated." Practical conclusions as to the best diameter and focal length are drawn towards the end of the paper, and finally very simple formulae for gains and for values of field are derived under the simplifying assumption of a focal distance equal to half the radius of aperture. *See* also June Abstracts, p. 346, same writer.

KURZWELLEN-RUNDSTRAHLANTENNEN (Short [and Ultra-Short] Wave Broadcasting Aerials [to Eliminate Skip Distance Effect: as at Zeesen Station]).—O. Böhm. (*Telefunken-Zeit.*, No. 60, Vol. 13, 1932, pp. 26–28.)

Illustrated description of the Zeesen aerial dealt with in *Wireless Engineer* of April, 1932, p. 194.

There are four horizontal squares strained out around the single 70-metre tower; in each square one pair of adjacent sides forms a dipole, the opposite pair a second dipole; one set of four dipoles vertically above one another is fed by vertical bus-bars formed by a Lecher wire pair, the other set by a second pair diametrically opposite to the first. The Lecher wire connected to the right-hand half-dipole of the lowest square is connected to the left-hand half-dipole of the square next above, and so on. Figs. 34 and 35 show the calculated radiation in the horizontal and vertical planes respectively; the former diagram, although a square with rounded corners, approximates to a circle; the latter shows a main beam at 10°, a very much smaller secondary (less than 0.3 for a main beam value of 1) at about 40°, and an insignificant component (less than 0.15) between 60° and 70°.

"The concentration in the vertical plane brings an eight-fold increase of energy density at distant points. That is compared with a single vertical dipole as previously used for broadcasting: an eight-times increase of signal strength in short-wave broadcasting is thus obtained." The aerial should also play an important part in ultra-short-wave transmission. Tests in connection with television at Nauen, and with broadcasting at Telefunken House, have already been carried out. Thorough investigations will shortly decide the comparative merits of horizontal and vertical polarisation.

LANGWELLEN-RUNDFUNKANTENNEN MIT UNTERDRÜCKUNG DER STEILSTRAHLUNG ("Long Wave" [Medium Wave] Broadcasting Aerials with Suppression of High-Angle Radiation [the "Disc" or "Wheel," "Cylinder" or "Polygon," and "One-Wire" Aerial Systems]).—O. Böhm. (*Telefunken-Zeit.*, No. 60, Vol. 13, pp. 21–26.)

The disc or wheel system is examined briefly and dismissed as inconvenient in practice (the currents in the central down-lead and in the disc itself must be 90° out of phase with each other) and as having no advantages over the other two systems.

The cylinder (or, as its practical form is better called, the polygon) aerial is next dealt with, and Fig. 25 shows the curve connecting the extinction angle and the current ratio in cylinder and central down-lead, while Fig. 26 shows the calculated radiation diagram for extinction at 60°. In its practical form the cylinder must be replaced by at least six outside aerials (otherwise the radiation will not be uniform all round). The earth losses of the central aerial are added to by these auxiliaries: for six auxiliaries and an extinction angle of 60°, the calculated added loss is 37.6%. Another objection is, of course, the area of land required: the diameter of the ring of towers is about 0.8λ.

The one-wire aerial with a current node at its middle point "gives the necessary compensation radiation in a far simpler manner," the middle-current-node distribution being superimposed on the normal working-current distribution, yielding a current node at a short distance above the ground (*cf.* Böhm, 1931 Abstracts, p. 605). Fig. 29 shows the distribution and vertical radiation of the one-wire aerial for Breslau broadcasting station. The top-of-aerial capacity here used, to obtain the necessary current distribution, is shown in Fig. 30: the vertical wire runs centrally up the lattice wooden tower and connects at the top to a 14-metre diameter ring of 10-cm diameter copper tubing.

THE BRESLAU BROADCASTING STATION ONE-WIRE AERIAL FOR THE SUPPRESSION OF NEAR FADING.—Böhm. (*See* above abstract.)

ON THE ACTION OF TUNED RECTANGULAR FRAME AERIALS WHEN RECEIVING SHORT WAVES.—L. S. Palmer. (*Proc. Roy Soc.*, 2nd May, 1932, Vol. 136, No. A 829, pp. 193–209.)

Author's summary:—(1) To explain certain observed peculiarities in the behaviour of a tuned rectangular frame aerial when influenced by an electromagnetic wave comparable in length with the frame dimensions, the wave is considered to cause a frame current which can be resolved into a "direct" current component due to the primary action of the wave and an "indirect" current component due to the field of the current in adjacent parts of the frame. This treatment leads to the conclusion that the resultant current is dependent on the dimensions of the frame, on the wavelength, and on the angle of incidence of the wave.

(2) A theory is developed from which it is concluded that for each particular height of the frame less than one wavelength there are at least two critical widths for which the frame current will be a maximum; that is, there are at least two critical areas for which the current will be a maximum and any variation of these areas will result in very great decrease of signal strength. (3) The resonant current which circulates in a tuned frame aerial under the influence of an electromagnetic wave is not necessarily the maximum current that can be produced in the frame by the incident wave. By a proper adjustment of the height and width of the frame the current may be increased to a very much larger value.

(4) The word "formatising," as distinct from "tuning," is suggested as appropriate for describing this process of adjusting the dimensions or form of a frame aerial. (5) Experiments on 7.54, 8.65 and 8.80 metres were carried out with a tuned frame capable of expanding and contracting in either or both dimensions. (6) The observed data lead indirectly to a determination of the conductivity of the ground, which was found to be about 4.4×10^8 e.s.u. for a wavelength of 8.65 metres.

(7) The experimental results show that the maximum frame current only results when the frame is both tuned and formatised. The formatising conditions determined by experiment approximate to the conditions given by the odd solutions of the theoretical equations

$$\tan [\alpha(1 + \cos \gamma) - \psi] = (\alpha^2 - 1)/\alpha$$

and $$\tan [\alpha'(1 + \sin \gamma) + \psi] = (\alpha'^2 - 1)/\alpha'.$$

AN EXPERIMENTAL AND ANALYTICAL INVESTIGATION OF EARTHED RECEIVING AERIALS.—F. M. Colebrook. (*Journ. I.E.E.*, July, 1932, Vol. 71, No. 427, pp. 235–251.)

In Part 1 of the paper the variation of resistance and reactance with frequency of a plain aerial with uniformly distributed constants is worked out by a method based on the classical transmission line equations. The resonance conditions and corresponding values of resistance are found. The actual variation of resistance and reactance with frequency of such an aerial was determined experimentally, and the observed variations were found to be in close agreement with the theory provided the actual length of the aerial (h) was replaced by an effective length $h + \epsilon$, where ϵ is about 5 per cent of h. This is in agreement with Abraham's analysis and Wilmotte's experimental results.

Part 2 deals with the effective e.m.f. in a plain aerial divided into three sections, in each of which a uniformly distributed e.m.f. is induced, the intensity of this e.m.f. in each part being different. The analysis of this case is used to obtain a line integral formula for the effective e.m.f. induced in a uniform aerial by a non-uniform field. The formulae developed for the 3-element case are applied to the Franklin suppressed half-wavelength aerial, and afford means of allowing for the effect of aerial resistance. The "effective height" of an aerial is considered in the light of the present analysis. It is suggested that the idea of "effective height" is one which has outlived its usefulness. An analysis of a receiving aerial as a collector of energy shows that the energy reaches a maximum for an aerial height of $\lambda/4$ and thereafter oscillates with rapidly decreasing amplitude. Finally, it is shown that "the current and potential distributions in receiving and transmitting aerials depend on the distribution of exciting field and that the distribution in a receiving aerial may be totally different from that in a transmitting aerial of the same height. Current nodes in a receiving aerial may be any distance apart from 0 to λ, and are not necessarily separated by half a wavelength as in a transmitting aerial with a point source of excitation."

DISCUSSION ON "A METHOD FOR DETERMINING THE EFFECT OF THE EARTH ON THE RADIATION FROM AERIAL SYSTEMS."—J. S. McPetrie. (*Journ. I.E.E.*, June, 1932, Vol. 71, No. 426, pp. 133–134.)

Discussion (Ratcliffe, Verman and the author) on the paper dealt with in June Abstracts, p. 347.

RADIATION CHARACTERISTICS OF BEAM ANTENNAS [AND THE DISPERSION OF THE BEAM BY THE HEAVISIDE LAYER].—T. Minohara, K. Tani, and Y. Ito. (*Rep. of Rad. Res. and Works in Japan*, March, 1932, Vol. 2, No. 1, pp. 63–74.)

The writers conclude that except at close quarters to the aerial the usual method of representing the directivity by "horizontal radiation characteristics" must be replaced by "space radiation characteristics," whose curves are derived from the equation

$$\overline{E} = \int_0^{\pi/2} 2A \mid F(n, h/\lambda, \theta) \,.\, G(m, \theta, \phi) \,.\, H(a/\lambda, \theta, \phi) \mid \cos\theta \,.\, d\theta.$$

These curves show much more radiation in unwanted directions than the "horizontal radiation" curves. As regards the beam concentrated in the desired direction, dispersion will occur at the layer owing to the surfaces not being perfectly plane, for short waves, from the standpoint of either time or space. As regards the latter point, it may be considered that the waves excite electrons and ions which form a number of small doublets of one electron and one ion: these doublets give out a secondary radiation, so that the excited layer acts as a large beam aerial whose characteristics depend on the distribution of free electrons and ions.

GRAPHICAL DETERMINATION OF POLAR PATTERNS OF DIRECTIONAL ANTENNA SYSTEMS.—G. L. Davies and W. H. Orton. (*Bur. of Stds. Journ. of Res.*, May, 1932, Vol. 8, pp. 555–569.)

Authors' abstract:—This paper describes graphical methods for the determination of polar patterns of directional antenna systems. These methods are less tedious and more generally applicable than computation from available mathematical equations.

At any distant point, the relative phases of the disturbances from the individual antennas of an array are dependent upon the differences in the paths from the antennas to the point, and upon the relative phases of the antenna currents. The path differences may be readily constructed on a scale drawing of the array, and by means of a special protractor these path differences are converted to phase angles for the construction of a vector diagram representing the disturbances at the field point. The resultant of this vector diagram gives the field intensity at that point. Such diagrams for a number of points equidistant from the array give the relative field intensities in various directions and thus enable a polar pattern to be drawn.

As illustrations, the polar patterns of two very simple arrays are determined; a broadside array of two antennas spaced one-half wavelength and carrying equal equiphased currents; and an end-on array of two antennas spaced one-quarter wavelength and carrying equal currents in time quadrature.

By a principle of the addition of the directive patterns of groups of antennas, the work involved in determining patterns of arrays containing a large number of antennas may be greatly simplified. This method also permits ground effects to be readily included, the image current being calculated by means of equations given by Wilmotte.

MAN-MADE STATIC AND THE BEST AERIAL FOR ITS SUPPRESSION.—Leithäuser: Zerlett. (*See* under "Reception.")

SPECIAL "SOLUDRA" CABLE FOR SCREENED DOWN-LEADS.—(*Rad., B., F. f. Alle*, July, 1932, p. 314.)

MAST FOUNDATIONS IN SEA AND IN WET GROUND.—(Summary in *Elektrot. u. Masch:bau*, 22nd May, 1932, Vol. 50, p. 313.)

VALVES AND THERMIONICS.

ÜBER DIE ARBEITSWEISE VON SCHIRMGITTER-SENDERÖHREN (The Mode of Action of Screen-Grid Transmitting Valves [based on the Philips' Company's Valves]).—C. J. de L. de la Sablonière: Philips' Company. (*Hochf:tech. u. Elek:akus.*, June, 1932, Vol. 39, pp. 191–199.)

"Since, in modern transmitters, the use of screen-grid valves in place of triodes is ever increasing, it is desirable to examine again their mode of action." A section of the Philips' Type QB 3/500 is shown, illustrating how the screen grid has two outside connections so that it can be earthed (through large condensers) at two points, as is desirable in a valve of considerable dimensions when working on very short wavelengths. For this type of valve and for the QB 2/75 the control grid/anode capacity is 0.02 $\mu\mu$F ; for the QC 05/15 it is only 0.001 $\mu\mu$F. Self-oscillation is therefore practically impossible, and no neutralising is necessary—a great advantage, particularly for transmitters with variable wavelengths.

The writer then takes the static characteristic curves of such a valve and from them derives curves giving, for a fixed control-grid voltage, the d.c. anode current, d.c. screen-grid current, and the aerial current, as functions of the screen-grid voltage. Approximate formulae are also derived for the values of screen-grid and anode losses. The above work leads to an exposition of the mode of action of the valve, eight main conclusions being set out in section 5, pp. 197–198. Many of these are of direct practical value in the design and adjustment of the circuits. Finally an approximation is obtained for the relation between aerial current and screen grid potential, giving a form of circle diagram.

A NEW WATER-COOLED POWER VACUUM TUBE [WITH WATER-COOLED GRID CONSISTING OF A COLUMN OF MOLYBDENUM DISCS].—I. E. Mouromtseff : Westinghouse Company. (*Proc. Inst. Rad. Eng.*, May, 1932, Vol. 20, pp. 783–807.)

Author's summary :—Part I. The evolution of transmitting tubes is outlined. The ever present desirability of using a single tube for a given power output instead of paralleling several smaller tubes leads finally to the design and construction of tubes with 100-kw output, or larger. The design of a tube for 100- to 200-kw output is described. A basically new feature of the tube is a water-cooled grid, consisting of a column of flat molybdenum disks. With such a structure, grid emission and dynatron effect are eliminated completely. The specific features in the manufacture of larger tubes are discussed.

Part II. Curves are given showing the operation of the tubes as Class A, B, and C amplifiers.

TRANSMITTING VALVES OF 300 KILOWATTS OUTPUT. —Telefunken Company. (*Rad., B., F. f. Alle*, July, 1932, p. 323.)

A water-cooled valve with constant vacuum. Anode voltage 12 000 V, current about 150 A, slope 0.3 A/V. The heating input is about 30 kw.

A NEW VALVE CHARACTERISTIC [FOR COMPARING OR DESIGNING DETECTORS].—P. K. Turner. (*Wireless Engineer*, July, 1932, Vol. 9, No. 106, pp. 384–387.)

" A means is suggested by which the performance of a valve as a grid rectifier can be judged as easily as its performance as an amplifier is at present." Curve sheets are made from I_a/E_a characteristics taken with varying amounts of a.c. input to a grid rectifying circuit.

DIE VERSCHIEDENEN KENNLINIEN-ARTEN (The Various Types of Characteristic Curve [particularly of German Screen-Grid and Pentode Valves]).—K. Nentwig. (*Rad., B., F. f. Alle*, July, 1932, pp. 310–314.)

LA LAMPE À PENTE VARIABLE (The Variable Slope Valve).—L. Chrétien. (Summary in *Rev. Gén. de l'Élec.*, 9th July, 1932, Vol. 32, No. 2, p. 16 D.)

After tracing the reasons for the desire for this type of valve, the writer mentions two ways of obtaining the variable slope : the use of a helical grid of varying pitch, and the use of two grids mutually controlling each other. Practical results are discussed.

THE FLASH-ARC [" ROCKY POINT EFFECT "] IN HIGH-POWER VALVES.—B. S. Gossling. (*Wireless Engineer*, July, 1932, Vol. 9, No. 106, pp. 391–393.)

Summary of an I.E.E. paper and subsequent discussion.

DIRECTIONAL WIRELESS.

ÜBER DIE PEILBREITE VON PEILEMPFÄNGERN (On the Bearing Breadth in Direction-Finder Receivers [and Its Dependence on Signal Strength and Background Noise Level]).—P. Hermanspann. (*Telefunken-Zeit.*, No. 60, Vol. 13, 1932, pp. 35–36.)

Fig. 41 shows that the minimum breadth is given by the angle ϕ determined by the points of intersection of the double-circle diagram and the background noise circle ; taking the subtending arc to be a straight line (an approximation the more justified the larger the ratio H/N, where H is the signal field strength and N that of the noise) ϕ is found from $\tan \phi/2 = H/N - \sqrt{(H/N)^2 - 1}$. Fig. 42 shows the minimum breadth, thus calculated, as a function of H/N. Fig. 43 gives the *observed* minimum breadth, of a Telefunken equipment on 1 000 metres, as a function of H. The upper curve represents telephony [tonic train] reception, the lower heterodyne reception. The smaller breadth in the latter case is accounted for by the fact that the test transmitter was modulated by a rather impure note. The course of the curves agrees with the calculated results.

NAVIGATION BY WIRELESS.—C. G. Phillips. (*Wireless World*, 15th July, 1932, Vol. 31, pp. 26–28.)

The author summarises the various services rendered by wireless to both marine and aerial navigation. The problem of direction finding both on the sea and in the air is dealt with at considerable length, a brief résumé of the various systems being given.

L'UTILISATION DES ONDES RADIOÉLECTRIQUES POUR LA SIGNALISATION MARITIME (The Use of Radioelectric Waves in Maritime Signalling).—Besson. (*Génie Civil*, 7th May, 1932, Vol. 100, No. 19, p. 478.)

A reference to Blondel's paper (1931 Abstracts, p. 328) and to P. Besson's survey (*Ann. P.T.T.*, Dec., 1931) of various recent d.f. methods : the latter writer emphasises that navigators have had a long experience of the radiogoniometer and have gained confidence in it; the new methods must be put into service (after long experimental tests) in order that the same confidence may be gained in them, with the result that coastal navigation in times of fog would be greatly improved. For the writer's own system *see* Jan. Abstracts, p. 39.

ACOUSTICS AND AUDIO-FREQUENCIES.

AKUSTISCHE NACHHALLMESSUNGEN MIT EINEM VOLLAUTOMATISCHEN GERÄT (Reverberation Measurements with a Completely Automatic Apparatus).—M. J. O. Strutt. (*E.N.T.*, June, 1932, Vol. 9, pp. 202–212.)

Researches to investigate the validity of Sabine's two "laws" and the limits in size of room for their application, and to measure by Sabine's method the absorption coefficients of certain materials at a number of frequencies, with a view to comparing the results with those obtained in the same laboratory on the same materials by a different method (Abstracts, 1930, p. 387), in order to elucidate certain points in absorption theory. The automatic apparatus employed is an improved version of that described in an earlier paper (Abstracts, 1930, p. 634). The new apparatus is described in considerable detail, and a long section (III) deals with sources of trouble in reverberation measurements and methods of avoiding them. Objections to the "howling note" artifice are mentioned: the writer prefers to dispense with it and to use a rotating loud speaker (about 3 r.p.sec.), which may be combined successfully with a second artifice. This consists in introducing, between the constant-note sound generator (tuning fork) and its amplifier, a contact-breaker rotating some 5 times in a second. The note thus interrupted keeps its constant pitch (to within 5 c/s) so that reverberation as a function of frequency can be investigated, while the phases of the various pulses are so upset that no interference pattern can be produced. In actual practice it is found that the interruptions can be varied from 2 to 10 per sec. without any measurable change in the reverberation time.

Section IV gives the investigation of the dependence of reverberation time on the position of the sound source in a large room; section V repeats this for smaller rooms, and a comparison of the two leads to the conclusion that Sabine's laws hold (within about 10 %) in rooms of simple shape over 200 m^3 in content, provided that all the walls are roughly equally absorbent. If this condition is not fulfilled, the laws only apply in rooms over about 400 m^3. Even in larger rooms (1 500 m^3) serious deviations from the laws may occur under certain conditions (par. 3, p. 211).

Section VI deals with the question whether the use of frequency-dependent absorptive materials is likely to cause an audible distorting effect on music or speech. So far as can be seen from the above researches, the answer would appear to be in the negative. A bibliography of 27 items ends the paper.

THE ACOUSTICS OF HALLS.—P. M. Prache. (*Ann. des P.T.T.*, May, 1932, Vol. 21, pp. 400–409.)

THE MÜLLER METALLIC MEMBRANE LIGHT-CONTROL DEVICE.—Müller: Mey. (*See* abstract under "Phototelegraphy and Television.")

DIE TECHNIK DES TONFILMS (The Technique of Sound Films).—H. Kotte. (*Zeitschr. V.D.I.*, 4th June, 1932, Vol. 76, No. 23, pp. 545–550.)

Including sections on the Klangfilm system and the Lignose-Breusing cathode-ray recording system.

NEW TALKIE FILM PRINTER.—Bell and Howell Company. (*Scient. American*, July, 1932, pp. 49–50.)

Paragraphs on "a device for simultaneously printing pictures and sound-wave records on talking motion-picture film, resulting in fuller tone effects and clearer and better defined pictures."

THE HOME-RECORDING OF GRAMOPHONE DISCS.—E. Nesper. (*Rad., B., F. f. Alle*, June, 1932, pp. 277–283.)

This instalment of a series includes a discussion of the correct angle for various types of recording point and of disc material.

DAS ELEKTRISCHE MUSIKINSTRUMENT: SCHWINGUNGSERZEUGUNG DURCH ELEKTRONENRÖHREN (The Electrical Musical Instrument: the Generation of Vibrations by Thermionic Valves [Comprehensive Survey, with List of Papers and Patents]).—O. Vierling. (*Zeitschr. V.D.I.*, 25th June, 1932, Vol. 76, No. 26, pp. 625–630.)

MUSIKALISCHE FORDERUNGEN FÜR TONMODULIERTE BILDABTASTUNG (Musical Requirements for Note-Modulated Scanning [Television of Music]).—F. W. Winckel. (*Fernsehen u. Tonfilm*, July, 1932, Vol. 3, No. 3, pp. 170–173.)

Further development of the work dealt with in 1930 Abstracts, p. 577.

BRUITS (Noises).—K. W. Wagner. (*Ann. des P.T.T.*, March, 1932, Vol. 21, pp. 222–237.)

French rendering of a Prussian Academy of Science paper. It includes a list of New York measurements.

GERÄUSCHMESSUNG (The Measurement of Noise [Barkhausen Noisemeter: Eisenberg's Modification: the Dold-Thiele Integrating Meter using Evolution of Gas]).—(*E.T.Z.*, 9th June, 1932, Vol. 53, pp. 561–562.)

THE DVL AUDIMETER USED IN MEASURING BACKGROUND NOISE OF AIRCRAFT RECEIVERS.—Brintzinger and Viehmann. (*See* end of abstract under "Reception.")

THE DYNATRON AUDIO-FREQUENCY METER.—J. Kahan. (*Wiadomości i Prace Inst. Radjot., Warsaw*, No. 5, Vol. 3, pp. 63–66: in Polish.)

An instrument using a tetrode-triode circuit with indirectly heated valves.

MULTIPLE PEAKS IN SUPERSONIC INTERFEROMETRY.—W. D. Hershberger. (*Physics*, April, 1932, Vol. 2, pp. 269–273.)

Author's abstract:—"An improved circuit for use in supersonic interferometry in gases is described, in which regeneration is under control and by the use of which the amplitude of the exciting e.m.f. may be varied between wide limits. Multiple peaks in the plate current maxima are observed, and several causes for such peaks, particularly the use of crystals having 'parasitic' frequencies, are pointed out." Methods based on supersonic interferometry may prove useful in studying the modes of vibration of such crystals.

NEW OPTICAL PROPERTIES OF LIQUIDS SUBMITTED TO SUPERSONIC WAVES.—R. Lucas and P. Biquard. (*Comptes Rendus*, 13th June, 1932, Vol. 194, pp. 2132–2134.)

ACTION OF SUPERSONIC WAVES ON ISOLATED CELLS IN SUSPENSION.—E. and H. Biancani and A. Dognon. (*Ibid.*, pp. 2168–2170.)

DIE REFLEXION DER SCHALLWELLEN IN ANISOTROPEN DÜNNEN PLATTEN (The Reflection of Sound Waves in Thin Anisotropic Plates). —A. Seiffert. (*Zeitschr. f. Phys.*, 1932, Vol. 76, No. 5/6, pp. 407–414.)

UTILISATION D'ÉLÉMENTS REDRESSEURS À OXYDE DE CUIVRE POUR LA PROTECTION CONTRE LES CHOCS ACOUSTIQUES (The Use of Copper Oxide Rectifying Elements for Protecting Operators from Acoustic Shocks).—Collet. (*Ann. des P.T.T.*, April, 1932, Vol. 21, pp. 329–341.)

PHOTOTELEGRAPHY AND TELEVISION.

DER FERNSEH - ZWISCHENFILMSENDER DER FERNSEH-AKT.-GES. (The Television System of the Fernseh Company using an Intermediate Film Stage).—G. Schubert. (*Fernsehen u. Tonfilm*, July, 1932, Vol. 3, No. 3, pp. 129–134.)

Giving 10 000 or 20 000 elements and 25 picture changes per second, the intermediation of the film causing a delay of only 10 to 20 seconds and giving the advantage in illumination hitherto only realised in telecinematography. The film is continuously developed and fixed, is only washed and dried after the television transmission is over, and is used in the negative form, the necessary reversal being accomplished electrically.

To enable the above procedure to be carried out successfully, the Zeiss Ikon Film Works have produced a special film and special developing and fixing solutions, which have cut down the times for development and fixing to half a second and 4–5 seconds respectively; while a special wiper so distributes the remaining moisture over the surface of the film that no drops or smears interfere with the scanning of the wet film.

DER EINFLUSS VON BILDINHALT UND ZERLEGUNGSSYSTEM BEIM FERNSEHEN (The Influence of the Nature of the Subject, as regards Contrast, and of the Analysing System, on Television Transmission). — E. Busse. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 13, 1932, pp. 312–316.)

The smallest a.c. potentials that can be amplified by a valve amplifier must exceed a limiting value set by the valve noises (Schrot effect). The Schrot potential lies around 10^{-6} volt; the minimum input voltage to overcome the background noise is therefore of the order of 10^{-5} volt. On this basis, and by a consideration of the steps in brightness of a normal subject and the percentage allowable loss of contrast in the reproduced image (Goldberg), the writer arrives at the conclusion that the transition from the brightest to the darkest part of a subject must produce a minimum voltage change of 1.2 mv at the input terminals of the transmitter amplifier. This value is independent of the picture-element number and of the scanning system employed, and can always be attained for a given illumination of the scene provided the scanning system is large enough: practical difficulties of course put a limit on this, whatever the system used.

The various scanning systems differ only in their optical efficiency, and in Section 3 the Nipkow disc, the lens disc and the mirror wheel are briefly compared with regard to this. Section 4 shows how the maximum allowable control voltage on the modulating system of the valve transmitter, combined with the minimum input voltage found above, determines the total amplification required. This section then goes on to deal similarly with the conditions at the receiving end, where once again the background noise has to be overcome: but in this case atmospheric disturbances may be added to valve noise. The total post-detector amplification at the receiver depends on the nature of the reproducing light source, and in this connection glow-discharge tubes, the light-spray lamp (May Abstracts, p. 292), cathode-ray tubes and Kerr cell are briefly compared.

Section 5 discusses the mean output currents and the corresponding mean control potentials at the reproducing light source, and their great dependence on the contrast qualities of the scene. Section 6 introduces the consideration (in Sections 7, 8 and 9) of image size and brightness as given by the various reproducing light sources (see above), while Section 10 deals with projected images, with a brief comparison of the optical efficiencies of the various recomposing methods, and with the effect of the magnitude of the source of light on the attainable brightness.

"NEWS" BY TELEVISION: A MARCONI DEVELOPMENT.—H. M. Dowsett. (*Television*, July, 1932, Vol. 5, No. 53, pp. 164–166.)

A practical application of existing television technique, giving continuous messages similar to those of the news bulletin electric signs. *See* also *Electrician*, 29th July, 1932, p. 151.

DIE BEDEUTUNG DES PROGRAMMS FÜR EINEN ERFOLG DES FERNSEHEN (The Importance of the Programme for the Success of a Television Transmission). — R. Thun. (*Fernsehen u. Tonfilm*, July, 1932, Vol. 3, No. 3, pp. 134–139.)

SOUND FILMS AND TELEVISION IN RUSSIA.—G. E. Roth. (*Funk-Magazin*, June, 1932, Vol. 5, pp. 455–458.)

90 YEARS OF TELEVISION: ON THE HISTORY OF TELEVISION.—(*Funk-Magazin*, June and July, 1932, Vol. 5, pp. 435–437 and 568–570.)

DER FERNSEHSENDER ROM (The Rome Television Transmitter).—R. Möller. (*Fernsehen u. Tonfilm*, July, 1932, Vol. 3, No. 3, pp. 153–156.)

DIE HELLIGKEITSSTEUERUNG VON BRAUNSCHEN RÖHREN (Spot Brightness Control in Cathode-Ray Tubes [and the German P.O. Methods]).—E. Hudec. (*E.N.T.*, June, 1932, Vol. 9, pp. 213–225.)

After comparing brightness control and ray-speed control (the so-called "line" control advocated by Thun) and describing the latter as mainly a transmission problem ("the assertion that the frequency band in line control is narrower [than in brightness control] is based on an error") the writer defines the chief difficulty in brightness control to be the controlling of the brightness of the spot without altering its position, form or size, Ordinary methods of concentrating the ray are not sufficient to maintain a round spot of constant size in the face of variations in the ray current, for reasons which are discussed.

The writer then describes how the problem is dealt with in the German P.O. system of "pure emission control." The electrons leaving the cathode are sent first through a control field and then through a concentrating field by which they are concentrated to an extent independent of their number. The control field is parallel to the ray axis; the concentrating field has a component directed slightly inwards, and is of such a value as to form a sharp ray immediately in front of the fluorescent screen. Fig. 9 shows the arrangement: *W* is the Wehnelt cylinder with a disc through whose central aperture the filament projects. A_s is the control field anode (positive with regard to the cathode), while A_k is the concentrating field anode.

Variation of the emission current may produce undesired changes in the *position* of the spot either by the effect of asymmetry, by space-charge effect, or by the action of the deflecting-plate currents. Asymmetry is avoided by suitable design and the use of a special jig and a special procedure in assembling (Section 3a). Space-charge effects are obviated by the use of an auxiliary electrode—a short, rather wide cylinder between the deflecting system and the screen, at a potential negative with regard to the concentrating anode; with this device in use, the ray current can be varied from 0–0.5 mA without the deflecting sensitivity being changed. Finally, the disturbing action of the deflecting plate currents is suppressed by suitable design of the external circuit (Section 3c).

ÜBER DIE BRAUCHBARKEIT VERSCHIEDENER KATHODENSTRAHLOSZILLOGRAFEN FÜR FERNSEHÜBERTRAGUNGEN (On the Suitability of Various Cathode-Ray Oscillograph Tubes for Television Transmissions [particularly a Comparison between Magnetic and Gas Concentration]).—H. Peters. (*Fernsehen u. Tonfilm*, July, 1932, Vol. 3, No. 3, pp. 159–168.)

Continuing previous work on the limitations imposed by the lack of homogeneity in the speed of the electrons in a cathode ray (January Abstracts, p. 45). One way out of the difficulty is to abandon brightness control in favour of the Thun scanning-speed control, and the present paper investigates the comparative qualities and merits of magnetic and gas concentration both in the brightness control and the speed control systems.

It is found that the speed control system has important advantages, in that even with gas concentration it will give pictures of ordinary size with 10 000 elements without the use of excessive voltages. Magnetic concentration, however, makes much lower voltages possible (400 v in place of at least 4 000 v), but has the objection that it needs a doubly curved screen, whereas gas concentration enables a flat screen to be used without causing distortion.

INCREASING THE BRIGHTNESS OF CATHODE-RAY TELEVISION BY USING THE RAY AS A MOBILE CONDUCTOR MAKING CONTACT WITH DIFFERENT CONDUCTING POINTS.—(French Pat. 724 524, Barthélémy, pub. 28th April, 1932: summary in *Rev. Gén. de l'Élec.*, 25th June, 1932, Vol. 31, p. 211 D.)

GLOW DISCHARGE LAMPS FOR THE GENERATION OF "KIPP" OSCILLATIONS.—von Hartel. (*See* under "Subsidiary Apparatus and Materials.")

SYNCHRONISED MECHANICALLY OSCILLATING SYSTEM FOR TELEVISION SYNCHRONISATION.—R. Barthélémy. (*Rev. Gén. de l'Élec.*, 28th May, 1932, Vol. 31, pp. 179 D–180 D.)

Summary of a patent. A moving coil system is given a definite frequency by spiral springs which carry the current. The axis of the system carries a mirror, and also a screening sector which during a certain part of the swing prevents a ray of light from falling on a photo-electric cell: the system is thus maintained in oscillation without mechanical contacts. The approximately correct frequency is brought into synchronism and proper phase by the incoming signals. *See* also 1931 Abstracts, p. 446.

BILDÜBERTRAGUNG MIT KLISCHEE-EMPFANG (Phototelegraphy with Cliché Reception [Guth "Radiotypo" System on the "Bremen"]).—Guth. (*E.T.Z.*, 16th June, 1932, Vol. 53, p. 584.)

From Zurich to the Bremen at sea. The pictures received are ready for immediate printing. No details are given.

ÜBER EINE WIDERSTANDSÄNDERUNG DURCH MAGNETISCHE FELDER AN LICHTELEKTRISCHEN SPERRSCHICHT- UND KRISTALLZELLEN [On Variation of Resistance of Attenuating Layer Photoelectric Cells and Crystal Cells, due to Magnetic Fields).—E. Rupp. (*Zeitschr. f. Phys.*, 1932, Vol. 76, No. 9/10, pp. 597–607.)

Author's summary:—The photoelectric currents of cuprous oxide attenuating layer rear-wall cells and of lead sulphide single crystals show decreases in magnetic fields proportional to the square of the field strength. At $-180°$ C the ratio of the decrease to the current is smaller than at room temperature. It is greatest when the surface of the attenuating layer is parallel to the lines of magnetic force. In lead sulphide the photoelectrons are set free with partial preference for the plane of the electric vector in the incident light. The current decrease is independent of the wavelength of the incident light. A comparison between the coefficient A of the resistance increase ($\Delta W/W = AH^2$, where W is the resistance and H the field strength) and the corresponding coefficient of a conduction current gives agreement to within 10%. Thus photoelectrons and conduction electrons move under the same mechanism of locomotion.

A Mechanically Controlled Bolometer and Its Use as a Highly Sensitive Quantitative Relay and as a Quantitative D.C. Amplifier [applicable to Photocell Currents].—Sell. (*See* under "Subsidiary Apparatus and Materials.")

Der Becquereleffekt von Kupferoxydul als Sperrschichtphotoeffekt (The Becquerel Effect in Copper Oxide as an Attenuating Layer Photoelectric Effect).—F. Waibel. (*Zeitschr. f. Phys.*, 1932, Vol. 76, No. 3/4, pp. 281–282.)

Photocells and Their Applications in Optical Technique [Survey and Bibliography of Recent Work].—H. Singer. (*Lichttechnik*, pp. 29–32, supplement to *Elektrot. u. Masch: bau*, 26th June, 1932, Vol. 50.)

Lichtelektrischer und Thermoelektrischer Effekt wasserstoffbeladener Palladium-Silber- und Palladium-Goldlegierungen (Photo- and Thermo-Electric Effect in Palladium-Silver and Palladium-Gold Alloys with Adsorbed Hydrogen).—F. Schniedermann. (*Ann. der Physik*, 1932, Series 5, Vol. 13, No. 7, pp. 761–779.)

The writer finds that "the amount of hydrogen adsorbed by palladium and its alloys with silver and gold decreases linearly with the amount of silver or gold present. The photoelectric and thermoelectric effects are steadily increased by the adsorbed hydrogen, which increases the vapour pressure and number of the free electrons in the inter-atomic space: the effects have a maximum for the alloys with 40% silver and gold and run exactly parallel to one another, while the hydrogen adsorption proceeds differently." The maximum of the photoelectric effect is found not to be due to any particular decrease of the work function as compared with alloys of other proportions. The investigations could be performed with a fraction of the hydrogen necessary for saturation, and the photo- and thermoelectric effects are found to be due to surface action.

The Depth of Origin of Photoelectrons.—H. E. Ives and H. B. Briggs. (*Phys. Review*, 1st June, 1932, Series 2, Vol. 40, No. 5, pp. 802–812.)

For previous work by the authors see February Abstracts, p. 102–two. Authors' abstract:—"Previous work has shown that the photoelectrons from a silver plate covered with an equilibrium film of alkali metal follow the wavelength distribution of energy just above the silver surface, *i.e.*, in the alkali metal. This question has been further investigated with particular references to alkali metal films in their early stages of development, where their average depth is less than one atom. Computations made on the absorption of light just within the silver surface show that there should be very definite and striking differences in the wavelength distribution of photoemission if emission occurs due to light absorption in the silver, as contrasted with emission from a film on the silver. Experimental tests made with sodium and caesium films show that in the earliest measurable state the emission exhibits characteristics peculiar to the light absorption in silver, and that as the films build up the emission becomes characteristic of the energy above the silver. It is concluded that the photoelectrons originate partly in the underlying metal and partly in the alkali metal film, the relative proportions varying with the film thickness.

Abhängigkeit der lichtelektrischen Emission des Kaliums von der Anordnung von atomaren Wasserstoff- und Kaliumschichten auf ihrer Oberfläche (Dependence of the Photoelectric Emission from Potassium on the Arrangement of Atomic Hydrogen and Potassium Films on its Surface).—P. I. Lukirsky and S. Rijanoff. (*Zeitschr. f. Phys.*, 1932, Vol. 75, No. 3/4, pp. 249–257.)

The authors find that "the maximum photoelectric current is obtained when the hydrogen is situated under the surface film of potassium atoms. The hydrogen film is exactly that electro-negative intermediate film which, according to Fowler, is necessary for the intense selective photoelectric effect. It also follows from the experiments that an intense photoelectric effect is given by a Fowler film twice repeated, *i.e.*, a film with the arrangement of atoms K–H–K–H–K. The films K–H, K–H–K–H–, etc., give photoelectric currents smaller than that given by pure potassium. If the thickness of the potassium film is greater than that of one atom, the photoelectric current quickly falls to the value corresponding to pure potassium."

Photoelectric Currents in Gases between Parallel Plates as a Function of the Potential Difference.—N. E. Bradbury. (*Phys. Review*, 15th June, 1932, Series 2, Vol. 40, No. 6, pp. 980–987.)

This paper describes experiments on the photoelectric current passing between two parallel plate electrodes in a gas. A quartz mercury arc and a plane zinc electrode were used as the source of photoelectrons, and current/potential difference curves were taken for different gas pressures in hydrogen and nitrogen. The experimental data applied to a formula given by J. J. Thomson gave values of the electron mobility k as a function of the ratio field strength/pressure which agreed well with those found by Loeb and by Townsend and Bailey. An equation given by Langmuir (April Abstracts, p. 228) proves to be applicable at low pressures only.

DER ÄUSSERE LICHTELEKTRISCHE EFFEKT AN FLÜSSIGKEITEN. BESTIMMUNG DER LANGWELLIGEN GRENZE DES WASSERS (The External Photoelectric Effect in Liquids. Determination of the Long-Wave Limit in Water).—P. Görlich. (*Ann. der Physik*, 1932, Series 5, Vol. 13, No. 7, pp. 831–850.)

Author's summary :—The long-wave photoelectric limits of water and of concentrated aqueous solutions of silver nitrate, potassium ferrocyanide, sodium sulphate and sodium chloride have been determined with a fluor-spar vacuum monochromator. The long-wave limit of water lies between 203 and 204 $m\mu$. Small variations in the conductivity of the water have no effect on this limit. Concentrated aqueous solutions of the salts named give the same long-wave limit as the solvent. The photoelectric spectral distribution has been measured in water for the range of wavelengths 204.0 to 171.9 $m\mu$. A strong absorption maximum was observed at about 185 $m\mu$. The fluor-spar vacuum monochromator (wavelength range 350–130 $m\mu$) used in the investigation is described.

ÜBER EINE NEUE LICHTSTEUERUNGSANORDNUNG NACH C. MÜLLER (A New Light Control Device by C. Müller [Thin Reflecting Metal Membrane]).—S. Wagener : Müller and Mey. (*Fernsehen u. Tonfilm*, July, 1932, Vol. 3, No. 3, pp. 143–152.)

A long paper on the device dealt with in June Abstracts, p. 354.

ON THE INTERPRETATION OF A MAGNETO-OPTICAL EFFECT.—M. Cau : Pogány. (*Comptes Rendus*, 6th and 20th June, 1932, Vol. 194, pp. 2042–2045 and 2204–2206.)

ON THE PHOTO-TELEPHONY [SUCCESSFUL USE OF INCANDESCENT ELECTRIC LAMP AT TRANSMITTER].—Kujirai. (*See* under "Miscellaneous.")

ÜBER MOMENTANE FREQUENZANALYSE VON LICHTSCHWANKUNGEN MITTELS ROTIERENDER SCHEIBEN (On Momentary Frequency Analysis of Light Fluctuations using Rotating Discs).—T. von Nemes. (*Archiv f. Elektrot.*, 17th June, 1932, Vol. 26, No. 6, pp. 403–408.)

Author's summary :—This investigation discusses the frequency analysis of light intensity fluctuations of audio-frequency as regards the phase and absolute magnitude of the several components. The stroboscopic methods hitherto known permitted of no quantitative analysis of the amplitudes of oscillation.

ÜBER DIE AUGENTRÄGHEIT (The Inertia of the Eye).—G. G. Reissaus. (*Fernsehen u. Tonfilm*, July, 1932, Vol. 3, No. 3, pp. 173–176.)

An analysis of the 1/10 sec. inertia of the eye into its components depending on muscle, iris and retina leads to an understanding of the effect of the number of picture changes per second on flicker and on the distortionless reproduction of moving scenes (*cf.* Jan. Abstracts, pp. 45–46). The advantage of first recording the scene on a sound film, and transmitting from this, is emphasised.

PLANE WAVES OF LIGHT : ABSORPTION BY METALS.—T. C. Fry. (*Journ. Opt. Soc. Am.*, June, 1932, Vol. 22, pp. 307–332.)

INTENSITY, AREA, AND DISTANCE OF VISUAL STIMULUS.—E. Freeman. (*Journ. Opt. Soc. Am.*, July, 1932, Vol. 22, pp. 402–407.)

MEASUREMENTS AND STANDARDS.

THE VIBRATIONS OF QUARTZ PLATES [CHLADNI PLATES INVESTIGATION].—R. C. Colwell (*Proc. Inst. Rad. Eng.*, May, 1932, Vol. 20, pp. 808–812.)

Author's summary :—By vibrating quartz crystals in an electric circuit Wright and Stuart have shown that the crystals break up into different parts while oscillating. The nodal lines thus formed are made visible to the eye by lycopodium powder. In the present paper it is pointed out that the mathematical theory of Chladni plates gives a general equation,

$$A \cos \frac{m\pi x}{a} \cos \frac{n\pi y}{a} + B \cos \frac{n\pi x}{a} \cos \frac{m\pi y}{a} = 0,$$

for the nodal lines of square plates. This equation is also applicable to quartz plates in so far as the forms of the nodal lines are concerned. It gives no information regarding the manner of vibration of the quartz.

Chladni plates both square and round have been vibrated by mechanical impact from a vacuum tube oscillator circuit. A few of the figures thus obtained are shown and may be compared with those of Wright and Stuart. The nodal lines for circular quartz plates do not in general resemble those of circular Chladni plates.

ON THE TEMPERATURE COEFFICIENT OF FREQUENCY OF Y-WAVE IN X-CUT QUARTZ PLATES.—S. Matsumura and S. Kanzaki. (*Rep. of Rad. Res. and Works in Japan*, March, 1932, Vol. 2, No. 1, pp. 35–48.)

The writers find that the coefficient of the so-called Y-wave in X-cut rectangular quartz plates varies with the dimensions, becoming smaller as the ratio l_z/l_y is reduced, and reaching a value of about minus two parts in a million for ratios smaller than 0.4. The direction of vibration approaches closer to the Y-axis the smaller the ratio, and in this direction the coefficient seems to reach its minimum value. The theory of the effect is given, and characteristic curves are shown from which (by the principle of similitude—Koga, 1931 Abstracts, p. 509) the design of X-cut plates with a very small temperature coefficient can conveniently be obtained. Rectangular plates cut so that their length dimensions are parallel to the actual direction of the Y-wave in X-cut circular plates were also studied : the coefficient appears to be hardly at all affected by the dimensions (Fig. 13).

EXPERIMENTAL STUDY OF PARALLEL-CUT PIEZOELECTRIC QUARTZ PLATES.—G. W. Fox and W. G. Hutton. (*Physics*, June, 1932, Vol. 2, pp. 443–447.)

Authors' abstract :—" Y-cut piezoelectric quartz plates were studied with respect to the charges developed on the plates when oscillating near their resonant frequencies. The attractive force between crystal and electrodes was measured. Two [indirect] methods for determining the piezoelectric voltage developed across the crystal are suggested. It is concluded from a study of crystal breakage that fracture is due to intense mechanical vibration." Circular plates seem to be preferable, being on the whole more uniform in response and capable of standing larger loads.

Die Abhängigkeit der piezoelektrischen Konstante bei Quarz von der Temperatur (The Variation with Temperature of the Piezoelectric Constant of Quartz).—V. Fréedericksz and G. Michailow. (*Zeitschr. f. Phys.*, 1932, Vol. 76, No. 5/6, pp. 328–336.)

The Use of Supersonic Interferometry in Studying the Modes of Vibration of Quartz Crystals.—Hershberger. (*See* abstract under "Acoustics and Audio-frequencies.")

Frequency Comparison at Great Distances [including Italian Measurements of U.S. Bureau of Standards' Standard Frequency Transmissions].—F. Vecchiacchi. (Summary in *L'Onde Élec.*, May, 1932, Vol. 11, No. 125, p. 16 A.)

The Bureau of Standards transmission on 5 megacycles/sec. with a power of only 50 watts was received in Italy, made to beat with the harmonic of a piezo-oscillator modulated by one of its sub-harmonics, and the beat frequency measured by a direct-reading frequency meter. Measurements could be made almost instantaneously and in spite of fading: the accuracy obtained was better than 1 in a million. The writer anticipates the use of this method for the very rapid comparison of chronometers.

Developments in the Testing of Radio Receivers.—Thomas. (*See* under "Reception.")

A Nernst Bridge Arrangement for the Highest Precision [Reduction of Input Energy and Amplification of Output].—J. Hadamard. (*Comptes Rendus*, 23rd May, 1932, Vol. 194, pp. 1799–1801.)

An Aperiodic Impedance Measuring Set.—A. T. Starr. (*Wireless Engineer*, June, 1932, Vol. 9, No. 105, pp. 325–328.)

Current induced from an oscillator (whose frequency need not be known unless a frequency characteristic is to be plotted) passes through the impedance Z and a variable resistance R_1. R_1 is adjusted until a valve voltmeter, connected alternately across Z and R_1, reads the same in both cases; the magnitude of Z is then equal to the value of R_1. R_1 is next connected across Z and the same operation performed, with a second variable resistance taking the position of R_1: if the resistance required for equal voltages is now R_2, the phase angle of Z is found by the equation $\phi = \pm 2 \cos^{-1} \frac{R_1}{2R_2}$, the sign being determined by a simple auxiliary test. Advantages of the method are discussed, and precautions to be taken. It can easily be arranged that the current passing through the impedance is that which it carries in ordinary use, so that the method is applicable to impedances which vary with the current carried. Errors due to harmonics in the oscillator are discussed in an appendix.

Sur une Méthode de Comparaison de Capacités faibles (A Method of Comparing Small Capacities [Oscillating Neon Tube Method]). M. Durepaire. (*Comptes Rendus*, 30th May, 1932, Vol. 194, pp. 1902–1904.)

Particularly suitable for capacities of the order of one-thousandth of a microfarad. The condenser under test is compared with a calibrated adjustable standard, the latter being turned to such a value that no change of note is detected on switching over from one condenser to the other. If the condenser under test is of inferior insulation an error will be introduced: this can be avoided by connecting a condenser of good insulation in series with the imperfect one. A satisfactory value for this auxiliary capacity is found to be 10 to 100 times that of the unknown condenser: the results are then independent of the insulation of the latter, provided it is not less than one megohm; below that, the measured values are slightly too great.

A simple commutator device, throwing in auxiliary fixed condensers and varying the resistance in the condenser-battery circuit, extends the range of the equipment and keeps the note given by the neon tube at a pitch where the difference-sensitivity of the ear is high (*i.e.*, round 1 000 c/s). With an untrained ear the error in measurement may be 0.5 %: with practice, greater accuracy is obtainable.

Capacitance and Power Factor of a Mica Capacitor as measured at the Bureau of Standards and the National Physical Laboratory.—H. L. Curtis, C. M. Sparks, L. Hartshorn and N. F. Astbury. (*Bur. of Stds. Journ. of Res.*, April, 1932, Vol. 8, pp. 507–523.)

"The following conclusions can be drawn from the information herein presented:—(1) The transportation of a mica capacitor may cause a change in the capacitance even when there is no visible indication of damage. (2) So far as the measurements here reported are concerned, the capacitance of an air capacitor of the type used at the Bureau of Standards is independent of the method of measurement, at least with an accuracy of 1 part in 10 000. (3) The mutual inductance between the coils of the standard inductor of the National Physical Laboratory can be computed from its dimensions and a correction made for the capacitance between the coils for all frequencies here reported, at least with an accuracy of 1 part in 10 000. (4) The unit of capacitance, the microfarad, is the same in the Bureau of Standards and the National Physical Laboratory within the limits of accuracy of the present measurements, about 1 in 10 000. (5) Measurements at the two laboratories of the power factor at any frequency below

1 000 cycles give values which agree to one or two in the fourth decimal place. (6) Increased accuracy in intercomparison must await the development of more stable standards of capacitance."

SENSITIVE INSULATION TESTER [USING GRID VOLTS/ANODE CURRENT CHARACTERISTIC OF A TRIODE].—T. A. Ledward. (Summary in *Sci. Abstracts, Sec. B*, June, 1932, Vol. 35, No. 414, p. 313.)

A BRIDGE FOR CAPACITANCE AND LOW POWER-FACTOR MEASUREMENTS.—H. W. Bousman. (*Gen. Elec. Review*, May, 1932, Vol. 35, pp. 295–298.)

VERZERRUNGSMESSER FÜR TELEGRAPHIE (The [Siemens and Halske] Distortion Meter for Telegraphic Signals).—A. Jipp and O. Römer. (*T.F.T.*, May, 1932, Vol. 21, pp. 121–126.)

AN A.C. WHEATSTONE BRIDGE FOR AUDIO- AND RADIO-FREQUENCY MEASUREMENTS.—A. Hemingway and J. F. McClendon. (*Physics*, May, 1932, Vol. 2, pp. 396–402.)

Using a Vreeland oscillator as a source of a.f. current, and a heterodyne method for r.f. measurements.

SUBSIDIARY APPARATUS AND MATERIALS.

EIN MECHANISCH GESTEUERTES BOLOMETER UND SEINE ANWENDUNG ALS HOCHEMPFINDLICHES QUANTITATIVES RELAIS UND QUANTITATIVER GLEICHSTROMVERSTÄRKER (A Mechanically Controlled Bolometer and Its Use as a Highly Sensitive Quantitative Relay and as a Quantitative D.C. Amplifier).—H. Sell. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 13, 1932, pp. 320–327.)

For a previous reference to this device *see* July Abstracts, p. 415. Small continuous currents, such as those from photocells or thermo-elements, are made to direct a current of air acting on a bolometer bridge arrangement. Applied to sensitive pointer-type meters, the device forms a quantitative relay, closing a contact when the pointer reaches a determined mark on the scale. Currents of 1×10^{-8} A are large enough to close the contact. The recently developed vacuum relays, which can close a 1 kw circuit, seem specially suitable as auxiliaries for the device.

The arrangement can also be used to actuate a continuous recorder—*e.g.*, of very small movements. It can regulate a process whose variation is indicated by a meter reading, thus maintaining constancy. In combination with a stop-layer photocell, it enables the latter to control a current circuit without the use of any valve amplifier, for light intensities as low as 10 lux or less. The device can be designed for great sensitivity or for less sensitivity and greater power output: in the latter case it can, for instance, drive an inker direct. The arrangement is discussed in detail and numerous applications are mentioned.

EIN NEUER GLEICH- UND WECHSELSTROMVERSTÄRKER (A New Amplifier for Direct and Alternating Currents).—H. Peek. (*Archiv f. Elektrot.*, 17th June, 1932, Vol. 26, No. 6, pp. 443–452.)

Author's summary :—No amplifier has hitherto been known which amplified direct and alternating currents equally well and only needed small expenditure on voltage sources. The amplifier here described satisfies this requirement, using a new kind of coupling of the separate amplifying stages, in which the chief circuit element is a glow lamp. Such amplifiers are very sensitive to variations of the voltages used. Some circuits are given which make the amplifier independent of such variations, so that it can be worked off the mains.

A THYRATRON "SCALE OF TWO" AUTOMATIC COUNTER.—C. E. Wynn-Williams. (*Proc. Roy. Soc.*, 2nd May, 1932, Vol. 136, No. A 829, pp. 312–324.)

Author's summary :—A new type of automatic counting circuit is described whereby several units of two thyratrons are arranged in cascade to form what might be termed a "Thyratron dial meter." This meter can be used to record the occurrence of physical events according to a notation on a "scale of two." Since there are no moving parts associated with the thyratrons, the time of response of the circuit is governed only by its electrical characteristics. Events can therefore be recorded at extremely high rates, two events separated by as little as 1/1250th second, or even less, being "resolved" and separately registered by the counting circuit.

To a certain extent, the circuit resembles the "thyratron ring" counting circuit previously described by the author (1931 Abstracts, p. 572), since both circuits utilise to the greatest advantage the "inertialess relay" characteristic of the thyratron. The present circuit, however, operates in a different manner, and has many advantages over the ring circuit. These include :—(1) All current supplies can be derived from the common laboratory mains. (2) An entire absence of delicate adjustments. (3) Large margins of safety, ensuring stability and reliability. (4) Simplicity of construction. (5) Only *two* thyratrons need be matched, and the impulses to be counted need be applied only to these two thyratrons. (6) When the number of thyratrons exceeds four, the counting efficiency exceeds that of a ring containing an equal number of thyratrons. The circuit has been fully tested, and is at present in use for the automatic counting of α-particles. Practical details are given of the various values of the components required for its construction.

A CIRCULAR TIME-BASE GIVING RADIAL DEFLECTIONS, FOR USE WITH THE CATHODE-RAY OSCILLOGRAPH.—Staff of Radio Research Station, Slough. (*Journ. I.E.E.*, June, 1932, Vol. 71, No. 426, pp. 82–85.)

Authors' summary :—"In the study of the electromotive forces varying with time, the electromotive force under examination is caused to modulate similarly and simultaneously two voltages which are applied in quadrature to the deflecting plates of a cathode-ray oscillograph. The resultant screen-image on the oscillograph consists of a circular time-base, on which are superposed radial deflections delineating the wave-form and the time relationships of the applied electromotive forces." The great advantage of the radial movement of the spot compared with the vertical departures from the circular time-base given by the Goubau-Zenneck method (1931 Abstracts, p. 432) lies in the fact that in the latter system if the signal arrives when the spot is moving nearly vertically, the departure from the circle is nearly tangential and the order of accuracy of the determination of time of arrival is relatively low.

COSSOR CATHODE RAY OSCILLOGRAPH.—A. C. Cossor, Ltd. (*Wireless Engineer*, July, 1932, Vol. 9, No. 106, p. 387.)

RECENT DEVELOPMENTS IN CATHODE-RAY OSCILLOGRAPHS [SURVEY WITH LITERATURE REFERENCES UP TO 1931].—A. B. Wood. (*Journ. I.E.E.*, June, 1932, Vol. 71, No. 426, pp. 41–56.)

ACCURACY OF MEASUREMENTS MADE WITH HOT-FILAMENT CATHODE-RAY TUBES OF THE GAS-FOCUSED TYPE [WITH PARTICULAR ATTENTION TO THE THRESHOLD EFFECT].—J. T. MacGregor-Morris and H. Wright. (*Ibid.*, pp. 57–69.)

DISCUSSION ON THE ABOVE TWO PAPERS.—(*Ibid.*, pp. 70–82.)

EINE NEUE BAUART DES KATHODENOSZILLOGRAPHEN MIT KALTER KATHODE UND VORKONZENTRIERUNG (A New Type of Cathode Ray Oscillograph with Cold Cathode and Pre-concentration).—H. Boekels. (*Archiv f. Elektrot.*, 17th June, 1932, Vol. 26, No. 6, pp. 453–456.)

A LECTURE-DEMONSTRATION OSCILLOGRAPH [WITH LINEAR TIME SCALE, USING WESTERN ELECTRIC GAS-FILLED HOT-FILAMENT TUBE].—W. W. Hansen. (*Review Scient. Instr.*, June, 1932, Vol. 3, pp. 305–308.)

A CATHODE-RAY FREQUENCY MULTIPLIER [FOR OBTAINING ULTRA-HIGH FREQUENCIES].—Jamison. (*See* under "Transmission.")

DAS KURZE RAUMLADUNGSFELD EINER HILFSENTLADUNG ALS SAMMELLINSE FÜR KATHODENSTRAHLEN (The Short Space-Charge Field of an Auxiliary Discharge as a Collecting Lens for Cathode Rays).—B. von Borries and E. Ruska. (*Zeitschr. f. Phys.*, Vol. 76, No. 9/10, pp. 649–654.)

Authors' summary :—It is known that cathode rays are concentrated by the positive space charge to which they give rise. The paper starts from this and shows how, by limiting the space charge to a part of the length of the ray, a collecting lens for cathode rays is formed which follows optical laws to a first approximation. The "short space charge column" which is necessary for this is obtained by means of an auxiliary discharge.

DEMONSTRATION DER BRENNPUNKTS- UND AUFLÖSUNGSEIGENSCHAFTEN DES FELDES EINES ZYLINDERKONDENSATORS AN KATHODENSTRAHLEN (Demonstration of the Focus and Resolving Properties of a Cylindrical Condenser Field on Cathode Rays).—H. Voges. (*Zeitschr. f. Phys.*, 1932, Vol. 76, No. 5/6, pp. 390–394.)

BEMERKUNG ZUR FORMGEBUNG VON BLENDEN BEIM ARBEITEN MIT ELEKTRONENSTRAHLEN IN GASEN (Remark on the Form of Stop to be Used with Electron Beams in Gases).—H. Seyfarth. (*Ibid.*, p. 395.)

The writer remarks that the quantities which determine the space charge, *i.e.*, gas pressure and current strength, are of much greater importance than the form of stop used in the formation of electron beams.

RELATIVISTISCHE KORREKTUR DER ABBILDUNGSGESETZE EINER MAGNETISCHEN SAMMELLINSE FÜR KATHODENSTRAHLEN (Relativity Correction of the Laws of Image Formation of a Magnetic Collecting Lens for Cathode Rays).—F. Ollendorff and G. Wendt. (*Zeitschr. f. Phys.*, Vol. 76, No. 9/10, pp. 655–659.)

Authors' summary :—The quasi-optical behaviour of fast cathode rays in the magnetic field of a coil is treated, using the equations of the special relativity theory. It is found that the relativity corrections to the Newtonian movement can become considerable even at accelerating voltages used frequently in practical technics [voltages $\geqq$ 10 kilovolts].

GLIMMLAMPEN ZUR ERZEUGUNG VON KIPPSCHWINGUNGEN (Glow Discharge Lamps for the Generation of "Kipp" Oscillations).—H. von Hartel. (*Funk-Magazin*, April, 1932, Vol. 5, pp. 300–304.)

Including studies of the different behaviour of different gases, pressures and electrode gaps, on the ignition and extinction potentials.

EIN KIPPGERÄT FÜR ELEKTRISCHE NERVENREIZUNG (A Trip Circuit for Nerve Excitation [for C.-R. Oscillographic Recording]).—H. König. (*Helvet. Phys. Acta*, Vol. 5, 1932, Fasc. 3, pp. 212–214.)

Previously the oscillograph time-base and the nerve-exciting impulse have been synchronised by some rotating contact device ; the present arrangement is a four-valve circuit which not only sets the spot in action and provides the time-base, but also—a fraction of a second later—supplies the nerve impulse itself.

AMPLIFIERS FOR PRECISE OSCILLOGRAPHIC MEASUREMENTS.—S. K. Waldorf. (*Journ. Franklin Inst.*, June, 1932, Vol. 213, No. 6, pp. 605–622.)

The conditions to be satisfied by an amplifier for precise oscillographic measurements are (1) equal amplification of all frequencies within the operating range of the oscillograph vibrator, including continuous current, (2) sufficient gain to give the desired overall voltage or current sensitivity,

(3) relatively high current output, of the order of 250 mA at 0.25 volt, (4) extreme steadiness. Condition (1) limits the amplifiers to the pure resistance coupled type. In the output stage, valves of low internal impedance operating with low anode voltages are needed. A suitable valve was found in Western Electric 104-D ; six were used in parallel as an output stage. In the voltage amplification stages, 400 was found to be a practicable value of amplification. Four-element tubes were found to be unsuitable, and their limitations are described. For steadiness and frequency requirements the Western Electric 102-D three element high μ tubes were found satisfactory. The diagram of connections of an amplifier with two voltage-amplification stages and the calibration curve of the amplifier-oscillograph when using this circuit are given. Precautions taken in its use and the adjustment of the amplifier are described. The method of compensation for the steady component of the output anode current involves the use of an auxiliary battery and connected resistances shunted across the vibrator ; four circuits for this are given and discussed. The problem of interference is touched upon, photographic considerations are indicated, and some typical applications to wave form of high voltages, and presence of parasitical corona on a high voltage system, d.c. charge and discharge records, etc., are described, with reproductions of the oscillograms obtained.

Über die Verwendung organischer Substanzen in der Hochvakuumtechnik, insbesondere bei dem Betrieb von Hochvakuumpumpen (The Use of Organic Substances in High Vacuum Technique, particularly in the Working of High Vacuum Pumps).—M. von Brandenstein and H. Klumb. (*Physik. Zeitschr.*, No. 2, Vol. 33, 1932, pp. 88–93.)

Speed, Speed Factor and Power Input of Different Designs of Diffusion Pumps, and Remark on Measurements of Speed.—T. L. Ho. (*Physics*, May, 1932, Vol. 2, pp. 386–395.)

Time-Pressure Characteristics of Various Diffusion and Molecular [Vacuum] Pumps.—P. J. Mills. (*Review Scient. Instr.*, June, 1932, Vol. 3, pp. 309–322.)

Berechnung der Einschwingzeit von Bandfiltern (Calculation of the Building-Up Time of Band-Pass Filters.).—J. Labus. (*E.N.T.*, June, 1932, Vol. 9, pp. 226–233.)

Author's summary :—The object of the present work is to determine the building-up time of band-pass filters and to compare the results with already known formulae. For this purpose the building-up process of the filter represented in Fig. 3, with an infinite number of sections, is calculated by operational methods. A d.c. potential is first taken as the source of excitation. The building-up process thus obtained serves as the foundation for the investigation of the corresponding process excited by a sinusoidal a.c. potential. If the exciting frequency lies within the comparatively narrow pass band of the filter, it is shown that the time within which the potential in a filter section rises, after the expiration of the so-called latent time, to the first approximate attainment of the stationary state, varies linearly with the number ν representing the position of the particular section in the chain.

New Theory and Design of Wave Filters.—W. Cauer. (*Physics*, April, 1932, Vol. 2, pp. 242–268.)

Author's abstract :—" A new mathematical theory of wave filters gives the following results :—It is possible to realise as constant an image impedance as desired in the transmitting bands. In the new theory there is no mathematical difference in the consideration of proper attenuation or proper image impedance characteristics : in other words, the same attack applies in both cases. All known wave filters, as far as they are symmetrical four-terminal networks or equivalent to such networks in series with a transformer, are contained in the filters of the new theory, which comprises all possible filters of this kind.

" The new theory has been carried through practically to find out the most economical filter for any practical purpose. This results in many cases in solving a given practical question, already solved by known methods, with considerable saving of material. The chief aim of this paper is to show the relation between the new theory and the older design methods due to O. J. Zobel and other members of the Bell laboratories." The writer's book " Siebschaltungen " is referred to (*see* Jan. Abstracts, p. 50).

Eine neue Art von Hochspannungskondensatoren (A New Type of High Voltage Condenser [replacing Leyden Jars]).—H. Wommelsdorf. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 13, 1932, pp. 328–330.)

Closed glass tubes containing a rarefied gas (neon or argon) which acts as the inner coating of the condenser. The form most nearly equivalent to the simple Leyden jar has a metal point at one end (making " connection " with the gas) and an outside layer of tinfoil over the far two-thirds of the tube. Another form has an external coat at each end, leaving bare a length about one-third the total length of the tube ; there is no internal connection, the gas acting as the internal coating for both ends and also putting in series the two condensers thus formed. A variation of this, in which the two end coats slide on the glass tube, gives a variable condenser. A fourth form makes use of no metallic coating whatever : one glass tube is fitted (for more than half its length) inside a slightly wider glass tube, the junction being sealed air-tight : each tube is gas-filled and each has a point electrode at its far end. Various advantages are claimed, including smaller size and cost, reduced losses in damp weather, and freedom from breakdown.

Capacitance and Power Factor of a Mica Capacitor as measured at the Bureau of Standards and the National Physical Laboratory.—(*See* under " Measurements and Standards.")

Les Piles électriques d'après les Brevets récents (Primary Batteries, Dry and Wet, according to Recent Patents).—L. Jumau. (*Rev. Gén. de l'Élec.*, 2nd and 9th July, 1932, Vol. 32, Nos. 1 and 2, pp. 13–24 and 54–61.)

New Storage Battery using Iodine.—Boissier. (*Sci. News Letter*, 18th June, 1932, Vol. 21, p. 388.)

Paragraphs on the accumulator dealt with in July Abstract, p. 420.

Der Philips-Triodenregler (The Philips Triode Regulator [for D.C. and A.C. Generators]).—N. A. J. Voorhoeve and F. H. de Jong. (*E.T.Z.*, 2nd June, 1932, Vol. 53, pp. 530–532.)

Where less accuracy is needed, the Philips diode regulator (1929 Abstracts, p. 162–Voorhoeve) is recommended, but the triode regulators here described give a higher accuracy of regulation; *e.g.*, in the case of the d.c. model, a constancy within 0.1% with a delay of only a small fraction of a second.

Die Gleichlaufregelung von Gleichstrom-Motoren mittels Kontaktscheiben (The Synchronisation of D.C. Motors by means of Contact Discs).—W. Bussmann: Steage. (*Zeitschr. f. Fernmeldetech.*, No. 5, Vol. 13, 1932, pp. 71–76.)

An investigation of the method patented by the Westinghouse Company and later described by S. A. Steage in *Journ. Am. I.E.E.* for 1926, p. 484.

Constructional Methods for the Driving of Bands or Tapes in Apparatus of High Precision.—K. H. Sieker. (*Zeitschr. f. Fernmeldetech.*, No. 6, Vol. 13, 1932, pp. 81–86.)

A Glowing-Wire Instrument for Burning Away Insulation during the Wiring of Broadcast Receivers, etc.—AEG. (*Elektrot. u. Masch:bau*, 15th May, 1932, Vol. 50, p. 301.)

Der schwingende Detektor (The Oscillating [Crystal] Detector).—F. Noack: Habann. (*Rad., B., F. f. Alle*, July, 1932, pp. 307–310.)

An article based on Habann's investigations (Feb. Abstracts, p. 108) and urging further research and development.

STATIONS, DESIGN AND OPERATION.

Der Stand der Rundfunktechnik in Amerika und Deutschland (The Position of Broadcasting Technique in America and Germany [A Comparison]).—W. Reichardt. (*E.T.Z.*, 9th and 30th June, 1932, Vol. 53, pp. 552–555 and 619–622.)

(1) Studio technique, including insulating materials and methods used in U.S.A. (2) Outside broadcasts: the "elephant's ear" microphone with its 1.5-metre parabolic reflector. (3) Volume control. (4) Microphones. (5) Switching. (6) Special cable network: temperature compensating links—hand-controlled in Germany, automatic in America. (7) Repeaters and amplifiers. (8) Measurements. (9) Transmitters. (10) Common-wave broadcasting, various methods. (11) Receivers: the ubiquity of the superheterodyne in U.S.A. (12) Programme exchange. (13) Television.

Contribution to the Theory of Interference Zones in Common-Wave Transmission.—Hübner. (*See* under "Propagation of Waves.")

The New French Broadcasting Network.—(*Rev. Gén. de l'Élec.*, 2nd July, 1932, Vol. 32, No. 1, pp. 24–25.)

La nouvelle Station de Radiodiffusion du Poste Parisien (The New [High Power] Broadcasting Station "Poste Parisien").—(*Génie Civil*, 2nd July, 1932, Vol. 101, No. 1, pp. 11–14.)

Broadcasting in a Train.—A. Dinsdale. (*Wireless World*, 22nd July, 1932, Vol. 31, pp. 54–55.)

The author gives an account of the methods and apparatus used in an "outside broadcast" which was given by the Columbia Broadcasting System from a train running between Washington and New York on March 27th, 1932.

Recording of Modulation Level of a Broadcast System.—H. L. Kirke. (*Wireless Engineer*, July, 1932, Vol. 9, No. 106, pp. 369–377.)

Description of the "programme meter" referred to in August Abstracts, p. 478. If used in conjunction with receiving apparatus at a distance such that fading occurs, automatic gain control is necessary: the autogain circuit is described.

Gleichzeitige Telegraphie und Telephonie auf Kurzwellenverbindungen (Simultaneous Telegraphy and Telephony on Short-Wave Circuits).—D. Thierbach. (*Telefunken-Zeit.*, No. 60, Vol. 13, 1932, pp. 36–47.)

The writer begins by discussing the possibilities of the multiple use of a short-wave link on lines already followed for wired circuits, and the special difficulties liable to be encountered. Of the two main types of process, the distributor principle (*e.g.* Baudot) and the multiple note-frequency principle, the paper deals only with the second. The probability of errors, both "positive" and "negative," is considered at some length, together with ways of reducing such probability by the combination of two or more channels for the transmission of one message: one form of such a procedure is mentioned which would give excellent results—the use of two note-frequency channels to send the same message with a constant displacement in time, this displacement being wiped out at the receiver by a delay device: "unluckily a simple and reliable delay device is not yet known."

The above treatment of the problem leads to Section D, an outline of a new system giving one telephony and two telegraphy channels, by the addition of low-frequency equipment to an existing short-wave telephony plant. Each telegraphy channel has one frequency for marking and a second or spacing : at the receiver the two channels are dealt with separately before the signals are taken to the rectifiers. Provision is made for the combination of the two telegraphy channels for one message for the reduction of errors : each channel is sufficiently wide for normal type-printing speeds. The paper is to be continued.

RADIO-TELEFOON-VERBINDING MET SCHEPEN (Radiotelephony Communication with Ships [including R.M.S. Olympic Installation]).—F. de Fremery. (*Tijdschr. Nederl. Radiogenoot.*, June, 1932, Vol. 5, pp. 171–183.)

"The special difficulties in establishing a radiophone terminal aboard ship are discussed. The advantages of carrier suppression are shown. The single wavelength system is explained as a step towards the solution of the problem of wavelength assignment. The radiophone installation of the R.M.S. Olympic is described."

THE BEELITZ OVERSEAS RECEIVING STATION.—H. Mögel. (*Telefunken-Zeit.*, No. 60, Vol. 13, 1932, pp. 7–21.)

(1) Short waves : beam aerial systems : feeders : aerial switching systems : receivers. (2) Long waves : general : aerials. (3) Control and measurements. (4) Power and workshops.

COMMUNICATIONS IN INDIA—FUTURE CONTROL OF TELEGRAPHS, TELEPHONES AND RADIO.—(*Electrician*, 1st July, 1932, Vol. 109, p. 4.)

WEATHER SERVICE FOR ALL.—T. Herbert. (*Wireless World*, 29th July, 1932, Vol. 31, pp. 76–77.)

A brief account is given of the working of the meteorological broadcasting service established at Heston Air Port in September, 1931, for the benefit of aviators and others.

GENERAL PHYSICAL ARTICLES.

PLASMASCHWINGUNGEN UND SELEKTIVE OPTISCHE REFLEXION DER METALLE (Plasma Oscillations and Selective Optical Reflection from Metals).—M. Steenbeck. (*Zeitschr. f. Phys.*, 1932, Vol. 76, No. 3/4, pp. 260–265.)

Author's abstract :—The plasma electron oscillations calculated by Langmuir and Tonks (1929 Abstracts, p. 273) and demonstrated by them in the positive column of a vacuum discharge are here applied to the electron gas in metals, without considering the gas degeneration. Frequencies for which $\lambda = 2\,000$ Å approx. are found to result. For this frequency, which is characteristic of the metal as a whole, a selective reflection and absorption maximum is to be expected, as is in fact observed. If the reflection maximum is actually due to space charge oscillations of the electron gas, it should only occur for light polarised with its electric vector in the plane of incidence, and not for light polarised perpendicularly to that plane.

THE SLOWING-DOWN OF ALPHA RAYS IN THE AIR, AND BETHE'S THEORY.—G. Mano. (*Comptes Rendus*, 23rd May, 1932, Vol. 194, pp. 1813–1815.)

DIELECTRIC CONSTANT AND CONTACT POTENTIAL.—T. Takéuchi. (*Proc. Phys.-Math. Soc. Japan*, Series 3, Vol. 13, No. 7, pp. 208–210.)

"The author has attempted to introduce the term of induced dipoles in the expression of refractivities of the electronic wave, and has suggested some method of determining the dielectric constant of metals."

THE DIAMAGNETISM OF THE FREE ELECTRON.—T. Takéuchi. (*Proc. Phys.-Math. Soc. Japan*, Series 3, Vol. 13, No. 9, pp. 267–268.)

"It is shown that when free electrons of metals are moving in a magnetic field, they exhibit a classical diamagnetism plus a paramagnetism, the latter being due to their spin. The present paper has been prepared before the appearance of papers by Landau and C. G. Darwin."

ELECTRONS IN A GRAVITATIONAL FIELD.—T. Takéuchi. (*Proc. Phys.-Math. Soc. Japan*, Series 3, Vol. 14, No. 2, pp. 89–92.)

"By using the simplest line-element for a uniform gravitational field, the electromagnetic field due to an electron at rest in Galilean space is evaluated."

MULTIPLE EXCITATION OF COMPLEX ATOMS BY ELECTRON IMPACT.—L. Goldstein. (*Comptes Rendus*, 29th Feb., 1932, Vol. 194, pp. 773–776.)

MISCELLANEOUS.

ELECTRONIC DEVICES AS AIDS TO RESEARCH.—A. W. Hull. (*Physics*, June, 1932, Vol. 2, pp. 409–431.)

Among new electronic devices, the writer deals with red-sensitive photocells ; pliotrons for measuring small currents ; the amplification of small voltages (including methods for amplifying small *direct* voltages, such as thermal e.m.fs, for measuring purposes : a promising method is to vary the input capacity by the vibration of an earthed reed—Fig. 14) ; the thyratron and its various applications.

A NEW USE OF THE VACUUM TUBE IN ELECTROMETRIC TITRATIONS. I. POLARISATION OF PLATINUM ELECTRODES IN OXIDATION AND REDUCTION REACTIONS.—Kassner, Hunze and Chatfield. (*Journ. Am. Chem. Soc.*, June, 1932, Vol. 54, pp. 2278–2284.)

A PRECISION PHOTOELECTRIC CONTROLLER.—C. W. La Pierre. (*Elec. Engineering*, July, 1932, Vol. 35, p. 403.)

Application of the recording circuit dealt with in July Abstracts, p. 422, to control purposes.

PHOTOCELLS AND THEIR APPLICATIONS IN OPTICAL TECHNIQUE [SURVEY AND BIBLIOGRAPHY OF RECENT WORK].—H. Singer. (*Lichttechnik*, pp. 29–32, supplement to *Elektrot. u. Masch:bau*, 26th June, 1932, Vol. 50.)

THE MEASUREMENT OF ACCELERATIONS OF MOTORS, ETC., BY A PIEZOELECTRIC EQUIPMENT.—H. Lund : AEG. (Summary in *Elektrot. u. Masch:bau.*, 17th April, 1932, Vol. 50, p. 251.)

A MECHANICALLY CONTROLLED BOLOMETER APPLICABLE TO ULTRA-MICROMETRIC USE.—Sell. (*See* abstract under "Subsidiary Apparatus and Materials.")

A NEW ELECTRICAL PICK-UP FOR MEASURING FORCES ON TOOLS, CUTTING PRESSURES, ETC. [BASED ON VARIATION OF LIQUID RESISTANCE].—A. Wallichs and H. Opitz. (*Elektrot. u. Masch:bau*, 12th June, 1932, Vol. 50, p. 348.)

See also August Abstracts, p. 480.

ON THE PHOTO-TELEPHONY [SUCCESSFUL USE OF INCANDESCENT ELECTRIC LAMP AT TRANSMITTER].—T. Kujirai. (*Rep. of Rad. Res. and Works in Japan*, March, 1932, Vol. 2, No. 1, pp. 27–34.)

It has been thought that an incandescent lamp would have too high a time constant, so that hitherto an arc has been used. The writer however shows theoretically that an incandescent lamp will be quite effective provided that a suitable differential photoelectric arrangement is used at the receiver: experiment confirms this, and communication over about 3 km is possible with a motor-car headlight lamp of 50 c.p.

READING MACHINES FOR THE BLIND: THE VISAGRAPH AND THE PHOTOELECTROGRAPH.—P. Henri: Naumburg: Thomas. (Summary in *Rev. Gén. de l'Élec.*, 11th June, 1932, Vol. 31, p. 814.)

THE USE OF BLOCKING (REJECTOR) CIRCUITS IN CARRIER CURRENT TELEGRAPHY OR TELEPHONY OVER POWER LINES.—(French Pat. 722 937, Fallou, pub. 30th March, 1932: summary in *Rev. Gén. de l'Élec.*, 25th June, 1932, Vol. 31, pp. 209–210 D.)

THE USE OF CABLE COATINGS AND CONDUCTORS AS CAPACITATIVE COUPLING FOR CARRIER CURRENT WORKING.—(French Pat. 723 246, Fallou, pub. 5th April, 1932: summary in *Rev. Gén. de l'Élec.*, 25th June, 1932, Vol. 31, p. 210 D.)

SOME ARRANGEMENTS FOR THE ELECTRICAL TRANSMISSION OF SIGNALS, ETC., ALONG POWER TRANSMISSION LINES [USING BEATS BETWEEN TWO MUSICAL FREQUENCIES].—J. Bethenod. (*Rev. Gén. de l'Élec.*, 25th June, 1932.)

COMMUNICATION ENGINEERING IN THE SECOND HALF OF 1931.—Kölsch: Watson. (*E.T.Z.*, 2nd June, 1932, Vol. 53, pp. 532–534.)

As regards wireless developments, an item not previously mentioned in these Abstracts is the "Watsonograph," tested in the U.S.A., by which a message typed on an "ordinary" typewriter is sent by a short-wave transmitter and reproduced by one or more similar typewriters at a distance. A large section of the article deals with traffic and organisation (cable and wireless).

EIN JAHRZEHNT DES FORTSCHRITTS IM ELEKTRISCHEN NACHRICHTENVERKEHR (Ten Years' Progress in Communication Services). —P. Craemer. (*Zeitschr. V.D.I.*, 30th April, 1932, Vol. 76, No. 18, pp. 425–432.)

A SURVEY OF THE MOST IMPORTANT WORK IN ELECTRICAL ENGINEERING DURING 1931.—German Elektrotechnischer Verein. (*E.T.Z.*, 21st and 28th April, and 5th May, 1932, Vol. 53, pp. 393–396, 416–419, and 442–445.)

ELECTRICAL ANALOGIES IN HYDRODYNAMICS.—J. Pérès and L. Malavard. (*Comptes Rendus*, 18th April, 1932, Vol. 194, pp. 1314–1316.)

THE CONCEPT OF BEAUTY AS RELATED TO ENGINEERING.—A. E. Kennelly. (*Journ. I.E.E. Japan*, April, 1932, Vol. 52 [No. 4], No. 525, pp. 299–308.)

ON THE FORCES ACTING ON DROPS IN AN ELECTRIC FIELD.—G. D. West. (*Proc. Physical Soc.*, 1st May, 1932, Vol. 44, Part 3, No. 243, pp. 336–342.)

Author's abstract:—If whilst a drop of electrolyte is falling in distilled water, a horizontal electric field be established, the drop rapidly spreads out into a filament parallel to the lines of force. An explanation of this phenomenon is given on the basis of the charge at the boundary between conductors that necessarily accompanies the transport of electricity. Experiments with dielectrics and with drops that contract instead of expand are described, and the paper is illustrated with photographs.

ON SOME PROPERTIES OF THE ELECTRET.—T. Tiku: Eguchi. (Summary in *Sci. Abstracts, Sec. A*, July, 1932, Vol. 35, pp. 635–636.)

For previous papers on the Eguchi electret, *see* 1931 Abstracts, pp. 168 and 516.

BREAKDOWN MESSAGE SPEECH TRANSMISSION SYSTEM OF THE LONDON UNDERGROUND RAILWAYS.—F. Clark and A. A. Chubb. (*G.E.C. Journal*, May, 1932, Vol. 3, No. 2, pp. 111–114.)

A NEW VOICE FREQUENCY TELEGRAPH SYSTEM.—J. A. H. Lloyd, W. N. Roseway, V. J. Terry and A. W. Montgomery. (*Elec. Communication*, April, 1932, Vol. 10, pp. 184–199.)

ÜBER DIE FREQUENZABHÄNGIGKEIT DES WIDERSTANDES DES MENSCHLICHEN KÖRPERS IM FREQUENZGEBIET VON 365 BIS 8×10^5 HERTZ (The Variation with Frequency of the Resistance of the Human Body in the Range 365 to 8×10^5 Cycles per Second).—N. N. Malov and S. N. Rschevkin. (*Hochf: tech. u. Elek:akus.*, March, 1932, Vol. 39, pp. 93–101.)

Further development of the work dealt with in 1930 Abstracts, p. 470. The writers have devised a method by which the two components of the total body impedance, that relating to the skin and that relating to the internal tissues, can be studied separately. A number of conclusions are thus reached. *See* also below.

ON THE NORMAL RESISTANCE OF THE HUMAN BODY FOR HIGH-FREQUENCY CURRENTS.—N. N. Malov and S. N. Rschevkin. (*Hochf: tech. u. Elek:akus.*, April, 1932, Vol. 39, pp. 127–130.)

Further development of the work dealt in 1930 Abstracts, pp. 470–471. *See* also preceding abstract.

ELECTRICITY IN HEALING. RECENT ADVANCES IN SURGICAL AND MEDICAL APPLICATIONS.—E. P. Cumberbatch. (Summary in *Sci. Abstracts, Sec. A*, May, 1932, Vol. 35, No. 413, p. 451.)

A COMPARISON OF THE EFFICIENCIES [IN THEIR ACTION ON NERVES] OF WEDGE-SHAPED WAVES OF THE SECOND TYPE AND CONDENSER DISCHARGES, OF EQUAL INITIAL INTENSITY.—P. Fabre and P. F. Quesnoy. (*Comptes Rendus*, 17th May, 1932, Vol. 194, pp. 1760–1763.)

SPECIAL ULTRA-SHORT WAVE ISSUE OF "FUNK-MAGAZIN."—(*Funk-Magazin*, July, 1932, No. 7, Vol. 5.)

Including a constructional article on a "home" telephone set, a paper on ultra-short waves in Medicine, a constructional article on a 10-metre transmitter, descriptions of 2- and 3-valve u.s.w. receivers of great reliability, a paper on quartz crystals for u.s.w., and articles on the human body as a generator of electricity, on the electric scalpel, etc.

ZUR PHYSIK DER ULTRA-KURZWELLEN-THERAPIE: DAS WELLENBAND DER SELEKTIVEN ERWÄRMUNG (On the Physics of Ultra-Short-Wave Therapy: the Wave Band of Selective Heating).—J. Pätzold. (*Zeitschr. f. tech. Phys.*, No. 5, 1932, Vol. 13, pp. 212–216.)

Continuation of the work dealt with in 1931 Abstracts, p. 54.

RESEARCHES ON THE EFFECTS OF ULTRA-SHORT-WAVE IRRADIATION ON PLANT LIFE AND ON SILKWORMS, ETC.—Mezzadroli. (*Rad., B., F. f. Alle*, July, 1932, pp. 19–20.)

An editorial paragraph on Mezzadroli's work at Bologna University, using 2-metre waves. A footnote refers to reports of similar work, with important results, in progress in Germany and other countries.

PHYSIOLOGICAL AND BIOLOGICAL EFFECTS OF HIGH FREQUENCY [SHORT BIBLIOGRAPHY OF RECENT PAPERS].—(*Electronics*, May, 1932, p. 169.)

THE ACTION AT A DISTANCE OF METALS ON BACTERIA AND YEASTS: ON MICROBES.—G. A. Nadson and C. A. Stern. (*Comptes Rendus*, 2nd May and 20th June, 1932, Vol. 194, pp. 1597–1600 and 2229–2231.)

A SPECIAL MODE OF ACTIVATION OF MATTER [AND THE EMISSION OF A PHOTOGRAPHICALLY-ACTIVE GAS FROM SEMI-CONDUCTORS].—G. Reboul. (*Comptes Rendus*, 29th March, 1932, Vol. 194, pp. 1122–1124.)

Continuation of the researches dealt with in May Abstracts, p. 301 (two). Further developments are given in *Comptes Rendus*, 17th May, 1932, pp. 1733–1735.

AN IMPROVED FORM OF ELECTROCARDIOGRAPH [WITH SPECIAL HIGH INPUT-IMPEDANCE VALVE AMPLIFIER].—S. H. Caldwell, C. B. Oler, and J. C. Peters. (*Review Scient. Instr.*, June, 1932, Vol. 3, pp. 277–286.)

A TRIP CIRCUIT FOR NERVE EXCITATION [FOR C.-R. OSCILLOGRAPHIC RECORDING].—König. (*See* under "Subsidiary Apparatus and Materials.")

THE PRACTICAL APPLICATIONS OF ULTRA-VIOLET RAYS.—R. Gourjon. (*Rev. Gén. de l'Élec.*, 28th May, 1932, Vol. 31, pp. 747–754.)

FUNDAMENTAL CONSIDERATIONS ON THE USE OF GAMMA RAYS FOR TESTING MATERIALS.—R. Berthold and N. Riehl. (*Zeitschr. V.D.I.*, 23rd April, 1932, Vol. 76, No. 17, pp. 401–406.)

CHART OF SOME ELECTROMAGNETIC RELATIONS [WAVELENGTH SCALE FROM 10^7 TO 10^{-13} CM].—W. E. Deming and F. G. Cottrell. (*Review Scient. Instr.*, June, 1932, Vol. 3, pp. 296–297.)

LA VARIAZIONE DI CONDUCIBILITÀ DI UNA PELLICOLA METALLICA PER EFFETTO DELLA CARICA ELETTRICA (The Variation in the Conductivity of a Thin Metallic [Tungsten] Film as an Effect of an Electric Charge [Increase of Conductivity for Negative Charge, Decrease for Positive: approximately Proportional to the Field]).—M. Pierucci. (*Nuovo Cimento*, No. 2, Vol. 9, 1932, pp. 33–42.)

For a discussion of the theory underlying these results, *see* Polvani, *ibid.*, No. 3, Vol. 9, 1932 pp. 69–71.

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Discussion on Radley's paper referred to in Feb. Abstracts, p. 114.

SOME ASPECTS OF ELECTRICAL PROSPECTING APPLIED IN LOCATING OIL STRUCTURES: EFFECTS OF HEAT TREATMENT ON FINE METALLIC SUSPENSIONS [ELIMINATING WANDERING ZERO]: ASYMMETRY OF SOUND VELOCITY IN STRATIFIED FORMATIONS: AND OTHER GEOPHYSICAL PAPERS.—(*Physics*, March, 1932, Vol. 2, pp. 103–199.)

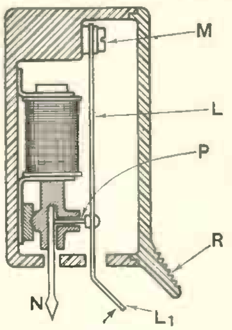
Some Recent Patents.

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.

GRAMOPHONE PICK-UPS.

Convention date (Germany), 28th November, 1930.
No. 370352.

The construction shown in the Figure enables the needle *N* of the pick-up to be exchanged in a convenient manner. It is clamped in position by a leaf spring *L* pivoted at *M*. To remove it, the curved end L_1 of the spring is grasped by the index finger and a roughened projection *R* on the casing by the thumb, and pressure is exerted to withdraw the holding-pin *P*, whereupon the needle falls away.



No. 370352.

Patent issued to Steatit-Magnesia Akt.

MAINS UNITS.

Convention date (Germany), 20th August, 1930.
No. 370790.

It is known that the voltage across the electrodes of a glow-discharge tube remains constant until the surface of the cathode is fully covered with glow-light, and it is only after this condition is reached that the current and voltage begin to rise. This property has been used to reduce " ripple " in mains supply units as a substitute for expensive smoothing-condensers. According to the invention such a lamp is also used as a voltage-divider, to provide different values of H.T., by providing several electrodes inside the same lamp. These give rise to a number of distinct discharge-paths, each of which can be used as an independent voltage tap.

Patent issued to Telefunken Ges. für Drahtlose Telegraphie m.b.H.

ELECTRON DISCHARGE TUBES.

Application date, 10th December, 1930. No. 370967.

The electron stream in a thermionic valve is traversed, by a local magnetic field, across the surface of a linear or strip-shaped anode, so that the particular point at which the stream strikes the anode determines the effective resistance in the output circuit. The linear anode is made of an extremely thin layer of metal, deposited on a non-conducting core such as a quartz thread, so that its ohmic resistance is of the same order as that of the anode-cathode path inside the valve. By using a similar form of anode in combination with a light-sensitive cathode, the effective load resistance can be varied in accordance with the lateral movement of a spot of light along the cathode. One or more auxiliary electrodes may be inserted in the discharge tube to increase the resistance-variation due to the movement of the incidental pencil of light.

Patent issued to A. Patin.

SIGNALLING SYSTEMS.

Convention date (U.S.A.), 31st October, 1929.
No. 370888.

Transmission and reception between two co-operating stations is effected on a single wave-length. The transmitter and receiver at each station are both coupled to a single aerial which is sharply tuned to the working frequency. When the transmitter at one station is in operation, the aerial serves to couple it to the receiver, and the circuits of the receiver are utilised to amplify further the outgoing signal. Similarly in reception, the amplifying circuits of the local transmitter co-operate with those of the receiver to help to strengthen the incoming signals.

Patent issued to International Radiophone Corporation.

EXTERNAL-GRID VALVES.

Convention date (Germany), 29th January, 1930.
No. 370541.

In valves of the kind in which the usual control grid is replaced by an external plate. *A*, the latter is utilised to form part of the tuning-condenser *A B* Fig. 1, of the input coil *L*. Tuning is effected by varying the distance between the plates *A*, *B*.

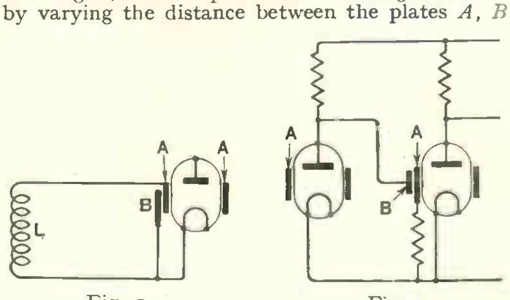


Fig. 1. Fig. 2.
No. 370541.

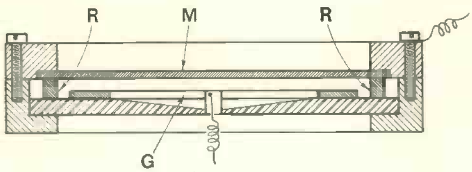
The plates may also be used as a neutralising condenser for stabilising the valve. In Fig. 2, the plates *A*, *B* constitute an interstage coupling which, it is stated, also serves to suppress " hum " when the valve is fed from A.C. mains.

Patent issued to Telefunken Ges. für Drahtlose Telegraphie m.b.H.

MICROPHONES.

Convention date (France), 7th April, 1930.
No. 370188.

A highly sensitive microphone of the electrostatic type consists of a metal diaphragm *M* separated by a distance of the order 0.02 mm. from the metallised surface of a glass or crystal electrode *G*. The glass admits of a high degree



No. 370188.

of grinding to give a perfectly flat surface on which a metal coating having a thickness which does not vary by more than 0.0001 mm. is deposited chemically. The spacing-ring *R* may be formed by a slightly thicker deposit of the metal. The instrument is suitable for detecting very feeble sounds, or for distinguishing between allied types of sound as in auscultation and similar forms of medical diagnosis.

Patent issued to Melodium S.A.R.L.

LOUD-SPEAKER DIAPHRAGMS.

Convention date (France), 19th December, 1929.
No. 369992.

An acoustic diaphragm for a loud-speaker or the like is constructed so that the ratio of its stiffness to the mass per unit area diminishes continuously and uniformly from the centre of the diaphragm to its outer edge. For instance, a disc of steel or hardened celluloid, of uniform thickness, is covered with a layer of rubber having a thickness which increases gradually from the centre of the disc outwards. Or a cone of hardened celluloid, of uniform thickness, is fitted with a rubber lining having a graded thickness from base to apex.

Patent issued to E. O. Persson.

SUPERHETERODYNE RECEIVERS.

Application date, 6th February, 1931. *No.* 370101.

The effective selectivity of a superheterodyne receiver is enhanced by designing the local heterodyne circuit so that it can only oscillate when it bears a definite frequency-relation to the tuned input circuit of the receiver. The object is to enable a signal of frequency $(n + a)$ to be distinguished from one having a frequency $(n - a)$.

It is, of course, known that a back-coupled valve will oscillate only when the positive reactance in the plate circuit, at a given frequency, exceeds a definite limit. According to the invention the inductance-capacity elements in the local oscillator circuit are so dimensioned that, when ganged to the main tuning-control, only one of the two usual side channels is heterodyned, and not both.

Patent issued to The General Electric Co., Ltd., and N. R. Bligh.

DRYING-OUT AERIALS.

Convention date (U.S.A.), 23rd June, 1930.
No. 370247.

A directional aerial-array comprising a number of parallel antennae is adapted to carry a heating-current for drying-off deposited sleet or snow without affecting the directive characteristic of the system. The open ends of the antennae are short-circuited by bent conductors substantially a half-wave long, or of such length that they offer a high impedance to H.F. energy. At the same time they provide a low-resistance path for the drying current. The wires forming each radiator are effectively in parallel with the radio-frequency supply, and in series with the source of heating-current.

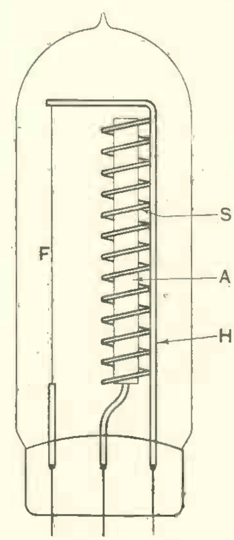
Patent issued to Marconi's Wireless Telegraph Co., Ltd.

EXTERNAL-GRID VALVES.

Convention date (Germany), 7th January, 1930 *(addition to patent No.* 314332). *No.* 369678.

Relates to valves of the type in which the control grid is mounted outside the bulb, and in which the electron stream takes place at right-angles to the longitudinal axis of the bulb, which is flattened in cross-section. According to the invention a valve of this type is provided with a screening grid by surrounding the anode as completely as possible with a wire-gauze or similar network structure. Alternatively the screen may be utilised to reduce the space-charge effect. As shown the screen *S* for the anode *A* is welded to a mounting-wire *H* which also serves to support one end of the filament *F*.

Patent issued to Telefunken Ges. für Drahtlose Telegraphie m.b.H.



No. 369678.

INDUCTANCE COILS.

Application date, 14th July 1931. *No.* 370281.

A multi-range coil-unit comprises two separate windings mounted on the same former, with a variable condenser arranged in parallel with each winding to compensate for the effect of stray capacities, and to ensure a complete balance on both wavebands, i.e., when either one or both coils are connected in circuit. The balancing-condensers consist of a common plate, mounted on the inside diameter of the former, and two separate concentric strips held a variable distance away by adjustable spacing-screws.

Patent issued to C. F. and H. Burton.

THERMIONIC CATHODES.

Application date, 29th May, 1931. *No.* 370722.

Measured by the ratio of thermionic emission to heat expended a cathode consisting of a tungsten wire coated with a monatomic layer of oxygen and calcium is the most efficient known. It suffers however from the drawback that the emission per unit area is low, and therefore a longer cathode, preferably wound in helical form, must be used to provide an adequate electron stream. This in turn introduces "microphonic" difficulties. Further, such cathodes are easily damaged by ionic bombardment. According to the invention, these difficulties are overcome by mounting the helical cathode on a relatively rigid core, which is coated with an insulating-material, such as a mixture of kaolin and alumina, containing oxygen which can be used to "revive" the cathode when necessary.

Patent issued to The M-O. Valve Co., Ltd., K. A. Macfadyen and J. W. Ryde.

AUTOMATIC "CALLING" APPARATUS.

Application date, 3rd February, 1931. *No.* 369713.

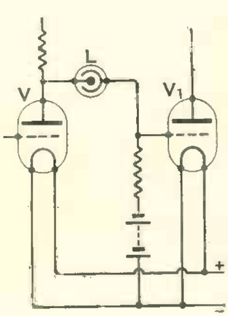
A relay is adapted to operate a bell or other alarm only on the receipt of a definite or prearranged sequence of signals, such as the timed "dashes" forming the standard "distress" signal at sea. The incoming signals are arranged to control a series of pre-selector switches of the kind used in automatic telephony. The switches are actuated by locally-generated impulses, and their progressive motion is determined by the "spacing" of the incoming wireless signal, so that the final setting actuates the alarm. Any deviation from the standard form of distress signal—within certain limits of tolerance—merely causes the selector switches to be re-set to zero, pending the reception of the correct sequence.

Patent issued to E. N. Elford.

INTER-VALVE COUPLINGS.

Application date, 20th December, 1930. *No.* 369578.

A gas-discharge device, such as a Neon lamp *L*, is connected between the anode of one valve *V* and the grid of a succeeding valve V_1 in such a way that it does not carry the anode-current supply. A positive voltage-rise on the anode of valve *V* initiates or increases the discharge current through *L*, which in turn increases the positive potential on the grid of the valve V_1 and the effective output of the latter. The arrangement may serve *inter alia* (*a*) as a direct-current intervalve coupling capable of giving interstage amplification; (*b*) as a rectifier-combination effective for any frequency; or (*c*) as a normal or "triggered" relay device.

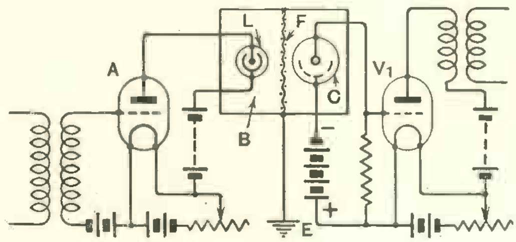


No. 369578.

Patent issued to W. B. Mackenzie; H. Smith, and E. G. Hill.

Convention date (U.S.A.), 11th January, 1930. *No.* 370050.

Two valve stages are coupled together in such a way that each is isolated from the other, both electromagnetically and electrostatically, so as to prevent any feed-back. As shown the output from amplifier *A* is fed through a Neon lamp *L* backed by a reflector, the corresponding light-fluctuations energising a photo-electric cell *C* in the grid circuit of the amplifier V_1. The lamp *L* and cell *C* are enclosed in a lightproof box *B*, and are separated by a copper-gauze screen *F* earthed at *E*.



No. 370050.

Patent issued to Associated Telephone and Telegraph Co.

RECEIVING SYSTEMS.

Convention date (France), 14th January, 1930. *No.* 369607.

Interference due to static, as well as signal fluctuations caused by fading, are eliminated by first converting both types of disturbances into one common form. For instance the blank periods due to fading, and the additional signals due to static, are combined on two differently-tuned receiving aerials which are coupled to the common input in opposition, so that the effect on the receiver is similar in both cases. Reception of the complete message is then ensured by successive repetition of the transmission in known manner.

Patent issued to C. E. Verdan.

POCKET RECEIVERS.

Application date, 1st November, 1930. *No.* 369983.

A self-contained receiver of the super-regenerative type, designed to be carried in an ordinary-sized coat pocket, is characterised by the use of one or more highly-damped quenching-circuits which serve to stabilise the set, especially against hand-capacity effects. The quenching-circuit consists of an inductive resistance of 1000 ohms shunted by a condenser. A single-valve pentode circuit is described and is stated to function satisfactorily with a high-tension supply as low as 1.5 volts.

Patent issued to C. L. P. Dean and C. W. H. Begbie.

EDISWAN
HOT CATHODE MERCURY VAPOUR RECTIFIERS

These half-wave rectifiers are capable of rectifying large currents at high voltages with a constant and extremely low voltage drop (15v approx.). They can thus be quite efficiently used on any voltage, providing that the inverse voltage does not exceed the stated maximum value. They are specially suitable for supplying high tension voltages to large power valves employed in public address amplifiers, etc., and to the anodes of transmitting valves.

The EHT.10 and EHT.15 are capable of rectifying up to 30 K.W. of power with output voltages of 10,000 to 12,000 volts D.C. A special hard glass is employed in the construction of these rectifiers (with the exception of the ESU.40), and troubles arising due to pinch electrolysis, etc., are eliminated.

PRICES ON APPLICATION

RATINGS

	EHT.15	EHT.10
Filament Volts	4	4
Filament Amps.	25	25
Max. Inverse Peak Anode Volts (kV.)	30	20,000
Peak Anode Current (Amps.) ...	15	15

	ESU.40	ESU.150	ESU.300
Filament Volts	2	4	4
Filament Amps.	4	10	16
Max. R.M.S. Inverse Anode Volts	3,000	5,000	7,000
Peak Anode Current ...	500 m/a	1.8 amps.	3.5 amps.

THE EDISON SWAN ELECTRIC CO. LTD. 155 CHARING CROSS RD., LONDON, W.C.2

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