EXPERIMENTAL WIRELESS & The WIRELESS ENGINEER

Vol. VIII. MAY, 1931. No. 92.

Editorial.

Band-Pass Filters in Radio Receivers.

THE ever-increasing need for greater selectivity combined with the demand for a high standard of reproduction has led to the incorporation of a simple type of band-pass filter between the aerial and the high-frequency amplifying valve in many recently constructed broadcast receivers. The filter usually takes the form of two coupled tuned circuits arranged in cascade, the aerial being coupled to the first circuit and the grid of the valve to the second. Strictly speaking, one should not regard them as two circuits, but rather as a single system. Such a device, if properly designed, gives a resonance curve with two more or less pronounced humps—a curve which, as a whole, approximates much more closely to the ideal of a constant response over a definite frequency range and zero response outside it, than does the ordinary single-circuit resonance curve.

The shape of the response curve depends on the decrements of the coupled circuits and on the degree of coupling. If we ignore for the present the effects of the aerial and valve on the filter and consider merely the two tuned coupled circuits, which we assume to be similar, and tuned in the ordinary way by means of ganged condensers, we can obtain in a very simple way a clear idea of the principle of the device. We shall apply to the problem the method which we first described in the *Electrical World* of 19th August, 1916, p. 368.

Inductive Coupling.

If two exactly similar oscillatory circuits, coupled together as shown in Fig. 1, have switches S whereby they can be opened while the condensers are equally charged and then simultaneously closed, a damped oscillation will take place in each circuit, the currents in the circuits being equal at every moment. If the two condensers are so charged that the upper plate of each is positive, then the initial current rush in each coil will be downwards and the currents will be equal and in the same direction in the two coils at every moment. If, on the other hand, the upper plates of the two condensers had been charged oppositely, the currents in the two coils would have been equal but in opposite directions at every moment. In one case the effect of the mutual inductance will be to reduce the effective value of L and in

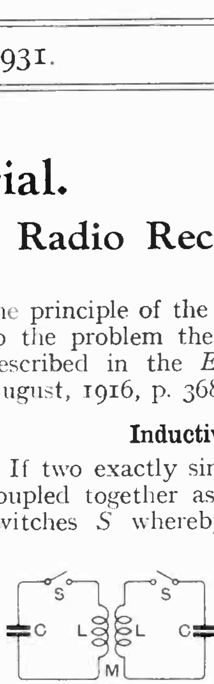


Fig. 1.

the other case to increase it. Since the currents are always equal in the two coils, M can be simply added to or subtracted from L.

If we neglect resistance, as we shall do for the present, the natural frequencies of the circuits corresponding to these two different initial conditions are therefore

$$f_1 = \frac{1}{2\pi\sqrt{C(L-M)}} \text{ and } f_2 = \frac{1}{2\pi\sqrt{C(L+M)}}$$

or

$$f_1 = \frac{f_0}{\sqrt{1-k}} \text{ and } f_2 = \frac{f_0}{\sqrt{1+k}}$$

where f_0 is the resonant frequency of each

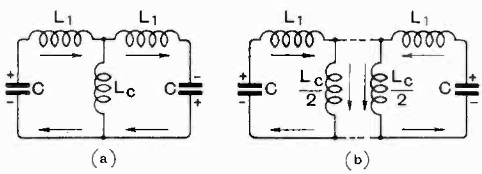


Fig. 2.

circuit alone and $k = M/L$ is the coupling coefficient. We see therefore that the system has two natural frequencies at which it can discharge. Whenever an impressed e.m.f. has either of these frequencies, resonance will occur and the system will give an abnormally large response.

$$\text{Since } f_1/f_2 = \sqrt{\frac{1+k}{1-k}}, \quad k = \frac{f_1^2 - f_2^2}{f_1^2 + f_2^2}$$

so that the coupling coefficient can be calculated from the position of the peaks in the resonance curve.

$$\text{Also} \quad \frac{f_1 - f_2}{f_0} = \frac{1}{\sqrt{1-k}} - \frac{1}{\sqrt{1+k}}$$

which, when k is small, is approximately equal to $\left(1+\frac{k}{2}\right) - \left(1-\frac{k}{2}\right)$ *i.e.*, to k, so that if the value of f_0 is varied by means of the ganged condensers, leaving L and M and therefore k unchanged, the peak separation will be a constant fraction of f_0 and not, as we should like, a constant quantity. If, by varying the capacity, we reduce the value of f_0 to a third, *i.e.*, if we increase the wavelength to three times its initial value, the frequency separation of the peaks will also be reduced to a third. Since $f_1 - f_2$ is approximately equal to f_0k, a constant peak separation would be obtained if the coupling coefficient varied inversely as the frequency, or directly as the wavelength. It should be possible to do this by causing the spindle of the condensers to operate a cam or other device arranged to move one or both of the coils.

A modification of Fig. 1 is shown in Fig. 2 in which the two circuits have an inductance L_c in common. If the two condensers were charged as shown in Fig. 2 (*a*) and simultaneously discharged, the inductance L_c would be like the galvanometer in a balanced Wheatstone bridge and would take no part in the oscillatory discharge which would flow in the circuit consisting of the two coils L_1L_1 and the two condensers in series. The frequency would be $f_1 = \frac{1}{2\pi\sqrt{CL_1}}$ which is therefore one of the natural frequencies of the system. If, however, the condensers are charged as shown in Fig. 2 (*b*) and simultaneously discharged, both the discharge currents pass through L_c. If we imagine L_c to be replaced by two coils each of inductance $L_c/2$ in parallel as shown in Fig. 2 (*b*), we have two separate circuits in each of which the oscillation occurs just as if the other were not there. This gives the other natural frequency of the system,

$$f_2 = \frac{1}{2\pi\sqrt{C(L_1 + L_c/2)}}$$

The two frequencies are thus the same as in Fig. 1 if we put $L = L_1 + L_c/4$ and $M = L_c/4$ from which $k = M/L = L_c/(4L_1 + L_c)$.

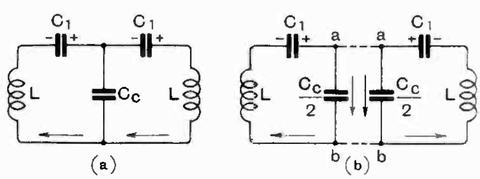


Fig. 3.

Here again the peak separation could be kept constant or varied in any desired way by making L_c in the form of a variometer operated from the condenser spindle.

Capacity Coupling.

Instead of a common inductance, a common condenser may be used to couple the two circuits as shown in Fig. 3. This case was also considered in the paper referred to. If the condensers C_1 are equally charged as shown in Fig. 3 (*a*) and then simultaneously discharged, there will be no P.D. across the coupling condenser, and it will therefore take no part in the oscillation, which flows in the circuit C_1C_1LL. The frequency will be

$$f_2 = \frac{1}{2\pi\sqrt{C_1 L}}.$$

If, however, the initial charges on the condensers are as shown in Fig. 3 (*b*) the joint discharge will pass through the coupling condenser which we may replace by two condensers of half the capacity in parallel.

Hence instead of being constant, $f_1 - f_2$ is proportional to $\sqrt{C_1}$ and consequently increases as the wavelength increases. Here again, this could be corrected by making C_c variable and operated from the main condenser spindle.

Another method of coupling also considered in the paper referred to above is shown in Fig. 4. As in Fig. 1 there need be no actual connection between the two circuits; in Fig. 1 the coupling was by means of a magnetic field, here it is by means of an electric field. If the condensers are initially charged as in Fig. 4 (*a*), and simultaneously discharged there will never be any P.D.

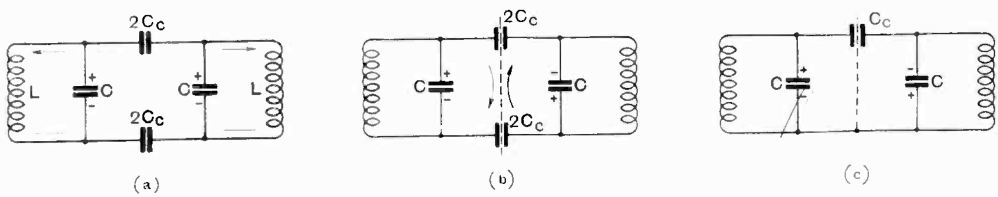


Fig. 4.

Since the points *aa* are always at the same potential it is immaterial whether the dotted connection between them is made or not; similarly for the points *bb*. Each circuit will oscillate with a natural frequency

$$f_1 = \frac{1}{2\pi\sqrt{L\dfrac{C_1C_c}{2C_1 + C_c}}}.$$

This then is the other natural frequency of the system. Since

$$k = \frac{f_1^2 - f_2^2}{f_1^2 + f_2^2},$$

the coupling coefficient in this case is

$$\frac{1}{1 + C_c/C_1}.$$

An approximate expression for the peak separation can be derived as follows :—

$$f_1 - f_2 = \frac{1}{2\pi\sqrt{L}}\left(\sqrt{\frac{2C_1 + C_c}{C_1C_c}} - \sqrt{\frac{1}{C_1}}\right)$$

$$= \frac{1}{2\pi\sqrt{LC_1}}\left(\sqrt{2\frac{C_1}{C_c} + 1} - 1\right)$$

since C_1/C_c is small, this is approximately equal to

$$\frac{1}{2\pi\sqrt{LC_1}}\left(1 + \frac{C_1}{C_c} - 1\right) = \frac{1}{2\pi\sqrt{L}}\frac{\sqrt{C_1}}{C_c}$$

across the coupling condensers and they will consequently have no effect on the oscillations, which will have a frequency $f_1 = \frac{1}{2\pi\sqrt{LC}}$ in each circuit. If charged as in Fig. 4 (*b*) and (*c*), we may imagine a sheet of metal introduced as shown by the dotted line; since this joins points which would be at the same potential it has no effect on the oscillation. The oscillation occurring on either side of the dotted line can be considered alone and it will be seen that there is a resultant capacity of $2C_c$ between the plates of the coupling condensers and the dotted plane and that this is in parallel with the tuning condenser. The natural frequency is therefore

$$f_2 = \frac{1}{2\pi\sqrt{L(C + 2C_c)}}.$$

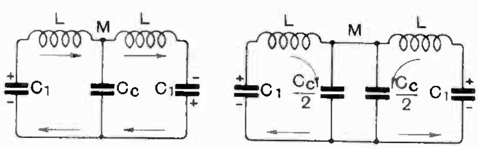
The case of the two tuned circuits with different values of L and C is solved in the paper referred to above, but will not be considered here. For the coefficient of coupling we have

$$k = \frac{f_1^2 - f_2^2}{f_1^2 + f_2^2} = \frac{C_c}{C_c + C} = \frac{1}{1 + \dfrac{C}{C_c}}$$

which decreases as C and the wavelength are increased, so that this method of coupling departs further from the ideal than the inductance method, since, instead of increasing with the wavelength, as is desired, k actually decreases. In Figs. 4 (*a*) and (*b*) the coupling is by means of two condensers each of $2C_c$ in series, giving a resultant coupling capacity of C_c as in Fig. 4 (*c*).

Mixed Coupling.

We have seen that with inductive coupling the peak separation increases as the frequency is increased, whereas with capacity coupling, as shown in Fig. 3, it decreases as the frequency is increased. A filter in which an approximation to constant peak separation is obtained by a combination of both methods was described by W. I. G. Page in *The Wireless World* of 18th Feb., 1931. Figs. 5 (*a*) and (*b*) are the same as Figs. 3 (*a*) and (*b*), except that the coils, which in Fig. 3 were assumed to have no effect on each other, are now so placed that there is a mutual inductance M between them. The coils are assumed to be wound in the same direction, as if they were a single coil tapped at the midpoint, so that the mutual is added to the self-inductance when the current flows through the two in series as in Fig. 5 (*a*). If the condensers are assumed



(a) (b)

Fig. 5.

to be charged as in Fig. 5 (*a*) and simultaneously discharged, the coupling condenser takes no part in the oscillation and the frequency is

$$f_2 = \frac{1}{2\pi\sqrt{C_1(L+M)}}$$

If, however, the initial charges are as shown in Fig. 5 (*b*) the joint discharge will pass through the coupling condenser, which we may assume, as before, to be replaced by two condensers of half the capacity in parallel. The frequency of each circuit will therefore be

$$f_1 = \frac{1}{2\pi\sqrt{\frac{C_1 C_c}{2C_1 + C_c}(L-M)}}$$

Since the currents are now in opposition, the effect of the mutual inductance is to reduce the effective inductance of each circuit.

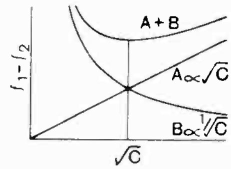


Fig. 6.

If we put k_l for the inductive coupling M/L, and k_c for the capacitive coupling $\frac{C_1}{C_1 + C_c}$, then $L - M = L(1 - k_l)$, and

$$\frac{C_1 C_c}{2C_1 + C_c} = C_1 \frac{1 - k_c}{1 + k_c}$$

The resultant coupling

$$k = \frac{f_1^2 - f_2^2}{f_1^2 + f_2^2} = \frac{(1+k_l)(1+k_c) - (1-k_l)(1-k_c)}{(1+k_l)(1+k_c) + (1-k_l)(1-k_c)}$$

which, if we neglect the product $k_l k_c$, is simply $k_l + k_c$, that is, the sum of the two separate couplings.

For the peak separation we have accurately

$$f_1 - f_2 = \frac{1}{2\pi\sqrt{C_1 L}} \left[\frac{1}{\sqrt{\frac{1-k_c}{1+k_c}(1-k_l)}} - \frac{1}{\sqrt{1+k_l}} \right]$$

and approximately

$$f_1 - f_2 = \frac{1}{2\pi\sqrt{C_1 L}}(k_c + k_l)$$

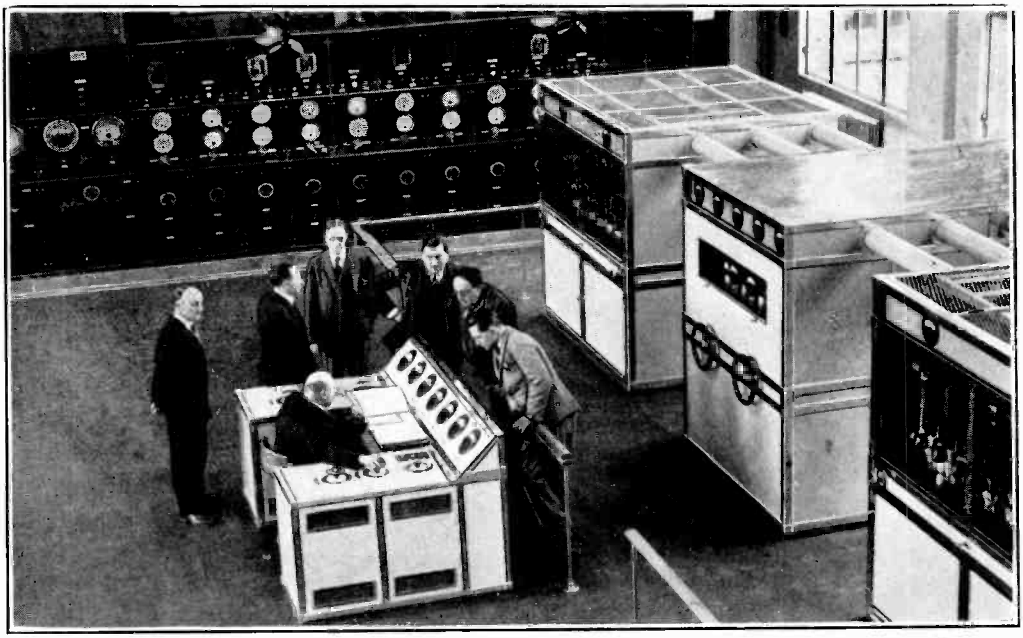
or $$f_1 - f_2 = \frac{1}{2\pi\sqrt{L}}\left(\frac{\sqrt{C_1}}{C_c} + \frac{k_l}{\sqrt{C_1}}\right)$$

where C_1 is the capacity of the variable condensers. Hence we see that the peak separation is the sum of two terms, one of which increases proportionately to $\sqrt{C_1}$, while the other is inversely proportional to $\sqrt{C_1}$. If plotted to a base representing $\sqrt{C_1}$, as in Fig. 6, one term gives a straight line through the origin and the other a hyperbola, so that their sum cannot be a constant. It will be approximately constant over a limited range where the negative slope of the hyperbola is equal to the positive slope of the straight line, which will occur when $C_1/C_c = k_l = M/L$, that is to say, when the two coupling coefficients are equal. For values of C_1 either smaller or greater than this, the peak separation increases, rapidly for smaller values because of the increasing steepness of the hyperbola, more slowly for larger values because of the straight line.

To obtain a peak separation of 10,000 when the frequency is 10^6 requires a resultant coupling of $10^4/10^6 = 0.01$, which can be obtained by making $k_c = k_l = 0.005$. If now the frequency is reduced to 500,000, the ganged condensers being adjusted accordingly, the first term in the above formula for $f_1 - f_2$ will be doubled and the second halved, giving a total separation of 12,500. Similarly, if the frequency is increased to 2×10^6, the first term will be halved and the second doubled, giving again a total separation of 12,500.

In all these considerations we have neglected the resistance of the circuits and the effects of the aerial and valve which are connected to or coupled to the filter. The aerial is a circuit of considerable damping, closely coupled to the first circuit of the filter, and any calculation of the effect of the resistance of the coils upon the characteristics of the filter which neglects the presence of the aerial can hardly be expected to give results in agreement with experiment. The effect of resistance will be to alter the whole shape of the response curve, not only moving the peaks but even obliterating them entirely in some circumstances. If one knows how the resistance varies over the tuning range, one may calculate how the couplings should be arranged to give an approximately constant peak separation, but it is by no means certain that this is desirable, since the variation of resistance changes the whole shape of the curve and not merely the separation of the peaks. Another point which appears to be frequently overlooked is that the sets which contain a band-pass filter between the aerial and the first valve generally have other tuned circuits between the high-frequency amplifying valves and in front of the detector. The whole chain of circuits from aerial to detector constitutes a filter, and it is the resultant response curve of the whole chain that determines the selectivity and quality of the receiver. There is room for more research in this direction.

G. W. O. H.



A view at the new B.B.C. station at Slaithwaite, Yorks, showing one of the two main control panels.

On the Amplitude of Driven Loud Speaker Cones.*

By Dr. M. J. O. Strutt.
(Physical Laboratory, Philips Glowlamp Works, Ltd., Holland).

I. Introduction.

In most modern loud speakers a cone of paper or other material is used as a sound-emitter. This cone is driven at the centre and loosely fastened (*e.g.*, with a flannel strip) at the circumference. Assuming that the movement of the centre is wholly in the direction of the axis of the cone, we can easily see which particular movements of the cone-surface are disadvantageous to the emission of sound. All non-linear effects, *i.e.*, the introduction of overtones by the cone itself, will be neglected. Hitherto, no trustworthy observation of such effects is known to the author.

The movements of the conical surface, by symmetry, may be described as due to circular and to radial nodal lines. These nodal lines influence the acoustic performance of the conical surface in two respects.

At two sides of a nodal line the surface moves in opposite directions. Therefore the air will have a tendency to stream over a nodal line, in order to equalise pressure differences. This first effect of nodes will be called *acoustic short-circuit*. The second effect of nodes has to do with the reaction of the conical surface on the driving point. If the cone had no nodes and moved as a perfectly rigid plate, the reaction would be entirely determined by the mass of the cone, if we neglect sound radiation. This mass can be found by weighing the cone. But if there are nodes, different parts of the surface move in opposite directions. Hence the reaction, which the mass of one part affords to the driving point may be compensated by the reaction of another. We can express this also by saying: *The effective mass* of the cone depends on the motion of the conical surface.

II. Acoustic Short-circuit and Variation of Effective Mass.

We shall now look a little more closely into the influence of acoustic short-circuit and variation of effective mass on the performance of a cone as a sound-emitter.

By acoustic short-circuit the pressure differences, which are the primary cause of the sound emitted, are partially levelled and hence extinguished at their origin. Let S be the total surface of the cone and P the amplitude of motion at the centre. If the top-angle is rather flat, as with all the cones described hereafter, the amplitude (square root of intensity) of the sound radiated, will be proportional to $S \times P$, as long as the amplitude of motion in every part of the cone surface equals P, *i.e.*, as long as the cone is perfectly rigid. As soon as the motion of some parts of the cone is less than P, the cone is no longer perfectly rigid and, with increasing frequency, will show nodes. Let ds denote an element of the cone surface and p the amplitude of motion of this element, then the amplitude of the emitted sound is proportional to

$$\int p.ds$$

the integral extended over the whole surface of the cone, as long as the wavelength of sound in air is large compared with the dimensions of the cone. If this latter condition is no longer fulfilled, the emission of sound depends on the motion of the cone in a more complicated way, which will not be discussed in this paper. From the considerations set forth above, we find for the efficiency of the cone as a sound emitter:

$$(1) \qquad \eta = \left| \frac{\int p.ds}{P.S.} \right|$$

It is easy to see that *radial* nodes of the cone have no effect on η. The cone surface, if only radial nodes occur and if it is otherwise perfectly rigid, being driven at the centre, will have the same *mean* displacement

$$\int p.ds$$

as if no radial nodes were present. Hence η is unaffected by these nodes.

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

Considering the variation of effective mass of the cone, much the same can be said as regarding the effective radiative surface. In fact, the expression (1) gives the effective mass of the cone, as a fraction of the true mass, found by weighing it.

III. Method and Apparatus for Amplitude-measurements.

The method here described is, so far as I know, essentially due to W. H. Bragg *.

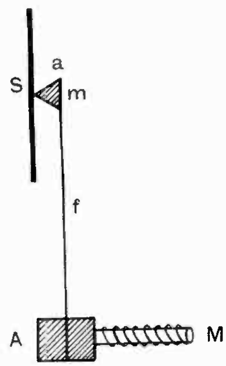


Fig. 1.—*Diagram of apparatus.*

Referring to Fig. 1, S is a part of the cone-surface, m a small mass with a copper point, f a spring (*e.g.*, of a small clock) and M a micrometer, set on a heavy metal block. The spring f is fastened to M at A. The characteristic frequency of the spring f with mass m when swinging freely will be denoted by ω_0. We proceed as follows: While S does not move, M is turned so as to let the point of m just touch S. This is controlled electrically by a current flowing from m to S, which surface is provided by a strip of platinum foil of 10 microns thickness. Now S is set in motion. The point of m no longer steadily makes contact with S but dances. This is observed by the ear and by the electric current flowing from m to S falling to less than half of its former value. The micrometer M is hereupon turned a certain amount, say A mm., till the contact of m with S is perfect again, as observed by the ear and by the current regaining its first value. In this condition, the maximum acceleration given to m by the motion of S is just equal in amount and opposite in direction to the acceleration, which m gets from the force, due to the tension of the spring f. Assuming S to move purely periodically with a single frequency ω, we have :

$$\omega^2 am = cA$$

where a is the maximum amplitude of the mass m and c the stiffness of f, while :

$$\omega_0 = \sqrt{\frac{c}{m}}.$$

We hence have :

$$a = A\left(\frac{\omega_0}{\omega}\right)^2. \qquad (2)$$

The amplitude a is thus measured by the distance A over which the micrometer was turned, with a large magnification. For instance, take $\omega_0 = 2\pi \cdot 10$; $\omega = 2\pi \cdot 10^3$; $A = 1$ mm., then $a = 10^{-4}$ mm. We are able to measure amplitudes of, say, one micron (1 micron = 0.001 mm.).

Fig. 2 gives a view of the apparatus, constructed according to the above principles. We here see three micrometers, each provided with a spring, acting on a loud speaker cone.

IV. Tests of the Apparatus.

Before actually measuring amplitudes of loud speaker cones, our apparatus was tested in various ways. We first measured the distance A, over which the micrometer

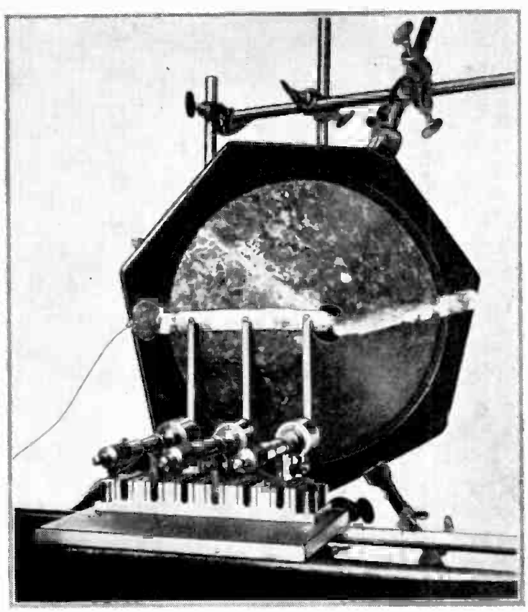


Fig. 2.—*View of apparatus for measuring amplitudes.*

must be turned, several times at the same spot of a loud speaker cone and obtained :

* *Journal Scientific Instruments*, Vol. 6, p. 196, 1929.

1.70 1.64 1.67 1.54 1.61
1.61 1.59 1.66 1.60 1.70

mean value : 1.63,
mean deviation : 4.3 = 2.6 %,
maximum deviation : 9 = 5.5 %.

Other series of measurements gave similar results. We conclude that an accuracy of 5 % may be reached by this method.

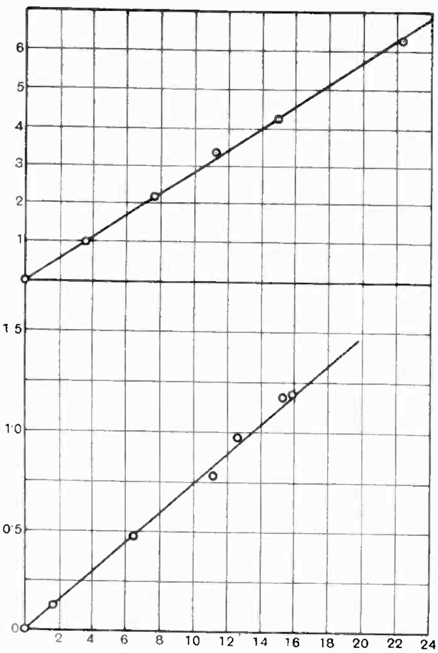


Fig. 3.—*Amplitude in microns (vertical axis) against A.C. at 500 cycles in milli-amperes (horizontal axis) of a paper cone driven at the centre by an electromagnetic loud speaker system. Upper curve, measured at centre of cone, lower curve measured at some other point of cone.*

We determined the characteristic frequencies of several springs, ranging from $2\pi . 10$ to $2\pi . 30$ by comparison with a tuning fork of known period. With these springs we measured the amplitude of the centre of a loud speaker cone and obtained the following numbers :

$$\omega_0 = 12 \; ; \; A = 3.17 \; ; \; \omega_0^2 A = 45.6$$
$$\omega_0 = 33 \; ; \; A = 0.46 \; ; \; \omega_0^2 A = 50.1$$

The current through the loud speaker was kept constant. We see that $\omega_0^2 A$ is approximately constant, thereby showing that springs of this stiffness do not measurably influence the motion of the cone.

From the values of ω_0 and A quoted above we may immediately calculate the absolute value of the amplitude, since $\omega = 2\pi . 256$ in these measurements. We find from eq. (2) :

$$a = 3.17 \cdot \left(\frac{12}{256}\right)^2 = 7 \text{ microns.}$$

Hence we conclude that the present method enables us to measure amplitudes of vibration amounting to something like 7 microns, within a few per cent. at 250 cycles.

V. Linearity of Different Loud Speaker Systems.

For the quality of the sound produced by a loud speaker, it is of great importance that the system should be linear, *i.e.*, that the amplitude of vibration should be exactly proportional to the current through the system. Various methods for testing this linearity have been published previously, but none of them seems as simple and direct as the one used here.

The current through the loud speaker was measured by inserting a thermocouple of commercial Philips type into the circuit. This couple did not show any skin effect or capacity effect at the frequencies used. Hence the d.c. calibration-curve of this couple could be used for determining the alternating currents.

The first loud speaker system tried was of the so-called electromagnetic type. It is the system used in the Philips loud speaker type No. 2007. The amplitude was measured at a frequency of 500 cycles per second, first at the metal centre of the cone and then at some place on the paper cone itself. The curves are found in Fig. 3. It is obvious that within this range, which corresponds to normal loudness, this loud speaker is entirely linear.

The second system was of the so-called electrodynamic type, provided with a spring of a material resembling bakelite. As is clearly seen from the curve on Fig. 4, this system is somewhat non-linear. Hence springs of this material ought to be rejected. We also applied this method successfully to the measurement of pick-ups.

VI. Circular Nodes of Paper Cones.

The amplitude of paper cones, at a fixed frequency, was measured as a function of the place along one *diameter*. Of course, measurements along one *radius* are sufficient to find the motion of the cone, but we always used measurements along a second radius, situated diametrically to the first one, as a check. The two curves generally coincided closely.

In Fig. 5 two curves, giving the amplitude of vibration as a function of the radial distance from the centre of the cone, belonging to a paper cone of the stiffness generally used in commercial loud speakers, are given. The total top angle was 120 degrees. The curves were measured at 500 cycles (curve *A*) and 821 cycles (curve *B*). It is seen that already at 500 cycles one circular node exists, and even three nodes at 821 cycles, while the beginning of a fourth one already manifests itself.

After many measurements of this type on different sorts of paper cones, provided

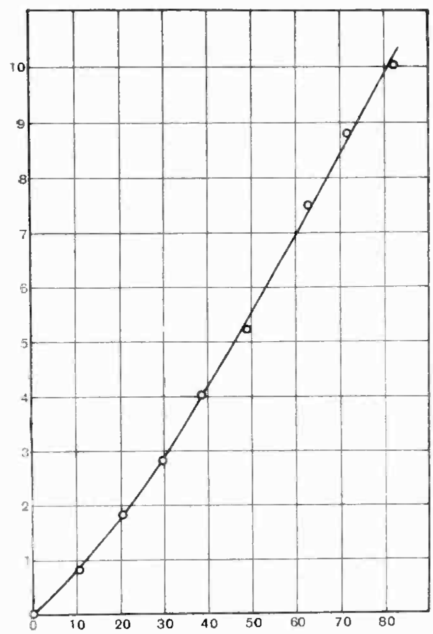


Fig. 4.—*Amplitude in microns (vertical axis) against A.C. at 500 cycles in milliamperes (horizontal axis) at centre of paper cone driven by an electrodynamic loud speaker system.*

with radial and circular ribs, of various thickness and material, we arrived at a type of cone which up to 2,150 cycles does not show any circular node. Curves belonging to this latter type of cone are given in Fig. 6, measured at various frequencies ranging from 500 cycles up to 2,150 cycles. The evidence, here given, that ordinary driven paper cones have circular nodes

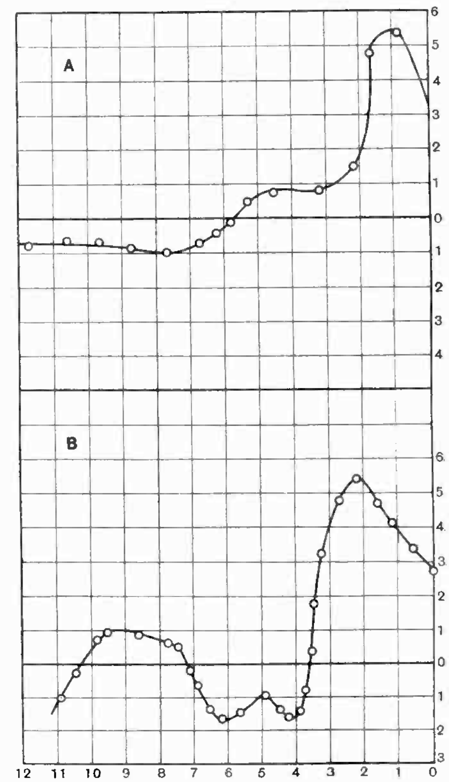


Fig. 5.—*Amplitude of paper cone (vertical axis) against distance from driven centre (horizontal axis) in cm. Upper curve, at 500 cycles. Lower curve at 821 cycles.*

already at 500 cycles seems to be somewhat unexpected, as most constructors of loud speakers assume that cones are nodeless up to much higher frequencies.

Some experiments, which have not yet been published, were carried out in this laboratory by Dr. A. Th. van Urk, concerning the *radial* nodes of paper and other cones. They show that such nodes already occur at 150 cycles, and at 600 cycles their number may be twenty or more. In the experiments of Dr. van Urk the cones were not driven at the centre, as in the ones described above, but at a point on the circumference.

As was shown above, with symmetrically driven cones *radial* nodes should not have any effect on the emission of sound.

VII. Effective Mass and Effective Radiative Surface of Paper Cones.

From curves such as given in Figs. 5 and 6, a quantity η, according to eq. (1), may readily be found by numerical integration. This quantity gives the ratio of the effective mass to the mass found by weighing and also the ratio of the effective radiative surface to the radiative surface if the cone were perfectly rigid.

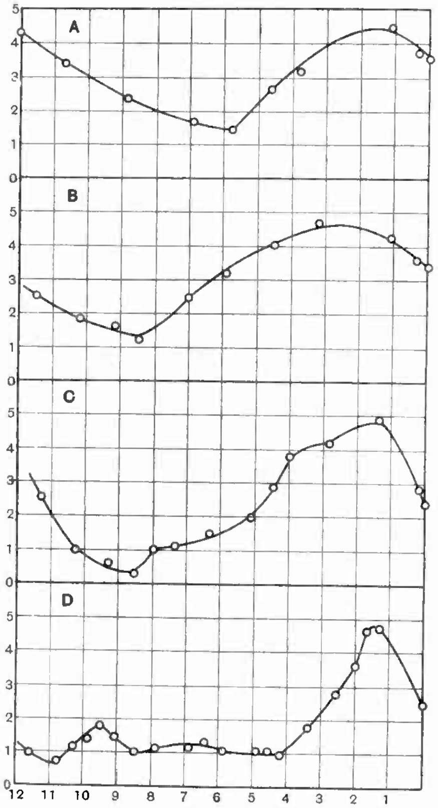


Fig. 6.—*Same as Fig. 5 for a paper cone of greater stiffness.*

A at 500 *cycles.* *C at* 1,250 cycles.
B ,, 821 ,, *D* ,, 2,150 ,,

In Table I this quantity is given for three cones, numbered 1 to 3, their stiffness increasing with the number.

Cone 3 was of the type of maximum stiffness. It seems difficult to arrive at larger values of η with paper cones without disproportionately increasing their weight.

In the construction of loud speakers it was often observed that cones of different weight fastened to the same system did

TABLE I.

Giving η of eq. (1) as a function of the frequency for the paper cones 1–3.

FREQUENCY.

Cone No.	500	821	1,250	1,740	2,150
1	0.030	0.0099	—	—	—
2	0.200	0.185	0.179	—	0.058
3	0.434	0.287	—	0.15	—

not behave as was expected. With increasing weight the amplitude of vibration was expected to diminish rapidly, and hence also the sound emitted. From Table I it is obvious that, except for cones of great stiffness, such as 2 or 3, the mass found by weighing the cone has very little to do with the effective mass which reacts on the driving system. In fact, the effective mass is only a small percentage of the weight. This evidence explains the observations with loud speaker cones just mentioned.

Of course, the choice of a cone for a given type of loud speaker depends also on other data than those in Table I. These latter data have, however, been found useful in the construction of loud speakers.

VIII. Direct Measurement of Effective Mass.

In order to check the conclusions, drawn above from the amplitude-measurements, a direct method for measuring the effective mass of cones was devised.

A steel rod of rectangular cross-section is connected by means of small coils to a circuit, consisting of two valves, acting as a negative resistance. This circuit automatically sets up and maintains the vibrations of the rod. The period of oscillation only depends on the mechanical properties of the rod.

A cone is suspended on and vibrates together with the steel rod. The rod-arrangement is seen in Fig. 7.

We proceed as follows. The oscillations of the rod are adjusted to give beats with those of a calibrated oscillator. This latter generator consists of an adjustable valve circuit of special design, and, by using a special valve with tungsten filament, is constant within one-twentieth of a period per second in about ten minutes, if the frequency amounts to something like a hundred cycles.

By removing the cone from the rod its oscillation changes by some periods per second. Now an adjustable mass is fastened in place of the cone to the rod, until its period, as checked by interference with the constant oscillator, is the same as with the cone fastened to it. We hence have a direct measure for the equivalent effective mass of the cone.

This procedure was applied to various cones, and a good qualitative agreement with measurements of the amplitude was reached.

Also, by measuring the time of decay of the rod, first with the cone and then without it, after disconnection from the maintaining circuit, we have measured the total radiation of sound by the cone. In these latter measurements, a special decay-measuring-arrangement * was used.

A full account of the measurements mentioned in this section will be published in the near future.

I have to thank Mr. W. M. Berkhout and Mr. N. S. Markus for their assistance on the measurements here described.

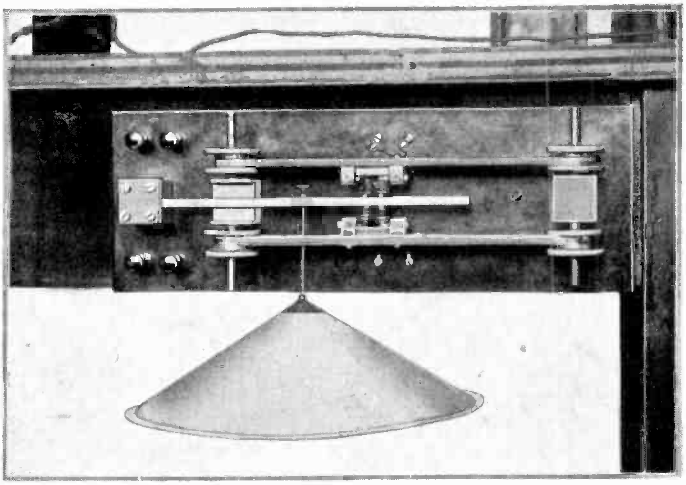


Fig. 7.—*Apparatus for determining effective mass of loud speaker cones.*

IX. Summary.

Bragg's method for measuring small amplitudes of vibration was developed technically for the measurement of amplitudes of driven loud speaker cones. It is shown that amplitudes of 1 micron at 500 cycles may easily be measured within a few per cent. Nodes of symmetrical cones may be diametral or circular. It is shown that diametral nodes do not influence the effective sound radiative area and the effective mass. Circular nodes do so, and for different cones, at different frequencies, a quantity η is calculated from experimental data, to which both effective mass and effective area are proportional. It is shown that circular nodes exist already at 500 cycles in most of the paper cones measured, except specially stiff ones, which up to 2,200 cycles did not show any circular node. Effective mass and effective area of most cones diminish rapidly with increasing frequency so as to become very small for, say, 1,000 cycles. Here again, specially stiff cones are a favourable exception. Different loud speaker systems were tested for proportionality of amplitude to A.C. strength.

* *Elektrische Nachrichten Technik,* Vol. 7, p. 280, 1930.

The Distortionless Amplification of Electrical Transients.*

By C. W. Oatley, B.A., M.Sc.

Introduction.

Up to the present time, the primary aim of designers of thermionic amplifiers has been to produce instruments giving uniform amplification over as large a range of frequency as possible. Their efforts in this direction have met with considerable success, and amplifiers, the frequency characteristics of which are almost perfect between 50 and 8,000 cycles per second, are now fairly common, while this frequency range can be extended considerably at both upper and lower limits without much trouble. In a recent series of articles, Dr. McLachlan (1) has published the results of some experiments on the amplification of *transient* voltages. These experiments have clearly demonstrated two things; first, that an amplifier which has a reasonably good frequency characteristic, judged by present standards, may yet produce considerable distortion when amplifying transients, and secondly, that this distortion will probably be negligible in comparison with that introduced by the best of present-day loud speakers. It would thus seem that the elimination of distortion of transients in amplifiers which form parts of sound reproducing systems is not, at the moment, of very great practical importance. There are other cases, however, where the distortion may be very objectionable; for example, when the amplifier is used to increase the sensitivity of an oscillograph for the determination of the form of transients, since a suitable oscillograph will not in itself introduce any appreciable distortion. The object of the present paper is to investigate the extent of the distortion which may be produced by thermionic amplifiers of various types.

Statement of the Problem.

We may define a transient voltage to be one which varies with time in a non-periodic manner. It may be well at the outset to indicate the nature of the complications which are introduced by the fact that the voltage variations are not periodic.

As is well known, any variation of voltage (say $V = \phi(t)$), which is periodic in time T, can be represented by a Fourier series of sinusoidal voltages with the addition of a constant term which may be zero. The fundamental, or lowest frequency, of the series will be $f_1 = 1/T$ and the frequencies of the other terms will be multiples of f_1. The amplitudes of the terms will tend to decrease as the frequencies increase, and will become negligibly small beyond some frequency f_2, the value of which will depend on the wave-form and frequency of the original voltage variation. It is usually stated that an amplifier, the frequency characteristic of which is uniform over the range from f_1 to f_2, will amplify the above voltage variation without distortion. This is not strictly correct since, although the various frequency components have been amplified to the same extent, their relative phases may have been changed. As far as acoustic reproduction goes, these phase changes are not important since the human ear is not able to detect them (2), but they may become important in amplifiers used for other purposes.

Let us next consider what will happen if the voltage variation $V = \phi(t)$ be suddenly applied to the input terminals of an amplifier. To simplifiy matters, we suppose that $V = O$ when $t = O$, and further, that the voltage is applied to the amplifier at the instant $t = O$. This is equivalent to saying that for negative values of t, the input voltage is zero, while for positive values of t it is represented by $V = \phi(t)$. Since the circuit differential equations for a thermionic amplifier are linear, we may treat each of the harmonic components of V separately and obtain our final result by adding these separate solutions. The general result for a sinusoidal voltage can most readily be obtained by an

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

application of the methods of the operational calculus (3). If the input voltage is of the form

$$v = A \sin \omega t$$

the output voltage will be of the form

$$v = B[\sin(\omega t + \psi) + D\epsilon^{-Ft}] \quad .. \quad (1)$$

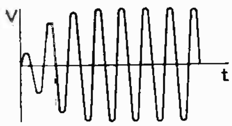


Fig. 1.

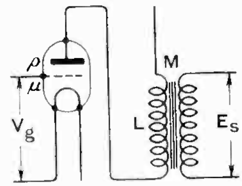


Fig. 2.

where ψ, B, D, and F are constants depending on the circuit used. Equation (1) is shown graphically in Fig. 1 for a case in which D is negative. The number of cycles which must pass before the steady state is practically attained will depend on the values of D and F. A similar relation will hold for each component of the voltage variation $V = \phi(t)$ and it is therefore obvious that the amplifier output voltage during the first cycle will not, in general, bear any particular relation to the steady state output. Now let us suppose that after time T the input voltage remains zero. Then the voltage variation during the interval $t = O$ to $t = T$ may be regarded as a transient, since it is no longer periodic. Furthermore, the solution previously obtained for the case when $V = \phi(t)$ was periodic, will still hold for the interval from $t = O$ to $t = T$, since the amplifier output during this interval will not depend on subsequent values of the input voltage.

From the above discussion, a possible method of determining the output from an amplifier when any transient voltage is applied to the input, would be as follows. Consider a periodic E.M.F. of which each period is the same as the given transient; then by graphical or other methods, obtain the Fourier components of this E.M.F. Next apply the methods of the operational calculus to determine the output from the amplifier when each of the components in turn is suddenly applied to the input. Finally, add these outputs.

While this method of attack is always theoretically possible, it would be very laborious to apply in practice. Furthermore, it is not complete as may be seen from the following considerations. If the input transient occurs during the interval from $t = O$ to $t = T$, the input voltage will be zero for all values of t outside this interval. Now, although the output voltage will be zero for all values of t less than $t = O$, it will not, in general, be zero for values of t greater than $t = T$. The method of solution given above obviously cannot be applied to find the output voltage for values of t greater than T, and so is not complete. We proceed to consider a more general method of solution.

General Solution for an Ideal Amplifier.

The term Ideal amplifier is not intended to mean a perfect amplifier, but one which can be represented by a simple circuit. That is, one in which the effects of stray inductances and capacities are neglected.

Consider first the case of a single stage transformer-coupled amplifier with constants as shown in Fig. 2. If the amplification factor and slope resistance of the valve be μ and ρ respectively, the equivalent circuit will be as in Fig. 3. Then

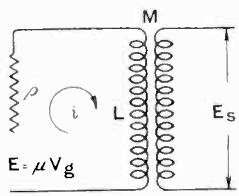


Fig. 3.

$$L\frac{di}{dt} + \rho i = E$$

$$\frac{di}{dt} + \frac{\rho}{L} i = \frac{E}{L}$$

Put $$\frac{\rho}{L} = A$$

Then $$i\epsilon^{At} = \frac{1}{L}\int E\epsilon^{At}\,dt.$$

$$i = \frac{1}{L}\epsilon^{-At}\int E\epsilon^{At}\,dt.$$

$$E_s = M\frac{di}{dt} = \frac{M}{L}\left[E - \rho i\right]$$

$$= \frac{M}{L}\left[E - A\epsilon^{-At}\int E\epsilon^{At}\,dt.\right] \quad .. \quad (2)$$

Now M/L is the ratio of the transformer, and consequently $ME/L = \mu M V_g/L$ is the theoretically possible output voltage which would be obtained with a perfect amplifier

B

if a *periodic* E.M.F. of magnitude V_g were applied to the input. It is obviously desirable in a perfect amplifier that the same magnification be obtained whether the input voltage V_g be periodic or transient. From this point of view, reference to equation (2) shows that the quantity $A\epsilon^{-At}\int E\epsilon^{At}\,dt$ is a measure at any instant of the amount by which the amplifier falls short of perfection in its amplification of the given transient. We return later to a more detailed discussion of this quantity.

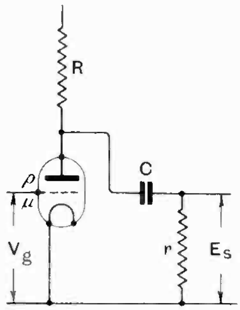


Fig. 4.

Consider next the case of a resistance-coupled amplifier as in Fig. 4 with equivalent circuit as in Fig. 5.

We have

$$\rho i_1 + R(i_1 - i_2) = E \quad \ldots \quad \ldots \quad (3)$$

$$(R + r)i_2 - Ri_1 + \frac{1}{C}\int i_2\,.\,dt = 0$$

i.e.,
$$(R + r)\frac{di_2}{dt} - R\frac{di_1}{dt} + \frac{i_2}{C} = 0$$

From (3)

$$(\rho + R)\frac{di_1}{dt} = \frac{dE}{dt} + R\frac{di_2}{dt}$$

$$\therefore \quad (R + r)\frac{di_2}{dt} + \frac{i_2}{C} = \frac{R}{(\rho + R)}\left[\frac{dE}{dt} + R\frac{di_2}{dt}\right]$$

Put

$$\frac{\rho + R}{C(\rho R + \rho r + Rr)} = A \qquad \frac{R}{(\rho R + \rho r + Rr)} = B$$

Then
$$\frac{di_2}{dt} + Ai_2 = B\frac{dE}{dt}$$

From which

$$i_2\epsilon^{At} = B\int \epsilon^{At}\frac{dE}{dt}\,.\,dt.$$

But
$$\int \epsilon^{At}\frac{dE}{dt}\,.\,dt = E\epsilon^{At} - A\int E\epsilon^{At}\,.\,dt.$$

Therefore

$$i_2 = B[E - A\epsilon^{-At}\int E\epsilon^{At}\,dt.]$$

and
$$E_s = ri_2 = rB[E - A\epsilon^{-At}\int E\epsilon^{At}\,dt.] \quad \ldots \quad (4)$$

Now rBE is the output voltage which would be obtained if a periodic E.M.F. of magnitude equal to V_g were applied to the input of the amplifier. Therefore, except for the difference in the values of the constants A and B, equation (4) is in every way identical with equation (2), which was obtained for the output of a transformer-coupled amplifier. Since the performance of an amplifier of either type depends on the magnitude of the term $A\epsilon^{-At}\int E\epsilon^{At}\,dt$, we proceed to consider how this magnitude is affected by the value of A. The form of the input voltage and therefore of E is unknown, but assuming it to be finite and continuous, we may write it in the form

$$E = p_0 + p_1t + p_2t^2 + \ldots + p_nt^n + \ldots \quad (5)$$

We may then multiply this series by ϵ^{At} and integrate term by term. Since the transient input commences at time $t = 0$, the integration must be taken between the limits 0 and t. Consider the term in t^n. By

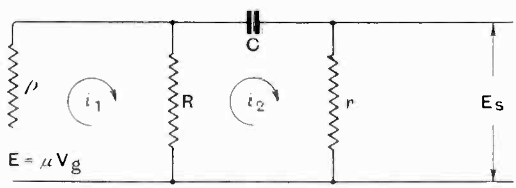


Fig. 5.

successive integration by parts it can be shown that

$$p_n\int_0^t t^n\epsilon^{At} = p_n\left[\frac{\epsilon^{At}}{A}\left\{t^n - \frac{n}{A}t^{n-1} + \frac{n(n-1)}{A^2}t^{n-2} - \ldots + (-1)^n.\frac{n(n-1)\ldots 3.2.1}{A^n}\right\}\right]_0^t = \frac{p_n}{A}\left[\epsilon^{At}\left\{t^n - \frac{n}{A}t^{n-1} + \ldots + (-1)^{n-1}.\frac{n(n-1)\ldots 3.2.}{A^{n-1}}t\right\} + (-1)^n.\frac{n(n-1)\ldots 3.2.1}{A^n}(\epsilon^{At} - 1)\right]$$

Therefore

$$A\epsilon^{-At}p_n\int_0^t t^n\epsilon^{At} = p_n\Big[\Big\{t^n - \frac{n}{A}t^{n-1} + \dots + (-1)^{n-1}\cdot\frac{n(n-1)\dots 3\cdot 2}{A^{n-1}}\,t\Big\} + (-1)^n\cdot\frac{n(n-1)\dots 3\cdot 2\cdot 1}{A^n}(1-\epsilon^{-At})\Big]$$

Remembering that

$$\epsilon^{-At} = 1 - At + \frac{A^2t^2}{2\,!} - \dots$$

the coefficient of the term in t^m, where $m < n$, is

$$(-1)^{n-m}\frac{n(n-1)\dots(m+1)}{A^{n-m}} - (-1)^n\cdot\frac{n\,!}{A^n}\cdot(-1)^m\cdot\frac{A^m}{m\,!} = 0$$

Thus all terms up to and including t^m will vanish. Therefore,

$$A\epsilon^{-At}p_n\int_0^t t^n\epsilon^{At}\cdot dt = \frac{p_n}{A^n}\cdot n\,!\Big[\frac{A^{n+1}t^{n+1}}{(n+1)\,!} - \frac{A^{n+2}t^{n+2}}{(n+2)\,!} + \dots\Big] = p_n\Big[\frac{At^{n+1}}{n+1} - \frac{A^2t^{n+2}}{(n+1)\,(n+2)} + \dots\Big] \quad \dots \quad (6)$$

By substitution from Equations (5) and (6) in (2) or (4), we obtain

$$E_s = D\Big[p_0(1 - At + \tfrac{1}{2}A^2t^2 - \dots) + p_1t(1 - \tfrac{1}{2}At + \tfrac{1}{6}A^2t^2 - \dots)\dots + p_nt^n\Big(1 - \frac{At}{n+1} + \frac{A^2t^2}{(n+1)\,(n+2)} - \dots\Big)\dots\Big] \quad \dots \quad (7)$$

where D is equal to rB for a resistance-coupled amplifier, and M/L for a transformer-coupled amplifier. Comparison of Equations (5) and (7) shows that the condition for input and output voltages to be of exactly the same form is that At shall be negligible compared with unity.

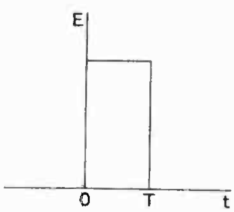


Fig. 6.

Practical Applications of the above Analysis.

We have seen that the condition for small distortion with either of the amplifiers considered above is that At shall be small compared with unity. Now t may have any value between O and T where T is the time

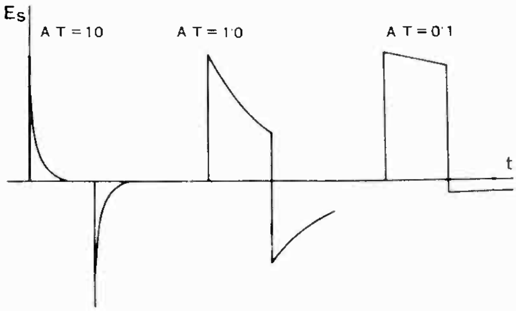


Fig. 7.

of duration of the transient. It is therefore desirable that A should be as small as possible. For a transformer-coupled amplifier $A = \rho/L$, and putting as possible values $\rho = 10{,}000$ ohms and $L = 100$ henries, we obtain $A = 100$. For a resistance-coupled amplifier, $A = (\rho + R)/C(\rho R + \rho r + Rr)$, and since, as a rule, $r >> R > \rho$ we may write approximately $A = 1/Cr$. Putting $C = 1$ microfarad and $r = 1$ megohm, we get $A = 1$. We may therefore conclude that resistance coupling is greatly superior to transformer coupling for the amplification of transients. Further, that the latter method would give rise to considerable distortion unless the total time of duration of the transient were less than 0.001 second, whereas the former might be used for transients up to 0.1 second's duration. We proceed to consider some examples of the application of the above results.

Suppose the input transient to be of the form shown in Fig. 6. This corresponds to the case treated experimentally by Dr. McLachlan. With reference to Equation (2) or (4) we may put $E = \text{const.} = p$ (say) when t lies between O and T and $E = O$ for all other values of t. Now

$$E_s = D[E - A\epsilon^{-At}\int E\epsilon^{At}dt]$$

So that for $O < t < T$

$$E_s = D\Big\{p - A\epsilon^{-At}\cdot\frac{p}{A}\Big[\epsilon^{At}\Big]_0^t\Big\} = Dp\epsilon^{-At} \quad \dots \quad \dots \quad \dots \quad (8)$$

For $t > T$

$$E_s = D\left\{ O - A\epsilon^{-At} . \frac{p}{A}\left[\epsilon^{At}\right]_0^T \right\}$$

$$= Dp(\epsilon^{-At} - \epsilon^{-A(t-T)}) \quad \ldots \quad \ldots \quad (9)$$

In Fig. 7, Equations (8) and (9) are shown graphically for three different values of AT. It appears that, so long as AT is not greater than 0.1, the distortion of the form of the transient is not serious. Furthermore, the curves shown in Fig. 7 are in agreement with the experimental curves obtained by Dr. McLachlan.

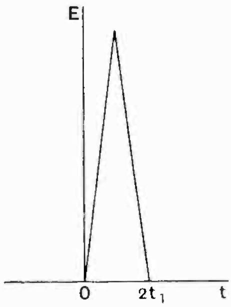


Fig. 8.

A rather more complicated type of transient is shown in Fig. 8 and is represented analytically by

$$E = pt \text{ for } O < t < t_1$$
$$E = p(2t_1 - t) \text{ for } t_1 < t < 2t_1$$
$$E = O \text{ for all other values of } t.$$

In the present instance the algebra is simplified by writing

$$E - A\epsilon^{-At}\int E\epsilon^{At} . dt$$

$$= E - A\epsilon^{-At}\left[\frac{1}{A}\epsilon^{At} . E - \frac{1}{A}\int \epsilon^{At}\frac{dE}{dt} . dt\right]$$

$$= \epsilon^{-At}\int \epsilon^{At}\frac{dE}{dt} . dt = x \text{ (say)}.$$

For $\quad O < t < t_1$

$$\frac{dE}{dt} = p$$

Therefore

$$x = \frac{p}{A}\epsilon^{-At}\left[\epsilon^{At}\right]_0^t$$

$$= \frac{p}{A}\left[1 - \epsilon^{-At}\right] \quad \ldots \quad (10)$$

for $\quad t_1 < t < 2t_1$

$$\frac{dE}{dt} = -p$$

Therefore

$$x = \epsilon^{-At}\left[\int_0^{t_1}\epsilon^{At}\frac{dE}{dt} + \int_{t_1}^{t}\epsilon^{At}\frac{dE}{dt} . dt\right]$$

$$= \epsilon^{-At}\left[p\int_0^{t_1}\epsilon^{At} . dt - p\int_{t_1}^{t}\epsilon^{At}dt\right]$$

$$= \frac{p}{A}\left\{2\epsilon^{-A(t-t_1)} - \epsilon^{-At} - 1\right\} \quad \ldots \quad (11)$$

For $\quad t > 2t_1$

$$\frac{dE}{dt} = O \quad \text{and}$$

$$x = \frac{p}{A}\epsilon^{-At}\left\{\epsilon^{At_1} - 1 - \epsilon^{2At_1} + \epsilon^{At_1}\right\}$$

$$= \frac{p}{A}\epsilon^{-At}\left\{2\epsilon^{At_1} - \epsilon^{2At_1} - 1\right\} \quad \ldots \quad (12)$$

Equations (10), (11) and (12) are shown graphically in Fig. 9 for three different values of $2At_1$. Once more it appears that, so long as the total time of duration of the transient, multiplied by A, is less than 0.1, the distortion is not serious.

In the two examples given above, it has been possible to represent the transients by simple analytical functions. When this is not possible the quantity $A\epsilon^{-At}\int_0^t E\epsilon^{At} . dt$ may be found by graphical methods. From the given curve of E against t, the graph of $E\epsilon^{At}$ against t is constructed. Then the

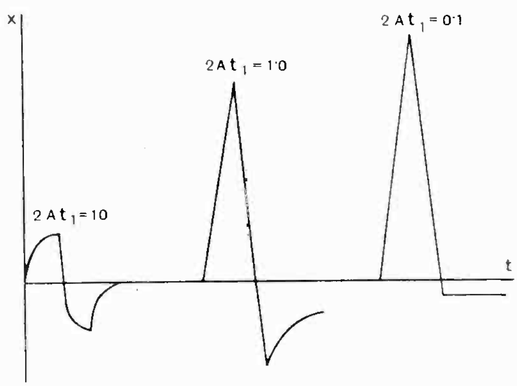


Fig. 9.

value of the integral up to any time t' is determined by measuring the area enclosed between this graph, the axis of t and the ordinate erected at $t = t'$. Finally, this area is multiplied by the appropriate value of $A\epsilon^{-At'}$.

It would be of some interest to extend the above analysis to include the case of a choke-coupled amplifier. The differential equation for such an amplifier is of the second order and so cannot be compared directly with the equations obtained above for resistance- and transformer-coupled amplifiers. We may, however, regard a choke coupling as a combination of a transformer of unit ratio with a condenser and grid leak. If the condenser and leak are of the order of a microfarad and a megohm respectively, they will produce distortion which is negligible compared with that introduced by the choke. Hence, under these conditions, a choke-coupled amplifier will behave in approximately the same manner as a transformer-coupled amplifier.

Finally, it must be remembered that the above results have been obtained from a consideration of the "ideal" circuits shown in Figs. 2 and 4. As far as the low frequency end of the frequency characteristic is concerned these "ideal" circuits correspond very closely with practical amplifiers. This is not the case for the high frequency end of the characteristic, for, whereas the "ideal" circuits would have perfect characteristics for frequencies no matter how high, practical amplifiers always show a gradual cut-off above some limiting frequency. In a future paper, the author hopes to deal with the effect of this cut-off on the amplification of transients.

References.

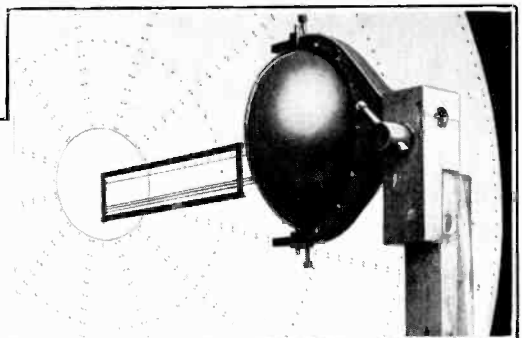
(1) N. W. McLachlan, "Transients in Loud Speakers and Amplifiers." *Wireless World*, Aug. 7th and 14th, 1929.

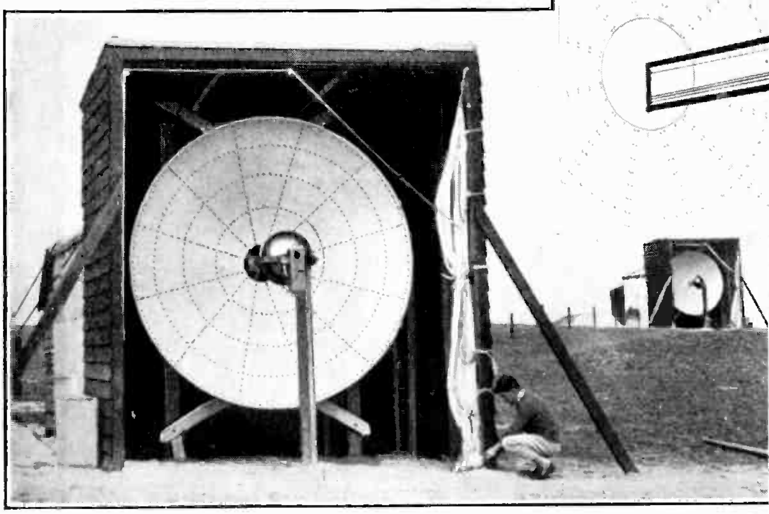
(2) Balth van der Pol, "A New Transformation in A.C. Theory with an Application to the Theory of Audition." *Phil. Mag.*, 1929, p. 477.

(3) *See* for example, "Heaviside's Electrical Circuit Theory," by Louis Cohen. (McGraw-Hill Book Co., Inc.)

Telephony on 18 Centimetres.

A VERY interesting demonstration showing the commercial possibilities of very short wavelength transmissions of the order of 18 centimetres was given recently by the International Telephone & Telegraph Laboratories, of Hendon, when two-way telephony communication between Dover and Calais was carried out with pronounced success.





The equipment used for the demonstration was largely developed by French engineers in the laboratories of Le Matériel Téléphonique, Paris. The two-way radio telephony transmissions showed no sign of fading and the quality was remarkably good. As the illustrations show, paraboloidal reflectors were employed with a small hemispherical reflector also arranged to face the paraboloidal reflector and to embrace the valve and doublet, to collect and reflect radiation back towards the source. The inset photo shows the receiver.

Experiments with a Quartz Crystal Receiver.*

By Arvid Palmgren, Doctor of Technology.

DR. ROBINSON'S receiver system, the Stenode Radiostat, has been the subject of comments on the part of many radio experts in various countries. The criticisms have in part been very sharp at least as far as the utility of this receiver system for broadcast reception is concerned. It is, however, remarkable that none of the critics, as far as I know, have carried out any experiments of their own in support of their opinions. As the action of a receiver of the above-mentioned type is of a very complicated nature, no exhaustive explanation has as yet been published.

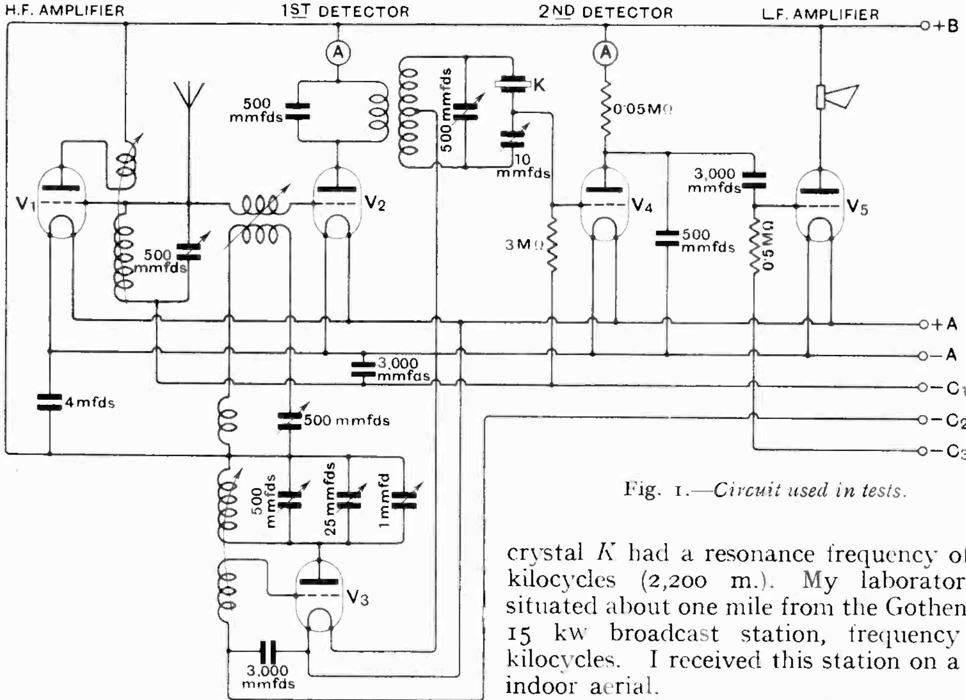


Fig. 1.—*Circuit used in tests.*

In my capacity as Editor of the Swedish radio periodical *Radio-Amatoren* I have been obliged to form a definite opinion on the Stenode Radiostat. As I am, however, only an amateur in the field of radio-technics I have preferred to forgo the mathematical treatment of the problem and instead confine myself to a detailed experimental study in my laboratory of the function of the quartz crystal receiver. As the results of these tests may be of interest to a considerable number of radio engineers, I am giving an account in the following of the manner in which the tests were carried out and my observations during the same.

The accompanying Fig. 1 is a circuit diagram of the apparatus used in my tests.

In the diagram the capacities are given in $\mu\mu$F. and resistances in megohms. The crystal K had a resonance frequency of 136 kilocycles (2,200 m.). My laboratory is situated about one mile from the Gothenburg 15 kw broadcast station, frequency 932 kilocycles. I received this station on a 1 m. indoor aerial.

The apparatus contains five valves. V_2 works as first detector or modulator. The amplitudes of the incoming signals are brought to a suitable magnitude by adjusting the reaction on the aerial circuit, delivered by the valve V_1. This method of H.F. amplification happened to be the most convenient in this case, although it is not

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

very economical for broadcast reception in general. The oscillator valve V_3 has a tuned anode circuit, the oscillations of which are transmitted to the grid of the modulator through a separate circuit and a pick-up coil. The intermediate frequency is transferred to the second detector V_4 through a crystal bridge circuit. Finally, the rectified current is magnified by the output valve V_5.

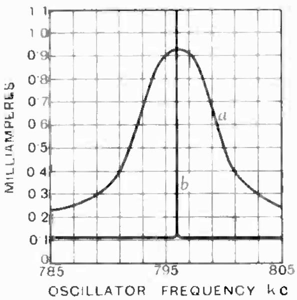


Fig. 2.

Both modulator and second detector work as anode bend rectifiers. The "rectified" currents could be read on a pair of milliammeters. For good reception without the crystal the apparatus was adjusted to give 2 mA. in the anode circuit of the modulator and 1 mA. in the anode circuit of the second detector. The output valve was then fully loaded, when the station transmitted a normally modulated wave.

Four different tests were made. In the first test the detector current was read for various heterodyne frequencies after substituting a fixed condenser or a short circuit for the crystal. In this test the curve *a* shown in Fig. 2 was obtained. No difference could be observed in the case of a 500 $\mu\mu$F. condenser or a short circuit being used. From Fig. 2 it is apparent that the selectivity was not very great and the quality of the reception was comparatively good.

The second test was made with the crystal in place. In this test the aerial circuit remained tuned to the carrier of the broadcast station and the frequency of the oscillator was varied. The readings of the instrument in the anode circuit of the second detector followed the curve *b* in Fig. 2. The curve shows that there was no rectified current except on the frequency of the crystal and possibly 50 cycles on either side of this frequency. On the carrier wave the current was somewhat greater than without the crystal. The modulation was heard in the following manner. At all frequencies except the carrier frequency certain separate notes were accentuated and could be heard, although they were very faint, being just audible in the loud speaker. It was possible to pick out any desired note from the transmission by turning the oscillator dial.

If the oscillator frequency was successively raised from 790 kc. up to about 796 kc., lower and lower notes in the transmission were accentuated. In the neighbourhood of 796 kc., only deep bass notes came within the boundaries of audibility. As soon as the carrier wave was tuned in, the whole transmission at once became audible. Its volume was considerable compared with that of the separate notes heard before, but small compared with the volume obtained in the first test without the crystal, in spite of the above-mentioned fact that the reading of the instrument remained practically the same. It was also observed that the audibility of the transmission in the second test depended upon the setting of the balancing condenser. The better the balance the less the volume, but the instrument reading remained constant.

From this test I come to the conclusion that the sideband oscillations exist physically, although their amplitude is very small compared with that of the carrier wave. This I have been able to show directly by heterodyning the separate sideband waves and making them audible, and indirectly by proving that the carrier wave passes the crystal with unaltered amplitude but without modulation, or almost without modulation.

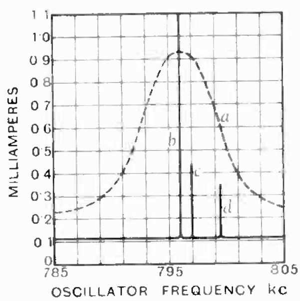


Fig. 3.

My third test was made with a separate heterodyne wave *c* in Fig. 3. In this case the oscillator was tuned so as to pull in the heterodyne wave. This wave acts, I found, as a carrier and brings with it a number of sideband frequencies from the broadcast transmission. These sideband frequencies do not, however, result in anything intelligible, but only give rise to a collection of sounds of which one certain note is especially noticeable.

Finally I placed a heterodyne wave at *d*, in Fig. 3, and varied the frequency of the oscillator between 791 and 801 kilocycles. By listening in a headphone I was then able to hear both the heterodyne and the broadcast transmission over the whole tuning range. The heterodyne note, of course, resulted from the interference between the heterodyne wave and the carrier of the station. The heterodyne note retained its relative strength unaltered even when the whole was intensified when passing the carrier wave of the broadcast station or the heterodyne wave.

From the last two tests I am led to conclude that the reason why the carrier wave brings with it a weak but complete modulation is as follows. The bridge circuit is not *fully* balanced. All oscillations in the circuit are therefore able to penetrate to the grid of the detector. The grid amplitude becomes very small since the high-frequency current must pass the considerable resistance presented by the very small unbalanced capacity. The detector is very insensible to small amplitudes, and the small amplitudes in question are therefore inaudible except in a headphone. As soon as the carrier wave is passed on to the grid through the action of the crystal, the detector will rectify effectively and the whole frequency band will become more audible. The carrier wave acts simply as—a carrier. But only the carrier of the station itself is able to make the transmission intelligible.

It is possible that the audible interference between two neighbouring modulated waves will be reduced by the use of the crystal, but the advantage of this eventual effect is largely reduced by the fact that the receiver is very insensitive when used for the reception of modulated waves.

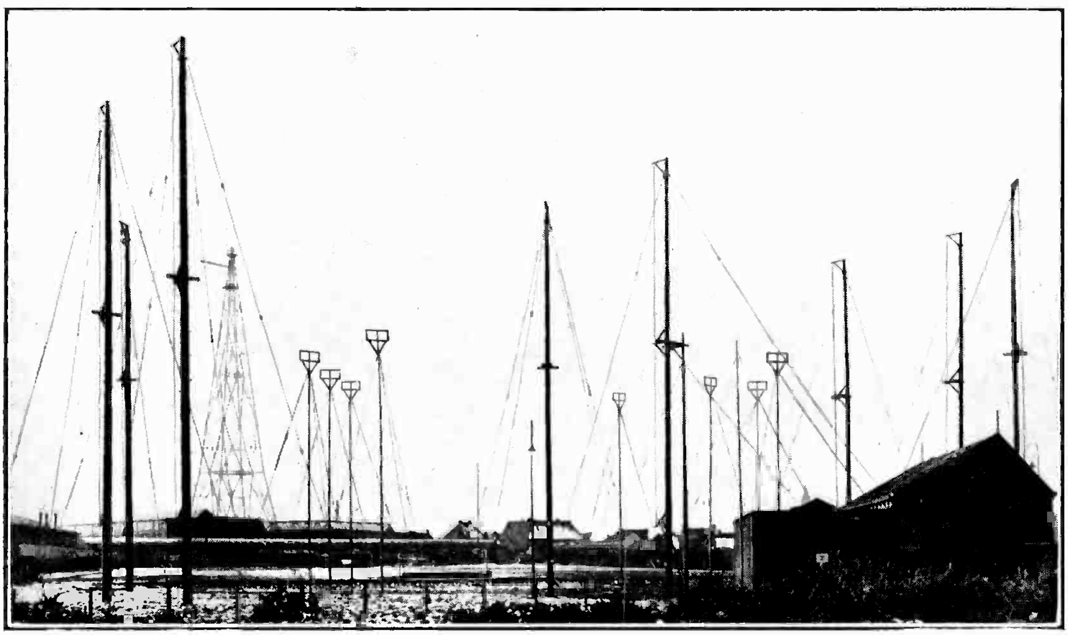
My final conclusions regarding the Stenode Radiostat as used for broadcast reception are :—

(1) The better the bridge circuit is balanced, the less will be the sensitivity of the receiver.

(2) The set is 100 times more critical to tune than an ordinary superhet.

(3) The power of all sideband frequencies of a received modulated wave is only a small fraction of the power obtainable with a corresponding superhet without crystal.

As far as I can see, the system is enormously uneconomical when used for broadcast reception, but it cannot be denied that it may give excellent results in other fields where no modulated waves are used.



PCJ, the well-known Dutch short-wave station, seen above, employs three sets of antennae—one for non-directional broadcasting, one for the East Indies service, and one for tests with South America. The lattice mast of the Hilversum broadcasting station is seen in the background.

Propagation of Waves.

(At the meeting of the I.E.E. Wireless Section, on 1st April, two papers by R. Naismith, A.M.I.E.E., were read, dealing with some experiments on propagation conducted under the auspices of the Radio Research Board, and published by permission of the Department of Scientific and Industrial Research.)

FIELD-STRENGTH MEASUREMENTS ON DAVENTRY 5XX.

Abstract.

Opening reference is made to field-strength measurements in Cornwall made by J. H. Reyner, from which it was concluded that the Beam Station at Bodmin cast a radio shadow. The present author points out that theoretical formulae postulate a flat, perfectly conducting surface, whereas at distances of 300 or 400 km. the curvature of the earth would raise the surface to a height of 7,000ft. between the stations. Waves from 5XX to Cornwall would therefore be considerably diffracted, and the author uses MacDonald's diffraction formula for derivation of his theoretical values. It is also pointed out that the populous areas of Bath and Bristol, as well as some hilly country, would all introduce attenuation effects.

These considerations suggested the desirability of further measurements on the signal-strength received in Cornwall. A first series of measurements was made in the East country between Ipswich and Yarmouth, over a path in which neither large towns nor hills above 300ft. intervened.

The next series was taken in the vicinity of the Dorchester Beam Station, in order to compare with those taken (later) round the Bodmin Beam Station. Results were consistent, giving an average value of 4.1 mv/m., which was about 15 per cent. lower than the measurements over corresponding distances in the Eastern country.

On arrival in Cornwall two tests were made to determine the extent to which reflected energy might be responsible for abnormal signal-strengths. The first of these was on a frequency-change method, the requisite change being made at the transmitter by the B.B.C. From this it was clear that in daytime at least sufficient energy was not received from the ionised layer to account for any abnormal signal-strengths. The second test over sunset period confirmed this conclusion.

Measurements in the immediate vicinity of the Bodmin Beam Station gave no indication of anything abnormal. A survey of the county was therefore begun by crossing from coast to coast while maintaining a constant distance from the transmitter. It was generally observed that the intensity at the centre of the country was 70 to 80 per cent. of that at the coast. The results obtained are shown in Fig. 2.*

In the course of observations over Bodmin Moor in the direction of Launceston it was apparent that a rapid increase in attenuation had occurred.

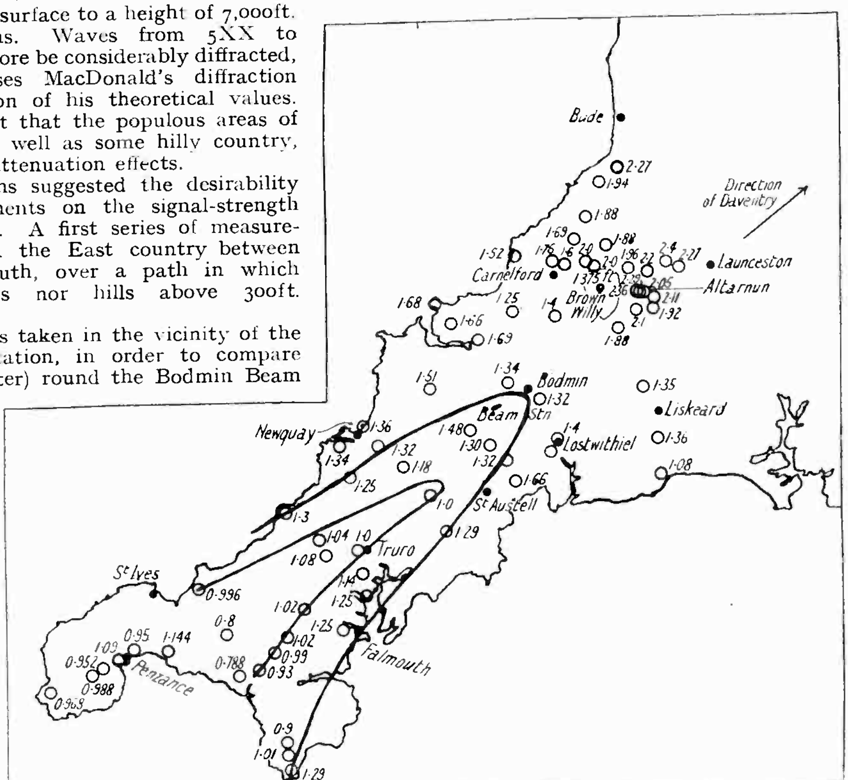


Fig. 2.—*Map of Cornwall, showing contours. Measurements in millivolts per metre.*

There appeared to be nothing to account for the drop except a hill 1,400ft. high (Brown Willy) slightly to the North. The effect of hills was therefore further studied under better conditions by measurements near Tavistock, in Devon. One

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

mile East of Tavistock on the side of the hill 2.4 mv/m. were measured. One mile further up the hill, travelling towards the transmitter, the field had dropped to 1.44 mv/m. Over the crest of the hill the signal rose to 7.04 mv/m. These effects are shown in Fig. 5. About a mile West of Two Bridges the field was still 6.768 mv/m.; at Postbridge it dropped again to only 2.8 mv/m. Further evidence on the subject was not sought as the only object of extending the measurements into Devonshire was to verify the possibility of a hill 1,500ft. high affecting the field-contours beyond it of a 1,500-metre wave. It is concluded from both sets of measurements that the cause of the rapid attenuation West of Launceston and of the peculiarly shaped contours plotted in Cornwall is the large irregularly shaped moor rising to the hill, Brown Willy.

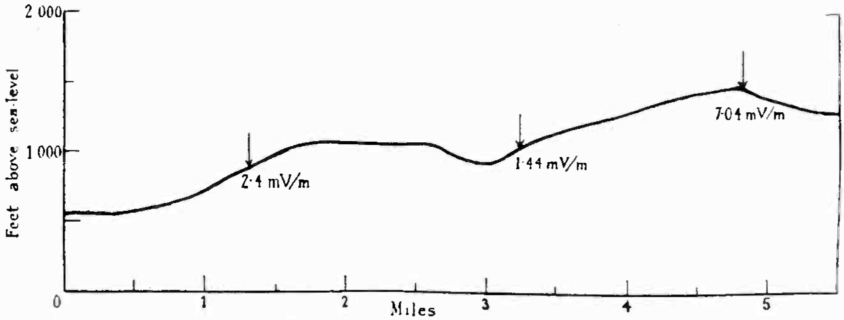


Fig. 5.—*Elevation of sites in Tavistock region.*

SHORT-DISTANCE OBSERVATIONS ON LONG-WAVE PHENOMENA.

Abstract.

The experiments described in this paper show that, contrary to the usual assumption, reflection from the ionised layer plays a part in the propagation of long waves, even to relatively short distances. The effect was first observed in experiments at Slough on the Rugby transmission of 18,700 m. At this distance of 111 km. surprisingly large variations of intensity were found during a period of six months' observation.

In order to investigate the effect, the polar curve of Rugby was checked at distances between 35 and 45 km., where no effect of the downcoming wave was found to exist. The results showed that there was no direction of maximum radiation. Simultaneous measurements of the Rugby signal at Tadworth, Surrey, and at Manchester—at approximately equal distances—gave 18.6 mv/m. at the former and only 11.4 mv/m. at the latter. This shows the importance of direction of transmission when distances are identical.

In a tour from Slough to Exeter regular measurements were made on the transmissions of Rugby and Northolt (6,950 m.). In the case of Rugby there was no evidence of a direction of maximum intensity, but the intensities measured were sometimes 50 per cent. of the calculated values. In the case of Northolt the directional bearing of the station was approximately constant at all sites, over distances of 50 to 250 km. Measured intensities all agreed closely with calculated values. The path from Northolt was approximately East to West, that from Rugby was more nearly North to South. This could not be checked for West of Rugby, on account of the Welsh hills, but other experiments were made on the subject of the direction of the transmission. Apparatus being already available at Manchester and Exeter, a 5-weeks' period of simultaneous observation at both places gave the results of Fig. 3. From this it is seen that the average intensity at Manchester was about 100 per cent. greater than at Exeter. Since the distances were almost equal, the indirect wave received at Manchester must have been much greater. In the case of Manchester the wave travelled approximately in the plane of the magnetic meridian, and in the case of Exeter more nearly at right angles to it.

Observations at Manchester and at Exeter of

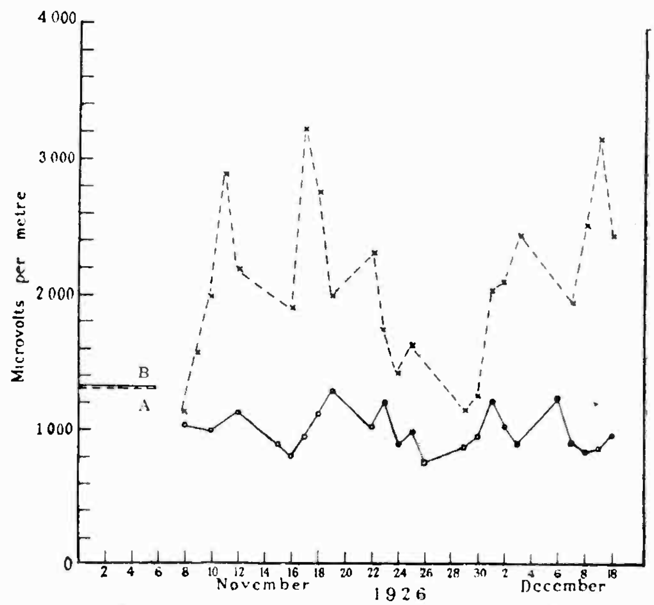


Fig. 3.—*GKB*, $\lambda = 6.950$ *metres. Broken line* :—*Manchester* (*distance* 243 *km., bearing* 149). *Full line* :—*Exeter* (*distance* 238 *km., bearing* 66). *A—Austin-Cohen value* (*Manchester*). *B—Austin-Cohen value* (*Exeter*).

transmissions from Ongar (GLP, 5,100 m.) showed generally similar effects.

The author then compares these results with those obtained on long-distance measurements. In a cruise conducted by the Marconi Coy. it was found that no signals were received from New York when the great-circle between the vessel and New York was over or near the North and South Poles. The same paper showed that measurements in S. Africa gave signal strengths of the European stations to the North of only 50 per cent. of the signal-strength of American stations to the West. The present author therefore suggests that the conditions are such that at short distances more energy is returned in the South-North than in the East-West direction, and therefore less energy is left to travel to greater distances in the former direction than in the latter. Further confirmation is obtained in magnetic-storm data. It has been found that at short distances magnetic storms do affect the transmission. On one occasion (October, 1927) measurements at Manchester of the Rugby transmission over a distance of 136 km. varied from 8.4 to 18 mv/m., while the reflection coefficient rose to nearly three times its normal value. It has also been noticed that the effect of the magnetic storm generally lasts for several days. In one case it took three weeks for radio conditions to become normal again. The U.S. Bureau of Standards has also reported that at times of magnetic storms short-distance long-wave stations increased their intensity at Washington, while the intensity on long-distance stations was low.

The author then draws comparisons between short-distance (less than 400 km.) and medium-distance (400 to 1,000 km.) transmissions.

It has been found that in summer long-wave signals from distances between 400 and 1,000 km. go through a perfect cycle of intensity variation for about two hours after sunset. Observations at Slough and Manchester on the Rugby transmission failed to show a typical sunset cycle. On the other hand, the curve of Fig. 5 shows simultaneous measurements at Manchester (short distance) and Aberdeen (medium distance) on the transmissions of Northolt. The sunset cycle is clearly shown in the Aberdeen graph, while over the earlier part of the graph it would seem that the part of the atmosphere from which the space wave is returned to Aberdeen has much more constant properties than is the case with the critical height for Manchester. Similar effects were obtained on the transmissions from Leafield.

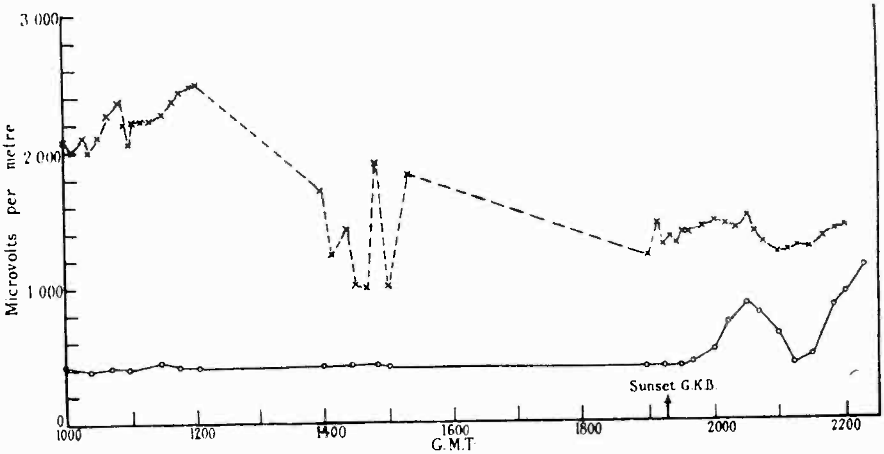


Fig. 5.—*GKB*, λ = 6,950 *metres. Broken line :—Manchester (distance* 246 *km., bearing* 149). *Full line :—Aberdeen (distance* 632 *km., bearing* 169).

These results indicate the existence of certain phenomena peculiar to short-distance transmission. It is known that about 100 km. up the atmosphere changes rapidly and consequently waves going above this height will be influenced differently from those which are reflected at the accepted height of daytime ionisation. At the greater heights the pressure is lower and the mean-free-path will be greater than at 75 km. Another outstanding feature of this short-distance reception is the large apparent rotation of the plane of polarisation, which gives rise to unusually large variations of direction-finding bearing.

Discussion.

In opening the discussion on both papers, Dr. R. L. Smith-Rose compared the author's results in Cornwall with those previously published by Mr. J. H. Reyner, pointing out that the contours lay oppositely in the two papers. He thought the effect of a hill which was a quarter-wavelength high could not cast a shadow of 40 or 50 miles. He would not like to rule out the possibility of the Bodmin Beam Station having an effect, and was at present somewhat doubtful about both sets of measurements. As regards the other paper he thought there had been previous reference to downcoming long waves at short distances, both in the work of Dr. Hollingworth and himself. Slides were shown of variation of d.f. bearings at Slough of the Leafield Station on 12,000 metres, the variations being due to the downcoming wave. Was there any evidence of comparative effects of the North-South or East-West paths on medium wavelengths ?

MR. J. H. REYNER said his measurements had simply been done as a holiday experiment and with imperfect apparatus. He had no explanation to offer of the differences shown between the author's measurements and his own. If the fall in signal-strength was due to natural features should not the shadow close up again after a distance ?

DR. J. HOLLINGWORTH said that although long waves were in less favour as channels of communication, they were still of great importance as electrical phenomena. With reference to the division of short and medium distances he quoted previous results on measurements of Rugby at steadily increasing distances, and said that the change of effects about 300 or 400 km. was quite real.

CAPT. P. P. ECKERSLEY, referring to the author's measurements of effective height, quoted measurements made round Daventry and said that measurements made close to the aerial usually appeared to come out higher. He described experiments on measuring the field-strength from 5XX in various parts of the Pennines, and said that better effects had been observed when signals went along a valley than if they went across it. In his experience the shadow would fill up after a distance. The author's work was of great importance in the practical estimation of service areas.

MR. H. L. KIRKE described experiments in Somerset and Devon on about 300 metres in connection with choosing a site for the Western Regional transmitter. The geology of the sub-soil had appeared to have a great bearing and over the granite of Dartmoor signals vanished completely.

MR. A. J. GILL expressed surprise at the two sets of results in Cornwall not being more discrepant than they were, and thought that not too great importance should be attached to field-strength measurements on portable apparatus.

MR. T. L. ECKERSLEY agreed that more was to be learned from the study of long waves. On these waves arguments of ray transmission and reflection were less applicable. In the case of the Cornish measurements, if the hill was small compared to the wavelength the result should be a symmetrical disturbance of field. He thought, however, that the effects were too great to be due to the hill alone and was of opinion that the shape of the contours suggested coastal effects.

COL. H. P. T. LEFROY referred to the effect of minerals on the soil, particularly the possibility of radioactive and other local fields. In Ireland it was a common experience for signals from Daventry in an East-West direction to fall to low levels, while signals from the South-North directions came up in strength.

MR. R. NAISMITH replied to several of the points raised in the discussion. He said he could find no effect due to the Bodmin Beam Station, but that the effect of the hill was most definite. He had not been able to trace any evidence of coastal effect, although this had been looked for.

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

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.

Physical Reality of Side Bands.

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

SIR,—In the January issue of this journal, Mr. F. M. Colebrook contributed an interesting article entitled: "The Physical Reality of Side Bands." I wish to comment on this article because I think the very completeness of Mr. Colebrook's elegant analysis has tended to obscure some interesting things which can be extracted from it. Following Mr. Colebrook's notation, an E.M.F., $e = E \cos (\omega - n)t$ produces a P.D. across the tuning inductance of value $v = Y_1 E \cos (\overline{\omega - nt} + \theta_1)$, where $Y_1 = \dfrac{1}{\sqrt{f^2 + 4a^2}}$: in this expression f is the power factor of the circuit and a is the fractional modulation frequency, n/ω. Since Y_1 depends on the square root of the sum of the squares of two quantities, it is very nearly equal to $1/f$ or else it is very nearly equal to $1/2a$, except when f and $2a$ are nearly equal. The borderland between the two approximate expressions is always small and the analysis, together with its physical interpretation, is much simplified by considering separately the two conditions when Y_1 is sensibly equal to one or other of the two approximate expressions. I am thinking mainly of circuits whose decrement has been reduced by retroaction to a very small value. I am aware that retroaction also has an effect on the effective reactance of the circuit, but examination will show that this effect is negligible for all values of a which have practical interest. Let us suppose that retroaction has reduced the decrement to 0.1% ($f = 0.001\pi$) and that the carrier wave frequency is 1,000 k.c.s. Then Y_1 is sensibly equal to $1/2a$ for all notes higher than 300 cycles/sec. and is sensibly equal to $1/f$ for all notes lower than 100 cycles/sec. If the decrement is 5% then Y_1 is sensibly equal to $1/f$ for all notes lower than 4,000 cycles/sec. with a carrier frequency of 1,000 k.c.s., and will not approach the value $1/2a$ until the note frequency is greater than 10 k.c.s.

Consider the voltage across the tuning inductance when the circuit is tuned to the carrier wave. If the circuit decrement is very small, that is, $4a^2 \gg f^2$, then the circuit will behave sensibly as a pure inductance to the upper side band and sensibly as a pure capacitance to the lower side band. For numerical purposes I shall always suppose the carrier frequency is 1,000 k.c.s.: the term small decrement will mean a decrement of the order of 10^{-3} and large decrement will mean a decrement of the order of 5%. To a small decrement the circuit will behave as an inductance or as a capacity to the side bands for all frequencies higher than 300 cycles/sec., and for a large decrement it will behave as a pure resistance for all frequencies less than about 4,000 cycles/sec. This has given us a numerical scale to show the range of applicability of the ensuing approximate expressions.

For the small decrement, the E.M.F.

$$e = E\left\{\cos \omega t + \frac{m}{2}\cos(\omega - n)t + \frac{m}{2}\cos(\omega + n)t\right\}$$

will produce a P.D. across the tuning inductance

$$v = E\left\{\frac{1}{f}\sin \omega t - \frac{m}{4a}\cos \overline{\omega - nt} + \frac{m}{4a}\cos \overline{\omega + nt}\right\}$$

$$= \frac{E}{f}\left(1 - m\frac{f}{2a}\sin nt\right)\sin \omega t \quad \ldots \quad (1)$$

So the effect of the circuit is to magnify the voltage $1/f$ times and to reduce the modulation ratio to a fraction $f/2a$ of its value in the impressed E.M.F. If the voltage across the tuning inductance is examined by a cathode ray oscillograph, the resulting oscillogram will be modulated, but the persistence of the circuit has done much to smooth the modulation. Thus suppose a decrement of 10^{-3} and a modulation frequency of 1,000 cycles/sec., then the modulation is reduced by the circuit to about 17% of its value in the incident E.M.F.

If the circuit has a high decrement, then the persistence of the circuit will do little to smooth the apparent modulation, and

$$v \doteqdot \frac{E}{f}\left\{1 - m\left(1 - \frac{2a^2}{f^2}\right)\cos nt\right\}\sin \omega t$$

$$\doteqdot \frac{E}{f}(1 - m\cos nt)\sin \omega t \quad \ldots \quad (2)$$

If now the low decrement circuit is tuned to the lower side band we have

$$v = \frac{E}{2}\left[\left(\frac{1}{a} - \frac{m}{f}\sin nt + \frac{m}{4a}\cos nt\right)\cos \omega t + \left(\frac{m}{f}\cos nt - \frac{m}{4a}\sin nt\right)\sin \omega t\right]$$

$$= \frac{E}{2}\sqrt{\frac{1}{a^2}\left(1 + \frac{m^2}{16}\right) + \frac{m^2}{f^2} - \frac{2m}{af}\left(\sin nt - \frac{f}{2a}\cos nt\right) - \frac{m^2}{2af}\sin 2nt}\;\sin(\omega t + \phi)$$

$$\doteqdot \frac{Em}{2f}\sqrt{1 - \frac{2f}{ma}\sin nt - \frac{f}{2a}\sin 2nt}\;\sin(\omega t + \phi)$$

$$\doteqdot \frac{Em}{2f}\left(1 - \frac{f}{ma}\sin nt - \frac{f}{4a}\sin 2nt\right)\sin(\omega t + \phi) \quad \ldots \quad (3)$$

if $\dfrac{2f}{ma} \ll 1$

So on tuning to the lower side band the octave of modulation is introduced (*See also* Editorial, Aug., 1930) and the apparent modulation for the fundamental note becomes f/ma. If the signal modulation is 100% then the apparent modulation when tuned to the side band is about twice as great as when tuned to the carrier. The expression remains unchanged whether the circuit is tuned to the upper or to the lower side band. If the circuit has a high decrement, equation (2) will remain substantially unchanged if the circuit is tuned to either side band.

Equations (1), (2) and (3) described the envelope of the voltage as explored by a cathode ray oscillograph, but now consider the effect of these voltages on a rectifier which has a parabolic characteristic. Consider first the high frequency response curve, corresponding to Fig. 5 of Mr. Colebrook's article. The mean rectified current is proportional to the mean square voltage, and so for the low decrement circuit tuned to the carrier we have $J_1 = \frac{k}{2}\frac{E^2}{f^2}$ and when tuned to the side band we have $J_2 = \frac{k}{2}\frac{E^2m^2}{4f^2}$.

So to this order the two side response peaks are of equal height and this height can approach one quarter that of the central peak in the limiting case of 100% modulation. If the circuit has a high decrement then the side peaks will be sensibly the same height as the central peak. In Fig. 5 of Mr. Colebrook's paper the height of the two side peaks is approximately one quarter that of the central peak. The slight difference of height between the two side peaks is probably due to the enormous value of α, namely 10%. It is perhaps useful to remember that with a low decrement circuit the side peaks will approach one quarter the height of the central peak.

Now consider the acoustic output. When a low decrement circuit is tuned to the carrier, the voltage applied to the rectifier varies slowly between

$$\frac{E}{f}\left(1 + \frac{mf}{2\alpha}\right) \text{ and } \frac{E}{f}\left(1 - \frac{mf}{2\alpha}\right)$$

Whence
$$J = \frac{k}{2}\frac{E^2}{f^2} \times \frac{mf}{\alpha}\sin nt,$$
$$= \frac{kmE^2}{2\alpha f}\sin nt.$$

When the circuit is tuned to the side band, the voltage varies slowly between

$$\frac{Em}{2f}\left(1 + \frac{f}{m\alpha}\right) \text{ and } \frac{Em}{2f}\left(1 - \frac{f}{m\alpha}\right)$$

Whence
$$J = \frac{kmE^2}{4\alpha f}\sin nt.$$

So the side peaks of the acoustic output will be half the height of the central peak. Figs. 6 and 8 of Mr. Colebrook's paper are in fair agreement with this estimate. These same results can be derived from Mr. Colebrook's analysis by putting

$$\theta_1 = -\frac{\pi}{2},\ \theta_c = -\frac{f}{2\alpha},\ Y_c = \frac{1}{2\alpha},\ Y_2 = \frac{1}{4\alpha},$$

etc., but it is helpful to have derived the expressions *via* the modulation of the voltage applied to the rectifier.

A square law rectifier always creates an octave, but tuning to the side band creates an octave independently of the effect of the rectifier, and its amplitude is approximately 25% of that of the fundamental note. The octave will make very little increment to the reading of a mean square instrument used to measure the acoustic output, but it would be perceptible in a telephone, as the effective height of the side peaks is more than half that of the central peak. Mr. Colebrook ignores the octave produced by the rectifier (arising from the product $v_1 v_2$ in his notation). When tuned to the carrier the fractional amplitude of this octave is $m/4$ for a circuit of high decrement and is $mf/4\alpha$ for a low decrement: so in this sense the low decrement circuit gives greater purity of response. When tuned to the side band, the octave will have a fractional amplitude $m/4$ whether the circuit decrement is large or small.

If a note of given frequency is received by a circuit of small power factor f' or large power factor f, the respective responses will be in the ratio $f^2/2\alpha f'$. Thus suppose the decrements are 6.3% and 0.314% and the note is 2 k.c./s then this ratio is 100 to 1 in favour of the low decrement circuit.

This result is analytically correct for a rectifier with parabolic response, but the low decrement may apply a voltage too great for parabolic response. The response of a cumulative grid rectifier becomes linear for applied voltages greater than about 300 mv. In the previous numerical example suppose the unmodulated signal E.M.F. is 1 mV, then the signal P.D. would be 50 mV for the high decrement and 1 V for the low: the response would be parabolic to 50 mV and linear to 1 V. It is well known that the decrease of mean grid potential of a cumulative grid rectifier is substantially equal to the peak value of the applied P.D. (provided this peak value is greater than about 0.4 V). So when tuned to the carrier this P.D. will fluctuate between

$$\frac{E}{f}\left(1 + \frac{mf}{2\alpha}\right) \text{ and } \frac{E}{f}\left(1 - \frac{mf}{2\alpha}\right)$$

Whence
$$J = \frac{E}{f}\frac{mf}{2\alpha}\sin nt,$$
$$= \frac{Em}{2\alpha}\sin nt.$$

This is independent of decrement. So if the decrement is reduced by retroaction there will come a point beyond which further reduction makes no increase of signal. Also such a rectifier would not produce an octave, though the time constant of the grid circuit would produce some corresponding effect. So the previous numerical comparison between the two circuits is probably invalid because the response for one would be linear and for the other parabolic. A general numerical comparison cannot be made because it would involve a particular and specific rectifier (the constant k), but it can be estimated as follows. With a signal E.M.F. of 1 mV maximum, a circuit power factor of 2×10^{-3}, and 100% modulation, the signal P.D. will fluctuate acoustically between 50 mV and zero. The grid potential will fluctuate between about 25 mV and zero, with a mean value of, say, 10 mV and a swing due to the fundamental note of about 10 mv. With $f' = 10^{-3}$ and $\alpha = 2 \times 10^{-3}$, the grid potential will fluctuate acoustically between 1.25 V and 0.75 V, with a swing of 250 mV. So now the comparison is about 25 to 1 instead of 100 to 1 in favour of the low decrement; further reduction of decrement will not alter this ratio.

With small decrement and a grid rectifier it can be shown that the side peaks of high frequency output are half the height of the central peak and the side peaks of acoustic output are the same height as the central peak.

Now consider the immunity from interference which a small decrement confers. This has been partly considered already when the circuit was supposed to be tuned to the side band, for this corresponds to an interfering station whose lower side band just happens to coincide with the carrier of the desired signal. The immunity with a low decrement was found to be twice that for a high decrement. But this comparison is scarcely fair, for it applies only to that particular note of the interfering station which gives a side band exactly in tune with the carrier of the desired station.

It is more important to estimate the general level of immunity. Let the desired station have a frequency ω modulated at frequency n, and let the interfering station have a frequency $(\omega + n)$ which is modulated at frequency n', where n' is appreciably less than n.

Let $e = E(1 + m \cos n't) \cos \overline{\omega + n}t$

and let $\alpha = \frac{n}{\omega}$, $\beta = \frac{n - n'}{\omega}$ and $Y = \frac{n + n'}{\omega} \doteq 2\alpha$

then $$v = \frac{E}{2}\left\{\frac{1}{\alpha}\cos \overline{\omega + n}t + \frac{m}{2\beta}\cos(\omega + n - n')t + \frac{m}{4\alpha}\cos(\omega + n + n')t\right\}$$

This will be valid so long as $2\beta \gg f$: thus suppose the decrement is 0.1% and that $\alpha = 5 \times 10^{-3}$ (that is 5 k.c./s separation on a carrier of 1000 k.c./s). Let us restrict β to 10^{-3} so that we are considering the immunity from the first 4 k.c. of the interfering station

$$v \doteq \frac{E}{2}\left[\left\{\frac{1}{\alpha} + \frac{m}{2\beta}\cos n't\right\}\cos \overline{\omega + n}t + \frac{m}{2\beta}\sin n't \sin \overline{\omega + n}t\right]$$

$$= \frac{Em}{4\beta}\sqrt{1 + \frac{4\beta}{\alpha m}\cos n't + \frac{4\beta^2}{\alpha^2 m^2}}\cos(\overline{\omega + n}t + \theta)$$

So the peak voltage applied to the rectifier is

$$V \doteq \frac{Em}{4\beta}\left(1 \pm \frac{2\beta}{\alpha m}\right)$$

and the mean square voltage is

$$V = \frac{E^2 m^2}{32\beta^2}\left(1 \pm \frac{2\beta}{\alpha m}\right)^2$$

Since $\beta \gg f$, the interfering station will not produce voltage sufficient for linear rectification, except on the very high notes. It is almost impossible to make a numerical comparison between the interfering station acting on a parabolic rectifier and the desired station acting on a linear rectifier. So we must be content with supposing the rectifier behaves parabolically to both signals. Then it follows that the ratio of desired to undesired signal is $2\beta/f$. Or if α is the fractional separation of the two carriers, α_1 the fractional frequency of modulation of the desired note, and α_2 the fractional frequency modulation of the undesired note, then the ratio of the desired to the undesired note is $\frac{2(\alpha - \alpha_2)\alpha}{\alpha_1 f}$. For notes of the same frequency $\alpha_1 \doteq \alpha_2$ and then this ratio is $\frac{2\alpha}{f}\left(\frac{\alpha}{\alpha_1} - 1\right)$. Thus, supposing the carriers are separated by 5 k.c./s, the decrement is 0.1% and the note is 2 k.c./s; then the ratio is 62 to 1.

In conclusion it may be interesting to compare the relative response of various notes from a circuit of decrement 0.1%, all expressed in terms of the response to a note of 3 k.c./s.

Note frequency in k.c./s ..	5	4	3	2	1	0.5	0.1
Response	0.6	0.75	1	1.5	3	6	15

E. B. MOULLIN.

Eng. Labty., Oxford.
13th March, 1931.

Carrier Waves and Side Bands.

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

SIR,—It is very frequently supposed that the method of breaking up a modulated signal into the familiar carrier waves and side bands is justified by the fact that an expression of the form :—

$$i = I\{1 + s_1 \sin(pt + \phi_1) + \ldots s_n \sin(npt + \phi_n) + \ldots\}\sin \omega t \quad \ldots \quad (1)$$

can be changed to the form :—

$$i = I \sin \omega t + I\frac{s_1}{2}\cos\{(\omega \pm p)t + \phi_1\} + \ldots I\frac{s_n}{2}\cos\{(\omega + np)t + \phi_n\} + \ldots \quad \ldots \quad (2)$$

by the aid of a few simple trigonometrical relations. But this is certainly not the case ! The equations (1) and (2) are merely alternative expressions of the same variation of the current i in terms of time, t. There is no more to be deduced from the fact that the second equation is derived from the first than there is from the two alternative forms of the alternating current power equation :—

$$W = IV \sin(\omega t - \phi)\sin \omega t$$

$$W = \frac{IV}{2}\{\cos\phi - \cos(2\omega t + \phi)\}$$

It is true that the second form of the two latter equations is more convenient when it comes to finding the mean value, but that does not justify the conclusion that the second form gives any new information. It cannot do so, because both equations are the equations of the same wave form. Similarly, for purposes of calculation, equation (2) of the modulated wave may be, and generally is, more convenient than equation (1) ; but that does not mean that it is giving any information that is not already included in equation (1). 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 and hides the fact that the derivation of this theory is far more fundamental.

The true basis of the theory is twofold ; theoretical and experimental.

In the first place it is demonstrable that every sequence of values that is repeated cyclically must be capable of being represented by an equation of the form of equation (2). The mathematician has established this conclusion beyond question and there is no experience contradicting it. The only difficulty is to determine the true values in any specific case, and it is for this reason that equation (1) is convenient. It gives a time variation very like that which is observed actually to take place, and if all the terms involved in equation (1) can be found by the aid of equation (2), it is a fair conclusion that the actually existing constituent carrier waves and side bands will agree closely with these calculated values. And, naturally, the more exactly equation (1) represents the actual modulated signal, the more nearly correct will be the results obtained from equation (2).

In the second place the reality of the carrier wave and side bands rests on two crucial experiments :—

(*a*) If a cyclically modulated signal is received on a self heterodyning detector, the characteristic beat notes are obtainable for the carrier wave and for the side bands. Moreover, accurate observation of the frequency made in this way proves that these side band frequencies are in fact those given by equation (2); as they must be according to the theory, whatever form is assumed for equation (1), provided only that the variations of amplitude repeat themselves in cycles of equal length of time.

(*b*) A resonant circuit will show resonant responses when tuned to the carrier wave and when tuned to the side bands respectively. This again enables the frequencies predicted from the side bands to be verified.

For the cyclically modulated signal there is therefore no possibility of doubt; but a further and troublesome question immediately arises, *viz.* :— Is it justifiable to make use of the results applicable to cyclical modulation when, in fact, the modulation is irregular as in the transmission of speed or morse? Again there is both theoretical and an experimental support for the carrier wave and side band theory. A yet more difficult mathematical demonstration—the rigid logic of which is nevertheless beyond criticism—shows that a complex modulation consists of an infinite series of side bands associated with a carrier wave. The infinite series of side bands differ in frequency by infinitely small amounts and it is no longer possible to separate them into individual constituents. They cannot be shown to have a separate existence either by means of a heterodyne detector or a resonant circuit, and the only way in which they can be expressed is by taking a small range of frequency and summing all the amplitudes of the side bands lying within this range. It then becomes possible to speak of the distribution of the side bands in terms of the summed amplitude per unit difference of frequency at each frequency. Every process of modulation must have—according to this theory—a particular distribution of side band amplitude and a particular magnitude of carrier wave (including, possibly, the case of zero magnitude). Should any change of relative magnitude of any portion of the side bands occur in transmission or reception a different distribution is set up corresponding to a different modulation. In other words, it is only a transmitting and receiving system that responds uniformly when tested by cyclically modulated test signals that will give a true rendering of any other process of modulation.

The strongest experimental support for this theory is that the conclusions based upon it prove to be correct. Audio frequency calculations relating to telephone equipment are almost always made on the assumption of a series of sinusoidal wave forms, each wave having a definite frequency and being continuously applied. The results thus obtained are then applied to the transmission of speech waves. The conclusions prove correct and justify the assumption that the speech variations may be considered as an infinite range of sinusoidal waves of appropriate amplitude and frequency distribution. Where there is a wireless link in the transmission, the high frequency term is involved as in equation (1) and this brings in the carrier wave and the infinite distribution of side bands.

To epitomise: the carrier wave and side band theory rests upon logical deduction supported by experiment, the latter support proving that the premises upon which the logical argument is based are correct and complete for all the conditions contemplated. To the mathematician the carrier wave and side band theory is merely one application of Fourier's Theorem.

C. L. Fortescue.
City and Guilds (Engineering) College,
London, S.W.7.
26th March, 1931.

Books Received.

The Orfordness Rotating Beacon and Marine Navigation. (Radio Research Board, Special Report No. 10.) By R. L. Smith-Rose, D.Sc., Ph.D., A.M.I.E.E.

Comprising a description of the principle of the Beacon method of taking bearings by stop-watch, Results obtained from observations made in ships at sea, Light vessels, etc. Pp. 14, with four illustrations, snap and specimen records taken at the N.P.L., Teddington, with the automatic recorder. Published by H.M. Stationery Office, price 6d.

Filters for the Reproduction of Sunlight and Daylight and the Determination of Colour Temperature (Bureau of Standards, Miscell., Publ. No. 114). By R. Davis and K. S. Gibson.

Pp. 165, with 33 diagrams, 37 charts, and formulae and bibliography. Published by the Department of Commerce, U.S.A., price 45 cents.

Abstracts and References.

Compiled by the Radio Research Board and reproduced by arrangement with the Department of Scientific and Industrial Research.

PROPAGATION OF WAVES.

SUR LES PHÉNOMÈNES DE PROPAGATION DANS LES GAZ IONISÉS PAR LES DÉCHARGES DE TRÈS HAUTE FRÉQUENCE (On the Propagation Phenomena in Gases Ionised by Very High-Frequency Discharges).—M. Chenot. (*Comptes Rendus*, 16th March, 1931, Vol. 192, pp. 673–675.)

Further development of the work referred to in March Abstracts, p. 166. Experiments with containers of different design show the occurrence (as in acoustics) of reflections with and without change of sign, and fit in well with the idea of a propagation of an oscillatory motion of electrified particles. The effects of a magnetic field have been observed. Finally, the formation of an ovoid nucleus, brilliant and of well-defined contour, was often noted at the middle of the inter-nodes, recalling the results of Wood (1930 Abstracts, p. 468) which Langmuir interpreted as due to oscillations in a "plasma" of ions and electrons, analogous to those observed by himself in the mercury arc.

Tonks and Langmuir also showed the possibility of a wave propagation of positive ion vibrations. In a medium containing n positive ions and n electrons per cubic centimetre, the wavelength λ for a frequency ν is given by the expression (derived from the Tonks-Langmuir formulae)

$$\lambda = \left[kT_e \left(\frac{1}{m_p \nu^2} - \frac{\pi}{ne^2} \right) \right]^{\frac{1}{2}}$$

where e is the charge of a particle, m_p the mass of the positive ions, k the Boltzmann constant and T_e the "temperature" of the electrons. The writers' tests have shown that for a constant frequency, the length of wave increases when the ionisation increases. To verify this, they have examined the propagation of high-frequency vibrations in a medium ionised by much lower frequency discharges, so that the ionisation produced was independent of the oscillations whose propagation was under investigation. *Here again the length of the inter-nodes increased with the ionisation.*

MECHANISCHE ANALOGIEËN VAN DE UITBREIDING VAN ELECTROMAGNETISCHE GOLVEN IN EEN GEÏONISEERD GAS (Mechanical Analogies for the Propagation of Electromagnetic Waves in an Ionised Gas).—W. de Groot. (*Physica*, 1930, Vol. 10, No. 10, pp. 317–330.)

Substantially the same paper as that dealt with in January Abstracts, p. 31.

WYNIKI 2-SERJI BADAŃ NAD ROZCHODZENIEM SIE FAL KRÓTKICH (Results of the Second [Polish] Investigations on the Propagation of Short Waves).—D. M. Sokolcow and J. Bylewski. (*Wiadomości i Prace Inst. Radjotech., Warsaw*, No. 1, Vol. 3, 1931, 32 pp.)

In Polish. Continuation of the work referred to in 1930 Abstracts, p. 501. A set of curves showing strength of signals on an average day received from Warsaw at Lwow, Berlin, and three other places, is given for each of the wavelengths 40, 50, 60, 80 and 100 m. Further sets of curves compare the strengths for the various wavelengths at each of these places. Another diagram ("Rys. 16") represents the times of day at which reception is strongest, for the various wavelengths, and also the corresponding strengths of the signals. The next diagrams show the effect of sunset and sunrise on the different waves; the next, the effect of increasing the power at the transmitter, for different waves; finally, the propagation of the 30 and 60 m. waves in autumn is compared with that in summer. Throughout, the strength of signals is represented in milliampères, but these are interpreted at the end of the paper in terms of the "international scale of intensity (0 to 5)" and of "audibility."

SOME ABNORMAL VALUES OF SIGNAL INTENSITY FROM BROADCASTING STATIONS.—M. N. Doraswami and S. R. Kantebet. (*Indian Journ. Phys.*, No. 4, Vol. 5, pp. 429–440.)

Measurements of the field strengths of the Bombay broadcasting station (357.1 m.) were made on 3-minute dashes received on a superheterodyne equipment with a sensitive galvanometer in the output circuit. While the observed intensities varied within wide limits, it was found that occasionally they exceeded the values calculated according to the Hertz, Austin-Cohen and Fuller formulae. Strong fading was observed. The fading factor obtained from the curves was 40 % higher than that of a theoretical curve built up on the assumption of a number of interfering rays. But the actual fading is not a periodic process, and the result is therefore regarded as the equivalent of the sum of a large number of harmonic oscillations *differing slightly in amplitude and period.* It is thought that the change in period may take place during propagation, presumably owing to reflection at the Heaviside layer.

NOTE ON HIGH-FREQUENCY [20 AND 25 MEGACYCLES] TRANSMISSION DURING THE SUMMER OF 1930.—G. W. Kenrick, A. H. Taylor and L. C. Young. (*Proc. Inst. Rad. Eng.*, Feb., 1931, Vol. 19, pp. 252–255.)

Authors' summary:—"The results of observations of echo signals at Cheltenham, Md., on 20 and 25 megacycles during the summer of 1930 are presented. A notable absence of strong echoes during this period is noted and marked abnormalities in their time of occurrence (as compared with previously reported results) are found. A comparison with field strength observations on GBU (18.62 mc.) is included and a discussion of possible causes of the abnormalities is given. The close correlation between the intensity of echoes and the intensity of the reception at Bellevue of the high-frequency signals from Rocky Point is also emphasised."

The note ends by suggesting that the explanation of these phenomena may perhaps involve considerations of turbulence, layer movements, and the relative density of several layers as well as electron density considerations in a single layer.

WIDE RANGE SCALES FOR FADING RECORDS BY ELECTRICAL MEANS.—G. D. Robinson. (*Proc. Inst. Rad. Eng.*, Feb., 1931, Vol. 19, pp. 247–251.)

Author's summary:—The electrical means discussed in the following paper are two in number. Relatively small modifications of the response characteristics of the recording system may be obtained by the use of a combination of plate detection and grid detection in which the latter becomes active only for strong signals. Great modifications of the response characteristics are produced by circuit arrangements of the type used for "automatic volume control."

Curves are given showing typical results. These show the possibility of obtaining greatly increased scale ranges and also of obtaining scales in which the recorder response is roughly proportional to the logarithm of the strength of the carrier wave. The response to side bands is stated to be small.

ELECTRON BEAM EXPERIMENTS IN CONNECTION WITH THE LONG DELAY ECHOES.—E. Brüche. (*Rad., B., F. f. Alle*, March, 1931, pp. 105–109.)

This long summary of Brüche's lecture (see past Abstracts) gives particulars of his method of obtaining a concentrated beam of slow electrons. A hot cathode of very small surface was used, and a hollow conical anode with its large end close to the cathode so that a very fine, concentrated beam emerged from an opening at the vertex. Voltages of only 150–200 v. were employed, and a vacuum of one-thousandth mm. mercury. The intensity of the beam (of length 1 metre and over) was so great that it could be observed and photographed with ease. *See* also March Abstracts, p. 167.

EXPERIMENTELLE UNTERSUCHUNGEN ÜBER BLECHSCHIRME IM ELEKTROMAGNETISCHEN STRAHLUNGSFELD (Experimental Investigations into the Effects of Metal Screens in an Electromagnetic Radiation Field).—W. Seiler. (*Zeitschr. f. hochf. Tech.*, March, 1931, Vol. 37, pp. 79–89.)

The distorting effects on the radiated field of a transmitter produced by trees, buildings, masts, etc., become of importance when the wavelength is brought down to the same order of magnitude as the dimensions of the obstructions (*i.e.*, in actual practice, $\lambda < 100$ m.). The writer has therefore carried out a series of tests on 2 m. waves, radiated from a vertical half-wave aerial, using metal screens (0.2 mm. zinc) of height varying from $\lambda/4$ to λ and breadth varying from 3 metres to strips so narrow as to behave like bars. The transmitter was raised 1.5 m. above the meadow ground, the receiver (with vertical dipole) was at a distance of 30 m. from the transmitter and was raised till the proximity of the ground no longer decreased the field—this point was reached at 2.5 m. above the ground. The screens were supported on trestles and moved about between transmitter and receiver; they were, apparently, raised so that their "equators" were on the line between transmitter and receiver.

A number of field diagrams are given, as well as curves showing the percentage variation as a function of the distance from screens of various heights and breadths. It was found that narrow screens (up to $\lambda/4$ breadth) gave a field identical with that produced by a dipole, both as regards phase displacement (depending only on the height) and amplitude. The resonance height was distinguished by a 90 deg. displacement and the maximum re-radiation. Field diagrams 9 to 15, in which the breadth varies from $\lambda/2$ to $3\lambda/2$, all show that standing waves are formed in front, while at the sides and behind the screen interference patterns are produced which are such as would be formed if only the edges of the screen acted as secondary radiators. Here again the phase displacement depends only on the height of the screen. Moreover, a variation in breadth has practically no effect on the *amplitude* of the re-radiation, except at the sides when the screen is of the resonant height.

Various other results are shown, including those obtained with a slanting screen, a grid of vertical wires, and two screens leaving a vertical gap between them.

RADIATION OF MULTIPOLES.—K. F. Herzfeld. (*Phys. Review*, 1st Feb., 1931, Series 2, Vol. 37, No. 3, pp. 253–259.)

"The radiation of multipoles formed by putting together elementary dipoles is investigated according to the classical theory and wave mechanics."

ZUR REFLEXIONSPOLARISATION DER ELEKTRONENWELLEN (On Polarisation of Electron Waves on Reflection).—O. Halpern. (*Zeitschr. f. Phys.*, 1931, Vol. 67, No. 5/6, pp. 320–332.)

SUR L'ABSORPTION DES RADIATIONS DANS LA BASSE ATMOSPHÈRE ET LE DOSAGE DE L'OZONE (The Absorption of Radiations in the Lower Atmosphere, and the Estimation of the Ozone Density).—Ch. Fabry and H. Buisson. (*Comptes Rendus*, 23rd Feb., 1931, Vol. 192, pp. 457–461.)

ÜBER DIE EXPERIMENTELLE ERFORSCHBARKEIT DER HÖHEREN SCHICHTEN DER ATMOSPHÄRE (On the Explorability of the Higher Layers of the Atmosphere).—H. Benndorf. (*Physik. Zeitschr.*, No. 13, Vol. 30, pp. 429–430.)

A continuation of the paper referred to in 1929 Abstracts, p. 324. The present part still deals with the use of air waves.

WEITERFÜHRUNG DER RIEMANNSCHEN METHODE ZUR INTEGRATION DER DIFFERENTIALGLEICHUNG DER GEDÄMPFTEN WELLEN (Further Development of Riemann's Method for the Integration of the Differential Equation of Damped Waves).—A. Korn. (*Zeitschr. f. angew. Math. und Mech.*, No. 4, Vol. 10, pp. 368–373.)

DISPERSION OF A SHOCK IN ECHOING- AND DISPERSIVE-ELASTIC BODIES.—K. Sezawa and G. Nishimura. (*Bull. Earthquake Res. Inst., Tokyo*, No. 3, Vol. 8, pp. 321–337.)

For a summary, see *Physik. Ber.*, 1st Jan., 1931, Vol. 12, p. 120.

THEORY OF EARTHQUAKE WAVES.—B. Gutenberg. (Long abstract in *Physik. Ber.*, 1st Jan., 1931, Vol. 12, pp. 121–122.)

SINUSOIDAL CURRENTS IN LINEARLY TAPERED [SEE BELOW] LOADED TRANSMISSION LINES.—J. W. Arnold and P. F. Bechberger. (*Proc. Inst. Rad. Eng.*, Feb., 1931, Vol. 19, pp. 304–310.)

A continuously loaded line possessing the following constants at a distance l from the beginning may be said to be "linearly tapered":—

$$L = L_0 + k_{L}e,\ R = R_0 + k_{R}e,$$

G and C constant. Working formulae for the calculation of input impedances and attenuation are obtained for such a line. The theory is applicable to the tapered loaded submarine cable.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

AUSTRALIAN ATMOSPHERICS ON RECEIVERS TUNED TO 3,000 AND 30,000 METRES.—Australian Radio Research Board.

Regarding par. iv. of the abstract on p. 55 of January Abstracts, the following has been received from the Commonwealth Radio Research Laboratory:—"Owing to a misplacement of the word 'only' in the original report, a wrong sense has been given to the statement quoted on atmospherics. The point is that only local sources, *i.e.*, within 1,000 miles, produce appreciable atmospherics on 3,000 metres by day, whereas both local and much more distant sources are observed on 30,000 metres."

ATMOSPHERIC PRESSURE AND THE STATE OF THE EARTH'S MAGNETISM.—J. M. Stagg. (*Nature*, 14th March, 1931, Vol. 127, p. 402.)

The writer has obtained results pointing to a hitherto unsuspected relation between the type of the diurnal variation of pressure and the general state of magnetic conditions, as regards disturbance and quiet, over the earth. There is a change in pressure variation from one type of magnetic day to the other. "The predominant features of the change are the reduced development of the forenoon maximum and enhancement of the evening maximum on disturbed as compared with quiet days."

VALUES OF THE MAGNETIC ELEMENTS AT VAL-JOYEUX, DEC. 1930 AND JAN., 1931.—E. Éblé and J. Itié. (*Comptes Rendus*, 16th March, 1931, Vol. 192, pp. 690–691.)

The only special point is the increase of the vertical component, involving that of the total force and the inclination. This element thus regains its Jan. 1911 value, after undergoing in the interval an oscillation characterised by a relative maximum in 1918 between two minima in 1915 and 1926.

GEWITTERHERDE UND GEWITTERZÜGE IN SCHLESIEN (Thunderstorm Groups and Trains in Silesia). — —. Langbeck. (*E.T.Z.*, 22nd Jan., 1931, Vol. 52, p. 121.)

THE MOBILITY OF AGED IONS IN AIR.—N. E. Bradbury. (*Phys. Review*, 15th Jan., 1931, Series 2, Vol. 37, No. 2, pp. 230–231.)

Abstract only. "The value of the mobility of air ions produced in pure air by X-rays has been studied for ions between the ages of 0.04 sec. and 1 sec. . . . Mobilities measured after ageing show a decrease whose magnitude increases with increasing age until values 10 per cent. lower than the normal are reached at ages of 1 sec. This effect can be partially correlated with the decrease in the coefficient of recombination."

ELECTRICAL CARRIERS IN THE ATMOSPHERE DURING RAINSTORMS.—K. Kähler. (*Gerlands Beitr.*, No. 2, Vol. 27, pp. 226–240.)

Potsdam observations during light and heavy rains, squalls and thunderstorms. The numbers of ions of various kinds are compared with synchronous potential gradient records, and the results discussed in relation to the Wilson theory of the origin of the charges on cloud drops.

ZUR DYNAMIK DES REGENS (On the Dynamics of Rain).—F. Ahlborn. (*Physik. Zeitschr.*, 1st February, 1931, Vol. 32, No. 3, pp. 139–147.)

ÜBER DIE MESSMETHODEN DER ELEKTRISCHEN LEITFÄHIGKEIT DER ATMOSPHÄRE (On the Methods of Measuring the Electrical Conductivity of the Atmosphere).—J. Scholz. (*Physik. Zeitschr.*, 1st Feb., 1931, Vol. 32, No. 3, pp. 130–139.)

A description of very sensitive apparatus, developed at the Meteorological Observatory, Potsdam, for measuring the electrical conductivity of the atmosphere. Two exactly similar models were constructed, of which one was used as a control apparatus, in order to eliminate the effect of the meteorological conditions. "It was found in the control measurements which were undertaken that it is advisable, whenever possible, to remove the apparatus for determining potential gradient by radioactive methods to a considerable distance from the place where the conductivity is being measured, for 100 per cent. deviations from the natural value may otherwise be caused. It was further discovered that, when the inlet tube of one condenser was covered with wire-netting, the positive conductivity increased slightly while the negative conductivity decreased. The influence of the earth's field was extraordinarily strong when the inlet was pushed beyond a piece of earthed wire-netting."

Measurements were also made for comparing the two methods (*a*) charging and (*b*) discharging. They showed that both methods lead to identical results. A further report is promised of work on the influence of the opposing field at the upper edge of the condensers and measurements of the conductivity of the light and heavy carriers of electricity.

REPORT ON THE EARTH-POTENTIAL OBSERVATIONS DURING THE TOTAL ECLIPSE OF THE SUN ON 9th MAY, 1929.—S. T. Nakamura and E. Hukusima. (*Sci. Reports Tôhoku Univ.*, No. 3, Vol. 19, pp. 283–291.)

During the eclipse the south component of the potential gradient (Ituaba Island) showed a marked decrease.

VERGLEICHENDE HÖHENSTRAHLMESSUNGEN AUF NÖRDLICHEN MEEREN (Comparative Cosmic Ray Measurements over the North Sea).—W. Bothe and W. Kolhörster. (*Berliner Ber.*, No. 25–27, 1930, pp. 450–456.)

Measurements on a voyage between Hamburg, N. England, Iceland, Spitzbergen and the Norwegian coast (53–81° N. and 24°W.–25°E.). Within the limits of error (5 %) no systematic change of intensity with geographical position could be found. This result is discussed in relation to the corpuscular theory of the radiations.

MESSUNGEN DER HÖHENSTRAHLUNGSINTENSITÄT ZWISCHEN 55 UND 70° NÖRDLICHER GEOGRAPHISCHER BREITE (Measurements of Cosmic Ray Intensity between 55 and 70° N. Preliminary Communication.)—A. Corlin. (*Ark. f. Mat. Astron. och Fys., B.*, No. 2, Vol. 22, 6 pp.)

Measurements show a decreasing ionisation with increase of latitude between + 55 and + 70 (geographical latitude) and suggest the existence of a zone of maximum intensity of the cosmic rays between + 50 and + 60° geomagnetic latitude, corresponding to the auroral conditions. This is regarded as support for the corpuscular theory of the cosmic rays.

ULTRA RADIATION (PENETRATING [COSMIC] RADIATION): ANNUAL VARIATION AND VARIATION WITH THE GEOGRAPHICAL LATITUDE.—J. Clay. (*Proc. K. Akad., Amsterdam*, No. 7, Vol. 33, pp. 711–718.)

Measurements at Bandoeng and on the voyage to Amsterdam. There was a sharp minimum in the Suez Canal. The writer's results with Kolhörster's Waniköe (+ 41°) observations and those of Corlin (see above) indicate a maximum radiation in Europe.

A section of the paper deals with a method of measuring very small capacities with the aid of a Wulf condenser and a very sensitive electrometer.

ÜBER DIE DURCHDRINGENDE KOMPONENTE DER ULTRASTRAHLUNG, FESTGESTELLT DURCH ABSORPTIONSMESSUNGEN IM BODENSEE (The Penetrating Component of the Ultra-Radiation [Cosmic Rays], determined by Absorption Measurements in Lake Constance).—E. Regener. (*Physik. Zeitschr.*, No. 22, Vol. 31, pp. 1018–1019.)

See also April Abstracts, p. 207, and below.

ÜBER DIE DURCHDRINGENDSTE KOMPONENTE DER ULTRASTRAHLUNG—HESSSCHEN STRAHLUNG (On the Most Penetrating Component of the Cosmic Radiation—Hess Radiation).—E. Regener. (*Naturwiss.*, 20th Feb., 1931, Vol. 19, No. 8, pp. 177–179.)

An account of experiments on the intensity of ionisation due to cosmic rays at various depths in Lake Constance from 0–235 metres. Four different components of the radiation were found.

A MORE ACCURATE AND MORE EXTENDED COSMIC-RAY IONIZATION-DEPTH CURVE, AND THE PRESENT EVIDENCE FOR ATOM-BUILDING.—R. A. Millikan and G. H. Cameron. (*Phys. Review*, 1st Feb., 1931, Series 2, Vol. 37, No. 3, pp. 235–252.)

ÜBER DEN URSPRUNG DER DURCHDRINGENDEN KORPUSKULARSTRAHLUNG DER ATMOSPHÄRE (The Origin of the Penetrating Corpuscular Radiation of the Atmosphere).—B. Rossi. (*Naturwiss.*, No. 50, Vol. 18, pp. 1096–1097.)

Certain difficulties in reconciling observed facts all disappear if it is assumed that the gamma rays early in their career—perhaps even at their origin—carry corpuscular rays with them.

ZUR STRUKTUR DER ULTRASTRAHLUNG (On the Structure of the Cosmic Radiations).—W. S. Pforte. (*Zeitschr. f. Phys.*, No. 1/2, Vol. 65, pp. 92–101.)

THE AUDIBILITY AND LOWERMOST ALTITUDE OF THE AURORA POLARIS.—S. Chapman. (*Nature*, 7th March, 1931, Vol. 127, pp. 341–342.)

A brief account of the evidence for the occasional occurrence of low and audible aurorae. A summary is given of evidence collected by J. H. Johnson from inhabitants of " a belt of country, about 300 miles wide, lying roughly along the auroral zone; the belt includes the Klondike region, where is situated the township of Dawson, with a population of several thousand; several reports come from this neighbourhood." The letters sent by inhabitants of this zone to Mr. Johnson " make it difficult to deny that aurorae occur, very rarely, quite near the earth, and are sometimes accompanied by noises." Critical examination of these appearances is necessary; it is hoped that the proposed New Polar Year (1932–33) will provide an opportunity for this, and it is " highly desirable that auroral investigation near the auroral zone should include not only visual and photographic observations, but also atmospheric electricity registration at a well-equipped observatory."

DIE SONNENBELICHTETEN NORDLICHTSTRAHLEN UND DIE KONSTITUTION DER HÖHEREN ATMOSPHÄRENSCHICHTEN (The Sun-lit Auroral Rays and the Constitution of the Upper Atmospheric Layers).—L. Vegard. (*Zeitschr. f. Geophys.*, No. 1, Vol. 6, pp. 42–56.)

WIE TIEF DRINGEN DIE POLARLICHTER IN DIE ERDATMOSPHÄRE EIN? (How Deep does the Aurora Penetrate into the Atmosphere?)—C. Störmer. (*Zeitschr. f. Geophys.*, No. 4/7, Vol. 6, pp. 334–340.)

ON THE ELECTROSTATIC FIELD OF THE SUN DUE TO ITS CORPUSCULAR RAYS.—H. P. Berlage, Jr. (*Proc. K. Akad., Amsterdam*, No. 6, Vol. 33, pp. 614–618.)

DER BLITZSCHLAG IN HOCHSPANNUNGSANLAGEN UND SEINE FOLGEN (Lightning Strokes on High Voltage Systems, and their Results).—E. Flegler. (*E.T.Z.*, 29th Jan., 1931, Vol. 52, pp. 129–133.)

SUR LA MORT EN FOULE DES VÉGÉTAUX PAR L'ÉCLAIR FULGURANT (Group Destruction of Vegetation by Lightning).—E. Mathias. (*Comptes Rendus*, 16th Feb., 1931, Vol. 192, pp. 390–393.)

SUR L'EXISTENCE OU LA NON-EXISTENCE DU FILETS DES ÉCLAIRS EN CHAPELET (On the Existence or Non-existence of "Bead Necklace" Lightning).—E. Mathias. (*Comptes Rendus*, 16th March, 1931, Vol. 192, pp. 653–655.)

In the most recent occurrence of this phenomenon, the linking thread was absent. Previous reports sometimes include the thread and sometimes do not, but agree that the necklace flash occurs as a *final* discharge. The writer explains all these results on his "fulminant matter" hypothesis (*see* past abstracts): the necklace discharge represents the exhaustion of the "fulminant jet."

LA FOUDRE GLOBULAIRE (Spherical Lightning).—E. Mathias. (*Bull. d. l. Soc. franç. d. Élec.*, Dec., 1930, Ser. 4, Vol. 10, pp. 1280–1301.)

A VISUAL STUDY OF THE INITIAL STAGES OF SPARK BREAKDOWN IN AIR.—F. G. Dunnington. (*Phys. Review*, 15th Jan., 1931, Series 2, Vol. 37, No. 2, p. 230.)

Abstract only.

PROPERTIES OF CIRCUITS.

ÜBER DIE MITNAHMEERSCHEINUNGEN AN RÖHRENGENERATOREN BEI VERSCHIEDENEN FREQUENZVERHALTNISSEN (On the "Mitnahme" [Pulling into Tune] Effects in Valve Oscillators, for Various Frequency Ratios).—H. Winter-Günther. (*Zeitschr. f. hochf. Tech.*, Feb., 1931, Vol. 37, pp. 39–51.)

This effect has been investigated by Möller, van der Pol and others, but most attention has been given to the case when the frequency imposed from outside is almost the same as the frequency of the oscillating circuit. This version of the effect has recently found a useful application in synchronising a locally-generated rotating field with the modulation frequency of a distant transmitter (Goubau, 1930 Abstracts, p. 328).

The present investigations deal exclusively with those versions of the effect in which the two frequencies are *not* nearly the same, but (*a*) one is nearly equal to a whole multiple of the other, or (*b*) the two frequencies are nearly in the ratio of two small whole numbers. Such an effect can be used in the crystal control of a transmitter where the frequency is too low for a crystal to be made to correspond: in such a case the long-wave transmitter can be guided by the "mitnahme" effect of a crystal-controlled transmitter of much shorter wavelength.

Current oscillograms are given for various values of the ratio imposed frequency/oscillating circuit frequency (namely, $\frac{1}{3}$, $\frac{2}{3}$, $\frac{3}{2}$, 2, and 3) to show the behaviour of the oscillator in the neighbourhood of the "mitnahme" zone. The circumstances on which the breadth of this zone depends are discussed. The process by which potential equilibrium is arrived at is investigated; it is shown that the correct phase relation between anode current and current in the oscillatory circuit can be established owing to the existence in the anode current of overtones and combination tones, of the potentials induced on the grid, whose phase is regulated by the phase of these grid potentials. Empirical rules are found for the stability of phase between imposed e.m.f. and reaction potential.

The latter half of the paper deals with the use of the dynamic characteristics; a method of plotting these for an oscillator in the "mitnahme" condition is given. They can be used to give a quantitative estimate of the effect which the amplitude of the imposed e.m.f. has on the amplitude of the oscillations in the oscillatory circuit and on the breadth of the "mitnahme" zone. The former does not vary very sharply with the ratio of frequencies, whereas the latter falls off extremely rapidly with increase of ratio. Finally, a case when the frequency ratio is as great as 17 is discussed.

ÜBER GEKOPPELTE OSZILLATOREN (On Coupled Oscillators).—W. Kossel. (*Physik. Zeitschr.*, 15th Feb., 1931, Vol. 32, No. 4, pp. 172–179.)

The variation of frequency due to coupling is first treated in the mechanical example of two pendulums connected by a weightless spring, and it is shown that the usual differential equation of motion has a term missing, thereby causing dynamical incompleteness. The corrected equation is solved and the resonance frequencies for symmetrical and anti-symmetrical motion obtained. The case of two equal masses connected by a small mass, and each attached to a spring, is also considered and the resonance frequencies deduced.

Consideration is then directed by strict analogy to the case of two electrical oscillating circuits. The missing term in the differential equation, a self-induction term, is inserted, and the resulting resonance frequencies obtained for both capacitive and inductive couplings.

The case of inductive coupling is treated more fully and suggestions are put forward for the most convenient handling of the coupling coil. The effect on the resonant frequency due to the variation of distance apart of the coils, and to "anti-symmetrical" and "symmetrical" direction of flow of current, is discussed.

DIE ANODENRÜCKWIRKUNG BEI VERSCHIEDENEN RÖHRENSCHALTUNGEN UND IHRE VERMINDERUNG (The Unwanted Reaction Effect of the Anode Circuit in Various Types of Valve Circuits, and its Reduction).—F. Below. (*Zeitschr. f. hochf. Tech.*, Feb., 1931, Vol. 37, pp. 65–69.)

The equivalent resistance transferred from the anode circuit to the grid circuit through the anode-grid capacity is here calculated. The writer then deals in turn with (*a*) the leaky grid detector, (*b*) the anode bend detector, (*c*) the resistance-coupled amplifier, (*d*) the choke-coupled amplifier, and (*e*) the tuned r.f. amplifier. For each of these he derives formulae for the unwanted ("harmful") capacity and equivalent leak-resistance, between grid and cathode, which together represent the resulting effect—a path from grid to cathode. From these formulae the conditions can be deduced for increasing as much as possible the grid-cathode resistance, as is so desirable for many purposes.* In the case of the tuned r.f. amplifier, the two oscillation points are calculated and the conditions given under which the amplifier can oscillate.

SPULE UND WANDERWELLE (Coil and Surge).—E. Flegler. (*Arch. f. Elektrot*, 27th Jan., 1931, Vol. 25, No. 1, pp. 35–72.)

From the author's abstract:—The investigation with the cathode ray oscillograph of surge phenomena in coils has led the author to make first a short record of the results of the two most important theoretical modes of treatment of the coil as (1) a loop circuit and (2) a chain filter. In the case of the chain filter, particular attention is paid to the question of the critical frequency. Investigations follow which deal with coils of one hundred and nine turns respectively, with varying capacity to earth and varying distance between the turns; a clear picture of the penetration of surges into coils is thus obtained. Experimental results in the main confirm both the loop circuit and the chain filter points of view. It was not found that a critical frequency had any special influence on the effect of single layer coils on surges.

DIE UMBILDUNG DER WELLENFORM DURCH KAPAZITÄTEN UND INDUKTIVITÄTEN BEI DURCH FUNKEN AUSGELÖSTEN WANDERWELLEN (The Changes Produced by Capacities and Inductances in the Waveform of Surges Produced by Sparks).—W. Schilling. (*Arch. f. Elektrot.*, 21st Feb., 1931, Vol. 25, No. 2, pp. 97–122.)

Author's summary:—A new form is found for the known relations giving the voltage of surges produced by sparks in air, for three different typical switching arrangements. The equations developed are suitable for simple calculation of the whole course of the surge voltage, and permit of the simple deduction of approximate representations.

The way in which such waveforms are changed by a condenser is shown. The change in the waveform is treated both from the point of view of increase in voltage and from that of the maximum voltage reached. Curves are given which enable the size of condenser necessary for protection against such waves to be estimated.

It is shown how the above calculations may also be applied to choke coils.

* *e.g.*, in the design of the two-valve voltmeter described by Kallmann, who uses these results (*see* under "Measurements and Standards").

SELECTIVITY AND RESPONSE.—E. E. Wright. (*E.W. & W.E.*, March, 1931, Vol. 8, pp. 133–134.)

"An attempt to find, from theoretical reasoning, the response of a selectively tuned circuit to a steadily modulated wave." The writer takes as a measure of the selectivity the pulsatance change $\triangle$ of the incoming wave which is enough to drop the power absorbed by 10 decibels. From his equation for the impedance near the resonating frequency, and from this definition, he obtains $\triangle = \frac{3R}{2L}$; finally, considering the response to a modulated wave whose pulsatance of modulation is μ, he obtains the equation of the response curve

$$P = 10 \log_{10}\left(\frac{\triangle^2}{\triangle^2 + 9\mu^2}\right)$$

ON THE DEFINITION OF SELECTIVITY.—P. David. (*E.W. & W.E.*, March, 1931, Vol. 8, pp. 140–142.)

The writer discusses the merits and disadvantages of the definitions due to Biedermann, Colebrook, and Beatty, and ends by giving the solution which he recommends: it consists in giving the *frequency-intervals corresponding to fixed degrees of weakening*, such as 10, 30, 50 and 80 decibels.

CORRECT AERIAL COUPLING.—W. T. Cocking. (*Wireless World*, 4th February, 1931, Vol. 28, pp. 116–119.)

Calculations of aerial circuit efficiency under different coupling conditions. The conflicting requirements of selectivity, quality and signal strength are examined.

THE MUTUAL REPULSION BETWEEN CURRENTS IN PARALLEL AND CONCENTRIC CONDUCTORS.—W. Beetz. (*Elektrot. u. Masch:bau*, 17th Aug., 1930, Vol. 48, pp. 761–764.)

A summary will be found in *Rev. Gén. de l'Élec.*, 24th Jan., 1931, Vol. 29, p. 26D. The repulsive force per cm. length is $P = \frac{2I^2}{a} \times 10^{-8}$ kgm., where a is the *effective* gap. For concentric conductors $a = \frac{d}{\log_e \frac{r}{m}}$ cms.

THE PARALLEL CONNECTION OF IDENTICAL NETS.—A. E. Kennelly. (*Proc. Am. Phil. Soc.*, No. 4, Vol. 69, pp. 161–173.)

NEW BAND-PASS FILTER.—Page. (*See* under "Reception".)

AN ANALYSIS OF DISTORTION IN RESISTANCE AMPLIFICATION.—Moullin. (*See* under "Acoustics.")

A Two-Valve Circuit Emitting Trains of Undamped Waves with Intervals up to Several Minutes.—La Rosa and Sesta. (*See* under "Transmission".)

TRANSMISSION.

Un Circuito a due Valvole emittente Treni d'Onda discontinui (A Two-Valve Circuit Emitting a Succession of Wave-Trains).—M. La Rosa and L. Sesta. (*Lincei Rendic.*, No. 8, Vol. 11 [6], 1930, pp. 731–734.)

For suitable values of capacity and resistance in a "Mazzotto" circuit with two amplifier valves capacitively coupled, trains of undamped waves separated by intervals completely free from oscillations are produced; these intervals may under certain conditions last as long as several minutes. The phenomenon—which was investigated with an oscillograph—is not yet completely explained.

More Power with Better Frequency Stability.—G. Grammer. (*QST*, Feb., 1931, Vol. 15, pp. 27–34.)

"Practical suggestions for [amateur] oscillator-amplifier transmitter design," for frequencies up to 14 megacycles/sec.

New Radio Transmitters for Airways Applications.—R. S. Bair. (*Bell Lab. Record*, October, 1930, Vol. 9, pp. 65–70.)

Experimental Researches on Ultra-Short Waves.—A. Rostagni. (*L'Elettricista*, 31st Aug., 1930, Ser. 4, Vol. 8, pp. 97–99.)

A quantitative study of the B.-K. oscillations, curves being given showing the relations between wavelength and amplitude on the one hand and the various working conditions such as grid potential, filament emission, and length of external circuit on the other. For each position of the condenser-bridge on the external circuit, there is a well-defined combination of grid potential and emission for which the current in the grid-plate circuit is a maximum.

Sidebands in Radio—Are they Real or Imaginary?—R. P. Glover. (*Rad. Engineering*, Feb., 1931, Vol. 11, pp. 27–28.)

The writer concludes:—"This discussion does not, of course, 'prove' that side frequencies 'exist.' On the other hand, no conclusive scientific evidence to the contrary has been presented up to this time. Just what will emerge from the current scramble of mathematical physics, vague descriptions and ambiguous explanations is an interesting subject for speculation. In the meantime, many enquirers will content themselves with the resolution of the modulated wave into component carrier and side frequencies."

The First Pupinised Broadcasting Cable in Russia.—M. Jurjew. (*Siemens-Zeit.*, Vol. 10 [1930], p. 459.)

Description of the cable, 38 km. long, connecting the Moscow studios with the 70 kw. broadcasting station at Schtschelkowo. At about every kilometre it is pupinised by a 15.5 mh. coil. It is designed to carry, without distortion, frequencies from 150 to 9,000 cycles/sec.; for the whole stretch, $(b_{10,000} - b_{1,000})$ is 0.33 Neper.

Kabelleitungen für die Übertragung von Rundfunkdarbietungen (Cable Lines for the Transmission of Broadcast Programmes).—K. Höpfner. (*Europ. Fernsp.dienst*, March, 1931, pp. 107–114.)

Oscillations in Discharge-Tubes and Allied Phenomena.—J. J. Thomson. (*See* under "General Physical Articles.")

RECEPTION.

Über die Pendelrückkoppelung (Super-regeneration).—H. Kohn. (*Zeitschr. f. hochf. Tech.*, Feb. and March, 1931, Vol. 37, pp. 51–58 and 98–105.)

The Armstrong super-regenerative receiver has become of great importance for the reception of very short waves, since the radio-frequency amplification of these waves involves great difficulties. The present paper investigates the dependence of the amplification produced by such a receiver on the quenching frequency, the quenching amplitude, the damping and other factors. The February instalment deals with the experimental side. It is found that (*a*) the minimum quenching voltage is independent (within wide limits) of the quenching frequency but increases with the reaction coupling; (*b*) the amplification increases with a decrease of the quenching frequency, and tends towards a minimum as this frequency increases towards infinity—this minimum representing the best that can be obtained with the ordinary receiver with reaction; in practice (receiving on a 350 m. wave) this minimum appears to be reached with a quenching wavelength of 5,000 to 7,000 metres.

(*c*) Further, the amplification increases with an increase of minimum quenching voltage, which itself depends on stronger reaction coupling (see above); (*d*) it increases rapidly with increase of damping in the receiver circuit—this is shown by a formula but can be explained by the fact that greater damping implies greater energy consumption, so that oscillation only sets in for a tighter reaction-coupling; and (*e*) it increases with a decrease of the radio frequency, in a manner not yet determined. The signals produced (for sufficiently small values of the currents) increase with the strength of the received radio frequency, the effective value of the anode current being linearly proportional to the amplitude of the received radio frequency.

The March instalment deals with the subject theoretically, use being made of a graphical construction as an auxiliary. A final formula is arrived at in which all the experimental results are implicit.

The "Stenode."—J. Robinson. (*Rad. Engineering*, Dec., 1930, Vol. 10, pp. 21–25.)

The Radio Club paper, a *Wireless World* summary of which was referred to in April Abstracts. In Part II, an appendix appearing in the February issue (p. 33), is given the full analysis leading to the formula for the output modulation given at the end of the *Wireless World* summary.

THE LOFTIN-WHITE AMPLIFIER.—R. Wigand (*Rad., B., F. f. Alle*, March, 1931, pp. 135–138.)

"A practical form of the direct-coupled amplifier." A diagram is given of a complete mains-driven broadcast receiver using this circuit, suitable German valves and the values of the various components being specified in the text.

AIRCRAFT RADIO RECEIVERS.—S. E. Anderson. (*Bell Lab. Record*, October, 1930, Vol. 9, pp. 71–76.)

RECENT DEVELOPMENTS IN AMERICA.—A. Dinsdale. (*Wireless World*, 11th February, 1931, Vol. 28, pp. 138–141.)

Three major developments mark the American 1930–31 radio season, and the Radio Corporation of America, as the initial monopoly patent holders, may be said to be responsible for them. They are (1) the return of the superheterodyne; (2) the still further development and perfection of tuned radio-frequency sets; and (3) the introduction of home recording into all electric gramo-radio sets. A fourth innovation is just now beginning to loom up over the horizon, viz.: the incorporation in gramo-radio sets of a moving-picture film projector, making use of the Bell-Howell home cinema equipment.

D.C. BAND-PASS FIVE.—L. E. T. Branch. (*Wireless World*, 4th and 11th February, 1931, Vol. 28, pp. 106–110 and 151–156.)

A four-stage long range screen-grid receiver for home construction incorporating an inductively coupled pre-selector, power grid detection and push-pull output.

PRE-SELECTION A.C. THREE.—H. F. Smith. (*Wireless World*, 25th February and 4th March, 1931, Vol. 28, pp. 197–200 and 224–227.)

A three-valve general purpose receiver for a.c. mains operation with an open aerial. The circuit embodies an input filter, screen-grid r.f. valve coupled by tuned-grid method to power-grid detector, choke l.f. coupling to pentode output, auto-transformer feed to loud speaker. H.T. supply is through a Westinghouse metal rectifier.

SPECIAL INSTRUMENTS FOR RADIO RECEIVER PRODUCTION TESTING.—R. P. Glover. (*Electronics*, Feb., 1931, pp. 500–501.)

TRACING HUM IN MAINS SETS.—W. T. Cocking. (*Wireless World*, 11th February, 1931, Vol. 28, pp. 134–137.)

The writer shows how hum can be traced methodically by examining the receiver stage by stage, isolating each stage from the others. The loud speaker is first tested, after which the output choke and the mains transformer are tackled for signs of electro-magnetic interaction. The output stage, detector and r.f. stages are isolated in turn. Types of modulation hum, caused by the modulation of the incoming signal, are discussed and remedies suggested.

NEW BAND-PASS FILTER.—W. I. G. Page. (*Wireless World*, 18th February, 1931, Vol. 28, pp. 164–169.)

The description of a mixed capacity-inductance filter. When the reactances of the inductive and capacitative elements of the coupling are made additive by the use of negative inductance, constant peak separation and constant selectivity over the waveband are obtained. The negative inductance consists of a separate r.f. transformer wound on a one-inch former.

Details are given for the construction of such a unit and response curves are shown which indicate the constancy of the peak separation over wavelengths between 240 and 600 metres. *Cf.* Uehling, Feb. Abstracts, p. 95.

A REVIEW OF REMOTE CONTROL DEVELOPMENT.—G. Lewis and A. A. Ghirardi. (*Rad. Engineering*, Feb., 1931, Vol. 11, pp. 29–32.)

SELECTIVITY AND RESPONSE.—Wright. (*See* under "Properties of Circuits.")

ON THE DEFINITION OF SELECTIVITY.—David. (*See* under "Properties of Circuits.")

WIDE RANGE SCALES FOR FADING RECORDS BY ELECTRICAL MEANS.—Robinson. (*See* under "Propagation of Waves.")

AERIALS AND AERIAL SYSTEMS.

OPTIMUM DIMENSIONS OF SHORT-WAVE FRAME AERIALS.—L. S. Palmer and L. K. Honeyball. (*Nature*, 14th March, 1931, Vol. 127, p. 407.)

A letter giving a preliminary account of theoretical and experimental investigations on the optimum dimensions of frame aerials for short-wave work. It has hitherto been thought that the best width of a frame aerial is 0.5 of a wavelength. "A more rigorous theoretical treatment shows that, for a frame aerial, there are several different critical widths and heights which depend upon the wave-length in use, and that none of these critical values is half a wave-length. . . . A square or circular frame is always less efficient than a correctly proportioned rectangular or elliptical frame of the same area."

It is also found that the optimum area of a frame is critical when used for wave-lengths comparable with the dimensions. For short waves it is not true, as assumed hitherto in current literature, that the larger the area of the frame, the greater will be the radiated power or the received current. A graph is given showing the connection between the area of frame with optimum dimensions and the frame aerial current, based on measurements made on 8.65 metres with a tuned frame capable of being expanded in either or both dimensions. The currents recorded were the greatest that could be obtained with a frame of the given area.

"A frame designed for best reception on a given wave-length is not the optimum shape for maximum radiation on the same wave-length."

[For a Lorenz patent for short-wave frame design, *see* April Abstracts, p. 212.]

ON THE SUPPLY OF ENERGY TO A SHORT-WAVE AERIAL BY A TWO-WIRE FEEDER, AND THE MEASUREMENT OF ITS RESISTANCE.—V. V. Tatarinov. (*Westnik Elektrot.*, No. 1, 1931, pp. 6–11.)

In Russian. Author's summary:—A method for the measurement of the resistance of any short-wave aerial fed by a two-wire transmission line is developed. The p.d. in the feeder is measured at a node and an antinode of potential. If the ratio of the measured voltages is denoted by k, and the distance of some point from the antinode of voltage by x, the impedance of the feeder at this point is expressed by

$$\zeta = w \cdot \frac{k - 0.5j(1 - k^2) \sin \frac{4\pi x}{\lambda}}{k^2 \cos^2 \frac{2\pi x}{\lambda} + \sin^2 \frac{2\pi x}{\lambda}},$$

where w is the characteristic impedance of the line. The travelling wave in the feeder may be established by inserting across it an inductance L at some distance x defined by the equation

$$\cot \frac{2\pi x}{\lambda} = \pm \sqrt{k}.$$

The value of the inductance L is determined from the formula $\frac{L\omega}{w} = \frac{\sqrt{k}}{1 - k}$. *Cf.* Roosenstein, Jan. Abstracts, p. 36.

ÜBER DIE ELEKTRISCHEN SCHWINGUNGEN IN DRAHTFÖRMIGEN LEITERN (Electrical Oscillations in Wire Conductors).—E. Hallén. (*Uppsala Univ. Arsskr.*, No. 1, 1930, 102 pp.)

A mathematical investigation of h.f. oscillations in metal wires used either as open aerials or in the form of coils, by a further development of Oseen's work. Instead of the integro-differential equation obtained by Oseen, for which no general method of solution is known, the writer obtains an integral equation resembling in type that of Fredholm and equally readily solved.

ENGINEERING ASPECTS OF THE BROADCAST ANTENNA.—H. E. Hallborg. (*Rad. Engineering*, Feb., 1931, Vol. 11, pp. 43–46, 48 and 50.)

THE EFFECTS OF METAL OBSTRUCTIONS ON THE RADIATION FIELD OF AN AERIAL.—Seiler.

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

VALVES AND THERMIONICS.

CHARACTERISTICS OF SMALL GRID-CONTROLLED HOT-CATHODE MERCURY ARCS OR THYRATRONS.—W. B. Nottingham. (*Journ. Franklin Inst.*, March, 1931, Vol. 212, No. 3, pp. 271–301.)

Author's abstract:—The principle of the grid-controlled arc or thyratron is briefly described and the nominal ratings as regards filament current, maximum plate current, etc., of four important thyratrons are given in table form. Methods of measuring the grid current, critical grid potential, etc., with d.c. power supply are given along with the results obtained on the General Electric Company thyratrons FG-17, FG-27 and FG-67. Characteristics obtained with a.c. power supply are also shown for these thyratrons and some of the relative advantages of the "phase-shift" and the "critical potential" methods of control are discussed when used in connection with photoelectric cell circuits. The a.c. measurements seem to show that a time of 10^{-3} second is required to start a thyratron. An amplifier circuit is shown by which it is theoretically possible to control a thyratron circuit using an input current to the amplifier of 10^{-11} ampère.

SPECIAL TUBES FOR AUTOMOBILE [AND AIRCRAFT] RADIO SETS.—R. M. Wise. (*Electronics*, Feb., 1931, pp. 516–517.)

Although it is desirable not to increase the number of valve types, the Sylvania Products Company has been led to design three special valves by the fact that the ordinary heater-type valves are not quite satisfactory for the above purposes (or for direct-current receivers) owing to their large space requirements, unsuitable heater current and voltage, etc. The 3 special valves are similar in dimensions ($1\frac{1}{8}$ inch max. diameter), and are of the screen-grid, general purpose, and power types respectively. Heater voltage may fluctuate between 4 and 9 volts.

COLD CATHODE VALVE WITH EMISSION DUE TO X-RAY ACTION PRODUCED BY H.F. CURRENTS.—(French Pat. 692421, Soc. d'Études scient. et industr., pub. 5th Nov., 1930.)

The plate forming the cathode is provided with very fine points made of metallised animal hairs. It is supplied with high frequency current from an Oudin resonator. The complete arrangement can be supplied direct from the mains.

LEAD-IN CONDUCTORS FOR QUARTZ GLASS BULBS.—(French Pat. 693219, Soc. anon. réunie de L. à incand. et d'Élec., pub. 18th Nov., 1930.)

To overcome the difficulty in making a gas-tight sealed joint between a metal and quartz, the current is led in through rods of the same material as the bulb, coated with a fine layer of metal.

SOME COMMENTS ON THE USE OF "GETTERS."—G. D. O'Neill. (*Electronics*, Feb., 1931, pp. 510–511 and 528.)

TESTING RADIO VALVES: THE A.C. BRIDGE METHOD.—C. S. Bull. (*E.W. & W.E.*, Feb., 1931, Vol. 8, pp. 70–74.)

Author's summary:—It is shown that in order to determine completely the performance of a valve it is necessary to measure two of the three characteristics M, g and R_a, and in addition to make tests on the uniformity of these characteristics over the range of conditions under which the valve may be operated. The accuracy and speed of various methods of test are discussed, and it is shown that an a.c. bridge provides probably the quickest and most useful method of testing.

An a.c. bridge test board is described in detail, to measure M values between 2 and 1,000, g values between 0.2 and 6.0 mA/volt, and R_a values between 500 and 50,000 ohms. In addition, it will measure the amplification given by a triode when used as a resistance-coupled amplifier. Finally, a particular example of the utility of the test board indications is given.

A STANDARD TEST SET FOR VACUUM TUBES.—M. H. A. Lindsay. (*Bell Lab. Record*, Oct., 1930, Vol. 9, pp. 85–89.)

THE ALIGNMENT REPRESENTATION OF VALVE DATA.—W. A. Barclay. (*E.W. & W.E.*, Feb., 1931, Vol. 8, pp. 75–82.)

(1) Introductory: the need for more adequate valve characteristics. (2) Some fundamental definitions. (3) The inverse use of the alignment principle. (4) The polygon of error. (5) An example—the Osram L.S.6A. valve. (6) The variation in μ_0. (7) The equation of the characteristic: "An important feature of the alignment process is that it provides not merely the values of the constants in an equation . . . but actually gives the form of the equation itself. This is a remarkable circumstance, and one which, in the writer's opinion, should do much to establish the method in favour with practical computors." (8) Application to the screened-grid valve. (9) Variation of mutual conductance. (10) Utility of the alignment process: ". . . many interesting facts regarding the screened-grid valve may be gleaned, and the writer hazards the suggestion that we may still be a long way from using such valves to the best advantage. There is considerable scope for the experimenter in studying the action of such a valve when the screened-grid potential is varied synchronously with that of the control grid. . . ."

OUTPUT VALVES IN PARALLEL.—W. A. Barclay. (*Wireless World*, 18th February, 1931, Vol. 28, pp. 171–175.)

Charts for simplifying the calculation of output of power valves in parallel. An alignment chart is provided from which it is possible, given the number of parallel valves, to find the amount of distortionless a.c. power output supplied and also the value of the supply voltage to effect this. If the number of parallel valves and the supply of h.t. voltage is fixed, it is also possible to find the a.c. power delivered to the load. A third use of this chart is to find the best number of parallel valves to supply a definite a.c. power output to a given load when the value of the h.t. voltage is fixed.

EINE EXAKTE METHODE ZUR TRENNUNG VON PRIMÄR UND SEKUNDÄRSTRÖMEN IN ELEKTRONENRÖHREN (An Exact Method for the Separation of Primary and Secondary Currents in Valves).—H. A. Schwarzenbach. (*Helvet. Phys. Acta*, No. 7, Vol. 3, pp. 446–447.)

Mathematical and experimental methods are given for the separation of the superposed primary and secondary electron currents, for a valve with nickel anode. A symmetrical cylindrical electrode system is considered, with a co-axial magnetic field imposed. The filament is so strongly heated that the anode comes close below the Curie point (360°C). Electron bombardment raises the temperature above this point; as a result, the internal magnetic field becomes greater by $\triangle H$ owing to the decrease of the demagnetising effect. If the energy input E_a is known, under the condition $V_a = V_g$ (no secondary electrons) the value $\triangle H$ can be determined from the curve $I_a = f(H)$; thus $E_a = \phi(\triangle H)$ is obtained. This gives the possibility of calculating primary and secondary currents when $V_a \neq V_g$, as is done in the paper.

SPACE CHARGE VS. IMAGE FORCE IN THERMIONIC EMISSION.—R. S. Bartlett and A. T. Waterman. (*Phys. Review*, 1st February, 1931, Series 2, Vol. 37, No. 3, pp. 279–282.)

Authors' abstract:—This paper is a joint report on work by the two authors, preliminary to further and more detailed publication on different phases of the problems here discussed. Attention is called to certain deficiencies in the Schottky image force as an explanation of the thermionic work function, both on theoretical and experimental grounds. Evidence is advanced to show that space charge is more important than image force over most of the region in which the image force is thought to be valid. It is further shown that space charge with Fermi-Dirac statistics is able to account for observed phenomena of thermionic emission, including the effect of external fields. Numerical examples indicate some of the consequences of this point of view.

DIE THERMIONISCHE EMISSION DER METALLE IN JODDÄMPFEN (The Thermionic Emission of Metals in Iodine Vapour).—S. Kalandyk. (*C. R. Soc. Pol. de Phys.*, No. 2, Vol. 5, pp. 141–156.)

More work on the lines described in 1930 Abstracts, p. 161. Here the negative emission from platinum is dealt with, its increase in the presence of the vapour (an effect decreasing with rise of temperature) and the reasons for this result.

THE INFLUENCE OF THE CRYSTAL-ORIENTATION OF THE CATHODE ON THAT OF AN ELECTRODEPOSITED LAYER.—Wood. (*See* under "Miscellaneous.")

ZUM VERHALTEN DES THORONYDS IN WOLFRAMGLÜHDRÄHTEN (The Behaviour of Thorium Oxide in Tungsten Filaments).—W. G. Burgers and J. A. M. van Liempt. (*Zeitschr. f. anorg. Chem.*, No. 1/2, Vol. 193, pp. 144–160.)

ZUM QUERWIDERSTAND DER OXYDSCHICHT VON GLÜHKATHODEN (The Transverse Resistance of the Oxide Layer of Hot Filaments).—J. Kroczek and E. Lübcke. (*Wiss. Veröffentl. a.d. Siemens-Konz.*, No. 2, Vol. 9, pp. 252–261.)

ÜBER DEN "NEGATIVEN" ANODENFALL (On the "Negative" Anode Fall [in the Mercury Arc. Remarks on I. Langmuir's Publications]).—J. v. Issendorff: I. Langmuir. (*Zeitschr. f. Phys.*, 1931, Vol. 67, No. 7/8, pp. 556–566.)

DIRECTIONAL WIRELESS.

LE GUIDAGE ET LE SONDAGE AÉRIENS (Direction- and Altitude-Finding for Aircraft [the General Situation in France]).—E. Fromy. (*Rev. Gén. de l'Élec.*, 14th February, 1931, Vol. 29, pp. 269–273.)

Land goniometers; goniometers on board the aircraft; rotating beacons ("particularly of interest to small—'touring'—aeroplanes"); equi-signal beacon (Abbeville), aural and with lamp indicator. The Aicardi system (1929 Abstracts, p. 332):—tests on a 350 w. set gave ranges of the order of 70 km. with an accuracy of about 1 degree: the chief difficulty lies in the satisfactory reception of the short waves (60 m.) in flight, but the experiments are continuing. The Loth system of rotating beams (Bourgonnier, 1930 Abstracts, pp. 217 and 572):—"there have been at present no full-scale tests." Aerodrome systems:—long lines of supported cables, and networks of supported or buried cables round the aerodrome—the former already installed over a 20 km. stretch between Chartres and Ablis, and in the process of construction between Le Bourget and Luzarches (for the Paris-London service); the latter not yet tried on the full-size scale.

Interference troubles: protection against aeroplane sources—whatever steps are taken, "the protection remains delicate and unstable"; a new solution is proposed, consisting in using supersonic modulation frequencies (10,000 p.p.s.) and receivers including one or more stages tuned to these frequencies. A short final section deals with altitude determination:—methods depending on variations of capacity, resistance or wavelength suffer from the smallness of the effects; Mesny obtained definite results, with a captive balloon, using the variations of wavelength under the influence of the reflected wave, but his results could not be reproduced on an aeroplane on account of disturbances due to mechanical vibrations. Acoustic sounding:—pistol-shot methods are not suitable; the Ministry of Air is developing a high-frequency sound wave equipment. Mechanical sounding:—only for landing, and more applicable to seaplanes than to land-planes; "in spite of its imperfections, it is the only system which up to now has given practical results. Tests at St. Raphaël have been satisfactory." Electromagnetic sounding with signals coming from the ground:—only at aerodromes, by cable systems (*cf.* Loth, 1930 Abstracts, pp. 47–48).

THE ABBEVILLE RADIO BEACON FOR AIRCRAFT. (*Bull. de la S.F.R.*, Dec., 1930, Vol. 4, pp. 181–193.)

Providing, at will, either the equi-signal zone system or the rotating-field beacon; the former for aircraft following a definite route, the latter to enable aircraft outside such a route to find their position. The former is said to give results accurate to about 1 degree, the latter to about 2.5 degrees: the "constant difference of a little more than 1 degree" being attributed to the lag in starting the stop watch.

CATHODE-RAY COMPASS FOR AIRCRAFT.—A. Salmony: E. Brüche. (*Teknisk Tidsk.*, 14th March, 1931, Vol. 61, p. 157.)

Short description and photographs of the A.E.G. cathode-ray compass making use of Brüche's work on the production of very slow electron beams (*see* Abstracts, March, p. 167, and April, last column of "Measurements and Standards").

SLOW CATHODE RAY AS A COMPASS OR INCLINATION INDICATOR FOR AIRCRAFT.—E. Brüche. (*See* abstract under "Propagation of Waves.")

The writer of the summary of Brüche's lecture mentions the use of the slow ray as a compass or "still better for the inertia-less indication of the inclination of an aeroplane."

ÜBER FLUGFUNKPEILUNGEN (Direction-Finding for Aircraft).—M. H. Gloeckner. (*Jahrb. d. D. Versuchsanst. f. Luftf.*, Special No., 1930, pp. 571–578.)

Reports on the serviceability of various methods—single frame d.f. on the aircraft and on land, leader cables, rotating and fixed beacons, target-flight instruments — Robinson, Dieckmann-Hell — and goniometers on the aircraft and on land.

ACOUSTICS AND AUDIO-FREQUENCIES.

ÜBER DIE ABLENKUNG DER KATHODENSTRAHLEN IN EINEM VON SCHWACHEN STRÖMEN ERZEUGTEN MAGNETFELD (The Deflection of a Cathode Ray in a Magnetic Field produced by Small Currents).—M. Slopkovitzer. (*Kinotechnik*, No. 15, Vol. 12, pp. 416–418.)

Landau uses a cathode ray for recording sound. The writer investigates mathematically whether a weak microphone current, without amplification, can produce sufficient deflection. He concludes that for a potential of 10,000 v. and a deflecting current of 1.0 mA., a satisfactory toroidal coil can be constructed.

AN ANALYSIS OF DISTORTION IN RESISTANCE AMPLIFICATION.—E. B. Moullin. (*E.W. & W.E.*, March, 1931, Vol. 8, pp. 118–123.)

Author's summary:—This paper describes a method of predicting from the static characteristic the output of a resistance coupled amplifier. A certain form of equation is assumed for the characteristic and this leads to simple rules for deducing the fractional amplitudes of the second and third harmonic currents which are produced by the curvature of the characteristic. The form of the equation is supported strongly by the shape of the characteristic, but it may be seen that a small departure from this form of equation would not alter the circumstances appreciably. It seems probable the output can be analysed into a Fourier series by the methods described with at least as much accuracy as could be obtained from any oscillograph method. It appears that the straight portion of the characteristic may be departed from appreciably and yet very small distortion introduced thereby. At any rate, it is a simple matter to describe in terms of Fourier coefficients the distortion which does result from a given departure from linearity.

THE ESTABLISHMENT OF AN ACOUSTIC [FREQUENCY] STANDARD: THE USE OF A PHOTOELECTRIC CELL IN OBTAINING A SCALE OF ACOUSTIC FREQUENCIES.—J. N. Egorov. (*Ann. Central Chamber of Weights and Measures, Leningrad,* Lief. 4 (16), 1930, pp. 147–167: 169–171.)

In Russian. The absolute determination of tuning fork frequency is carried out by a phonic wheel method, giving an accuracy of 10^{-6}. The revolutions of the wheel are recorded by a chronograph, and its angular velocity is controlled by a combination of tuning fork and oscillatory circuit. In the second paper, an arrangement is described in which 18 different stroboscopic discs, combined with 3 tuning forks (electrically driven) and a phonic wheel, cover a frequency range of 24 to 1,025 p.p.s.

THE DESIGN OF ATTENUATION NETWORKS.—W. F. Lanterman. (*Electronics,* Feb., 1931, pp. 508–509 and 532.)

A NEW ANALYZER OF SPEECH AND MUSIC.—H. K. Dunn. (*Bell Lab. Record,* Nov., 1930, Vol. 9, pp. 118–123.)

NOISE MEASUREMENTS.—J. C. Steinberg. (*Elec. Engineering* [late *Journ. Am. I.E.E.*], January, 1931, Vol. 50, pp. 42–45.)

Including a reference to a newly developed noise-meter and a chart showing the decibel rating of some common sounds as compared to the threshold of hearing.

ZUR STATISTIK DER INTENSITÄTSVERTEILUNG IM SPEKTRUM NATÜRLICHER KLANGBILDER (On the Statistics of the Intensity Distribution in the Spectrum of Speech, Musical Instruments, Orchestra and Opera).—H. Lueder. (*Wiss. Veröffentl. a. d. Siemens-Konz.,* No. 2, Vol. 9, pp. 167–225.)

ABHANGIGKEIT DER TONHÖHENEMPFINDUNG VON DER LAUTSTÄRKE UND IHRE BEZIEHUNG ZUR HELMHOLTZSCHEN RESONANZTHEORIE DES HÖRENS (The Dependence of Observed Pitch on Loudness, and its Relation to the Helmholtz Theory of Hearing).—G. Zurmühl. (*Zeitschr. f. Sinnesphysiol.,* Vol. 61, 1930, pp. 40–86; long summary in *Physik. Ber.,* 15th Dec., 1930, Vol. 11, p. 2693.)

EFFECTS OF PHASE AND TIME SHIFTS ON BINAURAL SENSATION OF DIRECTION.—A. W. Nye and A. K. Steunenberg. (*Phys. Review,* 15th Jan., 1931, Series 2, Vol. 37, No. 2, p. 228.)

Abstract only. "27 observers consistently judged direction as that of the leading phase, with tendency toward greater angle shift at higher frequencies. Interrupted tones gave effect of sound origin on side where sound first arrived. Phase shift exaggerated this if in same direction; if opposed, the temporal ruled first and effect shifted later in favour of phase."

MESSUNG DER SCHALLGESCHWINDIGKEITEN VON STOFFEN IM FESTEN UND GESCHMOLZENEN ZUSTAND (Measurement of the Velocity of Sound in Materials in the Solid and in the Melted State).—M. Reich and O. Stierstadt. (*Physik. Zeitschr.,* 1st Feb., 1931, Vol. 32, No. 3, pp. 124–130.)

"Directional audition has been developed to give a method of measuring the velocities of sound in solid and liquid bodies, even at high temperatures."

DIE THEORIE DER RESONANZMEMBRAN (The Theory of the Resonance Diaphragm).—G. Franke. (*Wiss. Veröffentl. a. d. Siemens-Konz.,* No. 2, Vol. 9, pp. 157–166.)

Calculation of the natural frequencies of a membrane loaded with a concentric rigid disc.

SOME MEASUREMENTS OF THE LONGITUDINAL ELASTIC FREQUENCIES OF CYLINDERS, USING A MAGNETOSTRICTION OSCILLATOR.—D. S. Muzzey, Jr. (*Phys. Review,* No. 5, Vol. 36, pp. 935–947.)

BROADCASTING WITHOUT A MICROPHONE.—Barton Chapple. (*Television,* March, 1931, Vol. 4, p. 9.)

"Experiments are being conducted in Hamburg in connection with the transmission of piano music without using a microphone. The string vibrations are immediately converted to electrical vibrations and fed to the transmitter. Tests are also being made to ascertain whether the principle can be applied to other musical instruments."

CONDENSER LOUD-SPEAKER WITH FLEXIBLE ELECTRODES.—P. E. Edelman. (*Proc. Inst. Rad. Eng.,* Feb., 1931, Vol. 19, pp. 256–267.)

Author's summary:—Condenser loud speakers employing flexible electrodes are described together with their uses as the input to an amplifier or for reproducing from the output of an amplifier unit. One electrode diaphragm utilises an impregnated cloth carrying a conductive coating. The co-operating electrode is also flexible and air-permeable. Textile threads at spaced distances are used to maintain the separation between the operating electrodes and to reduce backlash rustle noises.

The improvement in response, fidelity, and efficiency, as well as durability, are set forth, accompanied by examples of suitable operating circuits. It is pointed out that such condenser speakers operate most favourably with an amplifier arranged to compensate for their characteristics.

CORRECTING PICK-UP CHARACTERISTICS.—H. E. Watson. (*Wireless World,* 11th February, 1931, Vol. 28, pp. 142–144.)

Practical data for removing the resonance peak which so commonly occurs in the upper register. A simple band-stop filter was constructed and tested in conjunction with the Parlophone gliding-tone record, readings being taken every five turns. A B.T.H. pick-up was used. Characteristic curves are shown indicating the shifting of the resonance peaks by the introduction of different chokes and condensers. Stress is laid on the capacity effect of the cord connecting the pick-up to the amplifier.

MODERN TESTS ON LOUD SPEAKERS.—K. W. Jarvis. (*Rad. Engineering*, Feb., 1931, Vol. 11, pp. 23–26.)

SOME MEASUREMENTS OF A LOUD SPEAKER *in Vacuo*.—P. K. Turner. (*E.W. & W.E.*, March, 1931, Vol. 8, pp. 129–132.)

A long illustrated abstract of the paper referred to in April Abstracts, p. 215. The subsequent discussion is included.

THE BLUM RHYTHMOGRAPH AND RHYTHMOSCOPE FOR THE MAKING OF SOUND FILMS IN DIFFERENT LANGUAGES.—A. Gradenwitz. (*Die Sendung*, 20th Feb., 1931, Vol. 8, pp. 121–122.)

FREQUENCY CHARACTERISTICS OF OPTICAL SLITS.—J. P. Livadary. (*Electronics*, Feb., 1931, pp. 512–513 and 530.)

TESTING OF SOUND-PICTURE CHANNELS.—G. F. Hutchins. (*Electronics*, Feb., 1931, pp. 502–503 and 526.)

THE ACOUSTICS OF STUDIOS, WITH SPECIAL REFERENCE TO THE STUDIOS OF "BROADCASTING HOUSE," BERLIN.—W. Schäffer. (*Rad., B., F. f. Alle*, March, 1931, pp. 98–102.)

Summary of a recent lecture.

DIE AKUSTISCHEN EIGENSCHAFTEN DER NEUEN BERLINER SENDERÄUME (The Acoustic Properties of the New Berlin Studios).—von Braunmühl. (*Die Sendung*, 30th January, 1931, Vol. 8, p. 78.)

ESSAIS RELATIFS À L'INSONORITÉ DE CERTAINS MATÉRIAUX DE CONSTRUCTION (Tests on the Sound Insulating Properties of Certain Building Materials).— –. Cellerier. (Conservatoire des Arts et Métiers). (*Génie Civil*, 7th March, 1931, Vol. 98, pp. 246–247.)

An outline of the methods and apparatus employed. No results are given.

PHENOMENA IN A SOUNDING TUBE.—E. N. da C. Andrade. (*Nature*, 21st March, 1931, Vol. 127, p. 438.)

A letter giving a preliminary account of phenomena detected in experimental work on Kundt's tube. "It has been found that a combination of the general circulation and of the vortex motion caused by particles can account for practically all the phenomena which take place in a dust tube."

ÜBER DIE SCHALLGESCHWINDIGKEIT IN KOHLENSÄURE (On the Velocity of Sound in Carbon Dioxide.—H. O. Kueser. (*Physik. Zeitschr.*, 15th February, 1931, Vol. 32, No. 4, p. 179.)

Measurements of the velocity of propagation of high-frequency sound waves (in gaseous carbon dioxide) by Pierce's method showed that it increased as the frequency increased from 0.5×10^5 to 3×10^5 c.p.s. and then again became constant, the value reached being $268.2 + 0.3$ metres per sec.; this is an increase of 3.7 per cent. as compared with the normal value. The ratio of specific heats thus takes the value 1.40, which corresponds to a molecule composed of *two* atoms.

PHOTOTELEGRAPHY AND TELEVISION.

EIN NEUES FERNSEHVERFAHREN DER TELEHOR A.G. (A New Television System of the Telehor Company).—F. Noack. (*Rad., B., F. f. Alle*, March, 1931, pp. 109–112.)

In the new Telehor substitute for the Weiller mirror-wheel, the mirror elements—instead of being mounted round the periphery of a wheel—are mounted tangentially to a vertical cylindrical axle, each one being angularly displaced by a slight amount in relation to the one above it: the length of the axle being determined by the number and width of the mirrors. The actual construction takes the form of a pile of glass discs mounted on an axis: say 30 discs each 2 mm. thick. A flat surface is ground along the length of the cylinder thus formed, and is then silvered; the discs are then twisted progressively so that each mirror is at a slight angle to its neighbours. In the example taken, the cylinder would be 60 mm. long; the glow-discharge tube for use with it would produce a vertical column of light 60 mm. long, by a discharge between two long rod electrodes very close to each other. Among a number of advantages mentioned are the following:—ease of construction; small weight; practicability for the possible future increase of the number of lines above 30, by decreasing the mirror thickness; the picture can be observed directly in the mirrors, by an audience distributed within an angle of 60°. *Cf. Wireless World*, 1 April, 1931, p. 353, (picture).

DER HEUTIGE STAND DES FERNSEHENS (To-day's Position of Television).—F. Schröter and H. Lux. (*Zeitschr. V.D.I.*, 21st February, 1931, Vol. 75, pp. 237–239.)

The last section of this survey deals with methods of decreasing the frequency band. The double advantage of a screen endowed with persistence of luminosity (*e.g.*, by the use of phosphorus sulphide) is referred to—namely the possible decrease in the number of pictures per second and the increase in brightness. Thun's suggestion is also dealt with, that the darker parts of the scene or subject have [or need have] less detail than the bright parts; they can therefore be scanned more hurriedly and the time thus saved can be spent on the bright parts. Moreover, applying this principle to the receiver, Thun proposes to do away altogether with variation of *amplitude* in the reproducing beam, light and shade being produced by varying the *time* during which the beam stays at each spot.

The writers emphasise the importance of fundamentally new ideas such as the above, although they admit that such variable-speed scanning has not yet been accomplished and presents considerable difficulty.

SCANNING AT A SPEED INVERSELY PROPORTIONAL TO THE BRIGHTNESS OF THE PART SCANNED.—R. Thun. See preceding abstract.

INAUDIBLE TELEVISION—APPLICATION OF THE STENODE RADIOSTAT TO REDUCE INTERFERENCE.—E. L. Gardiner. (*Electrician*, 20th Feb., 1931, Vol. 106, p. 294.)

Summary of a lecture by Gardiner before the Television Society. "The application of the Stenode principles to transmission, he said, made it possible to send out a signal which would be inaudible in any receiver using the ordinary circuit arrangements. In the Stenode, however, it would be perfectly audible. This type of transmission had not yet been tried experimentally, but from a mathematical consideration of the problem it appeared possible to generate a signal to which only the Stenode would respond, and which, even when superimposed on ordinary transmissions, would cause no interference."

THEORIE DES RÜCKGANG-EFFEKTES DES GRENZPOTENTIALS BEI ZUSTRAHLUNG GERINGERER FREQUENZ DES EINFALLENDEN LICHTES (Theory of the Retrogression Effect of the Limiting Potential in Irradiation by Incident Light of Decreasing Frequency).—E. Marx and A. E. H. Meyer. (*Physik. Zeitschr.*, 15th Feb., 1931, Vol. 32, No. 4, pp. 153–163.)

In previous papers (*cf.* 1930 Abstracts, pp. 51 and 460) the authors have shown that the work function for irradiation by monochromatic light is, when the limiting potential is reached, independent of the frequency and intensity of the light; a variation of the work function in an opposing field can only be shown to be present when two or more frequencies are acting simultaneously. The theoretical conclusions arrived at in the present paper are as follows:—

"(1) Every space charge must give rise to an increase in the work function: the measured limiting potential V will therefore always be found to have a smaller value in the presence of space charge than in its absence.

(2) The work function for the limiting potential, when measured in the same apparatus, is found to be independent of the frequency and intensity of the exciting light, as long as there is only a single incident frequency. The course of the limiting potential when the monochromatic frequency is varied is thus not dependent on the space charge in the apparatus.

(3) On the other hand, when a second incident frequency is present, an additional space charge arises which increases the work function by the amount empirically found by the authors by means of the relation given for the retrogression of the limiting potential (*cf.* 1930 Abstracts, p. 460).

(4) The rays from the cathode (as assumed in the formulation of the present theory) must penetrate a double layer arising at the cathode in the opposing field and in this the only forces which affect the electron are those which require reversible change of kinetic into potential electron energy."

ÜBER DIE PHOTOELEKTRISCHE SENSIBILISIERUNG VON KALIUM MITTELS SCHWEFEL, SELEN UND TELLUR (On Photoelectric Sensitising of Potassium by means of Sulphur, Selenium and Tellurium).—W. Kluge. (*Zeitschr. f. Phys.*, 1931, Vol. 67, No. 7/8, pp. 497–506.)

A description of experiments showing that the spectral photoelectric effect of potassium is increased by the action of sulphur, selenium or tellurium vapour in suitable amounts. Each of the three substances gives rise to a definite selective maximum.

ÜBER DAS PHOTOELEKTRISCHE VERHALTEN VON SALZEN, INSBESONDERE ÜBER DIE WIRKUNG DES LANGWELLIGEN LICHTES AUF MIT KURZWELLIGEM LICHT BESTRAHLTE SALZE (On the Photoelectric Behaviour of Salts, in Particular the Effect of Light of Long Wavelength on Salts Irradiated with Light of Short Wavelength).—J. Klaphecke. (*Zeitschr. f. Phys.*, 1931, Vol. 67, No. 7/8, pp. 478–496.)

ÜBER DEN ZUSAMMENHANG ZWISCHEN DEM EINFLUSS VON STICKSTOFF-SAUERSTOFF-VERBINDUNGEN UND DEM IHRER KOMPONENTEN AUF DIE LICHTELEKTRISCHE EMPFINDLICHKEIT DES KALIUMS (On the Connection between the Influence of Nitrogen-Oxygen Compounds and that of their Components on the Photoelectric Sensitivity of Potassium).—R. Fleischer and H. Teichmann. (*Zeitschr. f. Phys.*, 1931, Vol. 67, No. 3/4, pp. 184–191.)

EIN EINFACHER VERSUCH ZUR DEMONSTRATION DER TEMPERATURABHÄNGIGKEIT DES SPERRSCHICHTPHOTOEFFEKTS (A Simple Experiment Demonstrating the Dependence on Temperature of the Attenuating Layer Photoelectric Effect).—H. Teichmann. (*Zeitschr. f. Phys.*, 1931, Vol. 67, No. 3/4, pp. 192–193.)

"An arrangement is described for convenient cooling of a copper-cuprous oxide photoelectric cell which enables the dependence on temperature of the attenuating layer photoelectric effect to be demonstrated to a fair-sized audience."

BEITRÄGE ZUR KENNTNIS DER PHOTOELEKTRIZITÄT (Contributions to the Knowledge of Photoelectricity).—J. Werner. (*Zeitschr. f. Phys.*, 1931, Vol. 67, No. 3/4, pp. 207–226.)

"It is shown that the decrease in photoelectric sensitivity under the inflnence of emission observed by Robinson only occurs with metals with adsorbed gaseous layers. The influence of the gaseous layer depends on the formation of a badly-conducting attenuating layer, which gives the metal surface a constitution similar to that of a bad conductor. The phenomenon is thus explained, in reference to the results found with salts, by an impoverishment of the surface in respect of electrons."

A TUNGSTEN SURFACE WITH A DUAL WORK FUNCTION.—A. H. Warner. (*Phys. Review*, 15th Jan., 1931, Series 2, Vol. 37, No. 2, p. 233.)

Abstract only.

THE INFLUENCE OF THE CRYSTAL-ORIENTATION OF THE CATHODE ON THAT OF AN ELECTRO-DEPOSITED LAYER.—Wood. (*See* under "Miscellaneous.")

PHOTOELECTRIC PROPERTIES OF ATOMIC LAYERS OF POTASSIUM ON A SILVER SURFACE.—J. J. Brady. (*Phys. Review*, 15th Jan., 1931, Series 2, Vol. 37, No. 2, p. 230.)

Abstract only.

ÜBER LICHTELEKTRISCHE WIRKUNG UND ELEKTRONENBEUGUNG, AN HYDRIERTEN KALIUMOBERFLÄCHEN (On the Photoelectric Effect and Electron Diffraction at Hydrated Potassium Surfaces).—W. Kluge and E. Rupp. (*Physik. Zeitschr.*, 15th Feb., 1931, Vol. 32, No. 4, pp. 163–172.)

RICHTER AND GEFFCKEN SCREEN-GRID PHOTOELECTRIC CELLS.—H. Wolfson. (*Television*, March, 1931, Vol. 4, p. 31.)

In an article on "Recent Developments in Photo-Electricity" the writer refers to this new design. "A remarkable condition is noticed when the potential of the control grid is increased from 100 to a value approaching the glow potential. At 100 there is no screening effect, but between 130–140 volts there is a portion of the curve which is practically horizontal, and the length of this horizontal portion is sufficient to allow full control of the three-electrode thermionic valve. The value of the auxiliary anode (screening grid) potential is fairly sharply defined, and for the cells already constructed a reduction of as little as 5 volts causes the horizontal portion to tilt about 20°. An increase of 5 volts from the optimum potential causes a similar tilt to the horizontal, but in the opposite direction."

NEW DEVELOPMENTS IN PHOTOELECTRIC CELLS.—F. Schröter. (*Rad., B., F. f. Alle*, March, 1931, pp. 115–116.)

Summary of a recent lecture. Attempts to combine in one container a triode valve and a photoelectric surface directly connected to the grid have so far led to no success; but already a photoelectric cell is available which is provided with a grid for modulating the photoelectric currents (taking the place of modulation by rotating disc), and now there is a further development in the form of a "screen-grid" cell, the extra grid reducing the internal capacity of the cell to make it suitable for very high frequencies. The Neutrodyne circuit is also used for the same purpose. Schröter considers that the "detector" cells of Lange and of Schottky (*cf.* past Abstracts) may play an important part in television; Telefunken tests have been favourable, and Lange has recently so increased the sensitivity of his cell (by a systematic study of materials) that without a biasing potential a cell of 5 cm² surface, illuminated by an ordinary incandescent lamp several metres distant, will give about 1 mA. with an e.m.f. of 0.1 v. Sunlight will give 50 mA. or more.

NEW DEVELOPMENTS IN THE LANGE PHOTOELECTRIC CELL.—B. Lange. (*See* end of previous abstract.)

LA SURFACE CARACTÉRISTIQUE i = f(F,V) D'UNE CELLULE PHOTO-ÉLECTRIQUE À ATMOSPHÈRE GAZEUSE (The Characteristic Surface i = f(F,V) of a Gas-filled Photoelectric Cell).—G. A. Boutry. (*Comptes Rendus*, 16th Feb., 1931, Vol. 192, pp. 411–413.)

The current i depends on the flux F, the voltage V, and the resistance R in series with the cell. Making R half a megohm, and varying V from 0 to 208 v. and F from 0 to 25 lumens, the writer plots the characteristic surface for a particular potassium cell. He finds six distinguishable regions, the properties and significance of which he discusses. "These results and their interpretation have been confirmed by the study of other cells of the same type and of different types."

MODIFICATIONS DE LA SURFACE CARACTÉRISTIQUE D'UNE CELLULE PHOTO-ÉLECTRIQUE À ATMOSPHÈRE GAZEUSE LORSQU'ON CHANGE LA RÉSISTANCE EN SÉRIE (Changes in the Characteristic Surface of a Gas-filled Photoelectric Cell for Change of the Series Resistance).—G. A. Boutry. (*Comptes Rendus*, 9th March, 1931, Vol. 192, pp. 620–622.)

Further development of the work referred to above. In the former researches the series resistance was kept at 0.5 megohm: this value was shown to act as an energy limiter and to determine the shape of the surface, particularly in controlling the cylindrical "nappe" [vertical face of a waterfall] representing the regions of instability. An increase of this resistance should diminish the height of this "nappe" for a given potential, and a resistance so large that the critical potential exceeds the dark discharge potential should abolish the "nappe" altogether.

The present note confirms this experimentally. A 30 megohm resistance abolishes the vertical "nappe." The new surface is shown and discussed, and a question arises as to what happens, in the absence of the vertical "nappe," when the applied potential is greater than the dark discharge potential. Experiment shows that even for zero luminous flux a constant current passes and the cell is the seat of a feeble luminosity which is the "parent" of the corona régime. A 50,000 ohms resistance, on the other hand, produces a vertical "nappe" of great height—its extent could not be determined without destroying the cell.

A practical conclusion drawn from the researches is that for a given flux and a given potential there is an optimum value of series resistance giving the maximum controlled current with the greatest utilisable slope of the current/flux characteristic. It is only for very small values of flux that the sensitivity is independent of the resistance.

SUR LES DIRECTIONS D'ÉMISSION DES PHOTO-ÉLECTRONS (The Direction of Emission of Photoelectrons).—P. Auger and T. Meyer. (*Comptes Rendus*, 16th March, 1931, Vol. 192, pp. 672–673.)

Further development of the work referred to in 1930 Abstracts, p. 516, on the asymmetrical distribution in space of the photoelectrons produced in a gas by a beam of X-rays.

ÜBER DAS ENTLADUNGSPOTENTIAL EINER PHOTOZELLE (The Discharge Potential of a Photoelectric Cell).—B. Stoll. (*Helvet. Phys. Acta*, No. 7, Vol. 3, pp. 448–449.)

THE BAIRD TELEVISION ARC.—(*Television*, February, 1931, Vol. 3, p. 511.)

"Hitherto the only available light sources for television have been the Kerr cell and the glow-discharge lamp. . . ." The new Baird arc, modulated directly by the current from a television signal, "gives to television a new modulated light source of much greater brilliance than anything hitherto achieved." At various other places in the same issue this arc is referred to enthusiastically, but no details are given.

REDUCING THE STRIKING VOLTAGE OF NEON LAMPS.—D. Walters. (*Television*, March, 1931, Vol. 4, p. 33.)

Attempts, at present without any great success, to reduce the striking voltage by the influence of radioactive substances.

NEON TUBE LIGHT AND FACTORS GOVERNING ITS LIFE.—R. R. Machlatt. (*Journ. Franklin Inst.*, March, 1931, Vol. 212, No. 3, pp. 319–326.)

GLOW DISCHARGE LAMPS FOR TELEVISION.—H. W. Weinhart. (*Bell Lab. Record*, October, 1930, Vol. 9, pp. 80–85.)

DIE GLIMMLAMPE ALS FERNSEH-LICHTRELAIS (The Glow-Discharge Lamp as Light Relay in Television).—F. Kirschstein. (*Fernsehen*, No. 11/12, Vol. 1, pp. 495–501.)

AN ARRANGEMENT FOR AMPLIFYING WEAK PHOTO-ELECTRIC CURRENTS [USING AN ELECTROMETER TRIODE AND AN IONISATION-CHAMBER AS ADJUSTABLE LEAK].—Lejay. (*See* under "Miscellaneous".)

ÜBER EINEN EMPFINDLICHEN LICHTZÄHLER (On a Sensitive Light Meter).—B. Rajewsky. (*Physik. Zeitschr.*, 1st Feb., 1931, Vol. 32, No. 3, pp. 121–124.)

"A photoelectric measuring arrangement with a sensitivity of about 9.10^{-11} erg/cm² sec. is described."

LEAD-IN CONDUCTORS FOR QUARTZ GLASS BULBS.—(*See* under "Valves".)

MEASUREMENTS AND STANDARDS.

FURTHER EXPERIMENTS ON MAGNETOSTRICTIVE OSCILLATORS AT RADIO-FREQUENCIES.—J. H. Vincent. (*Proc. Phys. Soc.*, 1st March, 1931, Vol. 43, Part 2, pp. 157–165.)

Author's abstract :—Work on magnetostrictive oscillators at radio-frequency is continued from a previous paper. It is shown that the coil surrounding the bar can be in either branch of a simple tuned anode circuit. When the bar-coil is in the inductive branch the circuit may be operated as a series or parallel arrangement ; in the latter case the direct plate current does not pass through the inductive branch of the flywheel circuit. The variation in either the anode or the grid current can be used to indicate resonance. Comparative experiments with corronil, nickel and glowray suggest that glowray is the most suitable of these materials for high-frequency oscillators. The experiments are carried on to the case of a glowray oscillator 1.9 mm. long which has a frequency of 1280 kc./sec. and weighs less than a fiftieth of a gramme.

THE EQUIVALENT CIRCUIT OF THE MAGNETOSTRICTION OSCILLATOR.—S. Butterworth and F. D. Smith. (*Proc. Phys. Soc.*, 1st March, 1931, Vol. 43, Part 2, pp. 166–185.)

Authors' abstract :—The Joule effect in magnetostriction is defined by the relation $S = \lambda B$, where S is the stress produced by a small increment of induction B of an existing induction B_0 ; and the converse effect by the relation $H = \kappa\xi$ where H is the magnetic field produced by a small strain ξ. Conservation of energy requires that $\kappa = 4\pi\lambda$. These equations are used in investigating the motion of a magnetostriction oscillator consisting of a closed circular ring inside a toroid, eddy currents and hysteresis being taken into account. It is shown that the oscillator can be represented by an equivalent electrical circuit comprising a pair of parallel impedances Z_c, Z_m, in series with an impedance Z_l, where Z_l represents leakage impedance and Z_c impedance due to core flux in the absence of motion, while Z_m is a resonant shunt to Z_c and represents the effect of the motion. Expressions for the elements of the circuit in terms of the fundamental constants of the material are given. The circle-diagram of impedances is deduced, and the modifying effects of eddy currents and hysteresis are investigated. Some simple geometrical relations between the vectors in the diagram are derived. It is shown that the size of the circle diagram for solid material having a large value of λ depends mainly upon permeability and resistivity and only slightly upon λ, and that a high degree of resonance may be associated with poor magnetostriction quality ; the circle-diagram may, in fact, lead to erroneous conclusions unless interpreted in the light of an adequate theory. An experimental investigation of the resonant radial vibrations of solid and laminated nickel rings verifies the theoretical deductions and leads to numerical values of λ and κ in agreement with values deduced from the work of Masumoto and Nara and of McKeehan and Cioffi. For nickel in the annealed state, $\lambda = 1.76 \times 10^4$ and $\kappa = 22.1 \times 10^4$

at a point on the curve corresponding to $H_0 = 14.5$ gauss.

THE DEVELOPMENT OF A STANDARD HIGH-FREQUENCY OSCILLATOR OF WIDE RANGE.—L. G. A. Sims and M. I. Ehwany. (*Engineering*, No. 3372, Vol. 130, pp. 253–257.)

Full description of the equipment and procedure, suitable for calibrating absorption-type wavemeters over a wavelength range of 5 to 4000 m. with a maximum error of about 1 in 1000. The ultimate standard is a Lecher wire system, excited by an oscillator working between 5 and 10 m. Two other oscillators, rich in harmonics, may be coupled with this: the one working between 10 and 130 m., the other between 110 and 4000 m. By using the standard oscillator to heterodyne with some particular harmonic of the second oscillator, or (for the longer waves) the second oscillator to heterodyne with the third oscillator, the whole range can be covered.

A VARIABLE-CAPACITANCE CYLINDRICAL CONDENSER FOR PRECISION MEASUREMENTS, AND A WAVEMETER FOR SHORT WAVELENGTHS.—E. B. Moullin. (*E.W. & W.E.*, Feb., 1931, Vol. 8, pp. 84–86.)

Long abstract of an I.E.E. (Wireless Section) paper, dealing with the theory and construction of a condenser in which the moving armature is a cylinder rotating eccentrically on its axis inside a larger cylinder which acts as the fixed armature and screen. By means of two mica condensers in the base chamber, the range is made continuous between 28 and 72 $\mu\mu$F. A simple wavemeter using this condenser is described, capable of measuring a wavelength to within about 0.07 %.

SOME METHODS OF MEASURING THE FREQUENCY OF SHORT WAVES.—H. Mögel. (*Proc. Inst. Rad. Eng.*, Feb., 1931, Vol. 19, pp. 195–213.)

Cf. 1930 Abstracts, pp. 284 and 463. Author's summary:—Four methods are given for practical frequency measurements on short waves (10–50 metres, 30,000–6000 kc.) with an absolute accuracy of $\pm$ 0.01 per cent. to $\pm$ 0.001 per cent. and a relative accuracy of $\pm$ 0.0001 per cent. Harmonic overtones are used in each method. The frequency standards are exclusively the luminous quartz resonators developed by Giebe and Scheibe, which are exceedingly useful and at the present time represent secondary standards constant to 1/100,000 so that continuous supervision with special calibration apparatus and chronograph is unnecessary. The indirect methods use fixed or variable fundamental frequency, while the direct methods use resonators whose response is indicated visually or acoustically. The methods were developed by Transradio A.G., Berlin, and are used by the transmitting and receiving stations in Nauen and Geltow-Beelitz.

FREQUENCY CHECKING: THE DEPARTMENT OF COMMERCE MONITORING STATION AT HINGHAM, MASS.—I. L. Weston and R. J. Renton. (*QST*, Feb., 1931, Vol. 15, pp. 9–13.)

ÜBER DEN EINFLUSS DES ERDMAGNETISCHEN FELDES AUF DIE SCHWINGUNGSZEITEN VON NICKELSTAHLPENDELN (The Effect of the Earth's Magnetic Field on the Periodic Time of Nickel Steel Pendulums).—M. Rössiger. (*Zeitschr. f. Instr:kde*, No. 9, Vol. 50, pp. 551–552.)

A NEW METHOD OF MEASUREMENT OF RESISTANCE AND REACTANCE AT RADIO FREQUENCIES.—F. M. Colebrook and R. M. Wilmotte. (*E.W. & W.E.*, Feb., 1931, Vol. 8, pp. 83–84.)

Long abstract of an I.E.E. (Wireless Section) paper, describing the procedure and apparatus used in this application of the "absorbing circuit" principle. The method is a development of that due to P. W. Willans. "The new method has the advantages: (i) All measurements are made at the same frequency $\omega/2$. (ii) The telephones carry an audio current of constant frequency from an auxiliary l. f. oscillator. The beat frequency is matched with this by the usual method of beats, giving an exceedingly sensitive method of synchronisation." For remarks in the subsequent discussion, *see* p. 87.

MEASUREMENT OF VERY SMALL CAPACITIES BY THE USE OF A WULF CONDENSER AND A SENSITIVE ELECTROMETER.—Clay. (*See* abstract under "Atmospherics.")

LABORATORY METHOD OF MEASURING INDUCTANCES WITH BALLISTIC GALVANOMETER.—B. L. Robertson and C. A. Nickle. (*Gen. Elec. Review*, Aug., 1930, Vol. 33, pp. 464–469.)

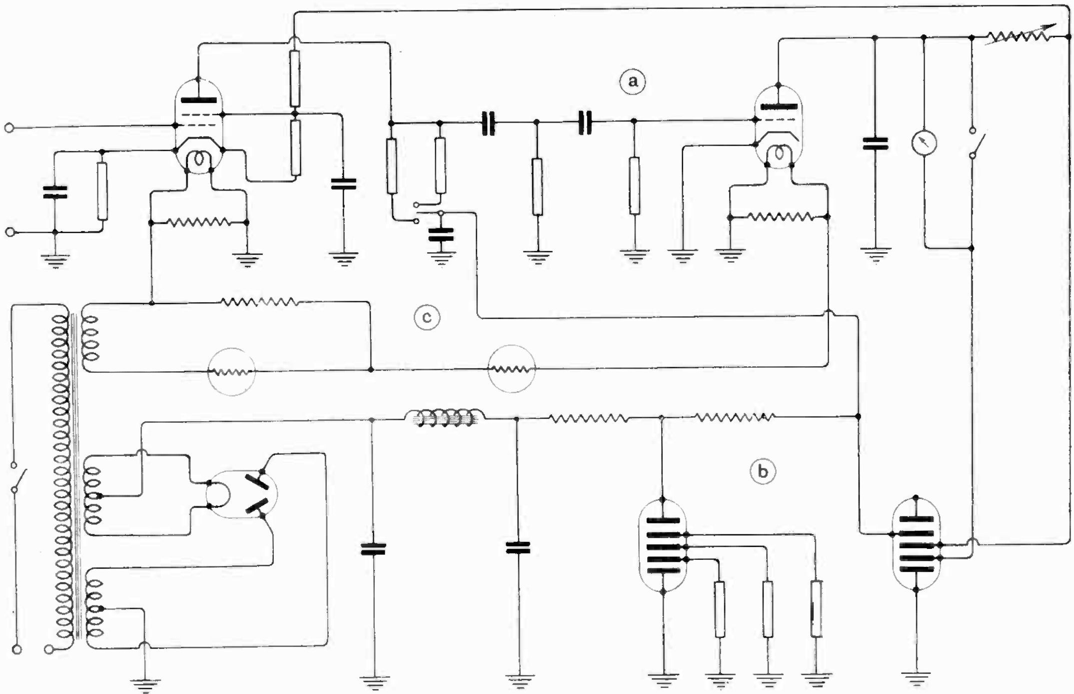
ON THE APPLICATION OF THE ULTRA-SHORT WAVE METHOD [WITH LECHER WIRE SYSTEM] TO THE MEASUREMENT OF SMALL CAPACITIES AND DIELECTRIC CONSTANTS.—D. V. Gogate and D. S. Kothari. (*Indian Journ. Phys.*, No. 4, Vol. 5, pp. 417–428.)

RÖHREN-VOLTMETER FÜR NETZANSCHLUSS (Mains-Driven Valve Voltmeters).—H. E. Kallmann. (*Zeitschr. f. hochf. Tech.*, February, 1931, Vol. 37, pp. 58–64.)

From the Lorenz laboratories. I.—For voltages from 1 v. upwards:—anode rectification, single directly-heated triode; constancy in the face of mains fluctuations tending to produce anode voltage changes is obtained by the device of influencing the grid by the p.d. along a tapped resistance traversed by the rectified anode current. II.—For a.c. voltages 0.1 to 4 v.:—leaky grid rectification, single indirectly-heated triode. Here the anode potential has a marked influence on the anode current, so that the former must be carefully stabilised; this stabilisation is successfully accomplished by a single glow-discharge potential divider (Körös, 1930 Abstracts, p. 408). A second design, for greater accuracy, gives heating current stabilisation also, by the inclusion of an iron-wire barretter.

III.—Two-valve voltmeter: leaky grid rectification with screen-grid valve in an aperiodic preliminary stage (resistance-coupled). The diagram of this elaborate voltmeter is given below; it embodies a number of refinements which the paper describes.

Take, for example, the circuit part marked (*a*) in the diagram:—the size of the grid condenser, regulated by the lowest frequency to be catered for (about 50 p.p.s.), is too great for the use of mica, since a mica condenser would have a considerable capacity to earth which would bring down the upper frequency limit. But if a paper condenser is used, a leakage current will flow from the first valve anode, through condenser and grid leak, which will be large enough to produce appreciable errors. To avoid this difficulty, the grid condenser is replaced by two condensers in series, each with its own leak: *e.g.*, the 0.1 μF. condenser (with its 3 megohm leak) originally decided on now has in series with



it a 0.5 μF. condenser with a 10 megohm leak. If the latter condenser has an insulation resistance of 1000 megohms, the d.c. potential between 1st valve anode and 2nd valve cathode will be divided in the ratio 1000 : 10, so that only one hundredth of it will be on the smaller condenser and the leakage current through the latter and its leak will be inappreciable. Both condensers may therefore be of a small type with little capacity to earth.

Part (*b*) of the diagram shows how a combination of two glow-discharge potential dividers is necessary for the stabilisation of the anode potential. Part (*c*) shows that the heating current of the s.g. valve, as well as that of the detector, is stabilised. This would appear unnecessary since the amplification of the s.g. valve is practically independent of the heating current: the stabilisation is, however, essential to ensure that the anode current producing the grid bias should be constant.

With a galvanometer giving a deflection of 100 scale divisions for every 3×10^{-6}A., the instrument (with an anode resistance of 1000 ohms) gave a range of 35–170 mv.; for frequencies of 50 and 1.2×10^6 p.p.s. the sensitivity fell by one-tenth. An anode resistance of 10,000 ohms increased the sensitivity (but also the damping due to anode-reaction) so as to give a range of 3–15 mv.

A further refinement, not shown in the diagram, gives a convenient way of checking the constancy of the instrument. Since the frequency dependence does not vary with time, and the shape of the calibration curve remains unchanged, one single measurement of a fixed a.c. potential is enough: this test potential is obtained from the instrument itself, being derived from the "twice-stabilised" heating current. This double stabilisation does not seem clearly indicated in the diagram, but in the text, and another diagram, it is shown how the heating potential is first applied to two barretters in parallel and how the stabilised potential across a resistance is then applied to a single barretter, and the valve supply tapped off a second resistance on the far side of this.

The final section gives two examples of the application of the instrument: the measurement of the damping in an oscillatory circuit, and the measurement of radio-frequency voltages in a series of amplifying stages.

TEST TRUCK FOR AIRCRAFT RADIO.—W. K. Gauchey. (*Bell Lab. Record*, October, 1930, Vol. 9, pp. 77–79.)

GERÄT ZUR MESSUNG KLEINER MAGNETISCHER WECHSELFELDER (Apparatus for Measuring Small Alternating Magnetic Fields).—G. Lubszynski. (*E.T.Z.*, 5th March, 1931, Vol. 52, pp. 312–314.)

MUTUAL INDUCTANCE AND REPULSION OF TWO ADJACENT DISK COILS.—H. B. Dwight and T. Y. Lu. (*Journ. Math. Phys.*, No. 4, Vol. 9, pp. 315–319.)

THE USE OF THE COPPER-OXIDE RECTIFIER FOR INSTRUMENT PURPOSES.—Sahagen. (*See* under "Subsidiary Apparatus.")

SUBSIDIARY APPARATUS AND MATERIALS.

EIN GASGEFÜLLTER KLEINGLEICHRICHTER MIT OXYDGLÜHKATHODE (A Small Gas-filled Rectifier with Oxide-coated Cathode).—M. Knoll. (*E.T.Z.*, 15th Jan., 1931, Vol. 52, pp. 65–68.)

A new full-wave rectifier with a special oxide-coated hot cathode and a filling of argon is described and discussed. It is a product of the Rectron Company, Berlin, and is suitable for mains units for broadcast receivers, and similar purposes. Long life is obtained, thanks to the special cathode; this is made by winding a thin nickel (*e.g.*) wire in close turns round a thick tungsten wire which is itself then wound into close-lying turns. Cheapness in construction is obtained by the use of a screen which lies between the two (graphite) anodes and allows an ordinary bulb to be employed, without branches. For the higher voltages up to 500 v_{eff} a plain bulb is still possible, thanks to the use of screening cylinders round each anode. The small size of these full-wave rectifiers is illustrated by the fact that one typical example measures 145 mm. (overall height) and 52 mm. (maximum diameter). This one rectifier can be used—by means of suitable alternative transformer windings—to provide 0.2 A. at 200 v. for anode supply or 1.0 A. at about 10 v. for battery-charging when the receiver is idle. For voltages up to 350 v. the life averages over 2000 working hours for 1000-times switching-on with the voltage applied to the cathode in its cold state: if this condition is avoided, the life reaches 3000 hours. Under specially favourable conditions a life up to 8000 hours can be obtained. Oscillograph records of the working are shown.

THE USE OF THE COPPER-OXIDE RECTIFIER FOR INSTRUMENT PURPOSES.—J. Sahagen. (*Proc. Inst. Rad. Eng.*, Feb., 1931, Vol. 19, pp. 233–240.)

Author's summary:—Mention is made of the need for high sensitivity a.c. measuring instruments and the development of the copper-oxide rectifier as a ready means of obtaining high sensitivity without sacrificing other desirable characteristics. Possibilities and limitations of half-wave rectification are discussed. An analysis is made of the copper-oxide full-wave instrument rectifier. Characteristics of this rectifier and of rectifier instruments under varying conditions of current, temperature, frequency, and wave-form are discussed. A study is made of the inter-relation of range and sensitivity in determining temperature coefficients of rectifier voltmeters. Methods of compensation are developed for offsetting errors due to temperature or frequency. The chief limiting factors in the use or manufacture of rectifier instruments are set forth.

INFLUENCE DES TRAITEMENTS THERMIQUES SUR LES CARACTÉRISTIQUES DES REDRESSEURS À L'OXYDE DE CUIVRE (The Effect of Thermal Treatments on the Characteristics of Copper Oxide Rectifiers).—L. Dubar. (*Comptes Rendus*, 23rd Feb., 1931, Vol. 192, pp. 484–485.)

DIE ERZEUGUNG VON HOCHGESPANNTEM GLEICHSTROM AUS DREHSTROM (The Production of High-Voltage D.C. from a Three-Phase Current [by a Mechanical Rectifier]).—W. Deutsch and W. Hoss. (*E.T.Z.*, No. 43, Vol. 51, pp. 1480–1483.)

ÜBER DETEKTOREN (On Detectors).—G. Siemens and W. Demberg. (*Zeitschr. f. Phys.*, 1931, Vol. 67, No. 5/6, pp. 375–387.)

THE PRACTICAL USE OF THE SELENIUM RECTIFIER.—E. Schwandt. (*Rad., B., F. f. Alle.*, March, 1931, pp. 118–124.)

For charging high- and low-tension accumulators, for direct mains heating of ordinary battery-driven valves, for direct anode supply from mains, and for field excitation of moving-coil loud speakers.

THE USE OF A KENOTRON AS A "CURRENT LIMITER" FOR THE RECTIFICATION OF A PULSATING CURRENT.—W. Witorsky and D. Stepanow. (*Westnik Elektrot.*, No. 3, 1930, pp. 93–97.)

In Russian. The writers' tests with different circuits, here described and illustrated by oscillograms, show that by using two series-stages of kenotron, functioning at the saturation point, a very complete rectification can be obtained. On the other hand, they show that the usual types of kenotron possess too high saturation voltages to be really suitable for the purpose: special types of "kenotron-limiter" are desirable, and would be of particular value in cases where the voltage is so high as to make it inconvenient to employ the usual filter circuits.

ON A KENOTRON RECTIFIER WITH A CONDENSER.—D. V. Stepanov. (*Westnik Elektrot.*, No. 9–10, 1930, pp. 316–319.)

On the assumption of a sinusoidal e.m.f. and a resistance constant in one direction of current and infinitely great in the other, a theoretical analysis is given. A graphical method for determining the voltage curve for polyphase rectification is given. The derived formula is proved by oscillograms.

POLYPHASE RECTIFICATION SPECIAL CONNECTIONS.—R. W. Armstrong. (*Proc. Inst. Rad. Eng.*, Jan., 1931, Vol. 19, pp. 78–102.)

Author's summary:—Characteristics of various rectifier circuits and factors governing their selection are given. It is pointed out that, in general, the double 3-phase circuit is most desirable from the standpoint of transformer and tube capacity requirements for mercury pool type tubes, and the 6-phase single *Y* for hot cathode mercury vapour tubes or high vacuum tubes, but that other factors may make other circuits more desirable for particular cases. Data are given for 3–, 4–, 6–, and 12–phase rectifiers using *T*-connected transformers, so that fewer transformers are required. Since it is cheaper to build two large transformers than three smaller ones of approximately the same total capacity, the *T*-connection may permit a saving in transformer cost. The voltage doubling circuit is discussed, its relation to other single phase circuits shown, and its characteristics given as a function of the product, *CR*, of condenser capacity and load resistance.

THE RECTIFYING ELEMENTS OF COPPER OXIDE.—L. Dubar. (*Comptes Rendus*, 9th Feb., 1931, Vol. 192, pp. 341–343.)

The writer has prepared the semi-conducting mixture said by Pélabon (1930 Abstracts, pp. 641–642) to be formed of cupric oxide disseminated in a large excess of cuprous oxide : if this is so, the conductivity would be due to the cupric oxide and would disappear on completely dissociating the latter. This is found to occur.

O MEJDUFAZOVOM DROSSELE DLIA MOSCHNIH KENOTRONNIH USTANOVOK (On Interphase Reactors for High Power Thermionic Rectifying Systems).—M. I. Kontorovitch. (*Westnik Elektrot.*, June, 1930, Part 1, pp. 233–239.)

In Russian. In the double three phase system of rectification the method usually employed for calculating the inductance of the interphase reactor is based on the assumption that the voltage drop in the rectifiers is negligible. When applied to rectifying systems using thermionic valves this method consequently gives only approximate results. It is, moreover, necessary in this case to take into account the maximum instantaneous currents flowing through the individual valves. The author discusses the problem with a view to ascertaining the modifications involved by these considerations.

Voltage and current curves for individual phases are given for the case when the internal resistance is negligible. Equations are then derived and curves given for determining the conditions in the individual phases when the internal resistance is taken into account. For calculating the inductance of the interphase reactor these equations are used, subject to the condition that, as already indicated, only a certain maximum current may be passed by each of the rectifier valves. This is important, particularly as under certain conditions a complete separation of phases may occur when the two secondaries will operate as independent three phase systems, and the whole of the rectified current be momentarily supplied by a single phase, that is, i_m may be momentarily equal to I.

The system of equations finally obtained does not lend itself to a general solution. In practice, however, the voltage drop in thermionic valve rectifiers is not very large, normally not exceeding 8 to 15 % of the rectified output voltage. For a small voltage drop in the rectifiers an approximate solution of the equations is arrived at and curves are given from which the inductance of the interphase reactor may be determined.

When the internal resistance of the rectifiers is negligible the usual formulae

$$4\omega L = (2 - \sqrt{3}) \frac{E_0}{I} \quad \quad (1)$$

is obtained as a particular case of the general solution. In this formula L is the inductance of one leg of the reactor (one half of the total inductance) I the total rectified current and E_0 the maximum voltage across each secondary phase of the transformer.

A numerical example is given which shows that even when the voltage drop in the rectifiers is as high as 29% of the rectified output voltage the inductance of the interphase reactor need only be about 33% greater than that calculated from formula (1). The difference between these two values would probably be still further reduced were the leakage reactance of the transformer and interphase reactor taken into account.

It appears, therefore, that formula (1) gives results which are sufficiently accurate for practical purposes. In any case this formula can safely be used when the ratio of the internal resistance of the rectifiers in one phase to ωL lies between zero and 0.3.

RÉALISATION D'UN ÉJECTEUR À VAPEUR DE MERCURE (A Mercury Vapour Ejector, its Design and Properties [for High Vacua]).—P. Ansiau. (*Comptes Rendus*, 16th March, 1931, Vol. 192, pp. 670–671.)

This pump, constructed of Pyrex glass, gives very rapidly a vacuum almost or quite beyond the limits of a MacLeod gauge. This is *without* a mercury vapour trap; if a trap is interposed, a vacuum is obtained in which 60 or 70 kv. at 50 cycles/sec. will produce no cathodic effect between points. Used without a trap in conjunction with a Dusham condensation pump, it appears to give a better vacuum than that obtained with the same condensation pump, with trap, in conjunction with a good primary-vacuum oil pump.

DRUCKREGLER FÜR QUECKSILBERDAMPF-GROSSGLEICHRICHTER (Automatic Pressure Regulator for Large Mercury Vapour Rectifiers). — —. Kotschubey. (*E.T.Z.*, 29th Jan., 1931, Vol. 52, p. 146.)

PARALLELGESCHALTETE INDUKTIONSSPULEN AUF GEMEINSAMEM KERN (Parallel-Connected Inductances on a Common Core).—R. Goldschmidt. (Summary in *E.T.Z.*, 29th Jan., 1931, Vol. 52, p. 148.)

METHOD OF CONSTRUCTION OF INDUCTANCES ALLOWING ADJUSTMENT IN TEST ROOM.—(French Pat. 693703, Comp. franç. Thomson-Houston, pub. 24th Nov., 1930.)

Part of the winding is separated from the main winding by a gap which can be altered by the special design of the bobbin, thus increasing or decreasing the inductance.

ÜBER EINEN APPARAT ZUR ERZEUGUNG VON TONFREQUENTEN WECHSELSTRÖMEN MIT RECHTECKIGER KURVENFORM (An Apparatus for the Generation of Audio-frequency A.C. of Rectangular Wave-form).—W. Keil and R. Sewig. (*Zeitschr. f. Instr : kde*, No. 10, Vol. 50, pp. 582–586.)

A beam of light falling on a photoelectric cell is interrupted by a disc with teeth of triangular shape. Suitable amplification gives a current up to 50×10^{-3}A., of rectangular form and with a periodic time of from 0.1 to 0.0001 second. The particular purpose in view is a medical one.

EINE NEUE FORM EINES WECHSELSTROMGALVANOMETERS (A New Form of Alternating Current Galvanometer).—H. Mukherjee and S. S. Mukherjee. (*Zeitschr. f. Phys.*, 1931, Vol. 67, No. 9/10, pp. 702–706.)

A description of an improved form of a sensitive alternating current galvanometer which is completely free from the influence of the earth's magnetic field.

APPLICATION OF THE WYNN-WILLIAMS BRIDGE VALVE AMPLIFIER TO MICROPHOTOMETRY AND ABSORPTION PROBLEMS.—H. G. Heil. (*Phil. Mag.*, March, 1931, Series 7, Vol. 11, No. 71, pp. 736–740.)

SUR LA THÉORIE DE L'ACCUMULATEUR AU PLOMB (On the Theory of the Lead Accumulator).—–. Tarrin. (*Bull. d. l. Soc. franç. d. Élec.*, March, 1931, Ser. 5, Vol. 1, pp. 280–287.)

"Refutation of some fundamental arguments of the theory of M. Ch. Féry: verification of the theory of double sulphating by the analysis of the active materials and the direct weighing of the plates."

ROTATING CONDENSER DEVICE FOR STEPPING UP TO HIGH D.C. POTENTIAL.—A. Verigo. (*C. R. Leningrad* [A], No. 18, 1929, pp. 441–445.)

A source of high voltage particularly suited to portable equipments on account of its small weight. The rotating condenser is charged from a battery as it passes through its maximum capacity.

EINE METHODE ZUR MESSUNG VON EISENVERLUSTEN BEI HOCHFREQUENZ (A Method of Measuring Iron Losses at High Frequencies [7000–70,000 Cycles/Sec.]).—P. Glebow: K. Schmidt. (*E.T.Z.*, 12th Feb., 1931, Vol. 52, pp. 205–209.)

ÜBER DEN ZEITLICHEN VERLAUF VON STROM UND SPANNUNG BEIM EINSATZ DER GLIMMENTLADUNG (On the Variation with Time of Current and Potential in the Onset of the Glow Discharge [in a Philips' Neon Lamp]).—F. Tank and L. Ackermann. (*Helvet. Phys. Acta*, No. 7, Vol. 3, pp. 468–476.)

GRID-GLOW RELAY FOR BREAKING 165 KW.—Westinghouse Co. (*Elec. Engineering* [late *Journ. Am.I.E.E.*], Jan., 1931, Vol. 50, p. 34.)

AN EXPERIMENTAL METHOD OF STUDYING TRANSIENT PHENOMENA [USING THE "TRANSTEN VISUALIZER"].—H. M. Turner. (*Proc. Inst. Rad. Eng.*, Feb., 1931, Vol. 19 pp. 268–281.)

Including a description and illustrations of the equipment referred to in April Abstracts, p. 222.

BEREKENING DER VELDSTERKTE BIJ PERMANENTE MAGNETEN (Calculation of the Field Strength for Permanent Magnets).—W. Elenbaas. (*Physica*, No. 9, Vol. 10, pp. 273–286.)

THE CONSTRUCTIONAL DEVELOPMENT OF THE COMMUTATOR OF THE JET WAVE RECTIFIER.—J. Hartmann. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 12, 1931, pp. 4–19.)

THE PHYSICS OF INSULATING MATERIALS.—A Morris Thomas. (*World Power*, Feb., 1931, Vol. 15, pp. 113–115.)

The third part of a comprehensive general survey. A bibliography of 16 items, referring to this part alone, is included. The previous parts were in the Dec., 1930, and January issues.

THEORIE DER POLARITÄTSEFFEKTE BEIM STROMDURCHGANG DURCH FESTE STOFFE (Theory of Polarity Effects [Rectification] in the Passage of Electrical Current through Solids).—P. Böning. (*Zeitschr. f. Phys.*, Vol. 66, No. 9/10, pp. 581–597.)

ÜBER DIE ELEKTRISCHE LEITFÄHIGKEIT VON AMORPHEM QUARZ (On the Electrical Conductivity of Amorphous Quarz).—W. Gnann. (*Zeitschr. f. Phys.*, Vol. 66, No. 7/8, pp. 436–452.)

RUBBER SEPARATORS: THE USE OF LATEX IN MAKING ACCUMULATOR SEPARATORS ["MIPOR" SEPARATORS].—H. Beckmann. (*Electrician*, 6th Feb., 1931, Vol. 106, p. 224.)

Description of a new German separator of microporous composition, made from latex coagulated to form a gel which is then vulcanised in water or saturated steam.

MAGNETIC CURVE TRACER.—F. E. Haworth. (*Bell Tech. Journ.*, Jan., 1931, Vol. 10, No. 1, pp. 20–32.)

Author's summary:—An apparatus for photographically recording hysteresis loops and initial magnetisation curves is described. It employs a rotating drum and a fluxmeter, the restoring torque of the latter being completely counterbalanced by a photoelectric cell arrangement. With this apparatus, curves may be taken so slowly that eddy currents are negligible. The accuracy of the instrument is intrinsically as great as that of a ballistic galvanometer. An analysis of sources of error is included.

AN AUTOGRAPHIC APPARATUS FOR DETERMINING INFLECTION POINTS IN MAGNETIC SUSCEPTIBILITY CURVES.—J. L. Haughton. (*Journ. Sci. Instr.*, Jan., 1931, Vol. 8, pp. 7–14.)

TWO IMPROVEMENTS IN THE TECHNIQUE OF KYMOGRAPH RECORDING.—Wichart, Thienes and Visscher. (*Science*, 23rd Jan., 1931, Vol. 73, pp. 99–100.)

The use of the pressure air gun for applying carbon particles in suspension, instead of smoking: and of transparent cellophane instead of glazed paper.

A VOLTAGE TRANSFORMER FOR USE IN THE MEASUREMENT OF SMALL VOLTAGES.—A. H. M. ARNOLD. (*Journ. I.E.E.*, Jan., 1931, Vol. 69, pp. 156–163.)

A transformer with mumetal core and tertiary shielding winding; maximum ratio 200 : 1, constant to 1 part in 10,000 over a frequency range 25–500 cycles/sec. and an applied voltage range of about 15 mv. to 3 v.

A PORTABLE SPARK CHRONOGRAPH FOR USE ON EITHER DIRECT OR ALTERNATING CURRENT.—C. N. Hickman. (*Journ. Franklin Inst.*, Jan., 1931, Vol. 211, No. 1, pp. 59–65.)

DAS EINDRINGEN ELEKTROMAGNETISCHER WELLEN IN HOCHGESÄTTIGTES EISEN (The Penetration of Electromagnetic Waves into Highly Saturated Iron).—F. Ollendorff. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 12, 1931, pp. 39–50.)

A mathematical investigation taking into account the variable permeability; results are checked by the experimental results at 30 cycles/sec. obtained by Hilpert and Schleicher in 1919. They agree qualitatively, and quantitatively also for ingot iron; but for cast iron allowance has to be made for hysteresis.

VEREINFACHTES KIPPRELAIS FÜR SYNCHRONE ZEITABLENKUNG EINER BRAUNSCHEN RÖHRE MIT GLÜHKATHODE (A Simplified "Relaxation Oscillation" Relay for Synchronous Time-Base for a Hot-Cathode C.-R. Oscillograph).—J. Kammerloher. (*E.T.Z.*, 15th Jan., 1931, Vol. 52, pp. 78–79.)

The first arrangement described gives a synchronous deflecting potential changing as an exponential function; the second, by the addition of a triode working at the saturation point, gives a synchronous deflection proportional to time. Both are free from the need of separate, insulated h.t. batteries required by Hudec's arrangement.

FURTHER ADVANCES IN THE TECHNIQUE OF THE BRAUN TUBE [CATHODE RAY OSCILLOGRAPH].—M. von Ardenne. (*E.W. & W.E.*, March, 1931, Vol. 8, pp. 127–129.)

An illustrated article on the mains-driven tubes referred to in February Abstracts, pp. 107–108.

CATHODE RAY DEFLECTED BY A MAGNETIC FIELD DUE TO SMALL CURRENTS [OF THE ORDER OF 1 MILLIAMPÈRE].—Slopkovitzer. (*See* abstract under "Acoustics.")

THE PRODUCTION OF SLOW CATHODE RAYS FOR LONG-DELAY ECHO EXPERIMENTS.—Brüche. (*See* abstract under "Propagation of Waves.")

UN OSCILLOGRAPHE AUTOMATIQUE POUR L'ENREGISTREMENT DES PERTURBATIONS DES RÉSAUX (An Automatic Oscillograph for Recording Disturbances of Power Networks). —J. Fallou. (*Bull. d. l. Soc. franç. d. Élec.*, Jan., 1931, Ser. 5, Vol. 1, pp. 91–99.)

A compound instrument made up of three Dubois oscillograph movements and the necessary relays, etc., for setting them and the moving photographic tape in action on the arrival of a disturbance.

THE USE OF TRIODE VALVES WITH DUDDELL TYPE OSCILLOGRAPHS.—E. L. E. Wheatcroft and A. Graham. (*Engineering*, No. 3385, Vol. 130, pp. 671–672.)

THE ELECTRICAL RESISTANCE OF MOISTURE FILMS ON GLAZED SURFACES.—G. G. Smail, R. J. Brooksbank, and W. M. Thornton. (*Journ. I.E.E.*, March, 1931, Vol. 69, pp. 427–436.)

"The depth of penetration of current into a conductor in a high-frequency circuit is small, and an insulator with a thin conducting film becomes an increasing source of uncertainty at high frequencies. A method of measuring the surface resistance of ebonite panels for radio apparatus is the subject of a British Standard Specification, but the atmospheric conditions under which the test is to be made are not stated. The potential gradient along a string of suspension-type insulators is influenced to a marked degree by the surface leakage over each unit. . . ."

Authors' summary:—The research described is in two parts, the first dealing with the relations between surface resistivity, humidity and temperature, and the second with the influence of gas pressure, both having for their object the discovery of the laws of film formation under controlled conditions. The first led to an expression of the form

$$\rho_s = \rho_{s(d)} e^{k(1 - p_a/p_s)^2},$$

where $\rho_{s(d)}$ is the surface resistivity immediately before dew point is reached, p_a the actual vapour pressure to produce a desired humidity, and p_s that required to saturate the air at the same temperature. The second part proves that at all humidities there is a very sharply defined critical pressure above which the resistivity falls as the pressure rises, and below which both fall together. Expressions are found for the variation of the thickness of the film and for the influence of temperature on resistivity.

THE ELECTRICAL INSULATING PAPER: THE EFFECT OF BEATING: THE DIELECTRIC STRENGTH OF CELLOPHANE AND THE PAPERS IMPREGNATED WITH PLASTICS.—K. Atsuki and K. Matsuoka. (*Journ. Soc. Chem. Ind. Japan*, No. 10, Vol. 33, pp. 385B–388B.)

BY-PASS CONDENSER PRODUCTION TEST EQUIPMENT.—F. W. Stellwagon. (*Electronics*, Feb., 1931, pp. 504–505.)

A VARIABLE CYLINDRICAL CONDENSER FOR PRECISION MEASUREMENTS.—Moullin. (*See* under "Measurements and Standards.")

DER SPANNUNGSVERLAUF BEI DER STOSSPRÜFUNG NACH AUFNAHMEN MIT DEM KATHODENSTRAHL-OSZILLOGRAPHEN (The Potential Curve in Impulse Testing [of Insulating Materials] as recorded with the C.-R. Oscillograph).—W. Schilling and J. Lenz. (*E.T.Z.*, 22nd Jan., 1931, Vol. 52, pp. 107–111.)

HOCHSPANNUNGSKONDENSATOREN AUS PORZELLAN (Porcelain High-Voltage Condensers).—(*E.T.Z.*, 15th Jan., 1931, Vol. 52, p. 87.)

THE INSULATION OF PYREX GLASS AFTER HEATING *in Vacuo*.—J. H. Mitchell. (*Phil. Mag.*, March, 1931, Series 7, Vol. 11, No. 71, pp. 748–753.)

It was noticed that pyrex glass loses permanently much of its electrical insulating property after baking out in a vacuum. This result is investigated, and it is found that a wash with hydrofluoric acid largely restores the insulating property, showing that the effect is a surface one probably due to some chemical change in the outer layers connected with the gas evolution which occurs.

MICA.—J. H. Frydlender. (*Rev. Gén. de l'Élec.*, 24th Jan., 1931, Vol. 29, p. 32D.)

Summary of a paper in a French technical journal. The paper ends with a section giving abstracts of various patents relative to the treatment and applications of mica.

STATIONS, DESIGN AND OPERATION.

DAS "HAUS DES RUNDFUNKS" IN BERLIN ("Broadcasting House," Berlin).—(*E.T.Z.*, 22nd Jan., 1931, Vol. 52, pp. 111–114.)

THE HEILSBERG HIGH POWER BROADCASTING STATION.—(*E.T.Z.*, 5th March, 1931, Vol. 52, pp. 315–316.)

RASIN AT WORK: GOOD CRYSTAL RECEPTION FROM THE NEW TRANSMITTER ALL OVER POLAND.—(*Electrician*, 13th March, 1931, Vol. 106, p. 397.)

FIELD STRENGTHS OF THE BOMBAY BROADCASTING STATION.—Doraswami and Kantebet. (*See* abstract under "Propagation of Waves.")

ON THE SIMULTANEOUS OPERATION OF DIFFERENT BROADCAST STATIONS ON THE SAME CHANNEL.—P. P. Eckersley. (*Proc. Inst. Rad. Eng.*, Feb., 1931, Vol. 19, pp. 175–194.)

Author's summary :—This paper gives a detailed account of experiments in the operation of several radio broadcast stations on a common frequency, conducted in England. The theory involved in synchronous transmission is set forth as well as accounts of tests. Three different methods of common frequency operation were tried. The results are discussed at length giving the relative advantages and disadvantages of each.

COMMON FREQUENCY BROADCASTING DEVELOPMENT.—G. D. Gillett. (*Bell Lab. Record*, November, 1930, Vol. 9, pp. 183–187.)

A short account of the problems solved in synchronising the Des Moines (WHO) and Davenport (WOC) stations.

OVERSEAS RADIO EXTENSIONS TO WIRE TELEPHONE NETWORKS.—L. Espenschied and W. Wilson. (*Proc. Inst. Rad. Eng.*, Feb., 1931, Vol. 19, pp. 282–303.)

Introduction : The Existing World Telephone Picture : Development of Interconnecting Links : North Atlantic Facilities : Short Wave Technique : Joining of a Radiotelephone Link with Wire Network : Transmission Results : Typical Magnetic Storm Effect : The Problem of the Transmitting Medium : Planning the International Use of Frequencies : Bibliography (35 items).

MONITORING THE OPERATION OF SHORT-WAVE TRANSMITTERS.—H. Mögel. (*Proc. Inst. Rad. Eng.*, Feb., 1931, Vol. 19, pp. 214–232.)

See January and February Abstracts, pp. 52 and 110.

RADIO TELEPHONE EQUIPMENT FOR AIRPLANES.—D. K. Martin. (*Bell Lab. Record*, October, 1930, Vol. 9, pp. 59–64.)

GENERAL PHYSICAL ARTICLES.

OSCILLATIONS IN DISCHARGE-TUBES AND ALLIED PHENOMENA.—J. J. Thomson. (*Phil. Mag.*, March, 1931, Series 7, Vol. 11, No. 71, pp. 697–735.)

Author's summary :—This paper consists of two parts : the first is a theoretical investigation of the behaviour of an ionized gas under the conditions existing in a discharge-tube. It is shown that the electrons will oscillate with a high frequency, their oscillations producing alternating currents of this frequency. It is also shown that under certain conditions the discharge through the positive column, whether it is striated or continuous, should be intermittent.

The second part contains a description of experiments made to investigate these effects. The method used was to examine the discharge by a rapidly rotating mirror. Intermittence or oscillation shows itself by a series of bright lines separated by intervals depending on the speed of the mirror. I have examined many types of discharge, and found that whether they are produced by a battery of cells or an induction coil they always between certain limits of pressure and current show intermittence. The appearance in the rotating mirror looks very much like a spectrum made up of three types of lines, which I call α, β, γ. The α lines occur when the pressure and current are such that dE/di is negative where E is the E.M.F. and i the current ; they represent a series of explosions following each other at regular intervals which increase when a Leyden jar is put in parallel with the discharge-tube.

The β lines I think are due to the intermittence in the positive column already alluded to; they are much nearer together than the α lines, from which they also differ in that they are not affected by the addition of a jar to the discharge-tube.

The γ lines are always close to the α lines: they are very close together, and therefore represent vibrations of far greater frequency than the α or β lines. I think they correspond to vibrations of the ionized gas excited by the disturbance which produces an α line. Like the β they are not affected by connecting a jar up to the tube.

In addition to these effects, there is another, which I have called "throbbing," somewhat similar in character to the α effect though on an entirely different scale. It is got most easily when the distance between the anode and cathode is but a little greater than the length of the Crookes dark space. The discharge passes for a time, then stops, and after an interval begins again, and may go on doing this for half an hour or more. I have known the intervals between the luminous flashes to be as long as a minute, though usually they are much shorter. I attribute "throbbing" to an effect similar to that which produces polarization when a current passes through a liquid electrolyte.

THE PROPAGATION PHENOMENA IN GASES IONISED BY VERY HIGH FREQUENCY DISCHARGES.—Chenot. (*See* under "Propagation of Waves.")

ÜBER MAKROSKOPISCHE OSZILLATOREN, DEREN FREQUENZEN EINDEUTIGE ENERGIEFUNKTIONEN SIND (On Macroscopic Oscillators, whose Frequencies are Unique Functions of the Energy).—C. H. Johansson. (*Ann. der Phys.*, 1931, Series 5, Vol. 8, No. 2, pp. 129–134.)

FREQUENCY VARIATIONS DUE TO THE ELECTRODELESS DISCHARGE.—J. T. Tykociner and J. Kunz. (*Phys. Review*, 1st Jan., 1931, Series 2, Vol. 37, No. 1, p. 100.)

Abstract only. "Experiments were carried out to show that an oscillator which excites electrodeless discharges undergoes variations of its frequency due to the reaction of the discharges. These variations were measured by means of a heterodyne method and the results were applied for a study of the intensity and character of the electrodeless discharge currents." It was found that the "ring" discharge causes a decrease of frequency.

MAGNETISM AND ELECTRODYNAMICS.—Irene E. Viney. (*Phil. Mag.*, Supp. No., Feb., 1931, Series 7, Vol. 11, No. 70, pp. 539–552.)

The author concludes that the only consistent formulation of the dynamical relations of the magnetic field is obtained by using B, and not H, as the magnetic force vector. This implies the non-existence of free magnetism. "The idea that the relations of the magnetic field can be formulated as a complete analogue of the electrostatic field is wholly incompatible with a logical formulation of the relations of electromagnetic theory."

VARIATION OF SPARK-POTENTIAL WITH TEMPERATURE IN GASES.—H. C. Bowker. (*Proc. Physical Soc.*, 1st Jan., 1931, Vol. 43, Part 1, pp. 96–112.)

DIELEKTRISCHE EIGENSCHAFTEN DER SEIGNETTESALZKRISTALLE (Dielectric Properties of Crystals of Seignette Salt—Sodium Potassium Tartrate).—P. Kobeko and J. Kurtschatov. (*Zeitschr. f. Phys.*, Vol. 66, No. 3/4, pp. 192–205.)

CONTRIBUTION TO THE THEORY OF DIELECTRICS.—G. Guében. (*Phil. Mag.*, Feb., 1931, Series 7, Vol. 11, No. 69, pp. 405–410.)

The current in a dielectric is regarded as due both to the contribution of dipoles and to the presence of ions. The part due to each of these two elements is determined and a formula is found which is proposed as the general expression of the current in a solid dielectric.

ON THE DISTRIBUTION OF SPACE-POTENTIAL IN HIGH-FREQUENCY GLOW DISCHARGE.—D. Banerji and R. Ganguli. (*Phil. Mag.*, Feb., 1931, Series 7, Vol. 11, No. 69, pp. 410–422.)

INTERPRETATION OF NEGATIVE VOLT-AMPÈRE CHARACTERISTICS OF NEON POSITIVE COLUMN.—C. G. Found. (*Phys. Review*, 1st Jan., 1931, Series 2, Vol. 37, No. 1, p. 100.)

Abstract only. The negative resistance of the positive column appears to be connected with the presence of metastable atoms.

CLASSICAL AND MODERN GRAVITATIONAL THEORIES.—A. Press. (*Phil. Mag.*, January, 1931, Ser. 7, Vol. 11, pp. 118–128.)

A sequel to the work referred to in 1930 Abstracts, p. 290. The writer here considers the three crucial problems (perihelion of Mercury, the bending of light, and the spectral shift) and shows that there is no need for departing from the Newtonian ideas of time and space to arrive substantially at Einstein's results.

ON THE INTERPRETATION OF DIRAC'S α MATRICES.—G. Breit. (*Proc. Nat. Acad. Sci.*, Jan., 1931, Vol. 17, pp. 70–73.)

"We see, therefore, that even though formally the $-c\alpha_k$ are velocities, the absence of negative energies in the physical world and the apparently false prediction of these energies by Dirac's equation necessitate considering only those experimental conditions for the measurement of the α_k which correspond also to a definitely infinite momentum in the same direction as the velocity."

NEUE UNBESTIMMTHEITSEIGENSCHAFTEN DES ELEKTROMAGNETISCHEN FELDES (New Properties of Indefiniteness of the Electromagnetic Field).—P. Jordan and V. Fock. (*Zeitschr. f. Phys.*, Vol. 66, No. 3/4, pp. 206–209.)

Authors' summary:—The measurement of an

electromagnetic field using a single electron (or proton) as the measuring instrument is considered; this gives certain limitations to the possibility of measuring exactly any component of the field-strength, if at the same time the point in space-time to which the field-strength corresponds is exactly determined.

QUANTUM-MECHANICAL MOTION OF FREE ELECTRONS IN ELECTROMAGNETIC FIELDS.—E. H. Kennard. (*Proc. Nat. Acad. Sci.*, Jan., 1931, Vol. 17, pp. 58–62.)

ÜBER EINEN KLASSISCHEN EFFEKT BEI DER STREUUNG VON STRAHLUNG (On a Classical Effect in Radiation Scattering).—O. Halpern. (*Zeitschr. f. Phys.*, 1931, Vol. 67, No. 7/8, pp. 523–530.)

The author shows that, in the case of scattering of natural monochromatic spectral lines at a single resonator, the scattered light contains in general light of the natural frequencies of the irradiated system, both when discussed on the classical theory and on the quantum theory. The intensity of these frequencies is of the same order of magnitude as the intensity of the radiation scattered with unchanged frequency.

THE INTRAMOLECULAR FIELD AND THE DIELECTRIC CONSTANT.—F. G. Keyes and J. G. Kirkwood. (*Phys. Review*, 15th Jan., 1931, Series 2, Vol. 37, No. 2, pp. 202–215.)

"A statistical calculation of the average internal field in a dielectric is carried out."

ZUR THEORIE DER GEDÄMPFTEN SCHWINGUNGEN (The Theory of Damped Oscillations).—V. S. Vrkljan. (*Zeitschr. f. Phys.*, 1931, Vol. 67, No. 3/4, pp. 289–291.)

"The law of the decrease in velocity of the wave surface for damped elliptical oscillations is derived."

A MORE ACCURATE AND MORE EXTENDED COSMIC-RAY IONIZATION-DEPTH CURVE, AND THE PRESENT EVIDENCE FOR ATOM BUILDING.—R. A. Millikan and G. H. Cameron. (*Phys. Review*, 1st Feb., 1931, Series 2, Vol. 37, No. 3, pp. 235–252.)

For other cosmic ray papers, *see* under "Atmospherics."

MISCELLANEOUS.

NUMERICAL SOLUTION OF DIFFERENTIAL EQUATIONS.—(*Nature*, 14th March, 1931, Vol. 127, p. 421.)

Abstract only of a memoir by E. Remes (Bulletin of the Academy of Sciences of the Ukraine, 1930–31, in the Ukraine language) giving a comprehensive survey of previous work on the numerical solution of differential equations, and contributing some valuable new methods. It is stated that "Mr. Remes and his colleagues at Kieff have sent to University College, Nottingham, a quantity of Russian work on the numerical solution of differential equations, including A. N. Kryloff's valuable book on this subject, together with manuscript translations or summaries in French and German. These may be borrowed for a short period by University librarians."

ÜBER EINE METHODE ZUR SCHNELLEN NUMERISCHEN LÖSUNG VON DIFFERENTIALGLEICHUNGEN ZWEITER ORDNUNG (On a Method for Rapid Numerical Integration of Second Order Differential Equations).—E. Madelung. (*Zeitschr. f. Phys.*, 1931, Vol. 67, No. 7/8 pp. 516–518.)

THE INFLUENCE OF THE CRYSTAL-ORIENTATION OF THE CATHODE ON THAT OF AN ELECTRO-DEPOSITED LAYER.—W. A. Wood. (*Proc. Phys. Soc.*, 1st March, 1931, Vol. 42, Part 2, pp. 138–141.)

Author's abstract :—The influence of the crystal-orientation of a cathode on that of an electro-deposited layer is studied by X-ray methods for the cases of copper and nickel, respectively, deposited on rolled copper. The conditions of cathode-surface and current-density which accompany an oriented deposit are determined. The orientation of the copper deposit for small currents is the same as that of the cathode. The nickel, at low current densities, assumes a distinct orientation. As the current is increased there is a region of no orientation, followed, at still higher currents, by an orientation the same as that of the cathode surface below.

GEO-ELECTRICAL PROSPECTING.—A. B. Edge. (*Nature*, 21st March, 1931, Vol. 127, p. 443.)

A disadvantage of the a.c. equipotential line method of geo-electrical prospecting arises from the fact that large out-of-phase components occur in the neighbourhood of the more highly conducting ore-bodies; in such circumstances it is impossible to locate equipotential points with any degree of accuracy.

This letter directs attention to a means of overcoming this difficulty, suggested to the writer by D. C. Gall, in which a small search coil is placed in series with the detecting circuit. The e.m.f. induced in the coil is in quadrature with the current; that in the ground is approximately in phase with the current and by suitably orientating the search coil it is possible to balance the out-of-phase component and so to locate the *in phase* equipotential points with precision. In recent tests, the coil was permanently attached to the amplifier box on the back of the operator, who need only slightly adjust the position of his body to attain complete silence in the telephones.

A VALVE-OPERATED CORELESS INDUCTION FURNACE FOR HIGH TEMPERATURE RESEARCH.—F. Adcock. (*Trans. Faraday Soc.*, No. 9, [112], Vol. 26, pp. 544–560.)

Frequencies up to one million cycles/sec. were provided by two quartz valves in push-pull.

THE MECASCOPE: AN EQUIPMENT FOR THE AUSCULTATION OF ABNORMAL SOUNDS IN MOVING MECHANISMS.—Vassillière-Arlhac. (*Bull. d. l. Soc. franç. d. Élec.*, February, 1931, Ser. 5, Vol. 1, pp. 148–153.)

THE HEATING EFFECT OF SHORT RADIO WAVES.—J. C. McLennan. (*Journ. Maryland Ac. of Sci.*, Jan., 1931, Vol. 2, pp. 14–24.)

Cf. Jan. Abstracts, p. 54. The paper ends by outlining the two directions in which further research should proceed. Exploration of temperatures produced in the various parts of animals, made possible by the perfection of thermocouple needles described by Karrer and Estabrook (*ibid.*, Vol. 1, 1930, p. 129), will show if the differential effects described are of importance or if they are made negligible by heat exchanges such as are promoted by the blood flow. At the same time, information as to the electrical properties of body materials, their conductivities and dielectric constants, will enable curves to be drawn for all the constituents, and the most suitable wavelengths to be chosen.

THE ACTION OF VERY HIGH FREQUENCY FIELDS [$\lambda = 15$ METRES APPROX.] ON ORGANIC TISSUES.—J. Saidman, R. Cahen and J. Forestier. (*Comptes Rendus*, 16th Feb., 1931, Vol. 192, pp. 452–454.)

MITOGENETIC RAYS.—Tokin: Stempell. (*Nature*, 7th Feb., 1931, Vol. 127, p. 214.)

Stempell considered that his Liesegang ring results were due to radiant energy (*cf.* Magrou, Naville, Choucroun, 1930 Abstracts, p. 177), but Tokin shows them to be due to volatile substances given off from the crushed tissue.

ACTION OF ULTRA-SHORT WAVES ON SILKWORMS.—G. Mezzadroli and E. Vareton. (*Nature*, 7th Feb., 1931, Vol. 127, p. 222.)

An exposure of 30 minutes daily to 2–3 m. waves accelerates the life cycle: after 20 days of the treatment, beginning at an age of 15 days, the increases in weight and length are 112 and 37 % respectively. The irradiated worms begin spinning some days earlier and give an appreciably greater yield than the untreated controls.

HIGH-FREQUENCY HEATER FOR PRODUCTION OF ARTIFICIAL FEVER.—(*Gen. Elec. Review*, Jan., 1931, Vol. 34, pp. 46–47.)

Description and illustrations of a 30-metre wave apparatus for the treatment referred to in 1930 Abstracts, p. 471.

THE MEDICAL AND SURGICAL APPLICATIONS OF ELECTRICITY.—B. Leggett. (*Journ. I.E.E.*, February, 1931, Vol. 69, pp. 213–262.)

A MICROSCOPIC METHOD [TO GIVE AN INCREASE OF RESOLUTION UP TO 10 OR 20 TIMES BEYOND THE ORDINARY MICROSCOPE, USING SCANNING AND BUILDING UP BY PHOTOELECTRIC MEANS].—E. H. Synge. (*Phil. Mag.*, January, 1931, Vol. 11, pp. 65–80.)

Development of the writer's previous suggestion has been held up by the difficulty in obtaining a scanning spot of intense light of dimensions small in comparison with a wave-length. The present paper deals chiefly with the solution of this problem.

DETECTING HIDDEN FISSURES IN RAILS.—H. C. Drake: —. Sperry. (*Elec. Engineering* [late *Journ. Am.I.E.E.*], Feb., 1931, Vol. 50, pp. 122–124.)

A paper on the work of the Sperry detector car referred to in 1929 Abstracts, p. 406.

SULLA TRANSMISSIONE A DISTANZA DEI VALORI DI MISURA (Telemetering).—O. Colonna. (*L'Elettrotec.*, 15th Jan., 1931, Vol. 18, pp. 32–36.)

KRITISCHER ÜBERBLICK ÜBER DIE STÖRSCHUTZBESTIMMUNGEN (A Critical Survey of the Anti-Interference Regulations).—F. Treydte. (*Die Sendung*, 20th and 27th February, 1931, Vol. 8, pp. 124 and 139.)

EINE WANDERWELLENLEITUNG MIT KLEINEM WANDERWELLENWIDERSTAND (A Surge Cable with Small Surge Resistance).—K. Beyerle. (*Arch. f. Elektrot.*, 21st Feb., 1931, Vol. 25, No. 2, pp. 123–124.)

ON THE POSSIBILITY OF APPLYING THE CATHODE-RAY OSCILLOGRAPH TO THE INDICATOR FOR HIGH-SPEED ENGINES.—J. Obata and Y. Munetomo. (*Rep. Aeron. Res. Inst. Tokyo.* No. 4, Vol. 5, pp. 93–100.)

AN ARRANGEMENT FOR AMPLIFYING WEAK PHOTOELECTRIC CURRENTS, AND ITS APPLICATION TO RECORDING THE LUMINOUS FLUX FROM STARS.—P. Lejay. (*Comptes Rendus*, 2nd March, 1931, Vol. 192, pp. 551–553.)

Using a new electrometer triode [not described] with leakage current of the order of 10^{-15}A., and the writer's special stabilising method in which an adjustable leak is provided by an ionisation chamber exposed through an iris diaphragm to the action of a radio-active body, a variation of 10 mA/sec. was obtained from the light of a star of 2.2 magnitude, with an 18 cm. objective and a 5-stage amplifier.

REPLACING THE TELEPHONE BY A LOUD SPEAKER IN CONDUCTIVITY MEASUREMENTS.—L. du Noüy. (*Nature*, 21st March, 1931, Vol. 127, p. 441.)

A letter pointing out the improvement in ease and accuracy obtained in conductivity measurements by the use of a loud speaker in place of the telephone.

AN ELECTRO-CHEMICAL INTERPRETATION OF MEMORY.—G. W. Crile. (*Proc. Am. Phil. Soc.*, No. 6, Vol. 69, pp. 359–368.)

OBSERVATIONS UPON THE USE OF THE DIVINING ROD IN GERMANY.—C. A. Browne. (*Science*, 23rd Jan., 1931, Vol. 73, pp. 84–86.)

The writer (of the U.S. Department of Agriculture) has been surprised, during his tour of Europe, by the extent to which the divining rod is being used for large undertakings. He describes tests which he witnessed in Germany, where the diviner used loop-shaped metal rods — steel for a preliminary exploration, aluminium (more sensitive) for estimating the depth. This particular diviner is said to have been correct in his predictions in over 90 % of his cases. Various views on the subject, and results from different parts of the world, are discussed. *See* also 1930 Abstracts, p. 587.

THE PHOTOGRAPHIC EFFECTS OF GAMMA-RAYS.—J. S. Rogers. (*Proc. Physical Soc.*, 1st Jan., 1931, Vol. 43, Part 1, pp. 59–67.)

ELECTRICAL METHOD FOR THE MEASUREMENT OF YOUNG'S MODULUS.—L. N. Tomilina. (*Westnik Elektrot.*, No. 4, 1930, pp. 144–146.)

A method based on resonance between mechanical longitudinal vibrations in a rod and electrical oscillations in a circuit.

A NEW PHOTOGRAPHIC EFFECT.—F. E. Poindexter. (*Journ. Opt. Soc. Am.*, January, 1931, Vol. 21, pp. 59–69.)

A pressure effect which the writer considers may be due to a direct (primary) photomechanical disintegration; if so, new fundamental ideas as to matter and radiation will be necessary. The writer's hypothesis regards light as a wave in the gravitational field of matter originating in the elastic segmental vibrations of the atoms and molecules.

EXPLORATION OF ROTATING FERROMAGNETIC PARTS BY THE USE OF ROTATING FIELDS.—J. Peltier. (*Comptes Rendus*, 9th February, 1931, Vol. 192, pp. 348–350.)

Further development of the work referred to in March Abstracts, p. 170. By the use of a rotating magnetic field from the 3-phase mains (or preferably from a special generator) the writer does away with the necessity for rotating the part under test. He hopes that this method can be applied to complex parts not possessing even a theoretical axis of revolution—by the use of a differential form of the apparatus working on the test piece and a "perfect" duplicate.

ULTRAMICROMETER MEASUREMENTS OF THE TENSIONS IN THE INTERIOR OF A HOMOGENEOUS SOLID.—P. Santo Rini. (*Génie Civil*, 14th March, 1931, Vol. 98, p. 274.)

The exploring condenser in this form of ultramicrometer has a set of fixed plates and an interleaved set of plates subject to longitudinal movement along the common axis.

DO RADIO MANUFACTURERS CARE? [A PLEA FOR CO-OPERATION IN RESEARCH AND MERCHANDISING].—A. C. Lescarboura. (*Rad. Engineering*, Jan., 1931, Vol 11, pp. 34–35 and 42.)

In the course of this article the writer says:—"After assessing the regular market and deducting the malodorous dumpings we find that the industry can still make five times what it can sell. . . Why not develop new markets? . . . Perhaps the greatest opportunity lies in radio for industrial purposes . . . in another two or five years, industrial radio may even surpass broadcasting in revenue to the parts manufacturer, while the broadcast receiver makers could easily turn to producing assembled sets to operate the many industrial devices now being developed; measuring instruments, safety devices, stop and starter machines and the like."

FEHLERORTSBESTIMMUNGEN MIT DEM KATHODENOSZILLOGRAPHEN (Fault Locating [in Cable Systems or Overhead Lines] by the C.-R. Oscillograph).—J. Röhrig: Rogowski and Flegler. (*E.T.Z.*, 19th Feb., 1931, Vol. 52, pp. 241–242.)

A new method based on the oscillographic recording of artificial surges.

TRAFFIC CONTROLLED BY LIGHT BEAMS.—R. C. Hitchcock. (*Electronics*, Feb., 1931, p. 515.)

A paragraph, with photograph and diagrams, on Westinghouse installations (at present experimental only) performing the functions referred to in 1930 Abstracts, p. 354.

NEON TUBE LIGHT AND FACTORS GOVERNING ITS LIFE.—R. R. Machlett. (*Journ. Franklin Inst.*, March, 1931, Vol. 212, No. 3, pp. 319–326.)

NOTE ON THE "NON-DANGEROUS" VOLTAGE OF ELECTRIC CURRENTS.— —. Féraud. (*Bull. d. l. Soc. franç. d. Élec.*, March, 1931, Ser. 5, Vol. 1, pp. 288–305.)

THE NEW TWELVE-CHANNEL CARRIER CURRENT SERVICE WITH 120 CYCLES/SEC. SPACING, BERLIN-COLOGNE.—K. Wedler: AEG. (*E.T.Z.*, 22nd and 29th Jan., 1931, Vol. 52, pp. 103–107 and 133–139.)

THE PHYSICAL SOCIETY'S EXHIBITION.—(*E.W. & W.E.*, March, 1931, Vol. 8, pp. 135–139.)

See also an Editorial on p. 117.

PHYSICAL AND OPTICAL SOCIETIES EXHIBITION.—(*Engineer*, 16th Jan., 1931, Vol. 151, pp. 82–86.)

Continued from the issue for 9th January.

THE TWENTY-FIRST ANNUAL EXHIBITION OF THE PHYSICAL AND OPTICAL SOCIETIES.—(*Journ. Scient. Instr.*, Feb., 1931, Vol. 8, pp. 33–80.)

BESCHLÜSSE DER INTERNATIONALEN ELEKTROTECHNISCHEN KOMMISSION [I.E.C.] ÜBER GRÖSSEN UND EINHEITEN (Decisions of the International Electrotechnical Commission [I.E.C.] on Magnitudes and Units.).—(*Ann. der Phys.*, 1931, Series 5, Vol. 8, No. 1, pp. 1–6).

THE OPENING OF THE DELFT LABORATORY OF TECHNICAL PHYSICS.—M. de Haas: H. B. Dorgelo. (*Physica*, Jan., 1931, Vol. 11, pp. 1–26.)

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.

METALLIC RECTIFIERS.

Convention date (U.S.A.), 27th September, 1928.
No. 319729.

A copper bar with a tapered end is first heated until the surface has been completely oxidised. The surface is then reduced to metallic copper, with the exception of a narrow band located near the tapered end. This band is first protected with a coating of paraffin, and the bar is then inserted into an electrolytic bath of which it forms the cathode. When used as a wireless detector the high-frequency circuit is connected across the two extremities of the bar. The efficiency of rectification depends upon the ratio of the area of the oxide band to the remainder of the bar.

Patent issued to Westinghouse Brake and Saxby Signal Co., Ltd.

WAVE TRAPS.

Application date 22nd July, 1929. No. 336973.

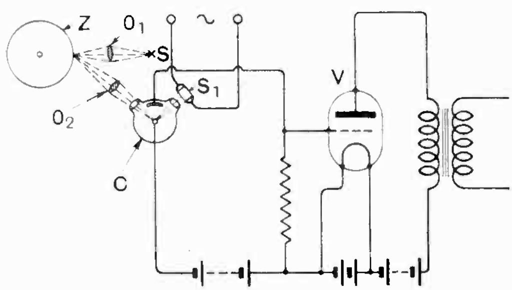
Closely coupled to the frame aerial of a multi-valve receiver is an extra winding, the terminals of which are adapted to be connected to a unit forming an adsorption wave-trap or interference-preventer. Alternatively the same terminals may be utilised to couple the frame windings to an outdoor aerial.

Patent issued to Aeonic Radio, Ltd., and E. V. Kayley.

PICTURE TELEGRAPHY.

Convention date (Germany), 11th February, 1929.
No. 338799.

To facilitate the modulation of a carrier-wave by visual effects, a photo-sensitive cell C is illumined



No. 338799.

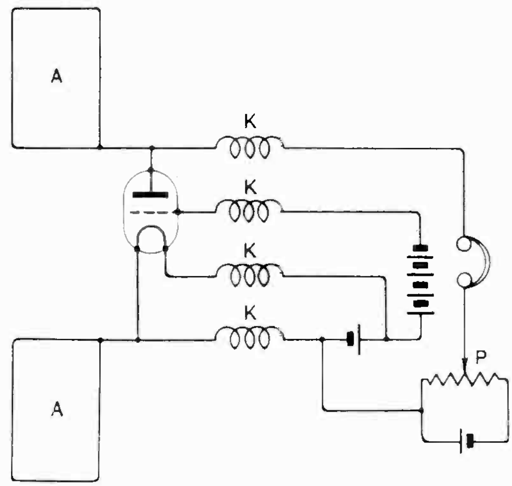
by a separate source of light energised at the frequency of the carrier. Light-and-shade effects from a cylinder Z are projected on to the cell C through an optical system consisting of a source of light S and lenses O_1, O_2. A second source of light S_1, consisting of a glow-discharge lamp energised from a source varying at the carrier frequency, is arranged as shown. The light impulses from both sources are added together in the cell C and produce a modulated current which is fed direct to an amplifier V.

Patent issued to C. Lorenz Akt.

SHORT-WAVE RECEIVER.

Convention date (Germany), 22nd November, 1928.
No. 336846.

The Barkhausen method of applying a high positive voltage to the grid and a negative voltage to the plate of a three-electrode valve is utilised



No. 336846.

for the reception of waves of the order of centimetres. Chokes K are inserted in the plate, grid, and filament leads. The negative plate voltage is critical, and is adjusted to the required value by means of a potentiometer P. The two halves of the aerial A may be connected either to plate and filament, as shown, or to plate and grid, or across grid and filament.

Patent issued to Telefunken Gesell. and W. Ludenia.

CARRIER-WAVE SIGNALLING.

Convention date (Germany), 30th June, 1928.
No. 314530.

Because of the dependence of phase-angle on frequency, the upper and lower sidebands of a modulated carrier-wave are subject to different phase-displacements when flowing in a tuned circuit. To prevent distortion due to this cause, phase compensating circuits are introduced to enlarge the phase-angle, so that frequencies lying at equal distances above and below the carrier wave have equal and opposite phase-displacements relatively to the carrier frequency.

Patent issued to Siemens and Halske A.G.

BROADCASTING STUDIOS.

Application date 16th September, 1929.
No. 337900.

Studios are usually constructed so as to have a reverberation period of about one second. The persistence of the sound-waves necessary to ensure this condition gives rise to interference effects which, though tolerated when heard binaurally, give rise to considerable distortion in broadcasting or recording, where only a single channel of response is available. In order to retain the desired reverberation, whilst eliminating the distortion referred to, the studio walls are formed with a series of reflecting surfaces or facets. which serve to break up regular reflection and cause the sound-waves to reach the microphone in scattered formation.

Patent issued to Columbia Graphophone Co., Ltd., P. W. Willans, and G. Millington.

AMPLIFYING CIRCUITS.

Convention date (U.S.A.), 8th June, 1929.
No. 337830.

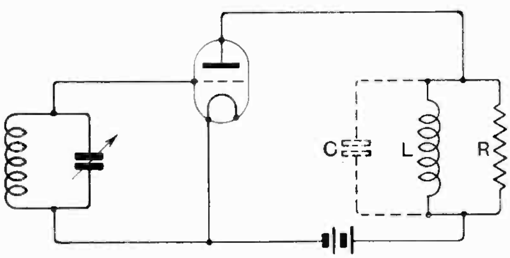
When tuning is effected by varying the capacity across a fixed inductance, the amplification gain is not uniform over a band of frequencies but increases progressively with increasing frequency. In order to overcome this disadvantage, an impedance is inserted between the cathode and the junction of the plate and grid circuits, and is so chosen that the radio-frequency potential-drop across it increases as the frequency rises. This derived potential opposes the normal grid potential built up in the tuned input circuit of the valve, and so tends to maintain a constant gain characteristic over the whole working range of the amplifier.

Patent issued to Radio Frequency Laboratories, Inc.

CONSTANT-REACTION CIRCUITS.

Application date 7th August, 1929. No. 338120.

In order to maintain a constant coefficient of back-coupling between the input and output circuits of a valve, over a wide range of frequency, the output circuit consists of two parallel branches,



No. 338120.

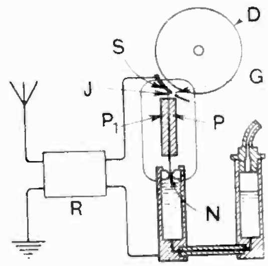
one a pure inductance L with distributed capacity C such that the combination is not resonant to any frequency within the working range, and the other a resistance R. Preferably the reactance of L is of the same order as the resistance R. At relatively high frequencies the resistance carries the greater part of the plate current, whilst at lower frequencies the inductance takes a larger share. The result is that the inductive reactance of the plate circuit automatically increases with decreasing frequency at such a rate that approximately uniform regeneration is maintained over a wide tuning-range.

Patent issued to A. A. Thornton.

RECORDERS FOR PICTURE TELEGRAPHY.

Convention date (Germany), 20th October, 1928.
No. 337937.

The received picture is recorded by means of a very thin, very light jet of liquid which is projected on to a suitable receiving surface. The jet may be paramagnetic or ferromagnetic (*e.g.*, a concentrated solution of an iron or nickel salt) so that it is deflected by a magnetic field controlled by the incoming signals. Or the jet may be a conductor which is traversed by the controlling current, or a non-conducting varnish controlled by a superposed electrical field. In the arrangement shown, the jet J is a conducting fluid, squirted under pressure through a diamond nozzle N and between the pole-faces P, P_1 of a deviating electromagnet. Signals from the receiver R are applied to the jet as shown, the circuit being closed when the jet impinges on the shield S. When the jet carries signal current, the electro-dynamic action of the magnetic field swings the jet through the gate-opening G on to the surface of the recording drum D.



No. 337937.

Patent issued to Telefunken Ges. für Drahtlose Telegraphie m.b.H.

MINIMISING FADING.

Convention date (U.S.A.), 16th November, 1928.
No. 338004.

A known method of overcoming the effects of fading consists in using a number of different receiving aerials spread over a considerable area, rectifying the pick-up energy from each, and feeding the rectified energy into a common receiver. It is found, however, that, in the case of telephony transmission, phase-differences may occur between the side-band and carrier frequencies at each individual aerial, and this makes it impossible to combine the rectified currents without introducing distortion. According to the invention, gain-regulating valves are utilised to magnify greatly the input from that aerial at which the received signal is strongest, whilst simultaneously reducing the pick-up from the others, so that the energy from the selected aerial gradually predominates. In this way conflict due to phase-fluctuation is eliminated, and effective volume control is provided, by using only one aerial at a time.

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

VOLUME CONTROL.

Application date 16th August, 1929. *No.* 337853.

Volume control is effected in the loud speaker, instead of in the amplifier. A separate winding is provided on the same former as the driving-coil of a moving-coil speaker, and is short-circuited by a variable resistance. The currents induced in the short-circuited secondary are in opposition to those flowing in the driving-coil, so that by varying the control resistance the effective force tending to impulse the diaphragm can be regulated as desired.

Patent issued to H. Brantom, H. G. Bawtree-Williams, E. A. Bitton, and H. Austin Storry, Ltd.

LOUD SPEAKERS.

Application date 19th August, 1929. *No.* 337499.

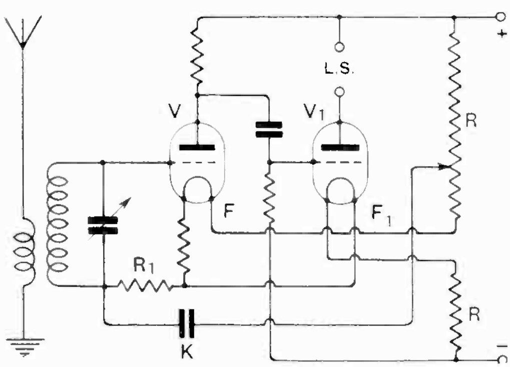
A thin short reed, having a low natural period, is attached to a long, thick, high-period reed, the two reeds supporting the armature over the magnet poles. The combination is sensitive to low-frequency impulses of small amplitude, though the maximum swing is restricted by the shortness of the low-period reed, so that the armature can be brought close to the pole-pieces without risk of chattering.

Patent issued to H. C. H. Smythe.

PREVENTING "HUM."

Convention date (Sweden), 12th September, 1928. *No.* 318922.

In a resistance-coupled amplifier, mains "ripple" is eliminated by feeding a compensating voltage from a point in the supply network to a single electrode of one of the valves. As shown in the figure, the potentiometer resistance R across the supply mains is in series with the filaments F, F_1



No. 318922.

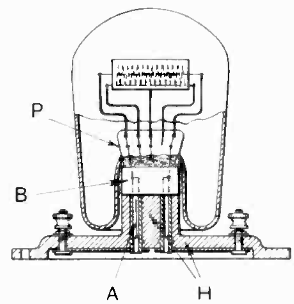
of the valves, V, V_1, and the grid of the first valve V is fed through a condenser K with a "ripple" component tapped from the resistance R at a point so chosen that the amplified resultant balances the mains ripple both as regards phase and amplitude in the plate circuit of the last valve. The steady grid-bias on the first valve is derived from a resistance R_1, the "ripple" impedance of which is much greater than that of the condenser K in the tap lead from the resistance R.

Patent issued to Telefonaktiebolaget. L. M. Ericsson.

THERMIONIC VALVES.

Convention date (Holland), 4th January, 1930. *No.* 338480.

In order to occupy less space, a valve is made with a re-entrant part housing a base-piece B which receives the leads from the internal electrodes through the usual "pinch" P. Valve-pins A of the ordinary type may be used with a holder H as shown. Alternatively the base-piece B may be extended flush with the lower end of the glass bulb, and fitted with contacts in the form of compact press-studs, which are snapped into engagement with corresponding socket-members mounted in shallow recesses on the valve-holder.



No. 338480.

Patent issued to N. V. Philips' Gloeilampen Fabrieken.

AUTOMATIC GRID-BIAS.

Convention date (Germany), 27th July, 1928. *No.* 316306.

Automatic grid-bias is derived in a mains-driven set from individual resistances inserted in series with each cathode and variably tapped back to each grid. The resistances are connected to a common bus-bar, which terminates at the negative pole of the high-tension supply and is tapped to the centre-point of the supply transformer for the heating filaments.

Patent issued to L. L. von Kramolin.

MULTIPLEX SIGNALLING.

Application date 28th August, 1929. *No.* 338617.

In order to economise ether space by reducing the frequency-spread of each carrier due to modulation, the transmission channels are arranged in pairs, each channel having its own carrier wave. The upper sideband of the transmission in one of the channels of a pair is suppressed, as is also the lower sideband of the transmission in the other channel of the pair. The difference between the carrier frequencies used in the respective channels is less than the width of the larger sideband involved. For instance, in the case where a television picture is to be transmitted in two halves (to avoid very high modulating frequencies) each half requiring a frequency spread of 20,000 cycles, the total width required, according to the invention, would be 20,000 + 20,000 + a spacing interval of 500, or 40,500 cycles in all. This compares with a spread of 80,000 cycles required under normal conditions.

Patent issued to J. H. O. Harries.