EXPERIMENTAL WIRELESS & The WIRELESS ENGINEER

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Editorial.

Mutual Demodulation and Allied Problems.

IN our issue of June, 1928, Dr. R. T. Beatty discussed the cause of the phenomenon that when two stations of different frequency are received simultaneously, the acoustic disturbance caused by the weaker one is less than one would expect from a comparison of their relative amplitudes on the input side of the detector. In our issue of November, 1929, Mr. S. Butterworth discussed the matter more rigorously and showed that one of Dr. Beatty's most striking results was due to the neglect of a term which is too important to be neglected. In our current issue Mr. F. M. Colebrook seeks to amplify this article for the benefit of those who, like himself, find Mr. Butterworth's mathematical treatment rather too compressed. We trust that we shall not be thought presumptuous if we seek to throw still more light on this problem by treating it graphically, before proceeding to discuss another aspect of the question. In Fig. 1 (*a*) the vectors *OA*, *AB* represent two radio-frequency electromotive forces acting simultaneously on an ideal rectifier, *OB* represents the resultant E.M.F. The whole diagram is assumed to rotate at the radio-frequency about the centre *O*, and the E.M.F. at any moment is the projection of *OB* on the vertical; the length *OB* is therefore equal to the amplitude of the E.M.F., and it is this in which we are interested. If the frequency of *AB* differs from that of *OA*, the vector *AB* will revolve about *A* relatively to *OA*, and as we are only concerned with the length *OB*, we can regard *OA* as stationary and the line *AB* as rotating at a frequency equal to the difference between the two radio-frequencies. The lengths of *OB* for eight equal intervals of time during a half revolution of *AB* are shown in Fig. 1 (*b*); the figure on each curve is the ratio *AB*/*OA*. These are not sine curves, and the departure from the sine form increases with the ratio *AB*/*OA*. Looking at the curves for *AB*/*OA* = $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and 1, it will be seen that although they go equally above and below the horizontal line *AA′* the areas above the line are greater than the areas below. It must be remembered that these curves give the gradually changing amplitude of a radio-frequency E.M.F. which we assume to be applied to an ideal detector which has an infinite resistance in one direction and a constant resistance in the other. To some suitable scale, then, the height of these curves above the line *OO′* represents the magnitude of the rectified current. We assume that the radio-frequency variations are smoothed out. If the difference between the two radio-frequencies is small enough the variations of the rectified current as it follows its of *AB* would vary up and down the straight line between *mr* and *ps*. The audio-frequency current is thus reduced and distorted by the presence of the other carrier. If *AB* were only

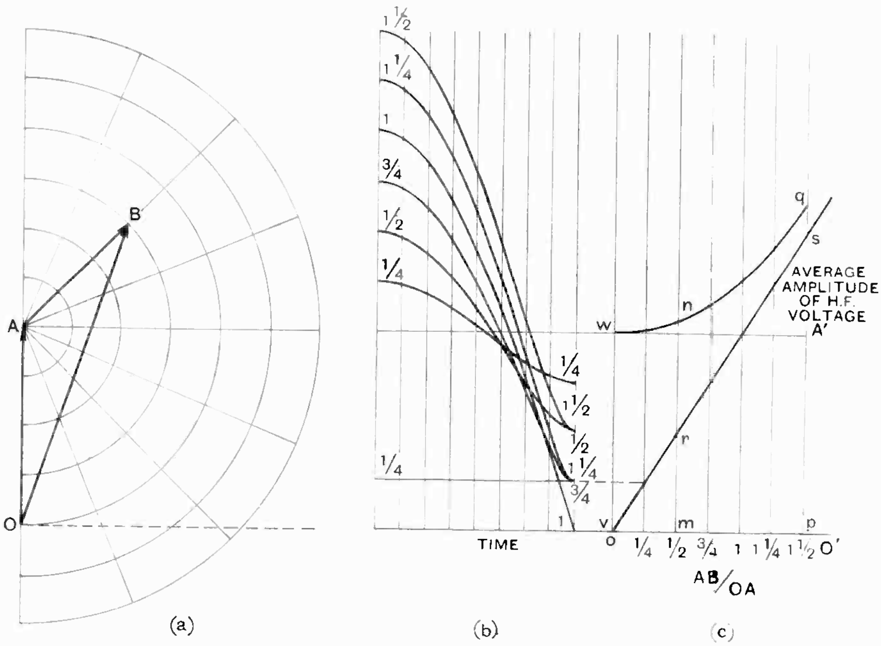


Fig. 1.

appropriate curve in Fig. 1 (*b*) will give a heterodyne note, but if the frequency difference is sufficiently great, or the apparatus sufficiently sluggish, the heterodyne fluctuations of the current will be smoothed out, and the resultant current will be given by the average height of the curves above the line *OO'*. It is obvious that this increases as *AB/OA* increases; it has been determined from Fig. 1 (*b*) and plotted as the curve in Fig. 1 (*c*). The abscissae are here the values of *AB/OA*. This is Mr. Colebrook's Fig. 1. Up to the present we have regarded *OA* and *AB* as representing two unmodulated carriers. If *AB* is modulated its amplitude changes and with it the ratio *AB/OA*. If the two carriers are of equal amplitude so that *AB/OA* is 1 and *AB* is now modulated 50 per cent., the ratio *AB/OA* will vary between ½ and 1½, and the rectified current will vary up and down between *mn* and *pq* in Fig. 1 (*c*), whereas, if the carrier *OA* were absent, the current due to the modulation

¼ *OA* and modulated 100 per cent., the current would only vary between *vw* and *mn* instead of between *O* and *mr*, hence the weak carrier is very severely demodulated by the presence of the strong carrier.

We now turn to another aspect of the problem not dealt with by the authors mentioned above. If two equally strong and equally modulated waves are affecting the aerial, one being the wanted signal to which the receiver is tuned, and the other a disturbing wave of a somewhat different frequency, the electromotive forces acting on the detector are very different from those acting on the aerial.

As an example, let us consider the case shown in Fig. 2. On separate lines are shown the carrier and the two sidebands of the wanted wave and the equally strong carrier and the two sidebands of an unwanted wave. Assuming 100 per cent. modulation in both cases the sidebands have half the amplitude of the carrier. The unwanted wave is shown as being modulated at half the frequency of the wanted wave, *i.e.*, with a pure note an octave lower. If the curve shown is the resultant resonance curve of the aerial and pre-detector tuning circuits, we can determine the magnitude and phase of the six currents set up by these six electromotive forces. Until we have done this, we do not know what it is that is supplied to the detector and cannot therefore predict the nature of the rectified output.

The ordinates marked on the resonance curve give the relative values of currents produced by equal E.M.F.s of the different frequencies. To find the relative magnitudes of the currents produced by the six E.M.F.s we have only to multiply these E.M.F.s by the corresponding ordinates of the resonance curve. Reading from left to right, the six currents will be $\frac{2}{5}$, $\frac{1}{2}$, $1\frac{1}{3}$, 2, 10, $\frac{1}{2}$. We must now consider the relative phases of

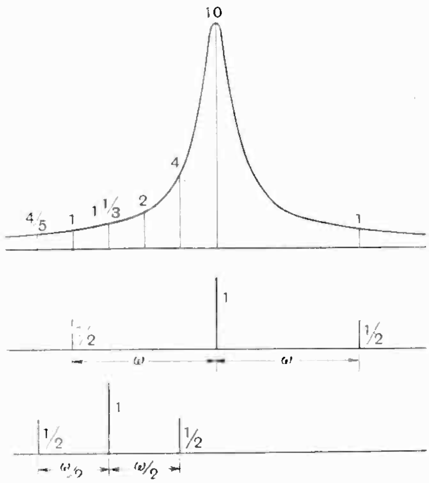


Fig. 2.

these currents. Unless the waves have suffered from selective fading *en route*, the E.M.F.s acting on the aerial will be as shown in Figs. 3 (*a*) and (*b*) in which all the angular velocities are those relative to the wanted carrier, and ω is the modulation frequency of the wanted signal (see Fig. 2). Fig. 3 (*a*) shows the wanted E.M.F.s and Fig. 3 (*b*), the unwanted ones. There is no fixed relation between the phases of the two signals, but for the sake of simplicity we shall take the condition shown in Figs. 3 (*a*) and (*b*) as our starting point. Now the wanted carrier E.M.F. acts on a circuit tuned to it and produces therefore a current

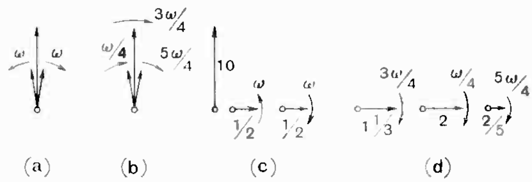


Fig. 3.

in phase with the E.M.F. One E.M.F., viz., the upper wanted sideband, is at a frequency above resonance and produces a current lagging about 90° behind it. All the other E.M.F.s being at frequencies below resonance will produce currents leading by about 90°. The currents will therefore have the phases shown in Fig. 3 (*c*) for the wanted and in Fig. 3 (*d*) for the unwanted signal, the order in each case being carrier, upper sideband, and lower sideband.

It is a simple but laborious matter to find the resultant of these six vectors for a number of successive moments taken throughout a whole cycle. To get a whole cycle of the $\omega/4$ component it is necessary to go through four cycles of the ω components. The simplest method is to find the sum A of the vertical or sine components of the five rotating vectors and add it to the stationary 10, and then to find the sum B of the horizontal or cosine components. The resultant R is then $\sqrt{(10 + A)^2 + B^2}$ as can be seen from Fig. 4. With the values and conditions assumed in Figs. 2 and 3 the values of A and B would be given by the formulae

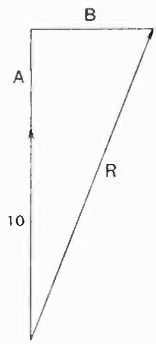


Fig. 4.

$$A = -\left(2 \sin \frac{\theta}{4} + \frac{4}{3} \sin \frac{3\theta}{4} + \frac{2}{5} \sin \frac{5\theta}{4}\right)$$

$$B = \cos \theta + 2 \cos \frac{\theta}{4} + \frac{4}{3} \cos \frac{3\theta}{4} + \frac{2}{5} \cos \frac{5\theta}{4}$$

where $\theta = \omega t$.

If the length of R be plotted to an angle or time base it will give the variation of amplitude of the radio-frequency current during a complete modulation cycle. If the grid of the rectifier be connected across a condenser or coil through which this current passes, the grid voltage will be very nearly proportional to the current, and if we assume straight line rectification, the same curve will represent to some scale the rectified current.

The curve must be analysed into its fundamental and various harmonic components to determine the nature of the acoustic output.

Two points of importance will have been noticed; first that, although two signals may have been equally modulated, the tuned selection of one automatically reduces its modulation compared with that of the other, and, secondly, that the phases of the various components are very much modified by the properties of the tuning circuits.

The carrying out of the analysis of the resultant curve should show whether there is any foundation for the suggestion that such a tuned circuit and detector can discriminate between the wanted and the unwanted components, so that when by audio-frequency correction the wanted components are restored to their full value, the unwanted ones remain obligingly in the background.

"The Wireless Engineer" —A Change in Name Only.

Experimental Wireless, when first the journal appeared, was devoted almost entirely to the interests of the wireless experimenter, and it was for this reason that the title was chosen. The rapid evolution in wireless theory and practice, however, resulted in the journal becoming regarded as the paper of the more highly qualified enthusiasts, professional and amateur. In consequence, the title was extended to *Experimental Wireless and The Wireless Engineer*. We feel that a stage has now been reached when the latter part of this title more accurately expresses the scope and policy of the paper, and accordingly with the September number the order will be reversed and our journal will be known as *The Wireless Engineer and Experimental Wireless*. The alteration will involve no change in the policy or contents of the journal, which will be maintained on the same level as in the past.

A Further Note on

The Apparent Demodulation of a Weak Station by a Stronger One.*

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

IN *E.W. & W.E.* for Nov., 1929, there appeared an article by Butterworth entitled "Note on the apparent demodulation of a weak station by a stronger one." The object of the article was to explain in general terms an interesting fact of experience in the reception of a modulated wave subject to interference from another modulated wave, the frequency difference between the two signals being supersonic. It is found that the extent of the interference as measured by the audio-frequency response of the receiver is very much less than would be inferred from the resonance curve of the receiving circuit. That is to say, for the same degree of modulation the acoustic ratio is very much less than the ratio of the carrier wave potential differences produced by the wanted and the interfering stations. The matter had been discussed by Dr. Beatty in an earlier article, also published in *E.W. & W.E.* Dr. Beatty's theory was stated in very simple language and afforded a valuable insight into this important and hitherto unexplained phenomenon, but unfortunately it contained an implicit approximation which led to erroneous conclusions in some cases. Butterworth gave a more rigid analysis, avoiding this approximation, and achieving full generalisation with a severe economy of material, in the effective mathematical style which is characteristic of his work. In fact, the only criticism one could offer would be that the economy was a little too severe for a discussion of a technical matter of some importance intended to be assimilated by persons of a technical rather than a mathematical habit of mind. The present writer found it necessary to amplify some of the steps—or perhaps jumps would be a better word—before he was able to grasp the full significance of the analysis. This more pedestrian pursuit of the subject was not without its own reward, however, for it brought to light another aspect of the matter which, though implicit in Butterworth's work, was not explicitly referred to. It appears that what Dr. Beatty described as a mutual demodulation effect can equally, and perhaps a little more clearly, be represented as a modification by each transmission of the effective rectification characteristic of the detector in relation to the other transmission. Moreover, the nature of this mutual modification of the rectification characteristic is such as to result, not only in a diminished interference from the weaker transmission, but also in an appreciable distortion effect in the reproduction of the modulation of the stronger.

Since this matter is likely to increase rather than decrease in importance as transmissions become more numerous, it has been thought worth while to emphasise this additional deduction from Butterworth's analysis, particularly as the appropriate restatement of the subject tends to make the main conclusion with regard to interference somewhat easier to grasp.

We assume in the first place a detector which gives an approximation to perfect rectification, *i.e.*, one which has zero conductivity in one direction and effectively constant conductivity in the other. This is the ideal type of rectifier for the reproduction of microphone modulation, and one which can be approximately realised in practice by large amplitude grid circuit rectification. The present tendency in reception technique is towards rectification of this type. It is further assumed that the detector output load is of low impedance relative to that of the detector at radio and high supersonic frequencies and of high relative impedance at audible modulation frequencies. (This is equivalent to Butterworth's assumption of an output instrument which is too sluggish to respond to radio

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

and supersonic frequencies but is able to record changes at zero and audible frequencies.) This again is approximately descriptive of the grid rectifier and also, though less exactly, of an anode bend rectifier. Considering, for example, the grid

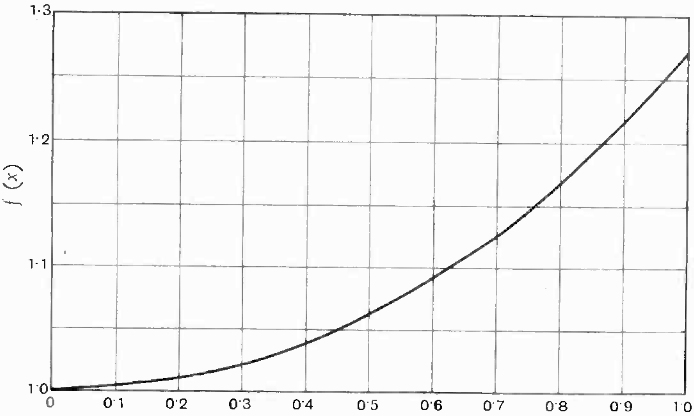


Fig. 1.

circuit rectifier, the grid leak and its associated shunt condenser can be regarded as the output load of the rectifying circuit proper, since it is the passage of the rectified currents through the grid leak and condenser which produces the potential changes required for the operation of the remaining elements of the receiver. The magnitude of the condenser is such as to make this output load impedance low at radio and supersonic frequencies and high at audio-frequencies and at zero frequency.

Expressing these characteristics in symbols, the rectified output voltage v_r for an input radio-frequency $v = V \cos \omega t$ is assumed to be

$$v_r = kV$$

if V is constant or only varies at audio-frequencies, and

$$v_r = \frac{k}{T}\int_0^T V dt$$

if the variation in V is supersonic of period T.

Now imagine a receiver embodying such a detector to be tuned to a continuous wave transmission of angular frequency ω_1, the resulting detector input voltage being

$$v_1 = V_1 \cos \omega_1 t$$

and suppose that there is in addition an interfering continuous wave transmission of angular frequency ω_2 giving rise to a detector input voltage

$$v_2 = V_2 \cos \omega_2 t$$

(The origin of t can always be chosen so as to give an initial zero phase difference, to avoid superfluous symbols.) The total detector input voltage is $v_1 + v_2$, which can be put in the form

$$v_1 + v_2 = v = V \cos (\omega t - \psi)$$

where

$$\omega = (\omega_1 + \omega_2)/2$$

$$\tan \psi = \frac{V_1 - V_2}{V_1 + V_2} \tan \frac{(\omega_1 - \omega_2)t}{2}$$

and

$$V^2 = V_1^2 + V_2^2 + 2V_1V_2 \cos (\omega_1 - \omega_2)t$$

(Butterworth gives a slightly different but equivalent transformation.) The angular frequency difference $(\omega_1 - \omega_2)$ is assumed to be supersonic, so that the detector will record the mean value of V, *i.e.*,

$$v_r = \frac{k}{T}\int_0^T \{V_1^2 + V_2^2 + 2V_1V_2 \cos (\omega_1 - \omega_2)t\}^{\frac{1}{2}} dt$$

where

$$(\omega_1 - \omega_2) = 2\pi/T$$

Following Butterworth, a simple transformation gives

$$v_r = kV_1 f(V_2/V_1) \text{ for } V_2 < V_1$$
$$= kV_2 f(V_1/V_2) \text{ for } V_2 > V_1$$

where

$$f(x) = \frac{2}{\pi}(1 + x)\int_0^{\pi/2} \left\{1 - \frac{4x}{(1 + x)^2}\sin^2\phi\right\}^{\frac{1}{2}} d\phi$$

x being equal to or less than 1. The integral is the complete elliptic integral of the second kind, so that $f(x)$ is easily evaluated from tables. It is shown plotted in Fig. 1. It is 1 when $x = 0$ and 1.273 ($4/\pi$) when $x = 1$.

What we are more concerned with, however, is the *change* in v_r as a function of V_1 (the amplitude of the wanted signal). Now when $v_1 = 0$,

$$v_r = kV_2 f(0) = kV_2$$

so that for values of V_1 less than V_2

$$\begin{aligned}\delta v_r &= kV_2 f(V_1/V_2) - kV_2 \\ &= kV_2\{f(V_1/V_2) - 1\}\end{aligned}$$

and for values of V_1 greater than V_2

$$\delta v_r = k\{V_1 f(V_2/V_1) - V_2\}$$

In the absence of interference the rectifier characteristic in relation to V_1 is given by

$$\delta v_r = v_r = kV_1$$

The above analysis shows that in the presence of interference represented by the potential V_2 the effective rectification characteristic becomes

$$\begin{aligned}\delta v_r &= kV_2\{f(V_1/V_2) - 1\}\ ;\ V_1 < V_2 \\ &= k\{V_1 f(V_2/V_1) - V_2\}\ ;\ V_1 > V_2\end{aligned}$$

The difference will be made clearer by an example. Fig. 2 shows δv_r plotted against V_1 (taking k as unity for simplicity) assuming $V_2 = 0.25$ volts. The slope of the effective characteristic is zero when V_1 is 0, and the characteristic approaches asymptotically the line

$$\delta V_r = k(V_1 - V_2)$$

when V_1 is very large. Thus in the presence of the interference the potential change due to the wanted signal is reduced, in the ratio $1 : (1 - V_2/V_1)$ when V_1 is large, and to a much greater extent when V_1 is small. From the point of view of the reception of a modulated wave, however, the more important feature is the effect of the interference on the shape of the apparent rectification characteristic, for faithful reproduction of modulation requires uniformity of slope in this characteristic. If we suppose V_1 to be modulated at audio-frequencies, it is clear that in the absence of interference the assumed straight line rectification characteristic will give a faithful reproduction of the modulation, free from amplitude distortion and the consequent introduction of spurious harmonics. On the other hand, the apparent rectification characteristic which arises from the interaction of V_1 and V_2 will not give faithful reproduction of the modulation if the latter is of sufficient depth to bring the minimum value of V_1 into the curved region of the rectification characteristic. In fact, however small V_2 may be, the apparent rectification characteristic will be curved at the foot on account of the interaction of the two signals, so that perfect reproduction of 100 per cent. modulation would be unattainable even with a perfect rectifier. However, the effect will be appreciable only when the interfering transmission gives a detector input voltage which is not very small compared with that due to the wanted transmission. Such conditions will quite often occur in practice, as, for example, when a distant station is received on a receiver situated in the neighbourhood of another station.

The mutual demodulation effect, which was the subject of Butterworth's original paper, is also made clear by these apparent rectification characteristics. As far as the wanted signal is concerned, it is obvious that the slope of the apparent rectification characteristic is affected only slightly by the interference, as long as the carrier wave voltage of the wanted station exceeds that of the interference. The interfering transmission, on the other hand, assuming it to give a smaller detector input voltage than the wanted transmission, will clearly have an apparent rectification characteristic very greatly reduced in slope. It is determinable in precisely the same manner as for the wanted transmission and by means of the same formulae. Thus, assuming V_1 to be constant at 1 volt, δv_r as a function of V_2 is as shown in Fig. 2, which also shows for the sake of comparison δv_r as a function of V_1

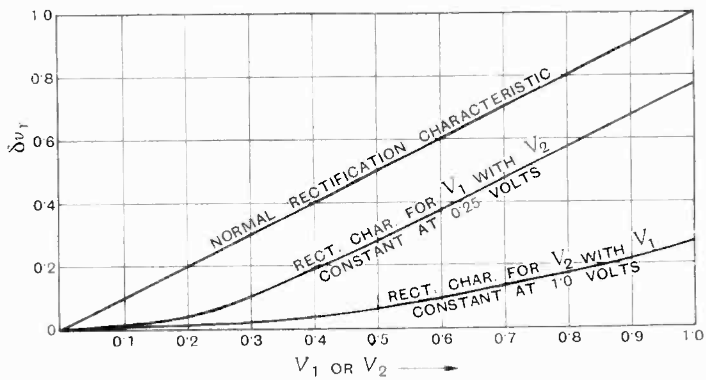


Fig. 2.

assuming V_2 constant at 0.25 volts, and the normal rectification characteristic for either transmission in the absence of the other. That for V_2 with V_1 constant at 1 volt has at $V_2 = 0.25$ only about 0.12 of its normal slope. The result is that for equal modulation percentages the ratio of the modulation frequency output voltages for the two stations is only about 0.03 to 1, though the detector voltages are in the ratio of 0.25 to 1. The greater the ratio of the detector voltages, the greater is the reduction in the apparent slope of the rectification characteristic for the weaker of the two. The effect is fully tabulated in Butterworth's paper to which reference can be made for fuller information on this aspect of the matter. It may be further pointed out, however, that the ratio of the modulation frequency output voltages is still further decreased by the fact that the interfering transmission is received on a circuit not tuned to it, so that its sideband voltage amplitudes will be unequal. The modulation frequency output produced by rectification in such a case is determined mainly by the smaller of the two. This effect will, however, be less important than the "demodulation" produced by the stronger signal.

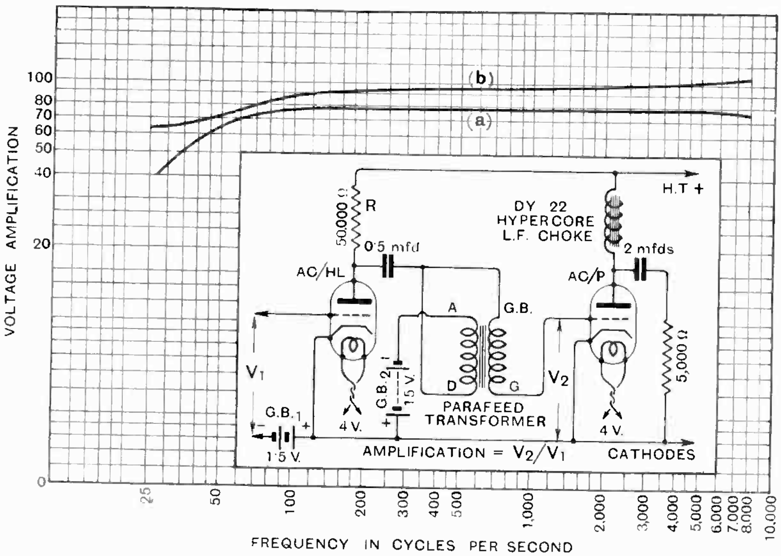
The above analysis is of course somewhat idealised. The actual rectification characteristic will not be a straight line through the origin, even in the absence of interference, but will in fact be curved at the foot. The principle is not greatly affected as long as the amplitudes are such as to come well into the straight line region. If the amplitudes are so small as to involve the foot of the characteristic only, then the rectification is practically square law in type and, as Butterworth points out, there will be no demodulation effect on either transmission in that case. In practice, therefore, the effect may be expected to vary up to the maximum represented by the assumption of linear rectification.

A New Development in L.F. Transformer Design.

As the result of careful investigation undertaken by the Research Department of R.I., Ltd., nickel iron of very considerably higher permeability than ever used before has been embodied in their new L.F. transformer, officially designated the "Parafeed" model. As its description implies, it is intended for use in circuits where the steady D.C. is deflected through a resistance, or anode choke as the case may be, and only the A.C. component passed to the transformer. On account of the special properties of the core material—a nickel-iron alloy with a large percentage of nickel—a high inductance can be obtained with a comparatively small amount of wire, and, furthermore, a considerable reduction is effected in the size of the core, since it is quite unnecessary to legislate for the magnetising effects of the D.C. in the windings.

As a consequence, the "Parafeed" transformer attains a primary inductance of about 120 henrys and the overall size is but 2in. × 1⅜in. × 1⅝in. high.

By a slight modification in the circuit a rising characteristic can be obtained and the average amplification raised from 80 to the order of 95 times. The rapid decline below 50 cycles is arrested and at 25 cycles the amplification is a shade over 60 times. To achieve these results the anode resistance is replaced by a high inductive L.F. choke. These curves were prepared by the N.P.L. and are produced by permission of the manufacturers, Radio Instruments, Ltd., Purley Way, Croydon; the price of the "Parafeed" transformer is 8s. 6d.



Curves showing the voltage amplification of R.I. "Parafeed" L.F. transformer (a) with 1 : 4 ratio and resistance-capacity feed; (b) with 1 : 4 ratio and anode choke in place of R.

The Variation of the Resistances and Inter-electrode Capacities of Thermionic Valves with Frequency.*

By L. Hartshorn, D.Sc., A.R.C.S., D.I.C.

(The National Physical Laboratory.)

1. Introduction.

It is now very generally recognised that the most convenient way of studying the behaviour of thermionic valves in any circuit is to represent each valve by its equivalent network, consisting of the three inter-electrode capacities, and the anode circuit resistance, associated with an electromotive force μe (where μ is the voltage factor of the valve, and e is the input p.d.), arranged in the well-known delta formation. The properties of this network† have been worked out mathematically in some detail by various workers, and it has been found capable of explaining many experimental results obtained over a great range of frequencies. In the mathematical analysis it is assumed that the valve capacities and resistance are constant for different frequencies, and in most practical cases it is assumed that the equivalent resistance of the valve in the network is the value which can be determined from the static characteristic curves, and that the capacities are the same as the electrostatic capacities between the electrodes, *i.e.*, the capacity measured when the filament is cold, and not emitting electrons. It is not difficult to show that these assumptions are not strictly true; the valve capacities are affected by the electron emission from the filament, and both the resistance of the valve and its capacities vary with frequency. The nature of these changes and their order of magnitude will now be considered, and thus an estimation of the errors arising from the usual assumptions will be possible in any given case.

2. Definitions of Capacity and Resistance.

It is first of all necessary to consider in detail what is meant by the terms capacity and resistance. Originally the term capacity was introduced to represent the relation between the charges acquired by conductors and the potentials imposed on them, it being assumed that the conductors were surrounded by a medium which was a perfect insulator and in which, therefore, there were no currents. Resistance was defined as the ratio of potential difference to current in any portion of a circuit, it being assumed that the current was constant, and that there was no accumulation of charge in that portion of the circuit, *i.e.*, that there were no capacity effects. In practice these conditions are seldom satisfied, accumulations of charge (or capacity effects) and currents occur at the same time, and for alternating current work it has been necessary to introduce new definitions of capacity and resistance, which can be usefully applied to practical conditions, and which at the same time give the same results as the old definitions when applied to the ideal conditions originally postulated. Some writers‡ have attempted to apply the old definition of capacity, *i.e.*, ratio of charge to potential, to the case of the filament and anode of a valve, under conditions in which an emission current is flowing, *i.e.*, conditions which are excluded by the definition. It is only necessary to compare their deductions with well-known experimental results to see that this definition cannot be applied in such cases.

Consider any two conductors separated by some kind of insulating material, for instance, two electrodes of a valve. If a variable potential difference v is applied to them a current flows out of one and into the other, and we therefore imagine them to be connected by a current path. In

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

† Colebrook, *J.I.E.E.*, 67 (1929), 157.

‡ Rajski, *L'Onde Electrique*, 7 (1928), 461. Petrucci, *Nuovo Cimento*, 6 (1929), 298.

practice the capacity and resistance of the system are the two electrical magnitudes representing this current path, which enable the current to be calculated in terms of the voltage v. In the case when both voltage and current are of sine wave form and frequency $\omega/2\pi$, the capacity C and resistance R are defined by the vector equation*

$$I = V\left(\frac{1}{R} + jC\omega\right) \quad .. \quad (1)$$

In order to find out how resistance and capacity thus defined vary as the conditions in the insulating medium are changed, we must interpret this definition in terms of known properties of the medium. The power P dissipated in the medium is given by

$$P = V^2/R \quad .. \quad .. \quad (2)$$

and thus R is given by the ratio V^2/P, and we may use this relation as a generalised definition of resistance. The quadrature component of the current $jVC\omega$ causes no net dissipation of energy, but it does involve a storage of energy in the current path every half cycle, this stored energy W_0 being returned to the source of the p.d. in the following half cycle. The energy stored per half cycle is given by

$$W_0 = \tfrac{1}{2}CV_m^2 \quad .. \quad .. \quad (3)$$

and we may regard this equation as determining the capacity C in terms of the insulating medium.

Consider now a small cylindrical element of the current path between the two conductors. Let its length tangential to the lines of current flow be δl and its cross section at right angles to these lines be δa. When a potential difference v is applied to the conductors let F be the electric intensity at the place occupied by this element.

The expression for the power dissipation δP in this small element may be written

$$\delta P = \sigma F^2 \delta a \delta l \quad .. \quad .. \quad .. \quad (4)$$

and that for the energy stored in it

$$\delta W_0 = \frac{\epsilon F^2}{8\pi} \delta a \delta l \quad .. \quad .. \quad (5)$$

* This equation defines the equivalent shunt resistance R, and the equivalent shunt capacity C, the quantities appropriate to the valve network. In other problems it is sometimes convenient to use the equivalent series resistance r and the equivalent series capacity c defined by the equation $V = I\ (r - j/C\omega)$.

where σ and ϵ are two constants of the material, viz., the specific conductivity and the dielectric constant, at the place considered. The values for the power dissipated and energy stored in the whole current path must be obtained by integrating these expressions throughout the whole of the space occupied by the path. Thus

$$P = \iint \sigma F^2 dl da \quad .. \quad .. \quad (6)$$

$$W_0 = \iint \frac{\epsilon F^2}{8\pi} da dl \quad .. \quad .. \quad (7)$$

Equations 2, 3, 6 and 7 may be regarded as the generalised definitions of the resistance R, and capacity C of any current path, in terms of the material constants σ and ϵ, the distribution of electric intensity F throughout the current path, and the terminal voltage V. For F we may, of course, substitute $-\dfrac{dV}{dl}$.

3. Deductions.

From these definitions several important deductions may be made. The resistance and capacity are functions not only of the material constants ϵ and σ, but also of the distribution of electric intensity or voltage gradient. The original definition of capacity, as the ratio of charge to potential, applies only to cases in which the voltage gradient is determined solely by the values of ϵ (and, of course, the shape and size of the conductors or electrodes), *i.e.*, σ is either zero or else its effect is negligibly small. The capacity under these conditions is often called the "geometric" or "electrostatic" capacity, and for convenience we shall refer to this distribution of electric intensity as the "electrostatic distribution." In practice it is only realised for very short time intervals or at very high frequencies. At such frequencies, although σ is not small, its effect on the voltage distribution is negligible compared with that of ϵ, the effect of ϵ being proportional to the frequency, and that of σ independent of the frequency. Now in this electrostatic case it is well known that the electric intensity takes up that distribution which makes the stored energy a minimum. Thus the "electrostatic" value of a capacity is the minimum possible for any current path, if the physical properties of the material remain unchanged.

Consider now the conditions which are assumed in ordinary direct current theory. A constant applied voltage produces a constant current, and the value of this current is determined solely by the resistance of the path. In this case the distribution of voltage throughout the path is determined solely by σ, *i.e.*, the effect of ϵ is assumed to be negligibly small. This condition is easily realised in practice by applying a constant voltage and then allowing a sufficiently long time to elapse for the current to reach its constant final value. The distribution of voltage and electric intensity in this case will be referred to as the D.C. distribution. In alternating current work it is only approached at very low frequencies. It is well known that this D.C. distribution is that which causes the minimum power dissipation for a given applied voltage. Thus the D.C. conductance is the minimum possible for any current path, or the D.C. resistance is the maximum possible. Anything which causes the voltage gradient to deviate from the " electrostatic " distribution causes an increase of capacity, and anything which causes it to deviate from the " D.C. distribution " causes a decrease of resistance. Thus, in general, conductivity in an insulating material causes an increase in its capacity. The only case in which conductivity causes no change in capacity is that in which it causes no change in voltage gradient, *i.e.*, when ϵ and σ are everywhere proportional to one another, or the ratio ϵ/σ is constant throughout the medium. In this case the voltage gradient determined by ϵ alone (the " electrostatic ") is the same as that determined by σ alone (the D.C.). It will, therefore, be unaltered when ϵ and σ are effective in varying degrees, and in this case and this alone, the capacity and resistance are independent of the frequency.

4. Application to a Valve.

Now apply these considerations to a valve. When the filament is cold we have the electrostatic case, and the capacity is the smallest possible. When the filament emits electrons the voltage gradient is immediately altered, and therefore the capacity must increase. The extent of the increase depends on the change in the distribution of the voltage gradient, and this again depends on the frequency. Thus at very high frequencies the current tends to pass more and more as a capacity current between the electrodes, *i.e.*, the voltage gradient tends to approach the electrostatic distribution and the capacity tends to approach its minimum value. At very low frequencies the voltage distribution is governed mainly by the space charge, and the capacity approaches a maximum value as the frequency is reduced to zero. Again at very low frequencies the voltage distribution is the steady current distribution and the resistance is a maximum. As the frequency increases the voltage distribution deviates more and more from the steady current distribution. It finally approaches the electrostatic distribution, and the resistance thus approaches a minimum value at very high frequencies.

5. Approximate Mathematical Theory.

The complete mathematical theory of these changes becomes very complicated and will not be attempted here. We shall now investigate the relation between the limiting values of the anode circuit resistance and capacity of a valve, *i.e.*, the values at zero and infinite frequency, and also find an approximation for the value at any intermediate frequency. Only the simplest possible case will be considered, viz., that in which the electrodes are plane and parallel, and therefore the current path is everywhere of uniform cross section.

For the thermionic current between an anode and cathode which are plane and parallel under the conditions in which a valve is normally operated, *i.e.*, temperature saturation of the cathode, we have the well-known equation obtained by Child* and by Langmuir†,

$$I = \frac{\sqrt{2}}{9\pi}\sqrt{\frac{e}{m}}\,\frac{V^{\frac{3}{2}}}{x^2} = \frac{AV^{\frac{3}{2}}}{x^2} \quad \ldots \quad \ldots \quad (8)$$

Here I is the electron convection current per unit area of cross section of the current path, V is the p.d. between anode and cathode, and x is the distance between anode and cathode. In obtaining this equation displacement currents are neglected, *i.e.*, strictly speaking it holds only for zero frequency.

* *Phys. Rev.*, 32, 498 (1911).

† *Phys. Rev.*, 2, 450 (1913).

In practice we are concerned only with small alternations of I and V. Let i and v denote such small alternations, then by differentiating (8) we find for the relation between i, v, and x.

$$v = \frac{2}{3} \cdot \frac{ix^{\frac{4}{3}}}{A^{\frac{2}{3}}I^{\frac{1}{3}}} \quad \ldots \quad \ldots \quad (9)$$

We wish to investigate the voltage gradient dv/dx and for this purpose we shall write this in the form

$$v = Bx^{\frac{4}{3}} \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

and since the currents i and I have the same value throughout the current path, B is independent of x. Thus we have

$$\frac{dv}{dx} = \frac{4}{3} Bx^{\frac{1}{3}} \quad \ldots \quad \ldots \quad (11)$$

This gives the A.C. voltage gradient between plane parallel electrodes when this voltage gradient is determined solely by the thermionic convection current, *i.e.*, at very low frequencies when the displacement current is negligible.

Applying our definition of capacity, we find for the capacity per unit cross section

$$C_0 = \frac{2}{v^2}\int_0^x \frac{\epsilon}{8\pi}\left(\frac{dv}{dx}\right)^2 dx. \quad \ldots \quad \ldots \quad (12)$$

$$= \frac{\epsilon}{4\pi v^2}\int_0^x \frac{16}{9} B^2x^{\frac{2}{3}}dx.$$

$$= \frac{\epsilon}{4\pi x} \times \frac{48}{45} \quad \ldots \quad \ldots \quad \ldots \quad (13)$$

Under electrostatic conditions the voltage gradient between parallel plane electrodes is constant. Thus at very high frequencies in which the displacement current forms almost the whole current

$$\frac{dv}{dx} = a = \text{constant, and } v = ax. \quad \ldots \quad (14)$$

Substituting this in (12) the capacity becomes

$$C_\infty = \frac{\epsilon}{4\pi x} \quad \ldots \quad \ldots \quad (15)$$

which is the well-known result for a parallel plate condenser. Thus the ratio between the capacity at very high frequencies, C_∞ and that at very low frequencies is $\frac{48}{45}$, or the capacity of the valve when it is working at low frequencies is nearly 7 per cent. greater than the capacity when the filament is cold.

Now consider the conductivity or the resistance. At very low frequencies, when the effect of capacity is negligible, equation (9) gives the total current. This may be written

$$v = Hix^{\frac{4}{3}} \quad \ldots \quad \ldots \quad \ldots \quad (16)$$

where H is independent of x, and from this we see at once that at very low frequencies the A.C. resistance R_0 is given by

$$R_0 = Hx^{\frac{4}{3}} \quad \ldots \quad \ldots \quad (17)$$

The specific conductivity σ at a point in the current path at a distance x from the cathode is given by

$$\sigma = i \Big/ \frac{dv}{dx} = \frac{3}{4Hx^{\frac{1}{3}}} \quad \ldots \quad \ldots \quad (18)$$

At very high frequencies, the actual voltage distribution is given by (14) and the A.C. resistance is now given by

$$\frac{1}{R_\infty} = \frac{1}{v^2}\int_0^x \sigma\left(\frac{dv}{dx}\right)^2 dx$$

$$= \frac{1}{a^2x^2} \cdot \int_0^x \frac{3}{4Hx^{\frac{1}{3}}} \cdot a^2 \cdot dx$$

$$= \frac{9}{8Hx^{\frac{4}{3}}} \quad \ldots \quad \ldots \quad \ldots \quad (19)$$

$$\therefore R_\infty = R_0 \times 8/9 \quad \ldots \quad \ldots \quad (20)$$

Thus the resistance at very high frequencies is smaller than that at very low frequencies (the value obtained from the static characteristic curves) by 11 per cent.

6. Variation of Valve Parameters with Frequency.

We have now obtained values for the resistance and capacity of a valve for the extreme cases of infinite and zero frequency. In order to find the form of the frequency curve it is convenient to approach the subject from a different point of view. When a valve is in operation the space between filament and anode is occupied by a cloud of electrons, its density being greatest at the surface of the filament and gradually diminishing as we proceed from filament to anode. These electrons endow the space with a certain conductivity, this conductivity steadily decreasing as we pass from filament to anode. If we divide up the current path between filament and anode by equipotential surfaces into a number of elementary volumes, each of these volumes may be regarded as a small condenser shunted by a certain resistance, and the whole current path is formed by a number of such condensers in series. If these condensers are arranged to have equal capacities, then their associated shunt resistances must increase as we pass from filament to anode. The properties of the current path are those of such a combination of capacities and resistances, and the variations of the overall resistance and capacity with frequency can be most easily studied in terms of these quantities. As a first approximation we shall divide up the current path into two parts only, and thus replace it by two condensers C_1 and C_2 shunted by the resistances R_1 and R_2 respectively, (Fig. 1.). It is easy to show that this network possesses the following properties.* At any frequency $\omega/2\pi$, the system may be replaced by a single capacity C, shunted by a resistance R (or a conductance $G = 1/R$) where

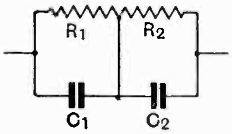


Fig. 1.—Equivalent network for inter-electrode capacity including effect of space charge.

$$\frac{C - C_\infty}{C_\infty} = \frac{a}{1 + \omega^2 T^2} \quad \ldots \quad \ldots \quad (21)$$

$$G - G_0 = \frac{C_\infty \times a\omega^2 T}{1 + \omega^2 T^2} \quad \ldots \quad \ldots \quad (22)$$

$$C_\infty = C_1 C_2/(C_1 + C_2) \quad \ldots \quad (23)$$

$$R_0 = 1/G_0 = R_1 + R_2 \quad \ldots \quad (24)$$

$$a = \frac{(R_1 C_1 - R_2 C_2)^2}{C_1 C_2 (R_1 + R_2)^2} \quad \ldots \quad (25)$$

$$T = \frac{(C_1 + C_2) R_1 R_2}{R_1 + R_2} \quad \ldots \quad (26)$$

It will be noticed that C_∞, as given by (23), is the capacity at infinite frequency of the combination, while R_0 and G_0, as given by (24), are the resistance and conductance respectively of the combination at zero frequency. From (21) we obtain, for the capacity C_0 at zero frequency,

$$\frac{C_0 - C_\infty}{C_\infty} = a \quad \ldots \quad \ldots \quad (27)$$

Now in the case of the valve we have found that $C_0/C_\infty = 48/45$. Substituting this in (27) we find that for the valve

$$a = \frac{1}{15} = 0.067 \quad \ldots \quad \ldots \quad (28)$$

Similarly by putting $\omega = \infty$ in (22) we get for the conductance at infinite frequency G_∞,

$$G_\infty - G_0 = aC_\infty/T \quad \ldots \quad (29)$$

But for the valve we have found that $G_\infty/G_0 = 9/8$, and, putting this in (29) and remembering that $a = \frac{1}{15}$, we get

$$T = \frac{8}{15} \cdot \frac{C_\infty}{G_0} = 0.53 R_0 C_\infty \quad \ldots \quad (30)$$

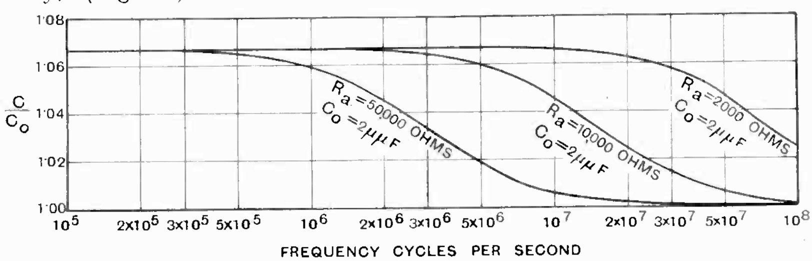


Fig. 2.—*C=Capacity at any frequency $\omega/2\pi$, C_0=the electrostatic value.*

Thus by (21), (28) and (30) we now get for the capacity C of the valve at any frequency $\omega/2\pi$

$$\frac{C}{C_\infty} = 1 + \frac{0.067}{1 + 0.28\, R_0^2 C_\infty^2 \omega^2} \quad \ldots \quad (31)$$

Similarly from (22), (28) and (30) we get for the conductance G or the resistance R at the frequency $\omega/2\pi$

$$\frac{1}{R} - \frac{1}{R_0} = G - G_0 = (G_\infty - G_0)\frac{\omega^2 T^2}{1 + \omega^2 T^2}$$

$$\text{or } G - G_0 = \tfrac{1}{8} G_0 \cdot \frac{0.28 R_0^2 C_\infty^2 \omega^2}{1 + 0.28 R_0^2 C_\infty^2 \omega^2} \quad \ldots \quad (32)$$

$$\text{or } \frac{R_0}{R} = \frac{G}{G_0} = 1 + \frac{0.035 R_0^2 C_\infty^2 \omega^2}{1 + 0.28 R_0^2 C_\infty^2 \omega^2} \quad \ldots \quad (33)$$

* *I.E.E. Jour.*, 64, 1152 (1926).

The expressions of equations (31) and (33) are shown plotted against frequency in Figs. 2 and 3 for three typical cases, corresponding to valves with resistances of 2000, 10,000, and 50,000 ohms respectively, the electrostatic value of the inter-electrode capacity (C_∞) being taken as $2\mu\mu$F. in each case. It must be remembered that it is only the capacity associated with the active parts of the electrodes that is considered in this investigation, *i.e.*, the capacities of the leads, external or internal, must be omitted.

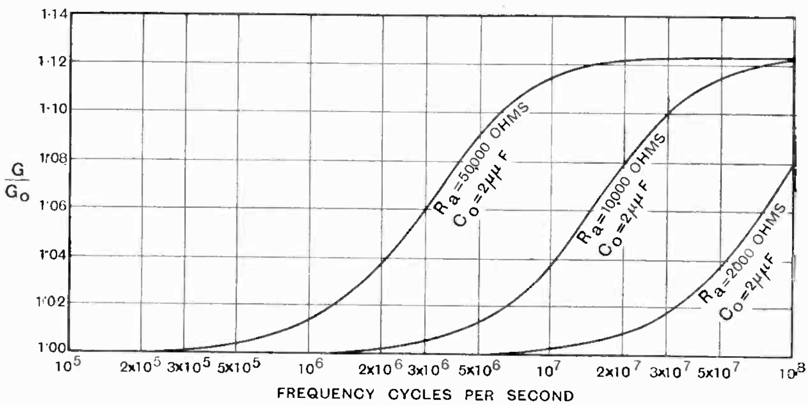


Fig. 3.—G_0=*D.C. Conductance* (*static value* $=I/R_a$), G=*conductance at frequency* $\omega/2\pi$. *Inter-electrode capacity* = $2\mu\mu F$.

The curves show that for high resistance valves practically the whole change of resistance and capacity with frequency may be expected to occur in the range 10^6 or 10^7 cycles, that is, in the wavelength range 300 to 30 metres. With valves of low resistance the changes occur at higher frequencies. For almost all valves the inter-electrode capacities at frequencies below a million cycles will exceed the electrostatic value by about 6 per cent. The theory given strictly speaking applies only to diodes with plane electrodes, and an emission current obeying the theoretical equation (7). It is well known that actual valves do not satisfy these conditions, but the approximation is sufficiently good to give useful results. It has been shown that the problem is essentially one of change of voltage gradient, and it is obvious that these changes must occur whatever the form of electrodes. In considering triodes we have to bear in mind the fact that the grid will affect the distribution of the electric field, and that the relation between the electrostatic distribution and the thermionic distribution is not likely to be exactly as described above. However, the nature of the effect must be the same, and it seems probable that the results will be of the same order, since it appears that the theoretical formulae for plane electrodes may with comparatively small modification be applied to the design of triodes.*

We have so far only considered the filament-anode capacity, but it will be obvious that much of what has been said applies also to the filament-grid and grid-anode capacities. These must also change with frequency and probably the changes will be of the same order, though in the case of the grid-anode capacity the changes are likely to be smaller, since neither electrode emits electrons, and the alterations of potential gradient are therefore likely to be less.

7. Grid-Filament Conductance.

In the consideration of the grid-filament capacity, another important point arises. When the grid-potential is made negative with respect to the filament it is usually assumed that the grid-filament conductance is zero. But this is only true of the electron convection current. Some electrons must be considered as linked by lines of force to the grid, and the motion of these electrons will constitute a current between the electrodes which is not entirely wattless, and which therefore corresponds to a certain conductance. The increase of conductance represented by equations (22) and (32) may be regarded as representing this grid conductance. The only difference from the previous case is that the value of G_0 in (22) must now be taken as zero. The value of α and T in (22) depends on the distribution of electrons between the electrodes.

* Kusonose, *Proc. I.R.E.*, 17 (1929), 1706.

If we assume that the distribution between filament and grid is similar to that between the filament and an anode of the same size as the grid (the grid is of course only another anode), we can apply equations (27) to (30) to the present case. The effect of this conductance will be to give the grid-filament capacity a finite power factor, and from (21) and (22) it is easy to see that this will be given approximately by

Power Factor

$$\doteqdot \frac{G - G_0}{C_\infty \omega} = \frac{a\omega T}{1 + \omega^2 T^2} = \frac{C - C_\infty}{C_\infty} \cdot \omega T \quad (34)$$

Taking the values of a and T previously obtained, the values of this power factor were calculated for the three typical valves previously considered. They are shown plotted against frequency in Fig. 4. At frequencies below 100 kilocycles the power factor is barely appreciable, but it arises gradually to a maximum value of about 3 per cent., and then diminishes. The lower

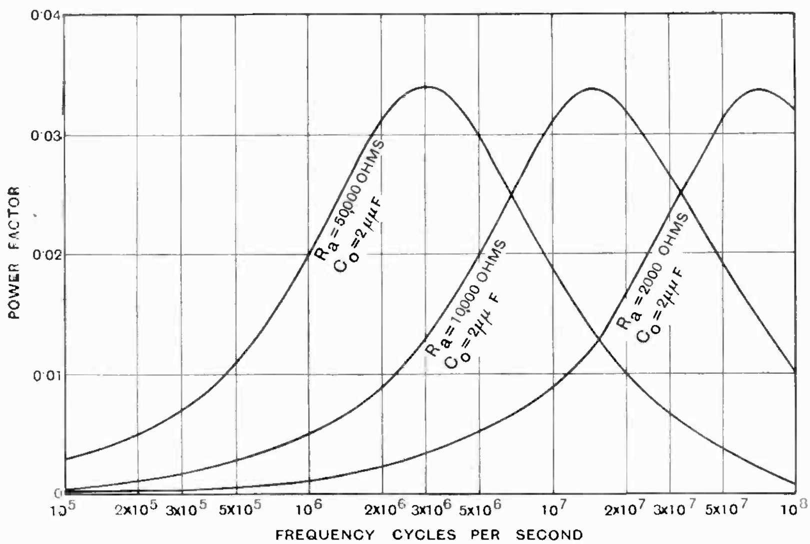


Fig. 4.—*Power factor of inter-electrode capacities. Effect of space charge. Inter-electrode capacity 2μμF.*

the resistance of the valve the higher the frequency at which the maximum power factor is reached. For valves of high resistance the maximum comes well within the ordinary working range.

8. Experimental Results.

It must be admitted that the experimental evidence bearing on this subject is at present somewhat meagre. Precision measurements on valves at radio-frequencies

TABLE I.

The Input Capacity (C_{fg} and C_{ga}) and Power Factor of a D.E.R. Valve at Audio-Frequencies.

Anode voltage : 100
Grid Bias : − 2 volts.

Frequency.	Filament Cold.		Filament Glowing.	
	Capa-city.	Power Factor.	Capa-city.	Power Factor.
Cycles/sec.	μμF.		μμF.	
1000	9.2	0.04	10.2	0.07
2000	9.0	0.03	9.8	0.04
3000	9.0	0.025	9.7	0.03

are required, and these are not yet forthcoming. The writer has made measurements of valve capacities and resistances at audio-frequencies by means of alternating current bridges, and the degree of precision attained has been sufficient to detect changes of the kind described, although in some cases the agreement between the approximate theory given above and the observed results is no more than qualitative.

Measurements of input capacity were first made by the method described in a previous article.* There was no added load in the anode circuit of the valve measured, so that the input capacity consisted simply of the sum of the grid-filament and grid-anode capacities, C_{fg} and C_{ga}. This was measured at three audio-frequencies, with the filament current switched on and then with the filament current switched off. The results are given in Table 1.

* *E.W. & W.E.*, 5 (1928), 419. Also *Proc. Phys. Soc.*, 39 (1927), 108.

The value of the capacity with the filament cold is the electrostatic value, and it will be observed that when the filament is emitting electrons the observed value of the capacity is about 10 per cent. larger than this electrostatic value. This is in general agreement with the above theoretical in-

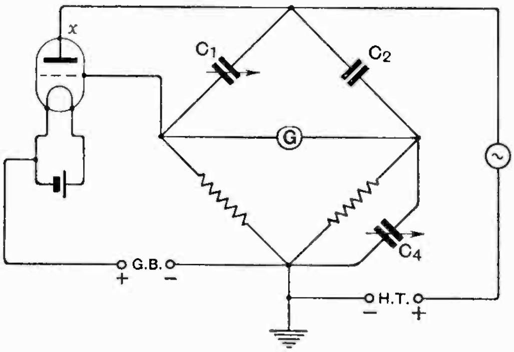


Fig. 5.—*Bridge for the measurement of grid-anode capacity.*

vestigation, although the increase of capacity is rather larger than the theoretical value, since it must be remembered that the capacity between the leads of the valve is not affected by the electron emission; it is only the active parts of the electrodes which are affected. The increase of capacity is accompanied by an increase of power factor, and this again is larger than might be expected from the theoretical curves of Fig. 2.

The grid-anode capacity G_{ga} of the same valve was next measured by means of the bridge shown in Fig. 5, which is self-explanatory. The bridge was first balanced by adjusting the variable air condensers C_1 and C_4. The anode of the valve was then disconnected at x, and balance again obtained. The change in the reading of C_1 gives the capacity C_{ga} of the valve, and its power factor is given by $C_1 \omega R_4 \triangle C_4 / C_{ga}$ where $\triangle C_4$ is the change in the reading of C_4 and C_1 is the final reading of the condenser in parallel with the valve. The filament-anode capacity does not affect the measurements since it is merely a shunt across the whole bridge. The grid-filament capacity is a shunt across R_3, but as it is not affected by the disconnection at x, it does not affect the difference of the two readings noted. The method fails if the grid-filament conductance becomes appreciable since this is shunted across the ratio arm R_3, but with a negative grid bias greater than 2 volts such conductance was entirely negligible. On making the measurements, with the filament cold, and then with it glowing, the same values of capacity and power factor were obtained, viz., 2.7 $\mu\mu$F. and 0.01: the bridge readings were entirely unaffected by switching the filament current on and off. Thus the changes in capacity and power factor previously noted must be entirely associated with the grid-filament capacity. This agrees with the theory since the greatest changes in voltage gradient due to electron emission occur round the filament. Valves of other types gave similar results to this D.E.R. valve; in all cases the input capacity with the filament glowing was slightly greater than the electrostatic value, and there was usually a small increase of power factor. As a possible alternative explanation of the change of capacity a slight sagging of the filament on heating was considered, but any such change would be just as likely to occur in one direction as the other, whereas the observed values were always greater when the filament was glowing, so that it seems fairly certain that the explanation is that previously given.

Measurements have also been made at audio-frequencies of the anode circuit capacities of a number of valves. This capacity consists of the sum of the grid-anode and filament-anode capacities. It was measured by a modification of the Wheatstone Bridge network, special precautions being taken to eliminate errors due to earth-capacities. Such precautions are essential in any attempt to measure the filament-anode capacity, since this capacity is associated with a comparatively low resistance or large conductance, so that it can only be measured if the corresponding phase angle can be determined with very high precision. In this respect the measurement of the other valve capacities is much simpler. Full details of the method are given in a paper in the Proceedings of the Physical Society,* to which the reader interested in the method is referred. As in the previous cases, measurements were made with the filament glowing, and then under the same conditions

* *Proc. Phys. Soc.*, 41 (1929), 113.

with the filament cold. Some typical results are given in Table 2. Qualitatively, the

TABLE 2.

The Anode-Circuit Capacities ($C_a = C_{fa} + C_{ga}$) of Typical Valves at Audio-Frequencies.

Valve.		Frequency.	C_a (Filament glowing.)	C_a (Filament cold.)
		Cycles/sec.	μμF.	μμF.
P.M. 1A		1000	17.2	13.2
Anode voltage :	100	2000	16.4	12.7
Fil. voltage :	2	4000	16.0	12.5
Grid Bias :	0	—	—	—
D.E.R.		1000	16.5	8.6
Anode voltage :	80	2000	14.5	8.3
Fil. voltage :	2	4000	14.0	7.8
Grid bias :	−2	6000	13.5	8.0
P.M. 252		1000	21.5	14.0
Anode voltage :	100	2000	18.0	13.8
Fil. voltage :	2	4000	16.0	13.8
Grid bias :	−10	—	—	—
R		—	—	—
Anode voltage :	100	1000	35.0	20.8
Fil. voltage :	4	2000	27.5	18.5
Grid bias :	0	4000	24.5	17.0

results are entirely in agreement with the theoretical discussion ; the capacity with the filament glowing is always somewhat greater than that when the filament is cold. The capacity when the filament is glowing also varies with frequency more than the corresponding "electrostatic value" does, being greater at the lower frequencies. As regards the magnitude of these changes, the agreement is not so satisfactory. The capacity increase, and its variation with frequency in the audio range, are both considerably larger than the theoretical values. This means that the voltage gradient between filament and anode is not simply that corresponding to the theoretical formula (7) for the pure electron space charge between parallel plane electrodes. The deviation from the electrostatic distribution appears to be greater than it is in this theoretical case. Several factors suggest themselves in explanation of this ; the shape of the electrodes, the effect of the grid on the potential distribution, and the possibility of ionisation of residual gas molecules. It would be difficult to calculate the magnitude of any such effects, and from the practical point of view it is probably hardly necessary. The experimental results are sufficient to show that the variations in the constants of the valve are of the nature of those revealed by the theoretical discussion. They also give an idea of the maximum change which is likely to occur in practice.

NEW BOOKS.

RADIOTELEFONIA—RADIOTELEGRAFIA AD ONDE GUIDATE. Published by Ulrico Hoepli, Milan, 1931. xii–292 pp. 18 Lire.

Those wireless engineers who persist in regarding carrier current work as a kind of infant brother of wireless which can be conveniently kept in the nursery must be liable to occasional shocks when they find, for instance, half a column in the *Daily Mail* devoted to it, or when they open the April number of *Electrical Communication*, the organ of the immense International Standard Electric Corporation, and discover it half full of articles about this sturdy infant. Or, again, when they open this excellent little book, by P. E. Nicolicchia, of the Italian State Telephone Service, and find that the second part—some 90 pages—is entirely taken up with details and diagrams of various systems, each backed by some important firm, which are in everyday use in various parts of the world. These include the single and multi-channel Ericsson systems, the Siemens and Halske infra-acoustic telegraph system, the telegraph and telephone systems of Standard Telephones and Cables, Limited, and others. In Italy alone examples of most of these systems may be found.

And if one of those aforesaid wireless engineers, convicted at last of his culpable ignorance, decides that it is quite time that he learned something about the subject, he can hardly do better—provided he can read technical Italian—than work steadily through this book. The first 30 pages or so will be familiar to him, but the remainder will do much to fill in a serious gap in his knowledge. Finally, if he *cannot* read technical Italian but would like to learn to do so, here is a good chance to begin : he will find that a little French, a faint glimmering of school Latin, and a good dictionary will make it easy for him to get along slowly.

The bibliography at the end includes a fair number of American references. Among the very few English references we note *The Wireless World* article on "Broadcasting by Wired Wireless," by O. F. B. (November, 1928). H. D.

JORNADAS DE ONDA CORTA.

A summary of the papers read and discussed at the meeting of short-wave radio engineers during the International Exhibition at Barcelona in November, 1929, including papers by Dr. B. Cabrera and Prof. R. Mesny, pp. 242 with numerous illustrations and diagrams. Published by "Iberica," Barcelona, Spain.

Approximate Formulae for the Inductance of Solenoids and Astatic Coils.*

By W. G. Hayman, B.E., B.Sc.
(University of Western Australia.)

THE calculation of the inductance of a solenoid is relatively simple provided tables, charts, or a calculator are available. It is the purpose of this note to show a simple formula containing but one numerical constant which is easily memorised and which gives results of sufficient accuracy for practical purposes.

Nagaoka has tabulated (1) the correction factor "K" to be applied to the formula applicable to the "long" solenoids, viz. :—

$$L = 4\pi^2 a^2 n^2 l \quad \ldots \quad (1)$$

where L = the inductance in centimetres,
a = the mean radius of the solenoid,
n = the turns of wire per centimetre length of coil,
and l = the length of the coil

in order that the inductance of coils of finite dimensions may be determined.

With this modification the formula becomes :—

$$L = 4\pi^2 a^2 n^2 l(K) \quad \ldots \quad (2)$$

where (K) is Nagaoka's end correction term.

(2) May be re-written

$$L = l_w^2 \times l \times K \quad \ldots \quad (3)$$

where l_w is the length of wire per centimetre of the coil $(2\pi\, a\, n)$ and l is the coil length.

Now (K) can be put into a convenient form for calculation, by noting that it is approximately a hyperbolic function of $\left(\frac{d}{l}\right)$, the "shape factor" of the coil.

Writing
$$K = \frac{m}{m + \left(\frac{d}{l}\right)} \quad \ldots \quad (4)$$

then
$$m = \frac{K\left(\frac{d}{l}\right)}{1 - K} \quad \ldots \quad (5)$$

* M.S. received by the Editor, December, 1930.

Table I shows the values of m for various values of $\left(\frac{d}{l}\right)$ in the range of 0.01 to 10 and curve (*a*) of Fig. 1 shows the values plotted.

TABLE I.

$\frac{d}{l}$	K	$m = \frac{K\left(\frac{d}{l}\right)}{(1 - K)}$
0.01	0.99577	2.37
0.04	0.99322	2.34
0.1	0.9588	2.33
0.4	0.8499	2.26
1.0	0.6884	2.21
4	0.3654	2.30
10	0.2033	2.55

A mean value for (m) of 2.25 gives K within 2 % over a range of 0.2 to 4.0, thus embracing most coils in common use.

Equation (3) may now be written :—

$$L = l_w^2 \times l \times \frac{2.25}{2.25 + \left(\frac{d}{l}\right)} \quad \ldots \quad (6)$$

By the aid of this formula (6) or the following modification (7), direct calculation of coil constants is possible. As an example of this Fig. 2 shows the relation between percentage inductance and percentage coil

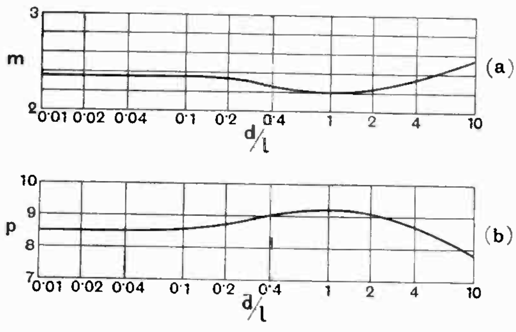


Fig. 1.

length so determined. A convenient modification of equation (2) for inch units is

$$L = \frac{d^2N^2}{40l} K = \frac{d^2n^2l}{40} K \text{ microhenries} \quad \ldots \quad (7)$$

where n is the turns per *inch*

N is the total number of turns

l is the coil length in *inches*

and d is the diameter in *inches*.

This together with the approximation for K, viz. :—

$$K = \frac{m}{m + \left(\frac{d}{l}\right)} \quad \ldots \quad \ldots \quad (8)$$

results in a simple formula for inductance.

$$L = \frac{d^2N^2}{40l} \times \frac{m}{m + \left(\frac{d}{l}\right)} \text{ microhenries (inch units)} \quad (9)$$

or if the radius (a) of the coil be inserted instead of the diameter (d)

$$L = \frac{a^2N^2}{10l + \left(\frac{20}{m}\right)a} \mu H \text{ (inch units)} \quad \ldots \quad (10)$$

Values of the factor $(20/m)$ in equation (10) are plotted as (p) curve (b) in Fig. 1 and indicate the required variation in this coefficient for various values of $\left(\frac{d}{l}\right)$.

Now substituting the mean value of $m = 2.25$

$$L = \frac{a^2N^2}{10l + 8.9a} \mu H \text{ (inch units)} \quad \ldots \quad (11)$$

Appendix I gives a number of formulae which have been proposed and which are capable of reduction to this same form.

The total inductance of three coaxial solenoids (formed as part of a single winding for instance) is given by

$$L = L_A + L_B + L_C + 2(M_{AB} + M_{BC} + M_{CA}) \quad (12)$$

where L_A, L_B and L_C are the inductances of the three coils separately and M_{AB} is the mutual inductance between coil A and coil B, etc.

$$L + L_B = L_{AB} + L_{BC} + 2M_{CA} \quad \ldots \quad (13)$$

where L_{AB} is the inductance of A and B in series and L_{BC} is the inductance of B and C in series,

$$\text{or} \quad 2M_{CA} = L + L_B - L_{AB} - L_{BC} \quad \ldots \quad (14)$$

an expression which gives the mutual inductance of coils A and C in terms of (a) the inductance of the whole solenoid, and (b) the inductance of the parts $(A + B)$ and $(B + C)$ all of which are easily calculable or determinable from tables. If A and C are wound aiding, then

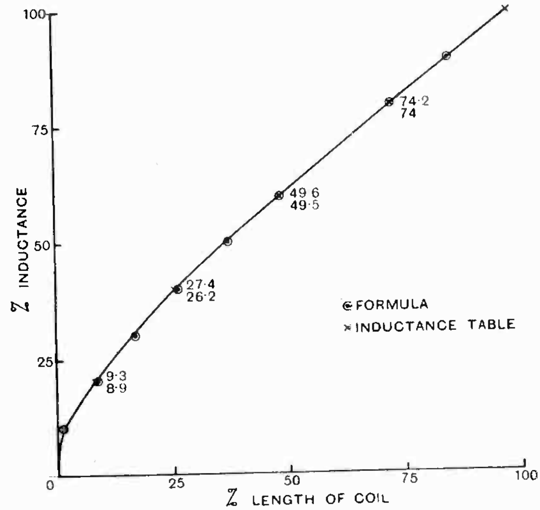


Fig. 2.

$$L_{AC} = L_A + L_C + 2M_{CA} \quad \ldots \quad \ldots \quad (15)$$

$$= L_A + L_C + L + L_B - L_{AB} - L_{BC} \quad \ldots \quad (16)$$

or if the coils are equal

$$L_{AC} = L + 2L_A + L_B - 2L_{AB} \quad \ldots \quad (17)$$

For equal coils A and C wound astatically (*i.e.*, opposing)

$$L_{AC} = 2L_A - 2M_{CA} \quad \ldots \quad \ldots \quad \ldots \quad (18)$$

$$= 2(L_A + L_{AB}) - L - L_B \quad \ldots \quad (19)$$

and assuming that there is no gap between the coils, then the inductance of an astatic pair becomes

$$L_{AC} = 4L_A - \text{L} \quad \ldots \quad \ldots \quad \ldots \quad (20)$$

That this is so can be seen by adding the formulae $L = 2L_A + 2M$ for the coils in conjunction and $L_{AC} = 2L_A - 2M$ for the coils in opposition.

The inductance of a solenoid has previously been shown (6) to be

$$L = l_w^2 \times l \times \frac{2.25}{2.25 + \left(\frac{d}{l}\right)} \text{ (cm. units)} \quad (6)$$

hence, substituting this value in (20) in order to determine the inductance of two equal astatic coils wound without gap

$$L = 4\left(l_w^2 \times \frac{l}{2} \times \frac{2.25}{2.25 + \left(\frac{2d}{l}\right)}\right) - \left(l_w^2 \times l \times \frac{2.25}{2.25 + \frac{d}{l}}\right) \text{ cms.} \quad \ldots \quad (21)$$

in which l is taken as the total length of the coil and l_w is, as before, the length of wire per centimetre of winding.

$$L = \frac{l_w^2 \times l}{1 + 1.35\left(\frac{d}{l}\right) + 0.4\left(\frac{d}{l}\right)^2} \text{ cms.} \quad \ldots \quad (22)$$

The ratio of inductance of an astatic coil to that of a solenoid of equal size and winding

$$\frac{L_{astatic}}{L_{solenoid}} = \frac{2.25 + \left(\frac{d}{l}\right)}{2.25\left(1 + 1.35\left(\frac{d}{l}\right) + 0.4\left(\frac{d}{l}\right)^2\right)} \quad \ldots \quad (23)$$

and consequently the percentage reduction in inductance of the astatic pair compared with that of a solenoid of the same total size and winding is

$$\frac{90\left(\frac{d}{l}\right) + 40\left(\frac{d}{l}\right)^2}{1 + 1.35\left(\frac{d}{l}\right) + 0.4\left(\frac{d}{l}\right)^2} \quad \ldots \quad (24)$$

The latter formula has been checked experimentally by measuring the inductance of a solenoid and an astatic pair each wound with 128 turns of 26 d.c.c. wire on tubes 4.4 cm. in diameter (l = 10.3 cms.). Successive turns were then stripped off and the inductance and dimensions of each noted.

Fig. (3) shows the results of this test and indicates a satisfactory agreement with the formula over the range of $\left(\frac{d}{l}\right)$ from 0.3 to 1.5.

Appendix I.

(*a*) Perry (references *Phil. Mag.*, 30, p. 223, 1890. Bib. (5)).

$$L = \frac{4\pi a^2 N^2}{0.2317a + 0.44l + 0.39c} \text{ (cms. and cms.)}$$

(*b*) Hazeltine, Bib. (2).

$$L = \frac{0.8a^2N^2}{6a + 9l + 10c} \text{ (inches and } \mu H)$$

a = mean radius
l = length
and c = radial depth of winding in inches.

" max. error about 1 per cent. when terms in denominator about equal."

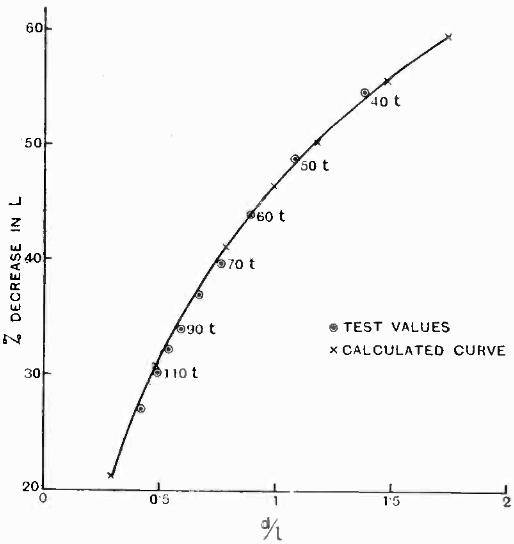


Fig. 3.

(*c*) Reyner, Bib. (3)

$$L = \frac{0.2N^2d^2}{3.5d + 8l} \times \frac{d - 2.25c}{d} \text{ (inches and } \mu H)$$

d = outside diameter of coil.

$$\frac{c}{d} < 0.3 \text{ and } \frac{l}{d} < 2.0$$

putting $c = 0$

$$L = \frac{a_1^2N^2}{8.75a_1 + 10l} \text{ where } a_1 = \frac{d}{2}$$

(*d*) Wheeler, Bib. (2)

$$L = \frac{a^2N^2}{9a + 10l} \text{ solenoid (inches and } \mu H)$$

" max. error 1 per cent. for coils $b > 0.8\ a$."

$$L = \frac{a^2N^2}{8a + 11c} \text{ (pancake coils)}$$

" $<$5 per cent. error $2a > b > 0.2a$."

and $$L = \frac{aN^2}{13.5} \log_{10}\left(\frac{4.9a}{l + c}\right)$$

(*e*) Batcher, Bib. (2)

$$L = \frac{a^2N^2}{9a + 10(l + c)} \frac{2lc}{a}$$

(*f*) Korndörfer, Bib. (6)

$$L = 21N^2a\sqrt{\frac{a}{l+c}}$$

$$\frac{a}{l+c} \leqq 3 \frac{c}{l} \geqq 7$$

$$L = 21N^2a^4\sqrt{\left(\frac{a}{l+c}\right)^3}$$

$$\frac{a}{l+c} < 1$$

"accuracy about 3 per cent."

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Modulation and the Heterodyne.*

By W. Jackson, M.Sc., A.M.I.E.E.

THE writer has found in the past that students of Radio Communication are apt to regard the production of a modulated wave and of a heterodyne note as different and distinct processes, due, no doubt, to the separate treatment which they receive in text books, rather than as different aspects of the common process of superposing in a valve circuit two alternating voltages of different frequency. The following simple treatment is therefore put forward in the hope that, for those who have experienced difficulty in this connection, it will co-ordinate the two in a helpful manner.

Consider the general expression for the triode static characteristic:

$$I_p = f(E_p + v + \mu_0 E_g) = F\left(E_g + \frac{E_p + v}{\mu_0}\right)$$

where I_p, E_p and E_g are the steady values of plate current, plate voltage and grid voltage; v is the internal E.M.F. of the valve, and μ_0 the voltage amplification factor of the valve. μ_0 can justifiably be regarded as a constant.

Let a small change e occur in the grid potential and let i_p be the resulting change in plate current. Then for the simple case in which there is no anode load

$$I_p + i_p = F\left(E_g + e + \frac{E_p + v}{\mu_0}\right)$$

On expanding by Taylor's Theorem

$$I_p + i_p = F\left(E_g + \frac{E_p + v}{\mu_0}\right) + \frac{e}{\underline{|1}} F'\left(E_g + \frac{E_p + v}{\mu_0}\right) + \frac{e^2}{\underline{|2}} F''\left(E_g + \frac{E_p + v}{\mu_0}\right) \ldots$$

where

$$F'\left(E_g + \frac{E_p + v}{\mu_0}\right); \; F''\left(E_g + \frac{E_p + v}{\mu_0}\right);$$

etc., are the first, second, etc., differentials of I_p with respect to E_g at the operating point on the characteristic.

Therefore

$$i_p = \frac{e}{\underline{|1}} F'\left(E_g + \frac{E_p + v}{\mu_0}\right) + \frac{e^2}{\underline{|2}} F''\left(E_g + \frac{E_p + v}{\mu_0}\right) + \ldots$$

$$= K_1 e + K_2 e^2 + \text{negligible terms.}$$

K_1 and K_2, that is, the first and second differentials, may be taken as constants over a small change e in E_g.

If e represents the instantaneous value of voltage resulting from the simultaneous

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

application of two voltages $E_1 \sin \omega_1 t$ and $E_2 \sin \omega_2 t$ to the grid circuit of the valve, so that $e = E_1 \sin \omega_1 t + E_2 \sin \omega_2 t$, then

$$\begin{aligned} i_p &= K_1E_1 \sin \omega_1 t + K_1 E_2 \sin \omega_2 t \\ &\quad + K_2 E_1^2 \sin^2 \omega_1 t \\ &\quad + 2K_2 E_1 E_2 \sin \omega_1 t \sin \omega_2 t \\ &\quad + K_2 E_2^2 \sin^2 \omega_2 t. \\ &= K_1 E_1 \sin \omega_1 t \\ &\quad + K_2 E_1 E_2 \{\cos (\omega_1 - \omega_2)t \\ &\qquad - \cos (\omega_1 + \omega_2)t\} \quad \ldots \quad \ldots \quad (1) \\ &\quad + K_1 E_2 \sin \omega_2 t + \frac{K_2 E_1^2}{2} (1 - \cos 2\omega_1 t) \\ &\quad + \frac{K_2 E_2^2}{2} (1 - \cos 2\omega_2 t). \end{aligned}$$

This represents the general form of the output current resulting from the process of "heterodyning" the two voltages $E_1 \sin \omega_1 t$ and $E_2 \sin \omega_2 t$ in the input of the valve.

Now suppose $\frac{\omega_1}{2\pi}$ to be of radio frequency and $\frac{\omega_2}{2\pi}$ to be of audio frequency. The circulating current which would be produced in an imaginary resonant circuit introduced into the output circuit of the valve and tuned to the frequency $\frac{\omega_1}{2\pi}$, could be expressed

$$i = A \sin \omega_1 t + B \{\cos (\omega_1 - \omega_2)t - \cos (\omega_1 + \omega_2)t\}$$

where A and B are constants. The double frequency component $2\omega_1$, the low frequency components ω_2 and $2\omega_2$, and the D.C. components of the output wave, would produce, in comparison, a negligible response.

On transformation this current can be written

$$\begin{aligned} i &= A \left(1 + \frac{2B}{A} \sin \omega_2 t\right) \sin \omega_1 t \\ &= A (1 + M \sin \omega_2 t) \sin \omega_1 t \end{aligned}$$

which is the familiar form for a simple amplitude modulated wave, in which M is the percentage modulation. The expression from which this form is derived, shows the current to consist of components of frequency $\frac{\omega_1}{2\pi}$; $\frac{\omega_1 - \omega_2}{2\pi}$, and $\frac{\omega_1 + \omega_2}{2\pi}$, known respectively as the carrier, lower and upper side band components.

If the valve characteristic is linear about the operating point, $F''\left(E_g + \frac{E_p + v}{\mu_0}\right)$, that is K_2, is zero, and the components of a modulated wave do not exist in the output circuit.

A modulated wave results, therefore, from the selection, by means of a broadly tuned resonant circuit, of three of the output wave components. Suppose, on the other hand, that the device inserted in the output circuit were capable of selecting only that output component identified above as the lower side-band, the one of frequency $\frac{\omega_1 - \omega_2}{2\pi}$. This is facilitated as ω_2 is increased beyond the audio frequency range. When ω_2 is increased until it becomes of the same order of magnitude as ω_1, this lower side-band output component itself becomes reduced to audio frequency, and an audio frequency device would be capable of selecting it and would recognise it as the familiar heterodyne note, resulting now from the superposition, or heterodyning, in the input of the two radio frequency voltages. None of the other output current components given in equation (1) is of low frequency, so that no interference would occur in this selection.

The processes by which the heterodyne note and the simple modulated wave can be produced are therefore the same. Both result from the application of two voltages of different frequency, that is, from the heterodyning of two voltages of different frequency, in the input circuit of a valve operating on the non-linear portion of its characteristic. That a heterodyne note, as it is understood, is provided on the one hand and a modulated wave on the other, is due merely to the selection of different components of the common output current wave.

In conclusion, then, a simple amplitude modulated wave can be obtained in a resonant output circuit following the heterodyning in the input circuit of a radio and an audio frequency voltage provided that the valve characteristic is non-linear. The use of a complex audio frequency voltage instead of the simple one does not alter the general principle. The familiar heterodyne note may be regarded as representing the lower side-band of this modulated output wave and becomes of audible frequency when the two input voltages are of similar radio frequency.

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.

Resistance Capacity Coupled Transformer.

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

SIR,—On page 312 of the June issue of *E.W. & W.E.*, Mr. Hodgson raises the question of the performance of the resistance capacity coupled transformer at high frequencies. It can easily be shown that if the feed resistance is pure and the coupling condenser of low resistance (a condition which usually exists in practice even at the highest frequencies if good quality components are used), then the performance of the arrangement is the same as that given by a simple, normal series connection with a valve having an anode A.C. resistance $\frac{RR_a}{R+R_a}$ ohms, and an amplification factor $\frac{R}{R+R_a}$ times that actually employed, the transformer constants being the same in the two cases.

The effect of this in practice is to increase the height of the leakage resonance peak by an amount usually quite trivial.

An aspect of more importance is that when using the circuit suggested it is possible to employ a valve of much lower R_a than would normally be permissible. This may give rise to a pronounced resonance peak at some high frequency unless the secondary is damped with a high resistance.

It is generally preferable when using the circuit to employ a smaller (and cheaper) transformer having lower primary and leakage inductances. In this way, instead of the improvement in performance appearing solely as a reduction of the lower cut-off frequency and levelling of the characteristic, it can be distributed, part at the upper and part at the lower end of the frequency scale.

Teddington, Middlesex. FRANK AUGHTIE. W. F. COPE.

SIR,—With reference to Mr. Joseph's letter in your July issue, under the above heading, in which he points out that the use of high permeability nickel iron alloys, with the resulting low iron volume, is advantageous in reducing leakage inductance and thereby ensuring flat high note response: it seems to the writer that the problem of securing high note response is merely a question of design, and he is not aware that any of the well-known transformers not employing these special cores are deficient in their high note magnification, as compared with the smaller types using nickle iron alloy cores.

J. BAGGS.

Manchester.

The Stenode Receiver and the Side Band Theory.

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

SIR,—Dr. J. Robinson's letter in your June issue has led me to consider carefully Mr. Moullin's long contribution to the correspondence columns of your previous number (p. 257 *et seq.*). The relevant part of Mr. Moullin's letter is on p. 259, and the assumed conditions are there carefully set out; viz.: a sharply tuned receiver subjected *only* to an interfering signal having its carrier wave length slightly different from that to which the receiver is tuned. Dr. Robinson, on the other hand, assumes that his sharply tuned receiver is receiving *simultaneously* the interfering signal *and* the desired signal. Also he expressly mentions "high-grade telephony" and he must therefore be presumed to include the frequency correction necessary in the audio-frequency amplifying units in order that a reasonably uniform response may be obtained over the audible-frequency spectrum of from, say, 50 to 8,000 cycles. Mr. Moullin's results are scarcely appropriate to this entirely different case, and it is a little unfortunate that Dr. Robinson should have made use of them to cast doubts on a method of calculating these problems which has proved to be of the greatest value in elucidating the theory of all systems of telephony.

Mr. Moullin cannot be completely exonerated from all blame for this error owing to his use of the phrase, "to estimate the general level of immunity." This certainly implied estimating the extent to which the signals are subject to interference and so implies the consideration of the *simultaneous* reception of signal and interference as the condition in need of investigation. The case that he ought to have taken is the application of an E.M.F.

$$\begin{aligned} e &= e_1 + e_2 \\ &= E(1 + m\cos pt)\cos \omega t \\ &\qquad + F(1 + n\cos qt)\cos(\omega + x)t. \end{aligned}$$

where :—E is the amplitude of the signal carrier wave, m the fractional modulation of the signal, $p/2\pi$ the frequency of the audible-frequency note being transmitted; F, n and $q/2\pi$ are the corresponding quantities for the interference and $x/2\pi$ is the frequency difference between the carrier waves of the signal and the interference. (I have changed the notation a little in order to avoid confusion in this much more complicated case.)

The voltage variation applied between the grid and filament of the detecting valve is then :—

$$v_g = \sqrt{(A^2 + B^2)}\sin(\omega t + \theta)$$

where A and B are complicated expressions involving E, F, m, n, p and x as well as $\sin pt$, $\sin xt$, $\sin(x \pm q)t$, $\cos xt$, and $\cos(x \pm q)t$.

For a square law detector where

$$i_a = kv_g^2$$

there are eighteen audible-frequency components of the wave form of i_a, all of which are interesting!

The true signal tone has a term

$$kE^2 \frac{m\omega}{2p\delta/\pi} \sin pt$$

showing that the correction in the audio frequency amplifying unit must be proportional to the frequency. The final true signal tone term will therefore be :—

$$K \frac{E^2}{\delta/\pi} \frac{m}{2} \omega \sin (pt + \phi)$$

where ϕ is the phase change of the audio-frequency unit.

Another interesting term is that corresponding to the carrier wave of the interference ; viz. :—

$$k \frac{EF}{\delta/\pi} \frac{\omega}{x} \sin xt.$$

This may or may not come within the range over which the correction is proportional to the frequency. But if it does—and Dr. Robinson suggests a separation of the carriers of only 5,000 cycles, whereas it is generally accepted that for high-grade telephony a level characteristic is necessary for at least 8,000 cycles on each side of the signal carrier—then this term becomes

$$K \frac{EF}{\delta/\pi} \omega \sin(xt + \phi_x)$$

and interference is unavoidable unless F is negligible compared to E when, of course, any receiver will be immune.

A third interesting term becomes, under the same circumstances :—

$$K \frac{EF}{\delta/\pi} \frac{n}{2} \omega \sin (x - q)t.$$

A fourth is :—

$$KF^2 . \frac{n}{2} \frac{\omega q}{x^2 - q^2} \cos qt$$

and so on for the whole eighteen.

Dr. Robinson suggests that a linear rectifier will assist, but it is difficult to see how that can be since most, if not all, of these terms are involved in the same proportion in the amplitude of v_g as well as in the components of kv_g^2.

C. L. Fortescue,
City & Guilds (Engineering) College.

Percentage Harmonic Distortion.

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

Sir,—In the correspondence columns of the last issue, the validity of the usual formula for the amount of second harmonic produced by an output valve is questioned by Mr. M. G. Scroggie. The editorial reply affirms the correctness of this formula, but in both cases the arguments do not apply to the usual arrangement of an output valve in modern high-quality amplifiers. Modern practice is to feed the anode of the valve through a low frequency choke, and to connect the load *via* a blocking condenser between anode and filament. The result is that the rectified D.C. follows a different path from that of the fundamental and second harmonic components. The value of the rectified D.C. component will therefore depend on the resistance of the choke, and not on the load resistance as in the straightforward series case ; the two cases will only be identical when the resistance of the choke is equal to the load resistance, and in addition, of course, no A.C. must flow through the choke, and the reactance of the blocking condenser must be negligible compared with the load resistance.

With the choke feed arrangement having the same

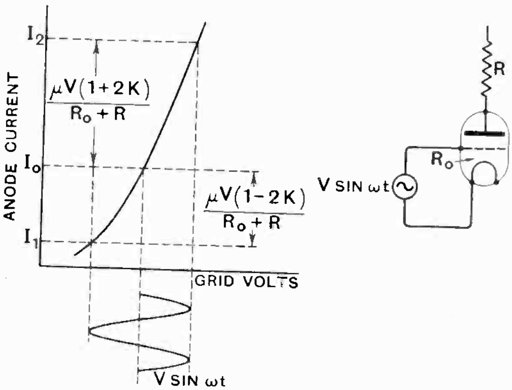

Fig. 1.

steady conditions as the series case, the harmonic distortion may be appreciably less than with the latter for the same anode current swing, especially if the choke has very low resistance and the load resistance is several times the valve resistance.

Assume that the voltage produced in the anode circuit by changes in grid voltage about the steady working condition follows a square law and can be represented by

$$v_a = a_1 v_g + a_2 v_g^2$$

Where v_a = anode voltage produced, v_g = change in grid voltage.

Let $v_g = V \sin \theta$.

Then $v_a = a_1 V \sin \theta + a_2 V^2 \sin^2 \theta$.

$$= a_1 V \sin \theta + \frac{a_2 V^2}{2} - \frac{a_2 V^2}{2} \cos 2\theta.$$

The term $a_1 V \sin \theta$ represents the fundamental component ; hence a_1 represents the amplification factor $= \mu$. The ratio of harmonic voltage to fundamental voltage $= \frac{a_2 V^2}{2a_1 V} = K$.

$$\therefore \quad v_a = \mu V \sin \theta - \mu K V \cos 2\theta + \mu K V.$$

The current produced by this voltage will depend on the impedance in the anode circuit, and if this consists of a series resistance R only (Fig. 1) then the current is given by

$$i_a = \frac{\mu V \sin \theta}{R_0 + R} - \frac{\mu K V \cos 2\theta}{R_0 + R} + \frac{\mu K V}{R_0 + R}$$

when R_0 = valve resistance.

The term $\frac{\mu K V}{R_0 + R}$ represents the steady rectified current.

The maximum value of

$$i_a = i_{\max.} = \frac{\mu V}{R_0 + R} (1 + 2K)$$

The minimum value of

$$i_a = i_{\text{min.}} = -\frac{\mu V}{R_0 + R}(1 - 2K)$$

If I_0 is the steady current at the point about which the sinusoidal voltage is applied the maximum total current

$$I_2 = i_{\text{max.}} + I_0 = I_0 + \frac{\mu V}{R_0 + R}(1 + 2K)$$

and the minimum total current

$$I_1 = I_0 + i_{\text{min.}} = I_0 - \frac{\mu V}{R_0 + R}(1 - 2K)$$

Hence it follows that the harmonic ratio K is given by

$$K = \frac{\frac{1}{2}(I_1 + I_2) - I_0}{I_2 - I_1}$$

which is the usually accepted formula.

This relation does not hold, however, when the valve is choke fed, as usually occurs in practice. The anode circuit impedance to D.C. is not the same for A.C., and the expression for the total current through the valve is determined by these impedances.

Consider the usual circuit shown in Fig. 2. The reactance of the choke L is assumed to be so large that all the A.C. components flow through the resistance R, and, due to the condenser C_1, which has negligible reactance compared with R, all the D.C. flows through L. Then the expression for the current through the valve now becomes

$$i_a = \frac{\mu V \sin\theta}{R_0 + R} - \frac{\mu KV \cos 2\theta}{R_0 + R} + \frac{\mu KV}{R_0 + R_c}$$

where R_c = resistance of choke.

The expressions for I_2 and I_1 now become

$$I_2 = I_0 + \frac{\mu V(1 + K)}{R_0 + R} + \frac{\mu KV}{R_0 + R_c}$$

$$I_1 = I_0 - \frac{\mu V(1 - K)}{R_0 + R} + \frac{\mu KV}{R_c + R_c}$$

Whence

$$K = \frac{\{(I_2 - I_1) - 2I_0\}(R_0 + R_c)}{(I_2 + I_1)(2R_0 + R_c + R)}$$

$$= \frac{(I_2 - I_1) - 2I_0}{(I_2 - I_1)\left\{1 + \left(\frac{R_0 + R}{R_0 + R_c}\right)\right\}}$$

If $R_c = R$ the expression becomes the same as for the ordinary series case.

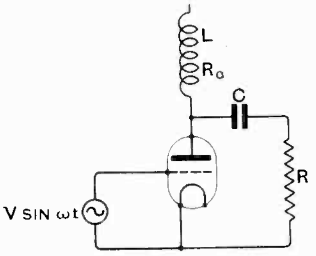

Fig. 2.

It will be seen that if R is large compared with R_c the harmonic ratio will be appreciably less than for the series case for the same values of I_1 and I_2 and R.

When a family of curves showing anode current against grid volts is used to determine the load line for a given harmonic ratio, a special scale can be used which has its two halves graduated in a particular way.*

The above formulae can be used to derive the following formulae giving the ratio of the divisions of the two halves of the scale; this ratio is equal to $i_{\text{min.}}/i_{\text{max.}}$.

Series Case.

Ratio of divisions

$$= \frac{1 - 0.02K'}{1 + 0.02K'} \text{ (where } K' = \% \text{ 2nd harmonic).}$$

$$= \frac{9}{11} \text{ for } 5\% \text{ harmonic.}$$

Choke Fed Case.

Ratio of divisions

$$= \frac{(1 - 0.01K')(R_0 + R_c) - 0.01K'(R_0 + R)}{(1 + 0.01K')(R_0 + R_c) + 0.01K'(R_0 + R)}$$

which is the same as the series case where $R_c = R$.

The optimum load resistance for an output valve is often stated to be either equal to or twice that of the valve resistance, depending on the assumptions made. It would seem, however, that the most satisfactory definition is the load which will produce a given amount of harmonic distortion, as such distortion is the thing that matters in practice. The ratio of the load to the valve resistance will depend on the figure assumed for the harmonic distortion, and for a figure of 5% it very often happens to be about two. If, however, a figure of 2% is assumed, the optimum load may be as much as 10 times the valve resistance with modern valves.

W. GREENWOOD.

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Carrier Waves and Side-bands.

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

SIR,—In your June issue Mr. H. W. Baxter raised the interesting question of what occurs when a crystal-controlled oscillator is modulated, and he suggested that the facts could not be explained on the so-called "Side-Band Theory." This is not correct. Analysis of this case into carrier plus side-bands does, however, present some points which may be of interest to some of your readers.

In practice, of course, a crystal-controlled oscillator is seldom, if ever, modulated. Instead, the output is used to drive a radio-frequency amplifier which may be modulated. Let us first analyse this case, as being the easier to follow. We will suppose that the oscillator frequency is N and the modulation frequency n. In some way or another the power amplifier is receiving two drives, one at frequency N and the other at frequency n. If the amplifier were working so that both drives were well inside the straight part of the valve characteristic, the valve would merely amplify them both and no modulation would take place: this state of affairs used to occur in some of the old reflex receivers when valves were used to amplify both H.F. and L.F. In order to obtain modulation of the H.F.

* See *The Wireless World*, p. 596, Nov. 26th, 1930.

by the L.F. it is essential that the amplifier shall not be a linear amplifier of the H.F. drive, but should distort it (with amplitude distortion.)

Now it is well known that when two different frequencies are applied to non-linear systems new frequencies make their appearance, these frequencies being known as harmonics, combination tones, and difference tones. The transmission system of the ear is an example of a system with a non-linear characteristic, and when two strong tones are applied to the ear the combination tones and difference tones produced can be heard.

It is not, perhaps, sufficiently recognised that the production of side-bands is precisely equivalent to this, so that those who deny the existence of side-bands must also deny the existence of the combination tones that they can hear.

When our non-linear amplifier receives its two drives at frequencies N and n, new frequencies are produced. Among these are the combination tone of frequency $N + n$ and the difference tone of frequency $N - n$. These are the side-bands.

Next consider the case where the crystal-controlled master-oscillator is itself modulated through receiving an audio-frequency drive at frequency n. As a first approximation we will suppose that the oscillations of the crystal itself are not modulated, so that the crystal supplies the valve with a drive at frequency N. The valve is now working under precisely the same conditions as the radio-frequency amplifier previously discussed. It is receiving two drives at frequencies N and n, and it is a non-linear device. Side-bands will be produced as before, and therefore in the valve circuits currents will be flowing at frequencies $N - n$, N and $N + n$. Thus currents of frequency N are flowing whether modulation is present or not, and these will maintain the crystal in oscillation.

Closer analysis than the above first approximation must consider the effect on the crystal of applied forces on it due to the circuit currents of frequencies $N - n$, $N + n$. Let us say at once that the crystal vibrations will be modulated, so that apparently three frequencies $N - n$, N, $N + n$ are being maintained by the crystal. There is nothing strange in this: it is not in any way a contradiction to state that a crystal and valve combination will maintain a single frequency, but that the combination of a crystal, a valve, and an external audio-frequency drive will maintain three frequencies (if not more). It would be strange if this were not the case, for although the crystal is a system with a natural frequency N, this does not mean that it will not vibrate at other frequencies. It will vibrate at the frequency of any external periodic force whatever for as long as that force is applied. But for as long as the valve is being subjected to the audio-frequency drive, the crystal is subjected to forces at frequencies $N - n$ and $N + n$, and it will therefore execute forced vibrations produced by these forces. Vibrations at frequencies $N - n$, N, $N + n$ will therefore occur in the crystal.

This is the side-band analysis of the case of a modulated crystal-controlled oscillator. According to it the crystal does keep the carrier frequency constant (at least to a very close approximation) and Mr Baxter is certainly in error in asserting that the carrier frequency varies by as much as ± 10 kilocycles per second during modulation. He has apparently misinterpreted statements to the effect that new frequencies appear in addition to the carrier frequency and situated, say, 10 kilocycles on each side of it.

The above discussion should make it clear that side-band analysis is as applicable to crystal-controlled oscillators as to other fields. It will not, I am afraid, pacify the opponents of the so-called "Side-Band Theory," for these, in the majority of cases, have become entangled in metaphysics, and are seeking answers to such questions as, "Have side-bands physical reality, or objective existence?" How answers to these questions would help anyone to understand interference problems, and what the answers would mean, if obtained, I do not know. These questions do not form the subject matter of radio-engineering nor even of physics; they are pure metaphysics. Have audible combination tones objective existence?

Nevertheless, opponents of the "Side-Band Theory" have at least the excuse that the unfortunate widespread use of the term "The Side-Band Theory" and some still more unfortunate defences of this so-called theory might well lead them to believe that there was a theory to be attacked, which, like other theories, might be right or wrong. *There never was a Side-Band Theory.*

I hold that Professor Fortescue is in error in stating in your May issue, "The supposition that the simple trigonometrical transformation from equation (1) to equation (2) is the justification of the carrier wave and side-band theory is thus fallacious. . . . The true basis of the theory is twofold; theoretical and experimental." It is significant that Professor Fortescue does not say what the theory states. I maintain that there is no theory other than the trigonometrical transformation referred to. Compare this "theory" with some that can truly be called theories, such as The Atomic Theory, The Relativity Theory, The Quantum Theory, The Electron Theory, and The Heaviside Layer Theory, and compare the answers that can be made to the questions: Who first propounded it? Where is it set out? What does it state? What are its postulates, and what is the mathematical expression of these postulates?

The last question is the most important. In no calculation involving modulated oscillations is it ever necessary to make some special assumption that must be taken for granted as being specifically a postulate of the "Side-Band Theory." Our calculations proceed by the ordinary laws of mathematics, and the only postulates involved are those contained in theories of the behaviour of electricity in circuits, or in theories of radiation and propagation, or in theories of the behaviour of rectifiers in receivers, and so on. Carriers and side-bands need never be mentioned in the analysis, nor in a complete catalogue of the laws assumed for the carrying out of the argument. "Side-Band Theory" only enters at all if the mathematical treatment is carried out in a particular way, in which the expression for a modulated oscillation is split into a number of sine terms, and then *it only enters by giving names to the terms*, calling one term the carrier term and the others the side-band terms. A theory which only affects calculations by giving names to mathematical expressions obtained during the development of the mathematical argument is not a theory at all. It also follows, *pace* Professor Fortescue, that experimental results cannot verify such a " theory " : at most they only verify the postulates *actually* involved (such as the laws of electricity and radiation assumed), and the accuracy of the calculations.

The whole point of the so-called Side-Band Theory is that the mathematical expression for a modulated oscillatory current can be transformed into the sum of a number of terms, each of which is the mathematical expression for an unmodulated oscillatory current. Consequently, we can, *for purposes of calculation*, replace the modulated oscillation by ideal co-existing oscillations on the carrier and on the side-bands, and the results of the calculations will be correct unless errors are made. This, and not questions of objective existence, whatever that may mean, is what is of interest to radio engineers.

The importance of this method of analysis is, of course, the simplicity of the expressions obtained, since for all linear effects (including in this all effects which are linear combinations of differentials and integrals) one can obtain the whole effect by adding the effects which would be due separately to the carrier and to each of the side-bands alone. Thus the importance is a practical, and not a theoretical, one, as by the aid of side-band analysis the tasks set to the memory can be greatly reduced.

Hendon, N.W.4. R. H. NISBET.

National Physical Laboratory Annual Visit.

Matters of Wireless Interest.

THE usual annual inspection and visit to the N.P.L. was held on June 23rd, the occasion being marked by the opening of the New Physics Building.

As is usually the case, exhibits of radio interest were mostly to be found in the Wireless Division, the Electrical Standards and Measurements Division, and in those sections of the Physics Department devoted to acoustic and allied measurements.

In the Wireless Division apparatus for measuring the performance of wireless receivers was exhibited. This consists of a highly screened cabin containing oscillators for radio-frequency and for audio-frequency generation, communicating by screened leads to the cabin containing the receiver. The apparatus covers the range of 7 to 20,000 metres and permits the testing of receivers for (*a*) overall sensitivity, (*b*) selectivity, and (*c*) fidelity in the reproduction of the audio-frequencies. It is, however, on the bulky side, and in its present form is hardly applicable commercially. Two interesting demonstrations were illustrative of applications of the dynatron principle by means of screened-grid valves. In one case the arrangement was of a dynatron oscillator working up to frequencies of 50 megacycles per second (6 metres), a frequency considerably higher than has hitherto been found possible with this type of oscillator. The other application used the dynatron principle to give controlled retroaction (short of oscillation) for the production of an audio-frequency circuit of low decrement. Used in this way, the circuit gave a very considerable improvement in the overall selectivity of a receiver for morse signals, the decrement being smoothly controllable up to the point of excessive " ringing ". The apparatus for the measurement of resistance and reactance at radio-frequencies (described in *E.W. & W.E.* for February, 1931) was also shown in operation.

In the Electrical Standards and Measurements Division, various exhibits were concerned with frequency standards. These included, besides the standard multivibrator apparatus: (*a*) new arrangements for the accurate balancing of tuning forks, (*b*) a chronograph driven by phonic wheel to give, to an accuracy of 2 in 10^7, the hourly rating of a tuning fork, (*c*) a new 20 k.c. quartz oscillator of annular form. An interesting experiment was a new method of measuring the anode/grid capacity in a screened-grid valve. This consisted of tuning the grid circuit to resonance with a choke in the anode circuit, then shorting out this choke, when the change in the grid circuit enabled the capacity to be determined by a simple formula. Several other exhibits in this division were concerned with absolute measurements, *e.g.*, of resistance and current, while various improvements in the technique of bridge measurements were also demonstrated.

The High-Voltage Laboratory provided several exhibits of interest although not of wireless application. The flash-over tests, however, suggested potential interest in the effect of high-voltage discharges in neighbouring wireless apparatus.

In the New Physics Building several experiments of acoustical interest were shown. One of these was the delineation of sound wave-forms (by cathode-ray oscillograph) and the analysis of the spectrum of the wave-forms, this being done by moving the tuning of a low-decrement audio-frequency circuit to give the frequency and relative amplitudes of the various components. Measurements of an allied character dealt with the analysis of noise generally and the relative intensities of sounds and noises most commonly occurring. Other experiments in progress concerned the transmission of sounds by walls and partitions, the measurement of sound-absorption co-efficients, the photography of sound-pulses and their application to the acoustics of buildings.

Abstracts and References.

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PROPAGATION OF WAVES.

OPTICAL AND EQUIVALENT PATHS IN A STRATIFIED MEDIUM, TREATED FROM A WAVE STANDPOINT.—D. R. Hartree. (*Proc. Roy. Soc. A.*, May, 1931, Vol. 131, pp. 428–450.)

Author's summary :—The limitations of a ray treatment of reflection of electromagnetic waves by a stratified medium are discussed and it is shown that a wave treatment is essential for the interpretation of some of the phenomena of reflection from the Heaviside layer. The object of this paper is to lay the foundations for such a treatment.

General expressions for the optical and equivalent paths in terms of the solutions of equations of wave propagation are obtained both for normal and oblique incidence, and the exact expressions are obtained for the optical path for normal incidence on stratified media with certain specified simple variations of refractive index, and it is shown that for a totally reflecting medium (for which $\mu^2 < 0$ for all sufficiently large heights) the difference between the optical path deduced from a wave and from a ray treatment is not likely to be greater than a vacuum wavelength, although at the height at which $\mu^2 = 0$ the conditions for application of a ray treatment are not satisfied.

Approximate expressions for the optical and equivalent paths are obtained for any stratified totally reflecting medium in which μ^2 varies sufficiently slowly.

DIE ENTWICKLUNG DES WELLENBEGRIFFES. II, III, IV (The Development of the Wave Conception. Parts II, III and IV).—K. Uller. (*Gerlands Beitr.*, No. 2/3, Vol. 24, pp. 309–334 ; No. 3, Vol. 26, pp. 199–238 ; Vol. 27, pp. 77–101.)

For long abstracts of all three parts, *see Physik. Ber.*, 15th April, 1931, Vol. 12, pp. 820–821. For previous papers by the same writer, *see* Abstracts, 1929, p. 203, and 1930, p. 331.

VISUAL STUDIES OF RADIO FADING.—E. Merritt, T. McLean and W. E. Bostwick. (*Journ. Franklin Inst.*, May, 1931, Vol. 211, pp. 539–566.)

The term "fading" is used in this paper to nclude changes in any of the characteristics of the radio waves by which the signal is transmitted. The cathode-ray oscillograph method already described by two of the authors (Merritt and Bostwick, 1929 Abstracts, p. 144) is used to study visually the signals from commercial broadcasting stations operating on wavelengths between 200 and 600 metres. An account is given of the requirements placed on the receiving system, and of apparatus and observation technique. The method of crossed loops gives partial separation of ground and sky waves.

During the daytime the oscilloscope figure is usually found to be a horizontal straight line of constant or very slowly changing length, indicating that daytime transmission from broadcast stations is effected apparently chiefly by means of the ground wave, though almost all stations occasionally show an appreciable sky wave during the daytime. As sunset approaches indications of a sky wave begin to appear. When night conditions have been established, the movements of the oscilloscope figure are in general very erratic ; phases and amplitudes change continuously.

Rough sketches were made, at intervals of a few seconds, to show the variation in the shape and size of the oscilloscope figure as it passed through sequences of changes. Several of these are reproduced, typical of both systematic and erratic changes, and a few general conclusions, applying to all the crossed loop experiments, are given. Interference between several different sky waves seems to be an important factor in determining the observed fading.

Differential fading between stations less than a wavelength apart was also studied and showed that the sky wave cannot ordinarily be regarded as a single wave train.

MESSUNG VON ECHOS BEI DER AUSBREITUNG ELEKTROMAGNETISCHER WELLEN IN DER ATMOSPHÄRE (The Measurement of Echoes in the Propagation of Electromagnetic Waves in the Atmosphere).—G. Goubau and J. Zenneck. (*Zeitschr. f. hochf. Tech.*, June, 1931, Vol. 37, pp. 207–218.)

On the "pulse" principle of Breit and Tuve, using the Goubau technique, both transmitting and receiving, which was outlined in 1930 Abstracts, p. 328. The tests described were on the German broadcasting wave of 530 m. ; they took place chiefly between midnight and 2 a.m. and extended over the period September, 1929, to July, 1930, totalling 75 hours with 550 records (the cathode ray figure was watched all the time but photographs were only taken frequently enough to register all the important changes).

The following typical results are taken from two nights in April :—1*a*.—By far the greatest number of reflections occur at a layer of effective height between 89 and 98 km. *Reflection at this layer is not absent even when simultaneous reflection is also indicated at some greater effective height, say between* 100 *and* 140 *km.* *b*.—At this 89–98 km. layer, not only simple but also double (and more rarely triple) reflection takes place. *c*.—The effective height of this layer is the same whether the Munich station (73 km. distant) or the Herzogstand station (126 km.) is transmitting, and also whether the reflection is simple or multiple. Moreover, the same constancy was observed when the receiving station at Ingolstadt was transferred to a point only 5 km. from Herzogstand and 51 km. from Munich. "According to theory a slight decrease in effective height is to be expected as the distance is increased; our measurements, however, agree on this point with those of Appleton and Ratcliffe."

d.—No appreciable variation in this layer-height was noticeable in the course of the two-hours' test (0^{00} to 2^{00}). *e*.—On the other hand, during the Herzogstand transmission (126 km. away) echoes were observed from an effective height appreciably over 100 km., although the normal 89–98 km. reflections were simultaneously present. It seemed as though only part of the ray was reflected at the ordinary layer, the rest of it penetrating until thrown back by a layer with a sufficiently sharp gradient of electron density. Later on in the paper, however, the writers suggest a very different explanation of this result (Section 11, p. 217). They point out that observations show that under some conditions the atmospheric layers are subject to very rapid changes, and that there are therefore no grounds for assuming a strictly horizontal stratification. A *wavy* surface of equal electron density would produce just those effects which would be interpreted on the horizontal layer assumption as the result of two different effective heights. Among the results which may be thus explained, the writers consider that the succession of small echoes, very closely following each other as in Fig. 23 on page 218, are undoubtedly due to this cause. Another result would be that the apparent heights given by a double and a single reflection would not necessarily be in the exact ratio 2 : 1.

2.—Most of the results here have been incorporated in the above. 3.—Tests on polarisation. The rapid changes in the polarisation conditions of the echoes, even on quiet nights giving single echoes and a constant effective height, are taken to indicate the important influence of the earth's magnetic field in splitting up the ray into components of differing polarisation, velocity and absorption. *It was often found that the two components of a double echo, even when separated by quite small time- (and therefore path-) differences, were differently polarised.* 4 and 5.—As regards the *strength* of the echoes, results are complicated by the fact of their changing polarisation. It can, however, be said definitely that they vary (on different nights and at different times of the same night) from very weak to twice or three times the strength of the direct signal—provided that this is from a sufficiently great distance, not (for example) from the 5 km. range of one set of tests. In frequency also the echoes vary greatly; they were actually absent on only two of the nights in question.

6.—Taylor and Young have suggested that the long-delay echoes may be due to reflection by distant mountain ranges (1930 Abstracts, p. 32). The writers have therefore carried out tests with Alpine peaks, 1,000–2,000 m. above the surrounding ground, in favourable positions for producing reflection. Not a single echo was obtained which could definitely be ascribed to reflection either from the mountains alone or from mountains and Heaviside layer in succession. But this negative result *may* be due to the height being equal to 2 or 3 wavelengths only and to the surfaces being too irregular.

7.—Effective height in relation to the time of year:—no definite connection is traced, though a slight increase in height appears to have taken place between the beginning and the middle of 1930 (the average height in June and July being well over 114 km. as compared with about 101 km. for December–February). As regards regularity of behaviour, no definite correlation with time of year was established, but the occurrence of great irregularities seemed to grow more frequent as summer progressed. 8.—Sunrise and sunset effects. A few tests were made at these times. The approach of sunset introduces stronger echoes, many double and some triple ones, giving in two cases an effective height of 150 km.; but *all* records include an echo from 90–96 km. (except one which gave 100 km.) a height which had also held good for a long time before sunset and during the previous night. Sunrise weakens the echoes, most of which vanish within an hour *without the effective height having been appreciably altered.* Not enough sunrise runs were obtained to establish whether the observed irregularities (double and multiple echoes, etc.) are always present at sunrise. In one case the echoes lasted long after sunrise and even increased in intensity. 9.—Slow and rapid variations. On many nights, such as the April nights referred to in (1), the effective height hardly varies at all. On others, the height may vary from 94 to 90 km. in half an hour, with echoes keeping at a constant strength; but even with such slow changes of height the intensity may vary greatly in a few seconds. Such slow height changes may be explained in terms of electron diffusion and ionformation and recombination. On the other hand, on some nights the effective height changes almost from second to second: the possible causes of such changes are discussed. Potsdam records of magnetic variations furnish no signs of a correlation; Störmer's auroral records show that by bad luck no echo observations were made on any night of great auroral display. "The question as to the cause of the rapid changes in the Kennelly-Heaviside layer must remain undecided for the present," but a foot-note refers to Nagaoka's meteorite theory (Quäck, July Abstracts, pp. 374–375).

In Section 10, page 216, the writers give their reasons for assuming, throughout their paper, that the apparent heights of about 200 and 300 km. indicated by many of the echoes recorded were the result of double and triple reflection from a layer of effective height around 100 km., and *not* the result of reflection at a second or third layer. These reasons are as follows:—*a*.—The heights are (within the limits of error of the technique) whole multiples of the simultaneous single-reflection heights. *This holds strictly and without exception for all cases when the single-reflection echoes were strong.* On occasions when they were weak and when, in spite of this, the longer-delay echoes presented themselves, the apparent heights of these were rather greater than would be given by multiples of the single-reflection height. *b*.—These "double and triple reflection" echoes *only occur simultaneously with the "single-reflection" echo;* on no occasion was a 200-km. echo observed without a simultaneous 100-km. echo (but a foot-note mentions one solitary occasion when a 300-km. echo, very weak, was observed without any corresponding 100-km. echo).

c.—The 200-km. echoes, and the rarer 300-km. echoes, occur chiefly when the 100-km. echoes are strong; and the average strength of the last is greater than that of the other kinds. This would be expected on the double and triple reflection hypothesis, but the exceptional cases where a 200-km. echo has been stronger than the 100-km. echo does *not* disprove the hypothesis, since the reflection points of the doubly-reflected ray are different from, and may be more favourable than, the reflection point of the singly-reflected ray. *d.*—As shown in Fig. 20, page 215, during the three hours of the run the apparent heights round 200 km. fell in the same proportion as those round 100 km. This would follow naturally on the double-reflection theory, but postulates (on the two-layers hypothesis) *an exact co-ordination between the two layers.*

e.—From May onwards the 200-km. echoes became less and less frequent, and the 300-km. echoes disappeared. This is understandable on the multiple reflection theory, since between two layer reflections there must be one earth reflection, and *the earth is in a better state to reflect before its summer growth.* The writers, however, are not perfectly satisfied with their observations on this particular point. *f.*—Frequent observations were made during the day, and particularly round noon; but only on one occasion, and then only for a few minutes, could echoes be observed. *g.*—The lowest effective height for any echo whatsoever was just below 98 km. (89 km. is mentioned in Section 1).

They sum up as follows:—"We can find, in our results, no grounds for believing in the existence of a strongly reflecting layer at about 200 km." Their results disagree in many ways with those of Appleton, "but one must await the results of further tests before one can decide the question finally." They are at present preparing for such tests.

MULTIPLE REFLECTION OR MULTIPLE LAYERS?—Goubau and Zenneck. (*See* preceding abstract, particularly Section 10.)

LA PROPAGATION DES ONDES RADIOÉLECTRIQUES COURTES (The Propagation of Short Radio-electric Waves).—R. Jouaust and N. Stoÿko. (*Comptes Rendus*, 18th May, 1931, Vol. 192, pp. 1207–1209.)

At the end of 1930 and the beginning of 1931 the forenoon 18.5-metre service between Indo-China and France was particularly disturbed by multiple signals. Particulars are given of one occasion, when every signal was duplicated; the first signal was slightly weaker than the second, which arrived after an interval of 0.06813 ± 0.00014 sec., having come presumably the longer way round but mostly through darkness. If the rays in each case are supposed to travel horizontally in the ionised layer, then from Pedersen's equation these results would give layer heights of 100 and 64 km., which the writers consider inadmissible, particularly at night. They conclude that the alternative hypothesis, that of several reflections between earth and layer, is better satisfied by these results: on the supposition of a layer height of 200 km. in the daylight zone, and of 300 km. in the dark zone, their calculations of the two paths, assuming emission angles giving a minimum number of reflections, lead to a value for the velocity of propagation of 299,300 km./sec., which is near enough to the velocity of light.

A THEORETICAL DISCUSSION OF THE ELECTRICAL PROPERTIES OF THE SOIL.—F. W. G. White. (*Proc. Camb. Phil. Soc.*, April, 1931, Vol. 27, pp. 268–276.)

This paper is an attempt to explain the variations with frequency of the effective specific inductive capacity and effective conductivity of soil placed, as dielectric, in a simple condenser, observed by Ratcliffe and White (Jan. Abstracts, p. 28) and to predict the effects to be expected at low frequencies.

The imperfect condenser is, for purposes of calculation, replaced by an equivalent network having three components corresponding to (1) the perfect condenser, (2) the steady conductivity, (3) the lagging polarisation. Two possible causes of a polarisation of the dielectric which has a relaxation time are discussed, (*a*) the formation of an ionic space charge, (*b*) polarisation due to the orientation of dipolar molecules in the field. Experimental evidence for the presence of (*a*) was obtained by placing probes in the soil between the condenser plates and measuring the distribution of potential. From this it is concluded that "any variation that the electrolytic effects may cause in the values of the s.i.c. or conductivity will occur at frequencies of the order 10 to 20 per sec."

Debye's theory of polar molecule phenomena is then applied and a sufficiently good agreement with experimental results is found "to justify the assumption that the dipolar molecules play an important part in causing the large variations observed in the specific inductive capacity and conductivity of the soil."

CIRCUITS FOR PROPAGATION RESEARCHES: PULSE-TRANSMITTING CIRCUIT USING NEON TUBE: BINAURAL MEASURING CIRCUIT FOR ECHO TIMES.—Ferrié: Bonnemaire: Jouaust and Decaux. (*U.R.S.I. Papers*, 1928 Assembly, Vol. 2, Fasc. 1, pp. 89–90.)

The binaural measurement circuit consists of a symmetrical two-valve circuit in which the two ear-pieces are energised one after the other, a local note frequency performing the commutation. By varying this local frequency it is possible to measure the interval between two signals and also the length of a signal—thus the pulse from the circuit mentioned above was found to be shorter than 1/10,000 sec.

CORRELATION OF LONG WAVE DAYTIME RADIO TRANSMISSION WITH MAGNETIC DISTURBANCES.—T. Minohara and T. Inouye. (*U.R.S.I. Papers*, 1928 Assembly, Vol. 2, Fasc. 1, pp. 146–148.)

Pearl Harbour signals (26.1 kc.) as received in Japan at 9 a.m. are plotted throughout a year and compared with curves of magnetic character. "We find that magnetic variation is accompanied by high value of daylight receiving strength and most of the high values of receiving strength occur usually within several days after and some time before the magnetic variations."

READABILITY OF LONG DISTANCE RADIO COMMUNICATIONS.—T. Nakagami and C. Anazawa. (*U.R.S.I. Papers*, 1928 Assembly, Vol. 2, Fasc. 1, pp. 101–105.)

English beam stations, Nauen, and Bolinas received in Japan: Japanese stations (short and long waves) received in California and at Chelmsford and Somerton.

OVERSEAS RADIO EXTENSIONS TO WIRE TELEPHONE NETWORKS.—Espenschied and Wilson. (*See* under "Stations.")

EXPERIENCES DE COMMUNICATIONS PAR ONDES COURTES (Short Wave Communication Tests [Italian Navy: Nobile Polar Expedition]).—G. Pession and G. Montefinale. (*U.R.S.I. Papers*, 1928 Assembly, Vol. 2, Fasc. 1, pp. 138–143.)

EFFECT OF THE MOON ON THE ATMOSPHERIC PRESSURE IN THE FAR EAST. (*Journ. Faculty of Sci., Tokyo*, 10th December, 1930, Vol. 2, pp. 73–131.)

Data for a 19-year period, from observations at 36 stations in and near Japan. It is concluded that there is a small but steady lunar influence on pressure distribution, while certain meteorological phenomena with 27- to 28-day periods are probably under lunar influence.

TRACING BALLOON DRIFT BY WIRELESS.—(*Wireless World*, 3rd June, 1931, Vol. 28, p. 663.)

A balloon radio transmitter weighing approximately 1 lb. developed by the American Signal Corps for meteorological tests. Small balloons carry the instrument which works automatically on a wavelength of 130.5 metres and can be followed by direction-finding equipment up to distances of 30 kilometres.

SCHALLGESCHWINDIGKEIT UND TEMPERATUR IN DER STRATOSPHÄRE (Sound Velocity and Temperature in the Stratosphere).—B. Gutenberg. (*Gerlands Beitr.*, No. 2, Vol. 27, pp. 217–225.)

Based on the 1927–1929 explosion experiments. For a long summary see *Physik. Ber.*, 1st April, 1931, Vol. 12, pp. 809–810.

EIN ALLGEMEINER SATZ ÜBER DEN ZUSAMMENHANG ZWISCHEN EIGENFREQUENZEN UND GRUPPENLAUFZEIT IN LINEAREN VERLUSTFREIEN DISPERSIONSSYSTEMEN (A General Law for the Connection Between Natural Frequencies and Group Transit Time in Linear Loss-free Dispersive Systems).—H. G. Baerwald. (*E.N.T.*, May, 1931, Vol. 8, pp. 224–227.)

Author's summary:—The natural frequencies of a linear system free from damping increase with its "length" L. For $L \rightarrow \infty$ their distribution is no longer discrete but continuous, and in this case their "density" can be defined. With the help of this quantity, which is shown to be equal to the group transit time per unit length or per element, it is possible to predict and interpret the characteristic dispersion phenomena appearing in the propagation of non-stationary processes in linear systems, in an easy and clear manner and without mathematical calculation.

DISPERSION VON HERTZSCHEN WELLEN IN FESTEN KÖRPERN (Dispersion of Hertzian Waves in Solid Bodies).—J. Errera. (*Physik. Zeitschr.*, 1st May, 1931, Vol. 32, pp. 369–373.)

An account of experiments on the dispersion of Hertzian waves of lengths between 300 m. and 882 km. in crystals of acid sodium potassium carbonate ($NaKC_4H_4O_6$, $4H_2O$).

MULTIPLE IMAGES IN CAR WINDOWS.—H. M. Reese. (*Journ. Opt. Soc. Am.*, May, 1931, Vol. 21, pp. 282–285.)

"If one looks obliquely through an automobile window at an outside lamp, he sees a row of images, about equally spaced in angle and of intensity decreasing rapidly from one end of the row to the other." The writer shows that the effect cannot be explained by treating the glass as a parallel-sided refracting layer, but that it fits in both qualitatively and quantitatively as the result of a small angle of taper (a few minutes of arc) actually found to exist in random samples of plate glass.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

THE RESIDUAL IONIZATION IN AIR AT NEW HIGH PRESSURES, AND ITS RELATION TO THE COSMIC PENETRATING RADIATION.—J. W. Broxon. (*Phys. Review*, 15th May, 1931, Series 2, Vol. 37, pp. 1320–1337.)

A description and discussion of measurements of the residual ionization in air at pressures up to 170 atmospheres, at an altitude of 5,400 ft.

ABSOLUTBESTIMMUNGEN DER INTENSITÄT DER KOSMISCHEN ULTRASTRAHLUNG (The Absolute Measurement of the Intensity of the Cosmic Rays).—A. Reitz. (*Wiener Anz.*, No. 26, 1930, p. 251.)

The writer investigated, in an aeroplane reaching a maximum height of 5,000 m., the variation of intensity with height. Results confirm the distribution curve deduced by Büttner (*Handbuch f. Exper: phys.*, Vol. 25, I, p. 499). A mass absorption coefficient for air is calculated. *See* also next abstract.

DIE EVESCHE KONSTANTE (Eve's Constant [with Supplement giving results of High Altitude Flights to Investigate the Distribution of Intensity of Hess' Cosmic Radiation with Height]).—A. W. Reitz. (*Zeitschr. f. Phys.*, 1931, Vol. 69, pp. 259–286.)

ÜBER DIE HERKUNFT DER ULTRASTRAHLUNG—HESSSCHEN STRAHLUNG (On the Origin of Cosmic Radiation—Hessian Radiation).—E. Regener. (*Naturwiss.*, 29th May, 1931, Vol. 19, pp. 460–461.)

A suggestion that cosmic radiation may be radiation which was emitted in a more distant time epoch than any we have as yet taken cognisance of and which has reached us by the longer of the two paths possible in a curved universe.

ENTSTEHUNG DER ELEMENTE UND KOSMISCHE STRAHLUNG (Genesis of the Elements and Cosmic Radiation).—M. v. Laue. (*Naturwiss.*, 5th June, 1931, Vol. 19, pp. 530–531.)

THE RESULTS OF A LEAST-SQUARE ADJUSTMENT OF COSMIC-RAY OBSERVATIONS.—L. R. D. Weld. (*Phys. Review*, 15th May, 1931, Series 2, Vol. 37, pp. 1368–1369.)

The results of the investigation indicate that it is necessary to look with reserve upon sweeping conclusions as to "atom building" deduced from experiments on cosmic rays.

A RECOMBINATION IN IONIZED STREAMS OF CORPUSCLES FROM THE SUN.—V. C. A. Ferraro. (*Monthly Not., Roy. Astron. Soc.*, No. 1, Vol. 91, pp. 184-187.)

VIOLENT MAGNETIC STORMS OCCUR A LITTLE MORE THAN ONE DAY AFTER A SOLAR HYDROGEN FLARE.—G. H. Hale. (Paragraph in *Science*, 1st May, 1931, Vol. 73, p. 14 of Supplement.)

ZODIACAL LIGHT AND MAGNETIC DISTURBANCE.—C. Bittinger and E. O. Hulbert. (*Phys. Review*, 1st May, 1931, Series 2, Vol. 37, p. 1190.)

A record of observations of unusual brightness of the zodiacal light during a period of magnetic disturbance.

THE PRESENT STATE OF BRITISH RESEARCH ON ATMOSPHERICS.—R. A. Watson Watt. (*U.R.S.I. Papers*, 1928 Assembly, Vol. 2, Fasc. 1, pp. 119–131.)

The full paper, two summaries of which were referred to in 1928 Abstracts, pp. 684–685 and 685. In the first of these abstracts, the last five lines are now seen to be incorrect, though they correctly reproduce the summary in question. The tracing of certain atmospherics to a thunderstorm thousands of miles away in Russia was a result of the British, not Russian, observations; and the law for the falling-off with distance of the 10 kc. component seems likely to lie "between an inverse square root law and an inverse first power law."

UTILISATION DE L'ENREGISTREMENT DES ATMOSPHÉRIQUES DANS L'ANALYSE MÉTÉOROLOGIQUE (The Use of the Recording of Atmospherics in the Analysis of the Meteorological Situation).—R. Bureau. (*U.R.S.I. Papers*, 1928 Assembly, Vol. 2, Fasc. 1, pp. 131–137.)

Further development of the work dealt with in 1928 Abstracts, p. 684. *See* also Abstracts, 1929, p. 443; 1930, pp. 153–154, 563; 1931, pp. 206, 213 and 318.

A NOTE ON THE DIRECTIONAL OBSERVATIONS OF GRINDERS IN JAPAN.—E. Yokoyama and T. Nakai. (*U.R.S.I. Papers*, 1928 Assembly Vol. 2, Fasc. 1, pp. 144–146.)

See *Proc. I.R.E.*, Feb., 1929, Vol. 17, pp. 377–379. The results of a former paper (1928 Abstracts, p. 684) are confirmed except that the directional nature of grinders was found to become vague, or to disappear, at night. From this it is deduced that grinders are received at night in Japan from tropical America (early), from Africa (late) and from the Dutch East Indies (any time of day or night).

THE DIELECTRIC CONSTANT OF AIR AT HIGH PRESSURES.—J. W. Broxon. (*Phys. Review*, 15th May, 1931, Series 2, Vol. 37, pp. 1338–1344.)

The dielectric constant of aged, dry, dust-free air, measured at pressures up to 170 atmospheres by an electrometric method, was found to increase linearly with the pressure.

OM LUFTELEKTRICITET OG LUFTELEKTRISKE MAALINGER (On Atmospheric Electricity and its Measurement).—H. Petersen. (*Fysisk Tidsskr.*, No. 4/5, Vol. 28, pp. 97–132.)

A survey of present ideas and methods of measurement.

THE MOBILITY OF AGED IONS IN AIR IN RELATION TO THE NATURE OF GASEOUS IONS.—N. E. Bradbury. (*Phys. Review*, 15th May, 1931, Series 2, Vol. 37, pp. 1311–1319.)

EIN EINFACHER DEMONSTRATIONSVERSUCH ÜBER WANDERUNG UND RAUMLADUNG VON LUFTIONEN (A Simple Demonstration Experiment Showing the Movement and Space Charge of Atmospheric Ions).—H. Greinacher. (*Physik. Zeitschr.*, 15th May, 1931, Vol. 32, pp. 406–410.)

DIE EINWIRKUNG UNMITTELBARER BLITZENTLADUNGEN AUF HOCHSPANNUNGSNETZE UND IHRE BEKÄMPFUNG (The Effect of Direct Lightning Strokes on High Voltage Networks, and the Counter-Measures to be Adopted.).—D. Müller-Hillebrand. (*E.T.Z.*, 4th and 11th June, 1931, Vol. 52, pp. 722–727 and 758–763.)

FREQUENZABHÄNGIGKEIT DER FUNKENSPANNUNG IN LUFT (Variation with Frequency of the Spark Voltage in Air).—H. Lassen. (*Archiv f. Elektrot.*, 9th May, 1931, Vol. 25, pp. 322–332.)

The full paper of which a preliminary account was referred to in Feb. Abstracts, p. 112.

PROPERTIES OF CIRCUITS.

EXTENSIONS TO THE THEORY AND DESIGN OF ELECTRIC WAVE-FILTERS.—O. J. Zobel. (*Bell Tech. Journ.*, April, 1931, Vol. 10, pp. 284–341.)

Author's abstract:—The problem of terminal wave-filter impedance characteristics is considered in this paper, in particular that of obtaining an approximately constant wave-filter impedance in the transmitting bands of a wave-filter of any class, which is of importance where the wave-filter is terminated by a constant resistance, the usual case.

The solution obtained is based upon the repeated use of the methods of deriving wave-filter structures which gave the M-types, combined with composite wave-filter principles. The results are wave-filter transducers which at one end have standard "constant k" image impedances and at the other have image impedances which can theoretically be made constant in the transmission bands to any degree of approximation desired. Practical fixed structures are shown.

Parts I and II give this derivation and composition of wave-filter structures. Two allied subjects, respectively, the designs of networks which simulate the impedances of wave-filters, and of loaded lines, are dealt with in Parts III and IV, such designs making use of the previous results.

The four Appendices contain new reactance and wave-filter frequency theorems, particular fixed transducer designs and certain equivalents; also, a chart for determining terminal losses at the junction of such a fixed wave-filter transducer and a resistance termination. This chart supplements those previously given in a chart method of calculating wave-filter transmission losses.

SELBSTERREGUNG VON SYSTEMEN MIT PERIODISCH VERÄNDERLICHEN INDUKTIVITÄTEN (Self-excited Oscillations of Systems with Periodically Changing Inductances).—H. Winter-Günther. (*Zeitschr. f. hochf. Tech.*, April, 1931, Vol. 37, pp. 172–174.)

Continuation of the work dealt with in 1929 Abstracts, p. 630. Experimental confirmation was obtained for the theoretical results arrived at; a three-phase asynchronous motor was specially connected so that its self-inductance passed through two complete half-cycles during each revolution.

THE FIELD PRODUCED BY A SIMPLE CONDUCTOR OF INFINITE LENGTH TRAVERSED BY AN ALTERNATING CURRENT.—F. Pollaczek: J. B. Pomey. (*Rev. Gén. de l'Élec.*, 30th May, 1931, Vol. 29, pp. 851–867.)

Translation of Pollaczek's 1926 paper in *E.N.T.*

THE DESIGN CALCULATIONS OF A DISTORTIONLESS LOW-FREQUENCY AMPLIFIER WITH TRANSFORMER COUPLING.—Forstmann. (*See* under "Acoustics and Audio-frequencies.")

TRANSMISSION.

UNTERSUCHUNGEN AN EINEM KURZWELLEN-GEGENTAKTSENDER (Researches on an [Ultra-] Short Wave Push-Pull Transmitter).—F. Müller and W. Zimbalin. (*E.N.T.*, May, 1931, Vol. 8, pp. 207–213.)

From the Ultra-Short Wave Laboratory of the Leningrad State Institute of Applied Physics. The writers begin by saying that the heating circuit often receives little of the careful attention which it deserves as an important element of the oscillatory circuit; its various parts, particularly the filament itself, are in the strong field of the valves and can therefore exert reaction effects on the rest of the circuit. In the case of ultra-high frequencies, where the electron distribution inside the valves is no longer uniform, it is especially important (for maximum efficiency) to get the best conditions for the heating circuit and the space charges round the cathodes. Choking coils in the filament leads are quite inadequate. Bergmann and Dennhardt both use wave-trap circuits (1930 Abstracts, pp. 392 and 505–506), while Heim arranges the filaments at current antinodes of a Lecher wire system (1928 Abstracts, p. 228).

The present writers have evolved a different system, based on the Holborn push-pull circuit. Not only the grid and anode systems, but also the filament system, are made in the form of tune-able parallel wires. It is found that as the filament system is shortened, *the generated wavelength remains unaltered* but the oscillations increase steadily in intensity up to a maximum, and then break off suddenly. Changes in the grid system length shift the curves and the break-off point and alter the wavelength. Proper adjustment of the filament system can thus give as much as an 8-fold increase of oscillation intensity. Further decrease of the system, beyond the break-off point, leads to the oscillations setting in again; presumably a sufficiently long filament system would give similar maxima at half-wavelength intervals (as in Heumann's experiments on shorter waves, soon to be published). Keeping the anode system constant and adjusting the filament system to the optimum point for various adjustments of the grid system, the greatest maximum appears to be for the grid system value giving a wavelength of 258 cms. Similarly, keeping the filament system constant and varying in turn the anode and grid systems, energy maxima occur for the same 258 cms. wave; the greatest maximum, of course, occurring when the filament-circuit is set at its optimum value for that wavelength.

The experimental arrangement used is shown in Fig. 2, p. 208. Each filament has two parallel telescopic leads; the two grids have similar leads forming a similar parallel pair, and so have the two anodes. These last two pairs lie in a plane at right angles to that containing the filament circuits. Owing to the different oscillatory circuits lying in different planes, the combined radiation diagram is of special interest. This is investigated under a number of different conditions. Three possible explanations of the influence of the filament-circuit tuning on the amplitude of the oscillations are discussed, the only tenable one being that it depends on the potential variations of the cathode, which produce an equalisation of the path times of the electrons emerging from the space charge round the cathode, and thus result in a more homogeneous electron-current distribution.

LAMPOVYI GENERATOR ULTRAKOROTKIH (METROVYH) VOLN S OBRATNOI SVIAZIU (The Ultra-Short Wave Thermionic Valve Oscillator).—N. A. Petrov. (*Westnik Elektrotechniki, Leningrad*, January, 1931, Part 1, pp. 26–38.)

In Russian. The author points out that with an ultra-short wave oscillator, the efficiency and the minimum wavelength obtainable depend not so much on the circuit used as on the constants of the oscillator valve. A detailed account is given of theoretical and experimental investigations into the type of valve most suitable for ultra-short work.

Starting from the case of a typical single valve oscillator, and taking into account the inter-electrode capacities of the valve and the inductance of the grid circuit, equations are derived for determining the conditions necessary for continuous oscillations to occur. The efficiency of the oscillator is then investigated and is found to be inversely proportional to the inter-electrode capacity and the impedance of the valve. A description is given of an oscillator specially constructed for the experimental verification of the above points, and an account is presented of various measurements involved and of the results obtained. These results were further verified by testing a number of different valves.

The necessary conditions under which oscillations can commence are then investigated and an involved formula is derived for calculating the minimum possible wavelength as determined by the constants of the valve and of the circuit.

In the light of the above considerations, a procedure for the design of a valve suitable for ultra-short work is indicated, and the necessary formulae are given. It appears that the main requirements are as follows: (1) Large saturation current and low operating anode voltage. (2) Grid mesh not too fine. (3) Large separation between the anode and grid leads.

It may be noted that the higher the power of the valve the greater is the minimum wavelength at which it will operate.

A brief outline is added of oscillator systems employing two valves, and a method is indicated for finding the equivalent single valve circuits in order to simplify calculations. It is pointed out that the two valve systems are capable of a greater power output than those in which only one valve is employed, and are in addition more stable in operation. With reference to the latter point it is mentioned that as in the case of long waves (Lazaref, 1929 Abstracts, p. 270) the frequency is dependent upon the anode voltage and the temperature of the filament, being directly proportional to the former and inversely proportional to the latter. Experimental curves are shown confirming this.

TREHFAZNYE ELEKTRONNYE GENERATORY (The Three-Phase Thermionic Valve Oscillator).—A. Arenberg. (*Westnik Elektrotechniki, Leningrad*, January, 1931, Part I, pp. 13–19.)

In Russian. A theoretical discussion of the three-phase inductively coupled oscillator (R. Mesny, *L'Onde Élec.*, p. 232, 1925; also 1930 Abstracts, p. 274, Tank and Ackermann) is presented. Equations are given for determining the conditions necessary for starting and sustaining the oscillations. It appears from these equations that the fundamental frequency is absent from the high tension supply circuit, while 3rd, 6th, 9th, etc., harmonics are present.

A vector diagram is given and the phase displacement of currents in the oscillatory circuit is proved to be equal to $\frac{2\pi}{3}$. A method is indicated by means of which the design of a three-phase oscillator may be based on that of a single-phase oscillator, and it is also pointed out that by omitting one of the valves the usual push-pull circuit is obtained. Expressions for determining the power output and the efficiency of the oscillator are also given.

The main advantages of the system are its stability and the absence of the fundamental frequency from the high tension supply circuit.

In conclusion, different circuits are suggested and possible applications enumerated, examples of which are the use of the high frequency rotating magnetic field for experimental purposes, and the application of the system as a harmonic generator by means of which a large step up in frequency can readily be obtained.

RASCHET LAMPOVOGO GENERATORA PRI PLOSKOI FORME IMPULSA ANODNOGO TOKA (The Design of a Thermionic Valve Oscillator for a Flat-Topped Anode Current Wave).—A. I. Berg. (*Westnik Elektrotechniki, Leningrad*, January, 1931, Part I, pp. 11–13.)

In Russian. A discussion is given on the design of an oscillator in which the variations of the grid potential are such that the valve is driven beyond the top and bottom bends of the characteristic and when, in consequence, the anode current wave has a truncated sinusoidal shape.

The angles of cut-off, *i.e.*, those values of ωt beyond which the anode current is either a maximum or zero, are introduced into the fundamental equation for the anode current, and an expression is obtained for determining the shape of the anode current wave. A general formula for the amplitude of the n-th harmonic is derived and curves are given enabling the amplitudes of the second harmonic to be found for different angles of cut-off.

The internal impedance of the valve is expressed as a function of the angles of cut-off, and from this expression the corresponding values of the grid swing may be determined. An expression is also derived giving the ratio between the alternating and constant components of the anode voltage, in terms of the angles of cut-off.

A numerical example illustrating the theory is added.

UNTERSUCHUNGEN ÜBER DAS VERHALTEN VON QUARTZGESTEUERTEN SENDERN (Investigations into the Behaviour of Quartz-Controlled Transmitters).—P. von Handel. (*Luftfahrtforsch.*, No. 5, Vol. 8, pp. 121–140.)

"The equivalent circuit of the oscillating quartz crystal is derived. The damping of the crystal is calculated as a function of the frequency, and the specific expansion as a function of the electrical potential on the crystal; it is thus shown that the specific expansion is independent of the frequency. The vector equation of the oscillating system is derived, but the calculation leads to complex expressions; the oscillating conditions are therefore examined with the help of vector diagrams. Stability conditions give the possibility of both stable and unstable oscillations. The behaviour of a quartz-controlled two-circuit transmitter in overcritical coupling is investigated, together with the effect of the active grid current and the grid/anode capacity." *See* also 1930 Abstracts, p. 334.

AMPLITUDE- AND FREQUENCY-MODULATED TRANSMITTERS: MEASUREMENT OF MODULATION, ETC.—A. Heilmann: W. Runge. (*E.N.T.*, May, 1931, Vol. 8, pp. 227–228.)

Heilmann, while recognising the advantages of Runge's method (March Abstracts, p. 149), points out that it is based on two simplifying assumptions:—that the frequency- and phase-modulation which occur as by-products of the amplitude-modulation possess a fixed phase relation to the latter, and that an oscillation which is simultaneously modulated as regards amplitude and frequency can be replaced by the product of the superposition of a pure amplitude-modulated oscillation on a pure frequency-modulated one. The first assumption is not always fulfilled (Runge replies that for modulated valve transmitters it is so generally true that for practical purposes the point need not limit the use of his method) while the second only holds good for very small degrees of frequency- or phase-modulation. Runge agrees that the separation of pure phase-modulation from the amplitude-modulation, by measuring the combination-oscillations at small amplitudes which prevent non-linear distortion of the amplitude-modulation, is in fact not a very exact procedure [results at higher degrees of modulation having to be deduced from these]: it is, however, much *more* exact than the one suggested by Heilmann, according to which the phase-modulation is to be deduced from the amplitude of the side-band oscillations for a known degree of amplitude-modulation: for quite high degrees of frequency-modulation, Runge points out, there is only a quite small increase in the side-band amplitudes, since the phase-modulated side-bands add themselves at right angles to the amplitude-modulated side-bands. To sum up, Runge quite agrees that a method giving not only the amplitudes but also the phases of all the side frequencies would be preferable, but considers that his simple method is of great use for practical purposes.

DETALI MODULIATSII (Study of Modulation).—M. A. Bonch-Bruevitch. (*Westnik Elektrotechniki, Leningrad*, January, 1931, Part I, pp. 3–6.)

In Russian. Early in 1930 the author pointed out that in the process of amplitude modulation not only is the amplitude of high frequency oscillations varied but also phase shifts occur and, therefore, frequency modulation takes place. In view of the practical importance of this the author gives a graphical method for studying and comparing different systems of modulation. The method is based on the representation of the carrier e.m.f. as a vector in a system of co-ordinates rotating at the same angular velocity as the vector itself, the latter being therefore shown as stationary. E.m.f.'s differing in frequency from the carrier are represented by rotating vectors, while e.m.f.'s of the same frequency but differing in phase are represented by stationary vectors having an angular displacement from the carrier vector. It is clear, therefore, that in order to change the phase of a stationary vector the latter must be rotated, and a frequency variation $\triangle = \frac{d\phi}{dt}$ thus takes place. Periodical variations in phase are, therefore, equivalent to periodical variations in frequency.

Diagrams are given for different methods of modulation. Resultant vectors are obtained in each case and their variations are indicated. It is pointed out that these diagrams would be modified if the inherent phase variations of the generated carrier frequency were taken into account.

CARRIER WAVES AND SIDE BANDS.—C. L. Fortescue. (*E.W. & W.E.*, May, 1931, Vol. 8, pp. 259–260.)

The writer shows that the accepted interpretation of a modulated continuous wave in terms of carrier and side frequencies does not depend on the equivalence of the well-known alternative trigonometrical formulae used in the analysis of this subject, but is rather based on fundamental theoretical and experimental data (enumerated in the letter) which show that either of the usual trigonometrical formulae is equally appropriate to the analytical description of periodic e.m.f.'s of this type. He also points out that even with irregular or impulsive modulation the same mode of description and interpretation is appropriate, the side frequencies in such cases forming continuous spectra and not isolated lines.

PHYSICAL REALITY OF SIDE BANDS.—Moullin: Colebrook. (*See* under "Reception.")

UN CIRCUITO EMITTENTE TRENI D'ONDA DISCONTINUI (A Circuit Emitting a Succession of Wave Trains).—M. La Rosa and G. Petrucci. (*Lincei Rendic.*, No. 5/6, Vol. 12[7], pp. 199–202.)

Further development of the work referred to in May Abstracts, p. 267. Trains of ten-metre waves lasting less than one-thousandth of a second have now been obtained, at regular intervals of the order of 20 minutes. The phenomenon is further investigated, and the differences between the writers' arrangements and the Mazzotto circuit are pointed out.

HARTLEY CIRCUIT WITHOUT RADIO-FREQUENCY CHOKE.—R. M. Wilson. (*QST*, Dec., 1930, Vol. 14, pp. 46–47.)

By re-arranging the ordinary Hartley circuit so that the positive plate supply is connected at a point of zero r.f. voltage, the r.f. choke can be transferred to the *grid* circuit and can then be dispensed with altogether by using an inductively-wound grid leak.

DECREASING THE NUMBER OF TURNS IN R.F. CHOKES.—(German Pat. 517011, Telefunken, pub. 30th Jan., 1931.)

A previous main patent deals with the reduction of the turns (and therefore of the opportunity for the production of natural frequencies) by coupling the reduced turns to an oscillatory circuit so that a counter-e.m.f. is produced which increases the choking action. The present patent deals with a special arrangement for the grid-circuit choke; the grid leak is cut in two and the choke (introduced between the two halves) is coupled to an adjustable oscillating circuit.

ECONOMICAL FULL-LOAD TESTING OF TRANSMITTERS.—(German Pat. 517486, Telefunken, pub. 4th Feb., 1931.)

To avoid using large quantities of electrical energy in prolonged load tests, the r.f. energy generated is led back to the input side of the set, so that only the losses have to be supplied. The rectifiers are isolated from the mains by r.f. chokes.

A VALVE GENERATOR OF VERY STABLE FREQUENCY.—David. (*See* under "Measurements and Standards.")

NEON TUBE R.F. TRANSMITTER CIRCUIT.—Hanhauser. (*See* abstract under "Acoustics and Audio-frequencies.")

RECEPTION.

PHYSICAL REALITY OF SIDE BANDS.—E. B. Moullin: Colebrook. (*E.W. & W.E.*, May, 1931, Vol. 8, pp. 257–259.)

A letter pointing out that the very complete and elegant analysis of the reception and rectification of a modulated continuous wave given by Colebrook (March Abstracts, p. 153) can be made more simple and more easily applicable to concrete examples by considering two extreme cases:—(*a*) power factor of receiving circuit *small* compared with the fractional modulation frequency (*i.e.*, with the ratio of modulation to carrier frequency), and (*b*) power factor of receiving circuit *large* compared with the fractional modulation frequency.

In the first case the side band response will be inversely as the modulation frequency, and in the second it will not depend on the modulation frequency until this becomes relatively high. Some of the results derived by Colebrook are illustrated in terms of these simple approximations. In addition it is pointed out that when a low decrement circuit is tuned to one of the side frequencies the octave of the modulation is introduced, quite apart from any rectification effect; and that the side peaks of the modulation frequency output will be approximately one quarter the height of the central peak with 100% modulation.

As an example of the immunity from interference given by low decrement circuits, the writer takes the following case:—decrement 0.1%, two carrier frequencies 1,000 and 1,005 kc., each modulated at 2 kc.; he shows that with square law rectification the ratio of the 2 kc. responses will be 62 : 1 in favour of the transmission to which the receiver is tuned. The intensity of the 5 kc. beat note produced by the two carrier waves is not discussed in the letter.

THE "STENODE."—J. Robinson: Moullin. (*E.W. & W.E.*, June, 1931, Vol. 8, p. 314.)

A letter commenting on the above letter from Moullin. The writer considers that this supports his view that in applying the side band theory it is necessary to consider the receiver as a whole, including the rectifier; and he implies that the 62 : 1 interference ratio quoted above illustrates the utility of high selectivity circuits in separating stations with a carrier frequency difference of only 5 kc.

THE STENODE RADIOSTAT: DISCUSSION AFTER LECTURE AND DEMONSTRATION.—(*Radio News*, March, 1931, p. 808.)

According to the fidelity curve shown by Robinson, at about 2,800 cycles per sec. there is a weakening of 1 : 2 and at about 5,000 a weakening of 1 : 9. A musical member of the audience appears to have thought that all notes below 200 and above 2,000 cycles per sec. were inaudible.

APPARENT DEMODULATION OF AN INTERFERING TRANSMISSION BY A STRONGER ONE.—F. M. Colebrook. (*Wireless World*, 27th May, 1931, Vol. 28, pp. 560–563.)

A simplified analysis of the effect noted by Beatty* and Butterworth,† viz., that the acoustic interference produced by a modulated transmission, separated by a supersonic frequency difference from that to which the receiving circuit is tuned, is very considerably less than would be inferred from the selectivity of the receiving circuit.

A NEW DEVELOPMENT IN POWER GRID DETECTION.—F. M. Colebrook. (*Wireless World*, 10th June, 1931, Vol. 28, pp. 625–628.)

Although as far as the grid circuit is concerned very large signal voltages can be rectified without distortion by the grid detector, there are limitations due to curvature in the anode characteristic. It is found, therefore, that the single valve power grid detector requires a high anode voltage before linear results are possible, and to avoid this, as well as to provide certain additional advantages, the author suggests the simple expedient of dividing the functions of rectification and amplification and allocating each to a separate valve.

WIRELESS WORLD SUPER-SELECTIVE SIX.—W. T. Cocking. (*Wireless World*, 3rd and 10th June, 1931, Vol. 28, pp. 597–602, and 616–620.)

A.C. band-pass five-valve super heterodyne for amateur construction. The specification includes all mains operation with valve rectification, ganged waveband tuning, dual ganged volume control, new non-radiating frequency changer, power grid detection, pentode power output of 1,900 milliwatts and special tuned smoothing circuit.

BAND PASS FILTERS IN RADIO RECEIVERS: ERRATA.—G. W. O. H. (*E.W. & W.E.*, June, 1931, Vol. 8, p. 293.)

Corrections to the editorial dealt with in July Abstracts, p. 383.

A SINGLE-DIAL CONTROL SHORT WAVE CONVERTER FOR WORKING A BROADCAST RECEIVER AS A SHORT WAVE SUPERHETERODYNE.—H. A. Chinn. (*QST*, June, 1931, Vol. 15, pp. 9–15.)

RECORDING BY ELECTRO-OSMOSIS.—Volmer. (*See* under "Phototelegraphy.")

* *Experimental Wireless*, June, 1928.
† *Experimental Wireless*, Nov. 1929.

TRACING THE SOURCES OF INTERFERENCE WITH BROADCAST RECEPTION.—Conrad and Schöne (*See* under "Miscellaneous.")

FRENCH RECEIVERS AT THE PARIS EXHIBITION.—(*See* Section VIII of long abstract under "Miscellaneous.")

AERIALS AND AERIAL SYSTEMS.

VERGRÖSSERUNG DER EFFEKTIVEN HÖHE VON FLUGZEUGSCHLEPPANTENNEN (Increasing the Effective Height of Trailing Aircraft Aerials). —F. Eisner, G. Sudeck, R. Schröer and O. Zinke. (*Zeitschr. f. hochf. Tech.*, June, 1931, Vol. 27, pp. 219–229.)

The usual trailing aerial is very simple as regards construction and use, but is not good as a radiator. The D.V.L. has therefore undertaken a thorough investigation of the subject, both theoretical and practical, and has evolved a new type of trailing aerial, approximating to the L form, which gives an effective height four times that of the ordinary type, and three times as many metre-ampères (three, not four times, owing to its higher resistance). The part representing the (ideally) vertical portion of the aerial is loaded with a heavy, stream-lined weight, from which the other arm of the L proceeds, of about equal length and kept as horizontal as possible by a small trailer at its free end. Since the stream-lined weight weighs 1.8 kg., and is thus several times heavier than the ordinary aerial "egg" weight, the 50-metre vertical part of the aerial has to be extra strong; it is made of 1 mm. diameter stranded steel wire, each strand heavily coppered.

It is of interest to note that the tests showed that an *ordinary* trailing aerial gave about the same improved effective height as the new L type when constructed of 0.52 mm. silvered steel wire and loaded with an 850 g. stream-lined weight. This good result, arising from the more vertical position assumed by the heavily loaded fine wire, is nullified by the fact that the high resistance cuts the current down to about one-third of the usual trailing-aerial current.

The experimental work included not only actual trial tests from an aeroplane but also a series of small-scale model tests—a procedure unusual in electrical engineering. A full description of these tests (based on Abraham's "rule") is given.

The writers end by admitting that at present the letting-out and winding-in processes are not so simple as with the ordinary trailing aerial, but they are convinced that in view of the advantages to be obtained (a 25-30 watt set with the new aerial will give more metre-ampères than a 70-100 watt set with the old aerial), a satisfactory arrangement will soon be evolved.

THE STUDY OF AERIALS BY SMALL-SCALE MODELS.—(*See* preceding abstract.)

CHARACTERISTICS OF AIRPLANE ANTENNAS FOR RADIO RANGE-BEACON RECEPTION.—H. Diamond and G. L. Davies. (*Bur. of Stds. Journ. of Res.*, May, 1931, Vol. 6, pp. 901-916.)

Authors' abstract :—This paper gives the results of an investigation on the characteristics of airplane receiving antennas to determine whether an antenna arrangement could be devised which would have all the desirable electrical properties of the vertical pole antenna and yet be free from the mechanical difficulties encountered in the use of the pole antenna. The antennas studied include the inclined antenna with both forward and backward inclination, the horizontal dipole antenna, the horizontal L antenna, the horizontal V antenna, the inclined V antenna, the symmetrical transverse T antenna, and the symmetrical longitudinal T antenna. A theoretical treatment is given which enables the voltage induced by a radio range beacon transmitting station to be calculated for any receiving antenna in space. This theoretical analysis is used to determine the received voltage, course error, and localising effect for each of the antenna types studied. An experimental study was also made to check the theoretical analysis. The results obtained by experiment check very well with the theoretical predictions for each type of antenna. The symmetrical transverse T antenna and the symmetrical longitudinal T antenna, with vertical lead-in portions, are both found to fulfil the desired requirements. Neither of these antennas shows any course errors and [both] give the same received voltage as the vertical pole antenna having much greater actual height, thus reducing the mechanical troubles caused by vibration and ice formation. An appendix gives the mathematical derivation of the equation used as a starting point for the theoretical analysis.

HIGH FREQUENCY FEEDERS: SOME INVESTIGATIONS INTO DESIGN AND MEASUREMENT.—H. O. Roosenstein. (*E.W. & W.E.*, June, 1931, Vol. 8, pp. 294–297.)

Damping measurements by a "node-width" measuring instrument: damping introduced by insulators: results with dry and wet insulators: measurement of characteristic impedances at very high frequencies: methods of matching aerials and feeders. *See* March Abstracts, p.p. 147-148.

NOTE ON THE ELECTROMAGNETIC GREEK-PATTERN OR SAW-TOOTH NETWORKS.—R. Mesny. (*U.R.S.I. Papers*, 1928 Assembly, Vol. 2, Fasc. 1, pp. 159–161.)

VALVES AND THERMIONICS.

THE VALVE TRIANGLE.—G. W. O. H.: Meyer. (*E.W. & W.E.*, June, 1931, Vol. 8, pp. 291–293.)

An editorial on the very convenient valve diagram dealt with by Meyer (Jan. Abstracts, p. 42).

FUNDAMENTAL TRIODE EQUATIONS.—U. Ruelle. (*L'Elettrotec.*, 25th Jan., 1931, Vol. 18, p. 52.)

According to the writer, the fundamental equation $i=f(v_g v_a)$ is sometimes wrongly considered to be of the form $i=av_g+bv_a$, in which the curve passes through the origin. It would be more correct to assume it to be of the form $i=av_g+bv_a+c$. Some of the errors resulting from the wrong assumption are mentioned.

NEW VALVES.—(*Wireless World*, 10th June, 1931, Vol. 28, pp. 621–624.)

A list of the new valves which will be incorporated in receivers for the coming season. The valves, which are classified under various headings, show great improvements in the standard performance.

FRENCH VALVES AT THE PARIS EXHIBITION.—(*See* Section I of long abstract under " Miscellaneous.")

TWO PENTODES AS THE IDEAL OUTPUT STAGE.—Forstmann. (*See* abstract under " Acoustics and Audio-frequencies.")

THE PENTODE AND SOME APPLICATIONS: IN A SMALL 3-VALVE RECEIVER OF HIGH SENSITIVITY: AS A R.F. POWER AMPLIFIER AND FREQUENCY DOUBLER IN LOW POWERED TRANSMITTERS.—(Papers in *QST*, June, 1931, Vol. 15.)

RÉPARTITION DES TEMPÉRATURES DANS UNE SECTION DROITE D'UN FILAMENT PLAT INCANDESCENT (Distribution of Temperatures in a Cross Section of a Flat Incandescent Filament).—G. Ribaud. (*Comptes Rendus*, 18th May, 1931, Vol. 192, pp. 1205–1207.)

THE PHOTOELECTRIC EFFECT FROM A BARIUM OXIDE COATED PLATINUM FILAMENT.—K. Newbury and F. Lemery. (*Journ. Opt. Soc. Am.*, May, 1931, Vol. 21, pp. 276–281.)

Continuation of the work dealt with in 1930 Abstracts, p. 216. The experimental results are :—The photoelectric current increased with increase of plate potential, and approached a saturation value at about 13 v. The photoelectric current for a constant voltage (high enough for the current to be near its saturation value) increased with filament temperature up to about 1,000° C. and then rapidly decreased above that point. The long wave limit of the effect is not more than 4,046 A.U.

UNTERSUCHUNGEN ÜBER DIE GLÜHELEKTRISCHE EMISSION VON METALLEN IN DER UMGEBUNG IHRES SCHMELZPUNKTES (Investigations of the Electrical Emission from Incandescent Metals in the Neighbourhood of their Melting-Point).—J. Ameiser. (*Zeitschr. f. Phys.*, 1931, Vol. 69, pp. 111–140.)

ACOUSTICS AND AUDIO-FREQUENCIES.

MESSUNG DER FREQUENZCHARAKTERISTIK MIT HILFE DER LICHTONGENERATORS (Frequency Characteristic Measurement using the Optical Siren Note Generator).—W. Schäffer and G. Lubszynski. (*E.N.T.*, May, 1931, Vol. 8, pp. 213–217.)

From the German State Broadcasting Laboratory. The indispensable note generator usually consists either of a valve circuit oscillating at note frequency or of two heterodyning circuits. The first method often presents difficulties at low frequencies such as 30 p.p.s., and its continuous adjustment over the range up to 10,000 p.p.s.—without varying the output voltage—is also a stumbling block. The second method is a good one, but requires rather expert handling. The optical siren note generator has therefore been designed, based on experience in phototelegraphy. The speed of the perforated disc is read off a tachometer, and is varied (for a 120-slot disc) from 15 to 5,000 r.p.m. by control of the motor speed and by two gear ratios of the belt drive. The photoelectric pulses are amplified by a completely symmetrical amplifier. If the rounded slots are made slightly broader than the slot in the screen in front of the cell, the wave form is found to be so nearly sinusoidal that the effective value of the harmonics formed is less than 4%. Variation of the output voltage with frequency is negligible for practical purposes. The apparatus is arranged so that the disc can be run up to its full speed and the motor then switched off and allowed to come to rest gradually, so that the whole frequency range is covered continuously and the test results recorded on a paper strip running at 12 cms. per minute. Definite frequencies can be registered as " jags " on the curve by automatically interrupting the light ray at the correct readings of the tachometer ; or—if the recorder is in the same room—the markings may be made by hand.

ÜBER DIE BEMESSUNG VERZERRUNGSFREIER NIEDERFREQUENZVERSTÄRKER MIT TRANSFORMATORENKOPPLUNG (The Design Calculations of a Distortionless Low-frequency Amplifier with Transformer Coupling).—A. Forstmann. (*E.T.Z.*, 7th and 21st May, 1931, Vol. 52, pp. 596–599 and 660–662.)

Author's summary :—" The conditions for the frequency-independence of transformer-coupled l.f. amplifier stages are given ; supplementary to these, the conditions for definite preferential amplification of the extreme frequencies are considered. Finally, the conditions for the avoidance of non-linear distortion, due to the valves or to iron cores, are found and the effect of the anode-circuit reaction investigated." References are given to a very large number of other papers, from 1917 to 1930 and from all parts of the world.

THE OBTAINING OF LARGE UNDISTORTED OUTPUTS FOR A MINIMUM OF PLATE POTENTIAL.—A. Forstmann. (*Funk-Bast.*, Sept., 1930, pp. 627–631.)

The writer has already advised the abandonment of the " straight part of the curve " limitation, showing that by the use of a symmetrical 2-valve output stage the curved portions of the characteristic may be employed without producing distortion and with a trebling of the power available (1930 Abstracts, p. 565). This arrangement, however, necessitates high anode voltages ; the present paper describes how this objection can be removed by the use of pentodes. The ideal output stage is thus found to be made up of two pentodes symmetrically connected.

THE DISTORTIONLESS AMPLIFICATION OF ELECTRICAL TRANSIENTS. — C. W. Oatley. (*E.W. & W.E.*, May, 1931, Vol. 8, pp. 244–249.)

McLachlan has shown that although even an amplifier with a reasonably good frequency characteristic may produce considerable distortion when amplifying transients, this distortion will probably be negligible in comparison with that introduced by the best of present-day loud speakers. It would therefore seem that the elimination of distortion of transients in amplifiers which form parts of sound reproducing systems is not, for the moment, of very great practical importance. The writer points out, however, that other cases arise where the distortion may be very objectionable, *e.g.*, where the amplifier is used in conjunction with a distortion-free oscillograph. In the present paper, therefore, he investigates the extent of such distortion which may be produced by thermionic amplifiers of various types, finding a general solution (neglecting the effects of stray inductances and capacities) for transformer- and resistance-coupled amplifiers, which is approximately applicable to a choke-coupled amplifier under certain conditions. So far as the low frequency end of the frequency characteristic is concerned, the neglect of stray inductances and capacities does not prevent the results from applying to practical amplifiers, but for the high frequency end the practical amplifier will show a gradual cut-off above some limiting frequency. In a future paper the writer will deal with the effect of this on the amplification of transients.

INFLUENCE DE LA DISTORSION NON LINÉAIRE (FONCTION DE L'AMPLITUDE) DUE AU FER SUR L'EFFICACITÉ ET LA NETTETÉ D'UN SYSTEME DE TRANSMISSION TÉLÉPHONIQUE (The Influence of Non-linear Distortion due to Iron on the Quality and Intelligibility of Telephone Transmission).—G. V. Békésy. (*Rev. Gén. de l'Élec.*, 9th May, 1931, Vol. 29, pp. 167D–168D.)

Long summary of a *Journal Télégraphique* paper which appears to be a French version of the German one dealt with in 1928 Abstracts, p. 528. Syllable articulation tests are dealt with, and the precautions essential for these.

IMPROVEMENTS IN AUDIO-FREQUENCY TRANSFORMERS. (French Pat. 696977, de Gialluly, pub. 10th Jan., 1931.)

This transformer does away with the need for a r.f. choke between primary winding and anode; an auxiliary, spaced winding, with insulation between the layers, is wound on the outside of the primary.

THE PERCEPTION OF THE DIRECTION OF SOUND.—M. Ishimoto and K. Kurihara. (*Proc. Imp. Acad. Tokyo*, Oct., 1930, Vol. 6, pp. 310–312.)

For sounds above 1,200 c.p.s. the perception is obscured; the perception curve is larger for musical sounds than for others, and for musical sounds the perception depends on frequency.

VERSUCHE ZU HÖRTHEORETISCHEM IM ANSCHLUSS AN NACHBILDER UND ELEKTRISCHE NERVENPHÄNOMENE (Experiments on a Theory of Hearing in connection with Images and Electrical Nerve Phenomena).—E. Kupper. (*Naturwiss.*, 3rd April, 1931, Vol. 19, No. 14, pp. 306–307.)

MESSUNG DER SCHALLGESCHWINDIGKEIT VON STOFFEN IM FESTEN UND GESCHMOLZENEN ZUSTAND. II. MITTEILUNG (Measurement of the Velocity of Sound in Materials in the Solid and Melted State. 2nd Communication).—O. Stierstadt. (*Physik. Zeitschr.*, 15th April, 1931, Vol. 32, No. 8, pp. 346–351.)

A continuation of the work referred to in May Abstracts, p. 272.

ORIGINES DES TERMES GYROSCOPIQUES DANS LES ÉQUATIONS DES APPAREILS ÉLECTROMÉCANIQUES (Origins of the Gyroscopic Terms in the Equations of Electromagnetic Instruments).—Ph. le Corbeiller. (*U.R.S.I. Papers*, 1928 Assembly, Vol. 2, Fasc. 1, pp. 167–177.)

With applications to the telephone, electrodynamic and electrostatic loud speakers, Fessenden submarine transmitter, and the Nukiyama-Matsudaira "vibrometer." The equations of all these are derived and discussed.

THE MOVING COIL LOUD SPEAKER [DIFFERENCE OF COIL CONSTANTS WHEN STATIONARY AND IN MOTION].—H. M. Clarke. (*E.W. & W.E.*, June, 1931, Vol. 8, pp. 304–306.)

Experiments in regard to the writer's suggestion (*ibid.*, Sept., 1930) that the resistance and reactance of the coil are different according to whether the coil is stationary or in movement, this difference being in the purely electrical constants and occurring in addition to changes due to air loading, diaphragm absorption and suspension losses. "The observed changes are small and may well be within the zone of natural variations of the system," but the bridge and potentiometer method evolved for the purpose may be used for other interesting measurements; *e.g.*, for measuring iron loss, mechanical load, air loading and mechanical losses for rigid diaphragm, etc. Possibly a combination of Chladni figure tests and potentiometer tests might give a method of integrating the output and losses for a non-rigid diaphragm.

PIEZOELECTRIC CONVERSION OF MODULATED RADIO-FREQUENCIES INTO SOUND.—(German Pat. 515789, Grützmacher, pub. 21st. Jan., 1931.)

One end of the crystal is fixed, the other presses against the diaphragm so that the crystal can oscillate at the radio frequencies and transfer the modulation frequencies to the diaphragm.

A NEW MOVING COIL LOUD SPEAKER MOVEMENT. (French Pat. 696762, Lévy, pub. 7th Jan., 1931.)

In the ordinary moving coil instrument the a.c. field created, by the current in the moving coil, in the core of the electromagnet gives rise to serious losses in the iron; short circuited turns, copper screens and neutralising windings have all been tried, but all lead to a diminution of the effective impedance and the necessity for more turns on the coil. According to the present invention, the sound-currents are passed into a fixed coil on the polepiece of the magnet, while the moving coil is represented by a small copper or aluminium ring fixed to the cone and surrounding very closely the fixed winding; the air-gap can be very small, partly because of the nature of the moving coil and partly because the fixed coil can be wound with wire of a magnetic material. The fixed winding and the moving ring combine to form a transformer; the a.c. field in the core, and the consequent losses, are greatly reduced.

A NEW LOUD SPEAKER.—H. J. Fanger. (*Scient. American*, May, 1931, p. 346.)

There are two voice-coils wound on the same support which is rigidly fixed to the centre of the cone: even when reproducing low notes, their movement is restricted electrically and mechanically to an amplitude of 0.001 inch. There are two gaps in the magnetic circuit of the field coil, and one voice coil is suspended in each. The higher tones are reproduced by the centre of the cone, the lower tones by the outer edge. Since the arrangement does not depend upon cone resonance for the reproduction of low notes, there is none of the "barrel-like" distortion common in ordinary loud speakers; and the type of construction enables very large sizes to be made—one model has dealt successfully with an input of 150 w. No distortion appears on over-loading. At present the design is available only in large sizes.

ELEKTRO-OPTISCHE GRUNDLAGEN DER LICHTSTEUERUNG MITTELS DER KERRZELLE FÜR DIE ZWECKE DES TONFILMS (The Electro-Optical Foundations of Light Control by the Kerr Cell for Sound-on-Film Purposes).—F. Hehlgans. (*Kinotechn.*, No. 24, Vol. 12, pp. 641–643.)

One point here dealt with, which is of particular importance for sound recording and phototelegraphy, is the question of d.c. bias working. If E_m is the e.m.f. necessary to reach the first maximum ($\omega t = \pi/2$), the optimum working point (reversal point of the static characteristic) is given by $E_0 = E_m/\sqrt{2} = 0.7171\ E_m$, and the maximum allowable amplitude by $E_{max.} = 0.2929\ E_m$. Under these conditions a control interval of 1 : 10 is obtained, which is sufficient for practical purposes.

DIE PHOTOGRAPHISCHEN ERFORDERNISSE DES TONFILMS (The Photographic Requirements of Sound-on-Film Films).—J. Eggert and R. Schmidt: A. Küster. (Long summary in *Physik. Ber.*, 1st April, 1931, Vol. 12, pp. 765–766.)

PAPERS ON THE CALLIER EFFECT AS A DISTORTING FACTOR IN SOUND-ON-FILM RECORDING.—Frieser and Pistor: Küster and Schmidt. (*Kinotechn.*, No. 22, Vol. 12, pp. 601–603.)

For summaries, see *Physik. Ber.*, 1st April, 1931, Vol. 12, p. 766.

SOUND-ON-FILM RECORDS WITH OPACITY VARYING WITH THE DISTANCE FROM AXIS OF FILM.—(French Pat. 700454, Brami, pub. 2nd March, 1931.)

For summary and diagram, see *Rev. Gén. de l'Élec.*, 30th May, 1931, Vol. 29, p. 194 D.

A MODERN LABORATORY FOR THE STUDY OF SOUND PICTURE PROBLEMS.—T. E. Shea. (*Bell Tel. Syst. Reprint*, April, 1931, Monog. B. 559, 9 pp.)

SOUND-FILM APPARATUS FOR EXPEDITIONS.—A.E.G. and Siemens & Halske. (*E.T.Z.*, 7th May, 1931, Vol. 52, p. 608.)

Summary of a paper by Freese and Lichte in the *AEG-Mitteilungen*.

ÜBER DEN FREQUENZBEREICH DES NADELGERÄUSCHES BEI SCHALLPLATTEN (The Frequency Range of Needle Scratch in Gramophone Records).—G. Buckmann and E. Meyer. (*E.N.T.*, May, 1931, Vol. 8, pp. 218–223.)

Since limiting the frequency range of reproduction at the upper limit is found to decrease needle scratch considerably, it is natural to assume that the latter contains very high frequency components. On the other hand it is often believed to contain particularly marked components round 4,000-6,000 p.p.s. The present investigation was designed to clear up these points. Grützmacher's automatic sound-analysis method was employed (1930 Abstracts, p. 163), the tests being made on "no-load" discs—*i.e.*, discs with only the unmodulated grooves.

It was found that, at the normal reproducing speed (80 r.p.m.) and with a "loud" needle, the velocity-amplitude of the needle noise increases with the frequency. The needle amplitude for individual partial tones, measured at the outer edge of the record, is about constant at around 3×10^{-6} cm. At the outer edge the high frequencies are more marked than at the inner edge. A decrease in r.p.m. brings a decrease of scratch; so does a wearing-out of the needle, at normal speed. The true scratch begins at about 400–600 p.p.s. (400 at the outer edge); but there is a second component, probably due to vibrations conveyed from the driving mechanism of the reproducer or else to a certain "waviness" of the surface of the record; this component begins round 400 p.p.s. and increases strongly at the lower frequencies, but on account of the ear's sensitivity curve it is barely noticed, being drowned by the high scratch frequencies.

ABSOLUTE AMPLITUDES AND SPECTRA OF CERTAIN MUSICAL INSTRUMENTS AND ORCHESTRAS.—L. J. Sivian, H. K. Dunn, and S. D. White. (*Journ. Acous. Soc. Am.*, Jan., 1931, Vol. 2, pp. 330–371; *Bell Tel. Syst. Reprint*, April, 1931, Monog. B.551, 42 pp.)

THE NATURAL FREQUENCIES OF THE ELASTIC TRANSVERSE VIBRATIONS OF LOADED STRINGS, RODS, MEMBRANES AND PLATES.—K. Klotter. (*Ing.-Arch.*, No. 5, Vol. 1, pp. 491–498.)

For summary see *Physik. Ber.*, 1st April, 1931, Vol. 12, p. 696.

LONG-PLAYING NEEDLES FOR GRAMOPHONES.—(*Rad., B., F.f., Alle* June, 1931, pp. 252–253.)

After discussing the ordinary tungsten-wire-in-steel needle, which he says requires great care in handling if it is to be used 100 times, the writer describes the new "Mil-Odi" needle, in which a much longer tungsten wire is embedded in a graphite cone. It is claimed that the extra working length of wire (3 to 4 mm. compared with 0.5 mm.) makes it possible to use this needle 1,000 times.

ELECTRICAL 'CELLO.—R. Raven-Hart. (*Wireless World*, 27th May, 1931, Vol. 28, pp. 572–573.)

Suggestions for replacing the sounding board and resonance chamber of a 'cello by an electrical amplifier. In the rough form of instrument described two high-resistance telephone earpieces are mounted on a board side by side, and over them is placed a piece of thin board on which, in turn, rests the 'cello bridge. The amplifier consists of a straightforward valve circuit and a tone former circuit as described by the author in *The Wireless World* of 10th December, 1930.

NOMOGRAMS FOR THE COMPLEX ROOTS OF CHARACTERISTICS (ESPECIALLY QUADRATIC OR CUBIC) EQUATIONS OF VIBRATION PROBLEMS: THE C. RUNGE DIAGRAM FOR FORCED VIBRATIONS.—Heck and Walther: von Sanden. (*Ing.-Arch.*, No. 5., Vol. 1, pp. 611–618: 645–647.)

For summaries see *Physik. Ber.*, 1st April, 1931, Vol. 12, p. 697

ON THE VIBRATION OF U BARS.—G. H. Keulegan. (*Bur. of Stds. Journ. of Res.*, April, 1931, Vol. 6, pp. 553–592.)

A NOTE-FREQUENCY OSCILLATOR STABILISED BY A TUNING FORK.—Mabboux. (*See* abstract under "Measurements and Standards.")

NEON TUBE OSCILLATOR CIRCUITS.—J. G. Hanhauser. (*QST*, June, 1931, Vol. 15, p. 39.)

Including a push-pull audio-oscillator circuit. Also an experimental r.f. transmitter circuit using only neon tubes. "It is probable that the circuit will work on frequencies as high as 3500 kc. and possibly higher."

PAPERS AND LETTERS ON ACOUSTIC (ECHO) SOUNDINGS: SYSTEMS: SLOPE CORRECTIONS: ULTRASONIC MIRAGE.—Florisson: Marti: Langevin. (*Hydrogr. Review*, May, 1931, No. 1, Vol. 8, pp. 122–143.)

BACTERICIDAL EFFECTS OF HIGH FREQUENCY AUDIBLE SOUND WAVES.—Williams and Gaines. (*See* under "Miscellaneous.")

PHOTOTELEGRAPHY AND TELEVISION.

ÜBER EINE NEUE SELEN-SPERRSCHICHT-PHOTOZELLE (On a New Attenuating-Layer Selenium Photocell).—L. Bergmann. (*Physik. Zeitschr.*, 1st April, 1931, Vol. 32, pp. 286–288.)

A preliminary account of a very sensitive attenuating-layer photocell consisting of a layer of selenium between two metallic surfaces, which behaves in a way analogous to the copper - copper oxide cell recently described by B. Lange (1930 Abstracts, p. 283 and Feb. Abstracts, p. 104. *See* also 1930 Abstracts, Duhme and Schottky, p. 636; Jan. Abstracts, Kerschbaum, p. 46; Feb. Abstracts, Schottky, Auwers and Kerschbaum, and Teichmann, p. 103; May Abstracts, Teichmann, p. 274) and may prove useful for relay regulation.

Increase of sensitivity is obtained by spraying a metallic surface on to the selenium in the form of a grating and also by covering the selenium with a transparent silver or gold surface by spraying from a cathode. The maximum sensitivity lies in the red end of the visible spectrum at 615 $\mu\mu$. The sensitivity is about 3.5 times as great as that of the copper - copper oxide cell. Conditions are altered when the cell has an electrical bias. *See* also next three abstracts.

THE LANGE PHOTOELECTRIC CELL: OUTPUT INCREASED FIFTY AND MORE TIMES BY USE OF SILVER SELENIDE: COST OF PLANT PER KILOWATT: GRONDAHL-GEIGER PATENT. (*Sci. News Letter*, 11th April, 1931, Vol. 19, pp. 227, 235–236.)

NEW LANGE PHOTOELECTRIC CELL APPLICATIONS. —B. Lange. (*Ibid.*, p. 235.)

"Patents on the newer photocells, with a fifty times augmented effect, have been applied for by myself and Siemens and Halske . . . The electrodes also differ in their arrangements from those already used by Grondahl and Schottky. . . The sensitivity of my cells is nearly the same as that of the human eye, the curves showing a value of only 10 % less than that of the eye. The cells are peculiarly sensitive to colour-differences and have a sufficiently large output of energy to be used for many purposes without amplification. We already have built up microscopes for metallurgical purposes, allowing an objective control, the ocular of the microscope being replaced by these cells. . . . We have already succeeded in transmitting phonograph records, working with infra-red rays instead of with the usual disks. All sorts of signalling methods through dense fog are possible by these methods. Even infra-red telephony over long range seems to be possible."

Other applications mentioned are for aircraft flying through clouds, to determine the sun's position: automatic control of rollers in steel mills by the glow from red-hot iron sheets; automatic determination of correct time for photographic exposures: microphotometers; and "one of Germany's biggest liners is going to be fitted with a new smoke and fire control on this principle." *See* also preceding two abstracts, and below.

ÜBER DIE SPEKTRALE EMPFINDLICHKEIT VON SPERRSCHICHT-PHOTOZELLEN (On the Spectral Sensitivity of Attenuating-Layer Photoelectric Cells).—B. Lange. (*Naturwiss.*, 5th June, 1931, Vol. 19, pp. 525–530.)

An account of exact measurements of the spectral sensitivity of various attenuating-layer photoelectric cells. Not only the whole visible spectrum but the neighbouring infra-red and ultra-violet regions lie within the range of a single cell. A description is given of an ocular form of photocell and investigations of the effect of temperature are described.

ÜBER EINIGE EIGENSCHAFTEN DES KUPFEROXYDULS (On Some Properties of Cuprous Oxide [Dependence on Temperature of Optical Absorption. Preliminary Communication]).—B. Gudden and G. Mönch. (*Naturwiss.*, 24th April, 1931, Vol. 19, No. 17, p. 361.)

DEVELOPMENTS IN TELEVISION.—W. G. W. Mitchell. (*Journ. Roy. Soc. Arts*, 22nd May, 1931, Vol. 79, pp. 616–642.)

Including references to the Baird directly-modulated arc (pp. 630 and 641) and to the principle of the modulated electron beam moving bodily past a fixed aperture for scanning purposes, as used by C. E. C. Roberts (Br. patent 318331) and by Farnsworth in America. The Farnsworth transmission system is described (pp. 636–637.)

SOME OPTICAL FEATURES IN TWO-WAY TELEVISION. —H. E. Ives. (*Bell Tech. Journ.*, April, 1931, Vol. 10, pp. 265–272.)

See April Abstracts, p. 218.

ZUR ERZIELUNG GRÖSSERER BILDPUNKTZAHLEN BEIM FERNSEHEN (Increasing the Number of Picture Elements in Television).—E. Kinne. (*Fernsehen*, No. 1, Vol. 2, pp. 36–38.)

The writer advocates an increase in the number of elements, without increasing the side-bands, by decreasing the framing frequency from 12.5 to 7 per sec. and projecting the image on to a screen with persistence of illumination. By the use of a suitable material the persistence-time may be as much as ½ sec. The fear that, with such a low framing frequency, motion would appear "jerky" is said to be disproved by experiment. On a 70-m. wave, each element of a 3×4 cm² picture can thus be reduced to ⅙ mm², giving a very clear image.

SYNCHRONISATION SYSTEM FOR TELEVISION, ETC.—(French Pat. 700457, Barthélémy and a Company, pub. 2nd March, 1931.)

For summary and diagram, see *Rev. Gén. de l'Élec.*, 30th May, 1931, Vol. 29, pp. 194 and 195D. *See* also Feb. and April Abstracts, pp. 102, 108, and 217 to 218.

SYNCHRONISIERUNG DES FERNSEHEMPFÄNGERS (Synchronising the Television Receiver).—G. Leithäuser and K. Sohnemann. (*Fernsehen*, No. 1, Vol. 2, pp. 5–8.)

After a description of the simpler methods and their disabilities (purely local control, requiring frequent re-adjustments; local control corrected by transmitting line-frequency impulses, satisfactory for still pictures but not for moving; use of a common a.c. mains network and its frequency, upset by phase changes caused by varying loads on the network) the writers concentrate on a method involving relaxation-oscillation trip-circuits. A sharp voltage peak is superposed at the transmitter at the beginning of every line. At the receiver, the current led to the trip-circuit is thus made up of these end peaks together with the actual picture current; the trip-circuit delivers only very sharp peaks which go direct to synchronise the phonic wheel. At the beginning of each line one element is thus wasted, but this is only noticeable for pictures with very few elements.

RECORDING AND THE PRODUCTION OF IMAGES BY ELECTRO-OSMOSIS.—M. Volmer. (*Zeitschr. f. wiss. Phot.*, Vol. 29, pp. 160–162.)

See also Feb. Abstracts, p. 96. In the apparatus now described, the impulses are given to a coloured liquid contained in an earthenware vessel lined inside and out with wire gauze. Any p.d. between these two coatings results in the emergence of the colouring matter. Ordinary paper is used, and half tones can be rendered.

THE ELECTRO-OPTICAL FOUNDATIONS OF LIGHT CONTROL BY THE KERR CELL.—Hehlgans. (*See* under "Acoustics.")

ZUR FRAGE DER ABHÄNGIGKEIT VON PHOTOSTROM UND LICHTSTÄRKE BEI GASGEFÜLLTEN ALKALIZELLEN (On the Question of the Relation between Photoelectric Current and Intensity of Illumination in Gas-Filled Alkali Photocells).—G. Kortüm. (*Physik. Zeitschr.*, 1st June, 1931, Vol. 32, pp. 417–425.)

An experimental investigation of the relation between photoelectric current and intensity of illumination in gas-filled alkali photocells shows that only very rarely is this relation truly linear; the relation varies with every change in the conditions under which the cell is used, and every cell used for photometric measurements must therefore be carefully tested and calibrated before use.

CYCLES ET TRAÎNAGE DANS LES CELLULES PHOTOÉLECTRIQUES À ATMOSPHÈRE GAZEUSE (Cycles and Lag-Effects in Gas-filled Photoelectric Cells).—G. A. Boutry. (*Comptes Rendus*, 7th April, 1931, Vol. 192, pp. 831–834.)

Further development of the work dealt with in May Abstracts, p. 275.

THE ANGULAR DISTRIBUTION OF PHOTOELECTRONS EJECTED BY POLARIZED ULTRAVIOLET LIGHT IN POTASSIUM VAPOR.—M. A. Chaffee. (*Phys. Review*, 15th May, 1931, Series 2, Vol. 37, pp. 1233–1237.)

PHOTOELECTRIC BEHAVIOUR OF ALUMINIUM AND ALUMINIUM-MERCURY ALLOYS: FATIGUE AND THE ABSORPTION OF OXYGEN.—H. Gerding. (*Zeitschr. f. phys. Chem.*, Dec., 1930, Vol. 11, Sec. B, pp. 1–37.)

Scraping *in vacuo* greatly increases the photoelectric sensitivity; fatigue is attended by oxygen absorption; the increase of the work of emergence is caused by the negative contact potential between oxygen and the metal.

BEMERKUNG ÜBER LICHTELEKTRISCHE ZELLEN UND DIE BILDUNG VON PHOTOELEKTRONEN (Remark on Photoelectric Cells and the Formation of Photoelectrons).—S. E. Sheppard and W. Vanselow. (*Physik. Zeitschr.*, 1st June, 1931, Vol. 32, pp. 454–455.)

CERTAIN PHOTOELECTRIC PROPERTIES OF GOLD.—L. W. Morris. (*Phys. Review*, 15th May, 1931, Series 2, Vol. 37, pp. 1263–1268.

THE PHOTOELECTRIC PROPERTIES OF SILVER.—R. P. Winch. (*Phys. Review*, 15th May, 1931, Series 2, Vol. 37, pp. 1269–1275.)

PHOTOELECTRIC EFFECT FROM A BARIUM OXIDE COATED PLATINUM FILAMENT.—Newbury & Lemery. (*See* under "Valves and Thermionics.")

MEASUREMENTS AND STANDARDS.

SUR UN ONDEMÈTRE ABSOLU POUR LA MESURE DES TRÈS PETITES LONGEURS D'ONDES (An Absolute [Cathode-Ray] Wavemeter for the Measurement of Ultra-Short Waves).—F. Dacos. (*U.R.S.I. Papers*, 1928 Assembly, Vol. 2, Fasc. 1, pp. 26–30.)

Depending on the deformations of an electron beam as it passes between two long deflecting plates connected to the condenser of a circuit oscillating at the required frequency. There are two variations of the method :—either the distance between nodes is measured and the wavelength obtained from this and from a knowledge of the electron velocity (which can be determined within about 1 %), or the arrangement is converted to a null method by the introduction of a series of spaced screens with openings, along the field of the deflecting plates ; when the electron velocity is adjusted to the correct value, these screens prevent any electrons from reaching the indicating electrode at the end of the tube, and the associated galvanometer gives a zero reading. The wavelength is then obtained from the electron velocity and the dimensions and spacings of the screen slits.

FREQUENCY MEASUREMENTS OF HIGH ACCURACY.—J. J. Vormer and C. van Geel. (*E.W. & W.E.*, June, 1931, Vol. 8, pp. 298–303.)

From the Dutch State Telegraphs Laboratory. The standard frequency is produced by a quartz oscillator (300,000 p.p.s.) whose output after amplification is employed to stabilise a tetrode multivibrator (150,000 p.p.s. for short waves, 60,000 p.p.s. for long waves) which thus acts as a synchronised oscillating amplifier with many and strong harmonics. For ease in determining the order of a certain harmonic, a second ("counting") multivibrator, of 600,000 frequency, is added in such a way that in the combined output the 4th, 8th and 12th harmonics are much stronger than the others and can easily be determined by an ordinary wavemeter. This is for short wave measurement ; for long waves a second multivibrator is also used, but in a different way : it is controlled by the 60,000-frequency multivibrator to give a frequency of 3,000 p.p.s.

After describing the procedures for long and short wave measurements of incoming signals, the writer deals with the stroboscopic method which is employed for *absolute* frequency measurements, such as the re-checking of the standard oscillator.

METHOD OF OBTAINING A QUARTZ-STABILISED FREQUENCY OF A REQUIRED EXACT VALUE.—Moens & Cosyns. (*See* abstract under "Stations, Designs and Operation.")

CONSTANT DIÉLECTRIQUE ET CONSTITUTION CHIMIQUE : MÉTHODE DE MESURE (Dielectric Constant and Chemical Constitution : Method of Measurement [by Improved Nernst A.C. Bridge].—A. Chrétien. (*Comptes Rendus*, 1st June, 1931, Vol. 192, pp. 1385–1387.)

The bridge is excited *indirectly*, by induction from an oscillating circuit maintained by a rather large triode ; in this way the frequency variation due to the adjustment of the capacity during the measurement is minimised. The indicator is no longer a telephone but a mirror galvanometer. Very careful screening is provided.

HOCHFREQUENZ-MESSEINRICHTUNG ZUR BESTIMMUNG DER DIELEKTRIZITÄTSKONSTANTEN (High Frequency Measuring Equipment for the Determination of Dielectric Constants).—K. Schlesinger. (*E.T.Z.*, 23rd April, 1931, Vol. 52, pp. 533–534.)

A compact equipment, for mains supply, for measuring dielectric constants at frequencies from 10^5 to 10^7 c.p.s. with an accuracy within 1 or 2 %. The bridge method used is based on the special capacitive potential divider evolved at the von Ardenne laboratory and dealt with in various past abstracts. *See* also next abstract.

EINE METHODE ZUR DEKREMENTSBESTIMMUNG DURCH KAPAZITÄTEN (A Method of Decrement [also Field-Strength Sensitivity, etc.] Measurement by the Use of Capacities [Capacitive Potentiometer]).—K. Schlesinger. (*E.N.T.*, April, 1931, Vol. 8, pp. 176–179.)

Description of the use of the von Ardenne Laboratory's capacitive potential divider (Feb. Abstracts, p. 106—3 abstracts) for the measurement of decrement, resonance resistance, and the field-strength sensitivity of receiving equipments ; it is mentioned that resonance curves and the transformation ratio of several coupled circuits can be measured by its use. The required values can be obtained by a single reading of the instrument. Sources of error are examined and are found to be avoidable by the employment of special auxiliaries (screened r.f. commutators with zero capacity between the contacts : such a device is illustrated and described). Practical experience in the calibration of field-strength measuring equipments has proved the accuracy of the method (within 3 to 5 %).

A full article on the subject will appear in *E.W. & W.E.* shortly.

ACCURATE MEASUREMENT OF SMALL ELECTRIC CHARGES [AND CAPACITIES] BY A NULL METHOD.—L. S. Taylor. (*Bur. of Stds. Journ. of Res.*, May, 1931, Vol. 6, pp. 807–818.)

A new method is described for calibrating a null system in such a way that the capacity of the leads does not come in ; the calibration error can thus be reduced to one tenth. When the system has once been calibrated, any unknown capacity whatever may be added to the leads without affecting the measurement of the desired quantities.

CALORIMETRIC INVESTIGATION OF THE DIELECTRIC LOSS OF LIQUID DIELECTRICS FOR SHORT WAVES.—Vogler. (*See* under "Subsidiary Apparatus and Materials.")

A METHOD FOR MEASURING HIGH VOLTAGES OR LOW CAPACITANCES [VIBRATING CONTACTS DEVICE].—J. A. Van den Akker. (*Review Scient. Instr.*, May, 1931, Vol. 2, pp. 290–292.)

Two vibrating tongues, each between a pair of contacts, are rigidly linked together and kept in motion (30 periods per sec.) by connection to an eccentric on a small motor. If C_1 a very small condenser and C_2 a much larger one, and V is the voltage to be measured, the cycle is as follows :—C_1 is charged to V and C_2 is discharged : C_1 shares its charge with C_2 and the two condensers assume the common potential $VC_1/(C_1+C_2)$: another contact is made and this potential is balanced against the potential V_p given by a potentiometer.

A.C. VOLTAGE MEASUREMENT BY EFFECT ON VALVE FILAMENT.—H. Keller. (*Rad., B., F.f.Alle*, June, 1931, pp. 250–252.)

After the anode current has been read with the filament heated by the a.c. under measurement, battery heating is switched on and adjusted to give the same anode current. *Cf.* Martyn, 1930 Abstracts, p. 461, who measured small alternating currents by passing them through the filament of a diode already partly heated by a fixed local current of the same frequency.

THE MAVOMETER AS A SELF-REGISTERING INSTRUMENT.—J. Dürrwang. (*Rad., B., F.f. Alle*, June, 1931, pp. 246–250.)

Application of a mirror mounted on the axis of the moving coil, together with photographic recording, to the "Mavometer," which is a sensitive and accurate instrument capable of measuring currents from 20 microampères and voltages from 1 millivolt.

A NEW TYPE OF BRIDGE BALANCE INDICATOR.—F. T. McNamara. (*Review Scient. Instr.*, June, 1931, Vol. 2, pp. 343–347.)

The thermionic valve type of balance indicator is subject to the objection that its rectifying action is poor for small voltages. The two-valve push-pull device here described overcomes this disadvantage and gives great sensitivity—adequate results being obtained with a portable microammeter. There is no need to match the two valves.

A NEW [SHUNTED] TYPE OF WATTMETER.—D. C. Gall. (*Journ. Scient. Instr.*, April, 1931, Vol. 8, pp. 126–130.)

ÜBER DIE KORREKTIONEN DER ZEITSIGNALE (Corrections to Time Signals).—E. Andersen. (*Gerlands Beitr.*, No. 4, Vol. 23, 1929.)

An intensive study of the differences between the corrections to the various European rhythmic time signals, throughout a six month period in 1928. The seasonal differences between observatories are analysed, and the systematic dependence of the difference between any two observations on the particular signal received is brought to light.

LES RETARDS À L'ENREGISTREMENT DES SIGNAUX HORAIRES RADIOTÉLÉGRAPHIQUES (Lag in Recording Radiotelegraphic Time Signals—R. Jouaust. (*U.R.S.I. Papers*, 1928 Assembly, Vol. 2, Fasc. 1, pp. 46–54.)

TIME FROM THE MAINS.—(*Wireless World*, 27th May, 1931, Vol. 28, pp. 556–559.)

Only during the last two or three years have the electricity supply companies paid attention to the constancy of the supply frequency. A list is given with this article of the various British undertakings which provide frequency-controlled a.c. and details are given of various electrical clocks now on the market. "The initial cost is no higher than that of a medium-grade spring clock, and at 1d. per unit the cost of running does not exceed 3s., and in some cases is as low as 6½d. per annum."

RADIOTELEGRAPHIC DETERMINATION OF LONGITUDE.—M. Hasimoto. (*U.R.S.I. Papers*, 1928 Assembly, Vol. 2, Fasc, 1, pp. 37–46.)

SUR UN GÉNÉRATEUR À LAMPE DE FRÉQUENCE TRÈS STABLE (A Valve Generator of Very Constant Frequency—Space-Charge Grid Connection).—P. David. (*Comptes Rendus*, 18th May, 1931, Vol. 192, pp. 1209–1210.)

The simple circuit finally adopted is so stable that variations of plus or minus 15 % in heating and plate voltages produce a frequency change not greater than 5 millionths. It is described as follows :—the oscillating circuit LC is connected, as usual, in the plate circuit of the two-grid valve. A reaction coil, coupled to L, yields an e.m.f. opposed to that of the plate ; this e.m.f. is applied simultaneously *to the two grids* by means of two polarising combinations each comprising a capacity shunted by a high resistance. The remarkable stability of such a simple arrangement has not yet been completely explained : it is certainly due in part to the shape of the plate and grid characteristics produced by the circuit, and there is also probably a control of phase by the condensers in the grid leads. But the large number of variables has, so far, prevented the writer from arriving at a mathematical explanation of the good results.

SUR UN OSCILLATEUR ÉLECTRIQUE À BASSE FRÉQUENCE STABILISÉ PAR UN DIAPASON (A Low Frequency Electrical Oscillator Stabilised by a Tuning Fork).—G. Mabboux. (*Comptes Rendus*, 11th May, 1931, Vol. 192, pp. 1154–1156.)

According to the writer, electrically driven tuning forks have hitherto depended either on a vibrating contact or on an auxiliary winding connected to the grid of a triode and fulfilling the same function in a more perfect way. But in such cases the *phase* of the impulses is not under control as it should be for obtaining isochronism. The writer employs the combination of a triode exciting a tuned circuit, and a tuning fork with a single iron-cored winding between its prongs. This winding (with a condenser in series to block the direct current) is connected between the grid (with its leak) and the oscillating tuned circuit. Thus the tuning fork takes the place of the quartz crystal in its ordinary grid-leak connection. In the case of the quartz, the piezoelectric vibration behaves as an imaginary self-inductance, as Dye has shown by his equivalent circuit. In the case of the tuning fork, the elastic and electromagnetic properties of the system introduce an imaginary capacity (after the fashion of Swinburne's "electro-dynamic condenser").

As the oscillating circuit is gradually brought into tune with the fork, the latter begins to move and beats are heard which get slower and slower until a sudden linking up occurs and the fork imposes its frequency on the oscillating circuit. The latter can then have its period varied by more than 5 % without breaking away from the fork control. The frequency thus stabilised is practically independent of feed potential. In the extreme case when this is changed from 40 to 120 v., the frequency variation is less than one-fifth of a period per second.

ÜBER DEN EINFLUSS DER UMGEBUNG AUF DIE FREQUENZ EINES SCHWINGQUARZES (On the Influence of Surroundings on the Frequency of an Oscillating Quartz Crystal).—E. Grossmann and M. Wien. (*Physik. Zeitschr.*, 1st May, 1931, Vol. 32, pp. 377–378.)

A preliminary account of an investigation of a possible source of error in the constancy of the frequency of a quartz oscillator, arising from the fact that the acoustic energy reflected from the surroundings back to the quartz influences the crystal oscillations (*cf.* theory of coupled circuits). The frequency variation may be avoided by placing the crystal in a vacuum or in an unalterable position in a constant temperature enclosure; the walls of the enclosure may be of irregular shape or covered with a medium absorbent for sound waves, *e.g.*, wadding or hydrogen or carbon dioxide gas. *Cf.* Florisson, July Abstracts, p. 394.

COMPARISON OF THE MAGNETIC ROTATIONS OF CRYSTALLINE AND MELTED QUARTZ.—A. Cotton. (*Comptes Rendus*, 18th May, 1931, Vol. 192, pp. 1166–1168.)

PIEZO-ELECTRIC QUARTZ OSCILLATOR WITH SINGLE FREQUENCY.—I. Koga. (*U.R.S.I. Papers*, 1928 Assembly, Vol. 2, Fasc. 1, pp. 15–16.)

This is the paper referred to by the writer in his *Proc. I.R.E.* paper dealt with in Feb. Abstracts, p. 104. "It is sometimes desirable that a quartz-oscillator should oscillate only at a single frequency, and at the same time very intensely. This paper gives a procedure to get such an oscillator." He sets up a second system of co-ordinates x', y' and z', connected by a given orthogonal scheme with the ordinary x (electrical axis), y (perpendicular to both axes), and z (optical axis) of the single quartz crystal. An oscillator cut perpendicularly to the y' axis cannot oscillate with more than one frequency, given experimentally by the relation $\lambda_{metres} = 150 \times t$, where t is the thickness in mm. in the direction of the y' axis.

INVESTIGATIONS INTO THE BEHAVIOUR OF QUARTZ-CONTROLLED TRANSMITTERS.—von Handel. (*See* under "Transmission.")

OSHIBKA PRI IZMERENII NAPRIAJENII ELECTRO-VACUUMNYMI VOLTMETRAMI S ZAKRYTYMI VHODNYMI TSEPIAMI (Errors associated with Valve Voltmeters employing Closed Input Circuits).—S. I. Panfilov. (*Westnik Elektrotechniki, Leningrad*, January, 1931, Part I, pp. 38–40.)

In Russian. In a valve voltmeter in which a thermionic valve is shunted across a resistance R, connected in series with a stopping condenser C across the source of the voltage V to be measured, the voltmeter gives an indication not of V but of V_R, the voltage across the resistance. The author discusses the error arising from this cause, and considers the cases of both diode and triode voltmeters. It is shown that (*a*) in the case of the diode voltmeter, the relative error

$$\epsilon = \frac{V - V_R}{V} \quad \ldots \quad \ldots \quad (1)$$

(*b*) in the case of the triode voltmeter, the relative error

$$\epsilon = \frac{V^2 - V^2_R}{V^2} \quad \ldots \quad \ldots \quad (2)$$

Using the fundamental equations:

$$\left.\begin{aligned} V^2 &= V^2_R + V^2_C \\ \frac{V_R}{V_C} &= RC\omega \end{aligned}\right\} \quad \ldots \quad \ldots \quad (3),$$

equations (1) and (2) are transformed as follows:—
(*a*) diode voltmeter:

$$RC\omega = \frac{1 - \epsilon}{\sqrt{2\epsilon}} \quad \ldots \quad \ldots \quad (5)$$

and (*b*) triode voltmeter:

$$RC\omega = \sqrt{\frac{1 - \epsilon}{\epsilon}} \quad \ldots \quad \ldots \quad (6)$$

From formulae (5) and (6) it is possible to select R and C so that a predetermined value of ϵ may not be exceeded. A table and curves are given from which ϵ can be found for different values of the factor $RC\omega$. It appears that ϵ is higher for a triode voltmeter. ϵ is almost entirely independent of frequency, except in the case of short waves.

RÖHRENSPANNUNGSMESSER FÜR STROMLOSE EMK-MESSUNG (Valve Voltmeter for the Currentless Measurement of E.M.F.).—Tödt and Thrun: E. Bluhm. (*E.T.Z.*, 11th June, 1931, Vol. 52, p. 772.)

LINE TRANSMISSION UNITS.—A. W. Ladner: O. S. Puckle: C. E. Rickard. (*Marconi Review*, March–April, 1931, pp. 19–25.)

A discussion on the use of the decibel in Wireless, prompted by Puckle's article (Jan. Abstracts, p. 50). Ladner points out that the line engineer has to deal with closely inter-connected circuits whose levels are maintained at a fairly constant value, so that it is relative values he talks in; but although he talks in these relative values, he has at the back of his mind all the time an input of definite value which is implied, if not actually stated. Further, his apparatus is always matched to a line of known constants both as regards input and output: in fact, it is the line which is the controlling factor in the system, and it is because the terminations are always the same that a relative system becomes useful.

The wireless engineer, on the other hand, has other conditions to deal with, and has to specify actual power output and input volts. Because of this, because the terminations are different and because of the necessity for stating actual figures, relative measurement is of little interest, "and it would be a great pity for us to adopt wholesale the telephone engineer's terminology, particularly as the units do not appear to be of too stable a character."

Puckle replies; Rickard sums up.

SIMPLIFIED INDUCTANCE CALCULATION.—L. H. Russell and G. B. Abraham. (*Electronics*, April, 1931, pp. 598–599.)

Curves are given, based on Nagaoka's formula, for the inductance of coils wound with one turn per inch; their use in practical receiver or transmitter design is explained.

GRAPHISCHE RECHENTAFELN (NOMOGRAMME) FÜR DIE BERECHNUNG DER SELBSTINDUKTION EINER SPULE (Nomograms for Calculating the Inductance of a Coil).—A. Fischer. (*E.N.T.*, April, 1931, Vol. 8, pp. 179–182.)

Two nomograms are given for the inductance formula $L = 9.87\,n^2 . \frac{d^2}{l} . \phi\left(\frac{d}{l}\right)$, where $\phi\left(\frac{d}{l}\right)$ is given in an auxiliary table for ten values of $\frac{d}{l}$ from 0 to 26. In both cases the "setting" and "reading-off" lines of the protractor are at right angles.

ÜBER DIE BERECHNUNG VON ZYLINDERSPULEN (Calculation of the Inductance of Cylindrical Coils).—A. Müller. (*Elektrot. u. Masch : bau*, No. 2, Vol. 49, pp. 29–30.)

The well-known formula $L = \frac{\pi^2 d^2 N^2}{b} . K$ (b being the axial length) gives no direct dimensions for a coil for a given required inductance. The writer, from tables of the constant K, obtains $K = \frac{1}{1 + 0.4\frac{d}{b}}$ so that d can be explicitly stated:—

$$d = \frac{0.2L}{N^2\pi^2} + \sqrt{\frac{bL}{N^2\pi^2} + \left(\frac{0.2L}{N^2\pi^2}\right)^2};$$

L is the inductance required, while b and N can be chosen to suit the particular requirements of the case. For a given inductance the total length of wire is least for $d/b = 2.5$.

THE EFFECT OF SMALL VARIATIONS IN PITCH UPON THE INDUCTANCE OF A STANDARD SOLENOID. —Chester Snow. (*Bur. of Stds. Journ. of Res.*, May, 1931, Vol. 6, pp. 777–790.)

Author's abstract:—A method is described by which the variations in pitch of a single-layer solenoid may be compared with those of the precision lathe screw used to wind it. Assuming that the pitch of the latter is constant, but not known with precision, it is shown how the precision measurements of the length of the windings may be combined with the former measurements to obtain the variation in pitch of the windings relative to an ideal helix whose beginning and end points coincide with the actual one. A mathematical formula for computing the correction δL to the inductance due to this variation in pitch is then developed. This formula requires the graphical integration of a certain function times the deformation, and practical methods of evaluating it are described. Application is made to observations on two standard solenoids and shows that the correction δL to the inductance L may amount to 4 or 5 parts in 100,000 even on the most carefully constructed solenoids. In absolute measurements the correction is, therefore, by no means to be neglected, although it seems hitherto not to have been taken into account in determinations of the ohm.

COMPARAISON ENTRE LES SYSTÈMES PRATIQUES D'UNITÉS ÉLECTROMAGNÉTIQUES (A Comparison of the Practical Systems of Electromagnetic Units.—First Part).—A. Blondel. (*Rev. Gén. de l'Élec.*, 16th May, 1931, Vol 29, pp. 771–783.)

A THERMIONIC MEGGER WITH LINEAR SCALE.—O. Stuhlman. (*Journ. Franklin Inst.*, May, 1931, Vol. 211, pp. 617–625.)

The slope of the characteristic of any three-element vacuum tube with dynatron characteristics may be calibrated in terms of an external resistance introduced into the anode circuit. The change in slope of a given phase of the characteristic can be shown to change in proportion to the change in external resistance, and it follows that for a predetermined current a voltmeter recording the potential across filament and anode can be calibrated to read resistances directly. "The voltmeter's linear scale is then a direct reading megohmeter."

THE DIRECT-READING CRYSTAL "GAUSSMETER" FOR MAGNETIC FIELD MEASUREMENT.—Dupouy. (*See* abstract under "General Physical Articles.")

RAPID METHOD OF MEASURING SOIL RESISTIVITY.—E. R. Shepard. (*Bur. of Stds. Journ. of Res.*, April, 1931, Vol. 6, pp. 706–707.)

In a long paper entitled "Pipe-Line Currents and Soil Resistivity as Indicators of Local Corrosive Soil Areas."

SUBSIDIARY APPARATUS AND MATERIALS.

Über Gleichrichterwirkungen an der Grenze von Kupferoxydul gegen aufgebrachte Metallelektroden (On the Rectifying Actions at the Surface of Contact of Copper Oxide and Applied Metallic Electrodes).—W. Schottky, R. Störmer and F. Waibel. (*Zeitschr. f. hochf. Tech.*, April and May, 1931, Vol. 37, pp. 162–167 and 175–186.)

The following are some points from this very long paper :—In the case of a copper plate with "grown-on" oxide layer and a graphite layer as front electrode, the blocking effect is only evident in practice at the surface oxide-mother copper, *not* at the oxide-graphite surface. This result, however, depends only on a quantitative, not a qualitative, difference in the blocking effects at the grown-on electrode (mother copper side) and at the applied electrode (front side). This was confirmed by measurements with silver, iron, gold and platinum sputtered on to the oxide. In these tests also, graphite showed only a very feeble blocking effect.

The blocking effect of sputtered gold is very slight at polished emery-cleaned or sand-blasted oxide surfaces, but great at surfaces chemically corroded. To determine whether the strong blocking action of the corroded surface was due to a special chemical state, tests were made with oxide layers in various states as regards saturation with oxygen. The blocking effect first decreased with increasing covering of CuO, then apparently increased slightly ; plates treated with hydrogen and plates evacuated both showed good blocking action. "There is nothing to indicate that the blocking action is not a property of the chemically pure Cu_2O." [Latest results showed that the corrosive action gives no quantitative difference in blocking effect whether it is performed by oxidising or reducing solutions. On the other hand, one and the same corroding medium can be made to produce a marked increase of pass-resistance relative to stop-resistance if it is allowed to attack very violently, so that the surface is mechanically affected by the development of gas.]

As a result of the above work, and of a discussion on conductivity observations on Cu_2O and CuO, the writers feel obliged to reject the electrolytic theory of the unipolar rectifying effect of the Cu_2O layer put forward by Pélabon (Feb. Abstracts, p. 110).

A number of experiments are described and discussed in which metal foils of various kinds served as electrodes (particularly high blocking effect being given by a mercury electrode pressing only by its own weight), and also others in which copper, silver or carbon points were used with varying pressures. Light pressure consistently gave high blocking action. To decide whether this pressure effect was a specific physical phenomenon or only an effect depending on the geometrical form of the surface of contact, *sputtered* electrodes of various very small dimensions were tested. The results lead to a theoretical treatment of the rectifying action on the assumption that with large electrodes, in those cases where a strong blocking effect is shown, there is no uniform contact between electrode and oxide but only a number of small separate surfaces of contact. It would appear that the pure geometrical effect has hitherto masked the specific effects of various electrode materials, various chemical compositions of the oxide surface, etc.

Copper-Oxide Rectifier of Many Series Elements of Wire Form.—(German Pat. 516394, Siemens and Halske, pub. 22nd Jan., 1931.)

Each element consists of a short piece of copper wire most of whose length is coated with oxide. A length of lead or zinc tube is pressed round the blank portion, and round the oxide-coated portion of the next element, leaving an air gap between the ends of the two elements. The whole wire can be wound into a spiral and placed in an oil bath.

Vacuum [Rectifier and Relay] Tubes in Industry.—P. G. Weiller. (*Rad. Engineering*, April, 1931, Vol. 11, pp. 31–34.)

Die Untersuchung dielektrischer Verluste flüssigen Isolierstoffe bei kurzen Wellen mit dem Kalorimeter (Calorimetric Investigation of the Dielectric Loss of Liquid Dielectrics for Short Waves).—H. Vogler. (*E.N.T.*, May, 1931, Vol. 8, pp. 197–207.)

A full description of measurement methods suitable for wavelengths from 100 to under 25 metres. The usual loss measurement methods (decrement and substitution methods) are unreliable for wavelengths below 300 m. owing to their dependence on frequency. The present procedure involves the use of the Kerr cell electrometer for the potential measurement and a specially developed high-frequency calorimeter (based on that employed by Pungs and Preuner) for the measurement of the losses.

In the final section of the paper the results are given of measurements on paraffin oil, xylol, transformer oil and turpentine ; the losses being plotted as functions of potential, frequency and temperature. They are found to vary with the potential according to an approximate square law (actually slightly higher than the square). For constant potential and temperature there is a linear relation between loss and frequency. The temperature curves show rapid decreases in loss with increase of temperature between about 5 and 30° C., attributed to the increased lack of homogeneity at the lower temperatures. Above this temperature more or less sudden increases in loss set in. "The character of the losses in liquid dielectrics becomes, at high frequencies, similar to that of the losses in solid dielectrics at low frequencies. At high frequencies the frequency-independent losses in liquids due to electrolytic conduction are completely submerged by the losses dependent on frequency."

A large number of references to other works are given. As regards the Kerr cell electrometer, the purification of the nitrobenzol was carried out by the distillation method used independently by Hehlgans (1930 Abstracts, p. 164) and the electrometer thus made reliable. The necessary great constancy of anode current in the amplification of the particularly minute photoelectric currents was only obtained by the use of the special Siemens space-charge-grid valves developed by Hausser, Jäger and Vahle (*see* Simon, July Abstracts, p. 391) with the control grid led out at the top through an amber insulator. Special compensation for fluctuations in the source of light was arranged for.

It is mentioned that some of the results do not agree with those described by Darmstaedter in his recent work on condenser losses (April Abstracts, p. 223).

EXTERNAL RECORDING WITH THE C.-R. OSCILLOGRAPH AT LOWER ACCELERATING VOLTAGES.—H. Boekels. (*Archiv f. Elektrot.*, Feb., 1931, Vol. 25, pp. 151–152.)

The accelerating voltage was decreased so that a photographic plate exposed (through a camera) to the outer side of the zinc sulphide screen received no appreciable blackening for a recording speed of 0.3 km. per sec. On increasing from 15.5 to 20 kv. an appreciable increase in the intensity of the trace occurred; at 17 kv. the recording speed could be increased to 4 km. per sec. Between 20 and 40 kv. the intensity was practically constant. Apparently the excited light in the zinc sulphide screen *undergoes a considerable change below* 20 *kv.* which makes it much less suitable for photographic purposes, though the change is not so noticeable to the human eye.

PAPERS ON THE CATHODE-RAY OSCILLOGRAPH AND THE SURGE GENERATOR.—F. D. Fielder: F. R. Benedict. (*Electric Journ.*, March and April, 1931, Vol. 28, pp. 161–164 and 216–218.)

Fielder's article is one of a series dealing with the general subject of c.-r. oscillographs; this instalment refers particularly to the methods for obtaining a time base. Benedict's article is also one of a series; it deals with the surge generator from the standpoint of the resulting wave forms: the practical damping-out of oscillations from the high voltage surge is discussed. The wave shape can be so controlled as to give wave fronts of from 1.5 to 20 microseconds, and tails of from 8 to 100 microseconds.

A NEW CATHODE-RAY OSCILLOSCOPE.—W. O. Osbon. (*Electric Journ.*, May, 1931, Vol. 28, pp. 322–324.)

Contained in a cabinet the size of an ordinary suit-case, this new portable oscilloscope for a.c. mains supply, with an indirectly heated cathode, gives images of recurring phenomena which can be seen in an ordinarily lighted room. A multivibrator oscillator provides the time base.

ÜBER DIE ZEITABLENKUNG BEI BRAUNSCHEN RÖHREN (The Time Base in Cathode-Ray Oscillographs).—G. Hauffe. (*E.T.Z.*, 2nd April, 1931, Vol. 52, pp. 446–447.)

A theoretical investigation of the common method of obtaining a time base by the discharge of a condenser through a resistance. The actual voltage curve is compared with the ideal, and is discussed in relation to the constants of the condenser circuit.

GROSS - KATHODENSTRAHL - OSZILLOGRAPH FÜR 200 KV. ABLENKSPANNUNG (Large C.-R. Oscillograph for 200 Kilovolt Deflection Potential).—L. Binder. (*E.T.Z.*, 4th June, 1931, Vol. 52, pp. 735–736.)

AN ULTRA-RAPID CINEMATOGRAPH RECORDING 2,000 TO 3,000 IMAGES PER SECOND.—E. Huguenard and A. Magnan. (*Comptes Rendus*, 1st June, 1931, Vol. 192, pp. 1370–1372.)

THE ACTION OF LOW SPEED ELECTRONS ON PHOTOGRAPHIC EMULSIONS.—R. E. Burroughs. (*Review Scient. Instr.*, June, 1931, Vol. 2, pp. 321–328.)

Among the conclusions reached are the following:—the developability induced by low speed electrons is largely due to radiations excited by the electrons in the residual gas about the plate, and is hardly, if at all (under the conditions of the work) due to the sensitive grain being hit by the electron and absorbing its energy directly; the lowest energy electron recordable is not a fundamental characteristic of the emulsion but is related to the critical potentials of the residual gas on and near the emulsion; and the sensitivity to slow speed electrons is proportional to the sensitivity of the emulsions to blue and ultra-violet light.

THE NEW SIEMENS UNIVERSAL OSCILLOGRAPH.—Eichler and Gaarz: Siemens Company. (*Siemens Zeitschr.*, No. 12, Vol. 10, pp. 635–644.)

Like the simple oscillograph referred to in July Abstracts, p. 396, this instrument uses a rotating mirror drum (of stainless steel) driven by the same motor that drives the paper drum. For a summary see *Physik. Ber.*, 1st April, 1931, Vol. 12, pp. 735–736; for an illustrated article, see *Zeitschr. V.D.I.*, 9th May, 1931, Vol. 75, pp. 583–584.

THE A.E.G. CONTINUOUS SURGE RECORDER.—A.E.G. (*Bull. de l'Assoc. suisse d. Élec.*, 29th May, 1931, Vol. 22, p. 270.)

The paper normally moves at from 2.5 to 20 mm. per hour, but the arrival of a surge speeds this up to 10 mm. per second for a length of time which may be regulated between 6 and 36 seconds.

THE DISTORTIONLESS AMPLIFICATION OF ELECTRICAL TRANSIENTS [FOR OSCILLOGRAPH WORK].—Oatley. (*See* under "Acoustics.")

THE "RECTRON" FULLY-AUTOMATIC MAINS VOLTAGE REGULATOR.—Rectron Company. (*Rad., B., F.f. Alle*, May, 1931, pp. 210–212.)

VOLTAGE REGULATORS, "RECTOX" AND OTHERS, AT THE PARIS EXHIBITION. (*See* Section VI of long abstract under "Miscellaneous.")

A SELF-REGULATING IRON-CORED CHOKE.—(French Pat. 696653, Optique et Précision de Levallois, pub. 6th Jan., 1931.)

The core ends in pole pieces which attract an armature: increase of current through the coil draws the armature nearer and increases the inductance of the winding. The armature is carried on a spring whose bending is controlled at its ends by cams of suitable shape or by fixed blocks traversed by adjustable screws; as a result, the current passed by the choke is kept constant. The application of the device to regulating a wind-driven aircraft generator is suggested.

GLEICHSTROMMASCHINEN ZUR BESEITUNG VON GLEICHRICHTERSTÖRUNGEN, I, II. (D.C. Motors for Smoothing the Output from Rectifier Plants, Parts I and II).—H. A. Rathke. (*E.N.T.*, April and May, 1931, Vol. 8, pp. 161–175 and 185–196.)

The use of a d.c. motor for this purpose has often been suggested and discussed, but up to the present has not met with success in practice owing to the fact that when the ordinary type of machine is used its dimensions have to be very large. The present paper examines the problem very exhaustively and describes the design of a special machine for the purpose which makes the method an economical one in all cases where continuous motive power is required for the auxiliaries of the rectifier plant. It has the added advantage that its smoothing is not affected by frequency fluctuations, whereas the usual resonant-circuit smoothing is often very sensitive to them.

NOTE ON THE OPERABILITY OF A SYNCHRONOUS MOTOR AT THE END OF A TRANSMISSION LINE.—W. H. Ingram. (*Proc. Camb. Phil. Soc.*, April, 1931, Vol. 27, pp. 244–249.)

The theory of integral equations is applied to the general case of a non-uniform transmission line. "The solution obtained for the current at any point on the line in the form of a rational function of the frequency of the two oscillators is of advantage when resonance effects are being considered; the latter effects are hard to trace in the case of the uniform line by the usual methods."

NEUE STRAHLUNGSMESSGERÄTE—THERMOELEMENTE—VON GESTEIGERTER EMPFINDLICHKEIT UND EINSTELLSCHNELLIGKEIT (New Radiation Measuring Apparatus—Thermo-elements—with Increased Sensitivity and Rapidity of Adjustment).—C. Müller. (*Naturwiss.*, 15th May, 1931, Vol. 19, No. 20, pp. 416–419.)

"A description of delicate new radiation thermo-elements of thickness down to .0002 mm., which considerably surpass the best types hitherto made both in sensitivity and rapidity of reading. A new construction principle is used which avoids soldering or welding and consists in covering a very fine conducting wire for part of its length with a layer of material of different thermo-electric properties, by diffusion of material placed on the wire."

PHOTOGRAPHIC METHOD OF SECURING COPIES OF DIAGRAMS, ETC., WITHOUT THE USE OF A CAMERA.—E. J. Haverstick. (*Review Scient. Instr.*, May 1931, Vol. 2, pp. 287–289.)

When the other side of the paper is printed on, the straightforward way of using the page as a negative is impossible. If, however, a piece of single-weight sensitised paper is placed with the sensitised side in contact with the picture, and light is applied to its back, a negative is obtained from which positives can be printed. Attention is called by the Editor to the Luminiophor Company's process using a phosphorescent screen in contact with the paper as a source of light. Durham's work is also mentioned.

A CAPILLARY ELECTROMETER OF IMPROVED DESIGN.—A. S. Gilson. (*Review Scient. Instr.*, June, 1931, Vol. 2, pp. 329–331.)

THE "PRISM DERIVATOR" AND THE "DIFFERENTIO-INTEGRAPH."—E. von Harbou. (*Zeitschr. f. angew. Math. u. Mech.*, No. 6, Vol. 10, pp. 563–585.)

The first instrument determines the direction of a curve at any point; the second enables the differential and integral curves to be drawn for any given curve. For a summary see *Physik. Ber.*, 15th April, 1931, Vol. 12, p. 818.

THE NEW STANDARD ECHO SUPPRESSOR.—W. F. Marriage, P. R. Thomas, and K. G. Hodgson. (*Elec. Communication*, No. 3, Vol. 9, 1931, pp. 196–202.)

Combining the desirable operating characteristics of the relay type with the simplicity of maintenance of the valve type, this "grid-jamming (valve type)" echo suppressor includes a "limiter," such that the output voltage is constant and independent of the input voltage between the levels normally encountered on present-day telephone circuits.

DISCHARGE TUBES AND THEIR TECHNICAL APPLICATIONS.—N. L. Harris and H. G. Jenkins. (*G.E.C. Journal*, May, 1931, Vol. 2, No. 1, pp. 4–15.)

Parts I and II, here given, deal chiefly with the historical development of these tubes and the detailed theoretical description of the discharge. Part III will deal with practical applications and methods of manufacture, with special reference to recent important developments.

PHOTOMETRIE DES NEONGLIMMLICHTES (Photometry of the Neon Glow Light).—M. J. Druyvesteyn and N. Warmoltz. (*Zeitschr. f. Phys.*, 1931, Vol. 68, No. 5/6, pp. 378–394.)

CURRENT COLLECTION IN HYDROGEN ATMOSPHERE.—R. M. Baker. (*Elec. Engineering*, April, 1931, Vol. 50, pp. 266–267.)

Giving five tentative conclusions from a series of test runs of commutators and slip rings in hydrogen.

HIGH OUTPUT NON-SULPHATING LEAD ACCUMULATOR.—Ch. Féry and Reynaud-Bonin. (*Comptes Rendus*, 27th April, 1931, Vol. 192, pp. 1035–1037.)

The negative plates are protected by separators which are permeable to the ions but impermeable to the gases tending to produce the sulphating. Remarkable comparative tests are described.

ÉTUDE SUR LES PILES THERMOÉLECTRIQUES (Research on Thermopiles: Part I.—Experimental. Part II.—Mathematical Theory).—J. Chappuis and A. Gouffé. (*Rev. Gén. de l'Élec.*, 18th April, 1931, Vol. 29, pp. 615–628.)

DISCUSSION ON TELEMETERING.—(*Bull. d. l'Assoc. suisse d. Élec.*, 20th March, 1931, Vol. 22, No. 6, pp. 137–146.)

COPIATORI DI MOVIMENTI A DISTANZA—TELEINDICATORI (The Reproduction of Movements at a Distance—Teleindicators).—G. Sartori: Piazzoli. (*L'Elettrotec.*, 5th May, 1931, Vol. 18, pp. 303–307.)

A comparison of the monophase field systems of the A.E.G., Siemens, and G.E.C. with the three-phase field system of Piazzoli; the writer sums up greatly in favour of the latter.

TELEMETERING.—V. Janicki. (*Bull. d. l. Soc. franç. d. Élec.*, April, 1931, Series 5, Vol. 1, pp. 341–386.)

ON THE SELF DISCHARGE OF DRY CELLS.—A. Makino. (*Journ. Soc. Chem. Ind. Japan*, No. 12, Vol. 33, p. 521B.)

For the purpose of developing methods of decreasing this self discharge, the following tests were made: (*a*) only the positive electrode was immersed in an electrolyte, and (*b*) the same electrode was immersed in the electrolyte in which a normal negative electrode was already placed. Manganese dioxide from different sources was tested. It was found that the drop in e.m.f. and capacity, for open circuit, sets in first at the anode and spreads gradually to the cathode; and that its amount depends on the concentration of the iron contained as an impurity in the manganese dioxide.

A DIRECT-READING HARMONIC MEASURING INSTRUMENT.—E. Hueter. (*E.T.Z.*, 9th April, 1931, Vol. 52, pp. 471–474.)

THE ELECTROSTATIC FIELD OF TWO TYPES OF CONDENSER. — W. Göhre. (*Zeitschr. f. angew. Math. u. Mech.*, Nov./Dec., 1930, Vol. 10, pp. 547–563.)

FIXED CONDENSERS (ELECTROLYTIC AND "ELECTRO-CHEMICAL") AT THE PARIS EXHIBITION. (*See* Section III of long abstract under "Miscellaneous.")

THE INSULATION OF HIGH VOLTAGE GENERATORS.—Brown Boveri Company. (Summary in *Zeitschr. V.D.I.*, 11th April, 1931, Vol. 75, pp. 468–469.)

PRESSGAS ALS ISOLATION IN HOCHSPANNUNGS-APPARATEN (Compressed Gas as Insulation in High Tension Apparatus).—A. A. Bölsterli. (*Bull. de l'Assoc. suisse d. Élec.*, 29th May, 1931, Vol. 22, pp. 245–254.)

"THIOBONITE," A NEW INSULATOR: "LA THIOLITHE" INSULATING VARNISHES (PHENOL DERIVATIVES). (*See* Section VII of long abstract under "Miscellaneous.")

STATIONS, DESIGN AND OPERATION.

OVERSEAS RADIO EXTENSIONS TO WIRE TELEPHONE NETWORKS.—L. Espenschied and W. Wilson. (*Bell Tech. Journ.*, April, 1931, Vol. 10, pp. 243–264.)

Authors' summary:—The development of intercontinental telephony through the agency of radio links connecting between the land networks is traced and its present trends indicated. A description is given of the facilities employed by the Bell System for overseas connections and connections to ships at sea. The transmission results secured with these facilities are set forth and some peculiar short-wave phenomena discussed. International problems of frequency use and conservation are briefly summarised. A fairly comprehensive bibliography of technical papers on transoceanic telephony is included at the end of the paper.

LE PROBLÈME DE L'ONDE UNIQUE EN TÉLÉPHONIE SANS FIL (The Problem of Common Wave Working in Wireless Telephony).—R. Moens and M. Cosyns. (*U.R.S.I. Papers*, 1928 Assembly, Vol. 2, Fasc. 1, pp. 85–88.)

It is easy enough to stabilise two stations by means of quartz oscillators; the difficulty is to stabilise them on the same frequency, or within 10 to 15 cycles of the same; for 1 mm. thickness on a quartz crystal represents some 3 million cycles per sec. The writers consider that Meissner's method of correcting the frequency of the quartz by a series condenser seriously decreases both the energy and the stability of the oscillations. They therefore recommend a method depending on the combining of a quartz-stabilised frequency ω with a much lower frequency Ω, one of the two resulting frequencies $\omega + \Omega$ or $\omega - \Omega$ being then filtered out for use as a stabilised wave of the exact length required. The procedure by which this result may be obtained in practice is described, two triodes of the same amplification factor and filament-plate resistance being employed. Two 20 watt "Fotos" valves were successfully used, plate voltage 440 v.

Theory indicates an advantage in giving a negative bias to both valves; this was found to be true in practice, and by a suitable adjustment an output wave was obtained of power "comparable with those of the component waves."

NEW TELEPHONY SYSTEM.—(*Wireless World*, 3rd June, 1931, Vol. 28, pp. 590–593.)

A description of the apparatus used in a public demonstration of short-wave single side-band duplex working recently carried out at the experimental station of the Matériel Téléphonique at Trappes, near Paris, by engineers of that company in co-operation with engineers of the International Telephone and Telegraph Laboratory through the radio station of the Spanish National Telegraph Co. of Madrid.

The method adopted for obtaining good synchronisation between the suppressed carrier at the transmitter and the local oscillator at the receiver, is that of transmitting a continuous radio-frequency "pilot wave" in addition to the speech side-band. This pilot is used at the receiver to synchronise the frequency of the local oscillator automatically, using purely electrical methods. The pilot frequency lies some 400 cycles outside the speech side-band, which has a breadth of some 3,000 cycles. This avoids any appreciable increase in total band width. The band width of the pilot itself is of the order of 30 cycles so as to cater for a maximum sudden fluctuation of ± 15 cycles of the carrier frequency in a period during which the synchronising circuit has not had time to take up a new stable position.

Fragen und Ziele der Flugsicherung (The Problems and Objectives of Aids to Aviation).—R. Benkenburg. (*Zeitschr. f. Flugtech.*, No. 24, Vol. 21, pp. 623–626.)

A short survey, including d.f. and weather services.

Die rundfunktechnischen Einrichtungen im neuen " Haus des Rundfunks " in Berlin (The Broadcasting Installations in the new Berlin " Broadcasting House "). — G. Lubszynski and K. Hoffmann. (*E.T.Z.*, 30th April, 1931, Vol. 52, pp. 561–566.)

Stockholms Nya Rundradiostation (The New Stockholm Broadcasting Station).—S. Lemoine and E. Magnusson. (*Teknisk Tidskr.*, 6th June, 1931, Vol. 61, pp. 114–122 of Supplement.)

Improvements to the Aircraft Set Type A.V.L. 10.—Soc. Franç. Radio-Élec. (*Bull. de la S.F.R.*, April-May, 1931, Vol. 5, pp. 59–62.)

GENERAL PHYSICAL ARTICLES.

A Theoretical Discussion of the Electrical Properties of the Soil.—White. (*See* under " Propagation of Waves.")

Material and Radiational Waves.—A. M. Mosharrafa. (*Proc. Roy. Soc. A*, May, 1931, Vol. 131, p. 335–339.)

Théorie électronique de l'Éther, de la Lumière, de l'Électromagnétisme et de la Gravitation (The Electronic Theory of the Ether, Light, Electro-Magnetism and Gravitation).—A. Véronnet. (*Rev. Gén. de l'Élec.*, 25th April and 2nd May, 1931, Vol. 29, pp. 651–660 and 702–710.)

" The mechanical theory of the ether has failed. The electronic theory of Lorentz, which has brilliantly explained the properties of matter and electricity, has lately been shown to apply equally to the ether. The writer helps to solve some of the difficulties which arise in such an application." *Cf.* 1929 Abstracts, p. 646.

Ansätze zur Quantenelektrodynamik (Suggestions for a Quantum Theory of Electro-dynamics).—M. Born and G. Rumer. (*Zeitschr. f. Phys.*, 1931, Vol. 69, pp. 141–152.)

The Sesmat Hypothesis and the Michelson Experiment. — A. Sesmat. (*Comptes Rendus*, 27th April, 1931, Vol. 192, pp. 1029–1032.)

The hypothesis referred to in June Abstracts, p. 340, is here used to explain Michelson's negative result.

Experimental Researches on the Magnetic Properties of Crystals: Contribution to the Measurement of Magnetic Fields [the Direct-reading Crystal " Gaussmeter "].—G. Dupouy. (*Ann. de Physique*, May-June, 1931, Vol. 15, pp. 495–591.)

X-Ray Studies of Motions of Molecules in Dielectrics under Electric Stress.—R. D. Bennett. (*Journ. Franklin Inst.*, April, 1931, Vol. 211, No. 4, pp. 481–487.)

Theory of Dielectrics.—J. H. J. Poole. (*Phil. Mag.*, April, 1931, Series 7, Vol. 11, No. 72, pp. 995–996.)

A letter pointing out a discrepancy between Guében's formula for the conduction current in dielectrics (May abstracts, p. 284) and a formula already obtained by H. H. Poole and confirmed by experiment. It is suggested that a possible explanation of the discrepancy is that both metallic and electrolytic conduction may occur in a dielectric.

Recent Dielectric Constant Theory and its Relation to Problems of Electrical Insulation.—J. W. Williams. (*Journ. Franklin Inst.*, May, 1931, Vol. 211, pp. 581–606.)

The Effect of Field Strength and Free Electrons on the Breakdown Time of Spark Gaps [Lichtenberg Figure Methods].—J. A. Tiedeman. (*Journ. Opt. Soc. Am.*, March, 1931, Vol. 21, p. 143.)

Die Theorien von G. Hertz über die Bewegungen langsamer Elektronen in Gasen (The Theories of G. Hertz on the Movements of Slow Electrons in Gases).—V. A. Bailey. (*Zeitschr. f. Phys.*, 1931, Vol. 68, No. 11/12, pp. 834–842.)

Hertz' diffusion equation proves to be only the special form assumed by Maxwell's equation for the diffusion of a gas under the irrelevant assumption that the electrons lose no energy in collision with molecules.

Remarks on some Publications of Ramsauer and of Franck and Jordan [on the Mean Free Path of Electrons in Gases].—V. A. Bailey. (*Phil. Mag.*, May, 1931, Vol. 11, No. 73, pp. 1052–1057.)

The Starting Potentials of the Corona Discharge in Neon.—F. M. Penning. (*Phil. Mag.*, April, 1931, Series 7, Vol. 11, No. 72, pp. 961–980.)

Oscillations in the Glow Discharge in Argon.—G. W. Fox. (*Phys. Review*, 1st April, 1931, Series 2, Vol. 37, No. 7, pp. 815–820.)

Author's abstract :—Report is made of radio frequency oscillations observed in argon glow discharges. The frequencies lie in the range of 10^4 cycles/sec. to 10^5 cycles/sec. in approximate harmonic relations. They are very sensitive to pressure changes but appear to bear no relation to the tube current. The peculiar action of a magnetic field on the oscillations is decribed. Some frequency calculations are made on the assumption that the potential distribution throughout the Faraday dark space can be represented by a parabola.

ELECTRICAL DISCHARGE IN GASES.—K. Schaposchnikof. (*Westnik Elektrot.*, No. 1, 1931, Part III, pp. 13–14.)

The writer calculates the value of the critical E_c on the basis of Spath's measurements, and finds $E_c \approx 95$ kv./cm.

THE SPECTRA OF THE CORONA DISCHARGE.—H. Oyama. (*Journ. I.E.E. Japan*, Jan., 1931, Vol. 51, pp. 2–6.)

Long summary in English. The d.c. corona discharge can develop continuously to the state of glow discharge—the positive corona to the positive glow and the negative to the negative glow. The main spectra are of the nitrogen band systems and no emission due to the molecular ions of oxygen is to be observed. The impulse voltage corona at atmospheric pressure forms a brush discharge and the spectra contain nothing but the second positive band of nitrogen.

ON THE FRACTION OF CURRENT CARRIED BY ELECTRONS AT THE CATHODE OF A MERCURY ARC. —K. T. Compton. (*Phys. Review*, 15th Feb., 1931, Series 2, Vol. 37, No. 4, pp. 468–469.)

Abstract only.

MECHANISCHE VERFORMUNGEN DURCH ELEKTRISCHE ENTLADUNGEN (Mechanical Deformations produced by Electrical Discharges).—O. Bethge. (*Ann. der Physik*, Series 5, 1931, Vol. 8, No. 4, pp. 475–499.)

ELECTRONIC VELOCITIES IN THE POSITIVE COLUMN OF HIGH FREQUENCY DISCHARGES.—E. Hedemann. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No, 8, pp. 978–982.)

THE FALL OF POTENTIAL IN CONDENSED DISCHARGES.—J. C. Street. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, pp. 1020–1021.)

Abstract only.

OSCILLATIONS AND TRAVELLING STRIATIONS IN AN ARGON DISCHARGE TUBE.—T. C. Chow. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, p. 1020.)

Abstract only.

UNIFORM COLUMNS IN ELECTRIC DISCHARGES.—J. S. Townsend. (*Phil. Mag.*, May, 1931, Vol. 11, No. 73, pp. 1112–1122.)

ON THE ELECTROSTATIC FIELD DUE TO AN ELECTRIFIED CONDUCTOR WITHIN A TUBE OR CHANNEL —Y. Miyamoto. (*Journ. I.E.E. Japan*, Feb., 1931, Vol. 51, No. 2, pp. 13–16.)

MISCELLANEOUS.

PUBLICATION INSTEAD OF PATENT. (*Electronics*, March, 1931, p. 560.)

" Out of the welter of patent contests and patent litigation in radio has come one interesting patent policy on the part of a company which maintains an important research department that is continuously making inventions and improvements. The executives of this company frankly declare that they are *not interested* in patents. They do *not* take out patents. Instead, they have found that the best way to avoid patent difficulties is to *publish*, as soon as possible, whatever their laboratory develops."

EXTENSION OF RADIO RESEARCH FACILITIES: NATIONAL BUREAU OF STANDARDS TO CONSTRUCT LABORATORY TO EXPAND RESEARCH FACILITIES.—Bureau of Standards. (*Commercial Stds. Monthly*, April, 1931, Vol. 7, p. 303.)

LA PROPAGATION CURVILIGNE D'INTÉGRALES INVARIANTES. CAS DES INTÉGRALES DOUBLES. PROPAGATION CORPUSCULAIRE (Curvilinear Propagation of Invariant Integrals. The Case of Double Integrals. Corpuscular Propagation).—A. Buhl. (*Comptes Rendus*, 27th April, 1931, Vol. 192, pp. 1006–1008.)

NOTE ON THE PROBABILITIES RELATING TO INTERMITTENT PHENOMENA OF VARIABLE DURATION.—E. Baticle. (*Comptes Rendus*, 8th June, 1931, Vol. 192, pp. 1429–1431.)

BAYES' THEOREM [ON *a posteriori* PROBABILITY PROBLEMS].—E. C. Molina. (*Bell Tel. Syst. Reprint*, April, 1931, Monog. B. 557, 11 pp.)

ON PERIODICITY IN SERIES OF RELATED TERMS.—G. Walker. (*Proc. Roy. Soc. A*, June, 1931, Vol. 131, pp. 518–532.)

DAS GENAUIGKEITSMASS VON SUMMEN, DIFFERENZEN, PRODUKTEN UND QUOTIENTEN DER BEOBACHTUNGSREIHEN (The Measure of Accuracy of Sums, Differences, Products and Quotients of Series of Observations). (*Naturwiss.*, 3rd April, 1931, Vol. 19, No. 14, p. 310.)

LES TENDANCES ACTUELLES DE L'INDUSTRIE RADIOÉLECTRIQUE (The Trend of Progress in the Radio Industry [based on the 1930 Paris Show]).—L. Abèles. (*Rev. Gén. de l'Élec.*, 23rd May, 1931, Vol. 29, pp. 827–840.)

I. Valves. For l.f., low impedance triodes with slopes of 3.5 mA./v. (Radiofotos F.5, Radiotechnique R.80), more than 5 mA./v. (Radiofotos F.10), or even 8 mA./v. (Celsior P.U.801), the filament of the last valve being of a total length of 40 cms. and absorbing 7.2 w. For output, 3-grid power valves are often used, with an "accelerating" and a "protection" grid (to prevent a reverse anode current)—*see* van Sluiters, 1929 Abstracts, p. 512. The Celsior H.P.100/63, however, has only an accelerating and a control grid. For very high powers, triodes with a high anode dissipation are used; some types for anode potentials approaching 1,000 v. (Fotos P.60 and Radiotechnique E.605) begin to resemble transmitting rather than receiving valves. The great progress in ordinary triodes is illustrated by curves of an old triode, a Fotos D.40 (for high and intermediate frequencies) and the Fotos F.10 mentioned above (for the last l.f. stage). A section deals with directly-heated filaments; the mechanical procedure for depositing the oxide coat is yielding to electrolytic (Celsior), chemical or physico-chemical methods. As core metal, tungsten, nickel (Celsior), and platinum-iridium are used; Konel, "which would give a greater emissive power, does not appear to be employed by French makers." In certain valves, such as the argon-filled types (Valvgaz Fotos), the filament is of molybdenum. Thoriated tungsten filaments are hardly used any more, except for high powers and for transmitting, where their higher consumption is made up for by their being workable with anodes at high temperatures. Another section deals with indirectly-heated cathodes. The writer ends by remarking that, in spite of the great progress, improvement is still needed especially with regard to uniformity in manufacture and to length of life. He also puts in a plea for standardisation of nomenclature among European manufacturers.

II. Photoelectric and "photoresistive" cells. The latter title refers to selenium and thallium cells, among which the "Fournier" cell (sensitive to infra-red light) is singled out for its "interesting applications" (infra-red pyrometer, burglar-alarm system). III. Fixed condensers: electrolytic (particularly "La Thiolite"; rolled bands of aluminium and tin separated by paper impregnated with a little-ionised electrolyte and then treated with glycerin to prevent evaporation: this self-healing condenser is treated at some length): the so-called "electro-chemical" condensers ("Oxiron," "Filtrad") rather on the lines of gas accumulators: paper condensers.

IV. Rectifiers. VI. Voltage Regulators: "Rectox" (double compounding of inductance), neon-tube regulators, "Oxiron" electro-chemical condenser (used as a regulator, the leakage current increasing very rapidly when the voltage rises above its normal value), magnetic, iron ballast regulators (only an imperfect solution), "Reglex" regulators "which on the other hand give a very satisfactory result" (using an inductance-capacity resonance circuit with a partially saturated magnetic circuit in the inductance; resonance is only obtained for a definite voltage across the inductance).

VII. Insulating materials, particularly "thiobonite," resembling "thionite" in its preparation but not so fragile and more easily worked, about 40 % of a "particular form of ebonite" being incorporated; the mixing takes place with the components in an almost colloidal condition. Dielectric strength is about 30,000 v./mm.—better than that of thiolite; resistivity, about 3×10^8 megohms-cms., is near that of amber. Many other particulars of this dielectric are given; its dielectric loss coefficient shows that it is very suitable for high frequency work. Insulating varnishes (phenol derivatives) are also mentioned. VIII. Receiving sets: "Radiola," superheterodyne (with L. Chrétien anti-fading device acting on the screen-grids of the intermediate-circuit valves); short wave receivers—"only represented by a few classical types" (except an American apparatus for commercial service).

IX. Loud Speakers. X. Pick Ups. XI. Resumé and conclusion. The writer remarks on the absence of receivers resembling the American sets with near- or distant-control by a single push-button, of band-pass filter receivers, of television sets, electrostatic loud speakers, copper *sulphide* rectifiers, etc.; on the comparatively few foreign exhibits; and on the lack of informative literature.

THE RÔLE OF RADIO IN THE GROWTH OF INTERNATIONAL COMMUNICATION.—H. H. Buttner. (*Elec. Communication*, No. 4, Vol. 9, 1931, pp. 249–254.)

LA PROPAGANDE ILLICITE ET LA RADIODIFFUSION (Illicit Propaganda and Broadcasting).—(*Journ. Télégraphique*, Jan., 1931, Vol. 55, pp. 7–11.)

REPORT ON THE GEODETIC APPLICATION OF WIRELESS TELEGRAPHY.—H. L. P. Jolly. (*Hydrogr. Review*, May, 1931, No. 1, Vol. 8, pp. 227–229.)

ENGINEERING TESTIMONY BEFORE OFFICIAL BODIES.—E. H. Felix. (*Proc. Inst. Rad. Eng.*, May, 1931, Vol. 19, pp. 851–855.)

Discussing the requirements for the effective presentation of testimony on engineering subjects.

PUBLIC UTILITIES REDUCE RADIO INTERFERENCE.—H. O. Merriman. (*The Bulletin, Hydro-Elec. Power Comm. of Ontario*, March, 1931, Vol. 8, pp. 80–105.)

A paper by the engineer-in-charge, Interference Section of the Radio Branch Department of Marine, on the methods and results of his Section in tracing and curing man-made interference. *See* also June Abstracts, p. 341.

DIE AUFSUCHUNG VON STÖRERN DES FUNKEMPFANGES (The Tracing of Sources of Interference with Broadcast Reception).—F. Conrad and A. Schöne. (*E.T.Z.*, 28th May, 1931, Vol. 52, pp. 697–700.)

The ordinary "d.f." methods are of limited application only, and special attention is here paid to the so-called "tracking" method in which distribution of the r.f. disturbance-voltage along the power supply network is traced and the disturbance thus followed to its origin. Several successful examples of the use of this method are described and illustrated by sketch maps. The most difficult case only took about one and a half hours.

MUTUAL IMPEDANCE OF GROUNDED WIRES ON THE SURFACE OF A TWO-LAYER EARTH.—J. Riorden and E. D. Sunde. (*Phys. Review*, 15th May, 1931, Series 2, Vol. 37, pp. 1369–1370.)

TÉLÉPHONIE PAR COURANTS PORTEURS SUR LIGNES À HAUTE TENSION (Carrier Current Telephony on H.T. Power Lines).—M. Saglio. (*L'Onde Élec.*, May, 1931, Vol. 10, pp. 189–220.)

SYMPOSIUM ON CO-ORDINATION OF POWER AND TELEPHONE PLANT.—(*Bell Tech. Journ.*, April, 1931, Vol. 10.)

Introductory Remarks : R. F. Pack (pp. 155–158). Trends in Telephone and Power Practice as Affecting Co-ordination : W. H. Harrison and A. E. Silver (pp. 159–183). Status of Joint Development and Research on Noise Frequency Induction : H. L. Wills and O. B. Blackwell (pp. 184–205). Status of Joint Development and Research on Low-Frequency Induction : R. N. Conwell and H. S. Warren (pp. 206–230). Status of Co-operative Work on Joint Use of Poles : J. C. Martin and H. L. Huber (pp. 231–240). Closing Remarks : B. Gherardi (pp. 241–242).

APPLICATIONS FOR THE LANGE PHOTOELECTRIC CELL : THE SILVER SELENIDE CELL.—B. Lange. (*See* two abstracts under " Phototelegraphy and Television.")

ÜBER OBJEKTIVE VERGLEICHSPHOTOMETER (On Objective Comparison Photometers).—H. Teichmann. (*Physik. Zeitschr.*, 1st March, 1931, Vol. 32, No. 5, p. 216.)

A note on the principle of construction of objective comparison photometers, using (*a*) a photocell (cf. February Abstracts, Teichmann, p. 102, and Lange, p. 104), and (*b*) e.m.fs. of thermoelectric origin, which give reliable comparison of energies when the light sources are of different colours.

SINGULARITIES PRESENTED BY BODIES SUBMITTED TO THE ACTION OF RESISTANCE CELLS.—G. Reboul. (*Comptes Rendus*, 20th April, 1931, Vol. 192, pp. 926–928.)

More work on the lines referred to in 1930 Abstracts, p. 413.

THE IONIC WIND VOLTMETER AND THERMO-ELECTROSTATIC RELAY.—W. M. Thornton, M. Waters and W. G. Thompson. (*Journ. I.E.E.*, April, 1931, Vol. 69, pp. 533–544.)

Investigation of the phenomenon of electric wind, leading to the design of a thermo-electric voltmeter which makes use of it for measuring high a.c. or d.c. voltages. It can be used also to actuate relays by which the line voltage is automatically controlled.

ELECTRON DEVICES IN D.C. POWER TRANSMISSION : REVOLUTIONARY PRACTICES, RESULTING IN ECONOMIES AND ADVANTAGES.—C. W. Stone. (*Electronics*, March, 1931, pp. 554–555.)

ENGINEERING APPLIED TO PACKAGING.—D. Cassidy. (*Electronics*, March, 1931, pp. 558–559.)

COUNTING BEES BY WIRELESS.—(*Discovery*, May, 1931, Vol. 12, p. 136.)

From America. A microphone is placed in the entrance to the hive, and as the bees pass over it the movement of their feet generates a current which, when amplified, operates a counting device.

GERMS KILLED IN LABORATORY BY HIGH-PITCHED SOUND WAVES.—O. B. Williams and N. Gaines. (*Sci. News Letter*, 21st March, 1931, p. 179.)

Experiments on the destruction of bacteria by audible sound waves of frequency about 8800 p.p.s.

BACTERICIDAL EFFECTS OF HIGH FREQUENCY AUDIBLE SOUND WAVES.—O. B. Williams and N. Gaines. (*Journ. of Infectious Diseases*, Dec., 1930, Vol. 47, pp. 485–489.)

Experiments with intense magnetostrictively generated waves of frequency about 8800 p.p.s.

DEPTH- AND SELECTIVE-EFFECTS OF SHORT AND ULTRA-SHORT ELECTRIC WAVES.—E. Schliephake. (*Fortschr. a. d. Geb. d. Röntgenstr.*, Vol. 42, Second Congress Number, p. 39.)

APPLICATIONS MÉDICALES DES ONDES ULTRACOURTES (Medical Applications of Ultra-Short Waves). P. Ancelme : Kotzareff. (*L'Onde Élec.*, May, 1931, Vol. 10, pp. 221–232.)

UN MYOGRAPHE PIÉZO-ÉLECTRIQUE. SON APPLICATION À L'ANALYSE DE LA SECOUSSE ISOMÉTRIQUE DES MUSCLES (A Piezoelectric Myograph and its Application to the Analysis of the Isometric Contraction of Muscles).—A. M. Monnier. (*Comptes Rendus*, 8th June, 1931, Vol. 192, pp. 1487–1490.)

Reference is also made to the work of Bugnard and Gley on the registration of arterial pressure.

AN AUTOMATIC RACE TIMER.—E. A. Speakman. (*Review Scient. Instr.*, May, 1931, Vol. 2, pp. 297–304.)

A combination of a microphone, a photoelectric cell, an amplifier and a clock, which will time track races without human intervention to an accuracy of 0.01 sec. A slight modification of the circuit would make it suitable for automobile or horse races.

PIEZO-ELECTRIC GAGE AND AMPLIFIER.—R. A. Webster. (*Journ. Franklin. Inst.*, May, 1931, Vol. 211, pp. 607–615.)

An account of a piezo-electric gage and a resistance-coupled amplifier for recording gun pressures.

AN INSTRUMENT FOR MEASURING SMALL DISPLACEMENTS [BALANCED MAGNETIC CIRCUIT AND VARIABLE AIR GAP].—B. F. Langer : J. G. Ritter. (*Review Scient. Instr.*, June, 1931, Vol. 2, pp. 336–342.)

INFRA-RED PHOTOGRAPHY WITH " AGFA " NEOCYANIN, KRYPTOCYANIN, ETC.—W. Dieterle. (Long abstract in *Physik. Ber.*, 1st April, 1931, Vol. 12, p. 765.)

VALVE METHODS OF RECORDING SINGLE ALPHA-PARTICLES IN THE PRESENCE OF POWERFUL IONISING RADIATIONS.—C. E. Wynn-Williams and F. A. B. Ward. (*Proc. Roy. Soc. A*, May, 1931, Vol. 131, pp. 391–409.)

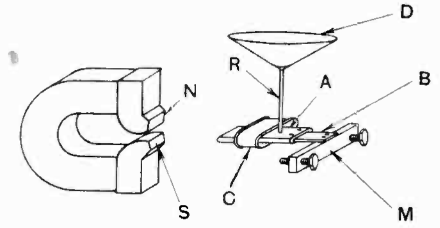
Some Recent Patents.

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.

LOUD SPEAKERS.

Application date, 15th November, 1929.
No. 343544.

The armature *A* carrying the speech coil *C* consists of a strip or bar mounted on a flat spring *B* attached to a member *M*, which is adjustably fixed to regulate the distance between the tip of the armature and the pole pieces *NS*. In operation,



No. 343544.

the armature, which does not appreciably overlap the air gap between the magnet poles, drives a conical diaphragm *D* through the rod *R*.

Patent issued to C. Grau.

DIRECT-COUPLED AMPLIFIERS.

Application date, 14th December, 1929. No. 344936.

A resistance-coupled chain of amplifiers, of the kind in which the plate of one valve is directly connected through a resistance to the grid of the next, is characterized by the provision of a resistance in the grid-filament circuit of each valve Either the filament-heating current, or the plate current, or both, flow through this resistance and produce a potential drop which counteracts the high positive potential on the grid due to its direct connection with the plate of the preceding valve.

Patent issued to Standard Telephones and Cables, Ltd., E. K. Sandeman, and J. S. Lyall.

DRY-CONTACT RECTIFIERS.

Application date, 7th October, 1929. No. 346653.

The rectifier is formed of an electrode system containing a solid substance sandwiched between two conductive surfaces, one of the latter and the intermediate substance being mutually adsorbed. By adsorption is meant a surface contact effect (as distinguished from ordinary chemical combination) between two layers of material one of which is deposited upon the other from vapour, the requisite condition being that the adsorbed substance has a lower vapour pressure in that state than in its free condition. One electrode is a thin sheet of latten brass or a strip of tin-foil. The intermediate substance is a film of common salt deposited by volatilizing the salt in the immediate neighbourhood of this sheet. The second electrode is a layer of magnesium deposited on the salt film from an atmosphere of magnesium.

Patent issued to S. G. S. Dicker.

BROADCASTING STUDIOS.

Application date, 14th October, 1929. No. 346792.

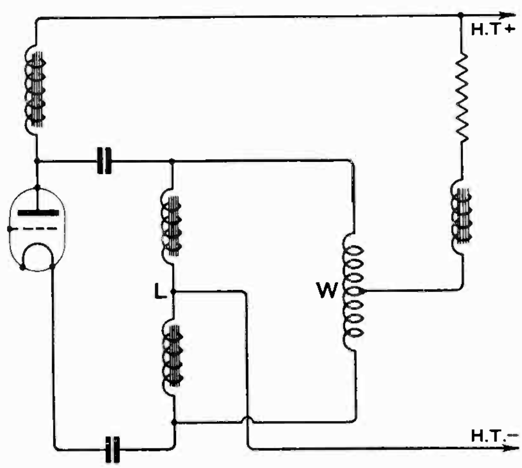
In order to impart desirable acoustic properties to a broadcasting studio, the walls are wholly or partly replaced by portable screens, formed of slats, laths, or panels of comparatively small area. This affords a flexible surrounding which may be rapidly adjusted to secure any required damping reflection or "sound scattering" effect.

Patent issued to A. Benjamin.

MOVING-COIL SPEAKERS.

Application date, 9th December, 1929. No. 342070.

The output from the amplifier is fed through a capacity filter to the moving coil *W* of the speaker. The coil is freely suspended and is centre-tapped to the H.T. supply, the ends being connected across an audio-frequency choke *L* centre-tapped to the negative H.T. terminal. Since direct current passes through the two halves of the coil *W*, the magnetic forces are equal so long as the coil is central. When in operation, one-half of the coil moves away from the centre of the magnetic field while the other half moves towards it. A resultant



No. 342070.

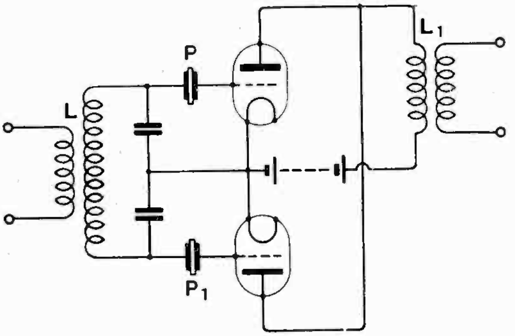
force is thus exerted on the moving system, tending to restore the coil to its central position. This ensures a damping action which is proportional to and in phase with the speech currents.

Patent issued to O. D. Lucas.

SELECTIVE RECEIVERS.

Application date, 28th November, 1929. No. 344034.

The incoming signals are fed in phase opposition to two piezo-electric oscillators, which have slightly different resonant-frequencies and are connected



No. 344034.

to a common output circuit. For instance the crystals P, P_1 fed from opposite ends of the input coil L may have a fundamental frequency-difference of ten cycles. Owing to the phase reversal, only currents having a frequency lying between that of the crystal P and the crystal P_1 will flow in the output circuit L_1, all other frequencies being substantially balanced out.

Patent issued to J. Robinson.

DISTANT CONTROL BY WIRELESS.

Convention date (Germany), 12th December, 1928. No. 343924.

The operation of a fog-horn, light-buoy, or other navigation signal is controlled by wireless transmission from a distant point of supervision. The unmanned station is fitted with a wireless receiver which is energised at short but regular intervals by suitable clockwork mechanism during the daylight hours when the signalling apparatus is normally out of operation. To bring the apparatus into action from a distance, say on the sudden onset of fog, a wireless impulse is transmitted from the supervisory station and is picked up by the distance receiver, during one of the periods when the latter is energised. The receiver then operates a relay, which in turn actuates the navigation signal.

Patent issued to J. Pintsch Akt.

GLOW-DISCHARGE AMPLIFIERS.

Convention date (Germany), 17th October, 1928. No. 341061.

A tube of the glow-discharge type, in which there is no heated cathode, is utilized as an amplifier for small current-variations in the same way as a thermionic valve. The discharge is first initiated between a cathode and anode, the electrons being drawn off by means of a second anode at a higher potential than the first. According to the invention, the first anode is made as a plate, *i.e.*, it has a substantially continuous surface though one or more openings may be provided opposite corresponding openings in the cathode. It may be surrounded by a spiral wire, which acts as a grid or control member. With this arrangement the discharge tube operates with an amplification factor of 6 and a mutual conductance of 2.5 mA.

Patent issued to G. Seibt and H. Bley.

DUPLEX SIGNALLING SYSTEMS.

Application date 16th October, 1929. No. 341480.

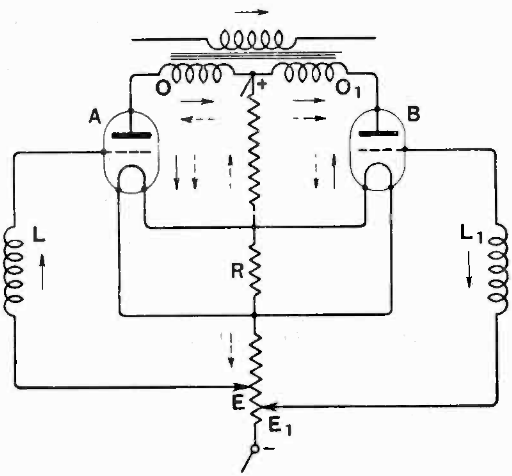
In long-distance radio signalling, the terminal equipment is so arranged as to allow both outgoing and incoming channels to be continually in use either for code messages or speech. When speech is being transmitted outwards, the incoming channel at the same station is automatically recording Morse messages transmitted by a code printer-sender from the distant station. As soon as the spoken message ends, the line is automatically connected to a Morse sender which is maintained in operation so long as speech is being received over the incoming line. The relays for effecting the necessary circuit changes are controlled by shunt currents derived from either the incoming or outgoing signal currents.

Patent issued to Standard Telephones and Cables, Ltd.

ELIMINATING MAINS "HUM."

Convention date (Germany), 13th October, 1928. No. 341472.

An amplifier energized from D.C. mains comprises two valves AB supplied in push-pull from the secondary windings L, L_1 of an input transformer. The filaments are fed in parallel across a portion R of the supply potentiometer, grid-bias being



No. 341472.

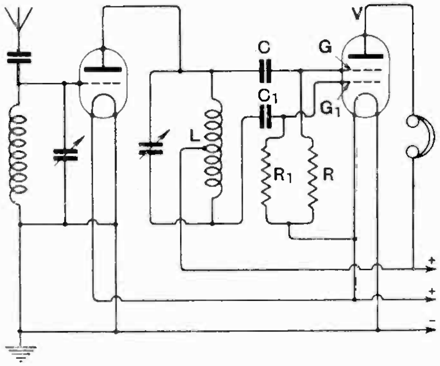
taken from tappings E, E_1. Any fluctuation in the mains supply voltage will set up "in-phase" variations on the plate and grid of each valve, and these can be made to balance out in the output windings O, O_1 by suitable adjustment of the grid-bias tappings E, E_1.

Patent issued to International General Electric Co., Inc.

GRID-LEAK DETECTION.

Convention date (Holland), 20th June, 1929. No. 347018.

A double-grid valve *V* is used to prevent fortuitous anode-bend rectification, such as is liable to occur if large voltage-swings are applied to a circuit designed for grid-leak detection. The two



No. 347018.

grids G, G_1 are so connected to the plate inductance L of the preceding high-frequency amplifier that the applied grid-voltages are 180° out of phase. As shown, the grid G is connected to the top, and the grid G_1 to the bottom of the plate coil L, which is centre-tapped to the high-tension supply. Should anode rectification occur, it is in phase-opposition from the two grids, and can have no effect on the output current; whereas detection due to the two condensers C, C_1 and leak resistances R, R_1 is cumulative.

Patent issued to N. V. Philips Gloeilampenfabrieken.

TRANSFORMER COUPLINGS.

Convention date (Holland), 28th September, 1929. No. 347085.

As the step-up ratio of a coupling-transformer is increased, the effective amplification falls off rapidly, particularly at the higher frequencies. This effect is avoided, and uniform amplification ensured over a wide frequency range, by inserting an inductance in series with the primary winding, and one or more shunt condensers across it. Formulae are given relating the dimensions of the inductance and capacity to the internal resistance of the valve. The net effect is that of a band-pass filter with a predetermined cut-off frequency. The arrangement gives satisfactory results with a step-up ratio as high as one to ten.

Patent issued to N. V. Philips Gloeilampenfabrieken.

PIEZO-ELECTRIC CRYSTALS.

Convention date (U.S.A.), 19th December, 1928. No. 345269.

Piezo-electric crystals may be cut so as to have either a positive or negative temperature coefficient, according as the cut is made parallel to the optical and electrical axes, or to the optical and mechanical axes. According to the invention this principle is utilized to produce crystals having a substantially-constant temperature coefficient. The same result may be attained by cutting one or more holes of calculated size through the body of the crystal. The crystal may be cut at a predetermined angle to its electrical or optical axis, or to both.

Patent issued to Standard Telephones & Cables, Ltd.

PHOTO-ELECTRIC CELLS.

Convention date (Germany), 29th July, 1929. No. 345189.

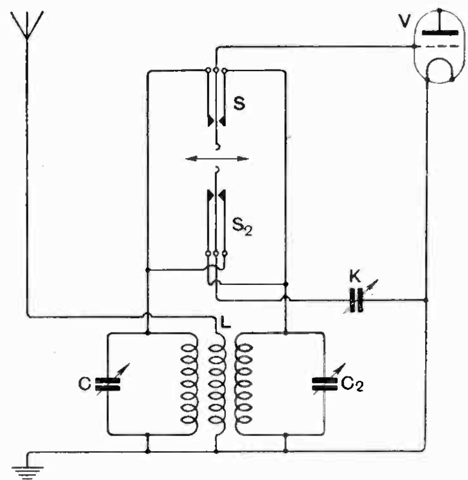
Photo-electric cells are filled with xenon or crypton, or with a mixture of these gases, instead of helium, neon, or argon. The result is a distinct freedom from inertia, probably due to the fact that the usual formation of electrical double layers at the cathodes of the cell is prevented or at least minimized.

Patent issued to M. A. E. Pressler.

WAVE-TRAP CIRCUITS.

Application date, 7th January, 1930. No. 346299.

As shown in the drawing, the circuits are so arranged that on one side of the switch S, the circuit C, tuned to a desired station and coupled to the aerial coil L, is connected across the input to the amplifier V, whilst a second circuit C_2 tuned to an interfering frequency serves as a wave-trap. On the other side of the switch S the functions of the



No. 346299.

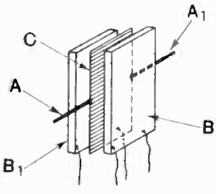
two circuits are reversed. In order to nullify the effect of the grid-filament capacity on the tuning, a second switch S_2 is provided for connecting a capacity K in parallel with the wave-trap circuit.

Patent issued to Standard Telephones & Cables, Ltd., and C. H. W. Brookes-Smith.

ULTRA SHORT-WAVE GENERATORS.

Application date, 3rd December, 1929. No. 344448.

Wavelengths of the order 20 centimetres to 2 metres are generated by the direct interaction of different electron streams in the same valve, the movements of the electrons being utilized to set up oscillatory currents in an aerial circuit associated with, but not including any portion of the space-discharge path of the generating valve.



No. 344448.

The system of generation is differentiated from the known Barkhausen method. As shown diagrammatically two electron-emitting electrodes *B*, B_1 co-act with a control electrode *C*. Under the influence of a high positive potential on *C*, two opposed electron streams start from *B* and B_1. After traversing the meshes of the control electrode *C*, each stream falls into a retarding field due to the space-charge from the opposite emitter. In their passage the electrons set up sustained oscillations in the electrode *C*, to which the radiator wires *A*, A_1 are directly connected.

Patent issued to Standard Telephones and Cables, Ltd.

RECEIVING CIRCUITS.

Application date, 10th December, 1929. No. 344887.

The tuning of a highly selective circuit, of the kind comprising a piezo-electric crystal, is simplified by providing means for rendering the crystal partly or wholly ineffective, at will, so that the receiver can be given a comparatively broad frequency-response, for instance during the preliminary process of tuning-in. In one arrangement a variable condenser is provided in shunt across the crystal, so as to increase its effective capacity; or one of the condensers normally used to balance the inherent capacity of the crystal may be thrown temporarily out of balance.

Patent issued to J. Robinson.

DUPLEX SIGNALLING.

Convention date (Germany), 16th September, 1929. No. 345918.

When a "wavelength" aerial is energized by means of a high-frequency generator coupled to one point of the aerial, the current and voltage distribution is different from that which exists when the same aerial is excited by an incoming wave. In the former case there is a current node, and in the latter a current loop, in the centre of the aerial. This difference is utilized, according to the invention, to secure duplex working on one wavelength, by coupling the receiving circuit to a point on the aerial at which a node is formed by the transmitted oscillations, so that the latter do not substantially affect the incoming signals.

Patent issued to Telefunken Gesell. für Drahtlose Telegraphie m.b.H.

CUTTING-OUT LOCAL DISTURBANCE.

Convention date (U.S.A.), 3rd January, 1929. No. 346034.

To prevent interference with broadcast reception caused by sparking in the high-tension circuits of the ignition system of a motor car, resistance units of low capacity and inductance are inserted in the secondary circuits from the induction coil to the spark-plugs and spark-producing elements of the distributor, as well as to the commutator brushes. High-capacity condensers are also shunted across any sparking points on the primary side of the induction coil. The resistance units make the high-tension circuits substantially aperiodic, and so reduce radiation without interfering with the normal or useful sparking of the plugs.

Patent issued to Automobile Radio Corporation.

DIRECTION-FINDING.

Convention date (Germany), 26th July, 1929. No. 345899.

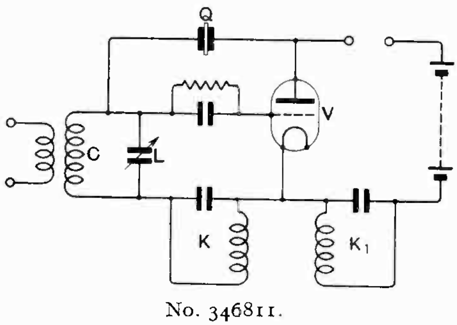
A number of glow-lamps are arranged on a circular disc which is rotated synchronously with two crossed radiogoiometer coils by the slip stream from an aeroplane motor. The high-frequency signal oscillations induced in the rotating frame aerial are amplified and rectified and then fed to a number of relays, each tuned to the characteristic signal note of the particular transmitting stations to be identified. The relays are, in turn, connected to the glow-lamps, so as to give the pilot a visual indication of the bearings of each transmitting station as it is received.

Patent issued to Telefunken Gesell. für Drahtlose Telegraphie m.b.H.

PIEZO-ELECTRIC CIRCUITS.

Application date, 2nd January, 1930. No. 346811.

A super-regenerative effect is applied to a crystal-controlled circuit forming part of a superheterodyne receiver. As shown a feed-back circuit comprising



No. 346811.

a piezo-electric crystal *Q* maintains the valve *V* in continuous self-oscillation at a frequency determined by the crystal and the tuned input circuit *C*, *L*. These oscillations are periodically quenched at a lower but supersonic frequency by the back-coupling between two other tuned circuits, *K*, K_1.

Patent issued to Jas. Robinson.