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Editorials.

Some Fundamental Definitions.

IN the March and April numbers we discussed certain difficulties which arise in defining Potential Difference and Electromotive Force in alternating current circuits. In the present number we publish a paper by Mr. Wilmotte dealing with the same subject from a slightly different point of view. It is satisfactory to note that Mr. Wilmotte's conclusions agree almost entirely with our own ; even in the few questions of detail where there is an apparent disagreement, with one exception, this is due to misunderstanding. We commend a careful perusal of Mr. Wilmotte's article to all those of our readers who desire to obtain clear conceptions on these fundamental terms of electrical science. In discussing his Fig. 3, Mr. Wilmotte says: "The reader will have noticed that the conduction current was said to be *practically* the same in all parts. If it were absolutely the same, as stated by Professor Howe, no charge could accumulate in the wire."

What we actually said was "the current is necessarily the same at every part of the ring *once the steady state has been established*" (see page 177). Surely this infers that the current is not the same at every part while the charges are accumulating. In discussing this same problem, Mr. Wilmotte says: "I do not understand Professor Howe's simple expression for the value of the potential difference."

Here we have to confess that the simple expression was wrong. The electromotive forces induced in the two halves of the ring, at the moment when the pole passed through the plane of the coil would not be proportional to the angles subtended as we assumed, in our simple numerical example, but, as Mr. Wilmotte says, they could be obtained by a more or less laborious analysis. Mr. Wilmotte's statement that "in connecting a voltmeter along wires *POQ* to find the potential difference between the points *P* and *Q*, Professor Howe is neglecting the *E.M.F.* induced by the current in the circle of wire *A*" would be a relevant criticism if the current in the ring were changing; we simplified the problem by assuming that the current had reached a steady state.

There is only one portion of Mr. Wilmotte's paper with which we do not entirely agree, and that is his arbitrary division of a circuit into several parts in dealing with self and mutual inductance. He rather disarms criticism by saying that "it is not intended to consider whether this is practically possible or not."

We should prefer to keep to things which are practically possible or, at least, conceivable.

What is Straight-line Amplification?

THIS question was recently asked and answered on the front page of a leading daily paper in connection with an advertisement for a well-known make of gramophone. The meaning attached to the term was, however, entirely different from the meaning associated with it in the mind of every radio and telephone engineer. To the latter the term is associated with a constant ratio of amplification over a certain range of frequencies, so that if the amplification is plotted to a base of frequency, a horizontal straight line is obtained. In the advertisement in question, the principle of straight-line amplification is stated to consist in replacing the rounded bends in the tone-arm of a gramophone by plane corners which are supposed to reflect the sound waves in the same way as a mirror would reflect a beam of light. The beams or rays of sound are thus reflected in an orderly *straight-line* way along the tone-arm as compared with distorting cross-reflections in previous tone-arms with nicely rounded corners. As the science of acoustics, especially in its application to the gramophone, is of ever-increasing interest to radio engineers, we need make no apology for referring to this matter in some detail. The analogy between light and sound must be used with great caution because of the enormous difference between the wavelengths in the two cases. A reflector to be effective must have dimensions of the same order at least as the wavelength concerned. In light we are dealing with wavelengths of less than a thousandth of a millimetre, whereas the wavelength of a high note with a frequency of 1,000 is over a foot, and that of a low note with a frequency of 50 is over twenty feet. To be at all effective as a reflector of sound, the reflecting surface must therefore be something of the order of twenty feet in diameter as a minimum; to act as a really efficient reflector it would have to be much larger; to be equivalent to a mirror the size of a pin's head, the reflector of sound would have to be made with a diameter of about two miles. We may leave our readers, therefore, to imagine how effective the sound reflection will be at the flattened corners of a gramophone tone-arm, and whether the sound waves are likely to be more or less distorted by such a departure from the smooth curves of the ordinary tone-arm.

It is amusing to note that this enunciation of the principle of straight-line amplification is hailed as "an important advance in scientific research." We wonder if it was originally evolved as a *jeu d'esprit* by some member of the scientific staff of the firm concerned and has fallen accidentally into the hands of some member of the advertising department who did not know enough of the elements of acoustics to see the joke.

Transmitting Amateurs in Conference.

A photograph taken at the Annual Convention of the Radio Society of Great Britain, which was held on September 29th last at the Institution of Electrical Engineers.

Surges in Eliminator Smoothing Circuits.

By A. G. Warren, M.Sc., M.I.E.E., F.Inst.P.

Summary.

WHEN changes occur in the H.T. potential applied to a receiving set through a smoothing circuit, surges are liable to take place, giving rise to voltages which may, in certain circumstances, be much in excess of the normal working potential. Risk of breakdown is thus incurred. The problem is here examined when the supply is D.C., though in some cases, which are indicated, the results are equally applicable to a rectified A.C. supply.

The surges are most serious at switching on and switching off, especially if this switching is done with the filaments not alight, or the set not connected. For this reason the main H.T. supply should only be switched with the set connected and the filaments alight.

For adequate smoothing (and regulation, when used with rectified A.C.) it is necessary to maintain reasonably high values for chokes and condensers; for all normal voltages, requirements are met if the product *LC* is of the order of 200 microfarad-henrys (*e.g.*, 4-microfarad condensers used in conjunction with a 50-henry choke, or 2-microfarad condensers with a 100-henry choke).

It is shown that a smoothing circuit which may be perfect on one set may give rise to bad surges upon another.

For a set requiring a definite anode current it is shown that reducing the size of the condensers and increasing the value of the choke, reduces the surge at switching on but increases the surge at switching off, and *vice versa*. There are therefore optimum values for these components. Rules are given enabling the condensers and choke to be so proportioned to the load that the normal working voltage is not exceeded either at make or break.

Introduction.

Recent advances in receiving sets have called for output valves capable of dealing with a considerable amount of power. For the supply of energy to these valves the eliminator is deservedly popular. When well designed it requires practically no attention and it is extremely economical in use.

It is, however, since the demand for more power has arisen that one has heard at all frequently of condenser breakdown. Such breakdowns suggest that surge voltages may occur in the smoothing circuit in excess of the test voltage of the condensers. The object of the present article is to examine how such excess potentials arise, and how they may be reduced by proper adjustment of the values of the components in accordance with the duty which the eliminator is called upon to fulfil. Such surges may occur both upon switching on and switching off, and their magnitudes are affected by the methods adopted in effecting those operations. The results given below are applicable to an eliminator used on D.C. mains; in some cases they are also applicable to an A.C. eliminator; those cases are indicated.

Surge on Switching On.

If we consider the circuit of Fig. 1 we see that when the switch *S* is closed (*S'* being already closed), the condenser C_2 is almost instantaneously charged to the potential of the mains. At the same time a current i_2 starts to grow through the inductance *L*. We may neglect the resistance of *L*—in any case its effect is small. Now an inductance of *L* henrys is one which requires *L* volts to cause a current through it to grow at the rate of 1 ampere per second. At any time the rate at which the current i_2 is growing, in amperes per second, is obtained by dividing $V_2 - V_1$ by *L*. Expressed mathematically this simple relation is

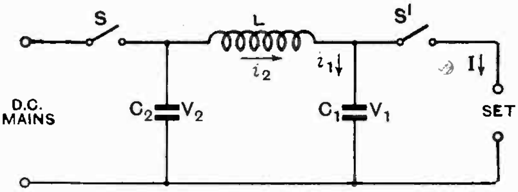

Fig. 1.

$$V_2 - V_1 = L\frac{di_2}{dt} \quad \dots \quad (1)$$

If, for instance, *L* is 50 henrys, and the mains voltage is 200, the current i_2 starts to grow at the rate of 4 amperes per second. At the end of one thousandth of a second the current will be 4 mA. Most of this current will be flowing into the condenser C_1, causing its voltage V_1 to rise. As V_1 rises, the rate of growth of i_2 diminishes and the current I through the set increases.

A condenser of C farads is one which requires C amperes to flow into it to cause its voltage to rise at the rate of one volt per second. At any time the rate at which the voltage V_1 is increasing is obtained by dividing i_1 by C_1. Expressed mathematically this relation is

$$i_1 = C_1 \frac{dV_1}{dt} \quad \ldots \quad \ldots \quad (2)$$

Thus, when the switch is first closed the potential of C_1 is not growing at all, but at the end of the first one-thousandth of a second, if $i_1 = 4$ mA. and C_1 is 4 microfarads, the potential is growing at the rate of 1,000 volts per second.

As the voltage V_1 grows, the current I grows in a manner depending upon the characteristic of the power valve. The equation

$$I = f(V_1) \quad \ldots \quad \ldots \quad (3)$$

is a mathematical way of stating that this characteristic is known.

We have also the obvious simple relation

$$i_2 = i_1 + I \quad \ldots \quad \ldots \quad (4)$$

The equations (1) to (4) are sufficient to determine the subsequent variations of voltage and current. The integration of these equations in general terms is impossible unless equation (3) can be expressed in a definite mathematical form. If, however, the characteristic is known, practical solutions of the equations may be obtained by "tabular integration." It is not proposed to detail the method here. But the results are of importance and will be dealt with carefully.

The first case we shall consider is the closing of the switch S with S' open or the filaments not alight. In these circumstances the whole of the current i_2 is expended in charging the condenser C_1. The current i_2 continues to grow until V_1 becomes equal to V_2; but the current i_2 does not then die out, *it only ceases to grow*. Current still flows and V_1 rises still further, the current i_2 diminishing. This process continues until V_1 becomes equal to $2V_2$, when i_2 becomes zero; thence i_2 reverses and V_1 falls. The voltage oscillates between zero and twice the voltage of the mains; the oscillation is only damped out slowly by the losses in the choke. The periodicity of this oscillation is determined by the product LC_1. For the case cited ($C = 4\,\mu$F., $L = 50$ H.) the frequency is about 11.3 cycles per second; the oscillation is illustrated in Fig. 2.

The magnitude of this surge may be expressed very simply mathematically. By the time the voltage V_1 has ceased rising, suppose the total quantity of electricity which has flowed through L to C_1 is q.

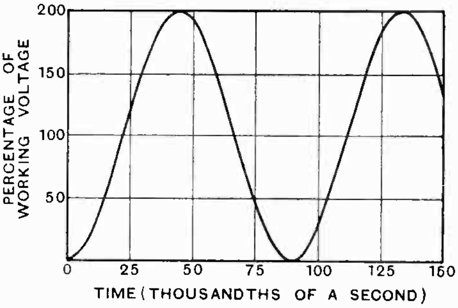

Fig. 2.—Surge at make.—Filaments not alight.

Then the energy thus supplied from the mains is V_2q. But the energy stored in the condenser is $\frac{1}{2}V_1q$. Hence $V_1 = 2V_2$.

In practice the switch S should not be closed unless the set is connected (S' closed) and the filaments are alight. We now consider the effect upon the surge of the energy taken by the set. In the results which follow it has been assumed that the current I is proportional to $V_1^{3/2}$. This relation approximates to practice closely enough to give results of reasonable accuracy.

As in the case already considered, when the switch S is closed, the current i_2 grows, raising the potential of the condenser C_1. As this potential V_1 increases, the current I, taken by the set, increases. It cannot be rigidly demonstrated without the use of fairly advanced mathematics that, in consequence, the extent to which the voltage rises is necessarily less than twice the voltage of the mains. But it can easily be shown to be extremely probable. The voltage V_1 will cease rising when the current i_1 diminishes to zero, i_2 will then still have a positive value equal to the current being taken by the set at the highest potential V_1; there is, therefore, still energy associated with the inductance; call this energy x. The rate at which current flows through the set increases with the voltage, and hence, if q_1 is the total quantity of electricity which has flowed through it, it is reasonable to assume that the average voltage at which it has flowed is greater than one-half the maximum. In other words, the energy supplied to the set exceeds $\frac{1}{2}V_1q_1$ by some amount which we will call y. If the quantity of electricity then stored in the condenser is q_2, its energy is $\frac{1}{2}V_1q_2$. We must then have:—Energy supplied by mains = energy stored in inductance + energy stored in condenser + energy used by set, or

$$V_2(q_1 + q_2) = x + \tfrac{1}{2}V_1q_2 + \tfrac{1}{2}V_1q_1 + y,$$

whence it follows that V_1 is less than $2V_2$.

A particular example of such a surge oscillation determined by tabular integration of equations (1) to (4) is illustrated in Fig. 3. This curve has been worked out for an eliminator having condensers each of value 4 μF. with a choke of 50 H. (quite normal values) when used with a set requiring 40 mA. at 200 volts. It is seen that the maximum pressure at switching on is about 244 volts—an excess over the mains voltage of 22 per cent., which need cause little alarm. If, however, this same eliminator is used on a set requiring only 10 mA. at 200 volts, the surge at switching on is more serious. It is illustrated in Fig. 4. The maximum voltage is now 336 or 68 per cent. above the working value.

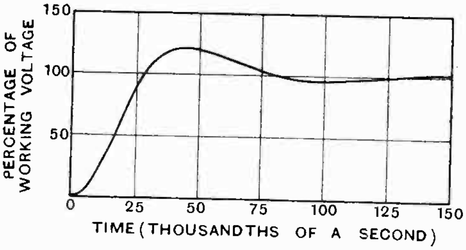

Fig. 3.

V = 100, I = 5 mA., C = 1μF., L = 200 H.
V = 200, I = 20 mA., C = 2μF., L = 100 H.
V = 400, I = 80 mA., C = 4μF., L = 50 H., etc.
Surge at make—I/CV = 0.05, LI/V = 10.

The question immediately arises whether, for this smaller current, different values for the condenser and choke will, while still being satisfactory from the point of view of regulation (when used on rectified A.C.) and freedom from ripple, give rise to a smaller surge at make. A brief examination of the fundamental equations (1) to (4) shows that the curves already drawn are applicable to other cases than those for which they have been calculated. Thus, if we imagine all currents to be reduced to one quarter, the equations will be satisfied by exactly similar variations of the voltage if we imagine C reduced to one quarter and L increased four times, the product LC being maintained constant. (The product in this case is 200 microfarad-henrys. With such a value for the LC product, smoothing is efficient. When used with rectified A.C., regulation is better the higher the value of C, but is satisfactory so long as the current taken by the set does not exceed 15 mA. per μF. per 100 V.)

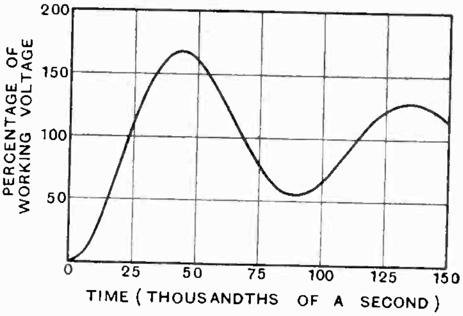

Fig. 4.

V = 100, I = 2.5 mA., C = 2μF., L = 100 H.
V = 200, I = 10 mA., C = 4μF., L = 50 H.
V = 400, I = 40 mA., C = 8μF., L = 25 H., etc.
Surge at make—I/CV = 0.0125, LI/V = 2.5.

Fig. 3 therefore not only represents the variation of voltage when I = 40 mA., C = 4 μF., L = 50 H., but also the variation when I = 10 mA., C = 1 μF., L = 200 H., and for all cases where I/C = 10 mA. per μF. and LI = 2,000 mA.H. Similarly, Fig. 4 applies to all cases where I/C = 2.5 mA./μF. and LI = 500 mA.H.

Again, if we imagine all voltages and currents doubled, equations (1) to (4) are similarly satisfied (the voltages being expressed as multiples of the working voltage), so that Fig. 3 is applicable to all cases in which I/CV = 0.05, and LI/V = 10, the units being milliamperes, microfarads, volts and henrys: *e.g.*, V = 200 V, I = 10 mA., C = 1 μF., L = 200 H.; V = 100 V, I = 10 mA., C = 2 μF., L = 100 H.; V = 300 V, I = 60 mA., C = 4 μF., L = 50 H., etc.

Figs. 5 and 6 are drawn for higher current to capacity ratios. Fig. 5 shows the voltage rising steadily to its normal working value without exceeding it. One set of conditions satisfying this curve is V = 200 V, I = 80 mA., C = 4 μF., L = 50 H. The same curve would also represent the conditions $V = 200$ V, $I = 40$ mA., $C = 2$ μF., $L = 100$ H. Fig. 6 represents a still slower rise to the normal working value.

We see, therefore, that it is possible by adjusting the values of L and C to eliminate any surge voltages at make greater than the normal working voltage.

Surge at Switching Off.

We saw that on switching on the high tension supply the surge voltage could never exceed the normal working voltage by more than 100 per cent. This limitation does not exist when the circuit is broken.

The instant before the circuit is broken we have no current flowing into the condenser C_1 (*i.e.*, $i_1 = 0$), and the current i_2 through the inductance is equal to the load current I. Suppose that the first operation in switching off is to open the switch S' (which it should not be). The whole current i_2 $(= I)$ is diverted from the set into the condenser C_1, which commences to rise rapidly in potential, continuing to do so until the current through the inductance has fallen to zero. By then, not only has this condenser received the whole energy previously stored in the inductance but also the extra energy received from the mains. The larger L and I and the smaller C, the greater will be the voltage to which the condenser C_1 is raised. From this point the voltage falls, energy flowing back into the mains; the process continues as an oscillation.

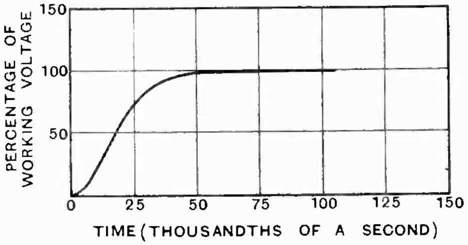

Fig. 5.

$V = 100$, $I =$ 10 mA., $C = 1\mu$F., $L = 200$ H.
$V = 200$, $I =$ 40 mA., $C = 2\mu$F., $L = 100$ H.
$V = 400$, $I = 160$ mA., $C = 4\mu$F., $L = 50$ H., etc.
Make—$I/CV = 0.1$, $LI/V = 20$.

The maximum voltage attained is easily calculated. Immediately before opening S' the energy stored in the inductance is $\frac{1}{2}LI^2$, and in the condenser $\frac{1}{2}q_1V_1$ (where q_1 is its charge). As the current i_2 is falling to zero, a quantity of electricity which we may call q_2 flows from the mains and becomes stored in the condenser C_1. By the time i_2 has fallen to zero, imagine the condenser C_1 to have risen in potential to V. Then we must have

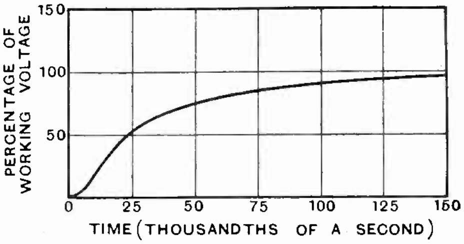

Fig. 6.

$V = 100$, $I =$ 10 mA., $C = 0.5\mu$F., $L = 400$ H.
$V = 200$, $I =$ 40 mA., $C = 1\mu$F., $L = 200$ H.
$V = 400$, $I = 160$ mA., $C = 2\mu$F., $L = 100$ H., etc.
Make—$I/CV = 0.2$, $LI/V = 40$.

$$\tfrac{1}{2}LI^2 + \tfrac{1}{2}q_1V_1 + V_2q_2 = \tfrac{1}{2}(q_1 + q_2)V \quad . . (5)$$

where $q_1 = C_1V_1$ and $q_2 = C_1V$ . . (6)

Substituting from (6) in (5) we get a simple quadratic equation for V. If $I = 40$ mA., $V_2 = 200$ V, $C = 4$ μF., and $L = 50$ H., we find that the roots of the equation are $V = 341.4$ or 58.6; that is to say, the oscillation is between those limits. If, however, $I = 40$ mA., $V_2 = 200$ V, $C = 1$ μF., and $L = 200$ H., we find $V = 765.7$ or $- 365.7$. Here the rise to 283 per cent. above the normal working voltage is very serious.

Conditions would not be so bad if both switches S and S' could be opened simultaneously. In this case the current I would, as before, be diverted into the condenser C_1, but the current i_2 would diminish more rapidly because V_2 falls as V_1 rises. It is easy to show that if $I = 40$ mA., $V_2 = 200$ V, $C_1 = C_2 = 4$ μF., and $L = 50$ H., that the maximum voltage would be 300; but that if $I = 40$ mA., $V_2 = 200$ V, $C_1 = C_2 = 1$ μF., and $L = 200$ H., the maximum voltage would be 600, again a very serious value. These surges would occur to the same extent in a set operated from rectified A.C.

If, however, the set is shut down, as it should be, by first opening the switch S, rise of voltage of C_1 cannot take place. The current I continues to flow, first at the value it had before the switch was opened, the energy coming almost entirely from the condenser C_2, which falls in potential. Now if the inductance L is large and the capacity C_2 small, C_2 will not only fall to zero but may acquire quite a large negative potential by the time the current i_2 ceases. Before this stage is reached the condenser C_1 has taken over the greater share of the load current and its potential is falling rapidly. The current i_2, having fallen to zero, reverses and C_2 begins to charge up again positively at the expense of C_1, whose potential falls to zero and reverses. As the potential V_1 falls to zero, the current I vanishes and remains zero so long as V_1 is negative, the oscillation then being "free." The oscillation continues, energy being sapped from it whenever the potential V_1 is positive. In some respects the oscillation resembles that just considered, but its amplitude is less because of the energy which is taken by the set. The fundamental equations (1) to (4) are also applicable to this case, together with the equation

$$i_2 = -C_2 \frac{dV_2}{dt} \quad \ldots \quad \ldots \quad (7)$$

Employing tabular integration for these equations, the curves given in Figs. 7, 8 and 9 have been obtained. Fig. 7 shows the characteristics just described, the maximum negative voltage being 1.93 times the normal working potential—a serious value. (If S' were opened instead of S, the surge potential would be 3.83 times the working potential.) For larger condensers and a smaller inductance the maximum negative potential is only 0.51 of the normal working voltage—Fig. 8. (In this case if S' were opened before S there would be a surge potential 2.41 times the working voltage.)

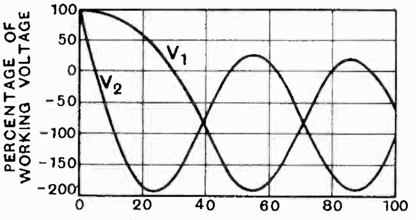

Fig. 7.

$V = 100$, $I = 10$ mA., $C = 0.5\mu$F., $L = 400$ H.
$V = 200$, $I = 40$ mA., $C = 1\mu$F., $L = 200$ H.
$V = 400$, $I = 160$ mA., $C = 2\mu$F., $L = 100$ H., etc.
Surge at break—$I/CV = 0.2$, $LI/V = 40$.

In the case illustrated in Fig. 9 the voltages oscillate without reversing, except to a very small extent after a considerable time interval. These curves are obviously equally applicable to a set working from D.C. mains or from rectified A.C.

Conclusion.

It is clear that in no case should voltage be switched on to, or off of, a smoothing circuit (except gradually) unless the circuit is connected to the set with the valve filaments fully alight. That point being established we may review briefly, but carefully, the results obtained above. We have seen that, in some cases, switching may be effected without any voltages occurring in excess of the normal working potential, *e.g.*, see Figs. 6 and 9. But the conditions of Fig. 6 are the same as those of Fig. 7; there is no excess voltage at make, but at break a voltage 1.93 times the working voltage occurs. Again, the conditions of Fig. 9 are the same as those of Fig. 3; there is no excess voltage at break but a voltage 1.22 times the working voltage occurs at make. Were the current only 10 mA. with this filter, no surge would occur at break, but on switching on there would be a rise of potential to 1.68 times the working voltage (Fig. 4).

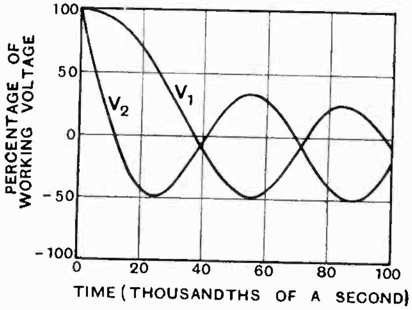

Fig. 8.

$V = 100$, $I = 10$ mA., $C = 1\mu$F., $L = 200$ H.
$V = 200$, $I = 40$ mA., $C = 2\mu$F., $L = 100$ H.
$V = 400$, $I = 160$ mA., $C = 4\mu$F., $L = 50$ H., etc.
Break—$I/CV = 0.1$, $LI/V = 20$.

We see that reducing the size of the condensers and increasing the value of the choke reduces the surge at make, but increases the surge at break, and *vice versa*. The following table, which has been prepared from calculated results, shows, however, that it is possible to choose the values of the components of the smoothing circuit so that no voltage in excess of the working voltage occurs, either at make or break.

TABLE

(FOR SMOOTHING CIRCUITS $LC = 200\ \mu$F.H.).

I/CV.	LI/V.	Maximum voltages expressed as multiple of normal.	
		Make.	Break.
0	0	2	1
.0125	2.5	1.68	1
.05	10	1.22	1
.1	20	1	1
.125	25	1	1
.2	40	1	1.93

From this table we see that it is desirable to arrange for I/CV to be between 0.1 and 0.125. If there is any doubt about the value of the load current it is better to have I/CV too low rather than too high. Since the regulation will be better on rectified A.C. if I/CV is low we may definitely adopt the values $I/CV = 0.1$ mA./μF.V. and $LI/V = 20$ mA.H./V. At 200 volts the current per microfarad would be 20 mA. This is satisfactory from the point of view of regulation. The curves relating to this series of circuits are given in Figs. 5 and 8.

Of course, surges may *theoretically* be eliminated, whatever the values of the components of the smoothing circuit, if the voltage is applied slowly through a potentiometer. This, however, is not simple to arrange in an economical manner. Nor is it really effective —it takes no account of those momentary interruptions of the supply (such as the change of a feeder) which, short as they are, are sufficiently long to puncture a condenser.

To conclude, a few examples may be given. The chosen values may be conveniently stated as $C = 10I/V$ and $L = 20V/I$, the units being microfarads, henrys, volts and milliamperes.

(*a*) Smoothing circuit for 50 mA. at 250 volts:

$C = 2\ \mu$F., $L = 100$ H.

(*b*) Circuit for 60 mA. at 150 volts:

$C = 4\ \mu$F., $L = 50$ H.

(*c*) Circuit for 10 mA. at 100 volts:

$C = 1\ \mu$F., $L = 200$ H.

The variety of these circuits is not surprising considering the different duties they have to perform. The surprising fact is that the same components are often expected to behave well under widely varying conditions. Considering circuit (*c*), which man be looked upon as representative of the load used by small horn speakers, the capacity suggested is less than that usually employed and the inductance greater. The reasons are not far to seek. Eliminators are more commonly used with rectified A.C., and a large condenser is employed to reduce the voltage drop. But this is quite unnecessary, since any voltage can be obtained with a transformer. A large condenser may do no harm, since the surge at make is limited by the rectifying system. But it is more desirable to follow the growing practice of designing the rectifying and smoothing elements as separate units (see, for example, *Wireless World*, February 22nd and 29th, 1928) so that the set is more or less independent of the nature of the supply. Again, the amateur is inclined when using rectified A.C. to connect in any and every condenser he may have available, with the object of improving the smoothing. This is quite unnecessary. With an LC product of 200 μF.H., hum should not be heard in the speaker. If a hum is heard, it is not due to lack of smoothing, as is indicated by the fact that increasing the condenser C_2 will often make the hum more pronounced. Hum in these circumstances may be due to induction. It is more likely to be due to a high frequency oscillation (modulated at 50 or 100 cycles) set up in the transformer leads by the sudden rushes of current through the rectifying valve as it becomes conducting. These oscillations may be prevented by short-circuiting them at the transformer with a 0.1 μF. condenser.

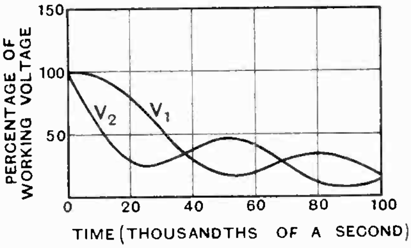

Fig. 9.

$V = 100$, $I = 5$ mA., $C = 1\mu$F., $L = 200$ H.
$V = 200$, $I = 20$ mA., $C = 2\mu$F., $L = 100$ H.
$V = 400$, $I = 80$ mA., $C = 4\mu$F., $L = 50$ H., etc.
Break—$I/CV = 0.05$, $LI/V = 10$.

Some Fundamental Definitions.

By Raymond M. Wilmotte, B.A., A.M.I.E.E.

Potential Difference and E.M.F.

In two recent numbers* of *E.W. & W.E.* Professor Howe has given a very lucid account of some difficulties underlying the ordinary meanings of potential difference and E.M.F. On the main issue I am in complete agreement with Professor Howe, but on certain questions of detail I cannot follow him. It is true that definitions of quantities are purely matters of convenience, and two separate sets of definitions may be independently correct; they will be so so long as they are self-consistent. The definitions of P.D. and E.M.F., when related to alternating current, do not appear to have been rigorously defined. On the other hand there are certain accepted conventions about them.

Thus, in the well-known problem of a magnet moving along the axis of a circle of wire, it is generally recognised that there is an E.M.F. induced in the wire, that a current flows; yet from symmetry there can be no potential difference between any two points of the wire.

Any definition of P.D. and E.M.F. must not only be mathematically rigorous but also submit to the generally accepted conventions of the terms. Below is an explanation of the manner in which, I believe, suitable definitions can be reached.

Among the fundamental units of electricity the definitions of potential difference and E.M.F. lead to remarkably vague and diverse opinions. There appears to be no difficulty about the definitions of charge, current and other quantities. The necessity for a rigorous definition of potential difference will be admitted when it is realised that it is directly involved in a number of other definitions of fundamental importance. These are impedance, capacity, self-inductance, and mutual inductance. The last two are of special importance, for all the electrical units are obtained experimentally from them. The ohm, the farad, the ampere, the volt, etc., are all fundamentally dependent on a self or a mutual inductance.

I am not quite sure of the exact definitions which Professor Howe gives to potential difference and E.M.F. Although fundamentally they appear to coincide with my own view, the result he gives in one example considered does not appear to agree with my conception of his meaning.

There are two points which Professor Howe has not mentioned, though they are so intimately connected with the problem that in my opinion their omission leaves important parts of the problem unexplained. These are the absolute necessity of the existence of capacity effects in order that potential differences may be formed, and that there are two very distinct meanings of E.M.F. depending on whether the term is applied to self-inductance or mutual inductance.

It is difficult to deal with the later steps of the argument without stating the first steps. As I shall deal with matter rather more mathematically and from a slightly different standpoint, perhaps it will not be out of place to repeat some of the fundamental principles explained by Professor Howe.

The difference in standpoint may be brought out by the fact that Professor Howe is always considering closed circuits, whereas in the following the whole explanation is based on portions of circuits. Professor Howe's standpoint is to a great extent illusory, as it is not possible to speak of the E.M.F. or potential difference between two points in a circuit without considering each portion of the circuit separately.

There is no difficulty in defining potential in electrostatics, when there is no variation of the field with time. The potential at a point is then defined as the work done in bringing a unit charge from infinity up to that point, assuming that this unit charge does not disturb the field. In this definition it is not necessary to specify the path which the charge is to take, for the work done is independent of this path. When, however,

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* March and April, 1928.

there are in the system currents varying with time, the value of the potential difference calculated from the above definition will materially differ with the path taken by unit charge, so that this simple definition breaks down.

This phenomenon is numerically stated in Faraday's experimental law. This law states that the E.M.F. induced in a circuit is proportional to the rate of change of the number of magnetic lines of force threading that circuit. Suppose we bring a unit charge from infinity (which we shall conveniently represent by the point O Fig. 1.) to the point A by the path OMA, a certain amount of work will be done. If now we return to O by the path ANO, the total quantity of work in going from O to A and back will not be zero, but will be equal to the rate of change of the total number of lines of force threading the circuit $OMAN$. The work done in going from O to A along the path OMA will therefore be different from the work done along the path ONA. The question arises, which is to be chosen ?

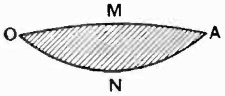

Fig. 1.

The simplest method would evidently be to choose the path along which no E.M.F. due to magnetic induction were induced, and we should now enquire how to find such a path.

For this purpose we shall introduce a conception familiar to mathematicians but looked at askance by all other scientists. This is Vector Potential. This quantity is such that a certain operation involving differentiation with regard to space gives the value of the magnetic field, and differentiation with regard to time gives electric intensity due to the magnetic field. Thus, if H_x, H_y, H_z are the components of the magnetic field, E_x, E_y, E_z, the components of that part of the electric intensity which is due to the magnetic field, and A_x, A_y, A_z, the components of the vector potential, we can write.

$$H_x = \frac{\delta A_z}{\delta y} - \frac{\delta A_y}{\delta z} \quad \ldots \quad \ldots \quad (1)$$

$$H_y = \frac{\delta A_x}{\delta z} - \frac{\delta A_z}{\delta x} \quad \ldots \quad \ldots \quad (2)$$

$$H_z = \frac{\delta A_y}{\delta x} - \frac{\delta A_x}{\delta y} \quad \ldots \quad \ldots \quad (3)$$

$$E_x = -\mu \frac{\delta A_x}{\delta t} \quad \ldots \quad \ldots \quad (4)$$

$$E_y = -\mu \frac{\delta A_y}{\delta t} \quad \ldots \quad \ldots \quad (5)$$

$$E_z = -\mu \frac{\delta A_z}{\delta t} \quad \ldots \quad \ldots \quad (6)$$

Equations (1) to (3) are usually written vectorially in the form $H = \text{curl } A$.

It happens that there are many expressions for the vector potential which will fit these equations. We are at liberty to impose arbitrarily other suitable condition to suit our convenience.[*] The condition generally imposed makes vector potential directly determinable from the conduction currents of the system. Just as the scalar potential, ϕ, known in electrostatics is derivable from the distribution of charges, q, in the system by the expression

$$\phi = \Sigma\left(\frac{q}{r}\right)\text{[||]} \quad \ldots \quad \ldots \quad (7)$$

so the vector potential is obtained from the conduction currents, of components i_x, i_y, i_z, by the expressions

$$A_x = \frac{1}{c^2}\Sigma\left(\frac{i_x}{r}\right)\text{[||][‡]} \quad \ldots \quad \ldots \quad (8)$$

$$A_y = \frac{1}{c^2}\Sigma\left(\frac{i_y}{r}\right) \quad \ldots \quad \ldots \quad (9)$$

$$A_z = \frac{1}{c^2}\Sigma\left(\frac{i_z}{r}\right) \quad \ldots \quad \ldots \quad (10)$$

where c, the velocity of the light, enters in the expression to keep units consistent.

Let us consider an elementary length of wire, say, of length δx, parallel to the X-axis, situated in the field. If the currents vary

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[*] This is similar to the solution of an ordinary differential equation, where there are always one or more constants which we adjust to suit our particular purpose.

[||] There is a further effect which it may sometimes be necessary to take into account at high frequencies. A charge or current will produce a scalar or vector potential at a point, but the potential takes a certain time to reach that point, since it travels with the velocity of light. If r is the distance, the potential arrives at the point considered with a time lag of r/c.

[‡] When there are present magnetic poles of intensity I, the full expression is

$$A = \Sigma\left(\frac{i + \text{curl } I}{r}\right).$$

with time, *e.g.*, alternating currents, charges are set up in the system.*

The electric intensity in the element of wire can only be due to the distribution of charges in the system and the way in which these are varying, that is to say, due to the charges and the currents. The contribution to the electric intensity due to the current we can state in terms of the vector potential introduced above. If ϕ is the potential due to the charges, we have that the electric intensity in the element considered is due to the terms

$$\frac{\partial \phi}{\partial x}\delta x \text{ and } \mu\frac{\partial A_x}{\partial t}\delta x$$

this must be balanced by the ohmic drop, so finally,

$$\mu\frac{\partial A_x}{\partial t}\delta x + \frac{\partial \phi}{\partial x}\delta x + Ri_x\delta x = 0 \quad (11)$$

where R is the resistance per unit length, and all the terms are measured in electrostatic units.

This equation is of the highest importance and is the basis of the present argument. The first term, which we shall in future call the "$\partial A/\partial t$ term" represents the E.M.F. induced according to Faraday's law, and is derived directly from the conduction currents only of the system. The second term, which will be called the "$\partial\phi/\partial x$ term" is derived directly from the distribution of charges alone and is not dependent on the conduction current (except in so far as variations in conduction current are the cause of the existence of charges).

If we calculated the sum of the $\partial A/\partial t$ terms between two points A and B, we would find that the result depended on the path taken. In the case of the $\partial\phi/\partial x$ term, which gives the electrostatic value of potential difference, this is, of course, not so, the difference in the value between the two points A and B being independent of the path taken. It would be convenient, therefore, to define potential difference in terms of the scalar potential ϕ alone. Let us examine if this will agree with the usual conception of the meaning of potential difference. What is the usual conception? It is that the potential difference between two points in a circuit is the ohmic drop plus the E.M.F. induced between those two points. The exact meaning of this E.M.F. is usually left undefined, but it is agreed that it contains at any rate the E.M.F. induced, in accordance with Faraday's law, in the wire joining the two points of the circuit. That is, it is the sum of all the $\partial A/\partial t$ terms added along the wire joining the two points considered.

If the E.M.F. is defined solely as this term, the potential difference is the sum of such terms as $\mu\frac{\partial A_x}{\partial t}\delta x + Ri_x\delta x$ added along the circuit joining the two points considered.

From Equation (11) we see that this is the same as the sum of $-\partial\phi/\partial x$ terms. This can be evaluated from the charge distribution alone, without considering the effects of the currents and the magnetic fields attached to them. This is a particularly satisfactory result, as such a definition of potential difference between two points will be independent of the path taken to go from one point to the other.

We therefore define potential difference at any instant as follows: We assume that all the electric charges of the system are suddenly stopped. By so doing the currents and the magnetic fields disappear together with that part of the electric intensity due to them. The potential difference between two points at that instant, then, is the work done in taking a unit charge from one point to the other. The value obtained will, of course, be independent of the path taken.

It will be seen, therefore, that for a potential difference to exist, there must be an accumulation of charges. Now these charges can only accumulate owing to variations in the conduction currents, which phenomenon is synonymous with capacity effects. This will be considered more fully later.

In order to illustrate this definition let us take the famous problem of a circle of wire A, Fig. 2. Let us suppose that another circle B (shown dotted) carrying alternating current is held above it. From symmetry there can be no potential difference between any two points on the wire A, yet there is an E.M.F. induced and this E.M.F. can be readily calculated. Now, the distribution of electric charge on such a system must be

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* Charges are formed when more conduction current enters a certain portion of a conductor than leaves it, or *vice versa*. We can write for the charge q in an element of wire parallel to the X-axis,

$$q = -\int\frac{di_x}{dx}dt$$

symmetrical, so that, according to our definition, there can be no potential difference between any two points on the wire A: the E.M.F. induced* is therefore balanced by the ohmic drop alone.

Up to this point I believe that the views expressed coincide with Professor Howe's, but in the next step, when the wires are not symmetrically above each other (Fig. 3), I do not understand Professor Howe's simple expression for the value of the potential difference. Let us consider this case.

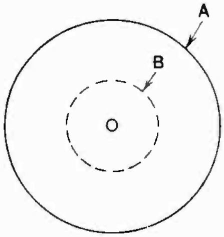

Fig. 2.

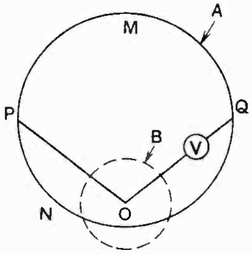

Fig. 3.

We are dealing with low frequencies. The value of the $\partial A/\partial t$ term is very different for different parts of the wire A, as will be readily seen by calculating the value of A for different parts of the wire from Equations (8) to (10), assuming that the current in the wire B is the same in all parts of the wire. We know experimentally that this is true; we also know that the current in the wire A is practically the same in all parts, so that the variation of ohmic drop along this wire is negligible. From Equation (11) we see that the difference between the ohmic drop and the E.M.F. (the E.M.F. corresponds to the $\partial A/\partial t$ terms) must be borne by the $\partial\phi/\partial x$ terms.

The physical meaning of this is that charges are set up in the various parts of the wire, so that in all parts the value of the sum of the $\partial A/\partial t$ and the $\partial\phi/\partial x$ terms is practically constant and exactly equal to the ohmic drop. Without very careful analysis, however, it is not possible to say exactly how the charges are distributed and, therefore, what is the distribution of potential along the wire A. We know that the ohmic drop is uniform, but cannot obtain a knowledge of the E.M.F. distribution except by a more or less laborious analysis.

Professor Howe stated that the E.M.F. along the wire PMQ was proportional to the angle subtended by that arc at this centre O of the wire B, which seems to indicate that his conception of E.M.F. is different to that explained above. Moreover, in connecting a voltmeter along wires POQ to find the potential difference between the points P and Q, Professor Howe is neglecting the E.M.F. induced by the current in the circle of wire A.

The reader will have noticed that the conduction current in the circle of wire A was said to be *practically* the same in all parts. If it were absolutely the same, as stated by Professor Howe, no charge could accumulate in the wire and there would be no potential difference between any two points of it. At low frequencies the variation of current from point to point of the wire may be small, but it will increase considerably as the frequency rises.

We have only considered the meaning of E.M.F. and potential difference when the whole configuration is known. In many cases it is convenient to divide a system into two or more parts, consider each separately, and take account of the reaction of one on the other. This important consideration, which shows a difference in the definition of E.M.F. when referred to self-inductance and mutual inductance, was not mentioned by Professor Howe. The most obvious example of such a case is that of a transmitting antenna and the receiving antennæ. They all form a single system, though the different parts of it may be thousands of miles apart. The problem is attacked by considering separately each antenna subjected to the reactions due to the other antennæ. In such a case the common meaning of E.M.F. induced from one antenna on the others does not simply consist of the $\partial A/\partial t$ terms, which only takes account of the part of the electric intensity due to the magnetic field, but also the $\partial\phi/\partial x$ terms of Equation (11) which takes account of the part of the electric intensity due to the charge distribution on the distant antennæ. In fact the E.M.F. induced in an element of length is taken as the sum of the $\partial A/\partial t$ and the

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* This includes the back E.M.F. due to self-induction as well as that due to the current flowing in the wire.

$\partial\phi/\partial x$ terms, which is usually called the electric intensity.

We can obviously bring the antennæ closer and closer together without affecting the above definitions. Eventually, when they are very close together, the reaction of one on the other is commonly called mutual induction, but the E.M.F. induced by mutual induction is the sum of the $\partial A/\partial t$ and the $\partial\phi/\partial x$ terms, while the E.M.F. induced by self-induction, that is by the action of one portion of the system on itself, consists only of the $\partial A/\partial t$ terms as obtained above (*see* Equation 11).

This difference in the meaning of E.M.F. is forced on us when we separate a system into two or more parts, because as soon as we do this, we consider each part under the action of the fields due to the others and we do not analyse these fields into the two terms corresponding to $\partial A/\partial t$ and $\partial\phi/\partial x$.

We may even go still further and consider a simple circuit arbitrarily divided into several parts to each of which the argument of the antennæ will still apply.

This will produce a deviation from the definition of instantaneous potential difference given above. Since, when a system is arbitrarily divided into sections, the part of the electric intensity which is due to the charge distribution of one section on another is included in the E.M.F., it must not appear in the potential difference, otherwise, it would be taken into account twice over. The definition of potential difference between two points is therefore altered to the work done by a unit charge in going from one point to the other against the forces caused by the distribution of charges on the section of the circuit under consideration only at the required instant.

Impedance.

Having now defined potential difference, there is no great difficulty in defining the impedance of a piece of apparatus. It is actually the ratio of the potential difference across it and the conduction current flowing in it, so long as no E.M.F. is induced within the apparatus from the external circuits. There is a difficulty when the current is not constant in amplitude in different parts of the apparatus. In such cases several values for the impedance are obtainable, and it must be specified where the current is measured.

In the general case with sinusoidal currents the potential difference is not in phase with the current, so that the impedance can be written in the form of a complex number. The real term is the resistance, while the imaginary is the reactance.

The reactance is usually divided into two parts, namely, inductance and capacitance; we must now enquire into the exact meaning of these two terms.

Inductance.

The idea of inductance arises directly from Faraday's law. If a certain field of force is produced by a conduction current flowing in a circuit and an E.M.F. is induced in another by this field, the value of the E.M.F. is equal to a constant multiplied by the rate of change of that current. This constant is called coefficient of induction and depends on the shape and position of the two circuits carrying the conduction current and induced E.M.F. It is self-induction when the same circuit carries both the current and the induced E.M.F., and mutual induction when the two circuits are separate.

Since we have defined induced E.M.F. for portions of a circuit, it is possible to define coefficients of self and mutual induction for incomplete circuits. Let us suppose that AB and CD are two incomplete circuits and that conduction currents varying with time can be made to flow in them. It is not intended to consider whether this is practically possible or not. Then, if we keep the current in CD constant and vary that in AB, the coefficient of self-induction L_{AB} in AB will be given by the ratio of the E.M.F., E_{AB}, induced in AB and the rate of change of the current.

That is

$$L_{AB} = -\frac{E_{AB}}{di_{AB}/dt} \quad \cdots \quad \cdots \quad (12)$$

If the E.M.F. induced in CD is E_{CD}, the coefficient of mutual inductance M will be given by

$$M = -\frac{E_{CD}}{di_{CD}/dt} \quad \cdots \quad \cdots \quad (13)$$

It may be noted that the definition for the induced E.M.F.s are the same as stated above. E_{AB} is the sum of the terms $\partial A/\partial t$ along AB. For the mutual inductance, however, when the two parts *AB* and *CD* are considered as separate, E_{CD} is the sum of the $\partial A/\partial t$ and $\partial\phi/\partial x$ terms. For the self-induction, then, the value depends on the conduction current only, while for the mutual induction we must also take into account the effect of the distribution of charge. It must be noted, however, that the sum of the $\partial\phi/\partial x$ terms taken round a complete circuit is zero. When dealing with complete circuits, therefore, no difficulty arises, since the induced E.M.F. can be taken to be due to the magnetic field alone and the effect of the distributed charges can be neglected without infringing the mathematical rigorousness of the analysis.

Capacitance.

The reader may have noted that the word current has often been qualified by the adjective conduction. Maxwell was responsible for dividing currents into two categories, which he called conduction and displacement currents. The former, conduction current, refers to the flow of charge. The latter, displacement current, is only another way of expressing the rate of change of stress in a dielectric. The *total current* (*i.e.*, the sum of the conduction and displacement currents) entering any closed surface must always be equal to that leaving it. If the conduction current entering a closed surface is greater than that leaving it, the balance must be made up by the dielectric current. In such a case, however, a charge is being accumulated within the closed surface. Such a phenomenon is called a "Capacity Effect."

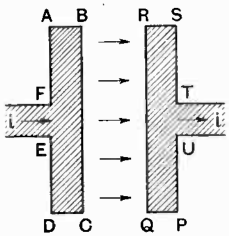

Fig. 4.

As an example, let us consider the most simple and common case of a condenser. *ABCD*, *PQRS* are the two plates of the condenser (Fig. 4); all the shaded portions are of metal. Consider the plate *ABCD*. A conduction current i enters this surface at *EF*, but none leaves it. There must accumulate within the surface *ABCD* a charge and, from definition, displacement currents of total value i must flow away from the surface of the plate. If the other plate *PQRS* completely surrounds *ABCD*, as in a totally screened condenser, the whole of the displacement current must fall on the plate *PQRS* and there produce an equal and opposite charge to that produced in the plate *ABCD*. Now this charge in the plate *PQRS* cannot be produced without the aid of conduction current. It is therefore necessary for a conduction current i to flow out of the plate *PQRS*. Thus, conduction current enters one plate and produces a charge. There is therefore a capacity effect. At the same time, conduction current leaves the other plate and produces an equal and opposite charge. As before there is a capacity effect. Since the displacement current flows through the dielectric from one plate to the other, the capacity effect is said to be between the two plates.

Very often the conditions are not as simple as this. For instance, a conduction current in a wire at high potential passing near an earthed conductor will vary in magnitude from point to point because displacement currents flow from the wire to the earthed conductor and charges are accumulating along the wire. We then say that there are capacity effects between the various points of the wire and the earthed conductor. There are three criterions of a capacity effect in alternating current circuits. They are merely different manifestations of the same thing. They are:

(*a*) A difference between the conduction current entering and leaving a given closed surface.

(b) The existence of a charge within a closed surface.

(*c*) The existence of unclosed loops of displacement current.

In the dielectric we have, therefore, lines of flow of displacement current. These lines of flow terminate on bodies capable of carrying a conduction current, and at these junction points a charge is accumulated. If i_1 is the difference between the outgoing and incoming conduction currents of a closed surface, and i_2 the same difference for the displacement currents, the charge q accumulated in the closed surface is given by

$$-\int i_1 dt = \int i_2 dt = q \quad \ldots \quad (14)$$

A tube of flow or displacement current starts from a negative charge q and ends on an equal positive charge. If the potential difference between the ends of the tube of flow is V, the capacity C connected with that particular tube is defined as

$$C = q/V \quad .. \quad .. \quad (15)$$

Now the flow of the displacement current depends on the distribution of electric intensity in the dielectric (*i.e.*, on the lines of force of the sum of the $\partial A/\partial t$ and the $\partial\phi/\partial x$ terms)*. We therefore see that there is a difference between the values of the capacity between two bodies in electrostatics and in an alternating current circuit. Since the dielectric intensity depends on the frequency, a given system of conductors will produce a configuration of displacement currents in the surrounding dielectric which will vary with the frequency. From equation (14) we see that this is equivalent to saying that there will be a different distribution of charges for each frequency. Not only will the charges be different but, since potential difference is obtainable directly from the charges only, this will also vary with frequency.

We may now complete the qualitative analyses of the two circles of wire A and B of Figs. 2 and 3. We saw in the second case, when the circles were eccentric, that charges must accumulate in the circle A to produce suitable values for the $\partial\phi/\partial x$ terms which will balance the E.M.F. induced. Since a charge accumulates there must be a capacity effect. This is what we expect. Since there are potential differences between the various points of the wire A, we would expect displacement currents to flow from one part of the wire to another, thus allowing a charge to accumulate on the wire. When, the two circles A and B are symmetrically above each other, as in Fig. 2, there is no potential difference and, therefore no displacement current between one part of the wire and any other. There can, therefore, be no capacity effect in this case and no charges accumulate, a result which agrees with the ideas outlined above.

Distributed Capacity and Inductance.

In many problems it is difficult to calculate the tubes of flow of the displacement currents and attach to each a correct capacity. It is often convenient to represent those capacities as going from one point to another convenient point irrespectively of the exact beginning and end of the tubes of displacement current. It is also often convenient to represent a wire as an infinite number of inductances all in series with their common points joined by condensers to suitable points as in Fig. 5. The criterion of the existence of those capacities is a change of conduction current along the wire, which change shows that there is a displacement current in the dielectric. Such arbitrary representation may appear very drastic, but, when intelligently carried out, produce enormous simplifications in the mathematics and give results to a remarkable degree of accuracy, for reasons that are given below.

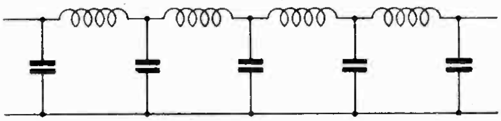

Fig. 5

The most common problem in which such a representation is used is that of the transmission line. In this problem the terms capacity per unit length and inductance per unit length are commonly used. It is usual to assume that this does not represent rigorously the lines of flow of the displacement currents, but that does not necessarily imply that the terms capacity per unit length and inductance per unit length are only approximate or, alternatively, are meaningless, as Professor Howe might lead one to infer. If they are approximate they must approximate to something rigorously correct, and we must endeavour to find this.

If we know the distribution of current and potential difference between the points to which the condensers are connected, there is no great difficulty in rigorously defining the terms capacity and inductance per unit length.

If i is the current at any point and V the potential difference between the terminals of the condenser at that point, the capacity

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* In fact, calling the electric intensity E, the displacement current is

$$\frac{K}{4\pi}\frac{\partial E}{\partial t}$$

per unit length, C, is the ratio of the change in the value of the charge in a unit length to the potential of that unit length or mathematically

$$C = -\frac{1}{V}\int\frac{di}{dx}dt \qquad .. \quad (16)^*$$

Similarly the self-inductance per unit length, L, is the ratio of the change in the value of V in a unit length and the rate of change of the current in that unit of length. Mathematically this can be written

$$L = -\frac{dV}{dx}\Big/\frac{di}{dt} \qquad .. \quad (17)^*$$

It will be seen that these definitions include the reaction of distant portions of the system. That is, in C we find the capacities to all parts, and in L the E.M.F. due to the mutual inductances of all parts, on the unit length considered.

The utility of these definitions may not be apparent since they depend on knowing the result. They are useful, however, in many cases for obtaining approximate results; in the theory of antennæ, for example. The values of the self-inductance and capacity per unit length at any point will depend mainly on the distribution of the charge and the current in the neighbourhood of the point considered. If this distribution is approximately the same as that which would obtain in electrostatics (or more correctly at infinitely low frequency) it will be a fair approximation to assume the distribution of capacity and inductance per unit length is the same at all frequencies.

It should be realised that this approximation is essentially dependent on the use of thin wires and plates. That is the distribution of charge and current in the neighbourhood of any point should be approximately the same at all frequencies considered over a distance which is large compared to the thickness of the wire or plate. That is, the wavelength should be very large compared with this thickness, a condition which almost invariably exists.

Summary.

The following definitions have been obtained.

(*a*) *Scalar potential* (ϕ) is the same as the potential found in electrostatics from the distribution of charges (q) alone

$$\phi = \Sigma\left(\frac{q}{r}\right)^* \qquad .. \qquad .. \quad (18)$$

(*b*) *Vector potential* (A) is similar to the scalar potential but current is substituted for charge. It has both magnitude and direction, the direction being parallel to the current

$$A_x = \Sigma\left(\frac{i_x}{r}\right)^* \qquad .. \quad (19)$$

where c is the velocity of light and the quantities are measured in electrostatic units

(*c*) *Electric intensity* (E) is given by

$$E_x = -\mu\frac{\partial A_x}{\partial t} - \frac{\partial\phi}{\partial x} \qquad .. \quad (20)$$

When applied to a conductor of resistance R, per unit length, we have

$$\mu\frac{\partial Ax}{\partial t} + \frac{\partial\phi}{\partial x} + Ri_x = 0 \qquad .. \quad (21$$

(*d*) *Potential difference* (V) is the potential difference due to the distribution of charges on the section of the circuit under consideration only, calculated as though the problem were an electrostatic one.

(*e*) *E.M.F.*, in the case of self-inductance, is the value of the sum of the $\partial A/\partial t$ terms integrated along the circuit. In the case of mutual inductance it is the sum of the electric intensity integrated along the circuit.

(*f*) *Impedance* (Z) is the ratio of the potential difference (V) between the terminals of the apparatus considered and the current (i) at some definite point either inside or outside the apparatus, when no E.M.F. is induced from outside sources within the apparatus.

$$z = V/i \qquad .. \qquad .. \quad (22)$$

(*g*) *Coefficient of induction* is the ratio of the E.M.F. induced and the rate of change of the conduction current. In the case of self-inductance the conduction current in

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* It may be noted that the velocity of electrical disturbance along wires is not accurately equal to the velocity v of light in vacuo, so that the equation $v = 1/\sqrt{LC}$ given by Professor Howe is not rigorously correct.

* Rigorously, the value of the charge q or the current i_x, is that which existed at a time r/c previous to the instant considered, because the action is not instantaneous but travels with the velocity of light.

the wire AB is inducing the E.M.F. on the same wire

$$L_{AB} = -\frac{E_{AB}}{di_{AB}/dt} \quad \ldots \quad (23)$$

In the case of mutual induction the conduction current in the wire CD induced the E.M.F. in the wire AB

$$M = -\frac{E_{CD}}{di_{CD}/dt} \quad \ldots \quad (24)$$

(*h*) *Conduction Current* (i_1) is a measure of the flow of charges q with a velocity v.

$$i_1 = q \cdot v \quad \ldots \quad \ldots \quad (25)$$

(*i*) *Displacement Current* (i_2) is a measure of the rate of change of dielectric stress.

$$i_2 = \frac{K}{4\pi} \cdot \frac{dE}{dt} \quad \ldots \quad \ldots \quad (25)$$

where E is the electric intensity and K the dielectric constant.

(*j*) *Capacity* (C) corresponding to a tube of displacement current is the ratio of the charge at the end of the tube to the potential difference across it.

$$C = q/V \quad \ldots \quad \ldots \quad (27)$$

(*k*) *Self-Inductance per Unit Length of a Wire* (L) is the ratio of the gradient of the potential difference at a given point of a wire to the rate of change of the current at that point ;

$$L = -\frac{dv}{dx}\Big/\frac{di}{dt} \quad \ldots \quad \ldots \quad (28)$$

(*l*) *Capacity per Unit Length of a Wire* (C) is the ratio of the charge per unit length at a point of the wire to the potential difference, V, across the (assumed) condenser.

$$C = -\frac{1}{V}\int\frac{di}{dx}dt \quad \ldots \quad (29)$$

It may be mentioned that definitions (*k*) and (*l*) are of no practical utility unless the thickness of the wire is small compared with its length, with the distance from neighbouring conductors, and with the wavelength.

Book Reviews.

LETTERS PATENT FOR INVENTION.*

At one time or other most workers in the field of wireless science have dallied with the notion of taking out Letters Patent, to protect either some sudden and brilliant inspiration or else a well-thought-out improvement on existing circuits. Yet it is curious how few of those who piously expect the Patent system to protect them from unauthorised piracy really understand the basic principles upon which this system works.

Its origin is buried in the midst of antiquity, being founded not upon Statute Law, but upon the Royal Prerogative. Its aim is to foster and encourage industry—by giving the inventor a temporary monopoly, so that the community at large may reap a larger benefit when the monopoly grant has expired.

Mr. Griffiths' book is not intended to guide the amateur inventor through the formalities and intricacies of Patent Office procedure, so much as to explain the fundamental ideas underlying the legal and common-sense structure of the system of monopoly grants *per se*.

A short historical survey is followed by a brief account of the essential nature of a patentable invention. It must be a " manner of manufacture " and not a mere discovery, nor yet a process of nature operating without the aid of machinery or apparatus.

The invention must have novelty and utility, though this last asset is more a matter for the Courts than for any official examination made prior to the grant. Yet if it be absent, the Courts will declare the patent, even if granted, void " for want of consideration."

The rights of the patentee are considered as well as the penalties for infringement and the procedure involved in an action for infringement. The manner in which patent rights devolve upon, or may be assigned to other parties, is touched upon, together with the question of licences and the relationship created between licensor and licensee.

A special chapter is devoted to the " Abuse of Monopoly Rights," a matter which is of outstanding interest in wireless circles at the present juncture.

EXPERIMENTAL RADIO. By R. R. Ramsay, Ph.D.
Third edition. Published by the Ramsay Publishing Co., Bloomington, Indiana, U.S.A.
Price $2.75, post free.

A review of the second edition of Prof. Ramsay's book appeared in our issue for September, 1927 when we stated that the only adverse criticism to be made was that some of the diagrams in that mimeographed edition were badly drawn. The book has now been reprinted and the diagrams greatly improved, so that this adverse criticism no longer applies to the new edition.

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* " Patent Law and Practice. By A. W. Griffiths, B.Sc., Barrister-at-Law. Published by Stevens and Sons, Chancery Lane. 7s. 6d. net, pp. xvii and 174.

A Portable Oscillograph Equipment for the Observation of Transient Electrical Phenomena.

By Philip R. Coursey, B.Sc., M.I.E.E.

THE basis of this apparatus is the latest pattern of three-element oscillograph constructed by the Cambridge Instrument Co., Ltd. This instrument consists of a metallic case holding the optical portion of the apparatus and carrying also places for three oscillograph vibrators, which may be either of the electromagnetic or of the electrostatic type, as desired, the two types being interchangeable.

This equipment is designed by the makers for photographic recording of the oscillograph records by means of a drum camera which can be attached to the end of the oscillograph case. The camera drum is normally driven round by a small electric motor, and the shutter of the camera is arranged for opening automatically by a cam mechanism, so as to permit of exposure of the film during a quarter, a half, or a complete revolution of the drum. Visual indication of the oscillograph record is obtained also by a rotating mirror when the camera film is not being exposed.*

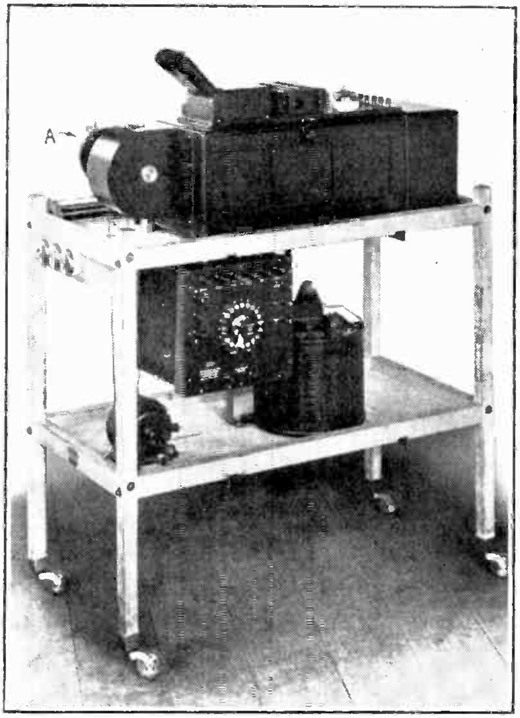

Fig. 1.—*Arrangement of oscillograph equipment on wheeled trolley. The special shutter release is marked A. Adjustable shunt for current measurements and adjustable resistance for voltage measurements are mounted beneath main instrument.*

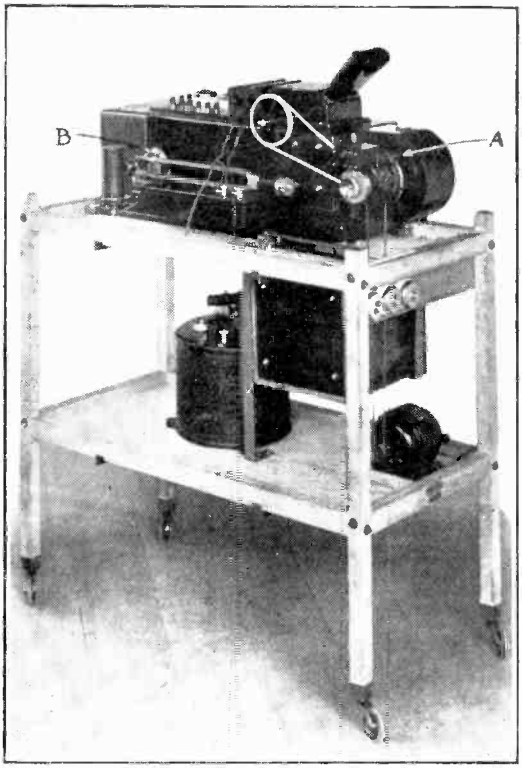

Fig. 2.—*Tuning fork timing mechanism for oscillograph. The shutter for timing beam is marked B and A is the camera shutter release.*

The equipment as thus arranged is eminently suited for recording stationary or periodically repeated electrical current

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* *Journal of Scientific Instruments*, 5, pp. 103-107, March, 1928.

or voltage waveforms or phenomena, but is quite unsuited for obtaining a record of a transient phenomenon unless the time of occurrence of the transient is definitely known and controllable. For instance, the waveform of the current and/or voltage in a circuit fed from an A.C. source of constant frequency can easily be recorded, as also can changes in the waveform when these are produced by switching, or similar means which can be linked mechanically or electrically with the control handle of the camera shutter so as to ensure that the exposure of the film is made at the correct instant. A change in the conditions of an electrical circuit produced by causes beyond the control of the operator cannot, however, be recorded by this arrangement.

For the purpose of certain experimental investigations in the laboratory of the Dubilier Condenser Co., Ltd., the observation and photographic recording of transient electrical phenomena was required. For this purpose certain modifications of the standard instrument have been carried out in order to overcome the above-mentioned difficulties.

First, as the instrument was required to be moderately portable without the necessity for setting up the apparatus and its accessories on each occasion, it was mounted on a small trolley fitted with small rubber-tyred wheels, Fig. 1. The oscillograph itself was fitted to the upper tray of the trolley, the weight being taken by two small strips of angle-iron fixed below the tray and fastened to the main framework. The small motor used for driving the camera drum and the rotating mirror was mounted on a lower shelf so that the driving belt passed straight up to the camera wheel above. The regulating resistance, connected in series with the motor for controlling its speed, was mounted on the top tray alongside the oscillograph case so as to be easily accessible when observing through the window provided. Three switches were also fitted, one for the motor, and two others for the lamp circuits, one being for the main lamp providing the light for the vibrators, and the

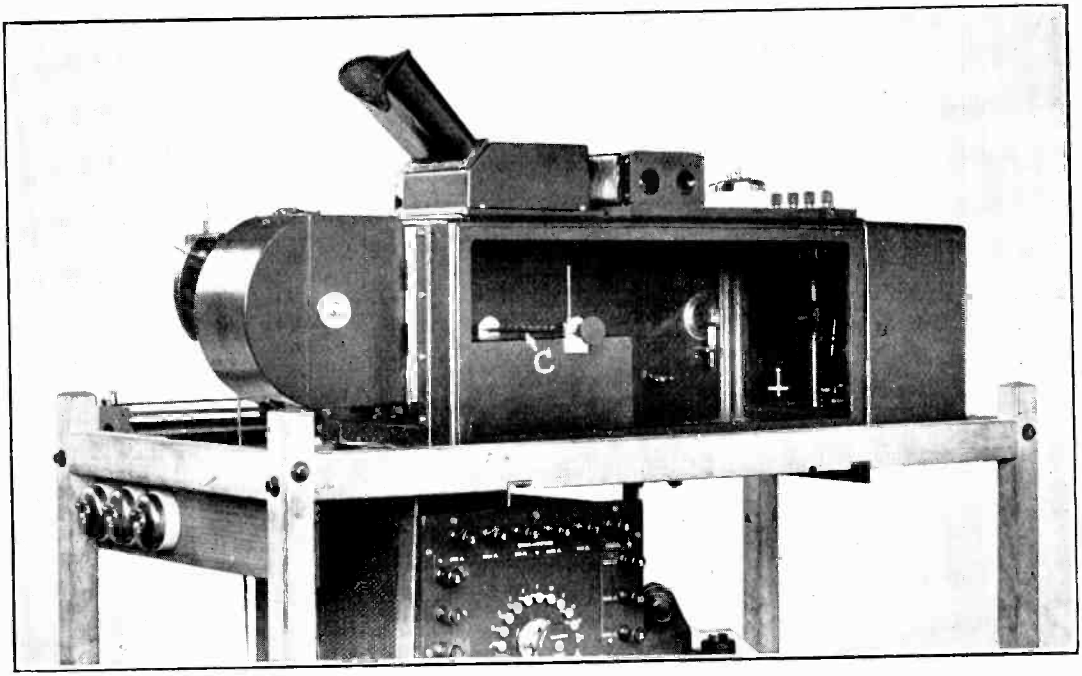


Fig. 3.—*Interior view of oscillograph case, showing adjustable position "shadow rod" C.*

other for an auxiliary lamp used to provide a time scale marking on the film in conjunction with a tuning fork.

The shunt-box supplied by the Cambridge Instrument Co. to enable current waveform measurements to be made up to currents of 100 amperes was also mounted on the lower shelf of the trolley, and connected up to one of the vibrator positions to enable observations of current waveforms to be taken immediately when required. For voltage waveforms a combined series resistance and vibrator shunt was constructed and mounted immediately beneath the oscillograph so as to be readily accessible when taking visual observations.

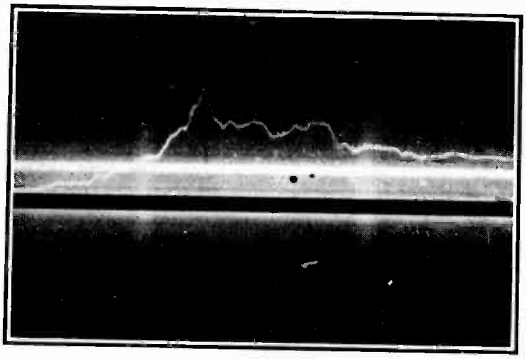


Fig. 4.—*Oscillogram of surge in D.C. circuit. (The black line is the " zero " shadow line; the straight white line is a calibration line for the voltage scale and indicates the normal circuit voltage.)*

To enable transients to be photographed when the time of their occurrence is only approximately known, it is necessary for the camera drum to be rotating continuously, and for the shutter to be opened for a predetermined time so as to include the transient which it is intended to record. To enable this to be carried out a small lever has been fitted to the instrument at *A*, Figs. 1 and 2, so as to engage the existing camera shutter mechanism and so to open and release the shutter independently of the normal cam-mechanism, to which reference has already been made. The film can thus be exposed to the trace of the vibrators for a predetermined length of time—covering several revolutions of the camera drum.

The mechanism for providing a time scale to the record may be seen in Fig. 2. It consists of an electrically driven tuning fork, having a frequency of 50 per second, which opens and closes a small slit shutter so as to allow a narrow beam of light to pass into the oscillograph case 50 times per second. This beam is concentrated into a narrow line by means of a cylindrical lens, so that a series of lines is obtained across the film, spaced 1/50 second apart. With the normal use of the camera using the cam-mechanism to limit the exposure time, the light from the fork can be allowed to pass continuously, but with continuous rotation of the camera drum, overlapping and consequent confusion of the time marking would occur. An ordinary type of camera shutter has therefore been fitted to the hole in the oscillograph case through which the light from the fork is passed. This may be seen at *B*, Fig. 2. This shutter enables the timing markings to be made on the film for a small fraction of a second only, so that they occur on the film during a part only of one revolution. The duration of the admission of light in this manner is adjustable by the shutter as in the case of an ordinary camera. A period of approximately 1/5 second has been found convenient. Since for the normal short periods of exposure the speed of

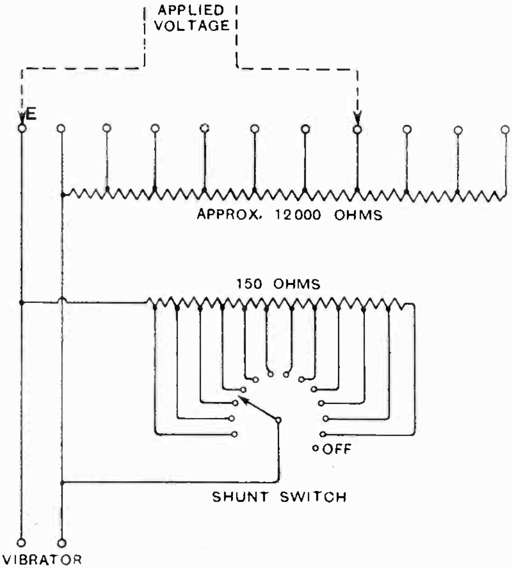


Fig. 5.—*Circuit diagram of combined series resistance and shunt box for oscillograph vibrator.*

rotation of the camera drum may be regarded as constant, the time scale for the whole record is thus obtained, even although the markings extend for a portion only of the length of the film.

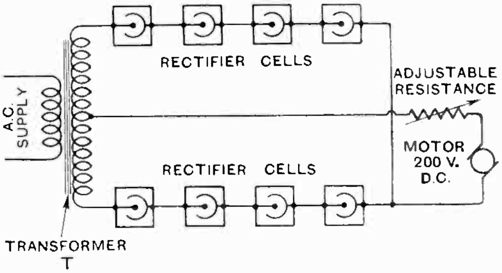


Fig. 6.—*Arrangement of electrolytic rectifier to operate D.C. camera motor from A.C. supply circuits. (The transformer T steps up the supply voltage from* 220 *to* 500 + 500 *volts.)*

A continuous rotation of the film in this manner with a stationary trace from an oscillograph vibrator tends to produce fogging of the film on account of unavoidable scattering of some light beyond the actual width of the " spot " on the film. A small rod has therefore been mounted in the oscillograph case in a vertical position so as to intercept the normal undeflected ray from one of the vibrators. The position of this shadow rod can be adjusted by means of a transverse screw carried by small supporting brackets, as may be seen more in detail at *C* in Fig. 3.

In Fig. 4 is reproduced a record taken with this equipment, in which the break in the trace caused by the shadow rod can be seen. This oscillogram shows a surge caused by the sudden opening of a short circuit on a line with D.C. voltage applied to it, the record indicating a pressure rise considerably in excess of the normal applied voltage.

The resistance box shown in the photographs for taking voltage curves with the electromagnetic vibrator is arranged as in the diagram Fig. 5, so that it acts both as a shunt for the vibrator and as a series resistance. The main resistance has a total value of approximately 12,000 ohms, and is suitable for a maximum voltage applied between its ends of 1,000 to 1,200 volts (R.M.S.). When the shunt switch is in the " off " position, the vibrator is joined directly in series with the high resistance, but as the switch is rotated a variable shunt resistance is connected across the vibrator. This permits easy control of the amplitude of the deflection of the vibrator without changing the high voltage connections. At the same time, also, it permits the main circuits to be closed with the vibrator short-circuited and therefore reasonably safe from damage, after which the shunt switch can be turned gradually until a convenient deflection is obtained.

The motor for driving the camera drum and rotating mirror of the oscillograph is normally operated from 200 volts D.C., with a series resistance to control the speed. In certain cases, however, when a suitable D.C. supply is not available, it has been found practicable to operate this motor from an A.C. supply through the medium of a small electrolytic rectifier—Fig. 6. The transformer *T* steps up the supply voltage (200/240 V, 50 ~) to approximately 1,000 volts, which is used to supply the two banks of rectifier cells, connected to give rectification of both half-waves of the supply.

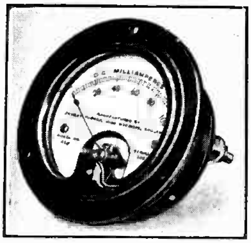
With eight small tantalum wire rectifier cells for each half of the rectifier, a supply of 120–150 mA. at 200 volts D.C. is obtained for the motor and this has proved quite adequate for most requirements. The rectifier cells used in this arrangement are each only about 1 in. diameter × 3 in. high, and are of a type often used in rectifier equipment for " battery eliminators " furnishing H.T. supply to radio receivers.

This rectifier equipment is quite a compact one and can be fitted to the oscillograph trolley when required for use when an A.C. supply only is available. The whole set-up has proved a very convenient and portable arrangement that lends itself to a variety of experimental investigations.

Scientific Instruments at Olympia.

A Review of some Apparatus of Laboratory Interest exhibited at the Recent Radio Show.

THERE can be no manner of doubt whatever that the recent Radio Exhibition at Olympia, from the point of view of those interested in the reception of broadcasting, contained a very large number indeed of extraordinarily interesting exhibits, but we must regretfully place on record our opinion that, for those primarily interested in laboratory work with high-frequency currents, and who therefore went to Olympia with the hope of seeing the latest developments in measuring instruments suited to their purposes, the Show was, on the whole very disappointing. Not only were several of the most famous makers of scientific instruments completely unrepresented, but even those who had stands occupied them in several cases purely in their capacity as makers of sets for broadcast reception. In the case of two firms, for example, who were making scientific instruments long before broadcasting was thought of, their exhibit was so purely directed towards broadcasting that they were not able to produce even a catalogue of their scientific instruments, though a promise was made, and promptly fulfilled, to send a copy of it by post from their Head Offices. From the point of view of those interested in wireless research work, the most notable absentees were the Cambridge Instrument Company, who hold manufacturing rights for the Moullin voltmeter. Their absence is the more to be regretted as they have produced during the last year three new models of this instrument, which is perhaps more frequently used in high-frequency work than any other.

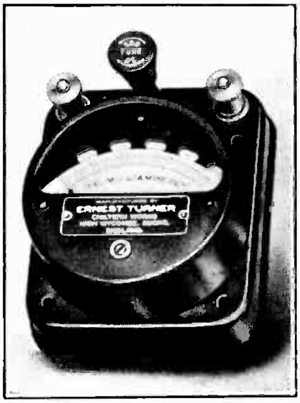


The Turner Model 505 milliammeter.

In considering the measuring instruments of various types that were to be seen, it will be convenient, both for comparison and reference, to group them by types rather than by makers, and to deal first with the biggest and most fundamental class, consisting of meters for direct current.

Direct-current Meters.

Meters for direct-current measurements were to be seen in a very wide range of types, from the small and remarkably inexpensive instruments intended to be left permanently in the plate circuit of the output valve of a receiver, but claiming to do little more than indicate overloading by showing up variations in plate current, to really good instruments guaranteed to give readings accurate within very small limits.

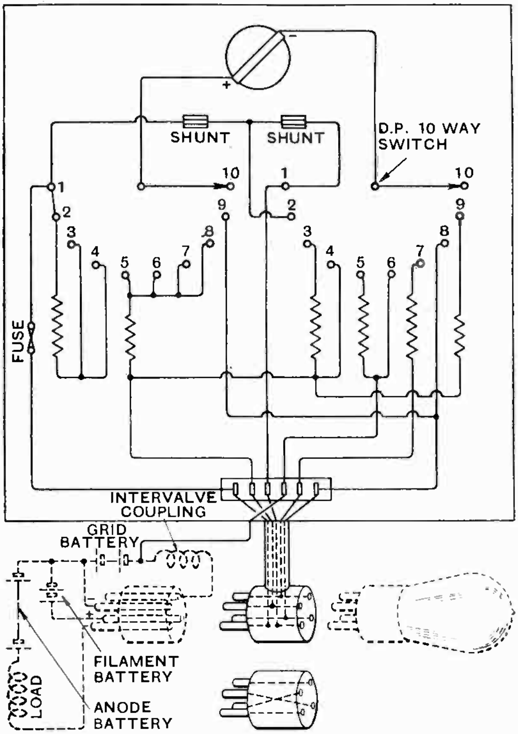


The Turner Model 707 moving dial double range milliammeter.

Mr. Ernest Turner, of High Wycombe, Bucks, was showing, on the stand of Messrs. Bakelite, Ltd., who make the cases for his instruments, a complete range of D.C. meters. These are available in several sizes at varying prices; the smallest series, known as Model A1, have a body diameter of 2½in. and sell at prices round about £2 10s. As milliammeters they have ranges from 0 to 1.5 mA. up to 0 to 750 mA., and the series is continued as ammeters reading up to 20 amps. In all these the voltage-drop across the instrument at full-scale reading is from 75 to 100 millivolts, indicating a resistance varying from some 50 ohms in the most sensitive of the series down to 0.1 ohm for the 1 amp. model. There is also available a galvanometer of the pointer type, with a centre zero, giving a deflection of one division per 20 microamps.

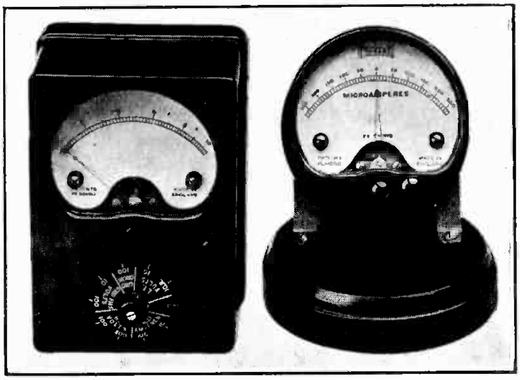
These instruments are also made up as voltmeters, in all ranges from 1 volt to 50 volts, and having in all cases a resistance of 133 ohms per volt, though higher resistances can be obtained to order. The resistance mentioned corresponds to a current of 7.5 mA. at full-scale reading.

The same maker produces larger instruments covering much the same ranges at rather higher prices; in these the same standards of resistance for both current and voltage meters are retained. In addition, a series of double-range instruments is produced, these having the interesting and novel feature that by operating the switch that alters the range the figures on the dial are also altered, so that there can be no danger of misreading, or accidentally overloading the instrument, by any confusion between the two ranges.



Circuit diagram of the Ferranti valve-tester.

All instruments made by Mr. Turner are guaranteed accurate within 1 per cent. of full scale reading for all positions of the pointer above half-scale reading; below this the accuracy is within 0.5 per cent. This standard is that prescribed in the British Engineering Standards Association Specification No. 89 for first-grade instruments, and will be referred to hereafter in this review as "B.S.1 Standard." It was interesting to learn that although these instruments have not been available to the public until comparatively recently, they have been produced in considerable numbers for large users, such as various Government departments and the B.B.C., for a considerable period.



The Ferranti valve-tester and pointer galvanometer.

The range of small instruments produced by Messrs. Ferranti, Ltd., will probably be known to most readers. It comprises a series of milliammeters with full-scale readings varying from 1 mA. up to 150 mA., which is extended by ammeters reading to from 0.75 to 20 amps. Throughout the series the voltage-drop across the shunt amounts to 75 mV., indicating that a satisfactorily low resistance has been attained. The price of these instruments is £1 10s. for all but the lowest range, and the standard of accuracy claimed is B.S.1. An unusual feature is the inclusion of a fuse in each instrument, whereby immunity from burnt-out coils and bent pointers may be expected; spare fuses can be obtained for a few pence. The aluminium pointers of these instruments appear to be very light, though the girder construction used evidently gives them considerable mechanical strength. A centre-zero galvanometer, reading 250 to 0 to 250 microamps., is also available.

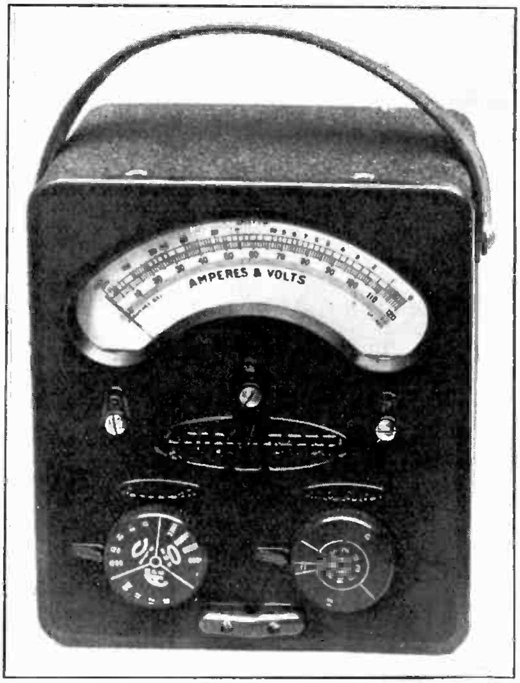
A corresponding range of voltmeters is made, the standard resistance of these being 200 ohms per volt, though on the higher ranges a resistance of 1,000 ohms per volt may also be obtained at a higher price.

Multi-range instruments are also available, these being primarily designed for permanent inclusion in a wireless receiving set, so that adequate control of battery voltages and plate currents may be obtained. They can, however, readily be adapted for laboratory use.

Those whose work involves the "servicing" of receiving sets will be interested in the "Valve Tester," made by Messrs. Ferranti; with this instrument it is possible to make all the essential measurements of voltage and current for any valve in a receiver under the actual conditions obtaining in the set itself. To do this the valve is removed from its socket, a plug attached to a flexible lead being put in its place. The valve is then inserted in a valve-holder mounted on the top of the plug. This returns the valve to its appropriate circuits, while the connections within the plug are such that it is possible to measure, by turning a switch on the multi-range "Valve Tester," the anode voltage and current, the filament voltage, and the grid-bias voltage. For all these measurements, except that of filament voltage, two alternative ranges are provided, so that the Tester can be used with practically any type of valve from a D.E.3 to an L.S.5a.

Another example of a "service" Testing Set was shown by Messrs. R. I. and Varley. This is a very useful instrument, designed principally for the requirements of those whose business it is to "service" wireless receivers in the home and trace faults, and for this reason it is built as compactly as possible, weighing 13¼ lb. in all, the overall dimensions being 12 in. × 11⅝ in. × 7½ in.

The R.I. Varley testing set.

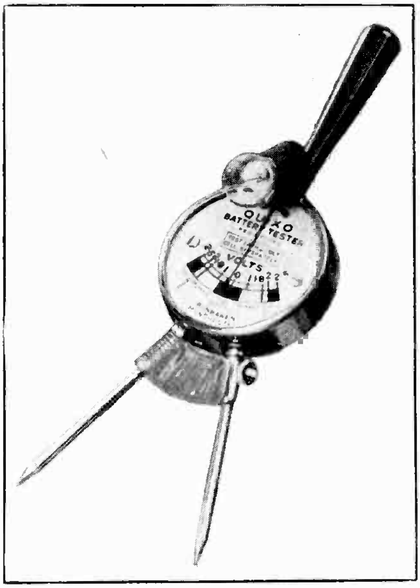


The "Avometer," a multi-range instrument for measuring voltage, current, and resistance.

The instrument is mounted in a mahogany case, provided with a carrying strap, and includes a 3-range Weston voltmeter—10, 50, and 250 volts—having a resistance of approximately 1,000 ohms per volt, and a 3-range Weston milliammeter—15, 150 milliamps., and 3 amperes. A Neon lamp with key is fitted for the purpose of checking continuity and insulation resistance of circuits. Voltage and current measurements can be made and valves can be tested for all ordinary faults. The instrument sells at £16.

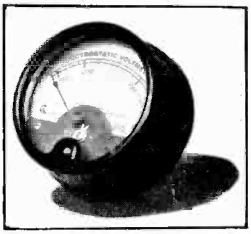
Another ingenious multi-range instrument, intended for general laboratory work, is marketed by the Automatic Coil Winder & Electrical Equipment Co., under the name of the "Avometer." This is intended to cover in one instrument all the most generally used ranges, and will measure currents from 12 mA. to 12 amps., volts from 0.12 to 1,200, and, by the use of a small dry battery incorporated in the instrument, it is also available for resistance measurements from 1,000 ohms up to 1 megohm. The figures given here are in each case full-scale reading. The resistance of this instrument arranged as a voltmeter is 167 ohms per volt, and the accuracy claimed on all ranges is B.S.1 Standard. The price of the complete instrument is £8 8s.

Cheaper meters, suitable for general testing purposes rather than for real laboratory work, were offered by Messrs. A. H. Hunt, Ltd. In addition to the usual moving-iron instruments, moving-coil meters in all ranges from 5 mA. to 50 amps, and from 2.5 to 250 volts are made, together with several varieties of multi-scale instruments. The price of these is from about £1 upwards, and the accuracy claimed is from 1 to 2 per cent. Voltmeters have a resistance of some 120 ohms per volt, while the voltage-drop across the milliammeters is round about 225 millivolts; these figures do not remain quite constant throughout the range.



The "Quixo" cell-tester of Messrs. Runbaken, for testing the state of charge of an accumulator cell.

Messrs. Siemens also produce meters of the general-purpose type, these being specifically designed for use with the amateur's wireless receiver. Two meters were exhibited, one a voltmeter with ranges to 7.5 and 150 volts, with a resistance of 300 ohms per volt, while the other measures current as well as voltage, the full-scale readings being 3, 15 and 150 volts, or 7.5, 75 and 750 mA. This latter meter is ingeniously arranged with only two terminals, the necessary range-changes being made by moving a plug from one socket to another. The accuracy claimed for both meters is 4 per cent.

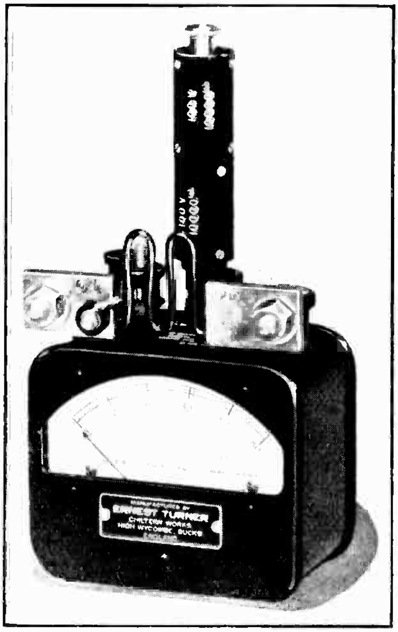


Turner electrostatic voltmeter.

Messrs. Runbaken were showing, not for the first time, an ingenious and simple cell-tester which permits one to find out, by a single rapid test, whether an accumulator is or is not discharged. A voltmeter test, as is well known, is quite unreliable, as any cell that is in reasonable condition will show full voltage after standing for a few moments without load. Similarly a hydrometer test is only of value if it is known that the acid has exactly its correct specific gravity when the cell is fully charged, which is seldom the case in a battery that has had some months of service. This "Quixo" cell-tester consists of a voltmeter shunted by a piece of stout resistance wire which, with two volts across it, draws a current in the neighbourhood of 12 amperes, so that the voltage of the cell is tested while under a heavy load. Under these conditions the test will show with certainty whether the cell requires a charge. A second model of this tester is made in which the load taken can be adjusted, while much more heavily built models are available for testing motor car batteries and other large installations, these drawing currents in the neighbourhood of 100 amps. Though the currents taken during the test are high, the duration of the test is so small that no damage to the batteries need be feared, though some care would perhaps be needed in using the cell-tester with slow-discharge cells made up with thick plates.

Meters for Alternating or High-frequency Currents.

The only representative of the hot-wire type of meter that was seen at the Exhibition was that made by Mr. Turner, who makes a range of seven meters at prices from £1 10s. Full-scale reading on the various models is from 0.25 to 3.0 amps. Owing to the liability of these instruments to errors, which is inherent in the principle upon which they operate, the newer type, consisting of a sensitive D.C. instrument reading the current yielded by a thermo-couple which is heated by the passage of the current to be measured through a fine resistance wire, is rapidly supplanting the simpler type. These also are made by Mr. Turner, and are marketed under the title of Thermo-ammeters at prices ranging from £4 5s. upwards. There is little in appearance to distinguish them from the other products of the same maker, except that the scale is not linear. It is to be noted that the heater is welded direct to the couple, and that one of the terminals is grounded to the metal case; this arrangement may or may not be approved, according to the purpose for which the instrument is to be used. The ranges available are thirteen in number, the lowest requiring 500 mA. for full-scale reading, and having a heater-resistance of 2.8 ohms, while the highest range reads up to 12 amps. These instruments can be used for currents of all frequencies, and are also available for use, if this should be required, for direct current, the same calibration holding good. The accuracy of these meters is guaranteed within 1 per cent., and they will safely withstand a temporary overload of 50 per cent.


Turner portable D.C. volt-ammeter. A self-contained multi-range instrument, fitted for outside multipliers for additional ranges.

Messrs. Ferranti make a meter of similar type in a number of ranges from 25 mA. up to 5 amps. The direct-current meter used for these is their standard small meter with a specially wound coil. In these instruments the heater is insulated from the thermo-couple, which is a great convenience when it is impossible to arrange to insert the meter at an earthed point in the circuit. Unlike the hot-wire instruments, the temperature error in these particular samples of the thermo-couple type is only about 0.1 per cent. per degree Centigrade, while the heater consumes only about 20 milliwatts, corresponding to a resistance in the 25 mA. instrument of about 32 ohms, with a voltage-drop of about 0.8 volt. High-frequency voltmeters, which are, of course, equally suitable for use on ordinary alternating or direct current, are also made on this principle; they have a resistance of 40 ohms per volt.

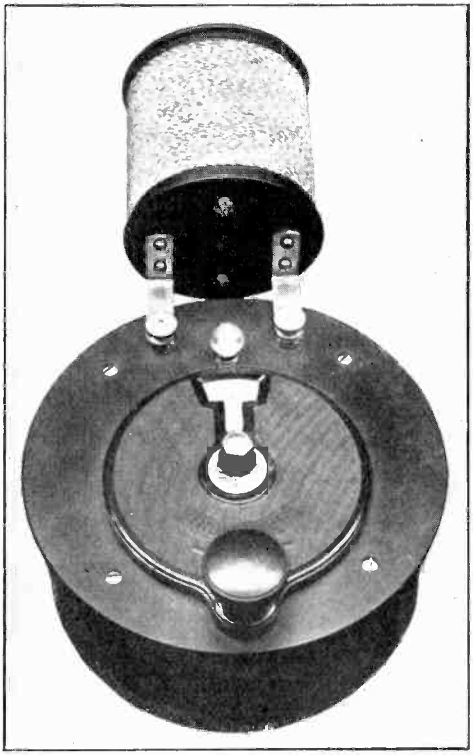
An entirely new type of meter, for use on A.C. of the ordinary supply frequencies, is also made by Messrs. Ferranti. This consists of the usual 1 mA. or 5 mA. moving-coil instrument combined with a bridge of four copper-oxide rectifiers; by this means it is possible to produce a simple meter sensitive enough to give full-scale deflection with no more than 1.5 mA. A companion instrument is made for voltage measurements, the resistance being 160 ohms per volt or, at a slightly higher price, 800 ohms per volt. These meters, owing to the limitations of the rectifier used in them, are at present only made in ranges up to 0.5 amp. or 10 volts, but as it is for low voltages and small currents that their superiority over the moving-iron instrument is chiefly valuable this limitation is not a very serious matter. In any case, the range can be extended by the use of transformers. They are calibrated in R.M.S. values, and so are strictly only accurate when used for pure sine-wave current; with this limitation, an accuracy of 1 per cent. is claimed. It is to be noted that the scale is far less cramped at the bottom end than is usual with A.C. instruments, the lowest reading that can conveniently be made being about 2 per cent. of full-scale reading, instead of the more usual 10 per cent. of the moving-iron ammeter. It is not, of course, possible to use these meters for high-frequency currents, nor will they read correctly on D.C.; but they can be relied upon between the limits of 25 and 100 cycles.

Burndept transmitters' wavemeter.

Wavemeters.

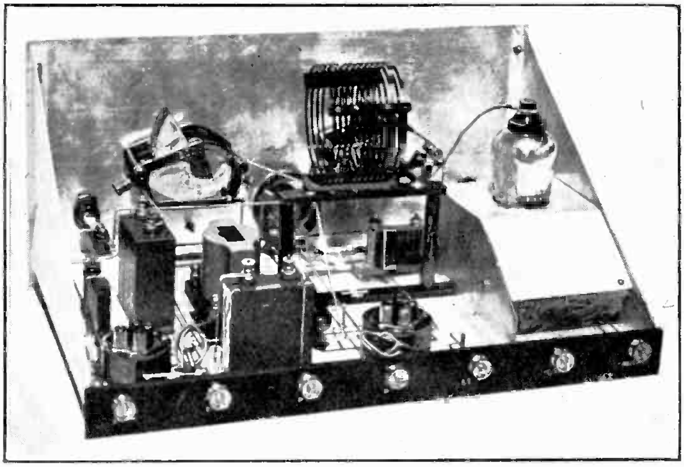
There were several wavemeters on view at Olympia, most of them being of the absorption type. The model made by Messrs. Burndept Wireless (1928), Ltd., was of especial interest to the short-wave transmitter in that a very small band of frequencies is covered by each swing of the condenser, so that a very high accuracy over a limited range is made possible. The permissible limits of working on the 20-metre band, for example, although small, spread over some twenty or thirty degrees of the scale, while the range covered by the whole swing of the condenser is from 20 to 23 metres. The wavemeter is supplied with two coils, one covering the range mentioned, and the other calibrated from 40 to 46 metres. The accuracy claimed is 0.05 per cent., and the price, with one coil, is £3 15s. A tiny Neon tube is incorporated for the purpose of indicating when resonance is reached.

The other wavemeters seen were designed for less specialised work, and consequently each swing of the condenser covered a much greater band of frequencies, giving greater convenience but much less accuracy. The usual ratio of wavelengths obtained, with one coil, at the two ends of the scale was about $3\frac{1}{2}:1$. Both the Bowyer-Lowe and the Igranic wavemeters were designed in this way; the latter is purely an absorption wavemeter, while the former can be used as an absorption wavemeter but is also provided with a buzzer (externally adjustable) for use with a receiving set. Both these instruments are contained in screened boxes, and both are accurate to within 1 per cent. when supplied.



Igranic absorption wavemeter for all wavelengths.

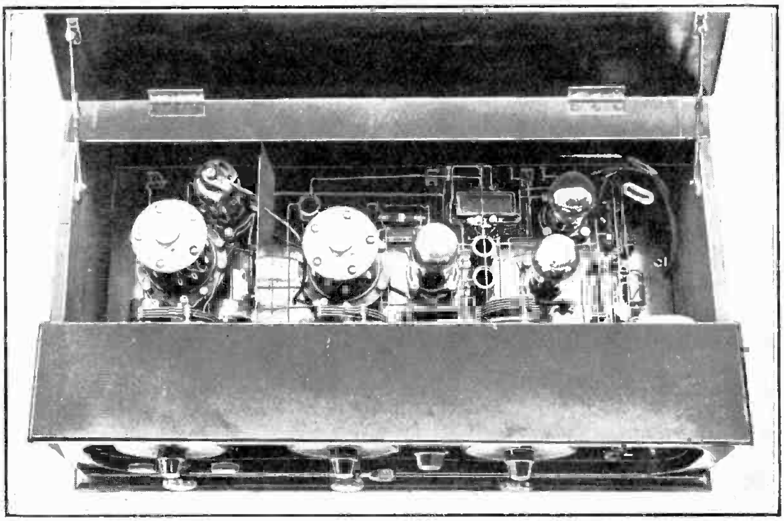
A whole series of wavemeters is offered by Messrs. Dubilier, ranging from a simple buzzer wavemeter with the buzzer connected across the whole coil, and therefore suitable only for approximate work, up to an absorption wavemeter with a Moullin voltmeter connected to it in such a way as to indicate with great exactness the precise setting of the wavemeter that brings it into resonance with the oscillating circuit to which it is coupled. Between these two extremes are to be found a simple absorption wavemeter, using a Neon tube as indicator of resonance, several heterodyne wavemeters, each especially designed for the waveband that it is intended to cover, and a double heterodyne wavemeter. This latter instrument contains, as its name implies, two oscillating valves, and is used where it is desired to obtain beats of known frequency for measurements at audio- or low radio-frequencies. Individual calibration curves are sent out with each instrument, and for an extra charge N.P.L. certificates can be supplied.



The Eddystone "Scientific Short-wave Three," with aperiodic aerial circuit.

In addition to their wavemeters, Messrs. Dubilier have a large range of standard condensers for laboratory work. They offer single fixed condensers guaranteed within 0.1 per cent. of nominal value, banks of fixed condensers with which, by means of switches, a large number of alternative capacities can be obtained, and precision variable condensers, designed for bridge work and similar purposes. For those concerned with the measurement of large radio-frequency currents, there is an ammeter in which condensers are used as shunts, so enabling low-reading instruments to be applied to the measurement of large currents. Since there are certain difficulties in the way of making an instrument for the direct measurement of large radio-frequency currents (see, for example, B.S. Scientific Paper 206) this mode of attacking the problem makes for an increase in accuracy.

The same makers produce two special high-resistance voltmeters, for use on either alternating or direct current, incorporating a diode valve for rectification. These instruments have a resistance of 10,000 ohms per volt, and each covers a large range of voltages.



The Igranic screened-grid neutrodyne for short waves.

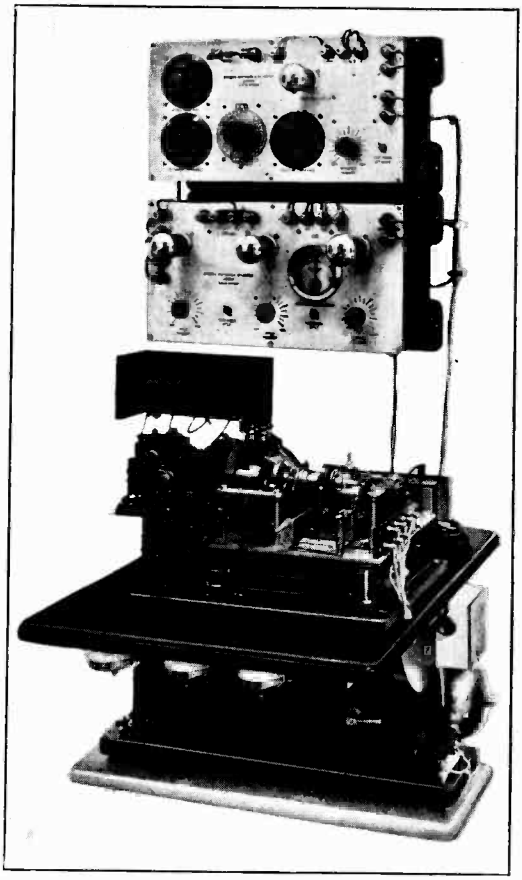
Other Exhibits.

In addition to laboratory instruments, there were a number of exhibits not primarily intended for broadcasting receivers. For example, there were on show a number of power transformers for supplying anode and filament current for public address equipment or gramophone reproducers for theatres and cinemas. Messrs. Partridge & Mee make a full range of such transformers, and express their willingness to design and make any non-standard model for special purposes. Messrs. Marconiphone have also a transformer of this type, and there is now a Marconi full-wave rectifying valve, the U8, suitable for providing the anode current for L.S.5a output valves. A new high-dissipation output valve, known as the L.S.6a, has also made its appearance; it is approximately equivalent to two L.S.5a's in parallel, but uses less filament current and costs only 5s. more than a single L.S.5a. A number of heavy-duty components were also on view on the stand of Messrs. R. I. & Varley, including intervalve low-frequency transformers rated for a primary current up to 15 mA. These are also available as push-pull models, and companion output transformers are also made. Heavy-duty smoothing chokes were in evidence on this stand, these having an effective inductance of 7 or 14 henrys, while carrying a D.C. load of 100 mA. For cases where larger direct currents than this have to be carried, the same makers have a choke of D.C. resistance 240 ohms in which the core has an adjustable air-gap to enable the effective inductance to be brought to the highest figure for each individual set of operating conditions. The figures given for this choke are these :—

No air-gap ; no D.C. ..	40 henrys
No air-gap ; 200 mA. D.C.	15 ,,
Max. air-gap ; no D.C. ..	27 ,,
Max. air-gap ; 200 mA. D.C.	23 ,,

For high-power receivers or small transmitters where the use of the mains is not convenient, it was noticed that nearly all the accumulator-makers were offering small high-tension cells rated at 5 to 10 ampere-hours capacity((1,000-hour rate), and able to withstand discharge-loads up to quarter or half an ampere, at very reasonable prices, ranging from 8s. to 12s. per 10-volt block.

Two novelties in the form of short-wave sets were noticed; one of these, the Igranic Screened-grid Neutrodyne, employs a stage of high-frequency amplification, the small residual capacity of the screened-grid valve being neutralised in the conventional manner. By this means the makers have been able to take advantage of the attractive figures of the screened-grid valve without incurring the oscillation troubles that the residual capacity (very high from the short-wave point of view) would otherwise cause. The amplification claimed for the stage is about three times, or about 50 per cent. greater than that attained in their receiver employing an ordinary valve. The other unconventional short-wave receiver is the Eddystone "Scientific Short-wave Three," in which a screened-grid valve is again used in the



The Siemens auto-alarm, which keeps automatic watch for an alarm signal from vessels in distress.

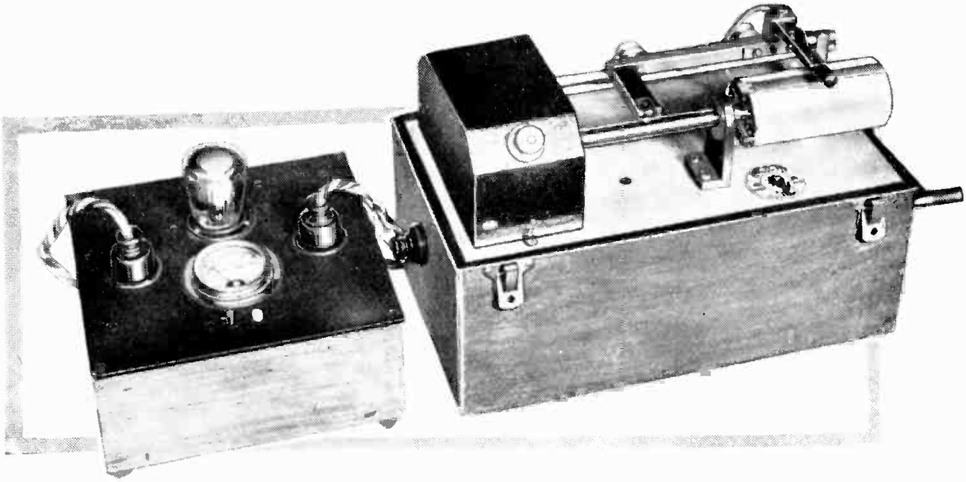
C

high-frequency stage. In this case the grid-circuit of the first valve contains a high-frequency choke in place of a tuned circuit, and it is claimed that amplification is reduced very little by this device, while the ease of handling is very greatly augmented. No definite claim as to the amplification of the stage is made.

Perhaps the most fascinating piece of apparatus in the whole Show was the Auto-Alarm equipment shown on the stand of Messrs. Siemens Brothers. It is intended that this should be installed on ships which carry only one wireless operator, and it provides an automatic watch for the alarm signal (three 4-second dashes, with 1-second spaces) that precedes the S.O.S. The timing in this apparatus is performed by a small synchronous motor, driven by a tuning-fork, and it is normally adjusted to respond to dashes from 3½ to 4½ seconds in length, thereby allowing for the probable excitement of the operator transmitting the alarm signal. The output from a receiving set is applied to the instrument, but it does not respond to any but the pre-arranged signal. On the receipt of this, however, it closes a relay, which is normally used, we understand, to ring bells in the wireless room, the operator's cabin, and on the bridge. Should anything whatever go wrong with the receiver—if a connection breaks, or a valve burns out, for example—the bell rings to draw attention to the fault ; the same thing occurs if the motor in the apparatus stops, or if the power supply either to it or the receiver fails.

We were informed that the equipment has been subjected to an official test, in which a certain number of false calls were permitted in a given time. We forget whether the false calls actually given during this period were one more or one less than half the maximum number permitted ; in any case the test was passed with flying colours. Apparently heavy congestion of traffic, such as occurs especially after the period of idleness enforced by an S.O.S. call, will sometimes give rise to a false alarm, a number of overlapping signals from different transmitters occasionally simulating the three prolonged dashes within the limits of error permitted by the timing of the relays. The Auto-Alarm has not yet been given so human an intelligence that it can separate different transmitters by their note, as does the operator, so that a certain small percentage of false calls is inevitable.

Picture Broadcasting Apparatus.



Complete Fultograph picture receiving equipment, consisting of rectifying panel and clockwork-driven machine with synchronising equipment.

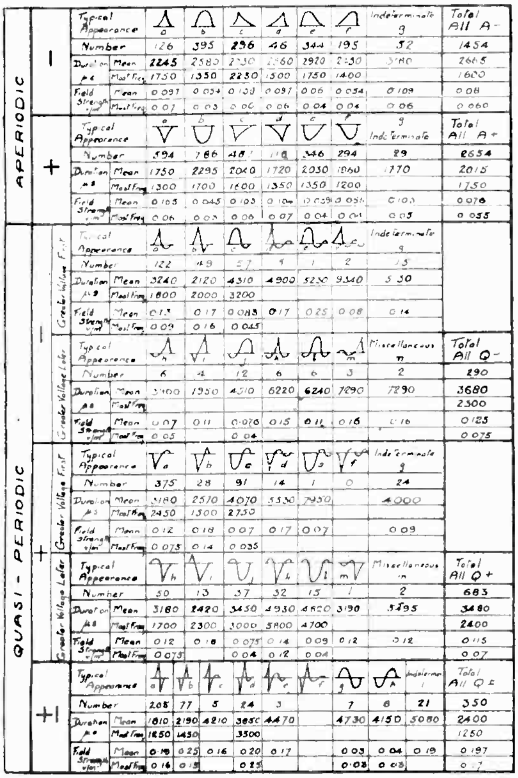
Present State of Knowledge of Atmospherics.

Paper by R. A. Watson Watt, B.Sc., F.Inst.P., A.M.I.E.E., read before Section A of the British Association meeting at Glasgow in Sept., 1928.

Abstract.

PERHAPS the most important paper of technical wireless interest at the recent British Association meeting was that given under the above title by Mr. R. A. Watson Watt, Superintendent of the Radio Research Station of the Department of Scientific and Industrial Research.

The paper reviewed our present knowledge of atmospherics, considering the subject from the point of view of data as regards the atmospherics themselves rather than that of their effects in wireless signalling, and is more concerned with results than with details of experimental methods. The author dealt with work on the waveform of atmospherics (as determined by observations with the cathode ray oscillograph), numerical incidence, directional observations (both by rotating frame aerial and pen recorder, and by cathode ray oscillograph), the intensity of the disturbance, and the range of atmospherics as determined by an extensive broadcast experiment.



APERIODIC −

Typical Appearance		a	b	c	d	e	f	Indeterminate g	Total All A −
Number		126	395	296	46	344	195	52	1454
Duration μs	Mean	2245	2580	2230	2560	2920	2430	3180	2665
	Most Freq.	1750	1350	2250	1500	1750	1400		1600
Field Strength v/m	Mean	0.091	0.054	0.138	0.091	0.06	0.054	0.109	0.08
	Most Freq.	0.07	0.03	0.06	0.06	0.04	0.04	0.06	0.060

APERIODIC +

Typical Appearance		a	b	c	d	e	f	g Indeterminate	Total All A +
Number		594	786	487	118	346	294	29	2654
Duration μs	Mean	1750	2295	2040	1720	2030	1960	1770	2015
	Most Freq.	1300	1700	1600	1350	1350	1200		1750
Field Strength v/m	Mean	0.105	0.045	0.103	0.104	0.059	0.056	0.103	0.076
	Most Freq.	0.06	0.03	0.06	0.07	0.04	0.04	0.05	0.055

QUASI-PERIODIC − Greater Voltage First

Typical Appearance		a	b	c	d	e	f	Indeterminate g
Number		122	49	57	4	1	2	13
Duration μs	Mean	3240	2120	4310	4900	5230	9340	5530
	Most Freq.	1800	2000	3200				
Field Strength v/m	Mean	0.13	0.17	0.083	0.17	0.25	0.08	0.14
	Most Freq.	0.09	0.16	0.045				

QUASI-PERIODIC − Greater Voltage Later

Typical Appearance		h	i	j	k	l	m	Miscellaneous n	Total All Q −
Number		6	4	12	6	6	3	2	290
Duration μs	Mean	3100	1950	4510	6220	6240	7290	7290	3680
	Most Freq.								2300
Field Strength v/m	Mean	0.07	0.11	0.076	0.15	0.11	0.16	0.16	0.125
	Most Freq.	0.05		0.04					0.075

QUASI-PERIODIC + Greater Voltage First

Typical Appearance		a	b	c	d	e	f	Indeterminate g
Number		375	28	91	14	1	0	24
Duration μs	Mean	3180	2510	4070	5530	7950		4000
	Most Freq.	2450	1500	2750				
Field Strength v/m	Mean	0.12	0.18	0.07	0.17	0.07		0.09
	Most Freq.	0.075	0.14	0.035				

QUASI-PERIODIC + Greater Voltage Later

Typical Appearance		h	i	j	k	l	m	Miscellaneous n	Total All Q +
Number		50	13	37	32	15	1	2	683
Duration μs	Mean	3180	2420	3450	4930	4820	3190	5195	3480
	Most Freq.	1700	2300	3000	5800	4700			2400
Field Strength v/m	Mean	0.12	0.18	0.075	0.14	0.09	0.12	0.12	0.115
	Most Freq.	0.075		0.04	0.12	0.04			0.07

QUASI-PERIODIC ±

Typical Appearance		a	b	c	d	e	f	g	h	Indeterminate i	Total All Q ±
Number		208	77	5	24	3		7	8	21	350
Duration μs	Mean	1810	2190	4210	3850	4470		4730	4150	5080	2400
	Most Freq.	1850	1450		3500						1250
Field Strength v/m	Mean	0.19	0.25	0.16	0.20	0.17		0.03	0.04	0.19	0.197
	Most Freq.	0.16	0.15		0.25			0.08	0.08		0.17

Fig. 1.

Waveform of Atmospherics.

In connection with the work on waveform a slide, here reproduced as Fig. 1, shows the characteristic shapes and magnitudes of a sample group of 8,000 atmospherics delineated in South-east England in autumn. Fig. 2 gives scale drawings of the most frequently occurring classes, and indicates their percentage frequency, while Figs. 3 and 4 respectively give similar results for Khartoum (observations in the month of April), and Western Australia (observations in March).

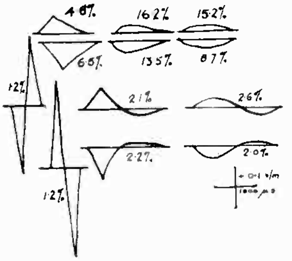


Fig. 2.—*England.*

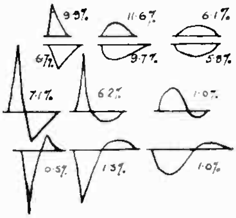


Fig. 3—*Sudan.*

Mean waveforms of main types of atmospherics.

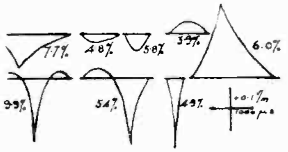


Fig. 4.—*Australia.*

The majority appear sensibly aperiodic—*i.e.*, no reverse field reaching 4 millivolts-per-metre occurred with a period comparable to some small multiple of the time occupied by the main field change. It is not yet clear whether these aperiodic forms are due to a wide separation in time between the period of strong acceleration and that of deceleration in the original discharge, or to selective dissipation.

Although the data are not adequate for a general survey of the geographical and seasonal variations of the characteristic waveform, the information available indicates that the mean peak field-strengths fall off with increasing latitude, while the mean duration of individual atmospherics normally increases with latitude. The mean rate of change of field—on which the interferent power of the atmospheric largely depends—therefore increases very steeply with decrease of latitude, There is a suggestion from the data that the negative aperiodic form is more universal in character than are any of the other main classes.

As regards the effects of such relatively slow field changes in producing the interference actually experienced in wireless signalling, it is pointed out that while the steep initial slopes shown would suffice to produce considerable E.M.F.'s in receiving apparatus, further explanation is to be found in the fine structure superposed on these fundamental forms. This is particularly so in the tropics and in the dark hours. Examples were given by slides of such forms taken at Khartoum, one of which is given in Fig. 5. In two cases taken at random, these ripples showed a 4,000-metre wavelength, and a field strength of 10 millivolts-per-metre—some 4,000 times as great as would be required for wireless signals.

Numerical Incidence of Atmospherics.

The circuits used for waveform delineations were also convenient, with very slight modification, for determination of the relative frequency of occurrence of atmospherics having peak field-strengths between specified limits. Fig. 6 shows the numbers of atmospherics per minute which passed amplitude limits up to 500 m.v./m. at Aldershot, Helwan and Khartoum. As an adequate first approximation, a law of the form $NE^2 = a$ constant is suggested by the author.

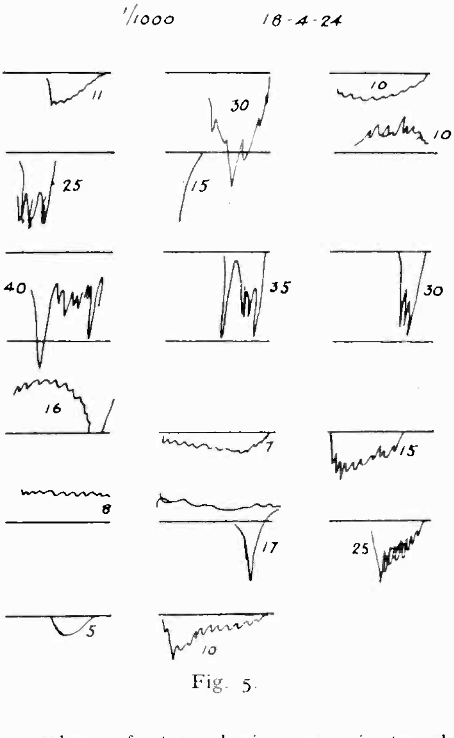


Fig. 5.

By a further modification of the same apparatus it was possible to determine the relative frequency of peaks so small as to be just over the limits of perception in the method used. This was first done in tropical waters (in conjunction with officers of H.M. Signal School), and the results, although then alarming, were found to be consistent with a large number of similar counts made at land stations. As examples, average numbers at Helwan (Egypt) were approximately 100 per second at 0800 G.C.T., 250 at 1800, and 200 at 2000. At Khartoum these numbers were almost always exceeded and counts up to 1,200 and 1,500 per second were not infrequent in the dark hours.

Combination of data on frequency of incidence and of the durations of individual impulses show that in the dark hours in the tropics it is a very rare occasion when no considerable voltage from atmospherics exists in the aerial. These observations explain the acute disturbance experienced in the tropics and the complete inadequacy of anti-atmospheric devices suggested in the past.

Directional Observations.

The directional work described in the paper is of considerable importance in correlating areas of atmospheric production with meteorology.

After preliminary work by aural methods on the mean direction of arriving atmospherics, pen-writing recorders were designed to supply more complete data of this nature.[†] A solid diagram showing the mean hourly duration of atmospherics at Aboukir for each month of a three-years' period was exhibited at the reading of the paper. This model shows that throughout the year a predominant stream is arriving from nearly south at noon G.C.T. This swings westwards throughout the afternoon, the swing being greatest near the autumnal equinox and least near the vernal equinox. This westward swing diminishes about 1700 G.C.T. when atmospherics from the North-east begin to predominate, these becoming more northerly until near noon, when the southern stream becomes most important. The swing of the Northerly stream is greatest near the spring equinox, and is not traceable in the records near the autumn equinox.

From simultaneous plotting of observations from all the recorder stations, a world map of travel of the chief atmospheric sources was prepared and exhibited at the reading of the paper. The predominant source normally lies in a summer afternoon or evening, so that the cum-solar travel, previously inferred by various workers, is substantiated and amplified by the more complete data given here. The inactivity of the Pacific Ocean, and the activity of mountainous regions as atmospheric-producing areas are also shown in the map.

While the recorders referred to deal with average values, observations on the direction of arrival of individual atmospherics have become possible by the use of the cathode-ray oscillograph. The principle of this arrangement has already been described.[*]

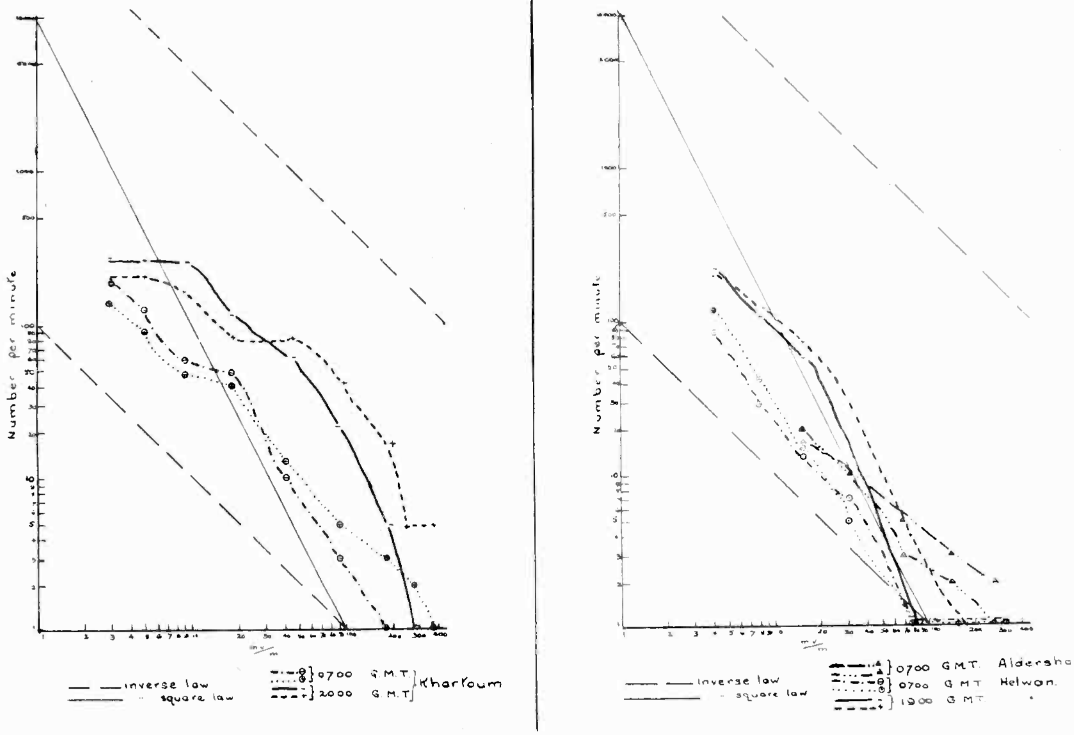
[†] See *E.W. & W.E.*, April, 1926.

[*] See *E.W. & W.E.*, April, 1926.

A very complete test of the method was recently made possible by collaboration with the Post Office during the summer of 1927, when apparatus was installed at the Radio Research Station (Ditton Park, Slough) and at the P.O. Radio Station at Cupar, Fifeshire. The observers were in direct telephonic communication with each other, so that practically complete certainty was attained as to the identity of the particular atmospheric whose direction was observed at each end of this base line. A number of slides were exhibited showing the distribution of places of origin on various days in June and July, 1927.

On the whole it is concluded that the picture of thunderstorm activity given by the maps shown at the lecture—yielded each by approximately 30 minutes total time of two observers—is of an adequacy comparable to that given by the daily weather reports.

From some of the measurements it is deduced that the peak field strength of the atmospheric component at 10 kc. (to which the frame aerials were tuned) received from thunderstorms 3,000 to 5,000 kilometres distant, is approximately inversely proportional to distance, but further subject to strong diurnal variation due to attenuation.



No of Atmospherics per minute of Field Strengths shown.
Aldershot, Helwan, Khartoum.

Fig. 6.

Intensity of Disturbance.

Curves of the integrated intensity of the disturbance at each hour of the day from the directional pen-writing recorder at Aldershot for the years 1922 to 1924, are shown in Fig. 7. These reveal a principal maximum about midnight and a principal minimum between 10 a.m. and noon local time. A secondary minimum becomes prominent about 14 hours in summer, but fails to appear in midwinter. The main deductions from the intensity curves are shown to be in good agreement with the world map distribution already described.

The Range of Atmospherics.

An interesting test of this subject was organised by the Royal Meteorological Society, with a group of observers distributed throughout Western

Europe, North Africa and Madeira. By the co-operation of the B.B.C., advance typescript copies of talks to be broadcast were supplied for circulation to the observers. At the time of the actual broadcast the observers marked the syllables and spaces overlaid by atmospherics, returning the marked typescript to a centre for analysis and reduction. An example of the results (shown in a slide at the reading of the paper) reveals that the streams of atmospherics are not peculiar to each station, coinciding only at random moments, but that a single disturbance makes itself felt over the greater part of the observing network at once. Check bearings were also taken at the Radio Research Station on the individual atmospherics disturbing the broadcast talks, and found to pass through sources as indicated by joint recorder location. It could thus be concluded that the atmospherics disturbing the broadcast had proceeded from these sources. The results gave sources on many of these occasions at great distances.

The French belief in the short range of atmospherics has been encouraged by apparent matching of curves of atmospheric strength and of wind velocity at the same place. A comparison made between the French atmospherics record and one at the Radio Research Station showed that the time of incidence of the chief features agreed within the accuracy of measurement of the two systems more closely than did the features of the French atmospheric of wind records.

Terrestrial Magnetism Influences.

Comparison of the atmospherics record on a long wave intensity recorder against that of magnetic elements on the occasion of a very severe magnetic storm in 1926, showed that when the vertical component of the earth's field assumed high values, the atmospheric disturbance rose to some four times normal. This type of effect must be investigated more fully as the quantitative recording of atmospherics proceeds.

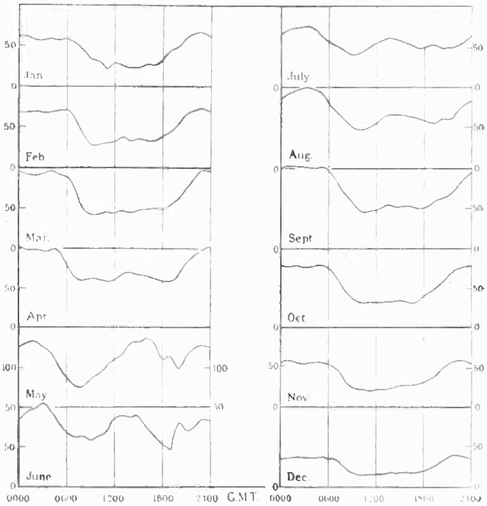
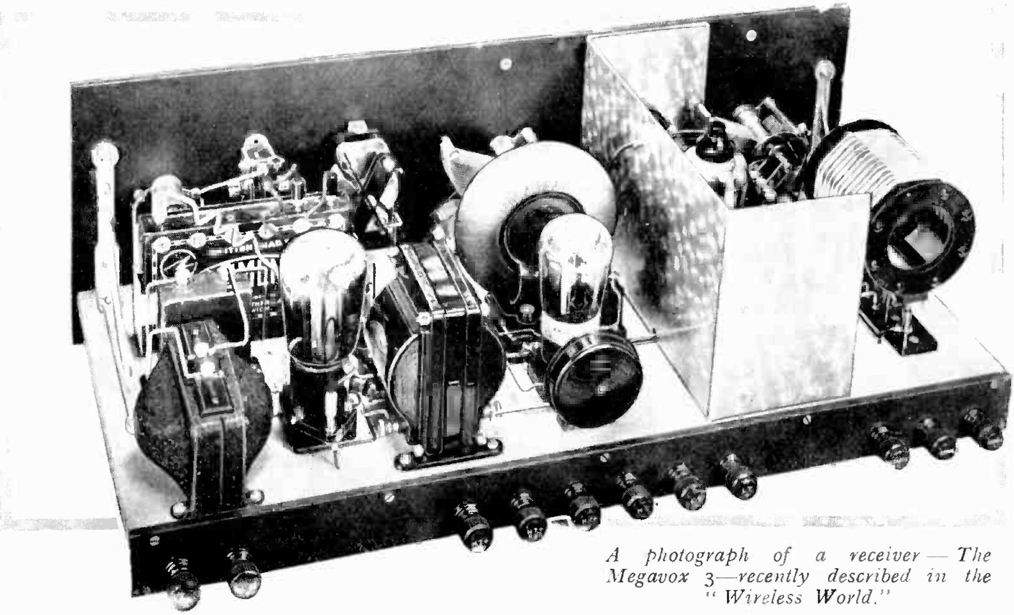


Fig. 7.—*Diurnal variation of intensity.*

A New Screened Grid and Pentode Receiver.



A photograph of a receiver — The Megavox 3—recently described in the "Wireless World."

A Method of Calibrating a Low Frequency Valve Generator with a Single Frequency Standard Source.

By T. S. Rangachari, M.A.

(Indian Institute of Science, Bangalore, India.)

A NUMBER of articles have appeared in wireless journals dealing with the construction of a valve-generator for audible frequencies, but methods of calibration have been rarely described. A fairly well-known method of calibration is that of comparison with the fundamental and harmonics of a standard valve-maintained tuning fork. In the application of this method it is necessary that the audio-generator must be capable of continuous variation of frequency so that it may be tuned to the harmonics of the fork for comparison (see for example Sylvan Harris, *Proc. Inst. of Rad. Eng.*, 1926, 14, p.213). The frequency for any given setting of the audio-generator is then read off from a calibration graph. In many cases where an audio-frequency generator is required it is superfluous to make it continuously variable. In many physical science laboratories, for instance, it is enough if the source is variable in steps by varying the tuning condenser in blocks. In such a case the problem of calibration becomes that of determining accurately the frequency of the generator at a given setting by means of a given standard valve-maintained tuning fork. The above method of comparison with selected harmonics of the fork now fails since one can no longer tune the audio-frequency generator continuously. Below is given a method which makes it possible to compare the frequency of the audio-generator at any setting of its condenser with that of the fundamental of a standard valve-maintained tuning fork.

Principle of the Method.

The principle of the method may be explained with reference to Fig. 1, which shows a non-inductive variable resistance R and an inductive coil L, whose resistance is R_L arranged in series. The procedure is as follows: Apply at AB the output from the tuning fork source whose frequency f_1 is known. Adjust R till the voltage drop V_1 across R equals the drop V_2 across the coil with the help of a thermionic voltmeter. The thermionic voltmeter is arranged such that it does not apply any load when connected either to the resistance or to the inductance. Note the value R_1 of the variable resistance required to balance the voltage drop across L.

Then $$R_1^2 = (2\pi f_1 L)^2 + R_L^2 \quad .. \quad (1)$$

Now apply the output from the generator. Let its frequency which is unknown and which is to be determined be f_2. Adjust the resistance R till balance is secured. Let R_2 be the resistance required for balance.

Then $$R_2^2 = (2\pi f_2 L)^2 + R_L^2 \quad .. \quad (2)$$

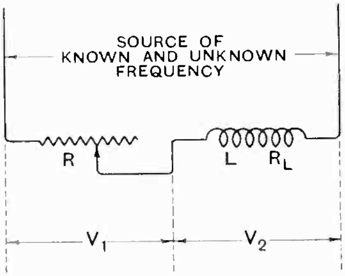


Fig. 1.

From (1) and (2)

$$\frac{R_1^2 - R_L^2}{R_2^2 - R_L^2} = \frac{f_1^2}{f_2^2}$$

or $$f_2 = f_1 \times \sqrt{\left[\frac{R_2^2 - R_L^2}{R_1^2 - R_L^2}\right]} \quad .. \quad (3)$$

All the terms on the right-hand side of the equation (3) are known. Hence f_2 is determined.

Practical Considerations.

In practice, R is made to be of the order of a few thousand ohms by suitably choosing the value of L. R_L, which is the D.C. resistance of the inductance coil is of the order of tens of ohms, so that any slight error in the determination of R_L does not affect the result appreciably.

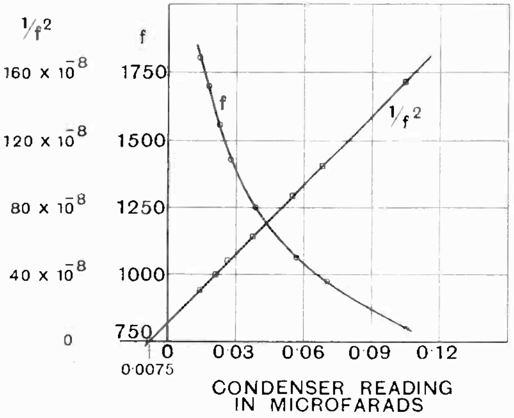


Fig. 2.

The thermionic voltmeter is of the anode bend type with negative grid bias, so that it does not apply any load when connected to the circuit. It is necessary that it should be arranged to be sensitive, but it need not be calibrated since this is a balance method. The thermionic voltmeter used in this method had a unipivot galvanometer, whose figure of merit was 4 divisions per microampere, in the anode circuit, the D.C. being balanced by a potentiometer. A calibration with A.C. showed a deflection of about 40 scale divisions per 0.15 volt R.M.S., provided the applied voltage is greater than 0.3 volt R.M.S.

The sensitivity of this method may be illustrated by the following data for an actual case. Using a standard valve-maintained tuning fork of 800 cycles per second, a resistance (R_1) of 3,035 ohms was found necessary to balance the voltage drop across the inductance coil. Since the impedance of L at 800 cycles per second is thus about 3,035 ohms, it can be calculated that it changes by nearly 4 ohms per cycle change of frequency. Now, a change of 4 ohms in R was found to alter the deflection by 4 divisions. This deflection depends both on the sensitivity of the thermionic voltmeter and on the input power, and can be increased by increasing both. Thus the arrangement could be adjusted for balance to an accuracy sufficient for many purposes.

Some Results.

This method was adopted to calibrate a valve generator from 300 cycles per second to 3,000 cycles per second, from which the following result is taken. The valve generator consisted of a master oscillator and a power amplifier, but the method can be applied to any type of generator. Table I shows the frequency of the generator thus determined at the various settings of its condenser. Fig. 2 shows the calibration curve, as also the relation between the condenser setting (C) of the generator and the reciprocal of the square of the frequency $\left(\frac{1}{f^2}\right)$, which is nearly a straight line, whose intercept on the condenser axis gives the self-capacity C_0 of the oscillator coil. As a check, the ratio $\frac{1}{f^2} \div (C_0+C)$ is calculated and given in the last column of Table I and is found to be fairly constant.

TABLE I.

Oscillator Condenser C Microfarad.	Frequency f Cycles per Second.	$\frac{1}{f^2} \div (C_0+C)$.
.1065	800	13.71×10^{-6}
.0710	969	13.57×10^{-6}
.0570	1,065	13.67×10^{-6}
.0380	1,263	13.78×10^{-6}
.0285	1,423	13.72×10^{-6}
.0225	1,564	13.63×10^{-6}
.0180	1,697	13.61×10^{-6}
.0150	1,800	13.73×10^{-6}

One advantage of this method of calibration is that there is no necessity to calibrate the condensers in the oscillator at all. For, whatever might be the true value of the condenser, the frequency is exactly determined at its face value. A sufficiently large number of settings could be thus calibrated and so there is no need for extrapolation.

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.

The Transmitting Station actually sends out Waves of one definite frequency but of varying amplitude.

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

SIR,—In the August number of *E.W. & W.E.*, Professor Howe in his editorial states: "The transmitting station actually sends out waves of one definite frequency but of varying amplitude," and goes on to state that, "such a modulated wave has the same effect on the *receiver** as waves of constant amplitude, but of varying frequency." For this reason receivers have to be designed to accommodate a band of frequencies.

From the way it is put I suspect Professor Howe is amusing himself by creating a controversial point, and although he may be able to justify such a statement, it is worded in such a way as to cause confusion in minds less agile than his own, and the statement as a whole is very open to criticism.

To commence with, one gathers that we have an irreversible effect, namely, a single wave radiated, giving rise to the effect of a spectrum at the receiver, in which case the characteristic of the transmitter would only need to be capable of accommodating a single frequency. But the spectrum effect is in evidence just so soon as modulation is impressed and hence the high frequency system of the transmitter, no less than the receiver, must be capable of accommodating the required band of frequencies. This is a point often overlooked, probably because of this method of visualising a modulated wave.

One of the difficulties of transmitting broadcast modulation on the longer wavelengths is because the aerial characteristic is not able to take in the wide band of frequencies involved, and hence artificial damping has to be added to make it possible.

A further impression one gets from Professor Howe's statement is that a modulated wave has only the *effect* of a spectrum and that the individual frequencies are intangible. But they are very real, and with the help of a very selective receiver, such as is used for commercial service C.W. work, it is easily possible to isolate any desired frequency from a modulated signal. Further, by the same selective receiver, one can prove that none of these individual frequencies varies in amplitude.

Further evidence of the existence of a spectrum is found in very short wave propagation. One gets selective absorption of certain waves due to the wave frequency coinciding with the collision period of ions in the upper layer and a modulated wave suffers severe distortion because groups of frequencies are "dropped out" during the passage of the wave. In fact, we have such concrete evidence in practice that a modulated wave does *not* consist of a single frequency but a band of frequencies, that it would appear more logical to talk of it as such. That is to say, think of modulation not as varying the amplitude of the original carrier wave (which it does not do), but as giving rise to a new group of frequencies, the whole forming a spectrum.

The heterodyning of these waves certainly forms a synthesis wave whose envelope conforms to the modulating waveform, but the pictorial conception of this wave does not assist our knowledge of what is happening.

It is agreed, I think, that whether one talks about the synthesis wave or the spectrum one means the same thing, and no doubt the theory of modulation could be argued out on an amplitude instead of a frequency basis. But surely one ought to be consistent, and having adopted the idea of the frequency band as being easier of solution stick to it, and give up the idea of a modulated wave as a single frequency varying in amplitude. Anyway, certainly not talk of a single frequency being radiated and a group being received.

A. W. LADNER.

Danbury, Essex.

[We would point out that Mr. Ladner misquotes us; we did not say that "such a modulated wave has the same effect on the receiver as waves of constant amplitude, but of varying frequency." What we said was, "as waves of constant amplitude but of different frequencies." But apart from this, we are quite impenitent. Imagine a being endowed with such powers that he could actually see the electric current rushing up and down the transmitting aerial at 2LO; what would he see? He would see an alternating current of which each pulse or alternation occupied the same time to a high degree of accuracy, or in other words, the number of alternations per second would be unchanging. He would notice, however, that the magnitude of the current differed from pulse to pulse. Surely he would say that it was a current of one definite frequency but of varying amplitude. To arrive at any other conclusion our imaginary being would have to be endowed with the powers of a harmonic analyser. The upper atmosphere and a tuned circuit behave as they do because they possess this analytic power.—G.W.O.H.]

Short-wave Fading.

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

SIR,—I was very interested to read the short article by Mr. T. S. Rangachari from Bangalore, India, on the subject of short-wave fading, in which he gives illustrations of both slow and rapid fading from the Dutch station, PCJJ, on 30.2 metres.

I have made careful observation on the European and Australian short-wave broadcasting stations, during the last nine months in Canada, and from the re-broadcasting standpoint, the major trouble would appear to be due to independent fading of

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* The italics are mine.—A.W.L.

the carrier wave and the side bands. Regular fading, such as Mr. Rangachari mentions, can, to a certain extent, be looked after, but I would be very interested to hear of any possible solution to the side band fading, which we have encountered here, and which tends to show no regular characteristics.

Toronto, P. H. Dorté,
17th Sept., 1928. Chief Engineer,
Trans-Canada Broadcasting Co.

Polar Diagrams Due to Plane Aerial Reflector Systems.

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

Sir,—There are two points on which I should like to comment in the article "Polar Diagrams Due to Plane Aerial Reflector Systems" in your October issue.

(1) The polar diagrams of Figs. 5 and 6 appear to show that the field strength in the direction $\psi = 90$ deg. has a value about two-thirds of the maximum value in the horizontal plane. Now $\psi = 90$ deg. is the end on direction for all the wires of the system, and I have always understood that the radiation from a wire in that direction was zero, and should therefore be zero for the whole system. The original expression given for the field strength contains a term cos $\frac{(\beta \cos \psi),}{\sin \psi}$ which appears later as cos $\frac{(\beta \sin \psi)}{\cos \psi}$. This may be a printer's error, or it may account for the result. If however the value of the radiation shown in the direction $\psi = 90$ deg. is correct, a direct physical explanation would be interesting.

(2) The three-quarter wave aerial chosen as an example is one which gives the maximum radiation at a high angle, and the reflector at $\frac{1}{4}\lambda$ spacing is only correct for aerials giving the maximum radiation horizontally ($\psi = 0$). In the vertical plane, the more sharply directional horizontally the aerial is the more effective such a reflector system will be. The system can be made thus sharply directional by making each aerial a wavelength or more in height, whilst arranging that all the radiating parts of the aerial are oscillating in the same phase. For an aerial 2λ high neglecting the effect of the earth (or 1λ high assuming a perfectly conducting earth) the theoretical maximum value of the field strength of the back radiation is about 5 per cent. of that for the maximum forward radiation. This is a much smaller value than that shown in Fig. 5. Greater heights of aerial and reflector system would reduce it still further.

E. Green.

Chelmsford.
October 1st, 1928.

Sir,—I have to thank Mr. Green for pointing out the clerical error in the cosine term. The correct expression is that used in computing the polar diagram, namely

$$\frac{\cos(\beta \sin \psi)}{\cos \psi}$$

With regard to the radiation at angles of 90 deg., I must concede that further consideration is needed in this matter. It is quite possible that some confusion has arisen in evaluating the products and quotients of sine and cosine terms as ψ approaches 90 deg. and an expression $\frac{0}{0}$ is obtained. I am inclined to admit that an error has been made. The main purpose of the article, however, was to show that even under the usual conditions of correct phrasing and amplitude of reflector current, the assumption so frequently made by Radio Engineers who have not given the matter detailed consideration that a reflector cuts off back radiation at all angles with the horizontal, is far from correct.

I agree with the main contention contained in the second part of Mr. Green's letter that low angle back radiation is almost completely suppressed by the ideal reflector. This at once follows from the application of the reflector multiplying factor $\sqrt{2(1 \div \cos \theta)}$, or its more convenient form $\frac{2 \cos \theta.}{2}$ The practical reflector, however, is far from ideal. Moreover, high angle radiation from an aerial such as Mr. Green mentions is not negligible.

T. Walmsley.

Ealing, W.5.

Output Measurements on a M/C Speaker.

Sir,—We wish to thank Dr. McLachlan for his letter in the October issue, and are pleased to note that he has found similar diaphragm resonances to those found by us. We must confess, however, that with the exception of the article in the *Wireless World* of 8th August, when, of course, our contribution was in the Editor's hands, we have been unable to find reference to the theoretical or practical effects of elasticity in the diaphragm or supports.

In the equivalent circuit, Fig. 10g, as pointed out, the reactance in the loud speaker circuit is admittedly drawn as a coil and may admittedly prove misleading, but, of course, is actually a complex reactance varying with frequency, as stated elsewhere in the text.

We were unable in this particular case to trace any resonances other than the main one, and do not believe that this was due to frequency gaps in the curves, since the change in impedance was carefully followed on the bridge, and readings were taken wherever rapid alteration took place.

In regard to the value of the motional impedance, it is hoped that more work will shortly be done on this and confirming or disproving results will be available.

We agree with the remarks that great care must be taken for suitable clamping at the high frequencies.

N. R. Bligh,
H. A. Clark.

London.

ERRATUM.

In the letter signed by Dr. N. W. McLachlan in the October number, the reference to "*a fifth*" should have read "*one half*."

Abstracts and References.

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PROPAGATION OF WAVES.

Über die Bestimmung des Günstigsten Ausstrahlwinkels bei Horizontalen Antennen (Determination of the optimum projection angle for horizontal aerials).—Meissner and Rothe. (*Elektrot. u. Masch : bau, Radio Supp.*, No. 9, 1928, pp. 81–83.)

Describes tests with a parabolic reflector, rotatable about a horizontal axis, using wavelengths of 20 and 15 metres. The author concludes that such constructionally difficult reflectors can be dispensed with, since the most effective projection is nearly parallel to the earth, and this can be accomplished more simply by horizontal aerials and reflectors. For previous papers see Abstract for January and February.

Über das Verhalten der Radiotelegraphischen Wellen in der Umgebung des Gegenpunktes der Antenne und Über die Analogie zu den Poissonschen Beugungserschienungen (The behaviour of radiotelegraphic waves in the neighbourhood of the antipodal point of the antenna, and the analogy to the Poisson diffraction effect).—J. Gratsialos. (*Ann. d. Physik*, 16th August, 1928, V. 86, pp. 1041–1061.)

The author's mathematical development (prompted by Sommerfeld) leads to the conclusion that at the antipodal point there must be a concentration of electromagnetic energy. This result is compared with the Poisson diffraction effect, and a great similarity found. No attention is paid to the Heaviside Layer.

L'État Magnétique de la Terre (The Earth's Magnetic Condition).—J. Granier. (*Q.S.T. Franç.*, September, 1928, pp. 43–46.)

A short survey of present ideas and methods of research on terrestial magnetism and telluric currents, both of which have—as the author points out—a certain influence on the propagation of e.m. waves.

Concerning Lunar Effects on Electromagnetic Waves.—Greenleaf Pickard. (*Q.S.T.*, Aug., 1928, V. 12, p. 20.)

The author criticises a recent article (*ibid.*, June, 1928, p. 33) in which C. E. Paulson deduces, from observations (over one month only) on the evening strength of 32.77 m. signals, that the plane-polarised rays of moonlight have an effect on the propagation of radio waves. He shows that Paulson's curves (showing minimum strength at new moon and maximum at full) can be correlated with sun-spot and magnetic field variations, and points out that full moonlight has less than one hundred thousandth the intensity of sunlight and is in addition only feebly polarised. He also mentions that he personally would require at least two years' reception data (instead of one month's) before deciding that a lunar effect existed.

The Propagation of Schrödinger Waves in a Uniform Field of Force.—G. Breit. (*Phys. Review*, August, 1928, V. 32, pp. 273–276.)

Author's abstract : The phase difference between a Schrödinger wave refracted by a uniform field of force and the primary wave is calculated. . . As the wave length increases, the phase difference decreases, reaches a minimum and then increases again. It is suggested that the intensity of some crystal reflections should vary anomalously as a result.

Fading on Short Waves at Long Distances.—E. Gherzi. (*Q.S.T.*, June, 1928, V. 12, pp. 31–32.)

Conclusions based on 12 months' observations near Shanghai on wavelengths from 20 to 100 metres over distances varying from 800 to 10,000 km. Over the long distances, periodic fading ("twinkling") was always noticed, the period being of the order of 10 seconds. The writer attributes this to oscillations of the lower layers of the atmosphere, depending for period on thickness, density and mean temperature. Observations on the vortex period of typhoons lead him to conclude that the oscillation period of the entire troposphere is not far from this value of 10 seconds.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

Die Erhaltung der Erdladung durch den Blitzstrom (The Maintenance of the Earth's Charge by Lightning Currents).—A. Wigand. (*Phys. Zeitschr.*, V. 28, pp. 65, 211, 260, 261.)

The writer estimates the average quantity of electricity in a flash as about 50 coulombs. There are about 100 flashes per second for the whole earth (according to Brooks' estimate). He considers that the proportion of these in the right direction is just about enough to maintain the earth's charge in face of the 1,400 A. vertical conduction current.

Wirkung Eines Blitzschlages (The Effect of a Lightning-stroke).—F. Janetzky. (*E.T.Z.*, 13th September, 1928, p. 1376.)

Referring to Binder's article (*see* July Abstracts) the writer describes the destructive effect of a stroke on a certain lightning conductor, made of copper 6.5 mm. in diameter.

A New Arrangement for showing the Diurnal Variation in the Intensity of the Earth's Surface Charge at a Given Place.—F. Sanford. (*Science*, 20th July, 1928, V. 68, p. 64.)

Electrometer records during seven years have shown both a solar and a lunar diurnal variation varying with the seasons (much greater at equinoxes than at solstices) which is not due to temperature, illumination or atmospheric pressure and which is sometimes greatly disturbed by solar activity and by auroras. The author has attributed this variation to the inductive effect of the electric charges of sun and moon upon the earth's charge, but other workers have contested this and attributed the effect to other causes, the most plausible explanation being that it is somehow due to a diurnal variation in atmospheric conductivity, due to penetrating radiations or other causes. The author now quotes new tests to prove that the variations are entirely independent of atmospheric conductivity, that they are of electrostatic nature, and that (since the solar effect is several times as great as the lunar) they are not due to gravitational tides.

RADIO RECEPTION AND NORTHERN LIGHTS. (*Science*, 20th July, 1928, V. 68, p. x.)

A paragraph based on a report by F. P. Ubrich summarising the results of five years' observations in Alaska, which says: " . . . in general, the condition of the earth's magnetic field is no index of the quality of radio reception." The aurora occurs in greatest brilliancy on magnetically disturbed days, but " observations seem to indicate that good radio reception is very much more apt to occur than poor reception, during a bright or faint aurora."

SUR L'ORAGE MAGNÉTIQUE DU 7 AU 8 JUILLET, 1928 (The Magnetic Storm of 7–8th July, 1928).—Ch. Maurain. (*L'Onde Élec.*, August, 1928, pp. 363–364.)

Some magnetic records and details of this storm, described as the most violent for several years.

ZUR FRAGE DER PERIODIZITÄT DER SEISMISCHEN UND VULKANISCHEN ERSCHEINUNGEN (The periodicity of seismic and volcanic phenomena).—W. B. Schostakowitsch. (*Abstract in Phys. Berichte*, 15th August, 1928, p. 1589.)

A correlation between earthquakes and sunspot activity.

PROGRESSIVE LIGHTNING.—C. V. Boys. (*Nature*, 1st September, 1928, V. 122, pp. 310–311.)

A pair of photographic lenses carried on a rapidly revolving disc gave photographic records of a weak flash, showing that the flash started at the ground, and almost immediately after started also in the length next the cloud. The flash then travelled from both these parts and finished in the middle about 1/7,000th sec. later. The author gives this result, obtained with his comparatively slowly moving pioneer apparatus, as an indication of the possibilities of the method of oppositely moving images.

SOME RECENT WORK ON THE LIGHT OF THE NIGHT SKY (Part I).—Rayleigh. (*Nature*, 1st and 8th September, 1928, V. 122, pp. 315–317 and 351–352.)

THE AURORA AND ITS SPECTRUM.—J. C. McLennan. (*Proc. Roy. Soc.*, September, 1928, V. 120A, pp. 327–357.)

This Bakerian Lecture forms a survey of our present knowledge, based on the already published work of various workers, including the author, and on recent work of the latter. The identity of the oxygen green line with the green line of the aurora was finally established by McLennan and McLeod in 1927. It would appear that to account for all the features of the spectrum of the polar aurora that are known and understood, a 20-volt excitation of molecular nitrogen and of molecular oxygen would suffice, if applied occasionally and at irregular intervals.

The ever-present green light from the night sky may, like this aurora, be due to electrons emitted by the sun, or may be due to electrons from some other source; but it is more likely in this case that the atoms of oxygen are excited to emit the auroral green light by ultra-violet radiation of short wavelength which must be emitted by the sun, but which cannot penetrate the denser lower layers of the atmosphere. The author's recent investigation on the Zeeman effect of the green line is summarised and conclusions drawn. Recent observations by him and his associates appear to show definitely that there is a gradual increase in the intensity of the auroral light from the zenith of the clear night sky from sunset to about 1½ hours after midnight, after which it decreases until sunrise. He suggests that it will be interesting to see if any connection can be established between these variations and the daily variations known to occur in the state of ionisation of the upper atmosphere; and between height and thickness of the ozone layer and the intensity of the night sky radiation.

NOTES ON APERIODIC AMPLIFICATION AND APPLICATION TO THE STUDY OF ATMOSPHERICS.—A. Hund. (*See under* Properties of Circuits.)

PROPERTIES OF CIRCUITS.

THE EFFECT OF REGENERATION ON THE RECEIVED SIGNAL STRENGTH.—Van der Pol. (*Proc. Inst. Rad. Eng.*, August, 1928, V. 16, pp. 1045–1052.)

This paper gives a theory of the effect of regeneration, using the solution of a non-linear differential equation. It is shown that (*a*) as a first approximation, detection has no effect on the radio-frequency grid voltage developed under the influence of an incoming signal; (*b*) the amplification obtained through regeneration equals the two-thirds power of the ratio of " grid-space " to the amplitude obtained with zero regeneration; " grid-space " being the grid-voltage change necessary to bring the anode current from zero to its saturation value. It is apparent from (*b*) that much greater gain is obtained, through regeneration, with weak signals than with strong. The theory is verified by tests on a circuit operating at 500 cycles p.s., the applicability of the results being proved by the following theorem: " if a model is made of a H.F. system consisting of linear inductances and capacities and non-linear resistances (*e.g.* triodes) and if the values of all the inductances (self and mutual) and capacities in the model are made n times these values in the original H.F. system, but if the resistances (linear and non-linear) in the model are made equal to those in the original circuit, then the currents and potentials occurring in this model will be exactly equal in magnitude to those in the original H.F. system, but—considered as a function of the time—they will vary n times more slowly."

Parallel Resonance and Anti-Resonance.—W. J. Seeley. (*Journ. Am.I.E.E.*, September, 1928, V. 47, pp. 662–665.)

By parallel resonance is meant that condition existing among the elements of a parallel circuit which makes the resulting reactance or susceptance equal to zero; by anti-resonance, the condition of maximum impedance. The paper investigates the relations between the two conditions, which for a series circuit are identical but for a parallel circuit only under certain conditions. It is concluded that at radio frequencies, for resistances below 100 ohms, the two conditions are identical when resistance or capacity are the variables, and practically identical when inductance is the variable.

At low frequencies, the conditions are not identical except when capacity is the variable. The larger the ratio of L to C, the nearer they approach identity. At radio frequencies, the values of the impedances are nearly alike for ω, L or C as variables, but at lower frequencies they are quite different.

Effect of the Antenna in Tuning Radio Receivers and Methods of Compensating for It.—Sylvan Harris. (*Proc. Inst. Rad. Eng.*, August, 1928, V. 16, pp. 1079–1088.)

The reflected effect of the primary circuit of a tuned transformer, or of the aerial circuit of a receiver, upon the secondary coupled to it, is discussed. Equations are given for determining the apparent change of inductance in the secondary, and methods of compensating for these changes. The whole question is of importance in connection with gang control.

An Experimental Investigation of Forced Vibrations.—L. W. Blau. (*Journ. Frank. Inst.*, September, 1928, V. 206, pp. 355–378.)

The solution of the equation $y'' + 2Ry' + n^2y = E \cos pt$ is written in a new form which clearly exhibits important facts regarding this type of motion which have been overlooked owing to the form of the usual solution. Thus Barton and Browning's statement "While the free vibration is dying away, the resultant motion grows from nothing to the fixed amplitude and phase of the forced vibration" is shown to be true only for the special case when $n^2 - p^2 = R^2$. Again, Rayleigh stated, "During the coexistence of the two vibrations in the earlier part of the motion, the curious phenomenon of beats may occur, in case the two periods differ but slightly." The writer shows that, on the contrary, beats occur in every case, whether the difference between the frequencies be large or small (except in the one special case mentioned above); beats occur even at resonance in a damped system. The first beat maximum is always the greatest, and the first relative minimum occurring after the beginning is always the smallest minimum. In the experimental verification of the theory, the upper extremity of a simple pendulum was moved in S.H.M. and photographic records (shown in the article) were obtained of the motion of the bob. Different degrees of damping were used, ranging from very small to critical. The results are in excellent agreement with the theory.

The Tuned-grid, Tuned-plate, Self-oscillating Vacuum-tube Circuit.—J. W. Wright. (*Proc. Inst. Rad. Eng.*, August, 1928, V. 16, pp. 1113–1117.)

Certain discrepancies in published reports on this circuit (*cf.* Dow, *ibid.*, May, 1927) are pointed out and it is shown that the frequency of oscillation is given by the real terms, and the necessary conditions for these oscillations to start by the imaginary terms, of the general equation. The report in question neglected the effect of the feed-back current upon the total plate current. (*Cf. also* September Abstracts, G. H. d'Ailly.)

The Stability of a Valve Amplifier with Tuned Circuits and Internal Reaction.—R. T. Beatty. (*Proc. Phys. Soc.*, 15th August, 1928, V. 40, pp. 261–268.)

Algebraic and graphical methods for determining the conditions of stability for a tuned multi-valve amplifier are given.

Notes on Aperiodic Amplification and Application to the Study of Atmospherics.—A. Hund. (*Proc. Inst. Rad. Eng.*, August, 1928, V. 16, pp. 1077–1078.)

That a certain type of amplifier produces harmonic output currents for harmonic voltages of the same frequency is by no means proof that the system would give correct repeater action in all cases, as for instance when aperiodic discharges, study of atmospherics and the like are to be investigated with respect to their shape. The output current can, however, be interpreted in terms of the coupling. For true aperiodic amplification, the time constants have to be chosen such that the system gives true repeater action. An aperiodic amplifier using space-charge valves is shown.

Chains of Resonant Circuits.—E. Mallett. (*Journ. I.E.E.*, September, 1928, V. 66, pp. 968–974.)

A chain of resonant circuits coupled by mutual inductance is reduced to the more usual type of filter circuit or chain of T-links. A solution is obtained for the currents flowing, and this is applied to the chain of resonant circuits and to the case of asymmetrical T-links. A graphical construction of the solution is worked out. An appendix gives an example.

Zur Theorie der Siebketten (The Theory of Filter Chains).—Winter-Günther. (*Zeitschr. f. Hochf. Tech.*, August, 1928, V. 32, pp. 41–46.)

The method of treatment first used by Riegger, considering the filters as coupled oscillating circuits, cannot readily be applied to obtain the natural frequencies except in certain limited cases. The author shows how the use of the system of Normal Co-ordinates (brought into favour by Rayleigh and Routh) simplifies and extends the application of the method.

The Cause and Prevention of Hum in Receiving Tubes Employing Alternating Current Direct on the Filament.—W. J. Kimmel. (*Proc. Inst. Rad. Eng.*, August, 1928, V. 16, pp. 1089–1106.)

Conclusions are as follows: (*a*) The hum component due to temperature variation cannot be neutralised by the other factors since it lags by very nearly 90 deg. behind the power supply. This component, however, can be made so small as to be negligible. Oxide filaments of ordinary size are satisfactory. (*b*) With the use of straight filaments, the lowest hum is obtained by so choosing the filament characteristics that the hum components due to voltage drop and magnetic field neutralise each other. (*c*) The use of V-shaped filaments enables a very low minimum of hum to be obtained. (*d*) The effect of the A.C. drop along the filament is to place a sinusoidal potential on the grid; consequently, the hum produced by an A.C. valve increases with the amplification factor.

The Resonance Curves of Coupled Circuits.—E. Mallett. (*E.W. & W.E.*, August, 1928, V. 5, pp. 437–442.)

Inter-electrode Capacities and Resistance Amplification.—L. Hartshorn. (*E.W. & W.E.*, August, 1928, V. 5, pp. 419–430.)

The Harmful Effects of Inter-electrode Capacity.—v. Ardenne and Stoff. (*E.W. & W.E.*, September, 1928, V. 5, pp. 509–513.)

Effect of Anode-grid Capacity in Detectors and L.F. Amplifiers.—W. B. Medlam. (*E.W. & W.E.*, October, 1928, V. 5, pp. 545–555.)

Characteristics of Output Transformers.—J. M. Thomson. (*Proc. Inst. Rad. Eng.*, August, 1928, V. 16, pp. 1053–1064.)

The paper deals with the operating characteristics of the Output Transformer, which are developed in terms of the known constants of loud speaker, valve and transformer. The general formula for the loud speaker current is developed, and the effect of varying the transformer constants shown. The turn ratio of the transformer for maximum speaker current is considered in relation to the commonly used impedance ratio formula (I_2 maximum when turn ratio squared equals $\sqrt{\frac{R_2^2 + \omega^2 L^2}{R_1^2}}$). The limitation of this formula is pointed out and limits set for its general use. The general form of the current frequency characteristic for exponential horns and electro-dynamic cone speakers is then obtained, and a general method for matching the speaker to the output valve is given. Curves are given checking the mathematical results with experimental. The effect of the turn ratio on the form of the current frequency characteristic is shown and a method of using the turn ratio to match the speaker to the output valve is given. A perfect transformer is compared with a good commercial transformer, and the general effect of the leakage inductance and the self-capacity of the transformer is shown.

TRANSMISSION.

Ultrakurze Elektrische Wellen (Ultra-short electric waves).—A. Esau. (*Elektrot. u. Masch: bau, Radio Supp.*, No. 8, 1928, pp. 78–79.)

The writer places 80 cm. as about the present limit of shortness of waves of practical use for communication. Waves about 3 m. are extremely advantageous, as they can be produced efficiently and reflected by parabolic reflectors: the power required for covering a given distance is reduced to 1/12 by such reflectors, or to 1/150 by the addition of similar reflectors at the receiving end. Former difficulties in telephony have been overcome, and quality is now as good as in broadcast transmission. Receiving difficulties have been solved by the use of the reaction-audion with supersonic regenerative frequency (about 20,000 p.s.) incorporated in a 4-valve receiver giving double L.F. amplification. The choice of the type of valve is very important.

Recent range tests have shown extraordinarily good results: duplex telephony (loud speaker) over 20 km. was carried out on 1/60 W.; over 130 km. on 10 W. (without reflectors). Of special importance was the freedom from atmospherics, which had been troublesome on 15 m. even with a far less sensitive receiver. Moreover, signals were not disturbed by fog, rain, snow, or the change from day to night.

Measurement by Lecher wire has been replaced by the use of a special wavemeter here described. This has also been successfully used for measurements of damping.

The paper concludes by references to the promising medical application of these waves and to their use in increasing the sensitivity of measuring processes.

Theorie der Erzeugung von sehr Kurzen Elektromagnetischen Wellen Mittels Elektronenröhren (Theory of valve-production of ultra-short E.M. Waves).—J. Sahánek. (*Phys. Zeitschr.*, 15th September, 1928, pp. 640–654.)

The first part of this paper was published in the same journal in 1925. The present part derives mathematically a common foundation for the several different methods for obtaining ultra-short waves (Barkhausen-Kurz, Gill-Morrell, Zácek), by considering the energy-changes in the diode with plane electrodes when an electron-stream, alternating in time with the external periodic E.M.F., proceeds from the cathode. The conditions under which the diode behaves as a positive resistance, and as a negative, are distinguished. The application of deductions from the diode to the production of waves as obtained by the beforementioned workers is justified. Experimental results are given verifying the theoretical conclusions.

Ein Röhrenoszillator für sehr kurze Ungedämpfte Wellen (A valve oscillator for very short undamped waves).—H. E. Hollmann. (*Ann. d. Physik*, 16th Aug., 1928, V. 86, pp. 1062–1070.)

The oscillator described and illustrated allows, by tuning of the external oscillatory system and a corresponding increase of working voltage, the wavelength to be decreased steadily down to 36 cm. Other waves, about an octave lower (down to 13.2 cm.) are also in evidence: these can be strengthened by tuning the grid lead. *Cf.* previous work, October Abstracts.

Die Erzeugung sehr kurze Elektrischer Wellen mit Wechselspannung . . . (The Productions of very short waves with A.C. Voltage . . .).—W. Wechsung. (*Zeitschr. f. Hochf. Tech.*, August, 1928, V. 32, pp. 58–65.)

Final part of the paper mentioned in the October Abstracts. Among the conclusions arrived at are: Wavelengths depend not only on the applied voltage, but on the value of condenser: the Gill-Morrell equation $\lambda^2.E_g = \text{const.}$ is modified by the statement that $\lambda^2.E_g$ is dependent on valve dimensions and is equal to the square of the anode diameter multiplied by a constant, if valve dimensions and voltage are kept within certain limits.

General Considerations of the Directivity of Beam Systems.—R. M. Wilmotte. (*Journ. I.E.E.*, September, 1928, V. 66, pp. 955–961.)

The author points out the ambiguity which arises from the use of the word " directivity " to cover two distinct quantities for which he introduces the terms " directive efficiency " and " sharpness of directivity." He then considers the general conditions for obtaining good sharpness of directivity in a beam system, and shows that a parabolic system is not, for given overall dimensions, the best arrangement for this. A method is described for obtaining maximum sharpness of directivity at any angle to the vertical, using an inclined antenna system and reflector. In considering the question of excitation, it is suggested that antennæ not directly connected to the source may be used. A possible improvement on the Franklin antenna is also described.

A Theoretical Investigation of the Phase Relations in Beam Systems.—Wilmotte and McPetrie. (*Journ. I.E.E.*, September, 1928, V. 66, pp. 949–954.)

To simplify problems connected with antenna systems and in particular beam systems, it is desirable to express the total field at any point in space in the form of a radiation field. In order to take account of the apparent change in type of field as the distance from the antenna increases, the equation for such a field must contain two variable factors depending on the distance, one governing the phase and the other the amplitude of the total field. The paper gives the calculations and curves for these factors. The best position for a reflector is considered and found to be not necessarily at a quarter wavelength behind the transmitter. The method of calculating from the curves the required positions of antennæ in a system for any given purpose is shown and specific cases are considered. The experimental results of Tatarinoff are compared with the theory.

The Nature of the Field in the Neighbourhood of an Antenna.—R. M. Wilmotte. (*Journ. I.E.E.*, September, 1926, V. 66, pp. 961–967.)

The problem dealt with is the calculation of the effective E.M.F. induced in a receiving antenna from the field of a neighbouring transmitting antenna. It is treated with particular regard to the need for the evolution of a measure of the amount of disturbance caused by a transmitting station, and at the end of the paper the author suggests that a satisfactory though not perfect criterion of the interfering properties of such a station would be one dependent on the current and potential spectrum at the foot of its antenna.

Polar Diagrams Due to Plane Aerial Reflector Systems.—T. Walmsley. (*E.W. & W.E.*, October, 1928, V. 5, pp. 575–577.)

Zusammengesetzte Rahmenantennen (Combined Frame Aerials).—Turlyghin and Ponomareff. (*Zeitschr. f. Tech. Phys.*, September, 1928, pp. 357–364.)

The equations and polar diagrams for various combinations of frame aerials are derived mathematically and confirmed by experiment.

RECEPTION.

Bau und Betrieb eines Kurzwellenempfängers mit einer N.F.-Dreifächröhre (Construction and Use of a Short-wave Receiver with One L.F. Triple Valve).—M. v. Ardenne. (*Rad. f. Alle*, September, 1928, pp. 385–395.)

A one-valve receiver (Audion and L.F. amplification) for wavelengths of a range of about 12 to 80 metres. A list of some 60 commercial short-wave stations coming within this range is given, with call signs and wavelengths.

Acoustic Wave Filters and Audio-frequency Selectivity.—R. B. Bourne. (*Q.S.T.*, August, 1928, V. 12, pp. 23–29.)

Theoretical and practical description of an acoustic filter made up of a series of " bottle " resonators constructed from pieces of 1 3/16 in. diameter brass tubing closed at one end and each connected to the main delivery tube by 3/8 in. diameter tubing, which is continued (on the other side of this delivery tube) to an open end. The combination forms a band pass filter which can be converted to a low pass filter by closing these open ends. The advantages, particularly for good autodyne reception, in place of the L.F. electric filter, are described, with particular reference to telegraphy in the crowded short-wave transmission bands prescribed for the U.S.A. amateur from 1st January, 1929.

TWO-RANGE FOUR.—F. H. Haynes. (*Wireless World*, 12th September, 1928, V. 23, pp. 311–316.)

An efficient long- and short-wave receiver without interchanging coils.

THE FINAL OR POWER STAGE OF AMPLIFIERS.—M. v. Ardenne. (*E.W. & W.E.*, October, 1928, V. 5, pp. 556–564.)

A NEW IDEA FOR A DETECTOR VALVE (Posthumous). (*E.W. & W.E.*, September, 1928, V. 5, p. 515.)

A NEW RECEIVER: THE DESIGN OF A SCREENED GRID AND PENTODE THREE.—N. W. McLachlan. (*Wireless World*, 12th September, 1928, V. 23, pp. 302–305.)

Theoretical description of the new "Megavox Three," constructional details of which follow in the next week's issue.

VALVES AND THERMIONICS.

LA DÉTECTION PAR LAMPE (Detection by Valve).—P. David. (*L'Onde Élec.*, August, 1928, pp. 313–361.)

The writer introduces his long paper by saying that the phenomena of detection are by now familiar so far as the static régime is concerned, though even here there are no precise formulæ giving, for each type of valve, the efficiency of detection; while when the régime is no longer static, where the time-constants of the organs interposed in the circuit are no longer negligible, little is known of what happens, and various authors disagree as to the magnitude of the effects introduced. He sets himself to clear up these points by calculation and experiment. The first nine pages are given to the general method of treatment of static and dynamic characteristics; the algebraic solutions are supplemented by the corresponding graphic representation.

The next eight pages examine, so far as detection is concerned, the various ways of representing the valve characteristic: (1) as parabolic (shown to be applicable only for some tenths of a volt—grid ,or a few volts—plate); (2) as exponential (Colebrook) —shown to begin to fail for signals passing + 0.1 *V*; as half rectilinear, half parabolic (Kuhlmann) —fairly good for signals up to 1 or 2 *V*; and as composed of two straight lines, which for strong signals is better than the other hypotheses. The next twenty pages give the application of the preceding work to actual circuits: (A) anode detection; (B) grid detection (shunted condenser) first for unmodulated, then for modulated C.W.; and (C) superheterodyne detection. In B it is shown, among other things, that detection by shunted condenser (grid) method gives a deplorable efficiency for supersonic frequencies, *e.g.*, 50,000. In C this is reconciled with the fact that super-heterodyne receivers function well, by the conclusion that detection in these, contrary to general belief and in spite of the presence of a shunted condenser, is not by grid but by plate. The final seven pages give a description of the apparatus used for the measurements on detection in the static condition and on detection of modulated waves. The paper ends with a bibliography of thirty-seven items and is followed by a short postscriptum.

ZUR THEORIE DER RAUMLADEGITTERROHREN (The Theory of the Space Charge Grid Valve) Part I.—F. Below. (*Zeitschr. Fernmeldetech.*, 29th August, 1928, pp. 113–118.)

THE APPLICATION OF ALIGNMENT CHARTS TO VALVE CHARACTERISTICS.—M. Reed. (*E.W. & W.E.*, October, 1928, V. 5, pp. 571–574.)

THE ACTION OF STRONG ELECTRIC FIELDS ON THE CURRENT FROM A THERMIONIC CATHODE.—de Bruyne. (*Proc. Roy. Soc.*, September, 1928, V. 120A, pp. 423–437.)

Results obtained with fields up to 10^6 volts/cm. showed that the Schottky relation, and therefore the Maxwellian velocity distribution, here holds good. It was known that electrons having energies greater than 4.53 V (the work function of tungsten) have a Maxwellian velocity distribution. These new results extend the limit down to about 4.2 volts, so that it may be said that not only do those electrons which are able to escape by their own energy in the absence of an external field have a Maxwellian velocity distribution, but also electrons of $\frac{1}{3}$ volt less energy than that corresponding to the work function. The writer points out that his results with filaments of different diameter show conclusively that it is the field at the surface of the cathode which is the decisive factor in controlling the rise in saturation current (*cf.* del Rosario, Bartol Foundation, August Abstracts, p. 469, work on *cold* emission from wires). The value $E = 4.8_1 \times 10^{-10}$ E.S.U. is obtained for the electronic charge, from results on three filaments.

DIRECTIONAL WIRELESS.

LE CHEMIN DU RAYON ÉLECTROMAGNÉTIQUE (The Path of the electromagnetic Ray).—de la Forge. (*Q.S.T. Fran.*, September, 1928, pp. 9–13.)

The first part of a long analysis of Special Report No. 5 of the Radio Research Board: "A Study of Radio Direction-Finding."

L'EXCITATION D'UNE ANTENNE EN FONCTION DE LA DIRECTION DU CHAMP ÉLECTROMAGNÉTIQUE (The Excitation of an Aerial as a Function of the Direction of the E.M. field). —G. Hack. (*Q.S.T. Fran.*, September, 1928, pp. 22–26.)

The author points out that with short waves the phase-differences produced by the waves striking different parts of the receiving aerial give a directional effect similar to that of a transmitting aerial oscillating on a harmonic. The article (which is to be continued) proceeds to analyse the effect.

MEASUREMENTS AND STANDARDS.

Sulla Misura della Lunghezza d'Onda (Wavelength Measurement).—Pession and Gorio. (*Electrotecnica*, 5th July, 1928, V. 15, pp. 524–530.)

A description of the methods of precise measurement employed by the Italian Royal Inst. Research (Communications) for wavelengths from 100 to 30,000 metres. Abraham multi-vibrators are employed, in combination with electrically maintained tuning forks based on Eccles' circuit.

A New Type of Standard Frequency Piezo-Electric Oscillator.—Wheeler and Bower. (*Proc. Inst. Rad. Eng.*, August, 1928, V. 16, pp. 1035–1044.)

Tests on the ordinary piezo-electric oscillators lead the author to conclude that the comparatively close coupling needed, and the effect of the associated valve constants, result in an unavoidable error of nearly 0.001 per cent. under ordinary laboratory conditions, or nearly 0.0001 per cent. under the very best conditions (*i.e.*, at the time of a calibration and with better than ordinary temperature control). The new type, developed at the U.S. Naval Laboratory, has given preliminary results indicating that its average frequency has not varied by as much as one part in a million (over a period of time not specified) and that in all probability the variations are much smaller than that. The chief cause of this constancy is the manner in which the energy necessary to sustain the oscillations of the quartz bar is returned to it, namely, by an acoustic feed-back: the amplified piezo-electric voltage operating a loud speaker element which in turn actuates a tunable air-column and resonator, from which the bar receives its sustaining energy. Extremely loose coupling is thus secured. The paper also describes auxiliary apparatus to permit the continuous operation of the oscillator over very long periods of time, and to measure the frequency with the highest possible precision.

Magnetostriction Oscillators.—G. W. Pierce. (*Nature*, 8th September, 1928, V. 122, p. 380.)

Résumé of a paper in the April number of the *Proceedings of the American Academy of Arts and Sciences*. The writer describes a method of applying the magnetostriction of a rod to produce, and control the frequencies of, electrical and mechanical oscillations ranging from a few hundred to several hundred thousand cycles per sec. These new oscillators seem likely to take the place of piezo-electric oscillators for frequencies below 25,000 p.s., and to compete with them at higher frequencies, though above 300,000 p.s. the present form of magnetostriction oscillator does not work well.

Über eine Neukonstruktion der Linear Thermosäule (A new construction of the Linear Thermopile).—H. Keefer. (*Phys. Zeitschr.*, 15th September, 1928, pp. 681–683.)

The author claims superiority in working and in ease of construction for this new design over the previous versions of Voege and Moll. Thin hair-filaments of copper and constantin or iron and constantin are used.

Frequency Stability of Piezo-electric Quartz.—P. Vecchiacci. (*L'Elettrotech.*, 15th June, 1928, V. 15, pp. 462–468.)

The method of investigation was designed for a high order of accuracy. Results indicated a constancy of control varying from 1/20,000 to 1/100,000, according to the order of frequency. Coefficients are obtained for variation due to change of temperature.

Notes on Quartz Plates, Air Gap Effect, and Audio-frequency Generation.—A. Hund. (*Proc. Inst. Rad. Eng.*, August, 1928, V. 16, pp. 1072–1076.)

Experiments on the frequency of piezo-electric elements are described, with special reference to the effect due to supersonic sound waves generated in the air-gap of the holder and due to its capacity. It is shown that a mechanical load on the crystal increases its thickness-frequency and that an air-gap has the same effect. The velocity of the supersonic waves is about the same as for ordinary sound waves. The value found is 338.68 metres p.s. at 24.5 deg. C. An appropriate air-gap gives even more H.F. output than a mechanically loaded crystal, and procures a steady frequency operation. Two sputtered elements can produce a beat frequency correct within a few parts in 100,000. A method is shown for obtaining a L.F. standard by harmonic division of a H.F. due to a piezo-electric element, sputtered metal electrodes being used. These sputtered electrodes seem most promising for L.F. work, while settings with an air-gap are of value for H.F.

A Quartz Fibre Electrometer.—D. R. Barber. (*Phil. Mag.*, September, 1928, V. 6, pp. 458–465.)

A double-plate instrument employing a single suspended quartz fibre as the moving system. The quartz is rendered conducting by cathode disintegration of silver. The high sensitivity obtained at comparatively low plate potentials, and the stability of the fibre over extended periods of observation, are advantages claimed.

Nagra Teoretiska Synpunkter pa Smärre Mottagnungsantenner (Some theoretical points on small receiving aerials).—E. T. Glas. (*Teknisk Tidskrift, Sweden*, 1st September, 1928, V. 58, pp. 150–155.)

Results are expressed in curves. In one of these figures the ordinates represent the ratio $\frac{h_{eff}}{h}$ while the abscissa represent $\frac{l}{h}$ (ratio of horizontal part of aerial to height) and the three curves correspond to $\frac{h}{\lambda} = 0$, $\frac{1}{60}$ and $\frac{1}{30}$. All three show how the effective height ratio varies from about one-half to nearly unity. A second figure shows how the eff. height ratio varies with an increase of the ratio vertical height to wavelength. Here the four curves correspond to $\frac{l}{h} = 0, 1, 2$ and 3. Other curves deal with the aerial with series inductance or capacity.

EIN INSTRUMENT ZUR MESSUNG VON INDUKTIVITÄTEN UND KAPAZITÄTEN (An instrument for the measurement of inductance and capacity).—Täuber-Gretler. (*Phys. Berichte*, 15th August, 1928, pp. 1509–1510.)

An induction dynamometer with associated apparatus enabling inductances, self and mutual, and capacities to be measured with an accuracy of about 1 per cent. Wide limits for the magnitudes are allowable, and the scale is marked directly in microfarads and henries.

A NOTE ON METHODS OF RAPIDLY ADJUSTING A RADIO-FREQUENCY OSCILLATOR IN SMALL STEPS OF FREQUENCY.—J. K. Clapp. (*J. Opt. Soc. Am.*, August, 1928, V. 17, pp. 132–137.)

Simple and rapid aural methods are described. By the use of the *n*th harmonic of the H.F. oscillator the steps of frequency can be made $1/n$ times a convenient fixed L.F., such as that of a tuning fork. By slight elaboration of the equipment, the adjustments may be made with an accuracy of $1/n$ cycles per second.

A NON-INDUCTIVE POTENTIAL DIVIDER OF HIGH PRECISION. (*Journ. Sci. Inst.*, August, 1928, V. 5, pp. 257–258.)

An instrument on the Thomson-Varley principle ; each graduation of the circular slide wire represents one part in a million of the total resistance. The four resistance dials are specially connected so that each is balanced.

THÉORIE DES APPAREILS DE MESURE ÉLECTROMAGNÉTIQUES ET DESCRIPTION D'UN NOUVEL APPAREIL À DEUX FERS RÉPULSIFS (Theory of electromagnetic measuring instruments, and description of a new instrument with two repelling iron elements).—S. S. Held. (*Rev. Gén. de l'Élec.*, 1st September, 1928, V. 24, pp. 307–317.)

The special (triangular) form of the magnetising coil and the use of two repelling iron elements gives a maximum couple with a minimum of ampere-turns, and a uniform scale starting at 1-10th of the maximum graduation.

RADIATION AND INDUCTION.—Ramsey and Dreisback. (*Proc. Inst. Rad. Eng.*, August, 1928, V. 16, pp. 1118–1132.)

The formulæ for radiation from an aerial and from a coil have been worked out by Dellinger, using a vector potential. The present paper derives these formulæ by more elementary methods. Radiation theory has been experimentally verified with considerable accuracy when the distances have been hundreds of miles, involving an attenuation factor the uncertainty of which explains any discrepancies. The writers state that there seems to have been no attempt made to verify the formula when the distance is small—one wavelength or less. This paper verifies the laws of radiation and induction experimentally, close to a loop aerial. Discrepancies are explained by reflection or re-radiation from certain trees and an iron fence.

ON THE MOUNTING OF WIRES IN STRING-ELECTROMETERS.—W. Clarkson. (*Journ. Sci. Inst.*, September, 1928, V. 5, pp. 298–299.)

In some recent work with a string electrometer, these modifications of the usual technique in mounting the wires were made with, it is believed, an increase in speed and in reliability.

A LONG-PERIOD GALVANOMETER.—D. C. Gall. (*Journ. Sci. Inst.*, September, 1928, V. 5, pp. 280–281.)

By using the magnetic properties of a galvanometer coil to increase its periodic time instead of allowing it to decrease that time, as is usually the case, the writer has increased the deflection per microamp. from 350 to 1,300 mm., since the sensitivity rises almost as the square of the periodic time. The zero-keeping qualities, however, are not good, and the scale law is very uneven, so that the usefulness of the arrangement would be limited to special cases.

THE VALVE VOLTMETER FOR THE MEASUREMENT, WITHOUT LOSS, OF HIGH TENSIONS.—L. Weisglass. (*E.T.Z.*, 24th May, 1928, V. 49 p. 796.)

BASIC MEASUREMENTS OF THE EFFECTIVE RESISTANCE OF CONDENSERS AT RADIO-FREQUENCIES.—D. W. Dye. (*Proc. Phys. Soc.*, 15th August, 1928, V. 40, pp. 285–295.)

The paper includes a description of a special air condenser, so constructed that a change in its capacity can be made without change in the losses, and of a method of using such a condenser to measure the losses in a variable air condenser.

CONTACT POTENTIAL IN THE DOLEZALEK ELECTROMETER CONNECTED IDIOSTATICALLY.—L. F. Richardson. (*Proc. Phys. Soc.*, 15th August, 1928, V. 40, pp. 234–239.)

The importance of reversing the voltage and taking the mean of the two deflections is pointed out. In the discussion. various ways of eliminating or reducing the contact potential effect are mentioned.

THE DIELECTRIC CONSTANT OF AIR AT RADIO-FREQUENCIES.—Bryan and Sanders. (*Phys. Review*, August, 1928, V. 32, pp. 302–310.)

By the radio-frequency method described, the value found for K for dry air free from CO_2 and at standard temperature and pressure is 1.0005893. Preliminary measurements made with a large D.C. voltage superimposed on the H.F. voltage across the condenser indicate no change in the value for air, hydrogen or ammonia. There is some indication that a discharge through the gas decreases its dielectric constant, but the effect is probably spurious.

A Simple Gold Leaf Electrometer for High-frequency Measurements. — Satyendranath Ray. (*Proc. Phys. Soc.*, 15th August, 1928, V. 40, pp. 307–311.)

The entire freedom from time-lag, the practically negligible power consumption, and the much lower degree of coupling to the exciting circuit, constitute very appreciable advantages over the thermo-element and micro-galvanometer usually employed in resonance-circuit measurements.

Druckmessung in Vakuumglühlampen Mittels Aussenelektrode (Vacuum measurement in incandescent lamps by the use of an external electrode).—Alterthrum and Ewest. (*E.T.Z.*, 30th August, 1928, p. 1303: summarised.)

The Measurement of Small Variable Capacities at Radio-frequencies.—W. H. F. Griffiths. (*E.W. & W.E.*, August, 1928, V. 5, pp. 452–459.)

A Graphical Construction for Resistance Amplifiers.—W. A. Barclay. (*E.W. & W.E.*, September, 1928, V. 5, pp. 499–502.)

Loop Permeability in Iron, and the Optimum Air-gap in an Iron Choke with D.C. Excitation.—A. A. Symonds. (*E.W. & W.E.*, September, 1928, V. 5, pp. 485–490.)

Some Output Power Measurements on a Moving Coil Drive Loud Speaker.—Clark and Bligh. (*E.W. & W.E.*, September, 1928, V. 5, pp. 491–498.)

A Direct-reading Valve Tester.—M. G. Scroggie. (*E.W. & W.E.*, September, 1928, V. 5, pp. 480–484.)

The Design of Non-contact Thermo-junction Ammeters.—Colebrook and Wilmotte. (*E.W. & W.E.*, October, 1928, V. 5, pp. 538–544.)

On the Application of Condensers to the Measurement of Large Radio-frequency Currents.—P. R. Coursey. (*E.W. & W.E.*, October, 1928, V. 5, pp. 565–571.)

SUBSIDIARY APPARATUS AND MATERIALS.

Eine Neue Methode Unmittelbarer Steuerung der Luft Durch Elektrische Schwingungen (A new method of direct control of air by electric oscillations).—Brenzinger and Dessauer. (*Phys. Zeitschr.*, September 15th, 1928, pp. 654–655.)

A method which avoids the usual mechanical go-between (membrane, vibrating string or metal band) and consequent distortion by the direct control of ionised air by the varying electric field. The ionisation is produced by a glow-discharge. The process is reversible, so that it can be applied to a microphone transmitter or to a loud speaker. Excellent quality is obtained, especially in the articulation of consonants. Practical difficulties are: the amount of power required (at present 20-40 Watts), and—more important—a background-noise even when a quiet glow-discharge is attained.

Die Erzeugung sehr hoher Gleichspannung (The production of very high D.C. voltage).—E. Marx. (*Elektrot. Zeitschr.*, No. 6, 1928, V. 49, pp. 199–201.)

From a transformer A.C. voltage of 100 kV, the arrangement described gives a D.C. voltage of 1,000 kV, which can be employed for X-ray production, for cathode-ray oscillographs, etc. The method depends on the charging of condensers in parallel and their discharge in series, spark-gaps and hot-cathode rectifiers being employed.

Cathode-ray Oscillographs and their Uses.—E. S. Lee. (*Gen. Elec. Rev.*, August, 1928, V. 31, pp. 404–412.)

Deals with the general principles: fundamental types: characteristics: detailed description of the G.E.C. portable instrument, including frequency range, sensitivity and timing arrangements: and finally, applications and uses, illustrated by specimen oscillograms taken on periodic and transient phenomena.

Characteristics of Photo-electric Tubes.—Koller and Breeding. (*G.E. Review*, September, 1928, V. 31, pp. 476–479.)

The article includes a number of characteristic curves of Light, Current, Sensitivity, and Gas Pressure, relating to various types of cell, some vacuum and some gas-filled.

Der Harmonische Analysator, ein neues Planimeter (The harmonic Analysator, a new planimeter).—K. Trott. (*Bull. d. l'Assoc. Suisse d. Élec.*, 22nd August, 1928, p. 534.)

This new planimeter, Mader-Ott system, gives the magnitudes and phase of the fundamental and harmonic oscillations of periodic curves.

Some New Methods of Linking Mechanical and Electrical Vibrations.—Eccles and Leyshon. (*Proc. Phys. Soc.*, 15th August, 1928, V. 40, p.p. 229–233.)

A full version of the paper, a notice of which was referred to in September Abstracts.

The Grid-glow-valve Relay.—D. D. Knowles. (*E.T.Z.*, 13th September, 1928, p. 1371).

Résumé from the *Electric Journal*, V. 26, p. 176. The writer points out that ordinary mechanical relays give a magnification of the order of 500, increased in the case of the more sensitive relays to 10,000. The Grid-Glow Relay will reach 100,000,000. Details of manner of employment are given: among applications, the use with photo-electric or selenium cells is mentioned. A general objection is the 400 V needed: the writer hopes that this will be reduced to about 100.

Note sur un Montage de Deux Lampes Amplificatrices en Pont Equilibré (Note on a Balanced Bridge Valve Circuit.)—H. Copin. (*L'Onde Élec.*, August, 1928, pp. 361–363.)

For radio-telegraphic recording, etc., where an electro-magnetic relay is used, it is often desirable to use an amplifier whose current keeps at zero during a "space." Suppression of the permanent current by negative grid bias is not always satisfactory. Differential relays are not always available. The arrangement described possesses all the advantages of these relays and involves no special apparatus. Two 3-electrode valves are opposed both for input and output, balancing being adjusted by filament control. If desired, a slight polarisation in the sense opposite to that of the marking current can be arranged.

The Jet-wave and its Applications.—J. Hartmann. (*Engineering*, 14th September, 1928, V. 126, pp. 345–348., and Die Konstruktive Durchbildung des Quecksilber-Wellenstrahl-Gleichrichters (The development of the Mercury-Jet-Wave-Rectifier).—*E.T.Z.*, 16th August, 1928, pp. 1224–1226.)

Two articles describing the work of Professor Hartmann in Copenhagen and his remarkable rectifier—a pendulum rectifier one form of which deals with some 400 A at 230 V and works without trouble for nine months on end. A jet of mercury flowing between the poles of a magnet carries the alternating current and is thus set into a kind of wave-motion which is used to connect the jet in turn with two fixed contacts. These, combined with a centre tapping of a transformer, lead to the production of a pulsating rectified current. The English paper describes other applications: as an interrupter for induction coils: as frequency-meter: and as oscillograph.

Die Verluste in Geschichteten Isolierstoffen (Losses in stratified insulating material).—W. Burstyn. (*E.T.Z.*, 30th August, 1928, pp. 1289–1291 and 1311–1314.)

These losses are attributed to glow-currents in the inferior dielectric (*e.g.*, shellac in the case of Micanite) and the author reckons approximately the variation of the loss-angle with the electrical strain. Loss-angle = $\tan^{-1}\frac{1}{2\pi}$ (energy lost in 1 period/charging energy).

Höchstspannungsisolatoren Hoher Lebensdauer aus Organischem Werkstoff (Extra high tension insulators of organic materials).—O. Scheller. (*Elektrot. Zeitschr.*, No. 8, 1928, V. 49, pp. 295–296.)

These materials are attractive because of their mechanical properties, but are liable to deterioration by corona, etc., which may lead to fracture, especially as the action usually coincides with the place where mechanical strain is taken. The author therefore suggests (and quotes results with) a special form of insulator in which the conductor is carried by a frill or ruffle separated from the point of mechanical strain.

Development of a System of Line Power for Radio.—G. B. Crouse. (*Proc. Inst. Rad. Eng.*, August, 1928, V. 16, pp. 1133–1148.)

Among interesting points in this paper (which begins by reviewing the gradual progress of mains supply arrangements from 1924 to to-day) may be mentioned two cheap and reliable voltage-control devices, one a temperature-variant resistance, the other purely magnetic; a table of the latest Tungar, Radiotron and Raytheon rectifiers; and a filter of the inductance-resistance type, which is a "blanket filter" having a high degree of suppression at all frequencies and a distinct anti-resonance point which may be designed to fall at one desired frequency.

Über Materialien mit Hoher Anfangspermeabilität (Materials of high initial permeability).—Yensen and Gumlich. (*E.N.T.*, August, 1928, V. 5, pp. 334–336.)

A discussion on a paper of this title (*E.N.T.*, February, 1928), dealing with the various new alloys, Permalloy, Conpernik, Hipernik, etc., some of which contain, in addition to iron and nickel, traces of silicon and manganese.

Magnetic Properties of Perminvar.—G. W. Elmen. (*Journ. Frank. Inst.*, September, 1928, V. 206, pp. 317–338.)

Perminvar is the name given to the group of iron-cobalt-nickel alloys which are characterised, when properly heat-treated, by constancy of permeability for a considerable range of the lower part of the magnetisation curve, by small hysteresis loss throughout the same range of flux densities, and by a very unusual hysteresis loop constricted at the origin for medium flux densities.

The Hall High-speed Recorder. (*Journ. Am.I.E.E.*, July, 1928, V. 47, pp. 516–519.)

Designed chiefly for studying effects which occur at the moment of a fault developing on a transmission line, this instrument is so constructed as to be portable, yet very sensitive owing to its optical system (photographically recording). It can be made quadruple for simultaneous records.

Oszillographische Untersuchungen an Gleichrichtern (Oscillographic Tests on Rectifiers).—G. Tenzer. (*Elektrot. u. Masch. bau, Radio Supplement*, No. 9, 1928, pp. 84–86.)

Oscillograms are given, showing the behaviour of various types of rectifier when charging accumulators or providing anode high tension.

Back-coupling in Eliminators.—W. I. G. Page. (*Wireless World*, 26th September, 1928, V. 23, pp. 381–384.)

The possibilities of a new neutralising scheme in L.F. amplifiers to overcome "motor-boating."

STATIONS, DESIGN AND OPERATION.

La Direction des Ondes Radioélectriques : Idées et Réalisations Récentes (The direction of radioelectric waves : recent ideas and results).—L. Bouthillon. (*Bull. d.l. Soc. Fran. d. Élec.*, September, 1928, V. 8, pp. 657–679.) and

Liaisons Radiotéléphoniques à Grande Distance par Ondes Courtes Projetées (Long distance radiotelephonic communication by short wave beam).—H. Chireix. (*Ibid.*, pp. 680–691.)

At the end of the first paper the writer gives results on the Ste. Assise—Buenos Ayres circuit, obtained during the past few months. The second paper deals with more specialised points : *e.g.*, simultaneous emissions from one transmitter ; secrecy ; suppression of "echo." The liaison Paris-Saïgon has just been successfully established.

A Propos de la Multicommunication par très Courtes Ondes Électriques.—A. Turpain. (*Bull d.l. Soc. Fran. d. Élec.*, September, 1928, V. 8, pp. 774–775.)

The writer chastises a compatriot who slighted his early experiments (see October Abstracts) as merely "laboratory results" : he firsts points out that the resulting patent has quite recently been modified (by the substitution of a 3-electrode valve for the detector which the writer specified) by someone else who has thus taken out a new patent and sold it lucratively to the Americans ; and then quotes example after example of "laboratory results" which have stimulated and inspired industry.

GENERAL PHYSICAL ARTICLES.

The Theory of Ferromagnetism.—W. Heisenberg. (*Nature*, 8th September, 1928, V. 122, p. 380.)

Résumé of a German article which is spoken of as "an important advance in magnetic theory." The new theory predicts two further conditions which must be satisfied for ferromagnetism to occur. One is that the space-lattice must be such that each atom has at least eight neighbours, and the other is that the total quantum number of the electrons responsible for the magnetism must be not less than three. (*Cf.* Honda, October Abstracts.)

Die Magnetostriktion (Magnetostriction).—A. Schulze. (*Zeitschr. f. Phys.*, 7th September, 1928, V. 50, pp. 448–505.)

The first long part of a systematic investigation of the phenomenon : its dependence on the purity of material, on thermal preparation, and on the constitution of alloys ; with a view to correlating this property with the magnetic and (if possible) with other physical properties of the material. Heterodyne methods used for the measurement of the dimensional changes are described in detail. The paper begins with a description of the work hitherto done on the subject, with many references, and points out its importance not only for the theory of the nature of magnetism but also for metallurgical purposes.

Über das Verhalten von Wismutschichten in Magnetfeld (The behaviour of Bismuth leaf in a magnetic field).—F. Gross. (*Zeitschr. f. Phys.*, 7th September, 1928, V. 50.)

Bismuth leaf (0.3 to 3μthick) shows resistance change in a magnetic field just as bismuth wire does. A thin leaf rotated in a field gives a resistance-change dependent on the angle with the lines of force. For a thick leaf no such dependence is found.

Negatively Modified Scattering.—Saha, Kothari and Toshniwal ; and The Scattering of Light by Free Electrons according to Dirac's New Relativistic Dynamics.—Klein and Nishina. (*Nature*, 15th September, 1928, V. 122, pp. 398–399.)

The first paper points out that Raman and Krishnan's discoveries are a confirmation of Smekal's "negatively modified scattering" theory rather than of Einstein's deduction of negative or stimulated emission ; that the theory of modified scattering explains the phenomena of resonance spectra of vapours of sodium, potassium and the halogens, described by R. W. Wood ; and that the phenomenon, though described as scattering, seems really to be intermediate between pure scattering (*e.g.*, by fog particles) and pure absorption. The phenomena should also be capable of extension to free electrons, and will thus probably afford an easy explanation of the origin of bright and broad bands in the spectra of Novæ and of winged lines in the solar spectrum. The second paper deals with the Compton scattering, and compares the writers' new formula with that of Dirac and Gordon ; pointing out incidentally the bearing which their calculations may have on the estimation of the wavelengths of the cosmic penetrating radiation.

A New Radiation.—C. V. Raman. (*Indian Journ. of Phys.*, No. 3, 1928, V. 2, pp. 387–398.)

A survey of the work done on the dispersion of light during the past year at the author's Institute (*vide* various recent abstracts).

Wavelength Shifts in Scattered Light.—R. W. Wood. (*Nature*, 8th September, 1928, V. 122, p. 349.)

A cabled message verifying and extending Raman's discoveries (*cf.* recent Abstracts). The writer says "Raman's discovery thus makes possible investigation remote infra-red regions hitherto little explored owing to experimental difficulties."

The Volta Effect.—A. W. Porter. (*Electrician*, 14th September, 1928, V. 101, pp. 289–290.)

Extracts from Address to Section A, British Association. Recent developments place controversial subjects on new footing : Lord Kelvin's discovery : what happens at the zinc-liquid junction ? difficulties of the electronic theory.

CORPUSCULAR THEORY.—G. Forbes. (*Nature*, 8th September, 1928, V. 122, pp. 345–346.)

The writer recalls his paper to the British Association of 1878 on "Mutual Action of Vortex Atoms and Ultramundane Corpuscles" based on the theory of Le Sage and its development by Kelvin. Le Sage's theory was roughly that ultramundane corpuscles are flying through space in all directions with great velocity; that they collide with the atoms of mundane matter; and that in consequence they issue from the sun or a planet with less velocity than that with which they entered it; thus producing the effect known as gravitation. Kelvin suggested that the energy of translation lost by the corpuscles might be converted into vibrations, or vibrations and rotations; and formulated his vortex ring ideas of atom and corpuscle. J. J. Thomson was also attracted by the Le Sage theory.

Then came Aitken with his experiments on the rigidity of endless chains in rapid motion; it then appeared that the vortex filaments in Kelvin's corpuscle would behave in the same way, and that these corpuscles might form the basis of a corpuscular theory of light. The present writer's paper endowed the corpuscle with kinks or saw-teeth; and by these explained radiation, propagation and absorption of light. He revives this theory as forming a physical basis for quanta, for Einstein's photo-electric theory, for the heat of stars, and for Eddington's law of the mass luminosity of stars.

CONDENSIBLE GAS MODIFICATIONS FORMED UNDER THE INFLUENCE OF ELECTRODELESS DISCHARGES.—J. Taylor. (*Nature*, 8th September, 1928, V. 122, p. 347.)

Experiments on the electrodeless discharge in the common gases, using a 7-metre wave oscillator, lead the writer to regard the glass of the container as a complex electrolytic solution probably containing peroxides (until they are reduced by continued discharge with hydrogen) and certainly containing compounds of carbon which produce chemical reactions with the gas ions impinging against the glass surface.

EINE METHODE ZUR BESTIMMUNG DER KERR KONSTANTE SCHLECHT ISOLIERENDER STOFFE MIT HILFE ELEKTRISCHER WECHSELFELDER (A method of determining the Kerr Constant of badly insulating materials with the help of electric A.C. fields).—W. Ilberg. (*Phys. Zeitschr.*, 15th September, 1928, pp. 670–676.)

ON THE ULTRA-VIOLET RADIATIONS EMITTED BY POINT DISCHARGES.—J. Thomson. (*Phil. Mag.*, September, 1928, V. 6, pp. 526–546.)

Experiments to find further evidence as to the nature of these radiations and their relation to the discharge. J. Taylor has pointed out the possibility that they (or radiations of slightly longer wavelength) may be of first importance in determining the mechanism of the spark discharge. The present writer suggests, from his preliminary results, that the radiations are molecular in origin. Oxygen shows, under the conditions of the tests, a particular phenomenon of spontaneous ionisation which is explained by the suggestion that accompanies a gradual change from the O_3 molecule to the normal O_2.

NOTE ON THERMIONIC EMISSION.—Lewi Tonks. (*Phys. Review*, August., 1928, V. 32, pp. 284–286.)

Author's abstract: Electron emission experiments can throw light on the surface heat of charging only if the density of electrons in equilibrium with an emitting surface is the same whether evaporation occurs with constant surface charge or with surface charge equal (and opposite in sign) to evaporated charge. This equality is proved thermodynamically in the present note.

SCHWINGUNGEN PIEZOELEKTRISCHER QUARTZSTÄBE HERVORGERUFEN DURCH EIN UNGLEICHFÖRMIG VERTEILTES FELD (p.e. quartz rod oscillations produced by a non-uniformly distributed field).—S. J. Sokoloff. (*Zeitschr. f. Phys.*, 28th August, 1928, V. 50, pp. 385–395.)

Mandelstam and Papalexi in Leningrad have carried out experiments on the above subject, obtaining by these specially-shaped fields stronger excitation and stronger effects than have been obtained before. The writer investigates the condition mathematically and concludes that with this method of excitation, the oscillation amplitude is not (as v. Laue found for a uniform A.C. field) inversely proportional to the third power of the overtone, but to the first power.

VERSUCHE ÜBER ELEKTRONENBEUGUNG AM OPTISCHEN GITTER (Experiments on the diffraction of electrons at an optical grid).—E. Rupp. (*Naturwissensch.*, 17th August, 1928, p. 656.)

The writer claims the first successful result.

KATHODENZERSTÄUBUNGSPROBLEME (Cathode Sputtering).—Blechschmidt and v. Hippel (*Ann. d. Physik*, 16th August, 1928, V. 86, pp. 1006–1024.)

Further development, theoretical and experimental, of the investigations by these workers published in 1926.

MISCELLANEOUS.

ELECTRICAL PROSPECTING.—J. J. Jakosky. (*Q.S.T.*, June, 1928, V. 12, pp. 9–18.)

A paper based on the work of the Radiore Company in prospecting by inductive methods. The "energizer" (with its frame aerial) can generate at will audio, high, or intermediate frequency currents. Two forms of D.F. receivers are illustrated, the more complex one being used in working with out-of-phase and distorted fields. This consists of a completely shielded ("compensated antenna pick-up") receiver and two coils rotatably mounted on a six-foot arm. The two identical coils impress their E.M.F.'s on separate valves whose outputs are opposed. The whole process of making a complete survey map is described.

Radio Acoustic Position Finding in Hydrography.—J. H. Service. (*Journ. Am.I.E.E.* September, 1928, V. 47, pp. 670–674.)

For fixing the exact position of a survey ship, the U.S. Survey has developed a radio acoustic method, differing from the British method in that the information is obtained directly on the ship instead of being obtained on shore and transmitted thence to the ship. In the former method, the temporary shore-stations are entirely automatic, their radio signals being started by microphone-and-relay arrangements on the arrival of the explosion wave at the microphone. The paper includes a bibliography of 11 items.

Kommission für Hochfrequenztechnik: Regulations for Electric Sound-apparatus such as Loud Speakers, Head-telephones, etc.—(*E.T.Z.*, 13th September, 1928, p. 1380, 1, 4, 5.)

Regulations of the Association of German Electrical Engineers as to insulation, etc.

Bildübertragung und Fernsehen (Picture Telegraphy and Television).—R. Hiecke. (*Elektrot. u. Masch. bau*, Radio Supplements, Nos. 7 and 9, 1928.)

Instalments (to be continued further) of a survey of the various progressive steps up to the present time, given in the form of a series of abstracts from patents and publications, roughly in chronological order.

Über Elektrische Felder Physiologischen Ursprungs (Electrical fields of physiological origin).—W. O. Schumann. (*Zeitschr. f. Tech. Phys.*, September, 1928, pp. 315–321.)

The paper is illustrated by a number of curves from a string galvanometer actuated, through an amplifier, by the rapidly varying fields in the neighbourhood of a living being enclosed in a Faraday Cage (*cf.* von Ardenne, October Abstracts).

The Possible Application of High-Frequency Power to Electric Traction.—W. Cramp. (*Engineer*, 21st September, 1928, V. 146, pp. 315–316.)

Résumé of the British Association paper, and consequent discussion, on work done during the past four years at Birmingham on the practicability of supplying H.F. power to moving vehicles by induction, thus getting rid of sliding contacts. Poulsen arcs are used as generators, functioning apparently fairly well, but needing more work as to reliability and steadiness. The efficiency of the transformation represented by an overhead system of the type proposed is very good. The mercury arc rectifier functions well even up to a frequency of 107,000 p.p.s. In the discussion, it is suggested that the advantages gained by getting rid of sliding contacts are liable to be exaggerated.

Das Induktive Zugbeeinflussungssystem mit Gleichstromerregung (Inductive train-control with direct-current).—O. Schirm. (*E.T.Z.*, 13th September, 1928, pp. 1357–1361.)

Deals both with theory and practice.

Sur L'Unification des Signaux Horaires Radiotélégraphiques (The Unification of Time Signals).—G. Bigourdan. (*Comptes Rendus*, 3rd September, 1928, V. 187, pp. 453–457.)

The writer points to the excessive number (about 40) of different systems at present in use over the world, and advocates the adoption of one common one. He proposes and describes a new system which would be serviceable for all purposes.

Sférographe: Appareil Téléphotographique de la Société Française Radioélectrique (Sferograph: a telephotographic Apparatus of the S.F.R.).— Chauveau. (*Bull. d. l. Soc. Fran. d. Élec.*, August, 1928, V. 8, pp. 835–838.)

A short description of this apparatus for transmitting and receiving pictures by radio, designed to be suitable for use by the general public in that it abolishes the complexities of the other systems——mirrors, photo-electric cells, etc.—and utilises the colouration of an impregnated paper.

Le "Télétype."—Bonnin. (*Bull. d.l. Soc. Fran. d. Élec.*, September, 1928, V. 8, pp. 915–920.)

Description of the teletype instrument, derived from the Baudot System of telegraphy, by which messages are transmitted telegraphically from a typewriter keyboard and reproduced at the other end in typewritten form. The pages following (to 928) describe the system "Télémixte" by which a telephone subscriber can telephone in the ordinary way and then (without making another call) change to the Télétype and leave a recorded message.

Zur Messung von Nachhalldauer und Schallabsorption (The Measurement of Echo-duration and Sound-absorption).—Meyer and Just. (*E.N.T.*, August, 1928, V. 5, pp. 293–300.)

The writers begin by recalling Sabine's results showing the dependence of the acoustic properties of a room on the duration of echoes. They point out that the study of such echoes is important not only from the musical point of view but for testing the sound-absorbing properties of materials, the absorption-coefficients of which can be determined by measuring echo-times of a room with and without the material. They go on to describe a new process for the demonstration and measurement of echo-duration. By the use of a heterodyne hummer and a loud speaker, a compound note (to avoid interference) is produced, whose decay in the room is registered by a Reisz microphone, amplifier and galvanometer. The curves directly confirm the exponential fading away of sound-strength in echo, and allow exact measurement of the echo-duration. Specimen records are given.

The International Union of Scientific Radiotelegraphy.—J. H. Dellinger. (*Proc. Inst. Rad. Eng.*, August, 1928, V. 16, pp. 1107–1112.)

A brief general outline of the U.R.S.I. (the 1928 meeting of which took place in Brussels last September) with a more detailed account of the American Section and of last year's meeting in Washington.

Co-operation Between the Institute of Radio Engineers and Manufacturers' Associations.—A. N. Goldsmith. (*Proc. Inst. Rad. Eng.*, August, 1928, V. 16, pp. 1065–1071.)

An address by the Institute's President before the Convention of Radio Division of the National Manufacturers' Association.

Some Experiments on Water-divining.—A. E. M. Geddes. (*Nature*, 8th September, 1928, V. 122, p. 348.)

Recent tests here described lead the writer to conclude: (1) that the faculty of water-divining is possessed by some individuals; (2) that the individual responds to some, at present unknown, external stimuli; and (3) that certain substances can prevent the arrival of those stimuli, in which case the individual cannot respond.

Frequenzverfielfachung durch Eisenwandler (Frequency multiplication by iron frequency transformers). Final Parts.—E. Kramar. (*Zeitschr. f. Hochf. Tech.*, August, 1928, V. 32, pp. 46–58.)

Surge-voltage Investigations. (*Elec. World*, 7th July, 1928, V. 92, pp. 5–8.)

Tests were carried out on six important American networks. Values are given for the length of time of the surges and for their voltages. Direction also is discussed. Surges due to lightning and to switching are included. Protection by earthing is discussed without any very definite conclusions.

Impressions of the Berlin Show. (*Wireless World*, 12th September, 1928, V. 23, pp. 306–310.)

The Series Capacitor: Construction and Operation of New Equipment designed to increase Load-carrying Capacity of Line and to improve Voltage Regulation. (*Electrician*, 31st August, 1928, V. 101, pp. 228–229.)

The tuned circuit, so well known in wireless and formerly so carefully avoided in commercial power transmission, is now being used most successfully on the lines of the N.Y. Power and Light Corporation at Ballston. For further illustrations and an editorial on the important future of this device, see also *Gen. Elec. Rev.*, August, 1928.

Some Experiments on the Light-sensitivity of Commercial Selenium Cells.—G. P. Barnard. (*Proc. Phys. Soc.*, 15th August, 1928, V. 40, pp. 240–248.)

Procédé d'Obtention du Maximum de Rayons Ultraviolets à Ondes Courtes (Method of obtaining the maximum short wave Ultra-violet Rays).—N. Iarotzky. (*Comptes Rendus* 3rd September, 1928, V. 187, pp. 459–461.)

By using a special quartz mercury-vapour tube, and voltages of 80,000 instead of the usual 20–80V, the author obtains ultra-violet light with practically no visible or heat rays and containing wavelengths down to $253\mu\mu$—whereas hitherto the shortest has been $579\mu\mu$. From a bactericidal point of view this method possesses great advantages.

Some New Applications of Short Radio Waves.—J. Taylor and W. Taylor. (*E.W. & W.E.*, September, 1928, V. 5, pp. 503–508.)

The Heaviside Operator and the Operational Calculus.—W. A. Barclay. (*E.W. & W.E.*, August, 1928, V. 5, pp. 431–436.)

Esperanto Section.

Abstracts of the Technical Articles in Our Last Issue.

Esperanto-Sekcio.

Resumoj de la Teknikaj Artikoloj en Nia Lasta Numero.

PROPRECOJ DE CIRKVITOJ.

Efekto de Anod-krada Kapacito en Detektoroj kaj Malaltfrekvencaj Amplifikatoroj.—W. B. Medlam.

Jen longa artikolo kun tre plena informdona diskutado pri la ĉi-supra temo. La efekto de l'anod-krada kapacito en la detektoro (anod-kurvo) estas unue diskutita, kun ekvivalentaj cirkvitoj por la enmetaj kaj por la elmetaj cirkvitoj, kiel modifita per ĉi tiu kapacito. La rezultanta enmeto sub reakciaj kondiĉoj estas tre plene pritraktita, kaj la efekto ĉe l'agordigo de l'cirkvito laŭ la portondo kaj laŭ ĉiu el la flankgrupoj estas bone klarigita, kaj per matematika rezonado kaj per kurvoj. Ĉi tio kondukas fine al konsiderado pri l'efektiva modulado ĉe krada tensio, montrante la gravan efekton, kiun la reakcio eble havos, kaŭzi distordon je profundaj enmetaj moduladoj.

La diskutado estas poste direktita al la reakcia efekto en malaltfrekvenca (rezisteca-kapacita) amplifado, la argumento estante denove bone ilustrita, kaj per matematika rezonado kaj grafike.

Laste la elimino de reakcia efekto pere de neŭtrodinaj aranĝoj estas konsiderita, unue por la detektoro kaj ankaŭ por la malaltfrekvenca amplifikatoro. Aranĝo estas aparte ilustrita por neŭtrodina "puŝ-tira" detektoro kaj rezistec-kapacita amplifikatoro, eliminanta la efektojn de krad-anoda kapacito en la detektoro kaj amplifikatoro.

SENDADO.

Polusaj Diagramoj Kaŭze de Ebenaj Antenaj Reflektilaj Sistemoj.—T. Walmsley.

La polusa diagramo de radiera sistemo estas kutime planita sole en la horizontala ebeno. Ĉi tiu artikolo derivas formulojn por la polusa diagramo en iu ajn vertikala ebeno, klarigante la bone konatan fakton, ke la kampo malantaŭ la reflektilo estas konsiderinda. La problemo estas, konstati la efekton de reflektilo ĉe ekscita anteno je ĉiu angulo en iu ajn vertikala ebeno. La formuloj estas diskutitaj kaj ilustritaj vektore, kaj rezultoj estas donitaj, montrantaj la polusajn diagramojn de specifita antena reflektila sistemo en la horizontalaj kaj en diversaj vertikalaj ebenoj.

RICEVADO.

La Fina Aŭ Grandpotenca Ŝtupo de Amplifikatoroj.—M. von Ardenne.

La aŭtoro unue konsideras la funkciajn tensiojn, per kiuj la difinita valvo liveras la maksimuman elmeton al iu laŭtparolilo. La limoj de rektlinia karakterizo estas pritraktitaj, kaj la tipo de l'dinamika kurvo kun reakcia laŭtparolila ŝarĝo estas montrita, kaj per ekvacioj kaj per grafika analizo.

La efektoj trans la frekvencoj de l'aŭdebla amplekso estas ankaŭ revuitaj laŭ ilia rilato al ĉi tiu rezonado. La aŭtoro poste pritraktas la rezultojn de ŝoka kuplado, kaj de konekto de laŭtparoliloj paralele kaj serie. Interaliaj, utila konkludo atingita estas ke, per konekto paralele de nombro da identaj valvoj, kaj per konekto paralele de interresponda nombro da laŭtparoliloj, estas eble pligrandigi la enmetan vatkvanton sen la neceso altigi la kradajn aŭ anodajn voltkvantojn. Oni ankaŭ sugestas ke, por obteni kiel eble plej malmultan variadon de frekvenco, estus eble uzi en la elmeta ŝtupo du valvojn, unu kun tre alta, kaj la alia kun tre malalta interna rezisteco, ĉiu el ili funkciiganta sendepende sian propran laŭtparolilon.

La utiligo de la kvinodo ("pentodo") kiel elmeta valvo estas laste mallonge konsiderita.

HELPA APARATO.

La Desegnado de Ne-Kontaktaj Termo-Kuniĝaj Ampermetroj.—F. M. Colebrook and R. M. Wilmotte.

La artikolo unue diskutas la avantaĝojn de la ne-kontakta tipo de termo-kuniĝa instrumento; poste paŝas al la ĝeneralaj principoj de desegnado, inkluzive sentemeco kaj konstanteco de kalibrado. Ĉi tio estas sekvita de detala priskribo pri du efektivaj desegnoj evoluigitaj ĉe la Nacia Fizika Laborejo, notinde estante la facileco de riparo aŭ anstataŭigo de la varmiga elemento. La preparado de l'kuniĝoj estas unue diskutita, kun detaloj pri la konstruado, ilustritaj de fotografaĵoj kaj diagramoj. La desegnado de l'varmigilo estas poste pritraktita, kun eksperimentaj rezultoj pri varmigila materialo, kaj pri l'efekto de variado de l'distanco inter varmigilo kaj kuniĝoj. La kalibrado estas ilustrita kaj la artikolo finiĝas per noto pri l'uzado de l'kuniĝoj kiel fonto de konataj radio-frekvencaj potencialaj diferencoj.

Pri L'Aplikado de Kondensatoroj al la Mezurado de Grandaj Radio-Frekvencaj Kurentoj.—P. R. Coursey.

La artikolo priskribas la utiligon de kondensatoraj ŝuntoj, kune kun malgrandampleksaj termo-kuplaj instrumentoj por la mezurado de grandaj radio-frekvencaj kurentoj. Post diskutado pri antaŭaj metodoj de tiaj mezuradoj, la aŭtoro montras la kondensatoran metodon, kiu konsistas el kondensatoro serie konektita kun la termo-instrumento, la tuto estante ŝuntita per alia kondensatoro. La teorio de la metodo estas diskutita, kun esprimoj por diversaj valoroj de ŝunto, dum la aplikado de resonanca absorba cirkvito por elimini iun nedeziritan harmonikan frekvencon (kiel kelkafoje okazas je mallongaj ondoj) estas ankaŭ pritraktita. Diversaj komercaj tipoj de tiaj instrumentoj estas montritaj, inkluzive la formo de kondensatora konstruado por stabila kalibrado. Oni diras, ke la indikaĵoj de metroj ĉiuspecaj restas tre konstantaj, tial ke ili povas esti tenitaj kiel normoj por radio-frekvencaj mezuradoj, dum iliaj malgrandaj dimensioj taŭgigas ilin por tre altaj frekvencoj.

DIVERSAĴOJ.

La Aplikado de Enliniigaj Grafikaĵoj al Valvaj Karakterizoj.—M. Reed.

La aŭtoro traktas pri l'utiligo de enliniiga grafikajo por obteni la ordinarajn karakterizojn per donitaĵoj pri valva desegnado. La ĝenerala konstruado de l'enliniiga grafikaĵo estas priskribita kaj ilustrita, kaj la kompleta grafikaĵo montrita, el kio estas obteneblaj la jenaj kurvoj:—(1) la kradvoltoj—anodkurenta kurvo, (2) la anodvoltoj—kradvolta kurvo por konstanta anodakurento, (3) la anodvolta—anodkurenta kurvo. Ekzemplo estas ellaborita en kiu la metodo estas uzita por determini la karakterizojn de valvo de difinita impedanco, amplifa faktoro, k.t.p.

Resumoj kaj Aludoj.

Kompilita de la *Radio Research Board* (Radio-Esplorada Komitato), kaj publikigita laŭ aranĝo kun la Brita Registara Fako de Scienca kaj Industria Esplorado.

Radio-Ekspozicio ĉe Olympia, 1928a.

Mallonga redakcia artikolo pri la Brita Nacia Radio-Ekspozicio, tenita ĉe Olympia (Londono), de Septembro 22a ĝis 29a. Revuo pri la montraĵoj aperos en la novembra numero.

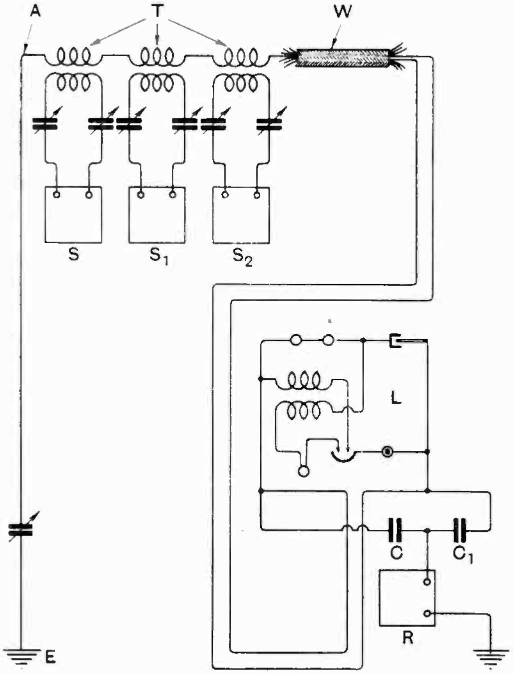
Some Recent Patents.

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.

WIRED WIRELESS.

(*Convention date* (*U.S.A.*), 17*th July*, 1926. *No.* 274491.)

A limited broadcast or television service is distributed over an existing telephone network by feeding the high-frequency currents into a central unused wire forming part of a cable containing, say, fifty subscribers' lines. Since the cable is sheathed in lead, there will be no stray fields, and as the effective "radiation" between the central radio-frequency wire and the surrounding telephone wires is limited to a distance of an inch or so, the induced currents will be relatively powerful. Such a system could be maintained throughout the hours when the radio broadcast service is not in operation, and could be "metered" and charged for at specified time-rates by the telephone company.

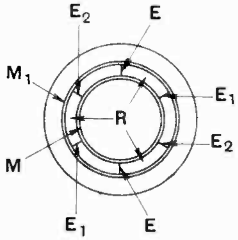


As shown in the figure, one or more studios S, S_1, S_2 feed modulated radio currents through transformers T into a central wire A, which may be tuned and earthed at E. From the wire A the radio-frequency currents are transferred to all the other wires in the cable W. A typical subscribers' loop is shown at L with the H.F. receiving set R branched off from two series condensers C, C_1 of sufficiently small capacity to pass the radio-frequency signals. Such a wired-wireless broadcast service is free from static or fading, offers a dependable selection from two or more programmes transmitted simultaneously on different carrier-frequencies, and does not interfere with the normal use of the telephone.

Patent issued to G. O. Squier.

QUARTZ RESONATORS.

(*Convention date* (*Germany*), 24*th April. No.* 269935.)



Frequency-control crystals cut in plate or rod form from the mother crystal are liable to oscillate both at certain harmonics of the fundamental frequency and also at several inharmonic or "secondary" frequencies. In order to overcome this source of uncertainty, a ring R is formed from a quartz plate which has been cut perpendicularly to the optical axis. The electrical axes of the ring are shown at E, E_1 and E_2.

When such a ring is subjected to a radial field from two concentric electrodes M, M_1, as shown, it can be demonstrated theoretically and confirmed by experiment that only one single oscillation can be produced, of such a frequency that three whole wavelengths are distributed around the periphery of the ring R. When used to produce the known "luminous" effect at resonance, the phenomenon is much brighter or more pronounced in the case of a ring crystal than with the standard "rod" crystals previously used.

Patent issued to Prof. E. Giebe and Dr. A. Scheibe.

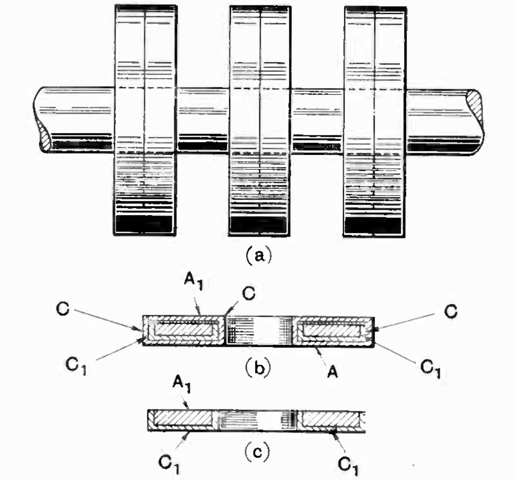
DRY-CONTACT RECTIFIERS.

(*Convention date* (*U.S.A.*), 26*th August*, 1926. *No.* 276622.)

A number of copper blanks are arranged in pairs upon a central spindle as shown in Fig. (*a*), and are heated until a layer of metallic oxide is formed upon the surface. The blanks are then dismounted and are in the condition shown in Fig. (*b*), where C_1 represents an inner layer of cuprous oxide or red oxide of copper, and C a thinner outer layer of cupric oxide or black oxide of copper.

Owing to the comparative protection of the inner faces of each pair of blanks from the heat, the depth of the coating on the face A_1 will be less than that on the outer face A and sides.

The blank is next treated with a solution of potassium cyanide until the cupric oxide deposit C has been removed from the entire surface, and the process is then continued until the cuprous oxide layer C_1 also has been removed from the inner face A_1, leaving the completed blank in the form shown in Fig. (*c*). The blanks are then re-assembled upon a central spindle under pressure, to form rectifying couples or units in the ordinary way. The method permits the mass production of rectifying elements of consistent standard at relatively small cost.

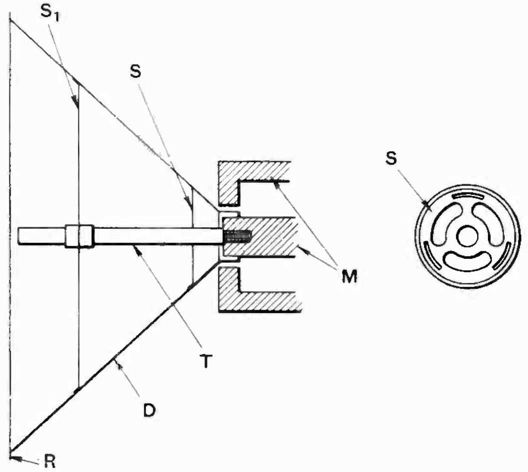


Patent issued to The Westinghouse Brake & Saxby Signal Co., Ltd.

LOUD SPEAKERS.

(*Application date, 22nd April*, 1927. *No.* 294285.)

In a moving-coil loud speaker provision is made to allow the diaphragm to move freely in the line of the "drive," whilst at the same time restraining any lateral movement. This object is achieved by screwing a guide-shaft *T* into the centre pole-piece of the magnetic movement *M* and inserting paper supports or "spiders" *S*, S_1 between it, and the conical diaphragm *D*. The shape of the inner spider *S* is shown in front view at the side of the figure, the outer spider S_1 being of similar design.



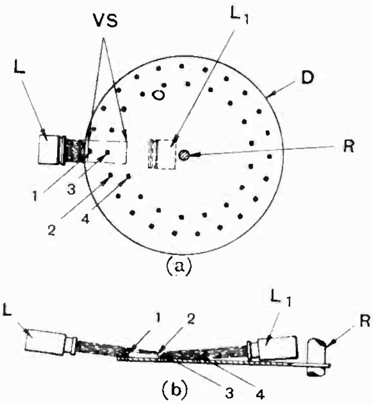
Each spider is perforated at the centre so as to ride freely on the guide-shaft *T*, the outer periphery being gummed or otherwise secured to the inner surface of the vibrating cone *D*.

Patent issued to H. J. Round and N. M. Rust.

TELEVISION RECTIFIERS.

(*Application date, 21st January*, 1927. *No.* 294267.)

In order to increase the brightness of the transmitted image, an exploring device is designed to permit the use of more than one source of light for simultaneously scanning the whole of the object in transmission, or for illuminating the whole of the viewing-screen in reception. Alternatively several sources of light may be used, each localised on different zones or areas of the object or viewing-screen.



The exploring device consists of a disc *D*, Fig. (*a*), rotated about a shaft *R* and pierced with two sets of spirally arranged holes. One spiral commences at 1 and ends at 2, whilst the other extends from 3 to 4. As shown in section in Fig. (*b*) the holes are fitted with small mirrors, those of the spiral set 1, 2 being inclined outwards so as to reflect the rays of light from a lamp *L*, whilst those of the spiral set 3, 4 incline inwards towards the shaft *R* and reflect rays from a second lamp L_1.

Assuming that the illumination of each lamp is controlled by the incoming signals, then the resulting fluctuations of light are thrown in proper sequence by the disc *D* on to a viewing screen *VS*, Fig. (*a*), so as to reproduce the original televised scene, the spiral set 1, 2 traversing the left-hand half of the screen, whilst the spiral set 3, 4 covers the right-hand half.

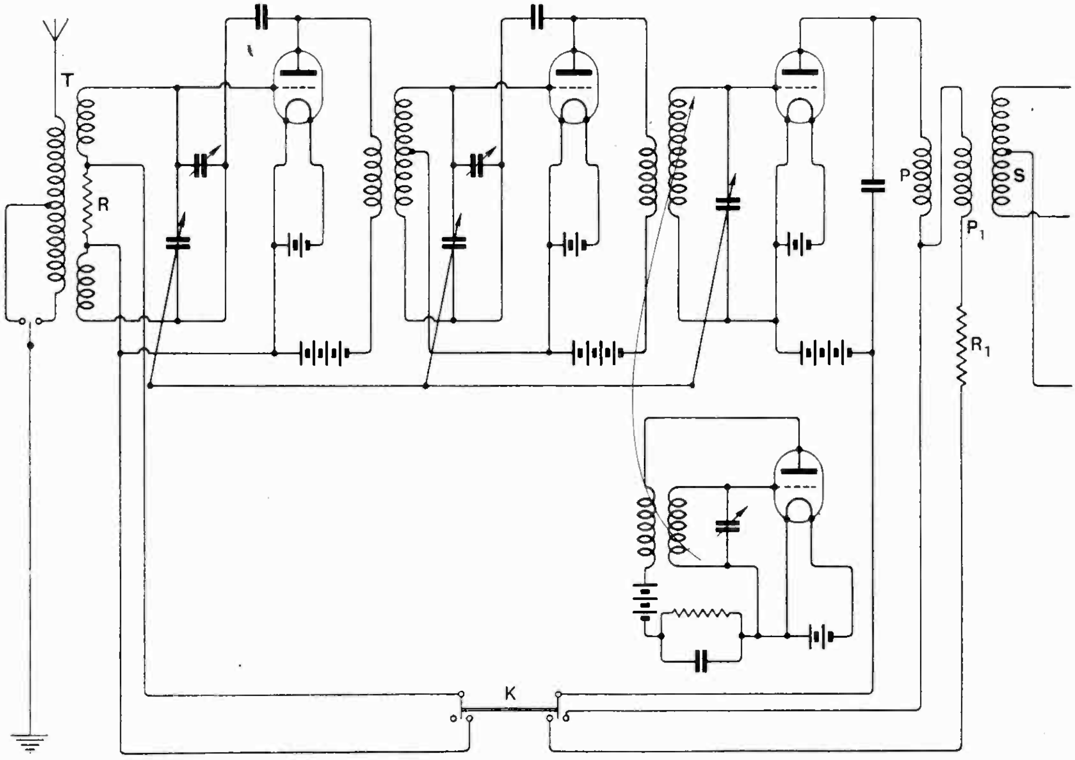
Patent issued to Television, Ltd., and J. L. Baird.

LONG AND SHORT RANGE RECEIVERS.

(*Convention date* (*U.S.A.*), *23rd May*, 1927. *No.* 291014.)

High selectivity for long-distance working is, in general, incompatible with fidelity of reproduction from the local station. If the full width of the modulation sidebands are covered when receiving from the nearby station, the selectivity of the set cannot be sufficient to separate other and more distant stations, spaced apart, say, by the standard frequency-gap of 10 kilocycles. The circuit illustrates an arrangement in which a set is switched over from high-quality reproduction of a local programme to selective reception from more distant stations.

The input transformer T comprises a resistance R, whilst the output transformer from the detector valve comprises two primary windings, one P_1 being more closely coupled to the secondary S than the other P_1, together with a resistance R_1. When the switch K is in the right-hand position, the input resistance R is short-circuited, whilst the closely-coupled winding P_1 and the resistance R_1 in the output transformer are open-circuited, giving high selectivity with poor fidelity. In the position shown, the windings P and P_1 and the resistance R_1 are in series, and give good-quality reproduction with poor selectivity. By removing the short-circuit on the resistance R, the quality may be still further improved.

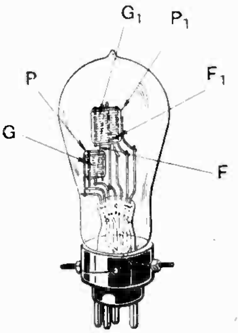


Patent issued to The British Thomson-Houston Co., Ltd.

MULTISTAGE VALVES.

(*Application date 19th May, 1927. No. 295079.*)

A single filament is surrounded at different parts of its length by two separate sets of electrodes of different sizes so that one set may serve as a detector, for example, and the other as a power-amplifying stage. The filament is V-shaped, one leg F being longer than the other F_1. If the filament supply is at 6 volts, the smaller set of electrodes P, G are arranged around the negative end of the filament, and the larger set P_1, G_1 at the positive end. By connecting the common grid return lead for both stages to the negative battery terminal, a grid bias of suitable value is automatically applied to the grid of each stage, that applied to the grid G_1 being greater than that applied to the grid G.



More than one set of electrodes, such as P, G, may be mounted around the longer leg of the V-shaped filament. The grid electrode of the smaller set may be extended towards the plate of the larger set of electrodes, thus creating a certain degree of favourable interaction between the stages. As the set P_1, G_1 co-operates with a greater length of filament than the set P, G, the available emission is sufficient to give rise to effective power-amplification.

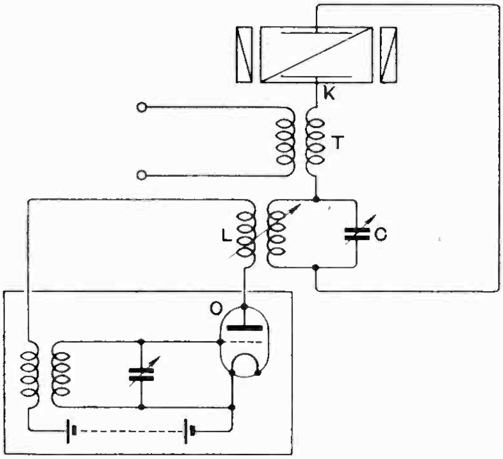
Patent issued to The British Thomson-Houston Co., Ltd.

PICTURE TELEGRAPHY.

(*Application date 26th May*, 1927. *No.* 296124.)

It is well known that the response of a Kerr cell or "light valve" as commonly used in high-speed picture telegraphy, varies as the square of the voltage applied across its electrodes, instead of linearly. In order to minimise the resulting distortion, it has been proposed to use a steady biasing voltage, but this gives rise in course of time to a brownish deposit or sludge which affects the efficiency of the optical cell as a whole.

According to the present invention, an approximately linear response is secured by applying a separate high-frequency biasing potential, instead of a steady voltage. As shown in the Figure, incoming signals are applied to the Kerr cell *K* across a transformer *T*, whilst a separate oscillating valve *O* applies a high-frequency biasing voltage through a tuned circuit *LC*, so that at any moment the operative voltage across the cell electrodes is the algebraic sum of the signal and local oscillations.



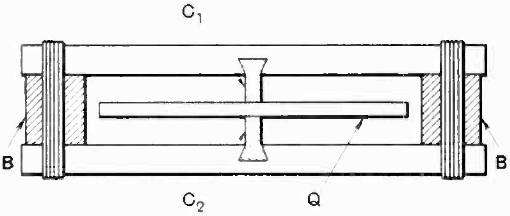
Patent issued to G. M. Wright.

PIEZO-CRYSTAL MOUNTINGS.

(*Application date 27th May*, 1927. *No.* 295081.)

Experience has shown that quartz crystals when used as frequency standards are prone to exhibit irregularities in frequency, due either to the manner of support or to the cleanness and dryness of the crystal, the aberrations probably arising from electrostatic losses occurring on the surface of the crystal. Changes of decrement, which take place simultaneously with changes of frequency, may be due in part to the frictional loading which occurs when a crystal is mounted with its opposite faces in contact with the electrodes and supports, and in part to the loading or pressure of the surrounding atmosphere.

According to this invention, a quartz resonator is so mounted that it is clamped only at parts of its surface that are substantially nodal zones, thus preventing any rocking motion about a central axis. "Air loading" may be avoided by housing the crystal unit as a whole within an evacuated vessel, from which every trace of moisture has been removed, thus eliminating any dielectric losses due to surface moisture. As shown in side elevation, the crystal *Q* is held between two clamping members C_1, C_2 dovetailed into the upper and lower electrodes. Spacing blocks *B* of fused quartz hold the electrodes apart, and are secured by a wrapping of silk.



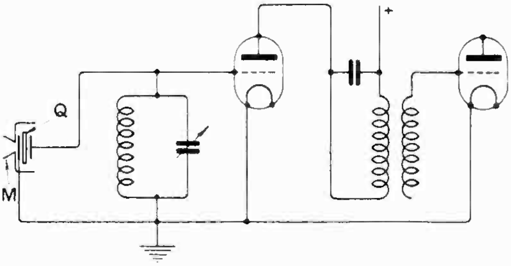
Patent issued to H. J. Lucas.

FREQUENCY MODULATION.

(*Application date 17th March*, 1927. *No.* 295957.)

Instead of transmitting a signal by causing the microphone current to vary the amplitude of the carrier waves, the frequency of the latter may be altered in rhythm with the signal, the amplitude remaining constant. The method is of general application. For instance, when transmitting optical effects, the carrier frequency is varied in accordance with the intensity of a source of light or with varying colours. Reception is effected by causing the incoming frequency variations to shift the working point of the valve up and down the slope of the resonance curve of the input circuit, thus creating an output current quantitatively proportional to the incoming frequency changes.

According to the present invention, the mean frequency of the transmitted carrier-wave is maintained constant by a piezo-electric oscillator, preferably at a point half-way between the top and bottom of one side of the "crevasse" on the crystal resonance curve. In transmission for example, one of the electrodes of the crystal *Q* may be the movable diaphragm of a sound box or microphone *M*. The frequency of the crystal, and therefore of the transmitted carrier-wave, will change with the width of the gap between the electrode and the crystal, though the mean frequency as well as the amplitude of the carrier remains constant.

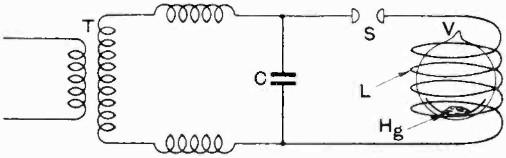


Patent issued to J. Robinson.

SHORT-WAVE RADIATION.

(*Convention date* (*U.S.A.*), *9th April*, 1926. *No.* 269161.)

Ultra short-wave energy, ranging from the visible to the infra-red region of the spectrum, is generated by passing high-frequency currents through a coil surrounding a vessel *V* containing a quantity of mercury, together with mercury vapour, and an added gas such as argon, in which the mean free path of the molecules is shorter than that of the mercury vapour. The presence of the argon facilitates the production of free electrons by collision, and thus enables the radiation of energy to be initiated.



An intense high-frequency field is set up in the coils *L* by the discharge through a spark-gap *S* across a condenser *C* fed from a step-up transformer *T*. The applied field induces ionization by collision, and an absorption of energy, which is subsequently given off as radiation until a balanced or stable condition is reached, depending upon the quantity and pressure of gas in the vessel *V* and other characteristics. Infra-red oscillations varying from 0.05 cm. to 0.3 cm. wavelength can be generated in this way.

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

TELEVISION BY INVISIBLE RAYS.

(*Application date*, *26th January*, 1927. *No.* 294671.)

The image of the televised scene is projected solely by means of ultra-violet or infra-red light on to a phosphorescent or fluorescent screen. The use of X-rays is specifically excluded. The screen may be coated with the sulphide or platino-cyanide of barium, or with sulphate of quinine; or a fluorescent liquid, such as paraffin oil may be used in a container which is transparent to the invisible radiation by which the projection is effected, and also transparent to normal light by which the projected image is seen by the observer.

Again, a fluorescent vapour, for example, that of sodium, contained in a similarly transparent vessel may be used as a viewing screen. Still more interesting effects, it is stated, may be obtained by projecting the image on to a free cloud of fluorescent vapour. The operation need not take place in the dark, for the screen and its surroundings can be illuminated by visible light from which the invisible components (*i.e.*, the ultra-violet and infra-red rays) have been filtered out.

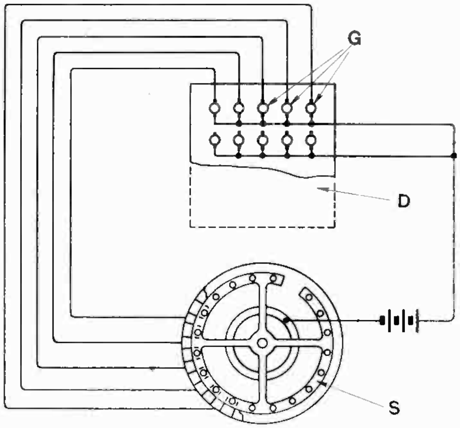
Patent issued to Television, Ltd., and J. L. Baird.

TELEVISION APPARATUS.

(*Application date*, *3rd March*, 1927. *No.* 293,474.)

Instead of scanning or analysing the object to be televised through a rotating disc, fitted with spiral holes or lenses, a more rapid effect is secured by utilising a stationary plate pierced by a large number of holes, each of which is obturated in turn by means of a small spark-gap. The arrangement is based on the fact than an electric discharge or spark taking place across the path of a ray of light absorbs or prevents the passage of the light.

Light from the object to be televised is focused upon a plate *D*, provided with a number of holes. In front of each hole is located a small spark-gap *G* suitably connected to a distributing switch *S*.



The switch is so arranged that at any one moment all the gaps are active (and therefore opaque to the focused light) except one. The position of the latter or "free" gap is then, in effect, moved progressively and at high speed along the series of holes, thus throwing a point image of each portion of the object in rapid succession upon a sensitive cell (not shown). The described arrangement is free from the speed limitation necessarily attaching to any mechanically-moving analyser, such as the familiar rotating disc.

Patent issued to W. Dawson and D. M. Milner.