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The British Wireless Exhibition.

THE Annual British Wireless Exhibition which opened at Olympia on the 18th September was unquestionably the most important annual Radio Show which has yet been held in this country. The space occupied was greater than in any previous year and the number of stands and variety of exhibits also broke all previous records. What, however, from our point of view is much more interesting is that there was everywhere evidence of substantial progress in technical efficiency, and many principles which a year ago were being discussed only from the theoretical point of view have found their way into the practical design of this year's receivers and components

The increase in the number of stations in Europe and their growing power has practically compelled the British manufacturer to increase the selectivity of his receivers, but it is interesting to observe that this result has been effected by increasing the number of tuned circuits, and especially by the introduction of band-pass tuning without increasing the average number of valves, rather than by adopting the American method of a number of tuned valve stages with low gain. The aim of the British designer has been to take full advantage of the high efficiency of British valves and keep down the number of valve stages while obtaining the required degree of selectivity with the aid of additional tuned circuits. The exception to this tendency in British sets of keeping down the number of valves occurs in the case of the superheterodyne, which has quite definitely returned to favour amongst manufacturers here this season. There were a large number of examples of interesting superheterodyne designs to be seen. Amongst a number of new valves produced for the Show several are outstandingly interesting.

Olympia displayed an enormous variety of small moving-coil loud speakers at remarkably low prices, both for the energised and permanent magnet types. It would seem that the production of these small-type moving-coil speakers is the result of a fashion set in America, but we doubt whether much efficiency is not being sacrificed in many of these types by the attempt to limit dimensions. It would be a pity to see the moving-coil speaker acquire a poor reputation merely because the American public has clamoured for a self-contained receiver where the manufacturer has been obliged to limit the dimensions of the moving-coil speaker. The moving-coil speaker has hitherto been accepted as a standard of excellence, but it must not be forgotten that a poor moving-coil speaker can be considerably worse than even an average specimen of some other types.

It is our intention to review some of the more interesting of the exhibits from a technical point of view in the next issue; it would not have been useful to include a report on the Show in the current number without adequate time for its preparation, and we therefore thought it better to postpone the report until next month, picking out carefully the more interesting technical features from amongst the vast assortment of apparatus which Olympia displayed.

The Design of Power Rectifier Circuits.*

Applications of Mercury Vapour or Thermionic Valves.

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Introduction.

SOME time ago, when the writer was engaged in the design of the rectifier system for an amplifier, it became obvious that some investigation into the underlying principles of power rectification by valves was necessary. As far as the author is aware, little has been published on this subject, and it appeared that to achieve efficient and accurate design necessitated special tests being carried out for each new design. The aim, then, in carrying out the following investigation was to provide information which would allow such power rectifier systems to be designed entirely "on paper," thus doing away with the necessity for special tests.

If the only data to hand, when designing rectifier circuits for power supply, are the usual family of curves, called "Regulation Curves," it is shown in this paper that such information in itself is quite inadequate. Circuits designed using these curves will usually be subject to large errors depending, as shown here, on the circuit resistance and "Reservoir" capacity, and also to a large extent on the resistance of the primary and secondary windings of the power transformer.

Methods are given here of calculating the effect of resistance in the circuit, and also the effect of variation in size of the "Reservoir" condenser. The optimum value of "Reservoir" condenser is defined as the minimum value which it can have without affecting the rectified voltage more than, say, five per cent. An expression is given for calculating this optimum capacity when the other constants of the circuit are known.

Finally, a comparison of the advantages and disadvantages of both half- and full-wave rectification is given. Here it is shown that, for most purposes, half-wave rectification presents the greater advantage.

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

While some of the assumptions made are open to criticism, the author thinks that such treatment as is given here, while not being a complete physical representation of the problem, is much more useful than such, inasmuch that to give an exact analysis would lead to results of doubtful use for design purposes due to their intricacy. Moreover, considerable confidence is placed in the methods as a result of extensive checking by measurement, and also because the assumptions are a good approximation to the truth.

An Expression for the Mean Rectified Direct Current.

It would be advisable to state clearly the operating curves assumed here for both the mercury valve and the thermionic valve. The curve for the mercury valve is shown in Fig. 1, No. 1. As can be seen, there is no emission until the anode voltage reaches the value OA_2; thereafter the emission curve follows a vertical line A_2B_2. This means that when the anode voltage reaches the value OA_2 the valve presents no resistance to the flow of current. This is actually what happens to a close degree of accuracy, the current, of course, being limited by circuit resistance, a reasonable value for OA_2 being fifteen volts. We will term the voltage OA_2 the "back voltage."

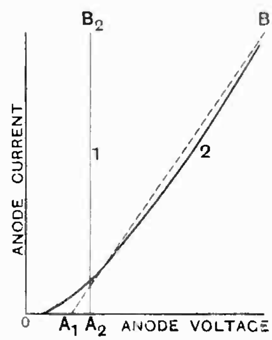


Fig. 1.

The emission curves for thermionic valves are usually of the shape shown in Fig. 1, No. 2.

This will be represented here by such a

line as that shown dotted A_1B_1. Now, such a line as A_1B_1 yields to exactly the same treatment as that of the mercury valve; OA_1 being the back voltage, and the slope of the line A_1B_1 being represented by a series resistance. Of course, should the rectifier work up to the saturation point the line A_1B_1 obviously cannot represent

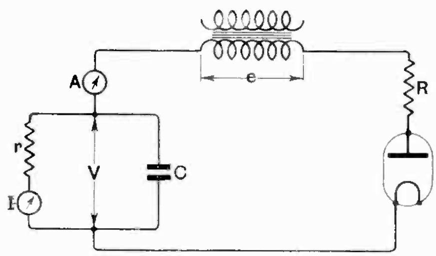


Fig. 2.

conditions to any degree of accuracy. Modern thermionic rectifiers seldom work up to their emission limit.

The standard rectifier circuit is shown in Fig. 2. C is the "Reservoir" condenser, r is the load resistance, e is the instantaneous value of applied alternating voltage, R is the circuit resistance, V the mean rectified voltage, A the root mean square of the current pulses through the valve, and I the mean rectified load current.

Firstly, assuming the capacity C as infinite with running conditions established, the wave form of the voltages and currents in the system is shown in Fig. 3. e is the alternating voltage, E_B' is the back voltage V, plus the valve back voltage, i is the instantaneous value of the current pulse; one every cycle for half wave, two for full wave. I is the mean rectified direct current, and is the mean of the current pulses i. The acting voltage on the valve is the voltage difference between e and E_B' and only acts for the period between θ_1 and θ_2.

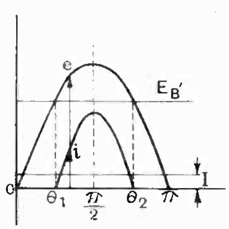


Fig. 3.

Assuming the emission curves as above, the mathematical treatment is quite straightforward. If E_m is the maximum of the alternating sinusoidal voltage, then its value at any instant t is:—

$$e = E_m \sin wt = E_m \sin \theta$$

And

$$i = \frac{1}{R}(e - E_B')$$

Whence

$$I = \frac{1}{2\pi}\int_{\theta_1 = \sin^{-1}\frac{E_B'}{E_m}}^{\theta_2 = \pi - \sin^{-1}\frac{E_B'}{E_m}} \frac{1}{R}(E_m \sin\theta - E_B')\, d\theta \text{ (for half-wave rectification)}$$

$$= \frac{1}{2\pi R}[E_m(\cos\theta_1 - \cos\theta_2) - E_B'(\theta_2 - \theta_1)] \quad .. \quad (1)$$

If now $\frac{E_B'}{E_m}$ is kept constant, then θ_1 and θ_2 are constant.

$$\text{Hence } I = K\frac{E_m}{2\pi R} \quad .. \quad .. \quad .. \quad (2)$$

$$\text{Where } K = (\cos\theta_1 - \cos\theta_2) - \frac{E_B'}{E_m}(\theta_2 - \theta_1)$$

$$\text{or} \quad K = \left[2\cos\theta_1 - \frac{E_B'}{E_m}(\pi - 2\theta_1)\right] \quad (3)$$

Since $\theta_2 = \pi - \theta_1$

TABLE I.

$\frac{E_B'}{E_m}$	θ_1	K
0.9848	80°	0.003_8
0.9397	70°	0.027_9
0.9063	65°	0.054_5
0.8660	60°	0.093_3
0.8192	55°	0.146_0
0.7660	50°	0.216_8
0.7071	45°	0.303_0
0.6428	40°	0.411_0
0.5736	35°	0.536_0
0.5000	30°	0.685_0
0.4226	25°	0.853_8

If, now, the values of K for various values of θ_1, or, what is the same thing, for various values of $\frac{E_B'}{E_m}$ are plotted against $\frac{E_B'}{E_m}$ the value of the mean rectified current I can be readily found from equation (2), provided R and the ratio $\frac{E_B'}{E_m}$ are known.

The values of K plotted against $\frac{E_B'}{E_m}$ are shown in Fig. 4, and are given for convenience in Table I.

The curves in Fig. 5 give the characteristics of a mercury vapour tube with $R = 300$, calculated by the above formulae. They show variation of the voltage V with the current I, as the load resistance r is varied,

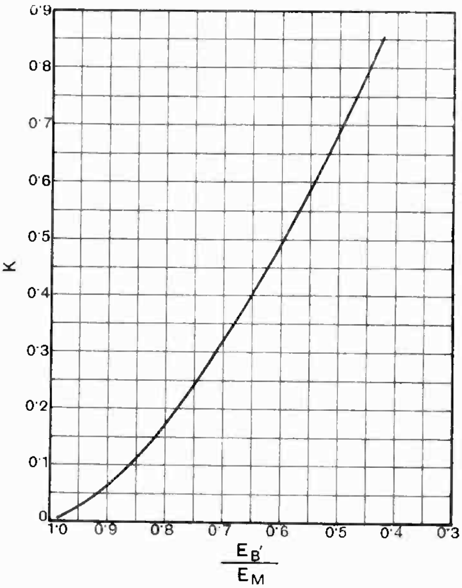


Fig. 4.

for several values of applied alternating voltage. The valve back voltage was taken as 15.

The characteristics of a thermionic rectifier can be calculated in the same way, care being taken to add the resistance, due to the slope of the emission curve, on to the circuit resistance.

With the range of Mazda indirectly heated rectifiers, the voltage OA_1 in Fig. 1 can be taken as zero, as it is usually of the order of five volts, and the error involved in neglecting it is of secondary importance.

In order to obtain working values of the resistance for the various types of rectifiers, it was found that the best method to employ was that of working backwards from values of E_B', E_m, and I, obtained when the valve was rectifying. This means evaluating $\frac{E_B'}{E_m}$, then finding K from Fig. 4, and finally, from equation (2), calculating R. Then if the transformer and circuit resistance is zero, R can be taken as the valve resistance.

Table II shows results obtained from a U120/500 valve, using this method. That the value of the resistance should decrease with increase of load current is to be expected, since such increase of current necessitates working higher up on the emission curve (see Fig. 1) and thus makes

TABLE II.—U120/500 VALVE.

E R.M.S.	I mA.	R
429	100	110
429	60	130
429	30	150

the assumed resistance line A_1 B_1 steeper. However, the error in taking a mean value of valve resistance from these figures is very small, and is no more than individual valve variations of the same type. Since the internal resistances of the Mazda type of indirectly heated rectifiers are so very small, it can be seen that when the probably

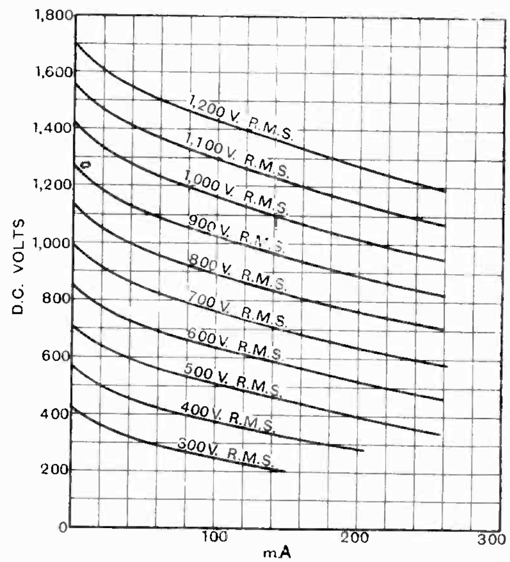


Fig. 5.—*Calculated characteristic curves of mercury tube with 300 ohms anode resistance.*

larger transformer and circuit resistances are added on, the above method gives very good results.

Tables III and IV give average values of the internal resistances of the Mazda indirectly heated group of rectifiers. These have been calculated from the values obtained when the valves were rectifying. Such a value of internal resistance for a rectifier gives the key to the performance of the rectifier under any condition, provided the rating is not exceeded. In order to avoid confusing this value of valve resistance with the circuit and transformer resistance, it has been termed R_v in Tables III and IV.

TABLE III.
MAZDA FULL-WAVE RECTIFIERS.

Type	R_v
UU30/250	720
UU2	520
UU60/250	250
UU120/250	220

TABLE IV.
MAZDA HALF-WAVE RECTIFIERS.

Type	R_v
U30/250	300
U75/300	140
U60/500	150
U120/500	130

For full-wave rectification, the above formulae hold, provided E_m is the peak voltage acting on each anode; this is usually one half the total secondary voltage. It is then only necessary to double the mean rectified current I given by equation (2).

Effect of Varying the "Reservoir" Capacity.

(1) *Half-Wave Rectification.*

In the foregoing expression for the mean rectified current, the "Reservoir" condenser was assumed infinite. If its value is decreased, keeping the supply voltage constant, a point will be reached where the value of the mean direct current, and mean rectified voltage, begin to decrease very rapidly with further decrease in C. Obviously it will be most economical to run the circuit with this minimum value of "Reservoir" capacity—ignoring for the moment, consideration of ripple voltage magnitude.

Referring to Fig. 8, which shows the variation in mean rectified voltage as the "Reservoir" condenser C is varied, it can be seen that the value of C can be reduced to approximately 3.5 μF. without reducing the rectified voltage greatly. If, however, it is reduced much below 3.5 μF., the rectified voltage falls away rather quickly. This value of approximately 3.5 μF. is termed the "Optimum Capacity," since for reasons of economy, the smallest practicable value should be used. This value of "Optimum Capacity" varies with several factors.

The wave form of the rectified voltage in the circuit for finite "Reservoir" capacity is shown in Fig. 6. It can be seen that during the period $\theta_1 - \theta_2$ when the pulse of current is flowing into the condenser, the voltage across the condenser rises. It falls off again between the pulses as shown. E_B' is no longer a steady back voltage, but has a ripple of approximately triangular wave form superposed.

It was found that the value of capacity which made the peak value of E_B' just reach the peak value E_m, was approximately the minimum, or optimum, capacity as defined above. Any further decrease in the capacity results in a further increase of ripple voltage, and also a considerable decrease in rectified output.

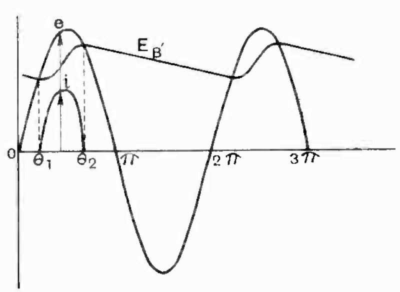


Fig. 6.

The reason for this is, to some extent, apparent from Fig. 6. It can be seen that while the back voltage rises higher than that with infinite capacity during approximately one half of the pulse, it falls to a similar extent during the other half of the pulse. Thus the average or mean rectified values are not greatly changed. However, when the peak value of E_B' reaches the value of E_m, conditions become, what we might term, no longer symmetrical, and this is reflected in a change in the rectified values of considerable magnitude.

Thus, if we can calculate the value of the "Reservoir" capacity, which will just make the peak value of E_B' equal to E_m, that value of capacity will be the optimum. To do this, we assume that the voltage of the condenser rises and falls an equal amount on either side of the mean value. With a triangular ripple this is obviously a wrong assumption, but is sufficiently accurate for this purpose.

Now, the charge that enters the condenser is very approximately the mean direct current multiplied by the period during which the valve is inactive, because during this period this amount flows out of the condenser. For half-wave rectification, this period is $\pi + 2\theta_1$ and if the supply frequency is f, this charge is :—

$$Q \doteq \frac{\pi + 2\theta_1}{2\pi} \cdot \frac{1}{f} \cdot I$$

and this is the charge entering per cycle. Hence, the condenser rises in voltage by an amount given by :—

$$\triangle V = \frac{\pi + 2\theta_1}{2\pi} \cdot \frac{1}{f} \cdot \frac{I}{C}$$

during the period that the pulse exists. Thus the condenser rises by $\frac{\triangle V}{2}$ above the mean value of rectified voltage as defined above. Equating this value to the difference between E_m and the mean value of E_B', we get :—

$$\frac{\triangle V}{2} = E_m - E_B' = \frac{\pi + 2\theta_1}{4\pi} \cdot \frac{1}{f} \cdot \frac{I}{C}$$

or $$C = \frac{\pi + 2\theta_1}{4\pi f} \cdot \frac{I}{(E_m - E_B')} \text{ farads} \qquad (4)$$

where $$\theta_1 = \sin^{-1} \frac{E_B'}{E_m}$$

We may define the optimum value of "Reservoir" condenser capacity as that value which reduces the mean rectified voltage, developed across a fixed resistance, by no more than a certain percentage of the maximum value with infinite capacity. For reasons of economy, or ripple voltage magnitude, this percentage drop must remain arbitrary. Thus if extreme economy was aimed at, a drop of from ten to fifteen per cent. might be permissible, in order to reduce the capacity as much as possible. It can be seen that the formula for the capacity given in equation (4) takes no account of the amount of voltage dropped. In general where very close design is aimed at and the percentage drop of voltage for a given capacity is required, equation (4) cannot be used. However, it serves as a rough guide to this value, and is sufficiently accurate for most purposes.

It should be noted that the required value of "Reservoir" capacity has been found experimentally to vary with the following factors :—

$$C = f(E, I, R, \%)$$

where E is the R.M.S. applied voltage, R is the total effective resistance including the internal resistance of the valve. % is the percentage drop as defined above, and I is the load current. Thus, if a set of curves was plotted showing the value of C for various values of E, I, R and % measured from an actual rectifier, then such results would hold generally for other rectifying valves, since it is only their internal resistance that affects C and this can be found. The writer has taken such a set of curves with E varying from 100 to 500 volts, but with the four variables E, I, R, and % some difficulty is experienced interpolating between the various curves.

When using equation (4), it has been found, by comparisons with actual measurements, that the following adjustment should be made. If the total effective resistance R, including transformer and circuit resistances, (see section below on effect of resistance in the circuit), plus the internal resistance of the valve, exceeds 600 ohms, then one microfarad should be added to the capacity calculated by equation (4). For voltages of over 800 R.M.S. this addition is unnecessary.

Curves are shown in Figs. 7 and 8 measured with the standard circuit shown in Fig. 2 by varying C. The value of r was kept constant and so the load current diminished with the mean rectified voltage. The value of load current shown on each curve is the value with maximum rectified voltage or with very large capacity. On each curve is shown the optimum capacity as calculated by equation (4), using the measured values of mean rectified and supply voltages. From these curves, an idea of the accuracy of the method of calculating C can be obtained.

If the magnitude of the ripple voltage is the limiting feature, and this limit is less than that for optimum "Reservoir" capacity, then, as shown above, the ripple volts are :—

$$\triangle V = \frac{\pi + 2\theta_1}{2\pi} \cdot \frac{1}{f} \cdot \frac{I}{C}$$

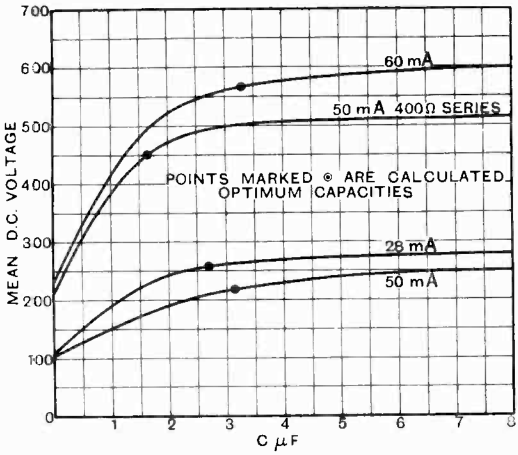


Fig. 7.—*Curves showing variation in output volts with change of capacity. Mazda U65/550 valve.*

and assuming a triangular wave, the R.M.S. value is given by :—

$$V_{R.M.S.} = \frac{1}{2\sqrt{3}} \cdot \frac{\pi + 2\theta_1}{2\pi} \cdot \frac{1}{f} \cdot \frac{I}{C} \quad .. \quad (5)$$

This wave can be represented by a fundamental sine wave of supply frequency, and several harmonics. As far as power smoothing goes, the fundamental alone need be considered, as the harmonics are of smaller amplitude, and in addition, due to their frequency, will be more effectively smoothed out if simple choke capacity smoothing is employed.

(2) *Full-Wave Rectification.*

Similar reasoning as for the half-wave gives :—

$$Q \doteqdot \frac{2\theta_1}{2\pi} \frac{1}{f} I$$

$$\triangle V = \frac{2\theta_1}{2\pi} \cdot \frac{1}{f} \cdot \frac{I}{C}$$

$$\frac{\triangle V}{2} = E_m - E_B' = \frac{2\theta_1}{4\pi} \cdot \frac{1}{f} \cdot \frac{I}{C}$$

or

$$C = \frac{\theta_1}{2\pi f} \cdot \frac{1}{(E_m - E_B')} \text{ Fds.} \quad (4a)$$

Also $$\triangle V_{R.M.S.} = \frac{1}{2\sqrt{3}} \cdot \frac{\theta_1}{\pi} \cdot \frac{1}{f} \cdot \frac{I}{C} \quad .. \quad (5a)$$

This ripple has a fundamental of twice the supply frequency, and as can be seen has less than one half the amplitude of the half-wave rectification ripple, for the same values of I and C. The angle θ_1 will, of course, be larger.

It should be stated here that equations (4*a*) and (5*a*) have not been checked by measurement, although the similar equations for half-wave rectification, that is, equations (4) and (5), have shown good agreement with measurements taken.

Effect of Resistance in the Circuit.

From the circuit shown in Fig. 2, it can be seen that any resistance in the transformer secondary is equivalent to a resistance directly in the anode circuit of the valve, and must be added to R. Also, it was found that any resistance in the primary winding, or circuit, of the transformer, should be referred to the secondary by the conventional "turns squared" method, in order to get the equivalent value to be added to R.

It can be seen from equation (2) the large effect that increase or decrease in R makes in the output. Indeed, if, when using small transformers especially, the resistances of their windings are not allowed for, calculations may be out by enormous amounts.

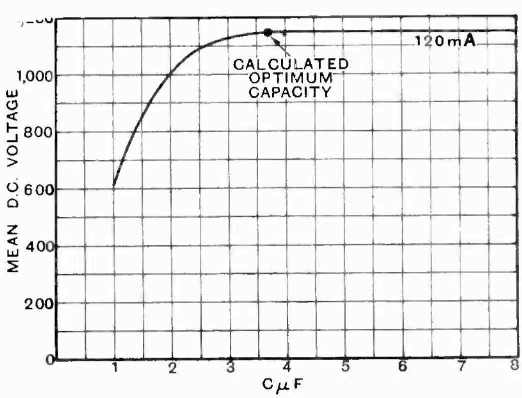


Fig. 8.—*Variation in output volts with capacity. Mazda U150/1100 valve.*

Also, the mistake in measuring the standard "regulation" curves with a primary regulating resistance in the transformer, is apparent.

When running mercury vapour valves as rectifiers, it is usual to limit the peak value of the current pulse to a certain value. This is achieved by inserting a resistance in the anode circuit of sufficient magnitude to give the desired results. If R is the total effective anode resistance, then the peak value of the current is given by :—

$$I_m = \frac{E_m - E_B'}{R}$$

Root-mean-square Value of the Current Pulses.

It might be as well to state here that the root-mean-square value of the current pulses is considerably greater than the mean rectified current. Especially is this so with half-wave rectification, where the root-mean-square value may be two to three times the mean value. This is due to the short period during which the pulse exists, which gives a relatively high peak current. The shorter the period the greater the ratio of root-mean-square current to mean current. As it is the root-mean-square value which must be used to calculate heating of the transformer through copper losses, this high ratio is a disadvantage when designing transformers to close limits.

Wave-form of the Supply Voltage.

It should be noted that the wave-form of the supply voltage has a pronounced effect on the output of rectifying valves. This can be seen readily from Fig. 3. Thus if there is a peak in the alternating voltage wave between the points θ_1 and θ_2, the current pulse would be greatly increased, and hence also the output current. This effect is much greater with low values of R. However, it must be emphasised that the errors due to such effects, although small with most mains supply, justify the assumption that the thermionic rectifier can be treated as a resistance since the error due to such an assumption is, in most cases, smaller than the wave-form error.

It is very important when measuring the effective resistance of a rectifier from actual rectifying conditions, that the supply wave-form be as nearly sinusoidal as possible.

Comparison of Half and Full-wave Rectification.

The major advantages derived from using full-wave rectification are :—

(1) The elimination of the direct current polarising effect on the iron of the power supply transformer.

(2) The relatively low value of the ratio of the root-mean-square to mean current.

The first of these advantages permits the use of a smaller transformer than if the polarising current were present—as it is with half-wave rectification. The second advantage also makes for a smaller design of transformer.

The advantages of using half-wave rectification are several ; chiefly they are :—

(1) Reduction in hum "audibility," from the full-wave case, the smoothing circuit being the same.

(2) For a given rectified voltage, the secondary voltage E is approximately half that for full wave.

(3) Simplicity in the circuit.

(4) Reduction in cost of the rectifier.

The first advantage is quite the opposite to what is usually thought to be the case. Due to the double ripple frequency with full-wave rectification this ripple is approximately four times as effectively smoothed by the standard choke-condenser method. Also, originally, as is shown previously, it has approximately only one-half the magnitude of the half-wave ripple. This means that the ripple voltage with full-wave rectification is approximately one-eighth that with half-wave rectification for the same output current, reservoir condenser and smoothing circuit. However, the *audible* output must not be judged from this *voltage* figure without other considerations. These are as follows :—

(*a*) Since the hum from the speaker is usually just on the threshold of audibility, we can find the power output to make a fifty-cycle note just audible and compare it with the power to make a one-hundred-cycle note just audible. This is obtained from the threshold of audibility curve on Wegel's sensation area.* Reference to this curve gives the following :—

$$\frac{\text{Power required at 50 c.p.s.}}{\text{Power required at 100 c.p.s.}} = 40$$

As we are dealing with voltages, it will be necessary to take the square root of this

* *See* "Speech and Hearing," Harvey Fletcher, pp. 157, 158.

to convert it to voltage output. This gives a ratio of approximately 6.3 : 1.

This means that due to the mechanism of our hearing alone, the much larger ripple voltage output at 50 cycles has been nearly compensated.

(*b*) With few exceptions the frequency response curve of amplifiers falls off at 50 c.p.s. We can take for a general figure a voltage output at 50 c.p.s. as 75 per cent. of that at 100 c.p.s. Usually the drop off will be greater than this.

(*c*) With the best speakers—moving coil included—the output at 50 c.p.s. is very much less than that at 100 c.p.s. It is very difficult to assume a figure for this due to harmonics, etc., but it would be a very exceptional speaker which would have more than 50 per cent. at 50 c.p.s. of the output at 100 c.p.s. It is possible that if the resonance of the diaphragm in a moving coil speaker occurs at 50 c.p.s. then the output there might exceed that of 100 c.p.s., but as this resonance is usually very sharp, it can be seen that it would be exceptional for it to occur exactly at 50 c.p.s. Again, for most cone speakers the output at 50 c.p.s. is probably negligibly small.

The result of (*a*), (*b*) and (*c*) gives on a very conservative basis as the ratio of the voltages required at 50 and 100 c.p.s. for the same aural amount of hum the following :

$$\frac{\text{Voltage at 50 c.p.s.}}{\text{Voltage at 100 c.p.s.}} = \frac{6.3}{1} \times \frac{1}{.75} \times \sqrt{\frac{1}{.5}} \doteqdot 12$$

Since the actual ripple voltage ratio is eight, the conclusion is reached that the audibility of the hum using full-wave is greater than that using half-wave. The actual ratio being :—

$$\frac{\text{Audibility at 100 c.p.s.}}{\text{Audibility at 50 c.p.s.}} \doteqdot \frac{12}{8}$$

on a voltage basis.

It is rather interesting in connection with this comparison to note that the apparent voltage output increase at 100 c.p.s. is $\frac{12}{8}$. However, the minimum perceptible change in power output at these low frequencies and threshold intensity is round about 180 per cent.* That is to say, if there were a hum output of a certain intensity then the minimum perceptible change in the intensity would be 1.8 times that intensity. This is equivalent to a change of $\sqrt{1.8}$ or approximately 1.35 times the voltage, but from the above, the apparent increase in voltage is $\frac{6}{4}$ or 1.5. Thus, the increase in hum output using full-wave rectification would be perceptible —at least with a switchover test.

The second advantage is rather important. If we wish to rectify up to about 500 volts, this would mean, with the conventional full-wave circuit, a secondary voltage of round about 1,000. Naturally, this is commercially undesirable for domestic articles. However, with half-wave the secondary voltage would need to be only round about 500. Moreover, the transformer would probably be considerably cheaper with the latter case.

The third advantage taken in conjunction with the fourth, means a considerable saving in manufacture over the full-wave type, for the higher voltages.

The two disadvantages of half-wave rectification are the polarising effect of the direct current and the high value of the root-mean-square current. However, these disadvantages may be practically eliminated by careful design of the transformer, and in any case, they only mean a slight increase in its size.

When using full-wave rectification with two separate valves, the breakdown of one valve usually means that, due to the increased load on the other, it also breaks down. This is a considerable disadvantage of using full-wave, although, of course, it may be necessary to use the two valves to get sufficient output.

It would appear from the above that, in most cases, half-wave rectification offers more advantages than full-wave rectification. This has been fully borne out in the writer's experience of amplifier design.

In conclusion, the writer wishes to thank Mr. G. S. C. Lucas for suggestions offered during the course of this work, and also the British Thomson-Houston Co., Ltd., for permission to publish this paper.

Example 1.

A rectified voltage of 1,000 is required with 120 mA. load single wave. The anode limiting resistance is 200 ohms and it is

* *See* "Speech and Hearing," Harvey Fletcher, pp. 157, 158.

estimated that the transformer primary will have 0.5 ohms resistance, secondary 50 ohms, and its ratio approximately 1 : 10. It is required to find the requisite secondary transformer voltage and the optimum condenser value. The supply frequency is 50 c.p.s. A mercury vapour tube is to be used, the back voltage being 15.

Required Voltage.

The effective anode resistance =

$$10^2 \times 0.5 + 50 + 200 = 300 \text{ ohms.}$$

From equation (2)

$$I = K \frac{E_m}{2\pi R}$$

Therefore $0.120 = \dfrac{KE_m}{6.28 \times 300}$

Therefore $KE_m = 226.$

E_m must now be found such that $KE_m = 226$. This is done by a process of trial and error.

Trying $E = 950,\ E_m = 1343$

$$\frac{E_B'}{E_m} = \frac{1015}{1343} = 0.755$$

From Fig. 4, $K = 0.235$.

Hence $KE_m = 0.235 \times 1343 = 316$

Thus E or E_m has been chosen too high.

Trying $E = 910,\ E_m = 1285$

$$\frac{E_B'}{E_m} = \frac{1015}{1285} = 0.791$$

From Fig. 4, $K = 0.183$

And $KE_m = 0.183 \times 1285 = 235$

This is sufficiently close to 226.

Thus the A.C. voltage required is approximately 910 R.M.S.

Optimum Capacity.

From equation (4) :—

$$C = \frac{\pi + 2\theta_1}{4\pi f} \frac{I}{(E_m - E_B')} \text{ Fds.}$$

$$\text{Sin } \theta_1 = \frac{E_B'}{E_m} = 0.791,$$

therefore $\theta_1 = \text{approx. } 52°$

And $E_m - E_B' = 1285 - 1015 = 270$

Therefore

$$C = \frac{284}{720} \cdot \frac{1}{50} \cdot \frac{0.120}{270} = 3.5 \times 10^{-6} \text{ Fds.}$$

$$= 3.5\ \mu\text{Fds.}$$

Example 2.

Using a Mazda type U65/550 half-wave rectifier valve, a rectified voltage of 450 is required with 50 mA. load. The transformer primary has a resistance of approximately 20 ohms, and its secondary 300 ohms. The supply voltage is 220 volts at 50 cycles per second.

It is required to find the secondary open circuit voltage and the optimum reservoir condenser capacity.

Taking 2.5 as an approximate transformer ratio and referring the primary resistance to the secondary, we get for the effective anode resistance :—

$$300 + 2.5^2 \times 20 = 425$$

Now, by drawing such a line as $A_1 B_1$ (Fig. 1) for the U65/550 valve, we get :—

$$OA_1 = 20\ V.$$

The slope is approximately 0.527 volts per mA. = 527 ohms. This valve of 527 ohms must be added to the effective anode resistance of 425 ohms. This gives a total of 952 ohms.

From equation (2)

$$I = \frac{KE_m}{2\pi R}$$

Therefore $0.05 = \dfrac{KE_m}{6.28 \times 952}$

or $KE_m = 299$

E_m must now be found such that $KE_m = 299$.

$$E_B' = 450 + 20 = 470$$

Try $E = 520\ E_m = 735$

$$\frac{E_B'}{E_m} = 0.64$$

From Fig. 4, $K = 0.415$

$$KE_m = 305$$

This is near enough to 299.

Thus the required voltage is 520 R.M.S.

Optimum Capacity.

From equation (4)

$$C = \frac{\pi + 2\theta}{4\pi f} \cdot \frac{I}{(E_m - E_B')}$$

Where θ is the angle whose sine is

$$\frac{E_B'}{E_m} = 0.64$$

Thus θ = approx. 40°

$$\text{Therefore } C = \frac{260}{720 \times 50} \cdot \frac{0.05}{265}$$

$$= 1.36\ \mu F.$$

Fig. 7 gives a curve showing the variation in mean rectified voltage with " Reservoir " capacity for a load of 50 mA., and a series resistance of 400 ohms. This series resistance is the total effective resistance R, including transformer resistances and any other resistance in the anode circuit. This curve then agrees approximately with the problem of optimum capacity in equation (2). It can be seen that the calculated value of 1.36 μF. is too small. However, it should be noted that the total effective resistance plus the valve resistance is greater than 600 ohms and the capacity should, therefore, be increased by 1 μF. (see p. 526).

The other curves in Fig. 7 were taken with no anode or transformer resistances, at least they were negligibly small. The optimum capacities calculated from equation (4) give good results in these cases without any adjustment.

It should be noted that in both the above examples, when calculating the transformer voltage, the " Reservoir " condenser capacity is assumed to be very large. Since in the actual case the condenser will cause a small drop in mean rectified voltage, it is advisable to calculate for a slightly greater mean rectified voltage than is actually required.

Transmissions of Wireless Waves of Standard Frequencies from the National Physical Laboratory.

(Station Call Sign G5HW.)

In connection with the work of the Radio Research Board of the Department of Scientific and Industrial Research, waves of accurately known frequency have been transmitted for some years past from the Wireless Station at the National Physical Laboratory for checking the calibration of wavemeters and other apparatus.

A standard frequency transmission is now sent out on a frequency of 1,785 kilocycles per second (*i.e.*, 168.6 metres). The next transmission will be on the first Tuesday in December, commencing at 9 p.m. G.M.T.

The standard transmission is preceded by the announcement C.Q. de G5HW, repeated several times, followed by standard wave transmission on 1,785 kilocycles. The announcement is followed by a continuous dash, the whole lasting 10 minutes.

This procedure is repeated six times, *i.e.*, at 21.00 (9 p.m.), 21 10, 21.20, 21.30, 21.40 and 21.50.

By the use of this standard frequency transmission a very accurate calibration of wavemeters or transmitters can be made, although, as is the case in all accurate measurements, a certain degree of skill is required. A method has been suggested by the Post Office for utilising this standard frequency transmission to obtain the greatest accuracy with the apparatus usually available at amateur transmitting stations.

The apparatus required to check a crystal controlled transmitter or to calibrate a crystal wavemeter by means of this transmission, is, first, a receiver, the settings of which can be accurately determined, having a range from 1,785 kilocycles to the highest calibration frequency required, secondly, a calibrated oscillator having a range of 200 to 1,785 kilocycles. If the receiver is not of the self-oscillating type it will be necessary to employ a separate heterodyne in conjunction with it.

For further details of the transmissions and method of utilising them application should be made to the Secretary, Department of Scientific & Industrial Research, 16, Old Queen Street, S.W.1.

A Capacitive Potential Divider for High Frequency Measurements.

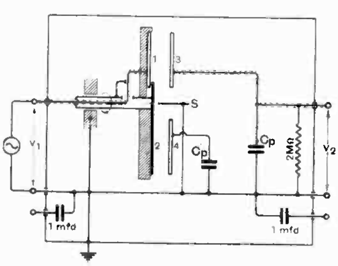
By Dr. K. Schlesinger

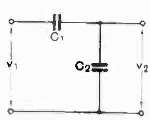
(von Ardenne Laboratory, Berlin.)

I. Description of the Potential Divider.

THE capacitive voltage divider consists essentially of two calibrated capacities connected in series (Fig. 1*a*). This arrangement has a number of advantages over an inductive or an ohmic coupling in a measuring equipment. In the first place, it gives a comparatively easy way of obtaining an extremely loose coupling, using a screened condenser for C_1. Further, it gives continuous adjustment, can be so designed as to be completely independent of frequency, and wattless within the useful range 10 kilocycles to 10 megacycles, and allows its working range to be changed within very wide limits by the addition of extra condensers to the load capacity C_2.

The recognition of these advantages led to the development of such an arrangement for measuring work in the von Ardenne Laboratory; in the following pages the apparatus will be described together with a number of typical applications. Its principle is shown in Fig. 1. An ebonite rotor carries the plates 1 and 2, of which 1 is connected to an input terminal while 2 is connected through the spindle to earth.





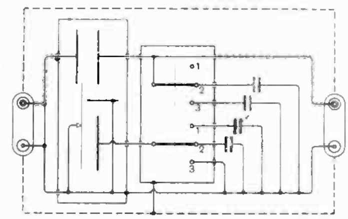
(*a*)

Fig. 1.—*Theoretical diagram of the potential divider.*

As can be seen in the diagram, the edge of plate 2 overlaps that of plate 1. Opposite the rotor lie the two stator plates 3 and 4, their edges so shaped as to avoid too rapid a decrease of the minimum capacity between 1 and 3.

The gap between the rotor and the stator amounts to 0.2 mm. An earthed metal screen *S*, between the two stator plates, comes within 0.1 mm. of the plates of the rotor.* As a result of this arrangement, the

Fig. 2.—*Connections of the "Universal" model of the divider.*



capacity between plates 1 and 3 in their minimum position amounts only to 0.005 cm. With a load capacity C_2 (Fig. 1*a*) ranging up to 20,000 cms., therefore, potential ratios of the order of one million can be obtained, so that standard potentials of a few millionths of a volt—such as are needed for receiver measurements—can readily be arrived at.

Fig. 2 gives the connection diagram of a "Universal" model of the potential divider; here there are three different load capacities which can be thrown in turn by a double-pole switch. The input load of the potentiometer is constant over the whole scale. This result is obtained by means of the special compensating plate 4, and is of particular importance in those cases where a valve with an ohmic anode resistance is used as generator (*e.g.*, in resistance-coupled amplifiers, etc.). In such a case a constant anode-cathode capacity is essential if a quantitative amplification adjustment, holding unchanged for all frequencies, is to be obtained. But apart from such cases, wherever the generator voltage must be kept constant during measurements this compensating arrangement is invaluable, especially when the generator has a high internal resistance. Figs. 3 and 4 show this "Universal" instrument.

* These small air-gaps naturally involve careful design, if the instrument is to be satisfactory. It is stated elsewhere that, thanks to rigid construction, the use of steel bearings, etc., the calibration has not varied after many thousand revolutions.—*Translator.*

II. Calibration of the Potential Divider.

The calibration curve of the voltage divider gives its potential step-down ratio r as a function of its angle of rotation ϕ. There are two different ratios, the *absolute* potential ratio $r_{abs} = |v_1/v_2| = 1 + \frac{C_2}{C_1}$, *i.e.*, the ratio of the generator voltage to the output voltage, and the relative potential ratio $r_{rel} = \left|\frac{v_{2\max.}}{v_{2(\phi)}}\right|$, *i.e.*, the ratio of the maximum output voltage at 180° to the output voltage at the setting ϕ. r_{rel} is a constant of the instrument, whereas r_{abs} depends on the values of the output capacity, but only differs from the relative ratio r_{rel} by a factor which is constant.

The calibration for the closer couplings is carried out with a note frequency, using standard resistances R_1 and R_2 in a bridge connection as in Fig. 5. In this way, in particular, is obtained the minimum step-down ratio, for $\phi = 180°$; this has an average value (for C_2=2000 cms.) of about 30. For very loose couplings, *i.e.*, when the transfer-capacity between plates 1 and 3 is very small, this procedure cannot be used, for when this capacity becomes as low as about 5 cms. the conductivity of the insulating material begins to play a part in the total transfer conductance. Here, therefore, it is necessary to change to radio-frequency calibration, using, say, a wavelength of 600 metres and replacing the resistances R_1 and R_2 by known capacities (*e.g.*, by an already calibrated capacity-potentiometer) and the telephones by a valve voltmeter with an aperiodic input stage. The curves thus obtained join up very well with the ones obtained with the note frequency, and errors can easily be kept down to 1 to 2 per cent. The *relative* step-down ratio, defined above, can be obtained by connecting a standard instrument in series with the one under test and can be checked by comparing the two calibration curves on logarithmic paper and seeing if the intervals are constant. A typical calibration curve for a "Universal" instrument is given in Fig. 6, where the various ranges are obtained with load capacities C_2 varying from 2000 to 20,000 cms.

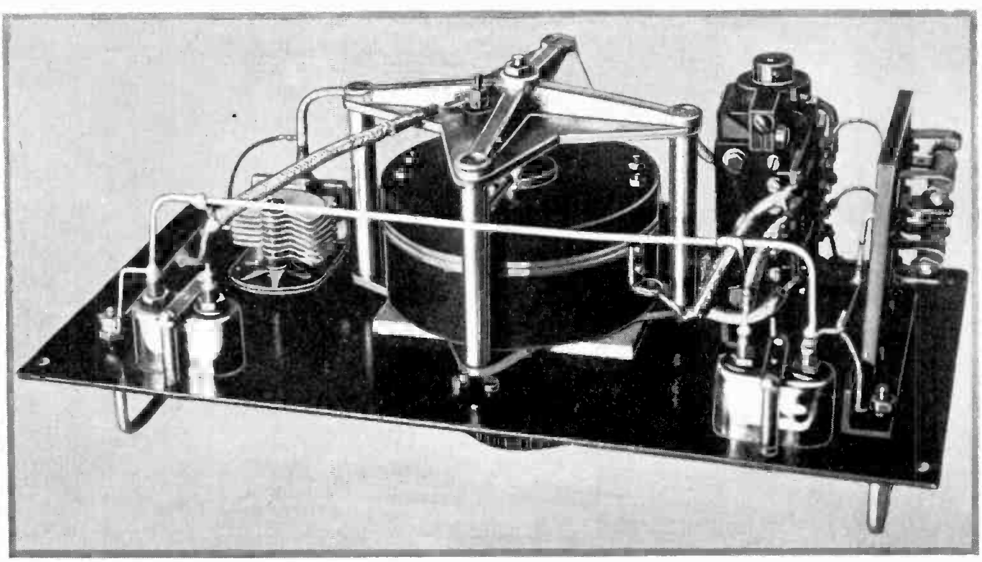


Fig. 3.—*The divider removed from its case.*

In using the instrument, the calibration curves are, of course, only reliable if the external leads to its input terminals are screened, or widely separated from each other, so that no lead-capacity interferes with the transfer-capacity between plates 1 and 3. The capacity effect of whatever apparatus is connected to the output terminals, if it needs attention when compared with the instrument's own load capacity of, say, 2000 to 20,000 cms., can either be calculated or measured with the potentiometer and valve voltmeter. But in the case of the 20,000 cms. capacity, at any rate, this effect is usually negligible, being within the limits of error.

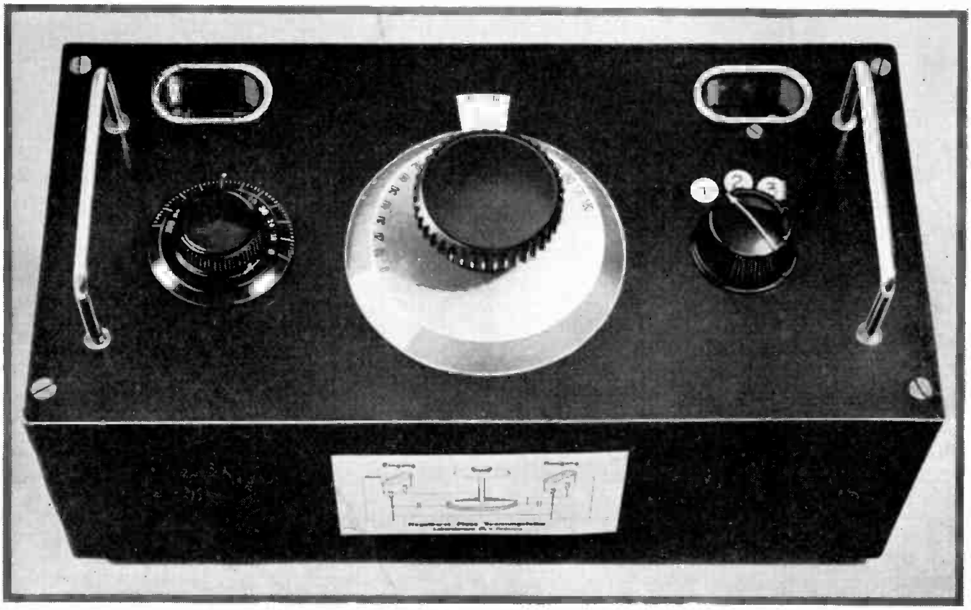


Fig. 4.—*External view of the potential divider.*

This Universal potential divider enables a large number of important high frequency measurements to be carried out. So far as amplification measurements are concerned, it may have to compete with other potential-dividing devices; but its wattless capacitive principle gives it the special advantages of serving also for the measurement of damping in oscillatory circuits, for the measurement of extremely small capacities, and for the determination of dielectric constants; all by the very simplest methods.

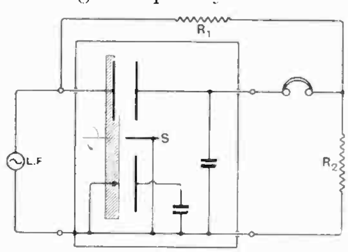


Fig. 5.—(*Above*) *Divider connected up for calibration.*

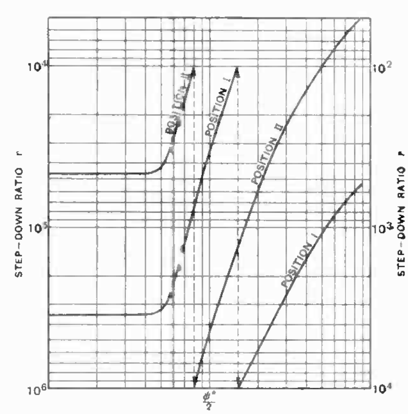


Fig. 6.—(*Right*) *Typical calibration curve.*

III. Amplification Measurements.

Using a radio-frequency generator and an uncalibrated valve voltmeter, combined with the potential divider in the circuit shown in Fig. 7, the amplification of any radio-frequency amplifier (for any wavelength) can be measured by adjusting the divider so that equal deflections are obtained with and without the amplifier; either the absolute or the relative step-down curves can be used, according to whether the divider is cut right out in one measurement or kept in the circuit set at 180°; in other words, the amplification $A = r_{abs}$ in the one case and r_{rel} in the other.

While the method of Fig. 7 gives results accurate to within a small percentage, the method shown schematically in Fig. 8 is useful for a rapid checking of amplifiers where very great accuracy is not needed. This method requires neither a generator nor a valve voltmeter. Here the instrument

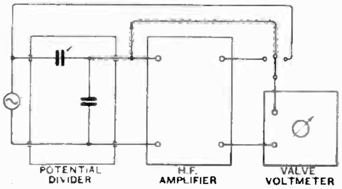


Fig. 7.—*Amplification measurement.*

plays the rôle of a calibrated capacitive reaction coupling—for which it is particularly suitable thanks to the automatic compensation of its input load, since this prevents it from affecting the amplification. At the point where oscillation sets in, in the oscillatory circuit on the left of the diagram, the input voltage must be equal to the voltage on the far side of the divider, or $v_1 = v_1 \cdot \frac{A}{r}$, by which A is given. The phase-adjusting circuit is only used to obtain

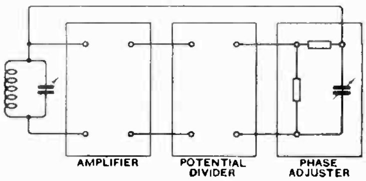


Fig. 8.—*Amplification measurement by the use of calibrated reaction.*

the best conditions for self-excitation, and need not be calibrated.

IV. Measurements on Oscillatory Circuits.

The damping decrement and resonance resistance of an oscillatory circuit can be determined in a very simple manner by the use of the divider. The decrement measurement depends on the fact that the instrument can be connected with its output circuit directly in an oscillatory circuit without adding to the loss resistance of the latter, so that a source of an exactly known exciting voltage is in series with the circuit. In Fig. 9, a blocking condenser C'_2 of 10,000 cms. is connected in series with the circuit under measurement, whose natural frequency is barely affected by it—since in general the circuit capacity is small in comparison with C'_2. The circuit, now containing this blocking condenser, is retuned exactly to the measuring wavelength, and the capacity C_1 of the potential divider adjusted until the potential across the coil, v_3, is equal to the generator potential v_1. When this is the case, we have :—

$$d = \pi \cdot \frac{C_1}{C_1 + C'_2}$$

This formula holds good for all values of C'_2, without it being necessary to know the value of the circuit capacity C_3. The only reason for using a large value of C'_2 is to keep the de-tuning of the circuit negligibly small.*

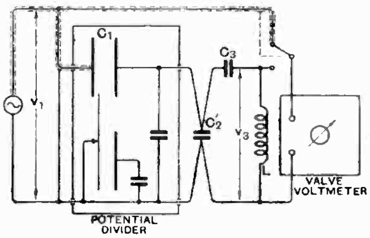


Fig. 9.—*Damping measurement.*

Fig. 10 shows a method of determining the resonance resistance of an oscillatory circuit, and depends on the fact that the screened divider can provide such small transfer-capacities that capacitive resistances can be obtained—for all radio frequencies—which are of the same order as the resonance resistance to be measured. In the condition of equality the following formula for the resonance resistance holds good :—

$$R_{res.} = \frac{477.5\lambda(r - 1)}{C_2}$$

when v_2^2 is made equal to $\frac{1}{2}v_1^2$. This potential relation is also obtained by means of the divider, so that an uncalibrated instrument can be used.

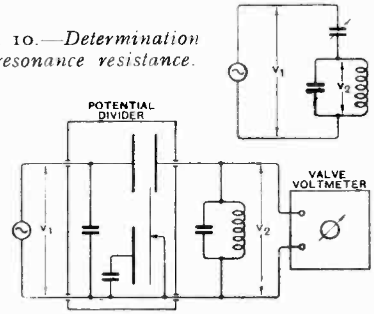


Fig. 10.—*Determination of resonance resistance.*

* *See E.N.T.*, 1930, Nov., p. 434.

V. Receiver Measurements.

In connection with measurements on receivers the potential divider performs two tasks among others :—(1) it measures the total radio-frequency- or field-strength-sensitivity of a receiver, including its primary (aerial) circuit, and (2) it measures the overall sensitivity to modulated radio frequencies. The first process is illustrated in Fig. 11. This diagram only differs from the damping-measurement diagram Fig. 9 by the introduction of the radio-frequency half of the receiver under test ; the amplification factor of this r.f. amplifier is denoted by A. The " field-strength sensitivity " is that r.f. output potential, from the amplifier, which is obtained when the receiver aerial is affected by one unit of field strength—*e.g.*, one microvolt/metre. If, in the arrangement shown in Fig. 11, the input and output potentials are adjusted to be equal, we have the direct relation :—

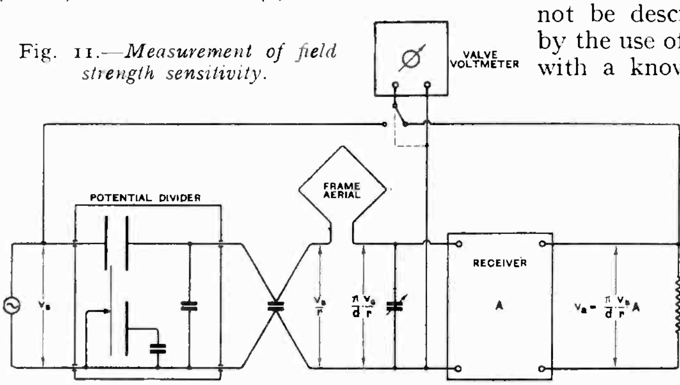


Fig. 11.—*Measurement of field strength sensitivity.*

$$\frac{\pi}{d} \cdot A = r_{abs}$$

This product is a special fundamental quantity for field-strength measuring equipments ; with its determination the calibration of the equipment is, in theory, complete. Since this product works out to a quantity of the order of $10^5 - 10^6$, the process is one which can obviously only be carried out by a potential divider which will give correspondingly large absolute step-down ratios, *i.e.*, which will give correspondingly minute transfer-capacities. In the diagram it is assumed that the receiver's normal open aerial is replaced, for measuring purposes, by a frame aerial of equal effective height. By the use of the divider the quantity $\frac{\pi}{d} \cdot A$ can be measured within a small percentage, whereas its determination from separate measurements of damping and amplification would naturally be subject to far greater errors.

An actual receiver-testing equipment will not be described here, except to say that by the use of a note-modulated r.f. generator with a known degree of modulation, combined with the divider, it is easy to determine the minimum input potential which will just give the required low frequency output power. Comparative measurements are particularly convenient, since the divider is continuously variable.

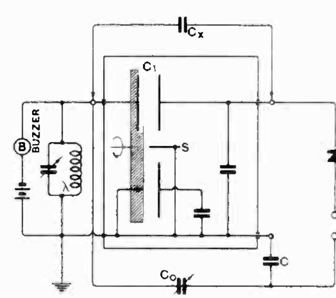
VI. Capacity Measurements.

If the divider gives an absolute step-down ratio r when it is loaded with an output capacity C_2, the capacity of its transfer-condenser C_1 is known, namely :—

$$C_1 = \frac{C_2}{r - 1}$$

Since this capacity can be made to range from 0.001 to 0.01 cm., it enables correspondingly small capacities to be measured very conveniently by the " added condenser " method (" difference " method). Fig. 12 shows a particularly convenient way of carrying this out with the simplest materials. C_x is the very small capacity to be measured (valve socket ; static determination of " durchgriff "—reciprocal of amplification factor ; investigation of screening, and so on). As a first step, the divider is set at zero ($r = r_{max.}$), and C_x is connected in

Fig. 12.—*Measurement of very small capacities.*



parallel to C_1. The variable condenser C_0 (500 cms.) is adjusted till the detector telephones of the bridge circuit are silent. C_x is then cut out of circuit and the divider readjusted till the bridge is again balanced. Then we have the direct relation $C_1 = C_x$, or—if the residual capacity is to be considered,

$$C_x = C_2\left(\frac{1}{r_{\text{max.}}} - \frac{1}{r_{(\phi)}}\right)$$

The process is extremely easy, and the bridge can be excited—as shown—by a simple buzzer without any need for a note-modulated valve generator or an amplifier. Capacities down to the minimum value of C_1 can be measured with the accuracy with

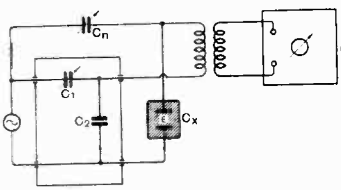


Fig. 13.—*Determination of dielectric constant.*

which the divider itself has been calibrated—as practical experience has confirmed.*

VII. Measurement of Dielectric Constants.

Since the calibration curve of the relative step-down ratio r_{rel} is fundamentally nothing more nor less than the curve of the capacity relations of the transfer-capacity C_1 (*i.e.*, the capacity between plates 1 and 3), an obvious thing to do is to use this curve for the determination of an unknown capacity relation by means of a bridge circuit. Looking at Fig. 13, it is clear that the divider, with its transfer capacity C_1, can give a direct measurement of ϵ (dielectric constant) without it being necessary to know the capacity of the containing condenser C_x in its empty state. With C_x empty, the bridge is adjusted to balance by means of the small neutralising condenser C_n; the divider being kept at its position of maximum transfer, $\phi = 180°$. If now the dielectric under investigation is introduced so that C_x becomes ϵ-times as great as before, the divider is adjusted so that with a smaller C_1 the bridge is again balanced. Then $\frac{C_1}{C'_1} = \epsilon$, so that the divider can in fact be calibrated directly in terms of ϵ, and the dielectric constant may be read off in a single reading.† If the testing wavelength

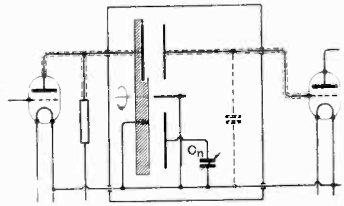


Fig. 14.—*Calibrated inter-valve coupling.*

is variable, dispersion measurements may thus be carried out in the shortest possible time. Such an equipment, arranged for mains supply, has proved very successful.

VIII. The Potential Divider in Receiving Circuits.

Radio-frequency measuring amplifiers, for example Field-strength measuring sets, are especially convenient to use if their sensitivity can be adjusted once and for all for all frequencies in question. If the divider is used, as in Fig. 14, as the coupling element between two valves, the capacitive load on the preceding valve is independent of the setting. The input voltage to the divider is therefore also independent of its setting, and is only influenced by the relations in the preceding, fixed-coupling stages of the amplifier. The effective amplifying power of the cascade therefore changes exactly as the relative step-down ratio of the divider, whose calibration curve can thus be applied

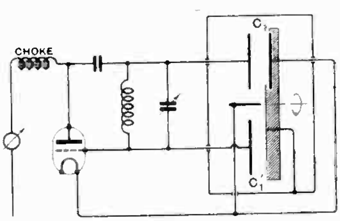


Fig. 15.—*Calibrated capacitive reaction coupling.*

directly. In Fig. 14, only the neutralising condenser C_n has to be made equal to the capacity to earth of the grid of the succeeding valve. With this capacity at from 40 to 60 cms., this adjustment must be made with the greatest care, since the anode earth-capacity of the valve in front of the divider is of the same order of magnitude, and the loading of this valve is chiefly capacitive—especially

* *See Zeitschr. f. tech. Phys.*, 1930, December, p. 537.

† *See E.N.T.*, Nov., 1930, p. 434.

for short waves. In such a case the compensation is therefore of special importance, and the neutralising condenser C_n is accordingly included in the "Universal" model of the divider, for switching in when required (see Fig. 2).

Fig. 15 shows a circuit with calibrated reaction coupling. The reaction-coupling factor k depends on the transfer capacity ratio $\frac{C_1}{C'_1}$, and can be calculated from the formula :—

$$k = \frac{r_0}{r - r_0}$$

This circuit, which works well even down to wavelengths of 4 metres, is particularly suitable for the determination of the dynamic slope of valves whose static characteristics cannot be plotted—for instance, valves with external grids.

Summary.

The paper describes a capacitive Potential Divider of special construction which gives potential step-down ratios of the order of one million with an error of only 1 to 2 per cent. Its numerous applications in high frequency measuring technique are also described. These applications chiefly concern measurements on amplifiers, receivers and oscillatory circuits, together with the determination of the values of very small capacities and of dielectric constants. The frequency range in which this potentiometer can be used includes all the frequencies met with in practice, from about 10 to 10^4 kilocycles per second.

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.

Carrier Waves and Side-Bands.

To the Editor, The Wireless Engineer.

SIR,—Mr. R. H. Nisbet in his letter on the above subject in your August issue, accuses the opponents of the Side-Band Theory of having become entangled in metaphysics. Personally, I think his accusation is not without considerable justification, but has not Mr. Nisbet himself become somewhat entangled in the possible meanings of the term *theory* when he asserts that "*There never was a Side-Band Theory?*"

Apparently, according to Mr. Nisbet's understanding of the term, a theory is not a theory unless it includes the enunciation of some new physical concept. With such a limitation of the meaning of the term it would not be correct to speak, for example, of the theory of alternating currents or of the theory of the induction motor, since these theories are merely particular applications of generally accepted electromagnetic principles and do not in themselves involve any new physical concepts.

I think Mr. Nisbet is wrong in thus restricting the meaning of the term *theory*, and that it is quite properly used in examples such as the above, where it denotes the mathematical deduction from the general laws of electromagnetism of the effects to be expected in certain specific applications. With this wider meaning of the term *theory*, there *is* a side-band theory—it is the application of a *particular form* of mathematical analysis to the reception of a modulated electromagnetic wave. The experimental basis of the theory is, however, not, as Prof. Fortescue appears to suggest in his letter in your May issue, the experiments he cites under (*a*) and (*b*), but the innumerable experimental researches on which the generally accepted laws of electromagnetism have been founded. The experiments he mentions are merely confirmatory of the deductions made by the side-band theory. What, I think, Mr. Nisbet is seeking, quite rightly, to emphasise, is that this theory involves no *new* physical concept, or postulate, and the correctness of its deductions can, therefore, be called in question only by pointing out some error in the mathematical development, or by questioning the validity of the generally accepted principles governing electromagnetic phenomena.

As a matter of fact, the implications of the side-band theory have scarcely yet been fully investigated, as is made clear by Prof. Howe's interesting editorial and Prof. Fortescue's further letter in your August issue. When they have been, there is little doubt the results will ultimately be found to be in entire agreement with experimental observations.

E. A. BIEDERMANN.

Brighton.

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

To the Editor, The Wireless Engineer.

SIR,—In an article, which appeared in your August issue, on the above subject Mr. F. M. Colebrook makes the following statement: "It is further assumed that the detector output load is of low impedance relative to that of the detector at radio and high supersonic frequencies and of high relative impedance at audible modulation frequencies. (This is equivalent to Butterworth's assumption of an output instrument which is too sluggish to respond to radio and supersonic frequencies but is able to record changes at zero and audible frequencies.) This again is approximately descriptive of the grid rectifier and also, though less exactly, of an anode bend rectifier." The assertion that the grid leak shunted by a condenser is approximately equivalent to the sluggish recording instrument is, I believe, a mistake. To make the distinction clear I propose to adopt the graphical treatment of the subject outlined by Dr. Beatty (issue June, 1928) and developed more exactly in the August editorial. In the case of the sluggish recording instrument the conclusions reached by both Butterworth's and the graphical treatment are identical and both are correct.

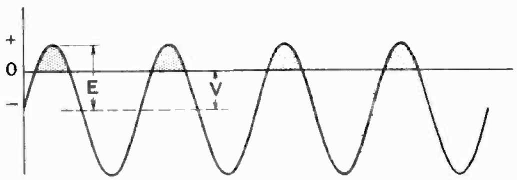


Fig. 1.

It is, however, assumed that the E.M.F. applied to the rectifier is simply the sum of the E.M.F.s produced by the wanted and unwanted signals, that is to say, there is no potential drop across the detector output load, which is in series with the rectifier. When the detector output load is of high impedance relative to that of the rectifier, as in the case of the grid detector, a large potential difference will be maintained across the output load. The E.M.F. applied to the rectifier is the difference between the input E.M.F. and this potential drop.

When a simple harmonic oscillation is applied to a detector with an output load impedance which is high at low frequencies and negligible at radio-frequencies, the potential applied actually to the rectifier is as shown in Fig. 1. The ratio V/E depends on the resistance (R) of the output load relative to that of the rectifier (R_a) when conductive. The steady current V/R flowing through the output load resistance R, is equal to the average current flowing through the rectifier, this current is proportional to the shaded areas under the tips of the curve. The ratio V/E which satisfies this condition may be calculated quite simply, and the solution has been published by F. M. Colebrook (The Theory of the Straight Line Rectifier, *E.W. & W.E.*, Nov., 1930). It should be noted that if R is very great V approaches E.

If the input to the detector consists of two oscillations $V_1 \sin \omega t$ and $V_2 \sin (\omega+p)t$, where p is much smaller than ω, the resulting envelope of the oscillation will be of the type shown in Fig. 2, which is similar to Fig. 1 (*b*) of the August editorial. If the impedance of the detector output load is negligible at a frequency $p/2\pi$ and high at low frequencies the potential V (see Fig. 2 (*b*)) across this load will be constant and must be determined as in the simple case just considered by making the sum of the areas shown shaded corresponding to a long time t equal to $V\frac{R_a}{R}t$. If R is much greater than R_a, V will tend to the peak value V_1+V_2, and the demodulation effect will be non-existent. With ordinary values of R it is to be expected that the demodulation effect will lie between this, and the amount when $R=O$ which is the case considered by Butterworth and Colebrook. With a grid detector, in practice, there will as a rule be an appreciable component of the frequency $p/2\pi$ in the detector output and in this case it is to be expected on general grounds that the extent of the demodulation will be just slightly less than that deduced in the articles referred to. For, if the detector output followed the modulation of the input perfectly, the mean value of the output would be increased by just the calculated amount and, as we have just seen, the demodulation effect is less if the detector output does not follow the modulation of frequency $p/2\pi$ at all. Even with the perfect rectifier it is therefore to be expected that the demodulation will be less than originally deduced by Butterworth.

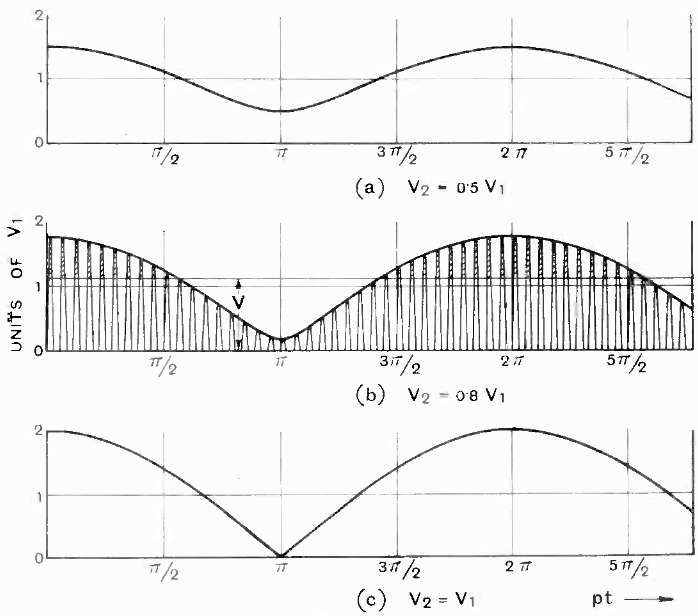


Fig. 2.

The main conclusion from the study of the phenomenon remains unaltered, namely that to avoid cross modulation and distortion as distinct from ordinary heterodyne interference, the ratio of the interfering signal to the main carrier must be kept as small as possible. This may be achieved either by tuning the receiver very sharply to the wanted carrier, as in the case of the Stenode receiver, or by enhancing the carrier by the homodyne method as I suggested in an article in this Journal, March, 1929.

W. B. LEWIS.

Gonville and Caius College,
Cambridge.

Transients and Telephony.

To the Editor, The Wireless Engineer.

SIR,—The absence of references from the article "Transients and Telephony," by T. S. E. Thomas in your September issue leads one to suppose that the work is quite novel. This, however, is not the case. In *Wireless World*, April 3rd, 10th, August 7th, 14th, 1929, I described experiments on loud speakers and amplifiers when impulsed. The work of amplifiers was ably confirmed mathematically by C. A. Oatley in this journal, May and June, 1931. In *Phil. Mag.*, p. 1036, June, 1929, and p. 45, January, 1931, an analytical method of treating transients associated with a point source and a coil-driven rigid disc is given. With these publications in existence, Mr. Thomas merely alters the shape of the transient and proceeds on similar lines. If our efforts had emanated from America we should doubtless have had honourable mention.

We are told : "In its ideal form the cone L.S. consists of a rigid *piston*—this is American whilst *disc* is ours—held in position by some elastic support." I thought I had exploded this "ideal" myth some time ago, by showing that due to interference the power output above 1,000 cycles decays rapidly (*Phil. Mag.*, Fig. 9, p. 1035, 1929, *Wireless World*, letter, May 14th, 1930, January 21st, 28th, 1931). I have also shown that the M.C. speaker depends on resonances throughout the acoustic register (*Wireless World*, January 21st, 28th, May 6th, 13th, July 29th, August 12th, 19th, all 1931). It is stated that the force on the disc is proportional to the original transient. Owing to variation in accession to inertia, radiation resistance and motional reactance with frequency, the force is not a replica of the wave form applied to the valve grid. Taking a case amenable to mathematical treatment, G. A. V. Sowter and myself compared the acoustic output from an ideal point source with that from a coil-driven rigid disc for a certain wave form on the axis and at 45° thereto. Electromechanical reaction and reactance variation were included (*Phil. Mag.*, p. 45, January, 1931).

N. W. MCLACHLAN.

The Stenode Receiver and the Side-Band Theory.

To the Editor, The Wireless Engineer.

SIR,—In a letter in your August issue Professor Fortescue has taken me to task for using Moullin's work to attack some theory, but we are left to guess which theory I am supposed to be attacking. Actually the facts are quite the reverse, for I am much more concerned with constructive work, such as establishing new facts. I would not in the least object to being criticised on the score that I deliberately set out to search for methods to receive modulated waves by utilising super-selective devices, such as a quartz crystal, notwithstanding the universally accepted belief that such high selectivity would inevitably result in cutting off all the side-bands, but I certainly do object to being accused of attacking fundamental mathematical equations.

Presumably, Professor Fortescue is under the impression that I have attacked the side-band theory. If this is his view, it would be of interest to know precisely what he means by the words "Side-Band Theory." He must be aware of my publications on the Stenode, and that at the basis of all mathematical work which I have published, there are the same fundamental equations on which the side-band theory is founded. There is considerable confusion as to what the side-band theory actually is, and this may account for the fact that Professor Fortescue appears to think I have attacked it. Other people are also recognising this confusion, and in a letter by Mr. Nisbet, in your August issue, there appears the statement that "*There never was a Side-Band Theory.*"

It is now well known that this work of mine has led to remarkable results, and has provided a new method for designing radio receivers which are exceedingly free from interference.

At the present moment we are concerned with facts and not with metaphysics, and it is pleasing to note that many of our leading wireless authorities are seriously investigating the new results of the Stenode, particularly Mr. Colebrook and the writer of your Editorial in your August issue, and, further, Professor Appleton, in *Wireless World* for June 17th, and Mr. Moullin in your May issue.

London, W.1. J. ROBINSON.

Nodal Lines on Vibrating Diaphragms.

To the Editor, The Wireless Engineer.

SIR,—At the moment, when attention is focused on the problem of vibrating diaphragms, it may be of interest to consider the nodal lines pertaining to symmetrical modes of vibration. It is usual to tacitly assume a nodal circle on a centrally driven disc to be a position of rest. When one performs an experiment, it is found that the so-called nodal circle moves, *i.e.*, the amplitude is not zero. If the amplitude at the centre is small, but sufficient to cause the sand to move slowly over the surface, it collects on a circle which appears to be at rest. By increasing the amplitude beyond a certain value, the sand about the circle jumps quite vigorously. When a free edge disc vibrates *in vacuo* and there is no loss, the energy transmitted radially outwards is equal to that transmitted radially inwards after reflection from the edge. At frequencies corresponding to various modes of vibration, the transmitted and reflected energies annul each other, thereby causing true nodal lines where there is no motion provided the disc is adequately thin. At the first centre stationary mode the node occurs at the centre, whilst at the first centre moving mode it occurs at about 0.68 of the radius. At the second centre stationary mode there are two nodes, one at the centre and one between this and the edge. The centre stationary and centre moving modes alternate in this manner. All portions of the disc moving in a certain direction at a given instant are in phase. Thus measurement of the maximum amplitude over a radius would give the shape of the disc during vibration since the phase changes by π at a node.

In practice, during vibration in air or *in vacuo*, losses occur. Consequently, the transmitted energy exceeds that reflected from the edge, whilst there is a phase difference in the maximum amplitude at different radii. Thus there is no actual node, but a position of minimum amplitude.

Owing to the phase difference between the maxi-

characteristic impedance is

$$I = \cosh P(l - x) / \sinh Pl$$

By aid of well-known identities this can be written

$$I = \left[\frac{\cosh^2 \alpha(l - x) - \sin^2 \beta(l - x)}{\sinh^2 \alpha l + \sin^2 \alpha l}\right]^{\frac{1}{2}}$$

the phase angle being $\tan^{-1} \tanh \alpha(l - x) . \tan \beta (l - x) - \tan^{-1} \cosh \alpha l . \tan \beta l$

where l = length of cable

x = distance from input

α = attenuation coefficient

$\beta = 2\pi/\lambda$ = wavelength coefficient.

Since $(\sinh^2 \alpha l + \sin^2 \alpha l)$ is constant for any given cable, it can be left out of account for our present purpose. [Its inclusion would make the amplitude

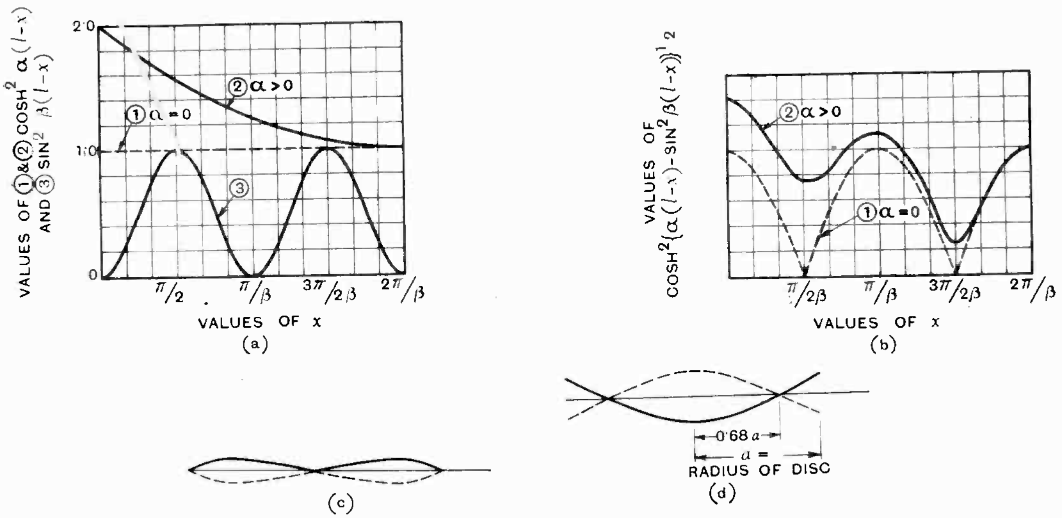


Fig. 1.

mum values at different radii, the shape of the disc cannot be plotted from measurements of amplitude only. To obtain the shape at any instant, the phase angles would have to be found. When the amplitude is plotted against the radius, there will be a zero point, but this is not a node except in a momentary sense. In fact, the circle of zero amplitude oscillates between the centre and the circumference—an iris diaphragm effect which might be followed in a transparent substance by aid of intermittent polarised light.

The various points enumerated above can be *illustrated* by reference to the transmission of energy in a loaded cable grounded at the far end to simulate the free edge disc. It is to be clearly understood that the cable is not analogous to the disc. In the latter case we are not concerned with the propagation of longitudinal, but of flexural, waves. Warren has pointed out (*J.I.E.E.*, Vol. 69, p. 615, 1931) that a bending moment cannot be represented by a real electrical quantity.

The current at any point of the cable corresponds to the amplitude of vibration of the disc at some radius. Its value for unit input voltage and unit

of curve 1 of Fig. 1*b* correct, *i.e.*, ∞]. Thus we can consider the expression

$$y = [\cosh^2 \alpha(l - x) - \sin^2\beta(l - x)]^{\frac{1}{2}}$$

with phase angle as above.

In Fig. 1*a* we have the curves (1) $\cosh^2 \alpha(l - x)$ for $\alpha = 0$, (2) $\cosh^2 \alpha(l - x)$ for $\alpha > 0$ and (3) $\sin^2 \beta (l - x)$. Considering curves (1) and (3) we see that for a cable with zero resistance and leakance, *i.e.*, $\alpha = 0$, y is the square root of the difference in the ordinates. Thus $y = [1 - \sin^2\beta(l - x)]^{\frac{1}{2}}$ and this —without reference to phase—is shown dotted in Fig. 1*b*, curve 1. The phase angle from 0 to $\pi/2\beta$ and $3\pi/2\beta$ to $2\pi/\beta$ is $- \pi/2$ and from $\pi/2\beta$ to $3\pi/2\beta$ it is $+ \pi/2$, *i.e.*, the current from $\pi/2\beta$ to $3\pi/2\beta$ is in opposite phase to that in the other portions, as in a cosine curve. The current in any particular portion is in phase throughout, and its amplitude is always zero at $\pi/2\beta$ and $3\pi/2\beta$. Thus there are true nodes whose separation is the half wavelength.

When $\alpha > 0$ we obtain curve 2 of Fig. 1*a*. y is the square root of the difference between (2) and (3), and is shown in Fig. 1*b* by the full line curve (2). This curve shows the maximum amplitude of the current, but not its phase. Moreover, curve 2 is not an instantaneous picture of the state of the cable. To obtain the latter it is necessary to calculate the phase of the current at various points, and then using the ordinates of Fig. 1*b* (2) to obtain the instantaneous values. The current can now be plotted. It is clear from curve (2) Fig. 1*b* that there are no nodes. Points of minimum amplitude occur at $\pi/2\beta$ and at $3\pi/2\beta$. The former has the greater value since the reflected energy is more highly attenuated at $\pi/2\beta$ than at $3\pi/2\beta$.

If we assume $3\pi/2\beta$ to be the centre of the vibrating disc and $2\pi/\beta$ the edge, then the curve between the two illustrates a centre stationary mode. When there is no loss the amplitude at the centre is zero and the whole disc moves in phase, whereas losses necessitate a central motion to replenish the wasted energy, *i.e.*, the centre is a point of minimum amplitude and there is a phase difference along the radius. If now the centre is π/β and the edge $2\pi/\beta$, $3\pi/2\beta$ represents the position of minimum amplitude of the first centre moving mode. With $\pi/2\beta$ for centre we get the second centre stationary mode with minimum amplitude at $3\pi/2\beta$ and so on. In Fig. 1*c* we have indicated approximately the shape of the disc to be expected at various epochs. These have not been calculated.

When the amplitude of vibration of a conical diaphragm is measured at various radii under the stimulus of a powerful driving force one might obtain a diagram of the form shown in Fig. 1*b*, curve 2. As we have already seen this is quite erroneous owing to the question of phase, and it probably explains why Dr. M. J. O. Strutt (this Journal, May, 1931) obtained no nodes on certain cones. Doubtless the losses or the amplitude or both were large. In any case there should be no nodes. I encountered this effect some time ago in experiments on discs and cones. A preliminary account of these appeared in the *Wireless World*, July 29th, Aug. 12th, 19th, 1931.

The problem of the effective mass M_e of a diaphragm is closely associated with the preceding, and curves of M_e for conical diaphragms are given in the above paper. I hope to deal with this in greater detail in the near future. It may be of interest to state that negative values of effective mass have been found for a cone amounting arithmetically to some 10 times its natural mass, and similar results have been obtained for an aluminium disc.

N. W. McLachlan.

Books Received.

From Telegraphy to Television.

The story of Electrical Communications, by Lt.-Col. Chetwode Crawley, M.I.E.E. A summary, in simple style, of the development of electrical communication. Pp. 212+xii, with 44 illustrations including 24 whole-page plates. Published by Frederick Warne & Co., Ltd., London and New York. Price 6s. net.

Television To-Day and To-Morrow (2nd Edition). By Sydney A. Moseley and H. J. Barton Chapple, with a foreword by John L. Baird.

A general account of the history and progress of Television chiefly relating to the Baird system. Pp. 163+xxvii, with numerous illustrations and diagrams. Published by Sir Isaac Pitman & Sons, Ltd., London. Price 7s. 6d. net.

Foundations of Radio. By R. L. Duncan.

A text book for students, covering the elementary theory of electricity and allied subjects that comprise the essentials of wireless but not the theory or practice of radio itself. Pp. 245+ix with 145 diagrams and illustrations. Published by John Wiley & Sons, Inc., New York, and Chapman & Hall, Ltd., London. Price 12s. 6d. net.

Quartz Resonators and Oscillators. By P. Vigoureux, M.Sc., of the N.P.L.

A summary of the practical application of the piezo-electric properties of Quartz. Pp. 217, with 125 diagrams and illustrations of extensive bibliography. Issued by the Department of Scientific & Industrial Research, and published by H.M. Stationery Office. Price 7s. 6d. net.

Siebschaltungen (Filter Circuits). By Dr. Ing. Wilhelm Cauer.

In loose-leaf form comprising 24 pages of text, with 19 diagrams and 68 charts (curves, etc.). Published by V D I—Verlag, G.m.b.H., Berlin. Price R.M.14.

Störschutz am Rundfunk-Empfänger in der Praxis. By Heinrich Ike.

A short description of various methods of reducing interference. Pp. 32, with 30 diagrams. Published by Rothgiesser and Diesing A.G., Berlin. Price RM 1.

Measurement of Small Capacities.*

By V. V. Sathe, B.E., and T. S. Rangachari, M.A., M.Sc.

(Indian Institute of Science, Bangalore.)

Synopsis.—A compact and self-contained d.c. mains operated arrangement working on the principle of substitution is described for measuring capacities from .002μF. down to minute capacities such as inter-electrode capacities of valves. A vernier arrangement which gives a small definite change of capacity is described which in conjunction with the particular method adopted for detecting resonance condition gives an accuracy of about 0.15$\mu\mu$F. in the measurement of small capacities. Sources of error are discussed. Results of measurement of capacities such as fixed and variable condensers met with in a wireless laboratory, the residual capacities of some variable condensers, the inter-electrode capacities of different types of receiving and transmitting valves and the capacities of wiring materials, such as lead-covered cables and flexibles, are given.

A NUMBER of well-known bridge methods are available for the accurate determination of capacities of condensers. In a radio frequency laboratory the order of capacities generally met with is from 2,000$\mu\mu$F. on the upper side to minute capacities, such as the inter-electrode capacities of valves and the stray self capacities of circuit wiring. The method described below is particularly suitable for the determination of those small capacities where bridge arrangements would appear to introduce stray capacity effects bigger in magnitude than the quantities to be measured.

An important feature of the circuit used is that it is a self-contained mains set requiring no auxiliary batteries. It is worked from a 110-volt battery-mains supplying power to the premises. The schematic diagram of connections is shown in Fig. 1. Valve V_1 functions as a self-oscillator with V_2 as an anode bend detector. The filaments of these valves are in series with each other and connected to the mains with additional resistance for reducing the voltage at each filament to the required value as indicated by the voltmeter permanently connected across one of the filaments. The grid bias for the detector is obtained from the voltage drop across a resistance in the filament circuit.

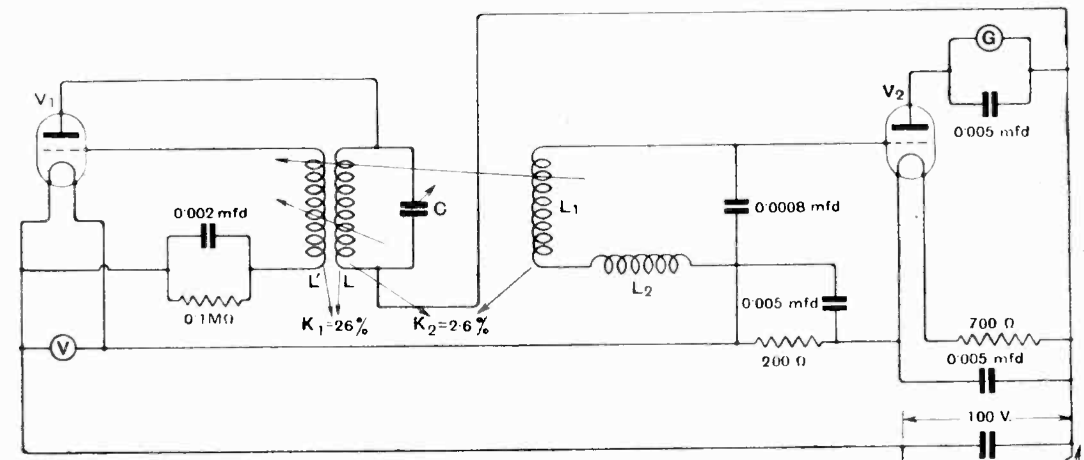


Fig. 1.—*Valve V_1 is Mullard PM 3. Valve V_2 is Mullard PM 5X. K_1 and K_2 are coefficients of coupling.*

The oscillator is of the orthodox type with magnetic reaction between the grid and the

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

plate circuits. The tuning condenser C in the anode circuit needs special mention. It is shown in Fig. 2 in detail. This consists of fixed value mica condensers of .001μF. and .0005μF. capacity, each with a cut-out switch. A variable air condenser of .0012μF. with vernier movement provides for fine adjustment of condenser value. In parallel with these there is a combination of three condensers c_1, c_2 and c_3, as shown in the branch *ab* of Fig. 2, of which c_1 is a variable condenser. Another parallel branch *cd* contains a small condenser of value about 15$\mu\mu$F. with a tapping switch with a long ebonite arm to minimise any hand capacity effects. The choice of these condensers is discussed in a later section of the paper. All these condensers were calibrated *in situ* against a sub-standard condenser connected at the terminals provided for the unknown. The oscillator was adjusted to about 960 metres and loosely coupled to the grid of the anode-bend detector V_2 by coil L_1. This coil and a series loading coil L_2 with a fixed parallel condenser C form the grid oscillatory circuit which tunes to the frequency of the oscillator. Due to the heavy negative bias, grid circuit tuning is very sharp the decrement being about 1.8%. The indicator in the detector anode circuit is a unipivot galvanometer having 100 scale divisions with a sensitivity of 2μA. per division. The value of the negative grid bias is so adjusted that when the first valve does not oscillate the galvanometer shows a small reading.

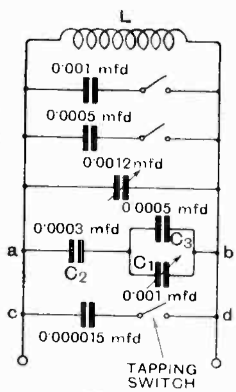


Fig. 2.

Experimental Procedure.

The procedure in determining the value of a condenser not exceeding .002μF. is as follows. The mains are switched on and the current in the filament circuit is adjusted till the voltmeter reads 4 volts. The galvanometer will now show a certain reading whose exact value is not of importance. Then the small 15$\mu\mu$F. condenser in the anode circuit of the oscillator is cut in and out of circuit with the tapper key. If a change of deflection is observed in the galvanometer the vernier condenser in the branch *ab* (Fig. 2) is varied until tapping produces no change in the galvanometer reading. In this position the reading of the condensers in the oscillator circuit is taken. The unknown condenser is next inserted in place and the oscillator condenser diminished till on working the tapper key mentioned above, no change of deflection is observed. A second reading of the condensers in the oscillator circuit is noted. From a set of curves obtained from calibrating the apparatus against a standard condenser, the difference in capacity is read off, giving the value of the unknown condenser.

The oscillator circuit condensers are selected, as explained later, so that in conjunction with the particular tapper method of detecting resonance an accuracy of the order of 0.2$\mu\mu$F. is obtainable.

Where great precision is not needed the vernier arrangement of branch *ab* (Fig. 2) need not be operated, as the accuracy obtainable by varying the .0012μF. variable condenser alone is of the order of 3$\mu\mu$F.

Tables I to IV give results of measurement carried out with this method. Table I deals with fixed condensers of well-known makes.

TABLE I.
Fixed Condensers.

Maker.	Rating. μF.	Observed Value. μF.
Dubilier	.002	.001743
Do.	.001	.000858
Igranic	.0002	.000214
Marconi	.002	.001800
Sullivan	.001	.000985
Do.	.0005	.000463

TABLE II.
Residual Capacities of Some Variable Condensers.

Maker.	Rated Max. Value.	Residual Capacity at Zero Dial Reading.	%
Marconi	.001 μF.	42 $\mu\mu$F.	4.2
Sterling	.00025 ,,	27.5 ,,	11.0
Jackson Bros. ..	.0005 ,,	12.5 ,,	2.5
Radio Instruments ..	.001 ,,	42.5 ,,	4.25

Table II shows the residual capacities of variable condensers while III and IV refer to inter-electrode capacities of thermionic valves and certain miscellaneous capacities associated with wiring materials.

TABLE III.

INTER-ELECTRODE CAPACITIES OF VALVES.

Maker.	Valve.	Capacity between Grid and Anode.	Capacity between Grid and Filament.
Mullard ..	PM 3	7.8μμF.	9.5μμF.
Do. ..	PM 254	7.8 ,,	11.0 ,,
Do. ..	HF	3.8 ,,	7.5 ,,
Do. ..	LF	3.8 ,,	7.5 ,,
Do. ..	O 10	5.3 ,,	9.0 ,,
Do. ..	O 15	4.5 ,,	8.0 ,,
Do. ..	VO 150	10.8 ,,	13.0 ,,
Marconi ..	R	4.0 ,,	7.0 ,,
Do. ..	DE 5	9.3 ,,	10.5 ,,
Do. ..	MT 4	13.5 ,,	12.0 ,,
Burndept ..	HL 310	5.0 ,,	9.3 ,,
Do. ..	L 525	7.0 ,,	9.0 ,,
B.T.H. ..	B 4 H	10.0 ,,	10.5 ,,
Six-Sixty ..	SS 230	7.0 ,,	9.8 ,,

TABLE IV.

MISCELLANEOUS CAPACITIES.

1 yard of maroon flexible	44μμF.
2 yards do. do.	90 ,,
1 yard of $\frac{1}{16}$ twin lead covered cable :	
Between the two conductors	83 ,,
Do. one conductor and lead sheath	162 ,,
Do. other do. do.	161 ,,

Vernier Arrangements in the Oscillator Circuit.

The arrangement of this vernier depends on the following considerations :

(i) The precision needed in the measurement.

(ii) The accuracy with which the condition of tuning can be ascertained.

(iii) The constancy with which calibration conditions can be maintained during normal use.

(iv) The accuracy to which the standard is known.

It is possible to produce and measure extremely small changes of capacity. For instance, Falconberg (*Annalen der Physik*, Jan., 1920, Vol. 61, pp. 167–172) has measured changes of capacity amounting to two parts in one hundred million. For the present purpose it is useless to attempt such an accuracy since if a condenser is measured to that accuracy and if it merely changes its position with respect to surrounding objects the resulting change of capacity will be greater than the order of accuracy attempted. In the present case an accuracy of 0.2 to 0.3μμF. reliably obtained was considered to be sufficient.

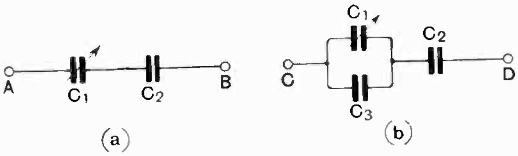


Fig. 3.

(b) $C_1 = .001\mu F$. $C_2 = .0003\mu F$. $C_3 = .0005\mu F$.

To achieve this it is necessary first to produce such a change in capacity and, secondly, to be able to detect clearly the effect of such a change. Both these points are discussed below.

In Fig. 3*a*, a variable condenser c_1 is shown in series with a fixed condenser c_2, the equivalent capacity between *AB* being given by the relation,

$$C = \frac{c_1 c_2}{c_1 + c_2} \quad \ldots \quad \ldots \quad (1)$$

c_2 being fixed the rate of change of C with respect to c_1 is given by

$$\frac{dC}{dc_1} = \frac{c_2^2}{(c_1 + c_2)^2} \quad \ldots \quad \ldots \quad (2)$$

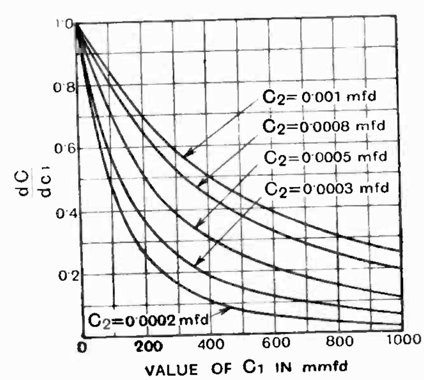


Fig. 4.

In Fig. 4 the relation between $\frac{dC}{dc_1}$ and c_1 is plotted for several values of c_2. It is observed from these curves that for any given value of c_2, if the value of c_1 is small, a small change in c_1 produces a large change in the total capacity C, while if the value of c_1 is large, a small change in c_1 produces a still smaller change in the total capacity. This suggests that a parallel condenser c_3, as shown in Fig. 3*b*, is needed if a small rate of change of the total capacity is desired when c_1 is varied. The actual values chosen, referring to Fig. 3*b*, were, c_1 a variable condenser of .001μF. maximum capacity with a scale of 180 divisions with a vernier

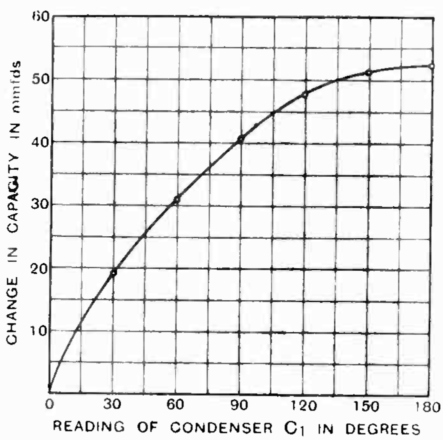


Fig. 5.

motion, c_2 a fixed condenser of value about .0003μF., and c_3 a fixed condenser of about .0005μF. This combination was calibrated against a standard for change in capacity between the terminals *CD* (Fig. 3*b*) when c_1 is varied between its limits. Fig. 5 shows this calibration curve from which it is seen that a change of 180 divisions on c_1 is equivalent to a change of only about 52$\mu\mu$F. between *CD* (Fig. 3*b*), thus giving on the average a sensitivity of about 0.27$\mu\mu$F. per division of c_1 which is the order of change aimed at.

Determination of the Resonance Condition.

The resonance curve of tuned circuits which finds general use in high-frequency measurements has a serious limitation in that its gradient is practically zero at its maximum value. The steep slopes of this curve are to be preferred where great accuracy is needed. Here measurable changes in current are produced even for small changes in the variable parameter. However, although a pre-assigned indicator reading may be reached as a reference mark, null methods are to be preferred. Further, by using a pre-assigned reading as a reference point on the sloping side of the resonance curve an ambiguity arises as to whether the point reached is on the right or the left slope of the resonance curve.

These defects can be obviated as suggested by Franklin (*Marconi Review*, No. 6, p. 11, March, 1929) and briefly described with reference to Fig. 6, which is the resonance curve obtained in the present arrangement. For a capacity C_1 in the oscillatory circuit the indication in the galvanometer would be given by the ordinate C_1P_1. Let P_1 be called the working-point. If now a small condenser of capacity $(C_2 - C_1)$ which is about 15$\mu\mu$F. in the present case, is thrown into the circuit the galvanometer reading will be given by the ordinate C_2P_2. There will be no change in the indicator, since a symmetrical point on the other limb of the resonance curve is reached. Suppose now,

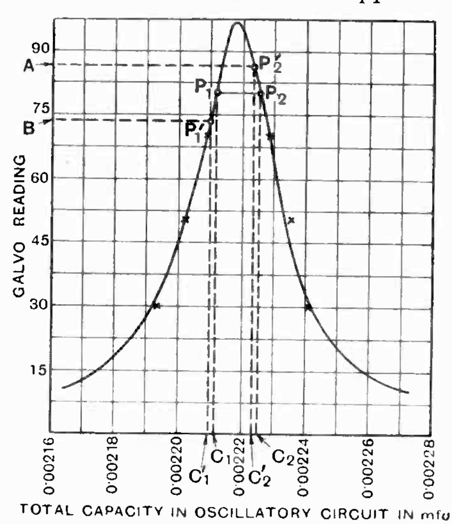


Fig. 6.

that instead of the value of the condenser in the oscillatory circuit being C_1 it is C_1' which is slightly (about 2$\mu\mu$F. in this case) below the value of C_1. Then the galvanometer deflection will be represented by the ordinate $C_1'P_1'$. If now the small 15$\mu\mu$F. is tapped into circuit by the tapping switch the galvanometer reading will alter and be represented by the ordinate $C_2'P_2'$. The change in the galvo reading is given by the difference AB between the ordinates of P_1' and P_2'. It is seen that even when the condenser value in the oscillatory circuit is

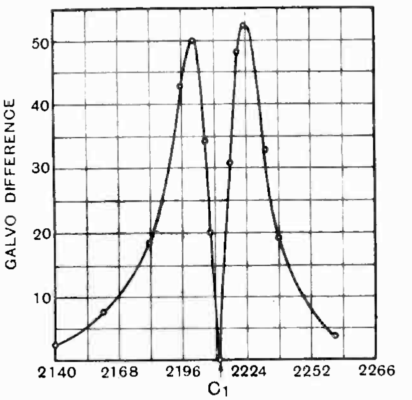


Fig. 7.

only very slightly different from the reference value, namely, C_1 in Fig. 6, a large change in the deflection of the galvanometer is observed. In Fig. 7 is plotted the change in the galvanometer reading brought about by tapping in the 15$\mu\mu$F. condenser, against condenser value in the oscillator circuit in the neighbourhood of the reference point C_1. It is seen that round about C_1 the trough is so steep that a change of 1$\mu\mu$F. from the reference point produces a change of approximately 7 divisions in the galvanometer. Hence one division change of the vernier arrangement which brings about a change of 0.3$\mu\mu$F. capacity, produces about 2 divisions change in the galvo. As the galvo can be easily read correct to one division the precision obtained is 0.15$\mu\mu$F.

Sources of Error.

Tables I to IV were the results of repeated observations which showed remarkable consistency. Since this method is one of substitution, any variation in the voltage of the mains would not appreciably affect the accuracy of the results. For example, it was found that even when the filament voltage lay anywhere between the limits of 3.75 and 4.25 instead of the rated 4 volts, the accuracy was not appreciably affected. It was thought that the inductance and capacity of the leads connecting the unknown condenser to the circuit might introduce indefinite errors. To minimise this two stout short leads were incorporated and clamped to the terminals provided for connecting the unknown condenser. Thus the capacity of the leads always forms part of the oscillator circuit. It is shown below that the error introduced by the inductance of the leads is also negligible.

Let l = inductance of leads.
L = inductance of oscillatory circuit.
C = capacity in oscillatory circuit.
$\triangle C$ = change in C to compensate for the unknown condenser.
C' = true value of the unknown condenser.

Then it can be shown* that,

$$C' \doteqdot \triangle C\left(1 - \frac{l}{L}\cdot\frac{C'}{C+C'}\right),$$

provided $C' \ngtr C$ and $L \gg l$. This is satisfied by the circuit under working conditions. Here $L = 135\mu$H., $l = .2\mu$H. as estimated, and $C = .002\mu$F. approximately. For a 10$\mu\mu$F. condenser the error due to the leads as calculated by the above formula is .001%, which is negligible.

In conclusion, we wish to thank Mr. S. R. Kantebet, B.A., A.M.I.E.E., for his keen interest in this work.

*Moullin, "Radio Frequency Measurements," p. 135.

Abstracts and References.

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PROPAGATION OF WAVES.

ON THE CONNECTION BETWEEN THE RAY THEORY OF ELECTRIC WAVES AND DYNAMICS.—T. L. Eckersley. (*Proc. Roy. Soc.*, July, 1931, Series A, Vol. 132, No. 819, pp. 83–98.)

Author's summary :—A formal analogy between the quantum theory and the transmission of electromagnetic waves in an ionised atmosphere is used to develop approximate solutions of the transmission of wireless waves round the earth. These solutions are based on the approximate phase integral methods of Bohr and Sommerfeld used in quantum dynamics. [The attenuation of the various types of freely propagated rays is found as a function of the angle of elevation of the ray, of the wavelength, and of the constitution of the ionised layer ; it is found that the calculation of attenuation for transmission between a plane and a plane stratified layer will be sufficiently accurate for all practical cases, even of long-distance transmission.] The results are used to explain the effect of magnetic storms on short wave transmission [by suggesting that at such times the region between the *E* and *F* layers, which is normally fairly free of electrons, is ionised by corpuscular radiation from the sun].

PAPERS DEALING WITH THE PROPAGATION OF WAVES READ BEFORE THE APRIL, 1931, JOINT ANNUAL CONVENTION OF THE THREE ELECTRICAL INSTITUTES IN JAPAN.—Namba ; Yokoyama and Tanimura ; Tanimura and Iso.

In Japanese. Namba gives observations to show that the distance of the propagation path from the magnetic poles is one of the most important factors in propagation, and finds that propagation conditions have deteriorated during the past two years, especially for short and broadcasting waves, probably owing to some kind of magnetic disturbance. Yokoyama and Tanimura deal with the difference of the sunset and sunrise effects on long waves over land and over sea, and also in the N–S and E–W directions : E–W signals over sea faded regularly several times during the passage of the twilight zone between the stations, while N–S signals over sea gave only a single fading, and overland signals no fading at all. They also give details of signal strength measurements on a long-wave station in Hawaii ; the daytime signals were always *stronger* than the night signals. Similar results by Baümler and Round are discussed. Tanimura deals with night errors in d.f. on long waves : the proportion of errors due to the state of polarisation of the downcoming wave to those due to ground- and space-wave interference varies according to the distance of transmission (*cf.* Namba, Sept. Abstracts, pp. 490–491). Iso deals with short-wave d.f. on the Adock-type aerials : long-distance stations always give bearings within $\pm 5^{\circ}$, but no bearings, or right-angled bearings, are obtained from stations at relatively short distances which are thought to lie within the skip distance. He also investigates the effects produced by various kinds of near-by conductors.

RADIO TRANSMISSION STUDIES OF THE UPPER ATMOSPHERE.—J. P. Schafer and W. M. Goodall. (*Proc. Inst. Rad. Eng.*, August, 1931, Vol. 19, pp. 1434–1445.)

This paper is of particular interest as almost the first confirmation from America of the two-layer hypothesis adhered to by the British workers as a result of Appleton's investigations. Authors' summary :—" In this paper are given a number of measurements which show time variations in the virtual height of the ionized regions of the upper atmosphere. These measurements were usually made simultaneously on two frequencies, 1604 kc. and 3088 kc. Single frequency data are also given. The following are the main points of interest presented.

" (1) The data indicate the existence of two distinct ionized regions or layers. The changes in virtual height are sometimes very abrupt. The existence of the lower layer even at night is indicated by an occasional return to low virtual heights during this period.

" (2) Experimental evidence has been found of large retardations in group velocity near the critical conditions for which the waves just penetrate the layer to the point of maximum ionization (Fig. 1). Absorption is especially marked at such times.

" (3) Except at these critical periods the records for the simultaneous transmissions show that the virtual heights of the upper layer are greater for the higher frequency than they are for the lower frequency. This statement would probably hold for the lower layer but no evidence on this point is presented.

" (4) In the discussion several possible methods of two-layer formation are suggested, one of which involves the formation of negative ions in the region between the layers."

PROGRESS DURING THE PAST YEAR IN THE STUDY OF THE PROPAGATION OF WAVES [DOUBLE-LAYER HYPOTHESIS : SLOW GROUP VELOCITIES AND LONG-DELAY ECHOES : ETC.].—Am.I.E.E. Electrophysics Committee. (*Elec. Engineering*, Aug., 1931, Vol. 50, pp. 652–653.)

A short survey, dealing first with propagation along conductors (including the influence of the earth on such propagation) and then with radio waves. " The Kennelly-Heaviside layer also has held the attention of many of the investigators. One of the more important results obtained has been the corroboration of the double-layer hypothesis advanced by Appleton. In this connection the work of De Mars, Gilliland and Kendrick [April Abstracts, p. 204] and of Schafer and

Goodall [*see* above] may be noted. A minimum of effective ionisation apparently exists between the heights of 110 km. and 250 km. . . . Cases of relatively long delays due to slow group velocities under certain critical conditions have been observed and these may conceivably have a bearing on the very long delay echoes discovered by Hals and Störmer. Hanson has presented orally some results on layer heights observed in the Antarctic by the Byrd expedition. It is of interest that even in the long winter night reflections are obtained, although from greater heights than those found in other latitudes. In general, the phenomena were erratic."

HEAVISIDE LAYER OBSERVATIONS IN THE ANTARCTIC.—Hanson. (*See* preceding abstract.)

OSSERVAZIONI SUI RAPPORTI TRA LE CONDIZIONI METEOROLOGICHE DELLA TROPOSFERA E LA PROPAGAZIONE DELLE RADIOONDE (Observations on the Relation between the Meteorological Condition of the Troposphere and the Propagation of Wireless Waves).—I. Ranzi. (*Nuovo Cimento*, March, 1931, Vol. 8, pp. 98–106.)

Observations were made on a 42 m. wave received at a point at the far edge of the first zone of silence, in such a way that small variations in the extent of this zone could be noticed. A clear correlation was established between the abnormal expansion of this zone and the arrival of equatorial air masses.

A SIMPLE SMALL-POWER EQUIPMENT FOR THE STUDY OF HEAVISIDE LAYER HEIGHT BY THE PULSE ECHO METHOD.—I. Ranzi. (*Nuovo Cimento*, May, 1931, Vol. 8, pp. lxxxviii–ix.)

A small transmitting valve (10 watts supply to the anode during transmission) is modulated, by means of an iron-cored choking coil traversed by sinusoidal current of 50 cycles frequency, in such a way as to send out trains of waves lasting one-thousandth of a second. Reception is carried out in the neighbourhood of the transmitter, on a cathode-ray oscillograph whose time-base deflection is governed by the same 50-cycle current.

DISCUSSION ON KENNELLY-HEAVISIDE LAYER HEIGHT OBSERVATIONS FOR 4045 KC. AND 8650 KC. [LUNAR EFFECT ON HEAVISIDE LAYER].—Gilliland: F. K. Vreeland. (*Proc. Inst. Rad. Eng.*, Aug., 1931, Vol. 19, pp. 1500–1505.)

Referring to Gilliland's results (February Abstracts, p. 88) Vreeland draws attention to the fact that the graphs show a marked periodic fluctuation in the height, with minima separated by about four weeks. Further, that the dates of these minima coincide very nearly with the times of new moon: the lowest minimum occurred on the date of the solar eclipse, and the other minima both before and after this are less marked. He elaborates these facts and then formulates "a working hypothesis which may point the way" to a complete answer to the following questions: What are the factors that determine the height of the layer? and how does the moon influence these factors?

This hypothesis pictures, in addition to the ultra-violet radiation and the intermittent bursts of high velocity electrons from sun-spots, a steady electron emission of smaller velocity from the intensely heated mass of the sun. The effect of sun-spot activity as shown in the graphs, in so far as a correspondence between the curves can be observed, appears to be a lowering of the layer; but this effect is completely masked by the larger general effect *as the season advances*. "May we not suppose that the sun-spot emission, having relatively high velocity, is able to penetrate the atmosphere obliquely when the angle of incidence is low, while the less penetrating emission and radiation become effective as the sun rises overhead in the summer?"

The effect of the moon is thus explained as an effect of its electrical charge on the distribution and penetrating power of the electron stream finally reaching the earth's atmosphere, *particularly on that portion of the stream which has relatively low velocity, i.e.*, the *steady* emission from the sun. This effect would be greatest when the moon is directly in line with the stream, as it was on the day of the eclipse, and less and less on the dates when the moon was further and further out of line; "this is just what Gilliland's curves indicate."

The writer ends: "Incidentally it would seem that our forefathers were not so foolish as we thought when they said that the new moon was a time of change of the weather, for certainly such powerful causes as these must have an effect on weather conditions. Meteorologists please note and give us your contribution to the discussion." For other papers on the lunar influence on wireless communication, *see* July Abstracts, p. 375.

THE EFFECT OF METEORS ON RADIO TRANSMISSION THROUGH THE KENNELLY-HEAVISIDE LAYER.—A. M. Skellett. (*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, p. 1668.)

The order of magnitude of the ionic concentration in the Kennelly-Heaviside layer which may be produced by meteors is comparable with that generally assumed in order to explain short wave radio phenomena, and meteors may thus be an important factor in short wave propagation. One effect of meteors might be a lowering of the Kennelly-Heaviside layer after midnight, which has been observed by a number of investigators. Tests during meteoric showers are planned.

A NOTE ON THE RELATION OF METEOR SHOWERS AND RADIO RECEPTION.—G. W. Pickard. (*Proc. Inst. Rad. Eng.*, July, 1931, Vol. 19, pp. 1166–1170.)

Author's summary:—"A comparison of reception measures with meteor showers over five-year periods indicates an accompanying increase of night fields and a decrease of day fields. The highest correlation appeared between monthly means of meteor hour rates and night fields. No associated disturbance of terrestrial magnetism was found." *Cf.* Goubau and Zenneck, August Abstracts, p. 433, r-h column.

Although Nagaoka first suggested that meteors may disturb the Heaviside layer and so affect radio transmission, the writer thinks that his hypothesis does not fit the above facts, for if meteors merely "scratched the mirror" *all* radio transmission should be adversely affected, whereas the night fields are actually increased. He thinks it more likely that meteors act as an ionising agent at such a level and in such a manner as to improve night transmission and depress day fields.

INVESTIGATION OF THE ATTENUATION OF ELECTROMAGNETIC WAVES AND THE DISTANCES REACHED BY RADIO STATIONS IN THE WAVE BAND FROM 200 TO 2000 METRES [INCLUDING EFFECT OF TRANSMITTING HEIGHT].—H. Fassbender, F. Eisner, and G. Kurlbaum. (*Proc. Inst. Rad. Eng.*, August, 1931, Vol. 19, pp. 1446–1470.)

English version, slightly modified, of the paper dealt with in 1930 Abstracts, p. 621. With regard to the authors' results that 650- and 2000-metre wave reception from an aeroplane showed no marked or systematic dependence on the altitude of the transmitter, a foot-note mentions recent tests by Jones and Ryan, who found that the transmitting height had a very considerable effect on the received field strength of waves between 53.3 and 198 metres. A 198-metre wave, for example, gave a fourfold increase of strength at 90 kilometres when the aeroplane climbed from 800 to 3000 metres.

EFFECT OF TRANSMITTING HEIGHT ON RECEIVED SIGNALS FROM AIRCRAFT: FADING ELIMINATION, ETC.—Wireless Division, German Aircraft Research Establishment. (*See* abstract under "Miscellaneous," Fassbender, sections iv and vii.)

NOTES ON RADIO TRANSMISSION [INVERSE DISTANCE LAW: AUSTIN-COHEN FORMULA: DAYLIGHT ABSORPTION BAND ROUND 40 KILOCYCLES: EFFECT OF SOLAR DISTURBANCES].—C. N. Anderson. (*Proc. Inst. Rad. Eng.*, July, 1931, Vol. 19, pp. 1150–1165.)

Based on the operation of radiotelephone services by the Bell System. From the author's summary:—"The general results which are arrived at are: 1.—Neglecting short time fading, the maximum field strengths received at a given point for frequencies up to at least 4 megacycles are in general agreement with those calculated by the inverse-distance law, and the minimum field strengths (over-water transmission) are in approximate agreement with those calculated by the Austin-Cohen formula.

"2.—There appears to be a daylight absorption band in the neighbourhood of 40 kilocycles (North Atlantic transmission) which reduces minimum daytime fields in that vicinity below the minimum limit given above.

"3.—The effect of solar disturbances is to increase the absorption to 'sky wave' transmission throughout the entire radio-frequency spectrum generally and to reduce or eliminate the 40-kilocycle absorption band, thereby increasing daylight fields for transmission on frequencies in that vicinity."

RECENT FIELD-STRENGTH MEASUREMENTS ON BROADCAST AND LONGER WAVES.—M. von Ardenne. (*Funk-B.*, March, 1931, Vol. 20, pp. 177–180.)

Measurements made with the apparatus referred to in Feb. Abstracts, p. 106, confirm the known laws of the propagation of waves. In the wave-range 200–600 metres there is a great difference between day and night strengths. By day the most powerful stations are practically inaudible beyond 300 km., their signals depending entirely on the ground wave. At night the space wave comes in with an intensity practically independent of the distance and of the order of 100 microvolts per metre per kilowatt radiated. In the range 600–3000 metres the difference between day and night strengths is much less marked, the ratio being of the order of 1 to 2 or 3, rarely 6. The level of interference is given as of the order of 5 to 10 microvolts per metre in the outskirts of a town and ten times greater at the centre. Examples of continuous recording are given showing fadings with periods of the order of 2 minutes on long waves and of 20 seconds on medium waves.

APPLICATION OF [ULTRA-HIGH] FREQUENCIES ABOVE 30,000 KILOCYCLES TO COMMUNICATION PROBLEMS.—H. H. Beverage, H. O. Peterson and C. W. Hansell. (*Proc. Inst. Rad. Eng.*, August, 1931, Vol. 19, pp. 1313–1333.)

Authors' summary:—The authors briefly describe the results of a number of experiments with frequencies above 30,000 kc. covering a period of several years. Since the major interest of radio communication companies has been in long-distance communications, this paper includes some qualitative data covering propagation beyond the optical, or direct vision, range. The authors have found that the altitude of the terminal equipment location has a marked effect on the signal intensity, even beyond the optical range.

Frequencies below about 43,000 kc. appear to be reflected back to earth at relatively great distances in the daytime in north-south directions, but east-west transmission over long distances is extremely erratic.

Frequencies above about 43,000 kc. do not appear to return to earth beyond the ground wave range, except at rare intervals, and then for only a few seconds or a few minutes. These frequencies, which do not return to earth, also appear to be free of echoes and multiple path transmission effects. Therefore, they are free from distortion due to selective fading and echoes. The range is also limited to the ground wave range, so these frequencies may be duplicated at many points without interference. As the frequency is raised, the range tends to approach the optical distance as a limit. Experiments with frequencies above 300,000 kc. have, so far, indicated that the maximum range is limited to the optical distance. A number of possible applications are suggested, based on the unique properties of these frequencies. A specific application to telephony between the Islands of the Hawaiian group is briefly described.

LES ONDES ÉLECTRIQUES ULTRACOURTES ET LEURS APPLICATIONS (Ultra-Short Electric Waves and Their Applications).—J. Marique. (*Bull. de la Soc. belge des Élec.*, June, 1931, Vol. 47, pp. 365–385.)

Including sections on propagation, the effect of the ground and its influence on the necessary height of the aerial above the earth, the effects of rain and fog, etc. Field strength measurements are given on fields produced inside a building by 2m.-waves.

SUR LA VIBRATION PROPRE DES GAZ IONISÉS (The Natural Vibration of Ionised Gases).—J. Placinteanu. (*Comptes Rendus*, 3rd August, 1931, Vol. 193, pp. 286–288.)

"The object of this Note is to show that J. J. Thomson's hypothesis (May Abstracts, pp. 283–284) is equivalent to the consideration of a double layer supporting the ion-electron systems, which should vibrate as a closed whole. In this case, either by elementary calculation, by the application of Coulomb's law, or simply by treating the gas as an electrical conductor, the result is Thomson's formula $\nu = \left(\frac{e^2N}{\pi m}\right)^{\frac{1}{2}}$. In the case of Jonescu's mechanical model (June Abstracts, p. 315) different results are arrived at: a correction, by a constant factor, of Thomson's formula, the possibility of progressive de-ionisation, and the appearance of a second frequency."

The correction to the Thomson formula arrived at by the writer is embodied in his formula

$$\nu = \left(\frac{3\epsilon e^2N}{\pi m}\right)^{\frac{1}{2}},$$

where ϵ is the fraction of the number of electrons which vibrate under the influence of the field. "An interesting point is the existence of a second frequency $\nu' = \frac{e^2}{2\pi}\left(\frac{3m}{4\pi N}\right)^{\frac{1}{3}}$, very small compared with the first and at present impossible to explain."

RÉFLEXION DES ONDES ÉLECTROMAGNÉTIQUES TRÈS COURTES SUR L'EAU SALÉE (Reflection of Ultra-Short Electromagnetic Waves at the Surface of Salt Water).—R. Guyot. (*Comptes Rendus*, 27th July, 1931, Vol. 193, pp. 230–232.)

Tests with a 17-cm. beam produced by a Pierret circuit (later simplified by introducing a ten-thousand ohm resistance into the plate circuit, thus getting rid of the 40-volt plate battery) using metal mirrors at transmitter and receiver. The concentration of the salt bath was varied from 0 to 13 % (sea water averaging 3 %), and the beam was made to fall on it at an angle first of 15° and then of 24°. The energy reflected was indicated by the readings of a thermo-galvanometer.

Comparative tests were made with a flat piece of duralumin foil. Results are given in the form of a table. For 15° angle of incidence, the galvanometer deflection is 340 mm. for 0 % salt, increasing steadily through 376 for "sea water" concentration up to 524 for 13 %; the metal foil gives nearly twice the "sea water" reflection. For 24° angle of incidence, the deflections start smaller (285 mm.) and form a similar regular series rising to 414 for 13 % concentration; here again the metal foil reflection is nearly twice that of the "sea water" (600 to 322). The depth of the bath is 15 cm.

ELECTRON RAY EXPERIMENTS ON STÖRMER'S AURORAL THEORY. Part I.—FLAT PATHS. —E. Brüche. (*Zeitschr. f. Astrophys.*, 15th Jan., 1931, Vol. 2, pp. 30–69.)

See also April and May Abstracts, pp. 207 and 262.

ÜBER DIE FORTPFLANZUNG VON SIGNALEN IN DISPERGIERENDEN SYSTEMEN. DRITTER (LETZTER) TEIL: DISKONTINUIERLICHE SYSTEME (SYMMETRISCHE VIERPOLKETTEN) UND GEMISCHTE SYSTEME (On the Propagation of Signals in Dispersive Systems. Third and Last Part: Discontinuous Systems [Symmetrical Quadripole Chains] and Mixed Systems).—H. G. Baerwald. (*Ann. der Physik*, Series 5, 1931, Vol. 8, No. 5, pp. 565–614.)

For Parts I and II of this investigation, *see* Jan. and April Abstracts, pp. 32 and 202. Author's summary:—"In this [theoretical] investigation, which completes a comprehensive theory of the propagation of signals in linear dispersive systems, a discussion is given of transients in discontinuous and mixed loss-free systems. The term 'discontinuous systems' is defined as meaning chains of symmetrical quadripoles, *i.e.*, bridge sections including the usual wave filters of the T and Π types as special cases. As was shown in the case of discontinuous systems, it is possible to find general laws valid for all imaginable loss-free combinations of bridge sections and thence to deduce certain dispersion theorems; using these, the general course of signals passing through such systems can be determined. The dispersion laws valid for discontinuous systems are, corresponding to their far greater multiplicity, less significant, *i.e.*, more complicated than those which hold for continuous systems. It is shown that for discontinuous systems in contrast to continuous systems the group-time can have several maxima and minima in the same pass band. Such a system then has several quasi-latent times (*i.e.*, group-time minima; *cf.* Part I) which each correspond to certain sections of the system; on the other hand, a new phenomenon occurs: from a so-called partial extinction time, corresponding to a maximum of the group-time, a portion of such a pass band ceases to contribute noticeably to the signal, *i.e.*, the component frequencies therein can no longer be heard. A special case of this is given by the so-called completely reciprocal systems, used for phase-compensation in transmission technique; they have no limiting frequencies and attenuation regions, so that with them there is a main extinction time, *i.e.*, the whole transient has in this case a fairly well-defined end, independent of the form of the original signal.

"A case of special interest in this connection is given by systems whose group velocity has maxima or minima of order higher than the first at certain frequencies: they have the physical property of being almost free from dispersion in the neighbourhood of these frequencies, *i.e.*, they act purely as retardation circuits, with no transients of considerable size.—The paper closes with a short investigation of mixed systems, by which is meant in general alternating chains of continuous and discontinuous partial systems. On account of the complicated behaviour of these systems it is not possible to formulate general rules for them as was done for their component systems. However, a discussion based on the theory of functions gives the most important properties of these systems and thence the general character of the propagation of signals in them. They have, as opposed to their components, an infinite number of pass and attenuation regions; of these only a few can be realised physically. Thus they may always be regarded with sufficient approximation for practical purposes as continua and discontinua: on these bases a short discussion is given of the simplest cases of mixed system, the Pupin cable and the acoustic high pass filter."

RADIATION OF MULTIPOLES.—K. F. Herzfeld. (*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, p. 1673.)

This note corrects formulae given wrongly in the paper referred to in May Abstracts, p. 262.

À PROPOS DES PHENOMÈNES ÉLECTROMAGNÉTIQUES À LA SURFACE DE SÉPARATION DE DEUX MILIEUX (On the Electromagnetic Phenomena at the Surface of Separation of Two Media).—Kotelnikoff; Liénard and Margand. (*Rev. Gén. de l'Élec.*, 25th July, 1931, Vol. 30, pp. 129–132.)

Criticisms of Kotelnikoff's two papers (1929 Abstracts, p. 501, and June Abstracts, p. 340). The author replies.

WAVE MOTION AND THE EQUATION OF CONTINUITY.—R. B. Lindsay. (*Proc. Nat. Ac. Sci.*, July, 1931, Vol. 17, pp. 420–426.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

DISCUSSION ON ULTRA-PENETRATING RAYS.—H. Geiger and others. (*Proc. Roy. Soc.*, July, 1931, Series A, Vol. 132, No. 819, pp. 331–352.)

A full account of the discussion already referred to in September Abstracts, p. 494.

A SURVEY OF NEW RESEARCHES ON COSMIC RADIATION.—V. F. Hess. (*E.T.Z.*, 16th July, 1931, Vol. 52, pp. 936–937.)

RICERCHE SULL' AZIONE DEL CAMPO MAGNETICO TERRESTRE SOPRA I CORPUSCOLI DELLA RADIAZIONE PENETRANTE (Researches on the Action of the Earth's Magnetic Field on the Corpuscles of the Penetrating [Cosmic] Radiation).—B. Rossi. (*Nuovo Cimento*, March, 1931, Vol. 8, pp. 85–97.)

RICHTUNGSMESSUNGEN DER HÖHENSTRAHLUNG MIT EINEM ZÄHLROHR (Directional Measurements on the Cosmic Rays by means of an Ion Counter Tube).—L. Tuwim. (*Berliner Ber.*, No. 4/5, 1931, pp. 91–106.)

AN INDICATION OF A CORRELATION BETWEEN COSMIC ULTRA-RADIATION AND TERRESTRIAL MAGNETISM.—A. Corlin. (*Lund Obs. Circular*, No. 1, 1931, pp. 3–12: Additional Note, *ibid.*, No. 2, 1931, p. 34.)

Measurements of cosmic ray intensities in Abisko are examined in connection with their relation to aurorae and to variations of terrestrial magnetism. The positive results are discussed in relation to measurements by other workers.

ANNUAL VARIATIONS IN MAGNETIC STORMS.—H. B. Maris.—(*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, pp. 1680–1681.)

Abstract only.

THE GEOGRAPHICAL DISTRIBUTION OF MAGNETIC DISTURBANCE.—W. F. Wallis. (*Terrest. Mag.*, March, 1931, Vol. 36, pp. 15–22.)

THE DIURNAL VARIATION OF THE AURORA POLARIS. E. O. Hulburt. (*Ibid.*, pp. 23–28.)

ON ATMOSPHERIC ELECTRICITY.—C. S. Dorchester and L. W. Butler. (*Science*, 7th Aug., 1931, Vol. 74, pp. 155–157.)

In an account of experiments in connection with the effect of atmospheric electricity on the growth of plants, results are described which contradict the conclusions of Wilson, Schonland, and Swan as regards the direction of the positive current during fair weather: in the vicinity in question—Iowa—the earth was found nearly always (except in the very driest part of summer) to be gaining negative charge, not only in rainy periods.

RESULTS OF RECENT INVESTIGATIONS ON LIGHTNING DISTURBANCES: SIX ARTICLES BASED ON TWELVE AM.I.E.E. PAPERS.—Peek, Fortescue and Conwell, Bewley and others. (*Elec. Engineering*, July, 1931, Vol. 50, No. 7, pp. 478–502.)

Some of the points dealt with, with occasional quotations: *a.*—Direct hits and induced surges: "it is evident that high-potential induced surges are possible only with very short waves and that for cloud discharges of long duration induced surges become quite harmless." Fig. 2 shows the proportion of cloud discharges of various durations, on the approximation that the duration is twice the time from crest to half-voltage on the tail: it is derived from cathode-ray oscillograms. *b.*—Wave shapes: "negative surges have steeper fronts than do those of positive polarity: it has been estimated that the former may have fronts as short as 1 microsecond or less, while the probable minimum for the latter is approximately 5 microseconds." "The wave shape of a particular surge appears to depend upon (i) whether the surge results from a direct stroke or is induced, (ii) polarity, and (iii) whether or not flashover takes place." *c.*—Attenuation, distortion and reflection. *d.*—Crest voltages and currents. *e.*—Polarity: "it seems well-established that both positive and negative cloud potentials exist. However, more direct strokes of negative polarity have been recorded than those of positive polarity, while the majority of induced strokes appear to be positive."

DIRECT STROKES TO TRANSMISSION LINES.—W. W. Lewis and C. M. Foust. (*Gen. Elec. Review*, Aug., 1931, Vol. 34, pp. 452–458.)

A short survey of present knowledge on the subject. "The great percentage of lightning strokes which terminate on transmission lines are initiated by breakdown streamers which progress from the line (positive) to the cloud (negative)." "Insulator flashover results from overvoltage between tower and conductor due to (*a*) a stroke which terminates on the line conductor, or (*b*) tower potential caused by tower footing resistances and the stroke currents. Conventional ground wires serve effectively as the initiating terminal for direct strokes and thereby shield the line conductors, and ground wires and *low* tower footing resistances provide immunity from lightning disturbances. Diverter wires are of value where low tower footing resistances cannot be obtained, provided such wires are grounded independently of the tower structure."

AREAS LIABLE TO LIGHTNING TROUBLES—INFLUENCE OF RADIO-ACTIVITY IN THE SOIL.—C. Dauzère. (*Electrician*, 14th Aug., 1931, Vol. 107, p. 222.)

Summary of a paper recently read before the Paris H.T. Conference.

POWER LINES AND THEIR INFLUENCE ON METEOROLOGICAL PROCESSES: AN ARGUMENT.—Franck, Dauzère, Ledoux. (*Rev. Gén. de l'Élec.*, 27th June, 1931, Vol. 29, pp. 1036–1042.)

THE HEAD VELOCITY OF ELECTRIC SPARKS AND LIGHTNING FLASHES.—R. Rüdenberg. (*Wiss. Veröffent. a.d. Siemens-Konz.*, No. 1, Vol. 9, pp. 1–6.)

Since every electric spark or lightning flash represents a conduction or convection current, it must be accompanied, in non-homogeneous fields, by a displacement current in the part of the field not broken down. The writer deduces that the head of the spark has a finite velocity, which for a particular case selected has a value about one-quarter of the velocity of light.

EINIGE VERSUCHE ÜBER STOSSSPANNUNGEN (Some Researches on Surge Potentials).—Y. Satoh. (*Mem. Ryojun Coll. of Eng.*, No. 1, Vol. 4, 1931, pp. 1–61.)

Including an investigation of the effect of electrode capacity and of inductance on the shape of the surge front.

VARIOUS ASPECTS OF THE SPARK DISCHARGE AND THE PROCESS OF DEVELOPING INTO BREAK-DOWN.—T. Nishi and Y. Ishiguro. (Summary in *Physik. Ber.*, 1st June, 1931, Vol. 12, p. 1235.)

Tests to determine the polarity of the charge finally leading to break-down. Some of the observations contradict those described by G. C. Simpson.

ZUR THEORIE DER ATMOSPHÄRISCHEN TURBULENZ (The Theory of Atmospheric Turbulence.)—H. Ertel. (*Zeitschr. f. angew. Math. u. Mech.*, No. 1, Vol. 11, 1931, pp. 20–26; summary in *Physik. Ber.*, 1st July, 1931, Vol. 12, p. 1543.)

PROPERTIES OF CIRCUITS.

HET RECIPROCITEITSTHEOREMA IN DE ELECTRICITEIT (The Reciprocity Theorem in Electricity).—J. W. Alexander. (*Tijdschr. Nederl. Radiogenootschap*, July, 1931, Vol. 5, No. 3, pp. 69–84.)

Various formulations of the reciprocity theorem since the time of Helmholtz are first given; starting from Maxwell's equations, the form of the theorem for electric fields which are general functions of the time is then deduced, using Fourier's theorem, and a form suitable for application to technical problems is found.

ON THE PROPAGATION OF SIGNALS IN DISPERSIVE SYSTEMS: DISCONTINUOUS (SYMMETRICAL QUADRIPOLE CHAINS) AND MIXED SYSTEMS.—Baerwald.

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

ON THE THEORY OF THE QUADRIPOLE CONNECTION: THREE REMARKS ON THE QUADRIPOLE THEORY.—E. Selach: H. König. (*E.N.T.*, July, 1931, Vol. 8, pp. 297–303: 304–306.)

THE OPERATING FREQUENCY OF REGENERATIVE OSCILLATORY SYSTEMS.—H. Benioff. (*Proc. Inst. Rad. Eng.*, July, 1931, Vol. 19, pp. 1274–1277.)

Author's summary:—The operating frequency of regenerative oscillatory systems is quantitatively derived in terms of the natural frequency, the damping constant, and the phase of the driving force. As an example the results are used to calculate the change in rate of a pendulum clock due to a given variation in the phase of the driving impulses. Applications to other types of systems are briefly indicated [valve oscillators, quartz oscillators].

SUR LES PROPRIÉTÉS COMMUNES À DIVERS PHÉNOMÈNES D'OSCILLATION ET SUR DES ANALOGIES GYROSCOPIQUES DES PHÉNOMÈNES ÉLECTROMAGNÉTIQUES (On Properties Common to Various Oscillation Phenomena, and Some Gyroscopic Analogies with Electromagnetic Phenomena).—B. Salomon. (*U.R.S.I. Papers*, 1928 Assembly, Vol. 2, Fasc. 1, pp. 177–190.)

GROUP THEORY AND THE ELECTRIC CIRCUIT.—N. Howitt. (*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, pp. 1583–1595.)

DIE EIGENSCHAFT EINES MIT SELBSTINDUKTION, KAPAZITÄT UND VERLUSTWIDERSTAND (L, C UND R) BEHAFTETEN KREISES (The Property of a Circuit Containing Inductance, Capacity and Ohmic Resistance).—M. Osnos. (*Zeitschr. f. hochf. Tech.*, July, 1931, Vol. 38, p. 33.)

By rearranging the ordinary equation for the natural frequency of such a circuit, the writer obtains the following "law":—If in such a circuit the values L, C and R are changed in any way, the natural frequency always alters in such a way that the impedance, made up of the inductive resistance and half the ohmic resistance, is always equal to the geometrical mean between the inductive and capacitive resistance.

The ordinary equation is thus given a physical interpretation and a more easily remembered form. The impedance $\sqrt{(\omega L)^2 + \left(\frac{R}{2}\right)^2}$ may be termed the characteristic impedance, while the expression $\sqrt{\frac{L}{C}}$, hitherto called the characteristic impedance, s similar to it but not identical owing to the absence of the frequency ω.

NOTE ON RADIO-FREQUENCY TRANSFORMER COUPLED CIRCUIT THEORY.—J. R. Nelson. (*Proc. Inst. Rad. Eng.*, July, 1931, Vol. 19, pp. 1233–1241.)

Author's summary:—Equations considering the effects of output and distributed capacities and primary resistance are developed for radio-frequency transformer-coupled amplifiers using either a tuned or an untuned primary. These equations are transformed to such a form that they may be compared with the well-known equations derived for an untuned primary neglecting the output and distributed capacities. The equations for an untuned primary are verified experimentally.

It is shown that the amplification obtainable with a tube and a transformer having an untuned primary may be made nearly uniform over a frequency range such as that covered by the broadcast band by adding resistance to the primary to reduce the high-frequency amplification. It is also shown that the addition of primary resistance reduces the selectivity approximately the same percentage as it reduces the amplification. The selectivity of a stage with a tuned primary is found to be approximately the square of the selectivity of a stage with an untuned primary.

DISCUSSION OF "OSCILLATION IN TUNED RADIO-FREQUENCY AMPLIFIERS."—B. J. Thompson: J. R. Nelson: H. A. Wheeler. (*Proc. Inst. Rad. Eng.*, July, 1931, Vol. 19, pp. 1281–1282.)

Referring to Thompson's paper (June Abstracts, p. 320) and his reference to Hull and Nelson's treatments as "ignoring the all-important effect of feed-back on amplification," the last-named points out that this statement is based on a misunderstanding of the symbol Av in the articles: the equations derived by Thompson for one and two stages are exactly the same as those derived by the writer; Thompson has gone two stages further. Nelson then refers to unpublished results by H. A. Wheeler which should lead to a general solution for any number of stages.

DISCUSSION ON THE RESISTANCE OF SPARK AND ITS EFFECT ON THE OSCILLATIONS OF ELECTRICAL OSCILLATORS.—J. Stone Stone: E. Amelotti. (*Proc. Inst. Rad. Eng.*, Aug., 1931, Vol. 19, pp. 1492–1499.)

TRANSMISSION.

THE SINGLE SIDE-BAND SYSTEM APPLIED TO SHORT WAVELENGTHS.—A. H. Reeves. (*Elec. Communication*, July, 1931, Vol. 10, No. 1, pp. 3–19.)

A paper by the inventor of the system used in the Paris-Madrid demonstration dealt with in July Abstracts, p. 381.

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

OSCILLATIONS PRODUCED BY GASEOUS DIODES [TUNGAR RECTIFIERS, ETC.].—P. H. Craig. (*Electronics*, May, 1931, pp. 639–640.)

A photograph is included of a model for the demonstration of the production of both audio- and radio-frequency oscillations, both circuits employing the same Tungar rectifier; either of two transformers can be switched into circuit, one for audio-frequencies and the other (a small one with thin laminations) for radio-frequencies. Oscillatory currents of the order of 250 mA. (l.f.) and 100 mA. (r.f.) are obtainable.

TWO GENERATING CIRCUITS FOR ULTRA-SHORT WAVES.—H. Pöhlmann. (*Rad., B., F. f. Alle*, Aug., 1931, pp. 343–345.)

Two single-valve circuits are discussed, for use with commercial German valves (RE 504 and RE 134 among others): the first, a Hartley 3-point circuit, is satisfactory down to 4-5 metres, the second goes down to 1.7 metre. Particular attention is given to the filament circuit chokes. Approximate sizes of the various components are given. The writer warns his readers of the care necessary in using the B.-K. circuit, having himself already lost two valves on "switching-on." "Pierret's successes must have been with special valves." Details of a receiving circuit complete the article.

SIMPLIFICATION OF THE PIERRET ULTRA-SHORT-WAVE GENERATING CIRCUIT.—Guyot. (*See* abstract under "Propagation of Waves.")

RECEPTION.

ERSCHÜTTERUNGSSTÖRUNGEN BEI ORTSBEWEGLICHEN EMPFÄNGERN (Interference Troubles due to Vibration in [Short Wave] Mobile Receiving Systems).—W. Brintzinger, P. v. Handel and H. Viehmann. (*Zeitschr. f. hochf. Tech.*, July, 1931, Vol. 38, pp. 1–14.)

A lengthy investigation into the effects obtained both by telephonic reception and on an oscillograph, mostly carried out in a stationary aeroplane suspended elastically and set into vibration, but finally confirmed in actual flight. The disturbances are divided into two classes, those due to the vibration of the aerial system (including the aeroplane frame-work) and those due to the vibration of the receiver itself. Tests on the first class of disturbance bring out the importance of proper bonding of the frame-work and of keeping the aerial system away from the oscillation threshold.

The use of a separate heterodyne is an advantage, but even with this the use of reaction must be restricted unless the coupling between aerial and the reaction audion circuit [leaky-grid detector with reaction] is reduced by the interposition of an r.f. stage. Such a stage also makes it possible to use the oscillating audion circuit (which otherwise gives very bad disturbances) with the advantage of simpler adjustment. A further improvement is obtained by coupling this r.f. stage aperiodically to the aerial.

As regards the second class of disturbance, the vibrations are conducted to the receiver both mechanically and acoustically. Those conducted mechanically can, of course, be greatly reduced by suitable elastic suspension of the receiver; probably a great deal remains to be done in the way of reducing the air-borne vibrations by designing receiver boxes which cannot vibrate at audible frequencies (rigid containers of light metal sheet). Meanwhile, the writers recommend the use of a quartz-stabilised heterodyne (*see* 1930 Abstracts, p. 276) which produces a vast improvement—as can be seen by comparing the actual flight results given in Figs. 70, 71 and 72. For ease in manipulation they express the hope that the quartz-controlled heterodyne may in the future be supplanted by some other form of stable heterodyne: but for the present the two salient points from the paper are the importance of the quartz-controlled heterodyne and the desirability of aperiodic coupling between aerial and receiver.

AUTOMATIC AND SEMI-AUTOMATIC VOLUME CONTROLS FOR AIRCRAFT RADIO RECEIVERS.—Hinman. (*See* abstract under "Directional Wireless.")

DIE MESSENDE BESTIMMUNG DER EMPFANGSGÜTE VON RUNDFUNKEMPFÄNGERN (The Quantitative Determination of the Merit of Broadcast Receivers).—A. Clausing. (*E.T.Z.*, 30th July, 1931, Vol. 52, pp. 999–1001.)

Long abstract of a lecture. From the author's summary:—"By means of certain measurements the linear and non-linear distortions of the receiver, and its figure of merit as a long-distance receiver, can be determined. For the first time the determination of the distortion coefficient of complete broadcast receivers is gone into." *See* also next abstract.

MEASUREMENT OF THE QUALITIES OF A BROADCAST RECEIVER.—A. Clausing. (*Funk-B.*, 13th March, 1931, pp. 161–164.)

For the writer's long *E.N.T.* paper on the same subject, *see* March Abstracts, pp. 151–152.

ADAPTING OLD-TYPE CIRCUITS FOR USE WITH MODERN VALVES.—(*Wireless World*, 5th August, 1931, Vol. 29, pp. 132–134.)

During the past three or four years the efficiency of all types of thermionic valves has shown an astonishing improvement. The figure of merit has increased in some cases as much as 600 per cent., while the average is of the order of 200 or 300 per cent.

This fact is a source of difficulty to those users who keep in service receivers of obsolete type, and it is for their benefit that this article has been written. Hints are given on the small adjustments necessary to incorporate modern valves while obviating self-oscillation and other troubles.

SMALL-SIGNAL DETECTION [THEORY REDUCED TO SIMPLEST FORM, WITH A GRAPHICAL AID TO ITS VISUALISATION].—E. L. Chaffee. (*Electronics*, May, 1931, pp. 641–643.)

AERIALS AND AERIAL SYSTEMS.

ZUR BERECHNUNG DES LEISTUNGSGEWINNES BEI VERWENDUNG VON RICHTANTENNEN (The Calculation of the Gain Obtained by the the Use of Beam Aerial Systems).—L. Högelsberger. (*E.N.T.*, July, 1931, Vol. 8, pp. 307–308.)

On the limiting assumption that the currents, current distribution, and phase are the same in all elements, the writer obtains the formula $g_{ab} = \frac{a \cdot b \cdot \rho_{11}}{\rho_{ab}}$ for the gain factor of a system of b ranks each of a elements, the ranks being spaced $\lambda/2$. Here ρ_{11} is the radiation resistance of a single separate element, and ρ_{ab} the mean radiation resistance of one element in the system $a \cdot b$, given by $\rho_{ab} = \frac{R_{ab}}{a \cdot b}$, where R_{ab} is the radiation resistance of the whole system and can easily be calculated by Pistolkors' formula. Examples are given for values of a and b up to 6, and are compared with the results obtained by Southworth's method. To compare with these, the present results must be multiplied by 2 owing to Southworth's use of a reflector system. The influence of the ground has not been taken into account.

LES ANTENNES DIRIGÉES À ONDES COURTES (Short Wave Beam Aerials [and the Calculation of Their Properties]).—(*Journ. télégraphique*, May, 1931, Vol. 55, pp. 154–159.)

DEVELOPMENTS IN SHORT-WAVE DIRECTIVE ANTENNAS ["TILTED WIRE" PRINCIPLE].—E. Bruce. (*Proc. Inst. Rad. Eng.*, Aug., 1931, Vol. 19, 1406–1433.)

Part I discusses the relative importance of the factors limiting the intelligibility of short-wave telephony—set noise, static, etc., and signal fading—and the possibility of counteracting these limitations by aerial directivity. Unpublished work by Jansky indicates that on many occasions short-wave static is highly directional.

Part II begins by mentioning that the aerial systems generally used are expensive in their larger sizes and often have only a very limited frequency range, so that, for example, the Netcong station uses ten systems, all differing in frequency but all having the same favoured direction towards England. The new "tilted wire" aerials not only have a considerable frequency latitude (a two-to-one range is mentioned, and Fig. 9 shows how slowly the optimum tilt angle increases as the wavelength is decreased from—say—one-sixth to one-twelfth of the length of the aerial: even this inaccuracy can be compensated by another wire in combination, having an opposite trend) but are actually less expensive than a single, equally effective unit of the previous type.

The Inverted V aerial is an example of such a combination of two tilted wires. This is improved by the addition of a second V wire to replace a "ground" connection (eliminating ground contact resistance instability and other troubles), forming a "diamond-shaped" aerial. This may be used on its side as a "horizontal diamond-shaped" aerial for horizontally polarised waves, and this arrangement forms the greatest application of the tilted aerial for various reasons, among which are the smaller cost and the increased stability under varying weather conditions, horizontally polarised waves being less affected by varying ground constants. Several observers have reported these waves to be stronger than the vertically polarised components, but the writer's experience is that there is little to choose between them. The rest of the paper devotes itself to this horizontal system. Finally, its use as a unidirectional transmitting array is mentioned.

The elementary principles underlying the "tilted wires" are outlined on pp. 1415–1417 by vector representation, showing how phase considerations limit the useful length of a simple vertical aerial to $\lambda/2$, so that in the extreme case when l is increased to λ the load power is zero, and how this situation can be altered completely by advancing the top end into the wave propagation.

THEORETICAL AND PRACTICAL ASPECTS OF DIRECTIONAL TRANSMITTING SYSTEMS.—E. J. Sterba. (*Proc. Inst. Rad. Eng.*, July, 1931, Vol. 19, pp. 1184–1215.)

Author's summary :—This paper discusses some of the more important principles involved in the development of the directional transmitting antennas at present employed in the Bell System short-wave facilities. The theoretical performance of directive arrays is presented by means of various curves which have been obtained by integrations based upon Poynting's theorem. The details of the mathematical derivations are omitted for the sake of brevity, but the general procedure and the resulting formulas have been placed in an appendix. Various practical problems encountered in the development are described. These include antenna tuning procedure, transmission line adjustments, and sleet melting facilities.

SHORT WAVE RADIATION FROM VERTICAL AERIALS.—W. Nakayama and K. Komatu. (*Mem. Kyoto Coll. Sci.*, Jan., 1931, Vol. 14, pp. 1–22.)

In German. On the assumption of an imperfectly conducting earth, the writers investigate the radiation of the ground and space waves from a vertical aerial. Their results agree with those obtained experimentally by Bergmann.

ON THE CALCULATION OF RADIATION RESISTANCE OF ANTENNAS AND ANTENNA COMBINATIONS.—R. Bechmann. (*Proc. Inst. Rad. Eng.*, Aug., 1931, Vol. 19, pp. 1471–1480.)

English version of the paper dealt with in February and March Abstracts, pp. 96–97 and 155. Author's summary :—It is shown that there are two methods for calculating the radiation of antennas and antenna systems. One depends on the consideration of the electromagnetic field produced by the radiating system, that is, on the integration of the Poynting vector over a surface enclosing the system. The other is based on a consideration of the electromagnetic phenomena on the conductor itself. The identity of the two methods is demonstrated. The second method is much simpler to treat formally and gives clearer results. The calculation of the radiated power is especially simple, using a law that provides a connection between the radiated power and the Hertzian vector for the system under consideration. This hitherto unknown law is derived. The radiated power of any arbitrarily loaded antenna and of short-wave antenna systems with parallel elements is calculated by means of this law.

THE DETERMINATION OF POWER IN THE ANTENNA AT HIGH FREQUENCIES.—A. Hoyt Taylor and H. F. Hastings. (*Proc. Inst. Rad. Eng.*, Aug., 1931, Vol. 19, pp. 1370–1383.)

Authors' summary :—Following a brief review of general methods of measuring radio-frequency power in the antenna, a series of tests on a particular transmitter operating from 4000 to 26,000 kc. is described. These tests indicate that it is reasonable for such a transmitter, continuously variable in frequency and of fairly modern design, to be expected to put not less than 50 per cent. of its input plate power of the last stage into the antenna as radio frequency from 4000 kc. to 8000 kc., and not less than 32 per cent. at 24,000 kc. Intermediate efficiencies are indicated for the intervening frequencies. Coil losses and stray losses have been separated and the indications are that with modern insulation a moderate increase in efficiency can be expected in a transmitter designed for as high L/C ratio as possible, which is particularly feasible in the case of a transmitter operating on only one frequency. Marked increases in efficiency in the upper end of the spectrum can only be expected by the use of tubes better adapted to the upper frequencies.

RAPPEL DE QUELQUES ERREURS AFFECTANT LES INDICATIONS DES MONTAGES DE T.S.F. (A Note Recalling Certain Errors Affecting the Indications of Wireless Circuits [Open and Closed Aerials, etc.]).—H. de Bellescize. (*L'Onde Élec.*, July, 1931, Vol. 10, pp. 317–324.)

The equation given by Bourgonnier in his recent paper on the antenna effect of closed aerials (July Abstracts, p. 385) is

$$E = \pm\, a \cos \omega t \,.\, \cos \theta + b \cos (\omega t + \phi),$$

where a and b are the amplitudes in the closed and open aerials with which he represents the frame, θ is the angle which the considered direction makes with the plane of the winding, and ϕ the phase difference between the two sets of oscillations. This equation gives the well-known figure-of-eight diagram. The writer compares it with the equation arrived at in his 1917 paper dealing with the general question of the *effects of dissymmetries, in both generating and receiving circuits, due to electrostatic couplings with the earth or with neighbouring circuits.* For a receiving frame aerial, the current developed by the incoming signal was found to be the sum of the "normal" oscillation and a second oscillation due to the virtual open aerial earthed through the dissymmetrical capacity to earth: the equation was given as

$$i = hf(C\lambda\gamma) \sin Z \,.\, \sin(\omega t + \psi) \pm h'\phi(C\lambda'\gamma') \sin(\omega t + \psi'),$$

where h and h' are the effective heights of the frame regarded as a closed and open aerial respectively, $f(C\lambda\gamma)(C\lambda'\gamma')$ the voltages due to the conditions of resonance and decrement in each of the two aerials, $\psi\ \psi'$ the phases of the two components, and Z the angle between the normal to the plane of the winding and the direction of the signal. "Allowing for the difference in the notations, the two equations are identical: as regards the directive properties of the frame, they are evidently the same whether it is used as a transmitter or a receiver."

He then points out how, apart from the question of the directivity of a frame aerial, the effect of such dissymmetry is extremely harmful in any resonator, closed or open, which forms one of the circuits of a receiver, *owing to its action on the resonance curve and on the selectivity of the whole.* He considers the case where a number of tuned resonators are coupled through valves, and the case where they are coupled directly. Dissymmetry is also injurious in an open aerial used for transmission: the efficiency is increased, for instance, by carefully adjusting to equality the inductances of leads to different earthing points. As regards a receiver, he sums up by the statement that for any receiver, open or closed, to give "normal" results so far as both resonance and directivity is concerned, it must be made entirely symmetrical with respect to the electrical actions on either side of its tuning condenser, notably by reproducing artificially on each side of the main condenser the electrical characteristics existing on the other side; by connecting the mid-point of the inductance to earth or to the "mass"; and by making the couplings symmetrical in relation to the point on the inductance whose potential has thus been stabilised. The last page is devoted to explaining why the effect on syntony is so little realised while the effect on directivity is so well known.

INCREASING THE EFFECTIVE HEIGHT OF TRAILING AIRCRAFT AERIALS.—Eisner, Sudeck, Schröer and Zinke. (*Luftfahrtforsch.*, No. 6, Vol. 8, pp. 141–154.)

See August Abstracts, p. 441.

VALVES AND THERMIONICS.

VERSUCHE MIT EINER VERSTÄRKERRÖHRE NACH DEM QUERFELDPRINZIP (Experiments with an Amplifier Valve on the Transverse Field Principle [as in the C.-R. Oscillograph]).—H. Alfvén. (*Zeitschr. f. hochf. Tech.*, July, 1931, Vol. 38, pp. 27–29.)

The experimental valve has a 0.25 mm.-thick filament of platinum wire heated by a 10 v. battery. "The filament is slightly flattened, to give the electrons a definite direction; it is covered with white sealing-wax to increase the emission, and is stretched between two aluminium supports." To hinder the emission in undesired directions, a screen at about the same potential is placed behind it, while in front there are two screens one close behind the other, each with a slit parallel to the filament. The deflecting plates are 7 cm. long by 2.5 cm. wide, and are spaced 0.7 cm. Beyond these, at the far end of the tube, is a screen with a slit parallel to the other slits and equally wide (2 mm.). Beyond this screen lies the anode.

The two slotted screens in front of the filament are maintained at 100–150 v., obtaining a current of about 5 mA. from the cathode. The deflecting plates have a potential 25–40 v., the anode screen is at about the same potential, while the anode itself is kept at about 70 v. The containing glass tube is kept in connection with an air pump; if the mercury is cooled sufficiently with liquid air, a high vacuum is obtained; if cooled less, an atmosphere of rarified mercury vapour exists in the tube. In the first case the cathode ray is diffuse, and only a small part of it reaches the anode; in the second case the ray concentrates itself and most of the electrons reach the anode screen in a 1 mm. line parallel to the slit. Then by acting on the voltage between the two deflecting plates the ray can be deflected so that the electrons passing through the slit to the anode vary in number, and characteristic curves can be plotted (Fig. 3). These are nearly linear over a considerable length; the maximum slope measured is 3.6 mA./v., but from the appropriate formula (1) it seems certain that this can be increased. The penetration coefficient ("durchgriff") is fairly large if the anode voltage is nearly the same as that of the anode screen, but for the values given above (anode 20–30 v. higher than screen) it amounts only to 1 %, while by special double screening of the anode as in Fig. 4 it can be reduced to 0.5 %. The last part of the paper deals with various complications—the size of the "grid" current (current to the deflecting plates, amounting in the above tests to as much as 0.2 mA.) and ways of reducing it; the importance of the mercury vapour and of its proper pressure, and of the values of the various potentials; both factors have their effects on the spacing of the nodes and antinodes formed in the electron ray, and the position of these is of importance. Moreover, the mercury vapour pressure has an effect on the deflectibility of the ray: too great a pressure results in poor deflections, while too small a pressure gives discontinuities in the curve.

GRAPHICAL REPRESENTATION OF THE THREE CONSTANTS OF A TRIODE.—I. Miura. (*Proc. Inst. Rad. Eng.*, August, 1931, Vol. 19, pp. 1488–1491.)

The writer refers to previous methods of representing the three constants of a triode by one graph—Decaux (1929 Abstracts, p. 331) and Meyer ("The Triangular Valve Diagram," Jan. Abstracts, p. 42) and proposes a method of similar nature but believed to be much simpler, more accurate, and of greater practical value. The amplification factor, internal resistance, and transconductance are represented by one point in an equilateral triangle logarithmically scaled. The relation $\mu = s . r$ treated logarithmically becomes

$$\log s + \log r - \log \mu = 0;$$

in actual cases s is less than unity and $\log s$ is negative, so that the relation is

$$\log r - \log \mu - |\log s| = 0.$$

Now in an equilateral triangle ABC, if from an inside point P straight lines are drawn parallel to the three sides AB, BC and CA, meeting the adjacent sides AC, AB and BC at D, E and F, then $AE - AD - CF = 0$, and the figure represents the above logarithmic formula if $AE = \log r$, $AD = \log \mu$, and $CF = |\log s|$. An example is given of such a triangle representing the constants of twenty-four typical American valves.

PERFORMANCE OF OUTPUT PENTODES.—J. M. Glessner. (*Proc. Inst. Rad. Eng.*, Aug., 1931, Vol. 19, pp. 1391–1405.)

Author's summary :—The comparison of power output, distortion, power sensitivity, and a-c/d-c power economy of a group of experimental pentodes is made with corresponding triodes. The apparatus and method of measuring are described.

The pentodes' a-c/d-c economy and power sensitivity is considerably higher than that of the corresponding triodes. The harmonic distortion is found to be generally worse with the pentodes. The variation in power output with changes in load resistance, arbitrarily called "output distortion," is shown to be about the same for both classes of tubes.

The need of a large capacity shunting the bias resistor in a self-biased pentode amplifier is shown. Its effect on power output and power sensitivity is discussed.

In the conclusion, five types of distortion occurring in triode and pentode operation are compared. The principal use for the pentode appears to be with battery and 110-volt d-c types of receivers.

TRIODE DÉMONTABLE DE 150 KW. (150 kw. Dismountable Triode).—F. Holweck and P. Chevalier. (*Comptes Rendus*, 20th July, 1931, Vol. 193, pp. 151–153.)

Description and diagrams of the valve with its molecular pump; working on a plate voltage of 7,500 and suitable for wavelengths of the order of 10,000 metres. It will function with an efficiency of 70 % and will stand a continuous dash for an indefinite time, giving more than 100 kw. of r.f. energy.

HIGH AUDIO POWER FROM RELATIVELY SMALL TUBES.—Barton. (*See* under "Acoustics and Audio-frequencies.")

NEW INDIRECTLY-HEATED VALVES FOR D.C. MAINS. —Telefunken Company. (*Rad., B., F. f. Alle*, Aug., 1931, pp. 337–338.)

THE "UNIT" METHOD OF VALVE MANUFACTURE CONTRASTED WITH THE "DEPARTMENTAL" METHOD.—E. Kauer and R. Brindle. (*Electronics*, May, 1931, pp. 630–631.)

THE COMPARISON OF CERTAIN COMMERCIAL GETTERS.—M. R. Andrews and J. S. Bacon. (*Journ. Am. Chem. Soc.*, No. 5, Vol. 53, 1931, pp. 1674–1681.)

HAFNIUM FOR CATHODES.—(*Scient. American*, Aug., 1931, Vol. 87, pp. 137–138.)

Hafnium has not yet found a definite place for itself in industry, but its high melting point and electronic emissivity have already led to the taking out of patents for its use in valves, X-ray tubes, and rectifiers.

THE ORIGIN OF THERMIONIC ELECTRONS FROM OXIDE-COATED FILAMENTS.—R. W. Sears and J. A. Becker. (*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, p. 1681.)

Abstract only :—The following experiments show that the emission is determined by the condition of the oxide surface and not the core-metal surface, as proposed recently by Lowry (1930 Abstracts, p. 510), and also Riemann and Murgoci (1930 Abstracts, p. 278). (1) When barium is deposited on the oxide surface either by evaporation from an external source or by electrolysis of the oxide itself, the emission changes even though the temperature is so low that the barium could not diffuse to the core surface. (2) A removal of the oxide coating while the filament is at room temperature causes the emission, as determined at low temperatures, to decrease by a factor of 6000 or more. (3) When space-charge limited current is drawn to a plate, the potential of a point in the oxide is always positive with respect to the core surface by an amount directly proportional to the current. If the current were determined by the core surface this potential should be negative and should not vary linearly with the current. The experimental facts adduced to prove a limitation by the core surface are not conclusive and can be explained on the view proposed here.

DER EINFLUSS DER SEKUNDÄREMISSION AUF DIE RÖHRENKENNLINIEN (The Influence of Secondary Emission on Valve Characteristics).—H. Bittmann. (*Ann. der Physik*, Series 5, 1931, Vol. 8, No. 6, pp. 737–776.)

Author's summary :—In order to investigate the systematic irregularities of the dynatron characteristic, a simple, exact bridge method is developed for the measurement of negative slope.

With this method the character of the irregularities is investigated by varying the external factors (grid bias, magnetic field) and by making changes inside the valve ; it is found that the irregularities are independent of the constitution of the anode, and the possible explanations of the effects as excitation voltages and electronic diffraction ("selective" reflection) become invalid. With a *symmetrical, cylindrical* arrangement of the electrodes, the anomalies occur in a confused and irregular manner when the anode surface is contaminated, but when the surface is clean they always occur at the same anode voltage. When the electrodes are *plane*, the anomalies are independent of the distribution of the field inside the valve, but are such that the form of the curve is not altered by increasing all potentials in the same proportion.

In the case of plane electrodes it can be shown that *the irregularities in the dynatron characteristic are caused by the spatial discontinuity of the (strongly positive) collecting electrode (the "grid")*: when the grid is in the form of a plate, the curve is regular and the transition from this arrangement to one with a grid can be achieved by an auxiliary electrode.

An attempt is made to explain the anomalies as due to the return of secondary electrons between grid and filament; the practical application is discussed, special reference being made to double grid valves.

With reference to the number of secondary electrons taking part in the action of valves it is shown that they may be reduced to about a quarter of their number by the use of a reticulated anode. It depends to a very large degree on the outgassed condition of the anode and, when this is insufficient, varies even after annealing, owing to gaseous diffusion to the surface from the interior. It is considerably increased by oxide deposits on the anode, and more by barium than by strontium oxide.

On the Nature of the Repulsive Forces which Keep the Electrons from Escaping out of a Metal.—C. Zwikker. (*Physica*, No. 6, Vol. 11, 1931, pp. 161–170.)

In English. Author's summary:—An investigation into the ratio of the contribution of space charge and image force to the total thermionic work function. Mathematical difficulties do not allow a rigorous solution to be given, but it is possible to fix an upper limit for the contribution of the space charge, which upper limit appears to be 3 per cent. of the total work function, the rest being ascribed to image and structure forces.

Influence of Space Charge on Current Fluctuations.—E. W. Thatcher and N. H. Williams. (*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, pp. 1681–1682.)

Abstract only.

Theoretical Interpretation of Experimental Richardson Plots.—W. H. Brattain and J. A. Becker. (*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, p. 1681.)

DIRECTIONAL WIRELESS.

Night Errors on Long Waves.—I. Tanimura. (*See* abstract under "Propagation of Waves.")

Short-Wave D.F. by the Adcock System.—E. Iso. (*Ibid.*)

Aircraft D.F. Research: Night and Twilight Errors, Ultra-Short Waves, etc.—Wireless Division, German Aircraft Research Establishment.

(*See* abstract under "Miscellaneous," Fassbender, section xi.)

A Note Recalling Certain Errors Affecting the Indications of Wireless Circuits [Open and Closed Aerials, etc.].—de Bellescize.

(*See* under "Aerials and Aerial Systems.")

Lichtstrahlzeiger zur Kartierung von Winkelwerten (Light-Ray Pointers for Charting Angles [for Direction-Finding, etc.]).—Askania Works: K. Möller. (*Zeitschr. V.D.I.*, 18th July, 1931, Vol. 75, p. 945.)

Each "pointer" consists of a little turret rotatable about a pin set into the map at its particular spot. The turret emits from a slot at its foot a narrow beam of light traversed along its centre by the fine black shadow of a thread, this shadow acting as the pointer; the foot of the turret carries a circle graduated in degrees. Or, for fixed points of reference, the graduated circle is not on the turret but on the map itself, in which case it may have a large radius.

A Course Indicator of Pointer Type ["Reed Converter"] for the Visual Radio Range Beacon System.—F. W. Dunmore. (*Bur. of Stds. Journ. of Res.*, July, 1931, Vol. 7, No. 1, pp. 147–170.)

The motion of the two reeds generates small alternating voltages which, when rectified by copper-oxide rectifiers and passed in opposing polarities through a central-zero indicating instrument, give the course indications by the deflection of the needle in the direction of deviation of the aircraft from the course. The device is described in detail, and the advantages and disadvantages as compared with the usual "reed indicator" are set out. One advantage is that it is adapted to holding an aeroplane automatically on the course.

Theory of Design and Calibration of Vibrating-Reed Indicators for Radio Range Beacons.—G. L. Davies. (*Bur. of Stds. Journ. of Res.*, July, 1931, Vol. 7, No. 1, pp. 195–213.)

A general treatment of the theory of design of vibrating-reed indicators, the equations for the frequency of free vibration of a uniform reed and for a particular type of non-uniform reed being obtained. From the results of both theory and experiment, the effect of the various factors of design and operation upon the reed frequency is discussed, and the calibration procedure necessary to take account of these factors is outlined.

Automatic Volume Control for Aircraft Radio Receivers [primarily in connection with the Visual Type Radio Range Beacon].—W. S. Hinman, Jr. (*Bur. of Stds. Journ. of Res.*, July, 1931, Vol. 7, No. 1, pp. 37–46.)

This control has been referred to in past abstracts. It maintains a practically constant output voltage for input voltage variations of the order of 5000 to 1. A distance indicator, operating in conjunction with it, serves as a gauge of the distance from the transmitting station. The paper also describes a variation of the device which is intermediate between completely automatic and manual volume control; it simplifies the use of the beacon on the part of the pilot, reducing to about one-fifth the number of adjustments necessary over a given range of inputs, while allowing him to retain the sense of approach to the beacon without the addition of the distance indicator.

AIRPLANES LAND BLIND—GUIDED BY RADIO.—H. Diamond and F. W. Dunmore. (*Scient. American*, July, 1931, Vol. 87, pp. 20–23.)

The system referred to in this article was dealt with in Feb. and June Abstracts, pp. 99 and 328. The present article includes a description and illustration of a combined landing-beam and runway-course indicator, with crossed pointers, which is much simpler to use than the two separate instruments; also of the 93,700 kc.-beam transmitting and receiving units, and a wiring diagram of the complete receiving apparatus for blind landing as installed in the aeroplane.

AIRPLANE FLIGHT AIDED BY ELECTRICITY [BEACONS, AUTOMATIC CONTROL, ALTIMETERS, ETC.].—C. F. Green. (*Elec. Engineering*, August, 1931, Vol. 50, pp. 654–657.)

One form of automatic control uses the magneto compass as the direction-sensitive element and the turn compensator as the turn-sensitive element, the magnetic clutches of the steering mechanism being controlled by amplified currents from a sensitive relay. The radio altimeter is stated not to give positive indications at less than 350 ft., but to give indications of high accuracy at 650 ft. or more. Of the sonic altimeter it is mentioned that the outgoing signal and the echo blend when the altitude is about 5 ft. or less.

THE PHOTOELECTRIC CELL IN FOG FLYING.—W. F. Westendorp. (*Scient. American*, Aug., 1931, Vol. 87, pp. 123–124.)

More on the subject of the "mechanical eye" referred to in July and Sept. Abstracts, pp. 388 and 502. Two indicators, connected through amplifiers to the photoelectric cell at the tail of the aeroplane, are mounted in the cockpit; one indicates on which side the beacon light is the more intense, the other shows whether the light is becoming stronger or weaker. Tests so far have been extremely promising.

ACOUSTICS AND AUDIO-FREQUENCIES.

HIGH AUDIO POWER FROM RELATIVELY SMALL TUBES.—L. E. Barton. (*Proc. Inst. Rad. Eng.*, July, 1931, Vol. 19, pp. 1131–1149.)

"The purpose of this paper is to present a method by which audio outputs five to ten times the usual output of a tube of a given size [low-plate-resistance valves developed primarily for ordinary audio-output systems] may be obtained with the same plate voltage, lower average plate dissipation, and no serious effects on the tube. The above results are obtained by using the tubes in such a manner that advantage is taken of the essential features of the 'class B' amplifier. . . . The 'class B' amplifier is a tuned radio-frequency system and is not useful as represented for an audio output amplifier. However, if advantage is taken of the fact that the output during one-half of a cycle into an untuned load is essentially sinusoidal for a sinusoidal input, another similar tube may be used in such a manner that an undistorted output may be obtained. . . . The curves indicate that the output power for the 2000-ohm load [with two UX-112A valves as 'class B' audio amplifiers] is about 6 watts. If the plate voltage is raised to 300 volts, the optimum load resistance is about 2,500 ohms and an output of 10 watts may be expected."

A NEW DEVELOPMENT IN L.F. TRANSFORMER DESIGN [THE "PARAFEED" TRANSFORMER].—R.I., Ltd. (*This journal*, Aug., 1931, Vol. 8, p. 412.)

LOUD SPEAKER SOUND PRESSURE MEASUREMENTS.—E. W. Kellogg. (*Journ. Acoust. Soc. Am.*, Oct., 1930, Vol. 2, pp. 157–200.)

The conditions under which acoustic measurements on loud speakers should be made are considered, together with the interpretation of response curves as criteria of performance.

NOTES ON LOUD SPEAKER RESPONSE MEASUREMENTS, AND SOME TYPICAL RESPONSE CURVES.—B. Olney. (*Proc. Inst. Rad. Eng.*, July, 1931, Vol. 19, pp. 1113–1130.)

From the author's summary:—"The difficulties encountered in loud speaker measurements are briefly reviewed and a description of the acoustic features of a particular indoor measuring system is given [very briefly: the Bostwick method of rotating the microphone over a circular path inclined to the axis of the loud speaker, at the same time constantly turning it to face the plane of the latter, is recommended; a slow-acting meter of the thermocouple type gives the output of the microphone]. Outdoor testing arrangements are described whereby double as well as single radiating loud speakers are measured with negligible ground reflection error [the loud speaker being suspended with its axis at least 35 feet above the ground]. It is pointed out that the overall electrical fidelity curve of a radio receiver is an inadequate performance index; the electro-acoustic fidelity embracing the frequency response of the loud speaker is suggested as more informative. The interpretation of loud speaker response curves in terms of what one may expect to hear is discussed."

A number of response curves are given, showing the effects of various factors: most of these were taken by the indoor method, while Fig. 9 compares the indoor and outdoor response of one loud speaker and Fig. 10 gives the outdoor curve for different sizes of baffle.

THE DIRECTIONAL CHARACTERISTICS OF SINGLE AND MULTIPLE CONE DIAPHRAGMS.—I. Wolff and L. Malter. (*Journ. Acoust. Soc. Am.*, Oct., 1930, Vol. 2, pp. 201–241.)

Mathematical treatment, with particular attention to the variation with frequency of the polar distribution of sound intensity.

THE THEORY OF THE ELECTROSTATIC LOUD SPEAKER: OF THE HORN-TYPE LOUD SPEAKER.—C. R. Hanna. (*Ibid.*, pp. 143–149: 150–156.)

THE "CONCATENATED CONE" LOUD SPEAKER.—A. V. Bedford. (*Journ. Acoust. Soc. Am.*, Oct., 1930, Vol. 2, pp. 251–259.)

Glyptal is used as a mechanical resistance between the circular sections of the cone diaphragm, which is designed to embody the inertia- and resistive-elements necessary to give the motions for simulating a point source at all frequencies. Measurements indicate a somewhat improved response, with a better polar distribution at the higher frequencies.

THE UPPER REGISTER IN MOVING COIL LOUD SPEAKERS.—N. W. McLachlan. (*Wireless World*, 29th July, 12th and 19th August. 1931, Vol. 29, pp. 106–109, 164–166 and 193–195.)

The object of the article is to explain the reason for the enhanced output at the upper frequencies.

Summary: 1.—The upper register obtained with a coil-driven conical diaphragm is due to resonances. 2.—For the standard size of diaphragm discussed (radius 12.2 cm., angle 90°), there are two important resonance frequencies both of which correspond to so-called centre moving symmetrical modes of vibration. 3.—The first mode (one circle of minimum amplitude) occurs about 900 cycles per second and the second (two circles of minimum amplitude) about 2,000 cycles. The latter mode is the more powerful. 4.—The frequency of the second mode is not influenced to a great extent by the mass of the moving coil. The upper register is, however, the more powerful the smaller the mass of the coil. 5.—The frequency of the second mode is not seriously affected by varying the thickness of the diaphragm.

6.—When a coil of moderate mass is attached to the diaphragm by a short neck, the added stiffness augments the frequency of the second mode somewhat, and the upper register is extended. 7.—The condition at the edge of the diaphragm, whether free, reinforced, or on a rubber surround, has no appreciable influence on the upper register provided the diaphragm is not too small. 8.—If the radius of the cone is constant, the frequency of the second symmetrical mode increases with decrease in the apical angle from 180°. After 90° the frequency increases very slowly. 9.—For any given apical angle, the frequency of the second symmetrical mode increases with decrease in radius of the diaphragm. 10.—The frequency of the second symmetrical mode of a diaphragm of given radius is increased by the use of thin sheet aluminium. The reproduction of broadcasting is unsatisfactory owing to lack of "body." This is caused by elevation in the frequency of the second mode, whereby the register between 200 and 2,500 cycles is weakened whilst that in the 5,000 to 8,000 cycle region is strengthened.

RECHERCHE DE LA FORCE ÉLECTROMOTRICE FICTIVE D'UN TRANSMETTEUR MICROPHONIQUE (Investigation of the Equivalent Electromotive Force of a [Carbon] Microphone Transmitter).—P. Massaut. (*L'Onde Élec.*, July, 1931, Vol. 10, pp. 303–316.)

The writer says that in calculations and designs relating to telephony the variations of resistance of the microphone transmitter are not taken into account; the microphone is, in fact, represented as a generator of constant impedance producing a variable e.m.f. ϵ which is independent of conditions in the external circuit provided the feed current i_0 is maintained. He examines these assumptions mathematically, and arrives at the following conclusions, implicit in the equation (17, page 311) which he obtains for ϵ:—(i) ϵ is zero when the diaphragm is at rest, when i_0 is zero, and when $\sin \omega t$ is zero; in other words, ϵ is in phase with the diaphragm vibrations, as would be expected from the fact that there is no reactive element present.

(ii) ϵ changes its sign with i_0, but not its absolute value; the maximum negative value of ϵ is *not* equal to its maximum positive value, so that the microphone introduces distortion.

(iii) Contrary to general supposition, ϵ depends largely on the resistance R of the external circuit, even if i_0 is maintained constant. ϵ increases with i_0 but rather more quickly, while it increases rather less quickly than $R + r_0$ (Fig. 4) if the other factors are kept constant. Finally, ϵ is not proportional to $\sin \omega t$ (Fig. 5) thus producing the distortion mentioned in (ii). It cannot be made strictly proportional to $\sin \omega t$, but equation 18 (a simplified form of 17 holding good under certain assumptions) shows the various ways in which it can be made more closely proportional: *e.g.*, by decreasing the diaphragm amplitude (decreasing the feed current i_0 gives hardly any advantage), increasing R, increasing the cross section (not the thickness) of the carbon charge, etc. All these measures, however, decrease ϵ: the writer therefore recommends a push-pull circuit with two capsules driven by the same diaphragm, which completely eliminates the difference between positive and negative waves.

The rest of the paper deals with the matching of the microphone resistance with the resistance of the line, when this is large enough to remove the danger of burning-out and simultaneously to render such matching necessary to obtain maximum efficiency. One of the results of the whole investigation is to show that no complete comparison of different microphones can be made simply by introducing them one after the other into the same circuit.

EIN NEUES ELEKTRODYNAMISCHES BANDMIKROPHON (A New Electrodynamic Band Microphone).—C. A. Hartmann: Siemens and Halske. (*E.N.T.*, July, 1931, Vol. 8, pp. 289–297.)

Hitherto the band microphone, in spite of its excellencies, has not been used generally on account of its too small transmission ratio (microphone e.m.f. to sound pressure in volts/bars). The new type here described equals in efficiency the best high-quality carbon microphone. Various characteristic diagrams are given.

RECORDING CONTOUR GAUGE [OPTICAL, FOR TESTING TELEPHONE DIAPHRAGMS].—E. C. Erickson. (*Bell Lab. Record*, Aug., 1931, Vol. 9, pp. 567–570.)

GOLD CONTACT SURFACES ON MICROPHONE DIAPHRAGMS BY CATHODE SPUTTERING.—Fruth. (*See* abstract under "Miscellaneous.")

LES RÉCENT PROGRÈS DE LA CINÉMATOGRAPHIE SONORE (Recent Improvements in Sound Films).—A. Soulier. (*L'Industrie élec.*, 10th May, 1931, Vol. 40, pp. 197–204.)

Including a description of the Western Electric method of speed regulation.

THE TWO GERMAN SOUND-FILM SYSTEMS—"TOBIS" AND "KLANGFILM."—J. Mayer. (*E.T.Z.*, 16th July, 1931, Vol. 52, pp. 925–928.)

Including a description of the Tobis recording glow-discharge lamp ("ultra-frequency" lamp) of special design.

THE ILLUMINATION OF SOUND-ON-FILM RECORDS.—L. Dunoyer. (*Rev. d'Optique*, Jan. and Feb., 1931, Vol. 10, pp. 1–21 and 57–68.)

OPTICAL METHODS FOR REDUCING THE EFFECTS OF PHOTOGRAPHIC PLATE GRAIN.—F. E. Wright. (*Journ. Opt. Soc. Am.*, July, 1931, Vol. 21, p. 438.)

UNBALANCED ABSORPTION IN ACOUSTIC TREATMENT FOR SOUND-PICTURE THEATRES.—V. A. Schlenker. (*Electronics*, May, 1931, pp. 625–627 and 660.)

GRUNDLEGENDE MESSUNGEN ZUR SCHALLISOLATION VON EINFACH-TRENNWÄNDEN (Fundamental Measurements on the Sound Insulating Properties of Single Partitions).—E. Meyer. (*Berliner Ber.*, No. 8/9, 1931, pp. 166–181.)

The factor measured is the logarithmic ratio of the sound energy impinging on the partition to the energy transmitted, multiplied by 10. It bears a linear relation to the logarithm of the weight of the partition (this varied from 2 to 500 kg/m^2.). The vibrations of the partition are investigated by a high-frequency capacity-change method; the amplitudes decrease with increasing frequency so that the acceleration remains constant; for partitions of different mass there is a linear relation between the logarithm of the mass and the acceleration. The insulating value is calculated from the velocity-amplitude and agrees well with the measured values. The oscillating mass of the partition amounts to about 0.2 to 0.1 of the actual mass. The natural frequency (below 50 c.p.s.), the damping (log. decrement of the order of 0.1) and the modulus of elasticity are measured by the same capacity method. The tests show that the insulating power of a single partition depends on its bending vibrations, whose amplitude depends on the mass of the partition.

THE MERCURY ARC [THYRATRON] AS A SOURCE OF INTERMITTENT LIGHT.—H. E. Edgerton. (*Electronics*, May, 1931, p. 628.)

Abstract of a paper read before the Society of Motion Picture Engineers. Among the advantages of the mercury arc are the actinic nature and high intensity of the light and the fact that the duration of the flash (whose frequency is easily and accurately controlled) can be made less than ten microseconds. *See* also under "Subsidiary Apparatus."

DESIGN PROBLEMS OF SOUND-ON-FILM FOR HOME MOVIES.—A. J. Koenig. (*Electronics*, May, 1931, pp. 621–622 and 655.)

AN APERTURELESS OPTICAL SYSTEM.—R. C. Burt. (*Electronics*, May, 1931, p. 628.)

Abstract only. The image of the source is elongated and flattened by a combination of positive and negative cylindrical lenses with their axes at right angles, and is then focused on the film. Several advantages are claimed.

RECENT DEVELOPMENTS IN ACOUSTICS, PARTICULARLY APPLIED ACOUSTICS.—F. Trendelenburg. (*Zeitschr. f. hochf. Tech.*, July, 1931, Vol. 38, pp. 33–40.)

Another instalment of the survey dealt with in September Abstracts, p. 505. It deals with various acoustic transmitters: the sound fields of membranes, the properties of baffles, the efficiency and fidelity of various sound-generating mechanisms, and methods for increasing them. Finally, various musical instruments—violins, trumpets, cymbals, etc.—are considered, and a number of spectrum curves are reproduced.

ENGINEERING ACOUSTICS.—(*Electrician*, 1930–1931, Nos. 2740–2761.)

Among the later sections the subjects dealt with are:—Articulation in an Auditorium, Reproduction in the Auditorium, Sound Reproducers, Loudspeaker Efficiency, Response of Telephone Receivers and of Loud Speakers, and Receiver Response Measurement.

ON THE PROPAGATION OF SIGNALS IN MIXED DISPERSIVE SYSTEMS [PUPIN CABLE AND ACOUSTIC HIGH PASS FILTER].—Baerwald. (*See* abstract under "Propagation of Waves.")

ABSORPTION DES ONDES ULTRA-SONORES PAR L'EAU (Absorption of Supersonic Waves [of the order of 8 Megacycles/Sec.] by Water).—P. Biquard. (*Comptes Rendus*, 27th July, 1931, Vol. 193, pp. 226–229.)

The waves are generated by a gilded disc of quartz excited to an odd harmonic by a 200-watt wireless transmitter with quartz-controlled drive. Radiation pressure was measured by a torsion pendulum, using a null method. Tests through constant water-distances showed that the radiation pressure thus measured was proportional to the square of the potential applied to the emitting disc. Tests through varying water-distances showed that the radiation pressure decreased exponentially with the distance x, according to the formula $p = p_0 e^{-2\alpha x}$. For a frequency 7.55×10^6 c.p.s. and a water temperature of 14°, the coefficient α is 1.74×10^{-2}; for 7.97×10^6 c.p.s. and temperature 17°7, it is 2.0×10^{-2}.

SUPERSONIC SATELLITES.—W. H. Pielemeier. (*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, p. 1682.)

THE VIBRATIONS OF A PLATE WITH A FIXED CENTER.—R. C. Colwell. (*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, p. 1684.)

THE ABSORPTION OF AUDIBLE VIBRATIONS IN THE AIR.—V. O. Knudsen and L. P. Delsasso. (*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, p. 1699.)

THE VELOCITY OF SOUND IN METAL RODS BY A RESONANCE METHOD.—L. C. Shugart. (*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, pp. 1683–1684.)

Abstract only.

LAME VIBRANTE EXCITÉE PAR LE MILIEU AMBIANT (A Vibrating Blade Excited by the Medium Surrounding It).—Z. Carrière. (*Journ. de Phys. et le Rad.*, June, 1931, Vol. 2, Series 7, pp. 165–188.)

Extract from author's summary :—" Excited by the vibrations of the surrounding air, a blade takes up an amplitude which is a function of the difference between its natural frequency and that of the excitation. The dissymmetry of the resonance curves leads to the variation, with frequency, of the so-called natural frequency. This variation explains the 'jumps' in amplitude of which I give numerous examples for the case where the frequency diminishes with increase of amplitude. I give one example for the exceptional case where the frequency increases with the amplitude . . ."

The method of investigation is a stroboscopic one, the air being set in motion by a telephone diaphragm closing one end of an acoustic tube.

A NEW METER FOR NOISE ANALYSIS.—Castner, Dietze, Stanton and Tucker. (*Elec. Engineering*, May, 1931, Vol. 50, pp. 342–343.)

MEASUREMENT OF MACHINERY NOISE.—H. B. Marvin. (*Ibid.*, pp. 349–351.)

A NEW PRINCIPLE OF SOUND FREQUENCY ANALYSIS.—T. Theodorsen. (*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, p. 1717.)

Abstract only :—A new method of sound frequency analysis has been developed by the National Advisory Committee for Aeronautics in connection with a study of aircraft noises. The method is based on the well-known fact that the ohmic loss in an electrical resistance is equal to the sum of the losses of the harmonic components of a complex wave, except for the case in which any two components approach or attain vectorial identity, in which case the ohmic loss is increased by a definite amount, even though the total current remains the same. This fact has been utilised for the purpose of frequency analysis by applying the unknown complex voltage and a known voltage of pure sine form to a common resistance. By varying the frequency of the latter throughout the range in question, the individual components of the former will manifest themselves, both with respect to intensity as well as frequency, by changes in the temperature of the resistance. No difficulties exist as to distortions of any kind. The fidelity of operation depends solely on the quality of the associated vacuum-tube equipment. An automatic recording instrument embodying this principle is described in detail.

MEASURING FREQUENCY CHARACTERISTICS WITH THE PHOTO-AUDIO GENERATOR.—W. Schäffer and G. Lubszynski. (*Proc. Inst. Rad. Eng.*, July, 1931, Vol. 19, pp. 1242–1251.)

See August Abstracts, p. 442.

THE MEASUREMENT OF FREQUENCY CHARACTERISTICS BY MEANS OF THE OPTICAL NOTE GENERATOR : A CORRECTION.—Lubszynski. (*E.N.T.*, July, 1931, Vol. 8, p. 315.)

Correction of an error in a formula given in the paper dealt with in August Abstracts, p. 442.

WAVE MOTION AND THE EQUATION OF CONTINUITY.—R. B. Lindsay. (*Proc. Nat. Ac. Sci.*, July, 1931, Vol. 17, pp. 420–426.)

PHOTOTELEGRAPHY AND TELEVISION.

LA RÉCEPTION EN TÉLÉVISION (Television Reception).—R. Barthélémy. (*L'Onde Élec.*, July and August, 1931, Vol. 10, pp. 281–302 and 338–346; *Rev. Gén. de l'Élec.*, 4th and 11th July, 1931, Vol. 30, pp. 3–12 and 52–59.)

In a previous lecture (April Abstracts, pp. 217–218), the author dealt with the transmitting end of his system of television. He now turns to the receiving end, illustrating his lecture by demonstrations of television and telecinema transmitted (with less than 5 watts in the aerial) from a 200-metre wave station $1\frac{1}{2}$ km. distant. The image, which was visible without the room being darkened, measured 40 × 30 cms., while the source of light only consumed 3 watts ; the author compares this result with figures quoted from an American source, relative to a demonstration of wired television, where the source of light consumed 250 watts and the size of the image was only 5 square centimetres [?], *i.e.*, 240 times smaller than his own.

The first instalment concentrates on the requirements of (*a*) the r.f. amplifier : the necessity, in view of the wide frequency band, of avoiding the use of reaction, since this only amplifies effectively close to the resonance point : the objections to the use of screen grid valves in their ordinary circuits : the solution of these difficulties by the use of a two-grid valve in the " isodyne " connection (Fig. 2) in which the effective internal resistance is composed of two resistances in parallel —the resistance filament-inner grid and the resistance filament-plate ; since each of these is less than 10,000 ohms (for a suitable filament temperature) the mean resistance is less than 5,000 ohms, which is very good for the purpose. Also, by suitably designing the coupling coils and by a proper adjustment of filament current, all reaction is avoided (given, of course, suitable screening).

(b) Detection: nothing very special here, leaky grid and anode bend both giving good results: to prevent the passage of radio frequencies to the succeeding stages, the plate-circuit inductance is shunted by a capacity (Fig. 3): the maximum value which this capacity may possess, without eliminating the high modulation harmonics of the television transmission, is calculated, and a further precaution is recommended in the form of a stopper circuit: these considerations make it desirable to employ *a detector valve of low internal resistance.*

(c) Low-frequency amplification: the obvious method is to use continuous current amplification, the stages coupled by counter-e.m.f. batteries; but such a system is very unsuitable for inexpert handling at the receiver. The writer therefore avoids the employment of c.c. amplification by using the impulses produced at the transmitter by a very short variation or interruption of the illumination at the end of each line (*see* April Abstracts, pp. 217–218, and *cf.* Leithäuser and Sohnemann, August Abstracts, p. 446). In this way a rectangular pulse-form is produced, each pulse lasting about $\frac{1}{500}$ sec. and being separated from the next by an interval of the order of one ten-thousandth of a second. The l.f. amplification of such signals can be carried out successfully by the use of inductance- (or resistance-) capacity coupling. A biasing battery must be introduced to prevent the grid from becoming positive (Fig. 6).

The rest of the first instalment is devoted to neon lamps for the receiver—at present, he considers, the only practical source of light for the purpose. "Measurements, not yet confirmed, indicate that it is possible to reproduce faithfully oscillations of the order of a millionth of a second, which is more than enough for television. It is certain that we have reached without difficulty frequencies of some tens of thousands" [*cf.* Ives, April Abstracts, p. 217, who says that the neon lamp used in the American two-way tests "had to be assisted by a frequently renewed admixture of hydrogen" when handling a 4,500-element picture]. Although he declines to describe the neon lamp actually employed in the demonstration, he discusses the requirements of such a lamp and the various methods adopted for producing uniform illumination over an area the shape of, and rather larger than, the complete image, and for economising in energy by generating the light only in the required direction. He then deals with the necessity for a long and comparatively straight characteristic (pp. 298-299) and for avoiding persistence effects (pp. 299–301): "there is an adjustment of the receiver which gives the best quality, and this adjustment is not, as a general rule, the one which gives the greatest intensity." He points out the convenience of, and the good fidelity given by, the method of connecting the lamp directly in the anode circuit of the output valve, and also the defects of this plan; the Baird method using transformer coupling seems to him to offer difficulties for pictures with a large number of elements, and he prefers an inductance-capacity circuit such as that of Fig. 19.

In the second instalment the writer first discusses the various known methods of synchronisation (synchronous motor, phonic wheel, "correction" methods, including the Lorenz copper-disc brake) with their advantages and disadvantages. He then deals with his own method (August Abstracts, p. 446).

Effect of a High-frequency Field on the Photoelectric Emission of a Cell.—Barthélémy. (*Ibid.*, p. 282.)

In the course of the paper abstracted above, the writer mentions that he encountered trouble with his modulating circuit, which was situated a few metres from the transmitting aerial. At first he attributed it to ordinary stray reaction, which seemed likely in view of the wide frequency band of the amplifier; but screening, the introduction of rejector circuits, and similar precautions were all useless and he was forced to the conclusion that the radio-frequency field was influencing the emission of his photoelectric cell. This supposition seemed strengthened by the fact that the parasitic oscillation only occurred when the ray of light fell on the cell. Gutton reports having observed the same effect under different conditions.

Betrachtungen über die Grenzen der Vergrösserung von Fernsehbildern (Considerations on the Limits of Magnification of Television Images).—H. Prinzler. (*Fernsehen*, No. 2, Vol. 2, 1931, pp. 128–131.)

Zur Netzsynchronisierung von Fernseh-Empfängern (The Synchronisation of Television Receivers by Mains' Frequency).—G. Schubert. (*Fernsehen*, No. 2, Vol. 2, 1931, pp. 105–120.)

A lengthy investigation by stroboscopic methods in the course of which the frequency stability of the Berlin network was studied. If transmitter and receiver are run off the same network (even a big overland network), synchronisation seems possible for systems using up to 25 picture changes per second and 5,000 elements, but the writer concludes that in the present state of the technique automatic synchronisation, in spite of its increased cost, is greatly preferable on account of its greater stability, at any rate for systems using a high framing frequency and a large number of elements.

Das Weillersche Spiegelrad: Nipkowscheibe oder Spiegelrad (The Weiller Mirror-Wheel: Nipkow Disc or Mirror-Wheel ?).—R. Moller: F. Kirschstein. (*Fernsehen*, No. 2, Vol. 2, 1931, pp. 80–97: 98–104.)

The Stresses in Rotating Discs.—A. F. Cornock. (*World Power*, Aug., 1931, Vol. 16, pp. 94–98.)

Public Service of Phototelegraphy in Japan [N.E. System].—S. Inada: Niwa and Kobayashi. (*Elec. Communication*, July, 1931, Vol. 10, No. 1, pp. 26–33.)

Description of the service between Tokyo and Osaka, on the N.E. System dealt with in 1930 Abstracts, p. 402, but with a few subsequent improvements. Two types of apparatus are used, one for operating at high speed over the telephone land-lines, the other for operating on the 4-wire repeatered cable. An interesting section deals with the precautions in installing and wiring necessary to give the best possible quality.

SUR LES PROPRIÉTÉS PHOTOÉLECTRIQUES DES COUCHES MINCES DE MÉTAUX ALCALINS (The Photoelectric Properties of Thin Films of Alkali Metals).—Déjardin, Schwegler and Warin. (*Rev. Gén. de l'Élec.*, 4th July, 1931, Vol. 30, pp. 20–21.)

Long summary of a recent lecture on researches into the chromatic sensitivity of cells with cathodes all consisting of a silver plate acted on superficially by caesium vapour and then subjected to a heat treatment, but all varying in one or more ways—amount of caesium introduced, degree of oxidation of the silver, thermal treatment, etc. The results all fit in with the hypothesis that there are three coexistent effects of different relative importance, whose maxima correspond roughly to 7,500, 4,500 and 5,400 A.U. The first type of cell tested, in which the oxidation of the silver plate is only slight (light blue colour before the introduction of the caesium), is the most important for practical purposes. It has a maximum emission round 7,500 and a minimum round 5,100 A.U., and keeps a high value between 9,000 and 11,500 A.U. Probably the photosensitive layer is composed of a monatomic skin of caesium strongly adhering to the metallic support by the intermediation of a layer of oxygen atoms. The effect of a supporting layer of magnesium, in conjunction with caesium, sodium, potassium or rubidium, is also studied; in particular, the influence of oxidation of the magnesium.

ÜBER EINE PHOTOELEKTROMOTORISCHE KRAFT IN KUPFEROXYDUL-KRISTALLEN (On a Photo-Electromotive Force in Cuprous Oxide Crystals).—H. Dember. (*Physik. Zeitschr.*, 15th July, 1931, Vol. 32, No. 14, pp. 554–556.)

Three types of photoelectric effect in cuprous oxide are known: the external effect, in which electrons are emitted from the surface; the photoelectric increase of internal conductivity; and the prodnction of a photo-electromotive force in the interior of the substance (Kennard and Dieterich, 1916). According to the recent work of Lange, Schottky and their colleagues, the photo-electromotive force is attributed to the action of a "blocking layer." They employed chiefly a cuprous oxide layer "grown" on mother copper to a thickness of a few tenths of a millimetre.

Much thicker layers (10–14 mm.) of cuprous oxide are available in natural cuprite crystals, and the present paper investigates the production of photo-electromotive forces in such crystals. A series of tests, in which the direction of the light ray, the exposure of the electrodes to direct illumination, etc., were varied, led to the following conclusions:—currents of the order of 5×10^{-8}A. (short circuit current 5×10^{-5} A.) could be obtained with a 500-watt tungsten lamp at 30 cm. distance: the electrodes need not be directly illuminated: and current could be produced in a direction opposite to that postulated by the Schottky "posterior wall effect" (January Abstracts, p. 46). The writer sums up:—"The production of an electromotive force within the crystal can only occur when the light is able to set free electrons so that these can diffuse into the interior of the crystal. Through the light absorption occurring along the path of the light, the electron concentration is altered in such a way that it is always greatest at the point of entry and decreases along the path in proportion to the amount of light absorbed at each point. *The concentration-drop thus produced drives the electrons in the direction of the light.* This view does not exclude the possibility of a blocking effect taking part in the action, but such an effect cannot by itself explain the observed phenomena."

THE ANGULAR DISTRIBUTION OF PHOTOELECTRONS EJECTED BY POLARIZED ULTRAVIOLET LIGHT IN POTASSIUM VAPOR.—E. O. Lawrence and M. A. Chaffee. (*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, p. 1718.)

NEGATIEVE FOTOEFFECTEN BIJ GASONTLADINGEN (Negative Photoelectric Effects in Discharges in Gases).—F. M. Penning. (*Physica*, No. 6, Vol. 11, 1931, pp. 183–196.)

From the author's summary:—"(1). It is possible in various ways to decrease the conductivity of a (neon) gas gap by illumination ("negative photo-effect"). This phenomenon has its origin either in the cathode or in the gas. (2) In a gas-filled photoelectric cell in which the current is gradually increased, the discharge becomes intermittent earlier in the dark than during illumination. The current can be so regulated that an intermittent discharge can be transformed into a continuous one by illumination, the mean current strength is then considerably decreased."

The rest of the paper deals with the two cases in which the photoelectric action originates in the gas itself:—First, when traces of argon are present and the metastable neon atoms can ionise the argon atoms; illumination increases the break-down potential, and an intermittent discharge can be extinguished by the light from a neon tube. Another example is the effect of illumination on the negative glow in such a mixture: the writer finds that much smaller quantities of argon than those mentioned by de Groot are effective in decreasing the current density in the normal cathode fall—*e.g.*, 0.001%. "The effect is due to ionisation by metastable atoms. Illumination with neon light decreases the effect of the admixture, the current density again increases. By the use of a cathode divided into two parts this effect can be used to transform light intensity changes into current changes."

The second case concerns the gas without admixture of argon, where the ions of the discharge are formed out of the metastable state by electron collision (step-by-step ionisation). An example is the effect, on the working-potential of a neon tube, of bringing a second neon tube of greater brightness near to the first: when close enough, the second tube extinguishes the first.

CONVERSION OF LIGHT CHANGES INTO CURRENT CHANGES BY A NEON TUBE.—Penning. (*See* preceding abstract.)

ON THE POSSIBILITY OF SEPARATING NEON INTO ITS ISOTOPIC COMPONENTS BY RECTIFICATION.—W. H. Keesom and H. van Dijk. (*Proc. Amsterdam*, No. 1, Vol. 34, 1931, pp. 42–50.)

THE MAKING OF MIRRORS BY THE DEPOSITION OF METAL ON GLASS.—Bureau of Standards. (*Bur. of Stds. Circular No.* 389, 1931, 17 pp.)

THE HOME CONSTRUCTION AND TESTING OF SELENIUM CELLS.—H. Günther. (*Rad., B., F. f. Alle*, Aug., 1931, pp. 362–366.)

A PHOTOELECTRIC METHOD OF MEASURING THE POWER OF SURFACES TO REFLECT AT DIFFERENT PARTS OF THE SPECTRUM.—J. B. Silberblatt. (*Westnik Elektrot.*, No. 1, 1931, Part III, pp. 1–12.)

In Russian. The "relative sensitivity" of the photoelectric cell employed is taken as the ratio of the illumination which produces a current i for an applied potential V to the illumination required to produce the same current i for a second applied potential V_0. It was found, for the cell and amplifier used, that the curve of "relative sensitivity" plotted against potential V had the same shape for various values of i and was also, within wide limits, independent of the wavelength provided this was sufficiently small. If such a curve is once obtained for a particular wavelength, the reflecting properties of a substance can easily be measured by comparison with a surface whose reflection-coefficient distribution along the spectrum is known: the potentials producing equal amplified photoelectric currents for the two substances are measured, and from the curve of "relative sensitivities" the required reflection coefficients are obtained.

A BOOK-PRINT READER FOR THE BLIND ["PRINTING VISAGRAPH"].—R. E. Naumberg. (*Scient. American*, August, 1931, Vol. 87, p. 113.)

An outline of the writer's apparatus, in which the scanning principle used by F. d'Albe and others (*cf.* Abstracts, 1930, p. 515—Rosing: September, p. 504—G. Fournier) is extended so that the currents representing the letters, instead of being converted into sounds, are made to actuate a printer which embosses a special aluminium foil with magnified versions of the letters (about the size of Braille characters). The foil is covered with criss-cross grooves to allow the metal to "flow" freely without being torn by the embossing point. The impressions may be erased by passing the foil between rollers, or they may be preserved by applying shellac or other material to the back so that the cavities are filled up.

MEASUREMENTS AND STANDARDS.

HOCHFREQUENZ-MESSGERÄTE (High-Frequency Measuring Apparatus).—A. Jaumann: Siemens and Halske. (*E.T.Z.*, 30th July, 1931, Vol. 52, pp. 985–991.)

An introductory section leads to Section 2, where a complete, screened r.f. generator for measuring purposes is described and illustrated; it gives a maximum output of 4 watts and a mean (telephony) output of 1 watt, with a frequency range of 100–1,700 (elsewhere given as 1,500) kilocycles per second. The output is through a special r.f. step-down transformer which covers the whole frequency range with uniformly good efficiency, thanks to the use of an iron core of very special material (effective permeability for these radio-frequencies = 13; losses at 1,500 kc. are only a little greater than in a corresponding air-core transformer). In conjunction with this test generator, a r.f. current filter (Figs. 6 and 7) may be employed, covering the frequency range in 8 steps and giving, in the worst case, a harmonic damping of 4 nepers.

Section 3 describes a r.f. thermionic voltmeter and a special aperiodic r.f. amplifier (Fig. 15) whose amplification curves for 1 . . . 4 valves are shown in Fig. 14 (these can be improved still further). This design was only arrived at after discarding transformer-coupled stages both with air and iron cores (Figs. 11 and 12); the use of the von Ardenne resistance-coupled multiple-valve system was considered not perfectly satisfactory for wavelengths under 1,000 metres. The arrangement finally adopted uses a combination of transformer and resistance couplings (Fig. 13) and has a number of advantages, one of which is a freedom from a tendency to oscillate which dispenses with any need for neutralisation. This amplifier unit is designed for direct connection in front of the valve voltmeter, and enables r.f. potentials from 2.8 v. down to 20 μv. to be measured absolutely. The section ends with a description of the potential-divider unit used in conjunction with the other instruments: this takes the form of a r.f. artificial line of several T links, more or less of which can be switched into series (Figs. 16 and 17).

Section 4 deals with impedance measurement at radio frequencies, and refers to the common practice of being satisfied with coil measurements at audio-frequencies. A simple instrument is then described for measuring inductance at radio-frequencies (Figs. 18, 19 and 20), consisting of a crystal-controlled oscillator whose anode circuit contains a calibrated condenser and the coil under measurement. So long as the circuit frequency is below that of the crystal, no oscillation can take place; but as the condenser is gradually reduced, oscillation sets in suddenly when the crystal frequency is reached (Fig. 19). Alternative crystals enable the inductance measurement to be made at various radio-frequencies, and thus the self-capacity of the coil can be found. The method can be used for inductances down to about 0.5 μH., thus including short-wave coils which can only be measured roughly at audio-frequencies; the instrument shown is for a range 3 mH.—30 μH.

Condenser loss measurement at radio-frequencies is then dealt with (Figs. 21 and 22), the instrument using a substitution method and a dynatron circuit: the breaking-off of oscillation is the indication employed. The rest of the section is devoted to differential and Küpfmuller r.f. bridges, the latter enabling impedances to be measured in a connection in which they are symmetrical with respect to earth. Section 5 deals with complete "test bench" equipments using the above and other components; *e.g.*, field strength and interference-level equipment, broadcast receiver test equipment, etc. The subsequent discussion is given on pp. 1013–1014.

THE QUANTITATIVE DETERMINATION OF THE MERIT OF BROADCAST RECEIVERS.—Clausing.

(*See* under "Reception.")

EIN NEUES ELEKTRO-OPTISCHES MESSVERFAHREN FÜR SPANNUNGEN UND STRÖME SEHR HOHER FREQUENZ (A New Electro-optical Method of Measurement for Voltages and Currents of Ultra-High Frequency).—L. Pungs and H. Vogler: Hoyer. (*E.T.Z.*, 13th Aug., 1931, Vol. 52, pp. 1053–1056.)

A full description of the writers' Kerr cell method dealt with in August Abstracts, pp. 451–452 (Vogler) and 1930 Abstracts, pp. 460–461. So far, the shortest wavelength used by the writers has been 25 m., but the literature of the subject shows that the Kerr effect is free from lag down to at least 10 m. and this is probably true down to 5 m. or less. The method has been improved in some ways by Hoyer's suggestion of the use of a comparison photometer in place of visual observation. Hoyer has also increased the sensitivity so that potentials down to 200 v. or less can be measured, and has been able to measure directly the effective value for potentials which are not sinusoidal.

UN MEZZO SEMPLICE PER MISURARE CAPACITÀ A MEZZO DI VALVOLE TERMIONICHE (A Simple Valve Method of Measuring Capacity [by Intermittent Trains of Undamped Waves]).—L. Sesta: La Rosa and Petrucci. (*Nuovo Cim.*, No. 3, Vol. 8, 1931, pp. 114–119.)

The method of generating intermittent wave trains by two capacitively coupled amplifier valves (August Abstracts, p. 439) is here used for measuring capacity; under suitable conditions the intervals between successive waves, as measured by a stop-watch, are proportional to the coupling capacity. For values between 0.3 and 0.0005 μF. the results agree with those from the ballistic method.

A BRIDGE FOR THE MEASUREMENT OF THE CONDUCTANCE OF ELECTROLYTES [TO A HIGHER DEGREE OF ACCURACY THAN HITHERTO ATTAINABLE].—P. H. Dike. (*Review Scient. Instr.*, July, 1931, Vol. 2, pp. 379-395.)

PRECISION MEASUREMENTS OF ALTERNATING CURRENTS UP TO 2000 AMPÈRES [USING A NICKEL-IRON CORED TRANSFORMER].—A. H. M. Arnold. (*Journ. Scient. Instr.*, May, 1931, Vol. 8, pp. 154–155.)

A NEW THEOREM CONCERNING TEMPERATURE-COMPENSATED MILLIVOLTMETERS USED WITH SHUNTS FOR THE MEASUREMENT OF CURRENT.—H. B. Brooks. (*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, p. 1692.)

AN ELECTROSTATIC VOLTMETER FOR D.C. VOLTAGES UP TO 80 KV.—O. Zdralek. (Summary in *E.T.Z.*, 2nd July, 1931, Vol. 52, p. 881.)

A [PLIO-] DYNATRON VACUUM-TUBE VOLTMETER.—R. de Cola. (*Electronics*, May, 1931, pp. 623–624.)

APPLICATION DU REDRESSEUR OXYMÉTAL À LA MESURE DES TENSIONS DE CRÊTE (Application of the Dry Plate Rectifier to the Measurement of Peak Voltages).—M. Robert. (*Comptes Rendus*, 15th June, 1931, Vol. 192, pp. 1539–1540.)

Moullin's method has the objections that it requires a three-electrode valve and an auxiliary source; the present procedure gives direct readings of peak potentials without any such accessories. If a condenser C is connected in series with a rectifier K, and an a.c. potential of maximum value V_m is applied to the ends of combination, C will be charged to a continuous p.d. equal to V_m. If now the rectifier alone is shunted by a moving-coil microammeter M in series with a resistance R such that the product CR is large compared with the period of the current, the p.d. across the condenser will not be changed appreciably and the current passing through M will be proportional to the peak voltage. The apparatus is calibrated by applying a known continuous p.d. to the circuit RM, the rectifier being cut out by means of a switch.

Measurement of mean voltages by the same arrangement. The ordinary method for this measurement consists in connecting one or more rectifiers in series with the moving coil instrument, and requires a different method of calibration since the resistance of the rectifier is involved. It is therefore of interest to use the above-mentioned arrangement for this purpose also: this can be done by introducing a small commutator by which the capacity C can be replaced by a resistance r small compared with R but large compared with the rectifier resistance in the "pass" direction. In these conditions the p.d. across the rectifier (and across the shunted circuit RM) will during one half-cycle be practically equal to that across the terminals of the apparatus. During the other half-cycle it will be zero, the rectifier behaving as a short circuit. The meter M, calibrated in volts as previously described, will indicate the mean value V_m of the p.d. across the rectifier and its shunted circuit RM, and from this the mean potential across the terminals is obtained for the whole cycle.

An important point in *both* the above processes is that the rectifier is *not* in series with the meter, so that readings are independent of the rectifier resistance and therefore of temperature.

EIN PENDELELEKTROMETER FÜR HOHE SPANNUNGEN (A Pendulum [Improved Gold Leaf] Electrometer for High Voltages).—W. Rogowski. (*Archiv f. Elektrot.*, 15th July, 1931, Vol. 25, pp. 521–522.)

Each "leaf" is represented by a light rigid element of tubular construction, presenting neither corners nor sharp edges; instead of the scale being fixed (so that readings must be differential) it moves with one vane, while the pointer is attached to the other. Readings are accurate to 1 %, and the design is suitable for voltages up to 1,000 kv.

SCHWINGUNGSFORM UND TEMPERATURKOEFFIZIENT VON QUARZOSZILLATOREN (Vibration Modes and Temperature Coefficients of Quartz Oscillators).—H. Straubel. (*Zeitschr. f. hochf. Tech.*, July, 1931, Vol. 38, pp. 14–27.)

Development of the ideas dealt with in June Abstracts, p. 335. Although quartz oscillators are now in use in innumerable laboratories and transmitting stations, "the literature of the subject shows that their functioning is not yet completely understood." Dye and Cady have dealt with the theory: the natural frequencies can be calculated from the dimensions and modulus of elasticity: comparatively small discrepancies actually observed can be accounted for by corrections according to the Rayleigh thickness formula and by the coupling effects of secondary simultaneous vibrations. But the literature shows certain observed modes of oscillation, and statements as to their physical causes, which cannot be reconciled with the crystal structure (*see* for example Namba and Matsumura, 1929 Abstracts, p. 397). Moreover, investigations into the attainable constancy of frequency, and particularly its dependence on temperature, show widely differing results. The work now described sets out to clear up these discrepancies, and in the course of it certain steps are encountered *which lead to improved results in constancy of frequency and independence of temperature.*

Part I deals with the various modes of oscillation. If a quartz oscillator is cut with its end faces at right angles to an electrical axis ("ordinary oscillator quartz") it possesses 3 different natural frequencies; one is in the direction of the electrical axis; the others are in directions at right angles to it, making angles of $-48^\circ\ 19'$ and $+71^\circ\ 32'$ with the optical (Z) axis—the directions, in fact, of the maximum and minimum elasticity moduli. *It is one of these two directions which should be followed in cutting a bar oscillator,* for only thus will the actual natural frequency give the best agreement with the single theoretical frequency $\nu = \frac{1}{2l} \cdot \sqrt{\frac{E}{\rho}}$ (actual samples gave agreement to within $+ 0.25\%$ for the $-48^\circ\ 19'$ direction and $+ 0.64\%$ for the $+71^\circ\ 32'$ direction). Of these two directions, the $+71^\circ\ 32'$ cut has the advantage that the small modulus of elasticity gives a *shorter* oscillator for a required small frequency, and the further advantage that the piezoelectric constant is much larger than that of the $-48^\circ\ 19'$ cut—only slightly smaller, in fact, than that of the Y cut. The result is that the $+71^\circ\ 32'$ cut requires far less reaction than the $-48^\circ\ 19'$ cut—even for quite large oscillators the anode/grid capacity gives sufficient regeneration.

In the case of quartz disc oscillators such as are used for 300 to 40-metre wavelengths, the modes of vibration are much more complex; the assumption that such a disc vibrates strictly like a thick membrane is falsified by the anisotropic nature of the material. Nodes and antinodes appear on the surface and change their positions as the exciting frequency is changed. Not only does this fact mean that the quartz oscillator frequency will alter as the valve anode circuit tuning changes, but also it leads to local overloading and the destruction of the quartz even when the total load on the oscillator is comparatively small. If the crystal could be made to possess one single frequency in the Y-Z plane (transverse oscillation), it would stand up to a much heavier load. Such a result cannot be obtained by giving the crystal a circular border, on account of the anisotropy of the modulus of elasticity; *but if the border is made to conform with the "elasticity surface"* (Fig. 3*a*) derived from the square roots of the moduli in the various directions, an oscillator is obtained in which the transverse oscillation can only have one single frequency, as is shown by the behaviour of the lycopodium powder in Fig. 10. "An examination of the longitudinal oscillations (X-direction) showed that the ideal condition was not yet completely attained. The number of resonance spots was, however, substantially decreased, and their size considerably increased, so that the objective of a more uniform loading of the oscillator surface has been brought nearer."

The writer mentions that the employment of the oscillations in the Y-Z plane has the advantage of considerably greater economy in material than is the case with the usual bar oscillators, and then goes on to describe and illustrate a few of the numerous other modes of vibration which can be obtained with ordinary disc oscillators (Figs. 11–15) and the phenomenon of "travelling" oscillation in a bar oscillator, where the lycopodium powder keeps moving very quickly along a definite course (Fig. 16). All these results are due to combination between longitudinal and transverse vibrations; *they do not occur in very thin discs.* He calls attention to the fact that the position of maximum and minimum points can only be determined (apart from optical methods) by scattering powder or by immersing in liquids, since the glow phenomena in rarified gases give no true indication of the positions, owing to the anisotropy of the modulus of elasticity being situated quite differently from that of the piezoelectric constant.

Part I ends with a short section on the strength of oscillators and resonators, their low internal damping (log. decrement about 10^{-4} as a maximum), and the possibility of the quartz being broken by comparatively small amounts of energy if the external (air) damping is very greatly reduced. Fig. 16*a* shows a quartz disc shattered in this way: It was excited in the vibration direction $+71^\circ\ 32'$, *i.e.*, in the direction of the minimum elasticity modulus. Every fragment shows, with an accuracy of 2′ to 3′, an angle of $104^\circ\ 4'$, indicating that the plate flew to pieces in the direction of smallest elasticity modulus and greatest amplitude.

Part II deals with factors which have a bad influence on the constancy of frequency of an oscillator or resonator. The writer uses the Huth-Kühn circuit shown in Fig. 17, which is less affected than other circuits by changes in filament and anode potentials. He first recalls that the oscillator can only vibrate if the natural frequency of the anode circuit is higher than that of the oscillator (J. W. Wright, 1929 Abstracts, pp. 217–218), so that the oscillations break off beyond the resonance point. Just before reaching this point a strong "mitnahme" ("pulling") effect comes into play, the oscillator frequency varying with the tuning of the anode circuit; this is shown in Fig. 18, in which the filament current serves as parameter. Figs. 19

and 20 show the effects of changes in filament and anode potentials respectively, for various anode circuit frequencies. They show that for a certain adjustment of the anode circuit, involving a fully heated filament and only a small anode-circuit oscillation output, the effect of de-tuning on the frequency of the oscillator is very small. *For the sake of constancy of frequency*, this small output must be put up with and compensated for by suitable amplification.

Another factor is the mounting of the oscillator. The writer, in order to get a definite electrode distance, used silver layers on the quartz; even when these were made very thin (almost transparent) they still had an appreciable effect (diminution) on the natural frequency, but were free from other troubles such as stripping. To obtain good adhesion for vibrations of large amplitude, the surfaces were not polished but only ground smooth, with the result that the silver held fast even up to the point of mechanical shattering. The most satisfactory method of contact was found to be by means of thin weak springs of copper wire, which pressed lightly and did not upset the natural frequency. Even for violent vibration the frequency of 10^6 c.p.s. kept constant to within 1 cycle, whereas commercial mountings gave sudden frequency jumps up to 100 cycles in extent. In the design of these springs care had to be taken that their natural frequency was not such as might be excited by the oscillating quartz. Attachments of thin bands of aluminium, etc., were found useless, fatigue of the metal always leading sooner or later to a break close to the fixing point. Figs. 21 and 22 show the methods of mounting disc and bar oscillators in their glass containers; cotton wool is introduced between quartz and glass walls. Fig. 33 shows how large discs may be gripped at the edges.

Part III deals with the temperature coefficient. The temperature coefficient of quartz oscillators is determined partly by the thermal coefficient of expansion and partly by the variation with temperature of the modulus of elasticity; but it cannot be predicted from a knowledge of these constants, since it depends also on the dimensions of the oscillator. Fig. 27 (curve *O*) shows how, in the case of a certain oscillator vibrating in the *Y* direction, the temperature coefficient changed its sign on a smooth curve. This result was not an anomaly, since a second oscillator of precisely the same dimensions gave the same result. This indicates that by choosing suitable dimensions the temperature-dependence of an oscillator at a definite temperature can be abolished (*cf.* Lack, 1929 Abstracts, pp. 518 and 582). If, as has been thought, this independence of frequency is due to the combined action of several oscillations, a slight change in the proportions of the dimensions would be expected to alter the temperature coefficient. The writer therefore took the oscillator of curve 0, Fig. 27, and after each test shortened it by 1/10 mm. in the *Y* direction (curves 1, 2 and 3). It is seen that irregularities now appear on the previously smooth curve. Of the other diagrams, Figs. 30 and 29 show how free from sudden jumps are the frequency-change/temperature curves for discs oscillating in the 71°32′ and 48°19′ directions and for bars in the 71°32′ direction, whereas Fig. 28 shows a sudden jump in a bar oscillating in the 48°19′ direction. Fig. 30 also shows that the temperature coefficient increases with the disc thickness. Finally, Fig. 31 shows the smoothness of the curve for the specially outlined plate referred to earlier (Fig. 10). The last section of the paper discusses the discrepancies between the calculated and observed values of temperature coefficient, and the reasons for them: finally, "one cannot say straight off that the temperature coefficient of frequency possesses such and such a value: its course over a wide temperature range must be known. Otherwise there is the danger of having measured it in the neighbourhood of an unstable or anomalous point. This may well account for the discrepancies between the results of individual workers."

PIEZOELEKTRISCHE OSCILLATOREN (PIEZOELECTRIC OSCILLATORS).—H. Straubel. (*Physik. Zeitschr.*, 1st Aug., 1931, Vol. 32, No. 15, pp. 586–587.)

Covering some of the ground of the long paper abstracted above but containing new matter. The greatly decreased friction between a surface lying on a quartz oscillator, when the latter is set into vibration, is described, and a possible application suggested to increasing the sensitivity of measuring instruments such as balances.

PIEZOOSCILLATORE CON GRANDE STABILITA' DI FREQUENZA (A Piezo-Oscillator with Great Frequency Stability).—F. Vecchiacchi. (*L'Elettrotec.*, 5th Feb., 1931, Vol. 18, pp. 79–82.)

Author's summary:—By using an oscillatory circuit with negative resistance it is possible to obtain a piezo-oscillator giving a frequency close to the resonance frequency; in this way the frequency obtained is very stable (about one in a million) and independent even of large variations of decrement and equivalent resistance of the piezo-resonator due to changes taking place between the plate and its electrodes. The circuits considered have been tested experimentally, using a piezo-resonator I.E.C. of frequency 640 kc./sec. Higher frequencies can be obtained. Various considerations are discussed as to the method of obtaining a frequency standard of high precision.

PERFORMANCE OF PIEZO-OSCILLATORS, AND THE INFLUENCE OF THE DECREMENT OF QUARTZ ON THE FREQUENCY OF OSCILLATION [LEADING TO AN IMPROVED ARRANGEMENT WITH VERY STABLE FREQUENCY].—M. Boella. (*Proc. Inst. Rad. Eng.*, July, 1931, Vol. 19, pp. 1252–1273.)

Part I deals with the performance of piezo-oscillators employing the usual Pierce circuits, on the basis of the experimentally plotted resonance curves and with the help of vector diagrams. Part II deals with the effect of the quartz decrement on the frequency, and the evolution of an arrangement whose frequency is very little affected by decrement changes (*see* July Abstracts, p. 394). The circuit recommended is shown in Fig. 17, p.

1270. The peculiarity of this circuit, in which the quartz is made to oscillate *at the frequency at which the admittance is lowest*, consists not in the arrangement itself but in the value of the resistance *r* (in the common lead from the grid and one side of the quartz) which should be about the size of the minimum impedance of the quartz, and should also be non-inductive and non-capacitive. In order that the voltages between the extremities of the anode oscillating circuit and the centre tap may be exactly in opposition, that circuit should have a rather small L/C ratio and a low decrement, and the triode should have a low internal resistance.

RESEARCHES ON THE AFTER-EFFECT IN QUARTZ.—Saegusa and Shimizu.

(*See* abstracts under "General Physical Articles.")

LE QUARTZ (QUARTZ).—Ch. Manguin. (*Journ. de Phys. et le Rad.*, No. 4, Vol. 2, Ser. 7, 1931, pp. 60S–64S.)

THE EFFECT OF PIEZOELECTRIC OSCILLATION ON THE INTENSITY OF X-RAY REFLECTIONS FROM QUARTZ.—G. W. Fox and P. H. Carr. (*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, pp. 1622–1625.)

MEASUREMENTS ON MAGNETOSTRICTION VIBRATORS.—J. M. Ide. (*Proc. Inst. Rad. Eng.*, July, 1931, Vol. 19, pp. 1216–1232.)

Measurements on nichrome, monel metal, stainless steel, stoic metal and nickel rods with natural frequencies near 30,000 c.p.s. The various sections deal with a summary of motional impedance theory; the method of measurement employed (a resonance bridge method); the effect of the polarising field (in general, the resonant frequencies increase with increasing field, but monel metal shows independence of field except near the upper bend of the magnetisation curve, where a dip or "wobble" is shown; while stainless steel shows a maximum at 40 gauss, decreasing after this); a comparison of the metals studied; effect of heat treatment (the writer is inclined to deduce that annealing is of doubtful value, at any rate for nickel); effect of alternating-current coil; effect of alternating field; effect of variations in rod diameter, and of boring axial holes in a nickel rod (to investigate how far the magnetic skin effect theory holds for vibrating rods: "we have here, then, direct experimental evidence that by some means or other the alternating flux does penetrate into the bar, while vibrating, much farther than magnetic skin effect theory will allow"—possibly owing to a decrease of permeability to alternating flux due in some way to the vibration). The final section deduces the engineering application of the various results.

A VIBRATING BLADE EXCITED BY THE MEDIUM SURROUNDING IT.—Carrière. (*See* under "Acoustics and Audio-frequencies.")

A VALVE GENERATOR CIRCUIT OF VERY CONSTANT FREQUENCY. (French Pat. 700498, David, pub. 2nd March, 1931.)

Covering a two-grid valve circuit (*cf.* Aug. Abstracts, p. 448) in which instability of frequency is prevented by (*a*) annulling the grid current by giving the grid a suitable negative potential, and (*b*) suppressing the disturbing effect of the plate current by causing this to pass to the oscillatory circuit *only in very short impulses of suitable phase*, so that these behave like the impulses given to a pendulum at the instant when it passes through its position of equilibrium. These, as is well known, do not affect the period of the pendulum. For a typical circuit diagram, see *Rev. Gén. de l'Élec.*, 27th June, 1931, Vol. 29, p. 230D.

OPERATING FREQUENCY OF REGENERATIVE OSCILLATORY SYSTEMS: APPLICATION TO CHANGE IN RATE OF A PENDULUM CLOCK.—Benioff. (*See* abstract under "Properties of Circuits.")

CAPILLARY WAVES PRODUCED BY ALTERNATING CURRENTS IN DIELECTRIC LIQUIDS, AND THEIR APPLICATION TO FREQUENCY MEASUREMENT.—M. Katalinić. (*Zeitschr. f. Phys.*, No. 7/8, Vol. 67, 1931, pp. 533–555.)

APPROXIMATE FORMULAE FOR THE INDUCTANCE OF SOLENOIDS AND ASTATIC COILS.—W. G. Hayman. (*This journal*, Aug., 1931, Vol. 8, pp. 422–425.)

By using the fact that the Nagaoka end-correction factor K is approximately a hyperbolic function of the "shape factor" d/l, the writer arrives at an approximate formula $L = l_w^2 \times l \times \dfrac{2.25}{2.25 + \frac{d}{l}}$ cms., where l_w is the length of wire per cm. of the coil length l. This applies to most coils in common use, since the fractional term gives K within 2 % over a range of 0.2 to 4.0. Another variation, keeping the same treatment of K, gives the inductance in microhenries for dimensions in inches: $L = \dfrac{a^2N^2}{10l + 8.9a}$. The rest of the paper deals with the application of these results to the calculation of astatic coils, leading to formula 24 for the percentage reduction in inductance of an astatic pair compared with that of a solenoid of the same total size and winding.

SUPPLEMENTARY NOTE TO THE "STUDY OF THE HIGH-FREQUENCY RESISTANCE OF SINGLE LAYER COILS."—A. J. Palermo and F. W. Grover. (*Proc. Inst. Rad. Eng.*, July, 1931, Vol. 19, pp. 1278–1280.)

The writers' paper, dealt with in March Abstracts, p. 162, was written in ignorance of Butterworth's work on the subject. This is now discussed, and the coils used in the first paper are evaluated by his three formulae, and the results compared among themselves and with the writers' results.

FORMULAE FOR CALCULATION OF MAGNETIC FIELD DUE TO CIRCULAR FILAMENT OR SOLENOID, BY ZONAL HARMONICS.—R. F. H. Chao. (*Journ. Math. Phys., Massach. Inst. Technol.*, Jan., 1931, Vol. 10, pp. 13–18.)

THE CALCULATION OF RESISTANCES TO GROUND AND OF CAPACITANCE.—H. B. Dwight. (*Ibid*, pp. 50–74.)

For a summary, see *Physik. Ber.*, 1st June, 1931, Vol. 12, p. 1231.

WHY THE DECIBEL ?—M. G. Scroggie. (*Wireless World*, 22nd July, 1931, Vol. 29, pp. 85–88.)

Besides defining the decibel the author gives numerical values for a potential divider advancing by equal amounts on an equal ratio scale.

CHAMPS TOURNANTS, CIRCULAIRE ET ELLIPTIQUE (Circular and Elliptic Rotating Fields [Graphical Construction]).—J. B. Pomey. (*Rev. Gén. de l'Élec.*, 27th June, 1931, Vol. 29, pp. 1019–1020.)

SUBSIDIARY APPARATUS AND MATERIALS.

GLAS- ODER METALLENTLADUNGSROHR ? (Glass or Metal Discharge Tubes ? [for C.-R. Oscillographs : the Use of an Auxiliary Electrode]).—H. Dicks. (*Archiv f. Elektrot.*, 15th July, 1931, Vol. 25, pp. 523–524.)

A Rogowski-type glass tube was perfectly serviceable after 1000 hours' running on 0.3 mA. and 50 kv. (0.1 mA. was sufficient to give a recording speed of 63,000 km./sec.). Throughout the whole test the discharge was perfectly stable, and no kind of trouble developed : in particular, no local overheating occurred in the tube. Only the cathode had to be replaced from time to time. With a metal tube, on the other hand, the discharge was often unstable, showing a tendency to diverge to the wall of the tube and from this to the anode tube : the current increased sharply and local hot spots developed, damaging the tube.

The introduction of an auxiliary cylindrical electrode, either inside or outside the tube and surrounding both cathode and tubular anode in the neighbourhood of the point where the former enters the latter, brought a great improvement. It was insulated from both electrodes and in the simplest case took up for itself an intermediate potential. It improved the distribution of the electric field, and consequently the space charge, with the result that the accelerating voltage and ray intensity could be considerably increased without any undesired discharges occurring. When introduced inside the tube, the auxiliary electrode prevented the formation of hot spots and consequent danger of tube breakage.

In tubes where the cathode and anode are widely separated the auxiliary electrode is still of use. Here it is advantageous to apply an external potential to it. In this way not only can the potential be adjusted to prevent parasitic discharges, but also the intensity of the ray can be controlled ; if, moreover, the control is worked by the incoming surge (according to one of the known methods), the electrode current can be made small during intervals and increased when required for recording, thus adding very greatly to the life of the cathode. The writer mentions that an auxiliary electrode has been used by Binder, Förster and Frühauf (1930 Abstracts, p. 642), but he says that this merely surrounded the cathode and served to concentrate the beam electrostatically.

UNTERSUCHUNG ÜBER DEN ELEKTRONENSTROM BEIM KALTKATHODENOSZILLOGRAPHEN (Investigations into the Electron Beam in the Cold-Cathode C.-R. Oscillograph).—E. Rühlemann. (*Archiv f. Elektrot.*, 15th July, 1931, Vol. 25, pp. 505–520.)

Author's summary :—In the first part of the paper it is shown that the intensity of the beam of electrons, in a cold-cathode c.-r oscillograph with preliminary concentration and a narrow glass discharge tube [28 mm. int. diam.], is subject to the most varied influences. Thus the variation of the intensity with the anode current, with the working age of the [replaceable] cathode inset and its consequent burning, with the material and diameter of the cathode, with the position of the pre-concentrating coil, with the residual gas, and finally with the diameter of the aperture, is shown by curves. No influence on the part of the diameter of the discharge tube could be measured.

As regards the investigation into the influence of the residual gas, the behaviour of hydrogen is of special interest. Here can be seen the possibility of an important improvement with respect both to recording speed and to decreased burning-away of the cathode [the intensity after 6 hours' running decreases to 30 or 25 % of its initial value in the case of nitrogen, air or carbon dioxide, whereas in the case of hydrogen it falls only to about 50 % ; the crater formed in an aluminium cathode, after a six hours' run with the discharge tube containing hydrogen, is only as large as that formed in the case of air after a two hours' run. Moreover, the initial value is about twice as high as with the heavier gases, owing to the small diffusion of the ray]. The values of anode current given in the curves are comparatively high and correspond to a very heavy load employed in order to obtain deterioration effects in a short time. Ordinary internal recording can be carried out with considerably smaller anode currents.

The second part of the investigation deals with the factors influencing the quality of the recording. It is shown that long and flat coils act equally well as concentrating coils ; but in the case of long coils the concentrating effect is practically independent of their position. The necessity for a narrow and clean ray is pointed out.

ÜBER EINEN EMPFINDLICHEN ZEITKIPPER FÜR DEN KATHODENOSZILLOGRAPHEN (On a Sensitive Time Switch for the Cathode Ray Oscillograph).—H. Peek. (*Archiv f. Elektrot.*, 19th June, 1931, Vol. 25, No. 6, pp. 453–458.)

A LINEAR TIME AXIS FOR A CATHODE-RAY OSCILLOGRAPH.—A. L. Samuel. (*Bell Lab. Record*, Aug., 1931, Vol. 9, pp. 571–575.)

Description of a sweeping circuit in which the "inconveniently high sparking voltage and the erratic, unreproducible and uncontrollable characteristics" of the ordinary cold-cathode two-electrode discharge tube are avoided by the use of a 3-element gas-filled tube of the hot-cathode type (*e.g.*, Western Electric 269-A type), in which the extra control afforded by the grid makes it possible to control the frequency of the sweeps more accurately and to maintain a constant relationship between it and the frequency of the phenomenon under investigation.

THERMO-JUNCTIONS AT HIGH RADIO-FREQUENCIES.—F. M. Colebrook. (*This journal*, July, 1931, Vol. 8, pp. 356–361.)

Author's summary :—The object of the investigation was to obtain information about the frequency variation of thermo-junction milliammeters. A valve rectifier milliammeter was specially designed for the purpose of inter-comparison of the thermo-junctions investigated and the valve instrument itself. A method of calibrating the valve rectifier milliammeter by direct current is described. The calibration so obtained was found to agree with a low-frequency calibration by thermo-junction to better than two parts in a thousand. The calibrations of the valve milliammeter and of three thermo-junction milliammeters were compared at frequencies from zero up to 10^7 cycles per second. The maximum mutual discrepancy was about 5 per cent. with one of the thermo-junctions and about $2\frac{1}{2}$ per cent. with the other two, most of the variation occurring over the range 10^6 to 10^7 cycles per second.

A PHOTOELECTRIC INTEGRAPH.—T. S. Gray. (*Journ. Franklin Inst.*, July, 1931, Vol. 212, No. 1, pp. 77–102.)

Author's abstract :—" A machine for the purpose of facilitating mathematical solution of problems requiring the evaluation of an integral in which the integrand involves a variable parameter is described in this article. It involves the use of an optical system in which the transmission of light is limited in a definite manner by apertures having the shape of the area under curves representing mathematical functions. The accuracy of the machine itself is from 2 to 5 per cent. Examples of the use of the device in the solution of the superposition theorem integral and a form of integral equation are given. Its application to other problems including the Fourier transform, correlation analysis and periodogram analysis is discussed, and its limitations are considered." *See* also 1930 Abstracts, p. 643.

COMPUTING CARDS FOR HARMONIC ANALYSIS.—P. Jerebesi. (*Engineering*, No. 3398, Vol. 131, 1931, p. 299.)

A description of Jerebesi's cards, published by Springer of Berlin, intended to simplify and systematise the harmonic analysis or synthesis of curves or other data. They should prove a great help in cases where Runge's approximation is permissible.

" CONOID " RADIO-FREQUENCY COILS.—(*Rad. Engineering*, June, 1931, Vol. 11, p. 66.)

In these cone-shaped coils the windings are self-supporting and the losses due to a former or core are thus avoided. The field is concentrated and unusually small copper screens can be used without loss of efficiency.

BUDICH-AUSGANGS-NIEDERFREQUENZDROSSEL (The Budich Low-Frequency Output Choke).—(*Zeitschr. f. hochf. Tech.*, June, 1931, Vol. 37, pp. 237–238.)

Description, characteristic and circuit diagrams of a screened and tapped iron-cored choke for the output circuit to a loud speaker (simple or push-pull methods), for use between l.f. stages, or for filtering purposes.

AN INVESTIGATION OF PROBLEMS RELATING TO THE USE OF PIVOTS AND JEWELS IN INSTRUMENTS AND METERS.—V. Stott. (*Journ. I.E.E.*, June, 1931, Vol. 69, pp. 751–756.)

THE MERCURY-VAPOUR LIGHT OF A THYRATRON AS A POWERFUL STROBOSCOPIC LIGHT SOURCE.—H. E. Edgerton. (*Elec. Engineering*, May, 1931, Vol. 50, pp. 327–329.) *See* also under " Acoustics and Audio-frequencies."

THE USE OF THYRATRONS FOR HIGH SPEED AUTOMATIC COUNTING OF PHYSICAL PHENOMENA.—C. E. Wynn-Williams. (*Proc. Roy. Soc.*, July, 1931, Series A, Vol. 132, No. 819, pp. 295–310.)

Several circuits are described whereby thyratron valves can be used for very high speed automatic counting of voltage impulses set up by physical phenomena which it is desired to record. The task of counting is distributed among a number of thyratrons interconnected in such a way that there is always a thyratron available for recording an impulse, however rapidly impulses follow one another.

THE STARTING-TIME OF THYRATRONS.—A. W. Hull and L. B. Snoddy. (*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, p. 1691.)

Abstract only :—Starting-time is defined as the time between the application of grid or plate voltage, and the attainment of full arc current. This time has been studied by means of high frequency alternating voltage, condenser discharge, and cathode ray oscillograms. The observed times depend upon vapour pressure, and upon anode and grid voltages, and lie between one-tenth (0.1) microsecond and 4 microseconds under practical conditions for all commercial thyratrons. Times of the order of one thousandth (0.001) second, as reported by Nottingham (May Abstracts, p. 269) have not been observed.

WAVE FORM OF PULSATING D.C. CURRENTS PRODUCED BY FG-67 THYRATRONS.—W. B. Nottingham. (*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, pp. 1690–1691.)

Abstract only :—A cathode ray oscillograph has been used to study the wave form in different parts of an " inverter " circuit using two General Electric FG-67 Thyratrons. (For the simple inverter circuit *see* Fig. 41, Hull, 1929 Abstracts, p. 512.) With the cathodes heated by independent 60 cycle-a.c. windings, an " output " can be taken from the lead between the cathode and the negative terminal of the d.c. plate supply. The current flowing in this lead can be made of the " square-top " type up to a frequency of about 6,000 cycles per second. The circuit conditions including the plate potential are critical at the highest frequencies, while at 500 to 1,000 cycles it is easy to obtain the desired wave form with a wide range of current and potential conditions. Under the best conditions the time required for the current to rise from zero to its full value was probably not more than 30 microseconds and a slightly shorter time was required for the current to fall from full value to zero. The exact wave form depends on the inductance, capacity and resistance of the d.c. supply. This system has been developed to heat a filament for the investigation of thermionic emission with low accelerations and retarding field, but undoubtedly has other possible applications.

TEMPERATURE RATING OF ENGINE-DRIVEN AIRCRAFT RADIO GENERATORS.—C. B. Mirick and H. Wilkie. (*Proc. Inst. Rad. Eng.*, July, 1931, Vol. 19, pp. 1175–1183.)

Authors' summary :—Previously described [1930 Abstracts, p. 171] methods of temperature measurement and computation are applied to engine-driven aircraft radio generators in flight. Observed and computed heating curves are shown from which an emission constant [0.067] for this type of machine has been derived.

LIGHT-RAY POINTERS FOR CHARTING ANGLES [FOR DIRECTION-FINDING, ETC.].—Askania Works: Möller. (*See* under " Directional Wireless.")

DETECTION AND COMPARATIVE MEASUREMENT OF IONIZATION IN DIELECTRICS BY MEANS OF OSCILLATIONS.—J. T. Tykociner and E. B. Paine. (*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, p. 1690.)

DIELECTRIC PROPERTIES AND CHEMICAL CONSTITUTION.—S. O. Morgan. (*Bell Lab. Record*, July, 1931, Vol. 9, pp. 535–542.)

SOME PROPERTIES OF FOREIGN AND DOMESTIC MICAS.—A. B. Lewis, E. L. Hall and F. R. Caldwell. (*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, p. 1690.)

PROPERTIES AND USES OF THE A.E.G. RUBBERLESS INSULATING MATERIALS [VARIOUS TYPES OF TENACIT].—A.E.G. (*Zeitschr. V.D.I.*, 25th April, 1931, Vol. 75, p. 43.)

MYCALEX—A MOLDING MATERIAL WITH UNIQUE PROPERTIES.—L. E. Barringer. (*Gen. Elec. Review*, July, 1931, Vol. 34, pp. 406–409.)

STATIONS, DESIGN AND OPERATION.

DAS MIKROSTRAHLENSYSTEM (The Micro-Ray System [Ultra-Short-Wave Beam Tests, Dover-Calais]).—(*Zeitschr. f. hochf. Tech.*, July, 1931, Vol. 38, pp. 40–41.)

See June Abstracts, p. 339.

ULTRAKURZWELLEN-RUNDFUNK (Broadcasting on Ultra-Short Waves).—F. Schröter. (*Telefunken-Zeit.*, No. 57, Vol. 12, 1931, pp. 46–49.)

A survey of the advantages, possibilities, and difficulties. Every 500 metres of built-on land weakens signals by absorption by about 1 neper ; aerials should therefore be fixed as high as possible. Since multiple modulation of one wave with N programmes involves decreasing the power for each programme in the ratio $1/N^2$, the setting up of N separate stations " appears more rational."

LA RÉUNION DE L'UNION INTERNATIONALE DE RADIODIFFUSION À SEMMERING 2 AU 14 FÉVRIER, 1931 (The Meeting of the International Broadcasting Union at Semmering).—(*Rev. Gén. de l'Élec.*, 4th July, 1931, Vol. 30, pp. 32–34.)

SOME DEVELOPMENTS IN COMMON FREQUENCY BROADCASTING.—G. D. Gillett. (*Proc. Inst. Rad. Eng.*, Aug., 1931, Vol. 19, pp. 1347–1369.)

A long paper on the methods used and results obtained in the synchronising of Des Moines and Davenport stations (*see* May Abstracts, p. 283, and June, p. 339). Curves are given showing the quality impairment caused by different degrees of isochronism and signal strength ratios. The improvement in distance reception with simultaneous operation is described, and an explanation given. The impaired reception in the area midway between the stations and outside their normal service range is shown to be a function of the degree of modulation of each transmitter, of the field strength, and of the audio phase angle, and independent of the carrier phase at the transmitters. It is pointed out that reception equal to that from either station alone may still be obtained in this area by the use of a simple directive aerial.

A MODERN BROADCASTING STATION [BERESFIELD, AUSTRALIA (2NC)].—R. Lawson. (*Journ. Inst. Eng., Australia*, May, 1931, Vol. 3, pp. 176–182.)

THE VATICAN WIRELESS STATION. (*Electrical Times*, 12th March, 1931, Vol. 79, p. 499.)

OVERSEAS RADIO TELEPHONE SERVICE : LOST CIRCUIT TIME ANALYSED.—F. A. Cowan. (*Elec. Engineering*, July, 1931., Vol. 50, No. 7, pp. 476–477.)

WIRELESS COMMUNICATIONS FOR AFRICA : A CHAIN OF NEW MARCONI STATIONS. (*S. African Engineering*, July, 1931, Vol. 42, p. 163.)

RADIO STATION INTERFERENCE.—C. R. Stoner. (*Electrical Review*, 10th July, 1931, Vol. 109, p. 50.)

In the case of short-wave transmission, minimum separation is chiefly governed by the question of constancy of frequency, and great improvements in this direction have already taken place. Beam services are of undoubted use, but on account of secondary radiation are not entirely free from interference. Minimum separation in the broadcasting band is dependent on the modulated frequency band width, and here there is little hope of improvement, the advent of television rendering the situation still more acute.

Possible solutions are suggested by methods of frequency modulation, suppressed carrier single-side-band transmission, common frequency systems, and by specially designed selective receivers such as the Stenode Radiostat, but the writer is of the opinion that although improvements are being made, a satisfactory solution has not yet been arrived at.

GENERAL PHYSICAL ARTICLES.

On the Saturation of the After-Effect of Quartz: Further Studies on the Anomalous After-Effect of Dielectrics in their Apparent Resistivity.—H. Saegusa and S. Shimizu: S. Shimizu. (*Sci. Rep. Tôhoku Univ.*, No. 1, Vol. 20, 1931, pp. 1–14; 15–35.)

Continuation of the work dealt with in 1930 Abstracts, pp. 644–645.

The Effect of Piezoelectric Oscillation on the Intensity of X-Ray Reflections from Quartz.—Fox and Carr. (*See* under "Measurements and Standards.")

Elektrische und mechanische Effekte an Metalldrähten bei thermischer, magnetischer oder akustischer Beeinflussung der Struktur (Electrical and Mechanical Effects on Metallic Wires Structurally Influenced by Heat, Magnetisation or Sound).—A. v. Hippel and O. Stierstadt. (*Zeitschr. f. Phys.*, 1931, Vol. 69, pp. 52–55.)

"Impulsive displacement currents occur when metallic wires are subjected to thermal, magnetic or acoustic influences. Among other things the phenomena are important in connection with the Barkhausen effect; they also show that the conductivity electrons may be centrifuged by sound waves."

Propagation of Magnetic Disturbances along Wires.—R. M. Bozorth and J. F. Dellinger. (*Nature*, 23rd May, 1931, Vol. 127, p. 777.)

A letter giving the results of experiments showing that the small steps in which the magnetisation of a ferro-magnetic material changes (Barkhausen effect) occur in many materials in groups of such size as to be detectable with a sensitive galvanometer. These steps appear only when the field is changed slowly. In fine wires the separate small discontinuities cannot be detected; "the whole change occurs in one step and travels along the wire with a speed inversely proportional to the square of the diameter of the wire."

Combination of the Simultaneous Optical Effects of Rotary Magnetic Polarisation and Magnetic Double Refraction in a Liquid.—G. Dupouy and M. Schérer. (*Comptes Rendus*, 4th May, 1931, Vol. 192, pp. 1089–1091.)

On the Combined Effects of the Internal Electric Field of a Uniaxial Crystal and of a Magnetic Field Normal to the Optical Axis.—J. Becquerel and L. Matout. (*Comptes Rendus*, 4th May, 1931, Vol. 192, pp. 1091–1093.)

Magnetic Lag at Low Flux Densities.—L. W. McKeehan. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, p. 1015.)

Abstract only.

The Study of the Magnetic Properties of Matter in Strong Magnetic Fields. I. The Balance and its Properties. II. The Measurement of Magnetisation.—P. Kapitza. (*Proc. Roy. Soc. A*, April, 1931, Vol. 131, No. 816, pp. 224–243 and 243–273.)

Ferromagnetismus und elektrische Eigenschaften. II. Mitteilung. Die Deutung der magnetischen Widerstandserhöhung ferromagnetischer Elektronenleiter (Ferromagnetism and Electrical Properties. II. The Interpretation of the Magnetic Increase of Resistance of Ferromagnetic Conductors).—W. Gerlach. (*Ann. der Phys.*, Series 5, 1931, Vol. 8, No. 6, pp. 649–662.)

Zur Theorie der Magnetostriktion und der Magnetisierungskurve (On the Theory of Magnetostriction and the Magnetisation Curve).—W. Heisenberg. (*Zeitschr. f. Phys.*, 1931, Vol. 69, pp. 287–297.)

MISCELLANEOUS.

The Wireless Engineer—A Change in Name Only. (*This journal*, Aug., 1931, Vol. 8, p. 408.)

A notification of the change of name from "Experimental Wireless and the Wireless Engineer" to "The Wireless Engineer and Experimental Wireless," and the reasons for it.

The Reciprocity Theorem in Electricity.—Alexander. (*See* under "Properties of Circuits.")

Compte rendu de l'Assemblée Générale de l'Union Radio-Scientifique Internationale tenue à Copenhague du 27 Mai au 6 Juin, 1931 (Report of the U.R.S.I. Assembly in Copenhagen, 27th May to 6th June, 1931).—G. Ferrié. (*Comptes Rendus*, 20th July, 1931, Vol. 193, pp. 121–124.)

The Coöperation Committee [U.R.S.I.] Program for 1930–1931. (*Proc. Inst. Rad. Eng.*, July, 1931, Vol. 19, pp. 1171–1174.)

Annual Report of the Wireless Division of the German Aircraft Research Establishment.—H. Fassbender. (*E.T.Z.*, 6th August, 1931, Vol. 52, pp. 1026–1029.)

Including sections on:—(i) increasing the effective height of trailing aerials (August Abstracts, p. 441);

(ii) effective height measurements of fixed aeroplane aerials (on 115–350 metre waves: effective heights of only about ½ metre were found); (iii) comparative advantages of telephony and telegraphy (measurements on the intelligibility of Morse signals, on the lines of Eisner's syllable intelligibility tests—1930 Abstracts, pp. 166–167—resulted in favour of telegraphy); (iv) investigations on "border" waves (100–400 m.), including measurements of propagation damping constants for the ground wave and the effect, on the strength of signals received on the ground, of the varying height of a transmitting aeroplane (while no systematic effect had been observed on *long* waves—650 to 2000 m.—the received field strength was found to vary more and more with the height as the wavelength decreased, decreasing first to a minimum as the height increased and reaching this minimum for lower and lower heights as the wavelength decreased; then increasing again as the height increased above this critical value, till at a height of 3,000 metres the field strength was four-thirds of the minimum value, for 353 m.-waves, and seven times the minimum value for 115 m.-waves).

(v) Short-wave aircraft apparatus for the oversea route Cadiz - Las Palmas (the aeroplane transmitter had a separate drive and gave 20–50 watts aerial power; two types of aircraft receiver were used, one comprising two r.f. stages with screen-grid valves, a leaky-grid detector with reaction, and two l.f. stages, the other using the principle of a quartz-controlled heterodyne giving an intermediate frequency beat—1929 Abstracts, p. 573—which was amplified on the ordinary d.f. amplifier or on the auxiliary aircraft receiver); (vi) directive characteristics of the Nauen beam aerial system for N. American traffic (July Abstracts, p. 385); (vii) fading investigations (further successful tests on the anti-fading two-aerial transmitting system dealt with in February Abstracts, p. 93: investigations on fading compensation by the simultaneous transmission of several frequencies on which the fading would act differently; for this purpose a modulating arrangement was devised by which the number of side-frequencies could be varied while their amplitudes remained equal and constant; early tests showed that ordinary receiving methods could give no clear picture of the complex relations involved, and the need became obvious of sending and receiving methods which would separate out the various fading effects according to their particular causes. The work is proceeding).

(viii) Improving the reception of telegraph signals in open aircraft: the output from the receiver is made to switch in and out a note generator connected to the telephones; this device is particularly useful when the signals, if amplified sufficiently to be workable, lose a large part of their musical tone and are only with difficulty read above the general interference background; (ix) investigation of the behaviour of quartz-controlled transmitters (von Handel, August Abstracts, p. 438); (x) reduction of the electrical noise level (successful tests of Bosch A.G. screened magnetos and sparking plugs; screened battery ignition is being developed in conjunction with the Bosch Company: tests on electrical disturbances due to vibration—*see* Brintzinger and others, under "Reception").

(xi) A whole group of sections deals with aircraft navigation by electrical, particularly radio-frequency, methods: night- and twilight-errors in d.f. have been tested, with the result that bearings on the aircraft navigation wave are considered unreliable in night and twilight over distances greater than 100 km.: day errors have also been investigated: in conjunction with the Lorenz Company, tests with radio beacons have been carried out, one result being to establish the superiority of the vertical mast aerial for this purpose; irregularities in the behaviour of the beams, arising at the transmitting end, require further investigation: the use of ultra-short waves for navigation purposes is being tested in collaboration with the Lorenz Company and Esau, one result being that super-regenerative reception is for the present discredited for this purpose, and developments on fresh lines, in connection with the use of these waves for assisting fog-landing, are anticipated: a section deals with the use of ring-shaped leader cables for fog-landing, and another with the further development of the cathode ray compass—Jan. Abstracts, p. 54; installation difficulties, due to magneto-ignition disturbances, require solution: a direct reading altitude meter, on the acoustic echo principle, has been developed.

FIXATION ÉLECTIVE DES IONS MÉDICAMENTEUX PAR L'ÉLECTRO-AIMANT (Control of Medicinal Ions by an Electro-Magnet).—D. la Tour du Pin. (*Comptes Rendus*, 8th June, 1931, Vol. 192, pp. 1502–1503.)

In transcerebral ionisation certain localities are liable to be outside the path of the ions. In spite of the theoretical impossibility of the plan, the writer has had good success in directing the ion flow by means of an electro-magnet.

CATHODE SPUTTERING IN A COMMERCIAL APPLICATION.—H. F. Fruth. (*Phys. Review*, 15th June, 1931, Series 2, Vol. 37, No. 12, p. 1690.)

Abstract only of paper on sputtering units used to produce the gold contact surfaces on broadcasting microphone diaphragms.

AN APPARATUS FOR REGISTERING CAPACITY CHANGES, AND ITS APPLICATION AS AN INDICATOR IN THE MANUFACTURE OF RUBBER.—H. Carsten and C. H. Walter. (*Siemens-Zeitschr.*, No. 3, Vol. 11, 1931, pp. 155–162.)

Based on the method of Schulze and Zickner (March Abstracts, p. 169 — two).

REDUCING THE FRICTION OF PIVOTS BY PIEZO-ELECTRIC VIBRATION.—Straubel. (*See* abstract under "Measurements and Standards.")

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.

"COLD" AMPLIFIERS.

Convention date (Germany), 27th November, 1928. *No.* 349584.

An "electronically active" material, such as a layer of copper oxide, lead sulphide, etc., is used as the source of an electron stream and is separated from a positively-charged anode by an "electron carrying" material, such as an oxide or iodide of suitable resistance. Embedded in, or located close to the "active" layer is a third electrode or "grid" suitably biased to control the density or drift of the moving electrons. The arrangement is stated to be analogous in operation to a thermionic valve except that there is no heated filament.

Patent issued to Dubilier Condenser Co., Ltd.

TONE-COMPENSATING CIRCUITS.

Application date, 24th February, 1930. *No.* 349929.

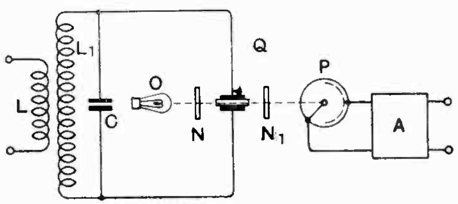
A tuned circuit, resonant to a band of low audible frequency, is inserted in the grid circuit or inter-valve coupling circuit of a thermionic amplifier; or it may be interposed between a gramophone pick-up and the first valve in order to restore or emphasise the lower notes. The circuit may be shunted by a variable resistance in order to control its low-note effect, or a variable-impedance may be connected for the same purpose between the grid side of the resonant circuit and the filament of the amplifier.

Patent issued to Igranic Electric Co., Ltd., and L. H. Paddle.

SELECTIVE RECEPTION.

Application date, 20th February, 1930. *No.* 349083.

(*a*) The incoming signals are fed by a coil L to a tuned circuit L_1, C, which is shunted by a piezo-electric crystal Q. A lamp O is arranged in conjunctions with crossed Nicols N, N_1 to transmit a ray of light parallel to the optical axis of the crystal on to a photo-electric cell P. The mechanical vibration of the crystal Q due to the applied



No. 349083.

signal wave affects its transparency to the beam of light in proportion to the amplitude-variations, or modulation, of the carrier wave. The modulation components are accordingly repeated in the photo-electric input to the amplifier A. The sharp tuning of the crystal Q ensures high selectivity, whilst the method of rectification is stated to eliminate all "stray" effects from the crystal output.

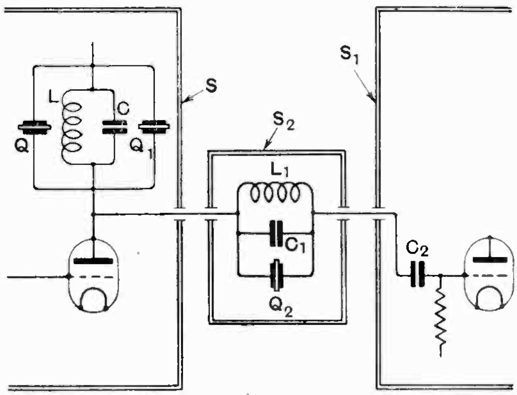
Application date, 28th February, 1930. *No.* 349557.

(*b*) In a development of the invention described above, the piezo-electric crystal oscillator is mounted on a tube containing neon gas which produces a luminous effect proportional to, and controlled by, the excitation of the crystal. In other words, the intensity of the neon glow reflects the modulation components of the incoming carrier wave, and "rectification" is then obtained as before by means of a photo-electric cell arranged in the input circuit of a valve amplifier.

Patents issued to J. Robinson.

Application date, 14th February, 1930. *No.* 350513.

One tuned circuit LC is inserted in series with the anode of an amplifier, and a second L_1, C_1 in



No. 350513.

series with the coupling condenser C_2 to the grid of the next valve. The circuit components are separately screened as shown at S, S_1 and S_2. The anode circuit is shunted by two piezo-electric crystals Q, Q_1, having different fundamental frequencies which determine the "cut off" limits of the frequencies actually built up in the circuit L, C and handed on to the next stage. The second tuned circuit L_1, C_1 acts as a rejector circuit to all frequencies except that of the crystal Q_2, by which it is shunted. The fundamental frequency of the crystal Q_2 is preferably midway between Q and Q_1. The circuits L, C and L_1, C_1 may be designed to have considerable damping, so that they are able to respond promptly to variations of amplitude in the received signal, the selectivity of the system being maintained by the action of the crystals.

Patent issued to P. R. Coursey.

SELECTIVE RECEPTION.

Application date, 20th July, 1930. No. 351446.

A highly-resonant circuit is combined with means for automatically introducing a periodic damping-factor, in order to ensure that the system as a whole will respond promptly and quantitatively to rapid variations in signal amplitude. As shown in Fig. 1, the output from a highly-resonant circuit A, which may be an amplifier, is fed to two valves arranged in cascade. A coil L coupled to the output circuit of the valve V_1 feeds a current, which varies with the signal input, to a coil L_2. The latter coacts with the grid of the valve V, so as periodically to deflect a part of the electron stream away from the anode of that valve. Fig. 1 (*a*) shows in sectional plan one form of construction of the valve V used in Fig. 1, in which the coil L_2 is enclosed inside the glass bulb. The coil operates to divert the normal electron stream away from the multiple-output anode A on to an intermediate or auxiliary electrode K, where the diverted energy is dissipated.

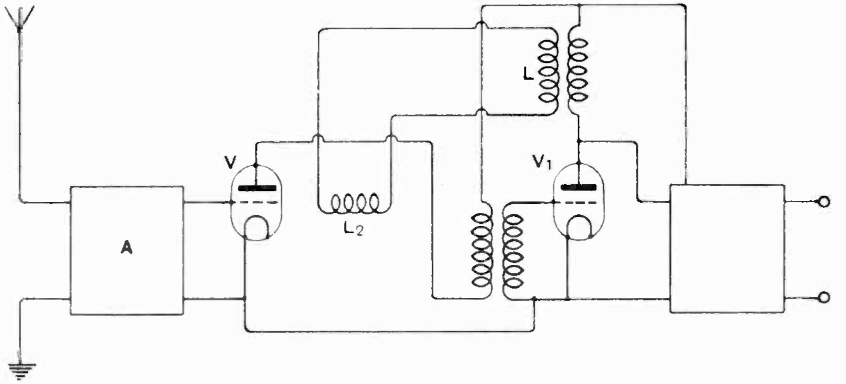
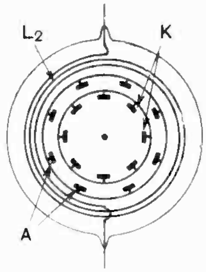


Fig. 1.



No. 351446.

Fig. 1 (*a*).

Patent issued to Sir Oliver J. Lodge and J. Robinson.

TELEVISION APPARATUS.

Application date, 14th February, 1930. No. 350672.

Instead of using a stationary neon lamp and a spiral series of holes in a rotating disc for assembling the received picture elements on to a viewing screen, each hole in the rotating disc is fitted with a small neon lamp, which is separately energised as it passes between a pair of coils carrying the signal currents. Or a signal spiral neon tube may be mounted on the disc, the particular point that is passing between the energising coils being "flashed" by the signal voltages existing at that moment. The object is to increase the amount or intensity of light available for building up the completed picture.

Patent issued to E. L. Gardner and R. G. Wilson.

Application date, 13th February, 1930. No. 350926.

The mechanical vibrations of a piezo-electric crystal oscillator are utilised for high speed scanning in television transmission or reception. Two piezo crystals, one having a high, and the other a comparatively low fundamental frequency, are fastened together at right angles to each other, and a lens or mirror is mounted on the composite base so formed. The ray from the lens or mirror is directed so that the high-frequency crystal controls the swift lateral traverse, whilst the low-frequency crystal superposes a more gradual oscillation in the vertical plane, so as to cover the entire area to be scanned.

Patent issued to Kolster-Brandes, Ltd.

PICTURE TRANSMISSION.

Convention date (U.S.A.), 16th November, 1929. No. 350371.

In a picture signalling system, synchronization between the transmitter and receiver is secured by filtering-out from the signal frequencies, before transmission, a narrow band of wavelengths, and replacing these by a synchronizing-signal, which at the receiving end is filtered out and applied to control the speed of the driving motor. The substituted band of frequencies is so narrow that it has no appreciable effect upon the formation of the received picture.

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

INDIRECTLY-HEATED VALVES.

Convention date (France), 9th April, 1929. No. 350605.

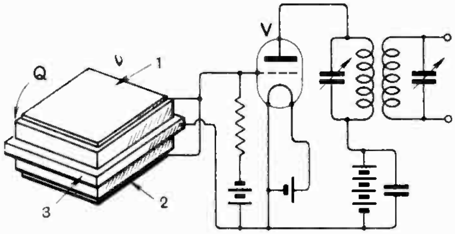
The magnetic field produced by the comparatively-heavy current flowing through the heating-element is known to affect the normal electron emission from the cathode, and to produce an objectionable "hum." In order to avoid this the cathode is constructed with at least one layer of cobalt, or a cobalt alloy, the "Curie" point of which is slightly higher than the temperature at which the cathode is normally operated. Since cobalt loses its magnetic properties at the Curie point, it serves as an effective screen between the heating-filament and the cathode when the latter is at the normal temperature of emission.

Patent issued to La Radiotechnique.

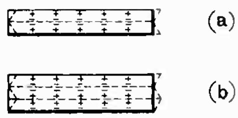
PIEZO-ELECTRIC OSCILLATORS.

Convention date (U.S.A.), 15th October, 1929. No. 350946.

A quartz crystal is made to oscillate at an even harmonic of its fundamental frequency (as distinct from known methods of generating the odd harmonics) by applying periodic voltages of like polarity to the two outer or surface electrodes, and a corresponding voltage of opposite polarity to an intermediate electrode lying parallel to the thickness of the crystal. As shown in Fig. 1, the upper and lower plate-electrodes 1, 2 of the crystal *Q* are connected in parallel to the grid of the valve *V*, whilst the intermediate or "band" electrode 3 is connected to the cathode. Fig. 2(*a*) shows the instantaneous distribution of the voltages in the crystal when the latter is oscillating on its second harmonic, the upper and lower surfaces being the seat of like potentials; whilst Fig. 2(*b*) shows the voltage distribution where the crystal is oscillating in known manner, on an odd harmonic.



No. 350946. Fig. 1.



No. 350946. Fig. 2.

Patent issued to J. R. Harrison.

WIRED-WIRELESS SIGNALLING.

Application date, 26th March, 1930. No. 352011.

A high-frequency cable consists of at least two tubular air-insulated conductors, arranged concentrically and separated by a series of spacing-discs. The outer tube serves as the return line for the inner tube, and not as a mere screen. Such a line is free from interference even when the outer conductor is earthed, so that the line can be carried directly upon the metallic supports of an ordinary overhead cable mast, or buried directly in the ground, or laid in a conduit. The total attentuation losses are localised in the air-space between the inner and outer tubes, so that they do not vary with climatic condition. In practice this means that repeaters can be spaced at least 100 miles apart as compared with 50 miles on an open wire line for the same quality transmission and range of frequency.

Patent issued to Standard Telephones and Cables, Ltd.

PUSH-PULL AMPLIFIERS.

Application date, 24th March, 1930. No. 351419.

The input to a push-pull amplifier is derived from a special phase-splitting valve which comprises two separate anodes, connected respectively to the two grids of the push-pull pair. The signal to be amplified is applied across two control grids, one located on each side of the filament of the phase-splitting valve, so that the electron stream is deflected from one anode to the other as the input voltage alternates. The "split" output is fed directly to the grids of the push-pull amplifier. The arrangement, unlike the usual centre-lapped transformer input, ensures accurate phase-opposition irrespective of changes in signal frequency.

Patent issued to Lissen, Ltd., and C. W. Oatley.

PREVENTING GRID-EMISSION.

Application date, 15th March, 1930. No. 350938.

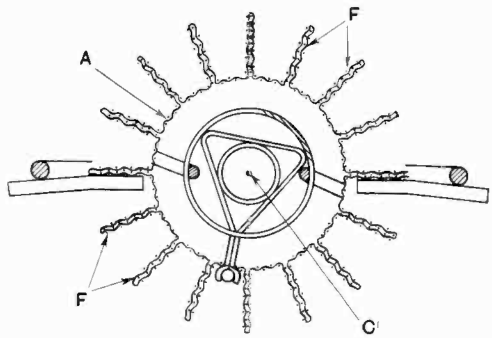
The grid of a power valve is coated with a layer of silver which is stated to prevent any electron emission from the grid when the valve is in operation. At the same time should any particles of silver from the grid be transferred, by sputtering or volatilisation, on to the cathode, they are found to have no deleterious effect on the normal emission from the latter.

Patent issued to F. Barton and Associated Electrical Industries, Ltd.

L.F. AMPLIFYING VALVES.

Convention date (U.S.A.), 18th March, 1929. No. 350941.

The anode of a mains-driven amplifier valve is made of wire mesh bent into a cylinder *A*, as shown in cross section in the Figure, with a series of radial cooling-fins *F*. The fins consist of folds made in the wire-mesh in such a way that the internal surface of the cylindrical anode is substantially closed to the electron stream from the cathode *C*.



No. 350941.

The heat radiated by the fins maintains the anode at a temperature below that at which any occluded gases are liberated.

Patent issued to Arcturus Radio Tube Co.