EXPERIMENTAL WIRELESS & The WIRELESS ENGINEER

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Editorial.

The Definition of Selectivity.

IN our issue of August, 1929, we published a paper by Mr. Colebrook under the above title, and it will, we think, be very generally agreed that it is highly important that a definition of selectivity should be arrived at, particularly at this time when the matter is becoming so much the concern of those whose business it is to design receivers for broadcast reception where the outstanding requirements are the utmost attainable in selectivity without loss in quality of reproduction.

In introducing his paper Mr. Colebrook stated "Selectivity is a very important circuit characteristic. There is, however, no universally accepted definition of this term, which is capable of general application to all cases of electrical resonance. Such terms and formulæ as are at present in use have been derived from the theory of the simple series resonant circuit and are not in a form which makes clear their application to some of the more complex types of resonance which are utilised in wireless practice."

The introduction of the Regional Scheme of Broadcasting in this country certainly helps to focus attention on this subject as far as the broadcasting services are concerned. Dr. R. T. Beatty, in *The Wireless World* of October 16th, 1929, also deals with the problem of selectivity, and states "The discussion of selectivity has been hampered in the past by lack of an exact definition of the term." In the article Dr. Beatty shows a method by which the selectivity of any receiver can be expressed as a numerical quantity and that having arrived at this value the H.F. resonance curve of the receiver can be readily drawn.

In the same issue as Mr. Colebrook's paper we commented editorially on his views and criticised certain of his suggestions. To these criticisms Mr. Colebrook replied in a letter published under Correspondence in our September number, and the concluding sentence of his letter reads: "My views were put forward mainly with the idea of stirring up comment and suggestion." It is to this invitation which we would particularly draw the attention of our readers. We feel that at this time it would be helpful if readers who have made a study of the subject would contribute their views for publication in the hope that these may assist in arriving at final agreement on the definition of selectivity.

INDEX TO THE VOLUME.

With our December number, as has been our custom in the past, we shall publish the complete index to the year's volume, including the detailed index to the *Abstracts and References* to technical radio literature of the world.

At the end of the year the opportunity occurs to invite our readers to offer suggestions as to any particular features which they would like to see incorporated with the new volume. Criticism will be welcomed equally with suggestions.

The Numerical Estimation of Grid Rectification for Small Signal Amplitudes.

By W. A. Barclay, M.A.

In a former paper * it was shown that for all but very small signal amplitudes, the slope of the grid current characteristic when plotted logarithmically might be regarded as an index of detecting efficiency as far as the grid circuit of the valve is concerned. Since, however, a merit of the "cumulative grid" method of rectification is its sensitivity to small signal amplitudes, a rapid means of utilising the grid characteristic to estimate detecting efficiency for such small signals may not be without interest.

In dealing with small signals, we may conveniently assume an exponential form for the grid current characteristic, so that its logarithmic plot will be a straight line. The objections to this procedure when large signals are involved were considered in the paper referred to; for small signals the exponential curve will be sufficiently accurate. Groeneveld and others have proposed the formula

$$i_g = I_{g0} \cdot \epsilon^{\frac{v_g - V_{g0}}{V_T}} \quad \ldots \quad \ldots \quad (1)$$

where the variables are indicated by lower-case italics and the valve constants by capitals.† In this formula V_T is termed the "temperature voltage," and is stated to be, roughly, 0.1 v. for oxide filaments, 0.18 v. for thoriated filaments, and 0.25 v. for tungsten filaments. This formula is undoubtedly very convenient when it is desired to express a characteristic in terms of a given pair of related values I_{g0} and V_{g0} which satisfy the curve. Nevertheless, one of the constants is redundant, as will be seen by rewriting the equation

$$i_g = \left(I_{g0} \cdot \epsilon^{-\frac{V_{g0}}{V_T}}\right) \cdot \epsilon^{\frac{v_s}{V_T}} \quad \ldots \quad (2)$$

where the bracket term is itself a constant. In this paper we shall use the equation

$$i_g = a \cdot \epsilon^{\frac{v_g}{V_T}} \quad \ldots \quad \ldots \quad (3)$$

as being simpler than formula (1). a is, of course, the bracket factor of equation (2).

Using the symbolism adopted by the present writer in his former paper, we shall denote by v_0 the initial value of grid potential prior to signal reception. We may then write

$$\frac{v - v_0}{R} = a \cdot \epsilon^{\frac{v_0}{V_T}} \quad \ldots \quad \ldots \quad (4)$$

where v is the positive bias voltage applied and R is the leak resistance. Again, denoting by v_s the mean value of potential assumed by the grid during reception of a C.W. signal of amplitude E, we shall have

$$\frac{v - v_s}{R} = \frac{1}{T}\int_0^T a\epsilon^{\frac{v_s + E\sin\omega t}{V_T}} \, . \, dt \quad (5)$$

$$= a\epsilon^{\frac{v_s}{V_T}} \cdot \frac{1}{T}\int_0^T \epsilon^{\frac{E\sin\omega t}{V_T}} \, . \, dt \quad (6)$$

It has been remarked by Mr. C. R. Cosens‡ that the mean value integral of equation (6) is the imaginary Bessel Function $J_0\left(j\,\frac{E}{V_T}\right)$, values of which are tabulated in Jahnke & Emde's "*Funktionentafeln.*" For most purposes, however, a sufficiently close approximation to its value may be obtained by using the "three-ordinate" method described by the writer (*art. cit.*, p. 464). Thus we may rewrite equation (5)

$$\frac{v - v_s}{R} = \frac{1}{3}\left\{a\epsilon^{\frac{v_s - .866E}{V_T}} + a\epsilon^{\frac{v_s}{V_T}} + a\epsilon^{\frac{v_s + .866E}{V_T}}\right\}$$

$$= a\epsilon^{\frac{v_s}{V_T}} \times \frac{1}{3}\left\{1 + 2\cosh\frac{.866E}{V_T}\right\} \quad (7)$$

Equations (4) and (7) afford us a theoretical means of calculating v_0 and v_s, and hence arriving at $\triangle = v_0 - v_s$, the required change of mean grid voltage due to rectification of signal E. Unfortunately, neither of these equations is in a form convenient for determining v_0 and v_s, and hence of $\triangle$ when E is given. It is therefore believed

* *E.W. & W.E.*, Aug. and Sept., 1927.—W. A. Barclay—Grid Signal Characteristics.

† See *E.W. & W.E.*, Sept., 1928—A New Idea for a Detector Valve.

‡ *E.W. & W.E.*, Vol. II, p. 994.

that a rapid means of obtaining $\triangle$ from the valve and circuit data would be of service to experimenters, who generally have little time for calculations of the complexity necessitated by the above equations. The writer has, accordingly, taken advantage of the Alignment Principle to show how $\triangle$ and E may be conveniently and accurately related for all values of circuit and valve constants, on the assumption of the exponential law of (3). In order to do this, let us rewrite equations (4) and (7) in terms of symbols V and $\triangle$ defined as follows:

$$V = v - v_0$$

$$\triangle = v_0 - v_s$$

We have, from (4)

$$\frac{V}{R} = a\epsilon^{\frac{v - V}{V_T}}$$

$$i.e., \log_{10} V - \log_{10} aR = \frac{v - V}{V_T} \cdot \log_{10}\epsilon$$

$$i.e., \frac{\log_{10} V - \log_{10} aR}{V - v} = -\frac{\log_{10}\epsilon}{V_T} \quad \ldots \quad (8)$$

Again, from (7),

$$\frac{(v - v_0) - (v_s - v_0)}{R} = a\epsilon^{\frac{v_0 - (v_0 - v_s)}{V_T}} \times \tfrac{1}{3}\left\{1 + 2\cosh\frac{.866E}{V_T}\right\}$$

$$i.e., V + \triangle = aR\epsilon^{\frac{v_0}{V_T}} \times \epsilon^{-\frac{\triangle}{V_T}} \times \tfrac{1}{3}\left\{1 + 2\cosh\frac{.866E}{V_T}\right\}$$

$$= V \cdot \epsilon^{-\frac{\triangle}{V_T}} \times \tfrac{1}{3}\left\{1 + 2\cosh\frac{.866E}{V_T}\right\}$$

by equation (4).

$$i.e., \left(1 + \frac{\triangle}{V}\right) \cdot \epsilon^{\frac{\triangle}{V_T}} = \tfrac{1}{3}\left\{1 + 2\cosh\frac{.866E}{V_T}\right\} \quad (9)$$

We shall now indicate a simple geometrical construction (in reality a form of the alignment process) by which V is determinable from (8). Knowing V we can then proceed to derive $\triangle$ by means of an alignment chart specially designed for the solution of (9).

Equation (8) is capable of geometrical interpretation as follows. If P denote a point whose cartesian co-ordinates are $(V, \log_{10} V)$ and Q a point whose co-ordinates are $(v, \log_{10} aR)$, the gradient of the line PQ will be the same as that of the line joining the points $(0, \log_{10}\epsilon)$ and $(V_T, 0)$. If, in Fig. 1 axes XOX' and YOY' be taken, the locus of the points P will be the curve $y = \log_{10} x$ as shown. Having given the valve constants a, V_T, and the circuit constants v, R, we proceed to find V as follows. Taking a point on the Y-axis $\log_{10}\epsilon$ above the origin, we join it to the value of V_T taken on the X-axis. Next seek the point Q of co-ordinates $(v, \log_{10} aR)$.

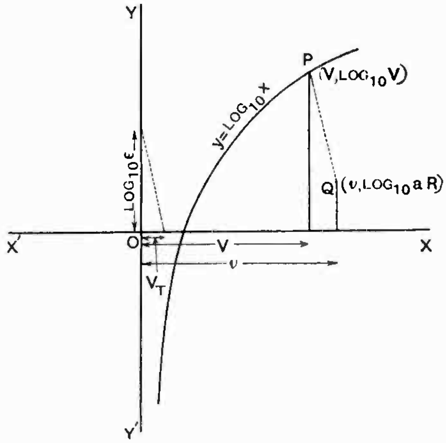


Fig. 1.

Through Q draw a line parallel to the first to meet the curve in P. The abscissa of P gives the value of V, the initial P.D. across the leak. It will be remarked that the diagram of Fig. 1 is permanently applicable to all grid characteristics (providing they are of exponential form) and does not have to be redrawn for individual cases. This universality of application is a feature of Alignment methods.

Having thus found V, we can proceed to the determination of $\triangle$ for signal E. This is effected by one or other of the two Charts, Figs. 2a and 2b, designed respectively for the alternative cases $E > V_T$ and $E < V_T$. Each chart has two vertical scales carrying values of the ratios $\frac{V}{V_T}$ and $\frac{E}{V_T}$, while the centre supports carry values of the ratio $\frac{\triangle}{V}$. Any straight line intersects all three scales in values related by equation (9) so that, in particular, when known values of $\frac{V}{V_T}$ and $\frac{E}{V_T}$

on the outer scales are joined, the value of $\frac{\triangle}{V}$ and hence of $\triangle$ is immediately ascertained. The facility with which Equation (9) may thus be solved for $\triangle$ provides a good example of the advantageous use of the Alignment Principle in the numerical evaluation of complex formulæ. The diagrams contain in compact form a wealth of statistical information about grid detection which is only otherwise obtainable with a disproportionate amount of arithmetical work. It is not too much to say that these methods, beautiful in their simplicity, will have a considerable future in wireless science, providing as they do a practical means of correlating three or more variables on a plane surface in cases where ordinary cartesian representation is quite inadequate. Their application to the correlation of experimental data has already been adumbrated by the writer in these pages.

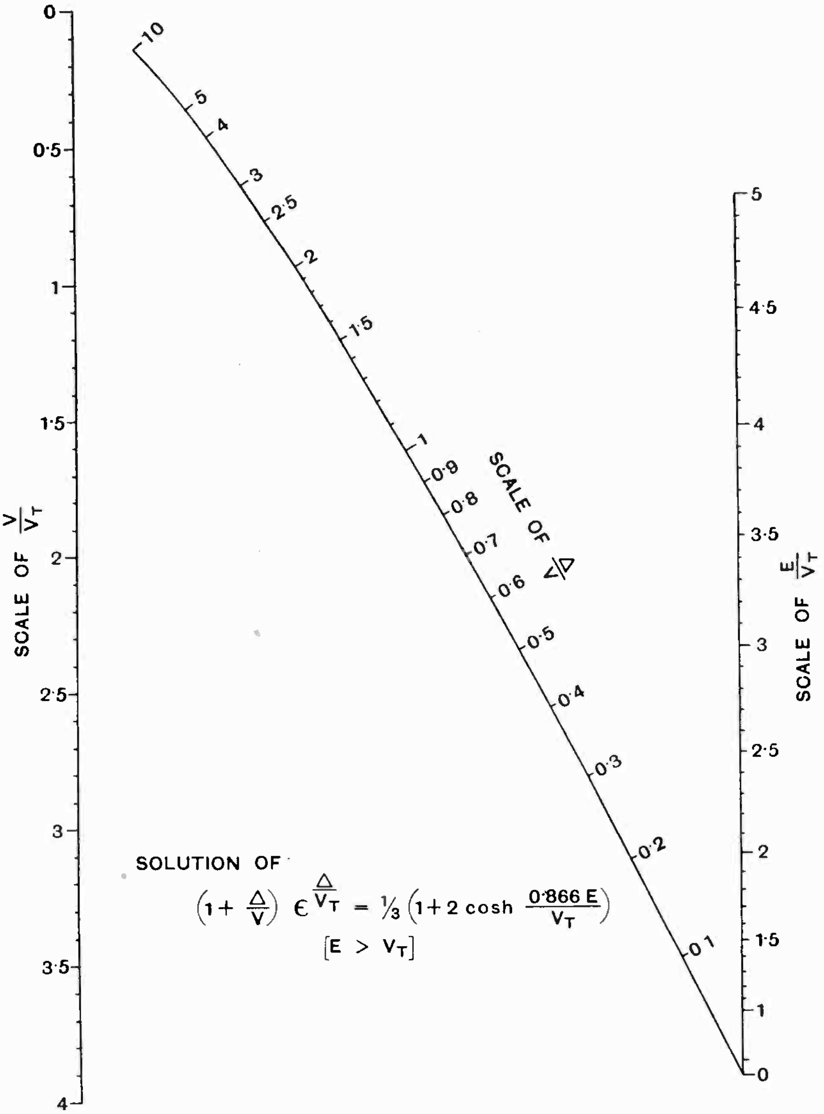


Fig. 2a.

As a practical example of the use of the foregoing diagrams, let us consider the effect on detection of potentiometer control of the voltage applied to the grid. Let us select a valve whose constants, as derived from the grid current characteristic, are $a = 0.88 \times 10^{-6}$ $V_T = 0.18$. (It should be observed in passing that the determination of these constants is an easy matter when the characteristic is plotted on semi-logarithmic paper. Its equation then becomes

$$\log_{10} i_g = \log_{10} a + \frac{v_g}{V_T} \cdot \log_{10} \epsilon$$

which is linear in v_g and $\log_{10} i_g$, so that the constants $\log_{10} a$ and $\frac{\log_{10}\epsilon}{V_T}$ are readily evaluated. It is worth noting that if i_g be taken in μA. and v_g in volts, the quantities a and V_T will also be expressed in μA. and volts respectively.) With the selected valve we shall use a leak resistance of 0.75 megohm, the filament end of which is connected

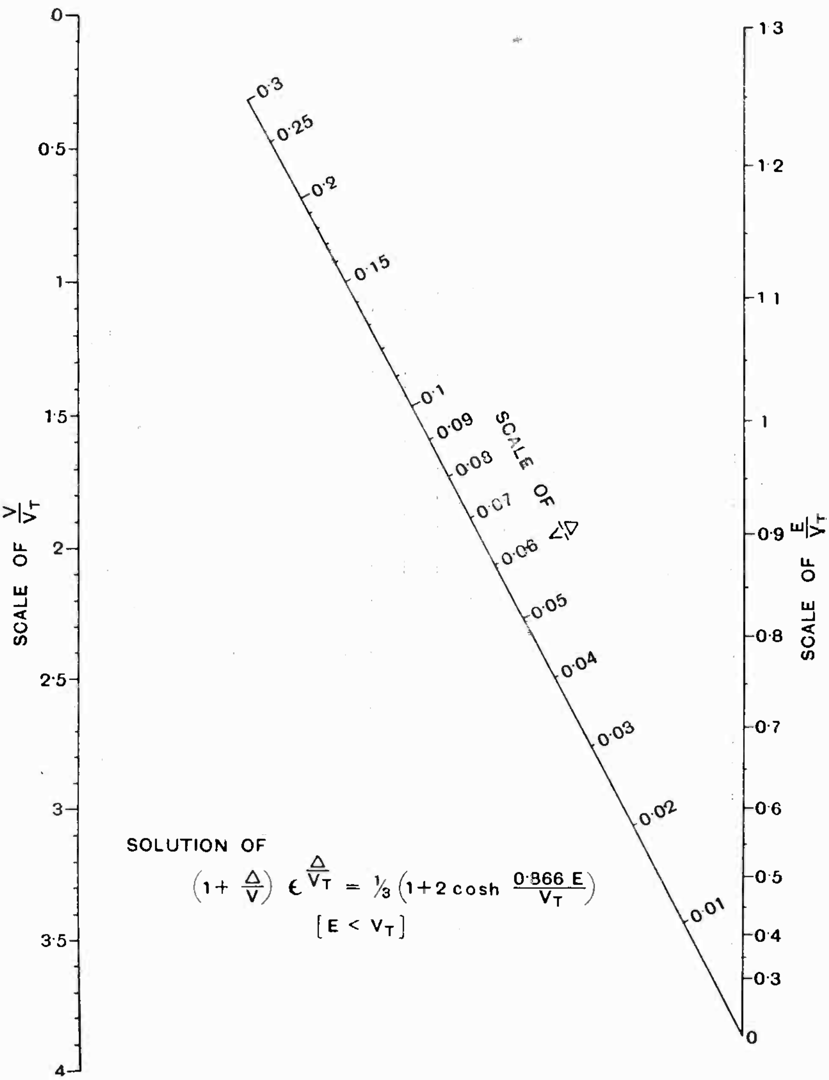


Fig. 2b.

to a potentiometer which can supply a potential of from zero to + 1 volt. We shall now calculate the detecting efficiency $\triangle$ for signals of 0.1 to 0.4 volt amplitude, tracing the variations in $\triangle$ as the bias potential v is altered.

In order to compute V as v varies from 0 to + 1, the use of semi-logarithmically ruled paper for the purpose of Fig. 1 will greatly simplify the work. In particular the curve $y = \log x$ is readily set out from the network with no calculation. In Fig. 3, the vertical axis is now graduated logarithmically, so that we seek on it the values of ϵ and aR direct, instead of the logarithms of these quantities. The left-hand sloping line has been drawn for $V_T = 0.18$; further, since $aR = 0.66$, the position of all Q points will be on the ordinate line of this value.

The particular Q point shown on Fig. 3 is that for an assumed grid voltage of + 1.8, the corresponding value of V being seen to be 1.64. As v varies from 0 to + 1 at intervals of 0.2 volt, the values of V found from Fig. 3 are given in the second column of the subjoined Table. The values shown in the remaining columns, found for signal amplitudes 0.1, 0.2, 0.3 and 0.4 volt by means of Charts 2a and 2b, are self-explanatory.

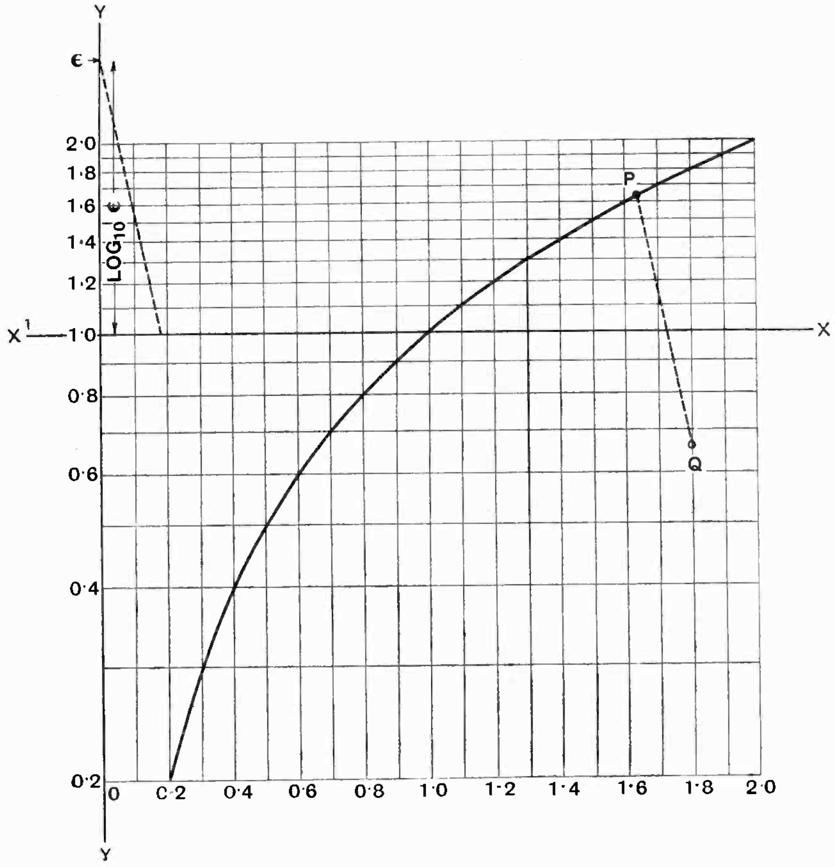


Fig. 3.

Finally the data given in the Table were graphed in Fig. 4 to show the relation between $\triangle$ and v for the various signal amplitudes concerned.

In interpreting the results obtained by this process, it should be borne in mind that, though $\triangle$ has been referred to as the "detection efficiency," this is true only as far as concerns the grid circuit of the valve, and takes no account of the equally important anode circuit with which it is associated. Thus $\triangle$ is not, after all, the quantity with which we are primarily concerned. It is our ultimate aim to find the actual values v_0 and v_s of grid voltage prior to and during the passage of the signal, in order that the variations in anode current may be ascertained. Knowing V and $\triangle$, however, this is a relatively simple matter, since by definition,

$$v_0 = v - V$$

and $$v_s = v_0 - \triangle$$

TABLE.

SHOWING VARIATION OF MEAN GRID POTENTIAL SHIFT $\triangle$ WITH GRID BIAS v FOR DIFFERENT SIGNAL VOLTAGE AMPLITUDES E.

$V_T = 0.18$ $a = 0.88 \times 10^{-6}$ $R = 0.75\ \Omega$

v	V	$\frac{V}{V_T}$	$E=0.1;\ \frac{E}{V_T}=0.55$		$E=0.2;\ \frac{E}{V_T}=1.11$		$E=0.3;\ \frac{E}{V_T}=1.66$		$E=0.4;\ \frac{E}{V_T}=2.22$	
			$\frac{\triangle}{V}$	$\triangle$	$\frac{\triangle}{V}$	$\triangle$	$\frac{\triangle}{V}$	$\triangle$	$\frac{\triangle}{V}$	$\triangle$
0	0.21	1.16	0.035	0.007	0.138	0.029	0.29	0.061	0.50	0.105
0.2	0.33	1.84	0.027	0.009	0.103	0.034	0.22	0.073	0.37	0.122
0.4	0.46	2.55	0.021	0.010	0.082	0.038	0.17	0.080	0.29	0.134
0.6	0.61	3.38	0.018	0.011	0.066	0.040	0.14	0.086	0.23	0.140
0.8	0.77	4.28	0.015	0.011	0.055	0.042	0.12	0.092	0.19	0.146
1.0	0.94	5.21	0.012	0.011	0.048	0.045	0.10	0.094	0.16	0.150

N.B.—The two last values of $\frac{V}{V_T}$ are found on Charts 2a and 2b by extrapolation, the $\frac{V}{V_T}$ scale being linear.

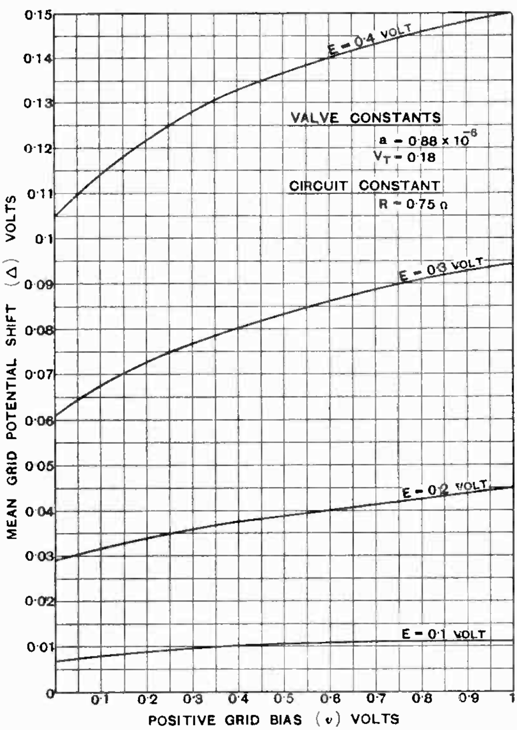


Fig. 4.—*Variation of "Detection Efficiency" with Grid Bias for various signal amplitudes.*

Physical and Optical Societies' Exhibition.

The Twentieth Annual Exhibition of Electrical, Optical and other Physical Apparatus is to be held by the Physical Society and the Optical Society on January 7th, 8th and 9th, 1930, at the Imperial College of Science and Technology, South Kensington.

In addition to a Trade Section and a new section for the work of Apprentices and Learners, there will be a Research and Experimental Section which will be arranged in three groups: (a) Exhibits illustrating the results of recent physical research; (b) Lecture experiments in Physics; (c) Historical exhibits in Physics.

The Exhibition Committee invites offers of exhibits from Research Laboratories and Institutions and from individual research workers. Offers of exhibits, giving particulars of space and other facilities required, should be communicated immediately to the Secretary, Exhibition Committee, 1, Lowther Gardens, Exhibition Road, London, S.W.7

Moving Coil Loud Speakers.

By H. M. Clarke, B.Sc.

A PREVIOUS article* has shown the effect of a compensating winding for moving coil loud speakers with regard to the effective resistance and impedance.

In the same number, p. 365, Mr. C. R. Cosens discussed the ability of a compensating winding to effect a substantial reduction in the self-induction of the moving coil. Using this expression $2L\ (1-K)$ for the combined self-induction of moving coil and compensating winding, and making use of the curves on pages 381, 382, we see that L and $2L\ (1-K)$ have mean values of 0.2575 henries and 0.0152 henries respectively. This gives K equal to 0.9705, a value well within the effective zone.

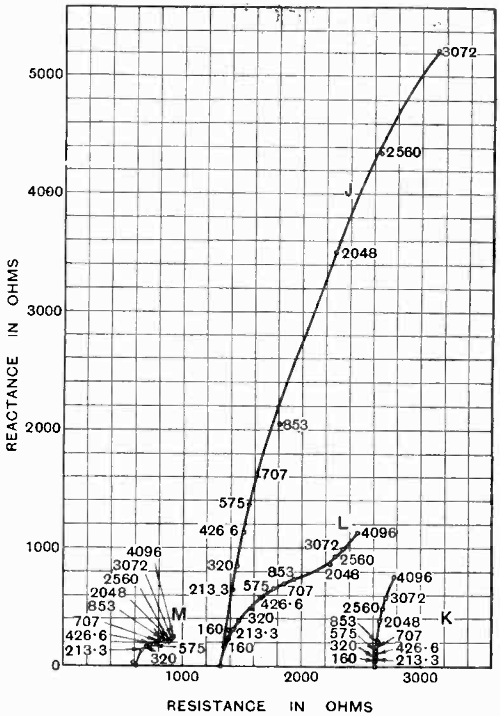
In the tests which were then described, the compensating winding was stated to be connected in series with the moving coil and therefore carried the same current. It was shown that a more uniform input could be obtained by a method of compensation which enabled the instrument to maintain approximately constant impedance and power factor under working conditions. The compensation consisted of coils concentrically situated with respect to the moving coil and fixed to the sides of the air gap, the fixed and moving coils being connected in series or in parallel in such a sense that they mutually opposed one another magnetically.

The question arises as to how far a compensating winding can effect its object if it is not electrically connected to the moving coil, but is shortcircuited so as to obtain its compensating current from the moving coil inductively, as if it were the secondary of a transformer.

The curves shown in the accompanying diagrams are the results of tests made without the polarising field, so that no sound was being emitted.

Curves J and K are for a 1,400-turn moving coil without compensation and with series compensation of 1,400 turns respectively. Curve L shows the electrical impedance characteristic of the same instrument with shortcircuited instead of series compensation, the shortcircuited secondary thus deriving its current inductively from the moving coil.

All curves were obtained from the same instrument with the same windings; the different conditions being obtained merely by changing the connections.



Vector impedance at frequencies varying from 0 *to* 4096.
Working current 12 *milliamperes A.C.*

J = 1,400-*turn coil, uncompensated.*
K = 1,400-*turn coil,* 1,400-*turn series compensation.*
L = 1,400-*turn coil,* 1,400-*turn shortcircuited compensation.*
M = 1,000-*turn coil, copper cylinders compensation.*

Ratio	$\frac{\textit{Impedance at } 4096}{\textit{Resistance D.C.}}$	5.51
,,	,,	1.1
,,	,,	2.04
,,	,,	1.55

The moving system was not moved during or between the tests. The same alternating current strength was used for all readings,

* *E.W. & W.E.*, July, 1929, Vol. VI, No. 70.

which were obtained by means of a modification of Anderson's alternating current bridge best suited to the wide range of conditions prevailing during the tests.

Curve *L* shows that compensation in power factor can be obtained inductively only at the expense of increased resistance. In this case the impedance has an increase of 104 per cent. over the test range of frequency and compares with 450 per cent. and 10 per cent. for the uncompensated and compensated cases *J* and *K* respectively, the increase being due principally to increase of resistance.

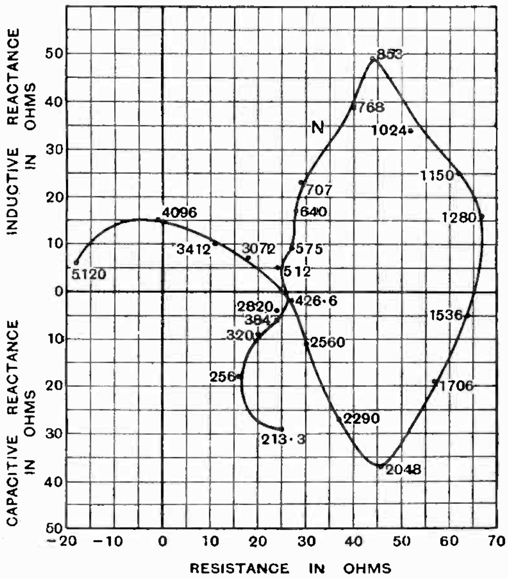
If, however, the compensation winding had a better conductivity, the compensating current could flow without requiring such an increase in the equivalent resistance of the moving coil. This improvement can be effected by making better use of the space available for the compensating winding. Another instrument was made having a moving coil of 1,000 turns and having the air gap lined on both sides with copper cylinders, each 0.5 millimetre thick. In this case the compensating winding consisted of two turns, one inside and one outside the moving coil with considerably more copper available for the secondary current.

The curve *M* shows the impedance of this instrument without its polarising field and is comparable with curve *L*. The increase of impedance is 55 per cent. compared with 104 per cent. for the same frequency variation.

It should be noticed that whereas series compensation tends to regulate for constant self-inductance and consequently for reactance proportional to frequency, induced compensation tends to regulate for constant reactance, and consequently for self-induction inversely proportional to frequency.

An important point in the case of induced compensation is that to reduce the effective secondary resistance the material and volume of the secondary winding must be the best possible.

In the case under consideration, using copper cylinders instead of enamelled wire, the effective area of cross section was increased fourfold. This advantage would have been neutralised if brass cylinders had been used, since the specific resistance of brass is not less than four times that of copper. The same effect would be produced by utilising only part of the polar surfaces as winding space. It is probable that still better compensation might be obtained by extending the copper secondaries to the iron surfaces immediately beyond the air gap sufficiently to ensure embracing all iron within the sphere of magnetic influence of

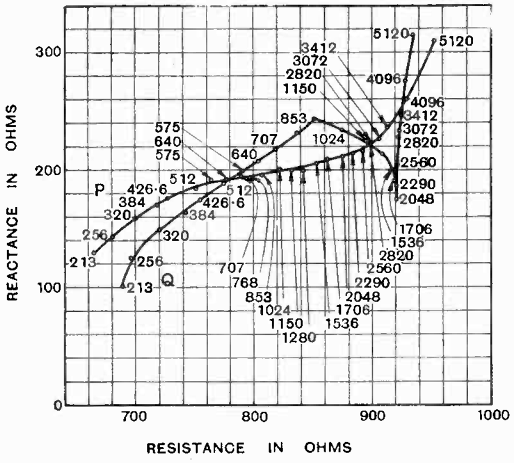


Vector difference of impedance with and without direct current field for 1,000-turn moving coil with copper cylinders compensation. Working current 12 milliamps. A.C.

the moving coil. This extra copper could be thicker than that in the air gap, where it can only be as thick as the gap permits. The copper external to the gap cannot, however, replace the copper in the gap, since the magnetic coupling between the moving coil and the external copper would be too loose to achieve anything but fractional compensation. The result would then be intermediate between the *J* and *M* cases.

In the inductively compensated cases, curve *M* shows that there is still considerable eddy current loss, so that the difference between impedances with and without the polarising field includes not only motional impedance but also the difference between the eddy current losses produced when the moving coil is stationary and when it is moving. In fact, the difference between the two resistances with and without field is the difference between the motional resistance and the resistance equivalent to the recovered secondary losses. An interesting point to notice is that this difference may be negative without implying that there is no sound output, and it was found that such was the case above 4,000 frequency in the particular instrument under test. Curves Q and P show the vector impedances with and without the main field for the 1,000-turn moving coil instrument with copper cylinder compensation, and curve N is their vector difference. Curves Q and P should be compared with B and D of the previous article.

While it appears that induced compensation is not so effective in maintaining constant impedance as series compensation, it appears to keep the variation of impedance with frequency down to 250 per cent. for frequencies up to 10,000, and it has the advantage that it is not in electrical connection



Vector impedances of offset origin for 12 milliamps. A.C. in 1,000-turn moving coil with copper cylinders compensation.

P *without direct current field.*
Q *with direct current field.*

with the moving coil, thus facilitating the insulation of the latter from the body of the loud speaker. This is important in the case of a centre-tapped moving coil operating directly in the anode circuits of a push-pull output stage without the intervention of an output transformer.

This may be done without risk of a breakdown since the small wires used in high-resistance moving coil windings may be operated at very large current densities. The writer has had 1,000-turn coils of 47 S.W.G., carrying 50 milliamperes for hours continuously. Push-pull output valves may be biased to half-way along the lower bend of the anode current grid volts characteristic and there will then be no undue heating in a 1,000-turn coil of 47 S.W.G., even if six L.S.5A valves are used in parallel push-pull with a mean grid swing of 30 volts.

The use of an output transformer should be avoided if full advantage of the constancy of impedance and power factor of the instrument is to be taken. It is doubtful if the characteristics of such transformers are good enough not to exhibit considerable leakage reactance and in this event one of the advantages of compensation will be lost, namely, the rapid damping of transients.

Damping of transients and shunting of resonances can be used in the case of induced compensation with practically the same effectiveness as in the series case, since the resonant peaks to be shunted are so pronounced that the impedance of the filter circuit is required to rise on either side of the resonant frequency so rapidly that the impedance of the instrument over this range of frequency has changed but slightly, perhaps about 10 per cent.

A summary of the above results may be made as follows :—

The electrical input to the loud speaker may be made constant at all frequencies by means of a compensation winding, connected in parallel or in series with the moving coil or closed through current adjusting apparatus. The last case may take the form of copper cylinders in the air-gap and extending over the neighbouring iron of the magnet. The motional impedance, depending upon the method of suspension, and the mass of the moving system and upon the strength of the polarising field, will exhibit resonances.

These resonances may be smoothed most effectively in the case of the constant impedance instrument by means of an external shunting circuit tuned to the resonant frequency and having a resistance adjusted to give the desired shunting effect.

The values of the inductance and capacity of the shunting circuit may be chosen to give the required attenuation of the shunting effect. More than one shunting circuit may be used if more than one resonant peak requires smoothing.

Experimental Transmitting and Receiving Apparatus for Ultra Short Waves.

By R. L. Smith-Rose, D.Sc., Ph.D., A.M.I.E.E., and J. S. McPetrie, B.Sc. (National Physical Laboratory).

(Published by Permission of the Radio Research Board.)

(*Concluded from page* 542 *of last issue.*)

Part II (concluded).

(d) Short-wave Limit of Small Valve Oscillators.

It is quite simple to design and operate a 5-metre oscillator with ordinary receiving valves. Shorter wavelengths than this, however, become progressively more difficult to obtain until we reach a limit between 1.5 and 2 metres. Beyond this region it is practically impossible to make an oscillator using ordinary voltages on the electrodes. Two factors account chiefly for this limit. One is the capacity between the electrodes in the valve itself; this capacity is in shunt across the oscillatory circuit and so limits the range of the oscillator. The other is the finite time that the electrons take to pass from the filament to the anode. The period of the waves produced by the valve must be greater than this time in order that the current through the valve may respond rapidly to the changes in potential of the grid and anode. The table below gives the approximate dimensions of some typical valves.

VALVE DIMENSIONS.

Type.	Anode Diameter.	Grid Diameter.
French R.	0.85 cm.	0.4 cm.
British R. (old type).	0.9 ,,	0.45 ,,
,, ,, (new type)	1.0 ,,	0.40 ,,
D.E.R.	0.85 ,,	0.35 ,,
D.E.2 L.F.	0.52 ,,	0.25 ,,
D.E.2 H.F.	0.5—0.55 cm.	0.25 ,,
T.15	1.15 cm.	0.4 ,,
Shortpath G.	0.3—0.35 cm.	0.15 ,,
,, B.	0.3 cm.	0.15 ,,
,, RR.	0.3 ,,	0.2 ,,
P.M. 1 H.F.	0.5 ,,	0.15 ,,
P.M. 1 L.F.	0.55 ,,	0.2 ,,
P.M. 252	0.55 ,,	0.3 ,,
L.S. 5A	0.75 ,,	0.27 ,,
R.C. 2	0.6 ,,	0.25 ,,
G.P. 2	0.55 ,,	0.25 ,,
D.E.V.	0.7—0.75 cm.	0.3 ,,

It will be seen that 0.5 cm. is an average value for the diameter of the anode. This means that the electrons have to travel at least 0.25 cm. before the grid has time to change from one to the other half of its cycle of potential variation. In the modern receiving valve the temperature of the filament is so low that the initial velocity of the electrons from the filament may be neglected. We shall assume that the variation in potential of the grid is not large. This need not be true in all cases, but the analysis will be much simpler and quite approximate if we neglect this variation. Suppose the anode is at a potential of 50 volts above that of the filament. We can find the time of passage of the electron between the filament and the anode by the well-known equation

$$s = \frac{1}{2} at^2$$

where s is the distance traversed, a is the acceleration and t is the time during which the acceleration takes place.

In this case a is equal to $\frac{eV}{dm}$ where e and m are the electronic charge and mass respectively, V the potential between the anode and filament, and d the distance between anode and filament. Substituting the above values for V and d, this gives an approximate value of the time t of 1.2×10^{-9} secs. This time, as shown above, must be less than half the period of the wave, *i.e.*, the period of the oscillation produced by the valve must at least be 2.4×10^{-9} secs., the wavelength corresponding to which is 72 cms. Thus, we cannot hope to obtain oscillations of less than this wavelength with ordinary valves working under ordinary conditions.* Actually the limit found by a series of experi-

* *Cf.* H. E. Hollmann: "On the Mechanism of Electron Oscillations in a Triode," *Proc. I.R.E.*, 1929, Vol. 17, pp. 229–251.

ments was found to lie in the region of 1.5 metres. |Fig. 12 shows a short-wave oscillator using circuit No. 11. The coils had a diameter of about 2 inches and no tuning condensers were used. The wavelength of this oscillator was about 1.7 metres when short-path valves were used. Fig. 13 is a photograph of another short-wave oscillator employing circuit No. 10. The coupling condensers had a maximum capacity of 100$\mu\mu$F and the wavelength of this oscillator was about 1.8 metres when the coil was in the form of an unclosed square, the length of side being 1.5 inches.

It will be noticed that the high-tension supply to the oscillator in Fig. 12 is by means of a thin wire (No. 47 S.W.G. copper). This wire at such high frequencies acts as a choke and also presents small capacity to neighbouring wires.*

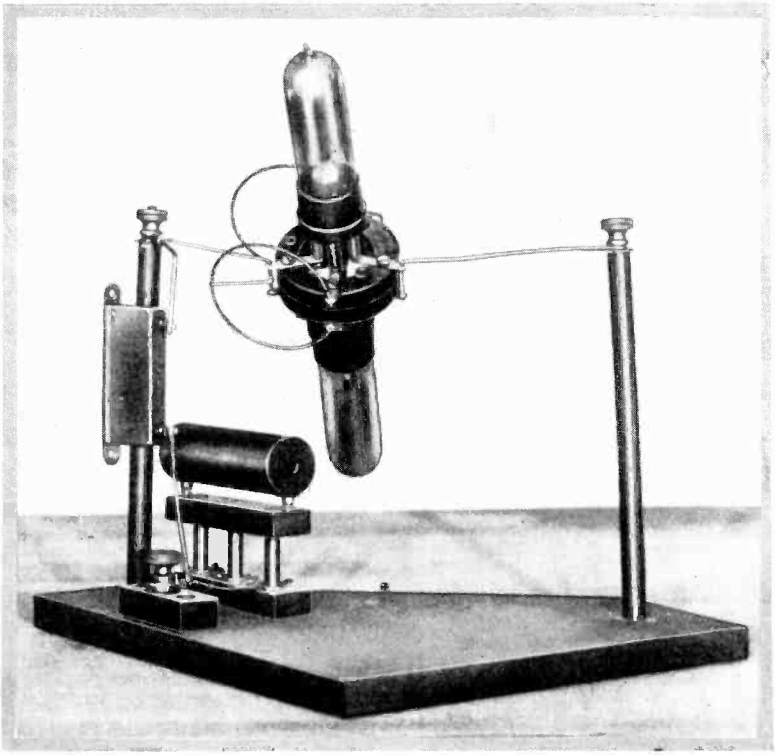


Fig. 12.—*Two-valve oscillator for a wavelength of 1.5 metres, using the circuit of Fig. 11.*

The two oscillators shown above suffered from a sort of fatigue. This may be due to the dielectric losses in the bases and glass wall of the valve. Fig. 14 is a curve in which the output from one of these oscillators is plotted against the time from the instant of starting the oscillator. The output was measured by inserting a thermo-junction in an untuned coil which was coupled to the oscillator. It will be seen that the amplitude of oscillations decreased by some 25 per cent. in three hours. After being switched off for a short time the oscillator output recovered its initial value.

Part III.

Design and Development of Small Transmitters for Powers up to 1,000 Watts.

(a) Valve Requirements.

Valves intended to dissipate power at very high frequencies must have special design features not essential for those

* *Cf.* R. M. Wilmotte: "Self-inductance of Straight Wires," *E.W. & W.E.*, 1927, Vol. 4, pp. 355–358.

working at lower frequencies. The first feature we desire is low self-capacity and intercapacity of the electrodes. This means that the leads to the electrodes should be brought out as far as possible from one another. This separation of the leads, however, is limited by the inherent increase in inductance due to their greater length.

Several years ago Franklin* drew attention to the possibility of the glass envelope melting as a result of the heat generated by eddy currents in metallic deposits which occur on the inside of the glass during evacuation of the valve. In certain types of transmitting valves it has been customary to use copper foil screens on the outside to avoid breakdown from this cause.

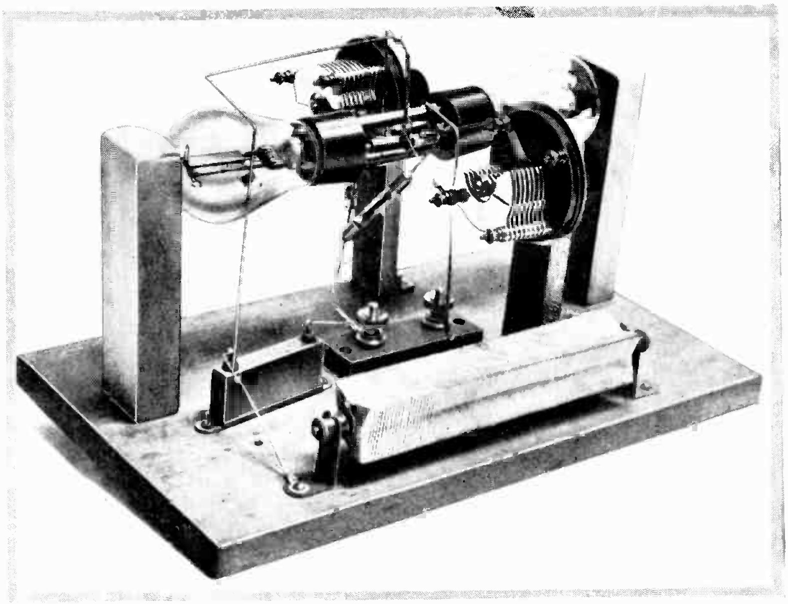


Fig. 13.—*Two-valve oscillator for wavelengths down to 1.8 metres, using circuit shown in Fig. 10.*

The loss in a dielectric in an alternating field increases with the frequency of the field. The glass envelope of a valve lies within the field between the grid and anode. The envelope should, therefore, be of as great dimensions as is consistent with short leads from the electrodes. The neck of an ordinary valve is in a concentrated part of the field, and punctures were very common at this part when valves were first used on short wavelengths. The field may be reduced by continuing the grid mesh beyond the ends of the anode. This construction concentrates the radio-frequency field between the grid and anode and so reduces that which reaches the glass wall of the valve.† It is also

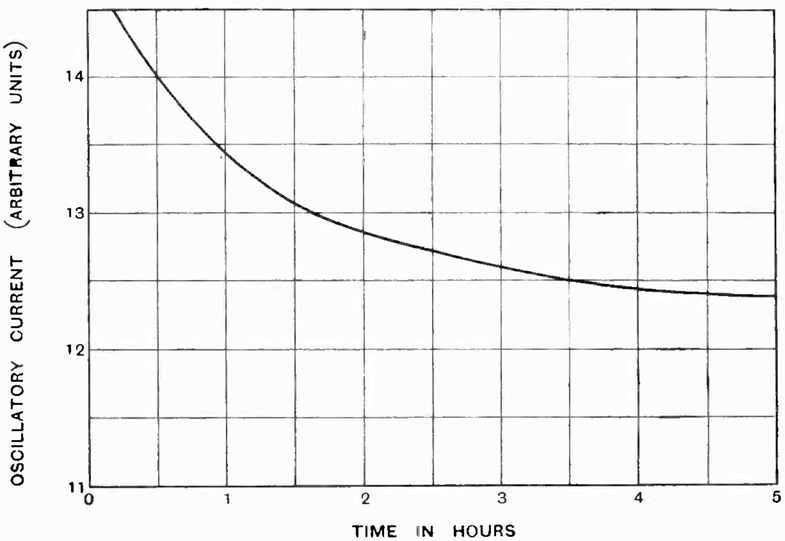


Fig. 14.—*Oscillator output.*

*C. S. Franklin: "Short Wave Directive Wireless Telegraphy," *Journal I.E.E.*, 1922, Vol. 60, pp. 930–934.

† Yojiro Kusunose: "Puncture Damage through Glass Wall of Transmitting Vacuum Tube," *Proc. I.R.E.*, 1927, Vol. 15, pp. 431–437.

advisable to thicken the leads to the electrodes at the places where they enter the glass.

(b) Circuit Layout of Transmitters.

We have designed several oscillators incorporating the circuits described in Part II. It is difficult to describe the different layouts in detail, but it is hoped that the typical photographs reproduced herewith will give a general idea of the methods adopted to obtain maximum efficiency.

The valves were usually mounted on panels of American whitewood, this material having low dielectric loss when dry.

Fig. 15 shows an oscillator using circuit No. 9 with a 100-watt valve: as shown set-up in this photograph, a rejector circuit was incorporated in the grid-filament lead of the valve: this rejector circuit tended to oscillate and was later discarded. This oscillator with the coil and condenser shown in the photograph was capable of oscillating down to about 5 metres.

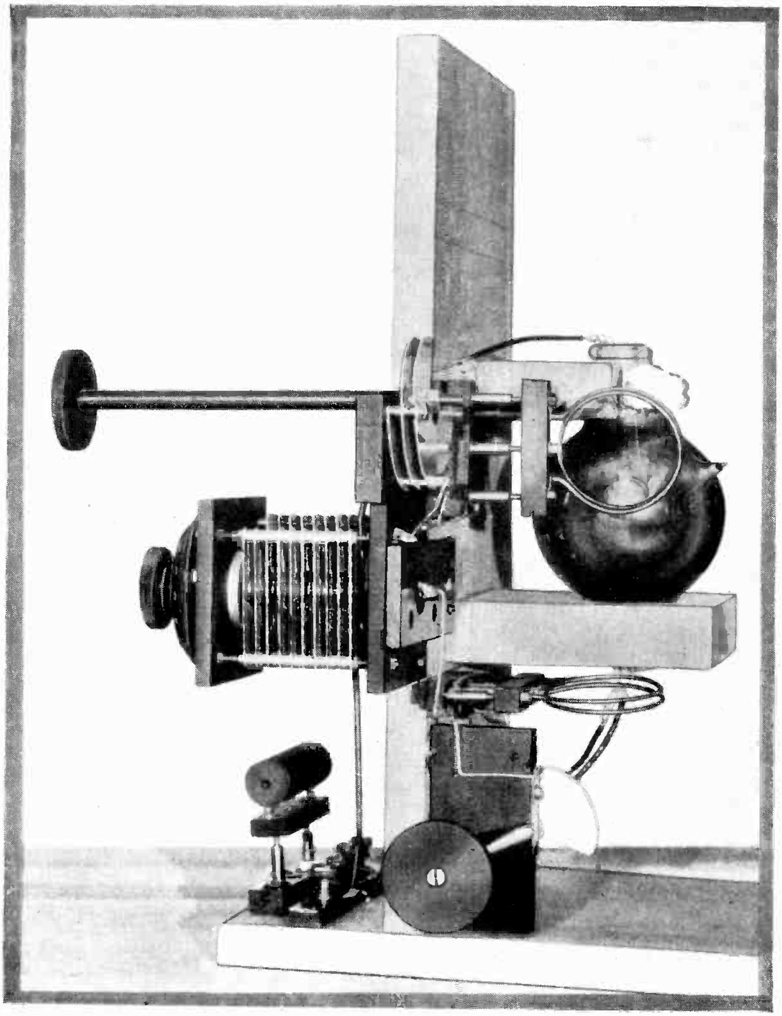


Fig. 15.—*Single valve transmitter employing* 100 *watt valve in the circuit of Fig.* 9 (*Series-fed Hartley Circuit*) *for wavelengths down to* 5 *metres. The lower coil forms part of a rejector circuit in series with the grid leak.*

A two-valve oscillator which could be used either with circuit No. 10 or 11 was built in order to compare the two circuits. The inconvenience of tuning two circuits when it was used as No. 11 decided us to concentrate on the single-coil capacity-coupled valves are mounted on opposite sides of a common panel of American whitewood in order to ensure the shortest possible leads from one valve to the other. It was found necessary to use chokes in series with the grid leaks to prevent leakage of high-

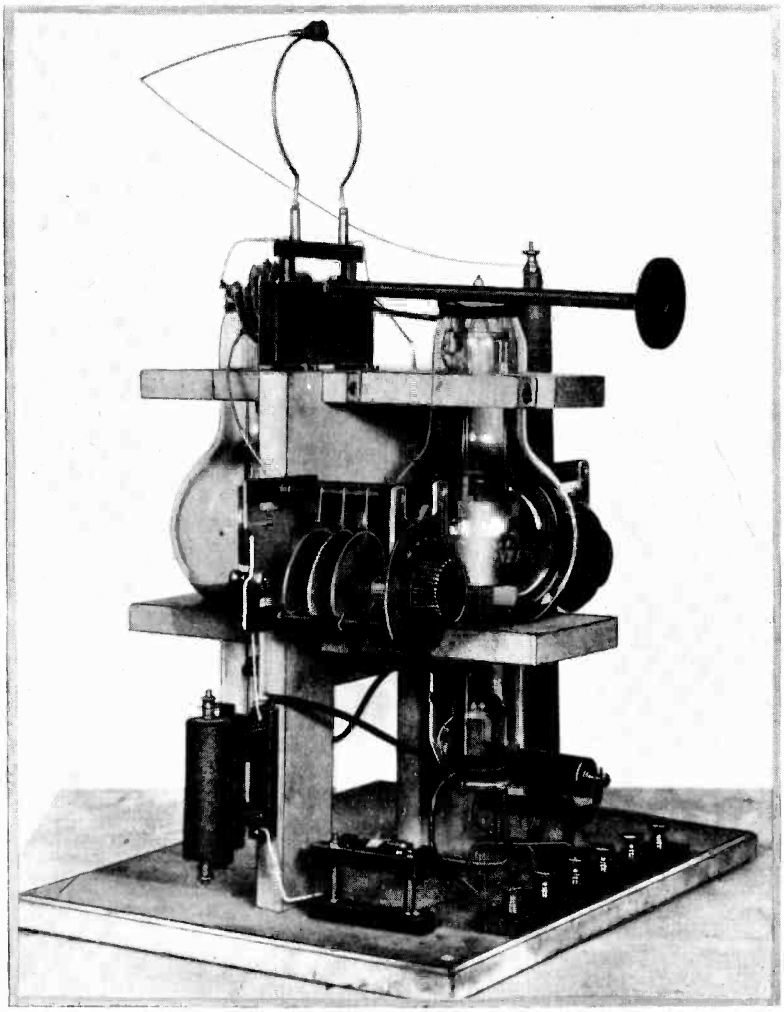


Fig. 16.—*Single-coil push-pull oscillator, using two 250 watt valves employing the circuit shown in Fig. 10 and operating on wavelengths from 5 to 20 metres, with interchangeable coils.*

push-pull transmitter with circuit No. 10. A typical oscillator of this type using two 250-watt valves is shown in Fig. 16. The tuning condenser had a maximum capacity of about 30$\mu\mu$F and the same size of condenser was used for coupling the anode of one valve to the grid of the other. The frequency power into the filament leads. This oscillator is shown in Fig. 17 under working conditions in a hut at the Radio Research Station, Slough. The valve filaments are operated from a 16-volt battery and the anode current is obtained from a D.C. generator at 2,000 to 5,000 volts. The transmitter is shown in the photograph, Fig. 17, set up on a movable table which carries the valve control panel. When using two 250-watt valves at a high-tension supply of 3,000 volts, and a total input power of 300 to 400 watts, the circulating current in the inductance is several amperes at a wave-length of 6 or 8 metres. By moving the table variable coupling is obtained to a Lecher wire system connected to the external transmitting aerial. The construction of a similar transmitter employing two 500-watt valves is now in progress.

Two-valve circuits are used more frequently than single-valve circuits as, by the use of push-pull generators we can obtain greater output without increase in the high-tension voltage. This is particularly valuable when a portable transmitter is required.*

It has been shown above that circuit No. 10 is simply a combination of two No. 9 circuits. Sometimes in a push-pull circuit we may suspect that one of the valves is not oscillating. If this is the case the oscillator will be working as circuit No. 9. This can easily be verified by dimming the filament of each valve in turn. If the dimming of one filament stops the transmitter from oscillating there is a probability that the other valve is not oscillating when the transmitter is used in push-pull.

The above oscillators may be modulated by varying the potential of the grid in any of the usual ways. For work on

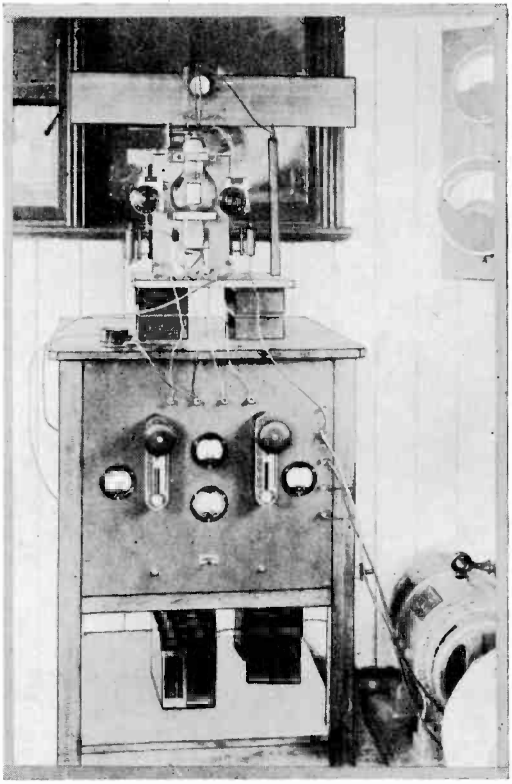
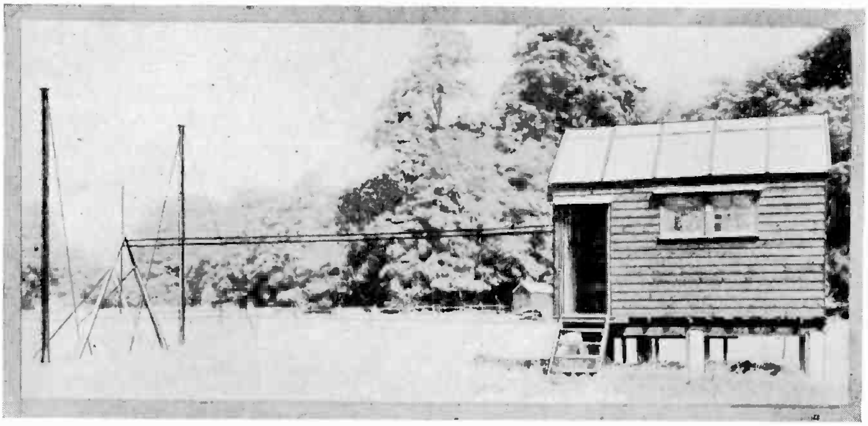


Fig. 17.—*The complete short-wave transmitter set up at the Radio Research Station, Slough. The oscillator is that illustrated in Fig. 16, and it supplies a half-wave antenna through the transmission line shown in the photograph below.*

* *See* R. L. Smith-Rose and E. L. Hatcher: *The Wireless World*, 1928, Vol. 23, p. 501.



The transmission line referred to in Fig. 17 above.

short waves we favour anode potential modulation as this removes the system of modulation from the high frequency end of the oscillator.

For the transmission of Morse signals it has been found that the operation of a key, one terminal of which is connected to a suitable point on the Lecher wire system, is convenient. The operation of the key imposes a lumped capacity on the Lecher wires thereby distuning them from the oscillator frequency. The resulting signals are clear-cut and free from "frequency-slurring" at make or break.

(c) Lecher Wires and the Measurement of Wavelength.

The simplest method of determining the wavelength of high-frequency oscillations is by means of Lecher wires. These may be described as two long parallel conducting wires short-circuited at the input end by a conducting bridge. If a sinusoidal oscillation is impressed at the input end of such a system stationary waves are set up in it. The velocity of propagation of these waves on the wires will be very nearly that of the velocity of similar waves in free space

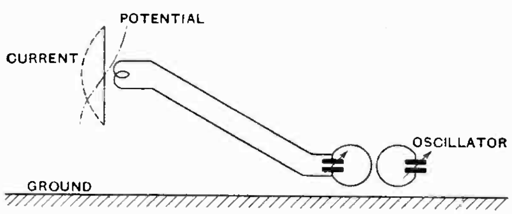


Fig. 18.—*Inductive supply to ungrounded* $\lambda/2$ *antenna.*

provided the wires of the Lecher system are good conductors and of a sufficient diameter to ensure that their inductance per unit length is not large. If these conditions are fulfilled the wavelength of the stationary waves will be very nearly equal to that of the oscillations impressed on the wires. The positions of the nodes and antinodes of current in the wires may be determined from the readings of a meter placed in a second bridge which may be moved along the wires. The distance between any two consecutive nodes or antinodes of current is half the wavelength of the stationary waves. These, however, as shown above, have the same length as those of the oscillator coupled to the Lecher wires. The measurement of the length of the stationary waves, therefore, gives us a determination of the wavelength of the oscillations of the transmitter coupled to the Lecher wires. Hund* has shown that a small condenser placed in parallel with the

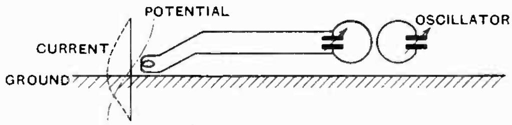


Fig. 19.—*Inductive supply to grounded* $\lambda/4$ *antenna.*

wires near their input end shifts the nodes and antinodes nearer the input end without affecting the distance between them. A variable condenser in this position may thus be used to bring the nodes and antinodes to convenient positions on the wires. This is particularly useful in transmission lines used to feed antennæ.

(d) Methods of Energising Antennæ.

The measurement of wavelength is not the only use to which Lecher wires have been put in short-wave installations. At high radio-frequencies the antenna either of a transmitting or receiving station should be situated in as open a space as possible. In a radiating field objects act as reflectors when their linear dimensions are comparable with the wavelength of the incident field. The buildings associated with a short-wave station are such that they give rise to this source of scattering and loss. The only method of diminishing this loss is to place the aerial at some distance from any buildings and to lead the energy to or from it by means of a transmission line. Most commercial short-wave transmitting and receiving stations are designed in this way. In feeding an antenna for transmission it is most efficient to make the load at the antenna end equal to the surge impedance of the transmission line. This prevents the reflection of the waves at the aerial end of the line and limits the current in the wires and so the ohmic loss in them.

The antennæ used in short-wave trans-

* A. Hund: "Theory of Determination of Ultra-radio Frequencies by Standing Waves on Wires," Bureau of Standards, 1924, Scientific Paper No. 491, pp. 487–540.

missions are usually comparable in length with the wavelength, the most common lengths being half and quarter of the wavelength. At these high frequencies it is important to supply the power in such a way as to suit the distribution of current and potential in the antenna. Fig. 18 shows the distribution of current and potential in an ungrounded half-wave antenna. If we wish to feed this antenna inductively from the transmission line we must do so at some point which is not a current node as shown in Fig. 18. Fig. 19 represents the current and voltage distribution in a grounded quarter-wave antenna. In this case current should be fed in inductively at the bottom. Voltage may be fed to the antinode of potential of the antenna. If we use voltage excitation of a

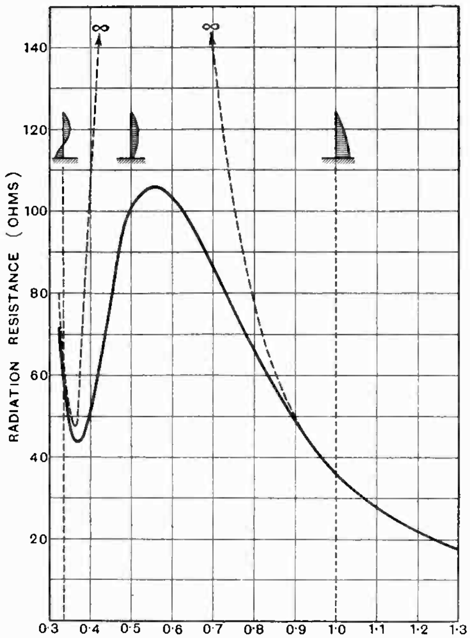


Fig. 20.—Radiation resistance of simple vertical antenna over perfect earth for wavelengths below the fundamental.

$\frac{\lambda}{2}$ ungrounded antenna we should do so at either end.

The radiation resistance of an antenna operating on medium and long wavelengths is given approximately by the expression

$$R_a = 40\pi^2\left(\frac{l}{\lambda}\right)^2 \text{ ohms},$$

where l is the length of the antenna. This relation is only very nearly true when the distribution of current in the aerial is linear, that is, when the amplitude of current at any point is proportional to its distance from the free end of the aerial. This condition is only satisfied when the length of the aerial is small compared with the wavelength. Short-wave antennæ are not small compared with the wavelength and we can no longer use the usual formula for radiation resistance given above. Ballantine* has computed the radiation resistance of an antenna for wavelengths less than the fundamental, and Fig. 20 is taken from his paper. It will at once be noticed that the radiation resistance of antenna used on short waves is usually much greater than that on longer waves. This increase in radiation efficiency of the aerial partly explains the apparently phenomenal distances sometimes covered by the waves with low input powers. With the transmitter described above and shown in Fig. 17 we can obtain 0.50 ampere in a half-wave antenna at 7 metres. The radiation resistance of this antenna, as seen from Fig. 20, is approximately 100 ohms. Thus the aerial output is a little over 25 watts. The input to the transmitter is of the order of 300 watts so that the overall efficiency is very small, but we have not yet endeavoured to increase it as the output is ample for our present purpose, viz., the measurement of attenuation along the ground near the aerial.

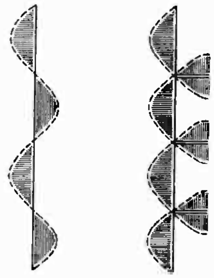


Fig. 21.—*Diagram showing the use of phasing coils in an aerial two wavelengths long to give maximum radiation in a horizontal plane.*

A glance at the distribution of current in an aerial working on wavelengths less than its fundamental will immediately indicate the possibility of radiating power in other than the horizontal direction. Each lobe of current may be considered roughly to act as a Hertzian oscillator at its centre with sign the same as that of the current in the

* S. Ballantine: "On the Radiation Resistance of a Simple Vertical Antenna at Wavelengths below the Fundamental," *Proc. I.R.E.*, 1924, Vol. 12, pp. 823–832.

loop. In this way we see that successive loops of current in an aerial being of opposite sign interfere with one another's radiation in the horizontal direction. Therefore any antenna having an even number of current loops of opposite sign should give zero horizontal radiation. Franklin has overcome this effect of alternate loops interfering with one another by inserting in the aerial small phasing coils having low radiation resistance so as to cut out alternate loops. Fig. 21 shows how this would be done with an aerial whose length is equal to twice the wavelength of the current in it.

Ballantine* in another paper has calculated the radiation in the vertical plane for different angles to the horizontal for aerials of different length. Fig. 22 is copied from his paper. He has shown that for a given output maximum horizontal radiation is obtained when the ratio of wavelength to the fundamental of the aerial is 0.39.

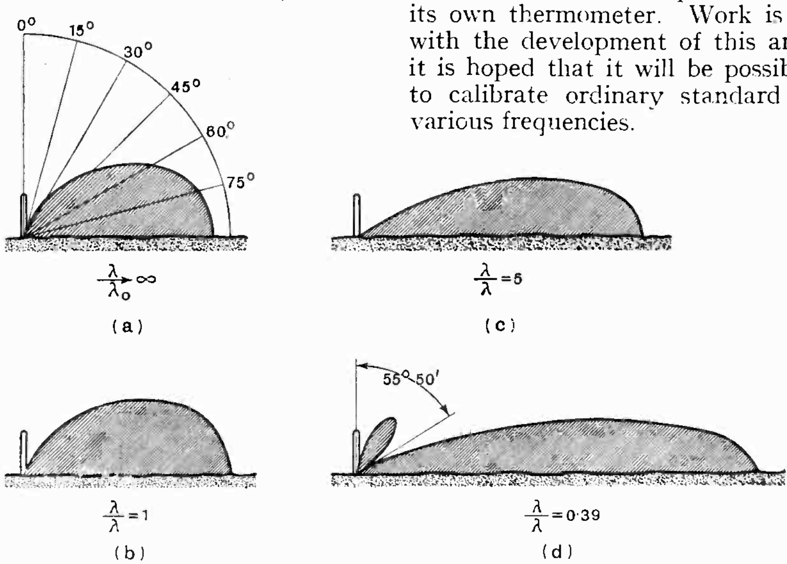


Fig. 22.—*Vertical antenna over perfect earth ; diagrams representing intensity of the radiation at various angles of altitude for various wavelengths.*

(e) The Measurement of Current at Very High Frequencies.

The measurement of current at very high frequencies presents many difficulties. An ordinary radio-frequency ammeter has a certain capacity to its case which acts as a variable shunt resistance for the radio-frequency current, and unless the measuring element is properly screened it is difficult to correct for this effect. The tendency for current to travel on the surface of conductors also becomes very important at these high frequencies. In this way the calibration of an instrument which is correct at low frequencies may be false for the high frequencies used in short waves. Moullin† has developed a method for the measurement of current at very high frequencies, in which the attraction between two cylinders carrying the same current is measured. An ammeter of this type may be corrected for the errors mentioned above. In a paper to be published shortly Wilmotte describes another method which may be used. Essentially the method consists in passing the current through a column of mercury which indicates its temperature by acting as its own thermometer. Work is in progress with the development of this ammeter and it is hoped that it will be possible to use it to calibrate ordinary standard meters for various frequencies.

Part IV.

Development and Use of Receivers at Very Short Wavelengths.

In considering the design of receiving apparatus for use on very short wavelengths,

* S. Ballantine : "On the Optimum Transmitting Wavelength for a Vertical Antenna over Perfect Earth," *Proc. I.R.E.*, 1924, Vol. 12, pp. 833–839.

† E. B. Moullin : "An Ampere Meter for Measuring Alternating Current of Very High Frequency," *Proc. Roy. Soc.*, 1928, Vol. 121, pp. 41–71.

it is perhaps natural to review the various types of receiver which have been used with success on longer waves. The simplest type of receiver which has found widespread use on wavelengths from 100 metres downwards, is that of the single-valve detector type employing variable capacity retroaction. For the reception of modulated continuous waves this retroaction can be set critically to a point just below that at which the valve oscillates, while at a point just above the receiver is very sensitive for the reception of continuous waves on the autodyne principle. Since any valve circuit which will oscillate freely at the working frequency can be controlled by suitable adjustment of the retroaction, it is evident that any of the various arrangements described above can be made to serve for reception purposes by a suitable modification. Where additional sensitivity is required the possibilities of direct radio-frequency amplification immediately arise. Considerable experience with various types of radio-frequency amplifiers has shown that it is extremely difficult to obtain any appreciable amplification on frequencies above 20 megacycles per second (wavelengths below 15 metres). In certain receivers employing one or more stages of amplification at such frequencies, it is usually found that any amplification that is obtained is at the expense of the retroaction setting of the detector, and that if the H.F. stages are omitted this retroaction can be increased thus avoiding any overall loss in sensitivity. As a means of obtaining increased sensitivity with the aid of greater retroaction the super-regenerative type of circuit has been used by some investigators. The advantage of this circuit arrangement would appear to lie in the possibility of using more retroaction, the valve being prevented from dropping into oscillation by the quenching action of the supersonic oscillation at a lower frequency. The authors have so far, however, had no experience of this type of receiver.

For the greatest sensitivity in short-wave reception, the supersonic heterodyne would appear to offer great possibilities, and it is perhaps somewhat surprising to find that little or no work on the adaptation of this type of receiver to wavelengths below 10 metres has so far been published. At the present stage of the technique of amplification, it is a comparatively simple matter to obtain considerable voltage amplification at a moderate intermediate frequency of the order of 100 kilocycles per second. For the conversion of such an intermediate frequency amplifier to a short-wave receiver, it is necessary merely to precede it with a frequency-changing unit, which generates oscillations at the original very high frequency to heterodyne those due to the incoming signals. By the substitution of different frequency-changing units, it would appear possible to extend the range of the receiver down to the shortest wavelengths at which the receiving valves can be made to oscillate. Experimental work on these lines is being conducted, and although certain difficulties have been encountered in extending the wavelength range below about 7 metres, it is not considered that these are insuperable. The method possesses advantages in the possibility of employing two or more intermediate frequencies where the utmost sensitivity is required compatible with stability. This portion of the research work is, however, still in progress and a detailed description of it will be given in a later communication. For the present the objects of the authors are served by adopting the simplest type of receiver available at the moment in order to proceed with preliminary experiments on the propagation of very short waves.

For these receivers the single-valve retroactive detector has been employed using one of the two circuits shown in Figs. 6 and 7. Since oscillations can be obtained with such arrangements down to wavelengths below 3 metres, it has not been considered necessary to adopt the somewhat more complicated two-valve arrangements. Using the centre-tapped inductance coil in the circuit shown in Fig. 6, an open aerial can be coupled through a variable condenser to one end of the coil. If a definite earth connection is employed it is preferable that this should be to the centre of the coil, *i.e.*, the negative end of the filament. If, on the other hand, an insulated counterpoise system is used, this may be connected to the other end of the coil by a variable condenser in the same manner as the aerial. The complete circuit diagram of such a receiver is shown in Fig. 23. The salient point to observe is that in this circuit the two ends of the inductance coil are at high alternating potential, and the aerial and counterpoise connected thereto should also be arranged to provide potential variations at these points. It is, therefore, necessary to ensure that the length of the aerial is not an odd multiple of a quarter of the wavelength since this would provide a potential node at the connection to the receiver. The search for optimum conditions with this type of receiver involves the adjustment of the length of aerial and of all the controls of aerial coupling, retroaction and tuning: in particular the correct adjustment of aerial coupling is important since if this is too great, the radiation resistance of the aerial will prevent the detector valve from oscillating, whereas if it is too small, a loss in sensitivity will result. A certain amount of experimental work was carried out on this type of receiver with satisfactory results, but for any sort of measurement work it is desirable to reduce the number of variables in the apparatus itself.

It was, therefore, decided to replace the receiving antenna by a closed loop and to mount this directly on the screened box containing all the receiving apparatus. In this way everything except the pick-up loop can be efficiently screened, a great advantage for many signal intensity and direction-finding measurements. Since for wavelengths below 10 metres the area-turns of the receiving loop will be comparatively small

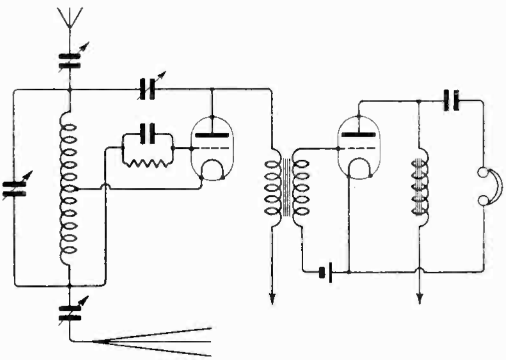


Fig. 23.—*Schematic circuit diagram of two-valve short wave receiver using centre-tapped input coil capacity-coupled to aerial and counterpoise.*

it will usually be desirable to make this of the single-turn type. In order to avoid the central tapping at the top of the coil the

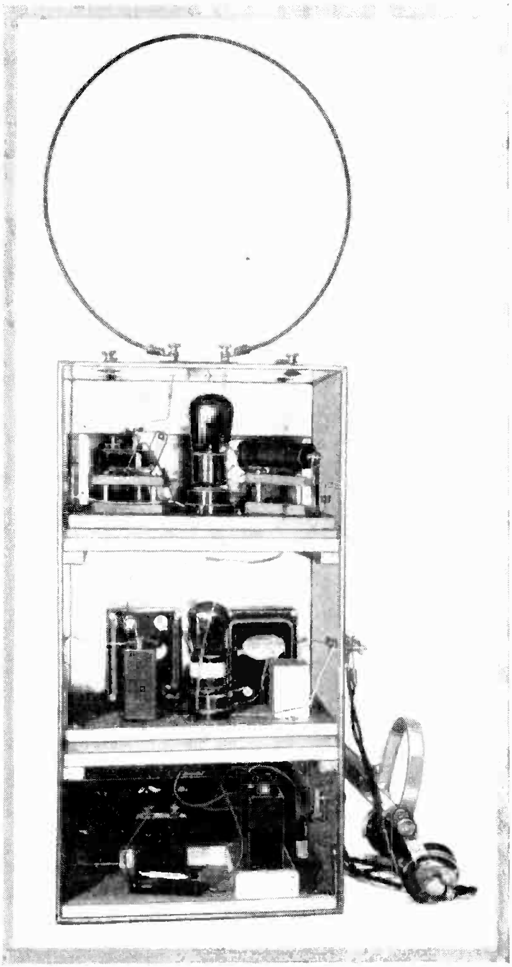


Fig. 24.—*Photograph of loop receiver using the circuit shown in Fig. 25. Wavelength range 4 to 10 metres.*

circuit arrangement shown in Fig. 7 was adopted for the detector valve. The tuning adjustment is effected by two variable condensers in series, the tapping to the filament being taken from their common connection. A photograph of a complete receiver built on these lines is shown as Fig. 24, while the diagram of connections and dimensions of the principal components are given in Fig. 25. In order to make the whole receiver as symmetrical as possible about the central axis of the loop, and also to shorten the lengths of the wiring to the first stage, the apparatus is arranged in three tiers as indicated in the photograph. The receiving loop is held rigidly to the top of the box by its terminals, to the underside of which is connected the tuning condenser. The controls for this and the retroaction condensers are taken out through the back of the box, and sockets are provided for interchangeable grid leaks and choke coils. A single audio-frequency amplifying stage is mounted on the middle platform, while the necessary filament and anode batteries are placed at the bottom of the box. The output terminals for telephones are placed as a shunt across an audio-frequency choke in the anode circuit of the second valve; by this means the telephone leads and hence the observer are maintained at the screen potential, thus avoiding certain difficulties due to capacity changes. In considering the possible receiving range of this apparatus it may be mentioned that a loop of 12 inches diameter has an inductance of less than one microhenry, and requires only 18$\mu\mu$F. of capacity to tune it to a wavelength of 7 metres.

Using single-turn loops constructed of $\frac{1}{8}$in. diameter copper tube, the following wavelength ranges could be covered with a tuning condenser of which the minimum and maximum capacities were 2 and 24$\mu\mu$F. respectively.

Diameter of Loop.	Wavelength Range.
Inches.	Metres.
5	4.8— 6.9
8	5.5— 8.8
10	6.2— 9.5
12	6.7—10.8

capacity between the coil terminals and the effect of various components upon this capacity. The measurements were made by a substitution method using a standard variable air condenser and a wavelength of about 17 metres. With both tuning and retroaction condensers set to their minimum positions, the capacity between the coil terminals with the first valve in its socket was 9 and 12$\mu\mu$F. with the filament current off and on respectively. To this amount the base of the valve contributed 1$\mu\mu$F., while the capacity of the valve itself, *i.e.*, between its grid and anode was about 1.5$\mu\mu$F., leaving about 7.5$\mu\mu$F. to be attributed to the wiring connections and their capacity to the screened box. The alteration of the retroaction condenser to its maximum position increased the capacity between the coil terminals by 5$\mu\mu$F. The substitution of various grid leaks and choke coils in the detector valve circuit made no appreciable alteration to this capacity. It will thus be seen that the minimum capacity obtainable is limited by the capacity of the valve and its connections, and little reduction can be obtained in its value by omitting the valve holder or using a tuning condenser with a still lower minimum capacity than that at present in use (2$\mu\mu$F.). The chief disadvantage of this limitation is that it restricts the range of wavelengths which it is possible to cover with any one loop, but the above table indicates that there is no difficulty in making the receiver operate at wavelengths down to less than 5 metres. When it is desired to proceed to still shorter wavelengths, it is

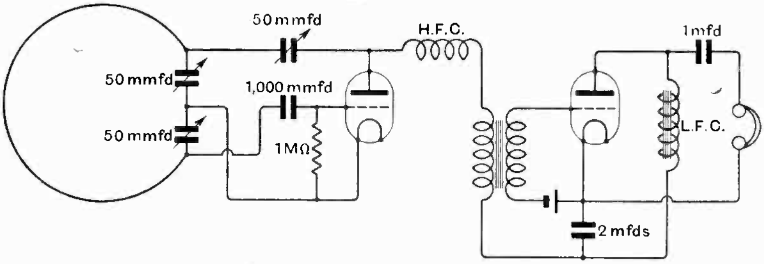


Fig. 25.—*Schematic circuit diagram of two-valve short wave loop receiver for field strength measurements and direction finding. Wavelength range 4 to 10 metres.*

In order to ascertain the possibility of reducing the minimum wavelength by a reduction in the stray capacity of the first stage, some measurements were made of the an advantage to remove the stray capacity due to the screened box. In this way the same receiver has been made to operate at a wavelength of 2.9 metres.

Wave-meters.

As a general source of radio-frequency oscillations for measurement purposes, the type of valve wave-meter previously described by F. M. Colebrook* is very convenient. One of these models has been constructed covering a total wavelength range of from 4.7 to 100 metres with 5 plug-in coils. The construction of a slightly modified design to cover shorter wavelengths is in progress, but by using harmonics it is possible to get as low as 2.5 metres with the existing model.

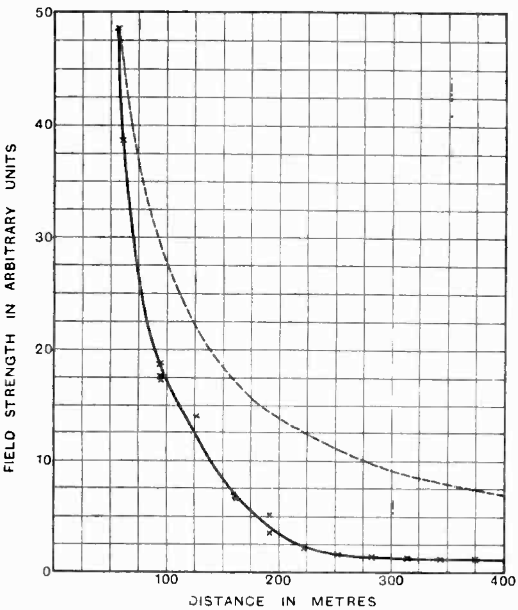


Fig. 26.—*Attenuation curve for wavelength of 8 metres.*

For making measurements upon a transmitter, it is convenient to have an absorption type of wave-meter, and one of these has been constructed with four interchangeable coils and a moderately good variable air condenser having a maximum capacity of 50$\mu\mu$F. As indicator a crystal detector and small pointer galvanometer are used in an aperiodic loop circuit coupled to the resonant circuit. The wavelength range of this instrument is 3.5 to 25 metres.

For laboratory work probably the most accurate method of measuring wavelengths is by means of a pair of Lecher wires. Such a system has been used for most of the development work described in Part III. above. Two copper wires are stretched horizontally three inches apart at a height of about nine feet and two or three feet away from all neighbouring objects. At one end these wires are short-circuited and form a means of coupling to the oscillating source. The positions of current and potential nodes are then located by means of a bridging link containing a vacuum thermo junction and micro-ammeter. The distance between successive nodes of either type is one-half of the wavelength. Where the length of the wires is greater than the wavelength, this method of measurement is convenient and accurate, but for field work and portable use one of the types of meter described above is much more convenient.

* F. M. Colebrook: *E.W. & W.E.*, 1927, Vol. 4, p. 722.

Some Typical Experiments at Short Wavelengths.

It will have been gathered from the early part of this paper that the object of the work described was to develop the necessary apparatus by means of which certain experiments on the propagation of waves might be carried out. In attempting to make measurements on the very short wavelengths in question the experimenter is soon impressed with the need for adopting much more than the ordinary precautions usually associated with radio measurements at lower frequencies. The worker must continually remember that the waves instead of being much longer are now much shorter than the dimensions of such objects as trees and houses, and that therefore these objects present moderately effective reflecting surfaces having dimensions of at least several wavelengths. Any experiments on propagation must, therefore, be carried out with great caution and every effort made to exclude the effect of neighbouring objects.

In order to obtain reasonable conditions in this respect the short-wave transmitter illustrated in Fig. 17 was erected at the Radio Research Station, Slough, on a site which, while hemmed in by trees on one side, provided a clear run across a field for a distance of about 600 yards in other directions.

The results of a typical set of relative field-strength measurements made at various distances across this field on a wavelength of 8 metres are plotted in Fig. 26. For reference purposes the attenuation curve over a perfect conductor on the assumption of an inverse distance law is given on the same

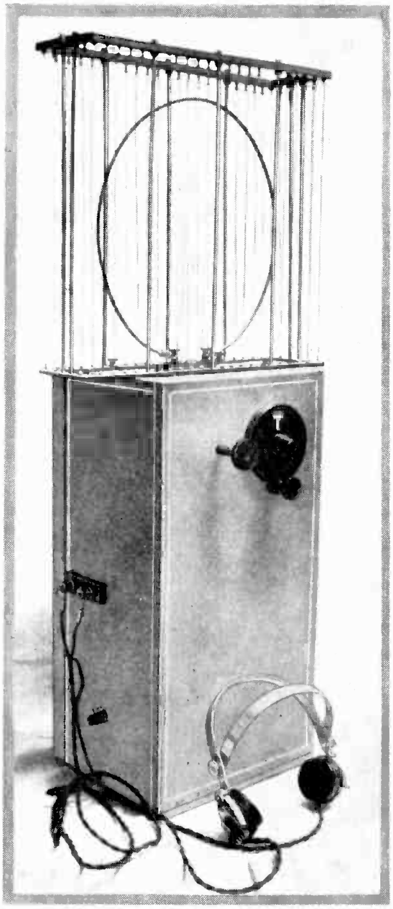


Fig. 27.—*Short wave loop receiver fitted with an electric screen for field strength and direction-finding measurements on wavelengths 4 to 10 metres.*

diagram, and it is seen from the two curves that the decrease of field-strength with distance is very great on such short wave-lengths.

The receiver with which the above measurements were taken, and which was illustrated in Fig. 24, can be used as a tolerably good direction-finder if it is mounted on a suitable turntable with a graduated scale. When used for aural reception in this manner bearings can be obtained fairly comfortably using modulated waves at the source on a wavelength of from 7 to 10 metres. If unmodulated waves are employed with autodyne reception it is difficult, to retain constancy of the audible note as the set is rotated, but with care and patience it is still possible to obtain bearings. In either case the signal minima on the set are considerably improved in quality and are made much more symmetrical by fitting an open vertical wire screen around the receiving loop, in accordance with the practice on longer waves first established by R. H. Barfield.* A photograph of the short-wave direction-finder fitted with such a screen is shown in Fig. 27 and with this instrument bearings can be obtained with care to an accuracy of 2° or 3°. These are, of course, subject to serious error under many conditions due to reflections from neighbouring objects. An attempt has been made to measure the polar diagrams of this direction-finder and the result of the observations

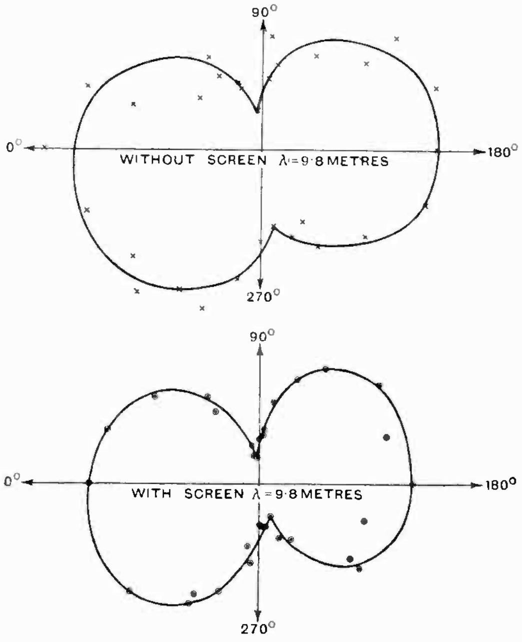


Fig. 28.—*Polar reception curves of the loop receiver shown in Figs. 24 and 27.*

made with and without the electric screen in position are shown in Fig. 28. The results

* R. H. Barfield: "Some Experiments on the Screening of Radio Receiving Apparatus," *Journal I.E.E.* 1924, Vol. 62, pp. 249-264.

are not of a high order of accuracy due, amongst other things, to the effect of the presence of the observers, but the polar curves show the kind of minima which it is possible to obtain, and indicate that the development of a reasonably accurate direction-finder for use on these very short wavelengths is certainly within the realms of possibility. These few results also serve to show that no new fundamental principles arise in the science and practice of radio work on very short wavelengths, but the technique of the subject merely requires the experimenter to adjust his ideas and experiences to conform to the smaller dimensions of the waves with which he is working.

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

The authors also wish to acknowledge the assistance rendered by Mr. A. C. Haxton in the experimental work.

ERRATUM.—In the first instalment of this article in last month's issue the diagrams of Figs. 4 *and* 5 *on page* 537 *should have been transposed.*

Note on the Apparent Demodulation of a Weak Station by a Stronger One.

By S. Butterworth, M.Sc.

IN the issue of *E.W. & W.E.* for June, 1928, Dr. R. T. Beatty discusses the nature of the rectified signal when two stations of slightly differing wave lengths are being received simultaneously. He points out that the carrier wave of the stronger station exerts a powerful demodulating effect on the signal from the weaker station, and thus explains the well-known fact that two stations are acoustically separable in cases where mere inspection of the resonance characteristic of the receiver would lead one to expect very powerful interference.

As this effect is of fundamental importance in the problem of selectivity, it is important that we should obtain quantitative notions as to its magnitude, and Dr. Beatty has given an elementary treatment leading to a numerical estimate of the amount of demodulation in simple cases.

In the case of perfect rectification, this treatment leads to a very surprising result, namely, that the carrier wave of the stronger station *completely* demodulates the weaker station, so that, if the conclusion is correct, the effect of varying tuning should be to cause a sudden change over of the received signal from one station to the other at the point where the voltages impressed on the rectifier are equal. This effect does not, of course, occur, and in order to account for the observed gradual transition, Dr. Beatty makes use of the curvature of the rectification characteristic. In the present note, however, it is shown that there is no need to do this as, owing to over simplification in order to avoid mathematical complexity, the amount of the demodulation with perfect rectification has been overestimated.

Take first the case of two unmodulated carrier waves having pulsatances* ω and $\omega + p$. The difference in pulsatance p is supposed small compared with ω, but it is still supersonic, so that there is no audible heterodyning. Let the strengths of the signals to be rectified be X and Y, so that the voltage received by the detector is of the form

$$v = X \cos \omega t + Y \cos (\omega + p)t \quad .. \quad (1)$$

This may be written

$$v = (X + Y \cos pt) \cos \omega t - Y \sin pt \sin \omega t \quad (2)$$

or, if we put

$$\left.\begin{aligned} X + Y \cos pt &= R \cos \psi \\ Y \sin pt &= R \sin \psi \end{aligned}\right\} \quad .. \quad (3)$$

---

* The pulsatance is the frequency multiplied by 2π.

that is

$$\left.\begin{aligned} R^2 &= X^2 + Y^2 + 2XY\cos pt \\ \tan\psi &= Y\sin pt/(X + Y\cos pt) \end{aligned}\right\} \quad .. \quad (4)$$

we get

$$v = R\cos(\omega t + \psi) \quad .. \quad (5)$$

Since p is small compared with ω, there are many cycles of the carrier wave for very small changes in R and ψ, so that R, when plotted against time, will give the outline of the envelope representing the succession of carrier wave peaks. With a perfect rectifier, that is, one which removes the negative pulses but leaves the positive pulses undistorted, the mean wave for many cycles of ω but few of p is $2R/\pi$, and this is what would be recorded after rectification by a linear detecting instrument capable of following variations of pulsatance p, but too sluggish to record variations of pulsatance ω.

If, however, the instrument is too sluggish to follow the supersonic ripple, it will only record the mean value of R for many cycles of pulsatance p. If this is R_m, we have

$$\pi R_m = \int_0^\pi (X^2 + Y^2 + 2XY\cos\theta)^{\frac{1}{2}} d\theta$$
$$= 2(X + Y)\int_0^{\pi/2} (1 - k^2\sin^2\psi)^{\frac{1}{2}} d\psi$$

in which

$$\psi = \theta/2, \text{ and } k^2 = 4XY/(X + Y)^2 \quad (6)$$

The latter integral is well known as the complete elliptic integral of the second kind to modulus k, and is usually denoted by $E(k)$, so that we may write

$$R_m = 2(X + Y)\,E(k)/\pi \quad .. \quad (7)$$

The equation shows that the mean recorded current will vary both with X and Y. This conclusion differs from that obtained by Dr. Beatty, who found that the mean recorded current was proportional to the strength of the stronger signal only. The difference in the two results is due to the fact that in equation (2) Dr. Beatty ignored the term $Y\sin pt\sin\omega t$ and thus obtained an erroneous form for the supersonic envelope.

Now let one of the stations (say X) be modulated at audio frequency and suppose the detecting instrument capable of following these variations. At any instant suppose x is the variation superposed on the steady value X and let x/X be small. Then

$$R_m \text{ is replaced by } R_m + x\frac{dR_m}{dX} \quad .. \quad (8)$$

and by differentiation of (7) we find

$$\frac{dR_m}{dX} = \{(1 + Y/X)\,E(k) + (1 - Y/X)\,K(k)\}/\pi \quad .. \quad (9)$$

Here $K(k)$ is the complete elliptic integral of the first kind to modulus k, viz. :—

$$K(k) = \int_0^{\pi/2} d\psi/(1 - k^2\sin^2\psi)^{\frac{1}{2}}$$

Using Tables of elliptic integrals, the following values of $\frac{dR_m}{dX}$ have been computed, in which equal intervals of Y/X have been taken when Y is less than X and equal intervals of X/Y when Y is greater than X.

VALUES OF $\frac{dR_m}{dX}$

X greater than Y.		X less than Y.	
Y/X		X/Y	
0.0	1.000	0.0	0.000
0.1	0.998	0.1	0.052
0.2	0.990	0.2	0.100
0.3	0.977	0.3	0.153
0.4	0.959	0.4	0.205
0.5	0.934	0.5	0.256
0.6	0.902	0.6	0.314
0.7	0.862	0.7	0.380
0.8	0.815	0.8	0.438
0.9	0.749	0.9	0.524
1.0	0.637	1.0	0.637

It is seen from the Table that when the disturbing station (Y) is absent, $\frac{dR_m}{dX}$ is unity, so that in all cases $\frac{dR_m}{dX}$ is a direct measure of the demodulation produced on X by the carrier wave of Y, and thus $\frac{dR_m}{dX}$ is the demodulation factor.

The demodulation factor giving the demodulation produced on Y by the carrier wave of X is similarly $\frac{dR_m}{dY}$. The values of $\frac{dR_m}{dY}$ are also given by the above Table, provided that we interchange X and Y at the top of the first and third columns. This is true because of the symmetrical way in which X and Y appear in equation (4).

Further, if we are considering the two

stations simultaneously, the second column will give the demodulation of X by Y and the fourth column the demodulation of Y by X for values of Y/X given by the first column in both cases.

Using this interpretation, if we take the ratios of the demodulation factors $\frac{dR_m}{dY}$ and $\frac{dR_m}{dX}$ for corresponding values of Y/X and multiply by Y/X we obtain the ratios of the received acoustic signals. This yields the following Table :

Carrier Wave Ratio.	Acoustic Ratio.	Carrier Wave Ratio.	Acoustic Ratio.
0.1	0.0052	0.6	0.209
0.2	0.0202	0.7	0.308
0.3	0.0470	0.8	0.430
0.4	0.0656	0.9	0.630
0.5	0.137	1.0	1.000

The carrier wave ratio is, of course, that which would be deduced from the resonance characteristic of the receiver, but it is the acoustic ratio which is important in estimating the selectivity. It must be emphasised that the above Tables only hold for perfect rectifiers. The curvature of the rectification characteristic will tend to increase the above acoustic ratios. In fact, when the rectification follows the square law, as is practically the case for weak signals, the demodulating effect completely disappears and in this case the acoustic ratio is the square of the carrier wave ratio. These squares are larger than the acoustic ratios given in the last Table, being nearly twice as large when the carrier wave ratio is small. This means that if we push up the H.F. amplification until there is a considerable swing of voltage across the grid of the detector valve, there will be a gain in selectivity which may be of the order of nearly 2 to 1 as compared with what would be got if detection occurred immediately and the necessary volume was obtained by L.F. amplification. This is altogether apart from the increased selectivity obtained by the resonant circuits of the H.F. amplifier and thus we are given an additional argument in favour of adequate H.F. amplification.

Correspondence.

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

Moving Coil Speakers.

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

SIR,—In a letter in the August number, Dr. McLachlan has raised several points in connection with my paper on Moving-coil speakers in the July number.

In the first place, if he thinks I have not given him sufficient credit for his pioneer work on the M.C. speaker, I can only apologise ; I do not think much harm has been done, for anyone taking an interest in the subject must be perfectly well aware of his work, and the addition of a footnote would have conveyed nothing new ; in any case, if he will refer to p. 364 (top of second column) he will see that I speak of " the design originated by Dr. McLachlan."

I have no references by me, but I have always been under the impression that Rayleigh did the mathematics of the plane diaphragm in the eighties, and that the first " M.C. speaker " (with a wooden board for a diaphragm) was made by Lodge in the nineties ; since when nothing further was done until Dr. McLachlan designed the first instrument at all resembling what we now call a " M.C. speaker " for the Science Museum. Reference to the files of *E.W. & W.E.* and of *The Wireless World* might settle this definitely.

It is very unfortunate that Dr. McLachlan's paper suffered so much delay before being submitted for publication ; had it appeared 18 months earlier it would have saved me a lot of work. I must, however, take exception to his statement that I have "*repeated*" part of his paper ; it would be equally correct, or rather incorrect, to say that he had " repeated " part of mine : we have both covered the same ground, to a large extent, but to say that either " repeated " the other is to suggest that one had previous knowledge of the other's work, for it is impossible to " repeat " what has not been previously heard or published. The acrimony engendered by disputes on priority is usually proportional to the square of their lack of interest or importance to anyone but the protagonists ; it is therefore fortunate that in the present case no such question of " priority " can arise, as the interval between the dates of publication is too small (I understand that the booksellers received the June supplement to *Phil. Mag.* and the July *E.W. & W.E.* on the same day), and of course even an interval of a month or two would not be sufficient for the preparation and printing of either paper. The truth of the matter is, of course, that neither knew of the other paper until it was seen in print, internal evidence of which is found in the fact that each paper contains matter not found in the other. For example, Dr. McLachlan goes far more fully into the transient question; but thanks to the kindness of Professor Watson, my paper shows that the function Dr. McLachlan, following Rayleigh's original notation, calls $K_1(z)$ is connected with a known and tabulated function (Struve's function) in fact, as stated on p. 359 of my paper,

$$K_1(z) \equiv z\mathbf{H}_1(z),$$

a fact which, had it been known to him, would have saved Dr. McLachlan much tedious summing of series.

I am, of course, perfectly well aware of Dr. McLachlan's earlier articles and his book; with the latter in particular, I was disappointed on account of its lack of information as to how various quantities such as motional (or radiation) resistance and motional capacity were to be obtained for any particular coil other than that described (with about 1,000 turns). While a number of vector diagrams were given, there was no indication of the accuracy of approximations such as the assumption that the motional capacity is constant. It is possible that the equation for the value of the motional capacity $\left(\text{in my notation } K = \frac{m}{y^2B^2}\right)$ may have been published previously in an issue of *The Wireless World* earlier than my current file contains, but I certainly cannot find it in my copy (1st edn.) of "Loudspeakers" (of course it appears, with different notation, in the *Phil. Mag.* paper).

Possibly Dr. McLachlan thinks in terms of vector diagrams, while I think rather in terms of differential equations; but whatever the cause, I must own I found the explanations in "Loudspeakers" very hard to follow; it was never stated that they were more than empirical approximations for the particular speaker described, justified by the fact that they "Worked," and it was not until I had worked it out for myself from the equations that I realised that they had a theoretical basis, and were accurate to a high degree of approximation for *any* M.C speaker.

I agree that the expression "adherent air" is misleading, "accession to inertia" is better, I did not refer to Dr. McLachlan's introduction of the question in 1927, as it was actually introduced by Rayleigh in 1887, to which I refer in the text; the footnote referring to *E.W. & W.E.* editorials of 1929 was given, as stated therein, because it included a recent bibliography (thereby saving a half-page of references) and a lucid explanation of the reasons why an accession to inertia is to be expected.

I should be most interested if Dr. McLachlan could give us an explanation of a method, even if only an approximate one, for predicting the (static) inductance of a moving-coil in place in the pot-magnet. I believe there is a method used by dynamo designers which could be adapted.

C. R. Cosens.

Definition of Selectivity.

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

Sir,—I am much indebted to Mr. Biedermann for his useful comments on my proposal for the specification of selectivity (see *E.W. & W.E* for August, 1929).

My proposal is, briefly, that given an impedance Z, which is a function of frequency $(\omega/2\pi)$, resonance shall be defined by

$$\frac{\partial Z}{\partial \omega_r} = 0$$

and selectivity by

$$\omega\sqrt{\frac{1}{Z_r}\left|\frac{\partial^2 Z}{\partial \omega_r^2}\right|}$$

Mr. Biedermann traces the derivation of this formula and shows that it is based on the coefficient of $\left(\frac{\delta\omega}{\omega_r}\right)^2$ in the expansion of $Z^2(\omega + \delta\omega)$ in terms of $Z^2(\omega)$ and $\delta\omega$. He then questions the validity of neglecting the remaining terms of the series. This really amounts to saying that the value of

$$\frac{\partial Z^2}{Z_r^2}\bigg/\left(\frac{\delta\omega}{\omega_r}\right)^2$$

may depend on $\delta\omega$. It certainly will in every case, and that is why I have proposed the above formula, which is independent of $\delta\omega$, since

$$\omega_r\sqrt{\frac{1}{Z_r}\left|\frac{\partial^2 Z}{\partial \omega_r}\right|}^{\,2} = \underset{\delta\omega\to 0}{lt}\sqrt{\frac{\delta(Z^2)}{Z_r^2}\bigg/\frac{\delta\omega}{\omega_r}}$$

In other words, I have introduced the limiting condition $\delta\omega\to 0$, in which case, assuming the convergency of the series for $Z^2(\omega + \delta\omega)$, all the terms of the series vanish except that on which the proposed definition of selectivity is based.

Mr. Biedermann's second comment is largely a matter of personal opinion. The question is, should the definition of selectivity be based on a proportional change in frequency (*cf.* resolving power in optics) or on some arbitrary agreed absolute change in frequency. I agree with Mr. Biedermann that the latter basis might have advantages from a practical and technical point of view. On the other hand, the former leads to a definition which is quite free from any arbitrary element and is thus more satisfactory from a logical and scientific point of view.

F. M. Colebrook.

Teddington.

Abstracts and References.

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PROPAGATION OF WAVES.

SUR LES ÉCHOS RETARDÉS (Retarded Echoes).—C. Störmer. (*Comptes Rendus*, 26th Aug., 1929, Vol. 189, pp. 365–368.)

The situation is most favourable to the occurrence of these echoes, according to the writer's "toroidal space" theory, when the line earth-sun makes the smallest angle with the magnetic equatorial plane of the earth, *i.e.*, the plane passing through the earth's centre and normal to its magnetic axis. The writer gives a list of the values of the angle, at the dates of the echoes observed in Oct. 1928, Feb. 1929, and also of the most recent echoes in April, 1929. Apart from one day (23rd April) the angles were of the order of 0.1 to 6 deg., whereas for the transmissions (67 in number) when no echoes were heard, the angles varied from −31 and 33 deg. The Indo-China echoes mentioned in Oct. Abstracts occurred with angles about 5.7 to 9.6 deg. The anomalous result on 23rd April occurred with an angle of about 24 deg. Previous echoes had been heard on 4th, 9th and 11th April (angle −0.2 to 2.9 deg.) after which there was a gap till the 23rd.

The writer points out that while his original note of 5th Nov., 1928, deals particularly with reflection at the surface of the toroidal space, there are other possibilities of reflecting surfaces; in particular he mentions the corpuscular ring outside the moon's orbit, whose existence he was led to suggest in 1910 in his explanation of the aurora borealis.

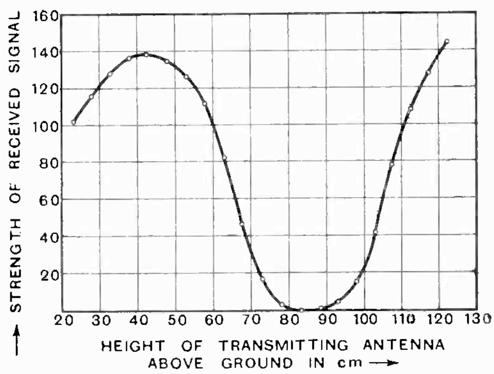
He refers to Pedersen's recent memoir (October Abstracts, p. 565) to the Danish Academy of Sciences in which that worker goes deeply into the various theories of long time echoes and adopts that of the writer; indicating as possible, moreover, echoes from corpuscular currents still more distant—a prophecy which is apparently confirmed by certain observations of Hals', quoted in Pedersen's paper, of echoes arriving 3 or 4 minutes after the signal.

The writer urges the need for international collaboration in studying the corpuscular currents of cosmic space by this new method; to see whether the usual theory of such currents can explain completely the echo phenomena, or whether it must be modified—*e.g.*, by taking into account the electromagnetic mutual actions of the corpuscles in motion: and to trace, by observations continued over several days at the right time, the great corpuscular beams which must emanate from the sun and (by the movements of sun and earth) may approach the earth little by little and finally cause magnetic storms and polar auroras. "The study of the approach of these currents and of their deformations by the earth's magnetism would be of the highest scientific interest."

MESSUNG DES LEITVERMÖGENS DER ERDE FÜR KURZE ELEKTRISCHE WELLEN (Measurement of the Conductivity of the Earth for [Very] Short Electric Waves).—M. J. O. Strutt. (*Naturwiss.*, 13th Sept., 1929, Vol. 17, pp. 727–728.)

A radiation-measurement method for obtaining the earth conductivity has been developed in connection with the writer's theoretical work dealt with in June Abstracts, p. 329. The receiving apparatus was suspended at a height of about 15 m. and a horizontal distance of about 13 m. from the transmitter. The latter (with horizontal antenna) was moved up and down so that the directly-received wave, interfering with the reflected wave, produced variations in signal strength. From a curve of the signal strength as a function of the height of the transmitting antenna the complex reflection coefficient of the earth was calculated, and from this the conductivity.

The transmitter gave a 1.42 m. wave, 100 per cent. modulated at 435 p.p.s. The receiver had one valve detector with tuned L.F. (435 p.p.s.) amplification. The final stage was a valve voltmeter. Preliminary calibration and tests established that the received signal varied strictly linearly with the transmitted strength and that radiation and reception took place only at the antennæ themselves.



The curve shown was taken over stripped heath-land. Immediately after the test, the specific resistance was measured with d.c. and with 500-cycle a.c.

For the 1.42 m. wave, reckoning the refraction coefficient as $n^2 = e - \lambda k . 6 \sqrt{-1}$ (where e = dielec. const., k = const. of measuring system), the conductivity was more than 10^{-12} e.m.u. For d.c. and 500-cycle a.c. it was 0.89×10^{-13} and 1.15×10^{-13} e.m.u. respectively. Further results over different types of land and on different wavelengths are promised.

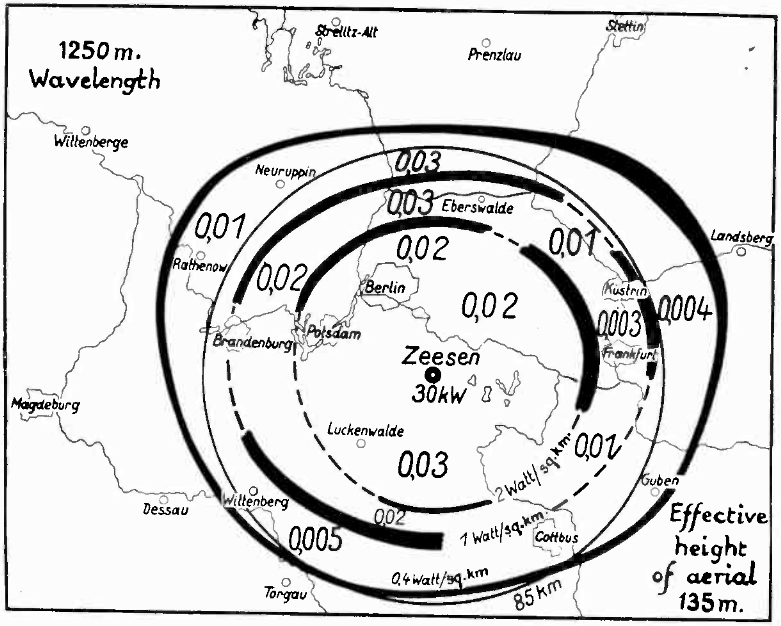
FURTHER NOTE ON THE IONIZATION IN THE UPPER ATMOSPHERE.—J. C. Schelleng. (*Proc. Inst. Rad. Eng.*, Aug., 1929, Vol. 17, pp. 1313–1315.)

"A recent paper [Feb. Abstracts, pp. 98–99] by the present writer has brought from other workers in the field a considerable amount of discussion through the medium of personal letters. The author believes that the objections which were in this way raised have been shown not to be valid and that his correspondents now agree in this statement. However, it may be well to put on record certain considerations the omission of which for the sake of brevity caused difficulty." The writer then clarifies his proof that the fringe experiment and the group experiment give identical results, the identity being proved regardless of what the mechanism will eventually prove to be. "The proof is more general than one based on ray theory, and attention is particularly called to the fact that Fermat's principle of least time is not needed to prove the equivalence of the two methods," as it was in Appleton's proof (also referred to in February Abstracts, and anticipating that of the present writer). It is, however, called in here to explain the equivalence also of the third ("triangulation") method of Breit and Tuve.

DIE WELLENAUSBREITUNG DES DEUTSCHLANDSENDERS (The Wave Propagation of the "Deutschland" Transmitter).—F. Kiebitz. (*E.N.T.*, August, 1929, Vol. 6, pp. 303–306.)

An account of measurements made last Autumn at about 100 places at distances of 50–100 km. from the transmitter. The absorption by the ground was different in different directions. Measured by the logarithm of the decreased radiation over 1 kilometre, the absorption, moreover, was of the order of 0.01 at close quarters and only 0.001 at long range. General results are shown in the map given below.

It is suggested that the decrease of absorption with increasing distance may be due to the course of the Elbe and Oder rivers, while the large near values may be produced by the wooded and hilly districts to the N. and S. of Berlin respectively. On the other hand, the decrease with increasing distance may be due to a more fundamental effect—the absorption may be considered as affecting the lower part only of the wave-front, and this lower part forms a smaller and smaller fraction of the whole front as the distance increases. "In fact, according to the Huygens-Fresnel principle the space wave must partially compensate for the energy-current absorbed in the earth."



THE PROPAGATION OF LOW POWER SHORT WAVES IN THE 1,000-KILOMETER RANGE.—K. Krüger and H. Plendl. (*Proc. Inst. Rad. Eng.*, Aug., 1929, Vol. 17, pp. 1296–1312.)

An English version of the paper dealt with at some length in June Abstracts, pp. 321–322.

ÄNDERUNG DER EMPFANGSFELDSTÄRKE ÜBER LAND MIT DER ENTFERNUNG BEI LANGEN WELLEN (Variation of Received Field Strengths with Distance, for Long Waves over Land.)—H. Fassbender. (*E.N.T.*, Aug., 1929, Vol. 6, p. 339.)

The earlier value found for the quantity a in the Austin-Cohen formula was 0.0015 over sea. Later measurements over land gave very varying results, most of which, however, could be explained by a change of a with the time of day. The writer refers to tests between a transmitter in an aeroplane and an Anders field-strength measuring apparatus on the ground, to investigate the changes of a in short times on different wavelengths. Tests at the same hour on different days agreed sufficiently well, but tests over different routes gave differing pictures of the distribution of field strengths. For the route Berlin-Hanover, the value for a was 0.01 for a 300 m. wave and decreased down to 0.004 for a 2,000 m. wave.

An Investigation of Short Waves.—T. L. Eckersley. (*Journ. I.E.E.*, August, 1929, Vol. 67, pp. 992–1032.)

The full paper, with discussion, summaries of which were dealt with in June and July Abstracts, pp. 321 and 385.

Difference in Long Wave Propagation in England and America: Earth Conductivities?—S. W. Dean. (*See* Discussion of Smith-Rose's paper, under "Directional Wireless.")

The Problems Centering about the Measurement of Field Intensity.—S. W. Edwards and J. E. Brown. (*Proc. Inst. Rad. Eng.*, Aug., 1929, Vol. 17, pp. 1377–1384.)

A continuation of the work dealt with in 1928 Abstracts, V. 5, p. 690. The activities of the Radio Division of the U.S.A. Department of Commerce are described, and specimen Field Intensity Contour Maps are reproduced. *Cf.* Barfield, *E.W. & W.E.*, Jan., 1928, pp. 25–30; also Barfield and Munro, Feb. Abstracts, pp. 98 and 262.

The Attenuation of Wireless Waves over Land: Discussion.—R. H. Barfield: C. R. Englund. (*Journ. I.E.E.*, July, 1929, Vol. 67, p. 931.)

A communication from Englund regarding points in Barfield's 1927 paper (see 1928 Abstracts, page 285). He considers the use of the optical analogy in the case of a ground wave as not justified and as liable to lead to error, and quotes Sommerfeld's warning on the point. In his reply, Barfield justifies its use as leading, in a few lines, to a solution of the problem identical with that reached by Sommerfeld after a prolonged and extremely complicated analysis; although the proof is not rigid, it gives a ready means of arriving at the exact nature of the field of a ground wave at the earth's surface, and enables one to express in a simple and (he considers) a rigidly accurate way the amount of energy absorbed from such a wave by the earth's surface. It ought to be realised that the analogy is only valid for conditions at the surface or so near that it can be reasonably assumed that the fundamental boundary conditions of electromagnetic wave theory hold good.

Ions and Electrical Currents in the Upper Atmosphere.—E. O. Hulbert. (*See* under "Atmospherics.")

Observations of the Height of the Ozone in the Upper Atmosphere.—F. W. P. Götz and G. M. B. Dobson. (*Proc. Roy. Soc.*, 2nd Sept., 1929, Vol. 125 A, pp. 292–294.)

A continuation of a previous paper (Abstracts, 1928, Vol. 5, p. 517) on measurements over Arosa. Recent improved determination of the spectrograph constant has led to the adoption of a higher value for this. This means that the heights previously published should be increased by about 18 km., bringing the average height to about 50 km. The most important result of the work is the establishment of the fact that the average height is *not* lower when there is much ozone than when there is little; if anything, the reverse would appear to be more nearly true. This contradicts most of the hypotheses which might be put forward to explain the connection between the changes in the amount of ozone and the meteorological conditions in the lower atmosphere.

Thermal Diffusion at Low Temperatures.—T. L. Ibbs, K. E. Grew, and A. A. Hirst. (*Proc. Phys. Soc.*, 15th Aug., 1929, Vol. 41, Part 5, No. 230, pp. 456–475.)

Measurements were made with one side of the apparatus at about 15° C. and the other at temperatures down to about − 190° C.

Low Frequency Sound Waves and the Upper Atmosphere.—E. H. Gowan. (*Nature*, 21st Sept., 1929, Vol. 124, pp. 452–454.)

A survey of our present knowledge. British work with the hot wire microphone is mentioned briefly, further information being indicated in Whipple's summary (Feb. Abstracts, p. 100): German work with the self-contained, portable and cheaper "undograph" is treated more fully.

The Recombination of Ions and of Ions and Electrons in Gases: The Theory of Recombination of Gaseous Ions: Recombination of Free Electrons and Positive Ions.—L. C. Marshall; L. B. Loeb and L. C. Marshall; R. Seeliger. (*Phys. Review*, 1st Aug., 1929, Vol. 34, pp. 541 and 542—Abstracts only. *Physik. Zeitschr.*, 1st June, 1929, Vol. 30, No. 11, pp. 329–357: a Survey.)

Über den Durchgang von Ionen durch verdünnte Gase (The Passage of Ions through Rarefied Gases).—H. Kallmann and B. Rosen. (*Naturwiss.*, 6th Sept., 1929, Vol. 17, pp. 709–710.)

Results from various sources on the ionisation processes resulting from electron impact, investigated by the Aston mass-spectograph, have been contradictory. By this method the separation of primary and secondary processes is attempted by means of pressure variations in the gas under investigation. The writers' investigations, made from a different view-point, lead them to conclude that no consistent results can be obtained by the former method, since the pressure changes affect not only that part of the apparatus where the ions are formed but also the part where the ions traverse the magnetic field, and here in an uncontrollable manner.

They have found that the ions in passing through this space are very strongly absorbed even at slight gas pressures, and to a different extent for different kinds of ion, so that the intensity ratio of the two sorts of ion is altered by absorption in a way which upsets any conclusions as to a secondary reaction in the ionising space. In their tests they kept the pressure constant in the ionising chamber and varied, under control, that in the magnetic field part. It was found that nitrogen atomic ions and molecular ions were differently absorbed in nitrogen, the latter more than the former; the same difference occurs for oxygen ions in oxygen, though to a less extent. On the other hand, with these same ions in neon the difference in absorption diminishes to vanishing point. These results may be explained by supposing that in a neutral gas the ions exchange their charges with the neutral molecules, but only when the ionisation potential of the ion system agrees as nearly as possible with that of the neutral gas: thus N_2+ is strongly absorbed in nitrogen and argon, O_2+ in oxygen, and $A+$ in argon; whereas $N+$ shows little absorption in nitrogen, $O+$ little in oxygen, and N_2+ and $A+$ little in neon. This exchange of charge takes place without appreciable decrease in a velocity range from 50 to 1,000 v.

TESTS OF SIGNIFICANCE IN HARMONIC ANALYSIS.—R. A. Fisher. (*Proc. Roy. Soc.*, 1st August, 1929, Vol. 125 A, pp. 54–59.)

ZUR QUANTENDYNAMIK DER WELLENFELDER (On the Quantum Dynamics of Wave Fields).—W. Heisenberg and W. Pauli. (*Zeitschr. f. Phys.*, 8th July, 1929, Vol. 56, No. 1/2, pp. 1–61.)

"In the Quantum Theory it has not yet been possible to connect together, without contradictions, mechanical and electrodynamical properties, electro- and magneto-statical interactions on the one hand and the interactions involved in radiation on the other hand. In particular it has not been possible to obtain a correct view of the finite velocity of propagation of electromagnetic action. It is the object of the present work to fill in this gap."

THE EFFECT OF A TRANSVERSE MAGNETIC FIELD ON THE PROPAGATION OF LIGHT IN VACUO.—W. H. Watson. (*Proc. Roy. Soc.*, 2nd Sept., 1929, Vol. 125 A, pp. 345–351.)

Since the photon is assumed to be electromagnetic in origin, and can produce electromagnetic effects, it is necessary to assign to it some electromagnetic character. The simplest particle properties which one can postulate are those of electric moment and magnetic moment—free electric charge being excluded by the fact that light is not deflected in a uniform electric or magnetic field. The paper deals with an investigation to detect, if possible, the existence of the magnetic moment of a photon. The result was negative; that is, the magnetic moment—if it exists—is less than 1.4×10^{-22} e.m.u.; i.e. it is less than 0.015 of a Bohr magneton. The alteration in the refractive index of vacuum produced by a magnetic field perpendicular to the direction of light propagation does not exceed 4×10^{-11} per gauss. The influence of a magnetic field component of 2,500 gauss *parallel* to the direction of propagation was also tested, with negative results. It is pointed out that the experiment proves conclusively that the Zeeman effect is determined completely by the emitting atom in the field, and that no effect (within the limits mentioned in the paper) is contributed by the propagation of the light from a region where the magnetic field is strong to a place where it is weak.

ÜBER EINE MÖGLICHE INTERPRETATION DES ELEKTROMAGNETISCHEN FELDES DES LICHTES (On a Possible Interpretation of the Electromagnetic Field of Light).—F. J. V. Wisniewski. (*Ann. der Phys.*, 12th August, 1929, Vol. 56, No. 9/10, pp. 713–716.)

By making three assumptions (the first of which is to attribute an electric moment to every light quantum) the writer converts the "wave-motion" properties of light, such as polarizability, interfering power, etc., into terms of quantum mechanics. The electromagnetic field of a source of light represents the behaviour, not of the quanta themselves, but of the electric moment of a totality of quanta.

THE INTERPRETATION OF THE BEHAVIOUR OF ALGOL, AND THE VARIABILITY OF THE VELOCITY OF LIGHT.—M. La Rosa. (*Reale Acad. Naz. dei Lincei*, 5th May, 1929.)

The behaviour of Algol and analogous stars, which Bernheimer and Salet regard as disproving the writer's application of the ballistic principle to the propagation of light, is shown actually to furnish a striking confirmation of that application.

DIE REFLEXION DES LICHTES AN EINEM BEWEGTEN SPIEGEL (The Reflection of Light at a Rotating Mirror).—J. Würschmidt. (*Zeitschr. f. Phys.*, 27th June, 1929, Vol. 55, No. 9/10, pp. 646–675.)

An investigation of the processes in the Michelson-Morley experiment, leading to the conclusion that the Lorentz contraction is a real contraction of the moving material body and that the idea of a stationary ether, as the carrier of electromagnetic phenomena, can be retained.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

LA GENÈSE DES ORAGES DE CHALEUR ET LEUR PRÉVISION À L'AIDE DES ATMOSPHÉRIQUES (The Genesis of Heat Storms, and their Prediction by the help of Atmospherics).—J. Lugeon. (*Comptes Rendus*, 26th August, 1929, Vol. 189, pp. 363–365.)

These "heat" or "convection" storms, originating in an instability of the air due to an excess of humidity and of temperature in the lower layers of the atmosphere, are frequent in Switzerland in summer. They are quite limited in extent, often being formed by one single cumulo-nimbus, and show during the afternoon. At any rate for a radius of 180 km. round Zurich, they show a very marked correlation with the curves of their atmospherics. The writer has repeatedly observed on summer days, calm to a height of 8,000 m., a very marked hump on the usual falling curve of atmospherics just before sunrise. This hump does *not* show on those days when no storm occurs, even though cumulus and strong convection may be present.

By the method of exploration previously proposed (Aug. Abstracts, p. 444) he calculates that the hump is connected with a thick layer of air, stratified and electrified, moving between heights of 4,500 and 6,000 m. It is probably a zone of temperature inversion, invisible because it contains no condensed vapour. During the formation and ascent of the cumuli, between 8^h and $11-14^h$, the atmospherics are "clicks," infrequent and weak. Suddenly, between 11 and 14^h, their curve shows a very sudden rise and their frequency changes in a few minutes from about 10 to about 100 per minute. The head of the cumulus becomes cloaked in a milky veil (false cirrus) which spreads over the sky. The atmospherics change their structure and wavelength, becoming oscillating and very strong (grinders). Lightning and rain follow one or two hours later.

Sounding balloons show that the veil of false cirrus develops exactly between the heights 4,500—6,000 m. Thus the phenomenon coincides with the moment when the condensed vapours, rising by convection and gaining (according to Simpson's theory) positive electricity, come into contact with the layer mentioned above, initially of opposite polarity. As they reach this level, the droplets are dispersed horizontally, partly neutralised. The layer forms an electric barrage opposing any further upward motion, except for a moment when it has given up all its initial charge. This moment corresponds with a sudden drop in the atmospherics curve, about 10 minutes after its big rise. Then the stratified cloud puts itself quickly at the potential of the head of cumulus which it envelops. By the Brillouin effect it becomes again charged, forming thus the plate of a gigantic condenser whose negative plate is the earth. The positive charges carried by the rain, passing through the dielectric some hundreds or thousands of metres in thickness, are not enough to discharge this condenser so long as it is being fed by the convection currents. But as soon as these cease, either on account of adiabatic reasons or by the weakening of the solar radiation, a few lightning flashes neutralise the whole condensed mass and the storm ends in a few minutes (as shown by a very sharply descending atmospherics-curve).

Thus it is hardly possible, by *ordinary* observations on atmospherics, to predict such storms more than an hour or two in advance. On the other hand, by the special exploration before sunrise they can be predicted much earlier, assuming the persistence during the day of the high electrified layer—which is the case when the weather is favourable to these local storms, with a slight barometric gradient.

DIURNAL VARIATION OF ELECTRIC POTENTIAL GRADIENT.—F. J. W. Whipple. (*Journ. Roy. Meteor. Soc.*, Vol. 55, pp. 1–13.)

COMMENT ON STOPPEL'S INVESTIGATIONS INTO LOCAL VARIATIONS OF EARTH POTENTIAL.—F. Linke. (*Zeitschr. f. Geophys.*, No. 1, 1929, Vol. 5, pp. 46–47.)

The changes which Stoppel noted in his electrometer readings are here said to be due *not* to potential variations but to variations in the insulation of his apparatus; the periodicity being probably due to the daily changes of temperature and moisture. See March Abstracts, p. 147.

TURBULENCE IN THE SUN'S ATMOSPHERE.—W. H. McCrea. (*Nature*, 21st Sept., 1929, Vol. 124, pp. 442–443.)

LIGHTNING PROTECTION IN PRACTICE AND THEORY. —(*Engineering*, 23rd Aug., 1929, Vol. 128, pp. 236–237.)

IONS AND ELECTRICAL CURRENTS IN THE UPPER ATMOSPHERE.—E. O. Hulbert. (*Science*, 30th August, 1929, Vol. 70, p. 216.)

Outline of a paper to be communicated to the American Physical Society, containing further development of the writer's ultra-violet light theory (February Abstracts, p. 101, and subsequent abstracts on pages 147, 265, 324, 503). The distribution of the ions over the earth, worked out from considerations of recombination, diffusion and drift, is found to be that required by the diamagnetic theory of the solar diurnal variation of the earth's magnetism (see Gunn, 1928 Abstracts, p. 578; also August Abstracts, p. 445).

The gravitational drift currents are found to flow mainly along the parallels of latitude thus:—(1) a current sheet flowing eastwards in the levels above 150 km., which at the sunrise and sunset longitudes divides into two sheets: (2) flowing westward on the day side of the earth underneath (1) in the levels below 150 km., and (3) continuing eastward in the upper levels around on the night side of the earth. The current is mainly between the fortieth parallels of latitude, N. and S., and falls to lower values at the higher latitudes. The total currents in the three sheets are about 10^7, 8×10^6, and 2×10^6 amperes respectively. The east and west daytime sheets (1) and (2) subtract from each other, leaving an eastward current of about 2×10^6 amperes flowing round the earth all the time, and causing a magnetic field agreeing in magnitude and type with Bauer's 1922 analysis.

As a result of the drift currents, the sunset longitude of the earth is at a potential several hundred volts above that of the sunrise longitude. This electric field combined with the earth's magnetic field causes the ions and electrons on the night side of the earth to drift upward with velocities of the order of 100 cm., per sec.; they move into regions of lower pressure and therefore do not recombine as fast as they otherwise would. This removes a difficulty from an earlier calculation, which yielded too great a night-time rate of disappearance of the free charges. The upward drift of ionisation causes a rise of the Heaviside layer which is, partially at least, compensated by the fall due to the cooling and contraction of the atmosphere at night, and is complicated by the diffusion of the ions.

"It is difficult to say how much of the night-time rise of the layer observed in experiments with wireless rays may be genuine rise and how much may be an apparent rise due to delayed group velocities, or to other causes."

PROPERTIES OF CIRCUITS.

THE FREQUENCY DEPARTURE OF THERMIONIC OSCILLATORS FROM THE "*LC*" VALUE.—S. W. C. Pack. (*E.W. & W.E.*, Sept. and Oct., 1929, Vol. 6, pp. 472–480 and 554–564.)

The preliminary sections describe the special points of the method; hitherto, in research on such oscillator frequency variation, the exact frequency departure has not been measured; the frequency has been kept constant by making small changes in the capacity of the oscillatory circuit as the conditions were varied. By the present method, L and C of the oscillatory circuit have been kept constant—as in a practical case—and the frequency differences themselves measured; the common trouble underlying the determination of small frequency differences (the "locking" tendency) being avoided by keeping the circuits electrically separated, the only connection being the brain of the observer, through the separate telephones of a double head-set.

The frequency theory, neglecting grid current, is given as developed by Gutton; a further theory of C. L. Fortescue's is also given which considers grid current. Curves of results obtained with varying conditions of coupling, filament current, anode voltage, etc., are given and are explained in the light of the theory. The "*LC*" frequency was 640 p.p.s. In most cases the variation was only about ½ cycle per sec., but in the case of adding resistance to the LC circuit there was a variation of 2 cycles per sec. In a practical case with a combination of small variations in the conditions the ½-cycle variation is probable. Various suggestions are put forward for further research on the subject.

OSCILLATION POWER OUTPUT OF A TRIODE SYSTEM AND PRINCIPLE OF ITS OPTIMUM DESIGN. PART I.—OSCILLATION POWER OUTPUT.—E. Takagishi. (*Res. Electrot. Lab. Tokyo* May, 1929, No. 257, 60 pp. and numerous plates.)

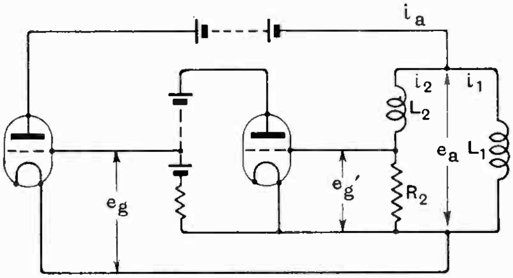
The paper begins by references to the work of Möller, D. C. Prince, Jouaust and Blanchard: so far as actual design calculations are concerned, all the results are condemned as too tedious and cumbersome or as depending on "cut-and-try" methods. The writer then sets out to develop a procedure, based on a series of experiments, to enable all the quantities concerning a triode and its associated circuits necessary for designing purposes to be obtained without elaborate calculations.

From consideration of a number of anode- and grid-current contour curves (co-ordinates E_a and E_g) reproduced from various sources including the writer's own tests, it is seen that they can all be represented approximately by a common fictitious contour curve, which in the case of the anode current curve is of a "deformed V" shape. After careful analysis of these fictitious curves, the writer obtains a similar contour curve for I_a/I_e instead of for I_a (I_e being the emission current) still keeping E_a and E_g as co-ordinates. Assuming, then, that for practical purposes it is good enough to take a single contour of one value of I_a/I_e, say 75 per cent., he obtains a simplified characteristic which he takes as the "standard characteristic" and which forms the basis of the whole theoretical calculation following. He then considers in what manner and to what degree this standard deviates from the actual characteristics. This completes the first chapter; the next begins by investigating the representation of an oscillating condition of a triode on its "standard characteristic" diagram. This leads to the classification of five different modes of oscillation, corresponding to five different wave-forms of anode current, according to the nature of the characteristic planes of the "deformed V" standard characteristic traversed by the oscillation line under consideration. It is shown how the dependable range of each kind of oscillation can be determined, together with the values of the various oscillating quantities. The present part ends with an application of the results obtained to the question of telephony and the obtaining of a linear form of modulation.

THE TRIODE VALVE EQUIVALENT NETWORK.—F. M. Colebrook. (*E.W. & W.E.*, Sept., 1929, Vol. 6, pp. 486–497.)

ÜBER SCHWINGUNGSERZEUGUNG MITTELS EINES ELEKTRONENRÖHRENSYSTEMS, BEI WELCHEM DIE KAPAZITÄT VON UNTERGEORDNETER BEDEUTUNG IST (The Production of Oscillations by a Valve Circuit in which the Capacity is of Secondary Importance).—K. Heegner & Y. Watanabe. (*Zeitschr. f. Hochf. Tech.*, Aug., 1929, Vol. 34, pp. 49–52.)

Heegner has already discussed a 2-valve circuit containing only capacity and resistance but capable of giving almost sinusoidal oscillations (Abstracts, 1927, Vol. 4, p. 573), and some of the same results



were obtained rather earlier by Roosenstein with his tetrode-multivibrator. The present article deals with such a (2-triode) circuit but with the capacity replaced by an inductance. The condition for the setting-up of oscillations is given by

$$SR_2k' > \frac{R_2}{R_i} + 1 + \frac{L_2}{L_1}$$

where k' is a measure of the amplifying power of the second valve (e_g/e'_g) and R_i is the internal resistance of the first valve; while the frequency $\omega = \sqrt{\frac{R_2R_i}{L_2L_1}}$. The latter equation holds for small amplitudes, but fails for small values of L_2, since the electrode capacities and the self-capacity of L_1 become of importance. If $L_2 = 0$ and kk' is about 1, small oscillations are still possible $\left(\frac{1}{\omega^2} = \frac{L_1L_2}{R_iR_2} + L_1C_1,\ C_1\right.$ being an equivalent small capacity parallel with $\left.L_1\right)$ but if $L_2 = 0$ and $kk' \gg 1$, a multivibrator oscillation sets in, as it did in the original capacity-and-resistance circuit when one capacity was reduced below a certain limit (but in the present case the times are influenced by the self-capacities mentioned above). It is pointed out that the case $L_2 = 0$ is represented by a dynatron circuit, in which an inductance is connected in the anode circuit and shunted by a resistance. This circuit is investigated for amplitude of oscillation.

It is mentioned that the system represented in the diagram can be replaced by one using one double-grid valve.

An Empirical Equation for Determining the d^2i_g/de_g^2 of Detectors.—Sylvan Harris. (*Proc. Inst. Rad. Eng.*, Aug., 1929, Vol. 17, pp. 1322–1325.)

Referring to Nelson's experimental method of determining the second derivative of the i_g/e_g curve (June Abstracts, p. 325) the writer points out that this method requires a knowledge of the values of the first derivative, which are usually obtained from the curve by graphical means and are subject to the same inaccuracies which the method seeks to avoid in passing to the second derivative. He considers it much more accurate, and quite simple, to obtain an empirical equation for the i_g/e_g curve: this can then be differentiated to obtain the first and second derivatives. The method of obtaining the equation is illustrated by an actual example.

Aids to the Numerical Solution of Rectification Problems.—W. A. Barclay: A. G. Warren. (*E.W. & W.E.*, Sept., 1929, Vol. 6, pp. 498–499.)

The second writer, in his paper dealt with in Oct. Abstracts, referred to Barclay's description (*ibid.*, Aug. and Sept., 1927) of his methods of approximate integration, but concluded that they are unsuitable to the type of characteristic which is most desired for rectification. In the present letter Barclay shows that on the contrary his methods can well be applied to Warren's own example, with considerable saving of labour and unimpeachable accuracy.

Reciprocal Theorem Reservations when applied to Wireless.—J. C. Schelleng. (See under "Directional Wireless.")

Aperiodische Hochfrequenztransformatoren (Aperiodic H.F. Transformers.)—H. Brykczynski. (*R., B., F. f. Alle*, September 1929, pp. 418–421.)

An article on the advantages and use of these "comparatively little-known" transformers: having a "most favoured" wave-band, they are more efficient for this band than the more strictly aperiodic choke or resistance couplings: they are particularly useful also in an input valve stage—between aerial and tuned receiver—and in this connection a particularly good (noiseless) volume control is obtained by shunting the primary with a variable resistance—or by varying the input valve filament heating. Another use is in the intermediate-frequency stages, especially for short wave reception: another, in band filters.

Theorie der elektrischen Schwingungssiebe (Theory of Oscillation Filters).—H. Schulz. (*T.F.T.*, Feb., March and June, 1929, Vol. 18, pp. 31–40, 66–74, and 179–187.)

Improvements in Electric Filters.—(French Patent 657760, Thomson-Houston, pub. 27th May, 1929.)

The use of piezoelectric oscillators in filter circuits to reduce the losses sustained in ordinary filter circuits and to improve the sharpness of cut-off.

Constantes caractéristiques des Générateurs électriques (Characteristic Constants of Electric Generators).—E. M. Galvez. (*Comptes Rendus*, 21st & 26th Aug., 1929, Vol. 189, pp. 329–331 and 360–361.)

A revision of the usual relation connecting terminal voltage V, electromotive force E, external resistance R and internal resistance Ω, namely $V = E \cdot \frac{R}{R + \Omega}$, which is not always convenient and not sufficiently general (*cf.* Chaumat, in connection with electrostatic generators, July and Aug. Abstracts, pp. 405 and 465). As a result of the writer's treatment, the voltage drop produced on closing the circuit through a resistance R is given by

$$E - V = \frac{\epsilon\rho Y}{1 + \rho R} - \frac{\epsilon\rho RY}{\rho RY + \rho + R}$$

where E is the e.m.f., V the terminal voltage, ϵ the generator e.m.f. for perfect insulation between its terminals, ρ the [working] internal resistance, and Y a constant named "charge conductance" such that the total generator current $I_g = Y(\epsilon - V)$. This is for the stable condition; the second note deals with the attainment of this stable condition.

The Definition of Selectivity.—F. M. Colebrook. (*E.W. & W.E.*, August, 1929, Vol. 6, pp. 422–424.)

The writer points out that the terms "selectivity" and "sharpness of tuning" (or "sharpness of resonance") are often used as if they were synonymous, whereas there is a distinct difference between them: the former refers to the variation of behaviour of a given circuit or network with respect to different incoming frequencies, while the latter refers to its variation of behaviour with respect to a variation of some specified element of its own, the incoming frequency being kept constant. He shows that in simple cases such as that of a series resonant circuit, assuming certain given definitions, the selectivity is approximately twice the sharpness of tuning (current resonance). In rather more complex cases the relation is less simple: examples are given. The definitions are not supposed to apply to such systems as band pass filters and similar circuit combinations; the writer considers it doubtful whether any simple numerical specification could be drawn up which would be applicable both to these and to the normal types of resonance. In an editorial (p. 411) G.W.O.H. suggests that if "sharpness of tuning" were expressed in terms of that property of the variable element which has a linear relation to the resonant frequency of the circuit, *i.e.*, $\sqrt{C}$ or $\sqrt{L}$ instead of the usual C or L, the highly undesirable 2 : 1 ratio anomaly would disappear. Colebrook replies in the September issue (p. 498) by maintaining that selectivity and sharpness of tuning are quite definite and distinct ideas, that the two-to-one relationship holding in certain simple cases is not really a "highly undesirable anomaly" but on the contrary a useful emphasis of the distinction, and that the proposed modification obtains an apparent simplification in some special cases at the expense of complicating the general definition.

General Solution for High Frequency Transformer and Oscillating Systems.—T. J. Hodgkinson. (*Electrician*, 30th August, 1929, Vol. 103, pp. 241–243.)

Diagramme zur Berechnung von Vierpolen konstanten Wellenwiderstandes (Diagrams for the Calculation of Quadripoles of Constant Impedance).—V. Gandtner and G. Wohlgemuth. (*Wiss. Veröffent. a.d. Siemens-Konz.*, No. 2, 1929, Vol. 7, pp. 67–84.)

Diagramme für die Parallelschaltung beliebiger Scheinwiderstände (Diagrams for the Connection in Parallel of a number of Virtual Resistances).—H. Rukop. (*Arch. f. Elektrot.*, No. 5, 1929, Vol. 21, pp. 443–448.)

Vierpole (Quadripoles).—W. Cauer. (*E.N.T.*, July, 1929, Vol. 6, pp. 272–282.)

The behaviour under varying frequencies of quadripoles (circuits containing self-inductance, mutual inductance, positive ohmic resistance and capacity, without any internal e.m.f., and provided with a pair of input and a pair of output terminals) is investigated; the design of quadripoles of predetermined frequency characteristics and of quadripoles equivalent to a given quadripole, for any frequencies, is examined.

Forced Electric Oscillations in Three Circuits with Electromagnetic Coupling.—W. J. Sette and R. E. Martin. (Summary in *Phys. Review*, June, 1929, Vol. 33, p. 1075.)

The Parallel Condenser in Frequency-multiplying Circuits.—Hilpert and Seydel: Kramar. (*E.T.Z.*, 8th Aug., 1929, Vol. 50, p. 1177.)

An argument on the paper dealt with in April Abstracts, p. 207.

Über die selbsterregten Schwingungen in Kreisen mit Eisenkernspulen (Self-excited Oscillations in Circuits containing Iron-cored Coils).—H. Winter-Günther. (*Zeitschr. f. Hochf. Tech.*, Aug., 1929, Vol. 34, pp. 41–49.)

Heegner, in 1924 and onwards, experimentally investigated these circuits and showed that when supplied with an external sinusoidal e.m.f. they gave, under certain conditions, subsidiary oscillations which were not necessarily equal to, or a whole multiple of, the frequency of the external e.m.f. He also arrived, by energy-considerations, at certain theoretical conclusions, particularly as to the relations between the frequencies. The present writer deals with the self-excitation of these oscillations in a different manner, based on Rayleigh's paper "On maintained vibrations." Here a string with one end connected to a tuning-fork is set into longitudinal vibration of frequency ω, and although there seems no cause for transverse vibrations, under certain conditions such vibrations are set up vigorously with a frequency $\omega/2$.

The electromagnetic analogy to this mechanical problem is provided by an oscillating circuit whose capacity or inductance is varied periodically, as would be the case for a circuit containing an iron-cored coil magnetised by an alternating current. The inductance of such a coil suffers a periodic change, of the same fundamental frequency as the a.c. if a d.c. component is present, or of double the a.c. frequency if the d.c. component is absent. The amplitudes of the fundamental and overtones of this periodic inductance-variation are functions of the effective value of the magnetising currents. Calculation leads to the differential equation obtained by Rayleigh in the mechanical case, which—as he showed—for certain values of coefficients possesses a solution representing stationary oscillations whose frequency is *half* that of the change producing them: *i.e.*, in the electrical case, half the frequency of the inductance-variation. Thus for a.c. with d.c. superposed, the self-excited oscillations have a frequency *half* that of the external e.m.f. (or a whole multiple of that half frequency) while for pure a.c. they have a frequency *equal* to that of the e.m.f.

The equations for the setting up of self-excitation are derived, and allow of calculation of the necessary tuning of the system and the magnitudes of the magnetising currents. The above is all for single circuits, but the paper ends with an extension to coupled circuits, an example of these being worked out.

Potential Difference and Electromotive Force.—E. A. Biedermann. (*E.W. & W.E.*, September, 1929, Vol. 6, pp. 481–485.)

A detailed examination of Wilmotte's proposed definitions for the above terms, in his paper "Some

Fundamental Definitions" (*ibid.*, November, 1928, Vol. 5, pp. 607–615). The writer says: "One is forced to the conclusion, therefore, that any attempt to generalise the meaning of potential difference by associating potential, as commonly understood, with the scalar potential of electromagnetic theory must fail, because it will not satisfy the second condition enunciated by Mr. Wilmotte that any definition must submit to the generally accepted meaning of the term." He considers that Wilmotte has omitted to take account of the fact that the scalar potential is a retarded potential, and by so doing has obscured the fact that other forces than electrostatic forces are derived from the scalar potential.

As an alternative, he suggests that the term P.D. shall be generalised to mean always the line integral of only that force which depends on the charge distribution, the force represented by $\sum \frac{[q]}{r^2} \cdot \frac{dr}{ds}$, which corresponds very closely to a true electrostatic force and forms a part in all circumstances of the force derived from the scalar potential. The line integral of all other forces, whether derived from the scalar or vector potential, would then define the e.m.f.; these other forces are all electromagnetic, depending directly on the distribution of currents and not of charges.

Über die Konstruktion des harmonischen Mittels (Graphic Construction for the Harmonic Mean).—H. Reppisch. (*Zeitschr. f. Hochf. Tech.*, August, 1929, Vol. 34, pp. 56–60.)

The graphic determination of the resistance of a paralleled system composed of similar, opposed and various composite resistances is illustrated by examples, the construction of the diagrams being explained geometrically. Among the examples are:—the parallel connection of positive and negative reactances; of negative reactance and ohmic resistance; of an impedance $(L + R)$ and a reactance.

TRANSMISSION.

Ein Sender für 3 m.-Wellen (A 3-Metre Wave Transmitter).—A. Pfeiffer. (*R., B., F. f. Alle*, September, 1929, pp. 421–423.)

Based on an article of Pfeiffer's in the Philips' Co. magazine. A Philips B409 is used as oscillator and a Philips B405 as modulator with 150–200 v. anode voltage. Practical details as to mounting, insulation, etc., are given.

Oscillation Power Output of a Triode System and Principle of its Optimum Design.—E. Takagishi. (*See* under "Properties of Circuits.")

RECEPTION.

The Wireless World Record III.—A. L. M. Sowerby and H. F. Smith. (*Wireless World*, 4th and 11th September, 1929, Vol. 25, pp. 212–218 and 244–248.)

"The highest H.F. stage gain yet attained." Three indirectly-heated Cosmos A.C. type valves are used, the r.f. stage giving voltage amplifications ranging from 515 at 250 m. to 433 at 600 m. (in the actual receiver these values will be less owing to the reverse reaction from the detector). The detector is an anode-bend rectifier in conjunction with a tuned circuit of the lowest attainable losses, making the use of reaction unnecessary. Owing to the exceptionally high efficiency of the indirectly-heated screen-grid valve in the r.f. stage, "a close approach to the very desirable characteristics of a receiver containing two r.f. stages has been attained while employing a single stage only." Full constructional details are given.

Recent Developments in Superheterodyne Receivers: Discussion.—G. L. Beers and W. L. Carlson: F. K. Vreeland. (*Proc. Inst. Rad. Eng.*, August, 1929, Vol 17, pp. 1454–1458.)

Referring to the paper dealt with in June Abstracts, pp. 327–328, Vreeland attacks various points in the design and performance of the apparatus described. (1) The overall frequency characteristic lacks the substantially rectangular form which characterises band selection at its best, and the effect of this is shown on the fidelity curve. He attributes this to the intermediate-frequency selectors and to the resonant radio-frequency circuits. He considers that the former could be designed to give a better band-form, and should have a bridging inductance coil instead of an inductive coupling (but in any case would require more material, space and elaboration than the corresponding r.f. band selector); while the latter should be not merely "broadly resonant circuits" but either a single band selector or sharply resonant circuits spaced in the frequency scale as suggested in his paper (1928 Abstracts, p. 286).

Beers, on the other hand, replies that the slightly rounded selectivity characteristic is necessary for a broadcast receiver: if the curve has a hollow top, the average user tunes to the peak on one side and side-band discrimination results. For fidelity and selectivity, the slightly rounded top is unimportant. The inductively coupled arrangement is just as convenient as the bridging inductance coil. The tuned r.f. circuits are used primarily to reduce undesired responses and are satisfactory for this without resorting to coupled circuits. There is a decided advantage in having the intermediate-frequency circuits determine the selectivity of a superheterodyne receiver, as by so doing the selectivity can be made very uniform throughout the broadcast range. This is not the case with a tuned r.f. band selector, as in the best receivers of this type the band width varies three to one from one end of the broadcast range to the other.

See also below.

Automatic Volume Control by R.F. or L.F. Voltage.—G. L. Beers; F. K. Vreeland. (*Proc. Inst. Rad. Eng.*, Aug., 1929, Vol. 17, pp. 1455–1458.)

Part of the above discussion. Vreeland prefers his "automatic governor" (deriving its governing e.m.f. from the audio-frequency output) to the carrier-actuated control described: the full e.m.f. applied to the loud-speaker may be employed or stepped up by a transformer, and the scope of effective governing is thus enormously increased; an applied signal strength of 100,000 μV. or more is readily handled, as against 900 μV. shown in the paper; the governor can operate directly on the anode supply of the valves, leaving the grid bias constant and avoiding the distortion which results from an excessive increase in bias. With bias control, the most faithful reproduction occurs on the weaker signals, "which are usually no good anyway." The l.f. governor keeps the output level constant regardless of the degree of modulation: the design for "quick response and slow recovery" ensures that "changes in the dynamic of music or voice are rendered with their true relative strengths." Tuning is easier, since the gain remains substantially constant for a sufficient time to tune accurately by ear without a separate indicator.

Beers replies that the objections to the arrangement described by Vreeland are so numerous as to prohibit a discussion of all of them. Regarding the points mentioned above, the carrier-actuated control is satisfactory for a field of 100,000 μV.—the curves were plotted only up to 900 μV. merely to show in more detail the shape of the curve where the control starts to take effect. Distortion by the use of high negative biases is not eliminated by varying the plate voltage instead of the bias, "as a brief study of tube characteristic curves will show."

SELBSTTÄTIGE REGELUNG VON SCHWUNDERSCHEINUNGEN BEIM KURZWELLENVERKEHR (Automatic Compensation for Fading in Short Wave Communication).— —. Thierbach. (*E.N.T.*, Aug., 1929, Vol. 6, p. 339.)

A regulating signal of constant amplitude is transmitted on a frequency close to the telephone band, its received energy being used to regulate the amplification of the telephone amplifier. Tests show that considerable improvement results, but within limits only—owing to the fading being different even on the two neighbouring wavelengths. *Cf. Wireless World*, 17th July, 1929, p. 52, Patent 298463.

LAUTSTÄRKE-REGELUNG (Volume Control).—H. Ziegler. (*R., B., F. f. Alle*, Aug., 1929, pp. 355–361.)

An article on various hand-operated volume controls, leading up to a description of an appliance invented by the writer, which is claimed to be almost completely independent of the resistance of valve, detector or pick-up and also of the frequency. It consists of a tapped iron-cored inductance connected across the primary of the l.f. input transformer. *Cf.* same writer, March Abstracts, p. 166.

THE ORIGINAL SUPERHETERODYNE PATENT.—L. Levy. (*Wireless World*, 31st July, 1929, Vol. 25, p. 105.)

A paragraph announcing that the German Patent Office has recognised the priority claims of L. Levy for the discovery of the superheterodyne principle, holding that his French patent 493660 of 1917 clearly contains the idea of an amplification of the intermediate frequency.

SOME CHARACTERISTICS OF MODERN RADIO RECEIVERS AND THEIR RELATION TO BROADCAST REGULATION.—L. M. Hull. (*Proc. Inst. Rad. Eng.*, Aug., 1929, Vol. 17, pp. 1334–1341.)

"The paper gives a brief discussion of the modern tendencies in radio broadcast receiver design, with particular regard to those characteristics of receivers which are related to the problem of allocation and regulation of broadcasting stations." Twenty American receivers ("Group A") of the 1927–1928 season are compared with twenty-four of the 1928–1929 season ("Group B"). As regards "discrimination between channels" (*i.e.* relative responses to a wanted signal and to an unwanted signal of the same field intensity in an adjacent channel, having a carrier separated by 10 kc. from the wanted signal carrier), it is considered that a conservative figure for the tolerable interference level is one thousandth of the power output provided by the wanted signal. In other words, the unwanted signal should be 30 db. below the wanted signal.

At 1,000 kc. and 30 per cent. modulation, Group A gave 5 sets with 30 or more decibels, 11 gave an average of 23 db. and 4 gave less than 20 db. Group B gave 11 with 30 or more db., and the same 4 with less than 20 db. At 600 kc. both groups behaved equally well, giving 30 or more db. Thus selectivity at the higher frequencies seems to be improving.

As regards "discrimination within a channel," a similar comparison is made between the two groups. The conclusion is that the modern tendency appears to be a progressive accentuation of the lower frequencies even at the expense of the higher frequencies within a channel. Thus Group B, on a carrier frequency of 1,000 kc., gave 5 receivers which were less than 4 db. down at 50 cycles (compared with 400 cycles) to only 1 from Group A; while all of Group B were 10 db. or more (some even more than 35 db.) down at 5,000 cycles, whereas Group A gave 10 at less than 10 db. down.

The next section deals with "uniformity of reception in all channels." "There is a steady increase in the uniformity of the response of the radio-frequency filter and amplifiers in commercial receivers over the broadcast band." The next section deals with amplitude fidelity. There is a growing disposition to improve and increase those elements of the r.f. filter-system which precede the first valve of the receiver, and to discard the practice of connecting the first valve directly to an aperiodic aerial system. The use of demodulators from which the output is proportioned to the percentage modulation of the signal over a range from zero to about 90 per cent., and in which the harmonic generation is negligible even at high modulation levels, is a step of the greatest significance. Five of Group B use "power" or "linear" detectors. Detector input levels from 2 to 10 v. are now not unusual. A particularly good set in Group B has a voltage gain from the first amplifier grid to the detector grid of about 50,000, not to obtain excessive sensitivity but to operate the detector at an input of about 3 v.

The paper ends with a section on "range of reception." The tendency even in the most elaborate receivers is to choose a sensitivity of only 20 to 50 microvolts, instead of striving for one of 5 μv.; and to apply the high-amplification features of modern valves to the provision of better reproduction, higher distortionless output levels, or to the automatic control of output. This latter point is considered very important by the writer.

A STUDY OF HETERODYNE INTERFERENCE.—J. V. L. Hogan. (*Proc. Inst. Rad. Eng.*, August, 1929, Vol. 17, pp. 1354–1364.)

The first class of heterodyne interference, in broadcast reception, is that between stations on adjacent channels. Even if one is 500 cycles too high and the other 500 cycles too low, this would not ordinarily produce a troublesome background note, since the average receiver response to 9 kc. is not much better than to the prescribed 10 kc. Therefore this type of trouble can be avoided by keeping the stations strictly within the 500 cycle limit.

The second and more important class is that produced by two or more transmitters in the same channel. Here the strict enforcement of the present regulations as to accuracy of frequency is quite useless, a total discrepancy of even 100 cycles producing distressing interference. Nothing so far suggested or likely to be suggested has been successful in curing this at the receiver end, without reducing the receiver response to musical tones of the same or similar frequencies. The transmitter organisation must therefore be looked to. The writer examines this question by considering the interfering capabilities of hypothetical stations of various powers at various distances, using the formula $E_f = \frac{5.8\sqrt{P}}{d}$ to calculate the "unabsorbed" value of the radiation which he treats as the maximum to be expected under any conditions (E_f in mv./m., P in watts, d in miles), one half of this being (according to the Bureau of Standards' results) about the average night-time signal strength. Another assumption which he uses is as follows: It is recognised that a signal of 10 mv./m. at least is required to give real and continuous freedom from noise. Since a field intensity ratio of 100 to 1 gives, with modern receivers, a discrimination of about 40 db. in the audio circuits, and since 40 db. represent about the difference between ordinary speech and a just intelligible whisper, he concludes that the average noise levels rise to values well over 1/100 of 10 mv./m., *i.e.*, 0.1 mv./m.; heterodyne interference, therefore, is only troublesome if its field is as large or larger than this. His investigation leads to the conclusion that for the broadcast band, if each channel cannot be kept "clear" for one station in the U.S.A., the solution is to require each station to maintain its carrier frequency within 25 cycles of the assigned value. "In the vast high-frequency range above 1500 kc., which is rapidly coming into more and more extensive use, we should apply carefully the principles that have been taught by our experience in broadcasting. . . . In the high-frequency spectrum, as has already been done in the broadcasting band, radiating receivers will have to be discarded."

DISTURBANCE OF BROADCAST RECEPTION BY HETERODYNE APPARATUS.—F. Vilbig. (*See under* "Miscellaneous.")

IMPRESSIONS OF THE BERLIN SHOW.—(*Wireless World*, 11th Sept., 1929, Vol. 25, pp. 239–242.)

"A wide range of screen-grid mains-driven sets but few portables." The artistic merit of the exteriors of the sets has, as a general rule, taken second place to electrical and mechanical efficiency. Little wiring is done by hand, most r.f. wiring being metal ribbon riveted on an insulating material; l.f. wiring is often cabled.

ON THE AMPLIFICATION AND DETECTION OF VERY SHORT WAVES WITH DIODES.—K. Okabe. (*Journ. I.E.E. Japan*, Suppy. Issue, Jan.–Feb., 1929, pp. 28–29.)

Summary only, in English. The diode consists of a filament and a grid-shaped anode, the diameter of the glass container being several times that of the cylindrical anode. The aerial (or Hertz resonator) is coupled to the valve by an external electrode. Weak modulated waves down to 62 cm. were well received. Apparently only with the Hertz oscillator, the magnification increased enormously for a particular value of filament current.

VARIABLE INDUCTANCE RADIO TUNERS.—T. E. Lander. (*Elec. Review*, 16th Aug., 1929, Vol. 105, pp. 266–268.)

"An account of an intriguing attempt to prove the possibility of dispensing entirely with the use of tuning condensers." The writer abandoned the idea of "elastic" inductances (coils of springy wire which could be pulled out concertina-wise) and used various mechanical methods of varying the intervals between four or five coils. He says "It has been stated that for sharp tuning, when direct aerial-coil tuning is employed, a fairly large condenser is necessary; but the fact remains that critically sharp tuning can be obtained even when all tuning condensers are dispensed with, simply by making the reaction coil of a very much larger diameter than the aerial-tuning coil."

WEITERE ARBEITEN ÜBER DIE APERIODISCHE VERSTÄRKUNG VON RUNDFUNKWELLEN (Further Work on the Aperiodic Amplification of Broadcast Waves).—M. v. Ardenne. (*R., B., F.f. Alle*, Sept., 1929, pp. 391–397.)

An article based on the author's paper referred to in Aug. Abstracts, pp. 448–449.

EIN HOCHSELEKTIVER KRISTALL - EMPFÄNGER GROSSER LAUTSTÄRKE (A Highly Selective Crystal Receiver giving Great Signal Strength).—R. Vieweg. (*R., B., F.f. Alle*, Aug., 1929, p. 384.)

An "apparently unimportant" modification of circuit is here claimed to give far better selectivity than that obtainable with any other crystal circuit, while the strength of signal (provided the apparatus is carefully designed so as to keep losses down) is enough to work a loud-speaker without any amplification. The aerial-tuning inductance leads through the crystal to earth, the crystal being shunted by a variable condenser. The telephones, shunted by a fixed condenser, are connected between aerial and earth in parallel with the first circuit.

EIN NEUER KRAFTVERSTÄRKER (A New Power Amplifier).—Telefunken Company. (*E.T.Z.*, 15th Aug., 1929, Vol. 50, p. 1190.)

An output amplifier for hotels, etc., which can be added to the ordinary loud-speaker amplifier and gives an undistorted output of 3 w.—sufficient for a number of loud-speakers (up to 8 " Arcophones "). The output valve is a Telefunken RV 218. The whole is fed from a.c. mains, two RGN 1503 rectifier valves in series being used.

AUTOMATISCHE- UND FERNBEDIENUNG VON RADIO-EMPFANGSGERÄTEN (Automatic and Distant Control of Radio Receivers).—C. Lübben. (*Funk.*, Vol. 3, 1929, p. 35: summary in *Elektrot. u. Masch:bau*, 25th Aug., 1929, p. 724.)

One of the numerous ways, complicated and simple, of distant tuning is by having an iron core in the tuning inductance and saturating this to a greater or less extent by d.c. through a control winding.

AERIALS AND AERIAL SYSTEMS.

THE ACTION OF A REFLECTING ANTENNA.—L. S. Palmer and L. L. K. Honeyball. (*Journ. I.E.E.*, August, 1929, Vol. 67, pp. 1045–1051.)

The currents produced in two tuned vertical aerials both acting as receivers in a radiation field are considered theoretically and experimentally. It is concluded :—

(1) That within one wavelength there are two critical values of the distance between two such aerials in the " end-on " position, namely, 0.33λ and 0.85λ, for which the current in the leading aerial and also the forward radiation field attain maximum values. Maximum forward radiation is incompatible with perfect reflection or zero backward radiation.

(2) For the " broadside-on " position, the best distance between the aerials, for maximum current, is 0.71λ.

(3) The values of the critical distances D for any angle β between the plane of the aerials and the direction of propagation are given approximately by the equation $\tan a\ (1 + \cos \beta) = (a^2 - 1)/a$, where $a = 2\pi D/\lambda$.

THE MUTUAL IMPEDANCE BETWEEN ADJACENT ANTENNAS.—C. R. Englund and A. B. Crawford. (*Proc. Inst. Rad. Eng.*, Aug., 1929, Vol. 17, pp. 1277–1295.)

Authors' summary :—" The simple theory for the computation of reflecting or multibranch antenna systems is sketched. If the points at which observations of electrical quantities are to be made are definitely specified, a knowledge of the self and mutual impedances (properly defined) between antennas is sufficient to make the computations determinate. Of the circuit constants, the most useful and accessible is the antenna current ratio

$$K_{12} = \frac{I_2}{I_1} = K_0 e^{i(\phi - (2\pi d/\lambda))},\ [\text{where } K_0 = /K_{12}/]$$

and in the work here reported ϕ has been measured in the range 0.33λ to 1λ. Experiment has shown that in this range ϕ is that theoretically calculable for a Hertzian doublet. Actually this range is equivalent to $\lambda/3$ to infinity. The discussion of experimental procedure is purposely thorough."

In the experimental work the wavelength used was about 4 m., and the experiments encountered more difficulties than were expected. All moving conductors, such as pedestrians and automobiles, definitely prevented readings when within some 50 metres; the system actually functioned as an automatic detective, the meter-oscillations betraying any human movement within that range. " This movement passes through a cycle every time the pedestrian has altered, by a whole wavelength, the generator-pedestrian-receiver ether path." Similarly, the operator has to remain immobile at a distance, reading through field glasses.

ENCLOSED LOOP AERIAL FOR SUBMARINES.—(French Patent 658093, Telefunken, pub. 30th May, 1929.)

The Telefunken patent for a loop enclosed in a metal tube. A summary may be found in *Rev. Gén. de l'Élec.*, 31st August, 1929, pp. 79–80D.

IMPROVING THE FRAME AERIAL.—M. v. Ardenne. (*Wireless World*, 11th September, 1929, V. 25, pp. 252–253.)

An account of experiments in shielding a frame aerial by means of a screen of parallel copper wires in which the continuity of the screening wires is broken by ebonite insulators. It is claimed that the arrangement has practically no effect on distant reception, but effectually eliminates the " aerial effect " of the frame due to lines of electric force and the consequent tendency to pick up local signals and interference regardless of the direction of the frame. *Cf.* August Abstracts, pp. 450–451.

VALVES AND THERMIONICS.

ELECTRONIC EMISSION IN A VACUUM TUBE (2).—L. Tieri and V. Ricca. (Summary in *Nature*, 31st Aug., 1929, Vol. 124, p. 359.)

Continuation of the work referred to in June Abstracts, p. 331. The pure tungsten filament of a Philips' E triode is dealt with. The inversion of δI is confirmed, I being the filament current. " The interpretation of this behaviour, and the definition of the conditions under which such inversion occurs, are to be discussed later."

UN TUBO AMPLIFICATORE A VAPORI DI MERCURIO (A Mercury Vapour Amplifier Valve).—G. Giannini. (*Nuovo Cimento*, March, 1929, Vol. 6, pp. LXX–LXXI.)

A short account of a three-electrode mercury-vapour valve, taking 7–10 A. at 20–25 V. in the arc. Its efficiency as a current amplifier is very great ;

it can also function as an oscillator. The design is improved by the addition of a cooling coil at the base of the arc close to the reservoir.

POWER VALVE OUTPUT.—F. E. Henderson. (*Wireless World*, 4th Sept., 1929, Vol. 25, pp. 219–221.)

Comparative figures for undistorted a.c. energy obtainable from typical output valves are given in the form of charts. The text of the article comments on the various factors guiding the choice of a valve.

BERECHNUNG DES GÜNSTIGSTEN DURCHGRIFFES DER RÖHREN IM WIDERSTANDVERSTÄRKER (Calculation of the Optimum "Durchgriff" —$^1/\mu$—for the Valves in a Resistance Amplifier).—H. G. Möller. (*Zeitschr. f. Hochf. Tech.*, August, 1929, Vol. 34, pp. 53–56.)

For transformer-coupled amplifiers, Schottky gave the equation $D_{opt.} = 2U_g/U_a$ where U_a was the anode voltage and U_g the value for negative grid-bias which reduced the grid current to a point where it did not appreciably load the grid circuit (about -2 v.). He assumed that the anode circuit-resistance was balanced ($R_i = R_a$) and that the valve was required to give maximum output. The mean voltage at the valve anode was of course about equal to that of the anode battery.

In resistance amplifiers, where the mean anode voltage is smaller than that of the battery, it is to be expected that $D_{opt.}$ would be greater, and that very high anode voltages would have to be used if small values of D were to be employed. But von Ardenne has found that such is not the case, and that it is surprisingly easy to obtain good amplification by the use of high resistances, small values of D, and low anode voltages. The present paper investigates these results and shows how to calculate $D_{opt.}$ for the valves of resistance amplifiers.

A curve connecting "durchgriff" D with amplification factor V (V = ratio of grid voltage amplitudes on successive valves) shows a maximum. When a series of such curves is plotted for various anode resistances, it is found that for $D_{opt.}$ the value of V is always approximately $\frac{1}{2D}$.

Equations for calculating $D_{opt.}$ are then worked out and applied to two examples, one with ordinary valves and one with Loewe multiple valves. It is then seen how von Ardenne's results came about, since for the higher anode resistances $D_{opt.}$ becomes smaller: it can be even *less than* U_g/U_a—*i.e.*, a negative control voltage is worked with, which according to the Langmuir formula and its derived amplification factor would result in zero anode current and zero amplification. This is explained by the fact that in amplifiers with such high anode resistances the currents are so small that the Langmuir formula no longer applies, being replaced by the initial current equation $i = I_s e^{\epsilon U_g/KT}$.

"KONEL" METAL FOR VALVE FILAMENTS.—(*Wireless World*, 4th Sept., 1929, Vol. 25, p. 225.)

A paragraph on the use of this metal by the Westinghouse Company of America. It is said to be saving £50,000 monthly as a substitute for platinum. "the life of a Konel filament is approximately ten times longer than that of others. Valves with the new filaments are operated 175 degrees cooler than those with platinum filament, but it is stated that the emission remains the same."

NEW SCREEN-GRID VALVE: THE MAZDA 215 S.G. BATTERY-HEATED VALVE.—(*Wireless World*, 4th Sept., 1929, Vol. 25, pp. 222–224.)

The residual grid-plate capacity was found to be less than 0.006 micromicrofarad. A test on the losses introduced by the sample (unlighted) valve into a tuned r.f. circuit showed that nearly 90 per cent. of these losses were due to the base.

RECHERCHES ET ESSAIS SUR LES LAMPES DE T.S.F. (Tests and Experiments on Wireless Valves). —A. Kiriloff. (*QST Franç.*, Sept., 1929, Vol. 10, pp. 46–52.)

Another instalment of the series referred to in Aug. Abstracts, p. 452. Valves with two, three, or four sets of electrodes (German, Polytron: French, Vatea) are briefly dealt with, and the Loewe multiple valves; valves for the simultaneous reception of several different wavelengths; the "Negatron," a tetrode whose second plate is on the opposite side of the filament; the "mirror" valve of Benno and Weber, where the second plate is in the form of a parabolic mirror: a positive potential on this mirror produces increased filament-plate current; Huth's "Platron," where the grid is replaced by a concave plate, the filament coming between anode and grid.

THE PENTODE AS AN ANODE RECTIFIER.—A. L. M. Sowerby. (*Wireless World*, 18th September, 1929, Vol. 25, pp. 252–253.)

The first part of an article describing experiments with the Mullard P.M.22 valve (2-volt pentode) when used as an anode bend rectifier. The tests show that for rectification the valve must be set so as to have an initial plate current, before signals are applied, in the neighbourhood of 20 or 30 microamps when a 220,000 ohm anode resistance is used and an anode battery voltage of 145. The maximum peak voltage that the valve can accommodate with the circuit conditions chosen is about 3 volts.

The sensitivity of the pentode as rectifier, whether for large or small inputs, is seen to increase very rapidly as the anode resistance is raised. Although this effect is present also in the case of triodes. the gain in sensitivity achieved by choosing an anode resistance of the order of megohms is very much greater with the pentode.

ELEKTRONEN-RÖHREN: 3 BAND.—EMPFÄNGER (Thermionic Valves: Vol. 3.—Receivers).—H. Barkhausen. (*Zeitschr. f. Hochf. Tech.*, August, 1929, Vol. 34, p. 80.)

A review, by Scheibe, of the newly published third and final volume of Barkhausen's book.

A SPECIAL CONNECTION FOR JOINING BULBS TO VACUUM PUMPS.—(French Patent 658233, Canello, pub. 1st, June, 1929.)

A summary, with diagram, may be found in *Rev. Gén. de l'Élec.*, 31st Aug., 1929, p. 80D.

DIRECTIONAL WIRELESS.

ÜBER FEHLWEISUNGEN BEI DER FUNKPEILUNG (On Errors in Direction-Finding by Wireless).—P. Duckert. (*Zeitschr. f. Hochf. Tech.*, August, 1929, Vol. 34, pp. 60–65.)

A comprehensive survey of the research done by various workers on the several sources of error (effects due to asymmetry or stray couplings in the apparatus, to re-radiated fields, to coastal refraction, etc.) but chiefly concerning the results of the writer in correlating certain types of error with atmospheric discontinuities (*cf.* Duckert, February and April Abstracts, pp. 106–107 and 214). Results are promised soon of a 1½ year's automatic direction-finding of sources of atmospherics, which will show that the same surfaces of discontinuity which cause the d.f. errors cause also the atmospherics. The atmospheric formations involved are not always due to weather conditions, being often the result of mountains, woods or coastal formation. Typical examples are given of errors found in Autumn, 1928, for bearings of Nordholz taken at List, on an 800 m. wave. Such indirect " coast effects " may, for certain conditions of weather, wind direction and strength, simulate direct coastal refraction. The writer points out that the very marked influence of specific humidity suggests that it is the hindering of ionic mobility, rather than the actual density of ionisation, which causes the effects. He concludes by announcing that the co-operation of three d.f. stations in investigating the various types of error has resulted in obtaining important information as to meteorological conditions; a report will shortly be published.

RADIO DIRECTION-FINDING BY TRANSMISSION AND RECEPTION (Discussion).—R. L. Smith-Rose. (*Proc. Inst. Rad. Eng.*, Aug., 1929, Vol. 17, pp. 1440–1453.)

Discussion on the paper referred to in June Abstracts, pp. 332–333. Stuart Ballantine refers to reception on a rotating coil and the fact that the surroundings, refraction at the coastline, currents on land lines, etc., destroy the simple plane wave and produce at the coil an elliptical rotating magnetic field, with the result that on rotating the coil the signal does not disappear but merely goes to a minimum. In compensating for the residual signal by an e.m.f. derived from the antenna effect of the coil (or—as on battleships—from an auxiliary aerial), the amount of compensation required for a perfect minimum varies with the azimuth.

Presumably, from the reciprocity theorem, a similar compensation would be needed on a transmitting loop. L. M. Hull replied that he believed Smith-Rose had tried varying the compensation, by varying the spacings of the various wires which were strung up around the loop, to produce an antenna effect varying with the azimuth. Ballantine rejoins that the necessary variation could probably be secured by a mechanical contrivance such as the cam system used with receiving loops.

He also mentions that with the 50 or 60 Naval coastal radio compass stations the deviations ranged from 1–10 deg., depending on the site.

Hoyt Taylor speaks at considerable length on the " night effect " (a name to which he objects because the effect occurs only too often in daytime: later on, Schelleng suggests " atmospheric error "), due to components coming down from the Heaviside layer with horizontal electric polarisation. Very long waves at great distances show very little of this error because their angle of " come down " is not far from the horizontal and the horizontally polarised components are absorbed: at short distances (100 miles or so) they show the greatest errors (*e.g.* complete rotations of 360 deg.). On the other hand, 20 megacycle waves, from a distance, nearly always arrive at relatively low angles also (10 to 20 deg. from the horizontal); they also might be expected, therefore, to give very good bearings; that this is not always the case is due to their antenna structure being a much larger fraction of a wavelength above the earth, so that horizontally polarised components can come a long distance without being completely absorbed; also this short wave horizontal polarisation is more readily reflected from the surface of the earth and water.

He does not agree with Smith-Rose as to the minimum distance for " night effects." He has found occasional variations as high as 30 deg. at a distance of less than six miles.

He then deals with the Adcock system, which he considers the best thing there is for obtaining a bearing on the vertical components alone, while inclined to lament at the idea that the receiver sensitivity will have to be increased very much. On very long waves difficulty has already been experienced in getting the necessary amplification; the Adcock system is particularly needed in the h.f. band, and the required 10 to 100-fold increase in sensitivity does not seem hopeful at the present moment, when h.f. receivers pick up motor-cars and aeroplanes at several miles' distance. He urges the need for improvement here.

Another point in the paper which he queries is the remark that there is no practical difference between bearings as obtained by continuous wave and by interrupted wave: he compares this with his own early observations, where C.W. gave much larger " night effect " errors than spark transmissions, the latter merely suffering a blurring of minimum whereas with C.W., where definite patterns could be produced with sequence of phase, the minimum was distorted. He quotes also earlier English work where the same results were obtained in comparing C.W. and I.C.W.

After a further discussion of the Adcock system, S. W. Dean discusses certain contradictions regarding wave-propagation, between Radio Research Board results and results obtained in America. He refers to Hollingworth's observations of a series of gradually diminishing maxima and minima when travelling away from a long-wave station, up to a distance of a few hundred miles, and to other results he himself has observed in England; he contrasts these with the smooth curves obtained in America (at any rate below 100 kc.) and attributes the difference to a greater conductivity in the English ground. He supports this by quoting Bailey's statement that wave-antennæ in the U.S.A. have considerably greater output than those in England, owing to the greater wave-tilt (attributed to greater earth-resistance) in the former bountry.

See also below.

ROTATING BEACON COMPARED WITH SHIP D.F. FROM NAVIGATIONAL AND ECONOMIC VIEWPOINTS.—G. R. Putnam. (*Proc. Inst. Rad. Eng.*, August, 1929, Vol. 17, pp. 1449–1452.)

Another contribution to the discussion abstracted above. The writer considers that the two systems cannot fill the same purposes, and gives a table of parallel comparison to show this. He ends: "The rotating beacon may very likely have valuable applications, either for special localities or special navigational needs; but it appears important to keep clearly in mind the requirements of radio bearings for general marine navigation, which can be met only by a truly general system."

RECIPROCITY THEOREM, THE EARTH'S MAGNETIC FIELD, AND "NIGHT EFFECT" D.F. ERRORS. —J. C. Schelleng. (*Proc. Inst. Rad. Eng.*, Aug., 1929, Vol. 7, pp. 1452–1453.)

Part of the above discussion.

Referring first to Carson's generalisation of the theorem (*Bell Tech. Journ.*, July, 1924: see also September Abstracts, p. 506) and the conditions which are not strictly satisfied in the case of transmission through an ionised upper atmosphere, the writer dismisses as negligible (for the small amplitudes used) the additional motion produced by the motion of the ions across the magnetic field of the wave itself. A real failure of reciprocity occurs, however, when the constant magnetic field of the earth is involved; and neglecting errors due to departure from the great circle path (though such departures certainly exist, at any rate for short waves) it is the effect of this field which causes deviations in apparent bearing. If the direction of this field could be reversed, the sign of the directional error would be reversed also. With the actual constant direction of the field, a loop receiver at a spot A taking a bearing of a spot B indicates a directional error the sign of which is opposite to that observed in the same way at B on A. It would appear, at least for a horizontal magnetic field, that "regardless of the disposition of the apparatus the errors are the same as long as the directions of propagation are the same," (assuming uniform conditions along the path, and a path short compared with the earth's radius). If readings in two directions could be taken closely enough together, equal errors of opposite sign would be obtained merely by reversing the direction of propagation through the same terminal apparatus, the average thus giving a bearing free from any error due to rotation of the plane of polarisation.

ACOUSTICS AND AUDIO-FREQUENCIES.

THE ABSOLUTE MEASUREMENT OF SOUND INTENSITY.—F. D. Smith. (*Proc. Phys. Soc.*, 15th Aug., 1929, Vol. 41, Part 5, No. 230, pp. 487–499.)

Author's abstract:—An absolute measurement of sound pressure is described in which the sound is received with a moving-coil receiver. The signal heard after suitable amplification is compared with the signal produced by a small known electromotive force v applied to the receiver. It is shown that when the two signals are equal in intensity the following simple relation connects the total sound pressure P on the receiver with the electromotive force v:— $P = vHl/Z_m$, where H is the strength of the magnetic field in which the moving coil, consisting of a length l of wire, moves, and Z_m is the motional impedance of the receiver at the frequency of the sound. It is shown that the phase also of the sound can be determined with the aid of a phase-shifting transformer. Since the measurement is independent of the amplifying circuit, it is possible to use a high degree of amplification and very feeble sounds may therefore be measured.

AN ELECTRO-MECHANICAL FREQUENCY ANALYZER. —L. P. Delsasso. (*Phys. Review*, 1st Aug., 1929, Vol. 34, p. 550.)

Abstract only. The complex sound is converted, by a condenser microphone and a high quality amplifier, into potential fluctuations which are impressed on the quadrants of a special electrometer. The needle of this is suspended by three fine tungsten wires, forming a sharply resonant mechanical circuit. The period is continuously variable by changing the angular separation and tension of the suspension. The amplitude and frequency of a component can thus be found. Frequency ranges of 10–200 and 100–1700 per sec. have been obtained. The work was in connection with acoustic methods of altitude measurement for aircraft.

ZUR THEORIE DER FREQUENZANALYSE MITTELS SUCHTONS (On the Theory of Frequency Analysis by means of an Exploring Note).—H. Salinger. (*E.N.T.*, Aug., 1929, Vol. 6, pp. 293–302.)

This much-used method is first described and its theory then investigated. The exploring note, of slowly changing frequency practically linear with time, is superposed on the mixture of frequencies to be analysed: the combination is passed through a filter which removes all frequencies above a certain limit (*e.g.* 30 p.p.s.) and the residual (difference) frequencies pass on to a recorder in which the paper moves so that the abscissæ represent the frequencies of the exploring tone.

The relations between the breadth of band passed by the filter and the rate of change of the exploring frequency, and the applicability of the method to noises, transients, etc., are gone into. It is shown that the method as it stands is not applicable to "irregular noises" such as speech, but an indication is given of the lines on which the apparatus could be modified for this purpose.

A MEASUREMENT OF THE SOUND PRESSURES ON AN OBSTACLE.—W. West. (*Journ.I.E.E.*, Sept., 1929, Vol. 67, pp. 1137–1142.)

Author's summary:—An investigation of the performance of a small condenser transmitter under different conditions of test is described in Part I. The results are reduced to terms of the augmentation of the sound pressures at the surface of the transmitter, considered as an obstacle in a sound field; and a comparison is made with the calculated pressures developed on a spherical obstacle. In Part II, which is of the nature of an Appendix, the accuracies of the methods of measurement are discussed.

An Electromagnetic Monochord for the Measurement of Audio Frequencies.—J. H. O. Harries. (*Proc. Inst. Rad. Eng.*, Aug., 1929, Vol. 17, pp. 1316–1321.)

As a rapid means of measuring the frequency of an audio current, or of setting a source of current to a desired frequency, an electromagnetic monochord has several advantages over an electrically maintained tuning fork or series of forks. The writer experienced difficulties with the monochord described by P. K. Turner, in which a bridge sliding along the wire adjusts the length in use, and the driving is done by a magnet between whose poles the wire (carrying the current under investigation) lies. He prefers to do without a bridge and to work on a system of harmonics. A piano wire about $\frac{1}{16}$in. in diameter and about 5 feet long will go down easily to 32 cycles and up to about 5,000 cycles in harmonics, but for convenience the writer uses this wire only up to about 261 cycles (8th harmonic) using a short length (about 16in. long and $\frac{1}{32}$in. in diameter) with a fundamental of 261 cycles—middle C philharmonic—from that point up to 5,000 cycles and probably well above this. He uses a Brown loud-speaker magnet pulling direct on the wire, instead of the arrangement mentioned above.

Die Selbstaufnahme von Schallplatten mit Hilfe des Rundfunkempfängers (Making Gramophone Records from Broadcast Reception).—O. Zache. (*R., B., F. f. Alle*, Aug., 1929, pp. 365–367.)

Based on an article in the Philips' Company's "*Radio Revue*." A crystal receiver aided by two stages of L.F. amplification is shown recording on a wax-covered record. The reproduction of the wax record in a hard material is admitted to be beyond the scope of the amateur, and is also forbidden by law; but Zache's "Phonoson" discs are coated with a special composition of wax, hard at the surface and soft beneath, the soft wax hardening when exposed to the air by the track of the needle.

Study of Noises in Electrical Apparatus.—T. Spooner and J. P. Foltz. (*Journ. Am.I.E.E.*, March, 1929, Vol. 48, pp. 199–202.)

An abridgment of a paper dealing with the analysis of the noises in electrical apparatus, gearing, etc. Circuits are given of two forms of portable analysers developed for this purpose.

"Akustik": "Speech and Hearing."—F. Trendelenburg (edited by): Harvey Fletcher. (Reviews in *Nature*, 7th Sept., 1929, Vol. 124, pp. 365–366.)

Sound Propagation in Gas Mixtures.—D. G. Bourgin. (*Phys. Review*, 1st Aug., 1929, Vol. 34, pp. 521–526.)

In *Phil. Mag*, Vol. 7, 1929, p. 821, the writer presented a theory of the propagation of sound in a single gas and mixtures of two gases (*see* July Abstracts, p. 387). The present paper extends the results on mixtures to the case of n gases and provides simpler forms for some of the earlier formulæ. It also comments from a kinetic standpoint on the rôles of viscosity and translational and internal energy conductivities.

Richtingshooren bij Sinusvormige Geluidstrillingen (Localisation by Ear of the Direction of a Pure Tone).—J. L. Van Soest. (*Physica*, July, 1929, Vol. 9, No. 7, pp. 271–282.)

Zur Theorie des Hörens (On the Theory of Hearing).—G. v. Békésy.—(*Physik. Zeitschr.*, No. 4/5, 1929, Vol. 30, pp. 115–125.)

Continuing his series of papers (*see* March Abstracts, p. 155) the writer deals here with the phenomena of fatigue.

Sur la Détermination de la Vitesse du Son, basée sur la Théorie cinétique des Gaz (The Determination of the Velocity of Sound, by a Method based on the Kinetic Theory of Gases).—S. Drzewiecki. (*Comptes Rendus*, 17th July, 1929, Vol. 189, pp. 122–125.)

By representing the static and dynamic states of a unit of a gaseous mass by a spherical surface of radius equal to the mean square of the molecular velocities, on which the Avogadro's number of molecules of mass m are uniformly distributed, the mechanism of the propagation of sound can be made clear and its velocity determined. It is suggested that this method can perhaps be applied to other forms of radiation.

PHOTOTELEGRAPHY AND TELEVISION.

Das Bildfunksystem Ranger der Radio-Corporation of America (The Ranger Picture Wireless System of the Radio Corporation).—F. Noack. (*R., B., F. f. Alle*, Sept., 1929, pp. 400–402.)

Illustrated by photographs. The transmitter is essentially similar to that of the Lorenz-Korn System, but the receiver is distinctly different, no photographic method being used. The paper strip is saturated with a sepia solution, and the picture or message is recorded—in various tones of brown—by a current of hot air (Sept. Abstracts, pp. 514–515). The control is not by varying this hot jet which is regular, but by varying a blast of cold air which opposes the heating effect of the hot jet. Apparently the cold blast is throttled down to a greater or less extent by the thread of a string galvanometer. A duplicate drum carries another paper strip, waxed in this case, and furnishes a copy which is retained at the receiving office. This copy is recorded by a hot air jet, which melts the wax. See also Aug. Abstracts, pp. 455–456, end of Zworykin discussion.

Television from 2LO. Baird Synchronising System Described. (*Wireless World*, 18th Sept., 1929, Vol. 25, p. 282.)

A short article which includes a description and illustration of Baird's method using the current which illuminates the neon tubes producing the picture. The perforated disc is driven by a small motor on the shaft of which is mounted an iron disc with narrow teeth projecting from its circumference. The neon tube currents pass through two electromagnets. When the synchronism is perfect the teeth pass the magnets during the extremely brief "dark intervals" when no current flows through the magnet coils.

VERSUCHE ZUM FERNSEHEN. I.—BAU EINES EXPERIMENTIER-GERÄTS (Experiments in Television. I.—Construction of an Experimental Apparatus).—R. Mücke. (*R., B., F. f. Alle*, Sept., 1929, pp. 385–389.)

C. F. JENKINS TELEVISION BROADCAST TRANSMISSIONS. (*Science*, 30th Aug., 1929, Vol. 70, p. XIV.)

W3XK, in Washington, is now broadcasting "radiomovies" every night (8–9 p.m., Eastern Standard Time) on greatly increased power—but not on the 1500 kw. stated, this being evidently a misprint for 1500 w. Aeroplane television broadcasts will be attempted soon, the scene being transmitted from aeroplane to station and re-transmitted with greater power.

FERNSEHEN IN AUSSICHT! (Television in Sight!)—F. Noack: v. Mihaly. (*R., B., F. f. Alle*, Aug., 1929, pp. 337–340.)

An optimistic article about the Mihaly system, a *Wireless World* article on which is referred to in Sept. Abstracts, p. 514.

NEUES BILDFUNKGERÄT VON MARCONI (A New Marconi Picture Wireless Telegraph Apparatus).—F. Noack. (*E.T.Z.*, 15th Aug., 1929, Vol. 50, pp. 1193–1194.)

An illustrated article on the Marconi-Wright Apparatus (*cf.* July Abstracts, p. 395.)

FULTOGRAPH TRANSMISSIONS.—(*R., B., F. f. Alle*, August, 1929, p. 386.)

A list of the European stations sending Fultograph transmissions.

LIGHT-SENSITIVE ELECTRIC GENERATOR.—(French Patent 657341, C^ie^ Gén. de Signalisation, pub. 21st May, 1929.)

One electrode, a disc of copper, has one surface covered with copper oxide. The second electrode rests on this oxide in such a way that it only partly screens it from the action of light—*e.g.*, the second electrode may be a spiral of bare wire. A glass disc covers this spiral and the whole is clamped together by a central bolt and nut. When light falls on the copper oxide, a p.d. is produced between the two electrodes, and varies with the intensity of the light.

ÜBER DAS PHOTOELEKTRISCHE VERHALTEN VON SALZEN (The Photoelectric Behaviour of Salts).—J. Werner. (*Zeitschr. f. Phys.*, 2nd Sept., 1929, Vol. 57, No. 3/4, pp. 192–226.)

The marked falling-off with time of the sensitivity of CdI_2, $PbCl_2$ and KNO_3 (in light from a quartz mercury vapour lamp) is due to the surface becoming impoverished of ions. This is investigated: among the results obtained, the sensitivity of CdI_2 increases to a maximum in the course of out-gassing and then decreases to zero. Dry gases will not restore it, only water vapour doing this.

SENSITIVITY AND SPECTRUM-RANGE OF PHOTO-ELECTRIC CELLS WITH SUPERPOSED SULPHUR LAYER.—(See Grondahl, under "Miscellaneous"; also *cf.* Olpin, Oct. Abstracts, p. 581.)

MEASUREMENTS AND STANDARDS.

MEASUREMENT OF EARTH CONDUCTIVITY FOR [VERY] SHORT ELECTRIC WAVES.—M. J. O. Strutt. (*See* under "Propagation of Waves.")

A PORTABLE RADIO INTENSITY-MEASURING APPARATUS FOR HIGH FREQUENCIES.—J. Hollingworth and R. Naismith. (*Journ. I.E.E.*, August, 1929, Vol. 67, pp. 1033–1044.)

The full paper, with discussion, a summary of which was dealt with in August Abstracts, p. 459.

A HIGH PRECISION STANDARD OF FREQUENCY.—W. A. Marrison. (*Proc. Inst. Rad. Eng.*, July, 1929, Vol. 17, pp. 1103–1122.)

See Sept. Abstracts, p. 518.

NEW GERMAN STANDARDS OF FREQUENCY.—(*E.T.Z.*, 29th August, 1929, Vol. 50, pp. 1276–1277.)

Part of an article on the 1928 work of the Imperial Physico-Technical Institute. The old standard frequency meter had an accuracy of $1 - 2 \times 10^{-4}$ (Thomson Oscillating Circuit). A standard fundamental frequency of 1,560 p.p.s. was obtained by a Karolus type tuning-fork, and a number of luminous quartz resonators were calibrated by harmonics of this throughout the range 10^3 to 10^7 p.p.s. The longitudinal vibrations have an accuracy of about $1 - 2 \times 10^{-5}$—ten times greater than that of the old standard. The frequency range 10^3 to 3×10^4 cannot be obtained by these vibrations, so transversely vibrating quartz resonators are used. The temperature coefficients of the luminous quartz resonators are very small, being for the transverse type about -5×10^{-6}, for the longitudinal about a fifth of this.

MAINTAINING H.F. OSCILLATIONS BY THE JOHNSEN-RAHBEK EFFECT.—F. L. Hopwood. (*See* Vincent, below, last paragraph.)

EXPERIMENTS ON MAGNETOSTRICTIVE OSCILLATORS AT RADIO FREQUENCIES.—J. H. Vincent. (*Proc. Phys. Soc.*, 15th August, 1929, Vol. 41, Part 5, No. 230, pp. 476–486.)

The full paper, a note on which was dealt with in September Abstracts, page 518, together with a subsequent discussion. Previous experiments had brought the length of the rod down to 7 mm. and the frequencies up to about 356 kc./sec. The latest tests have been with "glowray" (similar to "nichrome") bars of length 6 and 4.5 mm., placed in a coil in series with the main inductance of a simple valve-maintained oscillating circuit; the shorter bar (2.175 mm. in diameter) gave a frequency of 540 kc./sec. No magnetostrictive effects could be found until the bars had been annealed by heating to a dull red heat in lime. "Probably much higher frequencies could be obtained from thinner and shorter bars by modifying the apparatus. Experiments on the subject are in progress."

Replying to R. W. Wood, the author said that while static magnetostriction has been studied in single crystals,* he was not aware of any work having been done on dynamic magnetostriction in such crystals. Replying to C. V. Drysdale, he agreed that solid bars must presumably be less efficient than highly laminated bars having similar elastic properties, but said that the difficulty was to preserve these properties in the composite structure. The gain due to the elimination of eddy current losses by using a split tube of nickel is largely offset by the decrease in the inertia and restoring forces as compared with those in a solid bar. Replying to C. L. Fortescue, who pointed out that the forces arising from eddy currents might amount to about 5 dynes and might perhaps take part in maintaining the oscillations, he was inclined to believe that such forces would be very small compared with those due to magnetostriction: the most striking effects are provided by oscillators of metals which are known to have high coefficients of the direct static magnetostrictive or Joule effect. He has been unable to obtain any effect with brass: an effect found with commercial aluminium may very probably be due to the forces contemplated by Fortescue. He agreed with Owen that it would be preferable to connect the oscillator in the condenser branch of the oscillatory circuit instead of in the inductance branch.

During the discussion Hopwood mentioned that he had succeeded in producing high-frequency oscillations by (apparently) making use of the Johnsen-Rahbek effect.

THE EFFECT OF TENSION AND OF A LONGITUDINAL MAGNETIC FIELD ON THE THERMO-ELECTROMOTIVE FORCES IN PERMALLOY.—A. W. Smith and J. Dellinger. (*Phys. Review*, Vol. 33, 1929, pp. 398–402.)

The effect on magnetostriction is also dealt with. In permalloys rich in nickel, tension diminishes the intensity of magnetisation in weak fields but increases the magnetostrictive contraction and the variation of thermal e.m.f.

A VERY SENSITIVE QUADRANT GALVANOMETER. —W. F. G. Swann. (*Journ. Franklin Inst.*, Aug., 1929, Vol. 208, pp. 245–247.)

The higher the potential applied to the needle the higher the voltage sensitivity, but usually 100 v. is the maximum possible without instability. This instability has now been shown to be largely due to lack of planeness of the quadrants, and by careful attention to this, making the quadrants approach planeness to the order of a wavelengh of light, 750 v. can be applied to the needle and a sensitivity of 60,000 divisions per volt can be obtained with practically complete linearity over the whole scale. Ease of adjustments remains about equal to that of the ordinary Dolezalek instrument giving about 1,000 divisions per volt. The writer has planned a mirror-cum-photoelectric device to feed into the quadrant a compensating charge, to allow for the inductive action of the needle as it swings; he hopes thus to obtain a quantity-measuring sensitivity rivalling this voltage sensitivity.

* See Akulov, June Abstracts, p. 338.

A NEW ELECTROSCOPE.—B. F. J. Schonland. (*Proc. Cambridge Phil. Soc.*, July, 1929, Vol. 25, pp. 340–343.)

The electroscope "leaf" is formed by a small rectangular mirror of thin silvered mica, hung by two fine hinges of gold leaf. A practical working limit of 40 scale divisions (1 m. distant) per volt ensures a rapid and dead-beat movement: the charging voltage in this case is about 200 v. and the time of response about one-tenth of a second.

A BALLISTIC GALVANOMETER METHOD OF POTENTIOMETRIC MEASUREMENT FOR HIGH RESISTANCE CELLS.—H. T. Beans and G. H. Walden. (*Journ. Am. Chem. Soc.*, No. 10, 1928, Vol. 50, pp. 2673–2678.)

Electrical elements of internal resistance of the order of a megohm cannot have their voltage measured in the ordinary way. A ballistic method is here described.

THE USE OF THE QUADRANT ELECTROMETER AS A BALLISTIC ENERGY METER.—P. D. Morgan and S. Whitehead. (*Journ. Scient. Instr.*, Aug., 1929, Vol. 6, pp. 241–247.)

The method is described, and formulæ given by which the sensitivity as a ballistic energy meter can be calculated from the characteristics as a voltmeter. The method is applicable to d.c. or a.c. circuits, and has so far been used to record the transient energy consumed during the operation of fusible cut-outs, etc.

A PRECISE ELECTROMETER METHOD FOR VOLTAGE-TRANSFORMER TESTING.—R. S. J. Spilsbury. (*Journ. I.E.E.*, Sept., 1929, Vol. 67, pp. 1143–1146.)

RECENT PROGRESS IN MEASURING INSTRUMENTS (Extra High Voltage).—A. Imhof. (*Bull. de l'Assoc. Suisse des Élec.*, 22nd March, 1929, Vol. 20, pp. 149–159.)

DAS SELBSTGLEICHRICHTENDE RÖHRENVOLTMETER (The Self-rectifying Thermionic Voltmeter).—C. G. Suits. (*Helvet. Phys. Acta*, No. 1, 1929, Vol. 2, pp. 3–32.)

A valve voltmeter in which anode, grid and filament are all supplied from the same a.c. source (a transformer with tappings) can give a straight line calibration characteristic. The sensitivity is half as great as with d.c. The frequency of the voltage to be measured must not be too low or it will be interfered with by overtones of the a.c. Independence of frequency is obtained between 5×10^4 and 6×10^6 per sec. Errors due to harmonics in the voltage under measurement are considerably decreased by this method. The apparatus can also be used as a phase-meter, when the two frequencies are equal.

AN APPARATUS FOR THE MEASUREMENT OF MAGNETIC SUSCEPTIBILITY.—W. Sucksmith. (*Phil. Mag.*, Aug., 1929, Vol. 8, No. 49, pp. 158–165.)

A simple apparatus is described admitting of rapid measurement of magnetic susceptibilities. An accuracy of ½ per cent. is obtained on substances of moderate specific susceptibility, whilst for susceptibilities of the order of 10^{-6}, measurements can be made to 1 per cent. on half a gram of material.

ZUR MESSUNG DER MAGNETISCHEN PERMEABILITÄT VON EISENDRÄHTEN BEI HOCHFREQUENZ IN DER WHEATSTONESCHEN BRÜCKE (The Measurement of the Magnetic Permeability of Iron Wires for High Frequency, in a Wheatstone Bridge).—K. Kreielsheimer. (*Zeitschr. f. Phys.*, 5th July, 1929, Vol. 55, No. 11/12, pp. 753–770.)

EIN HOCHSPANNUNGSVOLTMETER (A High Voltage Voltmeter).—A. Nikuradse. (*Arch. f. Elektrot.*, 15th June, 1929, Vol. 22, pp. 171–176.)

A new form of electrostatic voltmeter depending on the attraction of a small circular horizontal plate, enclosed in the central aperture of a very much larger plate, by a second large disc. Movement of the small disc causes a magnified movement of a small mirror.

THE MODULOMETER: A SIMPLE DEVICE FOR MEASURING THE PERCENTAGE OF MODULATION AND GENERALLY CHECKING THE PERFORMANCE OF THE PHONE TRANSMITTER.—J. J. Lamb. (*QST*, August, 1929, Vol. 13, pp. 8–15 and 84.)

An article on the practical use of the thermionic voltmeter for measuring modulation as described by Jolliffe (August Abstracts, p. 459).

PORTABLE MODULATION-METERS.—E. Takagishi and S. Ueno. (*Electrotech. Lab., Tokyo*, February, 1929, No. 259, 61 pp.)

In Japanese. Two types of meter are investigated and compared, on the valve trigger and the valve voltmeter principles. For a constant modulation lasting for a little while, the two types give good agreement; but for a voice modulation the valve voltmeter instrument gave readings less by 20 per cent. on the average than those of the trigger type. This discrepancy, however, was practically removed by reducing the time-constant of the valve voltmeter to about one-tenth of the original; i.e., to about 0.01 sec.

A NEW RESISTANCE TESTING SET.—Evershed and Vignoles. (*Engineer*, 6th Sept., 1929, Vol. 148, pp. 260–261.)

Illustrated description of the "Bridge Meg," which by the operation of a switch will measure either insulation resistances (10,000 ohms to 100 megohms), or, by a bridge method, conductor resistances (0.01 to 999,900 ohms). It consists of an ohmmeter and 500 v. generator combined in a case with a set of resistances and the necessary switches.

UNBALANCE IN CIRCUITS.—M. Reed. (*Phil. Mag.*, Sept., 1929, Vol. 8, No. 50, pp. 341–353.)

In cases where accurate measurements have to be made, it is necessary to take into consideration the admittance to ground of various parts of the circuits under investigation. This paper considers how these admittances can influence the accuracy of a given measurement, and how it is possible to avoid such errors. It is concluded that it is desirable, where possible, to use an unbalanced measuring circuit with one side earthed. With this type of circuit it is possible to eliminate most of the errors arising from unbalances. Where it is essential to use a balanced measuring circuit, it is necessary to employ shielded and well-balanced transformers. When connecting a balanced to an unbalanced circuit, the circuits must be separated by a shielded transformer which is balanced on the side connected to the balanced circuit.

DIE MESSUNG HOCHFREQUENTER WECHSELSTRÖME MIT DREHSPULINSTRUMENTEN (The Measurement of H.F. Currents with Moving Coil Instruments).—R. Mücke. (*R. B., F. f. Alle*, August, 1929, pp. 351–354.)

Methods depending on the current/resistance curves of metal filaments.

NEW TYPE OF PRECISION FREQUENCY CHANGER FOR INSTRUMENT CALIBRATION.—E. H. Greibach. (*Elect. Journ.*, March, 1929, Vol. 26, pp. 125–126.)

The constant frequency source (e.g., a valve-maintained tuning-fork) drives a synchronous motor which turns a replaceable stroboscopic disc through reduction gearing. This disc influences a photo-electric cell and hence (through an amplifier) a neon lamp which in its turn illuminates a second stroboscopic disc driven from a synchronous motor supplied by a variable frequency supply. The frequency meter for calibration is connected across this circuit. A difference of 0.01 of the frequency is easily detected.

THE RECORDING OF CAPACITY-CHANGES. (*E.T.Z.*, 29th August, 1929, Vol. 50, p. 1277.)

Part of an article on the 1928 work of the Imperial Physico-Technical Institute. A capacity bridge circuit is illustrated, including the condenser whose variation is to be recorded, a standard condenser, 3 variable balancing condensers for obtaining the correct amplitude and phase conditions, and two fixed resistances. The indicator takes the form of a grid-rectifying valve circuit whose anode circuit contains a compensated recording d.c. galvanometer. The anode current variations are proportional to the capacity changes.

A CAPACITY MEASUREMENT METHOD.—W. van B. Roberts. (*Journ. Franklin Inst.*, May, 1928, Vol. 205, pp. 699–701.)

A "method of discontinuity" (as contrasted with null methods or methods of adjusting to a maximum or minimum of something) which gives very great precision with ease; reproducible readings can be made to less than a tenth of one micromicrofarad. The condenser X to be measured, in parallel with a calibrated variable condenser S of greater maximum capacity, is connected across an inductance of low resistance. One side of the condensers is earthed. The circuit is variably coupled to an oscillator, whose frequency is such that it tunes into the circuit when the unearthed pole of X is disconnected and S is near its maximum. Nearby there is a receiver (preferably with loud-speaker) together with its heterodyne.

By adjusting the mutual inductance M of the variable coupling, and the amount of reaction in the oscillator, a condition is reached in which, as S is increased, a point is passed where the beat note in the receiver changes discontinuously to a different pitch. If S is then decreased, the discontinuity in pitch occurs again, this time at a value of S slightly smaller than before. By careful adjustment of M these two critical values of S can be brought easily within a half of one micromicrofarad of each other. When this has been done, X is measured by noting the critical readings of S with and without X in parallel. The method is applicable also to inductances, etc.

SUBSIDIARY APPARATUS AND MATERIALS.

UN TRAVAIL EXPÉRIMENTAL RECENT SUR LA THÉORIE DE L'ACCUMULATEUR AU PLOMB (A Recent Research on the Theory of the Lead Accumulator).—Ch. Féry: A. P. Rollet. (*Rev. Gén. de l'Élec.*, 31st Aug., 1929, Vol. 26, pp. 319–323.)

Rollet's new results confirm Féry's theory of the reaction representing the charge and discharge of the lead accumulator. According to this, the action of the negative plate is given by $Pb \rightleftharpoons Pb_2SO_4$; the usual (Gladstone and Hibbert) theory being $Pb \rightleftharpoons PbSO_4$. The new results can only fit in with the latter reaction by admitting the following "rather surprising" fact—that whatever the experimental conditions may be, only one-half of the active negative material is susceptible to being used.

ÜBER HOCHOHMWIDERSTÄNDE UND EIN NEUES VERFAHREN ZU IHRER PRÜFUNG (High Ohmic Resistances, and a New Testing Process for Them).—G. Leithäuser. (*E.N.T.*, Aug., 1929, Vol. 6, pp. 335–338.)

After an introduction dealing with the first silicon-carbide high resistances and with the development of the more modern resistances consisting of thin layers of carbon, carbide or metallic oxides deposited (generally by sputtering) on an insulating core, the writer devotes himself to various practical points concerning these: the importance of large load-carrying powers—in power amplifiers they already have to stand up to ½ w. per cm.^{2}; since their temperature coefficient is generally negative, its value must be kept low not merely for constancy's sake, but because of the cumulatively increasing effect of a slight overload if the coefficient is at all large; microphonic noise—Riepka's patented method of testing, making use of the Barkhausen effect (reversal of magnetism). He then points out that the d.c. methods of testing generally employed are not really suitable or satisfactory, since the resistances are used in a.c. circuits. He has evolved, for the makers of the "Dralowid" resistances (June Abstracts, p. 342), a test process using high frequencies. A quenched-spark generator is employed, giving 50 kw. for loading 50,000 resistances up to 1 w. each.

GLASS WINDOW CATHODE RAY TUBES.—C. M. Slack. (*E.T.Z.*, 15th August, 1929, Vol. 50, p. 1211.)

A paragraph, from the Westinghouse Tech. Press Service, on the tube referred to in March Abstracts, p. 163. The window is of thin glass (less than 12.7 μ). The process of manufacture is as follows:—the glass-blower strongly heats the far end of a little bulb of thin special glass, sucks the air out quickly and so produces a hemispherical inward bulge. The bulb is then fused on to a larger tube fitted with electrodes.

WESTINGHOUSE "OSISO" OSCILLOGRAPH.—J. W. Legg. (*E.T.Z.*, 15th August, 1929, Vol. 50, pp. 1206–1207.)

Illustrated description, taken from the *Electric Journal*, Vol. 24, of this special design of loop oscillograph.

THE NEON LAMP AS A STABILISER: HOW FEED-BACK CAN BE AVOIDED IN ELIMINATORS.—S. O. Pearson. (*Wireless World*, 28th Aug. and 4th Sept., 1929, Vol. 25, pp. 200–202 and 229–230.)

"The neon lamp may thus be looked upon as a sort of trap which prevents voltage changes at either end of the circuit from getting through to the other end, besides limiting to a small figure the voltage changes across the load itself." *Cf.*, Körös, Aug. Abstracts, p. 460. In the present article one neon lamp is connected as a shunt, between eliminator and receiver, to prevent "motor-boating," etc.

RADIO BATTERY ELIMINATORS.—(*Elec. Review*, 14th June, 1929, Vol. 104, pp. 1048–1049.)

"Some notes and advice on the practical aspects of anode-circuit battery eliminators. . . ."

THE ALUMINIUM ELECTROLYTIC CONDENSER.—R. E. W. Maddison. (*Phil. Mag.*, July, 1929, Vol. 8, No. 48, pp. 29–55.)

VALVE EFFECT OF ELECTROLYTIC CELLS.—L. Dubar and R. Audubert. (*Rev. Gén. de l'Élec.*, 16th March, 1929, Vol. 25, pp. 399–403.)

Continuation of the argument electronic versus electrochemical theory, referred to in June Abstracts, p. 340.

A.C. RECTIFIERS.—A. Soulier. (*Bull. de la Soc. franç. des Élec.*, April, 1929, Vol. 9, pp. 381–387.)

A paper covering the same ground as that dealt with in June Abstracts, p. 342.

THE CASTLE SINE-WAVE ALTERNATOR.—J. H. Holmes & Co. (*Engineering*, 23rd Aug., 1929, Vol. 128, pp. 230–232.)

Primarily designed for meter testing, this plant consists of two sine-wave alternators coupled together and driven by a d.c. motor. The phase of one alternator, as compared with that of the other, can be regulated by adjusting its stator frame, which is rotatable through an arc exceeding one pole pitch.

HIGH TENSION DIRECT CURRENT GENERATORS.—(*Elec. Review*, 19th April, 1929, Vol. 104, pp. 721–722.)

Notes on the manufacture of German machines for Wireless and laboratory purposes.

GERMAN P.O. POWER PLANTS FOR WIRELESS PURPOSES.— —. Stüber. (*E.T.Z.*, 29th Aug., 1929, Vol. 50, pp. 1256–1257.)

ERSATZSCHALTUNG FÜR DIE RÜCKWIRKUNG DER ZUNGE DES RESONANZTELEPHONS (Equivalent Circuit for the Reaction of the Reed of a Tuned Telephone).—F. Bergtold. (*Zeitschr. f. Instr : kde*, No. 8, 1928, Vol. 48, pp. 400–404.)

A VARIABLE CONDENSER WITHOUT INITIAL CAPACITY.—(*E.T.Z.*, 29th Aug., 1929, Vol. 50, p. 1277.)

Part of an article on the 1928 work of the Imperial Physico-Technical Institute. The variable condenser is connected in a bridge-circuit in such a way that the plate-to-plate capacity is effective but the component to earth does not come into the measurement, or only indirectly. If now a conducting separator, connected to the earthed case, is slid between the plates, the plate-to-plate capacity is gradually reduced to zero.

SPARKING AND ARCING AT RELAY CONTACTS.—A. H. Jacquest and L. H. Harris. (*Inst. P.O. El. Eng., Paper No.* 118, 74 pp.)

The life of contacts made of various alloys is dealt with.

RELAYS FUNCTIONING AT A REQUIRED POWER FACTOR.—(British Patent 315679, G. L Porter and Ferranti Ltd., 12th April, 1928.)

The relay has two coil elements associated with a network of impedances. A rise in power factor produces an increase of current in one coil and a decrease in the other: the effects of the two coils can be made to balance at any determined value of power factor.

MAGNETIC LOSSES OF IRON IN HIGH FREQUENCY ALTERNATING CURRENT FIELDS.—J. R. Martin. (*Phys. Review*, April, 1929, Vol. 33, pp. 621–624.)

Frequencies ranged from 520 to 968 kc. The loss is found to increase with frequency in small samples and to decrease with frequency in larger samples. At any particular frequency the loss per unit volume is less the greater the area. These results are due to the magnetic shielding effects of eddy currents in the larger samples, and the disagreement between previous investigations may thus be explained.

ZUR BEURTEILUNG VON EISENKERNEN IN DER SCHWACHSTROMTECHNIK (Considerations in the Design of Iron Cores in Small-Current Apparatus).—G. Lohrmann. (*Wiss. Veroffentl. a. d. Siemens-Konz.*, No. 2, 1929, Vol. 7, pp. 163–196.)

NOUVEL ALLIAGE MAGNÉTIQUE (A New Magnetic Alloy).—Siemens and Halske Co. (*Génie Civil*, 31st Aug., 1929, Vol. 95, p. 215.)

French patent 653460 for an alloy of great permeability, containing nickel, iron and silicon, and prepared by a special process of heating.

DIE ABISOLIERUNG VON EMAILDRÄHTEN (The Cleaning of Enamel-covered Wires).—(*R., B., F. f. Alle*, August, 1929, p. 363.)

Paragraph on an article in *Funkbastler* pointing out that the usual method (heating and then rubbing with a pad soaked in alcohol) is not always satisfactory even after several repetitions. Bockelmann's method is recommended, needing no heating; a rag soaked in acetone is used.

DAS VERSILBERN VON KURZWELLENSPULEN (The Silver-Plating of Short Wave Coils.)—H. Thesing. (*R., B., F.f. Alle*, August, 1929, pp. 372–373.)

Description of a simple plant and method, employing as the source of silver the used fixing bath solution obtainable from a photographer.

PERTES DIÉLECTRIQUES: LEUR MESURE DANS LA TECHNIQUE INDUSTRIELLE (Dielectric Losses: Their Measurement in Industrial Technique).—J. Absil. (*Bull. de la Soc. belge des Élec.*, Jan. and March, 1929, Vol. 43, pp. 1–12 and 73–81.)

The writer lays stress on the advantages of determining the dielectric losses of raw materials, and even of finished articles, instead of (or in addition to) the usual high tension tests. Methods are described.

STATIONS, DESIGN AND OPERATION.

AN OUTLINE OF THE RADIO INSPECTION SERVICE.—A. Batcheller. (*Proc. Inst. Rad. Eng.*, Aug., 1929, Vol. 17, pp. 1365–1376.)

An article on the R.I.S. of the Department of Commerce. The subject matter is "historical and administrative, the latter including matters of engineering and law enforcement."

BROOKMAN'S PARK BROADCASTING STATION—"LONDON REGIONAL." (*Wireless World*, 18th Sept., 1929, pp. 288–289.)

A short illustrated outline of this station. It is mentioned that owing to limitations on the height of masts in the district, the masts have been restricted to 200 ft.

Heterodyne Interference in U.S.A. Broadcast Reception. (*See* Hogan, under "Reception.")

The Regulation of Broadcasting Stations as a Systems Problem.—E. L. Nelson. (*Proc. Inst. Rad. Eng.*, Aug., 1929, Vol. 17, p. 1342.)

Short abstract only.

Some Principles of Broadcast Frequency Allocation.—L. E. Whittemore. (*Proc. Inst. Rad. Eng.*, Aug., 1929, Vol. 17, pp. 1343–1353.)

Engineering Aspects of the Work of the Federal Radio Commission.—J. H. Dellinger. (*Proc. Inst. Rad. Eng.*, Aug., 1929, Vol. 17, pp. 1326–1333.)

United States Radio Broadcasting Development.—R. H. Marriott. (*Proc. Inst. Rad. Eng.*, Aug., 1929, Vol. 17, pp. 1395–1439.)

Author's summary :—Part I of this paper gives in detail the development of radio broadcasting in the United States from 1907 to 1928, inclusive ; Part II deals with the development of a radio broadcast from the studio to the listener. The characteristics and trends of these developments are then used for the purpose of pointing out possible future developments in radio broadcasting in Part III.

The New Berne Lists. (*Wireless World*, 4th Sept., 1929, Vol. 25, p. 224.)

A paragraph on the five volumes which now constitute the "Berne List." The contents and price of each volume are indicated.

Extension of Polish Broadcasting Organisation. (*Nature*, 28th Sept., 1929, Vol. 124, p. 493.)

The organisation is to be remodelled, following the English example, so as to provide alternative programmes for the greater part of the country. The new equipment (Marconi Company) will comprise one 120 kw. aerial input transmitter, two 16 kw., and three local relay stations working on a common wavelength with tuning fork control.

The Wave Propagation of the "Deutschland" Transmitting Station.—F. Kiebitz. (*See* under "Propagation of Waves.")

Der Deutsche Kurzwellen-Rundfunksender (The German Short Wave Broadcast Transmitter).—A. Semm. (*T.F.T.*, June, 1929, Vol. 18, pp. 187–190.)

Wireless Reigns in Turkestan.—L. Strong. (*Discovery*, Sept., 1929, Vol. 10, pp. 292–294.)

"The Russian Government is making full use of wireless in administering its Central Asiatic territory, and especially remarkable are the developments in Turkestan during the past two years. The principal broadcasting station is at Tashkent, which the writer visited."

Le Multiplex Marconi-Mathieu pour Radiosignalisation (The Marconi-Mathieu Method of Multiplex Signalling).—G. A. Mathieu. (*QST Franç.*, July, 1929, Vol. 10, pp. 15–19.)

A French version of the article referred to in September Abstracts, p. 523.

GENERAL PHYSICAL ARTICLES.

Note on the Zeeman Effect.—W. H. Watson. (*See* under "Propagation of Waves).

Two Distinct Kinds of Molecule in Hydrogen.— —. Bonhoeffer. (*Nature*, 21st Sept., 1929, Vol. 124, p. 455.)

The new mechanics predicted that two protons and two electrons could link together to form a normal hydrogen molecule in two quite different ways. Bonhoeffer has now shown that ordinary hydrogen consists of two molecular species (each with the formula H_2), has prepared at least one form in a practically pure state, and has found a number of its physical constants, which are not the same as those of ordinary hydrogen. *Cf.* McLennan and McLeod, *ibid.*, 2nd Feb., 1929, p. 160.

Über die magnetische Auslöschung der Jodfluoreszenz (The Magnetic Quenching of Iodine Fluorescence).—O. Oldenberg. (*Zeitschr. f. Phys.*, 2nd Sept., 1929, Vol. 57, No. 3/4, pp. 186–191.)

Über die Dielektrizitätskonstanten einiger Metalldämpfe (On the Dielectric Constants of some Metal Vapours).—F. Krüger and F. Maske. (*Physik. Zeitschr.*, 15th May, 1929, Vol. 30, No. 10, pp. 314–320.)

Two-dimensional Periodic Orbits in the Field of a Non-Neutral.—M. A. Higab. (*Phil. Mag.*, May, 1929, Vol. 7, No. 45, pp. 783–792.)

The motion of a charged particle in the field of an electric doublet is discussed. Earlier work (e.g., Wrinch, 1923) has limited itself to semicircular orbits for periodic paths, but Greenhill suggested the discussion of possible closed orbits : the present writer establishes the existence and studies the nature of such orbits.

Diffraction of Cathode Rays—III.—G. P. Thomson. (*Proc. Roy. Soc.*, 2nd Sept., 1929, Vol. 125 A, pp. 352–370.)

A continuation of the work referred to in 1928 Abstracts, p. 526. The paper begins by describing a technique for making metal films of the order of 10^{-6} cm. thick, approximately free from holes.

Bemerkungen zum Versuch Thomson's (Remarks on G. P. Thomson's Research).—S. C. Kar. (*Naturwiss.*, 13th September, 1929, Vol. 17, p. 727.)

Thomson and Davisson and Germer seem to have come near to proving the existence of de Broglie waves by obtaining, with retarded cathode rays, wave-trains agreeing in wavelength with those of the de Broglie theory. However fruitful Schrödinger's conception of material waves may have been, the idea of waves carrying no energy and travelling with a velocity greater than that of light is very difficult to accept. The writer suggests the following as a plausible, though incomplete, interpretation of the phenomena in question:—if, instead of Einstein's photoelectric equation (based on the energy-law), the maintenance-law of the impulse is taken, the equation obtained is

$$\frac{h\nu}{c} = \frac{m_0 v}{\sqrt{1 - \frac{v^2}{c^2}}},$$

or—as the velocity of light is in question—

$$\lambda = \frac{h\sqrt{1 - \frac{v^2}{c^2}}}{m_0 v}.$$

But this is exactly the equation encountered in Thomson's experiment, and seems to indicate that the waves are light waves. Why the one maintenance-law should be thus favoured, when both of them are valid for the Compton theory of the interaction of radiation and electrons, remains to be explained, as does the reason why the waves are deflected by external magnetic or electric fields.

ÜBER DEN GYROMAGNETISCHEN EFFEKT UND DIE MAGNETISCHE ABLENKUNG VON ATOMSTRAHLEN AUF GRUND DER NEUEN THEORIE DES MAGNETISMUS (The Gyromagnetic Effect and the Magnetic Deflection of Atomic Beams interpreted by the New—Honda's—Theory of Magnetism).—K. Honda. (*Zeitschr. f. Phys.*, 16th Aug., 1929, Vol. 56, No. 11/12, pp. 857–861.)

LONGITUDINAL MAGNETIC EFFECT ON BEAMS OF SLOW ELECTRONS (Periodic Concentrations and Dilatations).—J. Thibaud. (*Journ. de Phys. et le Rad.*, April, 1929, Vol. 10, No. 4, pp. 161–176.)

An investigation of the phenomena referred to in April Abstracts, p. 224. The interpretation of the effects, and the laws regulating them, are given. For very slow electrons (less than 200 v.) the beam in its compressed form takes on the appearance of a thread and keeps it even after passing through a field of many thousand gauss (apparent "cohesion" of electrons: magnetic moments ?). Beams of very slow electrons of about 100 v. excite great fluorescence in various substances, particularly crystals. This property disappears for voltages of 300 or more.

ÜBER DEN DURCHGANG LANGSAMER KATHODENSTRAHLEN DURCH METALLE (On the Passage of Slow Cathode Rays through Metals).—A. Becker. (*Ann. der Phys.*, 15th July, 1929, Series 5, Vol. 2, No. 3, pp. 249–263.)

ÜBER DAS MASSENVERHALTNIS VON PROTON UND ELEKTRON (On the Ratio of the Masses of Proton and Electron).—R. Fürth. (*Naturwiss.*, 30th Aug., 1929, Vol. 17, pp. 688–689.)

Calculations leading to a confirmation of the idea that this ratio μ has a theoretical connection with $z\left(= \frac{hc}{e^2}\right)$. An equation is obtained whose roots are $\mu = kz - 2$ and $\frac{1}{kz - 2}$; under certain reasonable assumptions k is found to be 32/15, so that $\mu = 1836$ (while the experimental value is 1846).

DIE ABWEICHUNGEN VON OHMSCHEN GESETZ BEI HOHEN STROMDICHTEN IM LICHTE DER SOMMERFELDSCHEN ELEKTRONENTHEORIE (Deviations from Ohm's Law at High Current Densities, in the Light of Sommerfeld's Electronic Theory).—H. Margenau. (*Zeitschr. f. Phys.*, 13th July, 1929, Vol. 56, No. 3/4, pp. 259–261.)

ZUR ELEKTRODYNAMIK DES ROTIERENDEN ELEKTRONS (On the Electrodynamics of the Spinning Electron).—I. Tamm. (*Zeitschr. f. Phys.*, 6th June, 1929, Vol. 55, No. 3/4, pp. 199–220.)

ZUR THEORIE DES LICHTES (On the Theory of Light).—F. v. Wiśniewski. (*Zeitschr. f. Phys.*, 6th June, 1929, Vol. 55, No. 3/4, pp. 221–230.)

A generalisation of the Maxwell equations is proposed, and it is shown that these generalised equations correctly represent the behaviour of light in a material medium.

ARTIFICIAL DISINTEGRATION OF ATOMS AND THEIR PACKING FRACTIONS.—H. Pettersson. (Summary in *Science Abstracts*, Sec. A., 25th May, 1929, Vol. 32, p. 441.)

ÜBER DEN BEGRIFF DER GESCHWINDIGKEIT IN DER DIRACSCHEN THEORIE DES ELEKTRONS (On the Conception of Velocity in the Dirac Theory of the Electron).—V. Fock. (*Zeitschr. f. Phys.*, 1st June, 1929, Vol. 55, No. 2, pp. 127–140.)

"To one and the same 'classical' mechanical quantity—the speed of the electron—there correspond in the Dirac theory two different quantum-mechanical quantities; these can be considered to represent the corpuscular and the wave velocities."

LES VÉRIFICATIONS RÉCENTES DE LA MÉCANIQUE ONDULATOIRE DANS LE CAS DES ELECTRONS (Recent Verifications of Undulatory Mechanics in the Case of Electrons).—M. de Broglie. (*Génie Civil*, 8th June, 1929, Vol. 94, pp. 549–551.)

A full summary of a recent lecture before the French Society of Civil Engineers. After describing the various theoretical points reached by modern workers, the lecture deals with the experimental results of Davisson and Germer, G. P. Thomson, E. Rupp, and Ponte.

LES NOUVELLES CONCEPTIONS SUR LA MATIÈRE ET LE RAYONNEMENT (The New Ideas of Matter and Radiation).—A. Boutaric. (*Génie Civil*, 25th May, 1929, Vol. 94, pp. 500–503.)

First part of a simple explanation of the new ideas and of the experimental results which have led to their formulation.

La Théorie électronique de l'Éther et l'Électromagnétisme (The Electronic Theory of the Ether, and Electromagnetism).—A. Véronnet. (*Comptes Rendus*, 3rd June, 1929, Vol. 188, pp. 1488–1490.)

A previous Note (*ibid.*, 27th May, 1929) having explained how an ether in stable equilibrium, composed of negative electrical particles (electrons or sub-electrons), would explain the propagation of light waves, the present Note extends the idea to the fundamental laws of Maxwell and Laplace. "Thus the whole of electromagnetism would be re-built and explained simply by electrons and their movements."

A Generalisation of Heaviside's Expansion Theorem.—W. O. Pennell. (*Bell Tech. Journ.*, July, 1929, Vol. 8, pp. 482–492.)

"It is thought that this extension to the expansion theorem will be of value as another way of evaluating in closed form certain operational expressions, especially those involving fractional exponents."

Sur l'Électrodynamique: Théorie classique, Développement moderne (Electrodynamics: a Modern Development of the Classical Theory).—R. Ferrier. (*Rev. Gén. d. l'Élec.*, 27th April, 4th and 11th May, 1929, Vol. 25, pp. 635–644, 677–682, and 715–721.)

Zur Physikalischen Kritik von Schrödingers Theorie der Lichtemission (The Physical Criticism of Schrödinger's Theory of the Emission of Light.) Parts I, II and III.—J. Stark. (*Ann. der Phys.*, 7th May, 1929, 5th Series, Vol. 1, No. 8, pp. 1009–1040.)

The Nucleus as Radiator.—W. M. Hicks. (*Phil. Mag.*, July, 1929, Vol. 8, No. 48, pp. 108–114.)

Gewöhnliche Materie und strahlende Energie als Verschiedene "Phasen" eines und desselben Grundstoffes (Ordinary Matter and Radiant Energy as Different "Phases" of one and the same Fundamental Material).—W. Anderson. (*Zeitschr. f. Phys.*, 12th April, 1929, Vol. 54, No. 5/6, pp. 433–444.)

Über die Grenzdichte der Materie und der Energie (On the Limiting Density of Matter and Energy).—W. Anderson. (*Zeitschr. f. Phys.*, 16th Aug., 1929, Vol. 56, No. 11/12, pp. 851–856.)

Stoner's theory on the limiting density of stars is criticised; the compressibility of electrons and protons is discussed. The levelling property of extreme pressure is pointed out: diminution of volume for the electron begins at 5.68×10^{30} dynes per sq. cm., for protons at 6.56×10^{43} dynes. At the latter pressure all differences of volume and mass between electrons and protons disappear: the opposition in the sign of their charges remains, but this plays a decreased rôle since the mass increases so that the ratio of charge to mass decreases.

A Molecular Theory of Friction.—G. A. Tomlinson. (*Phil. Mag.*, June, 1929, Vol. 7, No. 46, pp. 905–939.)

A New Conception of the Mechanism of Metallic Conduction.—H. M. Barlow. (*Phil. Mag.*, Sept., 1929, Vol. 8, No. 50, pp. 289–304.)

This theory follows on the work dealt with in August Abstracts, p. 464.

Zur Theorie des Radiometers (On the Theory of the Radiometer).—P. S. Epstein. (*Zeitschr. f. Phys.*, 27th April, 1929, Vol. 54, No. 7/8, pp. 537–563.)

Radiometer Effect of Positive Ions.—C. T. Knipp and W. S. Stein. (*Phil Mag.*, Jan., 1929, Vol. 7, pp. 70–79.)

Contrary to previous belief, a part at least of the bombardment of a beam of positive rays results in direct mechanical effect. The proportion between radiometer and mechanical effects is suggested tentatively as 1 to 3 or 4.

MISCELLANEOUS.

How Electricity Does Things.—Ll. B. Atkinson. (*Journ. I.E.E.*, Aug., 1929, Vol. 67, pp. 937–945.)

The Fifth Faraday Lecture.

Die Fernmeldetechnik im Spiegel der E.T.Z. (The Science of Telephony in the Mirror of E.T.Z.).—E. h. Feyerabend. (*E.T.Z.*, 3rd January, 1929, Vol. 50, pp. 3–5.)

A history of telephonic development (including also Wireless telegraphy) as recorded from time to time in *E.T.Z.* since that journal's birthday 50 years ago.

The Rôle of Physics in Modern Industry.—L. O. Grondahl. (*Science*, 23rd Aug., 1929, Vol. 70, pp. 175–183.)

Among some of the recent contributions of physics to industry, the writer deals with the Kodacolor process of coloured moving pictures; Pfund's goggles to protect workmen against ultra-violet and infra-red radiations, consisting of a thin sputtered layer of gold protected by glass; and the increased sensitivity and spectrum-range of photoelectric cells by the superposition of a layer of sulphur on the light-sensitive layer.

Zwanzig Jahre Arbeit am Physikalischen Weltbild (20 years' work in Physics).—M. Planck. (*Physica*, June, 1929, Vol. 9, pp. 193–222.)

A long lecture, in German, on the developments in Physical Theory in the last twenty years.

Wireless at the Leipzig Fair, 1929.—(*E.T.Z.*, 6th June, 1929, Vol. 50, p. 814.)

A short commentary on various exhibits. One tendency noted is to compress long-distance receivers into a small space: single knob adjustment and large wave-range are also to the fore. In loud-speakers, one firm tries to combine the advantages of the dynamic system with those of the electromagnetic system by means of "an elastic connection between the membrane and the radiating wall" (strahlwand). A pick-up by F. Paul (Berlin) works on the dynamic principle. The "Kondax" is a telephone receiver without coils, magnets or diaphragm: it works purely electrostatically and is extraordinarily light. Various cures for interference from power-lines, motors, etc., are shown.

Italienischer Nationalrat für funktechnische Forschungen (The Italian National Council for Radio Research).—(*E.T.Z.*, 30th May, 1929, Vol. 50, p. 791.)

A paragraph on the recent inauguration by Mussolini of this Council (of which G. Marconi is president) and on the book edited by Pession in honour of this event. This deals with the position of Radio in Italy, and contributors include Marconi, Vallauri, Pession and Montefinale, Vanni, Sacco, and Vecchiacchi.

Les radiotélégrammes "Seismo" (Radiotelegrams prefixed "Seismo").—E. Rothé. (*QST Franç.*, Sept., 1929, Vol. 10, pp. 25–31.)

The interpretation and utilisation of the earthquake warnings issued by radiotelegraphy.

Plan einer Fernsprechkabelverbindung zwischen Europa und Amerika (Plan for a Telephonic Cable Link between Europe and America).—K. W. Wagner. (*Berl. Ber.*, No. 6/7, 1929, pp. 109–121).

The possibility of such a link is discussed optimistically. It is suggested that such a cable could be used also for telegraphy (sub-audible frequency) and eventually for picture telegraphy.

Composited Telegraph and Telephone Working.—J. M. Owen and J. A. S. Martin. (*P.O. Elec. Eng. Journ.*, July, 1929, Vol. 22, pp. 89–95.)

A paper on simultaneous telegraphy (with sub-audible frequencies) and telephony, on a loaded underground circuit. It ends by quoting the proposals, recently proposed and now being reviewed by the C.C.I. conference in Berlin, for 8 requirements to be satisfied in circuits using this mode of working.

Teletype Model 14.—(*E.T.Z.*, 18th July, 1929, Vol. 50, pp. 1043–1049.)

First part of a very detailed description of this typewriter keyboard system of telegraphy (see Abstracts, 1928, Vol. 5, p. 649) which has been introduced from America to Germany and is now being tested by the German P.O. for use for public telegraph service. It gives a speed of about 7 letters per second—and is particularly simple to work and maintain.

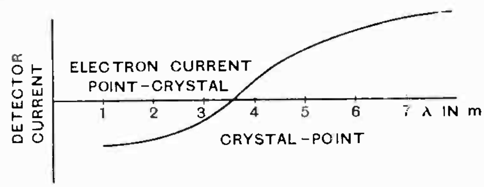
Voice-Frequency Telegraphs.—W. Cruickshank. (*Journ. I.E.E.*, July, 1929, Vol. 67, pp. 813–842.)

A discussion of the position of telegraphy in this country, compared with Germany and the U.S.A., is followed by a consideration of multiplex a.c. transmission and its limits, a description of the various systems in use, and proposals for its wider adoption in this country.

A Method of Determining the Axial Ratio of a Crystal from X-Ray Diffraction Data.—M. L. Fuller: W. P. Davey. (*Science*, 23rd Aug., 1929, Vol. 70, pp. 196–198.)

Umkehr des gleichgerichteten Detektorstromes bei sehr hohen Frequenzen (Reversal of the Rectified Crystal Detector Current at Very High Frequencies).—H. E. Hollmann. (*Naturwiss.*, 13th Sept., 1929, Vol. 17, p. 728.)

Schleede and Buggisch maintained that the electron current of any crystal detector combination, for small loads, always flowed from the metal point to the crystal; but Reissaus (July Abstracts, p. 403) showed that occasionally a microscopically sharp angle of the crystal would act as a "point" to the blunt metal point. But even this does not fully represent the facts, since the writer has shown that at very high frequencies reversals take place, even with currents so small (10^{-6} A.) that no heating effect or disturbance of the crystal structure can be likely as in the experiments of Collet and of Flowes. He has now found certain detector combinations with which, in addition to the reversal at increased energy input, a reversal takes place for a change of frequency, as is shown in the curve reproduced.



The critical wavelength, at which the detector current is zero, is here shown at 3.6 metres; but for different adjustments of the same crystal it may vary between 3 and 5 metres. The phenomenon was found with galena and various other commercial detectors, but *not* with synthetic crystals.

Über die elektrische Leitfähigkeit von natürlichen und künstlichen NaCl-Kristallen (The Electrical Conductivity of Natural and Artificial NaCl Crystals).—A. D. Goldhammer. (*Zeitschr. f Phys.*, 2nd Sept., 1929, Vol. 57, No. 3/4, pp. 173–185.)

Über Gleichstromverstärkung (The Amplification of Direct Current).—E. Rasmussen. (*Ann. der Phys.*, 15th July, 1929, Series 5, Vol. 2, No. 3, pp. 357–380.)

The writer thinks that the use of valve amplifiers in connection with ionisation and photoelectric currents has been prejudiced by the belief that they give inconstant results and are difficult to use. Here he investigates the conditions for maximum amplification and for constancy of amplifying factor, by considering the principles governing the action of such amplifiers when used for this purpose. He concludes that they are admirable for the measurement of currents from 10^{-9} to 10^{-12} A.

THE MEASUREMENT OF SMALL DISPLACEMENTS BY PHOTOELECTRIC OR THERMOELECTRIC MEANS. —G. D. Cristescu. (*Physik. Zeitschr.*, 1st Jan., 1929, Vol. 30, No. 1, pp. 24–27.)

The body whose displacement is to be measured is connected to one of two equal optical gratings one behind the other.

AUFZEICHNUNG SCHNELLER SCHWINGUNGEN (The Recording of Rapid Vibrations).—H. Thoma. (*Zeitschr. V.D.I.*, 17th Aug., 1929, Vol. 73, No. 33, p. 1155.)

Replying to a complaint by Kurrein that in a previous paper (*ibid.*, No. 19) no mention was made of the latter's work on the study of such vibrations in machine tools, Thoma points out the great difference between results by his electrical method (modified ultra-micrometer—see October Abstracts, p. 590) and those obtained with mechanical "vibrographs." He illustrates his point with curves of the vibrations in a steam turbine taken by the two methods.

RELATIVE VISIBILITY OF LUMINOUS FLASHES FROM NEON LAMPS AND FROM INCANDESCENT LAMPS WITH AND WITHOUT RED FILTERS.—F. C. Breckenridge and J. E. Nolan. (*Bur. of Stds. Journ. of Res.*, July, 1929, Vol. 3, pp. 11–25.)

Tests undertaken to decide between various conflicting reports. The conclusions are that there is no appreciable difference in any weather-conditions between the visibility of light from a neon lamp and of light of the same colour and same horizontal candle-power distribution from an incandescent lamp. Comparing a red light from an incandescent lamp with that from the unfiltered lamp, the red filter has no effect whatever in increasing the range, in fact it reduces it: but this reduction is more than made up for by the greater ease in picking-up, in cases where the background is thickly set with other lights.

PUBLIC ADDRESS RELAYS.—(*Elec. Review*, 26th April, 1929, Vol. 104, pp. 758–759.)

An account of the recent relaying of a speech from Manchester to 29 halls in other centres in the North and Midlands. Marconi-Reisz microphones and Marconi public-address amplifiers and special loud-speakers were employed.

THE DE VRY CINETONE.—(*Journ. Scient. Instr.*, Aug., 1929, Vol. 6, pp. 262–263.)

An illustrated description of a "home talking picture" apparatus now on sale in England (*cf.* July Abstracts, p. 406). The same electric motor drives the projector (which is for 16 mm. film) and the gramophone turn-table. A special mechanism guards against film-slip, which would upset synchronisation; with the same object, the backs of the records are covered with a rough material.

FERNTAGUNGEN (Conferences at a Distance).—P. Kaspareck and R. Feldkeller. (*E.T.Z.*, 4th July, 1929, Vol. 50, pp. 997–1003.)

A description (from the Siemens and Halske Laboratories) of the cable and over-head line linking of distant Conferences carried out in Germany in 1926–1929, and a discussion of the requirements of the apparatus used for such linking.

SELECTED RADIO-TELEPHONE APPARATUS: RECENT DEVELOPMENTS AND IMPROVEMENTS.—(*Elec. Review*, 9th Aug., 1929, Vol. 105, pp. 253–254.)

Among the products mentioned is a hydro-electric battery charger for trickle-charging a l.t. battery from the water main at an expenditure of 48 galls. per hour.

KINEMATOGRAPHIE AUF RUHENDEM FILM UND MIT EXTREM HOHER BILDFREQUENZ (Kinematography on Stationary Film with Extremely High Picture-frequency).—C. Cranz and H. Schardin. (*Zeitschr. f. Phys.*, 13th July, 1929, Vol. 56, No. 3/4, pp. 147–183.)

By the methods described, the interval between pictures can be regulated from one-tenth to one three-millionth of a second; in principle, there is nothing to prevent it being reduced still further. Numerous records are shown, including some of air-waves produced by detonation and therefore travelling with more than the velocity of sound.

THE RADIO ENGINEER'S RESPONSIBILITY IN COPING WITH MAN-MADE INTERFERENCE.—E. H. Felix. (*Proc. Inst. Rad. Eng.*, Aug., 1929, Vol. 17, pp. 1385–1389.)

"The radio engineer must exert his influence in electrical standardisation. Instead of viewing the electrical industry as competitive and disassociated, he must work hand in hand with the appliance, power, and traction industries. The radio engineer, through his engineering association's standards committees and through the manufacturers' standardisation groups, must clearly voice his opinions, or he will find eventually that the entire burden of eliminating the effect of electrical interference will necessarily be lodged with the radio receiver itself and the transmitting system which furnishes it with programmes—at a cost to the radio industry which I have endeavoured to indicate." Such co-operation is also needed in connection with power line voltage regulation. "Little progress has been made in this direction up to this time."

RADIO COORDINATION.—M. D. Hooven. (*Proc. Inst. Rad. Eng.*, Aug., 1929, Vol. 17, pp. 1390–1394.)

Another article on man-made interference, in which the work of the American Committee on

Inductive Coordination is referred to. Reference to its Serial Report, Aug. 1927 ("Radio Coordination") is recommended.

RUNDFUNKSTÖRUNGEN DURCH ÜBERLAGERUNGSGERÄTE (Disturbance of Broadcast Reception by Heterodyne Apparatus).—F. Vilbig. (*T.F.T.*, July, 1929, Vol. 18, pp. 217–223.)

An investigation by the German P.O. engineers into the effects of heterodyne receivers in interfering with other receivers. The conclusions are as follows:—to avoid radiating into the aerial, a preliminary valve is recommended. As a rule, however, the choice of a suitable intermediate frequency and the use of as little ohmic resistance as possible is enough to prevent trouble. The coupling condenser between the first and second circuits should also be kept small.

MINERALQUELLEN ALS URSACHE VON RUNDFUNKSTÖRUNGEN (Mineral Springs as Cause of Interference with the Reception of Broadcasting). (*R., B., F.f. Alle*, September, 1929, p. 415.)

At Wiesbaden, interference with broadcast reception occurring regularly just after sunset, and hitherto attributed to atmospherics, is now said to be due to the radio-active mineral springs under the town.

VIOLET AND ULTRA-VIOLET HOT-CATHODE TUBES. (French Patent 657936, Philips' Co., pub. 29th May, 1929.)

A special discharge tube (mercury vapour and rare gas, in glass) with auxiliary anode for starting up and an internal co-axial quartz tube for leading out the required rays.

A MACHINE TO DEMONSTRATE THE PROCESS OF MODULATING A CARRIER WAVE.—A. C. Timmis. (*P.O. Elec. Eng. Journ.*, July, 1929, Vol. 22, pp. 128–130.)

AN ACCELEROMETER UTILISING PIEZO-ELECTRICITY.—K. Yamaguchi. (*Bull. Inst. Phys. Chem. Res.*, No. 3, 1929, Vol. 8, pp. 164–179.)

In Japanese. The forces of acceleration produce piezoelectric charges which after amplification are recorded in an oscillograph.

THE ELECTRIC POLARISATION IN INSULATORS PRODUCED BY ACCELERATION.—E. Brody. (*Zeitschr. f. Phys.*, Jan., 1929, Vol. 52. No. 11/12, pp. 884–889.)

A theoretical consideration of the possible electric polarisation of a crystal, containing negative and positive ions of different masses, on being subjected to acceleration.

FRICTIONAL ELECTRICITY.—W. Kluge. L. Wolf. (*Ann. der Phys.*, 2nd and 19th January, 1929, Vol. 1, Nos. 1 and 2, pp. 1–39 and 260–288.)

In both sets of experiments the conditions were made as definite as possible so as to make the results consistent and reproducible. The first writer studies the effect of various degrees of vacuum; the second discusses his results in terms of the "solution pressure" theory.

ÉLECTROLYSE DE L'EAU EN COURANT ALTERNATIF (Electrolysis of Water by Alternating Current).—A. Canaud. (*Comptes Rendus*, 27th May, 1929, Vol. 188, pp. 1397–1398.)

SUR UN PROCÉDÉ DE PHOTOMÉTRIE PHOTOÉLECTRIQUE AVEC SOURCE DE RAYONNEMENT VARIABLE (A Photoelectric Photometry Process for Variable Sources of Radiation).—T. D. Gheorghiu. (*Comptes Rendus*, 17th June, 1929, Vol. 188, pp. 1609–1611.)

Usually, for variable sources of radiation, two photoelectric cells in opposition are employed. This involves certain difficulties (*e.g.*, "matching" the cells) and the writer has designed an arrangement avoiding these difficulties and giving results as accurate as those obtainable with a constant source. He uses two cells, each connected to a separate electrometer. The method is described and several advantages enumerated.

PROCÉDÉ D'EXPLORATION ÉLECTRIQUE DU SOL AU MOYEN DE COURANTS ALTERNATIFS À FRÉQUENCE EXTRÊMEMENT BASSE (Process of Electrical Exploration of the Soil by means of a.c. of extremely low Frequency).——. Ambroun. (*Génie Civil*, 10th August, 1929, Vol. 95, p. 144.)

The French patent (652418) deals with the use of frequencies varying from 0.3 to 10 p.p.s., the distribution of the fields being found without the use of non-polarisable electrodes. The indicating instrument may be electromagnetic, tuned to the low a.c. frequency, or of another type; before reaching the instrument, the slow a.c. component is filtered free from the d.c. component due to natural earth currents or to electrochemical action at the electrodes.

APPLIED GEOPHYSICS IN THE SEARCH FOR MINERALS.—A. S. Eve and D. A. Keys. (*Engineer*, 23rd Aug., 1929, Vol. 148, p. 201.)

A rather long review of the book recently published under this title—the "first British book on the subject."

ELECTRICAL METHODS OF PROSPECTING.—F. Vercelli. (*Accad. Lincei, Atti*, 11th Nov., 1928, Vol. 8, pp. 342–347.)

The use of armoured cable to connect generator and field instruments considerably reduces disturbance and interference, and has other advantages.

SOUNDING AND DISTANCE-MEASUREMENT BY VERY SHORT WAVE-TRAINS. (French Patent 650129, Warluzel, pub. 4th Jan., 1929.)

The echo, which on its return finds the generating wave-train completely extinguished, acts on a monotone receiver (*e.g.* tuned diaphragm). The time between signal and echo is measured by a hot-wire movement, in which the deflection of a pointer is proportional to the time during which the current is allowed to flow through the wire.

ICEBERG DETECTION.—H. T. Barnes. (*Nature*, 31st Aug., 1929, Vol. 124, p. 337.)

A cable announcing that one of the results of the Van Horne Expedition, just returned from iceberg study on the Atlantic, was the reception of very loud deep noises from an iceberg three miles away, by the submarine microphone detector. These noises (which became faint at six miles) are apparently due to the cracking under water of the iceberg, and they could readily be heard above the usual ship's noises. The succession of cracks was irregular, varying from 11 to 68 a minute. "The effect is so characteristic that we propose to extend the investigation in the hope of finding a method of iceberg detection."

ANALYSER FOR RESEARCH ON ACOUSTIC ALTITUDE MEASUREMENT FOR AIRCRAFT. — L. P. Delsasso. (*See* under "Acoustics.")

AUTOMATISCHE STEUERUNG VON AUFZÜGEN MIT HILFE VON ELEKTRONENRÖHREN (Automatic Control of Lifts by the use of Thermionic Valves).—*Elektrot. u. Masch : bau*, 14th July, 1929, Vol. 47, p. 607.)

The writer of this paragraph, on a paper by W. O. Lum, mentions that the same idea (the formation or screening of a reaction coupling of a valve circuit when the moving body reaches a certain position) has been used for switch-control on the Berlin Express Postal tube.

CLOCK SETTING BY WIRELESS AUTOMATIC SYNCHRONISATION FROM TIME SIGNALS.—(*Wireless World*, 14th Aug., 1929, Vol. 25, pp. 145–146.)

An illustrated description of the apparatus employed to make use of the clock-setting signals from Radio-Paris.

REMISE À L'HEURE DES HORLOGES ET COMMANDES À DISTANCES DIVERSES PAR LES LIGNES TÉLÉPHONIQUES (Clock-setting and Various Distant-controls by Telephone Lines).— —. Lavet. (*Bull. d.l. Soc. Franç. d. Élec.*, June, 1929, Vol. 9, pp. 639–646.)

THEORY OF THE DEION CIRCUIT BREAKER.—J. S. Slepian and others. (*Journ. Am. I.E.E.*, Feb., 1929, Vol. 48, pp. 93–104.)

The breaker here dealt with consists of a stack of copper plates separated by insulating spacers which breaks up the arc (blown by a magnetic field on to the stack) into a large number of small arcs in series: at the current zero each cathode layer is almost instantly deionised. See also June Abstracts, p. 347.

DAS SCHALTEN GROSSER LEISTUNGEN (High Power Switching).—F. Kesselring. (*E.T.Z.*, 11th July, 1929, Vol. 50, pp. 1005–1013.)

After a theoretical discussion of the problems of switching large amounts of power, the paper deals with new types of switches for this purpose, including the Deion circuit breaker referred to in June Abstracts, p. 347, and above.

STUDY OF NOISES IN ELECTRICAL APPARATUS.—T. Spooner and J. P. Foltz. (*See* under "Acoustics.")

ELECTROMAGNETIC TESTING FOR MECHANICAL FLAWS IN STEEL WIRE ROPES.—T. F. Wall. (*Journ. I.E.E.*, July, 1929, Vol. 67, pp. 899–911.)

SIGNALLING BY ULTRA-VIOLET RADIATION.—Y. Rocard. (*Rev. d'Optique*, January, 1929, Vol. 8, pp. 9–15.)

DOES NATURAL IONIZING RADIATION CONTROL RATE OF MUTATION ?—E. B. Babcock and J. L. Collins. (*Proc. Nat. Acad. Sci.*, 15th Aug., 1929, Vol. 15, pp. 623–628.)

The full paper on the researches referred to in October Abstracts, p. 589.

THE GENERATION OF ELECTRIC POWER FROM ENERGY IN UNFROZEN WATER UNDER SURFACE ICE.—H. Barjot. (*World Power*, Sept., 1929, Vol. 12, pp. 217–220.)

An illustrated expansion of Barjot's *Génie Civil* paper (April Abstracts, p. 228.)

ON THE EFFICIENT UTILISATION OF SOLAR ENERGY. —R. H. Goddard. (*Journ. Opt. Soc. Am.*, July, 1929, Vol. 19. pp. 42–46.)

After stating the conditions to be satisfied by an ideal solar engine, the writer describes his "vaporizer" (patented recently) and examines it to show how well it conforms with these conditions. An interesting feature is the extreme lightness for a given power, resulting from the small size, the possibility of using light materials, and the absence of the weight of fuel.

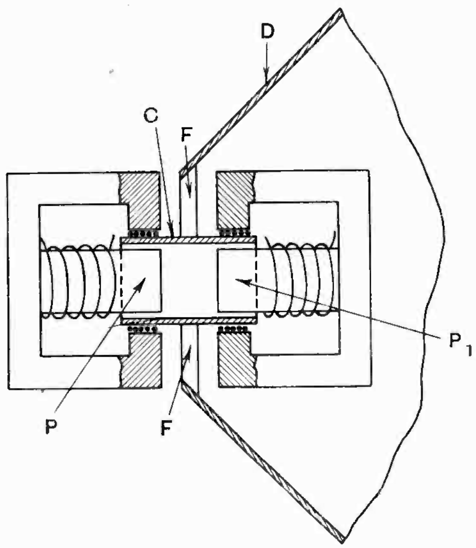
Some Recent Patents.

The following abstracts are prepared with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.

LOUD SPEAKERS.

Application date, 1st February and 22nd March, 1928. No. 312950.

The moving coil C is mounted to vibrate in the gap between two adjacent pot-magnets P, P_1.



No. 312950.

The windings on the coil are divided into two sections connected in series. The cone diaphragm D is connected to the moving-coil element by radial arms F extending outwards through the space between the adjacent magnets.

Patent issued to O. D. Lucas.

TELEVISION SYSTEMS.

Convention date (U.S.A.), 22nd June, 1927. No. 292546.

The quality of the image current sent out from a television transmitter is supervised or "monitored" at the transmitting end by tapping-off a portion of the outgoing current and diverting it back to the scanning disc used for transmission. The latter therefore serves simultaneously for re-assembling the monitoring currents and projecting them in proper sequence upon a local viewing screen. The aperture employed for monitoring is separated on the scanning disc by 90° from that used for modulating the outgoing current, so as to prevent interference.

Patent issued to Electrical Research Products, Inc.

INDIRECTLY-HEATED VALVES.

Convention date (Germany), 25th June, 1927. No. 292913.

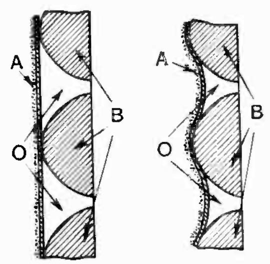
The ends of the filament are wound into open-ended coils, which are then heated by electronic bombardment from an A.C. supply and so raise the intermediate wire or filament to the required temperature by positive conduction from both ends. The rectifying action of the electronic bombardment may simultaneously be utilised, in combination with suitable filter circuits, to supply both the plate voltage and the direct current for operating subsequent stages of L.F. power amplifiers. It may also be used for energising the field magnets of a moving-coil loud-speaker.

Patent issued to S. Loewe.

ELECTROSTATIC LOUD SPEAKERS.

Convention date (Germany), 29th December, 1927. No. 303131.

The rigid conducting plate B of an electrostatic loud speaker is formed with a series of holes O, the bounding surfaces of which are parabolic in section as shown enlarged in the Figure. The vibrative membrane A consists of a rubber sheet with a thin layer of conducting material, such as carbon particles or metal foil. Owing to the shape of the curved portions of the plate B, the electrostatic field between the two surfaces remains constant over a large amplitude of vibration of the membrane A, thereby maintaining a proportional response over a wide range of input energy.



No. 303131.

Patent issued to E. Reisz.

GRAMOPHONE PICK-UPS.

Convention date (U.S.A.), 5th November, 1927. No. 300115.

The component parts of the pick-up are mounted on a base plate which lies in a plane substantially parallel with that of the gramophone record. The base plate is provided with an inclined platform to take the magnetic pole-pieces, between which the armature is placed in such a way that it can vibrate freely in a plane passing through the longitudinal axis of the base plate without the provision of end pivots or trunnions.

Patent issued to Federal Telegraph Co.

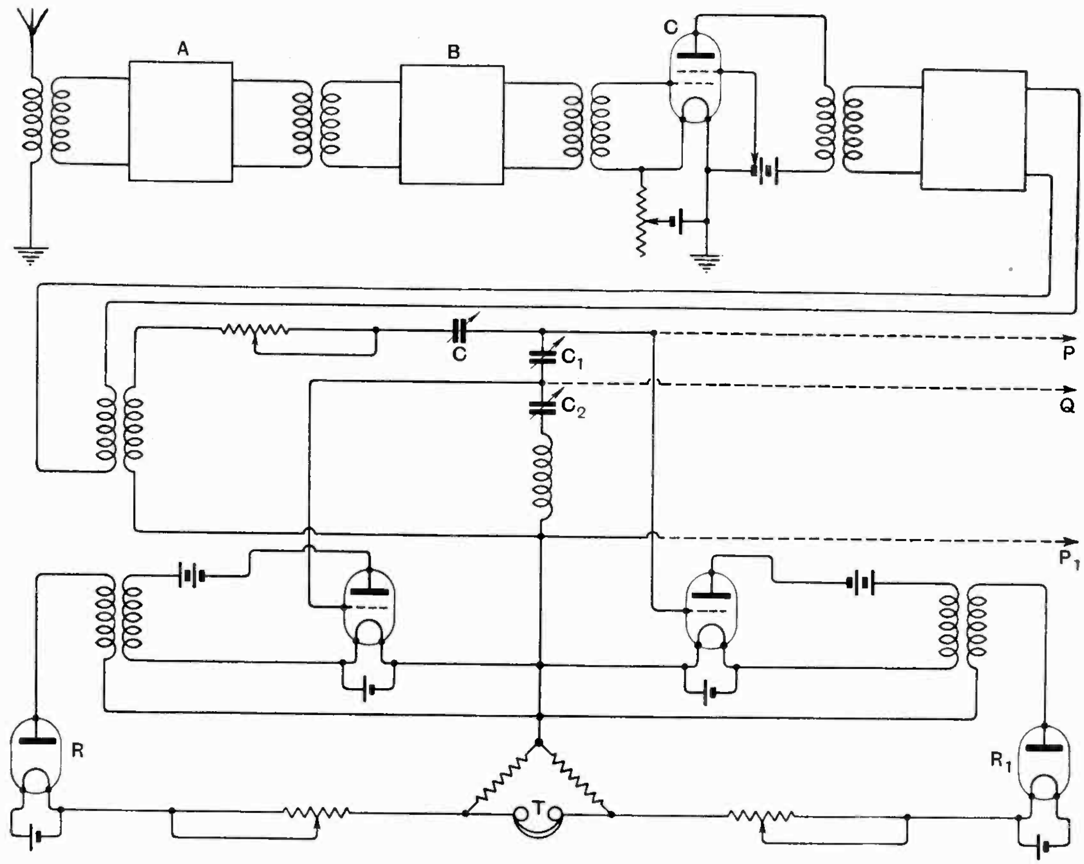
COMPENSATING FOR FADING.

Convention date (U.S.A.), 18th May, 1927. No. 290642.

Relates to means for overcoming the effect of rapid changes in the transmission efficiency of the ether as distinct from slow fading fluctuations. The signals are transmitted in the form of a frequency-modulated carrier wave. At the receiving end two branch circuits are used and are so arranged that changes in amplitude of the received signal induce substantially equal voltages, whilst changes in frequency (*i.e.*, signal currents) induce unequal voltages.

As shown the incoming signals are passed through a band filter A, are amplified at B, and passed through a limiter valve C, which removes any outstanding amplitude variations. The resulting frequency-modulated carrier is then passed to the network of impedances shown, the variable condensers C, C_1, C_2 being so adjusted that the circuit between P and P_1 is non-reactive for the highest frequency of the transmitted band, whilst the circuit between Q and P_1 is non-reactive for the lowest frequency. For intermediate (signal) frequencies the reaction (induced voltage) varies in proportion to the frequency. Any amplitude-variations will induce equal but out-of-phase voltages across P, P_1 and QP_1, which balance out across the rectifiers R, R_1 and phones T. Frequency variations across the circuits P, P_1 and QP_1, however, produce a cumulative effect in the phones, and so reproduce the original signal. Since static as well as rapid fading is usually manifested as amplitude variations, both effects are largely eliminated.

Patent issued to E. H. Armstrong.



No. 290642.

TOROID COILS.

Convention date (U.S.A.), 11th August, 1927. No. 295395.

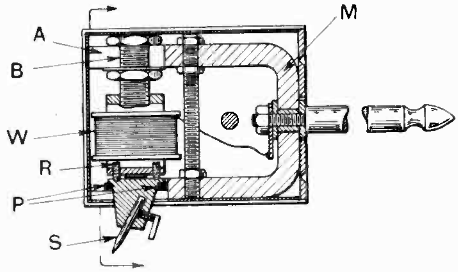
A basket coil is first wound on a former consisting of a circular series of hollow tubes of flexible material stiffened by the insertion of iron rods. As soon as a sufficient length of cylindrical basket-winding has been formed, the metal rods are withdrawn from the formers, and the whole winding is then bent around until the two ends meet. The ends are clamped in a suitable socket to form a closed toroid coil.

Patent issued to J. S. Lottrup.

GRAMOPHONE PICK-UPS.

Application date, 24th May, 1928. No. 314648.

The upper limb of the usual magnet M is slotted at A to take the screwed stem B of a U-shaped



No. 314648.

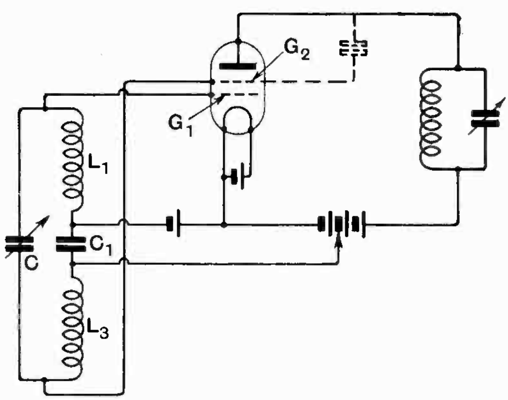
yoke carrying a pair of pole windings W. The yoke is adjustably mounted by means of the lock-nuts shown. The lower limb of the magnet M is also slotted to accommodate the armature R and the stylus holder, which together form a T-shaped piece extending under both pole-pieces. The point of the stylus is arranged to be on a vertical line passing through the axis of oscillation of the armature as a whole. A pad P of rubber or other resilient material is interposed between the lower surface of the magnet limb and the under-side of the armature as shown. By adjusting the lock-nuts holding the yoke in the upper slot A of the magnet, any desired degree of clamping between the armature and the pad P can be secured.

Patent issued to The Electramonic Co., Ltd., S. J. Tyrrell, D. W. Sayers, and L. N. Tyrrell.

STABILIZING CIRCUITS.

Application date 30th March, 1928. No. 314921.

Relates to four-electrode amplifiers comprising an inner or control grid G_1 and an outer grid G_2 carrying a positive bias. Although the presence of the grid G_2 reduces the inter-electrode capacity



No. 314921.

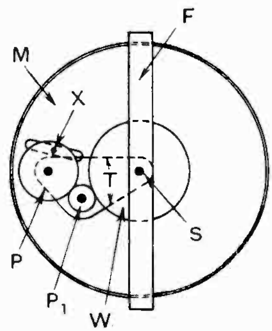
coupling between the plate and the control grid G_1, there is a residual capacity effect, which, according to the invention, is eliminated by applying a compensating voltage to the grid G_2 by means of a coil L_3 in series with the input coil L_1. The two coils are separated by a blocking condenser C_1, the tuning condenser C being shunted across both coils.

Patent issued to E. C. R. Marks.

DIRECTION FINDING.

Application date, 7th July, 1928. No. 315990.

Quadrantal error, arising from the presence of conducting bodies in close proximity to a directional receiving aerial, is automatically compensated by means of a moving scale actuated by gearing from the aerial shaft. Fixed to the shaft S of the frame aerial F is a triangular bracket T carrying pinions P, P_1, the latter meshing with a gear-wheel W fixed rigidly to the framework of the apparatus. A pin X adjustable radially on the pinion P engages with a slot formed in the calibrated scale-disc M. As the frame aerial is rotated into alignment



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with a given station, the eccentric action of the pin X in the slot imparts an independent forward or backward rotation to the disc M sufficient to compensate automatically for the degree of quadrantal error involved.

Patent issued to Radio-Communication Co., Ltd., and F. P. Best.

DRY-CONTACT RECTIFIERS.

Convention date (Germany), 27th January, 1928. No. 304748.

An electrode for contact rectifiers in which the rectifying action depends upon the presence of a sulphur, selenium, or tellurium compound of copper is made by inserting in a high-powered press a layer of pulverised copper, followed by a layer of cupric sulphide in the proportions of two to one. The mass is subjected to a pressure of several thousand kilogrammes per square centimetre. When it coheres a counter-electrode of aluminium or magnesium is applied, under a lesser pressure, to complete the rectifying unit.

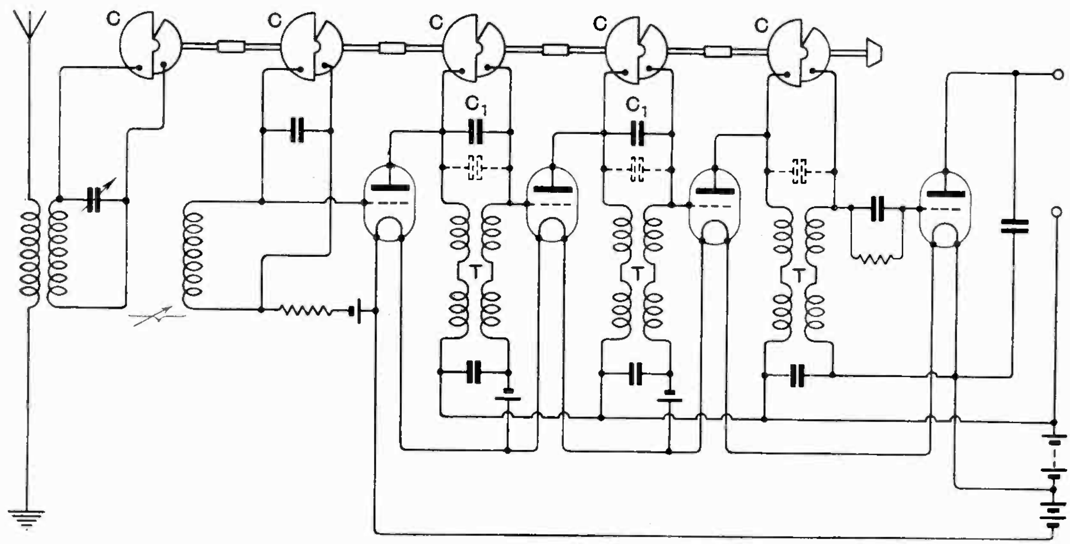
Patent issued to Siemens Schuckertwerke A.G.

SELECTIVE "BAND" AMPLIFIER.

Application date, 3rd *January*, 1928. *No.* 314884.

The input circuit and intervalve couplings are designed to accept and amplify a band of frequencies corresponding to the carrier-wave and modulation side-bands of a Broadcast programme. The response is uniform over a definite narrow band of frequencies, all frequencies lying above and below this band being substantially rejected. This ensures high selectivity without any distortion due to the loss of the essential side-band components. Preferably the central or "peak" frequency of each stage or amplification differs slightly from stage to stage, the respective outputs being combined to ensure a uniform overall amplification within the desired limits. The necessary tuning-characteristics of the coupling-transformers *T* may be ensured by varying the number of turns in the primary and secondary windings, or by varying the inherent capacity between the windings. Additional reactances such as the condensers *C* may also be added at each stage. Tuning up and down the frequency scale is effected by means of condensers *C* ganged together on a common control spindle.

Patent issued to E. C. R. Marks.

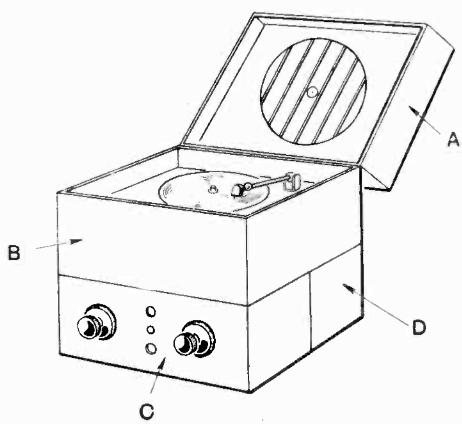


No. 314884.

COMBINATION SETS.

Application date, 11*th June*, 1928. *No.* 314660.

A compact portable installation, designed for Broadcast reception or for amplified gramophone reproduction, comprises a mains-eliminator unit and an electric driving-motor for the gramophone disc, the necessary electrical connections being automatically made as the unit is assembled. As shown diagrammatically, a cone loud-speaker is housed in the lid *A*, the output leads passing through the hinges. The gramophone and driving motor are housed in a unit *B* which is fitted by plug-and-socket connections to a two-part base, the front portion *C* of which forms the radio receiver and amplifier, and the rear part *D* a mains eliminator unit. The connections are made through plug-and-socket fastenings holding the whole assembly together.



No. 314660.

Patent issued to British Thomson-Houston Co., Ltd., A. P. Young and J. H. Butcher.