EXPERIMENTAL WIRELESS
& The WIRELESS ENGINEER

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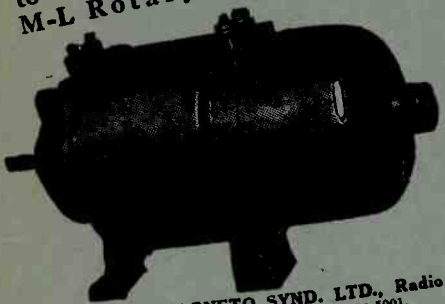

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Editorial.

Gridless Triodes.

AT the Berlin Radio Exhibition one of the principal novelties was the new type of valve fitted in some of their receivers by the Telefunken Company. Because of their shape they were called "Stäbe" which we translated "rods," but in their English publications the company refer to them as "pegs," and in view of their undoubted right to name their own offspring we shall refer to them as "pegs." The accounts given of their operation were somewhat vague, but in a recent number of the *Telefunken Zeitung* a much fuller description is given by three members of the Telefunken research staff, and from this a fairly clear picture can be obtained of the reasons for the peculiarities in the operation of this type of valve. The idea of placing the control electrode outside the glass envelope of the valve is an old one, Dr. de Forest having tried this method before it occurred to him to place a grid between the filament and anode. The idea was resuscitated in 1913 by Weagant, who patented several arrangements, but nothing came of it, which is not surprising in view of the many difficulties which the Telefunken engineers have encountered and the lengthy researches which have been necessary to overcome them. It is interesting to learn that the Telefunken Company were led to develop the idea through the behaviour of some special valves which they made up at the suggestion of Dr. Möller in connection with some patent litigation. These valves had their electrodes so arranged that the anode and grid had little screening effect on the filament and it was found that their behaviour was very susceptible to external conditions, the characteristics being greatly changed by movements of the hand or earthed objects in the neighbourhood. The form of the valve was modified until the present elongated oval was reached, with the filament at one end and the anode at the other, the control electrode consisting of a coating of metal sprayed over nearly the whole of the external surface. The object of the special form is to bring the control electrode so close to the filament that it has a sufficient effect on the space charge to give a satisfactory amplification factor and mutual conductance. It also lends itself to a cheap construction, a very small valve, and, as we shall see, a saving of auxiliary apparatus in the sets; the valve filaments can also be heated with alternating current without any noticeable hum.

Two Types, Hard and Soft.

In considering the action of the valves, it is important to distinguish between those with a very good vacuum and those with a gas filling; the former type are suitable for low frequency amplification and the latter for detection. Failure to appreciate the importance of this distinction led to many mysterious observations in the early days of the development, the characteristics changing with time as the vacuum improved.

The Hard Amplifier.

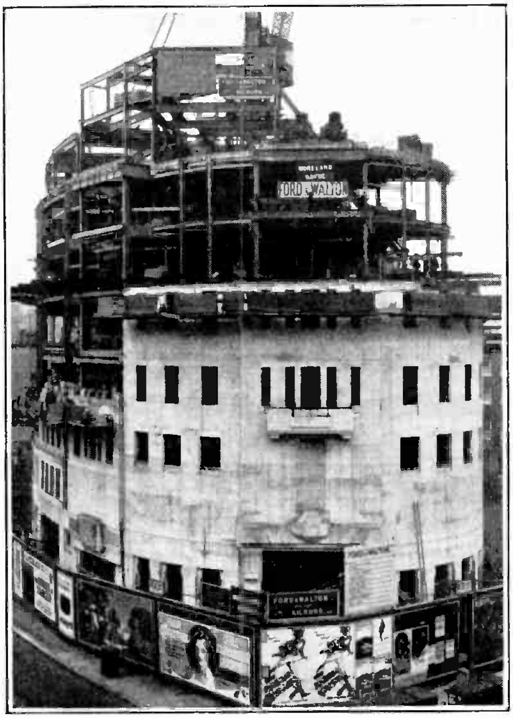
We shall assume in the first place that the vacuum is so good that the gas ions are negligible in amount. If the coating is at the filament potential a steady anode current will flow through the valve; if now the coating is suddenly made positive, electrons immediately leave the procession from filament to anode and rush to the glass wall in sufficient numbers to neutralise the positive charge on the coating. The mobility of the free electrons is so great that this neutralisation takes place practically instantaneously with the application of the potential, with the result that the anode current remains unchanged. If now the potential of the coating is suddenly reduced to that of the filament, the charges on the coating and inside of the glass wall still remain the same, the glass wall acting as a charged condenser maintaining the filament at a higher potential than the electron layer on the glass wall. Thus the potential difference which existed a moment before across the source of "grid" potential is suddenly applied between the filament and the electron layer in the direction which reduces the anode current. If a negative potential is applied to the coating it sets up an electric field through the glass and vacuum to the filament in the direction tending both to reduce the anode current and to prevent electrons coming to the walls. It will be seen therefore that on applying an alternating potential, the positive half-waves leave a negative layer on the walls and thus lower the point on the characteristic from which the negative half-wave must be reckoned. Any increase in amplitude of the applied voltage will, on the first positive half-wave, cause a further addition to the negative layer of electrons and thus further depress the working point on the characteristic. This is exactly what happens in leaky grid detection, except that we have not yet considered the leak; it must be noted, however, that we are considering the high vacuum "peg" which is used for amplification and not for detection, so that the negative bias which the coating automatically assumes is of no importance so long as the high frequency currents remain on the linear portion of the anode characteristic.

Using the Glass as a Leak.

If, however, a momentary high potential was given to the coating, due perhaps to some disturbance outside the set, it was found that the valve was paralysed for some time, and the elimination of this defect has proved a troublesome problem. A large positive potential on the coating collects a large negative layer on the inside wall, which, on the removal of the positive potential, reduces the anode current to zero; no anode current means no procession of electrons through the valve and therefore no production of positive ions, which, even in the best vacuum, are produced by the electron stream. Hence the layer of electrons cannot be neutralised or got rid of except by leakage. Many ingenious plans were tried such as coating the walls with a material of high photo-electric emission and running the filament bright enough to excite the emission; it was found that such valves recovered more rapidly in daylight than in the dark, but the scheme was not practicable. The final solution was found in the use of a glass of very low insulation so that the glass wall itself constituted both condenser and leak. Such a valve could then be used either as a detector or as an amplifier, but when used on a 50 cycle supply with the filaments heated with alternating current the hum was prohibitive.

The Soft Detector.

The high vacuum valve is, therefore, only used as an audio-frequency amplifier, the first valve—the detector—being similar except that it contains some mercury vapour. The electron stream from filament to anode will now produce a great number of positive ions. When the coating is made positive, electrons are attracted to the wall as before and the anode current is unchanged, but on removing the positive potential the negative electron layer is quickly neutralised by positive ions which are attracted to the walls. If the coating is made negative the instantaneous effect is to decrease the anode current, but the initial condition is quickly restored by the attraction of positive ions to the walls. A slowly alternating potential applied to the coating has, therefore, no effect on the anode current, but as the frequency is raised the anode current begins to fall because of the inertia of the heavy positive ions, until, at very high frequencies, the valve acts as if the ions were not present. If used as an amplifier, the amplification at 1,000 cycles is only 0·2 of what it is at 10,000 cycles and at 100 cycles it has fallen to 0·02; it is seen, therefore, that the vacuum type must be employed for amplification and the gas filled type for detection. It is due to the inertia of the heavy positive ions that the mean value of the anode current varies with the modulation and thus allows the valve to act as a rectifier; it will tend to favour the deeper tones since they allow a longer time between successive maxima of the radio frequency current, during which the positive ions can gather on the walls and neutralise the electrons.



"BROADCASTING HOUSE." A recent photograph of the new headquarters of the B.B.C. now under construction in Portland Place, London, W. The main entrance, seen in the picture, is viewed from the south.

Freedom from Hum.

The explanation given of the freedom from hum although the filament is heated with 50 cycles alternating current is very ingenious. The potential of every point of the filament is alternating with respect to the grid or coating. If the midpoint is earthed, the one end will at one moment be at +0·7 volt and the other end at −0·7 volt; the next moment the signs are reversed, assuming the valves to have 1 volt filaments, as they actually have. In an ordinary valve the grid must have the same potential at every point and it is difficult to eliminate the effect of this alternating grid potential on the anode current; in the Telefunken "pegs," on the other hand, the electrons and ions on each spot of the glass wall can adjust themselves to suit the momentary potential of the part of the filament nearest to them. It is as if one had a large number of separate grids interconnected through high resistances. Nothing is said of the effect of the variation of filament temperature during the cycle, but as the filaments are supplied at 1 volt the filament current in the all-mains set may well be chosen large enough to give a filament of sufficient thermal capacity to reduce the hum due to this effect to a negligible value. A photograph of one of these valves and a diagram of connections of a Telefunken three-valve set employing two of them will be found on page 534 of our October number.

G. W. O. H.

The Physical Reality of Side-bands.*

A Note on the Rectification of a Modulated Continuous Wave.

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

(Wireless Division, National Physical Laboratory.)

SUMMARY.—The reception and rectification of a modulated continuous wave is considered theoretically and experimentally, with special reference to the variation of the modulation frequency output with the tuning of the receiving circuit. The physical reality of the side frequencies is demonstrated, and their effect on the shape of the tuning curve is shown. A brief discussion is also given of the side-band cut-off effect, *i.e.*, the variation of amplitude of the modulation frequency output with modulation frequency.

1. Introduction.

THE following brief discussion of the reception of a modulated continuous wave may be of interest to those concerned with such matters, as it brings out certain points which can only be arrived at after a thorough and laborious analysis, and which may therefore be new to many. The analysis and calculations were made some years ago, but a recent practical demonstration by Professor Fortescue of the actual shape of the modulation frequency output curve, at a meeting of the Wireless Section of the Institution of Electrical Engineers, held at the City and Guilds College, together with the current interest in the "side-band" question, have given it a topical value which is thought to justify publication in spite of the obvious incompleteness of the treatment.

2. The Form of a Modulated Continuous Wave.

In order to emphasise the most important features of the result the system considered will be reduced to its simplest possible form. The modulated continuous-wave electromotive force operating in the system will be represented by

$$e = E(1 + m \cos nt) \cos (\omega t + \theta)$$

where $n/2\pi$ is the modulation frequency, $\omega/2\pi$ the carrier frequency and 100 m the modulation percentage.

This can be written in the form

$$e = E.\cos(\omega t + \theta) + \frac{mE}{2}\cos(\overline{\omega - n}t + \theta) + \frac{mE}{2}\cos(\overline{\omega + n}t + \theta)$$

$$= e_c + e_1 + e_2$$

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

Actually the phase angle θ will play no significant part in the subsequent analysis and will be made zero at this point for convenience, giving

$$e = e_c + e_1 + e_2 = E \cos \omega t + \frac{mE}{2}\cos(\omega - n)t + \frac{mE}{2}\cos(\omega + n)t$$

Observe that in actual practice the effective e.m.f. involved in the reception process will not necessarily be quite as simple as this in form, even in the reception of a single pure tone modulated wave. The mode of reception (*e.g.*, coil or aerial, with or without intermediate couplings) will enter into the matter. However, as already pointed out, the simplest possible case is here being considered.

3. The Response of a Tunable Circuit to a Modulated Continuous-wave Electromotive force.

The receiving system will first be considered in a generalised form. It will be assumed that the output quantity required is the potential difference v across some element of the system (*e.g.*, the tuning condenser), and that this potential difference is related to the e.m.f. $E \cos \omega t$ as follows:

$$v = YE \cos (\omega t + \theta).$$

On this basis, each of the above three components of the modulated e.m.f. will give rise to its own potential difference as under

$$v_c = Y_c E \cos (\omega t + \theta_c)$$

$$v_1 = Y_1 \frac{mE}{2} \cos (\overline{\omega - nt} + \theta_1)$$

$$v_2 = Y_2 \frac{mE}{2} \cos (\overline{\omega + nt} + \theta_2)$$

The total potential difference across the element concerned will be the sum of these, *i.e.*,

$$v = v_c + v_1 + v_2$$

It should be noted that v_c, v_1 and v_2 are in general of very different magnitudes and phases, depending on the magnitude and variation of Y with frequency.

4. The Rectification Process.

It is assumed that the above potential difference v is applied to the terminals of some rectifying device. The output current or voltage of the rectifier will contain a term of modulation frequency. In every known type of rectifier the characteristic is effectively parabolic for small input voltages, giving rise to what is known as square law rectification. This, as being the simplest case for analysis, will be considered first. In such cases the modulation frequency terms in the output of the rectifier will be derived from the products $v_c v_1$ and $v_c v_2$ and will be proportional to

$$mE^2 Y_c Y_1 \cos(nt + \overline{\theta_c - \theta_1})$$

and $$mE^2 Y_c Y_2 \cos(nt + \overline{\theta_2 - \theta_c})$$

(This step is detailed in Appendix 1).

The total modulation frequency output will thus be proportional to

$$mE^2 Y_c\{Y_1 \cos(nt + \overline{\theta_c - \theta_1}) + Y_2 \cos(nt + \overline{\theta_2 - \theta_c})\}$$

The quantity inside the brackets can be written

$$\{Y_1^2 + Y_2^2 + 2Y_1Y_2 \cos(\theta_1 + \theta_2 - 2\theta_c)\}^{\frac{1}{2}} \cos(nt + \phi)$$

and the amplitude term is the magnitude of the vector sum of the vectors

$$y_1 = Y_1 \epsilon^{j(\theta_1 - \theta_c)}$$
$$y_2 = Y_2 \epsilon^{j(\theta_c - \theta_2)}$$

Thus the modulation frequency output will be proportional to

$$mE^2 Y_c \mid y_1 + y_2 \mid$$

From this general expression some preliminary conclusions can be drawn without further analysis :—

(*a*) The modulation frequency output is proportional to the modulation percentage.

(*b*) It is proportional to the square of the carrier wave amplitude.

(*c*) The shape of the variation of the output with the tuning of the circuit is independent of the modulation percentage but will depend on the modulation frequency, since this will affect Y_c, y_1 and y_2.

For the present we are interested only in the shape of the variation of the output with circuit tuning. This is defined entirely by the product

$$Y_c \mid y_1 + y_2 \mid$$

which is investigated for a set of particular values in the following section.

5. Application to a Particular Circuit.

The circuit considered is that shown in Fig. 1. The operator y (*i.e.*, v/e vectorially) is given by

$$y = \frac{1}{(1 - \omega^2 LC) + j\omega CR}$$

For a given value of ω, the resonant capacity C_r is

$$C_r = L/(R^2 + \omega^2 L^2)$$

For simplicity in calculation y is more suitably expressed in the form of the circular locus

$$y = \frac{R - j\omega L}{2R}(1 + \epsilon^{-2j\psi})$$

where $$\tan\psi = \frac{\omega L}{R}\frac{\delta C}{C_r}$$

(This transformation is detailed in Appendix 2).

Putting $$\frac{R - j\omega L}{2R} = r_1 \epsilon^{j\phi_1}$$

and $$1 + \epsilon^{-2j\psi} = r_2 \epsilon^{j\phi_2}$$

$$y = r_1 r_2 \epsilon^{j(\phi_1 + \phi_2)}$$

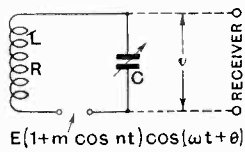


Fig. 1.

Here r_1 and ϕ_1 are constants with respect to δC (the change in capacity from C_r) while r_2 and ϕ_2 can be tabulated as functions of ψ, ψ itself being a function of δC.

By assigning to ω the values ω, $\omega - n$, $\omega + n$ in succession, the values of Y_c, Y_1, Y_2 and θ_c, θ_1, θ_2 can be determined over the relevant range of values of C. The process is clearly a laborious one and did, in fact, take a very considerable time. It involves the determination of the resonance curves corresponding to each individual component v_c, v_1 and v_2 and their combination in the manner indicated above.

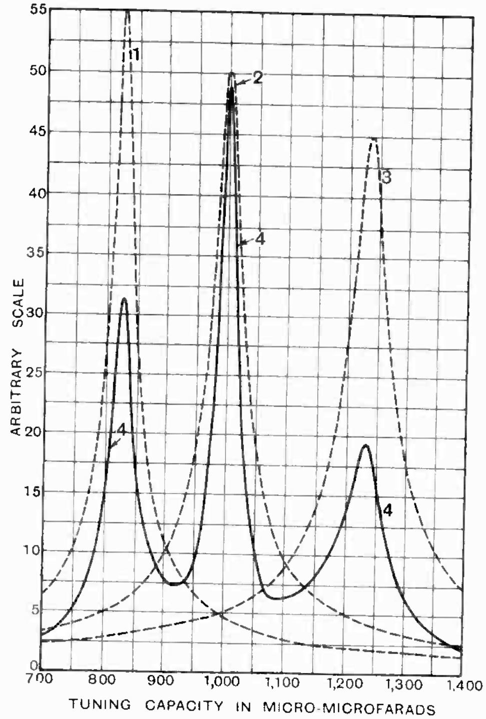


Fig. 2.—1, 2, 3, *Calculated resonance curves corresponding to carrier and side frequencies, assuming equal e.m.f.'s for each.* 4, *Calculated variation of the modulation frequency output with tuning capacity. Carrier frequency* = 80 *kC/s. Modulation frequency* = 8 *kC/s.*

The following numerical values were assumed :—

$\omega = 5 \times 10^5$, *i.e.*, $\lambda = 3{,}768$ metres.

$n = 5 \times 10^4$, *i.e.*, modulation frequency = 7,960.

$L = 4$ millihenries.

$R = 40$ ohms.

$\omega L = 2{,}000$ ohms.

$$\frac{\omega L}{R} = 50$$

The result is shown in Fig. 2, which gives the resonance curves of the circuit for each frequency component of the modulated wave, and the modulation frequency output, plotted against C.

6. Discussion of the Result.

(*a*) In this particular case there are three distinct peaks in the output curve. This is a fairly extreme case ($n/\omega = 1/10$). In many practical cases the peaks will be less distinct and separate, the curve showing a single peak with lateral inflexions, or even nothing more than a broadening of the single central peak due to the coalescence of the side peaks with it. An attempt has been made to obtain some general conclusions on this matter by analysis of the expression $Y_c \mid y_1 + y_2 \mid$ as a function of C, but the function when stated in full is unmanageably complicated, as might be expected from the fact that it has five critical values. It is fairly clear, however, that the greater the ratio of n to ω and the greater the value of $\omega L/R$, the greater will be the distinctness of the three individual peaks. The subject is comparable with resolving power in optics.

(*b*) The peaks of the modulation frequency output curve will not correspond exactly with the capacities corresponding to the individual side frequency maxima. In general, however, the difference will be exceedingly small.

(*c*) The centre peak is the only one the tuning capacity of which will be independent of modulation frequency. Thus if the carrier were modulated with, say, frequencies of 4,000 and 8,000 cycles, there would be five peaks in all, two 8,000-cycle peaks outside with two 4,000-cycle peaks inside them and a centre peak common to both modulation frequencies. As already pointed out, however, these peaks would not be resolvable except with a fairly low carrier frequency and a highly selective circuit.

(*d*) The side peaks are not symmetrical in respect of height or width. This is due to the fact that they are dependent on side-frequency tuning curves which themselves differ in width, the selectivities being $(\omega - n)L/R$ and $(\omega + n)L/R$ respectively. In the case analysed R has been assumed constant, and this gives a higher and narrower peak for the $(\omega + n)$ maximum. If, however, the circuit is such that R increases rapidly as the tuning capacity is reduced, then the $(\omega + n)$ maximum might be higher than the $(\omega - n)$ maximum. This case has been realised in practice and will usually occur when there is an appreciable shunt load on the tuned circuit.

(*e*) *Side-band cutting with square law rectification.*

From the formulæ already given it is a straightforward matter to calculate the variation of the modulation frequency output with modulation frequency, the circuit being assumed to be tuned to the centre peak. The formulæ resulting are somewhat complicated in the perfectly general case, but if it be assumed that $R/\omega L$ and n/ω are both small compared with unity, the following simple results are derived :—

Putting

$$\frac{R}{\omega L} = \delta \text{ and } \frac{n}{\omega} = a$$

$$Y_c = \frac{1}{\delta}\ \theta_c = -\pi/2$$

$$Y_1{}^2 = Y_2{}^2 = \frac{1}{4a^2 + \delta^2}$$

$$\theta_{1,2} = -\tan^{-1} \pm \frac{\delta}{2a}$$

the upper sign corresponding to suffix 1 (*i.e.*, $\omega - n/2\pi$)

Under these conditions

$$Y_c \mid y_1 + y_2 \mid = Y_c(Y_1 + Y_2) = 2Y_1Y_c$$
$$= \frac{1}{\delta}\,\frac{2}{\sqrt{4a^2 + \delta^2}}$$

The limiting value of this when a tends to zero is $\frac{2}{\delta^2}$.

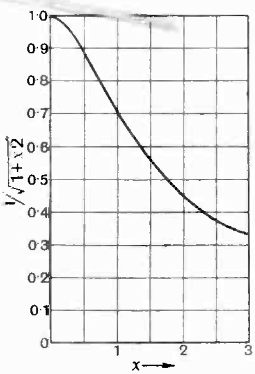


Fig. 3.

Thus, if ρ be the ratio of the modulation frequency output for modulation frequency $n/2\pi$ to the limiting value for zero modulation frequency

$$\rho = \frac{\delta}{\sqrt{4a^2 + \delta^2}}$$

$$= \frac{1}{\sqrt{1 + x^2}}$$

where $x = 2a/\delta$

Thus for $\delta = 0.01$ and $a = 0.01$ (corresponding to, say, 10,000 cycles modulation on a 300-metre wavelength) $x = 2$ and $\rho = 1/\sqrt{5} = 45$ per cent.

The variation of $1/\sqrt{1 + x^2}$ with x is shown in Fig. 3.

7. The Perfect Rectification of a Modulated Continuous-wave Potential Difference.

As already stated, nearly all forms of rectifier will give " square law " rectification with very small signal voltages. In most cases the rectification will tend to perfect

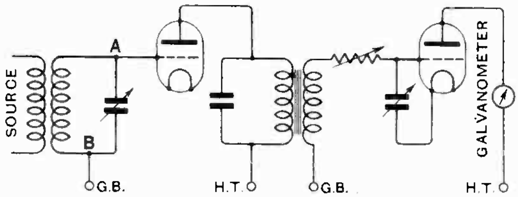


Fig. 4.

rectification as an upper limit with large signal voltages, a perfect rectifier being one having zero conductivity in one direction and finite constant conductivity in the other. In symbols

$$i = \phi(v) = av \text{ when } v > 0$$
$$= 0 \text{ when } v < 0.$$

The expression for the modulation frequency output in the case under consideration is easily formulated. In vector form it is

$$i_n = (a + jb)\epsilon^{-jnt}$$

where $$(a + jb) = \frac{2}{T_n}\int_0^{T_n} \phi(v)\epsilon^{jnt}dt$$

$$T_n = 2\pi/n$$

and $$v = v_c + v_1 + v_2$$

$$= E_c\left\{Y_c \cos(\omega t + \theta_c) + \frac{\mu}{2} Y_1 \cos(\omega - nt\right.$$
$$\left. + \theta_1) + \frac{\mu}{2} Y_2 \cos(\omega + nt + \theta_2)\right\}$$

Y_c, Y_1 and Y_2, θ_c, θ_1 and θ_2 being more or less complicated functions of the circuit constants and of ω and n. The evaluation of the integral is, however, quite another matter, owing to the difficulties introduced by the discontinuity at $v = 0$. It probably could not be solved except by the expansion of $\phi(v)$ in Fourier series or Fourier integral form and then only with great and probably prohibitive labour. Practically speaking, it seems that no analytical solution can be hoped for. The general character of the solution can, however, be anticipated. The modulation frequency output will involve all three terms v_c, v_1 and v_2, and the tuning maxima of these components will probably be apparent as maxima in the variation of the output with tuning, just as in the case of square law rectification. Experimental evidence of this will be given.

8. Experimental.

Qualitative confirmation of the preceding analysis was obtained by means of the arrangement shown schematically in Fig. 4.

A radio-frequency oscillator, modulated by means of a tuned audio-frequency circuit loosely coupled to an audio-frequency oscillator, was loosely coupled to the tuned receiving circuit. The latter was connected in the usual way to a valve adjusted for anode-circuit rectification, having an audio-frequency transformer in the anode circuit. The audio-frequency potential difference in the secondary of this transformer was measured by means of another rectifying valve with a reflecting galvanometer in the anode circuit, the normal anode current being balanced out in the galvanometer. The galvanometer deflections were proportional to the square of the amplitude of the audio-frequency voltages applied to the grid. These were controlled to a suitable magnitude for square law operation of the second rectifier by means of the resistance and capacity arrangement shown. The radio and audio-frequencies were 40,100 and 4,010 cycles per second respectively.

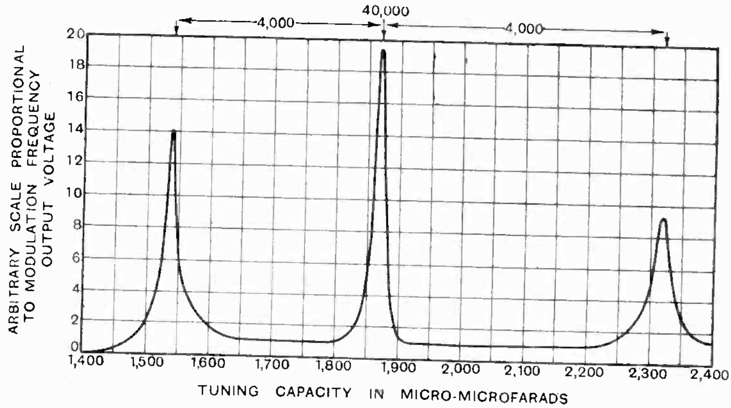


Fig. 6.—*Square law rectification of modulated continuous wave. Radio-frequency, 40,000 cycles/sec. Modulation frequency, 4,000 cycles/sec.*

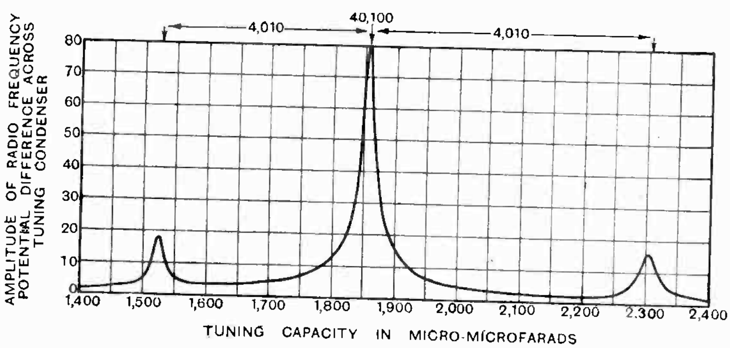


Fig. 5.—*Radio-frequency resonance curve. Radio-frequency, 40,100 cycles/sec. Modulation frequency, 4,010 cycles/sec.*

Fig. 5 shows the radio-frequency resonance curve of the receiving circuit (obtained by transferring the second rectifier valve direct to the terminals of the receiving circuit, marked AB in Fig. 4). The subsidiary peaks due to the side frequencies are evident, and it is noticeable that that due to the $(\omega - n)$ component is sharper than the other.

Fig. 6 shows the variation of the modulation frequency output with the tuning capacity, for the smallest measurable input e.m.f. (square law rectification). It was found that there had been a slight frequency change, about $\frac{1}{4}$ per cent., between the measurements of Figs. 5 and 6, but the effect of this is unimportant. The circuit is of lower damping than that considered in the theoretical case, and the peaks are correspondingly more distinct. The main features of the theoretical conclusions are clearly confirmed, however. There are three peaks, corresponding very approximately to the carrier and side frequency resonances, and the $(\omega - n)$ side peak is both taller and sharper than the other. A first measurement gave the reverse effect of this—the $\omega - n$ peak being lower and broader. It was realised that this might be due to the shunt load imposed by the first detector, which would, of course, produce much heavier damping for a smaller than for a larger tuning capacity. This input load was reduced by connecting a fairly large capacity (0.005μF.) across the primary winding of the transformer. The curve of Fig. 6 was taken under these conditions, and tends to confirm the above supposition. Incidentally, this is a reminder of the fact that an anode-bend rectifier valve may or may not impose an appreciable load on a tuned circuit according to the nature of the load in the anode circuit. Fig. 7 was taken with an input voltage as large as the rectifier valve could handle without any likelihood of saturation on the centre peak. (The mean value of the anode current was less than half the saturation value for the central resonance.) The actual shape of the resonance curve is surprising. It persisted, however, over a large range of variation of the input voltage, and under conditions which precluded grid damping on the centre resonance. The apparent point of discontinuity at the foot of the right-hand side of the centre peak is probably due to a slight excess of negative grid bias, producing a sharp cut off effect for small input amplitudes. In default of a fuller investigation, for which there is at present no opportunity, it cannot be stated whether the recorded effect is inherent in "perfect" rectification, to which the conditions approximated, or whether it is attributable to the rectifier characteristics. In any case, however, the recorded effect is one which will occur when ordinary anode-circuit rectifying valves are used under large amplitude conditions.

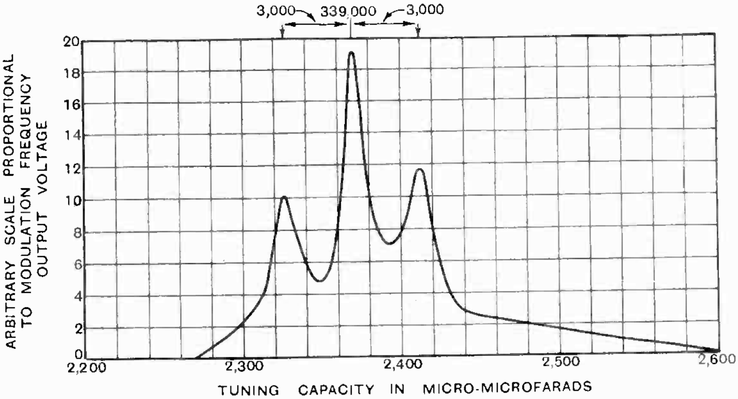


Fig. 8.—*Square law rectification of modulated continuous wave. Radio-frequency,* 339,000 *cycles/sec. Modulation frequency,* 3,000 *cycles/sec.*

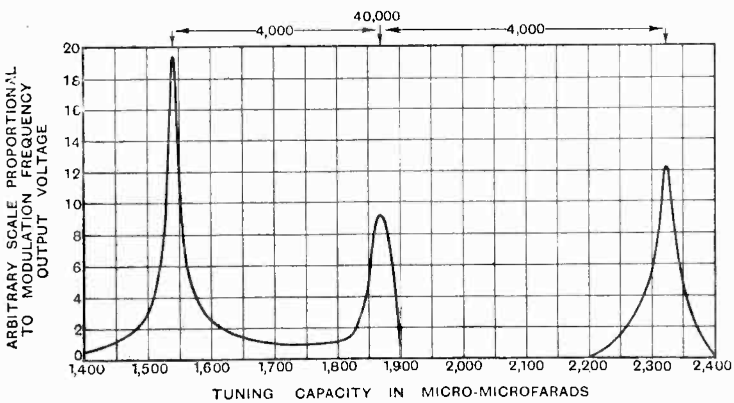


Fig. 7.—*Rectification of modulated continuous wave for large input voltages. Radio-frequency,* 40,000 *cycles/sec. Modulation frequency,* 4,000 *cycles/sec.*

(As a note of warning to any future experimenters—the first measured curve showed a number of auxiliary peaks which completely masked the required effect. This was found to be due to the effects of a high harmonic of the audio-frequency oscillator, heterodyning with the radio-frequency oscillator. The effect was eliminated by fine adjustment of the audio-frequency so that the interfering harmonic was in exact synchronism with the radio-frequency.)

Finally, in order to show that this triple peak effect is not confined to the somewhat academic conditions of the first measurement, where n/ω is larger than will occur in practical telephony, the curve shown in Fig. 8 was taken, corresponding to radio- and audio-frequencies of 339,000 and 3,000 cycles per second respectively. Here the rectification was square law, but it will be observed that the $\omega - n$ side peak is actually a little lower than the $\omega + n$ side peak. The reason for this is not quite certain, but it may be due to the shunt load effect already mentioned, though this was reduced as far as possible by a capacity connected across the primary of the audio-frequency transformer. It must be remembered, however, that the Miller effect load will probably be higher in this than in the preceding cases, owing to the higher frequency of operation.

Conclusions.

The foregoing work demonstrates conclusively the physical reality of the side frequencies of a modulated continuous wave.

It further shows that the reception and rectification of such a modulated continuous wave is a somewhat more complicated matter than is generally realised, and that there is need for a fuller theoretical and experimental investigation of the subject than it has yet received. It is of special interest in relation to broadcast reception.

In conclusion, I wish to thank Mr. A. C. Gordon-Smith for his assistance in this work.

APPENDIX 1.

The square of v is

$$v_c^2 + v_1^2 + v_2^2 + 2v_cv_1 + 2v_cv_2 + 2v_1v_2$$

Now

$$v_cv_1 = Y_1Y_c\frac{mE^2}{2}\{\cos(\omega t + \theta_c)\cos(\omega - nt + \theta_1)\}$$

Applying the formula

$$2\cos A\cos B = \cos(A - B) + \cos(A + B)$$

$$v_cv_1 = Y_1Y_c\frac{mE^2}{4}\{\cos(nt + \theta_c - \theta_1) + \cos(2\omega - nt + \theta_1 + \theta_c)\}$$

Of the terms inside the brackets the first represents a modulation frequency component. A similar component will be derived from v_cv_2 but none of the other terms in v^2 will yield any other modulation frequency components. The total modulation frequency component is therefore as stated in the text.

APPENDIX 2.

Vectorially $\frac{v}{e} = y = \frac{1}{j\omega C\left\{R + j\omega L + \frac{1}{j\omega C}\right\}}$

$$= \frac{1}{(R + j\omega L)\left\{\frac{1}{R + j\omega L} + j\omega C\right\}}$$

$$= \frac{1}{(R + j\omega L)\left\{\frac{R}{Z^2} + j\left(\omega C - \frac{\omega L}{Z^2}\right)\right\}}$$

Where $Z^2 = R^2 + \omega^2 L^2$

Resonance with respect to C is given by

$$\omega C_r = \frac{\omega L}{Z^2}$$

Therefore

$$y = \frac{1}{R + j\omega L}\,\frac{1}{\frac{R}{Z^2} + j\omega(C - C_r)}$$

$$= \frac{1}{R + j\omega L}\,\frac{1}{\frac{R}{Z^2} + j\omega\delta C}$$

δC being $C - C_r$.

$$= \frac{Z^2}{(R + j\omega L)R}\,\frac{1}{1 + jn}$$

$$= \frac{R - j\omega L}{R}\,\frac{1}{1 + jn}$$

where $n = \omega\delta C \cdot \frac{Z^2}{R} = \frac{\omega L}{R}\cdot\frac{\delta C}{C_r}$

Now $\frac{1}{1 + jn} = \frac{1}{2}\left\{1 + \frac{1 - jn}{1 + jn}\right\}$

$$= \frac{1}{2}(1 + \epsilon^{-2j\psi})$$

where $\tan\psi = n = \frac{\omega L}{R}\,\frac{\delta C}{C_r}$

As ψ varies with δC the vector $\frac{1}{2}(1 + \epsilon^{-2j\psi})$ moves round a circle of unit radius, and can therefore be determined very simply by a graphical construction.

The final formula for y is obviously

$$y = \frac{R - j\omega L}{2R}(1 + \epsilon^{-2j\psi})$$

as given in the text.

Effect of Output Load upon Frequency Distortion in Resistance Amplifiers.*

By H. A. Thomas, M.Sc., A.M.I.E.E. (National Physical Laboratory).

1. Introductory.

IT is well known that the input impedance of a valve stage is dependent upon the nature of its anode-circuit load, but it is not fully realised how this effect can be passed successively backwards from the output stage to the first amplification stage of an audio-frequency amplifier. Von Ardenne and W. Stoff† have shown that the amplification of a two or three stage audio-frequency amplifier cannot be calculated by examining each stage separately, but can only be obtained by proceeding backwards, *i.e.*, by calculating the input impedance of the last stage and transferring this to the output impedance of the previous stage and so on. They also state that for a high amplification factor resistance-capacity amplifier the frequency response characteristic of the first stage only is of importance, owing to the output load producing an appreciable modification of the input impedance of the previous stage. This is a somewhat unforeseen conclusion, since, from a cursory examination of the circuits, it would appear that the power stage had a major effect upon the stage immediately preceding it and that this effect would be reduced as the stages were further removed from the frequency distorting cause.

The author first noticed the presence of this distorting effect by measuring the overall amplification of a two-stage resistance-capacity-coupled amplifier followed by a power valve when the loud speaker was in circuit and when it was short-circuited. The difference in the frequency-amplification characteristic for the two cases was noticeable and led to the conclusion that the electrical properties of the loud speaker affected the amplification. As a result of this observed fact an examination was made of the magnitude of this effect, and an attempt was made to establish theoretically the nature of the phenomenon and to see whether the observed results could be explained from the known characteristics of the circuit.

The anode-circuit impedance of the power valve consists of a fairly low differential resistance due to the valve itself in series with the effective impedance of the output mechanism, usually a loud speaker. It is well known that this inductive load will affect the input impedance of the stage, and, since this impedance is in parallel with the anode-circuit impedance of the previous stage, this latter will be modified by the presence of the power-valve stage. The effect of the load is passed through the stages by virtue of the inter-electrode capacities. The circuit arrangement considered as typical

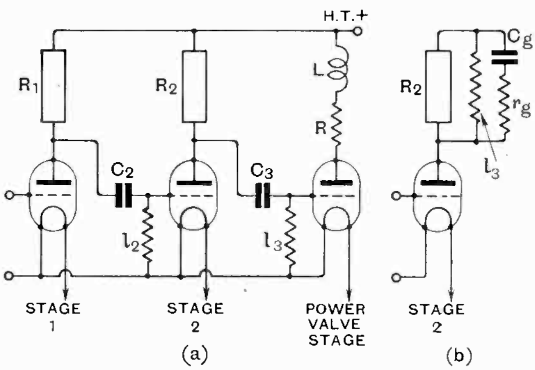


Fig. 1.—*Amplifier circuit.*

of a modern resistance-capacity audio-frequency amplifier is shown in Fig. 1 (a). The two amplifying stages considered are of the resistance-capacity type using high factor valves ($\mu = 40$) with anode resistances of 0.5 megohm and leaks of 2 megohms, followed by a power valve.

2. The Loud Speaker Load.

A standard semi-free-edged diaphragm loud speaker having a D.C. resistance of about 2,000 ohms was used for both the

* MS. received by Editor September, 1929.

† On the Values and the effects of stray capacities in Resistance-Coupled Amplifiers, Von Ardenne and W. Stoff. *Proc. Inst. Radio Eng.*, 1927, Vol. 15, pp. 895–901.

theoretical and experimental investigation. Its effective resistance, reactance and impedance was measured at various audio-frequencies and the results are shown graphically in Fig. 2. It was found that the motional resistance and reactance was so small that the curves apply to either the clamped or free condition. It will be noticed that the effective resistance rises very rapidly as the frequency rises. The inductance falls slightly with rising frequency and the impedance approximately obeys a linear relationship with respect to frequency change.

3. The Input Impedance of the Power Valve Stage.

A typical power valve was taken for use with this loud speaker, in which the voltage factor was 6.25 and the internal differential resistance was 6,250 ohms.

The inter-electrode capacities were of the order of 10 $\mu\mu$F each, and for the purpose of calculation C_{GF}, C_{AF} and C_{GA} were all assumed to have a value of 10 $\mu\mu$F and to be pure, *i.e.*, their power factor zero.

Miller* gives the input impedance in the form of a resistance and condenser in series in which

$$r_g = \frac{ac + bd}{c^2 + d^2}$$

and

$$c_g = \frac{c^2 + d^2}{\omega(ad - bc)}$$

where r_g is the resistance component of the input impedance and c_g is the effective capacity component. Where

$$a = R_p(C_2 + C_3) + \frac{L_p}{r_p}$$

$$b = \omega L_p(C_2 + C_3) - \frac{R_p}{\omega r_p} - \frac{1}{\omega}$$

$$c = \frac{R_p}{r_p}(kC_2 + C_1 + C_2) + C_1 + C_2 - \omega^2 L_p(C_1C_2 + C_1C_3 + C_2C_3)$$

and

$$d = \frac{\omega L_p}{r_p}(kC_2 + C_1 + C_2) + \omega R_p(C_1C_2 + C_1C_3 + C_2C_3)$$

in which R_p and L_p represent the effective resistance and inductance of the anode circuit load respectively.

k = the voltage factor of the valve.

r_p = the differential resistance of the valve.

C_1 = Inter-electrode capacity filament-grid.

C_2 = Inter-electrode capacity grid-anode.

C_3 = Inter-electrode capacity filament-anode.

Inserting the measured and assumed values in the above expressions, the input impedance of the power stage was determined for the following twelve frequencies :—100, 250, 500, 750, 1,000, 2,500, 5,000, 6,000, 7,000, 8,000, 9,000, 10,000. Curve 1 of Fig. 3 shows that the resistance component of the input impedance r_g is negative and has a large value at low frequencies.

The effective input capacity c_g is shown in Fig. 3, curve 2, the capacity rises from 29 $\mu\mu$F, at 100 cycles to 80 $\mu\mu$F, at 10,000 cycles.

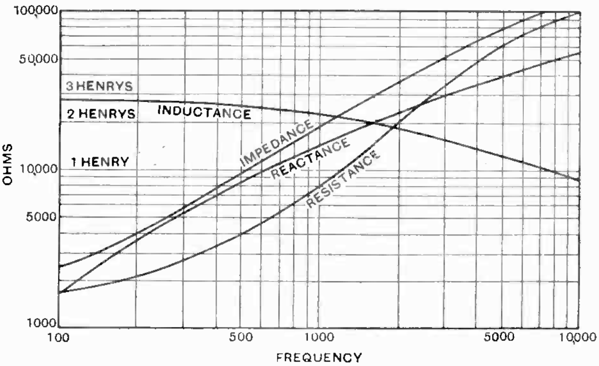


Fig. 2.—*Characteristics of loud speaker.*

If the loud speaker were short-circuited, r_g would be zero and c_g would equal $C_1 + C_2$ = 20 $\mu\mu$F.

4. The Anode Circuit Impedance of Stage 2.

Referring back to Fig. 1 (a), we see that the coupling condenser C_3 and grid leak l_3

* J. Miller, "Dependence of the Input Impedance of a Three-Electrode Vacuum Tube upon the load in the Plate Circuit." Scientific Papers of Bureau of Standards, No. 351.

in series form a shunt to the anode resistance R_2 of Stage 2. Now the reactance of C_3 can be made as small as we choose by

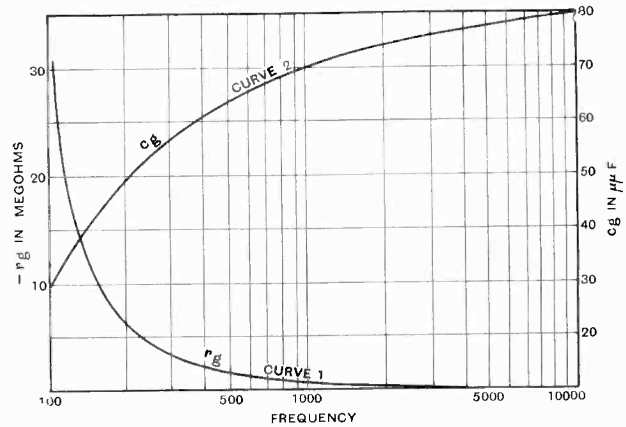


Fig. 3.—*Equivalent input impedance of the power stage.*

suitably increasing the value of C_3. If C_3 is 0.1 μF, its reactance at 100 cycles will be 0.0159 megohm, and since this reactance is vectorially added to the grid leak resistance l_3, which is usually 2 megohms, the total impedance of this circuit is 2+ 0.0159 megohms, which is 2.00012, so we can neglect the effect of the coupling condenser C_3.

The anode load of Stage 2 may, therefore, be represented as in Fig. 1 (b) in which r_g and c_g form a shunt to the anode resistance R_2 and the grid leak l_3 in parallel.

Taking the anode resistance as 0.5 megohm, the resistance of the anode resistance and 2 megohm leak in parallel will be 0.4 megohm. For the combination of a resistance R shunted by r_g and c_g in series, we have

$$\frac{1}{Z_2} = \left[\frac{1}{r_g + \frac{1}{j\omega c_g}} + \frac{1}{R} \right]$$

where Z_2 is the net impedance of the anode load of stage 2. Therefore,

$$Z_2 = \frac{R[1 + jr_g\omega c_g]}{1 + j\omega c_g(R + r_g)} = \frac{R + jh}{1 + jd}$$
$$= \frac{(R + bd) + j(b - Rd)}{1 + d^2}$$

where

$$b = Rr_g\omega c_g$$

and

$$d = \omega c_g(R + r_g)$$

The real term

$$= \frac{R + bd}{1 + d^2} = R_1$$

and the imaginary term

$$= \frac{b - Rd}{1 + d^2} = X_1$$

Inserting the known values of r_g and c_g, from the previous section, we obtain values for R_1 and X_1 shown graphically in Fig. 4.

Two cases have been taken over the frequency range, with the loud speaker load inserted and with this load short-circuited. These two cases will be spoken of as the loaded and unloaded conditions respectively. It will be seen that the effective resistance falls more rapidly as the frequency rises with the load inserted than when this loud speaker load is not present.

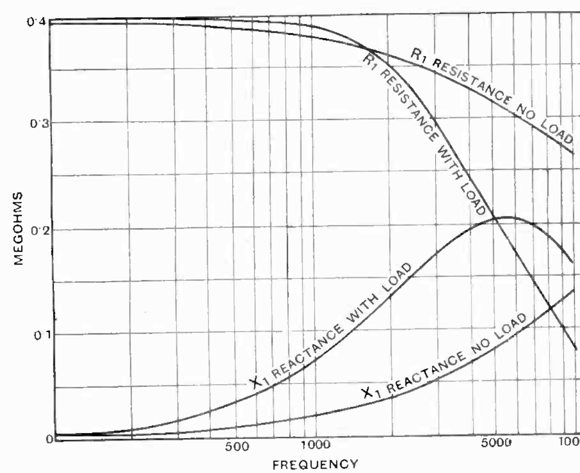


Fig. 4.—*Effective resistance and reactance of anode circuit of Stage 2.*

The reactance passes through a maximum value at about 5,500 cycles per second and is negative. For convenience in plotting, this reactance has been considered as positive.

5. Amplification of Stage 2.

The amplification of a single stage (K) is given by the following expression :

$$K = \frac{k + j\omega r_p C_2}{1 + \frac{r_p}{Z} + j\omega r_p(C_2 + C_3)}$$

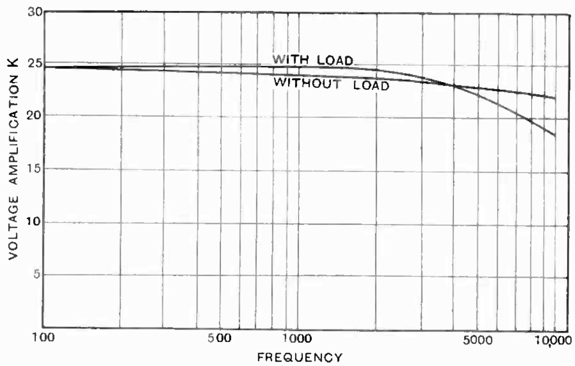


Fig. 5.—*Amplification of Stage 2.*

where k is the voltage factor of the valve

r_p is the differential resistance at the normal working point.

Z is the anode impedance

C_2 and C_3 are the inter-electrode capacities, grid-anode and anode-filament respectively.

We will consider the case of a typical dull emitter valve in which k is 40.

The measured inter-electrode capacities were as follows :—

$$C_{PF} = 7.0\ \mu\mu\text{F} = C_3$$
$$C_{GF} = 5.0\ \mu\mu\text{F} = C_1$$
$$C_{GP} = 4.8\ \mu\mu\text{F} = C_2$$

We will assume that $C_1 = C_2 = C_3 = 5.0\ \mu\mu$F, to simplify the equations and obtain an approximate solution.

The differential resistance may be taken as 0.25 megohm. Using these values, we obtain the amplification for the second stage, shown in Fig. 5.

The effect of the input impedance of the power stage acting as a shunt to the anode impedance of the second stage is shown in this figure, which shows that the amplification at various frequencies is dependent upon the power stage and its output load circuit in such a manner as to improve the uniformity of amplification at medium frequencies of from 300 to 3,000 cycles per second, but causing a marked decrease in amplification at frequencies above 5,000. At low frequencies, the amplification is given by the simple relationship

$$K = \frac{kR}{R + r_p} = \frac{40 \times 0.4}{0.4 + 0.25} = 24.6$$

where R is the inserted anode resistance and r_p is the differential resistance of the valve.

6. The Input Impedance of Stage 2.

Using the equations of Section 3, with the anode impedance of Stage 2 derived in Section 4, we can now calculate the input impedance of Stage 2 with and without the output load. These results are shown graphically in Fig. 6. The value of c_g is much larger than for the power valve, owing to the high voltage factor of the valve.

7. The Anode Circuit Impedance of Stage 1.

Using the expression derived in Section 4, we now obtain values of R_1 and X_1 for Stage 1. These are shown in Fig. 7. It will be noticed that the difference between the loaded and unloaded condition is here less marked than in the previous cases of Stage 2.

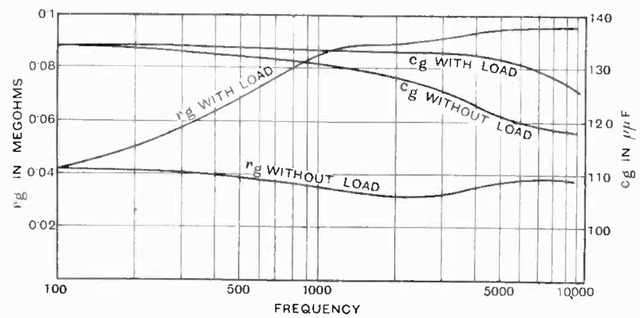


Fig. 6.—*Equivalent input impedance of Stage 2.*

8. The Amplification of Stage 1.

Using the equations of Section 5 and inserting the values of R_1 and X_1 from Section

7, we now obtain the voltage amplification for Stage 1. Fig. 8 shows how the amplification is dependent upon the power-stage load. Its effect is less marked than in the case of Stage 2, but the actual drop in amplification at high audio-frequencies is somewhat greater than that in Stage 2, due to the fact that Stage 1 is followed by a high factor valve having a large effective input capacity component, whereas Stage 2 is followed by a low factor valve.

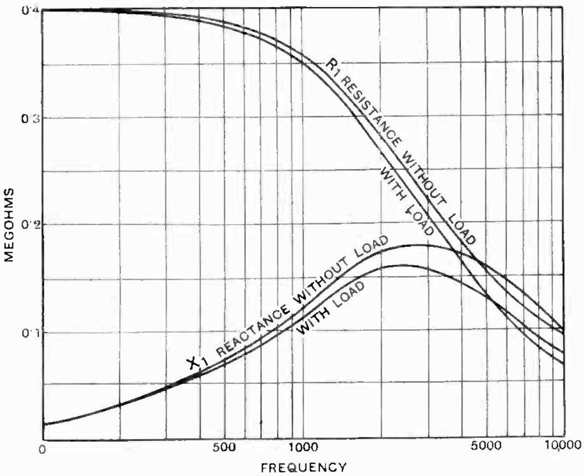


Fig. 7.—*Effective resistance and reactance of anode circuit of Stage 1.*

9. Overall Amplification.

The product of Stage 1 and Stage 2 gives the value of the overall amplification from the input of Stage 1 to the input of the power valve, and this is plotted in Fig. 9.

A reduction of amplification is obtained at high audio-frequencies and this reduction is more marked when the load is present than when it is absent. This curve shows that the nature of the output load affects the behaviour of the amplifier to a considerable extent.

10. Experimental Results.

A two-stage resistance-capacity-coupled amplifier was used, consisting of two high voltage factor valves, ½ megohm anode resistance, 2 megohm leaks and 0.1 μF. coupling condensers. The power stage consisted of a low voltage factor valve and a loud speaker having the characteristics shown in Fig. 2. The general measuring arrangement is shown in Fig. 10. The audio-frequency oscillator supplied a small current to a resistance of 1 ohm, R, the potential difference across this resistance being applied to the first stage. Since its resistance was so low, the shunting effect of the amplifier was negligible. The voltage produced on the grid of the power valve was measured by a valve voltmeter. This instrument produced a small loading effect, but since the experimental test was designed to record the difference in the amplification frequency characteristic with the load inserted and with it short-circuited, this load produces a negligible modifying element. It is usually wiser to connect the voltmeter across a low resistance of about 100 ohms inserted in series with the loud speaker, and this is always done in accurate measurement work, since its presence produces a negligible effect upon the circuit conditions, but for the purpose in hand the grid-filament connection is admissible. The results obtained are shown in Fig. 11.

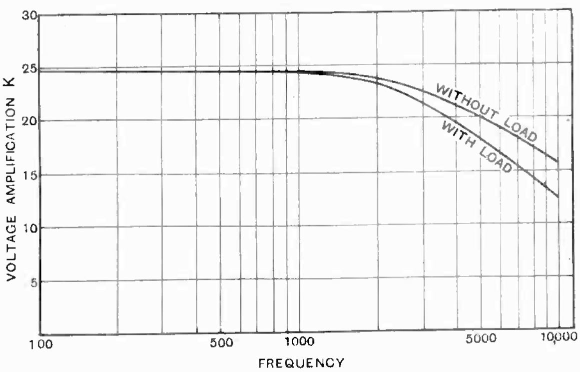


Fig. 8.—*Amplification of Stage 1.*

These experimental results were obtained to confirm the general theoretical results. The actual values in the experimental case are only approximately those assumed in the analysis, and consequently close agreement is not to be expected.

11. Summary of Results Obtained.

(*a*) When a loud speaker load is inserted into the power stage of an amplifier, the overall amplification of the preceding amplifier is modified by its presence and the amplification at high audio-frequencies is dependent on the nature of the output load and is always less than in the no-load case.

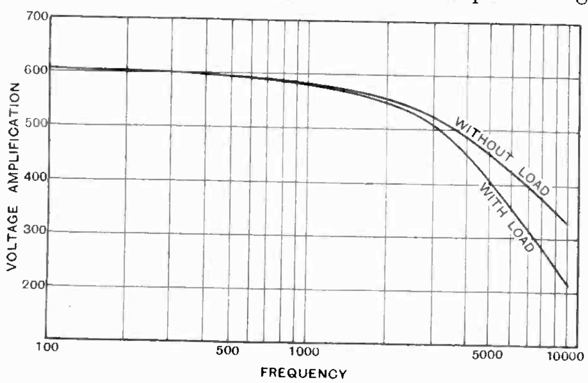


Fig. 9.—*Overall amplification of amplifier as shown in* Fig. 1 (*a*).

(*b*) The reduced amplification due to the load at high audio-frequencies is chiefly dependent upon the anode-grid capacity of the power valve. This fact was confirmed by deliberately increasing this anode-grid capacity by means of the small condenser shown at C, Fig. 10. The drop in amplification at high audio frequencies could be greatly increased by the insertion of such a small capacity.

(*c*) The frequency distorting effect is also largely due to the high effective input-capacity of high-factor stages, this effect being only slightly dependent upon the nature of the output load.

12. Case of 3 Stages of Low Factor Valves.

The amplification of the previous two-stage amplifier was taken as 615. It is interesting to compare the type of characteristic obtained in Fig. 9 with that which would be obtained by using three stages of lower factor valves in place of two stages of high factor valves, such that the total amplification in this latter case was the same as before, viz., 615. To do this, we require K^3 to equal 615 at very low frequencies where the inter-electrode effects are negligible, K being the stage factor in the latter case. This condition gives $K = 8.46$ and, assuming the same anode resistance of 0.5 megohms shunted by the leak of 2 megohms, we obtain the required voltage factor of the valve as 13.75. Thus three such lower factor stages will give the same amplification at very low frequencies as the previous two high factor stages.

If the same procedure is undertaken with this case it will be found that, although the effective input capacity of each individual stage is less than in the two stage case, the product of the three stages gives a frequency-amplification characteristic which is very nearly identical with the one already given in Fig. 11.

We thus arrive at the conclusion that such frequency distortion is inherent in any

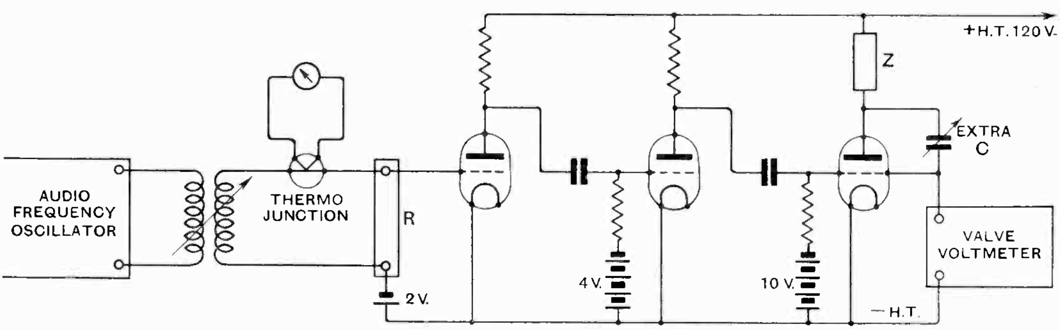


Fig. 10.—*Circuit arrangement adopted in experimental work.*

normal type of resistance-capacity-coupled amplifier employing triode valves, and that there appears to be no advantage in using a larger number of low factor stages in cascade.

The work described in this paper was carried out as part of the programme of the Radio Research Board, and the author is indebted to the Department of Scientific and Industrial Research for granting permission for publication.

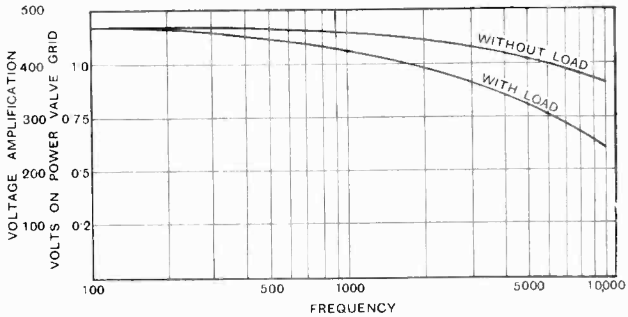


Fig. 11.—*Overall amplification of 2-stage amplifier obtained experimentally.*

Book Reviews.

Elementary Principles of Wireless Telegraphy and Telephony.

By R. D. Bangay.

Third Edition. Revised by O. F. Brown, M.A., B.Sc. Price 10s. 6d. Iliffe & Sons, Ltd.

This is a revised and modernised version of a book whose earlier editions have proved of great assistance to the beginner and student of Wireless Telegraphy. Revised by O.F. Brown, M.A., B.Sc., of the Radio Research Board, the present volume is brought up to date by the addition of material, chiefly as a continuation of Bangay's own work. The first twelve chapters constitute almost entirely the work of the original author, whose characteristically lucid methods of dealing with the elementary principles of electricity and magnetism, dynamos, transformers, oscillatory circuits, etc., are considered by the reviser to form one of the best means of introduction to the principles of valve circuits and modern methods. This part of the book relates almost entirely to matters concerned with the production and reception of damped oscillations.

The reviser has added 114 pages comprising fifteen chapters in which he covers a remarkably wide field chiefly devoted to valves and valve circuits. Among other items, chapters are devoted to a review of alternating current theory, principles of thermionic valves, valve amplifiers and detectors, radio transmitters, H.T. eliminators, loud speakers and radio direction finding. The phraseology throughout is clear and to the point and the book will prove of great educational value.—S.O.P.

Alternating Current Bridge Methods.

By B. Hague, D.Sc., Ph.D.

xvi + 391 pp., with 112 Figs. Pitman, 15s.

This is a second revised and enlarged edition of this well-known handbook. Although, according to the title page, it deals with the measurement of inductance, capacitance and effective resistance at low and telephonic frequencies, it really covers a much wider field. It is described as a theoretical and practical handbook for the use of advanced students, but in our opinion it will prove indispensable to anyone concerned in any way with A.C. bridge measurements. The only branch of the subject which is not specifically considered is that of bridge measurements at radio frequencies which introduce many new problems and call for a special technique. The first two chapters are devoted to fundamental principles of alternating currents and the symbolic method of treatment. The third chapter deals with the apparatus required in A.C. bridge work; this chapter runs to 135 pages; the essential characteristics of every piece of apparatus are fully discussed. Chapter IV is devoted to a description and analysis of every known A.C. bridge method, with a discussion of their applicability, sources of error, advantages and disadvantages. The last chapter will prove of special benefit to experimenters; it is entitled "the choice of a bridge method and precautions to be observed when using it." Schering of the Reichsanstalt, the inventor of the Schering Bridge, reviews this book in the *Elektrotechnischer Zeitschrift* of 16th October. He says that the whole literature of the subject is worked up and presented with marvellous completeness and that the presentation is clear and precise, and shows the author to have a thorough mastery of the wealth of material. With this opinion we are in entire agreement. G.W.O.H.

PHYSICAL AND OPTICAL SOCIETIES' EXHIBITION.

The twenty-first Annual Exhibition of the Physical and Optical Societies will be held at the Imperial College of Science, South Kensington, on January 6th, 7th, and 8th. It will be formally opened on Tuesday, January 6th, at 2.30 p.m. by Sir Arthur Eddington, F.R.S., and will continue open from 3 p.m. to 6 p.m., and from 7 p.m. to 10 p.m. each day

Two Discourses, with experiments, will be given at 8.0 p.m. on the second and third days: on January 7th Mr. E. Lancaster-Jones will speak on "Searching for Minerals with Scientific Instruments," and on January 8th, Prof. Sir Gilbert Walker, F.R.S., will give a short lecture on "Physics of Sport."

Admission on the first two days is by ticket only, for which application should be made to the Secretary, 1, Lowther Gardens, Exhibition Road, S.W.7.

Interaction in Amplifiers.*

With Special Reference to Common Impedance in Filament Circuits.

By L. Bainbridge-Bell.

SUMMARY.—Attention is drawn to a generally unsuspected cause of retroaction (common impedance in the filament battery circuits) and methods of prevention are discussed.

APART from the introduction of valves with high amplification factors (and to a great extent consequent on the high interstage gain made possible by such valves) the most marked improvement in the technique of amplification during recent years has been the diagnosis and elimination of various types of accidental retroaction between different circuits.

Capacitative coupling is prevented by metallic screens, inductive coupling is reduced by the use of toroidal or other astatic coils and by twisting leads carrying alternating currents.

Resistance coupling (due to resistance in leads or components common to two circuits) can be divided into three types.

(*a*) Resistance in common leads.

This can be cured by taking leads from valves, etc., separately to the battery terminals, instead of using "bus bar" systems of wiring.

(*b*) Coupling due to resistance in the source of high tension.

This trouble had been reduced considerably by the substitution of accumulators for dry batteries, but recently has again become important owing to the increasing use of battery eliminators which must necessarily have a considerable internal resistance. It can be cured in almost every case by a device sometimes called an "anode decoupling" arrangement. This consists of offering a high impedance Z Fig. 1 to the alternating component of the anode current in the H.T. battery circuit, and furnishing a comparatively low impedance path to this component by means of a condenser C connected to the filament of the valve. To make this arrangement efficient at low frequencies, Z should be a resistance, as the impedance of a choke may not be sufficient. The use of a resistance instead of a choke is due (the writer believes) to Messrs. Ferranti, Ltd.

(*c*) Coupling due to resistance in grid bias batteries.

This can be overcome as in (*b*) above.

(*d*) Coupling due to resistance in common filament leads or filament batteries.

This is only experienced when a high overall amplification is employed, and is an effect which is very seldom suspected. The mechanism of this coupling can best be understood by regarding the emissive surface of the filament of a valve as concentrated at two points respectively at its positive and negative ends, these points being connected by a (non-emitting) resistance equal to the resistance of the filament.

Considering only the alternating component of the anode current, this can be regarded as flowing from the anode through the anode load, and (*a*) through the H.T. battery te the $-^{ve}$ end of the filament, or (*b*) (if tho decoupling scheme is employed, as is essential in all high gain amplifiers) through the condenser C to the $-^{ve}$ end of the filament. In each case the current then divides, and half flows out of the (supposed) source at the $-^{ve}$ end of the filament, half flowing through the L.T. battery and its associated circuits out of the source at the positive end of the filament. This assumption is based on the following facts :

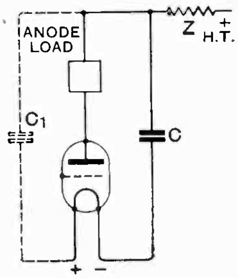


Fig. 1.

(1) The anode impedance is high compared with that of the filament or L.T. battery.

(2) The L.T. battery has a low resistance compared with that of the filament.

If the alternating component of the anode current has a value i and half of this flows

* MS. Received by the Editor, May, 1930.

through the L.T. battery circuit (of resistance R), it will cause a drop of $\frac{1}{2} iR$ in the battery.

If the valve considered above is the output valve of an amplifier, and the input valve of the amplifier is supplied from the same battery, the latter will have an alternating voltage of $\frac{1}{2} iR$ across its filament. Now, if the grid of the input valve is based (through the input impedance and possibly a biasing battery) on the negative end of the filament, the effect of the alternating voltage $\frac{1}{2} iR$ across the filament can be regarded as equivalent to a voltage of $\frac{1}{4} iR$ on the grid and zero A.C. voltage across the filament. If the amplification between the grid of the input valve and the anode of the output valve is A, this will produce an effect $\frac{1}{4} iRA$ at the output with a change of phase dependent on the intermediate circuits of the amplifier.

In order to check the above reasoning, the circuit shown in Fig. 2 was set up. V_1 and V_2 are respectively the input and output valves of an amplifier, and the existence of coupling between these was suspected. A valve circuit V_3 similar to that of V_2 was set up, fed from the same L.T. battery, as it was argued that any effect of V_2 on V_1 would be the same as that of V_3 on V_1 but with the difference that the effects were more easily separable by this arrangement. The output circuits of V_2 and V_3 (audio-frequency transformers) were connected to the plates Y,X of a cathode ray oscillograph. The grid of V_1 was connected to the $-^{ve}$ end of its filament, and the grid of V_3 was connected to a well-screened oscillator. The gain of the amplifier (expressed as a ratio of volts at Y to volts at the grid of V_1) was 4×10^5, *i.e.*, 112 decibels. The pattern produced on the screen of the cathode ray oscillograph (in the absence of coupling) would be a horizontal straight line. It was actually an ellipse with a ratio of minor and major axes of 1 to 12, showing that there existed at Y a voltage one-twelfth of that at X and out of phase with the latter. The current i in the anode circuit of V_3 was 1.24 *ma* when the voltage at Y was 5 volts. The resistance of the L.T. battery and its leads was $0.038\ \Omega$. Inserting these values in our expression ($\frac{1}{4} iRA$) developed above, the calculated voltage at Y is $\frac{1}{4} \times 1.24 \times 10^{-3} \times 0.038 \times 4 \times 10^5 = 4.7$ volts: a fair agreement with the observed figure of 5 volts.

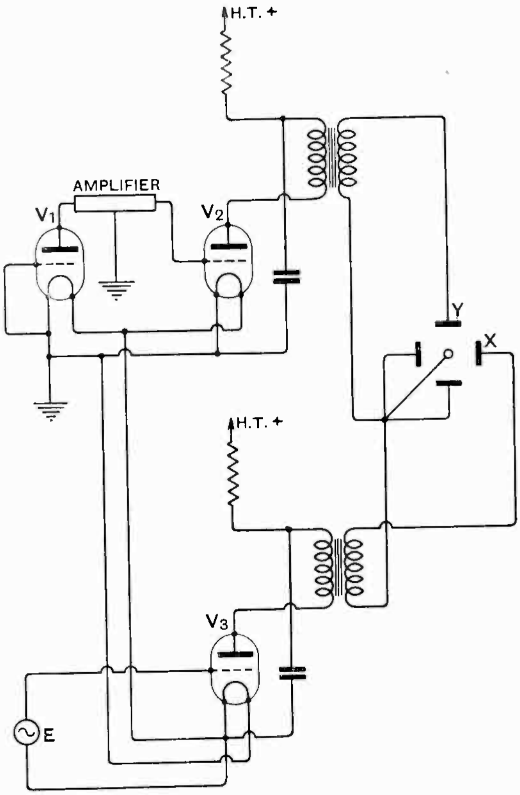


Fig. 2.

The Prevention of Coupling via L.T. Circuits.

The methods of prevention of reaction between two circuits A and B can always be divided into three categories: (it being supposed that A is the source of the harmful voltage):—Modifications (I) to A, (II) to the channel of communication (coupling) between A and B, (III) to B.

Method I.—This has as its object the prevention of the A.C. component of the anode current flowing through the L.T. battery. (*a*) Another condenser C^1 can be connected from the junction of C and Z (Fig. 1) to the positive end of the filament, C and C^1 being matched. (*b*) The condenser C can be connected to a potentiometer connected across the filament, or, when using an L.T. battery with an even number of cells, can be connected to the centre point of the

L.T. battery. (*c*) Valves with indirectly heated cathodes can be used.

Method II.—(*a*) The filament supply to the input and output valves can be completely separated. (*b*) Chokes can be introduced in the filament leads.

Method III.—(*a*) The grid of the input valve can be based (through the input impedance and biasing battery) on the centre point of the L.T. battery or a potentiometer connected across the filament. (*b*) indirectly heated valves can be used.

In the particular apparatus under review, I (*a*) and (*c*) II (*a*) and III (*a*) and (*b*) were tried, all with success. It is considered that I (*a*) is the best solution. II (*b*) was not tried as valves with large (.7 *a*) filament currents were in use, and any effective chokes would have necessitated higher voltage L.T. batteries.

The writer would like to draw attention to an article by G. Lubszynski† in which the cross-talk through L.T. and H.T. battery couplings is treated quantitatively, and the use of Method II (*b*) alone considered. In a subsequent note‡ by the same author, the use of indirectly heated valves is suggested.

The writer is indebted to the Department of Scientific and Industrial Research for permission to publish these results, which have been obtained in connection with the work of the Radio Research Board.

† *E.N.T.*, Dec., 1929, p. 500.
‡ *E.N.T.*, Jan., 1930.

Correspondence.

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

A Rule for the Impedance of Parallel Circuits.

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

SIR,—It is a little difficult to appreciate the significance of your correspondent, Mr. Fleming's "rule" for the impedance of parallel circuits.

If any impedance z is brought to the symbolic form

$$z = \frac{A + jB}{C + jD}$$

where A, B, C, D are real, the absolute value of the impedance may be written

$$Z = \frac{\sqrt{A^2 + B^2}}{\sqrt{C^2 + D^2}}$$

If Mr. Fleming will use this "rule" for each of his three examples, he will find that a still greater saving of labour will result.

W. A. BARCLAY.

Arcadia, Bieldside, N.B.

"Parmeko" Public Address Amplifier.

A description of the "Parmeko" Public Address Amplifier for cinema and hotel work was given in connection with our review of the Olympia Radio Show, 1930, in the issue for November last.

We have been asked to point out that in the two diagrams reproduced the chokes have been inadvertently drawn as low frequency instead of high frequency chokes. Also, on page 607, in the diagram, Fig. 5 (*b*), the spark gap should be shown on the other side of the chokes and should be a spark gap with a centre point earthed. The spark gaps vary in size according to the valves in use and, in most cases, a gap of ⅛in. is sufficient.

On the same page, at the top of the first column, half an inch of mica between windings should read $\frac{1}{32}$in.

Books Received.

EASY LESSONS IN TELEVISION. By R. W. Hutchinson, M.Sc.

A book for non-technical readers, explaining the elementary principles of Electricity and Light and describing the Apparatus used in Television with the purpose and use of each component, with a chapter on Tele-Cinematography, Tele-Talkies, Tele-photography, etc. Pp. 175+vi with 129 illustrations and diagrams. Published by the University Tutorial Press, Ltd., London. Price 1s. 9d.

THE ELECTRICAL EDUCATOR. (Second Edition.) Edited by Sir A. Fleming, M.A., D.Sc., F.R.S.

This publication, which is being issued in 28 Fortnightly parts, is the combined work of a large staff of experts and specialists, and covers the whole field of Heavy Current Electrical Engineering, with special sections on wireless subjects. In its complete form it will comprise about 1,500 pages, with many diagrams and illustrations. Part I includes a chapter on the Education of Electrical Engineers, 11 chapters on Electricity and Magnetism, and the preliminary pages on Direct Current Dynamos. Part II will be ready on 18th October. Published by Sir Isaac Pitman & Sons, Ltd., London. Price each part, 1s. 3d. net.

A CATALOGUE OF BRITISH SCIENTIFIC AND TECHNICAL BOOKS.

New and Revised edition, comprising books published by British firms and in their lists up to September, 1929. The sections devoted to General Physics and to Electrical Engineering cover 41 pages, of which the sub-section relating solely to Wireless Telegraphy, Telephony and Television, comprises the names of 118 books by well-known authorities. Pp. 754 + XXI, compiled by The British Science Guild and sold by A. & F. Denny, Ltd., London. Price 20s. net.

A Simple Capacity Test Set.*

Suitable for the Wireless Experimenter's Laboratory.

By W. H. F. Griffiths, F.Inst.P., A.M.I.E.E.

WIRELESS receivers and circuits on which experiments are being conducted consist chiefly of inductances and condensers. In fault tracing ordinary continuity or D.C. resistance tests and simple inspection will often suffice to check the former components, but the latter must be measured for capacity if any reliable check is to be obtained.

Since the capacities of the condensers of most "wireless" circuits may vary from $50\mu\mu$F. to a microfarad and the relative bulk of the units often gives no clue as to their value, a measurement to say 3 per cent. or even to 5 per cent. is very useful and is, in fact, all that one needs in the majority of cases. Expecially is this so when one is experimenting in the laboratory with apparatus which one usually collects together hurriedly from various sources and about which very little is known.

For this purpose the author has designed a compact portable capacity test set† which has a range of 0.00005 μF. to 1.0μF. on a single rotary dial with no troublesome multiplying devices or range extensions. Moreover, the accuracy of scale reading is of a constant order throughout the entire range of the instrument.

The set is essentially a simple four capacity arm bridge with supply buzzer and battery and standard condensers all contained in an 8-inch cubical box. Besides being of small dimensions the set is light and its utility is therefore increased by the ability to take it to what would otherwise be most inaccessible positions in an experimental "hook-up" on the laboratory table in order to measure the capacities of certain components with the minimum of disturbance of the lay-out.

The enormous range and the approximately constant openness of scale graduations throughout the entire range are due to the fact that the ratio-arms are made continuously variable by "ganging" two ordinary air condensers in such a manner as to render their operation differential. Thus only one value of "known-arm" capacity is necessary to balance a large range of unknown capacities.

If A and B are the differential capacities, Q the value of a single known arm condenser, and P the very small constant residual capacity across the unknown arm terminals in parallel with the capacity C to be measured, then, simply, for balance :—

$$\frac{P+C}{Q} = \frac{A}{B}$$

$$\therefore \qquad C = \frac{A}{B}Q - P \qquad .. \quad (1)$$

If the differentially operated variable condensers have semi-circular plates their capacities A and B must obey a linear relationship between capacity and angular displacement of rotor and so :—

$$A = a_1\theta + b_1$$

and $$B = a_2(180 - \theta) + b_2$$

where a_1 and a_2 are the capacity "slopes" of the variable condensers and b_1 and b_2 their residual capacities.

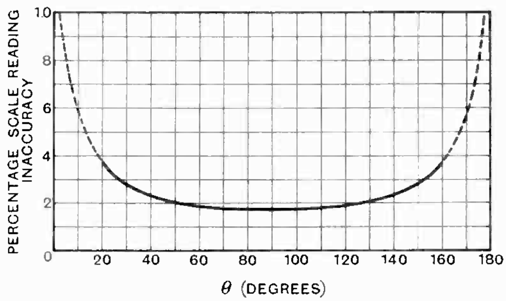


Fig. 1.

The scale may be read to an accuracy corresponding with 0.03 inch of scale circumference, which expressed as an angle in degrees is

$$\delta\theta = \frac{0.03 \times 180}{\pi R} = \frac{1.715}{R}$$

* MS. received by the Editor April, 1930.

† Patent applied for by H. W. Sullivan, Ltd., and the Author.

where R is the radius of the scale in inches.

The *inaccuracy* of reading at any point

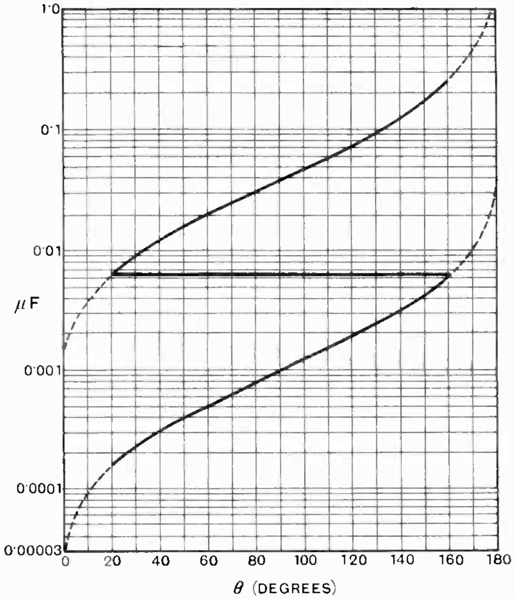


Fig. 2.

of the scale can therefore be expressed as

$$\delta\theta \, . \, \frac{dC}{d\theta} \Big/ C$$

or, as a percentage,

$$\frac{171.5}{R} \cdot \frac{1}{C} \cdot \frac{dC}{d\theta} \quad \ldots \quad \ldots \quad (2)$$

From (1),

$$C = \left\{ Q \frac{a_1\theta + b_1}{a_2(180 - \theta) + b_2} \right\} - P$$

In practice the capacity P may be made sufficiently small to be negligible throughout the useful range of the test set and so :—

$$\frac{1}{C} \cdot \frac{dC}{d\theta} = \frac{a_1 Q}{Q(a_1\theta + b_1)} - \frac{-a_2}{a_2(180 - \theta) + b_2}$$

From (2), the percentage scale reading inaccuracy is therefore

$$\frac{171.5}{R} \left\{ \frac{a_1}{a_1\theta + b_1} + \frac{a_2}{a_2(180 - \theta) + b_2} \right\} \quad \ldots \quad (3)$$

This may be simplified by assuming $a_1 = a_2$ and $b_1 = b_2$, it then being seen that the inaccuracy is inversely proportional to the product of the differential capacities A and B, the product being of a constant *order* if the multiplying and dividing ratios are limited to reasonable values.

In Fig. 1 is plotted a calculated curve of reading inaccuracy for the capacity scale of a test set whose ratio arm variable condensers are of 500μμF. capacity and whose scale radius is 2 inches. The reading accuracy is practically constant throughout the greater part of the scale from 20° to 160°, corresponding with the practically straight portions of the capacity calibration curves of Fig. 2, which is a calculated curve closely followed by results of experiment. The lower of these curves is obtained by using a " known " condenser of 1,000μμF. and the upper by the automatic augmentation of this condenser to a value 0.04μF., the

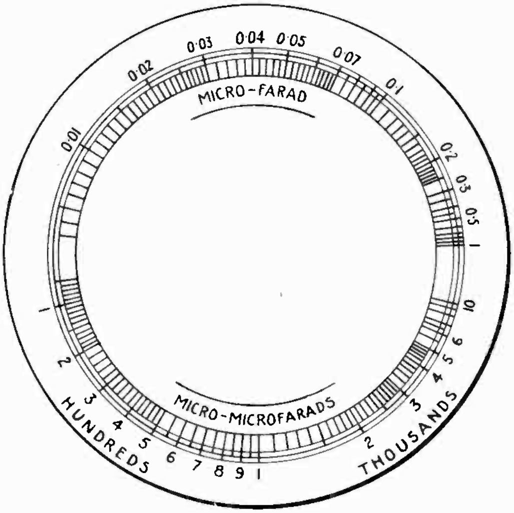


Fig. 3.

arrangement being that a condenser of 0.039μF. is switched in parallel with the 1,000μμF. condenser (after the condenser has been rotated through 180°) by means of a contact on the rotor. The actual scale of the test set is shown in Fig. 3.

The Design of Tuned Circuits to Fulfil Predetermined Conditions.*

By A. L. M. Sowerby, M.Sc.

IN designing the tuning circuits for a radio-frequency amplifier it is usually desired to attain as high a stage-gain as is possible, and at the same time to limit the sharpness of tuning in the interests of high-note reproduction. These two requirements are to a large extent mutually exclusive, in that a tuned circuit of low decrement provides high stage-gain but makes the tuning over-sharp. Much time may be consumed in attempting, by trial and error, to find a satisfactory compromise, whereas it is perfectly possible to prescribe a definite sharpness of tuning and a definite stage-gain, and then calculate quite simply the resistance and inductance which will be required in the tuned circuit.

Fig. 1 shows a tuned anode circuit following a screen-grid valve. The stage-gain of this arrangement with a given valve depends entirely on the tuned impedance $R = \frac{\omega^2 L^2}{r}$ of the anode circuit, which for stage-gain calculations must be deemed in series with the valve. The resonance curve depends on the magnification, and for calculating this the tuned circuit must be regarded as in parallel with the valve.

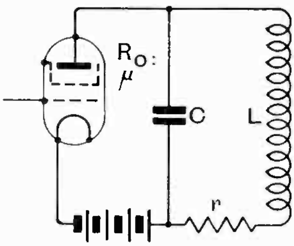


Fig. 1.—A tuned anode circuit. The tuned circuit must be regarded as in series with the valve for calculating stage-gain, but as in parallel with it for finding the resonance curve.

Let r denote the true equivalent resistance of the tuned circuit, neglecting the effect of the anode-filament conductance of the valve. In calculating the magnification we must allow for the damping imposed upon the tuned circuit by the A.C. resistance R_0 of the valve shunted across it. This is most readily done by imagining the valve removed, replacing it by its equivalent series resistance $\frac{\omega^2 L^2}{R_0}$ in series with r, so that for the whole tuned circuit, including the valve, we may write for the magnification :—

$$m = \frac{\omega L}{r + \frac{\omega^2 L^2}{R_0}} = \frac{\omega L R_0}{r R_0 + \omega^2 L^2}$$

The ratio of tuned impedance to magnification is

$$R/m = \frac{\omega^2 L^2}{r} \cdot \frac{r R_0 + \omega^2 L^2}{\omega L R_0} = \omega L \left(1 + \frac{\omega^2 L^2}{r R_0}\right) = \omega L\,(1 + R/R_0) \quad \ldots \quad (1)$$

If the response of a tuned circuit of magnification m at a frequency removed from the resonant frequency f by δf cycles is $1/n$ of the response at resonance, then, if $\delta f/f$ is small,

$$n = \sqrt{1 + 4m^2\left(\frac{\delta f}{f}\right)^2} \;*$$

whence $$m/f = \sqrt{\frac{n^2 - 1}{2\delta f}} \quad \ldots \quad \ldots \quad (2a)$$

If there are p tuned circuits instead of only one, and $1/n$ is used for the overall ratio, this becomes

$$m/f = \sqrt{\frac{n^{2/p} - 1}{2\delta f}} \quad \ldots \quad \ldots \quad (2)$$

If the conditions to be fulfilled permit a drop to $1/n$th in p stages at δf cycles from resonance, the value of m/f is known from equation (2).

Knowing the constants of the valve that is to be used for amplification, the tuned impedance R necessary to provide the specified stage-gain A can be determined

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

* Beatty, " Selectivity in Plain Terms," *Wireless World*, 19th Oct., 1929, p. 435.

from the equation

$$A = \frac{\mu R}{R + R_0}$$

or, more conveniently, from

$$R = \frac{AR_0}{\mu - A} \quad \cdots \quad \cdots \quad (3)$$

Combining (1) and (2), we have

$$R = \pi f^2 L\ (1 + R/R_0)\ .\ \frac{\sqrt{n^{2/p} - 1}}{\delta f}$$

or $$L = \frac{R\delta f}{\pi f^2\ (1 + R/R_0)\sqrt{n^{2/p} - 1}} \quad \cdots \quad (4)$$

In this equation every quantity save L is fixed by the conditions of the problem, so that L may be evaluated. If f and δf are in cycles, and R in ohms, L will be in henrys.

When L has been found, r may be determined from the equation

$$r = \frac{\omega^2 L^2}{R} \quad \cdots \quad \cdots \quad (5)$$

The value of r so found includes every source of loss in the tuned circuit except the damping due to the valve preceding it. If the grid circuit of the succeeding valve introduces appreciable damping, the resistance of the tuned circuit, measured by itself outside the receiver, must be less than the resistance found from (5) by a suitable amount.

It is interesting to note that the values of L and r determined for any values of n and A lead to the choice of an inductance inversely proportional to the square of the frequency to which it is desired to tune, so that the tuning capacity required is independent of the frequency. This would suggest that a variometer is the perfect tuning device, but, unfortunately, it is necessary that the resistance should also be proportional to the square of the wavelength, which does not occur in any practical circuit.

The equations given were developed as a guide to the design of the intermediate-frequency stages in a superheterodyne receiver. As an example of their use, calculations made in this connection will be quoted.

It was proposed to use two stages of amplification to follow a band-pass filter which, at 4,000 cycles from resonance, gave peaks rising to 6.2 times the height at resonance. This suggested that n be made equal to 6.2, so that the overall resonance curve would have the same height at resonance and at frequencies removed from this by 4,000 cycles. Mazda SG 215 valves were to be used, for which $R_0 = 10^6$ ohms, $\mu = 800$ at the operating voltages chosen. For a stage-gain of 400 times, R must be 10^6 ohms, so that we have the data :—

$$R = 10^6 \text{ ohms},\quad \delta f = 4{,}000 \text{ cycles},$$
$$(1 + R/R_0) = 2,\ n = 6.2,\ p = 2.$$

Inserting these values in (4), we obtain the following figures for L and r to fulfil the specified conditions at different frequencies of amplification.

Frequency (Kilocycles)	Inductance (Microhenrys)	Equiv. Series Resistance (Ohms)
30	311,000	3,450
40	175,000	1,940
50	112,000	1,240
60	77,800	860
70	57,100	635
80	43,700	485
100	28,000	310
120	19,400	215
140	14,300	158
160	11,000	122
200	7,000	77.7
1,000	280	3.1

At the lower frequencies, these figures are not difficult of realisation in a practical receiver, but become progressively more so as the frequency is raised. By the time 1,000 kc. is reached the prescribed resistance is about half the lowest that it is possible to reach in a completed receiver with a 280 μH. coil, even if all valves are decapped and the most elaborate precautions taken. This illustrates the obvious fact that if impossible conditions are laid down either L or r values calculated from the equations will also be impossible. In such a case one repeats the calculation on the basis of less stringent conditions.

Beam Arrays and Transmission Lines.

(Paper by Mr. T. Walmsley, B.Sc., read before the Wireless Section, Institution of Electrical Engineers, on 3rd December, 1930.)

ABSTRACT.

THE paper describes a new type of array developed by the author. After illustrating various short-wave aerial arrays that have been used, Fig. 6* is given as a diagrammatical representation of the author's array.

In considering the theory, it is pointed out that the criterion of effectiveness of a single vertical aerial is the ratio of electric field intensity, E, in a desired direction to the square-root of the power input, P, to the aerial, the half-wave vertical aerial being taken as the most efficient. As regards projection in the vertical plane, the best angle of projection appears to be a few degrees from the horizontal.

Two methods are then discussed for obtaining the ratio $E/\sqrt{P}$. Results for 16 vertical synphased radiators each half a wave long spaced half a wavelength apart, and having their lower ends a quarter of a wavelength above ground, show a gain of 13.4 decibels.

From considerations of height above ground it is concluded :—

(1) The best ratio of $E/\sqrt{P}$ is obtained by arranging a number of half-wave wires in a single row at equal distances from the ground. For example, 4 wires arranged in groups A, B, C and D (Fig. 13) show the following gains over a half-wave aerial : 6.85, 5.8, 4.1 and 4.5 decibels respectively ; 8 wires arranged in a similar manner give 10.0, 9.0, 6.9 and 8.7 decibels gain respectively, whilst 16 wires result in gains of 13.0 11.9, 10.3 and 11.7 decibels respectively.

(2) For a given span of array, the gain above a half-wave aerial is the greatest in the case of the arrangement D. For example, the gains for a span of 3½ wavelengths between extreme wires of the array are 10.0, 11.9, 13.4 and 14.7 decibels for arrangements A, B, C, and D respectively.

Economic conditions, however, impose limits of span and height, and, when reflectors are added to the arrays of Fig. 13, it is shown that the D type, to give 1.3 decibels gain over the C type, costs £950 additional per array. On the other hand, a C type of array gives a gain of 1.5 decibels over the B type for an additional cost of £190.

"T.W." Arrays.

Such considerations led the author, on behalf of the P.O. Engineering Dept., to devise and build arrays consisting of a number of units of the type shown in Fig. 6. In this figure the reflector curtain has been omitted for the sake of clearness. The units may be used in groups either of vertical radiators, as in Fig. 6, or by rotating the whole system through 90° of horizontal radiators ; as in Fig. 18. Each unit is "current-fed," *i.e.*, the attachment to the transmission lines is made at the centre of a half-wave element at the position of minimum impedance. By applying known properties of transmission lines and choosing the best positions for the junctions of feeders and transmission lines, reflections can be greatly reduced.

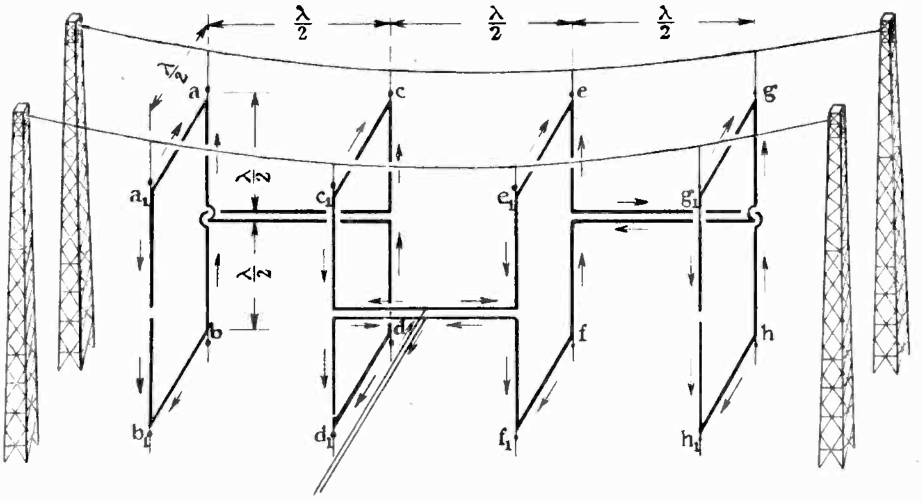


Fig. 6.—" *T.W.*" *short-wave aerial* (*single vertical unit*).

Tests and Polar Diagrams.—Comparison between a half-wave vertical receiving aerial and a T.W. 16-metre vertical type array consisting of four units (*i.e.*, having a span between extreme wires equal to 7½ wavelengths) disclosed a gain of 20 *db*. A measured polar diagram in a horizontal plane

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

is shown in Fig. 20. A polar diagram of a T.W. horizontal type array taken in a vertical plane normal to the array shows that the direction of maximum field makes an angle of 10° with the horizontal. Further, there is no horizontal radiation. Thus, if theory and practice agree, it should not be possible to make local measurements of field strength at ground level. This is actually the case, and in consequence a measured horizontal polar diagram cannot be plotted. However, measurements made at long distances from the array show that the theoretical expectation for this type of array can be realised.

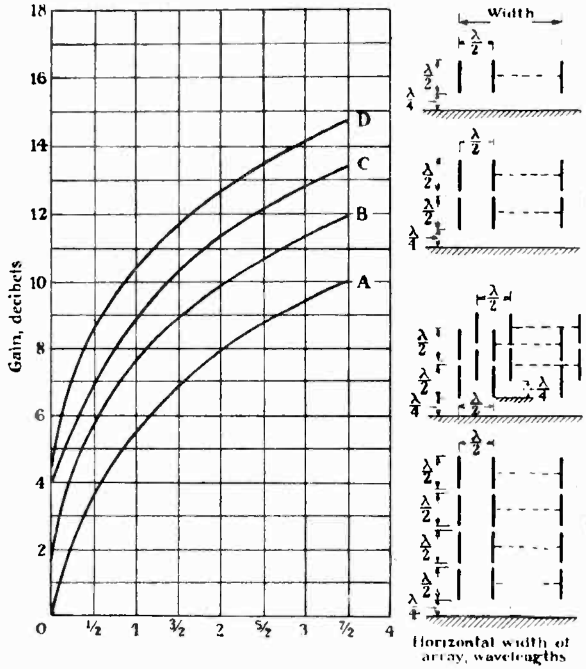


Fig. 13.—*Gain of various types of array over half-wave vertical aerial raised* $\frac{1}{4}\lambda$ *above the ground (theoretical values). A.—Single* $\frac{1}{2}\lambda$ *verticals spaced* $\frac{1}{2}\lambda$ *apart in one place, all wires* $\frac{1}{4}\lambda$ *above ground, currents in phase. B.—Double* $\frac{1}{2}\lambda$ *verticals spaced horizontally* $\frac{1}{2}\lambda$ *apart, all lower wires* $\frac{1}{4}\lambda$ *above ground, currents in phase. C.—Two lines as in B, lines separated by* $\frac{1}{2}\lambda$ *all currents in exciter line in phase, all currents in back line in phase by 180° lagging between front and back. D.—Four* $\frac{1}{2}\lambda$ *verticals spaced horizontally* $\frac{1}{2}\lambda$ *apart, lower wires* $\frac{1}{4}\lambda$ *above ground, all currents in phase.*

Transmission Lines.

The problem of suitable transmission lines is almost as important as that of types of array. The author resists the view that open transmission lines are inferior to lines in the form of concentric tubes, and considers the losses in several open lines connected to various types of array.

The losses in transmission lines may be classified as (1) ohmic, (2) dielectric hysteresis and eddy-current losses, (3) radiation losses. The resistance loss may be reduced by using copper instead of silicon bronze. A further reduction may be made by using several insulated wires of small diameter (instead of one larger wire) for each of the two members of the transmission line. No method is known of estimating dielectric hysteresis losses with any degree of accuracy. To reduce insulator losses the best type of porcelain or other insulation should be used and the insulator should be as long as possible and the cross-section as small as possible. From tests by the author the conclusion was reached that within the voltage gradients used for transmission-line insulators, the energy-loss in insulators increases as the square of the voltage. Thus a low-impedance line would have less loss per insulator than a high-impedance line. On the other hand, ohmic resistance losses would be increased unless the cross-section of the wires were increased. Radiation losses may arise from (*a*) radiation due to space separation of the two wires, (*b*) radiation due to irregularity of current. Examples are shown of the efficiency of two different transmission lines, and it is shown that the type of array employed has a pronounced influence upon the amount of energy radiated and, conversely, upon the amount of "pick up" on transmission lines used for receiver purposes. In conclusion the author summarises that the losses in transmission lines are caused by :—

(1) Unbalanced currents in the line wires,
(2) Ohmic high-frequency resistance,
(3) Space separation of the wires,
(4) Dielectric losses in insulators,
(5) Reflections from points where the line constants change.

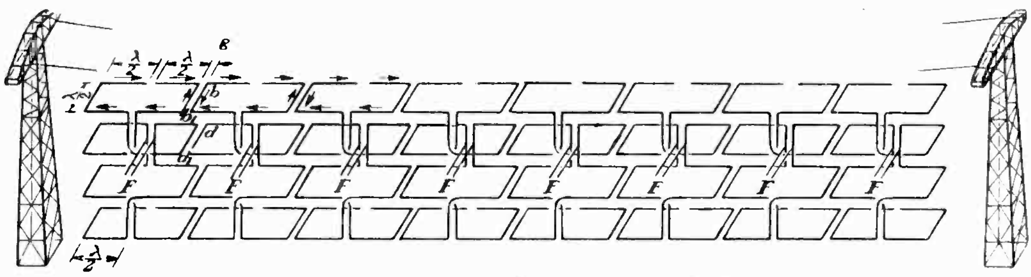


Fig. 18.—"*T.W.*" *horizontal type array (diagrammatic). Feeding-points shown at F.*

Methods have been suggested whereby the losses can be reduced and it has been shown that, contrary to the usually accepted belief, open transmission lines—particularly those used in conjunction with symmetrical types of aerial systems—may have low electrical losses.

Discussion.

MR. G. SHEARING referred to the value of the author's work in the matter of practical design. It was noted that the author confirmed the conclusion that the best vertical angle was about 0°. Signal School had made experiments on small arrays, making low angles to the horizontal, and the average results favoured low angles for waves of 15 to 40 metres. As regards the height of the lower end of the author's arrays, he would have expected earth losses to be considerable, and thought that the lower end should be one wavelength above earth. He enquired as to the length of the reflector curtains, and asked for more details of the aerials discussed (in Fig. 13) in relation to their economic aspect.

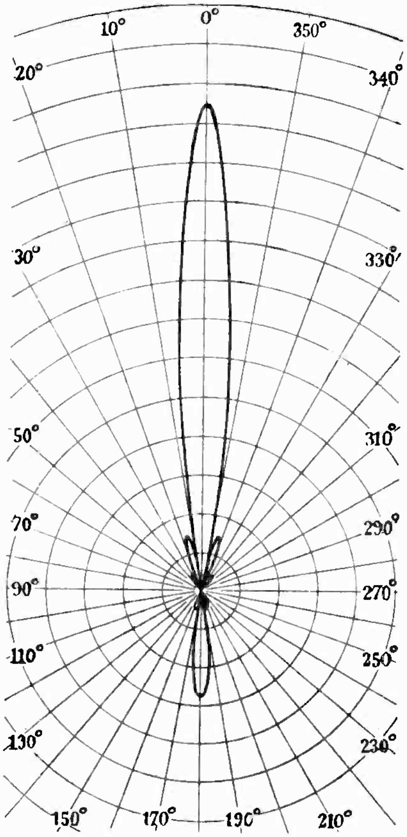


Fig. 20.—*Measured polar diagram in horizontal plane of "T.W." vertical 3-unit array. Span between end radiators* = $5\frac{1}{2}\lambda$.

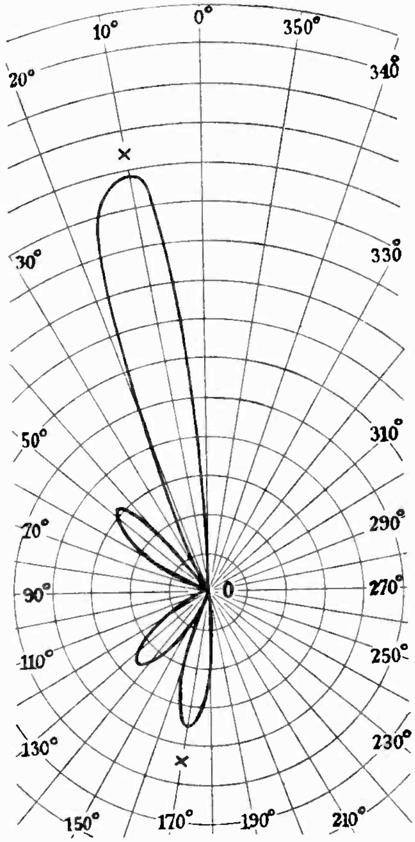


Fig. 24.—*Calculated polar diagram of "T.W." horizontal type array, taken in vertical plane normal to array. Currents in all exciting and reflecting elements considered to be equal; lower radiator* $\frac{1}{4}\lambda$ *above ground.*

DR. R. L. SMITH-ROSE referred to the advantage of short waves in permitting the aerial to be worked more efficiently besides the added advantage of the use of arrays giving power gains of 10 times. Theoretical work on the distance of the reflectors had been done by the Radio Research Board, and the optimum distance (0.32 of a wavelength) quoted in the paper agreed with the R.R.B. estimates. Had the author in practice used the spacing shown as optimum? On the matter of elevation, a slide was shown illustrating the advantage, for distant propagation, of horizontal radiation from the transmitting aerial.

COL. A. S. ANGWIN stressed the economics of site. Initially the tendency had been to stretch out in a long line. The tendency now was to combine. Two cases were quoted of a horizontal array being erected inside a vertical array working on a different wavelength, the measured loss in one case being only 0.5 decibel.

MR. T. L. ECKERSLEY queried the effects of currents in the ends of the wires, and also discussed the matter of earth conductivity in relation to the height above ground of the lower end of the array.

CAPT. DORLING, R.N., raised several points on the economics of arrays and sought information as to the advantage of opening out the beam.

MR. F. S. BARTON asked the author's opinion as to the importance of some aircraft measurements referred to in the paper. The possibility of using relatively simple arrays on mobile lines was of great importance in Service applications.

MR. A. J. GILL discussed the advantages of some of the different arrays referred to by the author, and asked several questions on the transposition of the transmission lines and the accuracy of the calculations in connection with these systems.

On the motion of the Section Chairman, Mr. C. E. Rickard, O.B.E., the author was cordially thanked for his paper.

Abstracts and References.

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PROPAGATION OF WAVES.

MESSUNG DER ELEKTRISCHEN ERDBODENEIGENSCHAFTEN ZWISCHEN 20 UND 2×10^7 HERTZ (Measurement of the Electrical Properties of the Ground at Frequencies between 20 and 2×10^7 Cycles per Second).—M. J. O. Strutt. (*E.N.T.*, Oct., 1930, Vol. 7, pp. 387–393.)

Author's summary :—" We have measured, for moderately damp meadow land, the conductivity for frequencies between 20 and 5×10^5 cycles/sec. and the conductivity and dielectric constant between 6×10^5 and 2×10^7 cycles/sec. (undamped waves). It was found that (1) the conductivity increased by about 30% between 20 and 500 cycles/sec. (polarisation effect) and then remained practically constant (about 5×10^{-14} e.m.u.) up to 2×10^7 cycles/sec. (2) These results applied approximately also when the moisture content of the ground was somewhat different.

" (3) The damping effect of the earth on waves in wires [for frequencies above 6×10^5 a 100 m. Lecher wire system was buried in the ground] *decreased after rain* for waves below 200 m.—contrary to our expectations. (4) Rain increased the dielectric constant proportionately more than the conductivity—which explains the last result. (5) The dielectric constants were about 10 and (for the same ground after rain) 15. They varied little with the frequency between 10^6 and 2×10^7 cycles/sec."

Laboratory tests on dry river sand, later slightly moistened, are mentioned in a postscript. These lead to the conclusion that under certain conditions in dry ground a marked dispersion of dielectric constant and conductivity may appear, this dispersion becoming slighter on damping the ground. From this standpoint it is clear that the meadow land in the above experiments had reached such a degree of dampness that the conductivity no longer varied with the wavelength—see (1) above.

THE ELECTRICAL PROPERTIES OF THE SOIL AT RADIO FREQUENCIES.—J. A. Ratcliffe and F. W. G. White. (*Phil. Mag.*, Oct., 1930 Series 7, Vol. 10, No. 65, pp. 667–680.)

An account of laboratory experiments made at radio frequencies to investigate the way in which the effective conductivity σ and the effective dielectric constant ϵ of the soil vary with frequency. Two types of soil were experimented upon, (*a*) garden soil from Cambridge and (*b*) surface soil from near the Daventry Broadcasting Station. The soil was used as a dielectric between the plates of a cylindrical condenser ; ϵ and tan ϕ [ϕ = phase angle made by current flowing in soil with impressed e.m.f.] were measured by (1) an oscillographic and (2) a resonance method. Curves giving the variation with frequency of ϵ and tan ϕ are given ; in a range of frequency from about 0.1×10^6 to 4×10^6 c.p.s., tan ϕ was found to increase from about 0.2 to values between 0.5 and 1.0, while ϵ decreased in the same range from values of about 45 to 14 e.s.u. At high frequencies ϵ assumes a low limiting value which remains approximately the same up to a frequency of 10×10^6 c.p.s. The moisture content of the soil plays a large part in determining its electrical properties ; this is shown by results obtained when the Daventry soil was dried and again used as the dielectric. At 0.2×10^6 c.p.s., ϵ was found to have decreased from 48.5 to 5.3 e.s.u., while tan ϕ increased from 0.14 to 1.25. A similar change was also found as the amount of solid rock in the soil was increased. The variation in the effective conductivity σ is deduced and also shown in the form of curves.

It is shown that in attempting to confirm Sommerfeld's attenuation theory it is not sufficient to obtain attentuation curves on two different wavelengths and expect to arrive at the same values of σ and ϵ ; nor is it possible to attempt a verification of Sommerfeld's expression by deducing the values of σ and ϵ (which are different for different samples of soil) from an attenuation curve and then comparing them with the values found for a specimen of soil in the laboratory. " The only possible method of verification is to measure [by the tilt method] the effective values of σ and ϵ for the ground *in situ* at the same frequency and under conditions where the penetration of the wave is of the same order as in the attenuation experiments.

" The method of predicting the attenuation of waves of one frequency from a knowledge of the attenuation at another frequency, assuming σ and ϵ to remain constant, now appears to be fundamentally incorrect."

The values of σ and ϵ required for an explanation of Ratcliffe and Barnett's " negative attenuation " effect on 1,600 metres (*Proc. Camb. Phil. Soc.*, Vol. 23, p. 288, 1926) are not far removed from those obtained in the present experiments.

SUR L'AURORE POLAIRE DU 3 SEPTEMBRE ET SUR SON ACTION DANS LES TRANSMISSIONS RADIOTÉLÉGRAPHIQUES (The Polar Aurora of 3 September and Its Action on Radio Transmissions).—P. Helbronner. (*Comptes Rendus*, 6th Oct., 1930, Vol. 191, pp. 536–538.)

Effects of the aurora referred to in 1930 Abstracts, p. 624, as reported by the Compagnie Radio-France. Short-wave communication to the U.S.A., both ways, was completely wiped out during the whole night, but long waves were unaffected. Similar effects occurred on the France-Japan service, in this case beginning several hours earlier. No effects were produced on the transmissions from France to Beyrouth and S. America ; only temporary fadings in the reverse directions.

In no case were the long waves affected, probably because " the frequencies brought into play by the aurora were of a different order from those of the long waves, and also because the latter travel more superficially and directly." The short waves appear to be affected when their paths lie near the regions involved in the auroral phenomena.

LOW-FREQUENCY RADIO TRANSMISSION [Field Strengths, Polarisation and Magnetic Storms].—P.A. de Mars, G. W. Kenrick and G. W. Pickard. (*Proc. Inst. Rad. Eng.*, Sept. 1930, Vol. 18, pp. 1488–1501.)

Observations on WCI (17.8 kc.) alternately on an open aerial and on a variously oriented loop. The mean strength in the absence of magnetic disturbances is lowest during the night, and strong sunrise and sunset peaks are found. During magnetic storm conditions an inversion takes place, the night field strength exceeding the day field.

Appleton and Ratcliffe's work on loop reception and the state of elliptical polarisation is reproduced and applied to an interpretation of the various observations. The writers conclude :—" From the above analysis we see that while it is possible to deduce the electric and magnetic vectors in the downcoming wave from low-frequency field strength computations along the lines indicated, the assumptions required to render the problem determinant are so questionable as to discourage attempts at such an interpretation at the present state of the observations, particularly as the transmission path is too long to render determination of α accurate." But it is possible to conclude that in the normal night field E_1 [usual notation] is at least comparable to one-half E_0 and that E_2 [abnormally polarised component] may be at least as great as and probably frequently much greater than E_1. " Strong evidence is furnished by the loop observations for large rotations of the plane of polarisation in the downcoming wave during the night (and particularly at sunrise and sunset) and the evidence also indicates a much more moderate change in amplitude of the resultant electric vector than might be inferred from antenna observations alone." For Hollingworth and Naismith's observations of polarisation changes in waves of the same order, *see* 1928 Abstracts, pp. 163 and 460.

THE INFLUENCE OF SUN SPOTS ON RADIO RECEPTION.—H. T. Stetson. (*Journ. Franklin Inst.*, Oct., 1930, Vol. 210, No. 4, pp. 403–419.)

See 1929 Abstracts, p. 566, for the ground covered. " It is believed that the distance of the spots from the centre of the disk, or the sun-earth line, is an important factor in the study of correlation of sun spots with radio reception and other electromagnetic phenomena on the earth."

A NEW THEORY OF MAGNETIC STORMS.—S. Chapman and V. C. A. Ferraro. (*Nature*, 26th July, 1930, Vol. 126, pp. 129–130.)

The new theory here given makes it seem likely that present theories of the aurora must be modified " because the particles of a neutral stream can approach much closer to the earth, in the equatorial plane, than the single charged particles hitherto considered." This may have a bearing on the theory of radio echoes.

LE SONDAGE SIMULTANÉ PAR LES PARASITES ATMOSPHÉRIQUES À ZURICH ET AU SAHARA (Simultaneous " Sounding " by Atmospherics at Zurich and in the Sahara).—J. Lugeon. (*Comptes Rendus*, 29th September, 1930, Vol. 191, pp. 525–527.)

Further developments of the work dealt with in 1930 Abstracts, pp. 502–503 and back references given there. Atmospheric-observations at sunrise, on 13 days in October and November, 1929, gave heights for the layer ranging from about 75 to 126 km. at Zurich and 92 to 140 km. at El Goléa (Sahara) ; except on one occasion (93.2 compared with 92 km.) the height over Zurich was definitely less than that over the Sahara, and the " tidal " variations day by day were synchronous.

The average heights work out at 98 km. (Zurich) and 114.7 km. (El Goléa). The writer proposes a formula based on these values and on the idea of atmospheric layers sloping from the equator towards the poles. This formula, $H = 129.782 - 58.316 \sin^2 \phi$ (where ϕ is the latitude), should be applicable to both hemispheres, at any rate from autumn to spring. The average sunrise height for the equator is thus 129.8 km., for the poles 71.5 km. Conclusions as to the heights of the ozone layer and tropopause are also given, fitting in with the slope theory. See also below.

LE SONDAGE DES HAUTES COUCHES IONISÉES PAR LES ONDES COURTES AU LEVER DU SOLEIL ENTRE PARIS ET LE SAHARA (The " Sounding " of the High Ionised Layers by Short Waves at Sunrise between Paris and the Sahara).—J. Lugeon. (*Comptes Rendus*, 20th October, 1930, Vol. 191, pp. 676–678.)

Tests in conjunction with Bureau, on waves of 56 and 36 m. from Paris recorded at El Goléa, 2,000 km. away. Particular attention is given to the effects noted on 2nd November 1929, which, in conjunction with his atmospherics results—see above—lead the writer to conclude that on that day the atmosphere above France contained four reflecting surfaces at heights of 280, 185, 85 and 50 km. The process is thought to be as follows :—During the night the short waves are sent back by the highest layer. As daylight encroaches on the darkness, the waves transfer their point of reflection from the layer now illuminated to the next lower layer which is still in darkness, and so on until they are reflected from the lowest layer. Thus in a section drawn of the Paris-Sahara region at sunrise, the writer shows a zig-zag path with many reflections between earth and the various layers, starting with the highest (still in darkness) and changing to the lower ones according to the position of the earth's shadow. The lowest (50 km.) layer is represented as the ozone layer.

MEASUREMENT OF THE HEAVISIDE LAYER HEIGHTS.—D. F. Martyn. (*Nature*, 11th Oct., 1930, Vol. 126, p. 568.)

In measurement of the Heaviside layer height by the frequency-change method, it is possible to arrange that the beat-note in the receiver shall be of audible pitch ; the writer finds that this arrangement possesses the advantage of simplicity and is adapted to the obtaining of continuous records.

The carrier frequency is alternately increased and decreased many times a second. "Corresponding to the change-over from increasing to decreasing frequency at the transmitter, there will occur at the receiver a short period during which the frequency of the beat-note decreases rapidly to zero and rises again to its former value. The duration of this period must be made small compared with the time during which the beat-note remains steady. Preliminary tests of the method have been made and an audible beat-note has been detected at a distance of seven miles from the transmitter, on a wavelength of 250 metres."

REMARQUES AU SUJET DES OBSERVATIONS D'ÉCHOS RADIOÉLECTRIQUES FAITES À POULO-CONDORE EN MAI 1929 (Remarks on the Echo Observations in Indo-China, 1929).— —. Gallin. (*L'Onde Élec.*, Oct., 1930, Vol. 9, pp. 493–495.)

The writer considers in turn the three possible cases at totality, where the distance L, at which the normal through the point of observation passes out of the shadow cone, is less than, equal to or slightly greater than, or markedly greater than the height H of the layer. Astronomical data give L as 115 km., and the writer concludes from Appleton's results in less tropical regions that H was certainly rather less than this at the time in question. Störmer's theory is not, therefore, invalidated by the disappearance of the long-delay echoes at totality (1930 Abstracts, p. 206); it would have been, if L had proved to be less than H.

EINE METHODE DER AUFNAHME DER ECHOS BEI WELLEN DER DRAHTLOSEN TELEGRAPHIE (A Method of Recording Wireless Echoes).—J. Zenneck. (*T.F.T.*, September, 1930, Vol. 19, p. 279.)

Pulses (on 550 m.) on the Breit and Tuve principle were transmitted 500 times per second, each wave-train being about 10^{-4} sec. long. The received wave-trains, after amplification, were made to synchronise a rotating field of 500 cycles/sec. which caused the spot of a cathode ray tube to rotate in a circle. The pulse signal and its echoes appeared on this circle as protuberances [*cf.* Goubau, 1930 Abstracts, p. 328].

Triple echoes have thus been recorded. The decision whether these are the result of three different layers or of multiple reflection "must await exact measurements."

WIRELESS REFLECTIONS AND ECHOES.—J. Larmor. —(*Nature*, 4th Oct., 1930, Vol. 126, p. 504.)

A letter suggesting that an effective mode of test of the phenomena of wireless echoes may be to augment the effect by using waves of lower frequency.

LONG WAVE RADIO RECEIVING [FIELD STRENGTH] MEASUREMENTS AT THE BUREAU OF STANDARDS IN 1929.—L. W. Austin. (*Proc. Inst. Rad. Eng.*, Sept., 1930, Vol. 18, pp. 1481–1487.)

Monthly averages of daylight signal intensity for 1929 as received from a number of European and American stations. The annual average field intensities of the European stations have not shown much change from the previous year, but atmospherics have increased.

SUR LES PROPRIÉTÉS DES GAZ IONISÉS DANS LES CHAMPS ÉLECTROMAGNÉTIQUES DE HAUTE FRÉQUENCE (The Properties of Ionised Gases in High Frequency Electromagnetic Fields).—C. Gutton. (*Ann. de Physique*, July–August, 1930, Vol. 14, Series 10, pp. 5–14.)

Description of experiments confirming H. Gutton's explanation of the sudden changes in dielectric constant and absorption, at certain frequencies, as being the result of resonance with the natural periods of the electrons. See 1930 Abstracts, p. 329. for a *Comptes Rendus* note on the same work.

ÜBER DIE AUSBREITUNG ELEKTROMAGNETISCHER WELLEN ÜBER EINE EBENE ERDE (On the Propagation of Electromagnetic Waves over a Plane Earth).—B. van der Pol and K. F. Niessen. (*Ann. der Physik*, Series 5, 1930, Vol. 6, No. 3, pp. 273–294.)

Authors' summary :—The methods of the operational calculus are used to transform Sommerfeld's general formula for the propagation of electromagnetic waves over a plane earth into another exact formula :

$$\Pi(r) = \frac{h^2}{k_1 k_2} \cdot \frac{k_2^2}{(k_2^2 - k_1^2)} \left[\frac{k_2}{k_1} \cdot \frac{e^{ik_1 r}}{r} - \frac{k_1}{k_2} \cdot \frac{e^{ik_2 r}}{r} + ih \int_{k_1}^{k_2} \frac{e^{irs}}{\sqrt{s^2 - h^2}} ds \right]$$

[usual notation] in which the integrand contains no products involving Bessel functions and which is therefore of more practical value. Sommerfeld's known ρ-formula for a perfectly conducting earth is deduced as a special case, and in addition a simple correcting term is given which gives a second, improved approximation to the ρ-formula and makes it applicable to the case of an imperfectly conducting earth. The whole problem is treated from the beginning on operational lines, by which Sommerfeld's solution can also be obtained. See also 1930 Abstracts, pp. 560–561.

MESSUNGEN IM STRAHLUNGSFELDE EINER IN DER GRUNDSCHWINGUNG UNGEDÄMPFT ERREGTEN DIPOLANTENNE (Measurements in the Radiation Field of a Dipole Aerial excited to its Undamped Fundamental).—H. Peters. (*E.N.T.*, Oct., 1930, Vol. 7, pp. 378–386.)

Working with a rotatable horizontal dipole on a wavelength of 7.15 metres, the writer confirms the theoretical polar curves of Abraham (*Ann. der Phys.*, 1898, Vol. 66), for distances of 300 and 4,000 metres (*cf.* Bergmann, *ibid.*, 1927, Vol. 82, working at a distance of 45 m.). By rotation of the receiving aerial in a vertical plane he also investigates the state of polarisation of the waves at these two distances. At 300 m., where d/λ is still comparatively small, the wave maintains the linear polarisation with which it leaves the transmitter but rotated through 4° ; at 4,000 m., where d/λ is really large, *the polarisation is elliptical and the principal plane is rotated through* 18°. The elliptical polarisation is *not* due to superposition of a field reflected from the tower on which the apparatus was placed. Whether the result is affected by the nature of the ground, or by the direction relative to the earth's magnetic field, must be decided by further experiments, over homogeneous land.* The writer mentions Anderson's treatment of propagation on his "tubes of force" theory (see below) and tentatively suggests that an explanation of the above results may be found therein.

The apparatus used is described and illustrated. A push-pull transmitting circuit with 250 w. aerial power was employed.

Polarisation, Dispersion, Photoelectric Effect and Compton Effect from the Standpoint of the [Writer's] "Tubes of Force" Theory of Light Quanta.—W. Anderson. (*Zeitschr. f. Phys.*, 15th April, 1930, Vol. 61, No. 7/8, pp. 566–575.)

Reflection of Waves in an Inhomogeneous Absorbing Medium.—P. S. Epstein. (*Proc. Nat. Acad. Sci.*, 15th Oct., 1930, Vol. 16, pp. 627–637.)

Referring to his previous paper (1930 Abstracts, p. 206) the writer points out that the methods of geometrical optics used in it only enable one of the two waves, occuring in general in an inhomogeneous medium, to be traced ; this one wave being, for absorbing media, always the refracted wave. But circumstances may occur in which the main part of the incident energy is contained in the reflected wave ; the present paper therefore supplements the former treatment by a discussion as to what amount of reflection can be expected and what the conditions are in which the reflected rays may not be neglected, by abandoning the methods of geometrical optics and dealing with the rigorous equation of wave motion $\Delta^2\psi + k^2\epsilon\psi = 0$, where $k = 2\pi/\lambda$ and ϵ is the dielectric constant. This equation applies directly to one state of polarisation only (electric vector normal to the stratification of the medium), but the results are qualitatively true also for the other state of polarisation.

"With regard to the problems of radio-telegraphy, the result is satisfactory in its simplicity. It can be shown that in a continuous medium there is no appreciable reflection from a conducting inhomogeneous layer unless the conductivity is small and the conditions approximate those of total reflection. According to the preceding paper it is, then, permissible to neglect the conductivity altogether and to apply ordinary geometrical optics. This is exactly the procedure that has been followed in radio-telegraphic investigations, and our results give its complete justification."

Note on Frequency Shifts in Dispersing Media.—G. Breit and E. O. Salant. (*Phys. Review*, 1st Sept., 1930, Series 2, Vol. 36, No. 5, pp. 871–877.)

Authors' abstract :—The propagation of a light wave through a dispersing medium is discussed. The absorption frequencies of the medium are shown to be the absorption frequencies of the coupled system formed by molecules contained in a cavity elongated in the direction of the electric intensity of the incident wave. The cavity is supposed to contain a large number of molecules and yet to be small compared to the wavelength.

The absorption bands of the coupled system are discussed. For tenuous media the shift is small and of the order of the Lorentz-Lorenz shift. The modification introduced by the quantum theory consists in replacing the classical $e^2/8\pi^2m\nu$ by $|x\,(\mathrm{I},\mathrm{II})|^2$ where $x\,(\mathrm{I},\mathrm{II})$ is the unperturbed matrix element of the polarisation in the fixed direction X, the normal state is I, the excited state II. In this approximation the shift is obtained by replacing the classical e by Dennison's effective charge. For regular arrangements of molecules, no broadening due to coupling is expected.

For dense media there are additional effects even to the first order. These are : (1) the electrostatic interaction of a molecule with its neighbours due to its excitation, (2) the effect of the finite space extension of the $u_{\mathrm{I}}\, u_{\mathrm{II}}$ charge distribution. A comparison of the measured shifts in liquid HCl and HBr with the extrapolation of the Lorentz-Lorenz formula modified by $|x(\mathrm{I},\mathrm{II})|^2$ is made. The observed shift is much too large to be explained without taking into account effects (1), (2). Particle exchange has been neglected.

Some Remarks on the Analogy of Certain Cases of Propagation of Electromagnetic Waves and the Motion of a Particle in a potential Field.—W. de Groot. (*Phil. Mag.*, Oct., 1930, Series 7, Vol. 10, No. 65, pp. 521–540.)

From the author's summary :— . . . The conditions are investigated for which a wave-equation of the type $\Delta\phi + \frac{\omega^2}{u^2}\phi = 0$ may be such that a group of waves moves as a mass-point in a field of force which is independent of the frequency of the group. This leads to either the relativistic or the non-relativistic Schrödinger-equation for the dependence of u on ω.

In the case of the propagation of electro-magnetic waves in a medium containing charged particles, the movement of a group of waves may also be made to correspond to that of a particle in a potential field of force ; in this case the potential, however, depends on ω. . . . The formulæ derived . . . are applied to the case of radio-waves reflected by the Heaviside-Kennelly layer, and it is shown that the problem of finding the height of the layer, *i.e.* the determination of the concentration n of the electrons as a function of the height from group-time measurements, is related to the integral-equation of the "tautochrone" as solved by Abel. . . . It is shown that if z is a multivalued function of n the problem becomes indefinite. The bending of the rays round the earth and the calculation of the "effective height" is treated.

. . . Possible objections to the calculations contained in this article are anticipated. [(1) Absorption

* In the tests described, the transmitter and the two receivers were situated about 25 metres above the ground ; judging from the photographs, at least one receiving site was densely wooded.

has not been taken into account and (2) the relative variation of the phase velocity, when proceeding in the direction of its gradient along a distance equal to the local wavelength, is assumed to be small. If (2) does not hold, something may happen at the maximal height which affects the results and a careful examination of the original wave equation containing the time will be necessary.]

ÜBER EINE ERWEITERUNG DER GLEICHUNGEN DES ELEKTROMAGNETISCHEN FELDES (On an Extension of the Electromagnetic Field Equations).—B. Lagunoff. (*Zeitschr. f. Phys.*, 28th Aug., 1930, Vol. 64, No. 5/6, pp. 425–430.)

Author's summary :—The asymmetric complete tensor N=grad ϕ is introduced instead of the anti-symmetric partial tensor M = rot ϕ as the field tensor in the general equations for the field in a material medium ; this extension of the electromagnetic field equations is presumably correct.

ÜBER DIE FORTPFLANZUNG VON SIGNALEN IN DISPERGIERENDEN SYSTEMEN. ERSTER TEIL: ALLGEMEINE GRUNDLAGEN. KONTINUIERLICHE SYSTEME OHNE VERLUSTE (On the Propagation of Signals in Systems with Dispersion. Part I: General Principles. Continuous Systems without Loss).—H. G. Baerwald. (*Ann. der Physik*, 1930, Series 5, Vol. 6, No. 3, pp. 295–369.)

GROUP VELOCITY AND WAVE MECHANICS.—H. S. Allen. (*Nature*, No. 3154, Vol. 125, 1930, pp. 561–562.)

The writer recommends the introduction of new quantities in the place of frequency and wave length, namely "pulsatance" ($p = 2\pi\nu$) and "undulatance" $\left(k=\frac{2\pi}{\lambda}\right)$. Phase velocity then becomes p/k, group velocity dp/dk. In this way a distinct simplification is obtained in speech and writing. Also the Planck constant should be changed to $b = h/2\pi$.

OPTICAL PROPERTIES OF THE ATMOSPHERE : DIFFUSION AND ABSORPTION.—Y. Rocard. (*Rev. d'Optique*, March, 1930, Vol. 9, pp. 97–111.)

For summary, see *Sci. Abstracts, Sec. A*, Oct. 1930, p. 893. "The variation with wavelength gives the coefficient of absorption as approximately $1/\lambda^{2.5}$."

APPLICATION OF INTEGRAL EQUATIONS TO DIFFRACTION AND CHARACTERISTIC VIBRATIONS IN THE ELECTROMAGNETIC THEORY OF LIGHT.—Sternberg. (*See* under "Miscellaneous.")

THE DISPERSION OF LIGHT IN METALS.—J. B. NATHANSON. (*Journ. Opt. Soc. Am.*, Sept., 1930, Vol. 20, pp. 469–483.)

CONTEMPORARY THEORIES OF LIGHT.—W. F. G. Swann. (*Journ. Opt. Soc. Am.*, Sept., 1930, Vol. 20, pp. 484–523.)

ELECTRO-OPTICAL MODIFICATIONS OF LIGHT WAVES.—L. H. Stauffer. (*Phys. Review*, No. 11, Vol. 35, 1930, p. 1440.)

Cf. Bramley, Wawilow, Rupp (Abstracts, 1929, pp. 463, 114, and 1928, p. 587). The results now described support the generalised Doppler principle.

COMMUNICATION RADIOTÉLÉPHONIQUE SUR ONDES TRÈS COURTES (Radio-telephonic Communication on Ultra-Short Waves [France to Corsica]).—G. A. Beauvais. (*Ann. des P.T.T.*, No. 4, Vol. 19, 1930, pp. 293–307.)

Jouaust, in a paper dealt with in 1930 Abstracts, p. 268, refers to the France-Corsica service (distance 205 km., stations on hills 1,100 and 550 metres high, giving nearly an optical path). The present paper gives particulars of the apparatus. On a 5 or 6 m. wave, regular communication can be maintained on a transmitter power of 35 w. Under favourable weather conditions 2.5 w. (from two receiving valves) is enough. On a 3.75 m. wave, larger power seems to be required. The transmitter uses the Mesny push-pull circuit with inductive coupling between grid and anode-circuits and with modulation by a valve in parallel. The receiver is super-regenerative. The Mesny "saw-tooth" aerial was found to be particularly effective. Some particulars are given of land-line linking.

TELEPHONY ON ULTRA-SHORT WAVES WITH VERTICAL RADIATION.—J. J. Long, Jr. (*QST*, Sept., 1930, Vol. 14, pp. 13–16 and 76.)

In a descriptive article entitled "Making Practical Use of the 56-Mc. Band," the writer mentions that a half-wave rod placed a quarter wavelength behind the aerial "helped to some extent," but when the reflector was placed the same distance *below* the aerial "we got the surprise of our lives when the signal increased about double." This arrangement has been used ever since. Aerial current was 0.3 A., duplex telephony was over a distance of the order of 10–20 miles.

AIRCRAFT TESTS OF ULTRA-SHORT WAVE BEAM.—Fassbender. (*See* abstract under "Miscellaneous.")

AIRPLANE RADIOPHONE COMMUNICATION [on 30–190 m. Waves].—C. H. Vincent. (*See* 1930 Abstracts, pp. 523–524.)

METHOD OF OBTAINING A VISIBLE SPECTRUM OF WAVES OF RADIO FREQUENCY.—McLennan and Burton. (*See* under "Miscellaneous.")

AUSTRALIAN R.R.B.—WORK ON HEAVISIDE LAYER.—(*See* under "Miscellaneous.")

ON RADIATIVE DIFFUSION IN THE ATMOSPHERE.—O. F. T. Roberts.—(*Proc. Roy. Soc., Edinburgh*, Part 3, Vol. 50, 1930, pp. 225–242.)

"Recent papers on radiation in the atmosphere, notably one by Brunt [1929 Abstracts, p. 386], have led the writer to examine the extent to which the consequences of radiative processes may be regarded as diffusion-like."

An Early Note on Wave Propagation.—L. de Forest. (*Proc. Inst. Rad. Eng.*, Sept., 1930, Vol. 18, pp. 1600–1602.)

A letter to G. W. Pierce written in 1912 to defend and amplify the writer's paper in the *Electrician* on the subject of fading and its production by interference between ground and space waves.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

Untersuchungen über luftelektrische Phänomene und die atmosphärischen Störgeräusche der Radiotelegraphie (Researches on Atmospheric Electrical Phenomena and Radiotelegraphic Atmospherics).—J. Fuchs and J. Scholz. (*Gerlands Beitr.*, Vol. 27, 1930, pp. 176–216.)

Further development of the work dealt with in 1930 Abstracts, p. 35. The intensity of "clicks" has no direct relation to the magnitude of the coincident changes in potential gradient; probably because the latter depend on the electric moment of the flash while the former are caused by the electromagnetic radiation component of the charges set free. Fronts and thunderstorms within 300 km. produce clicks independent of the time of day; between 300 and 1,000 km., only at night; beyond 1,000 km., they are unable to produce marked effects—only the regular daily period is then noticeable.

Observations of the polarities of field changes coincident with flashes show (on the basis of Wilson's theory) that positive polarity prevails in thunderclouds.

Grinders, a discussion of the disturbances caused by sheet lightning suggests, are due to irregular glow discharges between vertical air currents of different temperature, brought into contact and thus electrifying themselves. A limit of 15 km. is suggested for their range. "Hissings" are due to brush discharges which appear in audio-frequency rhythm on points rising high into the air, if the potential gradient is very high (1800–7000 v./m.; from 5500 v./m. upwards the discharges are visible as St. Elmo's fire).

The writers end by observing that under foggy conditions the Wilson apparatus may lead to wrong results, since the vertical current may be augmented by the convection current carried by fog particles, with the result that an apparent negative conductivity may be deduced from the potential gradient.

Vertical Electric Currents below Thunderstorms and Showers.—T. W. Wormell. (*Proc. Roy. Soc.*, June, 1930, Series A, Vol. 127, No. 806, pp. 567–590.)

In this paper results are given of a study of "the discharge of electricity from a raised metal point in the strong electric fields which occur at the surface of the ground during thunderstorms and showers." The methods used have already been described (*Proc. Roy. Soc.*, A, Vol. 115, p. 443, 1927); in the first, measurement is made of the quantity of electricity of each sign which is discharged from the point in a definite period of time and the results obtained over a period of two years are discussed. The preponderance of negative potential gradients during periods of intense electric field has been confirmed.

Records obtained by a second method of obtaining a continuous record of the current from the point throughout a storm are also described. The observations definitely show that shower-clouds have frequently positive electric moments. This result together with the preponderance of negative potential gradients is interpreted as indicating that many of the clouds were of positive polarity, in agreement with the results of C. T. R. Wilson, Appleton, Watson Watt and Herd, and Schonland, and not with those of G. C. Simpson [*cf.* also Fuchs and Scholz, above].

The problem of the interchange of electricity by known processes between the ground and the atmosphere is re-discussed, using the results of observations tabulated in the paper. A rough estimate of the annual charge per square kilometre brought to the ground by four main processes gives :—

Fine weather current . . . + 60 coulombs, precipitation . . . + 20, lightning discharges . . . − 20, currents carried by point discharges . . . − 100 coulombs.

There seems to be effectively a vertical upward current through a cumulo-nimbus cloud from the earth to the upper atmosphere: a similar conclusion was reached by Schonland. The results of all the observations discussed are "in entire agreement with Wilson's theory that the fine-weather current into the ground over the whole earth is balanced by the currents maintained between the earth and the upper atmosphere by shower clouds."

The Electric Field of Overhead Thunderclouds.—S. K. Banerji. (*Quart. Journ. Roy. Met. Soc.*, July, 1930, Vol. 56, No. 236, pp. 305–334.)

Author's summary :—Changes in the electric field produced by eighteen thunderclouds during their passage over the Colaba Observatory in 1929 are discussed in the paper and these suggest that the majority of them were of the "unitary" type and had their front part negatively charged, the central part positively charged, and the rear negatively charged. A few were of the "double type" and produced changes in the field as if two thunderclouds of unitary type had passed over in succession, and this is confirmed by meteorological evidence. The distribution of charges in both the unitary and double types, therefore, agrees with Simpson's breaking-drop theory of the origin of electricity in thunderstorms. In those thunderclouds which caused heavy rainfall, fluctuations in the central positive field, sometimes very rapid and violent, were found to occur on account of loss of charge by rainfall or increased concentration of positive charge owing to increased vertical current, in agreement with the breaking-drop theory.

The monsoon clouds produced an electric field, which was predominantly negative during periods of rainfall. The intensity of the negative field was in general more pronounced when the monsoon was vigorous than when it was weak. The observations appear to support the breaking-drop theory of the origin of electricity in non-thunderstorm rain.

In the discussion of the paper it was pointed out by Wormell and Watson Watt that the records of the electric field were obtained with a system which would not follow rapid variations in the field and was limited in recording range. If the lightning flashes were frequent, it was not obvious that a recording system which did not show the rapid changes would give a reliable indication of the magnitude or even of the sign of the electric field of the cloud.

SUBMARINE CABLE INTERFERENCE.—E. T. Burton: A. L. Meyers. (*Nature*, 12th July and 2nd Aug., 1930, Vol. 126, pp. 55 and 169.)

A letter giving a short account of measurements made on interference voltages received on a submarine cable in Trinity Bay, Newfoundland, during the summer of 1929. The amplifier and associated apparatus used were designed to permit analysis of interference frequencies from 100 to 4000 c.p.s. "Occasional comparisons were made between cable interference and audio-frequency atmospherics applied to the amplifier by a large untuned loop. The two inputs were essentially the same regarding types of natural interference, but the higher frequency components of the former were considerably attenuated due to shielding effect of the sea water." The various types of interferences observed are described, particular attention being paid to "tweeks," a type of interference frequently observed consisting of a damped oscillation of substantially constant frequency usually starting with a static kick, the audible duration of which is of the order of $\frac{1}{8}$ sec. "It is probable that electromagnetic disturbances resulting from static kicks could produce tweeks by multiple reflection between the earth's surface and a Heaviside layer."

Meyer's letter contains a criticism of the above letter and a suggestion that an attempt to correlate the "intermediate frequency" interference with the strength of the aurora borealis might meet with success.

DIE KOPFGESCHWINDIGKEIT ELEKTRISCHER FUNKEN UND BLITZE (The Velocity of the Front of Electric Sparks and Lightning Flashes).—R. Rüdenberg. (*Wiss. Veröff. a. d. Siemens-Konz.*, No. 1, Vol. 9, 1930, pp. 1–6.)

THUNDERSTORMS AND THE PENETRATING RADIATION.—B. F. J. Schonland. (*Nature*, 13th Sept., 1930, Vol. 126, p. 423.)

Abstract only of paper read to the Royal Society of S. Africa on June 18th, 1930. An examination of the effect of thunderclouds upon the intensity of the penetrating radiation, using a new type of ionisation-electroscope, was made at Johannesburg, in the summer of 1929–1930. Overhead storms give rise to a reduction in intensity, amounting to so much as 40%. No evidence could be obtained for the existence of beams of "run-away" electrons below these clouds. The reduction effect indicates that the majority, if not all, of the ionising particles have energies less than 5×10^9 electron-volts.

ATMOSPHERICS CONSIDERED AS IMPULSED OSCILLATIONS ON QUASI-STATIONARY AND NON-STATIONARY CIRCUITS.—Müller. (*See* abstract under "Properties of Circuits.")

A POLAR AURORA AND ITS ACTION ON RADIO TRANSMISSIONS.—Helbronner. (*See* under "Propagation of Waves.")

"SOUNDING" BY ATMOSPHERICS AND SHORT WAVES AT ZURICH AND IN THE SAHARA.—Lugeon. (*See* 2 abstracts under "Propagation of Waves.")

PROPERTIES OF CIRCUITS.

DER ANSTOSS QUASISTATIONÄRER UND NICHTSTATIONÄRER SCHWINGUNGSKREISE DURCH APERIODISCH GEDÄMPFTE KONDENSATORKREISE MIT SELBSTINDUKTION BEI INDUKTIVER KOPPLUNG (The Impulsing of Quasi-stationary and Non-stationary Oscillatory Circuits by Aperiodic Damped Condenser Circuits with Inductance, by Inductive Coupling).—H. Müller. (*Zeitschr. f. tech. Phys.*, Oct., 1930, Vol. 11, pp. 405–427.)

A theoretical treatment confirmed by experiment. In the final section the results are considered in relation to the interference with wireless reception caused by aperiodic damped processes; non-stationary receiving systems must be more subject to interference than quasi-stationary systems, and long wave receivers more than short wave receivers (if both employ an open aerial). In this connection Binder's results are mentioned, namely, that the length of a "top" of a lightning flash increases greatly with the distance between the point of striking and the observation point. The behaviour of grinders, hisses and clicks are also considered separately but briefly.

THE TRIODE OSCILLATION GENERATOR AND AMPLIFIER; LIMITATIONS ON SINOIDAL PERFORMANCE.—L. B. Turner and L. A. Meacham. (*Proc. Camb. Phil. Soc.*, October, 1930, Vol. 26, No. 4, pp. 507–527.)

This paper contains a theoretical and experimental investigation of the conditions obtaining in the "sinoidal régime" of an oscillating triode and of "the limits between this régime and what may be called the high efficiency régime lying beyond." The investigation is based on the "lumped characteristic" of the triode, *i.e.*, the curve representing the characteristic relationship between anode current i_a, anode potential e_a and grid potential e_g, namely, $i_a = \phi(e_a + \mu e_g) = \phi(e_l)$, where $e_a + \mu e_g$ is the "lumped potential" e_l, μ being assumed constant.

This equation is valid only while: (1) e_a is positive, (2) the anode potential exceeds the grid potential, (3) no grid current flows. In using the lumped characteristic to investigate the conditions for linear operation in an amplifying or self-oscillating condition, a point (P_m, J_m) must be selected which may be regarded as the lower limit of the sensibly rectilinear portion of the characteristic; and it must be decided "what restrictions must be placed on e_a and e_g separately in order that the lumped characteristic shall be followed."

A theoretical analysis of the "sinoidal régime" is made on the assumptions that the lumped characteristic is straight down to the point (P_m, J_m), and that the maximum potential of the grid during a cycle is zero. Equations are derived which give "the most economical choice of anode and grid batteries for a special triode and circuit, oscillating with the greatest amplitude consistent with their linear performance," and expressions are found for the amplitudes of alternating component of anode and grid potentials, E_a and E_g respectively, and anode current I_a, for the input power W_i supplied by the anode battery and the output power W_o delivered to the oscillating circuit, and for the efficiency $\frac{W_o}{W_i}$ when the best performance of the triode oscillator with a given triode, oscillating circuit and high tension supply has been attained. It is shown that the efficiency of the maximum output is 25% ; it is impossible for the efficiency to reach 50%, with any real characteristic, in the linear régime.

The analysis was checked experimentally with an Osram DEL 410 triode at a frequency of 75 kc/s ; observations were also made with the amplitude "pushed well beyond the nominally linear region, and the strengths of the 2nd, 3rd, 4th and 5th harmonics in the anode current were measured." A full description of the oscillating circuit and amplifier used and of their tests and calibrations is given ; the amplifier was very highly selective. A perceptible second harmonic was found always to be present, "presumably introduced by the . . . slight curvature of the nominally straight portion of the characteristic. Higher harmonics and grid current set in simultaneously at about the value of I_a predicted by the analysis and selection of (P_m, I_m)."

A very close approach to absolute purity of the sinoidal régime can be attained with a suitable triode, steady conditions and a fine adjustment of retroaction. The harmonics in the anode potential are much less pronounced than those in the anode current, which were measured here.

DIE KENNLINIENFELDER DER WIDERSTANDSVERSTÄRKERRÖHRE (The Characteristic Curve Fields of Resistance-coupled Amplifier Valves).—R. Feldtkeller. (*T.F.T.*, Sept., 1930, Vol. 19, pp. 265–275.)

After describing the three possible families of characteristic curves ("characteristic fields"), namely, the E_g, I_a curves with E_a as parameter, the E_g, E_a curves with I_a as parameter, and the E_a, I_a curves with E_g as parameter, the writer points out the superior utility of the last type for obtaining the work curves, which for this type of field take the form of straight lines sloping *in the opposed direction*. With the other two types of field they are curves and slope in the same direction as the characteristic curves. The rest of the paper deals, therefore, exclusively with the E_a, I_a fields and their construction, and with the superposition on them of curves of constant amplification, constant derivable output power, constant "klirr"-factor [measuring the non-linear distortion], etc. An appendix deals with the calculation of the "klirr"-factor in the case of transformer coupling.

A NOTE ON THE MATHEMATICAL THEORY OF THE MULTIELECTRODE TUBE.—P. Caporale (*Proc. Inst. Rad. Eng.*, Sept., 1930, Vol. 18, pp. 1593–1599.)

"It has heretofore been customary to set up a Taylor expansion for the current (usually the plate current) in the electrode considered, and by assuming a power series for the same current and equating to the Taylor series, the coefficients of the power series were determined. An investigation of these coefficients then gave the various modes of operation of the device. In the case of multi-electrode tubes, however, this procedure leads to a complexity that hides the general properties of the device, although it has been applied to the four-element tube [Brainerd, 1929 Abstracts, p. 512]. The results given herein are intended to give a more extensive and general, though less detailed, view of these properties."

Author's summary :—The expression for the a-c current (rather the change in current due to applied a-c voltages) in any electrode is expanded in an ascending power series in terms of all the applied a-c voltages. It is shown that the coefficients in these series must satisfy a number of systems of linear simultaneous equations (one system for each power and frequency of the terms), and that hence, to obtain the coefficients in any particular case, it is merely necessary to set up these equations and solve them. The solution of the equations of course increase in complexity as the number of electrodes increases.

The development does not make any assumptions of approximations, although in the discussion only the terms of the first and second degree are considered. It is shown, however, that however slow be the convergency of the series, the coefficients must always satisfy similar sets of algebraic equations.

CONCERNING KUSUNOSE'S DYNAMIC DIAGRAMS.—Marique : Kusunose. (*See* under "Valves and Thermionics.")

APERIODIC AMPLIFICATION AND RECTIFYING AMPLIFICATION USING THE ENTIRE AMPLIFICATION FACTOR OF TRIODES.—Rudolph. (*See* under "Valves and Thermionics.")

DIE RÜCKGEKOPPELTE HOCHFREQUENZVERSTÄRKERSTUFE (The Retroactive H.F. Amplifier Stage).—E. Zepler. (*Telefunken Zeit.*, No. 54, Vol. 11, pp. 59–61.)

THE MULTISTAGE VALVE AMPLIFIER [MATHEMATICAL THEORY].—A. C. Bartlett. (*Phil. Mag.*, Oct., 1930, Series 7, Vol. 10, No. 65, pp. 734–738.)

Author's summary :—The *n*th power of a second order square matrix is first obtained, and then from this the equations of the multistage amplifier.

THE THEORY OF THE STRAIGHT LINE RECTIFIER.—F. M. Colebrook. (*E.W. & W.E.*, Nov. 1930, Vol. 7, pp. 595–602.)

An analysis of the ideal straight line rectifier to which various practical forms of rectifier may be considered to approximate under certain conditions.

The questions (i) what is the effective input resistance, (ii) effective output-frequency internal resistance and e.m.f., (iii) do the above quantities vary with amplitude and load, and (iv) what are the characteristics from the point of view of modulation frequency distortion ?—are answered, and the answers supported by experimental evidence; it is shown that such a rectifier can be calibrated to a good degree of accuracy by simple d.c. measurements of the static characteristic.

DIE FORTLEITUNG HOCHFREQUENTER ELEKTRISCHER SCHWINGUNGSENERGIE (The Conduction of H.F. Oscillating Energy).—H. O. Roosenstein. (*Zeitschr. f. hochf. Tech.*, Sept. and Oct., 1930, Vol. 36, pp. 81–85 and 121–133.)

From the Telefunken Laboratories. The first of two instalments deals with symmetrical conductors, *i.e.*, those in which the go- and return-currents are equal in intensity and in voltage but of opposite phase. The general fundamental principles are first explained, the various factors involved being defined and discussed :—*e.g.*, " wave-ratio " (ratio of absolute values of current amplitudes at nodes and loops) and " node-breadth " (gap between two points on either side of a current or potential node where the amplitude is $\sqrt{2}$ times that at the node). Next, the writer uses these principles to deal with the conduction and loss of energy in such conductors, showing the relations between the conducted energy and the wave-ratio and node-breadth. Expressed in words, under given conditions for the heating of the conductor at current loops and of the dielectric at potential loops the conducted energy is proportional to both of these factors. The final section deals with the calculation of the losses and of the efficiency of the conductors. The second instalment deals theoretically and experimentally with the measurement of characteristic impedance, damping and radiation-damping of conducting systems in practical use—concentric tubes, parallel wires, etc. The last sections deal with asymmetry, and a method for the practical systematic avoidance of this.

THEORIE UND KONSTRUKTION DER SIEBKETTEN KONSTANTER RESONANZBREITE (Theory and Design of Wave Band Filters of Constant Breadth of Resonance).—G. Schweikert. (*Zeitschr. f. Fernmeldetech.*, 27th Aug. and 27th Sept., 1930, Vol. 11, pp. 127-128 and 135–144.)

ÜBER EINE BEMERKENSWERTE EIGENSCHAFT DER VERZÖGERUNGSKETTEN (A Noteworthy Property of Delay Networks).—F. A. Fischer. (*Zeitschr. f. tech. Phys.*, Oct. 1930, Vol. 11, pp. 402–405.)

The writer shows theoretically and confirms by experiment that all the frequencies in the pass band of a delay network pass with constant velocity not only through the whole network *but also through each individual link* (this applies also to surges). A knowledge of this fact assists in the design of such networks and allows the number of links to be reduced.

UNTERSUCHUNG DER ERZWUNGENEN KOPPELSCHWINGUNGEN EINES ELEKTROMECHANISCHEN SYSTEMS UNTER VERWENDUNG EINES GRAPHISCHER VERFAHRENS (Investigation of Forced Coupled Oscillations of an Electromechanical System by a Graphical Method).—E. Lehr. (*Arch. f. Elektrot.*, 27th Sept., 1930, Vol. 24, No. 3, pp. 330–348.)

ON THE THEORY OF FILTER AMPLIFIERS.—S. Butterworth. (*E.W. & W.E.*, Oct., 1930, Vol. 7, pp. 536–541.)

The theory is given, and embodied in a set of design tables, of systems of simple filter units separated by valves so that filtering and amplification are combined. A low-pass unit can be so designed that it takes up little more space than the anode resistance in the ordinary resistance-capacity amplifier, and can be of of the plug-in type. A band-pass filter would use two units of similar size. A further advantage over the ordinary filter system is that the effect of resistance is under complete control, so that the sensitivity may be made uniform in the pass region.

PAPERS ON PHASE DISTORTION IN FILTER AND OTHER CIRCUITS.—Steinberg : Lane : Nyquist and Brand. (*See* under " Acoustics.")

THEORY OF THE THREE ELEMENT FILTER.—A. G. Lurié. (*Westnik Elektrot.*, June 1930, No. 6, pp. 229–233.)

BEITRAG ZUR THEORIE DES RESONANZTRANSFORMATORS (Contribution to the Theory of the Resonance Transformer).—H. Laub. (*E.N.T.*, Sept. 1930, Vol. 7, pp. 348–362.)

A theoretical and experimental investigation in special connection with the working out of systems of train control, such as one in which the reaction of a short-circuited secondary winding (on the track) on a resonant primary winding (on the locomotive) excited by a.c., produces such current changes in the latter that the control relays are actuated. The experimental work is done on frequencies from about 2 to 6 kilocycles per second.

ZUR THEORIE GEDÄMPFTER ELEKTRISCHER SCHWINGUNGEN (Contribution to the Theory of Damped Electrical Oscillations).—A. Kneschke. (*Ann. der Physik*, Series 5, 1930, Vol. 6, No. 2, pp. 186–194.)

In this paper dyads (second rank tensors) are used to prove the mutual energy theorem and to give a formal solution of the problem of transient oscillations for a finite number of coupled electrical circuits and for the telegraph equation.

RESONANZ UND MITNAHMEFFEKT AN RÜCKGEKOPPELTEN VERSTÄRKERSYSTEMEN, WELCHE NUR KAPAZITÄTEN UND WIDERSTÄNDE ODER NUR INDUKTIVITÄTEN UND WIDERSTÄNDE ENTHALTEN (Resonance and Pulling into Tune in Reactivity Coupled Amplifier Systems possessing only Capacities and Resistances or Inductances and Resistances).—F. Tank and L. Zelwer. (*Helvet. Phys. Acta*, 5/6, Vol. 3, Oct. 1930, pp. 329–334.)

Zur Theorie des Mitnehmens von van der Pol (On van der Pol's Theory of Forced Oscillations).—A. Andronow and A. Witt. (*Arch. f. Elektrot.*, 28th June, 1930, Vol. 24, No. 1, pp. 99–110.)

A mathematical investigation on the lines of Poincaré's theory of the forced oscillations of an oscillatory circuit containing a triode with non-linear grid voltage/anode current characteristic. It is found among other things that a region of forced oscillations always exists, even when the amplitude of the external periodic force is very small; this is contrary to the conclusions of Ollendorff (*Arch. f. Elektrot.*, Vol. 16, p. 280, 1926).

Variation of the Inductance of Coils due to the Magnetic Shielding Effect of Eddy Currents in the Cores.—K. L. Scott. (*Proc. Inst. Rad. Eng.*, Oct. 1930, Vol. 18, pp. 1750–1764.)

Author's summary:—An analysis is made of the shielding effect of eddy currents on the flux in the interior of cores of cylindrical or flat sheet material. It is shown that the counter voltage of self inductance of an iron-cored coil is due only to the component of flux in the core which is in phase with the flux at the surface of the core. Expressions are obtained and curves plotted showing the variations of inductance of a coil with frequency, or with the conductivity and permeability of the core material. Sample calculations and some experimental results are given. The results show that the inductances at high frequencies are actually less than the predicted values, which leads to the suspicion that some factor other than eddy currents causes the flux in the interior of the cores to decrease with increasing frequency.

A Two-Valve Circuit Emitting Trains of Discontinuous Waves.—M. La Rosa and L. Sesta. (*Nature*, 27th Sept., 1930, Vol. 126, p. 495.)

Note of a Acc. Naz. Lincei paper: "The mode of action of a two-valve circuit coupled with a resistance amplifier is considered."

TRANSMISSION.

Harmonic Attenuation.—W. T. Ditcham. (*Marconi Review*, Sept. 1930, pp. 1–8.)

"It is apparently impossible with any feasible arrangement of existing valve oscillators to prevent the generation of harmonics, and efforts therefore have to be confined to the prevention of their direct radiation, and to means for securing maximum attenuation before they reach the aerial . . . The object of the present article is to call attention to certain remedial measures which are applicable, although, unfortunately, not all without additional expense and some degree of complication." Among the various expedients dealt with are:—(i) the use of a condenser as the coupling member (for valve circuits in cascade or in coupling to an aerial), instead of an inductance; the advantage is very marked as regards the higher harmonics, since the harmonic voltage across a condenser—as compared with the voltage drop across an inductance of equal impedance to the fundamental—is in the ratio $\frac{1}{n^2}$, n being the number of the harmonic; (ii) push-pull connection, whose theoretical balancing-out of the even harmonics is only questionably fulfilled in practice, but which is useful to prevent the asymmetrical amplitudes per half-cycle due to the damping produced by the load: a point in design which may reduce direct radiation in some degree is to construct the tuning inductance of the oscillatory circuit in the form of an astatic pair; (iii) locating aerial and tuning components at a distance from the transmitter, and the provision of a feeder and suitable coupling devices, with or without the addition of harmonic traps: the writer's experience is that where the second harmonic is concerned the improvement resulting from such traps is not enough, normally, to meet modern requirements: such traps, *effectively screened*, sometimes give good results in the valve circuits themselves; (iv) filters or harmonic attenuators between output circuit and aerial: great stress is laid on the necessary high degree of screening, to prevent harmonic fields from "jumping" these: the difficulties of such screening are discussed, and it is suggested that one day the transmitter will be situated below ground level, the basement being covered with a metal roof forming the floor of an upper storey, housing control rooms, machinery, offices, etc.

A New Frequency-Stabilized Oscillator System.—Ross Gunn. (*Proc. Inst. Rad. Eng.*, Sept, 1930, Vol. 18, pp. 1560–1574.)

Author's summary:—"A new vacuum-tube self-oscillating system having extraordinary frequency stability is described which depends on the reëntrant circulation of oscillations through tuned filter or coupling units. The reëntrant circulation through the filter sections attenuates all but a single frequency in a manner analogous to the attenuation produced by a filter system having an infinite number of sections. The unattenuated component having a single frequency is amplified at each passage through the system and constitutes the single-frequency oscillation. The methods and necessary precautions for attaining frequency stability are given. Frequency shifts due to ordinary variations of plate potentials, filament current, or keying are found to be of the order of one thousandth of one per cent. The extreme flexibility of the circuits permit the construction of satisfactory radio transmitters operating from the lowest frequencies up to 20,000 kc. without the use of frequency-doubling stages. The oscillator system has found wide application in commercial and naval aircraft radio communication problems."

The circuit used is based on that described by the writer (*Journ. Opt. Soc. Am.*, 1924, p. 545) for an audio-frequency oscillator, which when first adapted to radio frequencies failed to show great frequency stability and was therefore temporarily abandoned so far as these frequencies were concerned. Later work showed that this difficulty lay not in the fundamental idea of reëntrant circulation but in the feed-back of some of the control oscillation energy through the plate-grid and other stray capacities; this could be avoided by bridge and balanced circuits, but at the cost of loss of flexibility. The present system, using two screen-grid valves and very careful shielding, requires no balancing adjustment over nearly the entire frequency range up to about 20 megacycles. At 15 megacycles a 10% change in plate potential produces a frequency change of only 45 cycles; an 8% change in filament potential produced a change of 400 cycles. Keying of the entire circuit in the plate lead gave rise to no " lilt " until 20 megacycles frequency was reached, and then it was only just noticeable. But the valves must be lightly loaded only, and the filaments fed with d.c., to obtain results as good as these—unless special non-inductive filaments are used, when a.c. heating would probably be satisfactory.

THE TRIODE OSCILLATION GENERATOR AND AMPLIFIER; LIMITATIONS ON SINOIDAL PERFORMANCE.—Turner & Meacham. (*See under " Properties of Circuits."*)

NOTE ON THE RELATIONSHIPS EXISTING BETWEEN RADIO WAVES MODULATED IN FREQUENCY AND IN AMPLITUDE.—C. H. Smith. (*E.W. & W.E.*, Nov. 1930, Vol. 7, pp. 609–611.)

The writer considers the frequency-modulated wave dealt with by van der Pol (1930 Abstracts, p. 626), equivalent to a carrier wave and an infinitude of sidebands, separated in frequency by integral multiples of q, whose amplitudes are given by Bessel functions of increasing orders. " On first thought it appears that such a sideband system, on being applied to a detector, must of necessity produce an audible output of frequency q. Such, however, is not the case, owing to the phase relationships which exist between the sidebands, and it can be shown that in the nature of these phase relationships lies the basic difference between amplitude and frequency modulation." A number of conclusions are reached, among these being that while a wave modulated in frequency only is incapable of producing an audio-frequency output in a parabolic detector, it can be made to produce current modulated in amplitude also by the effect of a resonant circuit tuned to a frequency not that of the carrier, or, more efficiently, by a circuit arranged for single sideband reception.

DIE IDEALISIERTE STATISCHE MODULATIONSKENNLINIE BEI DER PARALLELRÖHREN-MODULATION (The Idealised Static Modulation Characteristic in the Parallel Valve [Heising] System of Modulation).—H. Rieche. (*Zeitschr. f. hochf. Tech.*, Sept. 1930, Vol. 36, pp. 112–113.)

From the Barkhausen elementary equations the writer derives a formula for the modulation characteristic on the assumption of an ideal functioning of the stabilising choke [*i.e.*, that the total supply current remains constant]. Results agree well with those obtained by Kuhn's graphical method. From the formula it is deduced that the modulator should be of such dimensions that the current through it is from 2 to 5 times greater than the current through the oscillator: a still larger ratio brings no appreciable advantage. Further considerations show that the internal resistance of the oscillator should be from 2 to 5 times that of the modulator, so that the final recommendation is that the modulator should consist of 2 to 5 paralleled valves of the same type as the oscillator.

EINE VEREINFACHTE MODULATIONSSCHALTUNG (A Simplified Modulating Circuit [H.F. Supply for Filaments of Modulators]).—F. Weichart and W. Langewiesche. (*E.N.T.*, Oct. 1930, Vol. 7, pp. 408–409.)

From the laboratories of the State Post Office. In the usual grid-d.c. system of modulation, the filament of the modulating valve is connected to the grid of the transmitter valve and is thus at a considerable potential with regard to earth; its filament supply therefore presents some difficulty as regards capacity effects and insulation. Alternating current has great advantages owing to the use of transformers, but introduces difficulties of its own; these are avoided by the use of high-frequency current, which may be derived from the oscillating circuits in the manner shown. A further refinement enables the modulator grid-bias battery to be abolished, the grid bias being taken from a potentiometer supplied from the high-frequency circuit through a rectifying diode. For H.F. heating of transmitter valve filaments *cf.* Lorenz, 1930 Abstracts, p. 455.

ON THE MAGNETRON OSCILLATION OF NEW TYPE.—K. Okabe. (*Proc. Inst. Rad. Eng.*, Oct. 1930, Vol. 18, pp, 1748–1749.)

In an earlier paper (1929 Abstracts, pp. 447–448) the author distinguished between two types of magnetron oscillations: A, with frequency approximately independent of the external circuit, and B, with frequency depending principally on that circuit. The present paper deals with the latter type, which prove to be much longer in wavelength than type A (*e.g.*, 14.5 cms. compared with 3.16 cms.) and of very much greater strength (*e.g.*, 1000 : 1). Intense and stable oscillations down to 10 cms. could be produced. It may be that the types A and B correspond to the B.-K. and Gill-Morrel types, but on the other hand the G.-M. oscillations are always shorter than that of the B.-K. under similar conditions [with the magnetron, the conditions for A and B types were " slightly different " —*e.g.*, 1,500 compared with 1,600 v. anode volts]. " The existence of a negative resistance is very probable . . . this may be the cause of the oscillations of the type B."

RAUMLADUNGSSCHWINGUNGEN IN DIODEN (Space-Charge Oscillations in Diodes).—W. Gerber. (*Zeitschr. f. hochf. Tech.*, Sept., 1930, Vol. 36, pp. 98–112.)

The space-charge oscillations of Barkhausen and Kurz are here investigated under the simplest conditions so as to eliminate complicating factors such as coupling through leads, complex electrostatic fields, etc. Special valves are used in which the electrodes consist of two (in one case three) parallel stretched filaments, one of which is heated and serves as the cathode while the others are left cold and serve as anodes. A vacuum of 10^{-4} mm. of mercury is used (10^{-6} mm. in the case of the 3-filament valve). The wave-range investigated is approximately 100 to 500 cms., shorter waves being deliberately neglected as being less convenient to measure.

Among the results reached are the following:— It is shown that the oscillations produced by the Eccles arrangement using similar valves (Brit. Pat. 258989) are typical B-K. oscillations—thus contradicting the general belief that these latter depend essentially on concentric electrodes. They depend on the presence of "swinging" electrons; electrons passing direct from cathode to anode produce no oscillations, while among the swinging electrons only those are productive which describe periodic, closed paths. In these special valves the closed paths lie approximately in the plane containing anode and cathode. Electrons traverse these paths both clockwise and anti-clockwise: tests with a magnetic field, increasing the path-time of one set of electrons and decreasing that of the other set, show a separation of the two frequencies. Along the common path-loops the density of the space-charge varies periodically with position and with time; this produces standing "space-charge waves."

The electron gas of a path-loop is to be considered as an oscillatory system possessing, like a pipe, a whole spectrum of anharmonic natural wavelengths which can be excited separately. The fundamental period corresponds approximately with the path-time of an electron along a particular orbit and forms the so-called "long" wave; the second overtone gives the "short" wave, equal to or greater than half the long wave. The writer has often found the third overtone also. Each of these natural wavelengths possesses a spectrum of harmonics more or less pronounced according to circuit conditions.

Leaving his special valves and dealing with commercial types, the writer shows that in these, owing to mechanical and electrical asymmetries, the productive, closed-path electrons are divided into a number of groups with different periods. The intensity of the oscillations obtainable on a particular frequency is greater, the greater the number of electrons with the same period. In this connection the "polarity of heating current effect" is investigated: this is shown to be an internal effect, unconnected with the external circuit, and due to the combined action of mechanical and electrical asymmetries (voltage drop along filament, magnetic field, etc.); according to whether these compensate for each other or add together, the number of electron paths with the same frequency increases or decreases.

Investigations of the relations between the valve and the Lecher wire system show that the latter oscillates most strongly when the oscillating space-charge system is coupled to a potential antinode: "this result is important and shows definitely that the coupling between the two systems is capacitive." Consequencies of this are discussed.

Other points dealt with are in-phase, concentric space-charge oscillations (*e.g.*, using a central cathode and the two outside filaments as anodes), push-pull connections, and polyphase circuits; also the rectifying effect at the electrodes and at the walls of the valve. The apparatus used is described in some detail: as indicator for the Lecher wire system a very small valve, supplying a high resistance galvanometer, is employed instead of the more usual crystal detector; the method of mounting as a slider is described. Being highly sensitive, this indicator does not upset the continuity of the system.

RÉSULTATS EXPÉRIMENTAUX DE TÉLÉCOMMUNICATIONS AVEC LES ONDES ULTRA-COURTES (Experimental Results in Distant Communication with Ultra-Short Waves [15–18 cms.]).—G. Beauvais. (*L'Onde Élec.*, Oct., 1930, Vol. 9, pp. 484–492.)

See also 1929 Abstracts, pp. 326 and 448. The present paper deals entirely with telegraphic results (on modulated c.w.), with practical methods devised for selecting suitable valves—for transmission and reception—from a number of the same type, and with a comparison of different types of reflector. The longest range obtained was from the Eiffel Tower to a spot 24 miles distant, when "some signals were perceived."

ÜBER EINIGE WEITERE DEMONSTRATIONSVERSUCHE MIT DEM 2.4 M.-RÖHRENSENDER (Further Demonstrations with the 2.4 Metre Valve [Ultra-Short Wave] Transmitter).—L. Bergmann. (*Zeitschr. f. Unterr.*, No. 3, Vol. 43, 1930, pp. 122–129.)

Demonstrations with the transmitter referred to in 1930 Abstracts, p. 392.

THE EFFECT OF COMBINED A.C. AND D.C. PLATE SUPPLY ON A [ULTRA-] SHORT WAVE TRIODE OSCILLATOR.—G. S. Field. (*Canadian Journ. of Res.*, Oct., 1930, Vol 3, No. 4, pp. 287–290.)

"By combining a.c. and d.c. on the plate of a triode oscillator, more stable and much stronger oscillations were obtained than with pure d.c. Increase in r.f. current up to 2.5 times were noted. Experiments with 200-cycle and 60-cycle a.c. showed that the higher frequency gave stronger oscillations." Wavelength used was about 1.6 m. If the increased voltage at the a.c. peaks were the cause, a direct voltage equal to the peak a.c. voltage plus the d.c. voltage should result in even greater output, but in fact it gave less. The importance of the proportion of a.c. to d.c., and the effect of using different frequencies of a.c., are being investigated.

THE HEATING OF DIELECTRICS IN A [ULTRA-] HIGH FREQUENCY FIELD.—Pätzold. (*See* abstract under "Miscellaneous.")

TONE MODULATION OF TELEGRAPHIC TRANSMITTERS [FOR THE NEUTRALISATION OF FADING].—N. Wells. (*Marconi Review*, Sept., 1930, pp. 9–14.)

Second and final part of the article dealt with in 1930 Abstracts, p. 566. Practical points in obtaining the desired tone modulation are considered, particularly in connection with the Absorber method of keying—"the only satisfactory method when speeds of over 100 w.p.m are desired." Faults such as allowing the peak anode voltages to cause a momentary saturation of the magnifier filaments, which may not be discernible on the instruments, but which lead to "flat top" emission and accentuation of the higher harmonics, are briefly dealt with.

UNTERSUCHUNGEN ÜBER SCHWUNDERSCHEINUNGEN BEI KURZER WELLEN (Investigation of Short Wave Fading).—K. Krüger and H. Plendl. (*Zeitschr. f. tech. Phys.*, Nov., 1930, Vol. 11, pp. 478–482.)

Further details of the anti-fading transmission method dealt with in 1930 Abstracts, p. 452.

TESTS ON THE H.F. ALTERNATOR BROADCASTING TRANSMITTER AT MUNICH.—Baumgartner: Teilmann. (*T.F.T.*, Sept., 1930, Vol. 19, p. 279.)

LONG DISTANCE CABLE CIRCUIT FOR PROGRAM TRANSMISSION.—A. B. Clark and C. W. Green. (*Bell Tech. Journ.*, July, 1930, Vol. 9, No. 3, pp. 567–594.)

See 1930 Abstracts, p. 567.

RECEPTION.

LES PARASITES QUI GÊNENT LA RÉCEPTION DES SIGNAUX DE T.S.F. EN AVION SONT-ILS DUS UNIQUEMENT AU SYSTÈME D'ALLUMAGE ? (Is the Interference with Reception in Aircraft due entirely to the Ignition System ?). —A. Mahoux. (*L'Onde Élec.*, Sept., 1930, Vol. 9, pp. 446–448.)

The writer's experiences with various types of engines (including Diesel), various grades of spirit and various systems of screening, lead him to conclude that an important additional source of interference is the actual combustion of the fuel; possibly the explosion waves generate electrical oscillations. He considers that the various phenomena described should be investigated thoroughly. Incidentally his results suggest a simple method of testing the quality of the fuel used.

SCREEN-GRID DETECTORS IN PUSH-PULL.—J. S. Cebik. (*QST*, Aug., 1930, Vol. 14, pp. 38–39.)

"It has been occasionally mentioned that screen-grid tubes do not oscillate readily on frequencies above 18 or 19 megacycles because of the internal capacity between the elements. A way to get around this is to use screen-grid detectors in push-pull so that the tube capacities are in series."

ON THE SELF-INDUCTANCE OF [ROLL] CONDENSERS AT VERY HIGH FREQUENCIES.—W. Rotkiewicz. (*Wiadomości i Prace, Inst. Radjot.*, Warsaw, No. 5, Vol. 2, pp. 185–193.)

The writer gives the formula $L = \frac{4\pi dl}{a}$ cm. for the inductance of paper-insulated roll condensers used in telephony and also in wireless receivers, and illustrates by an example the effect of this inductance in a reaction receiver with r.f. amplification: it forms a parasitic resonant circuit which prevents retroaction and renders the receiver insensitive to a certain band of wavelengths—in the example taken, from 21 to 25 metres.

THE STENODE RADIOSTAT: A SUGGESTED EXPLANATION.—P. David: S. O. Pearson. (*L'Onde Élec.*, Oct., 1929, Vol. 9, p. 47A.)

In a criticism of Pearson's article (1930 Abstracts, p. 508), the writer remarks that "many readers have protested—*Wireless World*, 11 June, 1930, pp. 633–634—against the insufficiency of this explanation. Not without reason, in our opinion. May one take it that the Stenode Radiostat is so selective that it receives only *one* sideband, and consequently eliminates interference, however near [in frequency], provided it is on the other side of the carrier? If so, it would be well to say so."

BROADCAST RECEIVERS: A MODERN NEED [AUTOMATIC FADING COMPENSATION].—G.W.O.H. (*E.W. & W.E.*, Nov., 1930, Vol. 7, pp. 593–594.)

AUTOMATIC FADING COMPENSATION IN SUPERHETERODYNE RECEIVERS.—H. Enthofer. (*Rad., B., F. f. Alle*, Oct., 1930, pp. 452–455.)

MODERNI ORIENTAMENTI NELLA TECNICA COSTRUTTIVA DEI RICEVITORI PER RADIODIFFUSIONI SU ONDE MEDIE (Modern Trends in the Design of Medium Wave Broadcast Receivers).—M. Boella. (*Reg. Accad. Nav. Livorno*, No. 52, 1930, 9 pp.; *Rass. d. Poste, d. Teleg. e. d. Telef.*, No. 6, June, 1930.)

Largely concerned with British and American practice, the *Wireless World* being frequently cited.

SHORT WAVE RADIO TELEPHONE AND TELEGRAPH RECEIVERS.—E. H. Ullrich and R. E. Gray. (*Elec. Communication*, No. 4, Vol. 8, 1930, pp. 224–229.)

CAN ONE TAKE A RECEIVER ON A JOURNEY ABROAD WITHOUT PAYING DUTY ?—(*Rad., B., F. f. Alle*, Oct., 1930, pp. 456–457.)

AERIALS AND AERIAL SYSTEMS.

THE RADIATION DISTRIBUTION OF ANTENNÆ IN VERTICAL PLANES.—R. M. Wilmotte. (*Journ. I.E.E.*, Sept., 1930, Vol. 68, pp. 1191–1204.)

Author's summary :—The radiation distribution of an antenna in a vertical plane was obtained by measuring in an aeroplane the strength of a received signal from an excited antenna on the ground. The position of the aeroplane relative to the antenna was obtained by means of a theodolite on the ground, the signal strength being recorded on a cinematograph film.

Although the ground site appeared very good, it was found that spurious radiations were obtained and these were probably the cause of the discrepancies found between the theoretical and the experimental results. The measurements were made on a horizontal antenna at several frequencies.

The reason for this particular arrangement is that it should be possible to separate the effect of the reflection of the antenna in the earth from that of the antenna itself, and thereby obtain a double result from a single measurement.

The results showed very definite maxima and minima and the position of these could be ascertained accurately within a few degrees, but the difficulties of the experiment prevented an accurate value of the field strength being obtained. Substantial agreement was obtained between theory and experiment, the discrepancies increasing with the frequency.

The radiation distribution was also obtained for one of the beam stations erected by the Marconi Co. Owing to the sharpness of the beam, considerable experimental error was liable to occur. Nevertheless, substantial agreement between theory and experiment was also obtained in this case.

GENERAL FORMULÆ FOR THE RADIATION DISTRIBUTION OF ANTENNA SYSTEMS.—R. M. Wilmotte. (*Journ. I.E.E.*, Sept., 1930, Vol. 68, pp. 1174–1190.)

A number of general formulæ are here given and discussed—*e.g.*, effect of an imperfect earth (image effect); radiation distribution of a straight wire inclined at any angle; of a system of similar antennæ spaced in any given manner. A number of special cases are deduced, and curves given to facilitate computation.

UNTERSUCHUNGEN AN STRAHLWERFERANLAGEN IN NAUEN (Investigation of the Nauen Beam Aerials).—W. Pfitzer. (*T.F.T.*, Sept., 1930, Vol. 19, p. 280.)

Tests on the Telefunken aerial system directed to Japan; wavelength 16.92 m.; 64 dipoles in two vertical planes of 32 each. The horizontal aperture of the radiated beam appears to be 15°. Field strength measurements in the main beam at 1.4 km. distance gave only about 50 mv./m., or 100 times less than might be expected by theory: the main radiation must be high above the ground. *Cf.* 1930 Abstracts, p. 631.

CERTAIN FACTORS AFFECTING THE GAIN OF DIRECTIVE ANTENNAS.—G. C. Southworth. (*Proc. Inst. Rad. Eng.*, Sept., 1930, Vol. 18, pp. 1502–1536.)

Author's summary:—This paper analyses the performance of antenna arrays as influenced by certain variables within the control of the designing engineer. It starts with an extremely simple analysis of the interfering effects produced by two sources of waves of the same amplitude. This is followed by a short discussion of a paper by Ronald Foster, which considers two antennas and also 16 antennas when arranged in linear array. Two antennas separated in space by ¼ wavelength and in phase by ¼ period give sensibly more radiation in one direction than in the opposite. This, for convenience, has been called an unidirectional couplet. A number of these couplets may be arranged in linear array, thereby giving an extremely useful directive system. Diagrams are shown for such arrays as affected by the number and spacings of the individual couplets. The gains from such arrays are calculated and data are given showing fair agreement between calculation and observation.

Directional diagrams for arrays of coaxial antennas indicate that somewhat less gain may be expected from this form than when the elements are spaced laterally. Combinations of these two types of arrays give marked directional properties in both their horizontal and vertical planes of reference. This principle has been used rather generally in short-wave communication. This paper also discusses effects resulting from combining two or more arrays. In one case the space between two arrays tends to emphasise spurious lobes. The directional diagram of such a combination may be rotated within limits by changing the phasing between adjacent arrays or sections of an array. In all of the above cases the influence of the earth is ignored.

A mathematical appendix gives general equations for calculating directional diagrams of linear arrays. Special cases of these equations apply to the figures included in the main part of the text. General equations are also given for calculating the gains of arrays. Similar equations permit the areas of diagrams to be calculated. An extended bibliography on antenna arrays is appended.

ON THE CALCULATION OF MASTS WITH STAYS.—B. S. Loonin. (*Westnik Elektrot.*, June, 1930, No. 6, pp. 221–225.)

A method based on the assumption that a mast with its stays forms a single elastic system, and on the finding of such tensions in the stays that horizontal displacements of their points of attachment to the mast are equal to the displacements—at the same points on the mast—due to the action of wind and the tension of the stays.

BRITISH P.O. SHORT WAVE AERIAL ARRAYS.—Lee.

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

SHORT WAVE DIRECTIVE TRANSMITTING AND RECEIVING ANTENNAS.—E. H. Ullrich and N. K. Fairbank. (*Elec. Communication*, No. 4, Vol. 8, 1930, pp. 235–241.)

THE ARTIFICIAL CHARACTERISTIC OF NON-DIRECTIVE POINT RADIATORS DISPOSED OVER A SPHERICAL SURFACE.—Fischer.

(*See* under "Acoustics.")

MEASUREMENTS IN THE RADIATION FIELD OF A DIPOLE AERIAL.—Peters.

(*See* under "Propagation of Waves.")

VALVES AND THERMIONICS.

APERIODISCHE VERSTÄRKUNG SOWIE RICHTVERSTÄRKUNG UNTER AUSNUTZUNG DES VOLLEN VERSTÄRKUNGSFAKTORS VON ELEKTRONENRÖHREN (Aperiodic Amplification and Rectification with Full Utilisation of the Amplification Factor of Thermionic Valves).—H. Rudolph. (*Arch. f. Elektrot.*, 28th June, 1930, Vol. 24, No. 1, pp. 1–3.)

In aperiodic amplification with resistance coupling, the efficiency is low owing to the high internal resistance with small "durchgriff."

Author's summary :—" A method is described for aperiodic voltage amplification, which it is proposed to denote as the 'constant anode current' method. This employs a diode to limit the current in the anode circuit of an amplification valve and permits the amplification factor $\frac{1}{D}$ [D = 'durchgriff'] to be utilised to the full ; the filament and anode voltages have very little influence on the effect. The use of the arrangement as a rectifier with linear characteristic passing through the origin is also discussed and reference is made to other possible applications."

HERABMINDERUNG DES STORENDEN EINFLUSSES DER HEIZSPANNUNG AN DEN ENDEN EINER GLÜHKATHODE DURCH EINE GEGENELEKTRODE MIT ÜBERLAGERTEM SPANNUNGSGEFALLE (Reduction of the Disturbing Influence of the Filament Voltage at the Ends of an Incandescent Filament by means of an Opposite Electrode with Superposed Voltage Drop).—G. Mönch. (*Physik. Zeitschr.*, 15th Oct., 1930, Vol. 31, No. 20, pp. 904–909.)

Author's summarising remark :—Theoretical considerations and experiments show that it is possible to reduce the disturbing influence of the filament voltage on the velocity distribution of electrons arriving at the anode and on the so-called "steepness" [of the grid voltage, anode current characteristic] by means of an electrode with superposed voltage drop. The connection of the electrode to the battery producing the auxiliary voltage increases the capacity of the electrode and this limits the possibilities of application of the idea.

DIMINISHING THE GRID CURRENT AT ZERO GRID POTENTIAL IN RECEIVING TUBES.—S. A. Obolensky. (*Westnik Elektrot.*, June 1930, No. 6, pp. 203–212.)

The principal cause of large grid currents at zero grid potential in tungsten and thoriated tungsten valves was found to be magnesium condensing on the grid and reducing the work function of the grid material. If the deposition of magnesium cannot be avoided, the work function must be increased artificially. By preliminary oxidation of the grid, followed by such a heat treatment during the evaporation of magnesium that the oxides formed do not evaporate from the grid surface, the grid currents of a large quantity of "Micro" type valves were reduced to less than one microampère. "It is shown that by the change of the contact e.m.f in the grid-cathode circuit, the plate and grid characteristic curves are shifted in the same direction, so that troubles arising from a large grid current at zero grid potential may be avoided by using a grid bias of suitable value."

DAS RÖHRENDREIECK (The Triangular Valve Diagram).—E. Meyer. (*Telefunken Zeit.*, No. 54, Vol. 11, pp. 54–58.)

This diagram, a graphic representation of Barkhausen's equation connecting slope, "durchgriff," and internal resistance ($S \times D \times R = 1$). gives the simplest possible view of the properties of an amplifier valve and is useful in solving certain problems. Advantages over alternative methods—groups of hyperbolas, nomograms, etc., are discussed. The paper ends with a table of constants for a number of Telefunken valves.

AU SUJET DES DIAGRAMMES DYNAMIQUES PUBLIÉS PAR KUSUNOSE (Concerning Kusunose's Dynamic Diagrams).—J. Marique. (*L'Onde Élec.*, Aug. 1930, Vol. 9, pp. 389–396.)

The writer briefly summarises the "remarkable work" of Kusunose (1930 Abstracts, p. 47), and then shows how a few simple changes of co-ordinates enable his diagrams to bring out interesting facts with regard to the action of self-excited and separately-excited triodes. Thus Rukop's second zone of instability (*Telefunken Zeit.*, No. 31, 1923) can be shown in the case of the former, while for the separately-excited triode light is thrown on Heising's statement (*Proc. I.R.E.*, Aug., 1921) that to obtain a linear variation of r.f. current as a function of plate voltage, the grid voltage must be modulated in proportion and in phase.

THE CHARACTERISTIC CURVE FIELDS OF RESISTANCE-COUPLED AMPLIFIER VALVES.—Feldtkeller. (*See* under "Properties of Circuits.")

A NOTE ON THE MATHEMATICAL THEORY OF THE MULTIELECTRODE TUBE.—Caporale. (*See* under "Properties of Circuits.")

BEMERKUNG ZUR ADSORPTIONSTHEORIE VON SEXL (Remark on Sexl's Adsorption Theory).—A. Ganguli. (*Zeitschr. f. Phys.*, 14th Aug., 1930, Vol. 64, No. 1/2, pp. 81–83.)

ABNORMAL SHOT EFFECT OF IONS OF TUNGSTOUS AND TUNGSTIC OXIDE.—J. S. Donal, Jr. (*Phys. Review*, 1st Oct., 1930, Series 2, Vol. 36, No. 7, pp. 1172–1189.)

ELECTROSTATIC SURFACE FIELDS NEAR THORIATED TUNGSTEN FILAMENTS BY A PHOTOELECTRIC METHOD.—L. B. Linford. (*Phys. Review*, 15th Sept., 1930, Series 2, Vol. 36, No. 6, p. 1100.)

MEASUREMENTS, TESTS AND RECEIVERS WITH EXTERNAL-GRID VALVES [TELEFUNKEN "ROD" ("ARCOTRON") AND "VALVO" FLAT VALVES].—von Ardenne : H. Kröncke. (*Rad., B., F. f. Alle*, Oct. 1930, pp. 440–444 and 458–462.)

DIE AUSSENSTEUERRÖHRE (External Grid Valves [Telefunken "Rod"]).—F. Noack. (*Zeitschr. V.D.I.*, 8th Nov. 1930, Vol. 74, pp. 1550–1551.)

After referring briefly to earlier designs of external grid valves (de Forest, Weagant, Round) the writer deals in some detail with the two types of "rod" valve (high-vacuum and gas-filled) now made by the Telefunken Company. The gas-filled type is unaffected by frequencies below 10,000 p.p.s. and is therefore very useful in the audion stage ; the vacuum type is used as a l.f. amplifier, and one (or two) ordinary power valves serve as the output stage.

THE MEASUREMENT OF SMALL CURRENTS: GRID CURRENT CHARACTERISTICS AND THE SUITABILITY OF DIFFERENT TYPES OF VALVES.—Bh. S. V. Raghava Rao & H. E. Watson. (*E.W. & W.E.*, Oct. 1930, Vol. 7, pp. 552–556.)

An investigation of bright emitter valves of various types from the viewpoint of their suitability for measuring (*e.g.*) photoelectric currents of the order of 2.5×10^{-10} A.

ULTRA-SENSITIVE VACUUM TUBE.—General Electric Company. (*Electrician*, 7th Nov. 1930, Vol. 105, p. 554.)

Paragraph on a new G.E.C. valve "capable of measuring 10^{-17} A." In the measurement of small currents "it will, to a great extent, replace electrometers."

STATO ATTUALE DELLA TECNICA DELLA COSTRUZIONE DEI TUBI A VUOTO (Present State of the Technique of Valve Construction).—C. Matteini. (*Reg. Accad. Nav. Livorno*, No. 51, 1930, 6 pp.; *Rass.d.Poste, d. Teleg. e d. Telef.*, No. 5, May, 1930.)

DIRECTIONAL WIRELESS.

UN NOUVEAU RADIO-COMPAS (A New [Direct-Reading] Radio Compass).—H. Busignies. (*L'Onde Élec.*, Sept., 1930, Vol. 9, pp. 397–415.)

The full paper foreshadowed by David in his general survey (1930 Abstracts, pp. 511–512), in which he refers to the Busignies system as giving results "without any ambiguity and with an excellent precision (two degrees)." The inventor mentions that with the receiver installed in a motor boat, on certain occasions the motor "noise" so interfered with aural reception that the extinction angle for the signals amounted to 25 degrees, whereas the direct-reading instrument gave a reading accurate to within 1–2 degrees. The order of magnitude of the necessary strength of signals is 40 μv./metre. The apparatus is suitable for ships, aircraft (*e.g.*, as a target-flight indicator, showing at once the slightest deviation from the proper course) or fixed stations.

The principle of the apparatus is that a cardioid combination rotating at a constant speed (about 600 r.p.m. is found to be best) carries with it the field magnet of a galvanometer. This galvanometer has enough inertia to integrate the current, and its coil sets itself so that its flux lies in the direction of that of the field magnet at the instant of maximum current. The paper gives full details of the way in which this principle is carried out, and also describes a modification (particularly suitable for aeroplanes, where it is difficult to obtain a true cardioid diagram) in which the field magnet is rotated twice as rapidly as the aerial system, which here consists of a single vertical frame. This arrangement, however, gives 180° ambiguity.

DISTANCE DETERMINATION BY FOGHORN AND WIRELESS TELEPHONY: EXTENSION TO PREVENTING COLLISIONS AT SEA.—(*Engineer*, 19th September, 1930, Vol. 150, p. 311.)

A further paragraph on the Cumbrae (Clyde) installation referred to in 1930 Abstracts, p. 117. "Experiments . . . suggest that the risk of collision at sea through fog is likely to be appreciably diminished by its use . . . While these experiments have been successful only with the [transmitting] apparatus on land, it is considered certain that with a few minor adjustments the device will be equally useful at sea."

THE EQUI-SIGNAL ZONE RADIO BEACON AND AIR NAVIGATION.—R. L. Smith-Rose. (*Nature*, 19th July, 1930, Vol. 126, pp. 98–100.)

A general account of recent progress in the application of directional wireless methods to assist aerial and marine navigation. The equi-signal zone radio beacon is particularly described and a list of relevant literature is given.

THE "DEVIOMETER" [RADIOBEACON REED INDICATOR ATTACHMENT].—Bureau of Standards. (*Bur. of Stds. Tech. News Bull.*, Oct., 1930, No. 162, pp. 95–96.)

A rheostat device for changing the relative sensitivity of the two reeds. In addition to enabling the pilot to follow a course chosen, within limits (about 15°), on either side of the equi-signal zone (thus reducing risks of collision in fog, and also helping a pilot who has deviated for some reason from the strict course), it is suggested that it may also serve as a position finder for aircraft not flying a beacon course. It is not yet certain whether the direction discrimination of the system is sharp enough for this last application.

A TUNED-REED INDICATOR FOR THE 4 AND 12 COURSE AIRCRAFT RADIO RANGE: CORRECTION.—F. W. Dunmore. (*Proc. Inst. Rad. Eng.*, Sept., 1930, Vol. 18, p. 1480.)

A wrong diagram was given in the paper referred to in 1930 Abstracts, p. 398. The correct one is here given.

SAFETY IN AERIAL NAVIGATION THROUGH RADIO COMMUNICATION.—E. T. Allen. (*Mech. Engineering*, Sept., 1930, Section 1, Vol. 52, pp. 846–848.)

WIRELESS DIRECTION FINDING AS AN AID TO AERIAL NAVIGATION.—(*Marconi Review*, Oct. 1930, pp. 17–29.)

The advantages and disadvantages of various systems are discussed, including the American Equi-signal Beacon; the "Rotating Beacon"; the rotating beam transmitters of various types, including the combination of two rotating beams [Loth, see 1930 Abstracts, p. 217]; the Marconi-Bellini-Tosi system, either on the ground or on board the aircraft; the Marconi-Adcock and Marconi-Robinson systems; and finally the "Fuselage Coil" system and the ambiguity-free transverse loop and trailing aerial combination.

ORTHODROMIC CHARTS FOR FIXING THE POSITION BY RADIOGONIOMETRIC BEARINGS: THE ASKANIA PATENTED TELECOMPASS AND AIRCRAFT COMPASSES: ECHO SOUNDING.—(*Hydrographic Rev.*, Nov., 1930, Vol. 7.)

WIRELESS EQUIPMENT OF THE DORNIER DO X.—W. Völkel. (*E.T.Z.*, 6 Nov., 1930, Vol. 51, p. 1542.)

A short paragraph in an article on the whole electrical equipment.

GERMAN RESEARCH ESTABLISHMENT FOR AIRCRAFT, 1930.—Fassbender. (*See* under "Miscellaneous.")

D.F. receiver in aeroplanes: screening: cathode-ray compass.

ACOUSTICS AND AUDIO-FREQUENCIES.

ABSOLUTE GELUIDSMETINGEN AAN LUIDSPREKERS EN MICROFOONS (Absolute Intensity Measurements on Loud-Speakers and Microphones). J. L. Snoek and C. Zwikker. (*Physica*, 1930, Vol. 10, No. 7, pp. 219–230.)

Authors' summary:—A new method for measuring the acoustic response curves of loudspeakers and microphones is described, in which the mean intensity of sound in the room is taken as a measure for the total acoustic output of the source according to the formula: $E = 13.8 \frac{IV}{t}$ (E = output, I = mean intensity, V = volume of the room, t = time of reverberation). By means of a calibrated condenser microphone the mean intensity can be expressed in absolute units.

In order to eliminate the distortions in the energy distribution which are due to the presence of nodes and antinodes in the room, the source as well as the microphone and a large screen are continuously moving during the measurement. At the same time the frequency is continuously varied over a small region (30–100 cycles/sec.). The region between 100 and 5,000 cycles/sec. can be easily covered by this method, with a mean error of 9%.

A new method of determining the absorbing power of different materials along the same lines is suggested.

DAS AMPLITUDENSIEB, EINE ANORDNUNG ZUR AMPLITUDENSTATISTIK UNREGELMÄSSIGER VORGÄNGE (The Amplitude Filter, an Appliance for obtaining Amplitude Statistics of Irregular Processes).—H. G. Baerwald. (*E.N.T.*, Sept., 1930, Vol. 7, pp. 362–368.)

An important example of the "irregular processes" in question is afforded by speech currents; certain syllables, especially those containing the vowel sounds *a* and *ei* [German], give rise to peak values enormously exceeding the average intensity. It is of great importance to obtain statistics of these, in order to decide how much allowance must be made for them in designing all the apparatus for satisfactory transmission of speech. These statistics are conveniently obtained by interposing, between the input amplifier and the integrating meter, the amplitude filter here described; this consists of a special circuit of two valves in push-pull connection, each working non-linearly on the lower bend of its characteristic, combined with one rectifier valve.

This arrangement has a characteristic $g[(u - U); u_0]$, where u and g are the input voltage and output currents respectively, such that g vanishes for all values of u except the small zone $\pm u_0$ on either side of the adjustable level U. Thus the amplitude distribution curve of the irregular process $u(t)$ may be obtained, the integrating instrument only responding during the time interval when $u(t)$ lies between $(U - u_0)$ and $(U + u_0)$.

SOME MICROPHONE MEASUREMENTS AND SOME SUGGESTIONS WITH REGARD TO MICROPHONE ARRANGEMENTS.—Siffer Lemoine. (*Elec. Communication*, Oct., 1930, Vol. 9, No. 2, pp. 139–154.)

Suggestions concerning microphone arrangements are here put forward in which calculations are based on the variations of the diaphragm effect (i) with angle of incidence, and (ii) with distance between microphone and source. The mathematical expression derived for (i) is considered to yield results within certain limits verified in practice; with regard to (ii) the highly variable influence of local acoustic conditions comes into the calculation, so that the formula derived for this relation applies fully only when the conditions for its deduction are fulfilled, *i.e.*, wall-surfaces highly damped. But even under the non-ideal conditions usually obtaining, the formulæ have a certain guiding value as to the mutual arrangement of microphone and orchestra.

A PRECISION STIFFNESS METER [APPLICABLE TO TELEPHONE AND LOUD SPEAKER DIAPHRAGMS].—D. A. Oliver. (*Journ. Scient. Instr.*, Oct., 1930, Vol. 7, pp. 318–322.)

ÜBER FORMFAKTORMESSUNGEN (On the Measurement of Form Factor).—H. König. (*Helv. Phys. Acta*, No. 3/4, Vol. 3, 1930, pp. 249–268.)

EFFECTS OF PHASE DISTORTION ON TELEPHONE QUALITY: PHASE DISTORTION IN TELEPHONE APPARATUS: MEASUREMENT OF PHASE DISTORTION.—J. C. Steinberg: C. E. Lane: H. Nyquist and S. Brand. (*Bell Tech. Journ.*, July, 1930, Vol. 9, No. 3, pp. 550–566: 493–521: 522–549.)

The first paper discusses the effects of the type of phase distortion found in low pass filters and the loaded line on telephone quality. The second shows the types of phase characteristics found in various networks and discusses their relation to the transmission properties (apart from telephony, telegraph, picture transmission and television circuits are dealt with briefly). The third describes and discusses various methods of measuring the quantity defined as "envelope delay"—the first derivative of the phase-shift with respect to frequency.

ÜBER DIE KÜNSTLICHE CHARACTERISTIK DER KUGELGRUPPE (The Artificial Characteristic of Non-directive Point Radiators disposed over a Spherical Surface).—F. A. Fischer. (*E.N.T.*, Sept., 1930, Vol. 7, pp. 369–372.)

Further development of Stenzel's work (Abstracts, 1929, p. 450; 1930, p. 455). It is shown that the directive sharpness of a compensated spherical surface is equal to the natural sharpness of its diameter, *i.e.*, it is proportional to the square of the ratio d/λ. If it is to have no subsidiary maxima, d must be less than $\lambda/2$, so that great sharpness must be paid for by the presence of subsidiary maxima. The sharpness of a sphere-group of individual radiators, which lie on m equally spaced "parallels of latitude," is calculated and its dependence on m investigated. For $m = 6$, this arrangement already possesses more than 90% of the sharpness of the continuous spherical surface.

"STATOLA" ELECTROSTATIC LOUD SPEAKER, BIAS PROVIDED BY SIGNAL CURRENTS.—W. Burstyn. (*E.T.Z.*, 16th Oct., 1930, Vol. 51, pp. 1447 and 1448.)

Only two input leads are required, the static bias for the membrane being provided by the speech currents rectified by a small glow-rectifier.

THE DIFFERENTIALLY-WORKING CONDENSER LOUD-SPEAKER (VOGT).—E. Schwandt. (*Rad., B., F. f. Alle*, Oct., 1930, pp. 444–447.)

AEG "CANTOLA" LOUD SPEAKER.—(*Rad., B., F. f. Alle*, Oct. 1930, p. 461.)

The movement is a four-pole one with a centrally-pivoted armature with no mechanical bias.

SOUND-ABSORPTION COEFFICIENTS OF THERMATEX, ACOUSTOLITH TILE, AND ARMSTRONG CORK TILE.—Bureau of Standards. (*Bur. of Stds. Tech. News Bull.*, Oct., 1930, No. 162, p. 103.)

ABSORPTION OF SOUND AT OBLIQUE INCIDENCE.—E. T. Paris: P. R. Heyl. (*Nature*, 5th July and 6th Sept., 1930, Vol. 126, pp. 9–10 and 350–351.)

A criticism of the U.S. Bureau of Standards paper by Heyl, Chrisler and Snyder (1930 Abstracts, pp. 340–341): Heyl replies.

LA DURÉE DE RÉVERBÉRATION DANS LES SALLES "SOURDES" (Reverberation Time in Studios with Highly Absorptive Walls). C. F. Eyring (*Journ. Acoust. Soc. Am.*, Jan., 1930, Vol. 1, pp. 217–241.)

The Sabine formula applies only badly to studios where the absorptive powers are exaggerated; the writer develops a theory leading to the formula $T = \frac{0.16V}{-S \cdot \log_e (1 - \alpha)}$, where V and S are volume and wall surface (metric system), α the mean coefficient of absorption, and T the time for decay to one-millionth of the initial intensity.

ZUR THEORIE DES HÖRENS. ÜBER DAS RICHTUNGSHÖREN BEI EINER ZEITDIFFERENZ ODER LAUTSTÄRKENUNGLEICHHEIT DER BEIDERSEITIGEN SCHALLEINWIRKUNGEN (Contribution to the Theory of Audition. On Directional Audition in the Case of a Difference in Time or Inequality in Intensity of the Sounds from the Two Sides).—G. v. Békésy. (*Physik. Zeitschr.*, 15th Sept. and 1st Oct., 1930, Vol. 31, No. 18, pp. 824–835 and 857–868.)

EXPERIMENTS ON BINAURAL SENSATIONS.—S. R. Humby. (*Nature*, 1st Nov., 1930, Vol. 126, pp. 682–683.)

A letter giving a preliminary account of a survey of "the various experiments which have been taken as evidence that binaural sensations with musical notes of low pitch are due to the appreciation of phase differences produced at the ears." The author has repeated the experiments and found that, with the forms of apparatus used, there have been possibilities of intensity changes of which sufficient account has not hitherto been taken. These may be an important factor in producing the binaural effect. See below.

EXPERIMENTS ON BINAURAL SENSATIONS.—J. H. Shaxby and F. H. Gage. (*Nature*, 15th Nov., 1930, Vol. 126, p. 761.)

Experiments made by the authors on binaural sensations show that "the variation of intensity required to counterbalance the effect of a given phase (time) shift is very much larger than that which is unavoidably associated experimentally with that shift."

BEDEUTUNG DER MITNAHME IN DER AKUSTIK (Importance of the "Mitnahme" Effect [Pulling into Tune] in Acoustics).—J. Zenneck. (*T.F.T.*, Sept., 1930, Vol. 19, p. 281.)

MICROPHOTOMETRIC ANALYSIS OF MOVIETONE SOUND RECORDS.—L. V. King: J. T. Tykociner. (*Nature*, 19th July and 4th Oct., 1930, Vol. 126, pp. 92 and 504: *ibid.*, 4th Oct., p. 504.)

THE R.C.A. PHOTOPHONE SYSTEM OF SOUND RECORDING AND REPRODUCTION FOR SOUND MOTION PICTURES.—A. N. Goldsmith and M. C. Batsel. (*Proc. Inst. Rad. Eng.*, Oct., 1930, Vol. 18, pp. 1661–1689.)

ORGUE ÉLECTRIQUE (The Electric Organ.)—E. Coupleux and —. Givelet. (*Comptes Rendus*, 6th Oct., 1930, Vol. 191, pp. 557–560.)

MEASUREMENTS ON AUDIO-FREQUENCY INTERFERENCE IN SUBMARINE CABLES.—Burton: Meyers. (*See* abstract under "Atmospherics.")

PHOTOTELEGRAPHY AND TELEVISION.

Über eine Methode zur Trennung des Sperrschicht-Photoeffektes und des inneren Photoeffektes an Zellen aus krystallinen Halbleitern—Vorläufige Mitteilung (On a Method of Separation of the Photoelectric Effect at the Boundary Surface and the Internal Photoelectric Effect in Cells Composed of Crystalline Semi-Conductors—Preliminary Communication).—H. Kerschbaum. (*Naturwiss.*, 26 Sept., 1930, Vol. 18, No. 39, pp. 832–833.)

Crystalline semi-conductors, *e.g.*, Cu_2O with a metallic surface layer sprayed on from a cathode, are known to show a large photoelectric effect at the boundary surface (*cf.* 1930 Abstracts, p. 636, Duhme and Schottky) and also a large internal photoelectric effect. A preliminary description of a method of separating and observing these effects is given in the present letter. A cell is illuminated through a rotating perforated screen so that the light cycles have a frequency 50–10,000 c.p.s. and the alternating photoelectric voltage thus arising is measured by means of a valve voltmeter. In this way the photoelectric voltage can be separated from the direct voltage simultaneously impressed on the cell. A curve is given for the variation of alternating photoelectric voltage with impressed direct voltage in the case of a cuprous oxide cell and explained in terms of the photoelectric effect at the boundary surface and the internal photoelectric effect. Curves showing the variation with frequency for different impressed voltages are also given; the internal photoelectric effect is dependent on the frequency, but the photoelectric effect at the boundary surface is to a very large extent independent of frequency. Further investigations of the degree of dependence on intensity of illumination, of the effect of colour and of the resistance of the boundary surface, are proposed.

Über den Entstehungsort der Photoelektronen in Kupfer-Kupferoxydul-Photozellen (On the Source of the Photoelectrons in the Copper-Cuprous Oxide Photoelectric Cell).—W. Schottky. (*Zeitschr. f. tech. Phys.*, Nov., 1930, Vol. 11, pp. 458–461.)

Author's summary:—"The discovery of the photoelectric effect in copper-cuprous oxide cells, in the Siemens Laboratories. It is a special case of a new photoelectric effect known as 'blocking layer (sperrschicht) photoeffect'; in the cell described (the 'posterior wall' type—see 1930 Abstracts, pp. 636–637) the photoelectrically active layer lies between the oxide and the mother-copper. Measurements of the photoelectric current produced by a narrow beam of light, according to its distance from a similarly narrow metal electrode applied to the oxide layer, confirm this theory." The writer ends by a reference to his experiments with the combination, less favourable electrically but more favourable optically, of a transparent metallic film on a thick copper oxide layer ("anterior wall" cell) which gives even stronger currents.

Photo-electric Cells.—A. Ferguson. (*Nature*, 21st June, 1930, Vol. 125, p. 953.)

A general account of the discussion on photoelectric cells arranged by the Physical and Optical Societies, June 4th and 5th, 1930.

Effects of Gases on Photoionization of Cæsium by Line Absorption.—F. L. Mohler and C. Boeckner. (*Bur. of Stds. Journ. of Res.*, Aug., 1930, Vol. 5, pp. 399–410.)

Über die Beeinflussung der Kathodenstrahlreflexion an Aluminium und Platin durch Belichtung und die Realität der dabei auftretenden positiven und negativen Zusatzströme (On the Influence of Illumination on the Reflection of Cathode Rays from Aluminium and Platinum and the Reality of the Existence of additional Positive and Negative Currents).—W. Kohl. (*Ann. der Physik*, Series 5, 1930, Vol. 6, No. 3, pp. 391–408.)

The Photoelectric Behaviour of Solid and Liquid Mercury.—D. Roller. (*Phys. Review*, 15th Aug., 1930, Series 2, Vol. 36, No. 4, pp. 738–742.)

Sull'Esistenza di un Ritardo dell' Effetto Kerr in Alcuni Liquidi (On the Existence of a Retardation of the Kerr Effect in Certain Liquids).—I. Ranzi. (*Nuovo Cim.*, July, 1930, Vol. 7, pp. 270–282.)

Les derniers Progrès réalisés dans la Construction des Cellules photo-électriques (Latest Progress in the Construction of Photoelectric Cells).—C. Roy-Pochon. (*L'Onde Élec.*, Aug., 1930, Vol. 9, pp. 366–388.)

(i) Short summary of the fundamental principles as known up to the present, including Metcalf's work on the "dynamic sensitivity" (1930 Abstracts, p. 165). (ii) The cathode:—The selective effect and its dependence on the angle of incidence: "surface condition": adherent or adsorbed gases: vapours of sulphur, water, benzene and organic colouring matters: process for the sensitisation of potassium cells: very thin films (Campbell, and Ives and Olpin—1928 Abstracts, p. 692; 1929, p. 581; 1930, p. 109; and elsewhere): methods of depositing the sensitive layer. (iii) The anode:—Various mechanical forms: the Dunoyer hemispherical cell and its straight wire anode close to the flat side of the container (1929 Abstracts, pp. 515–516) utilising "reversible illumination" and an anode corona effect: other cells using this effect—the Soc. Rhône-Poulenc cell with auxiliary cathode close to anode: the little-used (at present) central-cathode cell with external anode, which has the property of being very quickly saturated. (iv) Cells with auxiliary electrodes for modifying the field distribution:—The Rhône-Poulenc cell type PA 2 with two ring-shaped anodes, one close to the potassium layer and the other three times as far from that layer: various modes of employing these two anodes to increase the utilisable current. (v) Gas fillings. (vi) Different kinds of glass for the containers. (vii) Mathematical theory of the circuit (Metcalf—*loc. cit.*). (viii) Bibliography.

THE DEPENDENCE OF THE BREAKDOWN VOLTAGE OF LIQUID DIELECTRICS ON PRESSURE.—Edler. (*See* abstract under "General Physical Articles.")

INTERESTING PROBLEMS IN TELEVISION.—F. Noack. (*Rad., B., F. f. Alle*, Nov., 1930, pp. 502–507.)

Kirschstein's researches on the frequency-dependence of gas-filled photoelectric cells—increasing grid bias increases the capacity so much that this may reach values of 120 microfarads; screen-grid amplifiers are much more suitable than resistance-capacity amplifiers. Okolicsanyi's work on the possibility of improving television results with or without changing the standard regulations. Zworykin's cathode ray system. Television in colours—Ahronheim's and Andersen's systems; the possibilities of "central television services" (*e.g.*, in blocks of flats, ships—a big German shipping company is seriously tackling this problem). Attempts to improve the brightness of the picture; to improve synchronisation—Korn's proposal of a powerful wireless station emitting a synchronising frequency, proposals to keep the a.c. network at absolutely constant frequency, or to superpose a special synchronising frequency.

A GERMAN OPINION OF [BAIRD] SCREEN TELEVISION.—Horst Hewel. (*Television*, Nov., 1930, Vol. 3, p. 391.)

A letter giving the writer's opinion of the large screen demonstration at the Berlin "Scala."

INERTIA-LESS LIGHT SOURCES FOR TELEVISION RECEIVERS.—F. Winckel. (*Rad., B., F. f. Alle*, Nov., 1930, pp. 489–491.)

The ordinary neon-tube lamp; the v. Mihaly "super-frequency" glow lamp with iron-alloy electrodes, costing no more than an incandescent lamp and requiring no special supply; Braun tubes; tungsten arc lamps; Kerr cells.

TELEVISION NEEDS NEW IDEAS—AND LESS BALLYHOO.—A. Dinsdale. (*Scient. American*, Nov., 1930, Vol. 86, pp. 366–368.)

An article by the late editor of *Television*. Television is to-day at an impasse. For successful "home" use the picture, without magnifying lenses, should be not smaller than 9in. × 12in.; the number of elements should be not less than 1,080,000 (100 lines per inch), and at the rather low speed of 15 images per second this involves a band of 8,100 kilocycles. Only fundamentally new ideas can overcome the practical difficulties.

SYNCHRONIZATION SYSTEM FOR TWO-WAY TELEVISION.—H. M. Stoller. (*Bell Tech. Journ.*, July, 1930, Vol. 9, No. 3, pp. 470–477.)

This paper "describes the development of a new control circuit which is in use in the new two-way television system between the Bell Telephone Laboratories at 463, West Street and the American Telephone and Telegraph Company building at 195, Broadway, New York."

IMAGE TRANSMISSION SYSTEM FOR TWO-WAY TELEVISION.—H. E. Ives, F. Gray, and M. W. Baldwin. (*Bell Tech. Journ.*, July, 1930, Vol. 9, No. 3, pp. 448–469.)

SOUND TRANSMISSION SYSTEM FOR TWO-WAY TELEVISION.—D. G. Blattner and L. G. Bostwick. (*Bell Tech. Journ.*, July, 1930, Vol. 9, No. 3, pp. 478–486.)

"In this paper is described the speech transmission part of the two-way television system described in companion papers"—see above.

RADIO PICTURES FOR SHIPS: POSSIBILITY OF THE FUTURE—TECHNICAL AND COMMERCIAL DIFFICULTIES.—(*Electrician*, 31st Oct., 1930, Vol. 105, p. 527.)

GERMAN CABLES FOR PICTURE TELEGRAPHY [BERLIN—NAUEN].—(*Europ. Fernsp:dienst*, Nov., 1930, No. 20, p. 401.)

Some details regarding this 50 km. cable linking up Nauen and its receiving station Beelitz with Berlin.

MEASUREMENTS AND STANDARDS.

EIN NEUER STROMMESSER FÜR HOCHFREQUENZ (A New Ammeter for High [and Ultra-High] Frequencies).—K. Schlesinger. (*Zeitschr. f. hochf. Tech.*, Aug., 1930, Vol. 36, pp. 62–65.)

"A new thermal ammeter is described in which the expansion of the hot wire is measured, not directly as in the usual 'hot-wire' instrument, but by the alteration to the vibration frequency of the stretched wire produced by the warming. Since this decrease in frequency gives a far more sensitive indication of the heat produced by the current than is provided by the mere increase in length, high frequency currents smaller than 10 mA. can easily be measured using an internal resistance of only 1 ohm."

The hot wire is stretched in an evacuated glass bulb, the wall of which is connected to a vibrator (*e.g.*, a loud-speaker movement) which communicates to it a series of very feeble vibrations originating in a variable-note generator. When the note is adjusted to be in resonance with the stretched wire, the latter is set into vigorous vibration which is observed on a screen or through a microscope (× 20). The note generator scale is calibrated to read current directly. In a special form of the hot-wire tube, the tension of the wire can be regulated so that the range of the apparatus is extended. Errors of reading are under 1 %; the effect of the outside temperature can be compensated for, and the over-load capacity is of the order of 1,000 %. "The chief application appears to be for ultra-high frequencies."

THE DEVELOPMENT OF A PRECISION AMMETER FOR VERY HIGH FREQUENCIES: DISCUSSION.—E. B. Moullin: W. F. Dunton. (*Journ. I.E.E.*, Sept., 1930, Vol. 68, p. 1173.)

See 1930 Abstracts, p. 461. The discussion concerns the correctness of formulæ for the electromagnetic force between parallel conductors.

ÜBER HOCHFREQUENZMESSUNGEN NACH DER BARRETTER-METHODE (On High Frequency Measurements by the Barretter Method).—M. Wien. (*Physik. Zeitschr.*, 1st Sept., 1930, Vol. 31, No. 17, pp. 793–797.)

For measurements at high frequencies of the order of 50 megacycles per sec., the barretter method has many advantages, which are here discussed in principle. Great care must be taken in designing the components used, as small variations in dimensions alter the capacity and may have considerable effect at frequencies of this high order.

MESSUNG VON ZEITLICH VERÄNDERLICHEN SPANNUNGSVORGÄNGEN MIT HILFE DES KERREFFEKTS (Measurement of Temporally Variable Voltage Phenomena Using the Kerr Effect).—K. Hoffmann. (*Physik. Zeitschr.*, Oct. 1, 1930, Vol 31, No. 19, pp. 841–849.)

The Kerr cell appears to be very suitable for the measurement of rapidly varying electric fields. (1) The relaxation time of the Kerr effect is in general smaller than 10^{-8} sec. (2) The ohmic resistance of a Kerr cell is very high when benzol chloride or carbon bisulphide are used as the doubly-refracting materials. (3) The capacity of the cell is small (a few centimetres) and becomes effective only at very high frequencies; it is practically independent of the voltage across the cell. The Kerr effect is on the other hand very strongly influenced by temperature and this is a disadvantage as regards its practical application.

The present paper is limited to the investigation of the extent to which electro-optical methods can be applied to measurements of average voltage values.

Method I: Light from an arc lamp is condensed and passed through a Nicol prism N_1, the Kerr cell K, a Babinet-Soleil compensator B_1 and a Nicol prism N_2, crossed with N_1. If the variations of the voltage impressed on K are rapid, the eye will register the mean intensity of the light passing through N_2. The compensator is adjusted so that the observed intensity is a minimum. Then, as is shown by a theoretical investigation, the position of the compensator corresponds sufficiently exactly to the effective value of the voltage across the Kerr cell. Thus measurements can be made with the Kerr cell in the same way as with an electrostatic voltmeter. Experimental results with a 500 c.p.s. generator and about 150 volts across the Kerr cell are given which show that the possible error reaches 8 %. This is ascribed to the broad intensity minimum, which renders subjective observation inaccurate.

Method II: In a second arrangement two Kerr cells are used, the condensed light passing through a Nicol prism N_1, a Kerr cell K_1, a second Nicol N_2, crossed with N_1, a second Kerr cell K_2, the compensator B_1, and a third Nicol N_3, crossed with N_2. Light can only reach the observer when a voltage is impressed on K_1. Theoretical investigation shows that the position of the compensator is closely related to the maximum voltage value.

K_1 acts as a "filter cell" and K_2 is the measuring cell. Experimental results under the same conditions as those used in the first method show that observed values differ from their mean by as much as 3.7 %.

Method I was also tested at different voltages and with undamped high-frequency oscillations and Method II was applied to high-frequency damped oscillations, errors of the same order being observed. Photographic recording was also applied to Method II. See also Pungs and Vogler, 1930 Abstracts, pp. 460–461.

DÄMPFUNGSMESSUNGEN AN INDUKTIVITÄTEN BEI HOCHFREQUENZ (The Measurement of the Damping of Inductance Coils at [Ultra] High Frequencies).—F. Benz. (*Zeitschr. f. hochf. Tech.*, Aug., 1930, Vol. 36, pp. 41–49.)

After a theoretical discussion of the factors contributing to the damping of coils, the writer deals with certain usual methods of measurement for low and for ordinary high frequencies (bridge methods, up to a few thousand cycles/sec.; Lindemann's method for higher frequencies, depending on the values of resonance current with and without a known non-inductive and non-capacitive resistance added; Stürmer's little-known method, in which the damping effect of the coil is transferred by a small coupling coil to the circuit of a valve generator, and measured by obtaining an equal deflection in the grid-circuit meter of this generator circuit on switching over from the coil under test to a calibrated non-inductive load). He points out the limitations of these methods when applied to ultra-high frequencies, and goes on to describe the desirability of thermal methods for these frequencies. He dismisses the well-known Pungs and Preuner thermal method as introducing too many subsidiary losses, and then describes his own method used in the German State Research Department.

In this, the Pungs and Preuner calorimeter is replaced by a thermo-couple or -pile, whose temperature rise is a measure of the heat produced in unit time in the coil, and whose calibration is effected on d.c. The connection of the thermo-element to the coil is such that neither eddy current nor dielectric loss is introduced, and no h.f. current can enter the thermo-element. With this arrangement it is possible to follow the course of the damping curve for a large range such as from 10 to 10,000 kilocycles/sec., and to trace the behaviour of the various components of the total damping. Results thus obtained lead to practical recommendations for the construction of coils for various frequency zones in this range.

As a useful check on the thermal method, particularly in separating the various components, a ponderomotive method is also described in which the current-carrying coil is coupled to a short-circuited secondary coil attached to a delicate balance.

EINFLUSS DER OBERFLÄCHENBESCHAFFENHEIT VON DRÄHTEN AUF DIE SELBSTINDUKTION BEI HOHEN FREQUENZEN (The Influence of the Surface State of Wires on the Inductance at High Frequencies [Wavelengths 20 to 300 Metres]).—H. Illgen. (*Zeitschr. f. hochf. Tech.*, Aug., 1930, Vol. 36, pp. 50–62.)

The heterodyne method is used to investigate the inductances of straight wires of about 1 mm. diameter with various surface coatings. Försterling's formula for the case of a conducting coating is found to give good results. In the wave-range named, no influence on the skin effect could be found—either for oxide coating or for thin layers of insulating materials (the change in inductance on oxidation, being found to be quite independent of frequency, is attributed simply to the change in thickness of the wire consequent on the oxidation). On the other hand, electrolytically deposited coats had a marked effect, which was, however, chiefly of a capacitive nature. The typical behaviour of Litz wires, as regards inductance at various frequencies, was confirmed. The paper ends by a discussion of practical applications of the heterodyne method of inductance-measurement: *e.g.*, for checking small variations in thickness and conductivity in the manufacture of wires, for estimating the thickness of the oxide layer in the manufacture of oxide-coated resistance wire, and for measuring the permeability of ferromagnetic wire.

KAPAZITÄTSBERECHNUNG FÜR EINEN DRAHT IM QUADRATISCHEN ZYLINDER (Calculation of the Capacity of a Wire in a Cylinder of Square Cross-Section).—H. Jenss. (*Arch. f. Elektrot.*, 27 Sept., 1930, Vol. 24, No. 3, pp. 317–322.)

BANCO DI DEMOLTIPLICAZIONE STATICA PER LA MISURA DI FREQUENZA SINO A 10^8 CICLI/SEC. (Demultiplication Equipment for the Measurement of Frequencies up to 10^8 Cycles/Sec.).—F. Vecchiacchi. (*Reg. Accad. Nav. Livorno*, No. 46, 1930, 8 pp.; *Rass. d. Poste, d. Teleg. e d. Telef.*, No. 7, July, 1930.)

ACCURATE METHOD OF MEASURING TRANSMITTED WAVE FREQUENCIES AT 5,000 AND 20,000 KILOCYCLES PER SECOND.—E. L. Hall. (*Bur. of Stds. Journ. of Res.*, Sept., 1930, No. 3, Vol. 5, pp. 647–652.)

"This paper describes a method of measuring station frequencies applicable to any frequency, but dealing primarily with frequencies of approximately 5,000 and 20,000 kc. A high order of precision is obtained by the use of harmonics and audio-frequency beat notes. Most of the units of the equipment employed have been previously described in connection with other applications." [Hall, 1929 Abstracts, p. 279; 1930, p. 223; Case, *below*.]

A PRECISE AND RAPID METHOD OF MEASURING FREQUENCIES FROM FIVE TO TWO HUNDRED CYCLES PER SECOND [CONDENSER DISCHARGE PRINCIPLE].—N. P. Case. (*Proc. Inst. Rad. Eng.*, Sept., 1930, Vol. 18, pp. 1586–1592; *Bur. of Stds. Journ. of Res.*, Aug., 1930, Vol. 5, pp. 237–242.)

A development from Maxwell's method for capacity measurement, later modified by Fleming and Clinton. The unknown frequency is made to control the number of times per second a condenser is discharged through a resistance, and the resultant voltage-drop across the latter gives the required frequency. A null method is employed by balancing this drop against a battery and potentiometer. In the range mentioned the accuracy is better than one-tenth cycle.

NEW FREQUENCY METERS USING DYNATRON OSCILLATORS.—G. Grammer: O. P. Susmeyan. (*QST*, Sept., 1930, Vol. 14, pp. 21–26 and 35: pp. 33–35.)

THE EXCITATION OF [EVEN] OVERTONES OF SHEAR VIBRATIONS IN Y-CUT QUARTZ PLATES.—J. R. Harrison. (*Phys. Review*, No. 11, Vol. 34, 1930, p. 1417.)

These difficult harmonics are now obtained by using two commoned flat electrodes, on the XZ-planes, and a frame-shaped third electrode, one-third the thickness of the plate, symmetrically disposed. This gives the 2nd harmonic; the 4th is given by the use of the same two flat electrodes and three frame electrodes.

SUR LES VIBRATIONS DU QUARTZ PIÉZOÉLECTRIQUE SUIVANT L'AXE OPTIQUE (The Vibrations of Piezoelectric Quartz along the Optical Axis).—P-Tcheng Kao. (*Comptes Rendus*, 3rd Nov., 1930, Vol. 191, pp. 768–770.)

A reconciliation of the observed fact of fundamental oscillations following the optical axis (Tawil; *see* 1929 Abstracts, pp. 581–582) with Curie's law. Experiments lead the author to conclude that these oscillations are *not* of the same piezoelectric origin as those of the other two axes; as to their actual origin, all that can be said at present is that it cannot be purely dielectric deformation.

7-MEGACYCLE CRYSTALS.—H. Hollister. (*QST*, Aug., 1930, Vol. 14, pp. 36–37.)

"The few 7-mc. plates which have been used during the past three years have been almost without exception cut on the thick axis ('X cut'). Plates cut on this axis average about 2.6 metres per 0.001 inch of thickness, which means a 7-mc. plate will finish up about 0.016 inch thick. This would seem to be a very desirable advantage over the 0.011 inch thickness of the thin-cut plates of the same frequency." But the writer states that the thick-cut plates have earned a bad reputation through their erratic behaviour [the Editor disagrees with this] and "it is the purpose of this article to emphasise the fact that these ultra-thin plates are in every way practical and desirable."

SULLA MISURA DELLA RESISTENZA AD ALTA FREQUENZA (The Measurement of Resistance at High Frequencies).—P. Ilardi. (*Dati e Mem. sulle Radiocomunic.*, 1930, Vol. 8.)

At the end of this survey, which includes sections on the substitution, resistance-variation, and decrement methods, the writer describes his own experiences—on short waves—with the resistance-variation method modified so that instead of depending on current measurement it relies on voltage measurement by the Moullin voltmeter.

A SPECIAL THERMOSTAT FOR CRYSTAL OSCILLATORS AND ITS EMPLOYMENT IN COMMON WAVE BROADCASTING.— —. Jacobs. (*E.N.T.* Oct. 1930, Vol. 7, p. 410.)

Paragraph on a recently read paper. The thermostat not only takes into consideration the surrounding temperature but also the heat produced by the crystal itself in its vibrations.

A NEW DESIGN OF PRECISION RESISTANCE STANDARD.—J. L. Thomas. (*Bur. of Stds. Journ. of Res.*, Aug., 1930, Vol. 5, pp. 295–304.)

The Bureau's standard 1-ohm resistances since 1910 were of the Rosa type. As a result of investigations into the causes of the slight resistance changes developed by these, a new type (here described) has been developed. The coils are wound of bare manganin wire and are annealed at a red heat to remove winding strains. They are mounted in double-walled sealed containers which contain no oil or other cooling liquid. A number of these standards, for which data are given, have been "remarkably constant in resistance"—the average change in six months being slightly over 2 parts in a million; the greatest part of this change generally takes place in the first month.

NOTES ON TRANSMISSION MEASUREMENTS: THE MARCONI TRANSMISSION MEASURING SET.—O. S. Puckle. (*Marconi Review*, Sept., 1930, pp. 15–28.)

THE AMPLITUDE FILTER, FOR OBTAINING AMPLITUDE STATISTICS OF IRREGULAR PROCESSES.— Baerwald.

(*See* under "Acoustics.")

METHOD OF OBTAINING A VISIBLE SPECTRUM OF WAVES OF RADIO FREQUENCY.—McLennan and Burton.

(*See* under "Miscellaneous.")

SUBSIDIARY APPARATUS AND MATERIALS.

DISPOSITIF DE TÉLÉCOMMANDE PAR ONDES ÉLECTROMAGNÉTIQUES TRÈS COURTES (Distant Control Device [Fog Signal] working on Ultra-Short Waves).—P. Besson. (*L'Onde Élec.*, Aug. 1930, Vol. 9, pp. 349–365.)

An account of the development of a distant control service, using 4 m. waves, for working the acetylene gun at the Antioche tower from the Chassiron lighthouse 2½ kilometres away. The final apparatus was installed in October, 1929, and its performance has been so satisfactory that similar installations will probably be set up at various points on the French coast, particularly in Brittany. The transmitter, which has a wave-range 3–5 m., uses a symmetrical 2-valve circuit supplied with 600 cycle a.c. at 1,800 v. A Greek "key-pattern" transmitting aerial was proposed, but this was abandoned in favour of a simple vertical dipole aerial (each wire 1 m.) at the top of the lighthouse, with a reflector of three wires a metre behind it.

The super-regenerative receiver comprises two detector valves symmetrically connected, a "heterodyne" valve working on 5,000 metres ("in order to avoid affecting the relay by the a.c. produced by this valve if the frequency were musical"), a l.f. amplifier and l.f. rectifier (using grid polarisation). The plate circuit of the last valve contains the windings of a Dubois relay. This relay requires 0.2 mA. to work it, but it is adjusted to function on 0.5–1 mA., while the normal current available from the Chassiron signals is 3.5 mA.; there is therefore an excellent factor of safety. The Dubois relay controls a second relay which itself controls a Soulat ratchet-wheel on-and-off contact-device governing the acetylene valve. To keep down the current-consumption, the valves are "lit" only for 7 seconds every 5 minutes, by means of a clock control. Since the transmitter wavelength is not quite stable, it is necessary to swing its circuit-tuning condenser to ensure that the signals pass through the receiver tuning point during the 7 seconds of activity. The arrangement for this swinging must avoid sending *two* successive signals on the right wavelength, since these would neutralise each other on the Soulat device.

In certain localities where ship interference is too severe even for the very interference-free 4 m. circuits, it is intended to modify the receiving circuits after the manner adopted by Mesny and David in the French navy: namely to utilise the fact that a super-regenerative receiver becomes saturated by sufficiently strong c.w. signals so that it cannot respond to modulated or damped oscillations. A little local generator of such oscillations acts continuously on the receiver during the 7 seconds activity and keeps a relay (in place of the Dubois relay) *open*: the arrival of the lighthouse signals saturates the receiver, removes the local signals and closes the relay. Instead of using a local generator, it is also possible to adjust the receiver so that the characteristic background noise of super-regeneration keeps the relay open.

USE OF A THERMIC FLASHER IN A RELAY CIRCUIT [TO AVOID SPARKING AND CHATTERING IN GRADUAL WORKING].—A. W. Stevenson. (*Journ. Scient. Instr.*, Sept. 1930, Vol. 7, pp. 293–294.)

DIE GLIMMLAMPE ALS RELAIS (The Glow-Discharge Lamp as Relay).—H. Laub. (*E.N.T.*, Oct. 1930, Vol. 7, pp. 373–377.)

An investigation of the use of two-electrode glow-discharge tubes as relays, in particular connection with the train-control system referred to in the writer's paper on resonance transformers (*see* under "Properties of Circuits").

For this purpose the gap between discharge voltage and extinction voltage must be as large as possible; commercial tubes gave too small a gap, and special tubes, with bigger spacing of the electrodes, were designed to give a potential gap of about 35%. The paper gives curves showing the behaviour of these tubes under different modes of connection, and an investigation—illustrated by oscillograms—into the discharge and extinction processes.

THEORIE DES THUNSCHEN ZEITDEHNERS UND IHRE ANWENDUNG IN DER AUFNAHMEPRAXIS (Theory of the Thun "Time Extender" [Special Slow-Motion Apparatus] and its Use in Recording).—W. Ende. (*Zeitschr. f. tech. Phys.*, Oct., 1930, Vol. 11, pp. 394–402.) *See* also Isermann, *Zeitschr. V.D.I.*, 27th Sept., 1930, pp. 1363–1366.

A NEW TYPE OF RECORDING DRUM.—Casella & Co. (*Journ. Scient. Instr.*, Oct., 1930, Vol. 7, pp. 327–328.)

A vertical axis drum which gives a spiral length of track of about 20 feet. Two electromagnetic marking pens, on a common carrier, are provided. A second pair can also be fitted.

A NEW [ROTATING PRISM] FORM OF STROBOSCOPE.—R. G. Standerwick. (*Gen. Elec. Review*, Oct., 1930, Vol. 33, pp. 566–567.)

The stroboscopic disc only allows one point of the cycle to be studied at a time; so does the neon tube stroboscope or oscilloscope. By using an inverting prism revolving (in the inside of a ball bearing) at exactly half the rate of the moving system, the latter is brought visually to rest and may be watched all the time.

A SPHERICAL PROJECTION CHART FOR USE IN THE STUDY OF ELLIPTICALLY POLARISED LIGHT.—F. E. Wright. (*Journ. Opt. Soc. Am.*, Oct., 1930, Vol. 20, pp. 529–564.)

CATHODE-RAY OSCILLOGRAPH WITH LENARD WINDOW.—M. Knoll. (*Review Scient. Instr.*, Sept., 1930, Vol. 1, pp. 507–511.)

A short paper on the relative advantages of Slack's glass bubble window (1929 Abstracts, pp. 341 and 642) and the flat metal window (Knoll, Knoblauch and v. Borries, June and Sept. Abstracts, pp. 345 and 520.)

LEUCHTSCHIRM - KONTAKTPHOTOGRAPHIE BEIM KATHODENSTRAHLOSZILLOGRAPHEN (Fluorescent Screen Contact Photography with the C.-R. Oscillograph).—M. Knoll. (*Zeitschr. f. tech. Phys.*, Nov., 1930, Vol. 11, pp. 491–493.)

For external recording by the screen-contact method, the writer dispenses with the need of a secondary vacuum (to prevent the driving-in of the screen by atmospheric pressure) by strengthening the screen with a scaffolding or grid as in the case of the window referred to in 1930 Abstracts, p. 345. See below. The method is particularly advantageous where only low voltages are available and very high recording speeds are not essential.

AUSSENPHOTOGRAPHIE BEIM KATHODENSTRAHLOSZILLOGRAPHEN DURCH GROSSE BILDFENSTER (External C.-R. Photography using a Large Window).—M. Knoll and B. v. Borries. (*Zeitschr. f. tech. Phys.*, Nov., 1930, Vol. 11, pp. 493–495.)

A paper on the construction of the large reinforced windows [or screens referred to in the preceding abstract. Dimensions can be extended to 9 × 12 cm. Specimen oscillograms are given, both contact and electron beam types. The maximum recording speeds are 300 and 50 km./sec. respectively (voltage 70 kv.).

EIN KATHODENSTRAHLOSZILLOGRAPH ZUR AUFNAHME PERIODISCHER VORGÄNGE (A Cathode Ray Oscillograph for Recording Periodic Phenomena).—M. Brenzinger. (*Arch. f. Elektrot.*, 28th June, 1930, Vol. 24, No. 1, pp. 80–87.)

DER KATHODENOSZILLOGRAPH ALS PRAZISIONSMESSGERÄT (The Cathode Ray Oscillograph as a Precision Measuring Instrument).—H. Viehmann. (*Arch. f. Elektrot.*, 27th Sept., 1930, Vol. 24, No. 3, pp. 349–352.)

LINEAR CORRECTION FOR CATHODE RAY OSCILLOGRAPH.—F. Bedell and J. Kuhn. (*Phys. Review*, 1st Sept., 1930, Series 2, Vol. 36, No. 5, pp. 993–996.)

Authors' abstract:—The deflection of the cathode beam in a cathode-ray oscillograph tube, while substantially proportional to the voltage applied to the deflecting plates within the tube, is not proportional for small voltages in tubes commonly used. This non-linearity is due to the heavy cloud of ions between the plates. In the practical use of such a tube, error due to this non-linearity is avoided by applying a bias to the plates so as to work on the straight part of the curve.

A DIRECT-READING ELECTRICAL VACUUM METER.—M. Wellauer. (*Arch. f. Elektrot.*, No. 1, Vol. 24, 1930, pp. 4–7.)

RUBBER VULCANISED WITH TRINITROBENZENE WILL NOT TARNISH COPPER, SILVER OR MERCURY.—Bureau of Standards. (*Bur. of Stds. Tech. News Bull.*, Oct., 1930, No. 162, pp. 98–99.)

EIN FETTFREIES GLASVENTIL (A Grease-less Glass Valve).—M. Bodenstein. (*Zeitschr. f. phys. Chem.*, No. 5, Vol. 7 (B), 1930, pp. 387–389.)

GUMMIDICHTUNG MIT PRÜFEINRICHTUNG FÜR DEN KATHODENOSZILLOGRAPHEN (Rubber Seals with Testing Arrangement for use with the C.-R. Oscillograph).—K. Beyerle. (*Arch. f. Elektrot.*, 23rd August, 1930, Vol. 24, No. 2, pp. 257–258.)

DESIGN OF VACUUM PREBAKING FURNACE [FOR OUTGASSING METAL PARTS OF VACUUM TUBES].—L. R. Hafstad & O. Dahl. (*Review Scient. Instr.*, Sept., 1930, Vol. 1, pp. 517–522.)

A METHOD OF WINDING [PANCAKE] REGENERATOR COILS.—J. R. Roebuck. (*Review Scient. Instr.*, Nov., 1930, Vol. 1, pp. 620–629.)

At the end of a paper on a method of winding tubes into regenerator coils [for liquefaction, etc.]

such that each tube progresses axially along the coil only in one direction, the writer mentions that such coils made of insulated wire have particular electrical properties which may be valuable. The inductance is approximately the same as with ordinary winding, but the distributed capacity and the strain on the insulation are much reduced because of the smaller average p.d. between neighbouring wires, especially for long, small diameter coils.

ON THE SELF-INDUCTANCE OF [ROLL] CONDENSERS AT VERY HIGH FREQUENCIES.—Rotkiewicz. (*See* under " Reception.")

A HIGHLY SELECTIVE " PULSE AMPLIFIER."—Roters and Paulding. (*See* " Radio Electric Clock System " under " Miscellaneous.")

STATIONS, DESIGN AND OPERATION.

EINE METHODE ZUR SCHAFFUNG GUTER EMPFANGSVERHÄLTNISSE FÜR DEN RUNDFUNK IN DER GROSSSTADT (A Method of Ensuring Good Broadcast Reception Conditions in a Large City).—M. von Ardenne. (*E.T.Z.*, 20th Nov., 1930, Vol. 51, pp. 1632–1633.)

Measurements show that in large cities the average interference is 50–100 times as great as in the country, while the field strengths due to distant stations often fall to 10 % of their values in open country owing to absorption in buildings and conductors. The writer proposes that, say, 4 or 6 frequency bands from distant stations should be received on a corresponding number of aerials and receivers about 30 km. from the centre of the city, provided with all the modern devices against fading and other troubles. After amplification in a common aperiodic power amplifier, the mixed radio frequencies would be transmitted by line, or by ultra-short waves, to the centre of the city, where the various bands would be separated, each one controlling a relay transmitter of, say, 300–500 w. power (the local transmitter, which should be close to this group, being assumed as of 5 kw.).

VIELFACHRUNDFUNK AUF EINER ULTRAKURZWELLE (Multiple Broadcasting on One Ultra-short Wave).—M. von Ardenne. (*E.T.Z.*, 20th Nov., 1930, Vol. 51, pp. 1619–1620.)

The paper dealt with in the preceding abstract received a good deal of criticism in the subsequent discussion, and in the present article the writer has modified his scheme to one which should avoid the weak points not only of his first scheme but also of Esau's project of broadcasting on ultra-short waves. The central receiving station, as before, lies well outside the city; the mixed radio frequencies are conveyed by line to a single ultra-short wave (9 m.) transmitter which is either a short distance outside the city—in which case it uses a wide beam system—or actually in the city, and is at a suitable height.

The ultra-short carrier is not directly modulated at the audio-frequencies, *but at broadcasting frequencies corresponding to waves between* 300 *and* 2,000 *m.* These intermediate frequency waves are modulated by the audio-frequencies, and several of them are imposed simultaneously on the one 9 m. carrier. The listener uses a simple rectifier for the 9 m. wave, and then has at his disposal a number of intermediate radio-frequencies which can be selected and dealt with by his ordinary broadcast receiver. The scheme has already been tested with successful results.

BETRIEBSKONTROLLE VON KURZWELLENSENDERN (The Monitoring of Short Wave Transmitting Stations).—H. Mögel. (*E.N.T.*, Sept., 1930, Vol. 7, pp. 333–348.)

The results of five years' experience of home and foreign stations are embodied in the systems of monitoring used at the Nauen Station of the Transradio A.-G., here described and illustrated. Various sections deal with the checking of signals and modulation, by oscillograph or undulator: the measuring of the frequencies of carrier, side-bands and overtones: and the checking, from time to time, of the directive characteristics of the aerials.

THE RADIO COMMUNICATION SERVICES OF THE BRITISH POST OFFICE.—A. G. Lee. (*Proc. Inst. Rad. Eng.*, Oct., 1930, Vol. 18, pp. 1690–1731.)

I. Ship and Shore Radiotelegraphy Services: (i) Long-range ship service: Portishead station with its receiving station at Burnham—one 25 kw. and two 10 kw. transmitters, long wave, and two short wave transmitters (36.54 and 17.81 m.) each with a single 3.5 kw. valve. The 17.81 m. wave uses a horizontal array with a 2-wavelength aperture, mounted as a rotating system. (ii) Short-range coastal services. II. Long Distance, Long Wave Telegraph Service (Rugby) for all parts of the Empire and ships in any part of the world: an auxiliary short wave service is now operated in parallel, for press broadcasts. A description of a test voyage between England and New Zealand (via Panama Canal) includes mention of the marked increase in the fields of transmitting stations in the neighbourhood of their antipodes [*cf.* Gratsialos, 1928 Abstracts, p. 637].

III. Point-to-point Telegraphy Services to various European countries (Rugby and Leafield, receiving station St. Albans, operation and control at Central Radio Office, London). IV. Point-to-point Telephone Services: Rugby—one long wave and six short wave transmitters, probably at least doubled by 1933: reception at Cupar and Baldock. V. Telephony to Ships: Rugby, reception at Baldock, control centred on the London trunk exchange; four different short wavelengths to span the Atlantic: " horizontal transmitting aerials are used on all frequencies and have been found to give distinctly superior results to those obtained with vertical aerials "—this applies also generally, for arrays of the same number of elements suspended from structures of the same height. A section here deals with the voice-operated linking device, entirely thermionic, as contrasted to the American use of electro-mechanical relays.

The paper ends with sections on broadcasting, amateur transmitters, frequency measurement, mobile receivers for tracking interference, and emergency services (to islands around the coasts).

A WIRELESS BROADCASTING TRANSMITTING STATION FOR DUAL PROGRAMME SERVICE.—P. P. Eckersley and N. Ashbridge. (*Journ. I.E.E.*, Sept., 1930, Vol. 68, pp. 1149–1173.)

The full paper, a long summary of which was referred to in 1930 Abstracts, p. 467. In the subsequent discussion, the pros and cons of generating the power locally are dealt with; the future of h.t., d.c. generators; the possibility of increasing the constancy of carrier frequency still further—it is mentioned that the present stability, 300 cycles/sec. in 1,148 kc./sec., is obtained without any day-to-day readjustment of the drive circuit; and the difficulty in rectifying, without distortion, signals modulated as much as 80 or 90%—it is mentioned that although the transmitters are capable of being modulated linearly to 100%, the maximum peak modulation normally reaches about 80% and the average is very roughly around 20%. P. K. Turner comments on the superiority of the audio-frequency response curve over those of other broadcasting stations.

SUGGESTED LAY-OUT OF A TRANSMITTING STATION TO AVOID THE RADIATION OF HARMONICS.—Ditcham. (*See* abstract under "Transmission.")

THE WARSAW BROADCASTING TRANSMITTER.—W. T. Ditcham. (*Marconi Review*, Oct., 1930, pp. 10–16.)

SOME DEVELOPMENTS IN BROADCAST TRANSMITTERS.—I. J. Kaar and C. J. Burnside. (*Proc. Inst. Rad. Eng.*, Oct., 1930, Vol. 18, pp. 1623–1660.)

A paper by engineers of the G.E.C. and the Westinghouse Company.

UN NOUVEAU POSTE DE RADIODIFFUSION À GRANDE PUISSANCE (A New High Power Broadcasting Transmitter).—D. B. Mirk. (*L'Onde Élec.*, Sept., 1930, Vol. 9, pp. 416–445.)

French version of the description of the transmitter referred to in 1929 Abstracts, p. 462, constructed by Standard Telephones and Cables, Ltd.

RADIODIFFUSION EN FRANCE DE L'ATTERRISSAGE DES AVIATEURS COSTES ET BELLONTE AUX ÉTATS-UNIS (Broadcasting, in France, of the Account of the Landing in the U.S.A. of the Aviators Costes and Bellonte).—C. Platrier. (*Comptes Rendus*, 6th Oct., 1930, Vol. 191, pp. 561–562.)

ULTRA-SHORT WAVE TELEPHONY AND TELEGRAPHY SET FOR TANKS, ETC.—Marconi Co. (*Marconi Review*, Sept, 1930, pp. 30–32.)

Wavelengths employed are 7 to 8 metres. The transmitter uses two oscillator and two modulator valves; tonic train is provided by an interrupter disc on the shaft of the rotary transformer. The receiver uses four valves, the last two being note magnifiers: an interesting innovation (previously confined to aircraft apparatus) enables two occupants of the vehicle to operate the wireless equipment at will, or to communicate with each other through the telephones, the note magnifier stages being here brought into use.

ULTRA-SHORT WAVE RADIO-TELEPHONIC SERVICE FRANCE-CORSICA.—Beauvais. (*See* under "Propagation of Waves.")

THE MARCONI DORY TRANSMITTER [EMERGENCY: WITH AUTOMATIC CALL LETTERS TRANSMITTING DEVICE].—Marconi Company. (*Marconi Review*, Oct., 1930, pp. 7–9.)

DESERT MOBILE WIRELESS TELEGRAPH STATIONS [20–50 AND 600–2,150 METRE WAVES] FOR THE EGYPTIAN GOVERNMENT.—Marconi Company. (*Marconi Review*, Oct., 1930, pp. 1–6.)

URSI COSMIC DATA BROADCASTS.—(*Proc. Inst. Rad. Eng.*, Sept., 1930, Vol. 18, pp. 1469–1475.)

GENERAL PHYSICAL ARTICLES.

EIN KATHODENOSZILLOGRAMM DES DURCHSCHLAGS BEI STATISCHER SPANNUNG (A Cathode-Ray Oscillogram of Breakdown with Statical Voltage).—W. Rogowski and A. Klemperer. (*Arch. f. Elektrot.*, 28th June, 1930, Vol. 24, No. 1, pp. 127–128; also Correction in Vol. 24, No. 2, p. 258.)

ÜBER DIE DRUCKABHANGIGKEIT DER DURCHSCHLAGSSPANNUNG BEI DIELEKTRISCHEN FLÜSSIGKEITEN (On the Dependence of the Breakdown Voltage of Dielectric Liquids on Pressure).—H. Edler. (*Arch. f. Elektrot.*, 28 June, 1930, Vol. 24, No. 1, pp. 37–43.)

ÜBER DIE TEMPERATURABHÄNGIGKEIT DER KERRKONSTANTEN VON GASEN UND DIE ERGEBNISSE BEI METHYL- UND ÄTHYLALKOHOL—VORLÄUFIGE MITTEILUNG (On the Temperature Variation of the Kerr Constant for Gases and the Results in the Case of Methyl and Ethyl Alcohol—Preliminary Communication).—H. A. Stuart. (*Physik. Zeitschr.*, 1st July, 1930, Vol. 31, No. 13, pp. 616–617.)

For a long paper on the same subject, see *Zeitschr. f. Phys.*, 28th July, 1930, Vol. 63, No. 7/8, pp. 533–557.

ÜBER DIE BETEILIGUNG VON PROTONEN AN DER ELEKTRIZITÄTSLEITUNG IN METALLEN (On the Part played by Protons in the Conduction of Electricity in Metals).—A. Coehn and W. Specht. (*Zeitschr. f. Phys.*, 12th May, 1930, Vol. 62, No. 1/2, pp. 1–31.)

A full paper on the phenomenon referred to in 1929 Abstracts, p. 51.

ÜBER EIN GESETZ, DAS VERSCHIEDENE EIGENSCHAFTEN FERROMAGNETISCHER KRISTALLE MITEINANDER VERKNÜPFT (A Law Linking up Various Properties [Magnetostriction, Internal Energy Density, etc.] of Ferromagnetic Crystals).—N. S. Akulov. (*Zeitschr. f. Phys.*, 2nd January, 1930, Vol. 59, No. 3/4, pp. 254–264.)

POSITIVE IONEN MIT HOHEN IONISIERUNGSVERMÖGEN UND DEREN EINFLUSS AUF DEM ELEKTRISCHEN DURCHBRUCH IN LUFT (Positive Ions of High Ionising Power and Their Influence on Electrical Breakdown in Air).—O. Mayr. (*Arch. f. Elektrot.*, 28th June, 1930, Vol. 24, No. 1, pp. 8–14.)

FORCED VIBRATIONS WITH COMBINED VISCOUS AND COULOMB DAMPING [MATHEMATICAL INVESTIGATION].—J. P. D. Hartog. (*Phil. Mag.*, May, 1930, Ser. 7, Vol. 9, No. 59, Supplementary No. pp. 801–817.)

ON THE FUNDAMENTAL CONSTITUTIVE EQUATIONS IN ELECTROMAGNETIC THEORY.—C. Kaplan and F. D. Murnaghan. (*Phys. Review*, 1st April, 1930, Vol. 35, No. 7, pp. 763–777.)

A COMPARISON OF THE CRITICAL ANGLE OF REFLECTION AND THE INDEX OF REFRACTION OF X-RAYS.—H. E. Stauss. (*Journ. Opt. Soc. Am.*, Nov., 1930, Vol. 20, pp. 616–617.)

"Apparently it must be decided that the character of the total reflection of X-rays is such that it is truly characteristic of the body of the reflector and is not influenced to any appreciable extent by surface conditions in the case of a good, polished reflector, even for X-rays of short wavelengths."

MISCELLANEOUS.

WORK OF THE GERMAN RESEARCH ESTABLISHMENT FOR AIRCRAFT FOR 1930.—H. Fassbender. (*E.T.Z.*, 30th Oct., 1930, Vol. 51, pp. 1525–1527.)

Many of the items in this short survey have been dealt with in various abstracts. In continuation of the ultra-short wave tests referred to in 1930 Abstracts, p. 40, reception tests in aircraft were carried out on signals from a system of 6 dipoles and 6 reflecting dipoles, raised 10 m. above the ground. Ranges were obtained up to 3.2 times the optical range—"a new proof that the idea of a horizon-imposed limit for ultra-short waves is not generally true." The beam effect, sharply defined in reception on the ground, could hardly be noticed in the aeroplane owing to the levelling effect of the super-regenerative receiver used there.

Other sections refer to work on screening against ignition and other interference. The aircraft d.f. receiver (Gloeckner, 1929 Abstracts, p. 393) has been further developed: protective measures have been so successful that the accumulator feeding its filaments can be charged while bearings are being taken.

The deficiencies of the ordinary magnetic compass have led to the development, with the A.E.G., of the inertia-less cathode-ray compass. For fog-landing, leader cables are being developed actively, and ultra-short waves are also being tried.

DIE ERWÄRMUNG DER ELEKTROLYTE IM HOCHFREQUENTEN KONDENSATORFELD UND IHRE BEDEUTUNG FÜR DIE MEDIZIN (The Heating of an Electrolyte in an [Ultra-] High Frequency Condenser Field, and its Significance in Medicine).—J. Pätzold. (*Zeitschr. f. hochf. Tech.*, Sept., 1930, Vol. 36, pp. 85–98.)

Work undertaken under the auspices of A. Esau and O. Pfetscher (*cf.* 1930 Abstracts, pp. 176, 287. *See* also Schliephake, Heinrich, 1929, pp. 347, 588). Two types of condenser arrangement are dealt with, (i) in which a uniform dielectric is in direct contact with the condenser plates, and (ii) in which a stratified dielectric is in the field of the condenser but there are gaps between the plates and the dielectric. The relation between conductivity (κ), dielectric constant (ϵ) and frequency (ν) to give maximum heating is evaluated theoretically for both these cases: for (i) it is $\kappa = \frac{\epsilon\nu}{2}$, for (ii) it is $\kappa = \frac{\epsilon\nu}{2}\left(1 + \frac{4\pi l}{aq\epsilon}\right)$, where l and q are the length and cross section of the liquid layer; a is the reciprocal sum of the various equivalent capacities involved in the arrangement (ii), and is a constant for fixed values of gaps and areas. *See* also Richards and Loomis, 1929 Abstracts, p. 589.

The theoretical results are confirmed by tests on a number of electrolytes. From measured values of ϵ and κ, the wavelength for maximum heating for serum comes out at $\lambda = 0.84 - 0.92$ m.; for blood without fibrin, 2.50 – 2.80 m.; for blood with fibrin, 3.00 – 3.70 m. For bacteriological investigations, bouillon and agar-agar were taken; for these the optimum wavelength was of the order of 1.20 m.

THE HEATING OF ELECTROLYTES IN HIGH FREQUENCY FIELDS.—J. C. McLennan and A. C. Burton. (*Can. Journ. of Res.*, Sept., 1930, Vol. 3, No. 3, pp. 224–240.)

Researches on wavelengths from 10 to 200 m. using a "field" method as contrasted to the "circuit" method of Richards and Loomis (1929 Abstracts, p. 589). Doubt is thrown on certain conclusions of these workers; *e.g.*, their deduction that the shorter waves have less lethal effect. A theory is given explaining how the field inside the specimen depends on the shape and orientation in the external field and on the dielectric constant. Application to a heterogeneous body is discussed: the distribution of field in the interior is determined largely by the dielectric constants, and the heating then upon the conductivities. The possibility of directed selective heating is suggested, and illustrated by experiments on blood.

METHOD OF OBTAINING A VISIBLE SPECTRUM OF WAVES OF RADIO FREQUENCY.—J. C. McLennan and A. C. Burton. (*Nature*, 26th July, 1930, Vol. 126, p. 130.)

"In the course of a research on the heating effects of radiation of wavelengths 10–200 metres, it was found that for a given wavelength there is a maximum heating effect produced in a medium the specific conductivity and dielectric constant of which are connected with the frequency by a simple law. This law, proved theoretically as well as shown experimentally to hold for dilute solutions, is $\frac{2c}{nD} = 1$, where c = specific conductivity in absolute units, D = dielectric constant and n = frequency of wave. . . . The above relation suggested that it might be possible to produce a spectrum of a radio-field, where a line would by its position in the spectrum indicate the wavelength emitted by a valve oscillator."

A jelly (of which details are given) was made up in a tube so that the conductivity increased along the tube; when this was placed in the field of radiation of an oscillator, a red patch appeared (when the intensity was sufficient) in a position where the conductivity was that determined by the relation given above. The application to ultra-short waves might be interesting, as any changes in the dielectric constant would show themselves as anomalous dispersion.

RADIO ELECTRIC CLOCK SYSTEM.—H. C. Roters and H. L. Paulding. (*Proc. Inst. Rad. Eng.*, Sept., 1930, Vol. 18, pp. 1537–1559.)

A clock system which employs radio time signals from a government station to correct automatically an electric master clock. "As interference is the usual limitation of a system of this sort, special emphasis has been placed upon the 'pulse amplifier' by means of which pulses of a periodic character are amplified with an extremely high selectivity against interference. The mathematical theory of this amplifier [a three-stage circuit with maximum response for a frequency of 1 cycle/sec., combined with increased output for a constant signal duration of 0.35 sec. and a response nearly constant from some minimum value of signal voltage to any maximum value desired—these three properties together being 'only possible for a 3-stage amplifier'] is developed in detail, and response curves for several stages are drawn."

The system comprises the master clock, secondary clocks, the radio receiver [2 stages r.f. amplification, a detector, the pulse-frequency amplifier, and an output valve] and a magnetic selector. "The only time that static is harmful is when it occurs in the silent interval . . . thus spoiling the chances of correcting the master clock during that silent interval. But, since there are four chances to correct every day, it very seldom happens that daily correction is not attained."

AUSTRALIAN RADIO RESEARCH BOARD—SECOND ANNUAL REPORT.—(*Journ. Council for Sci. and Ind. Res.*, Australia, Aug., 1930, Vol. 3, No. 3, pp. 156–160.)

The following are some extracts :—

(i) Enlarged programme of research.

(ii) Field strength work. (iii) Work on Fading:—the Appleton wavelength change method of studying height of layer, etc., is being used; a labour-saving device has been introduced into this method. 100 m. tests already suggest that conditions regarding the layer are very different from those in England, perhaps on account of the more intense power of the sun. A modification of the method of determining the layer height is mentioned (*see* Martyn, under "Propagation of Waves.").

(iv) Atmospherics :—observations on 3,000 and 30,000 m. at present indicate that, except at night, local sources only produce appreciable atmospherics on the shorter wavelength.

ANWENDUNG DER INTEGRALGLEICHUNGEN AUF BEUGUNG UND EIGENSCHWINGUNGEN IN DER ELEKTROMAGNETISCHEN LICHTTHEORIE (Application of Integral Equations to Diffraction and Characteristic Vibrations in the Electromagnetic Theory of Light).—W. Sternberg. (*Zeitschr. f. Phys.*, 10th Sept., 1930, Vol. 64, No. 9/10, pp. 638–649.)

Author's summary :—This paper gives the solution of the problem of the diffraction of electromagnetic waves by an infinitely long cylinder with any cross-section and electromagnetic constants. The mathematical foundation of the new method used by the author is given in a paper in the *Mathematische Annalen* where it is applied to problems of diffraction and characteristic vibrations. The present paper gives approximate solutions which may be used for numerical calculation.

ON THE UNIDIRECTIONAL CONDUCTIVITY OF DETECTORS.—V. D. Kuznetsov and A. A. Gabovitch. (*Westnik Elektrot.*, June, 1930, No. 6, pp. 212–220.)

Authors' summary :—A microscopical investigation of a polished crystalline lead sulphide (PbS) and ferrosilicium showed that between crystals of the substance there are present other ingredients, dielectrics or metals, having no detecting property. Since the breaking of the detector substance takes place on boundaries of crystals, between which such ingredients are included in quantity, the writers advise for practical purposes the use of the polished crystalline substance. Microscopical investigation of such polished surfaces enables one to choose the best crystals. Instead of point contact, the authors recommend using a contact with mercury which has constant properties and requires no adjustment. Experiments show that by the substitution of a point contact with a liquid one, change of temperature and ionising agencies have no influence on rectifying property. With increased pressure of a contact wire the detecting property decreases. A theoretical explanation of this phenomenon is given.

DISTANT CONTROL DEVICE WORKING ON ULTRA-SHORT WAVES.—Besson. (*See* under "Subsidiary Apparatus.")

DISTANCE DETERMINATION BY FOGHORN AND WIRELESS TELEPHONY: EXTENSION TO PREVENTING COLLISIONS AT SEA.—(*See* under "Directional Wireless.")

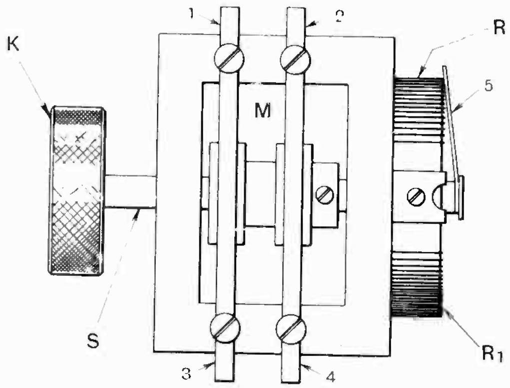
Some Recent Patents.

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.

TUNING AND VOLUME CONTROL.

Application date, 5th February 1928. *No.* 330551.

To simplify manipulation the tuning-knob is combined with a volume-control device, which may either take the form of a variable resistance in the filament circuit of a screened-grid valve, or a potentiometer for adjusting the biasing voltage in the grid of an amplifier. As shown in the Figure, the shaft S of the tuning-knob K carries a composite cam member M coacting with contact strips 1, 2, 3, 4 which adjust the set either for long or short wave reception. At the end of the shaft S an arm 5 simultaneously engages the edge of one or other of the volume-control resistances R and R_1, according to the direction of rotation.



No. 330551.

Patent issued to B. Hesketh.

DIRECTIONAL BROADCASTING.

Convention date (Germany) 20*th October*, 1928. *No.* 330750.

A clear-cut beam of radiation, having a degree of divergence comparable with that of a search-light, is produced by using a rod-oscillator situated at the focal point of a parabolic reflector system. The characteristic feature of novelty is that the focal distance is much larger than a quarter of the working wavelength, so that the overall size of the reflector is at least several wavelengths. The system is applied to wavelengths of the order of 1 metre. One suggested application is for broadcasting in a horizontal plane above the houses in a town area, a portion of the energy then being reflected downwards on to the houses by means of interposed prisms, so as to prevent losses due to ground absorption.

Patent issued to C. Lorenz Akt.

DIRECTIONAL AERIALS.

Application date 1*st May*, 1929. *No.* 330710.

A half-wave rod-oscillator is placed at each of the two focal points of an elliptical system of reflectors. The reflectors form an open-ended barrel-shaped enclosure, from which a directioned beam of radiation is projected, the energy emerging from each end of the barrel. The arrangement is such that the fundamental wave from each rod-oscillator travels out to the elliptical system of reflectors and is returned to the oscillator in phase with the succeeding wave. Means are provided for suppressing harmonics. One open end of the barrel-shaped reflector may be backed by a screen to give a unidirectional " beam."

Patent issued to R. C. Galletti and Ferranti Ltd.

COMBINED TELEVISION AND TELEPHONY.

Application date 8*th May*, 1929. *No.* 331041.

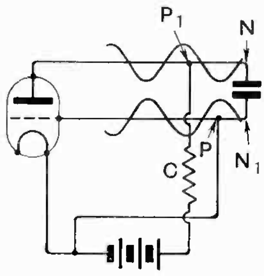
A single high-frequency wave serves to carry both visual and audible signals, one component being impressed on the upper and the other on the lower half of the same wave. The carrier wave is applied to two modulating valves arranged in parallel. One valve is biased so that it relays only the positive pulses of the wave upon which the television signals are then impressed, whilst the second valve passes only the negative pulses to which the speech frequencies are separately applied.

Patent issued to Universal and General Radio Co. Ltd. and L. M. Myers.

HIGH-FREQUENCY GENERATORS.

Application date 14*th June*, 1929. *No.* 330769.

Relates to the generation of very high frequencies along a Lecher-wire system connected to the grid and plate electrodes of a thermionic oscillator, the operating voltages being supplied at nodal points N, N1, as shown in the Figure, where the sinusoidal curve indicates the wave distribution. In such an arrangement alternating voltages may exist between the points N, N_1 and the cathode, giving rise to parasitic high-frequency currents. To prevent this, the cathode is directly connected to the grid lead at the point P, and also through a battery and choke C to the plate lead at P_1, the point P being located as much to the right of one of the nodes as the point P_1 is to the left.



No. 330769.

Patent issued to S. G. S. Dicker.

LIGHT-SENSITIVE DEVICES.

Convention date (Germany), 14th January, 1928. No. 304132.

Light rays are passed through a translucent dielectric subjected to a strong electric field. Under the ionizing influence of the light, the current passing through the dielectric is quantitatively controlled. The dielectric may comprise layers of conducting or semi-conducting material separated by layers of glass or porcelain.

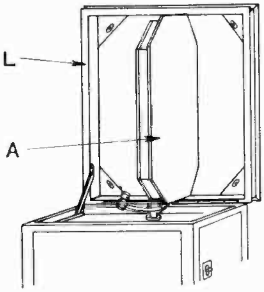
Patent issued to Dr. A. Joffé.

FRAME AERIALS.

Application date 19th June, 1929. No. 331374.

A frame aerial A is housed inside the lid L of a cabinet and is pivoted centrally, top and bottom, as shown, so that when the lid is opened the aerial can be swung out at any desired angle.

Patent issued to E. N. Kent-Lemon.



No. 331374.

WIRELESS RECEIVERS.

Application date 1st May, 1929. No. 331969.

In order to provide a receiver of relatively simple construction adapted to receive signals over two distinct wave bands, say 200–600 metres and 1,000–2,000 metres, the circuits are designed to give "straight" reception on the lower wave-lengths, whilst for the higher range the aerial is switched over to a local oscillator, so that the set operates on the superheterodyne principle. The switch also couples the output from the oscillator-detector with the input circuit of the HF stage, which thereupon operates as an intermediate-frequency amplifier.

Patent issued to The Gramophone Co. Ltd., and C. E. G. Bailey.

STABILISED AMPLIFIERS.

Convention date (U.S.A.) 17th May, 1928. No. 311817.

In order to stabilise a two-stage HF amplifier, the intervalve coupling-transformer comprises two primary windings connected in series, one winding being shunted by a condenser. The primary side of the transformer is so proportioned that it possesses a capacity reactance over the whole tuning range, whilst the transformer as a whole (including the secondary windings) presents a resistance characteristic to the plate circuit of the preceding valve. A feed-back condenser compensates for the slight damping introduced by the capacitative load on the grid circuit of the second valve.

Patent issued to Westinghouse Electric and Manufacturing Co.

PHOTO-ELECTRIC CELLS.

Application date 11th April, 1929. No. 332197.

Two pairs of photo-sensitive electrodes are incorporated in phase oppositions in a single cell, and are separated by an opaque central screen which may be adjusted about a pivot to secure an accurate balance. The intensity of light from a local source is controlled by an optical sound-film so that as the light falling upon one electrode increases that supplied to the other decreases, and vice versa. The output from the photo-sensitive cell is fed to a pair of push-pull amplifiers.

Patent issued to R. E. H. Carpenter.

STABILISING REACTION.

Application date 8th April, 1929. No. 331007.

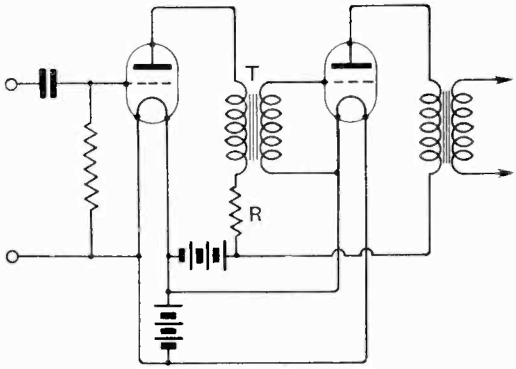
In a back-coupled amplifier or detector, a resistance is inserted in series with the anode reaction coil and between the anode of that valve and the grid of a subsequent valve. This is stated to maintain reaction substantially constant for all settings of the tuning condensers, without giving rise to any loss in sensitivity.

Patent issued to The Gramophone Co. Ltd., and A. Whitaker.

DETECTOR VALVES.

Application date 22nd April, 1929. No. 331022.

Although the grid-leak is more sensitive than anode-bend rectification, the response of the former is not strictly proportional to the strength of the applied signals. It is found that the rectified current increases more slowly at first, and then remains constant, or it may even fall off as the input voltage is increased. This is probably due to fortuitous anode-bend rectification, which tends to counteract the effect of grid rectification. According to the invention distortion from this cause is obviated by inserting an aperiodic impedance, *e.g.*, a resistance *R*, in series with the primary winding of the coupling transformer *T*. The resistance *R* enlarges the straight-line portion of the characteristic curve and so minimises undesired anode-bend rectification.



No. 331022.

Patent issued to S. G. S. Dicker.

SAFETY DEVICES FOR POWER GENERATORS.

Convention date (*U.S.A.*), *26th May*, 1928. *No.* 312336.

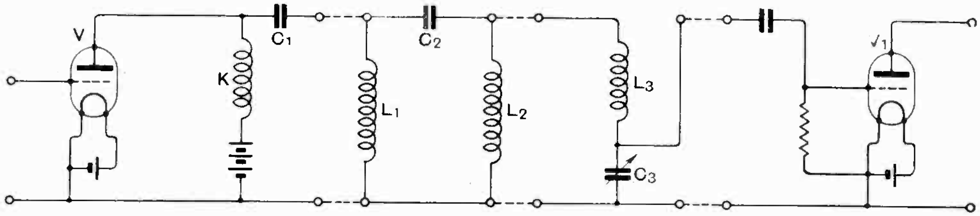
For transmitters utilising plate voltages of the order of 10,000 volts, a relatively-inexpensive relay inserted in the low-voltage or filament supply circuit is arranged to open a safety switch in the high-voltage supply circuit should any valve be over-run. The filament current flows through the relay windings in opposition, whilst the normal plate current passes through in parallel, so that an excessive plate current produces an additive field which brings the safety switch into operation.

Patent issued to Standard Telephones and Cables, Ltd.

"BAND" COUPLINGS.

Convention date (*U.S.A.*), *13th February*, 1928. *No.* 306003.

Two or more valves are coupled in cascade through a "transducer" circuit, which is defined to be any network of impedances which receives alternating energy at one pair of terminals and delivers it to another pair of terminals usually at a different voltage which is, however, independent of the frequency. Such a system of constant coupling utilises a constant ratio of two impedances, each of which varies with frequency, as distinct from a known method where the sum of two variable impedances is maintained constant for different frequencies.



No. 306003.

The band coupling is shown in the Figure, the circuit L_1, C_2, L_2 forming the "transducer" network. The plate circuit of the valve *V* is fed through a choke *K*, the output passing through a coupling condenser C_1 to the transducer network. The input to the succeeding valve V_1 is tapped off from a series-resonant circuit L_3, C_3. The coupling gives uniform selectivity and amplification over a given range of frequencies.

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

TELEVISION APPARATUS.

Application date, *19th February*, 1929. *No.* 329664.

The holes of the scanning-disc used for television transmission and reception are usually formed along a series of radii, each making an equal angle with its neighbour. This produces a picture which is shaped as a sector in outline. According to the invention the picture is made more approximately rectangular by arranging the series of spiral holes so that the length of the holes, radially of the disc, is greatest at the ends of the spiral and least at the mid-point of the spiral. The holes may either be graduated in size, or may be of two sizes only, the larger holes then being situated towards each end of the spiral.

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

DIRECTION-FINDING SYSTEMS.

Convention date (*Germany*), *23rd August*, 1928 *No.* 317826.

A beacon station transmits a continuously-rotating beam of signals. These are received on a non-directional aerial and are fed to an optical indicator, such as a neon lamp, which is fixed to a disc rotated by known means synchronously with the directed beam. The lamp lights up each time the beam is received at maximum strength, thereby indicating on an associated compass the direction of the transmitting station. A non-directional transmitter may be switched in once in each revolution so as to light up the indicator also along, say, the North-South line. The two positions of illumination then give a direct and rapid visual indication of the required bearings.

Patent issued to Telefunken ges für Drahtlose Telegraphie m.b.h.

DRY RECTIFIERS.

Convention date (*Germany*), *21st March*, 1928. *No.* 308306.

A copper plate of rectangular form is first coated with cuprous oxide by heating in an atmosphere containing oxygen. Two spring strips of copper or brass are then applied along the opposite sides of the plate, and the combination is sprayed with liquid zinc so that the side strips are firmly fixed to the electrode plate. The alternating input is applied across one of the side strips and a central electrode on the copper plate, so that current passes through the strip and the zinc coating to the oxide layer underneath, and thence to the rectifying junction between the oxide and the core of metallic copper.

Patent issued to Siemens Schuckertwerke Akt.