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Editorial

The Tellegen Effect

HOW often has one heard the layman express his wonder at the fact that the waves from all the various broadcast transmitters do not get mixed up as they jostle one another in space, and that the receiver is able to pick out and respond to one—and that perhaps a very distant station—just as if that one had the ether entirely to itself. And now we know that it is not quite true, and that the cause of the departure from the ideal, like that of so many of the wonders of wireless, is to be found in the Heaviside layer. It was in 1933 that Tellegen announced his discovery that the waves from Beromünster in Switzerland, which pass Luxembourg on their way to Holland, become contaminated so that on arrival it is impossible to obtain the Swiss programme without a background of the Luxembourg programme. The frequencies of these two stations are very different, the former being a medium-wave and the latter a long-wave station, so that ordinary interference from a neighbouring wavelength is out of the question. The modulated Swiss carrier in its passage over Luxembourg has its modulation modified, that is, it has another modulation superimposed, so that it is doubly modulated. The distance between the stations is too great for the ground wave to have any appreciable amplitude, and the waves arriving in Holland from Switzerland are almost entirely those which have been refracted in their passage through the ionosphere. At first sight it seemed highly improbable that the waves from even such a powerful station as Luxembourg could modify the properties of the ionosphere to such an extent and at such a rate that the waves from another station could be appreciably affected, but there appeared no way of escape from such a conclusion.

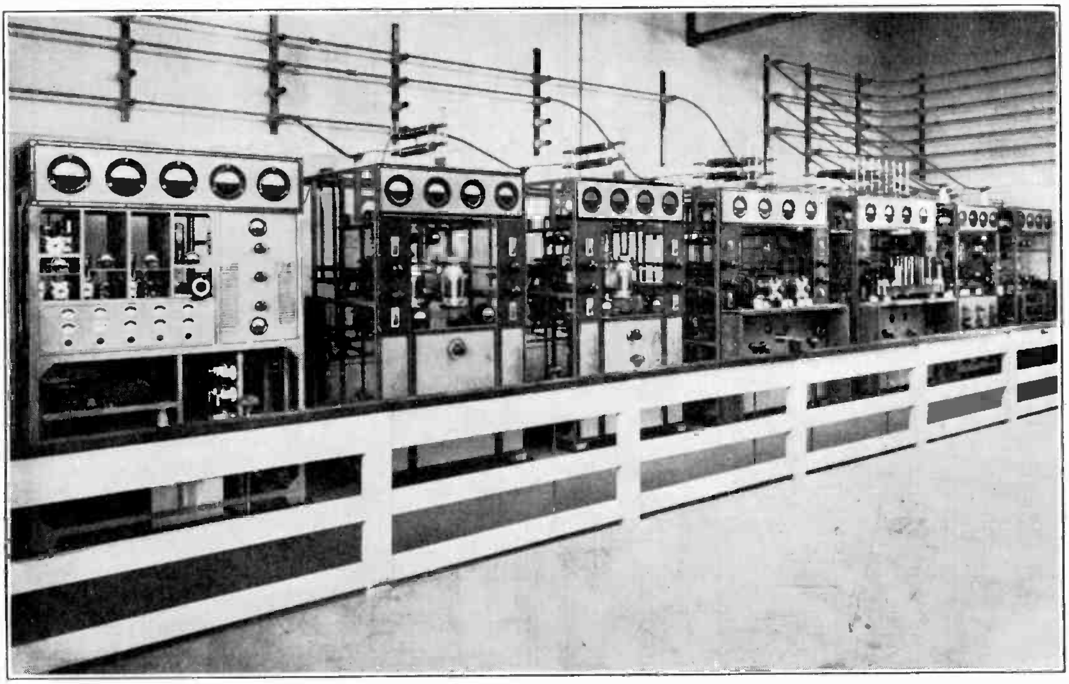
A paper of particular interest has recently been published by Prof. V. A. Bailey and Dr. D. F. Martyn* of the Australian Radio Research Board in which this question is very thoroughly investigated, and they arrive at the result that the field strength produced in the ionosphere by a high-power long-wave transmitter is quite capable of giving the observed effect. Any wave passing through the ionosphere must cause electronic

*Philosophical Magazine, Ser. 7, Vol. XVIII., p. 369, August, 1934.

movement, otherwise it would not be refracted or reflected, but if the effect is proportional to the electric force acting, the two waves would be simply superimposed as they are in the lower atmosphere. To give the observed effect it is necessary for the effect of the electric force in the ionosphere to be non-linear, that is to say, it is necessary for a field of 2 mV per metre to produce either more or less than double that due to a field of 1 mV per metre. When an electric wave passes through an ionised medium it imparts velocity to the electrons which collide with the molecules and give up some of their energy to the molecules, thus converting some of the energy of the wave into heat. If the power dissipated is strictly proportional to the square of the electric force the medium may be regarded as having a constant resistance, but if the power dissipated is not proportional to the square of the electric force, the equivalent resistance of the medium will vary with the amplitude of the electric force, that is to say, the resistance will be modulated by the wave. According to the calculations of Bailey and Martyn the field strength of a station such as Luxembourg is sufficient to cause something of this nature to occur in the ionosphere over a region of 100 or 200 km diameter, and to occur rapidly enough to give an appreciable modulation. The waves from Beromünster pass through this region, and, even if unmodulated at the transmitter, will be modulated by the medium in accordance with the Luxembourg programme. The paper referred to above is very mathematical, but we hope to publish shortly an article on the subject by Professor Bailey.

G. W. O. H.

Holland's Colonial Short-Wave Station



THE Philips short-wave transmitter at Huizen now maintains a regular "Empire" beam service from PHI (16.88 metres) and PCJ (19.71 metres) to both the West and East Indies. The photograph gives a general view of the PHI transmitter, which has been constructed on the unit system with facilities for quick adjustments and exchange of defective parts. The transmitter is crystal-controlled, the crystal stage being tuned at 135 metres. Final frequency doubling up to 16.88 metres takes place in two 1,500-watt valves. The last amplifier stage consists of two 10kW. water-cooled valves.

Mixing Valves*

By M. J. O. Strutt

(*Natuurkundig Laboratorium der N. V. Phillips, Gloeilampenfabrieken, Eindhoven—Holland*)

SUMMARY.—Two types of mixing valves are considered, having respectively input signal and local oscillator voltage on one single grid or on two separate grids. It is shown that for both types conversion conductance is approximately 1/5 to 1/4 of the maximum transconductance encountered during oscillator swing. Conditions for best conversion as regards valve noise require $\sqrt{i_a}/S_c$ to be as small as possible, where i_a is the d.c. anode current under operating conditions and S_c the conversion conductance. Optimum adjustment of local oscillator is derived from this condition. Minimum whistling notes lead to a still further condition for local oscillator voltage and a compromise with the noise condition is recommended.

Contents:

I. Single-grid Mixing Valves

As an example with cathode coil injection, a well-known scheme, using a pentode mixer, is given in Fig. 1. An input voltage $E_i \sin \omega_i t$, together with a local oscillator voltage $E_h \sin \omega_h t$ are put between cathode and first grid, bias being such as to prevent grid currents. In the anode an intermediate frequency transformer tuned to the frequency $\omega_0 = \omega_h - \omega_i$ is used. If the voltage across the primary of this transformer is $E_0 \cos \omega_0 t$, then $E_0/E_i = g_c$ is called the conversion gain of the valve. The internal resistance of the valve R_i under operating conditions is obtained by varying the d.c. anode tension by an amount $\triangle V$ and observing the variation $\triangle i$ of the d.c. anode current: $R_i = \triangle V/\triangle i$. If R is the impedance (being a resistance at

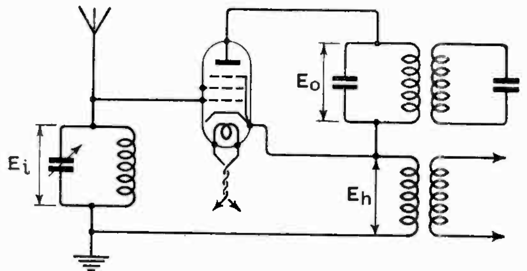


Fig. 1.—*Single grid mixing tube (pentode) with cathode coil injection of local oscillator voltage.*

* MS. accepted by the Editor November, 1934.

frequency ω_0) measured at the primary side of the i.f. transformer, then

$$g_c = S_c \frac{R_i R}{R_i + R} \quad \cdots \quad (1)$$

where S_c is called the conversion conductance of the valve. The first question dealt with

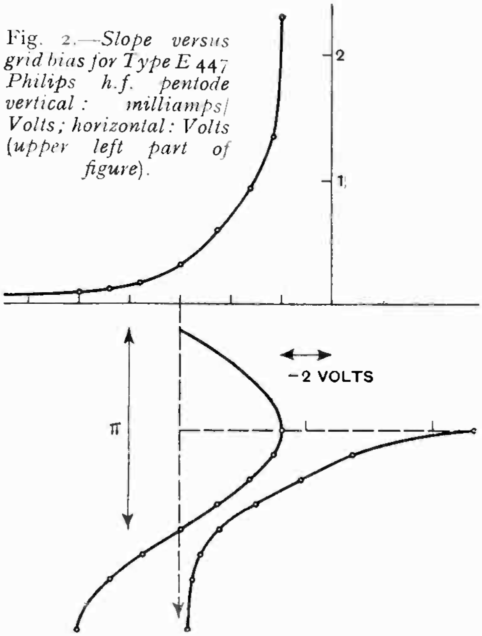


Fig. 2.—*Slope versus grid bias for Type E 447 Philips h.f. pentode vertical: milliamps/Volts; horizontal: Volts (upper left part of figure).*

is the determination of S_c from the static valve characteristic.

Consider the slope *versus* grid bias characteristic of a h.f. pentode valve, given in Fig. 2. An oscillator voltage, together with a proper bias so as to prevent grid current, is put between grid and cathode (lower part of Fig. 2). The outcome is a slope *versus* time curve (right part of Fig. 2) which, if decomposed in a Fourier series, has a basic component :

$$S = S_0 \sin \omega_h t.$$

Now add a signal voltage between grid and cathode. Evidently the anode current

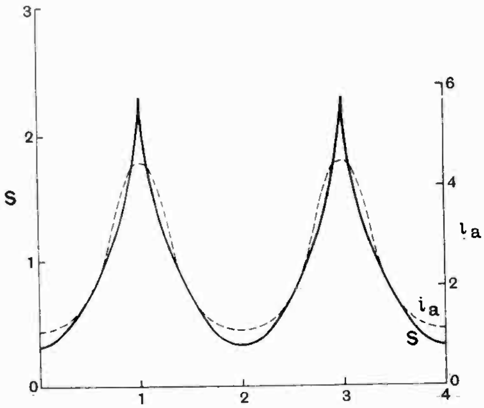


Fig. 3.—*Slope versus time and anode current (dotted) versus time for Philips type E 447 tube and 2 Volts oscillator peak value.*

will have a component

$$S_0 E_i \sin \omega_i t \sin \omega_h t = \tfrac{1}{2} S_0 E_i \cos \omega_0 t + \tfrac{1}{2} S_0 E_i \cos (\omega_i + \omega_h) t,$$

where ω_0 stands for $\omega_h - \omega_i$. The quantity $1/2\ S_0 = S_c$ is equal to the conversion conductance. The process of deriving S_c from the static valve characteristic will be plain enough from Fig. 2.

In Figs. 3, 4, 5, 6, 7 and 8 some slope *versus* time curves were constructed for different valves, applying different oscillator voltages between grid and cathode. Anode current *versus* time is also shown in these figures. As a simple approximation, the slope *versus* time curve might be assumed triangular, as shown in Fig. 9. For this case it is easy to evaluate the quantities S_0 and S_c defined above. One obtains (see Fig. 9) :

$$S_0 = \frac{2}{\pi} S_{\max.} \frac{1 - \cos b}{b} \quad \ldots \quad \ldots \quad (2)$$

II. Optimum Conditions for Single-grid Valves

Now, conversion conductance is equal to $S_0/2$ and so is as great as possible, if S_0 has a maximum value. This occurs for b approximately equal to $2\pi/3$, as is shown by table I :

TABLE I

$\frac{1 - \cos b}{b}$	0	$\frac{2}{\pi}$	$\frac{2\frac{1}{4}}{\pi}$	$\frac{2}{\pi}$
b	0	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	π

Let the fixed grid bias exceed the amplitude E_h by an amount V_0 and call V the tension in the anode slope *versus* grid bias characteristic, where the slope has practically attained a zero value, then the most favourable value of E_h, in order to cause a maximum conversion conductance, is given by

$$E_h = \tfrac{2}{3} (V - V_0) \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

where the factor $\frac{2}{3}$ is not critical and may be taken anywhere between $\frac{1}{2}$ and 1.

If a signal of frequency ω_0 is applied to the grid, as a means of testing the valve, together with the oscillator voltage, a slope S_g will be measured for this intermediate frequency. It is interesting to notice the relation between $S_{\max.}$, S_g and S_c under optimum conversion conductance conditions.

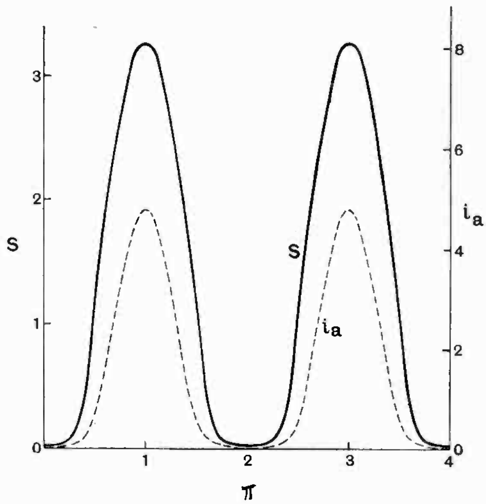


Fig. 4.—*As Fig. 3, but Philips tube E 446 with 2 Volts oscillator peak value.*

One obtains from equation (2) :

$$S_c = \frac{1}{\pi} S_{\max.} \frac{2\frac{1}{4}}{\pi} = 0{,}23\, S_{\max.} \quad \ldots \quad (4)$$

and furthermore :

$$S_g = \frac{b}{2\pi} S_{\max.} = \tfrac{1}{3} S_{\max.} = 1{,}45\, S_c \quad \ldots \quad (5)$$

These equations provide an easy means of rating the maximum conversion conductance of a single grid valve. Taking V_0 the minimum negative grid bias, unto which the oscillator voltage is permitted to swing and $S_{max.}$ the valve slope corresponding to V_0, then S_c will be somewhat less than one-quarter of $S_{max.}$.

Up to now we have dealt with optimum conversion conductance. But this use of a valve is not coincident with minimum shot noise. Often, what is wanted, is a minimum

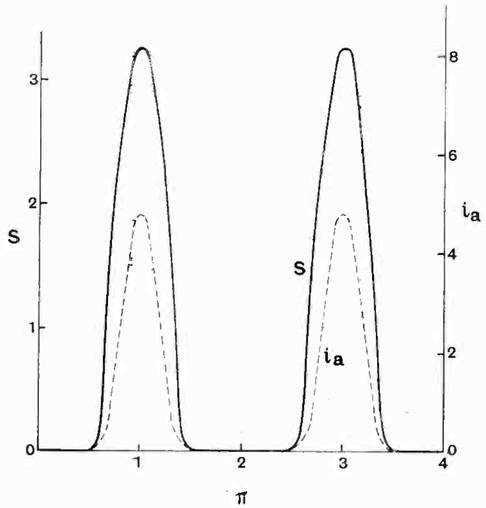


Fig. 5.—*As Fig. 4, but 3 Volts peak value.*

value of relative shot noise. This shot noise may be represented by a certain voltage on the input grid, called shot noise voltage. As is well known, the shot noise voltage of a tube is approximately proportional to the square root of the d.c. anode current. Assuming internal resistance to be high, this comes to imagining a noise voltage on the input grid which is proportional to the square root of the d.c. anode current over the conversion conductance. Adjusting dimensions, etc., one finds a shot noise voltage on the input grid of converters, approximately given by

$$E_n = f\frac{\sqrt{i_a}}{S_c}\sqrt{\frac{B}{10\,000}}\ \text{microvolts} \quad .. \quad (6)$$

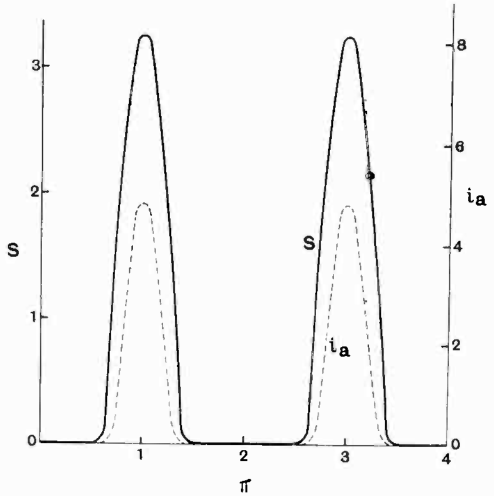


Fig. 6.—*As Fig. 4, but 4 Volts peak value.*

where B is the total band width of the set, used in observing the noise, i_a in milliamp, S_c in milliamp/volts, and f a factor, approximately unity, but depending on the type of tube, cathode, etc. So the expression $\sqrt{i_a}/S_c$ is to be made a minimum. Assuming the anode current *versus* time curve approximately conform to the anode slope *versus* time curve (see Figs. 3, 4, 5, 6, 7 and 8) and hence given by Fig. 9 on a different scale, the expression to be minimised turns out to be

$$1 \Big/ \frac{1 - \cos b}{b\sqrt{b}}$$

and table II shows its values:

TABLE II

$\frac{1 - \cos b}{b\sqrt{b}}$	0	0,46	0,51	0,49
b	0	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$

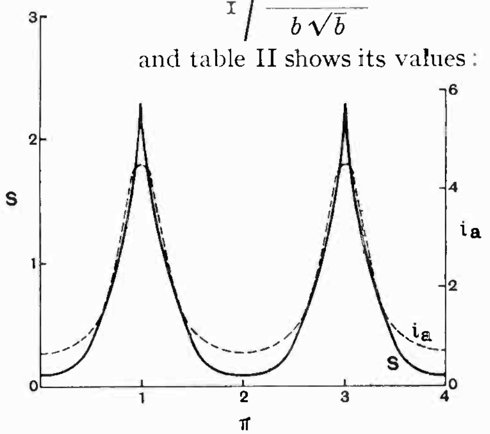


Fig. 7.—*As Fig. 3, but 3 Volts peak value.*

whence the optimum b value is $\pi/2$, yielding an optimum value of E_h:

$$E_h = \tfrac{1}{2}(V - V_0) \quad \ldots \quad \ldots \quad (3a)$$

instead of equation (3). The equations (4) and (5) are little affected hereby.

III. Double-grid Mixing Valves

A scheme, illustrating the use of double grid mixing valves is seen from Fig. 10, giving the operating scheme of the octode mixer tube. The local oscillator voltage is generated on grid number one, while the input signal circuit is connected to grid number four. Here the slope of anode current *versus* tension on grid number four: $S_4 = \partial i_a/\partial V_4$ may be

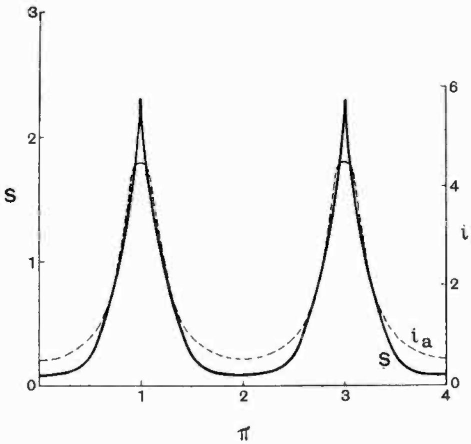


Fig. 8.—*As Fig. 3, but 4 Volts peak value.*

Fig. 10.—*Operating scheme of octode.* R_1 = 50,000 *Ohm*; R_2 = 250 *Ohm*; R_3 = 25,000 *Ohm.*

plotted against bias tension on grid one. If the octode oscillates, it provides an automatic bias on grid one, besides the oscillator voltage. One obtains then an anode slope S_4 *versus* time curve, as drawn in Fig. 11. Obviously this latter curve may be approximated by a rectangle as in Fig. 12. It is seen that the (dotted) anode current curve of Fig. 11 has a character, similar to the slope curve and hence also may be represented by a curve as in Fig. 12. Decomposing the anode slope curve of Fig. 11

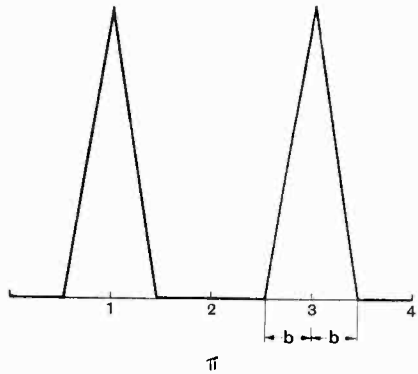


Fig. 9.—*Triangular approximation of curves in Figs.* 3, 4, 5, 6, 7 *and* 8.

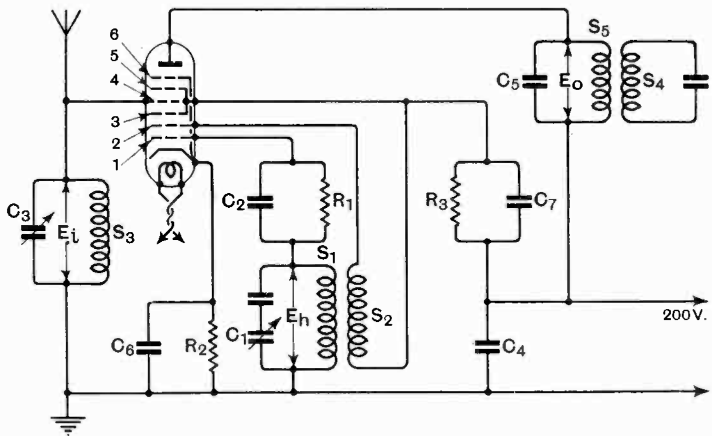
into a Fourier series, one obtains a basic component:

$$S_4 = S_0 \sin \omega_h t \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

Again, as with single grid mixer tubes, conversion conductance $S_c = S_0/2$.

Considering the rectangular curve of Fig. 12, one might ask again, what optimum conditions hold, if $\sqrt{i_a}/S_c$ is to be a minimum, where i_a stands for the d.c. anode current under operating conditions. If $S_{max.}$ is the maximum anode slope during one oscillator swing period, one obtains

$$S_c = \frac{1}{\pi} S_{max.} \sin a \quad \ldots \quad \ldots \quad (8)$$



$$\text{and} \quad \frac{S_c}{\sqrt{i_a}} \text{ proportional to } \frac{\sin a}{\sqrt{a}} \quad \ldots \quad (9)$$

From table III it is seen that this

expression (9) has a maximum value for $a = \pi/3$.

The relation between $S_{max.}$, S_c and S_g (this latter being the *mean* anode slope, *i.e.*, the slope for an intermediate frequency input signal) is for $a = \frac{\pi}{3}$:

$$S_c = 0{,}27\ S_{max.} = 0{,}83\ S_g \quad \ldots \quad (10)$$

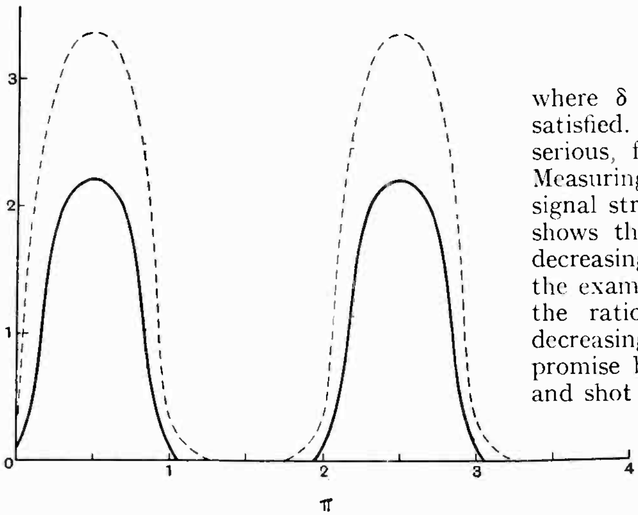


Fig. 11.—*Anode/grid four slope of octode versus time and anode current versus time (dotted). Vertical axis slope in mA/Volts and current mA.*

Again, as with single grid converter tubes, the optimum conversion conductance for minimum shot noise is about one-quarter of the maximum anode slope during one oscillator swing period.

The equations (5) and (10) provide an easy means to control the behaviour of converter tubes in sets by means of a standard signal generator. Putting first a h.f. input signal on the input grid and then an intermediate frequency input signal, the gains should be related as S_c over S_g in either equation (5) or equation (10), if a single or a double grid mixer is used.

TABLE III

$\frac{\sin a}{\sqrt{a}}$	0	0,8	0,85	0,8
a	0	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$

IV. Whistling Notes

From a discussion of whistling notes (see article "Whistling notes in superheterodyne Receivers") it appears that even with perfectly selective input circuits, serious whistling notes may arise with one single signal on the input grid, if the relations

$$\omega_h - \omega_i = \omega_0$$
$$\pm m\omega_h \pm n\omega_i = \omega_0 \pm \delta,$$

where δ is small with respect to ω_0, are satisfied. Often those whistles are most serious, for which $n = 2$ and $m = 0$ or 1. Measuring the ratio of whistling note to signal strength after the second detector, it shows that this ratio often diminishes for decreasing oscillator voltage, as shown in the example of Fig. 13. At the same time, the ratio noise to signal increases with decreasing oscillator voltage. Hence a compromise between strength of whistling note and shot noise must be made.

The author wishes to thank Mr. N. S. Markus for his assistance in the measurements, quoted in this paper.

For an extensive bibliography and a description of measurement arrangements, reference is made to an article: "On conversion detectors" in the *Proc. Inst. Rad. Eng.*, vol. 22, pp. 981–1008. This

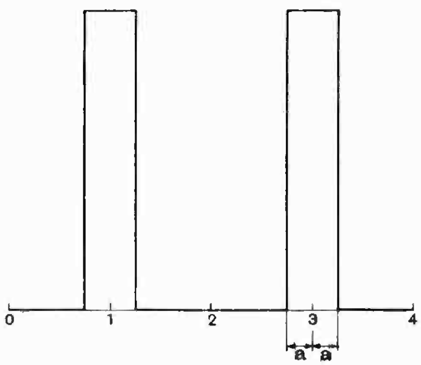


Fig. 12.—*Rectangular approximation of curves in Fig. 11.*

contains also methods, which permit one to compute the complete detector performance, including whistling notes from the static valve characteristic.

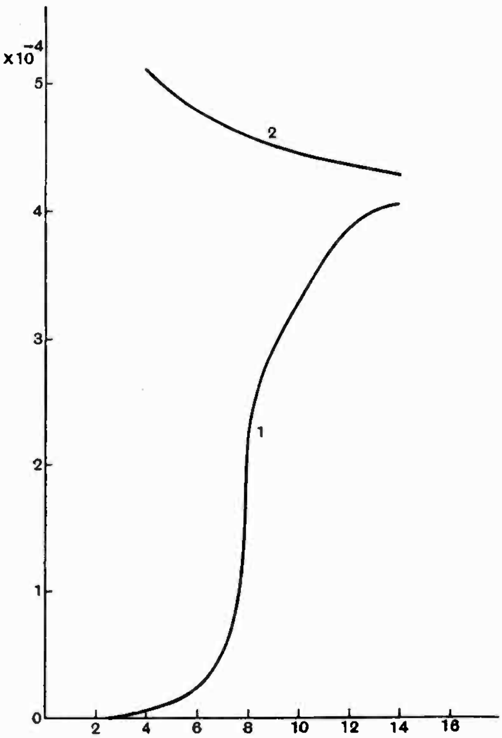


Fig. 13.—*Curve number one : vertical relative strength of whistling note behind second detector with m = 1 and n = 2 and a signal input of* 0,003 *Volts. Curve number two vertical relative valve noise behind second detector for same input signal on grid of mixing valve. Horizontal for both curves : oscillator volts on first grid of octode.*

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I.E.E. Informal Meetings

THE Wireless Section Committee have decided to include in the programme of activities of the Section, informal discussions of a popular character on subjects of wide interest, such as broadcasting, transmitters, and receivers.

Apart from members of the Section, it is thought that these informal discussions will be of considerable interest to many non-members who are concerned in the practical side of wireless, and they are cordially invited to attend. Tickets of admission will not be required. The following two informal meetings remain of the present Session (*Tuesdays at 6 p.m. Light Refreshments at 5.30 p.m.*) :

26TH FEBRUARY.—Discussion on "Production Testing of Broadcast Receivers," to be opened by Mr. F. Murphy, B.Sc. (Eng.).

26TH MARCH.—Discussion on "The Servicing of Broadcast Receivers," to be opened by Mr. A. Hall.

Incremental Permeability and Inductance

The Rôle of Waveform in Measurement

By L. G. A. Sims, Ph.D., M.I.E.E.

(Concluded from last issue.)

(4) *Measurement by Valve Voltmeter.*

The valve voltmeter has frequently been employed for incremental measurements on account of its ability, when an input condenser is employed, to ignore an unwanted D.C. voltage component and to take practically zero power from the test circuit.

In a series of tests upon a small transformer, of which details have been published, both the induction and the exciting current were measured by valve voltmeter, the induction being calculated from the voltage across a tapped secondary winding and the excitation from a resistance in the input circuit of the transformer. The circuit was as shown in Fig. 8. The reading of the D.C. milliammeter gave the steady polarising current.*

The convenience of this method is so great that it has probably found appreciable application, but it is open to several objections which appear to exclude it from use when large excitation amplitudes, with consequent bad waveform distortion, are concerned.

In the circuit shown the use of resistance control on the A.C. side is liable to lead to a non-sinusoidal voltage upon the primary of the main transformer, particularly as this must take an abnormally distorted input current due to the polarisation of its core by the flow of D.C. in its secondary winding. The secondary voltage of this transformer is therefore unlikely to be sinusoidal, and the voltage at the terminals of the test coil still less so on account of the interposition of further resistance in the test circuit carrying the exciting current of the test coil.

Under these conditions neither the test current nor the test induction is a sinusoid. Both of these quantities are measured by a valve voltmeter. The liability of valve voltmeters to waveform error has been discussed very fully by E. B. Moullin† and a number of measurements upon various types of such meters has been given by Medlam and Oschwald.‡ The error depends upon the type of instrument employed. It may be negligible or it may assume a very serious magnitude. In the type of instrument which appears convenient for incremental per-

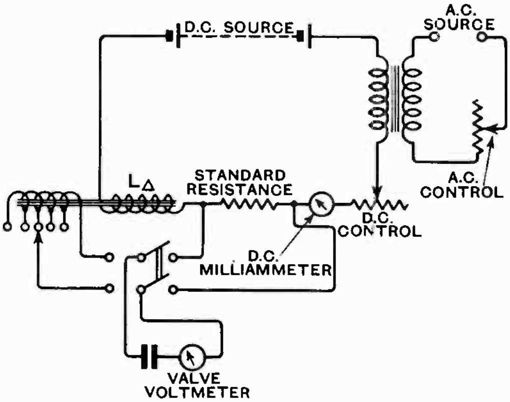


Fig. 8.

meability measurements—namely, that in which an isolating condenser is used in the grid circuit—waveform error is relatively serious. This type of instrument is shown in use in Fig. 8. Using a waveform obeying

* See Symonds, *Experimental Wireless*, September, 1928.

† See for example, *J.I.E.E.*, Vol. 68, No. 404, 1930.

‡ *Experimental Wireless*, Vol. III, No. 37 and No. 38.

the expression

$$e = \sin\theta + 0.26\sin\left(2\theta + \frac{\pi}{2}\right),$$

Medlam and Oschwald found errors exceeding 100 per cent. of the sine wave calibration of the meter when the R.M.S. test voltage exceeded about half the meter scale range.

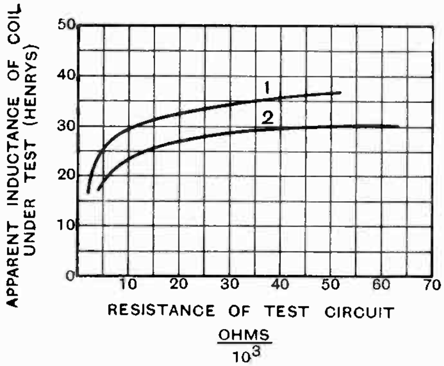


Fig. 9.—*Curve* (1) *without steady current; curve* (2) *with a steady current.*

The error, when even harmonics are present, depends upon the sense of the connections to the meter—that is, the error is altered if the connections are reversed. It cannot readily be allowed for by a correction factor and it varies steeply with the amplitude of input voltage.

On this type of meter E. B. Moullin (*loc. cit.*) makes the following comment: "The reading must be very sensitive to waveform and quite uninterpretable in terms of R.M.S. valves . . . the indications will be some function of the crest of the wave and quite independent of the shape of its main portion." This statement is not in relation particularly to waves containing even harmonics, the presence of which could doubtless render the reading still more in error, as indicated by the measurements of Medlam and Oschwald. Referring to the even harmonic error, particularly to the difference of reading which results from a reversal of connections to the meter, Moullin says that a waveform oscillogram will at once explain the difference of readings, but that it does not suggest how to interpret them.

(As we have already seen in the introduction to the present paper, the complex wave containing even harmonics must always lack true half-wave symmetry.)

It is perhaps desirable to stress the fact that the case we are considering is particularly onerous upon the valve voltmeter. Its utility and advantages in other applications are undoubted. The dangers of its use in incremental measurements are further illustrated by the curves of Fig. 9, which were taken by the writer upon a small audio-frequency transformer with a nickel-iron core. The test circuit was exactly similar to that of Fig. 8, and the valve voltmeter employed was a standard high-grade meter by a well-known instrument firm and accurate if used with sinusoidal voltage. The A.C. voltage, *as measured by the valve voltmeter* at the terminals of the transformer, was kept constant, and so was the value of the steady current (zero in the case of curve 1 and 1.0 milliamps in the case of curve 2). Only the circuit resistance was changed. This had the effect of changing the waveforms of current and voltage, an increase of circuit resistance reducing the current distortion and increasing that of the exciting voltage. (The source was not affected by these changes in any way.)

The result was that the supposedly constant voltage at the terminals of the transformer under test was actually not constant because a constant reading at this point was not reliable, due to the waveform error of the

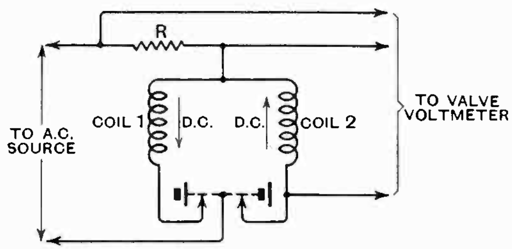


Fig. 10.

voltmeter. Similarly, errors of continuously changing magnitude occurred in the alternating current readings, which were measured by the same meter.

The inductance curve calculated from such readings is therefore vitiated by the meter errors.

(5) *Test Method using Parallel Coils.*

A further method of measuring incremental inductance which offers apparent advantages for quick work, and which has been used commercially, resembles the case discussed above in so far that a valve voltmeter may be employed. The susceptibility of this instrument to waveform error has therefore again to be considered, and in addition the apparent advantages of the parallel circuit lay-out lead to a waveform peculiarity which may not be generally appreciated, but which, in any case, introduces a further possible source of error. The transformers or chokes are tested in pairs of the same type, the measured combined inductance being thereby one half of that of either coil. The arrangement is shown in Fig. 10. The direct current is introduced within the closed circuit, and, since the coils are similar, it is easy to arrange that there is no tendency for D.C. to flow in the outside circuit. The isolation of the D.C. is an advantage, particularly as it enables a smaller battery to be used than that necessary in the circuit of Fig. 8, where the D.C. has to flow through the standard resistance, which may be several thousands of ohms.

Suppose that the A.C. test current is small, and that it is most readily measured indirectly by the resistance R, situated as shown in the external circuit where it does not affect the D.C. conditions; the valve voltmeter which measures the voltage across the test coils also measures the current in R and the D.C. is measured by a moving-coil meter in the closed circuit. Apparently the circuit then resembles that of Fig. 8 in every important detail, and the same errors might therefore be expected. But this is not the case. The sense of the direct current through one coil is opposite to that through the other, whilst that of the A.C. is the same. The result is that the coil A.C. magnetising currents, when superimposed in the measuring resistance R, have a combined waveform which is totally different from that of either coil alone. This is due to the fact that whilst in one coil the A.C. at a given instant opposes the D.C., in the other coil it assists.

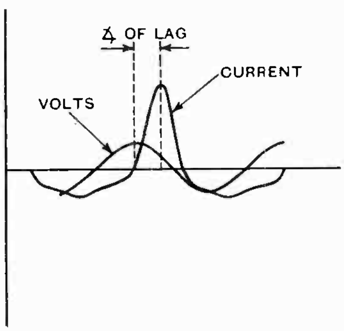


Fig. 11*a*.—*Alternating current and voltage conditions for coil* 1.

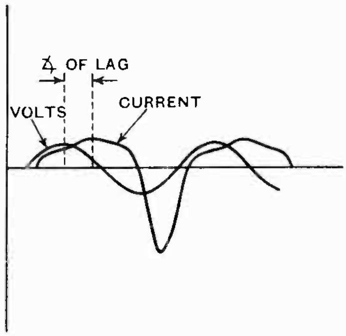


Fig. 11*b*.—*Corresponding conditions for coil* 2.

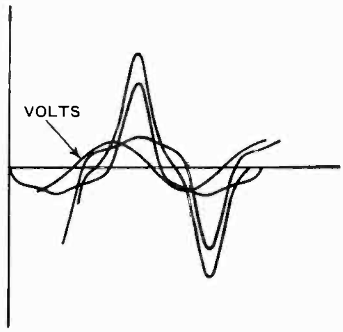


Fig. 11*c*.—*Process of superposition of branch currents.*

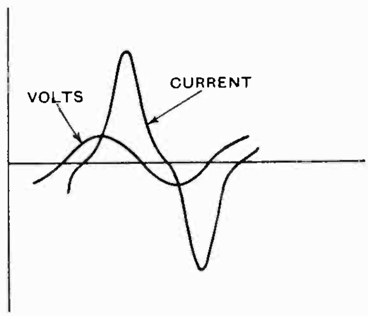


Fig. 11*d*.—*Approximate waveform conditions in external circuit.*

The process of superposition is illustrated approximately in Figs. 11*a*, *b*, *c* and *d*, the current wave shapes being fairly typical of large amplitude incremental excitation with approximately sinusoidal induction changes.

It is interesting to observe this effect by oscillograph, by which instrument it is confirmed very definitely.

It will be clear that this method of measurement, however convenient, can hardly be expected to yield results in close agreement with those obtained by any other of the methods so far described, except in those cases where, for any reason, distortion is small.

In conclusion, it is important to consider what is probably the most powerful of all dynamic methods—namely, measurements by the alternating current potentiometer and harmonic analyser.

(6) *Measurement by A.C. Potentiometer and Harmonic Analyser.*

We shall consider the co-ordinate potentiometer designed and developed by D. C. Gall (the fundamental principle of which resembles to some extent that of the Larsen potentiometer). The principle of Gall's

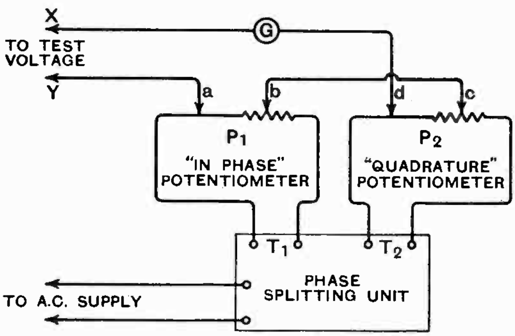


Fig. 12.

instrument is illustrated in Fig. 12, and as it is now well known (though in other applications) this illustration may suffice without detailed description of the main apparatus.

It is of importance, however, to note that the vibration galvanometer *G*, being a sharply tuned device, indicates balance only for a single frequency, and therefore the potentiometer, like the A.C. bridge, ignores harmonics. But the latter can be treated separately by means of a harmonic analyser. A convenient analyser, consisting of a synchronously running disc having tracks fitted with segments equal in number to the orders of the various harmonics to be measured, has also been developed by Gall. (The contact lengths in the various tracks are so chosen as largely to eliminate the effects of harmonics of undesired orders.)*

Referring to Fig. 12, it will be clear that either potentiometer P_1 or P_2 could be used as a D.C. potentiometer, since this is only a matter of disconnecting from the terminals T_1 or T_2 and connecting instead to a battery. The vibration galvanometer may then be replaced by a moving-coil instrument, and if the analyser is inserted in series with X or Y the waveform† and harmonics can be measured.

Therefore this procedure can be followed: The potentiometer excited by A.C. enables the phase and magnitude of A.C. voltages (fundamental components only) to be measured. In general the losses in any given test sample can thereby be computed. By changing the potentiometer and galvanometer over to D.C. working the effects of the harmonics can be determined.

Therefore this combination of apparatus enables the true ratio $\frac{\Delta B}{\Delta H}$ to be determined as well as it can be done ballistically, but with the advantage that the method is a truly dynamic one and not a method of simulation. For this reason it must also include any eddy current effect which is present in the sample —a refinement of which the ballistic galvanometer and fluxmeter are not capable. In addition, the great sensitivity and wide range which is characteristic of the potentiometer makes the method extremely powerful and much more flexible than the A.C. bridge.

In Fig. 13 a complete lay-out for the measurement of iron characteristics under incremental magnetisation is shown in simplified form. The test circuit contains the iron-cored test coil L_{Δ}, the voltage across which (or better across a search coil) is measured by the potentiometer. For this purpose, the switches S_1, S_2 and S_3 are placed in the right-hand positions, thus

* This method of harmonic analysis is also associated with the names of Wedmore and Professor Lombardi. It has also been dealt with by B. G. Gates (*J.S.I.*, Vol. IX, No. 12), and the present writer has suggested modifications to render it more accurate for work of the nature described here (see "Analysis of Waveforms: Half Period Contact in Waveforms Containing Even Harmonics." Sims, *Wireless Engineer*, Vol. XI., No. 131, August, 1934.)

† By means of a Joubert contact included on the analyser disc.

bringing the vibration galvanometer G into circuit and, at the same time, exciting the potentiometer by alternating current. The analyser A is short-circuited by the switch S_4.

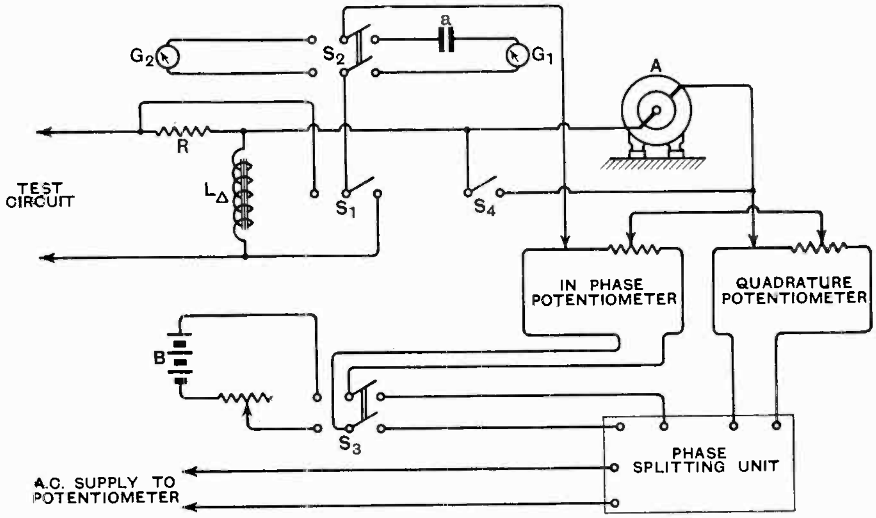


Fig. 13.

By moving S_1 into the left-hand position the alternating current flowing into the test coil can be measured indirectly by the voltage it develops across a standard shunt R, placed in series. Owing to the sensitivity of the potentiometer, R can be very small compared with ωL_Δ, thereby enabling a sinusoidal supply voltage to be practically undisturbed by the volt loss in R, and so retaining sinusoidal pressure at L_Δ. This is important in the accurate measurement of iron losses, which will be affected if the waveform at the test coil terminals changes appreciably.

When incremental magnetisation is to be tested there will be a D.C. voltage across R. This will be ignored by the galvanometer if a condenser a is inserted in series with it. The switching to enable the change-over to D.C. working and harmonic analysis will be clear in Fig. 13 without further explanation.

Finally, it should perhaps be stressed that the errors of measurement with which this paper has been concerned are characteristic of the larger excitation amplitudes, when waveform distortion is serious. For very small amplitudes, when the incremental quantities approach their differential values, distortion is probably unimportant. In either case an appreciation of the pitfalls is desirable.

Acknowledgments are gratefully paid to Professors Cramp and Howe for modern experimental facilities readily granted and for valuable criticisms during the preparation of the paper.

The Industry

THE Copper Development Association, Thames House, Millbank, London, S.W.1, has just published a useful booklet dealing with the technical applications of brass. The publication is in the form of an engineer's notebook, and copies will be issued freely to members of engineering institutions, engineering students, and to others interested in the specification of metals.

The Cossor Portable Oscillograph, a compact piece of apparatus for mains operation, is described in a pamphlet received from A. C. Cossor, Ltd., Cossor Works, Highbury Grove, London, N 5.

A pamphlet dealing with the Bosch Electric Screw-driver, which should be of interest to wireless manufacturers, has been sent to us by Bosch, Ltd., Larden Road, Acton, London, W.3.

Valve manufacture now forms an increasingly important part of the Ferranti activities. The firm has issued a new valve list, of which copies are available from Hollinwood, Lancs.

Inter-Modulation in Audio-frequency Amplifiers*

By A. C. Bartlett, M.A.

(Research Staff of the M.O. Valve Co., Ltd.)

INTER-MODULATION or the production of difference frequencies in the radio frequency portion of a wireless receiver is a familiar thing, but the inter-modulation that may occur in the audio portion is very seldom mentioned and its importance does not seem to be generally recognised. If, for example, to the grid of a valve two different frequencies—say 60 ~ and 1,500 ~ are applied simultaneously, then if the operating conditions are such that there is non-linearity, the output current will contain the 60 ~ and the 1,500 ~ frequencies and their harmonics; the 1,500 ~ note will also be modulated by the 60 ~ and thus cause components of frequencies (1,500 ± *n*60) ~. These additional modulation frequency components may be comparatively large and give unpleasant results. A simple non-mathematical discussion† and a description of an experimental method of observing simple cases of inter-modulation both by eye and by ear will be given below.

Consider a simple output stage consisting of a pentode, that for simplicity's sake is working into a resistance load and not a loud-speaker; such a pentode circuit is shown in Fig. 1.

The characteristics of the pentode will be of the form shown in Fig. 2, which, however, does not represent any actual standard type.

Suppose that the bias is −20 volts and the H.T. voltage 250 V., then through the point O' on the diagram for $eg = -20$ V. and $E_A = 250$ V., draw a line A, B, C, D, E, F, G, H such that its slope corresponds to the value R. Provided that the choke L and the condenser C of Fig. 1 are sufficiently large, then, whatever wave form is applied to the grid, the anode current and voltage at any instant will be determined by the point on the line AH which corresponds to the grid voltage at the time. From this diagram we may plot another curve, Fig. 3, which gives the voltage across the anode load resistance R corresponding to any grid voltage.

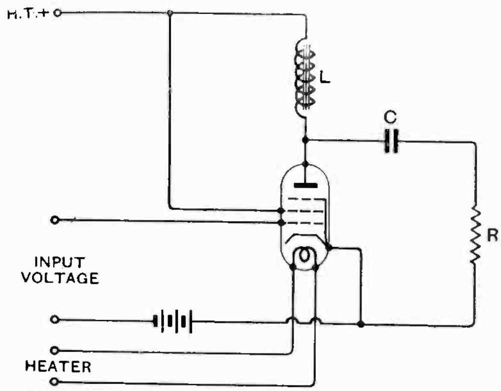
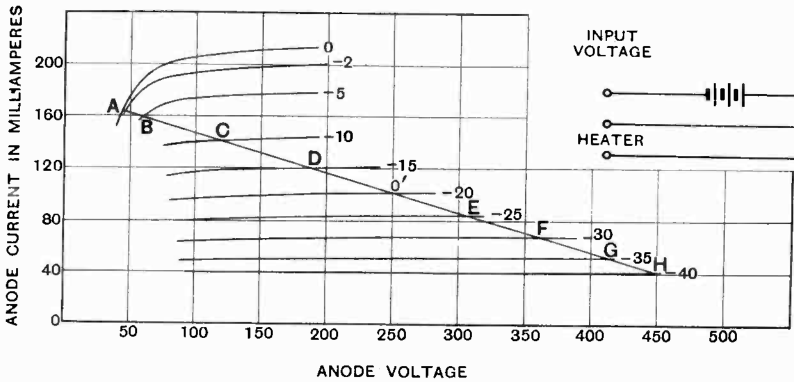


Fig. 1.



(*Left*) Fig. 2.

* MS. accepted by the Editor, November, 1934.

† For a more mathematical treatment see D.C. Espley, *Proc. I.R.E.*, June, 1934, p. 781.

We are now in a position to plot the wave form of voltage across *R* when a wave of any form is applied to the grid. First, suppose a sine voltage of peak value 20 volts is applied to the grid. Then on a time base whose length is the time of a period we can draw a sine wave representing the grid voltage; this is shown in the dotted curve in Fig. 4.

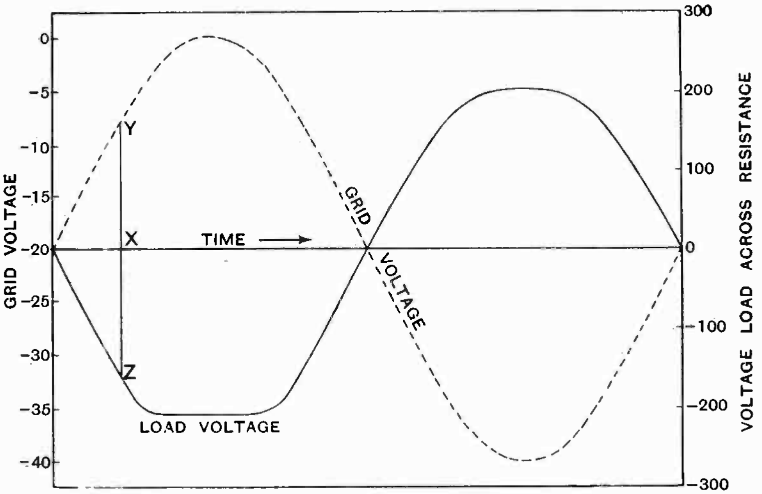


Fig. 4.

Then take points such as *X* on the time axis, draw *XY* vertically to cut the sine curve. *XY* gives the grid volts at this instant of the cycle, and then using Fig. 3 we may take a point in *Z* in *XY* so that *XZ* is proportional to the volts across *R*. Proceeding thus we obtain the solid curve in Fig. 4, which gives the voltage across *R*. It is not a pure sine wave, and if desired a Fourier analysis may be made to determine its harmonic content.

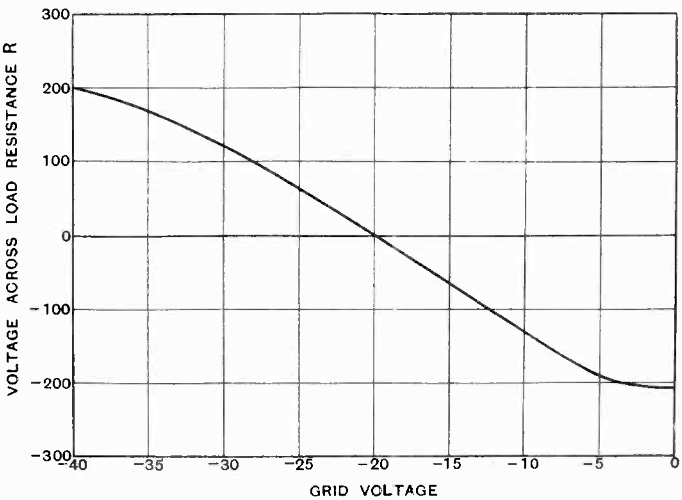


Fig. 3.

We now turn to the consideration of the voltage across *R*, when two sine voltages of different frequencies are simultaneously applied to the grid, and to simplify the problem will consider the case where one of the voltages is a low-frequency one of nearly 20 volts peak, and the other one is a small one of 1 volt peak, but of 10 or 15 times the frequency. Such an applied wave is as shown in Fig. 5.

By the method used before we could plot the resultant output curve, but this would require the plotting of a very large number of points. Instead we will consider what happens to the small higher-frequency ripple component of the output volts only.

From Fig. 3 it is seen that the change of voltage across *R* for a small given voltage change applied to the grid depends on the grid voltage; thus, for instance, when the grid changes from -20 to -15, the voltage across *R* changes from 0 to -65, hence over this 5 volt range the average voltage amplification is $\frac{65}{5}$ or 13; similarly over the 1 volt range from 0 to -1, the volts across *R* change by only about 1 volt, hence over this range the amplification is about 1. Thus, obviously, by drawing tangents to the curve of Fig. 3 and measuring their slopes we can derive a curve relating amplification along the load-line AH to grid volts; this is shown in Fig. 6.

If the small ripple voltage only were present the grid would oscillate from -19 to -21 volts. From Fig. 6 it is seen that the amplification is constant and equal to 13 in this range; hence there would be a peak A.C. voltage of 13 across R. When, however, the large low-frequency voltage is simultaneously applied the grid will be carried up to nearly zero voltage once every low-frequency cycle. But in the neighbourhood of zero voltage the amplification is only about unity, and hence the 1 volt ripple during this portion of the low-frequency cycle will produce only one volt across R instead of 13.

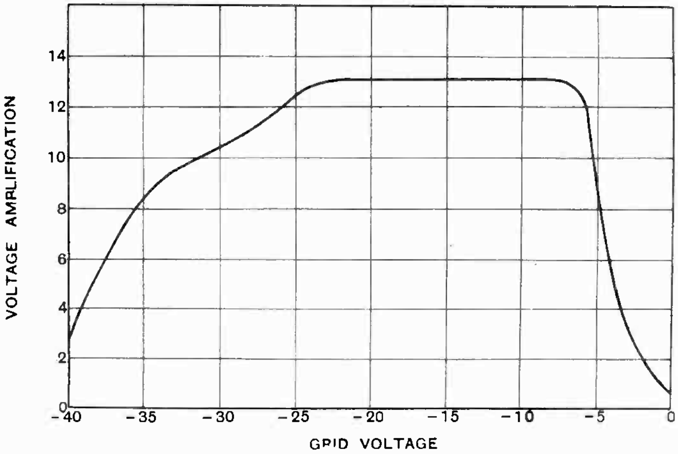


Fig. 6.

The output voltage due to the small ripple is thus varied in amplitude to a great extent during the low-frequency cycle. We can now determine more exactly how the ripple is modified by the presence of the large signal in the following way.

Take a time base, Fig. 7, whose length represents the time of one complete cycle of the low-frequency voltage.

As before, draw a sine wave to represent the low-frequency signal. At point X draw a vertical to meet the sine wave in Y, then take a point W so that WX is proportional to the amplification obtained from Fig. 6. Doing this for a number of points we obtain a curve which gives the amplification at any time on the lower-frequency cycle. Next take a time base, Fig. 8, corresponding to the time base of Fig. 7, and, remembering that the ripple voltage is 1 volt, plot a curve whose height is equal to $1 \times M$ where M is the amplification obtained from Fig. 7. Draw the reflection of this curve in the axis. It is then obvious that these two curves form the envelope of the output ripple and we can sketch it in approximately. The high-frequency wave is modulated by the low-frequency, its amplitude pulsating from about 1 volt to 13 volts every cycle of the low-frequency voltage. Such effects can be both seen and heard by the experimental arrangement of Fig. 9.

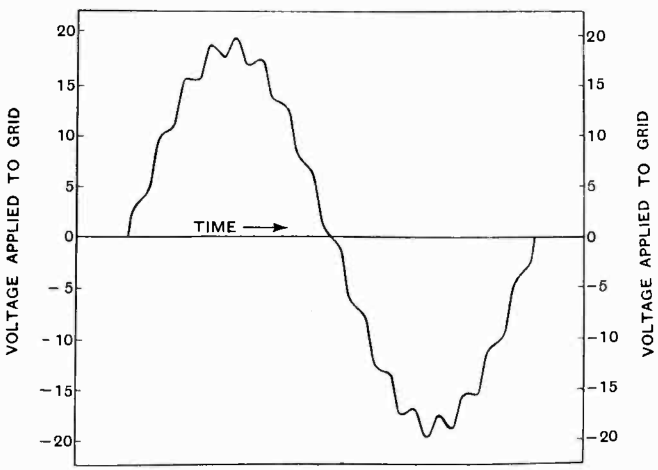


Fig. 5.

A high pass filter is shunted across a small portion of the load resistance: the filter is designed so that it passes the ripple frequency but almost completely cuts out the low frequency. The output from the filter is then passed through an amplifier which can be terminated either by a loud speaker or cathode ray oscillograph.

Fig. 10 shows some tracings from the screen of a cathode ray oscillograph when a large signal of 60 ~ and a small additional ripple of 1,500 ~ were applied to the grid of a pentode; the filter had a cut-off frequency of 800 ~.

Fig. 10a corresponds closely to the load condition shown in Fig. 1; the load resistance is considerably higher than should be used in practice. The 1,500 ~ is modulated nearly to extinction; when heard on the speaker the result is an emphatically unpleasant croaking noise entirely different from the pure 1,500 ~ which is heard if the 60 cycle input (itself unheard owing to the filter) is switched off. Fig. 10b shows the results from the pentode with a more or less normal load, and Fig. 10c that from the same pentode with a small load of only a few hundred ohms.

Fig. 11 shows two tracings of tests on a triode—a *PX*. 4, (*a*) with 3,000 ohms load and (*b*) with 10,000 ohms load. Here the modulation is more gentle, and aurally the results are less unpleasant than in the case of a pentode.

There is no doubt that such inter-modulation accounts for the differences to be found between amplifiers having the same ordinary response curves. For the purposes of high-grade musical reproduction very careful attention to details of design is required to avoid this form of distortion.

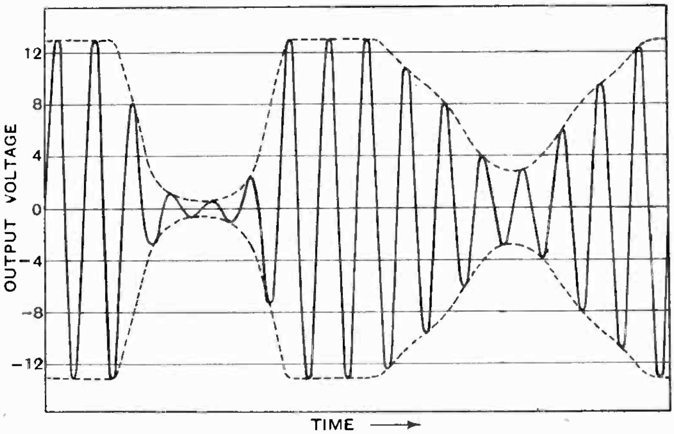
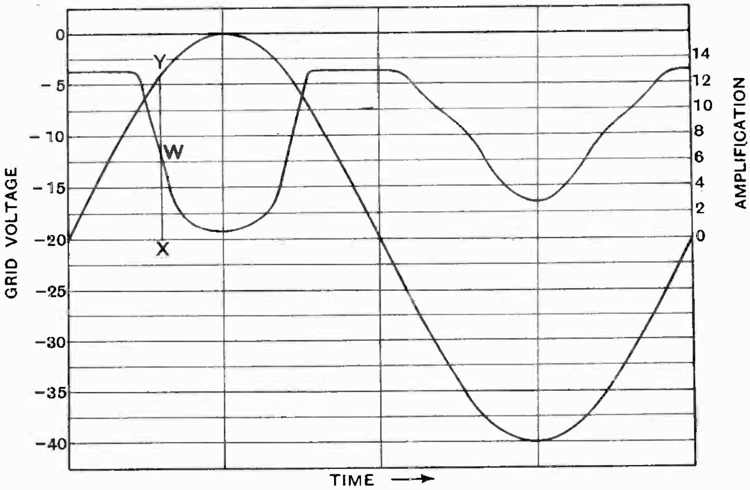


Fig. 8.



(*Left*) Fig. 7.

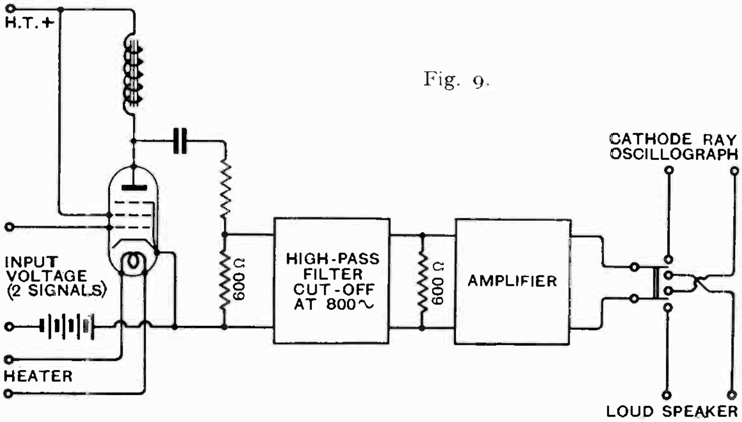


Fig. 9.

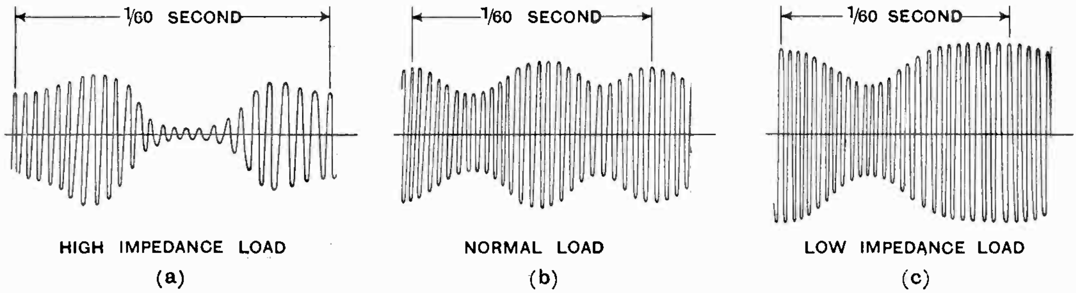


Fig. 10.

The experimental method described above forms a very simple and extremely searching test of almost any amplifier and is most useful as a laboratory tool; it will show up at once any non-linearity due to iron circuits, valves, incidence of grid current, etc.; it may also be used to test modulated oscillators and detectors, and indeed complete transmitters and receivers.

The author desires to tender his acknowledgment to the General Electric Company and the Marconiphone Company, on whose behalf the work was done which has led to this publication.

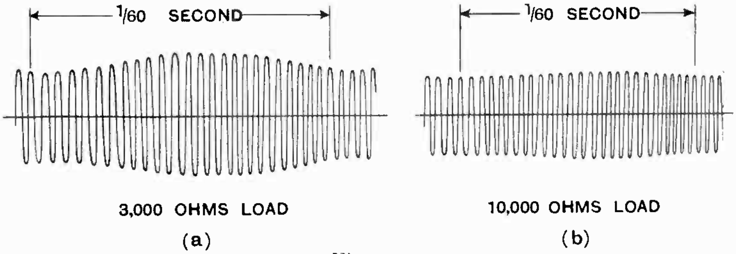


Fig. 11.

The Physical Society's Exhibition

Notes on Exhibits of Wireless Interest

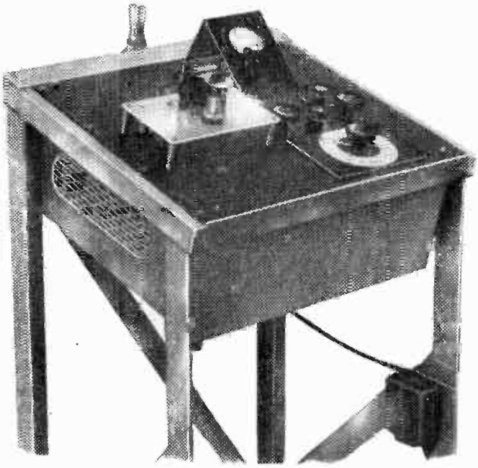
SINCE the art of radio communication is based upon the science of physics, it is only natural that the annual exhibition of physical instruments and apparatus should illustrate the latest developments in both the research and production sections of the wireless industry.

From the point of view of production tests the range of instruments produced by E. K. Cole may be taken as examples. This series includes two inductance bridges, working on 10 kc/s and 100 kc/s respectively, each of which is a self-contained unit incorporating the necessary oscillator and amplifier-detector. The coil to be tested is compared with a pre-set standard, and the accuracy of the bridge is such that a difference of the order of 0.1% can be observed; an out-of-balance adjustment is provided, indicating, by the position to which it must be set for balance, the magnitude and sign of the difference between the test and standard coils. The scale of this latter adjustment is very open near zero, so that small differences can be measured, but closes up at the ends so as to cover an adequate range of coil variation. The 100 kc/s model is intended for testing two-range coils; consequently the standard inductance and also the power-factor correcting arrangement are duplicated, so that both sections of the coil can be tested in turn by changing over a switch.

There are also capacity bridges (10 kc/s) of various types, with either a continuously variable standard comparison condenser or switch controlled pre-set standards, and a "Portable Impedance Comparison Bridge." The latter is a mains-driven unit built in a steel case containing oscillator, bridge arms, and amplifier plus valve voltmeter as detector, but has no internal standard reactance or resistance; it can be used to compare any two impedances of the same kind to an accuracy of 0.2%. Another type of bridge is the distortion factor meter, which is a bridge tuned to eliminate the fundamental frequency (the nominal working range is 150 to 3,000 c/s), so that the output, consisting only of harmonics, can be measured on a meter which indicates the R.M.S. sum of all the components present; by substitution this sum is then equated to a fraction of the total input derived from a calibrated attenuating system, thus giving the percentage distortion.

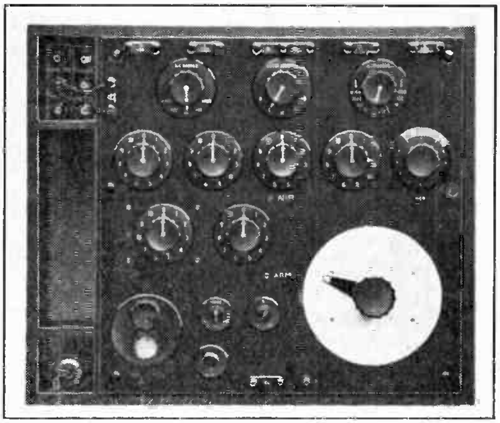
In another class of testing equipment there is an Ekco machine for the continuous testing of the insulation of enamelled wire in which the wire is run through a mercury bath; any fault causes a current impulse to be applied to the grid of a mercury vapour tube whose anode circuit works a mechanical counter. The sensitivity can be varied, and test switches are provided so that it can be adjusted to operate on a fault of 10,000 ohms but not on one of 15,000 ohms. If there should be one or more short-circuited turns on a finished coil, they may be detected by a bridge type tester which merely requires that the coil for test be slipped over a projecting core; provision is made for balancing the capacity loading effect of a sound coil, and sensitivity is sufficient to detect a single shorted turn of 44 gauge wire of 1½in. diameter.

Of the various audio-frequency bridges one of the most useful is the Cambridge Universal bridge, which is direct reading for resistances (which are



Ekco 100 kc/s. inductance bridge for the rapid comparison of coils with a sub-standard. Range 20 to 5,000 microhenries.

measured on d.c.) from 10^{-4} to 1.11×10^{6} ohms, self-inductances up to 100 henries, mutual inductances up to $\pm$ 11,100 microhenries, and capacitances up to 11.1 microfarads, and gives an indication of resistance of inductances or power-factor of capacities. It is a self-contained unit, with pointer

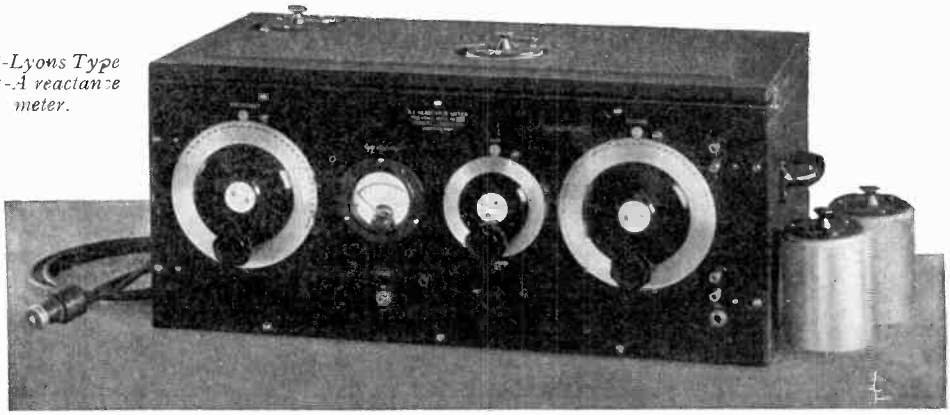


Cambridge Universal bridge.

galvanometer for d.c., telephone as a.c. detector, and a 900 c/s microphone hummer driven from the internal 8 volt battery as a.c. source. There is also a Cambridge capacity meter which is run direct from a.c. mains, has a pointer galvanometer as balance indicator, and is direct reading from 10 $\mu\mu$F to 2.4 μF.

A sensitive megohm meter made by Claude Lyons is in effect a small portable resistance bridge using a 4-electrode valve with backed-off galvanometer in its anode circuit as balance indicator. The instrument is complete with either dry batteries or mains unit supplying 90 volts to both bridge and valve anode; the range is 10,000 ohms to 10,000 megohms on a two-decade dial with five-range multiplier switch. An unusual type of reactance meter by the same firm is a heterodyne oscillator with provision for connection of the unknown reactance in parallel with the tuned circuit of one of the oscillators; zero beat between the two oscillators is used as the reference point, and after connecting the unknown this condition is restored by adjusting a calibrated condenser in the tuned circuit to which it is connected. This is a very sensitive method of measuring small capacities, and is independent of

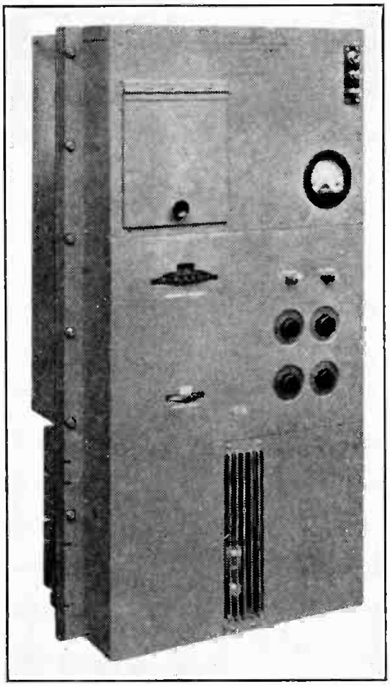
GR-Lyons Type 421-A reactance meter.



power factor provided the latter is not so great as to produce a change in the frequency of the oscillator *per se*. The most interesting exhibit on this stand, however, is a radio-frequency bridge for use on frequencies up to 5 megacycles per second. It does not include oscillator or detector, but is otherwise self-contained and as portable as the corresponding audio-frequency bridges; as a direct reading instrument its range is from a fraction of a micro-microfarad to 1,150 $\mu\mu$F and from 0.1 ohm to 111 ohms, with an accuracy of 1 to 5% up to a frequency of 2 megacycles, but higher accuracy can be obtained by substitution methods. By changing the input transformer the bridge can if desired be used on lower frequencies.

Of the Sullivan series of capacity bridges (operating on 1,600 c/s) the lowest range model measures from 0 to 3 $\mu\mu$F with a scale reading to 0.01 $\mu\mu$F, and from 0 to 30$\mu\mu$F; this can be used for direct measurement of valve inter-electrode capacities. The Griffiths type of temperature compensated inductance is well known, but there is now in addition a temperature compensated silica insulated variable air condenser. The temperature coefficient is stated to be between 5 and 6 parts in 10^6 per degree centigrade, and the scale accuracy from 1 to 3 in 10^4 for maximum and minimum settings respectively; the power factor for 1,000 $\mu\mu$F is 2×10^{-5} at frequencies up to 1,000 kc/s. In addition to the Ryall-Sullivan Precision Heterodyne Oscillator (described in *The Wireless Engineer*, May, 1934) and a number of wavemeters there is a Sullivan-Griffiths Continuously Variable Stable Oscillator for use in the monitoring of broadcasting stations; it covers the frequency band from 660 to 1,200 kc/s, and has an accuracy of 50 c/s with a daily stability of 1 c/s.

GR-Lyons Type 516-C radio-frequency bridge.



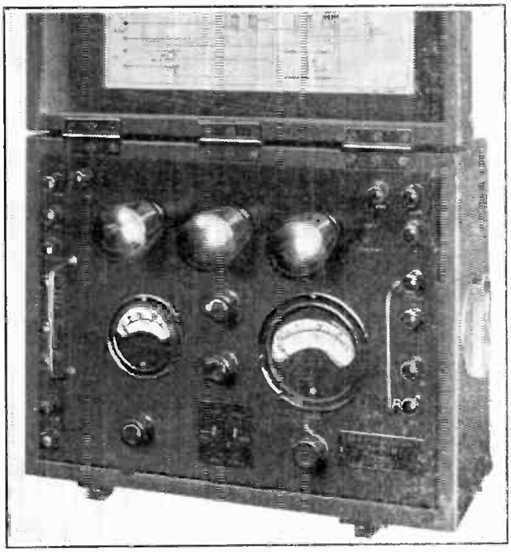
Ryall-Sullivan precision heterodyne oscillator in its latest form.

A heterodyne oscillator is a valuable source of audio-frequency signals for all kinds of laboratory work, and a battery model such as is produced by Standard Telephones and Cables has advantages from the point of view of portability. This particular model covers the range from 20 to 10,000 c/s and is continuously variable; the output is 15 mA into 600 ohms (i.e. 0.24 watt). Where a larger power output is required a mains driven model is essential, such as the Salford Electrical Instrument Company's oscillator which gives an output of 4 watts when driven by a mains unit, or 1 watt when running from repeater station batteries. This is mounted in a steel case, and a good feature of the design is that all valves and resistors are mounted in the upper half, with adequate ventilation, so that there should be no appreciable temperature rise of the tuned circuits in the lower half. Working with this there is a Salford valve voltmeter which is mains driven and by using a neon stabiliser for the anode supply and a barretter in the low-tension lead is independent of mains voltage between 200 and 250 volts. An anode bend rectifier is used, with bias obtained from a resistance in the cathode lead; this bias system improves the scale shape, and the range can be changed by varying the value of the bias resistor. Though not strictly a wireless instrument, an interesting device on the Salford stand is a drive for recording instruments which gives a logarithmic time scale; this would be useful for the recording of life tests on apparatus which is likely to show very wide variation between different specimens, and will probably have other applications as well.

There is an Ekco two-stage valve voltmeter for audio-frequency work, and an Avo experimental two-stage meter which covers the broadcast radio frequencies as well as audible frequencies. Both employ the first valve as a resistance-coupled amplifier before the rectifier; but in the Avo instrument the first valve is a screened pentode type, so that the input impedance is high at all frequencies, and by using a relatively low gain the response can be kept practically constant over both audio and radio frequencies. The rectifier is an anode bend triode, and if required the sensitivity can be made sufficient to give full-scale deflection for an input of 0.05 volt.

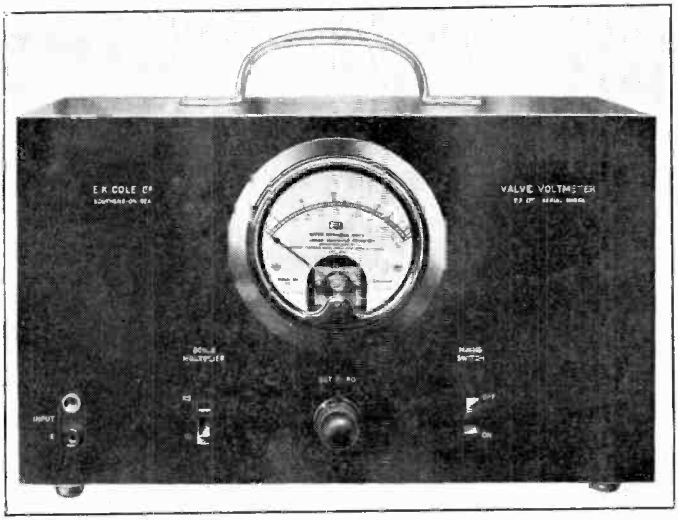
Standard Telephones battery-operated portable heterodyne oscillator.

Fundamentally an oscillator and a voltmeter are all that is necessary for the measurement of attenuation or transmission in telephone lines and apparatus, but there are various refinements which are incorporated in sets specially designed for transmission measurement to facilitate observations. The Standard Telephones transmission measuring set works in conjunction with a suitable oscillator and consists of an amplifier with an output meter calibrated in decibels which, with an adjustable attenuator, makes it possible to observe changes of input level from −45 to +15 decibels. In making a measurement the amplifier gain is first adjusted so that when it is fed directly from the oscillator the output meter reads zero db.; the circuit to be measured is then inserted between oscillator and amplifier, and the change in reading of the output meter indicates the loss or gain introduced by the circuit. Alternatively bridge measurements may be required at either audio or carrier frequencies; for use in such cases there is the Standard Tele-



Standard Telephones transmission measuring set.

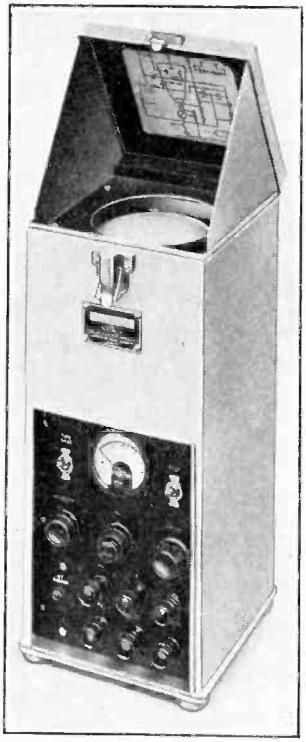
phones portable detector-amplifier which gives a gain of at least 75 db. at all frequencies between 700 c/s and 50,000 c/s, and can be used with either telephones or a rectifier type output meter. For frequencies up to 3,000 c/s a two-stage tuned amplifier is used, but for frequencies above this and up to 50,000 there is a heterodyne arrangement with a balanced modulator employing copper-oxide rectifiers. The variable-frequency oscillator required in the latter case has both variable capacity and permeability tuning ganged together on the same control. The variable capacity is of the two-plate compression type, with very thin solid dielectric,



Ekco two-stage valve voltmeter.

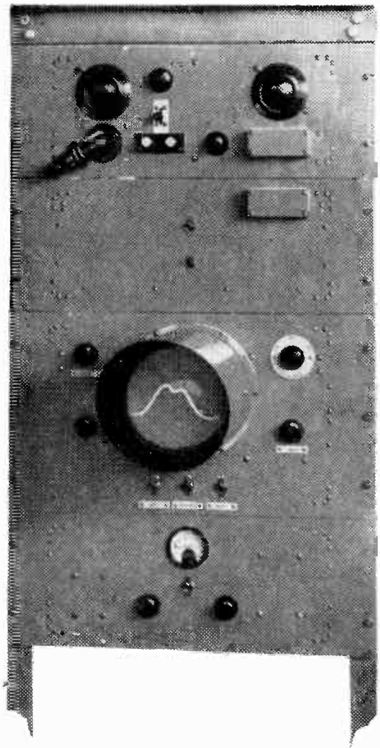
which enables the maximum capacity to be 10,000 $\mu\mu$F while the minimum is very small.

Part of the exhibit by the Post Office Engineering Research Station is an automatic recording level indicator, for measurements on lines such as are used for international relays of broadcast programmes. The transmitting equipment at one end of the line first sends out a preliminary " start " signal (1,300 c/s for $1\frac{1}{2}$ secs.) and then transmits the output of an oscillator of constant output but continuously varying frequency from 30 to 10,000 c/s (the frequency is varied linearly with time up to 100 c/s and then logarithmically up to 10,000 c/s). At the receiving end there is an amplifier feeding a rectifier and visual indicator, which may be followed by a d.c. amplifier and recording instrument ; the chart of the latter is started by the transmitter's " start " signal, and moves at a predetermined speed, so that the frequency scale is known. The response curve which is thus traced out can be read to about $\frac{1}{2}$db.



Standard Telephones cathode ray unit in which both filament current and HT voltage are derived from a 2-volt accumulator.

The measurement of noise is nowadays of great importance, and one of the best methods of making observations is to convert the sound into electrical energy by means of a calibrated microphone and then make the necessary analysis. In the Western Electric noise measurer the microphone is followed by amplifiers which include an attenuating network such that the response of the whole equipment is similar to that of the human ear, and adjustable gain controls. A heterodynearrangement is employed to enable measurements to be made at any region in theaudio-frequency spectrum, a variable oscillator ("search tone") and filter selecting a band of the desired width (40, 160 or 640 c/s) at the desired position. The output is normally measured on a rectifier type meter, but can be applied to a cathode ray tube for demonstration purposes. For the measurement of electrical interference with wireless reception the Electrical Research Association has developed a receiver which can be adapted to give results in accordance with any of the proposed methods of definition, such as radio-frequency field-strength or audio-frequency output with or without a carrier. Following a radio-frequency amplifier, which uses triode valves to ensure a linear relation between input and output even on strong signals, there is a detector which gives an indication of field strength and may be followed by any desired type of audio-frequency output meter. A screened oscillator is used for introducing a carrier when necessary.



Plessey cathode ray equipment for viewing response curves of filters.

The cathode ray tube is a most valuable tool in all electrical work, and it is perhaps worth mentioning that the Ediswan tube is of the vacuum type, being capable of very high writing speed in consequence, and can be supplied with a white screen. One of the handiest forms of cathode ray oscillograph which has so far been produced is the Standard Telephone portable unit which is completely self-contained. An internal 2-volt accumulator supplies the filament current, and by means of an induction coil and metal rectifier also provides the necessary high-tension voltage. Included in the unit is a single-sweep time base of adjustable speed suitable for audio-frequency wave-forms. Alternatively, of course, an external time-base may be used. The cover forms a cowl over the screen for visual observation, but may be completely removed for photography. The same firm also makes a transient recorder using a high-voltage cathode ray tube and film camera. The transient itself releases the time-base, and after each record the film is automatically moved on.

An interesting use of the oscillograph is for the visual observation of the frequency response curves of radio-frequency filters. The filter or tuned circuit is fed from an oscillator whose frequency is cyclically varied by means of a rotating condenser, and the time-base of the tube is synchronised with this frequency variation. The voltage developed across the circuit is rectified, passed to a d.c. amplifier, and finally applied to the other plates of the cathode ray tube, so that the image on the screen is a curve of response of the circuit against frequency. Examples of this type of apparatus were demonstrated by G.E.C. (in the Research section) and Plessey, the latter using an Ediswan cathode ray tube. The Plessey equipment employs a synchronous motor to drive the oscillator frequency varying condenser, and applies the mains voltage directly as a time-base. This gives a sinusoidal sweep, of which only the central portion is actually used, and the screen is calibrated directly in frequency by means of a highly selective wavemeter which forms part of the apparatus. To eliminate the return trace, a suitable potential is applied to the focusing system of the tube via a commutator on the motor shaft. Part of the Marconi's Wireless Telegraph Co. exhibit is a general purpose cathode ray equipment, comprising a gas-filled tube of 18 cms. diameter in a screen of soft iron with mu-metal inside, a time-base unit, and the necessary power supplies. The time-base is linear, and employs hard valves, so that any frequency up to 150 kc/s can be obtained. A camera unit for roll-film, including a lens and shutter with speeds from 1 sec. to 1/300 sec. slips on in front of the screen, and there is provision for obtaining a single sweep only from the time-base.

Another important item in the Marconi exhibit is equipment for feeding a single side-band and carrier signal to an existing broadcast transmitter.* So that normal electrical filters may be used to eliminate the unwanted sidebands, the modulation is first applied to a carrier of very low frequency; in actual fact the audio-frequency band is split into two sections, components from 50 to 900 c/s initially modulating a carrier of 2.7 kc/s and from 900 to 8,100 c/s modulating a carrier of 24.3 kc/s. The subsequent processes are briefly as follows:

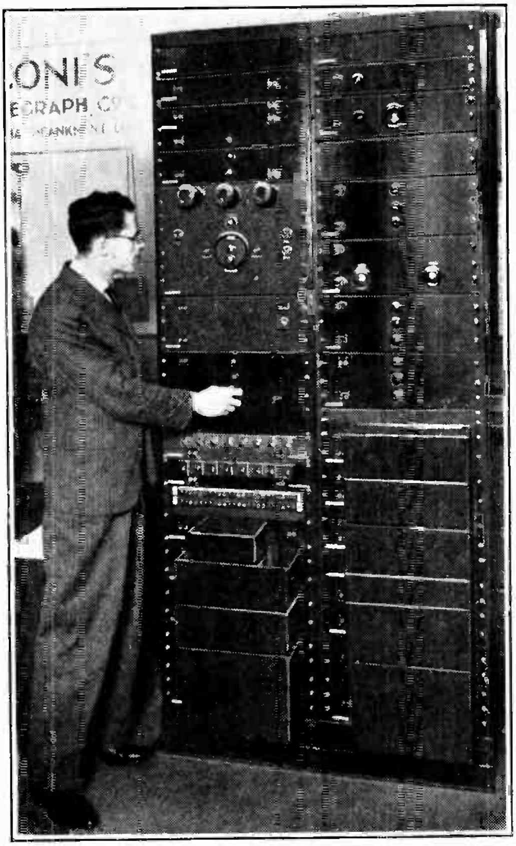
(i) The 2.7 kc/s signal is converted to 24.3 kc/s by modulating a carrier of 24.3—2.7 kc/s and selecting the upper sideband.

(ii) The two sections of modulated signal are now combined, after equalising their levels, to form a complete single sideband signal with a suppressed carrier of 24.3 kc/s.

(iii) If the final transmission is to be on say 200 kc/s, the complete signal is now applied to a further balanced modulator working on a carrier frequency of 200—24.3 kc/s, the output of which will be a single sideband signal on a suppressed carrier of 200 kc/s.

(iv) At this point an attenuator is inserted to serve as control of depth of modulation, and then the carrier is fed in from the master oscillator.

The satisfactory working of this system requires exact relations between the various carrier frequencies, and this is ensured by the manner in which they are derived. The actual oscillators employed are a master oscillator on 200 kc/s, an oscillator for stage (iii) on 200—24.3 kc/s, and one for the 2.7 kc/s carrier. The carrier of 24.3 kc/s is then obtained as the difference frequency between the master oscillator and the stage (iii) oscillator, while the remaining frequency required is both nominally and by derivation the difference between the above derived frequency of 24.3 kc/s and the 2.7 kc/s oscillator frequency. The overall response is uniform within 3 db. between 55 and 9,000 c/s, and with the sideband energy 8 db. below the carrier satisfactory reception is possible with ordinary receivers.

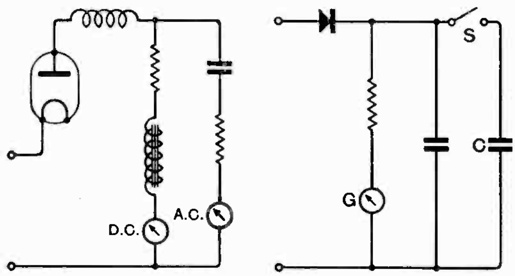


Marconi single side-band and carrier transmission equipment.

In the G.E.C. research exhibit there is a modulated signal generator employing a heptode as modulated amplifier and feeding a cathode ray tube to show the final modulated wave-form. As an alternative

*For a full account of this equipment, see "Marconi Review," No. 50 (Sept.-Oct. 1934), p. 8.

modulation meter for this generator there is the arrangement shown below in (a); the input is rectified by the diode, whose output is divided into d.c. and a.c. components. The d.c., corresponding to the carrier, is measured by the meter in the first branch of the circuit, while the audio-frequency a.c., representing the modulation, is measured by the meter in the second branch. The ratio of the two gives depth of modulation, and if the carrier be adjusted to a standard value, the a.c. meter can be directly calibrated in percentage modulation. Another modulation meter in the research section, shown by Mr. D. A. Bell, has in the simplest case



Circuits of modulation meters exhibited in the Research Section (a) by the G.E.C. Laboratories and (b) by Mr. D. A. Bell.

the circuit shown above in (b). With the switch *S* open, the circuit is a simple diode rectifier, such as might be used in a broadcast receiver, so that the d.c. indicated by the galvanometer *G* represents the carrier strength; on closing switch *S* the large condenser *C* increases the time-constant of the rectifier circuit to something above the period of the lowest audio-frequency, so that it no longer follows the modulation. The current through the galvanometer is now proportional to the maximum value which is attained by the input voltage at the crest of a modulation cycle, and from this and the former reading the depth of modulation can be deduced; direct calibration is again possible if the carrier input is set to a standard value. This meter has the advantage of measuring the peak value of the depth of modulation even on a complex wave-form such as speech. Neither of these meters will be satisfactory however if the modulation is distorted; for such cases an instrument is required of the type of the Claude Lyons modulation meter, which rectifies the radio frequency, measures the carrier, and also rectifies the audio-frequency output of the first rectifier in either sense. It is thus possible to measure the extent of modulation both upward and downward from the mean value.

For the purpose of exploring the sound pressures in the mouthpiece of a telephone microphone, the Post Office use a "probing microphone" in which the moving element is placed at some distance along an "infinite" tube whose opening is placed at the point where the sound pressure is to be measured. (Actually the tube behind the microphone proper is a long length coiled into a spiral.) Another "conduit" microphone, designed by Mr. P. W. Willans, is exhibited by Muirhead. In this case the effect of an "infinite tube" is obtained by filling the length of tube behind the actual microphone with absorbent material so that there is no reflection; a much shorter length of tube can then be used. The same instrument may conversely be used as a reproducer, and with a stethoscope attachment the sound channel is continued uniformly up to the ear. Demonstration with these two units showed a remarkably realistic transmission of both speech and transients over the system.

Also designed by Mr. P. W. Willans and made by Muirhead is a series of audio-frequency transformers using mu-metal cores and fitted with efficient magnetic screening. An interesting design is a choke of 700 henrys when carrying 5 mA, which is obtained by using a mu-metal core with an air-gap.

As an alternative to the mercury vapour relay tube, there are now Ediswan tubes with inert gas fillings. These have similar current ratings to the mercury types, but will work in time-base and similar circuits up to 60,000 c/s. Their only disadvantage is that after a reliable life of 500 hours or so there may be a tendency for the gas to "clean up," causing erratic working. Another application of gas filling is to extra high tension rectifiers; a valve on the G.E.C. research stand is capable of passing 1 amp. peak and withstanding 100 kv. reverse voltage. It is an air-cooled anode type with metal to glass seal, and the power loss is only 20 watts at full load. At the other extreme in valve design are the Marconi "Midget" valves consuming 0.1 amp. at 1 volt in the filmaent, which are intended for deaf-aids and miniature portable receivers. As an alternative to valves for high-tension rectification there are metal rectifiers; in the Research section there is an electron diffraction camera which is run from a Westinghouse full-wave rectifier delivering 50 kv.

For moderately high voltages of 1,000 to 2,000, such as are used for cathode ray tubes, there are some new Dubilier oil-immersed condensers. These use paper dielectric immersed in oil, instead of impregnated with wax, and are considerably less expensive than the older type.

Among meters mention should be made of the rapid thermal instruments produced by Ernest Turner; by using contact thermojunctions and extra light instrument movements the time lag usually associated with thermal instruments has been greatly reduced. Another convenient instrument is the Cambridge "Pot" vibration galvanometer; it is constructed for use only at one particular frequency, and is as compact and convenient in use as the d.c. "Pot" galvanometer. The latter is also supplied mounted in a metal box as a reflecting instrument, complete with lamp and scale, under the title of "Spot" galvanometer; there are actually two scales, so that it may be used with the length of the box either horizontal or vertical.

A Magneto-striction Echo Depth Recorder

Paper by A. B. Wood, D.Sc., F. D. Smith, D.Sc., A.M.I.E.E., and J. A. McGeachy, B.Sc., read before the Wireless Section, I.E.E., on January 2nd, 1935.

Abstract

THE echo-sounding apparatus described in the paper was designed to meet a definite requirement not met by any system then in existence, viz.: a continuous record of the depth of water beneath a survey motor-boat of draft about 2ft., travelling at full speed. A depth-range of 0 to 200ft. was specified, with an accuracy of 1ft. The first attempts were made with a modified form of the Admiralty pattern depth-sounder of sonic type, difficulties with which led to the development of the high-frequency magneto-striction system described in the paper.

The general arrangement is illustrated diagrammatically in Fig. 1. Two magneto-striction oscillators, a transmitter and a receiver, are mounted side by side in water-filled tanks and fitted in a chosen position in the motor-boat. The transmitter is excited into resonant vibration at regular intervals by impulses timed to synchronise with the traverses of the recording point across the record.

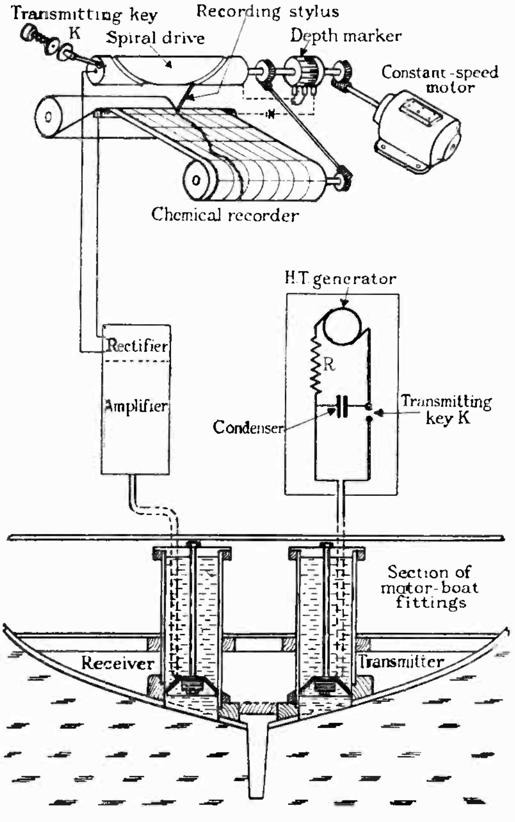


Fig. 1.—*Magneto-striction echo depth recorder. General arrangement.*

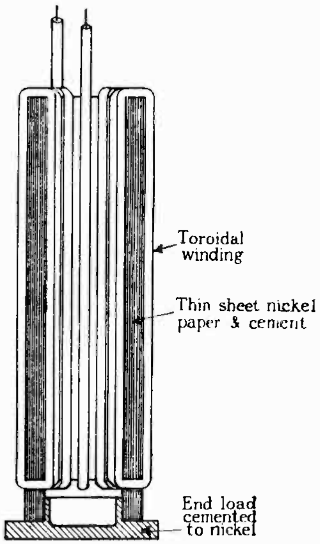


Fig. 3.—*Cylindrical scroll-type oscillator.*

While the sound impulse is travelling from transmitter to receiver via the sea-bed the recording point has travelled a corresponding distance from left to right of the paper, and marks are given on the paper corresponding to the incidence of the transmitted impulse and echo respectively.

After a brief discussion of the principles of magneto-striction, the authors decide that nickel of ordinary commercial purity appears to be the most suitable material for the purpose. They then proceed to describe three different designs of magneto-striction oscillator developed for the purpose of the echo sounder. The first of these, the cylindrical scroll type, is illustrated in Fig. 3. The core is constructed by winding tightly on a mandrel long strips of nickel sheet and thin paper coated with cement, the hollow cylinder then being consolidated by baking. A load attached to one end serves to tune the oscillator, which is found to be sufficiently resonant mechanically and exhibits good magnetostrictive properties at supersonic frequencies. The winding is of 10 turns of low-resistance wire wound toroidally round the cylinder as shown. The second, or ring type of oscillator, is illustrated in Fig. 4, this comprising a cylindrical pile of annular nickel rings.

A series of equidistant holes spaced round the periphery of the stampings accommodates the toroidal winding and leaves the sound-emitting surface, *i.e.*, the edge of the stamping, free from obstruction. The circular magnetisation results in a small change of diameter of the magnetised ring, the amplitude of the change reaching a maximum value when the frequency of the current coincides with f, the fundamental radial frequency of the annulus. To present sound emission in opposite phase from the inner cylindrical face, the latter is covered with a layer of rubber mousse. The third, or strip oscillator is illustrated in Fig. 5. The thin nickel stampings are rectangular in shape and consist essentially of two nickel strips connected by two tuning legs. The longitudinal members which connect the tuning legs may be regarded as loads and the legs as springs. By varying the length and width of the legs and the depth of the end loads any desired frequency can be obtained. The rectangular nickel stampings are insulated from each other and mounted to form a rectangular block of the required size. The magnetising coils are wound round the tuning legs, which form part of the closed magnetic circuit. The edges of the stampings constitute the active sound-emitting surface in contact with the water, the opposite vibrating edges being screened by rubber mousse.

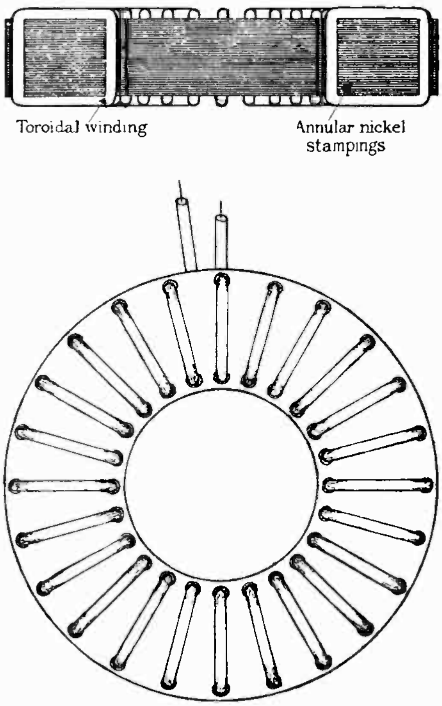


Fig. 4.—*Ring-type oscillator.*

In order to obtain sufficient directional effect the oscillators, more particularly the first and second types, must be mounted in some form of reflector, and the complete mounting in conical reflectors is illustrated in the paper.

The oscillators may be used either for transmission or reception, but it is more convenient, particularly in very shallow water, to use independent transmitters and receivers. Methods of existing resonant high-frequency vibration in the transmitter are conveniently described as (*a*) damped impulse and (*b*) continuous wave. The first is illustrated in Fig. 8, where a condenser C is charged through a current-limiting resistance R from a voltage V, the key K being then in position 1. At a pre-determined time the key switches over to position 2 and the condenser discharges through the low resistance winding of the oscillator, giving a heavily damped high-frequency alternating current in the oscillator circuit. The frequency and amplitude are given approximately by the usual relations between capacity, inductance and resistance. Cathode-ray oscillograms illustrating the current-discharges are given in the paper.

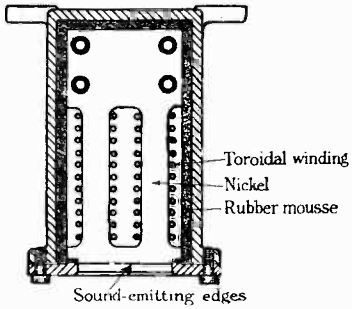


Fig. 5.—*Section through strip oscillator.*

The C.W. method of generation is illustrated in Fig. 12, the short heavily damped train being replaced by a short "dot" lasting about 0.02 second. In this case it is of advantage to magnetise the nickel oscillator by means of an auxiliary direct current supplied via h.f. chokes. The superposed a.c., adjusted to the resonant frequency of the oscillator, is obtained from a valve generator

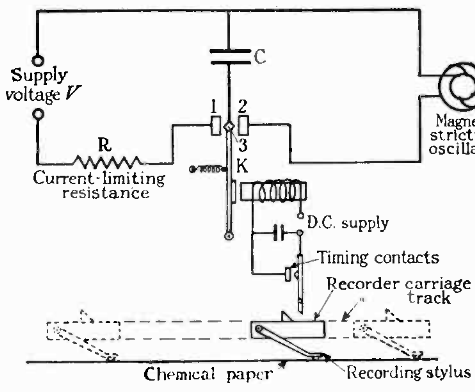


Fig. 8.—*Damped-impulse transmission.*

and the transmitting key now connects the a.c. supply for the required short time.

The receiver is identical in construction with the transmitter and both may be mounted side by side in the bottom of the ship (as shown in Fig. 1) without risk of serious interference by direct sound. The sensitivity of the receiver depends on its initial state of magnetisation. Since the magnetic circuit through the nickel is closed, any residual magnetisation may be regarded as "permanent." This process is effected by passing a large current momentarily through the toroidal winding, after which the receiver retains its sensitiveness. Receiver and transmitter must be of the same frequency and it is therefore usual to assemble both from the same batch of nickel stampings. The small voltages from the receiver are amplified by means of a step-up transformer with tuned secondary winding which is joined to a resistance-capacity amplifier of conventional design. The output circuit has a step-down transformer feeding through a bridge-connected copper-oxide rectifier into the recorder, the d.c. from which passes through the platinum recording stylus (positive) and the aluminium recording bar (negative) of the chemical recorder, which is seen in Fig. 14.

The paper gives details of tests of the apparatus carried out in a laboratory tank and in various vessels at sea. Trials in deeper water are also

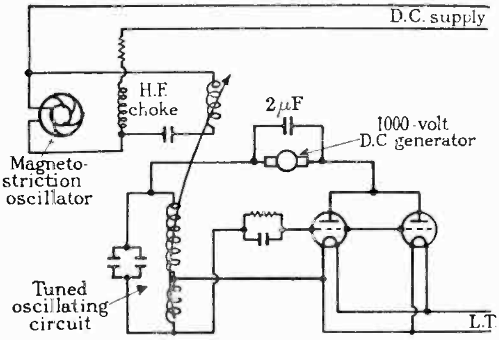


Fig. 12.—*Continuous-wave transmission.*

described, *i.e.*, up to 1,000 fathoms. A record from a commercially made model of the apparatus is shown in Fig. 23.

The paper concludes with a general discussion of the subject, dealt with under the headings (*a*) Requirements of Echo-sounding Apparatus; ranges of Depth Sounding, (*b*) Choice of Position of Echo-sounding Apparatus in ships of shallow draft, (*c*) Simplicity and Reliability, (*d*) Directional properties.

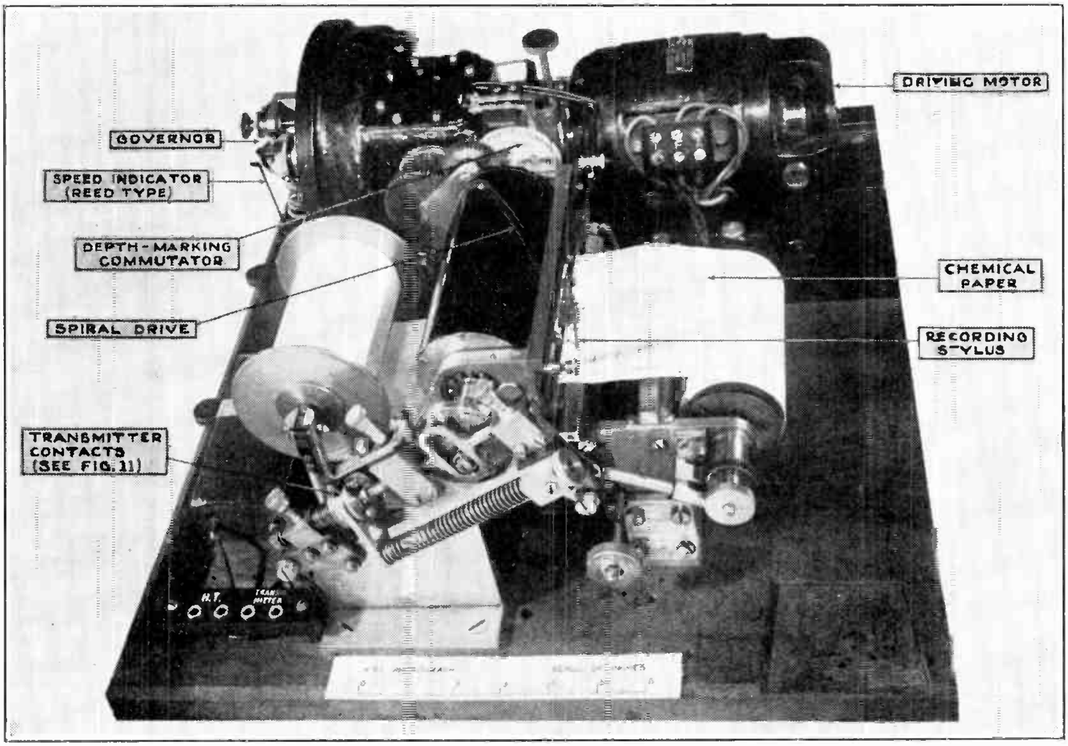


Fig. 14.—*Recorder.*

Demonstration

After the reading of the paper a demonstration of several of the principles of magneto-striction was given. A demonstration of the actual working apparatus, in commercial form, made by Messrs. H. Hughes & Son, was also given and a working record projected on to a large screen as it was made.

Discussion

The discussion was almost entirely nautical in character, being opened by Commander J. A. Slee, followed by Messrs. C. G. Wright, H. Hughes, F. Minter and D. Harley and Capt. F. R. Hutchons.

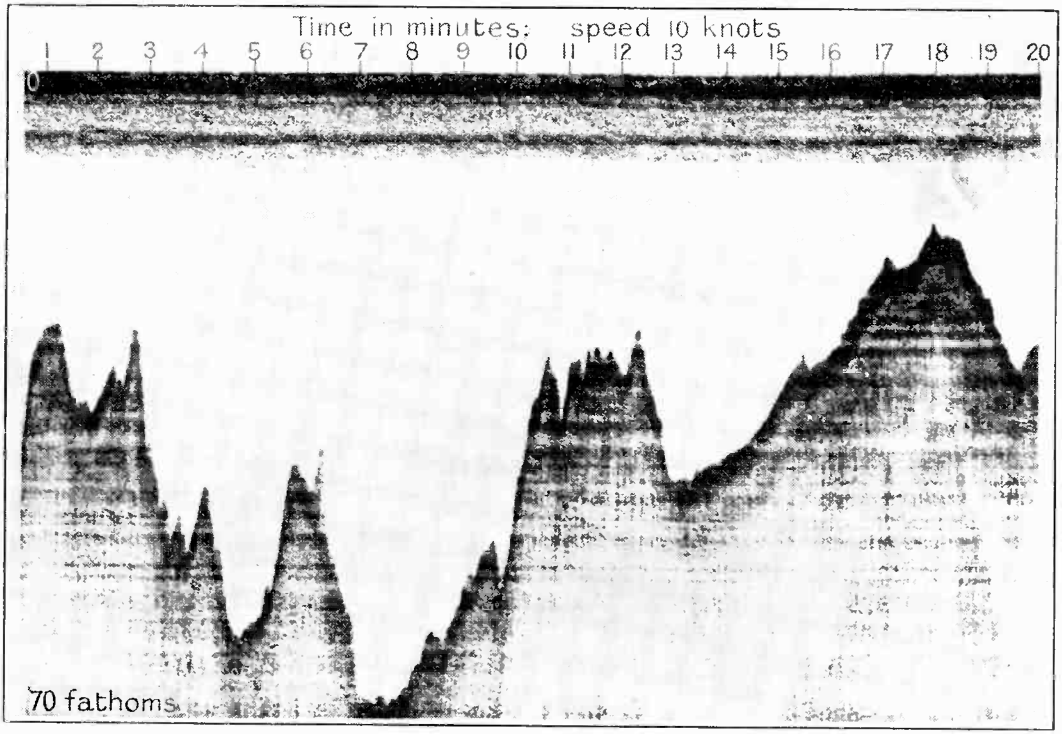


Fig. 23.—*Record made by Grimsby trawler, "Glen Kidston," near Bergen. Damped-impulse transmission.*

Correspondence

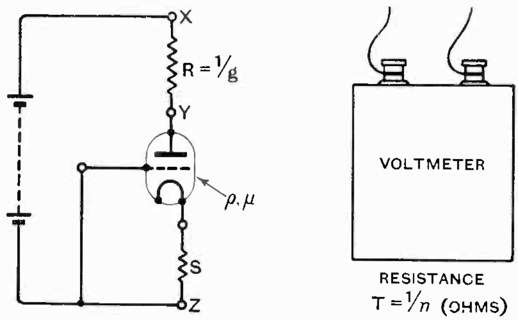
Letters of technical interest are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

Anode Potential Measurements with a Voltmeter

To the Editor, The Wireless Engineer

SIR,—It is frequently desirable to determine the potential of a valve anode under working conditions; as a concrete example, say the p.d. across *YZ* in the figure. The most satisfactory method would, perhaps, be to remove and measure the resistances *R*, *S*, on a bridge, replace them with a milliammeter inserted at *X*, and use Ohm's Law; but this may be inconvenient, involving breaking soldered joints, etc.

It is, of course, possible to connect a voltmeter across *YZ*, giving a reading V_{YZ}; but unless an electrostatic voltmeter be used, this will not give the true working value of the p.d. across *YZ* (say *e*), since the voltmeter current upsets the working conditions, due to the current taken, however small this may be.



The writer has just realised that it is possible to find the true value of e for undisturbed working conditions at the cost of taking two extra readings; in fact:

$$e = \left[\frac{V_{XZ}}{V_{XY} + V_{YZ}}\right] \times V_{YZ} \quad \ldots \quad \ldots \quad (1)$$

where V_{YZ} is the reading of the meter when connected between Y and Z, etc. Subject to the following conditions this equation (1) is exact, not a mere approximation.

(α) The voltmeter must be the same, and used on the *same range* (*i.e.*, instrument resistance the same) for measuring V_{XY} and V_{YZ}. A higher range may be used for V_{XZ} if desired.

(β) The valve characteristics are straight over the relevant portions.

(γ) The H.T. supply is not of high enough internal resistance to alter appreciably in p.d. due to the presence of the voltmeter.

(β) is usually true, even if a screen-grid be considered in place of the anode.

(γ) If not true, usually produces negligible error, with any reasonable meter and H.T. source.

The proof of equation (1) is, as follows:

The figure sufficiently explains the resistances (and conductance = 1/resistances), note that for brevity R includes the anode load and the decoupling resistance.

v_{XY}, etc., is the p.d. across XY (in general different for the three cases considered), a capital V is used to denote the voltmeter reading in each case, *i.e.*, *when meter is connected across XY (and then only)* $v_{XY} = V_{XY}$. But in accordance with assumption (γ) $v_{XZ} \equiv V_{XZ}$ always.

In all Cases the valve electrode potentials to cathode are $v_a = v_{YZ} - Si_a$ and $v_g = -Si_a$, where i_a = anode current, and the valve equation is:

$$\rho \delta i_a = \delta v_a + \mu \delta v_g$$

Integrating:

$$\rho i_a = v_a + \mu v_g + K$$

$$\rho i_a = (v_{YZ} - Si_a) - \mu S i_a + K$$

$$\therefore [\rho + S + \mu S]\, i_a = V_{YZ} + K,$$

or if we write

$$\beta = 1/(\rho + S + \mu S)$$

$$i_a = \beta v_{YZ} + \beta K \quad \ldots \quad \ldots \quad (2)$$

Case I.—Voltmeter connected across XZ.

$$V_{XZ} = v_{XY} + v_{YZ}$$

$$= Ri_a + v_{YZ}; \text{ or on multiplying by } g = 1/R$$

$$gV_{XZ} = i_a + gv_{YZ}$$

$$= [\beta v_{YZ} + \beta K] + gv_{YZ}, \text{ on using (2)}$$

$$(\beta + g)v_{YZ} = gV_{XZ} - \beta K$$

But in this case, v_{YZ} is the true working potential across YZ sought, $v_{YZ} = e$

$$\therefore \quad e = \frac{gV_{XZ} - \beta K}{\beta + g} \quad \ldots \quad \ldots \quad (3)$$

Case II.—Voltmeter connected across YZ.

Meter current is now $v_{YZ}/T = nv_{YZ}$, and current in R is $i_a + nv_{YZ}$

$$\therefore v_{XY} = R[i_a + nv_{YZ}]$$

But $V_{XZ} = v_{XY} + v_{YZ} = R[i_a + nv_{YZ}] + v_{YZ}$

or on multiplying by $g = 1/R$

$$gV_{XZ} = i_a + nv_{YZ} + gv_{YZ}$$

$$= [\beta v_{YZ} + \beta K] + nv_{YZ} + gv_{YZ}$$

(using equation 2)

$$\therefore (\beta + g + n)v_{YZ}$$

$$= gV_{XZ} - \beta K. \text{ But in this case } v_{YZ} = V_{YZ}$$

$$\therefore V_{YZ} = \frac{gV_{XZ} - \beta K}{\beta + g + n} \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

Case III.—Voltmeter connected across XY.

i_a = (current in R) + (current in meter).

$$i_a = v_{XY}/R + v_{XY}/T = (g + n)v_{XY}$$

But $V_{XZ} = v_{XY} + v_{YZ}$, and on muliplying by β

$$\beta V_{XZ} = \beta v_{XY} + \beta v_{YZ}$$

$$= \beta v_{XY} + (i_a - \beta K) \text{ (using equation 2)}$$

$$= \beta v_{XY} + [g + n]v_{XY} - \beta K$$

(using above value of i_a)

$$\therefore (\beta + g + n)v_{XY}$$

$$= \beta V_{XZ} + \beta K. \text{ But in this case } v_{XY} = V_{XY}$$

$$\therefore \quad V_{XY} = \frac{\beta V_{XZ} + \beta K}{\beta + g + n} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

Dividing equation (3) by equation (4)

$$\frac{e}{V_{YZ}} = \frac{\beta + g + n}{\beta + g} \quad \ldots \quad \ldots \quad (6)$$

Adding equations (4) and (5)

$$V_{XY} + V_{YZ} = \frac{gV_{XZ} - \beta K + \beta V_{XZ} + \beta K}{\beta + g + n}$$

$$V_{XY} + V_{YZ} = \frac{\beta + g}{\beta + g + n} V_{XZ}$$

$$\therefore \quad \frac{\beta + g + n}{\beta + g} = \frac{V_{XZ}}{V_{XY} + V_{YZ}} \quad \ldots \quad \ldots \quad (7)$$

Finally, on substituting (7) in (6), and multiplying the result by V_{YZ}

$$e = \frac{V_{XZ}}{V_{XY} + V_{YZ}} V_{YZ} \quad \ldots \quad \ldots \quad (1)$$

In am not clear if this is new, but at any rate it does not appear to be well known.

Cambridge. C. R. Cosens.

Transmitters on the Same Wavelength

To the Editor, The Wireless Engineer

Sir,—I have read with interest the editorial on the operation of several transmitters on the same wavelength in the December number of *The Wireless Engineer*.

In the B.B.C. the original attempts to achieve a practical form of common wave working in 1926–1929 were made without tuning forks. The relay stations were equipped with LC circuit master oscillators, working on relatively high power and without separating stages.

The first experiment in more accurate synchronisation was made, also in 1926, with the Sheffield and Bradford stations, where tuning forks having a frequency in the neighbourhood of 1,000 cycles were used. These tuning forks had no temperature control, but were made of Invar steel having a low temperature coefficient.

Experiments were carried out driving each station by a separate fork and driving the two stations by one fork by means of a line. In the case of line driving, considerable difficulty was experienced with what was thought at the time to be phase change on the line.

Following these experiments, an attempt was made to operate the Aberdeen and Birmingham transmitters on a common wavelength using separate tuning forks. This was soon abandoned mainly due to the increased interference when stations radiate different programmes. This attempt also served to emphasise the need for temperature control.

The next experiment was conducted in 1928 between 5GB Daventry and Birmingham using, as stated in your editorial, a radio link of one half the carrier frequency. This experiment was undertaken to provide the data required for planning the system of driving all B.B.C. relay stations from forks on a common wavelength and having a common programme. For this experiment the synchronising was quite rigid. The result provided the data that a 5 : 1 ratio of field strength was required for an aurally undetectable change of quality. The percentage modulation used was normal, peaking to about 80 per cent. in both cases, the average modulation being of course considerably lower than this.

It is to be noted that during this experiment all the listening tests were carried out under direct ray conditions, viz. : between Birmingham and Daventry which is a distance of only 40 miles, whereas in the relay station and subsequent systems the interference between one station and another was mostly due to the indirect ray, and therefore was not constant in amplitude.

Following on this experiment, ten relay stations were equipped with tuning fork drives early in 1929. These tuning forks had temperature control, and the frequencies remained constant to about one part in 10^5 and often better. The frequency multipliers for the relay station drives consisted of a series of frequency doublers, each doubler comprising a double wave rectifier, the total frequency multiplication usually employed being 1,024 times. This system was chosen as being the most rigid and the least likely to give trouble due to flexibility or instability. Considerable difficulty had been experienced in the frequency multipliers in the original Bradford-Sheffield experiment, due to the latter.

In 1932, the Bournemouth transmitter was synchronised with the Scottish National transmitter on 288.5 metres, using Invar forks and considerably improved temperature control apparatus. This gave a constancy of temperature of the order of 0.01°C., but despite daily frequency checks and adjustments, the frequencies could not be kept nearer than 1.5 parts in 10^6, resulting in beats of up to 3 per second. Most of the time, however, the beats were in the neighbourhood of 1 per second.

In 1933, the London and West National transmitters were synchronised. The forks in these cases were housed in sealed compartments in which the air pressure was reduced to about 5 cms. of mercury. It was intended that these outfits should follow the N.P.L. design, but their performance was considerably below the stated performance of the N.P.L. apparatus, and it was not possible to get an accuracy of better than about 4 parts in 10^6 without very frequent frequency checks and adjustments. It is interesting to note that the results obtained with this apparatus were inferior to those obtained with the equipment previously installed at Bournemouth and Scottish National, despite the fact that the latter apparatus has no pressure control. The fork maintaining circuit in the latter case was of the Horton type using a single valve.

Experiments were then carried out with line driving, and at first troubles were met somewhat similar to but less severe than those experienced in the original experiments with Sheffield and Bradford. It was noticed, however, that there was a certain amount of line noise present. Previous experience with frequency doublers had shown us that, at any rate with this form of frequency multiplier, any interference on the input of the frequency multiplier which could in any way modulate any of the frequencies in the multiplier was liable to result in a very troublesome phase modulation of the subsequent carrier. It can be shown that if any stage of a frequency multiplier be modulated, then the coefficient of modulation is increased by each stage in the chain of multiplication, and that a very small modulation in an early stage may result in a considerable modulation at a later stage.

It was thought possible that the curious effects which had been observed with line driving were due to the combination of line noise and frequency doublers. Very selective fork frequency band-pass filters were constructed. These filters consisted of three loosely coupled tuned circuits, two of the circuits having a "Q" of the order 100, while the other had a "Q" of the order of 30. It was found that the filters cured the trouble, and at the present time the two transmitters in question are still driven by a line using the filters. Only a severe disturbance on the line, such as an intermittent fault, will cause any audible disturbance.

In connection with the effect of a carrier being phase modulated by any disturbance, the difficulty is that in synchronised working the two carriers and two sets of sidebands are mixed together at the point of reception, and under certain conditions it is possible for a phase modulation to be converted into an amplitude modulation and thus made audible in an ordinary receiver.

Some experiments were carried out using one of the tuning forks as a filter circuit, but this was not found so effective as the electrical filter circuit described above, although it is understood that the Americans have used a tuning fork successfully as a filter. However, very little time was spent on this experiment in view of the success of the electrical filter.

Early in 1934 the Plymouth and Bournemouth stations were synchronised using, again, modern tuning fork apparatus, and the frequency constancy was slightly better than that of the London and West National forks. As these two stations are of low power and situated very close to the areas which they have to serve, it is not justifiable to resort to line driving, and beats of up to 5 per second have not been found objectionable with the amplitude ratios which exist between the interfering and the local signal.

Reverting to the question of line driving, the method does not appear to be as elastic as your editorial would indicate, and considerable improvement in performance can be obtained by using this method.

With regard to Harbich's suggestion that the modulation should preferably be kept down to 30 per cent. or less for such systems, this would be a very attractive thing to do; but it must be remembered that a reduction of peak modulation from 90 per cent. to 30 per cent. is equivalent to a reduction of sideband energy of 9 to 1.

I am of the opinion that unless an accuracy of 1 part in 10^7 can be obtained with not more than one check per day, it is necessary to resort to line driving. There do not appear to be any difficulties in multiplying directly the tone received over a line, and this method is much easier and simpler than controlling the frequency of a local oscillator by a tone incoming from the line. H. L. Kirke.

Research Department,
The British Broadcasting Corporation.
London, S.W.12.

To the Editor, The Wireless Engineer.

Sir,—In my letter as printed on page 23 of your January issue a line has been omitted between the first and second lines at the top of the page. The sentence should run as follows:

"I submit that what we should specify about the relation between two such oscillations is their phase-difference θ, where θ may be defined as that angle which makes $\theta/2\pi n$ the time interval between instants of zero value of the two oscillations, and n is the frequency of the periodic oscillation to which both actual oscillations approximate."

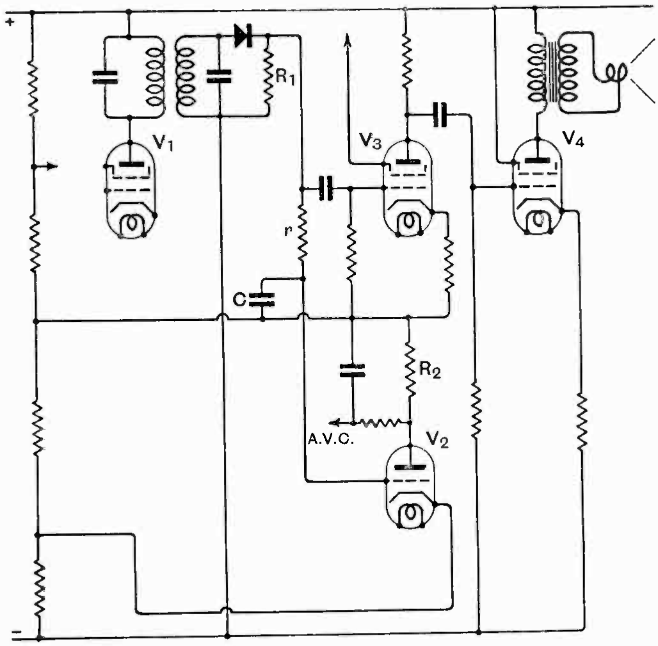
In view of the next sentence of my letter it must, I think, have been subconscious humour which caused the printer to stumble; but now that he has had his little joke I shall be glad if you will publish this correction.

Engineering Laboratory, Cambridge. L. B. Turner.

A.V.C Systems

To the Editor, The Wireless Engineer

Sir,—May I add another scheme to the already numerous ones that Mr. Cocking has reviewed in the recent issues of your Journal?



(*Left*) Fig. 1.

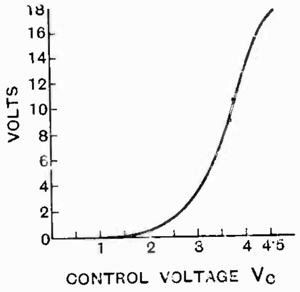


Fig. 2.

Having had to apply myself to these questions since the beginning of 1933, I have adopted the scheme of Fig. 1, after various attempts with more orthodox ways.

The amplified signal is detected by a linear detector (Westector). Thus, is obtained across R_1 an A.C. voltage $V_{eff.}$ corresponding to the modulation, plus a D.C. voltage V_c proportional to the carrier.

$V_{eff.}$ is amplified normally by the valves V_3, V_4. As to V_c, separated from $V_{eff.}$ by r c, it is used to govern V_2 which functions as a D.C. non-linear amplifier. The control voltage which appears across R_2 is nil for weak signals, and increases strongly as soon as the signal exceeds a predeterminated limit (Fig. 2).

Delayed A.V.C. is thus realised without the inconvenience of the disturbing effects of the modulation, and without the necessity of applying a large voltage to the detector.

Of course, this system does not present advantages only. The elimination of "motor-boating," which appears on a powerful carrier, a phenomenon pointed out by Mr. Cocking in connection with other devices, required much patient investigation. Its efficiency is nevertheless remarkable.

Paris. P. Gantet.

Abstracts and References

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PROPAGATION OF WAVES

355. SOME GENERAL PROPERTIES OF THE FORMULAE OF THE MAGNETO-IONIC THEORY.—H. G. Booker. (*Proc. Roy. Soc.*, Series A, 15th Nov. 1934, Vol. 147, No. 861, pp. 352–382.)

An analytical discussion of the properties of quantities involved in the Appleton-Hartree formula for the indices of refraction and attenuation in magneto-ionic propagation—*see* for example Abstracts, 1931, p. 143 (Hartree); 1933, pp. 30 (Appleton), 263 (Taylor) and 495 (Ratcliffe); and 1934, p. 373 (Taylor). The theoretical nature of the transition from quasi-transverse to quasi-longitudinal propagation with increasing friction in the neighbourhood of the point of reflection of the ordinary wave is discussed with the help of the Argand diagram; the changes in the polarisation ellipses near this point are described. The writer gives sets of curves for the squares of the indices of refraction and attenuation as functions of the height [*i.e.*, ionisation] when there is a small constant value of friction; these curves he obtains by the method of "rounding off corners," *i.e.*, by fitting on to the dispersion curves valid when friction is absent, small portions of curves which have the type of curvature which he has deduced for the neighbourhood of the point of reflection of the ordinary wave when some friction is present.

A generalisation to oblique incidence is made, in which each magneto-ionic component is considered on its own merits. It is found to be possible that the two magneto-ionic components may have polarisations of the same sign when they reach the receiver. The nomenclature "ordinary" and "extraordinary" wave is considered to be satisfactory only when incidence is nearly vertical.

356. THE FORMATION OF LONG-DELAY ECHOES [Hals Echoes].—J. Fuchs. (*Hochf:tech. u. Elek:akus.*, November, 1934, Vol. 44, No. 5, pp. 163–166.)

"On account of the great irregularity with which echoes of this type occur, and the consequent great difficulty in observing them, no definite decision between the view of Störmer [toroidal space reflection] and that of van der Pol and Appleton [slowing-down of the group velocity] has yet been come to. In the following treatment the problem is approached from another side, and it is shown that the idea of an ionospheric origin of the long-delay echoes no longer meets with any theoretical difficulties." The argument is based on the fact that in every case the main signal is also found to be present, suggesting that the signal from the transmitter is split into two separate wave trains with differing directions of propagation. This might be due to the vertical radiation diagram of the aerial having maxima at two different angles of elevation, but is more likely to arise from double refraction due to the earth's magnetic field. The writer proceeds on the hypothesis that the ordinary ray is little affected as to direction by the field and, after reflection at a point of steep ionisation gradient, forms the main signal, whereas the extraordinary ray proceeds at a considerably steeper angle to a higher level where the low ionic gradient exists such as would lower the group velocity. Since very steeply incident rays require a high electron density to reflect them, the low gradient would be accompanied by a high density. Fig. 1 shows the highest point of the ordinary ray at A, corresponding to a moderate density and maximum gradient, and that of the extraordinary ray at B, near to a point of maximum density but zero gradient. "The electron density at the top point of the extraordinary ray, calculated on this hypothesis by Appleton's formula from the available data, fits in with propagation theory and definitely locates the action in the F layer of the ionosphere [the writer's calculations give about 2×10^6 electrons/cm³ and a collision frequency of about 0.5/sec.]. Moreover, the other effects observed regarding the long-delay echoes—influence of solar eclipse, multiple long-delay echoes, signal distortion, diurnal period, and dependence on terrestrial magnetism—are explained simply by this theory. The experimentally found value of 0.5/sec. for the collision frequency at the top of the extraordinary ray path may prove useful in improving our ideas on the constitution of the ionosphere."

357. ON THE QUESTION OF THE CONNECTION BETWEEN APPARENT AND TRUE REFLECTION HEIGHTS IN THE IONOSPHERE.—G. Goubau. (*Hochf:tech. u. Elek:akus.*, October, 1934, Vol. 44, No. 4, pp. 138–139.)

Supplement to the paper dealt with in 1934 Abstracts, pp. 549–551. There it was assumed that c was $\frac{1}{3}$; it is here taken as zero. The conclusion is that a consequent difference in results occurs only in a very small frequency range and then only affects the extraordinary ray; the latter is, however, so strongly absorbed in this frequency range that the discrepancy will not be noticed in practice.

358. ANALYSIS OF RECENT MEASUREMENTS OF THE IONOSPHERE.—E. O. Hulburt. (*Phys. Review*, 1st Nov. 1934, Series 2, Vol. 46, No. 9, pp. 822–823.)

Preliminary letter summarising results of recent measurements already referred to in past papers [*see*, for example Abstracts, 1934, p. 374 (Kirby, Berkner and Stuart) and 1932, p. 335 (Hulburt)]. The data are analysed from the view-point that the ionisation is caused by solar ultra-violet radiation, and the following conclusions are reached: (1) the temperature of the ionosphere from about 100 to 200 km above sea-level is constant within about 30° K at a value above 300° K; (2) ionisation in E region conforms with ultra-violet theory equations for ions and ionic recombination loss of 10^{-12}; (3) ionisation in F_1 region is electronic, the loss of electrons by attachment to oxygen molecules being 10^{-4}; (4) ionisation in F_2 region (above F_1) suggests an ionisation wave caused by thermal expansion of the ionised atmosphere at this height during the daytime.

359. MEASUREMENTS OF THE ELECTRICAL STATE OF THE UPPER STRATOSPHERE IN THE POLAR REGIONS.—M. A. Bontch-Bruewitch. (*Russian Journ. of Tech. Phys.*, No. 4, Vol. 4, 1934, pp. 804–812.) *See* 1934 Abstracts, p. 608.

360. THE MUTUAL ACTION OF WAVES [Interaction: "Luxembourg Effect": the URSI International Plan].—R. Mesny. (*L'Onde Élec.*, November, 1934, Vol. 13, No. 155, pp. 429–431.)

361. EXPERIMENTAL INVESTIGATION OF THE PROPAGATION OF SHORT WAVES.—E. Keondjan. (*Izvestia Elektroprom. Slab. Toka*, May, 1934, No. 4, pp. 33–38.)

An account of observations on short-wave propagation carried out by a motor car expedition in the Moscow and Leningrad regions in October and November, 1933. An aerial power of 15 to 20 watts was used with an aerial of 2 m effective height. The operating wavelengths were 62, 76 and 91 m. No field-strength measuring set was available and the signal strength was estimated on the QSA code. Charts are given showing the signal strength on each of these wavelengths at distances from 100 to 1 000 km and at different times of day. The results obtained generally confirm previous observations made both in the U.S.S.R. and abroad with the following two notable exceptions:

(1) On a wavelength of 91 m and at a distance of 400 km the signal was observed to deteriorate from 18 hours onwards and completely fade out at 21 hours (Moscow time). This contradicts the observations made in Poland (Sokolcov and Bylewski, Abstracts, 1933, p. 386), and in the U.S.A. (2) Complete fading was observed at night on all three wavelengths at a distance of 1 000 km. This again contradicts the observations made abroad (Heising, Schelleng and Southworth, *Proc. I.R.E.*, 1926, Vol. 14, p. 613; Edes, Abstracts 1931, p. 145; Dowsett, 1930, p. 115).

In addition, it is pointed out that all three wavelengths show a sudden increase in strength between 11 and 12 hours as a distance of 1 000 km is reached, and this feature, taken in conjunction with the common behaviour referred to above, calls for further investigation.

362. NORTH ATLANTIC SHIP-SHORE RADIOTELEPHONE TRANSMISSION DURING 1932/1933.—C. N. Anderson. (*Proc. Inst. Rad. Eng.*, Oct. 1934, Vol. 22, No. 10, pp. 1215–1224.)

A summary was dealt with in 1934 Abstracts, p. 375. An error in the corresponding charts for 1930/1931 is pointed out in a footnote. Regarding the effects of solar activity and the fact that during individual solar storms of greatly increased activity transmission on the higher frequencies is impaired as well as on the lower, the writer says: "There must, therefore, be some upper limit to the extent to which the transmitting medium can be effected by solar activity without having an adverse effect on transmission on these higher frequencies. Present data are insufficient to determine whether this phenomenon is a function of the degree of ionisation with its accompanying effect upon reflection and absorption, whether it is a function of layer heights, or of other factors resulting from solar activity."

363. SUNSPOT NUMBER AND THE REFRACTIVITY OF THE AIR [No Correlation from Astronomical Evidence].—N. Dneprovsky. (*Nature*, 1st Dec. 1934, Vol. 134, pp. 853–854.) *See* Tilton, 1934 Abstracts, p. 608, who found a correlation.

364. ON THE DISTRIBUTION OF ENERGY IN THE ULTRA-VIOLET SOLAR SPECTRUM AS INFERRED FROM THE PHOTOCHEMICAL THEORY OF THE OZONE EQUILIBRIUM IN THE EARTH'S ATMOSPHERE.—D. Eropkin. (*Phil. Mag.*, November, 1934, Series 7, Vol. 18, No. 121, pp. 838–841.)

The sun's ultra-violet spectrum will correspond to Planck's curve if the ozone mean height is 20 km which accords with the results of Götz, Meetham and Dobson. *See* also Regener (19 of January).

365. ON THE AUTOMATIC REGISTRATION OF THE AMPLITUDE OF DOWNCOMING WIRELESS WAVES. PART I.—F. W. G. White. (*Proc. Phys. Soc.*, 1st Nov. 1934, Vol. 46, Part 6, No. 257, pp. 805–817.)

The Breit and Tuve pulse method is adapted to the measurement of amplitude of the reflected pulses by the use of an optical system to separate the records made by the first and second reflections on the photographic paper. The echoes to be recorded can be selected by magnetic deflection of the cathode-ray beam. Different types of signal fluctuations are discussed. The reflection coefficient is deduced from measurements of the amplitudes of the first and second reflections.

The relation between the reflection coefficient and the frequency may be found by determining the former for a number of different frequencies, a record on each frequency being taken over a period of about 5 minutes to obtain a good average value of the amplitude.

366. A SELF-SYNCHRONISED SYSTEM FOR IONOSPHERIC INVESTIGATION BY THE PULSE METHOD.—O. O. Pulley. (*Proc. Phys. Soc.*, 1st Nov. 1934, Vol. 46, Part 6, No. 257, pp. 853–871.)

A transmitting system for d.c. operation is described, with the necessary modifications for the use of a.c. The method of modulation uses a thyratron alone, without the usual amplifying or auxiliary control valves. Synchronisation is obtained by using the arriving ground signal, which must be somewhat above the general noise-level, to start the time base at the receiver; the pulse controls the amount of drive obtained from the anode circuit of a thyratron. Technical details and diagrams of the circuits are given and the calibration of the time base is described; the latter is impressed permanently on the record. Typical records are given, illustrating the amount of detail available in them.

367. APPARATUS AND REGISTRATION METHODS USED BY THE TROMSÖ WIRELESS EXPEDITION OF THE SOCIETY FOR THE ADVANCEMENT OF WIRELESS, BERLIN.—W. Stoffregen. (*E.N.T.*, October, 1934, Vol. 11, No. 10, pp. 341–350.)

The work of this expedition has previously been referred to in Abstracts, 1934, pp. 259 (Wagner: the pages should be 910–923, not 1–16) and 29 (Hollmann and Kreielsheimer). The present paper gives technical details of the final form adopted for the apparatus. Fig. 1 is a circuit diagram of the photocell amplifier used to record the light of the night sky. Fig. 2 shows a typical record. Fig. 4 is a circuit diagram of the receiver used to measure the directional errors and field-strength variations of European broadcasting stations. A cathode-ray oscillograph was included to measure, in the usual way, the polarisation of the waves received (Fig. 5). A typical record is shown in Fig. 6. Fig. 4 also shows the auxiliary transmitter used for calibrating the receiver for the absolute measurement of field strength.

Fig. 7 shows the circuit used for producing pulses for the range 25–300 m and Fig. 8 that of the transmitter used over this range. Fig. 9 gives a simple circuit for pulse generation, Fig. 10 the circuit used for emission of a constant wavelength of 75 m. Fig. 11 shows the circuit for the emission of waves of length between 6.5 and 20 m, Fig. 12 a control apparatus involving a cathode-ray tube to show the form of pulse emitted, and the wavemeter. Figs. 13 and 14 are photographs of the lay-out. Fig. 15 gives the circuit diagram of the intermediate frequency receiver. Figs. 16–18 illustrate the method of recording with the cathode-ray tube and the type of record obtained.

368. TRANSPORT PHENOMENA IN AN IONISED GAS [Theoretical Discussion].—R. C. Majumdar. (*Zeitschr. f. Physik*, No. 9/10, Vol. 91, 1934, pp. 706–716.)

The gas is supposed to consist of free electrons and ions in a definite condition. The equations of hydrodynamics are applied, with the distribution function for electrons in the absence of an external field, and the generalised Boltzmann equations in the presence of such a field. The collisions between electrons and ions are taken as elastic; the general equation of motion is deduced and two particular solutions are given. The general formulae governing electrical and thermal conductivity, diffusion, and viscosity are obtained, but to obtain definite results an assumption must be made as to the form of the potential field between ions and electrons. A final application is made to the internal state of the stars.

369. THE ION MANTLE EFFECT IN GAS DISCHARGES [Negative Space Charge produces Thread-Like Discharge in Molecular but not in Noble Gases].—A. Güntherschulze. (*Zeitschr. f. Physik*, No. 11/12, Vol. 91, 1934, pp. 724–726.)

370. THE LAW OF CHARGE OF A SPHERICAL PARTICLE IN AN IONISED FIELD.—M. Pauthenier and L. Agostini. (*Comptes Rendus*, 15th Oct. 1934, Vol. 199, No. 16, pp. 705–706.)

It is shown experimentally that the formula found (1932 Abstracts, p. 575) for the value of the charge acquired in time t by a conducting sphere at rest, in a cylindrical ionised field, still holds within 3% when the sphere has a velocity half that of the ions.

371. GROUND ABSORPTION OF WIRELESS WAVES, AND THE ELECTRICAL CONDUCTIVITY OF THE EARTH [Calculation by Sommerfeld's Formula applied to Field-Strength Data of Various Broadcasting Stations: Open-Country Values of σ Larger than City Values: Influence of Transmitting Aerial on Attenuation Measurements].—S. R. Khastgir. (*Current Science*, Bangalore, November, 1934, Vol. 3, No. 5, pp. 199–200.)

372. CHEMICAL FIXATION ON PAPER OF THE RECORDS GIVEN BY ELECTRIC WAVES.—W. Arkadiew. (*Zeitschr. f. Physik*, No. 3/4, Vol. 92, 1934, pp. 194–203.) *See* also 25 and 26 of January.

373. THE APPLICATION OF HUYGHENS' PRINCIPLE TO CYLINDRICAL WAVES.—J. Picht. (*Zeitschr. f. Physik*, No. 11/12, Vol. 91, pp. 717–723: *Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 660–661.)

Huyghens' principle may be applied to cylindrical waves if elementary linear sources are invoked instead of the usual point sources, and if these are supposed to emit elementary cylindrical waves.

374. WAVE PROPAGATION PARALLEL TO THE PLANE SURFACE OF AN ELASTIC SOLID, WITH SEISMOLOGICAL APPLICATIONS.—S. Higuchi. (*Technol. Rep. Tôhoku Imp. Univ.*, Japan, No. 3, Vol. 11, 1934, pp. 12–20 and Plates.) Showing the possible existence, in addition to the Rayleigh wave, of a wave having the horizontal and vertical components of the displacement propagated parallel to the free surface of a semi-infinite elastic solid.

375. A Resistance Transformer and Methods for Controlling the Characteristic Impedance and the Velocity of Propagation along Wires.—Michelson. (*See* 436.)

376. The Electromagnetic Theory of Coaxial Transmission Lines and Cylindrical Shields.—Schelkunoff. (*See* 435.)

377. Determination of the Form of Pulse Waves [Transients on Cables] by the Method of Simultaneous Measurement of Two Voltages.—S. Szpor. (*Arch. f. Elektrot.*, 10th Nov. 1934, Vol. 28, No. 11, pp. 695–702.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

378. Nature of Atmospherics [Average Duration Some Tenths of a Millisecond : Atmospheric consists of Discrete Pulses].—G. H. Munro and H. C. Webster. (*Nature*, 8th Dec. 1934, Vol. 134, pp. 880 and 897.)

The writers have used a time-base of considerably slower period (0.1 sec.) than was used by Appleton, Watson Watt and Herd (*Proc. Roy. Soc.*, Series A, Vol. 111, 1926) or Cairns (*Proc. I.R.E.*, Vol. 15, 1927) and find that an "atmospheric" of the "grinder" type is of longer duration than that found by these writers and consists of a number of discrete pulses, separated by clear intervals; the sizes and separations of the pulses vary irregularly but the observations generally confirm the results of Schonland and Collens (Abstracts, 1934, p. 262), Boys (1933, p. 441: *see* also p. 389) and Halliday (1933, pp. 208–209).

379. Investigations of Discharges [from Positive and Negative Points in Air at Various Pressures] with the Cloud Chamber.—H. Kroemer. (*Arch. f. Elektrot.*, 10th Nov. 1934, Vol. 28, No. 11, pp. 703–710.)

380. Luminescence excited by the Rotation of Mercury in a Glass Bulb containing Impure Neon at Low Pressure [and Deductions regarding Light of Auroras and Night Sky].—Déjardin and Schwegler. (*Comptes Rendus*, 19th Nov. 1934, Vol. 199, No. 21, pp. 1110–1112.)

381. Electric Deflection of Cosmic Ultra-Radiation.—E. Lenz. (*Nature*, 24th Nov. 1934, Vol. 134, p. 809.)

The writer has succeeded in deflecting cosmic radiation by strong electric fields. Preliminary results are given for fields of 700 and 70 000 volts per cm respectively.

382. Correspondence on "The Electrical Conductivity of the Lower Atmosphere produced by the Cosmic Radiation."—H. F. Hess: Lenz. (*Hochf:tech. u. Elek:akus.*, October, 1934, Vol. 44, No. 4, p. 142.) *See* Lenz, 1934 Abstracts, p. 262.

PROPERTIES OF CIRCUITS

383. Contribution to the General Theory of [Passive] Quadripoles and Wave Filters.—K. Dahr. (*Ann. der Physik*, October, 1934, Series 5, Vol. 21, No. 2, pp. 182–212.)

The writer brings the fundamental circuit equations into the canonical form

$$(Z_1 - P)/(Z_1 - Q) = \lambda \,.\, (Z_2 - P)/(Z_2 - Q)$$

(eqn. 5c) where Z_1 and Z_2 are primary and secondary impedances, P and Q "fixed-point" impedances and λ the "transformation ratio": P, Q and λ are the "canonical data" of the quadripole and the solution is given in terms of them. They can be calculated from circuit constants. The secondary current is found in terms of the primary current; the quantity $\Gamma = \pm \sqrt{\lambda}$ is called the "transmission" or "propagation" constant or "transmission operator." The theory of linear equations is applied to prove the *theorem*: when the secondary [output] side is closed by the iterative impedance P, the primary current is the same as when the current source is closed directly by P, and the secondary current is equal to the product of primary current and transmission constant.

§ 2 contains the application of the quadripole equations to wave filters, *i.e.* a finite or infinite series of quadripoles. P and Q are assumed the same for all quadripoles; λ however may vary. The current and voltage at the input terminals of any one of the quadripoles are to be calculated, when the wave filter (of n members) is closed by an impedance Z'' and connected at the beginning to a current source of impedance Z' and e.m.f. $e'(t)$. Multiplication of all the equations (5c) for the sections gives finally (eqn. 23)

$$(Z_1 - P)/(Z_1 - Q) = \lambda_1 \,.\, \lambda_2 \,.\, \ldots \,.\, \lambda_n \,.\, (Z'' - P)/(Z'' - Q),$$

so that the whole wave filter can be regarded as a quadripole with fixed-point impedances P and Q and transformation ratio $\lambda_1 \,.\, \lambda_2 \,.\, \ldots \,.\, \lambda_n \equiv \lambda^{(k)}$. The input current i_{k+1} for the $(k+1)$th section is then given by eqn. 26, in terms of the reflection coefficient G_{k+1} of the load attached to the kth section. Eqn. 29b gives i_{k+1} in terms of G' and G'' (which are given by eqns. 10). Eqn. 31 gives the input voltage v_{k+1} for the $(k+1)$th section. The results are much simplified when $G'' = 0$, *i.e.* the filter is closed by its iterative impedance. This corresponds also to the case when the number of sections is infinite.

The filter properties of the rational wave filter (*i.e.* one which consists of a finite number of circuit elements and whose impedances are therefore rational functions of the frequency) for sinusoidal oscillations of angular frequency ω are discussed in § 3. The filter is also assumed homogeneous, *i.e.* composed of similar sections, and infinitely long. The expression for λ as a function of ω is given by eqn. 21a; the filter is then assumed loss-free. λ can then be written in the form (eqn. 33) $\lambda = (j \,.\, U - \sqrt{W})/(j \,.\, U + \sqrt{W})$, where U and W are real polynomials in ω^2. Fig. 3 shows the general form of $W(\omega)$, when n is even, and Fig. 4 that of $\beta(\omega)$, the attenuation coefficient. These figures demonstrate the filter action of the circuit.

The general method of treatment of transient phenomena with the help of symbolic operators is shortly described in § 4, starting from eqns. 32 for the infinitely long filter. v_{k+1} and i_{k+1} are given as functions of the time by eqns. 35, in terms of the transmission operator $\Gamma(p)$, where $p \equiv d/dt$, and the reciprocal $A(p)$ of one fixed-point operator $P(p)$. The method of finding primary functions of the operators (*i.e.* functions of the time which have the operators as basic integrators) and, from these, the explicit expressions for $v_{k+1}(t)$ and $i_{k+1}(t)$, is then described.

Some applications of the general theory to special classes of wave filters with simple forms of $\Gamma(p)$ are given in § 5. The first is the T- or Π-section filter, to which the general name "three-circuit filter" is given (tripole, in star or delta connection). The form of $\Gamma(p)$ is worked out (eqns. 45, 47). The second is the transformer section, with capacity between the windings. The mathematical evaluation of $\gamma(t)$, the primary function of $\Gamma(p)$, by means of complex integration, is given in detail, with the result in eqn. 56, and the form of the integral operator Γ is given in eqn. 59. $v_{k+1}(t)$ is derived directly by generalising eqn. 56 to the case of k sections and operating therewith on the unit function $H(t)$ (eqn. 60). This equation brings out the formal analogy between propagation through wave filters and along homogeneous cables, with the analysis of the total effect into a series of reflected waves.

A power series development may be used for $\gamma(t)$ when the result is only needed for small values of t; this may be replaced by the development of $\Gamma(p)$ in powers of $1/p$. The voltage $v_{k+1}(t)$ in the case when a sinusoidal e.m.f. is suddenly switched on to the filter is calculated as an example of the procedure. Asymptotic methods may be employed to calculate the result for larger values of t; eqn. 74 shows that this has the character of a sum of decreasing sinusoidal oscillations with limiting frequencies ω_1 and ω_2 (the characteristics of the filter used).

An extended investigation of the general properties of $\Gamma(p)$ is given in § 6. An appendix gives the derivation of the expressions for primary and secondary currents by successive approximation (repeated application of Thévenin's theorem) and the definition and properties of the "three-circuit filter," referred to above.

384. Contribution to the Theory of the Two-Circuit Band Filter for I.F. Stages.—Kafka. (*See* 414).

385. Some Aspects of Parallel Resonant Circuits [Analysis of Conditions in which Antiresonance gives Maximum or Minimum Impedances].—L. M. Craft. (*Proc. Inst. Rad. Eng.*, October, 1934, Vol. 22, No. 10, pp. 1211–1214.)

"In general, the frequency for which the maximum impedance occurs is different from the resonant frequency where the term resonance is used to mean unity power factor. The frequency of maximum impedance has been called antiresonance by K. S. Johnson and others. It was first observed some time ago that for certain circuits, having resistances of relatively large magnitude in both arms, the impedance was a minimum instead of a maximum. . . . It is the purpose of this paper to discuss the conditions for which the impedance is a minimum, and for purposes of discussion it is proposed that the minimum impedance shall also be called antiresonance." After the algebraic work and the graphical representation of the results, the writer gives experimental curves: "it is noticed that in the case of minimum impedance the resonance curve is not sharp and so would not be useful in the same sense as a series resonant circuit."

386. Discussion on "Resistance Tuning."—Cabot. (*See* 415.)

387. On the Theory of "Kipp" [Relaxation] Oscillations [Unified Theory for "First-" and "Second-Type" "Kipp" Oscillations].—F. Klutke. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 622–624.)

"Two externally quite different phenomena are known as 'kipp' or relaxation oscillations. As representatives of the two groups I would cite the periodic charging and discharging of the condenser C in the 'kipp' generator shown in Fig. 1 [with glow-discharge tube] and the more or less sinusoidal oscillations produced by a valve oscillator. . . . That there can be a connection between the two phenomena may be deduced from the fact that the oscillations of the 'kipp' generator are synchronisable—*i.e.* that under the influence of an external a.c. voltage of period τ_0 they can (under certain conditions to be defined later) take up the frequency τ_0, $2\tau_0$ or $n\tau_0$ (n = positive whole number); while a valve oscillator can be 'pulled-in' by an external a.c. voltage in the neighbourhood of its own natural frequency—*i.e.* it can be synchronised; sub-harmonics, however, do not occur as with the 'kipp' generator."

To obtain a unified theory for the two types of phenomenon (which he calls "kipp oscillations of the first and second types") the writer points out that the first-type generator and its mechanical and electrical analogues (Fig. 2) consist essentially of a source of energy, of limited productiveness, and an energy-storing component which on reaching a certain fullness is discharged by some kind of switch (*e.g.* the glow-discharge tube), whereupon the process is repeated. The second-type systems, analogous to the valve oscillator, differ from this in that the energy-storing component possesses a natural frequency. Starting with the first-type system (Fig. 3, theoretical circuit) he obtains as the fundamental equation for the unified theory equation 3, $U_0 = J.R(V) + U$, where $R(V)$ is the suddenly-changing resistance such as a Wagner (induction-coil) hammer. From this he obtains for the first-type system the equation 2a, comparable with Hudec's equation 2. For the second-type system the fundamental equation yields equation 5, whose solutions agree, at least qualitatively, with van der Pol's solutions of equation 1. In the final section the writer applies his unified theory to the case of a 'kipp' generator in which $R(V)$ jumps from infinity to zero. The resulting diagram agrees remarkably well with the experimental results on the synchronisation region, found in 1927 by van der Pol and van der Mark.

388. THE TRANSITORY RÉGIMES AT THE EXCITATION OF AN OSCILLATING CIRCUIT CONTAINING AN IRON-CORED INDUCTANCE [and the Factors determining Which of the Two Alternative Permanent Régimes will be set up].—E. Rouelle. (*Comptes Rendus*, 19th Nov. 1934, Vol. 199, No. 21, pp. 1103–1105: Errata, 26th Nov. 1934, No. 22, p. 1260.)

389. A THEORY OF MAGNETIC CIRCUITS.—V. I. Kovalenkoff. (*Izvestia Elektroprom. Slab. Toka*, May, 1934, No. 4, pp. 38–49.)

Based on the analysis of the magnetic properties of the circuit as functions of the quality of iron and the form of the circuit. The analysis shows a large group of circuits whose reluctance/flux variation may practically be neglected. Active quadripole theory is applied to these, and formulae are found for the distribution of magnetic energy over magnetic conductors and leakage paths, and for the attracting force on the armature. The design principles for electro-magnetic relays are given. The paper was begun in the previous issue of the journal (No. 3) and is to be completed later.

390. CALCULATION OF TRANSIENT PHENOMENA [in D.C. Circuits] WITH VARIABLE INDUCTANCE.—J. Hak. (*Arch. f. Elektrot.*, 20th Oct. 1934, Vol. 28, No. 10, pp. 664–670.)

The variable inductances considered are relays or electromagnets. The differential equations for various types of switching are solved in the form of power series, and graphs of the solutions are given. A note on graphical integration is added.

391. GRID MODULATION AND HETERODYNE RECTIFICATION.—M. P. Doluhanov. (*Izvestia Elektroprom Slab. Toka*, May, 1934, No. 4, pp. 19–27.)

A theoretical comparison of the system in which a frequency ω_1 is (*a*) modulated by, and (*b*) heterodyned with, a frequency ω_2 in the grid circuit of a valve. Each case is examined separately assuming the valve characteristic is, firstly, of the form

$$i_a = a_0 + a_1 e_g + a_2 e_g^2 + a_3 e_g^3 + \ldots$$

and, secondly, a straight line; the study is general, including the modulation of one frequency by another of the same order, and the heterodyning of widely different frequencies.

The following main conclusions are reached:—(i). *Assuming curved characteristic.* Theoretically, modulation can take place for any value of ω_1/ω_2, and heterodyne detection is merely a particular case in which the required frequency is selected in the output circuit. (ii). *Assuming linear characteristic.* Modulation is only possible when ω_1/ω_2 exceeds a certain value; heterodyne detection is not a particular case of grid modulation and when both ω_1 and ω_2 are high frequencies, $\omega_1 + \omega_2$ can not be selected in the output circuit.

392. AN EXTENSION OF THE THEORY OF THREE-ELECTRODE VACUUM TUBE CIRCUITS.—S. A. Levin and L. C. Peterson. (*Bell. S. Tech. Journ.*, October 1934, Vol. 13, No. 4, pp. 523–531.)

Authors' summary:—The relations between input voltage and output current of the three-electrode vacuum tube are discussed when arbitrary feed-back is present between grid and plate circuits. Fundamental assumptions are that the amplification factor is constant and conductive grid current absent. The relations developed in the present paper are generalisations of those given by J. R. Carson (*Proc. Inst. Rad. Eng.*, April, 1919, p. 187). The use of the theory is illustrated by application to a simple modulator circuit. The numerical calculations in this case indicate that neglecting the effects of interelectrode capacitances may introduce serious errors.

393. REGENERATION THEORY AND EXPERIMENT [Confirmation of Nyquist's Stability Criterion: Extension to Non-Linear and Negative-Impedance Cases].—E. Peterson, J. G. Kreer and L. A. Ware: Nyquist. (*Proc. Inst. Rad. Eng.*, October, 1934, Vol. 22, No. 10, pp. 1191–1210.) For Nyquist's paper *see* 1932 Abstracts, p. 279.

394. THE ADJUSTMENT OF PHASE-PURE REACTION IN SELF-EXCITING SYSTEMS [Experimental Criterion].—W. von Philippoff. (*E.N.T.*, September, 1934, Vol. 11, No. 9, pp. 310–313.)

The writer considers an oscillating circuit containing an electromagnet and a triode and gives the corresponding equations and vector diagrams. He finds theoretically that the phase angle for the anode current relative to the movement of the iron core of the electromagnet can be reduced to zero by altering a variable condenser in the circuit of the electromagnet. Measurements at various frequencies confirm this. The principle can also be applied to valve oscillators; a relation for determination of the damping in the oscillating circuit can be deduced.

395. GRAPHICAL CALCULATION OF LINEAR AND NON-LINEAR RETROACTION.—H. Bartels. (*E.N.T.*, September, 1934, Vol. 11, No. 9, pp. 319–329.)

The principle of the method is the construction of a set of characteristics of a "substitute valve" from the retroaction conditions of a circuit; the behaviour of this valve in a circuit without retroaction is then equivalent to that of the original valve in the circuit with retroaction. Only retroaction through phase-free resistances is considered.

The (anode current i_a, anode voltage e_a) set of characteristics with the grid voltage e_g as parameter is assumed known, also the retroaction condition (*i.e.* for given i_a and e_a, an amount Δe_g of grid voltage is coupled back, and a new grid voltage $e'_g = e_g - \Delta e_g$ is obtained). This new voltage e'_g is calculated for all points of the (i_a, e_a) field and lines joining equal values of e'_g form the characteristics of the "substitute valve." It is only assumed that the grid resistance of the valve is either large compared with the internal resistance R_i of the current source or has a definite relation to R_i. The characteristic fields are shown for retroactions *via* anode voltage $[\Delta e_g = f(e_a)]$, anode current $[\Delta e_g = f(i_a)]$, and (anode voltage, anode current) $[\Delta e_g = f(e_a, i_a)]$. Some applications are also given, *e.g.* improvement of the efficiency of the valves, diminution of the distortions produced by the external circuit. General remarks on the effect of non-linear retroaction and the linearisation of the valve are made; the special case of a constant amplification factor is considered. Almost any characteristic field can be arranged for the "substitute valve" by the use of suitable retroaction, and the amplification of the valve may be greatly increased without the occurrence of instability.

396. ON THE THEORY OF THE "PULL-IN" (Mitnahme) EFFECT IN RETROACTIVELY COUPLED RECEIVERS.—R. V. Lvovitch. (*Izvestia Elektroprom. Slab. Toka*, July, 1934, No. 6, pp. 21–26.)

The limiting "pull-in" zones of tuned-grid and tuned-anode receivers are investigated. In the former, the limiting phase difference between the e.m.f. in the tuned circuit (the internal e.m.f.) and that induced by the external e.m.f. depends on the amplitude ratio of the two e.m.fs and is never equal to 90°. Only in the one particular case of the induced e.m.f. being very small in comparison with the internal one does the phase difference approach 90°, and—as follows from the analysis—becomes exactly 90° when the induced e.m.f. is zero: *i.e.*, in the absence of any external e.m.f. In receivers with tuned-anode circuit, on the other hand, the phase angle is actually equal to 90°. The writer's deductions are illustrated by vector diagrams and curves. The two types of receiver are compared as to the breadth of the "pull-in" zones.

397. SPECIAL CASES OF THE MUTUAL INDUCTANCE BETWEEN CIRCLES, WITH SOME PRACTICAL APPLICATIONS.—F. H. Llewellyn. (*Proc. Phys. Soc.*, 1st Nov. 1934, Vol. 46, Part 6, No. 257, pp. 824–840.)

This paper discusses the general formula for the mutual inductance between two coaxial circles (*see* Nettleton and Llewellyn, 1932 Abstracts, p. 357) with special reference to lines of isomutual inductance, lines of constant inductance gradient, the effect of multiplicity of layers, the mutual inductance between twin coils and a solenoid, the design of a solenoid to measure an angle, and the measurement of the absolute moment of a magnet. Experimental curves illustrating and confirming the theoretical discussion are given.

TRANSMISSION

398. ON THE THEORY OF THE BRAKE-FIELD CHARACTERISTIC [Extension of Below's Theory].—E. Schulze. (*Hochf:tech. u. Elek:akus.*, October, 1934, Vol. 44, No. 4, pp. 118–125.)

"All modern methods of generating ultra-short waves make use, in one form or another, of the Barkhausen brake-field method. The so-called brake-field characteristic [anode current in a triode plotted against anode voltage as the latter is raised from zero, the grid being kept at a high positive potential] has thus assumed a great interest. It is, moreover, the foundation of every theory for valves with a grid for dispersing the space charge. An exact theory of this characteristic is therefore desirable." Below's theory (Abstracts, 1929, p. 44: *see* also 1934, p. 325) is based on certain assumptions. It agrees, so far as the upper part of the characteristic is concerned, with measurements in the case of low heating, if no secondary electrons appear at the anode. For the lower part, the Maxwellian velocity distribution becomes important, and the Below theory requires modifying. Since it is here that the greatest slope occurs, a knowledge of the shape is of great practical importance. Also the theory has to be extended to cylindrical electrodes, and other extensions and corrections are required.

The present paper deals with these problems and gives experimental confirmation of the theoretical results. The constant C, from Below's formula with the writer's corrections (p. 122), is calculated to have the value 0.475 for a particular valve, and is found experimentally to be 0.46. The case of indirectly heated valves is dealt with. The production of a dip (Fig. 7) in the brake-field characteristic by "true reflection" (deflection of the electrons in the neighbourhood of the anode by the effect of surface atoms) is examined. Incidentally it is shown (p. 121) that the brake-field characteristic gives a much easier and more accurate way of measuring contact potential than the diode characteristic hitherto employed.

399. PLATE SUPLY TO VALVE OSCILLATORS FROM ALTERNATING CURRENT SOURCE WITHOUT RECTIFICATION [for Aural-Type Radio Beacons: Analysis of Half- and Full-Wave Sine Modulation].—A. Plemianikoff. (*Izvestia Elektroprom. Slab. Toka*, May, 1934, No. 4, pp. 27–33.)

400. THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF FREQUENCY- AND PHASE-MODULATED OSCILLATIONS.—F. Lautenschlager. (*E.N.T.*, October, 1934, Vol. 11, No. 10, pp. 357–363.)

The problems are discussed in the light of their application to sound-on-film technique but the mathematical analysis is the same as in the case of a frequency- or phase-modulated wireless transmitter. The distortion of a pure tone by sinusoidal variations in the motion of the film has been discussed by Fischer and Lichte ("*Tonfilm*," Leipzig, 1931, A VII 2) who gave the Fourier spectrum of the "howl" produced by the combination of both types of modulation. This is shown here in Fig. 1a, with the changes produced in it when phase-modulation alone (Fig. 1b) and frequency-modulation alone (Fig. 1c) are considered. The case when the "howl" is itself amplitude-modulated is worked out in §3; the frequencies present are the same as when the amplitude is constant, but their amplitudes are different. The forms of the oscillations for amplitude-modulated "howls" in which the amplitude-modulation differs in phase by 0° or 180°, or ± 90°, from the frequency- or phase-modulation, are shown in Fig. 2; Fig. 3 shows the corresponding Fourier spectra and Fig. 4 the influence exerted on the spectral components of order zero to three by an amplitude-modulation differing in phase by 90° from the frequency-modulation. The spectrum becomes asymmetrical; the acoustic centre is displaced towards the preferred frequencies in the frequency-characteristic of the system. Fig. 5 shows how the amplitudes of the Fourier components approximate to a Bessel function. The Fourier series is given for the case when the frequency of the amplitude-modulation is twice that of the frequency- or phase-modulation. If the modulation functions are not sinusoidal, they cannot be accurately analysed.

The theory was tested experimentally with an apparatus for producing periodic disturbances in the motion of the sound-film. The "howls" were analysed by a simple resonant circuit consisting of variable air condensers and the secondary winding of a transformer, whose primary winding was in parallel with a loudspeaker. Fig. 6 shows the experimental spectra for tones of frequency 426 $\pm n.40$ c/s and gives the corresponding theoretical spectra for comparison; Figs. 7 and 8 show spectra of frequencies $875 \pm n.66\frac{2}{3}$ c/s and $1574 \pm n.66\frac{2}{3}$ c/s respectively. Beats in "tone-colour" are finally shortly considered.

401. THE POWER IN PHASE MODULATION [for Sine and Rectangular Wave Forms].—A. Istrashkin. (*Izvestia Elektroprom. Slab. Toka*, May, 1934, No. 4, pp. 13–18.)

It is shown theoretically that the rectangular wave form is more effective, giving on the carrier frequency 0.81 of the total h.f. power, whereas the sine wave form can only give 0.68. "It seems that the greatest gain is obtained on side frequencies in sine modulation with out-balanced carrier, whereby the total power can be used for reception. The theoretical deductions are still to be proved experimentally."

402. A NEW MODULATION METHOD FOR BROADCASTING STATIONS ["Floating Carrier"].—L. Pungs and F. Gerth. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 609–613.)

Economy by suppression of carrier wave is impracticable for broadcasting on account of the complicated receiver design necessary. On the other hand the full carrier is only needed for detection when the modulation is at its maximum, and a possible economy is obvious if the carrier amplitude is made to vary with the modulation depth (*cf.* Ditcham, 1934 Abstracts, pp. 150–151). Preliminary tests, however, soon showed that the ideal arrangement, with carrier proportional to the depth of modulation, is only practicable for an ideal receiver with a straight-line characteristic passing through zero. Since the majority of broadcast receivers have other characteristics (mostly approximating to the square law) the variation of carrier amplitude must be arranged to suit the receivers. The simplest way of doing this is to give a linear variation but with a definite residual current at zero modulation (Figs. 2–5). The method is applicable to all types of modulation, including the Chireix method involving phase modulation; it can be added to an existing transmitter.

Part III deals with the reception of such signals on receivers with linear and square-law characteristics and with fading compensation. Part IV deals with the economy in power, and Part V gives the results of tests with the old Witzleben transmitter, carried out by the German P.O. and the Broadcasting Company. Even with receivers with a square law curve the difference between the signals and the ordinary type could only be detected if a special very high-quality loudspeaker was used. *See* also next reference.

403. INCREASING THE EFFICIENCY OF BROADCASTING STATIONS [Comparison of New Transmission Methods].—Model. (*See* 568.)

404. A SYSTEM FOR SINGLE-SIDEBAND AND CARRIER BROADCAST TRANSMISSION [developed as Result of Appointment of C.C.I.R. Sub-Committee].—F. M. G. Murphy. (*Marconi Review*, Sept./Oct. 1934, No. 50, pp. 8–15.)

The "split band" method was decided on for stability, ease of reproduction and ease of operation. "A feasible means of producing and transmitting such signals [single sideband and carrier broadcast signals] has been found, and has proved reliable in practice. Typical modern receivers can provide satisfactory quality from these transmissions, provided that the carrier/sideband ratio exceeds a figure between 5 and 8 db. Changes in interference remain unexplored, since transmissions during British broadcast hours were not possible. Change of service area in comparison with normal transmission is still problematical, while transmitter problems were not examined to any extent beyond that necessary for the tests." For a reference to Koomans's work *see* 1934 Abstracts, p. 572 (Harbich).

405. A 500-KILOWATT BROADCAST TRANSMITTER IN AMERICA. (*See* 564 and 565.)

406. THE MEASUREMENT OF HARMONIC POWER OUTPUT OF A RADIO TRANSMITTER.—Honnell and Ferrell. (*Proc. Inst. Rad. Eng.*, October, 1934, Vol. 22, No. 10, pp. 1181–1190.)

The full paper, a summary of which was referred to in 1934 Abstracts, p. 379. "The method may be used to measure subharmonic output from transmitters which employ frequency multiplication in their earlier stages. It may be used to measure spurious power at frequencies not related to the nominal carrier frequency . . . and in making power measurements at the fundamental frequency."

RECEPTION

407. INTERFERENCE FROM INTERNAL COMBUSTION MOTORS AND ITS MEASUREMENT IN THE ULTRA-SHORT-WAVE BAND.—A. Neubauer. (*Hochf:tech. u. Elek:akus.*, October, 1934, Vol. 44, No. 4, pp. 109–118.)

Author's summary:—"From the experiments discussed, using a calibrated receiver ($\lambda = 3.50$–11 m) which is fully described [as are also the difficulties encountered until the super-regenerative receiver was adopted], it is clear that internal combustion motors yield disturbance maxima which, although weak in themselves, are quite capable of causing serious interference. The disturbances propagate themselves not as surges but as free radiation [unlike the usual interference with broadcast and short-wave reception—*see* Larsen, Abstracts, 1932, p. 407, and Alexander, 1932, p. 639].

"Motors of very different types and sizes were tested. The energy of interference increased with the size of the machine, its revolutions per minute and its sparking frequency. The interfering waves vary with the length of the leads and with the distributed machine capacities and self inductances. Small changes in the length of the leads cause displacements of the disturbance maxima. Thus two externally similar machines may behave quite differently electrically and interfere on quite different wavelengths. The interfering band breadth in the case of motors with short leads can be traced right down to the centimetre wave region. In general, the lead oscillates with a shortest wave equal to twice its own length.

"Tests on interference quenching, by the insertion of resistances between 5 000 and 15 000 ohms (according to the size of the machines), gave good results, whereas chokes did not work so well and for the most part only transferred the interference to other wavelengths [Figs. 20 and 21]. Even the most careful screening of the electrical equipment may let through interference, so that the additional damping is recommended to suppress this. For the machines examined the interfering energy was of the order of 10^{-5} w; it decreased with the length of the connections to the sparking plugs. The range of interference may amount, in spite of the smallness of the energy, to several hundred metres for large motors" [aeroplanes 900–1 000 m, lorries up to 500 m, light motor-cycles 50–100 m]. In built-over land or inside a building the interference range decreases markedly, the interference being as a rule only audible on the lowest floors.

408. Radio Interference caused by Lamps [Street and Domestic: due to Small Breaks in Filament, particularly in Lamps with Very Rigidly Supported Filaments with Little Sag].—H. P. Moss. (*Journ. Inst. Eng. Australia*, September, 1934, Vol. 6, No. 9, p. 318.)

409. Radio Interference: Post Office Service for Listeners.—A. Morris. (*Wireless World*, 16th Nov. 1934, Vol. 35, pp. 384–385.) *See* also 410.

410. Radio Interference Detector.—A. Morris. (*Wireless World*, 23rd Nov. 1934, Vol. 35, pp. 411–412.) Further details of the apparatus used by the G.P.O. engineers (*see* 409).

411. The Technique of Radio Interference.—A. Morris. (*Wireless World*, 30th Nov. 1934, Vol. 35, pp. 445–447.)

Discussing the problems to be faced in securing international agreement upon a suitable technique for dealing with the whole question of disturbances set up by electrical plant to broadcast programmes. Methods at present in use in Germany and France are compared with those in this country.

412. VDE Regulations for the Reduction of Industrial Interference with Broadcast Reception.—Verband Deutscher Elektrotechn: (*E.T.Z.*, 18th Oct. 1934, Vol. 55, No. 42, pp. 1036–1043.)

413. Radio Interference Committee [Summary of I.E.E. Report].—(*Wireless World*, 16th Nov. 1934, Vol. 35, pp. 394.)

414. Contribution to the Theory of the Two-Circuit Band Filter for Intermediate-Frequency Stages [of a Superheterodyne Receiver].—H. Kafka. (*Hochf:tech. u. Elek: akus.*, October, 1934, Vol. 44, No. 4, pp. 125–132.)

Author's summary:—"The course of the voltage amplification is examined for an i.f. stage consisting of an amplifying valve and a band filter with capacitive coupling. The effect of the coil resistances is taken fully into account. It is found that the transmission curves can be derived, in the useful region, from parabolas. Of special importance is the introduction of the so-called 'normalised [normierte] transmission curve' [with ordinates proportional to those of the actual transmission curve: Fig. 3b] with whose help the form of the transmission region can be fixed by a single numerical measurement. The transformation from the 'normalised' curve to the actual transmission curve if accomplished by simple changes of scale. Finally, the fundamental equations for the calculation of a band-filter stage are collected and a numerical example given." The final paragraph deals briefly with the effect of the wide resistance variations of a variable-mu ("exponential") valve and the effect of a change of value in the coupling condenser. It also points out that for the sake of simplicity the two rejector circuits have been assumed to be exactly similar: if L_1 is not the same as L_2, a symmetrical transmission curve can only be obtained if $L_1(C_1 + C_{coup}) = L_2(C_2 + C_{coup})$. By suitable choice of the ratio L_1/L_2 a filter can be matched with extreme values of internal valve resistance. For a previous paper by the same author, on the representation of a resonance curve by a "selectivity index," *see* 1933 Abstracts, pp. 448–449.

415. Discussion on "Resistance Tuning" [Difficulties in obtaining Sufficiently Constant Negative Resistances by Dynatron Methods: Superiority of Negative Transconductance Method: etc.].—E. W. Herold: Cabot. (*Proc. Inst. Rad. Eng.*, November, 1934, Vol. 22, No. 11, pp. 1311–1312.) *See* 1934 Abstracts, pp. 497 and 615.

416. Some Remarks on Detectors [General Principles of Detection and Their Application to Galena, Westector, Diode, Leaky-Grid and Anode-Bend, and Binode Types].—P. David. (*L'Onde Élec.*, October, 1934, Vol. 13, No. 154, pp. 403–414.)

"There are no good and bad detectors: only detectors well or badly employed." Comparing leaky-grid with binode detection, the writer asks whether, when every flat has its loudspeaker, and listeners care more for volume than quality, the automatic volume limitation of the former detector is not really an advantage.

417. On the Theory of the "Pull-in" (Mitnahme) Effect in Retroactively Coupled Receivers.—Lvovitch. (*See* 396.)

418. Amplification with Modern Valves [and the Stability Problems].—(*Wireless World*, 9th Nov. 1934, Vol. 35, pp. 371–373.)

419. The Elimination of Instability in Multi-Stage Amplifiers caused by Coupling through a Common Anode Supply.—Smirnov. (*See* 478.)

420. Those High Notes [Importance of the Higher Frequencies].—R. T. Beatty. (*Wireless World*, 23rd Nov. 1934, Vol. 35, pp. 408–410.)

421. THE UNIVERSAL RECEIVER [for A.C. and D.C. Mains].—F. R. W. Strafford. (*Wireless World*, 21st Dec. 1934, Vol. 35, pp. 519–520.)

422. DESCRIPTION OF A RADIOELECTRIC [Broadcast] RECEIVER: THE G.E.C. TYPE K-80 [R.C.A. Types 140 and 240].—P. Besson. (*L'Onde Élec.*, October, 1934, Vol. 13, No. 154, pp. 415–428.)

423. DEVELOPING SINGLE-SPAN TUNING [Further Improvements].—W. T. Cocking. (*Wireless World*, 16th Nov. 1934, Vol. 35, pp. 391–392.) *See* also 424.

424. DEVELOPING THE BATTERY RECEIVER [Single-Span Tuning].—W. T. Cocking. (*Wireless World*, 23rd Nov. 1934, Vol. 35, pp. 418–419.) *See* also 423, and Cocking, 1934, pp. 500 (two) and 615: also pp. 381 (G. W. O. H.) and 615 ("Step-by-Step"). Also 425, below.

425. THE WIRELESS WORLD NEW SINGLE-SPAN BATTERY FOUR.—W. T. Cocking. (*Wireless World*, 7th and 14th Dec. 1934, Vol. 35, pp. 454–457 and 488–492.)

426. THE WIRELESS WORLD STANDARD A.C. TWO. (*Wireless World*, 9th Nov. 1934, Vol. 35, pp. 364–367.)

427. THE WIRELESS WORLD STANDARD A.C. THREE. (*Wireless World*, 19th and 26th Oct. 1934, Vol. 35, pp. 310–312 and 326–329.)

428. NEW YORK RADIO SHOW.—A. Dinsdale. (*Wireless World*, 26th Oct. 1934, Vol. 35, pp. 330–331.)

AERIALS AND AERIAL SYSTEMS

429. MEASUREMENTS IN THE RADIATION FIELD OF A LINEAR ANTENNA EXCITED INSIDE A HOLLOW METALLIC CYLINDER [and Results of Practical Importance for Ultra-Short-Wave Working].—L. Bergmann and L. Krügel. (*Ann. der Physik*, Series 5, No. 2, Vol. 21, 1934, pp. 113–138.)

For a preliminary note *see* Abstracts, 1934, p. 324. The present paper describes the experimental tests of Weyrich's calculations (shortly to be published) of the field due to an emitting antenna inside and along the axis of an infinitely long, conducting hollow circular cylinder. The work is an extension of that of Bergmann and Doerfel (1932, p. 453) on the field produced by a vertical antenna between two conducting horizontal planes (theory by Weyrich, 1928, p. 516; 1930, p. 101; and 1932, p. 28). From the expressions found by Weyrich for the Hertzian potential at a point (r, z) [usual cylindrical coordinates] due to an axial dipole (eqn. 1) the electric and magnetic forces are deduced (eqns. 3 and 4). Standing waves are found for the variations along the radius vector but there are progressive waves and therefore energy transport in the z-direction. The time averages of the squares of the forces E_z and H_ϕ are then worked out (eqns. 5). The corresponding expressions for an antenna of finite length are given in eqns. 5a; they are however so complicated that the equations 5 for the dipole are used for comparison with the experiments. It is found theoretically that, for certain values of the ratio cylinder-radius/wave-length, the field strength at the surface of the cylinder should be zero. These radii are termed "critical radii" and correspond to the overtones of the fundamental frequency (the frequencies of the overtones are given by eqn. 2). For each overtone there is a set of nodal surfaces in the form of concentric cylinders.

The experimental test was carried out with waves of lengths 14, 33 and 52 cm. The 14 and 33 cm waves were produced by the method used by Kohl (1928, pp. 464–465) and the 52 cm waves by the normal B.-K. circuit. The Lecher-wire method of communicating the energy to the dipole inside the cylinder is described. The field from the 14 and 33 cm waves was measured with a crystal detector, and that from the 52 cm wave with a thermo-element. These are described. The magnetic component of the field could only be measured in the case of the 52 cm wave. The cylinders used were from 2½ to 3 wavelengths long. Various preliminary test experiments were made; an aperiodic receiving antenna was used. The adjustment of the cylinder radius to its critical values was very sharp, as Fig. 5 shows. The measured value of the mean square of E_z is shown as a function of r and z for the first, second and third critical radii for $\lambda = 14$ cm in Figs. 6, 7 and 8; there is good agreement with the theoretical curves (also given), slight deviations being attributed to the fact that the cylinder is never infinitely long. Fig. 9 shows corresponding curves for non-critical radii; Figs. 10–15 represent the results of similar measurements with $\lambda = 33$ and 52 cm. Fig. 16 is a comparison of the effects when the cylinder is (1) open at both ends, (2) open at one end only, (3) closed at both ends; the formation of standing waves in the two last cases is shown.

Further experiments deal with the polar diagrams for the energy radiated from the open ends of the cylinders. Fig. 17 shows the diagram for a cylinder of the first critical radius for $\lambda = 33$ cm. It strongly resembles the diagram for a linear antenna oscillating freely in its fundamental mode. In Fig. 17 the diagram for the linear antenna alone, without the surrounding cylinder, is also shown, and it is found that the excited cylinder with first critical radius radiates about twice as strongly as the linear antenna itself (analogy with sound-box and tuning-fork). Fig. 18 shows the polar diagram of a cylinder with second critical radius open at both ends, for $\lambda = 52$ cm. This is similar to that of a linear antenna excited in its third harmonic. Double strength was obtained when the cylinder was closed at one end.

Results of practical importance are the increased strength of radiation obtainable, and the possibility of altering the form of the polar diagram, by surrounding an antenna by a resonating cylinder. In the case of waves of length less than 10 m the dimensions of the necessary cylinders would not be prohibitive.

430. EXPERIMENTAL CONFIRMATION OF THE SIMILARITY THEOREM FOR HERTZIAN ANTENNAE WITH ULTRA-SHORT WAVES.—A. W. Nagy. (*E.N.T.*, September, 1934, Vol. 11, No. 9, pp. 305–309.)

Abraham's similarity theorem (*Ann. der Physik*, 1898, Vol. 66, p. 436) states that the linear dimensions of similar antennae are proportional to their resonance wavelengths. The writer has tested this experimentally, using copper and brass rods of various lengths with copper discs at one or both ends. The wavelengths used ranged from 0.5 to 5.5 m. Good agreement with theory was found. The graphical representation of the results allows simple formulae to be given for the connection between the dimensions of the antennae and their resonance wavelengths. The field distribution and polarisation in the immediate neighbourhood of the emitter are also being studied.

431. DESIGN OF AN ULTRA-SHORT-WAVE GROUNDED STEEL POLE AERIAL TO GIVE GREATEST POSSIBLE EFFECTIVE HEIGHT.—Kell, Bedford and Trainer. (*See* 476.)

432. A COMPARISON OF SHORT-WAVE NON-DIRECTIVE ANTENNAS.—V. K. Zavarikhin. (*Izvestia Elektroprom. Slab. Toka*, June, 1934, No. 5, pp. 1–20.)

Author's summary :—A comparison is made of different types of horizontal and vertical non-directive antennas. Diagrams are given for the distribution of field in the horizontal and vertical planes. The radiation resistance is calculated. The maximum voltage at the antinodes is calculated for the different types of antenna, for a radiated power of 250 kw.

433. RADIATION RESISTANCE OF "V" AND "W" TYPE AERIALS.—V. K. Zavarikhin. (*Izvestia Elektroprom. Slab. Toka*, July, 1934, No. 6, pp. 1–11.)

Author's summary :—(1). The power induced by the wire A in the wire B of a "V" type antenna is calculated under the following conditions: (a) both wires are of the same length, (b) they run in one plane, (c) they intersect at an angle, and (d) the currents are in phase or in quadrature. (2). A curve is given representing the radiation resistance of a "V" type antenna as a function of the length of the wires forming the antenna. (3). The radiation resistance of a "W" type antenna having wires of equal length ($= 8\lambda$) is calculated. (4). The radiation resistance of a "V" type antenna with a reflector, for $l = 8\lambda$, $\alpha = 35°$, and an antenna/reflector spacing of 3.25 λ, is also calculated.

434. DISCUSSION ON "MAINTAINING THE DIRECTIVITY OF ANTENNA ARRAYS" [Apparent Discrepancies with Air Navigation Division's Results].—H. S. Stokes: Kear. (*Proc. Inst. Rad. Eng.*, November, 1934, Vol. 22, No. 11, pp. 1313–1314.) *See* 1934 Abstracts, p. 563.

435. THE ELECTROMAGNETIC THEORY OF COAXIAL TRANSMISSION LINES AND CYLINDRICAL SHIELDS.—S. A. Schelkunoff. (*Bell S. Tech. Journ.*, October, 1934, Vol. 13, No. 4, pp. 532–579.)

The paper starts with Maxwell's equations for circularly symmetric electromagnetic fields, then restricts them to the case of two-dimensional fields, and finds the usual exponential solution and the propagation constant for transmission lines. The solution appropriate to perfectly conducting coaxial cylinders in terms of Bessel functions is given and expressions for longitudinal and transverse impedance are found. Imperfect coaxial conductors are then considered. The e.m.f. in the dielectric between two conductors, the external inductance, and the propagation constants of coaxial pairs are calculated. The current distribution in cylindrical conductors, the surface impedance of a solid wire, the surface impedances of hollow cylindrical shells, the complex Poynting vector, approximate formulae for the surface impedance of tubular conductors, the internal impedances of laminated conductors, the use of discs as terminal impedances for coaxial pairs, cylindrical waves and the problem of cylindrical shields, cylindrical waves in dielectrics and metals, power losses in shields and the resistance of nearly coaxial tubular conductors are other subjects discussed. A list of literature references is given.

436. A RESISTANCE TRANSFORMER AND METHODS FOR CONTROLLING THE CHARACTERISTIC IMPEDANCE AND THE VELOCITY OF PROPAGATION OF ELECTROMAGNETIC WAVES ALONG WIRES.—G. J. Michelson. (*Izvestia Elektroprom. Slab. Toka*, July, 1934, No. 6, pp. 11–20.)

Author's summary :—The problem of obtaining a travelling wave in transmission lines with uniformly distributed constants, by varying the characteristic impedance and the velocity of propagation of electromagnetic waves along different sections of the line, is discussed. Methods of accomplishing such variations are given, and the possibility of utilising these methods for the improvement of different types of antennae and transmission lines is shown.

437. AERIAL TERMINATIONS.—N. Wells. (*Marconi Review*, Sept./Oct. 1934, No. 50, pp. 16–22.)

Complementary to the article referred to in 1934 Abstracts, p. 383. "The notes are intended to cover an outline of the principles involved, principles that are a matter of routine to the radio-physicist but that are, sometimes, not so familiar to those whose main duties lie outside the study of aerial problems." The notes deal with aerial reactance, terminations of quarter- and half-wave aerials, feeder-line termination, and terminal impedance of the half-wave aerial.

438. LEAKAGE LOSS OF OVERHEAD LINES DUE TO HOAR FROST.—Kaden and Brückersteinkuhl. (*E.T.Z.*, 22nd Nov. 1934, Vol. 55, No. 47, pp. 1146–1148.)

VALVES AND THERMIONICS

439. THE AMPLIFYING AND TRANSMITTING VALVE AS AN ELECTRON-OPTICAL PROBLEM [and the Alteration of a Triode or Tetrode Characteristic by Matching the Electron Beams with the Grid Openings].—M. Knoll. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 584–591.)

Extension of the work dealt with in 1934 Abstracts, p. 618. Author's summary :—"By the application of the Watson formula, for the spreading of a parallel beam of electrons, to the current/potential field of amplifying and transmitting valves, it is found that in the first approximation the electron paths there are determined only by the electrostatic electrode field (Fig. 1). The model of the electron paths in the amplifier valve REN 904, constructed on this basis [with the help of an enlarged model in an electrolytic trough—*cf.* 1933 Abstracts, p. 273], shows that the curved potential surfaces present in each grid opening can be considered as electron-concentrating lenses which split up the homogeneous electron stream into separate elementary rays. The aperture error of the elementary electron lenses leads to the formation of a caustic analogous to the optical phenomenon, and to a corresponding current distribution in the grid/anode space (Fig. 2). When the grid is modulated by an a.c. potential the form of the resulting ray alters, and there occurs simultaneously a discontinuous current distribution on the anode (Fig. 3). This discontinuity is made visible by using an anode of poor thermal conductivity, such as a thin molybdenum wire (Fig. 4, Table VI).

"The 'electron-optical current distribution' has, in multi-grid valves, a marked influence on the characteristic if the grids are so constructed that one grid covers the openings of the other as seen from the cathode. A displacement of one grid with respect to the other (Fig. 5) produces, in a tetrode, changes of screen-grid current in the ratio 1 : 10, and slope changes in the ratio 1 : 2 (Fig. 7). Since a hot cathode provided with cup-like or cylindrical recesses itself produces elementary beams (Fig. 8, Table VI), it is also possible, by arranging the grid openings opposite to the recesses, to construct triodes with unusually small grid current consumption (Figs. 9 and 10)."

440. THE OCCURRENCE AND TECHNICAL APPLICATION OF A SATURATION CURRENT EFFECT IN INDIRECTLY HEATED AMPLIFIER VALVES WITH SPACE-CHARGE GRIDS.—F. Hehlgans. (*Hochf:tech. u. Elek:akus.*, October, 1934, Vol. 44, No. 4, pp. 132–137.)

The saturation-current effect is used for various purposes such as in Kipping's "flashing" circuit (*Wireless World*, 1923) which has been applied to a cathode-ray oscillograph time base (Dantscher, Abstracts, 1933, p. 635) and in Rudolph's "constant anode current" aperiodic amplifier making full use of the amplification factor of the valves (*see* Herd: Rudolph, 1931, p. 326). The effect is easy to obtain with battery-heated valves, but difficulties are immediately encountered when a.c. heating is attempted: in directly heated valves the anode current fluctuates with the a.c. alternations, and ordinary indirectly heated diodes and triodes have no marked saturation effect owing to their oxide cathodes. Attempts to use directly heated tungsten cathodes, by adding a special rectifying equipment, have not led to satisfactory results. The "American solution" (the reference given is to the *Wireless Engineer*, Oct. 1932, Vol. 9, p. 570, Fig. 2, showing a Cossor time-base unit) using indirectly heated screen-grid valves, has the objection that one rectifying unit will not suffice to provide the various grid-, screen-grid-, and anode-voltages.

The present writer's solution is to use an indirectly heated space-charge-grid valve. Measurements with the circuit of Fig. 2 showed satisfactory saturation curves when the space-charge grid 4 had a slight positive bias or even was at cathode potential. The positive bias increased the value of the saturation current and also the steepness of the initial slope, but was not employed, for simplicity's sake, in the practical applications. Telefunken type REN 704d was particularly satisfactory (Fig. 1, where curve II was taken with this valve with its space-charge grid shorted to cathode). A completely satisfactory explanation of the result has not yet been found, but apparently the presence of the cathode-connected space-charge grid considerably reduces the "penetration" of the anode potential on to the cathode, and the space-charge grid takes on the function of the cathode. The fact that valves with low "penetration coefficient" ($1/\mu$), such as the above-named valve, are particularly suitable, seems to support this explanation.

Section IV deals with the application of the above results to the construction of a mains-driven "flashing" circuit (Fig. 3) which can be added as a very compact auxiliary unit to the commercial a.c. mains unit developed by the writer for the AEG low ray-velocity oscillograph (Dobke, 1932, p. 653). But it is convenient to combine the tube-voltages mains unit with the time-base unit, and Fig. 4 gives the circuit of such a combination, while Fig. 5 shows an experimental model of the complete equipment. Section V deals with the application of the results to the conversion of Rudolph's aperiodic amplifier (referred to earlier) to mains supply, the space-charge-grid valve being here used as the "limiting" valve (17, Fig. 7) while the amplifier valve is a screen-grid valve (11). Fig. 9 shows an aperiodic amplifier with a triode first stage and a second stage as Fig. 7, supplying a cathode-ray oscillograph. Such an arrangement is particularly suitable for small static or very low-frequency potential variations, such as in the recording of electrocardiograms (Fig. 10).

441. GRAPHICAL CALCULATION OF LINEAR AND NON-LINEAR RETROACTION [and its Application to Improving the Efficiency, etc., of Valves and Circuits].—Bartels. (*See* 395.)

442. GRID MODULATION AND HETERODYNE RECTIFICATION.—Doluhanov. (*See* 391.)

443. THE MEASUREMENT AND REDUCTION OF MICROPHONIC NOISE IN VACUUM TUBES.—D. B. Penick. (*Bell S. Tech. Journ.*, October, 1934, Vol. 13, No. 4, pp. 614–633.)

Measured values of microphonic noise, reducible to within 5 db, have been obtained with a laboratory test set comprising a vibrating hammer agitator, a calibrated amplifier and a thermocouple galvanometer indicator. Sputter noise is made measurable by frequency-discriminating methods.

Indirectly heated cathode type tubes are found to be intrinsically less microphonic than filamentary types. The effectiveness of cushioning by cushion sockets and other methods is also discussed, with the factors affecting microphonic noise levels and possible methods of reducing sputter noise.

444. ELECTROLYTIC METHOD OF MEASURING INTER-ELECTRODE CAPACITIES OF A VALVE [by filling Bulb with Electrolyte and using A. C. Bridge].—N. P. Kalinsky. (*Izvestia Elektroprom. Slab. Toka*, Aug./Sept. 1934, No. 7, pp. 35–37.)

445. THE APPLICATION OF EXPONENTIAL [Variable-Mu] VALVES TO HEAVY-CURRENT TECHNIQUE.—H. Kieling. (*E.T.Z.*, 8th Nov. 1934, Vol. 55, No. 45, pp. 1100–1102.)

The power of the variable-mu valve to give a constant output voltage when the input voltage varies greatly should be of great use both in test room and in service, particularly in connection with the measurement or indication of frequencies; *e.g.* by vibrating-reed frequency indicators, which with the aid of such valves can work faultlesssly on from 5 to 100% of the maximum voltage instead of requiring some five different adjustments of series resistance.

446. NEW METHODS OF LEADING-IN TO VACUUM CONTAINERS [including "Metal-Skin" Lead-Ins].—Handrek. (*See* 539.)

447. DESCRIPTION OF A WATER-COOLED HIGH-POWER VALVE [the S.F.R. Type E 2051 for 30 kW Carrier Power with about 100% Modulation].—M. Ponte and R. Warnecke. (*L'Onde Élec.*, November, 1934, Vol 13, No. 155, pp. 432–457.)

448. THE MIGRATION OF ADSORBED ATOMS ALONG THE BOUNDARY SURFACES OF SOLID BODIES [Thorium in Tungsten and Molybdenum].—A. Gehrts. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 15, 1934, pp. 456–461.)

449. THE EXCHANGE OF ENERGY BETWEEN A PLATINUM SURFACE [of an Electrically Heated Wire] AND GAS MOLECULES.—W. B. Mann. (*Proc. Roy. Soc.*, Series A, 15th Oct. 1934, Vol. 146, No. 859, pp. 776–791.)

DIRECTIONAL WIRELESS

450. THE NIGHT PERFORMANCE OF THE MARCONI-ADCOCK DIRECTION FINDER TYPE D.F.G.8.—S. B. Smith. (*Marconi Review*, Sept./Oct. 1934, No. 50, pp. 1–5.)

For an earlier paper *see* 1932 Abstracts, p. 588. The present tests were on Kalundborg signals, which are subject to violent night variations on a loop aerial: "the communication represents a typically difficult aircraft-to-ground requirement." "Using the theory of probabilities in engineering, it will be seen that the improvement in night D.F. accuracy due to the use of the Marconi-Adcock aerial is approximately five times, and under ordinary circumstances the Adcock accuracy will not be worse than 2.37°, and under precisely similar circumstances the loop will not be worse than 12.35°." But this does not mean, of course, that the Adcock will not on occasion show errors exceeding this value of 2.37°: Fig. 4 (curve of heavy night deviations) shows peak errors of +23° and −23° when the corresponding loop errors are +90° and −90°; but the curves also show that the total time during which serious night errors are given by the Adcock aerial is not a large percentage of the total time of the night observations, whereas with the loop the instrument is almost completely useless. After experience with the Adcock aerial "a skilled operator will obtain an all-round night accuracy approaching that possible when using the equipment during the day."

451. DISCUSSION ON "MAINTAINING THE DIRECTIVITY OF ANTENNA ARRAYS."—Kear. (*See* 434.)

452. HALF- AND FULL-WAVE MODULATION FROM A.C. SOURCE, FOR RADIO BEACONS.—Plemianikoff. (*See* 399.)

ACOUSTICS AND AUDIO-FREQUENCIES

453. SOUND SPECTROSCOPY, A NEW METHOD OF ACOUSTIC ANALYSIS.—E. Meyer and E. Thienhaus. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 630–637.)

Authors' summary:—"In the technique of acoustical measurement the optical method of sound analysis has never up to now been used. The present paper describes sound-grating spectroscopy. The design considerations of a grating [composed of 3.4 mm diam. steel needles with their ends set into two parallel iron sheets 12 cm apart; there are some 300 needles spaced about 1 cm apart in a curve about 3 m long; if this curve is of circular shape the results are not sharp, and the form actually used is based on the equation of a logarithmic spiral—pp. 633–634]; the resolving power; the dispersion; and particularly the image sharpness, are all discussed at length as functions of various parameters—grating size, angle of incidence [δ in Fig. 2], grating constant and grating shape. . . . For the purposes of analysis the audible sound [taken up as usual by microphone and amplifier] is transformed in frequency by means of a push-pull modulator [which suppresses the 45 kc/s frequency used as a carrier and leaves two sidebands of 40–45 and 45–50 kc/s, the lower of which is cut off by a condenser chain, leaving the 45–50 kc/s band to be amplified and radiated], is sent out from a ribbon radiator, and after diffraction at the grating is received with a small highly tuned condenser microphone [mounted so as to be swung along the focal circle, with a mechanical linkage which simultaneously swings the light beam of the recording mirror galvanometer].

"The advantage of sound spectroscopy over the exploring-note method of analysis lies in the remarkably short building-up time of the complete spectrum, equal to the reciprocal of the resolving power [p. 634]. In this way the sound spectrum can be made visible at the very instant of its formation. Specimen records are given." The disadvantage is the appearance of a large number of subsidiary maxima.

454. NEW METHODS OF PHYSICAL INVESTIGATION OF TONE QUALITY [with the "Sound Prism"]—H. Macdonald and O. H. Schuck. (*Journ. Franklin Inst.*, November, 1934, Vol. 218, No. 5, pp. 613–618.) On the device already dealt with last month (166 of 1935). Photographic records can also be made. For an earlier paper by Schuck *see* 1933 Abstracts, p. 39.

455. MEASUREMENT OF NON-LINEAR DISTORTIONS [of Audio-Frequency Voltages and Currents].—H. Faulhaber. (*E.N.T.*, October, 1934, Vol. 11, No. 10, pp. 351–357.)

Fig. 1 shows the circuit diagram of a bridge for analysing the harmonics of audio-frequency voltages and currents. The harmonics are filtered out twice, first by a high-resistance bridge whose output diagonal supplies voltage to the amplifier only at the resonance frequency of an oscillating circuit; the fundamental audio-frequency is suppressed by suitable choice of the frequency characteristics of the impedance curve for the bridge, whose arms consist of condensers. A formula is given for the ratio of output and input voltage at any frequency. The absolute value of this ratio defines the "bridge weights" $k(\omega)$. The second filtering is done by a resonant transformer between amplifier and valve-voltmeter. Fig. 2 shows the type of analysis curve obtained. The fifth harmonic can be clearly separated from the fourth and sixth in sounds with 25% "klirrfaktor" [harmonic coefficient]. The arrangement measures harmonics whose amplitude is 1% of the fundamental with an accuracy of $\pm$ 2%, but those of amplitude 0.1% of the fundamental to $\pm$5% only. The smallest measurable harmonic has amplitude 0.03% of the fundamental, which must however have an input voltage of at least 7 v for this harmonic to be measured.

Fig. 3 shows measured curves of the distortions in a valve with a real load and small output; theoretical curves calculated from a Taylor series are given for comparison and the agreement is good. The *n*th harmonic is proportional to the *n*th derivative of the characteristic, so that the distribution of the harmonics along the characteristic can be determined by differentiation. A dry cuprous-oxide rectifier was also chosen as an example and the measurements again agreed with theory, as did those for the first difference tone in a valve, shown in Fig. 4.

Distortions produced by iron were estimated by examining the third harmonic of the voltage drop in a resistance connected (a) before and (b) after the transformer under examination. Table 2 shows how the distortions increase as the amplitude of the current and voltage used increases. By connecting a valve to a dry cuprous-oxide rectifier, every single harmonic may be suppressed by correct adjustment of circuit conditions.

The complex steepness S of a valve characteristic (the ratio of the projections of the working ellipse on the axes of ordinates and abscissae) may be measured by the circuit shown in Fig. 6, where the voltage drops before and after the valve are compared. Fig. 7 shows how S depends on the load in the anode circuit. The theory of the working ellipse is considered and the following conclusions are reached: (a) the non-linear distortions will be smaller for real anode resistances than for complex resistances of the same amplitude; (b) the distortions diminish with increasing frequency, when the anode resistance gives an inductive wattless component; (c) the distortions increase with increasing frequency when the anode resistance gives a capacitative wattless component. Fig. 8 shows a comparison of measurements of the second harmonic in the anode circuit of a valve when the loads are resistances of equal amplitudes but opposite p ses; these should theoretically be equal and the measurements confirm this.

The usual definition of the "klirrfaktor" does not take into account the combination tones, which in practice cause most of the distortion. As an extended definition, it is suggested that the "klirrfaktor" should be the square root of the quotient of the sum of the squares of all harmonics *and combination tones* divided by the sum of the squares of the fundamentals. Fig. 9 shows the circuit for measuring this quantity by compensating the measuring voltages behind the distorting quadripole (two-tone method, using two fundamental frequencies). Fig. 10 shows measurements of "klirrfaktor" with and without inclusion of the combination tones; it is clear that their inclusion gives a much better idea of the non-linear distortion produced by any circuit.

456. New Investigations on Non-Linear Distortions of Electro-Acoustic Transmitting and Recording Apparatus [based on Measurement of Strength of Difference Tones instead of usual "Klirr" Factor].—H. J. von Braunmühl. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 617–622.)

For reasons given, the writer replaces the usual "klirr" factor measurements by measuring, at different frequencies, the strengths of the difference tones and expressing them in percentages of one of the two equal exploring tones. It is usually enough to deal with the difference tones of the first and second order, the former being a measure for the asymmetrical distortion and the latter for the symmetrical. The comparatively simple equipment required is described, and some conclusions as to the distortion in carbon, electrostatic, and moving-coil microphones, and sound-on-film records, drawn from the results of tests by the new method, are discussed. *See* also 1934 Abstracts, p. 103, l-h column.

457. An Approximate Method for the Determination of the "Klirr" [Non-Linear Distortion] Factor of Electro-Acoustic Apparatus from the Amplitude Characteristic [and the Definition of "Overloading Factor" and the Relation between this and the "Klirr" Factor].—G. D. Maljuginetz. (*Izvestia Elektroprom. Slab. Toka*, July, 1934, No. 6, pp. 26–32.)

458. A Study of an Electrically-Maintained Vibrating Reed and its Application to the Determination of Young's Modulus. Part I. Theoretical [Theory of Tuning Forks].—R. M. Davies and E. G. James. (*Phil. Mag.*, November, 1934, Supp. No., Series 7, Vol. 18, No. 122, pp. 1023–1052.)

459. A Bridge for the Determination of the Frequency of an Alternating Current in the Audio-Frequency Range.—Pegler. (*See* 509.)

460. A Method of Production of Measuring-Tone [Test-Frequency] Films.—F. Lautenschlager. (*E.N.T.*, September, 1934, Vol. 11, No. 9, pp. 330–334.)

The films referred to are records of single pure tones of different frequencies. The light is controlled by two Nicol prisms, one at rest and one rotating. The latter is firmly coupled to the mechanism for moving on the film, giving constancy of wavelength and pureness of sinusoidal form.

The conditions for a linear connection between the exposure and transparency of the films have also been studied experimentally and the optimum photographic treatment is described.

461. "NEEDLE-SCRATCH" IN GRAMOPHONES [and Corresponding Phenomenon in Sound-Films: How to Estimate].—Kotowski. (*E.N.T.*, October, 1934, Vol. 11, No. 10, pp. 364–365: abstract only.)

"Scratch" or rustling sound in electro-acoustic transmission apparatus is chiefly determined by the smallest number N of elementary processes which are used per unit time in any stage of the transmission, *e.g.* by the number of electrons moving per second in the input circuit of a broadcast receiver or the number of grains of the record surface passed over per second in gramophone reproduction. The "relative scratch voltage" e_{rel} is the ratio of the effective voltage produced by scratch to the maximum effective useful voltage obtainable and equals $C/\sqrt{N}$. C is not a universal constant but may be taken as approximately 750 when the transmission range is about 7 000 c/s and the unit of time is one second. The manufacture of a film to estimate the scratch is described; it is a mosaic of particles of the size of a grain of silver and its average transparency is measured. The scatter of the transparency of small parts of the surfaces is calculated by the theory of probability. Scratch due to dust and markings on the surface of much-used films is also described and an expression is given for the total scratch of a sound-film. "Natural" papers with uneven surface are found to be unsuitable for the proposed printing of sound-films. Table 1 gives the "scratch" properties of different kinds of paper.

A formula is given for the calculation of "relative scratch voltage" on gramophone records from the size of grain of graphite used to dust over the wax plates and the cutting material used for the shellac.

462. THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF FREQUENCY- AND PHASE-MODULATED OSCILLATIONS [in Sound-on-Film Technique].—Lautenschlager. (*See* 400.)

463. AVOIDING HUM WHEN USING A PICK-UP.—"Cathode Ray." (*Wireless World*, 9th Nov. 1934, Vol. 35, p. 377.)

464. RECORD GRAFTING.—R. Arbib. (*Wireless World*, 7th Dec. 1934, Vol. 35, pp. 458–459.)

Details are given of the method adopted by the recording companies for excising certain words and phrases from a gramophone record and substituting others: particulars are also given of the measures used to blend certain records and to provide a new accompaniment to an irreplaceable vocal recording as in the case of the Caruso records.

465. THE WORLD'S LARGEST LOUD SPEAKER.—(*Wireless World*, 21st Dec. 1934, Vol. 35, p. 525.)

Short account of a 500-watt loudspeaker and associated equipment designed by the Bell Telephone Laboratories and intended to be used to direct members of fire brigades, shipwrecked mariners, and on other occasions where a large volume of outside noise has to be overcome.

466. MAKING THE MOST OF A DUAL LOUD SPEAKER [Experiments on Stereoscopic Listening].—"Cathode Ray." (*Wireless World*, 16th Nov. 1934, Vol. 35, pp. 389–390.)

467. THE EXTENSION LOUDSPEAKER.—"Cathode Ray." (*Wireless World*, 7th Dec. 1934, Vol. 35, pp. 463–464.)

Various methods are discussed of connecting additional loud speakers to a receiver so that a minimum of disturbing effect is caused to the loud speaker already incorporated.

468. RESISTANCE CHANGES IN THE INTERIOR OF THE CARBON CHAMBER OF A CARBON MICROPHONE.—G. Madia. (*E.N.T.*, October, 1934, Vol. 11, No. 10, pp. 338–341.)

The aim of this work was to discover how sound is propagated from the microphone membrane into the carbon chamber and what part is played by the separate layers of carbon. The motion of the carbon particles is deducible from the changes in their contact resistances, and measurements were made, by means of probes, on the distribution of these changes through the carbon chamber. The experimental method is described and illustrated. The results for one definite amplitude of membrane movement are shown in Fig. 5. For low frequencies the modulating ratio (*i.e.*, the ratio of alternating voltage produced by the microphone as a whole to the direct voltage across the microphone) is very small in the first layer, compared with that of the whole microphone, but this is not the case at higher frequencies. Fig. 6 shows modulating-ratio curves for the successive layers between the probes. These curves show that phase differences occur within the carbon chamber. This was confirmed by measurements of the phase angles themselves, using a cathode-ray oscillograph: these are shown vectorially in Fig. 7, for various frequencies. At low frequencies practically the whole of the carbon oscillates in the same phase but the phase differences increase rapidly with frequency. The apparatus used did not show the origin of these phase differences.

469. THE PHENOMENA OF OPTICAL MIRAGE DUE TO [Supersonic] ELASTIC WAVES [and a Possible Application to the Measurement of Acoustic Reflecting and Absorbing Powers].—R. Lucas. (*Comptes Rendus*, 19th Nov. 1934, Vol. 199, No. 21, pp. 1107–1108.)

Arising from the work dealt with in many past abstracts (*e.g.* 1934, p. 100). The equation for the deviation of a light ray, on traversing a supersonic beam at right angles to it, is given, and deductions made from it. If the light ray is subjected to the action of two similar supersonic beams at right angles to each other, the trajectory traced by it on a screen will change if the phase of one of the supersonic beams alters.

470. TESTING ACOUSTIC VIBRATION INSULATING MATERIALS [Körperdämmschallstoffe].—W. Willms and L. Keidel. (*E.N.T.*, September, 1934, Vol. 11, No. 9, pp. 314–318.)

These materials are characterised by their properties of elasticity and resistance. The paper describes measurements of these properties at audio-frequencies for a large range of amplitudes.

The material is placed so as to couple two masses, whose oscillations are measured. One mass is excited at audio frequency and the other executes forced oscillations which depend on the properties of the coupling material. The apparatus used is described and shown in section, with its equivalent mechanical circuit. Calculated resonance curves for the movement of the second mass are shown for various amounts of damping by the material under test. Actual resonance curves are shown for a cork/rubber/cork material and the properties of various other materials are tabulated.

471. A New Method of Measuring the Acoustical Conductivities of Orifices.—N. W. Robinson. (*Proc. Phys. Soc.*, 1st Nov. 1934, Vol. 46, Part 6, No. 257, pp. 772–782.)

A tube is driven by a loud-speaker and the acoustical impedances on the two sides of a fixed point are adjusted so that the acoustical pressure at the point is zero. The terminating impedance on one side is the orifice under investigation, together with an adjustable tube. The conductivity of the orifice can be calculated from known impedance relations. Empirical formulae are given for the conductivity of orifices forming constrictions in or terminations to a tube.

472. On the Problem of Coupled Rooms.—M. A. Saposchkow. (*Russian Journ. of Tech. Phys.*, No. 4, Vol. 4, 1934, pp. 822–843.)

473. On the Acoustic Radiation Pressure on Spheres [Theoretical Investigation].—L. V. King. (*Proc. Roy. Soc.*, Series A, 15th Nov. 1934, Vol. 147, No. 861, pp. 212–240.)

474. On the Acoustic Radiation Field of the Piezoelectric Oscillator and the Effect of Viscosity on Transmission. Part II.—L. V. King. (*Canadian Journ. of Res.*, October, 1934, Vol. 11, No. 4, pp. 484–488.) Experimental data and their comparison with the theoretical results of Part I (1934 Abstracts, p. 622).

475. Measurement of the Velocity of Sound in Anisotropic Media, in particular in Quartz using Piezoelectric Excitation.—Bechmann. (*See* 504.)

PHOTOTELEGRAPHY AND TELEVISION

476. An Experimental Television System [Camden, New Jersey, Tests using Iconoscope and Kinescope: including New York (Empire State Building) Transmission broadcast in Camden].—Engstrom: Kell, Bedford and Trainer: Holmes, Carlson and Tolson: C. J. Young. (*Proc. Inst. Rad. Eng.*, November, 1934, Vol. 22, No. 11, pp. 1241–1245: 1246–1265: 1266–1285: and 1286–1294.)

Various changes were made from the New York tests (1934 Abstracts, p. 158). The use of the iconoscope in place of the flying-spot disc gave many advantages: "experience indicated that it provided a new degree of flexibility in pick-up performance, thereby removing one of the major technical obstacles to television": ("the resolution of the iconoscope is considerably better than the rest of the system is capable of transmitting"—p. 1253). Except for the Empire State Building relay (120-line), a 240-line progressive scanning was used instead of the 120-line. The framing frequency remained at 24. In the second paper ("The Transmitter") amplifiers with uniform frequency response between about 20 and 600 000 c/s are described: also a new type of aerial structure (for the ultra-short waves) to give the greatest possible effective height—a hollow steel pole, grounded, forms the aerial and one side of the transmission line conveying the signal to the upper end of the pole, the other side being a copper conductor spaced from the pole: standing-wave phenomena act so as to insulate the structure from ground for the operating frequency, and only the top section of the pole radiates. Among other things, an outdoor programme was televised and relayed to the main studio over a distance of about one mile. The last paper deals with the 86-mile relay from New York on 44 Mc/s, and the special double V type directive aerials employed.

477. Automatic Controller of Television Signals [Signal-Amplification Control compensating for Variation in Illumination of Object scanned in Daylight].—M. F. Volkoff. (*Izvestia Elektroprom. Slab. Toka*, June, 1934, No. 5, pp. 41–47.)

The amplification is controlled by the p.d. across the load resistance of a photocell circuit. A formula is developed for the permissible load for the avoidance of amplitude distortion; the theoretical analysis is checked experimentally.

478. The Elimination of Instability in Multi-Stage Amplifiers caused by Coupling through a Common Anode Supply.—N. D. Smirnov. (*Izvestia Elektroprom. Slab. Toka*, May, 1934, No. 4, pp. 1–13.)

The case of a number of resistance-coupled amplifiers connected in cascade, with a common anode battery, is examined in detail with special regard to wide-band amplifiers for television. The conditions are established for which self-oscillations appear and formulae are derived for determining the maximum number of stages which will remain stable for a given frequency band and type of valve. The usual de-coupling circuit consisting of an additional anode resistance and a by-pass condenser to earth is considered and it is shown that the maximum number of stages which can be used remains approximately the same, while the improvement in stability is not very satisfactory on the lower frequencies in the band, owing to the comparatively high impedance of the by-pass condenser on these frequencies.

A modified de-coupling circuit is then described, developed by the Electrical Institute of Moscow. In this the by-pass condenser is replaced by a neon lamp, the voltage across which is arranged to be sufficient for a continuous discharge (in a particular case the lamp took 8 mA steady current). The lamp offers a constant impedance at all frequencies and it is shown that with this system the maximum number of stages for stable operation can be increased from 5 to 11 for a typical case. An experimental verification of the results obtained is given, and it is pointed out that the neon stabiliser should be connected in the later stages rather than early in the amplifier, as otherwise the noise level is unduly increased. It is particularly advisable to employ a neon lamp in the last stage when the anode power is obtained from a rectifier common to all stages, as this not only improves stability but also reduces distortion on the lower frequencies.

479. THE PRINCIPLES OF DESIGN OF ELECTRON-OPTICAL SYSTEMS.—L. Polotovsky. (*Izvestia Elektroprom. Slab. Toka*, June, 1934, No. 5, pp. 22–36.)

"The problem of the electron motion in the axial electric field of a television cathode-ray tube is solved, and formulae are derived defining the electron path for a given potential distribution, and also for computing the potential distribution over a given electron path. A method of designing electron-optical systems is given, and a simple calculation of one such system is carried out."

480. COMPUTATION OF CATHODE-RAY DEFLECTION IN THE MAGNETIC FIELD OF A COIL.—N. Dozoroff. (*Izvestia Elektroprom. Slab. Toka*, June, 1934, No. 5, pp. 36–41.)

The deflection is calculated as a function of the dimensions of the coil and its distance from the ray, for cylindrical and single- and multi-layer flat coils. The experimental curves agree well with the calculated.

481. ELECTRON-OPTICAL IMAGE FORMATION WITH PHOTOELECTRICALLY LIBERATED ELECTRONS.—Pohl. (*See* 529.)

482. THE SENSITIVITY OF PHOTOCELLS, AND TELEVISION IN TRUE NATURAL COLOURS.—P. W. Schmakow. (*Russian Journ. of Tech. Phys.*, No. 4, Vol. 4, 1934, pp. 768–776.)

Author's summary:—Formulae are given (5 and 6) for transforming the calibration values of photocell sensitivity into sensitivities for commercial light sources and for the conditions of daylight television. For television purposes a new definition of photocell sensitivity is put forward, *i.e.* the current strength which the cell yields for each watt of energy falling on it (formula 9).

To obtain reproduction in the true natural colours it is necessary that the photoelectric effect should be proportional only to the brightness of the object. From this standpoint, examples are considered of the selection of light filters (17), photocells (19), light sources (21), and the colour-technique of the preparation of the object for scanning purposes.

483. ON THE COEXISTENCE OF THE INDEPENDENT AND DEPENDENT DISCHARGE [in Gas-Filled Photocells and elsewhere].—W. Kluge. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 591–594.)

An experimental investigation of the question whether, and under what conditions, the photo-controllable "dependent" discharge in a gas-filled photocell can persist after the "independent" discharge (not dependent on illumination) has set in when the striking potential has been reached and the series resistance is of suitable value. A special circuit with pulsating illumination (Fig. 1) had to be used in order to overcome the masking of the photocurrent by the glow-discharge current and to allow the two currents to be measured separately, and a special cathode with low vapour pressure (adsorbed caesium on tungsten) was employed so that the prolonged independent discharge should not, by ionic bombardment, alter its photoelectric properties.

It was found possible by these methods to plot the curves of the photoelectric current up to and long after the setting in of the glow discharge. The maximum value of the photo-controllable discharge lies in the transition zone between the Townsend space-charge-free discharge and the normal, space-charge-impeded glow discharge. The complete characteristic given in Fig. 3 ("Zündpunkt" = striking potential) shows an interesting double maximum: this was not given by cathodes containing no caesium, and it is shown later in the paper that its appearance has some connection with the wavelength of the incident light. When a family of curves similar to Fig. 3 is plotted for different light intensities it is found that there is no strict linearity visible between photocurrent and light intensity: this is being investigated further, particularly for regions of stronger illumination. It is pointed out that the above investigation is of interest in connection not only with photocells but also with the genetics of gaseous discharges in general.

484. INVESTIGATION OF THE ACTION OF THE IONS IN GAS-FILLED PHOTOCELLS [and an Increased Output by Delaying the Stable Glow Discharge by means of a "Draining Loop" Auxiliary Electrode].—H. Richter. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 598–601.)

Author's summary:—"By introducing an auxiliary electrode [on the far side of the anode] into a photocell in which the anode is of network form, the majority of the ions appearing in the discharge space can be drained off, whereby the electron liberation by ionic bombardment can be transferred from the cathode to the auxiliary electrode. As a result it is found that even in the region of unstable ionisation this electron liberation plays an important rôle, and that it is possible to increase the output of the cell by delaying the setting-in of the stable glow discharge"—thus raising the "Koller maximum" of the cell as well as diminishing the load on the cathode: Fig. 6 shows the improvement in an "ionic cell" due to the auxiliary loop: without it the discharge sets in around 120 v (curve *ins*) and the maximum photocurrent is comparatively small, whereas when the loop is present it begins to capture the ions directly ionisation begins at about 20 v, with the result that the striking potential is raised to 180 v and the useful power output considerably increased.

485. ABNORMALITIES IN THE CHARACTERISTICS OF VACUUM PHOTOCELLS.—H. Geffcken. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 595–598.)

While ordinary potassium-layer vacuum cells present the usual regular saturation characteristic, "artificial-layer" cells (where the work function is artifically reduced by chemicals in the layer) often show a sudden transition to a higher or a lower curve. This is usually due to wall charges: the "Bainbridge" type of cell (metallic base, oxide intermediate layer and monatomic top layer), for instance, would seem particularly likely to show this phenomenon owing to the process for producing the extremely thin top layer, which removes all traces of non-adsorbed potassium from the walls.

It is unexpectedly found, however, that vacuum cells with "Phonopress"-layer cathodes (Otto Pressler, Leipzig: a homogeneous mixture of a number of chemical compounds deposited in a spongy, porous form on the metallic base) regularly show this zone of discontinuity (Fig. 2), although they have a rich excess of free alkali metal just as the ordinary potassium cells have. Investigation of this result shows that these discontinuities are due to equilibrium displacements in the space charges close to the cathode surface and in its pores. Work directed to the complete compensation of these space changes have led to the conclusion that "although the 'Phonopress' vacuum cell must already be the vacuum cell with the highest emission yet attained," it could be improved still further by the introduction of traces of gas. "Semi-vacuum" cells, based on this idea, have the high sensitivity of 80–100 μA primary photo-electron current per lumen.

486. "PHONOPRESS"-LAYER VACUUM PHOTOCELLS, AND THE "SEMI-VACUUM" TYPE.—Geffcken. (*See* 485.)

487. THE EXTERNAL PHOTOELECTRIC EFFECT IN COMPOSITE PHOTOCATHODES AT LOW TEMPERATURES.—R. Suhrmann and D. Dempster. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 549–551.)

Further development of the work dealt with in 1934 Abstracts, p. 276. At liquid-air temperature the special cathodes showed a decrease in sensitivity when illuminated with the light of selective maxima: this is explained as due to the excitation of light-absorbing centres in the surface. Such excitation occurs also at room temperatures, but with so short a duration that it is not noticeable. The excitation at low temperatures is extinguished by illumination with red light: an electron current is then emitted which decreases with the irradiation time. The final section shows that both processes can be expressed quantitatively in equations (1a and 2a respectively) involving the irradiation time.

488. ON THE CALCULATION OF PHOTOCELL EQUIPMENTS FOR WORK IN VARIOUS SPECTRAL REGIONS.—G. N. Markow and A. M. Pylajew. (*Russian Journ. of Tech. Phys.*, No. 4, Vol. 4, 1934, pp. 777–791.)

From the authors' summary:—The paper describes: (1) some properties of the photocells and some special conditions of use, (2) fundamental properties of the light sources and light filters employed, and (3) determination of the integral sensitivity of the cell. The derivation of the expression for the magnitude of the photocurrent is given. By the use of the equations obtained and with the help of certain coefficients it is possible to find the integral sensitivity if the following values are known: (a) the spectral distribution of the radiated energy, the spectral transparency of the light filter, and the relative sensitivity of the cell (in arbitrary units) in the different regions of the spectrum; (b) the sensitivity of the cell in amperes/lumen; and (c) the radiated power in watts of the light source.

489. ENERGY DISTRIBUTION OF PHOTOELECTRONS AS A FUNCTION OF THE THICKNESS OF A POTASSIUM FILM.—J. J. Brady. (*Phys. Review*, 1st Nov. 1934, Series 2, Vol. 46, No. 9, pp. 768–772.)

The potassium films were formed on a silvered glass surface at room temperature by means of a molecular beam. Current/voltage curves were taken for photoelectrons ejected from films of different thicknesses. The film thicknesses were computed from experimental data. The curves obtained (of which several are given) were analysed by Du Bridge's method (1933 Abstracts, p. 455) and agreed well with the theory. For films of less than three molecular layers, a constant decrease in photocurrent after the formation of the film had to be taken into account, but the photocurrent was constant for thicker films. The photocurrent for films of less than three molecular layers did not saturate for accelerating potentials up to 20 volts but, as the film thickness increased, the photocurrent began to saturate at lower voltages.

490. THE TEMPERATURE DEPENDENCE OF THE PHOTOELECTRIC EFFECT OF METAL SURFACES, BOTH PURE AND COVERED WITH DIFFERENT ATOMS, AT LOW TEMPERATURES. —R. Suhrmann and A. Schallamach. (*Zeitschr. f. Physik*, No. 11/12, Vol. 91, 1934, pp. 775–791.) The full paper, a preliminary account of which was referred to in 1934 Abstracts, p. 216.

491. MEASUREMENT OF THE CURRENT GENERATED BY A RECTIFIER PHOTOELECTRIC CELL.— H. H. Poole and W. R. G. Atkins. (*Nature*, 24th Nov. 1934, Vol. 134, pp. 810–811.)

This letter refers to Campbell and Freeth's method of measurement, designed to reduce the internal leakage of the cell (1934 Abstracts, p. 331), and describes a slight modification of the circuit useful over a large range of illumination. A standard potentiometer of known resistance is used as a source of potential, and the microammeter used by the writers named is replaced by a known resistance variable from 100 ohms for full sunlight up to 100 000 ohms for very weak light. The current is immediately deducible from the setting of the potentiometer and the value of the resistance. For work at sea, the galvanometer may be replaced by an interrupter/amplifier/telephone combination.

492. THE ACTION OF LIGHT ON THIN METAL PLATES [Metallic Photo-Resistance].—Q. Majorana. (*Physik. Zeitschr.*, 15th Sept. 1934, Vol. 35, No. 18, pp. 740–744.)

Previous work on the subject of the increase of resistance of thin metallic plates under the action of an intense beam of light was referred to in Abstracts, 1933, p. 170: *see* also 231 of January. The compensator used for the experiments is described; an ordinary vacuum potassium photoelectric cell was employed. The effect is specially marked in Pt, Ag, Au and Sn, while Al and Na do not show it at all: it is greater in metals which have a very high photoelectric threshold. The magnitude of the effect depends on the thickness of the metal, on the interruption frequency of the beam of light, and in certain cases on the nature of the radiation; it appears to be more marked at longer wavelengths. Experiments with Pt in water showed a considerable decrease of the effect in still water and no further decrease in running water. The effect is still observed when the light pulsates with a frequency of 16 000 c/s but weakens when the frequency is raised above this value: with pulsating light there is a phase difference of 45° from the primary light. The writer is of the opinion that this effect involves a new direct action of light on metallic resistance, which is not without inertia, as is the photoelectric effect.

493. Flicker Relations within the Fovea.—F. A. Geldard. (*Journ. Opt. Soc. Am.*, November, 1934, Vol. 24, No. 11, pp. 299–302.)

494. A Visual Thresholdometer [Spectacle Device for appraising Relative Visibilities].—Luckiesh and Moss. (*Journ. Opt. Soc. Am.*, November, 1934, Vol. 24, No. 11, pp. 305–307.)

495. A Cold-Cathode Neon-Sodium-Vapour Lamp for Television [with Correct Sodium Vapour Pressure maintained by Auxiliary Heater].—Rust. (*See* 560.)

496. Laws Governing the Radiation Emission from the Positive Column of the Neon Discharge.—H. Krefft and E. O. Seitz. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 556–559.)

497. Electrical and Optical Characteristics of the High-Pressure Mercury-Vapour Discharge [Dependence of Luminous Output (and its Distribution) and Positive-Column Potential Gradient on Pressure, Current and Tube Diameter].—B. N. Klarfeld and E. S. Plochozkij. (*Russian Journ. of Tech. Phys.*, No. 4, Vol. 4, 1934, pp. 796–803.)

498. The Characteristic of the Mercury-Vapour Arc between Fixed Electrodes.—W. Ende. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 601–604.)

499. The (Physical) Radiating Properties of the Discharge in Mercury Vapour [at Constant Current Strength and Pressures from 0.01 to 1 000 mm Hg].—H. Krefft. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 554–556.)

500. A Steady Mercury Lamp for Use in [Photoelectric] Research.—A. L. Johnsrud. (*Review Scient. Instr.*, November, 1934, Vol. 5, No. 11, p. 408.)

MEASUREMENTS AND STANDARDS

501. Constant Electrical Oscillatory Circuits with Small Variation with Temperature [New Possibilities of Frequency Constancy equal to that given by Crystal Circuits].—L. Rohde. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 613–617.)

The control quartz oscillators of short-wave transmitters have, under good conditions, a temperature coefficient of frequency of the order of 2×10^{-5}; if crystals of special cut are used, this may be reduced to 3×10^{-6}. Such a constancy is sufficient, but crystal control is inconvenient for portable sets and where wavelengths have to be changed. The writer shows that a circuit with a wide frequency range can be built which will give a frequency constancy within about 1×10^{-4} and will not vary with change of temperature.

The steps taken to obtain this independence of temperature include:—(i) Replacement of wire-wound coils, with their variation due to the expansion of the copper wire, by "windings" fused firmly into ceramic carriers, so that expansion depends not merely on the copper but also on the carrier. The Hescho "ardostan" is mentioned for its low expansion coefficient: "calit" for the remarkable reproducibility of results over large temperature ranges. (ii) The use of a condenser whose dielectric ("condensa" or "kerafar") has a *negative* temperature coefficient, to neutralise the variation of another condenser whose dielectric (*e.g.* "calit") has a positive temperature coefficient. Fig. 6 shows the remarkably good compensation thus obtained.

502. The Temperature Cofficient of Quartz Oscillators.—H. Straubel. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 607–608.)

The tests on the special "cuts" were over the temperature range −180 to +300°C (*see* 246 of January). Similar tests are now applied to a number of different "cuts," hitherto only tested between 20 and 80°C. They all oscillated uniformly and without fluctuation of power up to over 300°C, the output only dropping at a high temperature, about 10° below the breaking-off point. The frequency variation with temperature is shown in Figs. 1 and 2 for several different "cuts." For all of them except those with low temperature coefficients the variation per degree diminishes at the low temperatures. At high temperatures only the +51.8° cut shows a frequency maximum in the positive quadrant.

The diagrams show that the temperature coefficient can be made very small over quite a good temperature range. Thus in the positive quadrant (Fig. 1) the +41°-cut curve gives a variation less than 1×10^{-6}/°C between −40 and +56°C, which (assuming a parabolic course) means a variation of 0.75×10^{-8}/°C over an interval of 2°C. The +40° cut is even better. For a given cut the plate must be thin—those investigated had an average thickness of 0.28 mm and a surface of about 18 × 18 mm. The fundamental frequency was 7.14×10^6 c/s. *See* also Bechmann, next abstract (503).

503. THE TEMPERATURE COEFFICENTS OF THE NATURAL FREQUENCIES OF PIEZOELECTRIC QUARTZ PLATES AND BARS.—R. Bechmann. (*Hochf:tech. u. Elek:akus.*, November, 1934, Vol. 44, No. 5, pp. 145–160.)

After an introductory paragraph the writer says: "For practical purposes, quartz oscillators and resonators with small T.K. [temperature coefficient] are of considerable importance. It was Giebe and Scheibe who first noticed that thin bars of suitable orientation, excited to longitudinal vibrations, possess a very small T.K. [Abstracts, 1930, p. 462, and 1933, pp. 337–338.].

"Further, the conditions for the obtaining of small T.K. by quartz bars were examined in detail by Matsumura and Kanzaki [1932, p. 533: *see* also 1933, p. 514]. The production of small T.K. by means of coupling effects [between two types of oscillation], for plates and bars within a certain interval of temperature, was reported on by Lack [1929, p. 582] and Parkin [1932, pp. 594–595]. That the T.K. for thickness vibrations of quartz plates is a function of the angle of orientation was first observed by the writer [1934, p. 47, *Naturwiss.* letter] who showed that plates of a certain orientation possess null points of T.K. for their natural frequencies, for two special values of angle of inclination to the optical axis. This result has been described anew by Straubel [1934, p. 332: *see* also 246 of January, and 502, above]. In the investigations described in the present paper it is found that plates, both for oscillations depending on the thickness and on the transverse dimensions, possess numerous null points of T.K. dependent on their orientation and on their shape. The purpose of these investigations is to arrive at a generalised representation of the T.K. of the natural oscillations of quartz plates and bars, and to separate the pure phenomena from the composite effects mentioned above." Thus the greatest care is taken to eliminate multiple oscillation, which is at the root of a whole number of contradictory results—such as the large jump in temperature coefficient produced by a quite inconsiderable change in diameter or length of side. As a result of such elimination it is found, as expected, that the thickness vibrations of plates depend for their frequency only on the crystal orientation and not on the shape of the plate, provided the thickness is small compared with the transverse dimensions. If the ratio thickness/transverse dimensions is *not* small, the temperature coefficient is a function of this ratio.

Two methods of excitation were used: the Pierce connection with the quartz between grid and cathode, and a two-valve circuit independent of capacities in parallel with the electrodes (*e.g.* holder capacities: Bechmann: Telefunken, 1934, p. 47). The temperature coefficients were for the most part measured with the help of a precision wavemeter with luminous-quartz control. In Part I the theory is given of infinitely large plates and infinitely thin bars, with experimental confirmation. In Part II the laws are derived for the temperature coefficients of the natural oscillations of these structures, and from them the temperature coefficients of the elastic constants are determined. Part III deals with some experimental investigations on those natural oscillations, and their temperature coefficients, which are dependent on the transverse dimensions, and for which no satisfactory analytical representation has yet been worked out.

504. MEASUREMENT OF THE VELOCITY OF SOUND IN ANISOTROPIC MEDIA, IN PARTICULAR IN QUARTZ USING PIEZOELECTRIC EXCITATION.—R. Bechmann. (*Zeitschr. f. Physik*, No. 9/10, Vol. 91, 1934, pp. 670–678.)

A theoretical investigation is given of the velocities of sound in various directions through anisotropic media; they are found to be determinable from the natural vibrations of plates excited piezoelectrically. These are measured for quartz crystals of various cut and good agreement is found with theory.

505. LAWS OF THE DISENGAGEMENT OF ELECTRICITY BY TORSION IN QUARTZ CRYSTALS.—Ny Tsi-Ze and Tsien Ling-Chao. (*Comptes Rendus*, 19th Nov. 1934, Vol. 199, No. 21, pp. 1101–1102.) Further development of the work referred to in Abstracts, 1934, p. 332. *See* also 1934, p. 569 and Tawil, 251 of January.

506. DIELECTRIC LOSSES IN QUARTZ, ROCK-SALT AND MICA.—Bogorodizky and Malyschew. (*See* 552.)

507. THE VARIATION OF THE COEFFICIENT OF RIGIDITY OF NICKEL AS A FUNCTION OF THE MAGNETISATION [in connection with Low-Frequency Vibrators using Torsional Magnetostriction].—R. Jouaust. (*Comptes Rendus*, 26th Nov. 1934, Vol. 199, No. 22, pp. 1195–1196.)

508. THE VOLTAGE RESONANCE CIRCUIT FOR INDICATOR FREQUENCY-METERS WITH THE FERRARI QUOTIENT SYSTEM [Conditions for Linearity of Scale and Size of Circuit Components].—H. Boekels. (*Arch. f. Elektrot.*, 10th Nov. 1934, Vol. 28, No. 11, pp. 723–727.)

509. A BRIDGE FOR THE DETERMINATION OF THE FREQUENCY OF AN ALTERNATING CURRENT IN THE AUDIO-FREQUENCY RANGE.—G. D. Pegler. (*Proc. Phys. Soc.*, 1st Nov. 1934, Vol. 46, Part 6, No. 257, pp. 783–789.)

The principle of the bridge is the measurement (with any suitable bridge—the Owen bridge is chosen) of the changes in effective resistance and inductance of the primary coil of an air-cored transformer as the resistance of the secondary circuit is varied. The absolute resistance of the primary coil or its variation with frequency and temperature need not be known; there is a linear relationship between the frequency and a measured resistance. A Wagner earth system is added, to eliminate earth-capacity effects. The theory of the method is given and corrections due to residuals are described.

510. A NEW METHOD OF MEASURING COMPLEX RESISTANCES [Substitute for A.C. Bridge, based on Campbell's Method of comparing Capacity with Mutual Inductance].—R. Witting: Busch. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 669–673.)

The imaginary component of the voltage drop at the unknown impedance is compensated by the secondary voltage of a standard mutual inductance, while the real component is taken through a standard resistance and, after being reversed in sign by a voltage or current transformer so as to be in the right sense for producing compensation, is led to the primary of the compensating mutual inductance. The method has advantages over bridge methods, in the precision and convenience with which small loss angles can be measured directly.

511. A BALANCE-DETECTOR FOR ALTERNATING CURRENT BRIDGES [Balanced Valve with Portable D.C. Galvanometer].—C. R. Cosens. (*Proc. Phys. Soc.*, 1st Nov. 1934, Vol. 46, Part 6, No. 257, pp. 818–823.)

512. THE ELECTRICAL CONDUCTIVITY OF STRONG ELECTROLYTES AND ITS VARIATION WITH TEMPERATURE [Measurement by Sensitive and Accurate A.C. Bridge Method].—C. J. B. Clews. (*Proc. Phys. Soc.*, 1st Nov. 1934, Vol. 46, Part 6, No. 257, pp. 764–771.)

513. DIELECTRIC POWER FACTOR MEASUREMENTS AT AUDIO- AND RADIO-FREQUENCIES [for Liquid and Solid Dielectrics: Frequencies 60 c/s to 7.2 Mc/s).—G. M. L. Sommerman. (*Review Scient. Instr.*, October, 1934, Vol. 5 No. 10, pp. 341–345.)

A Wien bridge with Wagner ground and special double shielding of the series resistance arm was used up to 10 kc/s; above that the resonance-substitution method was employed. It is shown that power factor measurements give a much more delicate test of the presence of anomalous dispersion than do dielectric constant measurements.

514. ABSOLUTE LOSS FACTOR MEASUREMENT IN INSULATING MATERIALS [using a Condenser of Special Design].—A. Wirk. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 15, 1934, pp. 487–491.)

Previous air condensers (such as the P.T.R. condenser with two fixed and one rotating plate) used as loss factor standards have been found liable to variation owing to the intrusion of dust, the formation of an oxide layer, and other causes. The special condenser here used has two plates only, one fixed and the other combining a rotational with a translational movement: the axle of this second plate is in two parts linked by an easy-running thread, and is driven by a knob through a friction clutch. Turning the knob first rotates the plate, until a stop is reached which ends the rotation and brings in the forward or backward motion. By the use of this condenser and a series of readings in different connections, absolute loss factor measurements can be made with a possible error of 1×10^{-6}.

515. ELECTRICAL PROPERTIES OF MATERIALS AT HIGH RADIO FREQUENCIES [Accurate Measurement from Distance between Antinodes of Current or Potential on Lecher Wires immersed in Material].—J. S. McPetrie. (*Nature*, 8th Dec. 1934, Vol. 134, pp. 897–898.)

516. ELECTROLYTIC METHOD OF MEASURING INTER-ELECTRODE CAPACITIES OF A VALVE.—Kalinsky. (*See* 444.)

517. THE SEMI-ABSOLUTE MEASUREMENT OF HIGH-FREQUENCY CURRENTS [3 to 15 Mc/s, with Error of less than 2%].—R. E. Albrandt. (*Izvestia Elektroprom. Slab. Toka*, Aug./Sept. 1934, No. 7, pp. 24–35.)

An equipment is described for checking and calibrating hot-wire instruments at high frequencies. The meter to be checked is connected in a standard test circuit, to which is inductively coupled a small winding with a thermojunction/galvanometer combination. This combination is previously calibrated with direct current, and the galvanometer reading is multiplied by the transformation ratio mathematically calculated. Currents of 5 amperes upwards can be measured.

518. THERMOELECTRIC AMMETERS OF THE "ELECTROPRIBOR" [with Manufacturing Considerations regarding Thermojunctions].—J. S. Averbuch. (*Izvestia Elektroprom. Slab. Toka*, Aug./Sept. 1934, No. 7, pp. 38–45.)

519. A NEW TYPE OF ELECTROSTATIC VOLTMETER FOR SMALL POTENTIALS AND HIGH FREQUENCIES [with "Quadrant" Box divided into Three Parts by Two Parallel Cuts, and an Isolated Vane of Special Shape].—A. Bestelmeyer. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 661–664.)

The two outer parts of the box are connected together and form one pole, the other pole being the central part. A potential difference between these two elements causes the vane to set itself so that the best possible capacitive linkage between the two elements may be produced. The fact that the vane is isolated enables the ideal suspension —quartz fibre—to be employed. According to calculation such an instrument, with properly calculated vane form, should have a very remarkable performance; the vane should remain motionless at zero up to a definite value (in the particular case 1 v) and then should have a uniform voltage scale up to the end (20 v). Or, by suitable design of the vane, the scale could be made logarithmic, Naturally, owing to gaps between the box elements, etc., the actual performance would only approximate to the calculated.

520. HIGH-TENSION VOLTMETER ON ELECTRON-OPTICAL PRINCIPLES [giving Accuracy within 1% on Voltages up to 40 kV].—E. Fünfer. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 582–584.)

521. MEASUREMENT OF THE PEAK VALUES OF SHORT SURGE-POTENTIALS BY MEANS OF A SPHERE SPARK GAP.—A. Walther and L. Inge. (*Russian Journ. of Tech. Phys.*, No. 4, Vol. 4, 1934, pp. 813–821: with long German summary.)

522. DETERMINATION OF THE FORM OF PULSE WAVES [Transients on Cables] BY THE METHOD OF SIMULTANEOUS MEASUREMENT OF TWO VOLTAGES.—S. Szpor. (*Arch. f. Elektrot.*, 10th Nov. 1934, Vol. 28, No. 11, pp. 695–702.)

523. FUNDAMENTAL POINTS ON THE CALIBRATION OF INTERCHANGEABLE SHUNT AND SERIES RESISTANCES [for Moving Coil Meters].—H. Freytag. (*E.T.Z.*, 4th Oct. 1934, Vol. 55, No. 40, pp. 979–980.)

524. MAGNIFIER FOR GALVANOMETER DEFLECTIONS [Moving System carries Centre Electrode of Three-Electrode Liquid Resistance in Bridge Connection with Push-Pull Transformer].—R. Sewig and W. Appuhn. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 668–669.)

525. REPRODUCTION OF THE LOAD CURVE BY MEASURING INSTRUMENTS GIVING THE MEAN VALUE.—H. Dallmann. (*Arch. f. Elektrot.*, 10th Nov. 1934, Vol. 28, No. 11, pp. 710–716.)
Application to the measurement of large quantities of power.

526. MEASUREMENT OF NON-LINEAR DISTORTIONS.—Faulhaber. (*See* 455.)

527. SPECIAL CASES OF THE MUTUAL INDUCTANCE BETWEEN CIRCLES, WITH SOME PRACTICAL APPLICATIONS.—Llewellyn. (*See* 397.)

SUBSIDIARY APPARATUS AND MATERIALS

528. CONTRIBUTION TO THE DEVELOPMENT OF THE CATHODE-RAY OSCILLOGRAPH WITH FLUORESCENT-SCREEN CONTACT-PHOTOGRAPHY FOR RECORDING PURPOSES.—Freisewinkel. (*Arch. f. Elektrot.*, 20th Oct. 1934, Vol. 28, No. 10, pp. 602–611.)

The efficiency finally reached with the arrangement here described was a recording spot velocity of 2 000 km/sec. with magnetic locking, 55 kv beam voltage and a few microamperes beam current. The oscillograph employed was that of Rogowski, Flegler and Tamm (*Arch. f. Elektrot.*, No. 6, Vol. 18, 1927, p. 515). Glass discharge tubes as described by Beyerle were used (Abstracts, 1931, p. 396). The fluorescent screens were made by covering the base with a solution of waterglass, sprinkling crystals of the fluorescent material (znscu or $cawo_4$) on it to sufficient thickness, and evaporating the water. Photographs are given to illustrate the effect of various screen thicknesses and size of crystal. Mica is recommended as a base for the fluorescent material. The screen was supported by a grid of steel as used by Knoll and von Borries (1931, p. 51). Photographs of the camera are given; roll film was used (Knoll, 1931, p. 163). The control relay and its circuit diagram are also shown. Pictures taken with the apparatus are given, to illustrate its efficiency.

529. ELECTRON-OPTICAL IMAGE FORMATION WITH PHOTOELECTRICALLY LIBERATED ELECTRONS.—Pohl. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 579–581.)

Following on the work of Brüche (Abstracts, 1934, p. 107, l.h column: *see* also Knoll and Ruska, 1933, p. 51). The efficacy of the equipment used is illustrated by the comparison of photographs taken with it and with light photography. The method is applied to show the influence of gas content and crystal structure on the geometrical distribution of the photoelectric and thermionic emission from platinum.

530. THE PRINCIPLES OF DESIGN OF ELECTRON-OPTICAL SYSTEMS, *and* COMPUTATION OF CATHODE-RAY DEFLECTION IN THE MAGNETIC FIELD OF A COIL.—Polotovsky: Dozoroff. (*See* 479 and 480.)

531. THE INFLUENCE OF THE ACCELERATING GRID [and Its Inhomogeneous Field] ON THE SPOT FOCUS OF THE CATHODE-RAY OSCILLOGRAPH.—Graupner. (*Arch. f. Elektrot.*, 10th Nov. 1934, Vol. 28, No. 11, pp. 727–728.)

Consideration of the lines of force of the second accelerating grid shows that the inhomogeneity of the field will have least effect on the sharpness of the record if the oscillogram is recorded in a direction perpendicular to the grid wires. If however it is desired that any particular co-ordinate should be recorded very exactly, it must run parallel to the grid wires; the record is then broader and of correspondingly smaller intensity.

532. A NOTE ON DAVISSON'S ELECTRON-LENS FORMULAE [Proof and Interpretation].—Bedford. (*Proc. Phys. Soc.*, 1st Nov. 1934, Vol. 46, Part 6, No. 257, pp. 882–888.) *See* Davisson and Calbick, 1933 Abstracts, p. 224.

533. CONDITIONS AND LIMITS OF CORRECT IMAGE FORMATION BY MEANS OF ELECTRON PROJECTION. ELECTRON PATHS IN THE CYLINDRICAL ELECTRIC FIELD OF A ROUGH CRYSTALLINE INCANDESCENT WIRE [Distortions due to Irregular Fields surrounding Filaments and Producing Initial Curvature of Path: Theory and Experimental Confirmation].—Seemann. (*Zeitschr. f. Physik*, No. 3/4, Vol. 92, 1934, pp. 253–273.) *See* also 1933 Abstracts, p. 161, r-h column.

534. A TIMING METHOD FOR CATHODE-RAY OSCILLOGRAPHS [using a Grid to control the Flow of Electrons].—Sundt and Fett. (*Review Scient. Instr.*, November, 1934, Vol. 5, No. 11, pp. 402–404.)

As used for the automatic calibration of the time-axis in fuse and neon-glow-tube characteristic recording (*see* also Abstracts, 1934, p. 512). "It also adapts the cathode-ray tube to the measurement of 3 variables such as current, voltage and time. The method is applicable to both transients and steady state conditions." The time-marking method using a change of focus is mentioned (Richardson, 1933, p. 283, l-h column): "the advantage of using the grid is obvious, since the focus is not disturbed and a low potential is handled. . . ."

535. SATURATION IN INDIRECTLY HEATED SPACE-CHARGE-GRID VALVES AND ITS APPLICATION TO TIME BASE FOR CATHODE-RAY OSCILLOGRAPH.—Hehlgans. (*See* 440.)

536. ON METHODS IN ELECTRON MICROSCOPY.—Gen, Zelmanov and Shalnikov. (*Russian Journ. of Tech. Phys.*, No. 2, Vol. 4, 1934, pp. 358–362).

A description is given of an electron microscope built by the Institute of Chemical Physics of Leningrad. The microscope comprises a Coolidge-type discharge tube, a water-cooled cylinder with three consecutive diaphragms for selecting a narrow beam, a diffraction camera in which the object to be investigated is placed, and a photographic plate holder. A number of photographs obtained are shown, and various uses of the apparatus are indicated.

537. THE ELECTRON-OPTICAL OBSERVATION OF CHANGES IN IRON AT TEMPERATURES BETWEEN 500 AND 1 000° C.—Brüche and Knecht. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 15, 1934, pp. 461–463.)

538. THE MEASUREMENT OF LOW PRESSURES [Comparison of High-Vacuum Measuring Methods, leading to the "Molvakumeter" using Thermal Molecular Pressure to affect Period of Oscillating Aluminium Vane: Range 10–10^{-7} mm Hg].—Gaede. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 664–668.)

539. NEW METHODS OF LEADING-IN TO VACUUM CONTAINERS [Air-Tight Seals between Ceramic Materials and Glass: "Metal-Skin" Lead-Ins: etc.].—Handrek. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 15, 1934, pp. 494–496.)

Author's summary:—A large variety of ceramic materials with linear expansion coefficients from below 2.5×10^{-6} up to 9×10^{-6} have been successfully fused with glass to form gas- and liquid-tight joints. The most important condition for the durability of the seal is that the expansion coefficient of the glass should be *smaller* than that of the ceramic material [not, as commonly assumed, equal to it]. The fusing process can be done by blow-lamp flame or electrically.

By the use of glass as an intermediary, thick metal leads can be sealed into ceramic containers [*e.g.* into porcelain mercury-relay tubes]. The application of the knowledge obtained as to the forces acting at the boundary surfaces between metal and glass has led to the design of a quite new type of lead-in—the "metal skin" lead-in [*e.g.* a rod of porcelain or calit on to which a layer of silver or other noble metal is fused at 700–800° C]. Its advantages are freedom from strain, high carrying power and good h.f. properties, as well as the ease with which it can be fused electrically into ceramic containers.

540. PROGRESS IN OSCILLOGRAPH TECHNIQUE [Loops with Natural Frequencies of 20 000 c/s: High Sensitivity: etc.].—Jaekel. (*Zeitschr. V.D.I.*, 13th Oct. 1934, Vol. 78, No. 41, pp. 1205–1206.)

541. CONTRIBUTION TO THE STUDY OF SOME DRY-PLATE RECTIFIERS [Elkon Pb/CuS/Mg Rectifier and "Insensitive" Galena].—Peychès: Anastasiades. (*Comptes Rendus*, 26th Nov. 1934, Vol. 199, No. 22, pp. 1198–1199.)

Tests prompted by the experiments and conclusions of Anastasiades (Abstracts, 1934, pp. 106–107) on the double rectification (normal and opposing) of the Elkon cell. Direct measurements were made of the various mean p.ds when the cell was acting as a voltage rectifier. In the conditions obtaining, no sign was found of the slightest p.d. between the lead and the copper sulphide (to which contact Anastasiades attributed the opposing rectification); it appears that the main contact CuS/Mg is responsible for the opposing as well as for the normal rectification. Preliminary tests on "insensitive" galena (*cf.* Cabanel and Cayrel, 1934, p. 106) indicate that there also the point/crystal contact alone is responsible for the opposing rectification at low potentials as well as for the normal rectification.

542. INFLUENCE OF TEMPERATURE ON THE ELECTRICAL CONDUCTIVITY OF CUPRIC SULPHIDE IN A THIN LAYER.—Devaux and Cayrel. (*Comptes Rendus*, 5th Nov. 1934, Vol. 199, No. 19, pp. 912–914.) Further development of the work referred to in 1934 Abstracts, p. 335, r-h column.

543. RECTIFICATION PHENOMENON IN PYROLUSITE CRYSTAL [dipped into Mercury, giving Very Large Contact Area: *Not* Crystal/Point-Contact Action but associated with Layer of Air between Crystal Surface and Mercury].—Khastgir and Gupta. (*Current Science*, Bangalore, October, 1934, Vol. 3, No. 4, p. 153.)

544. NEW SCHEMES OF CONTROLLED RECTIFIERS [with Uncontrolled Rectifier Valve connected between Transformer Zero Point and Cathode].—Babat. (*Izvestia Elektroprom. Slab. Toka*, Aug./Sept. 1934, No. 7, pp. 46–57: to be concluded.)

The arrangement makes the voltage control depend not merely on phase displacement of the pulses through the controlled anodes but also on the variation of their duration; this gives better power factor, less ripple and other advantages.

545. HIGH-FREQUENCY INSULATING MATERIALS WITH LOW LOSS AND HIGH DIELECTRIC CONSTANTS [Ceramic Materials with Magnesium Silicate Base: Comparative Data].—Handrek. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 15, 1934, pp. 491–493.)

546. HIGH-FREQUENCY DIELECTRICS—STEATITE AND SINTERCORUNDUM [and the Measurement of their Dielectric Losses under Load at Wavelengths down to 70 m].—Popoff. (*Izvestia Elektroprom. Slab. Toka*, May, 1934, No. 4, pp. 50–57.)

547. OBTAINING NON-HYGROSCOPIC PAPER [Two Methods, giving Values of tan δ such as 0.001 at 10 Mc/s].—Soletchnik and others. (*Izvestia Elektroprom. Slab. Toka*, Aug./Sept. 1934, No. 7, pp. 58–63.)

548. THE PAPER CONDENSER, PARTICULARLY FOR POWER WORK.—Gönningen. (*E.T.Z.*, 18th Oct. 1934, Vol. 55, No. 42, pp. 1021–1024.)

549. AGEING OF INSULATING MATERIALS.—Vul and Goldman. (*Russian Journ. of Tech. Phys.*, No. 2, Vol. 4, 1934, pp. 268–284.)

The application of high voltages to insulators of organic origin causes minute electrical discharges in the pores. Experiments with paper, varnished cambric and cellulose acetate show that these materials deteriorate with time, mainly owing to chemical action set up by such discharges. Various practical suggestions are made.

550. CORROSION IN WIRE RESISTANCES FOR RADIO PURPOSES WOUND ON STEATITE INSULATING MATERIALS [due to Action of Traces of Pyrites in the Steatite on Nickel and Its Alloys ?].—Schürmann and Esch. (*E.T.Z.*, 11th Oct. 1934, Vol. 55, No. 41, pp. 1003–1005.)

A letter from Albers-Schönberg in the issue for 25th October, p. 1066, accuses the writers of this paper of ignorance of what Steatite really is. They talk, for instance, of a 4.5% MgO content: no Steatite contains less than many times this amount. They are apparently dealing with a porous magnesium-containing kaolin product such as is used for carrying heater windings. But even these materials are made at temperatures of 1300–1450°, whereas pyrites is converted into iron oxide below 400°.

551. NEW DEVELOPMENTS IN THE FIELD OF FIXED AND VARIABLE HIGH RESISTANCES.—Riepka. (*E.T.Z.*, 1st Nov. 1934, Vol. 55, No. 44, pp. 1073–1075.)

Including the glance-carbon on ceramic carrier types; the Allen-Bradley variable resistance with the desired characteristic obtained by mechanical gear; and a newly patented noiseless adjustable resistance in which a globule of mercury forms the rotating contact. American and European tendencies and standards are contrasted in the final paragraph.

552. DIELECTRIC LOSSES IN CRYSTALS [Experimental Study of Rock-Salt, Mica and Quartz].—Bogorodizky and Malyschew. (*Arch. f. Elektrot.*, 20th Oct. 1934, Vol. 28, No. 10, pp. 644–653.)

The a.c. conductivity of various single crystals was measured and compared with their d.c. conductivity. In rock-salt the two were found to be the same; in mica they were the same at high temperatures but differed at low temperatures. In quartz cut parallel to the optical axis they were the same but differed in quartz cut perpendicular to the axis: in amorphous quartz they were again the same.

In all crystals the h.f. dielectric losses were found to be vanishingly small. The law of change was exponential, to the power of the negative reciprocal of the temperature. All losses were purely of ohmic character.

553. ABSOLUTE LOSS FACTOR MEASUREMENTS ON INSULATING MATERIALS.—Wirk. (*See* 514.)

554. DIELECTRIC POWER FACTOR MEASUREMENTS AT AUDIO- AND RADIO-FREQUENCIES.—Sommerman. (*See* 513.)

555. LITZ WIRE COILS [and the Agreement between Theoretical and Experimental Values].—Hak: Gönningen. (*E.T.Z.*, 25th Oct. 1934, Vol. 55, No. 43, pp. 1049–1052.)

Gönningen's new measurements on the h.f. resistance of air-cored coils wound with litz wire (1934 Abstracts, p. 277) were presented rather as though they gave unexpected results. Hak therefore examines them and shows that they can be reconciled with the theoretical values. He first makes use of the Rogowski formula for the a.c./d.c. resistance ratio of a long single-layered coil, and later applies the correction for short coils from Butterworth's formula.

556. A THEORY OF MAGNETIC CIRCUITS [and the Design of Electro-Magnetic Relays].—Kovalenkoff. (*See* 389.)

557. ON THE "STARTING" OF VOLTAGE-STABILISING CIRCUITS USING GLOW-DISCHARGE TUBES.—K. Lämmchen. (*Hochf:tech. u. Elek:akus.*, November, 1934, Vol. 44, No. 5, pp. 160–163.)

Both the "Stabilisator" circuit (*see* Abstracts, 1934, p. 51, r-h column, various; and p. 453, l-h column, Körös and Seidelbach) and the writer's bridge circuit (1934, p. 51) allow much greater currents to be stabilised than can be carried actually by the glow-discharge tube: there is however the difficulty that the discharge will usually refuse to start on switching on. In the Stabilisator connection this can, within certain limits, be remedied by a series iron/hydrogen resistance, but with the bridge connection this method is only partly satisfactory. The writer now describes a method which, by the use of two variable "starting" resistances mechanically coupled together, ensures the proper starting of the discharge whichever system is employed. He shows how to calculate the suitable resistances in either case.

558. IMPROVED VOLTAGE STABILISING CIRCUIT COMPENSATING SUDDEN FLUCTUATIONS NEGLECTED BY CIRCUITS USING HEATER-TYPE VALVES.—Lozier. (*Review Scient. Instr.*, November, 1934, Vol. 5, No. 11, pp. 393–394.) In Dunning's paper on amplifier systems.

559. SATURATION IN INDIRECTLY HEATED SPACE-CHARGE-GRID VALVES AND ITS APPLICATION TO "CONSTANT ANODE CURRENT" APERIODIC AMPLIFIER.—Hehlgans. (*See* 440.)

560. A DAYLIGHT STROBOSCOPE LAMP [Cold-Cathode Neon/Sodium-Vapour Lamp as developed for Television: driven off A.C. Mains with Rectifier cutting out One Half-Cycle to avoid Double Images].—N. M. Rust. (*Marconi Review*, Sept./Oct. 1934, No. 50, pp. 23–26.)

561. CHEMICAL FIXATION ON PAPER OF THE RECORDS GIVEN BY ELECTRIC WAVES.—W. Arkadiew. (*See* 372.)

562. THE TRANSITORY REGIMES AT THE EXCITATION OF AN OSCILLATING CIRCUIT CONTAINING AN IRON-CORED CHOKE.—Rouelle. (*See* 388.)

563. THE ION MANTLE EFFECT IN GAS DISCHARGES.—Güntherschulze. (*See* 369.)

STATIONS, DESIGN AND OPERATION

564. THE WLW 500-KILOWATT BROADCAST TRANSMITTER [with High-Level Class B Modulator, "Isolation" Operation of Control Circuit, Concentric Transmission Line, and 831-Foot Tower Aerial].—J. A. Chambers and others. (*Proc. Inst. Rad. Eng.*, October, 1934, Vol. 22, No. 10, pp. 1151–1180.)

100% modulation is obtainable at all frequencies between 30 and 10 000 c/s. At 95% the over-all audio harmonics are 5.3% r.m.s. The frequency characteristic, at 50% modulation, ranges from 1 db below the 1 000 c/s value at 30 c/s, through zero db at 5 000 to 0.5 db low at 8 000 and 2 db low at 10 000 c/s. The strongest (second) r.f. harmonic, so far as radiation along the ground is concerned, has a strength of 0.002 w compared with 525 kw for the fundamental.

565. A 500 kW Broadcasting Station in America [Cincinnati].—Arendt. (*E.T.Z.*, 25th Oct. 1934, Vol. 55, No. 43, pp. 1047–1048.)

566. A System for Single-Sideband and Carrier Broadcast Transmission.—Murphy. (*See* 404.)

567. A New Modulation Method for Broadcasting Stations [" Floating Carrier "].—Pungs and Gerth. (*See* 402.)

568. Increasing the Efficiency of Broadcasting Stations [by New Transmission Methods].—Z. I. Model. (*Izvestia Elektroprom. Slab. Toka*, Aug./Sept. 1934, No. 7, pp. 1–7).

The operation of a modern high-power broadcasting station is examined both from the technical and economic points of view, and a basis for comparison of different systems of operation is laid down. A survey is then given of the following systems with their relative advantages and disadvantages :—(a) Phase modulation, (b) high power anode push-pull modulation, (c) separate transmission of the carrier and sidebands using either one, two, or three separate aerials, and (d) floating carrier, *i.e.* the variation of the carrier amplitude at syllable frequency in accordance with the strength of the speech (*see* also 402).

Of these, (d) is considered the most promising as it gives a considerable saving in power consumption for a small initial cost and is comparatively simple in operation. It is pointed out, however, that even a saving of 40 to 45% in consumption is only important for stations of the highest power, where the cost of power is an appreciable proportion of the total cost of broadcasting.

569. Technique of Common-Wave Broadcasting [particularly the Hahnemann Plan, and Its Extension, for giving Certain Day-and-Night Service, with Alternative Programmes, over the Whole of Germany].—P. R. Arendt : Hahnemann. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 15, 1934, pp. 624–630.)

570. Common-Wave Broadcasting Transmitters.—P. R. Arendt : Lorenz Company. (*Zeitschr. V.D.I.*, 13th Oct. 1934, Vol. 78, No. 41, pp. 1177–1182.)

571. Common-Wave Broadcasting Transmitters [Survey].—Gerth. (*E.T.Z.*, 8th and 15th Nov. 1934, Vol. 55, Nos. 45 and 46, pp. 1097–1100 and 1121–1123 : Discussion pp. 1140–1141.)

572. Reorganisation of State Broadcasting—Decrees of 12th and 15th October, 1934.—de Fabel. (*Génie Civil*, 27th Oct. 1934, Vol. 105, No. 17, p. 392.)

573. The Future of Broadcast Transmission.—R. W. Hallows. (*Wireless World*, 14th Dec. 1934, Vol. 35, pp. 486–487.)

The writer suggests that ten years hence, owing to the increasing crowding of the ether, most broadcasting stations will operate on ultra-short waves.

574. Measuring Europe's Wavelengths [Equipment and Work of the Brussels Checking Station].—A. A. Gulliland. (*Wireless World*, 21st Dec. 1934, Vol. 35, pp. 516–518.)

575. Radiotelephonic Communications [Outline based on France/Algeria Service and Ship/Shore Working].—R. Picault. (*L'Onde Élec.*, October, 1934, Vol. 13, No. 154, pp. 386–402.)

576. England-Australia Air Race [Some Radio Apparatus used].—(*Wireless World*, 19th Oct. 1934, Vol. 35, p. 313.)

577. North Atlantic Ship-Shore Radiotelephone Transmission during 1932/1933.—Anderson. (*See* 362.)

GENERAL PHYSICAL ARTICLES

578. The New World-Picture of Modern Physics [British Association Paper].—J. H. Jeans. (*Science*, 7th Sept. 1934, Vol. 80, No. 2071, pp. 213–222.)

579. New Knowledge in the Field of Radiation [Lecture to Zurich Physical Society].—P. Scherrer. (*Bull. Assoc. suisse des Élec.*, No. 15, Vol. 25, 1934, pp. 405–412.)

580. On the Formation of Hydrogen in a Vacuum [Materialisation of the Ether].—V. Posejpal. (*Comptes Rendus*, 16th July, 1934, Vol. 199, No. 3, pp. 186–188.) Confirmatory tests of the writer's theory referred to in March Abstracts, p. 166.

581. Some Special Cases of the Indeterminacy Principle [including Linear Oscillator in Uniform Field : Anharmonic Oscillator].—F. E. White. (*Proc. Nat. Acad. Sci.*, September, 1934, Vol. 20, No. 9, pp. 525–529.)

582. Modified Ritz Method [Variation Method for Approximating to Lowest Energy Level, etc.].—D. H. Weinstein. (*Ibid.*, pp. 529–532.)

583. Observations on Hilbert's Independence Theorem and Born's Quantization of Field Equations [Formulation of Independence Theorem and Modification of Born's Scheme to Agree with Quantum Mechanics].—H. Weyl. (*Phys. Review*, 15th Sept. 1934, Series 2, Vol. 46, No. 6, pp. 505–508.) For Born's field equations *see* 1934 Abstracts, p. 223.

584. The Electromagnetic Fields of the Quantum Theory. I.—L. Goldstein. (*Journ. de Phys. et le Rad.*, October, 1934, Series 7, Vol. 5, No. 10, pp. 545–552.)

585. THE FUNDAMENTAL EQUATIONS OF ELECTROMAGNETISM, INDEPENDENT OF METRICAL GEOMETRY.—D. van Dantzig. (*Proc. Camb. Phil. Soc.*, October, 1934, Vol. 30, Part 4, pp. 421–427.)

586. DUALITY PRINCIPLE IN OPTICS [Corresponding to Point and Impulse Coordinates in Mechanics].—M. Herzberger. (*Naturwiss.*, 21st Sept. 1934, Vol 22, No. 38, p. 649.)

587. QUASI-STATIC MAGNETIC CYCLES IN WEAK FIELDS.—H. Wittke. (*Ann. der Physik*, No. 1, Vol. 20, 1934, Series 5, pp. 106–112.)

588. THE EMISSION OF SECONDARY ELECTRONS FROM VARIOUS METAL TARGETS.—L. H. Linford. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, p. 325: abstract only.)

589. THE ACTION OF ALTERNATING AND MOVING MAGNETIC FIELDS UPON PARTICLES OF MAGNETIC SUBSTANCES [Translatory Motion under Multi-Phase Alternating Field Explained].—H. S. Hatfield. (*Proc. Phys. Soc.*, 1st Sept. 1934, Vol. 46, No. 256, pp. 604–610.)

590. MAGNETIC HALL EFFECT IN CRYSTALLINE MEDIA, *and* CHANGE OF RESISTANCE OF CRYSTALLINE MEDIA IN A MAGNETIC FIELD.—M. Kohler. (*Ann. der Physik*, No. 8, Vol. 20, 1934, Series 5, pp. 878–890 and 891–908.)

591. CHANGE OF THE THERMAL AND ELECTRICAL CONDUCTIVITY OF A SINGLE BISMUTH CRYSTAL IN A MAGNETIC FIELD.—H. Reddemann. (*Ann. der Physik*, No. 4, Vol. 20, 1934, Series 5, pp. 441–448.)

592. MAGNETIC DOUBLE REFRACTION IN LIQUIDS [Water and Organic Liquids].—H. A. Boorse. (*Phys. Review*, 1st Aug. 1934, Series 2, Vol. 46, No. 3, pp. 187–195.)

593. INFLUENCE OF THE MAGNETIC FIELD ON THE DIELECTRIC CONSTANT OF LIQUIDS.—Piekara and Schérer. (*Comptes Rendus*, 29th Oct. 1934, Vol. 199, No. 18, pp. 840–843.)

A resonance method of measurement was used, with a wavelength of 600 m. No positive results could be obtained below 25 000 gauss, but at 51 000 gauss considerable increases in dielectric constant, up to 250×10^{-3} for nitrobenzene, were measured. These values, of an order of magnitude 1 000 times greater than those predicted by theory for gases, together with discrepancies between them and the refractive behaviour of some of the liquids, suggest that the molecular orientation effect must be accompanied by a second effect; it may be imagined that under the influence of the magnetic field the frequency of oscillation of the molecules approaches that of the electric field.

594. THE PRESSURE OF PLASMA ELECTRONS AND THE FORCE ON THE CATHODE OF AN ARC [Plasma Electrons exert Pressure depending on Their Density and Temperature].—L. Tonks. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, pp. 278–279.)

595. MEASUREMENTS OF RESISTANCE TO ALTERNATING CURRENT AND PLASMA OSCILLATIONS IN THE DIRECT CURRENT ARC.—E. Gerber. (*Ann. der Physik*, No. 5, Vol. 20, 1934, Series 5, pp. 529–556.)

596. TERMINAL ENERGY DISTRIBUTION OF ELECTRONS DRIVEN THROUGH A GAS BY AN ELECTRIC FIELD [Theoretical Work].—A. M. Cravath. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46. No. 4, p. 332: abstract only.)

597. THE EMISSION OF ELECTRONS UNDER THE INFLUENCE OF CHEMICAL ACTION [and a New Method of Determining the Contact Potential Difference].—A. K. Denisoff and O. W. Richardson. (*Proc. Roy. Soc.*, Series A, 1st Oct. 1934, Vol. 146, No. 858, pp. 524–564.)

598. THE INFLUENCE OF SPACE CHARGE ON THE RESULTS OF MEASUREMENT OF IONISATION CURRENT.—A. Trost. (*Physik. Zeitschr.*, 15th Sept. 1934, Vol. 35, No. 18, pp. 725–730.)

The theoretical part of this paper develops formulae showing the effect of the dimensions and form of the ionisation chamber, the gas used, the degree of ionisation, and the pressure and voltage, on the influence of space charge on ionisation measurements. Some experimental results on the effect of pressure on the natural ionisation in argon in a cylindrical chamber are also given.

MISCELLANEOUS

599. A NEW TRANSFORMATION THEORY FOR LINEAR CANONICAL EQUATIONS [giving Method for Approximate Solution of Differential Equations].—C. Lanczos. (*Ann. der Physik*, No. 6, Vol. 20, Series 5, 1934, pp. 653–688.)

600. ON THE OPERATIONAL SOLUTION OF LINEAR MIXED DIFFERENCE DIFFERENTIAL EQUATIONS.—J. Neufeld. (*Proc. Camb. Phil. Soc.*, October, 1934, Vol. 30, Part 4, pp. 389–391.)

601. "ON THE SOLUTION OF BOUNDARY PROBLEMS IN MATHEMATICAL PHYSICS" [Corrections].—J. Neufeld. (*Phil. Mag.*, October, 1934, Series 7, Vol. 18, No. 120, p. 624.) *See* 1934 Abstracts, p. 433.

602. "PRINCIPLES OF STATICAL ANALYSIS OCCASIONALLY OVERLOOKED." A. G. McNISH: CRITICISM.—A. Corlin: McNish. (*Journ. Franklin Inst.*, August, 1934, Vol. 218 No. 2, pp. 255–258.) The paper criticised was referred to in 1933 Abstracts, p. 499, l-h column.

603. ACCURACY OF LEAST SQUARES SOLUTIONS.—T. E. Sterne. (*Nature*, 15th Sept. 1934, Vol. 134, p. 421: *Proc. Nat. Acad. Sci.*, 15th Nov. 1934, Vol, 20, No. 11, pp. 565–571.)

604. NOTE ON THE CORRELATION OF TIME SERIES.—J. T. Morrison. (*Phil. Mag.*, October. 1934, Series 7, Vol. 18, No. 120, pp. 545–554.)

605. THE SOLUTION OF ALGEBRAIC EQUATIONS BY MEANS OF TABLES OF LOGARITHMS.—V. A. Bailey. (*Phil. Mag.*, October, 1934, Series 7, Vol. 18, No. 120, pp. 529–539.)

606. THIS SUBJECT OF ERROR [Most Reliable Determination has Lowest Range per Risk].—L. E. Dodd. (*Journ. Franklin Inst.*, November, 1934, Vol. 218, No. 5, pp. 619–621.)

607. THE EXACT SOLUTIONS OF SOME POTENTIAL PROBLEMS IN ELECTROTECHNICS WITH A SPECIAL CLASS OF BOUNDARY CURVE [Calculation of Induced Charges on Cylindrical Boundary Surfaces: Appropriate Solutions of Integral Equation for Curves which invert into Ellipses].—K. Dahr. (*Ann. der Physik*, Series 5, No. 2, Vol. 21, 1934, pp. 213–240.)

608. ON THE FLOW OF ELECTRIC CURRENT IN SEMI-INFINITE MEDIA IN WHICH THE SPECIFIC RESISTANCE IS A FUNCTION OF THE DEPTH.—L. V. King. (*Phil. Trans. Roy. Soc. London*, Series A, Vol. 233, 1934, No. A 728, pp. 327–359.)

609. MECHANICAL PROPERTIES OF MONOMOLECULAR FILMS.—I. Langmuir. (*Journ. Franklin Inst.*, August, 1934, Vol. 218, No. 2, pp. 143–171.)

610. AUTOMATIC COMPENSATION OF VARIATIONS IN THE OVERALL ATTENUATION OF CARRIER-TELEPHONE SYSTEMS [Application of "Automatic Volume Control" Principles: with Patent and Literature References].—H. Sterky and R. Stalemark. (*Ericsson Technics*, No. 3, 1934, pp. 39–52.)

611. SAFETY MEASURES IN X-RAY WORK, INCLUDING HIGH-VOLTAGE FLEXIBLE CABLES.—L. G. H. Sarsfield. (*Journ. I.E.E.*, September, 1934, Vol. 75, No. 453, pp. 253–277.)

612. THE APPLICATION OF VARIABLE-MU VALVES TO POWER ENGINEERING.—Kieling. (*See* 445.)

613. THE INSTRUMENTAL SIDE OF [Photoelectric] COLORIMETRY [and the "Blancometer"].—J. W. Perry: Guild. (*Journ. Scient. Instr.*, September, 1934, Vol. 11, No. 9, pp. 304–305.)

614. THE PHOTOELECTRIC ANALYSIS OF ELLIPTICAL VIBRATIONS [with the Photoelectric Shadow Photometer].—Bruhat and Grivet. (*Comptes Rendus*, 29th Oct. 1934, Vol. 199, No. 18, pp. 852–854.)

615. THE LIGHT COUNTER [Combination of Geiger-Müller Counter with Photocell].—Rajewsky. (*See* 236 of January.)

616. A SIMPLE PHOTO-PLANIMETER [using Photocell in Ulbricht Sphere].—S. Gradstein. (*Review Scient. Instr.*, September, 1934, Vol. 5, No. 9, p. 311.) *Cf.* 1933 Abstracts, p. 231, Savage.

617. LIGHT BEAM [Photocell] FENCE PROTECTS HIGH-VOLTAGE TEST WORKERS.—T. R. Watts. (*Elec. World*, 7th July, 1934, Vol. 104, No. 1, p. 22.)

618. THE AMPLIFICATION OF GALVANOMETER DEFLECTIONS [by Photocell: Equation for the Secondary Deflection: Speed].—A. V. Hill. (*Journ. Scient. Instr.*, September, 1934, Vol. 11, No. 9, pp. 281–282.) For previous work *see* 1934 Abstracts p. 516. *See* also 619.

619. A SIMPLE METHOD OF ATTACHING A PHOTO-ELECTRIC CELL RELAY TO A MOLL GALVANOMETER [giving Sensitivity around 10^{-11} A/mm].—R. V. Jones. (*Journ. Scient. Instr.*, September, 1934, Vol. 11, No. 9, pp. 302–303.) *See* also 618.

620. A PHOTOELECTRIC ASTRONOMICAL TELESCOPE OF POWER EQUIVALENT TO A 51-METRES' LENS DIAMETER.—(*E.T.Z.*, 8th Nov. 1934, Vol. 55, No. 45, p. 1106: paragraph only on an American report.)

621. AN ULTRA-MICROMETER [Use of Heterodyne Frequency from Two Dynatron Oscillators to measure Changes in Pressure down to 10^{-3} dyne/cm²].—C. L. Utterback and H. Wirth. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, p. 328: abstract only.)

622. INVESTIGATION OF MECHANICAL VIBRATORY SYSTEMS BY MEANS OF EQUIVALENT ELECTRICAL CIRCUITS.—L. Kettenacker. (*Physik. Ber.*, 15th July, 1934, Vol. 15, No. 14, p. 1141.) For previous work *see* 1934 Abstracts, p. 456.

623. ON DETECTORS OF MECHANICAL VIBRATIONS.—Zahradniček. (*See* 192 of January.)

624. A NEW METHOD FOR THE STUDY OF THE EXPLOSION IN A MOTOR [Electro-Magnetic Device with Dubois Oscillograph].—Tchang Te-Lou. (*Comptes Rendus*, 5th Nov. 1934, Vol. 199, No. 19, pp. 927–929.)

625. "PHOTOGRAPHY" BY ELECTRICAL MICRO-WAVES.—Arkadiew. (*See* 372.)

626. A CATHODE-RAY FURNACE [giving 2 700°C in 15–20 Seconds].—M. F. Trombe. (*Current Science*, Bangalore, August, 1934, Vol. 3, No. 2, p. 73: summary only.)

627. ELECTRON CONTROL FOR HIGH-SPEED MOTION PICTURES [Stroboscopic Camera for 1 200 Pictures per Second].—D. G. Fink. (*Electronics*, August, 1934, pp. 250–251.)

628. TELEVISION SCANNING TECHNIQUE APPLIED TO X-RAY DIAGNOSIS [Three-Colour Process permitting X-Ray Images to be transmitted over Telephone Lines].—Simjian. (*Electronics*, August, 1934, p. 253.)

629. THE USE OF PIEZOELECTRIC QUARTZ FOR THE STUDY OF SOME BIOLOGICAL PHENOMENA, AND PARTICULARLY FOR THE STUDY OF THE VARIATIONS OF BLOOD PRESSURE IN VEINS AND ARTERIES.—Gomez and Langevin. (*Comptes Rendus*, 29th Oct. 1934, Vol. 199, No. 18, pp. 890–893.)

630. RADIOLOGICAL AND ELECTRO-MEDICAL APPARATUS [Review of Progress, including X-Ray Technique, H. F. Scalpel, Diathermy, etc.]. —L. G. H. Sarsfield. (*Journ. I.E.E.*, July, 1934, Vol. 75, No. 451, pp. 33–40.)

631. "CELLULAR OSCILLATION: A COLLECTION OF EXPERIMENTAL RESEARCHES" [Book Review].—G. Lakhovsky. (*Rev. Gén. de l'Élec.*, 11th Aug. 1934, Vol. 36, No. 6, p. 188.)

632. SOME EXPERIMENTS SHOWING THE ACTION OF METALLIC REFLECTORS ON THE GROWTH OF PLANTS [Thermal and Luminous Action greater than Electrical].—Failletaz: Marinesco: Lakhovsky. (*Rev. Gén. de l'Élec.*, 2nd June, 1934, Vol. 35, No. 22, pp. 763–764.) Correspondence on the researches referred to in Abstracts, 1932, p. 660, and 1933, p. 117, with some new results. *See* also 28th July, pp. 114–116.

633. EXPERIMENTS RELATIVE TO THE DANGEROUS CURRENT VALUE AND THE MINIMUM RESISTANCE OF THE HUMAN BODY.—H. Ourson: Freiberger. (*Rev. Gén. de l'Élec.*, 9th June, 1934, Vol. 35, No. 23, pp. 779–784.) Freiberger's *Berlin Thesis*, 1934, 154 pp., is available in Patent Office Library, London.

634. CALCULATION OF THE HEATING OF CYLINDRICAL BODIES IN A CONDENSER FIELD [Field Distribution in Cylindrical Dielectrics: Temperature Effects in High-Frequency Fields]. —N. N. Malov. (*Zeitschr. f. Physik*, No. 11/12, Vol. 90, 1934, pp. 802–809.)

635. THE BEHAVIOUR OF BIOLOGICAL BODIES IN A HIGH-FREQUENCY FIELD [Properties of Inhomogeneous Dielectrics].—H. Dänzer. (*Ann. der Physik*, No. 5, Vol. 20, Series 5, 1934, pp. 463–480.)

This paper extends the results of Wagner (*Arch. für Elektrot.*, 1914, Vol. 2), on the frequency dependence of the losses in inhomogeneous dielectrics, to the case of biological bodies and compares them with results of Debye's dipole theory. The theory is applied to various biological problems (spherical red blood corpuscles, complex conductivity of blood, thin membranes).

636. DIELECTRIC POTENTIALS OF PHYSIOLOGICALLY ACTIVE SUBSTANCES [Explanation of Adsorption at Tissue Interfaces].—B. Kamienski. (*Nature*, 17th Nov. 1934, Vol. 134, p. 776.)

637. ELECTRICAL CHARGES ON BACTERIA.—H. A. Abramson. (*Science*, 5th Oct. 1934, Vol. 30, No. 2075, Supp. pp. 10–11.)

638. NIKOLA TESLA INVENTS ELECTRICAL "DEATH BEAM" [of High-Velocity Particles: applicable also to Transmission of Power].—Tesla. (*Elec. World*, 14th July, 1934, Vol. 104, No. 2, p. 63.)

639. POSSIBLE ACTION OF COSMIC RAYS ON LIVING ORGANISMS [White Mice in Mine have Greater Mean Weight than Controls above Ground].—R. B. Engelstad and N. H. Moxnes. (*Nature*, 8th Dec. 1934, Vol. 134, p. 898.) *Cf.* Lakhovsky, Rivera, 1933 Abstracts, p. 117.

640. THE 10TH "DEUTSCHE PHYSIKER- UND MATHEMATIKERTAG" IN BAD PYRMONT, 1934 [Summaries].—(*E.T.Z.*, 22nd Nov. 1934, Vol. 55, No. 47, pp. 1151–1154.)

641. NATIONAL RADIO EXHIBITION: MOST SPECTACULAR R.M.A. SHOW YET HELD: THE TREND IN SET DESIGN: RADIO RESEARCH BOARD'S WEATHER-HOUSE.—(*Electrician*, 24th Aug. 1934, Vol. 113, No. 2934, pp. 237–240.)

642. THE OLYMPIA EXHIBITION—CRITICAL REVIEW OF APPARATUS AND POLICY.—(*Elec. Review*, 24th Aug. 1934, Vol. 115, No. 2961, pp. 237–238.)

643. MEETING OF INTERNATIONAL RADIO CONSULTING COMMITTEE IN LISBON AND OF THE INTERNATIONAL SCIENTIFIC RADIO UNION IN LONDON [Notes on Programmes].—Nat. Bureau of Standards. (*Journ. Franklin Inst.*, October, 1934, Vol. 218, No. 4, pp. 499–501.)

644. THE INTERNATIONAL SCIENTIFIC RADIO UNION [Notes on 1934 meeting].—(*Nature*, 29th Sept. 1934, Vol. 134, p. 502.)

645. SCIENCE MUSEUM, SOUTH KENSINGTON: HANDBOOK OF THE COLLECTIONS ILLUSTRATING ELECTRICAL ENGINEERING. II.—RADIO COMMUNICATION.—W. T. O'Dea. (95 pp., illustrated: H.M. Stationery Office, Kingsway, London.)

646. "BILDWORT-ENGLISCH: TECHNISCHE SPRACHHEFTE NO. 6: CABLE AND WIRELESS COMMUNICATION" [Review of German Brochure teaching English Technical Terms by means of Illustrated "Text Book" and Vocabulary].—(*Hochf:tech. u. Elek:akus.*, July, 1934, Vol. 44, No. 1, pp. 35–36.)

647. "THE ENGINEER AND THE FREE ELECTRON" [Tenth Faraday Lecture].—C. C. Paterson. (*Journ. I.E.E.*, October, 1934, Vol. 75, No. 454, pp. 447–452.)

648. "LA SCIENCE, SES PROGRÈS, SES APPLICATIONS" [Book Review].—Ed. by Urbain and Boll. (*Rev. Gén. de l'Élec.*, 17th Nov. 1934, p. 682.)

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.

AUTOMATIC VOLUME CONTROL

Application date, 28th March, 1933. *No.* 413443

In order to accentuate the "muting" action in a set provided with A.V.C., the blocking grid-bias is applied both to a double-diode triode valve (acting as the volume control valve and second detector in the main transmission path of a superhet receiver) and to a second double-diode triode which acts as the muting device. When a worth-while signal arrives, it not only removes the muting bias but also increases the overall sensitivity of the set.

Patent issued to General Electric Co., Ltd., and C. N. Smyth.

CATHODE-RAY TUBES

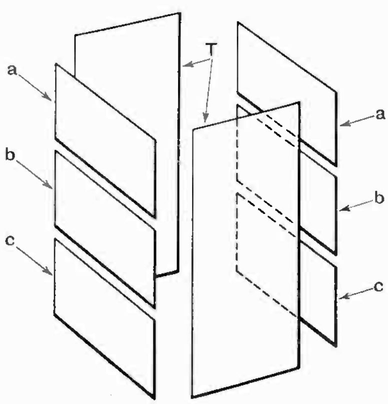
Convention date (Germany), 24th *December,* 1931. *No.* 413720.

In order to make full use of all the light emitted from the fluorescent screen of a cathode-ray tube, a thin but highly-reflecting coating of silver is applied over the surface of the fluorescent material nearest the cathode. The metal coating is so thin that it causes no appreciable loss in the impact of the electron stream against the fluorescent material, but whatever light is produced it is reflected back towards the point from which the reproduced picture is intended to be viewed.

Patent issued to K. Schlesinger.

Application date, 26th June, 1933. *No.* 413757.

The usual arrangement of control electrodes used in a cathode-ray tube is modified so as to adapt the tube to handle a number of different



No. 413757.

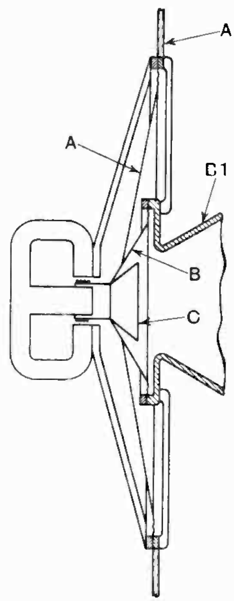
waves simultaneously. As shown, one pair of control electrodes marked *T* serves to provide the usual time base. The second pair of electrodes is subdivided into three co-operating segments marked *a*, *b* *c*, respectively. The different waves to be examined are applied to these segments in a manner which ensures an even action on the stream for a given applied deflecting potential. For instance, one voltage is applied across the middle pair of segments, *b*, *b*; the second voltage is connected from the lower segment marked *c* across to the diagonally opposite segment *a*; the third voltage then goes to the remaining pair of segments.

Patent issued to Marconi's Wireless Telegraph Co., Ltd., and A. W. Ladner.

LOUD SPEAKERS

Application date, 27th January, 1933. *No.* 413758.

The frequency response of a loud speaker is broadened by energising a plurality of diaphragms, having different frequency characteristics, from the same driving-unit. The various diaphragms are coaxial with each other, each being attached directly to the moving-coil former, or to an extension of it; or one diaphragm may be connected to a second diaphragm near the point where the latter joins the driving-unit. As shown, a large shallow cone *A*, terminated by a baffle plate, *A*1, is mounted concentric with a medium-angle cone *B*, which ends in a wide-throated horn, *B*1. A third diaphragm takes the form of a free-edge cone, *C*, of smaller diameter than the throat of the horn, *B*1. To avoid any tendency for the large diaphragm *A* to pull the moving coil out of centre, it may be driven through a linkage system capable of absorbing side-shocks.



No. 413758.

Patent issued to P. G. A. H. Voigt.

MAGNETROSTRICTIVE OSCILLATORS

Application date 30th January, 1933. *No.* 413762.

An oscillating body consists of a magnetostrictive metal such as iron, nickel or cobalt alloys, ground into a fine powder, then moulded into a solid block, and finally coated with an insulating material. This construction cuts down eddy-current loss to a minimum, and gives sufficient mechanical strength to generate a comparatively large power-output.

Patent issued to A. B. Wood; F. D. Smith; and C. V. Drysdale.

GRAMOPHONE PICK-UPS

Application date, 2nd May, 1933. No. 413840.

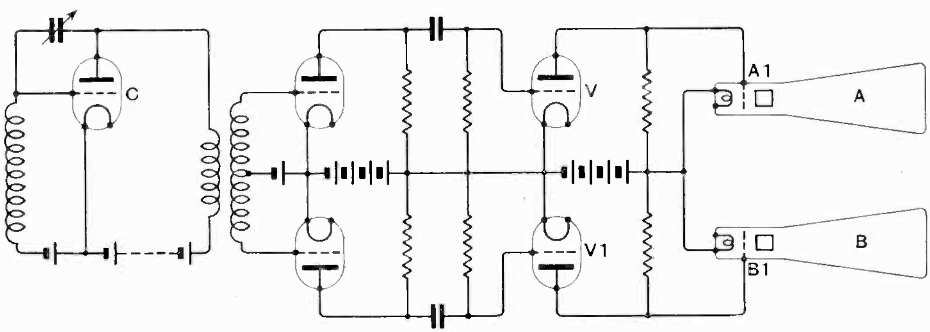
The winding around the bobbin of the pick-up is tapped, and the leads are brought out to a series of studs covered by a small rotating switch arm mounted on the face of the instrument. This allows the characteristic of impedance of the instrument to be adjusted to match any particular type of amplifier. The switch studs are preferably marked to indicate the effective impedance placed in circuit.

Patent issued to H. J. Camp and C. Watson.

TELEVISION SYSTEMS

Application date, 13th September, 1933. No. 413894.

The object is to reproduce a televised picture in stereoscopic relief. In transmission the lines for the right eye are scanned alternately with those for the left eye. Two cathode-ray tubes, *A*, *B*, are used for this purpose, and are brought successively into operation by a thermionic valve oscillator *C*, and a chain of amplifier valves, *V*, *V1*, arranged to throw the control grids, *A1*, *B1*, successively above and below the cut-off point. Each of the tubes *A*, *B*, contain a photo-sensitive electrode on to which the two stereoscopic images are projected. In reception the two images are thrown alternatively on to the screen of a single cathode-ray tube, the reproduced picture being viewed through a grating so that a different set of lines is seen by each eye.



No. 413894.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

Convention date (U.S.A.), 15th December, 1932. No. 413954.

The image to be transmitted is first focused upon a photo-sensitive plate or grating coated with a layer of caesium superimposed on layers of caesium and silver oxide. This grating co-operates with a second plate or grating, the holes in one being opposite to the solid portions of the other. Both gratings, together with an anode, are mounted in a tube.

The picture is projected through an opening in one end of the tube and is subjected to a beam of light from the other end. A cathode-ray "gun" is arranged to project a scanning beam across the tube at such an angle that the beam does not pass through the openings in the second grating.

The projection of the picture upon the first grating results in the production of an electrostatic "image," whilst the scanning of the second grating by the cathode-ray gun causes the emission of an electron stream of substantially constant magnitude from the second grating. This stream is modulated by the electrostatic "image" before it reaches the anode of the tube. The process is repeated at cinematographic speed by the action of a beam of light from the opposite end of the tube, which reduces the two gratings periodically to a uniform potential.

Patent issued to F. C. P. Henroteau.

SHORT-WAVE GENERATORS

Convention date (Germany), 9th January, 1933. No. 413973

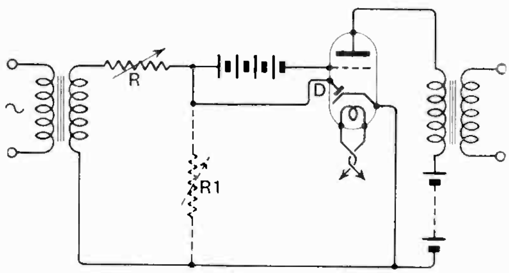
Four, six, or eight valves are arranged in pairs symmetrically around a common H.T. source. The anodes of each pair are joined by a loop of wire connected at the centre point through a choke to the supply. The grids are similarly connected together, and to the supply. The combination oscillates at a frequency determined by the inductance of the loops and the interelectrode capacities of the valves. By using a large number of "pairs" a favourable ratio of inductance to capacity is obtained.

Patent issued to Telefunken Ges. Fur Drahtlose Telegraphie m.b.h.

COMPENSATING FOR DISTORTION

Application date, 31st January, 1931. No. 414359.

Distortion may be caused by the fact that the positive half of an incoming signal (i.e. when the grid bias is more positive) is more strongly amplified than the negative half. The output will then contain various harmonic frequencies, of which the second harmonic is most prominent. According to the invention this defect is avoided by inserting an electrode *D*, acting as a diode, between the control grid and the cathode. The diode then absorbs energy only during the positive half of the input wave. The resulting flow of rectified current through the resistance *R* produces a voltage drop which lowers the effective input voltage applied to the grid during this part of the cycle. A variable resistance *R*1, shown in dotted lines, may be placed in shunt with the diode in order to control the degree of compensation applied.



No. 414359.

Patent issued to General Electric Co., Ltd.; L. I. Farren; and G. C. Marris.

VALVE AMPLIFIERS

Convention date (Holland), 26th January, 1933. No. 414051

The use of H.F. amplifiers having a steep characteristic is restricted by the fact there exists between the control grid and cathode a certain conductivity which acts to damp any tuned circuit in shunt. In order to minimise this effect, the grid-cathode return is separated from the anode-cathode return, each circuit being completed over a distinct lead connected directly to the cathode. An extra terminal is provided, and the two return leads are spaced as far apart as possible in order to minimise any magnetic coupling between them.

Patent issued to N. V. Philips', Gloeilampenfabrieken.

COMPENSATING FOR VALVE CURVATURE

Convention date (U.S.A.), 29th October, 1932. No. 414251

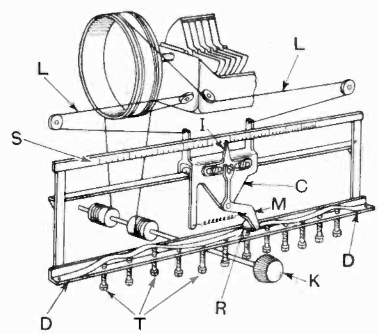
In order to correct for curvature in the valve charactersitic, particularly in the case of Class B amplifiers, a resistance of the kind known as Thyrite is included in the circuits. Thyrite is a porcelain-like material containing minute particles of conducting material. It is substantially an insulator at low potentials, but increases its conductivity progressively with the applied voltage. The compensating element takes the place of the usual coupling resistances, or it may be inserted as a shunt across a coupling transformer. In certain cases it is biased by passing a direct current through it.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

TUNING MEANS

Convention date (U.S.A.), 30th January, 1932. No. 414402

Variations in tuning as between one receiver and another, particularly in mass production, are offset by means of a flexible compensating device which can be adjusted, in each case, after the set has been assembled. As shown, the indicating-needle *I* of the tuning scale *S* is mounted on a carriage *C*, which moves to and fro under the control of cords *L* driven from the tuning-knob *K*. The needle *I* is deflected to one side or other of its normal centre by a bell-crank lever *M* which ends in a roller *R*. The roller is spring-pressed into contact with the compensating device, which consists of a flexible strip *D* of bronze or copper. This forms a cam surface the contour of which is adjusted by means of a series of set-screws *T* so as to "standardise" the tuning.



No. 414402.

Patent issued to British Thomson-Houston Co., Ltd.

FLUORESCENT SCREENS

Convention date (Germany), 22nd February, 1933. No. 414597.

It is known that the response of the fluorescent screen of a cathode-ray tube to the action of the electron stream is greatly improved when small particles of metal are incorporated in the fluorescent material. According to the invention, calcium tungstate or zinc sulphide is used as the basic material, and a small content of copper is added to it by cathode sputtering in a vacuum flask. The mixture is then withdrawn, and subjected to the usual mixing and heating processes before being applied to the wall of the cathode-ray tube.

Patent issued to A. C. Cossor, Ltd.