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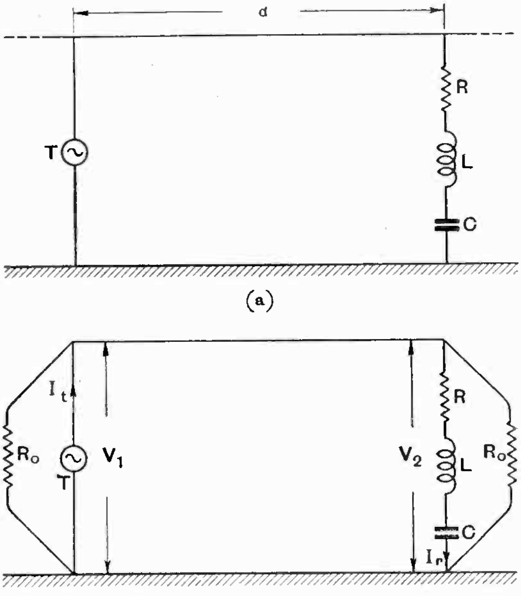
Editorial.

Radiation Resistance and Line Impedance. An Instructive Analogy.

OF the power supplied to a transmitting aerial a part is dissipated in conductor resistance, a part dissipated in dielectric loss and a part radiated into the surrounding space. If an oscillatory circuit is made up to represent the aerial, it must be given an inductance and capacity equal to the effective values of these quantities in the aerial, and a resistance which absorbs the same amount of power as the aerial dissipates and radiates for the same current. A part R_r of this resistance is then of such a magnitude that IR_r is equal to the radiated power of the actual aerial, which is therefore said to have a radiation resistance of R_r ohms. Strictly speaking, no such resistance exists, it is merely a way of expressing the relation which exists between the square of the aerial current and the radiated power. We shall see later that there is another and more accurate way of expressing the radiation resistance.

When an alternating current generator is connected to the sending end of a transmission line, there is a relation between the voltage and the current flowing into the line; we speak of the apparent impedance of the line. If the line is infinitely long, or so long that it may be assumed to be infinitely long, this impedance is called the characteristic impedance, or surge impedance, of the line. If the construction of the line is such that $R/L = G/C$, where R, L, G and C are the resistance, inductance, leakance, and capacity per unit length, then the infinitely long line will take a current exactly in phase with the voltage, so that, so far as the generator is concerned, it might as well have a resistance R_0 connected between its terminals. The power which the generator supplies to the transmission line is equal to I^2R_0. If the transmission line extends to infinity in both directions and the generator feeds into it at a tapping point, it is equivalent to supplying two such lines in parallel, and the apparent resistance will be $R_0/2$. The generator is now very analogous to a transmitting aerial with a radiation resistance $R_0/2$; it radiates a power of $I^2R_0/2$, not freely in every direction, but along two well-defined channels which lend themselves to relatively simple calculation. If $R/L=G/C$ as we have assumed, then all currents, whatever their frequency, are attenuated equally in their passage along the line and all travel with the same speed. In mathematical language, the voltage V at a distance x is related to the voltage V_1 at the transmitter by the formula $V = V_1\epsilon^{-\alpha x}$, where $\alpha = p + jq$; $p = \sqrt{RG}$ and $q = \omega\sqrt{LC}$. In this respect the line has the properties usually assumed for radio waves at distances not too great from the transmitter, although the field strength varies with the distance according to a different law in the two cases. It may be objected that, unlike the case of the radio transmitter, R_0 being a property of the transmission line is independent of the generator, but this is not so, for we may couple the generator to the line through a transformer of any desired transformation ratio and thus adjust the apparent resistance in the generator circuit to any desired value. It may also be noticed that by taking suitable values of R, L, G and C, we may make the line have any value of R_0 we like without departing from the condition that $R/L = G/C$ —we are not concerned at present with practical limitations.



(a)

(b)

Fig. 1.

Fig. 1 (a) represents an A.C. generator T supplying a line stretching to infinity in both directions, and at a distance d a tuned receiving circuit RLC is connected between the line and earth. By connecting it through a transformer the voltage applied to the tuned circuit could be adjusted to any desired value, but for the sake of simplicity we have shown it connected directly. We wish to calculate the current set up in the receiver by the transmitter T, taking into account the fact that the receiver reacts upon the transmitter. The line stretching away to the left of T can be replaced by its equivalent resistance R_0 across T, and similarly the line to the right of the receiver can be replaced by a resistance R_0 connected across the receiver as shown in Fig. 1 (b). The receiving circuit being tuned will act as a non-inductive resistance R in parallel with R_0, their combined resistance being $\frac{R_0 R}{R_0 + R}$. This combined resistance, which we shall call R_2, constitutes the load at the end of the transmission line of length d. The apparent impedance of a line of length d, terminated by a resistance R_2 is

$$R_0 \frac{\cosh ad + \frac{R_0}{R_2} \sinh ad}{\sinh ad + \frac{R_0}{R_2} \cosh ad} = Z_1$$

The transmitter current I_t is made up of two components, viz., V_1/R_0 going to the left and V_1/Z_1 to the right; hence

$$I_t = V_1 \cdot \frac{R_0 + Z_1}{R_0 Z_1} \text{ and } V_1 = I_t \frac{R_0 Z_1}{R_0 + Z_1}$$

$$= I_t R_0 \frac{\cosh ad + \frac{R_0}{R_2} \sinh ad}{\epsilon^{ad}\left(1 + \frac{R_0}{R_2}\right)}$$

The voltage V_2 at the receiving end is related to the voltage V_1 at the sending end by the formula

$$V_1 = V_2 \left(\cosh ad + \frac{R_0}{R_2} \sinh ad\right)$$

and if I_r is the current in the receiving circuit, $I_r = \frac{V_2}{R}$.

Hence

$$I_r = \frac{V_1}{R\left(\cosh ad + \frac{R_0}{R_2} \sinh ad\right)}$$

$$= \frac{I_t R_0}{R \epsilon^{ad}\left(1 + \frac{R_0}{R_2}\right)}$$

or, putting $R_2 = \frac{R_0 R}{R_0 + R}$,

$$I_r = I_t \cdot \frac{R_0}{2} \cdot \epsilon^{-ad} \cdot \frac{1}{R + \frac{R_0}{2}}.$$

This is a very interesting result. $I_t \frac{R_0}{2}$ is the product of the current in the transmitter and the apparent resistance of the double infinite line, neglecting any effects due to the receiver; it is therefore what the sending-end voltage would be with the current I_t in the absence of such effects. We may regard it as the product of the aerial current and the radiation resistance of the aerial. In the absence of any receiver the voltage would decrease exponentially along the line and at the distance d it would have fallen to $I_t \cdot \frac{R_0}{2} \cdot \epsilon^{-ad}$. To obtain the current in the receiving circuit we have to divide this fictitious voltage by $R + \frac{R_0}{2}$, *i.e.*, by the sum of its actual resistance and its radiation resistance. This is the procedure usually adopted in radio calculations, but it is interesting to note that it is correct even when the distance is so short that the receiving aerial reacts appreciably on the transmitter.

We now turn to another problem and that is the effect of the tuned receiving aerial on the field strength or voltage at points to the right of it. Consider a point at a distance b beyond it, and therefore at a distance $d + b$ from the transmitter, as shown in Fig. 2.

In the absence of the disturbing receiver the voltage V_3 would have been given by the formula

$$V_3 = I_t \cdot \frac{R_0}{2} \cdot \epsilon^{-a(d+b)}$$

Its actual value will be

$$V_3 = V_2\epsilon^{-ab} = I_rR\epsilon^{-ab}$$

and putting in the value found above for I_r,

$$V_3 = I_t \cdot \frac{R_0}{2} \cdot \epsilon^{-ad} \frac{R}{R + R_0/2} \cdot \epsilon^{-ab}$$

$$= I_t \cdot \frac{R_0}{2} \cdot \epsilon^{-a(d+b)}\left(1 - \frac{R_0/2}{R + R_0/2}\right)$$

Hence the voltage V_3 is the difference of two component voltages, one of which is the voltage which would have existed at this point if the disturbing receiving circuit had not been present. It is easy to see that the other component is due to the radiation from the disturbing circuit, since the current I_r in it is equal to $I_t \cdot \frac{R_0}{2} \cdot \epsilon^{-ad}, \frac{1}{R + \frac{R_0}{2}}$, and a transmitter with a current I_r would produce at a distance b a voltage equal to $I_r \cdot \frac{R_0}{2} \cdot \epsilon^{-bd}$, that is,

$$I_t \cdot \frac{R_0}{2} \cdot \epsilon^{-a(d+b)} \frac{R_0/2}{R + R_0/2}.$$

That this must be subtracted from the main component can be seen from Fig. 2, for when

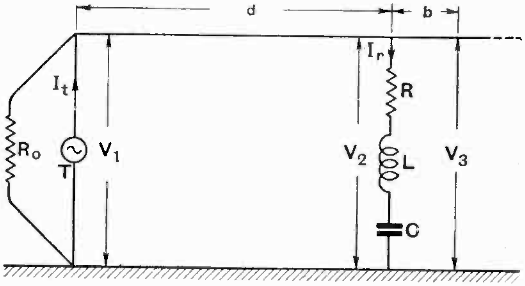


Fig. 2.

the line at the disturbing circuit is positive, I_r flows downwards, but if we regard this circuit as a generator, this direction of the current corresponds to a negative line voltage. Hence the disturbing circuit is radiating a negative voltage at the moment when the voltage at this point due to the main wave is a positive maximum. Hence the shadow cast by the tuned circuit, or its screening effect, is correctly calculated by taking the differences of the fields due to the currents in the two aerials—or their sum if proper regard be paid to the phase or sign—each being calculated independently of the other.

If the disturbing aerial is not tuned it will not take a current V_2/R in phase with V_2, but a smaller current V_2/Z out of phase with V_2, but it can be easily shown that the above principle of the superposition of the two fields at the proper phase angle will still give the correct value of the voltage V_3. The current in the aerial will now be

$$I_r = I_t \cdot \frac{R_0}{2} \cdot \epsilon^{-ad} \cdot \frac{1}{Z + \frac{R_0}{2}}$$

which is the fictitious voltage $I_t \cdot \frac{R_0}{2} \cdot \epsilon^{-ad}$ which would exist at this point in the absence of the disturbing aerial, divided by $Z + \frac{R_0}{2}$.

The superposed voltage $I_r \frac{R_0}{2}$ which the disturbing aerial impresses on the line will not be in opposition to the main voltage, but will lag or lead with respect to this condition depending on whether the aerial is detuned in such a way as to make its current lag or lead on the impressed voltage.

We wish to draw special attention to the fact that, although we have taken into account the reaction of the receiving aerial upon the transmitting aerial, we have assumed that the distances *d* and *b* are greater than that at which the effects of direct electric and magnetic induction from an aerial become comparable with the effects of the radiated field.

A reader who is familiar with Hertz's formula for the radiation of power from an aerial, may raise the objection that an aerial is radiating power at a maximum rate at the moment when its current passes through zero, whereas the tuned circuits connected to the line in Figs. 1 and 2 are supplying power to the line, or taking power from it, at the maximum rate when their currents have their maximum value. So far as its function as a radiator of electromagnetic energy is concerned, a tuned transmitting aerial should not be regarded as a series resonant circuit connected to the line as in Figs. 1 and 2, but rather as shown in Fig. 4. The transmitter will now supply power

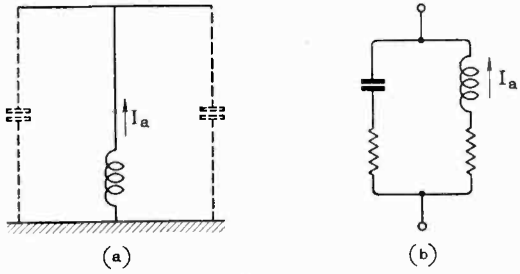


Fig. 3.

to the line at the maximum rate when the voltage across the condenser is a maximum—*i.e.*, when the generator current is approximately zero. The current flowing to and from the line will be but a fraction of the generator current and the line would have to have a much higher value of R_0 than that assumed in the simplified consideration, as shown in Figs. 1 and 2. It would be more accurate to take as the radiation resistance of a transmitting aerial that resistance which, when connected between the top of the aerial and earth, dissipates the same amount of power as is radiated. Such a

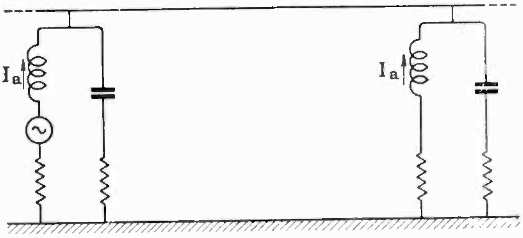


Fig. 4.

resistance would absorb power at the same moment as it is normally radiated, whereas the ordinarily assumed radiation resistance absorbs power at the maximum rate at the moment when the actual radiated power is zero. The question then arises: should the receiving circuit be regarded in the same way and represented as shown in Fig. 4? If so, then it would have its maximum current at the moment when the P.D. across the line and therefore also the magnetic and electric fields were zero; but, unless there is something seriously wrong with our usual conceptions, a receiving aerial has its maximum current when the fields are a maximum. This brings out an important difference between the transmission line and wireless radiation. In the former case, the current which supplies power at a maximum rate when its current is approximately zero, as in Fig. 4, also absorbs power from the line at a maximum rate when its current is approximately zero, whereas a tuned aerial radiates power at a maximum rate when its current is zero, but absorbs it from space at a maximum rate when its current is a maximum. This would appear to limit very considerably any application of the line analogy to wireless problems, since a receiving tuned aerial absorbs energy in phase with the oncoming wave and then re-radiates a portion of it, not in opposition to, but in quadrature with the wave.

G. W. O. H.

Measurement of the Performance of Loud Speakers.

By E. J. Barnes, A.C.G.I., A.M.I.E.E.

(Concluded from page 255 of May issue.)

The Recorder.

When taking the frequency output characteristic of a device with anything but a very smooth curve it is necessary to have some rapid means of recording the curve, in order that a reasonable time only may be required. The method adopted is to put the condenser which is used to vary the frequency of the heterodyne oscillator inside a cylinder which can be slowly rotated. The output from the device under test, in the case of a loud speaker picked up on a condenser microphone, is made to operate a galvanometer which deflects a beam of light along the surface of the cylinder. The spot therefore traces out on the cylinder the characteristic. The cylinder rotates inside a light-tight box, and by means of a cylindrical lens the light is focused to a fine point which will record its movements on photographic paper placed on the cylinder. This enables every small movement to be recorded, but requires the transport of the box and cylinder to a dark room to change the paper for each record. Where a large number of curves have to be taken (showing, say, the effect of changes in the apparatus under test) the operation can be speeded up at the expense of some detail in the records by using a pencil in a small carrier which is arranged to slide along the edge of the box adjacent to the cylinder. The pencil point comes just in the spot of light and it is easy to follow its movements as the cylinder is rotated. The record is then immediately available for inspection. Several coloured pencils may be used to draw different curves on the same paper.

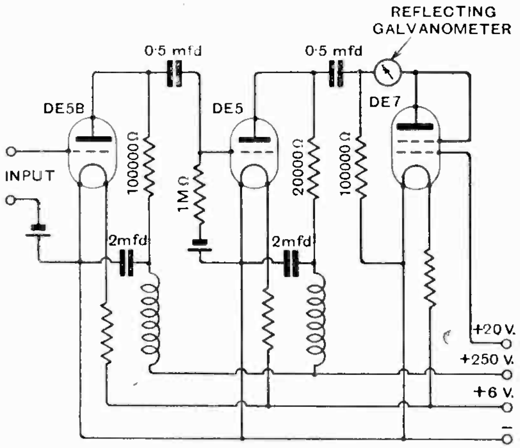


Fig. 7.—*Amplifier rectifier.*

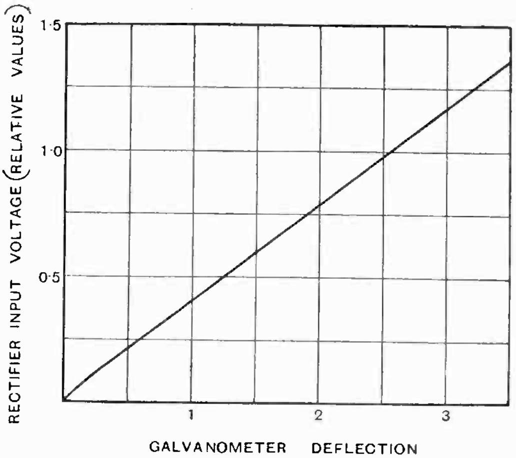


Fig. 8.—*Recorder calibration.*

It has been found convenient for general testing to operate the recording galvanometer by means of a rectifying valve preceded by two stages of resistance-coupled amplification. This outfit is made up as a unit and can be applied directly to telephone transmitters and circuits. A potentiometer is provided to vary the sensitivity, or one stage may be cut out. When testing loud speakers this amplifier and rectifier is connected across the output load of the condenser microphone amplifier. Much more amplification is available than really is required, but as the same apparatus can be used for different tests this makes the most generally useful arrangement.

It is considered that when measuring the output of a sound generator the results should be recorded in terms of the pressure (or velocity) rather than power (pressure²). For one thing, as most acoustic devices at present have a very variable output with frequency, the use of the power would result in an excessively peaky curve, making it difficult to measure points of small output if those of large output are to appear on the same diagram.

It has become customary in telephone engineering to express all measurements in Transmission Units (now called decibels), *i.e.*, units proportional to the logarithm of a power ratio. This has certain advantages but not sufficient to warrant the additional apparatus required to give a direct record. The rectifier is therefore arranged to give a current through the galvanometer proportional (or nearly so) to the R.M.S. voltage applied. This result is shown in Fig. 7, and the relation between input voltage and deflection in Fig. 8.

Loud Speaker Tests.

For tests of loud speakers the various units are combined as shown in Fig. 9. With the switch in position T the oscillator output is applied to the loud speaker amplifier, and as the camera condenser is rotated the output is recorded on the paper. This output includes the chacteristics of the oscillator, the loud speaker and its amplifier, the microphone, its amplifier and the amplifier rectifier. By putting the switch to position C, switching off the loud speaker and taking a second curve, the characteristics of the oscillator and all the amplifiers up to the grid of the power stage can be obtained. This calibration is done for each characteristic taken, and thus the variations with frequency and time of the various amplifiers are obtained. The true output of the loud speaker is the characteristic curve as taken, divided at each frequency by the

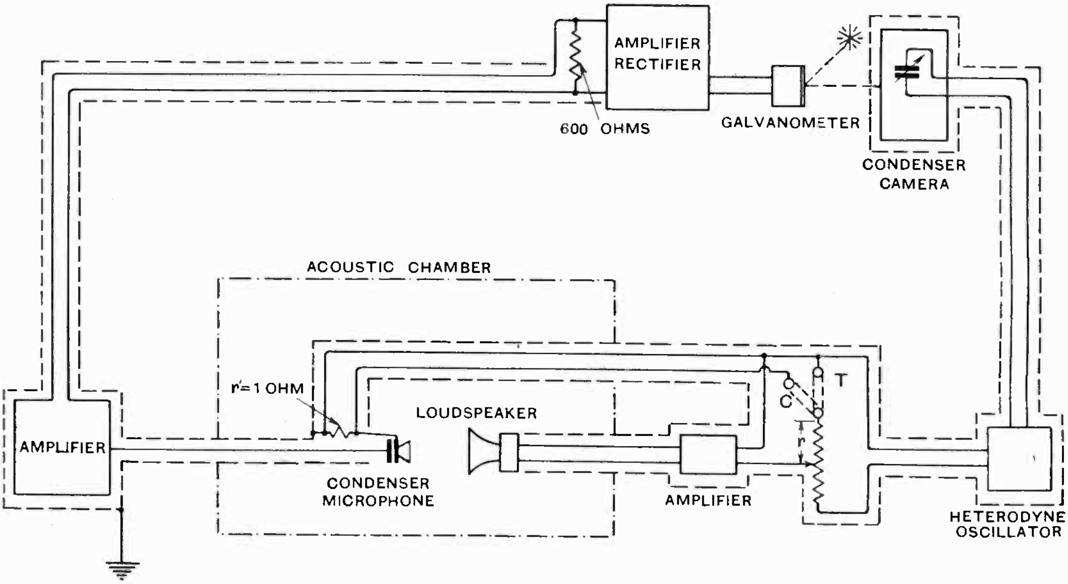


Fig. 9.—*Circuit for loud speaker tests.*

obtained by the well-known expedient of making the impedance of the valve as low as possible in comparison with the galvanometer circuit. A space-change neutralising grid is used with a two-electrode rectifier. The circuit of the whole recording unit is product of the calibration reading and the microphone characteristic (Fig. 5) at the same frequency.

When proceeding to test a loud speaker a decision must be made as to whether the total output over the whole space surrounding the loud speaker is required or whether it is desired to know the output in a particular direction. Also, at what distance from the centre of the radiating surface the measurements should be made. As pointed out previously, if the measurements are made at a point too close to the loud speaker there will be a variation in pressure with frequency due to a diffraction effect which is not part of the dynamic characteristic of the loud speaker itself. In most cases it is

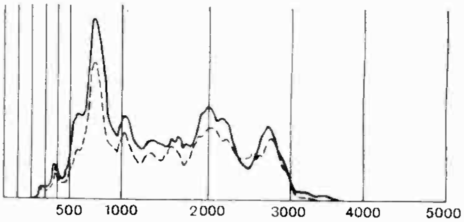


Fig. 10.—*Frequency-output characteristic of horn loud speaker.*

easy to avoid this effect, but in some cases with large radiating surfaces at high frequencies there may be some variation from this cause. This effect would be minimised if the radiating surface decreased with frequency. This actually happens with some forms of cone diaphragms.

As the frequency is raised the sound will be more and more radiated as a beam or series of beams. When the wavelength is large (low frequencies) the loud speaker will be small in comparison and act as an approximate point source, and the sound will be radiated as a more or less spherical wave, but when the frequency is high, so that the wavelength is less than the dimensions of the radiating surface, the sound will be radiated in a beam. A wireless aerial behaves in a very similar manner.

Therefore the output at different frequencies will not be evenly distributed, and measurements must be made in a number of different directions. If sufficient are made in all directions it is possible to calculate the total power output, and if the electrical input is also measured the absolute efficiency of the instrument can be calculated. However, this is of not much practical value as in almost all cases the loud speaker will have directive properties, and we are more concerned with what a person situated at a particular point near the instrument will receive.

For the majority of uses to which loud speakers may be put it is thought to be desirable for the sound to be radiated in a small-angled cone, and not dispersed over the whole spherical space surrounding the instrument. This is certainly desirable in order to economise power and, in the presence of reflecting surfaces indoors, to produce the effect of direction. This is particularly necessary for talking films. In certain cases, such as supplying music to crowds in the open, cylindrical distribution of the sound may be desirable, but it will rarely be necessary to radiate the sound equally over a sphere. It is, however, very desirable that throughout the sound field all audio-frequencies should be radiated equally.

A constant P.D. at all frequencies should be applied not to the loud speaker terminals but to the grid of the power stage in the amplifier. The impedance of the loud speaker will change with frequency, and hence the power it will absorb from the amplifier will also change. Tests should therefore be made with the loud speaker connected as it will be used and not under either constant voltage or constant current applied to the loud speaker itself.

A swinging or rotating microphone has been used by some experimenters to mini-

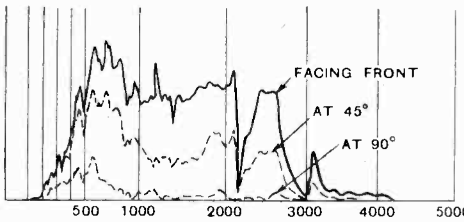


Fig. 11.—*Frequency-output characteristic of small exponential horn.*

mise the effect of standing waves, but unless the distance through which the microphone moves is made large it will not move through half a complete standing wave at low frequencies, and the object will not be achieved. On the other hand, if the distance moved through is large it may move in and out of a beam at high frequencies, and the true output in any direction will not be measured.

For all the tests so far made by the author a fixed microphone has been used, placed at various distances from the loud speaker and at different angles from the axis. It would have been better to have worked at greater distances, but the quantity of material required to construct a larger testing cabinet would have been prohibitive.

Some Typical Characteristics.

Some typical characteristics are shown in Figs. 10 to 18c. They are directly as recorded without any correction for the amplifier or microphone. The shape of the combined oscillator and amplifier characteristic is as shown in Fig. 16a and will be the same for the remainder of the figures, although its absolute height will vary. As already mentioned the true shape of the curves can be obtained by dividing by the product of the amplifier characteristic (Fig. 16a) and the microphone (Fig. 5). In Fig. 12 both the recorded curve and one corrected as above are shown. All the tests of which the results are shown were made with the loud speakers choke and condenser connected to one L.S.5A valve with 300v. anode supply, its impedance being about 1,600 ohms.

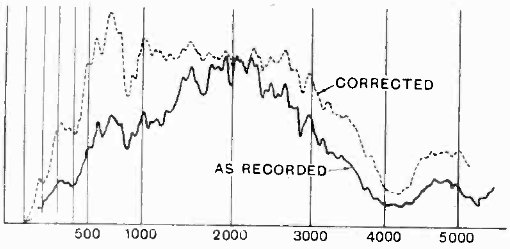


Fig. 12.—*Frequency-output characteristic of large exponential horn.*

Fig. 10 shows the characteristic of a horn-type instrument which was one of the most popular commercial instruments a few years ago. The curves were taken at two different distances on the axis of the mouth of the horn. Their similarity shows that the various peaks are not due to standing waves. The very limited frequency range will be noticed. The manufacturer has attempted to compensate for the lack of low notes by having a pronounced resonant hump as low down as he could get it (about 760 cycles/sec.). This hump, of course, gave a characteristic colouration to the sounds emitted. The presence of some non-linear distortion causing the production of harmonics is indicated by the small hump at about 380 cycles/sec.

Fig. 11 shows the response of a straight horn whose area increased exponentially. It was operated from a small watch-type telephone and its theoretical lower cut-off frequency was about 200 cycles per second. The fundamental resonance of the diaphragm at about 800 is well damped out by the load due to the horn. The upper cut-off is fixed by the dimensions of the diaphragm. The deep valley at 2,100 is due to a diametrical resonance of the diaphragm or to resonance in some part of the receiver other than the diaphragm, and the peak at 3,100 to the first nodal circle resonance.

Fig. 12 shows the response of a larger exponential horn driven by a special type of movement. The dotted curve is the true output of the loud speaker. The lower cut-off frequency was calculated to be about 100 cycles per second. The fall at the upper end is due to the movement. The very even response of these horns will be noticed. The exponential horn can be made to give very good results between definite frequency limits. The lower limit is fixed by the size of the mouth and the length permissible, the upper limit is fixed by the interference which occurs between waves arriving at the throat from different parts of the diaphragm or piston of the driving unit. Several designs have been produced recently which are aimed at raising this limit.

Fig. 13 is the characteristic of a small, cheap cone with unbalanced moving iron drive. It has no baffle, and the convex side of the cone is intended to face the listener. It will be noticed that the range of response is much better than the small horn, particularly at the lower frequencies. As it is also small and of pleasing appearance the

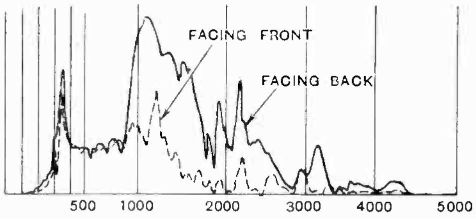


Fig. 13.—*Frequency-output characteristic of small cheap paper cone loud speaker.*

reason for the great popularity of this type of loud speaker in competition with the horn type is obvious.

Fig. 14 shows the response of a better type of cone instrument. The cone is somewhat larger and shallower than that of Fig. 13. The edge is semi-flexibly attached to the cabinet, which is completely closed at the back. It has unbalanced moving-iron drive. The range of response is slightly better at the top end than Fig. 13. This improvement is, however, easily noticeable on some kinds of music. The generally even response is also an improvement.

Fig. 15 shows the curves obtained with a paper cone and a balanced moving-iron driving unit which has become very popular lately. The cone had a flexible edge and

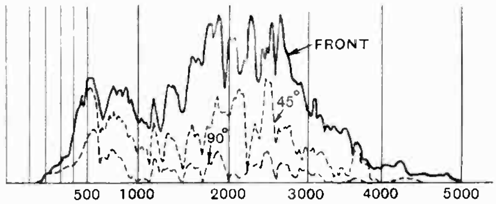


Fig. 14.—*Frequency-output characteristic of cone loud speaker with unbalanced moving-iron drive.*

was enclosed in a box-type baffle about 14in. square, 7in. deep, open at the back. The range of response is still further improved.

Fig. 16a and 16b are for a large double paper cone without baffle. It is about 18in. diameter and has a balanced moving-iron drive. The range of response is very good, but there are a large number of very sharp small peaks and valleys which somewhat tend to give a peculiar tone to the reproduction. These are mostly due to the paper cones vibrating in a large number of separate sections which change at different frequencies.

Similar ripples are produced in Figs. 13 and 14, and their effect is noticeable when rapidly changing over on music to, say, the loud speaker for which curves are given in Figs. 17 (a) and (b). The deep valley at 1,700 cycles per sec. in Figs. 16a and 16b is probably due to some resonance in the driving unit.

Figs. 17a and 17b show some curves obtained with a paper cone (9in. diameter) in a box baffle (18in. cube) with the back open. It had a moving coil drive. The cone is very freely supported on a rubber surround and, as a whole, is practically aperiodic when connected in circuit. With the coil disconnected its natural period is under 25 cycles per second. The coil (2in. diameter) is wound with about 1,200 turns to a resistance of about 1,100 ohms. As mentioned above, the power valve had an impedance of about 1,600 ohms. The very large range of

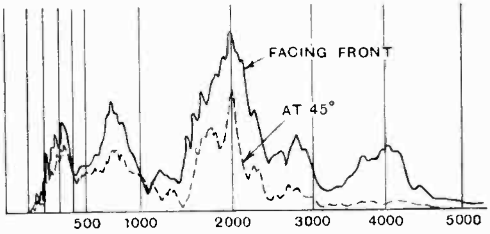


Fig. 15.—*Frequency-output characteristic of cone loud speaker with balanced moving-iron drive.*

response, particularly at the lower frequencies, will be noticed, also the general smoothness of the curves. The chief fault appears to be the big hump at about 2,500 cycles/second. The cause of this may be due to the method of attaching the coil. In order to prevent the formation of an air pocket between the end of the central pole and the centre portion of the cone, which has no hole or centring device at the apex, the coil is attached to the cone by eight paper legs. At 2,500 cycles per second these and part of

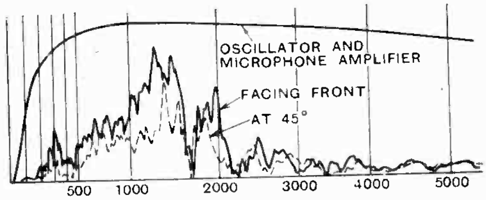


Fig. 16a.—*Frequency output characteristic of double cone with balanced moving-iron drive.*

the cone act as springs and, with the mass of the coil at one end and the outer portion of the cone at the other, make a resonant system. Most moving coil instruments have a hump of this type to a greater or less extent. A similar effect occurs with the moving-iron type of cone loud speaker due to the driving rod. Usually, however, this resonance comes much higher up the scale. Its effect in some cases may be very unpleasant.

The smoothness of the curves obtained

with some cones (Figs. 15 and 17 (a) and (b)) appears to be due to the type of paper used. If this is fairly soft and not hardened by impregnation, the internal resonances which always occur are damped by molecular friction.

It will be noticed that the addition of the grille, which partially closed the front of the cone, adds a blunt resonance at about 900 cycles/sec., which on the whole somewhat improves the curve. It should be noted that the curves in Figs. 17a and 17b are not all to the same scale.

Figs. 18a, 18b and 18c are for a cone (7in. diameter) in a flat baffle (3ft. square), with moving coil drive. It was wound to a low resistance and connected to the amplifier through a transformer. The cone is of thick, stiff material and was carried on a rather stiff leather surround. It will be noticed that the curve starts with a resonance followed by a deep valley. This resonance is thought to be due to the stiff leather surround. The exceptionally good response at the very high

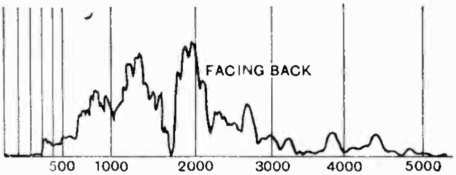


Fig. 16b.—*Frequency-output characteristic of double cone with balanced moving-iron drive.*

frequencies is noticeable ; this appears to be obtained by the stiff small cone ; on the other hand, the stiff cone does not give such a smooth curve as obtained in Figs. 17 (a) and (b) with the limper paper cone.

Further Discussion of Results.

It must be remembered that Fig. 10 is for what was considered a good horn-type instrument, and that far worse examples were in common use. Their very poor range at both ends of the scale is especially noticeable. The improvement with the later type of instrument has been made at both ends of the scale, and a remarkably even response can be obtained. In this connection it should be remembered that with all the instruments their impedance rises with frequency, and that they "match" the power valve at or near the lower end of the scale. In spite of this the response as measured on the axis facing the instrument is on the average fairly level up to the cut-off points. As a set-off, however, as mentioned earlier the high frequencies will be confined to a fairly well-defined beam, see Figs. 11, 14, 17 (a) and (b) and 18 (a), and hence the total power output will fall with frequency. (The

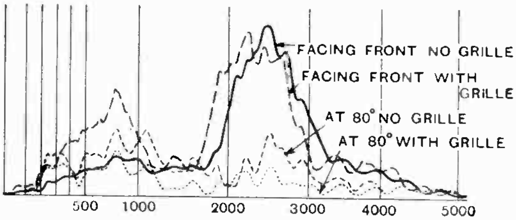


Fig. 17a.—*Frequency-output characteristic of cone loud speaker with moving coil drive in a box-type baffle.*

instrument of Figs. 16 (a) and (b) appears to radiate more uniformly than others.) The result is that in a room with fairly high absorption or in the open a listener directly in front of the loud speaker would hear a fairly uniform response while to one at a point on one side the response would sound low-toned. This effect can easily be observed with the moving coil instruments, but will be a minimum in a room with little absorption. If it is desired to compensate for this and allow the characteristic on the axis to rise with frequency, the instrument could be wound to a lower impedance or connected *via* a transformer. A somewhat more uniform polar distribution might be obtained in some cases by a suitable deflector placed in front of the cone.

There appears to be an impression that a

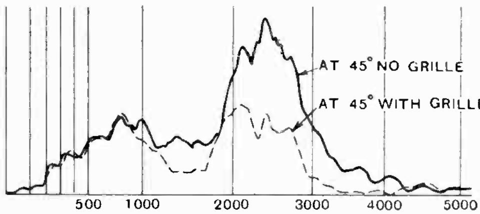


Fig. 17b.—*Frequency-output characteristic of cone loud speaker with moving coil drive in a box-type baffle.*

moving coil loud speaker is less efficient than other types and requires a very powerful amplifier. For about 13 instruments tested, the output over the frequency range of from 50 to 5,000 cycles per second was averaged, and the moving coil instruments were found to be the most efficient, although over a shorter range some of the others were better. This means that if it is required, say, only to reproduce intelligible speech, which needs only a range of from 300 to 2,500 cycles per second, it might be possible to choose a somewhat more efficient instrument and a relatively lower-powered amplifier, as there is no need to amplify the very low notes. The ear is less sensitive at very low frequencies, and greater power must be expended than is necessary with higher notes in order to produce sounds of an equal apparent loudness. Therefore, when the low notes are amplified the valves are more likely to be overloaded. If the loud speaker is incapable of reproducing really high notes the overloading will not be seriously noticed against the background of overtones normally present in music and speech. But if the loud speaker radiates very high notes any overloading in the

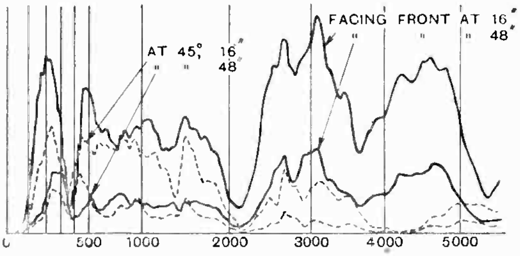


Fig. 18a.—*Frequency-output characteristic of stiff paper cone with moving coil drive in flat baffle.*

amplifier will be audible as an unpleasant rattle. In short, a really good loud speaker must have a really good amplifier, whereas an indifferent loud speaker will give results almost as good (or bad !) as it is capable of, on a mediocre amplifier.

As regards overloading of the loud speaker itself, a properly designed moving coil instrument is unlikely to be overloaded by any power which does not actually overheat the moving coil, although it may be mechanically damaged. A moving-iron loud speaker of the balanced type will carry more power than one of the unbalanced type. The effect of overloading appears as the production of overtones and as the modulation of high notes by currents of lower frequency, which are put through the coils and which may be of such a low frequency that they do not cause any sound to be radiated. This is an additional argument for not attempting to amplify notes lower than those the loud speaker is capable of handling.

As regards uniformity of output at different frequencies within the range radiated, a smooth flat curve is the ideal, but there is no

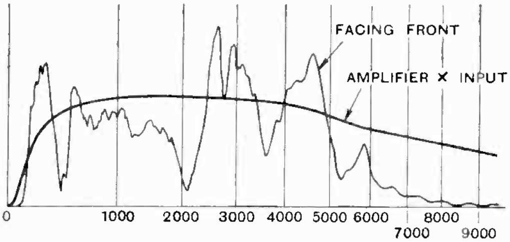


Fig. 18b.—*Frequency-output characteristic of stiff paper cone with moving coil drive in flat baffle.*

need to obtain absolute flatness. A trained ear under ideal conditions cannot detect intensity changes much less than about 25 per cent. (the minimum change detectable varies with the intensity level and frequency), and under ordinary conditions of use, with rapidly varying volume and frequency, much greater changes in the output with frequency are unnoticeable. Also, even if the loud speaker itself gave a perfect output this would be very much spoiled in most surroundings due to standing waves. For example, at home if I make a moving coil loud speaker sound a note of, say, 50 cycles per second (by inducing a small voltage from the lighting mains), in some parts of the room it will be easily audible while in others practically nothing can be heard, and in another room, some distance away, in one spot the note will sound very loud. There-

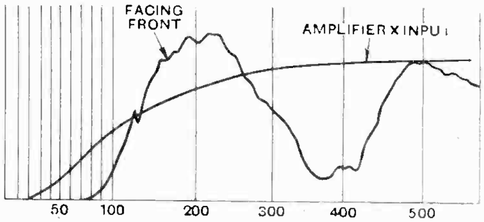


Fig. 18c.—*Frequency-output characteristic of stiff paper cone with moving coil drive in flat baffle.*

fore, if this note happens to be present in the music it may or may not be heard according to the position of the listener except perhaps during the transient period at the beginning and end of the time it is sounding. The same thing applies to a greater or less extent to every note; each produces a pattern of standing waves throughout the space. High notes may sometimes be heard in one ear and not in the other.

It is important to avoid in the loud speaker curve abrupt change in output with frequency. A sharp peak will have a considerable effect on transient sounds. The loud speaker may be excited by any impulsive sound at the natural frequency of the peak. This note will persist after the impulse has passed. In a bad case, of course, also, if a note coincides with a peak this may sound painfully loud.

With a characteristic having steep changes in level, if a sound of varying frequency is applied it appears that as the frequency of the output varies along the curve side-bands must be produced, depending on the rate of frequency change and the steepness of the curve.

In the neighbourhood of a change in level in the characteristic, sharp changes in the phase of the notes must occur.

As transient sounds contain all frequencies from zero up it seems that in order to reproduce them properly the range of response at both ends of the scale should be as great as possible.

It is not clear what relative importance should be attached to these various effects, but it appears that the response-frequency characteristic of a loud speaker forms the best single criterion of its performance.

It may be of interest to add that a rough attempt was made to get a figure for the absolute efficiency of the loud speaker whose characteristic is shown in Figs. 18(a), (b), and (c).

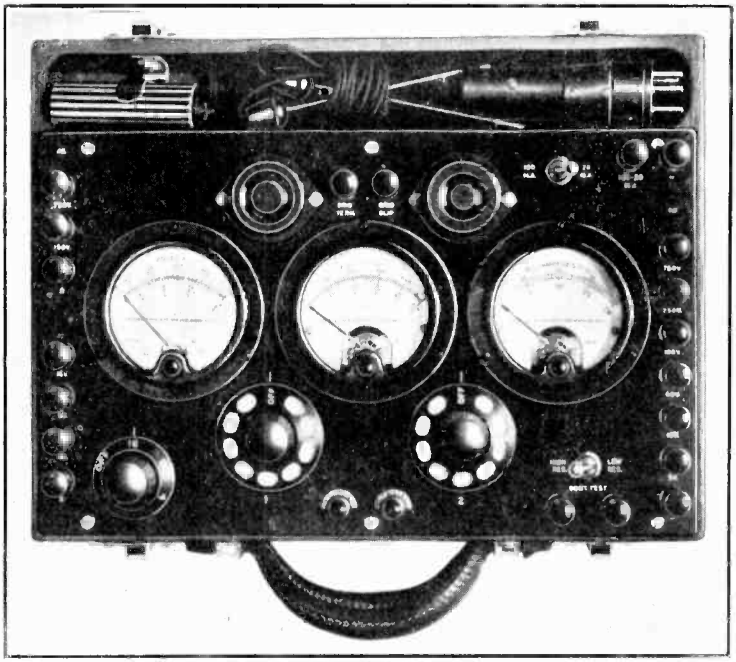
The curves in different polar directions were measured at every 200 cycles per second and the average power for all frequencies from 50 to 5,000 cycles per second radiated over a hemisphere, was obtained. Knowing the amplification and impedance of the valve and the impedance of the loud speaker and the input voltage the input power could be found. It was found that somewhat under half of 1 per cent. of the input was radiated as sound over the hemisphere facing the cone.

Radio Set Tester.

THE Weston Model 547 Set Tester is a multi-purpose instrument, designed to enable practically every test required in servicing of receivers to be carried out without auxiliary apparatus.

There are three instruments included on the panel: a D.C. milliammeter, a D.C. volt-milliammeter, and an A.C. voltmeter. Each instrument is designed for a multiplicity of ranges. The tester will measure the various A.C. and D.C. voltages used in a radio set, either at the valve sockets or at any part of the set, and is applicable for mains-operated sets, both A.C. and D.C.

A special instruction book is supplied with the instrument, which is in loose-leaf form and embodies complete instructions with a good deal of useful data on set testers. The loose-leaf form is adopted so that the booklet can be kept up to date with new information, particularly on tests on new types of receivers.



The Weston Model 547 Set Tester for servicing receivers.

Applications of the Method of Alignment to Reactance Computations and Simple Filter Theory.*

By W. A. Barclay, M.A.

(*Continued from page 247 of May issue.*)

PART IV.

§30. Various Filter Types.

IN the previous sections methods were described by which the filter response curves for the most general combinations of reactive filters and loads might be estimated with fair rapidity and accuracy. We now proceed to a more practical aspect of the subject, namely, a more detailed consideration of the response curves of various standard types of filter when used at different frequencies. In the following sections, practical alignment charts will be given from which the performance of several particular types of filter may be conveniently studied in conjunction with different loads.

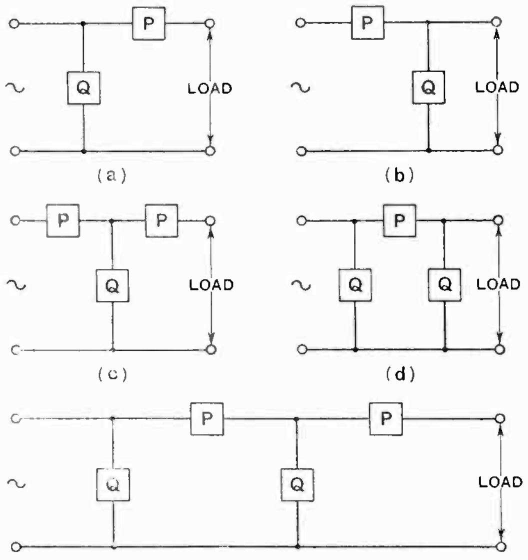


Fig. 21.—*Various filter types.*

There are many simple filters whose performance over different ranges of frequency and for different loads may be usefully studied with the aid of alignment. The simplest of such filter types are shown in Figs. 21(a) and (b). More complicated are the types (c) and (d) of Fig. 21, representing the standard "symmetrical" T and π types of filter, in which the reactive components are symmetrically arranged. Other types of filter may be considered as combinations of two or more stages of these; thus that of Fig. 21(e) may be regarded as two stages of (a).

§31. The Symmetrical T-Filter.

In the following notes we shall confine our treatment to one only of these types, it being understood that a similar analysis is readily applicable to any other type. We shall select for discussion—arbitrarily—the symmetrical T-filter of Fig. 21(c), and show how, by a suitable selection of components, its effect will vary for different types of load.

For any reactive load the reactance W is, of course, a function of the frequency applied. It was shown (§11, p. 184) that the filter reactance of such a T-filter is expressed by

$$F = AW + B \qquad \text{.. .. (32)}$$

where A and B are the frequency characteristic functions of the filter, in the present case having the values (§14, p. 185)

$$A = 1 + \frac{P}{Q} \text{ and } B = P\left(2 + \frac{P}{Q}\right) \qquad \text{.. (33)}$$

P and Q are, as usual, the reactances of the components shown in the diagram, and, of course, vary with the frequencies in question.

§32. Another Filter Classification.

It is usual, in discussing simple frequency filters, to classify them in four categories: the "high-pass," "low-pass," "band-pass" and "band-stop" filters, the properties of which have already been discussed by Mr.

* MS. received by Editor, January, 1930.

Turner in these pages.† Though, as before pointed out, the total filtering effect of a given assemblage depends to some extent upon the load, it will be convenient to adopt the above broad distinction of filter types. It should be remembered, however, that in strictness the names refer rather to the arrangement of the constituents of filters than to their actual performance. Bearing this in mind, we shall now illustrate the working of four typical varieties of T-filter corresponding to the four types above mentioned when each is arranged to work with an inductive load. These filters and their component values are shown in Fig. 22. For simplicity, all the inductances and capacities of the band-pass and band-stop filters of Figs. 22(c) and 22(d) have been taken as of equal value. The effect of varying the values of some of these components will be considered later. (*See* §39, *post.*)

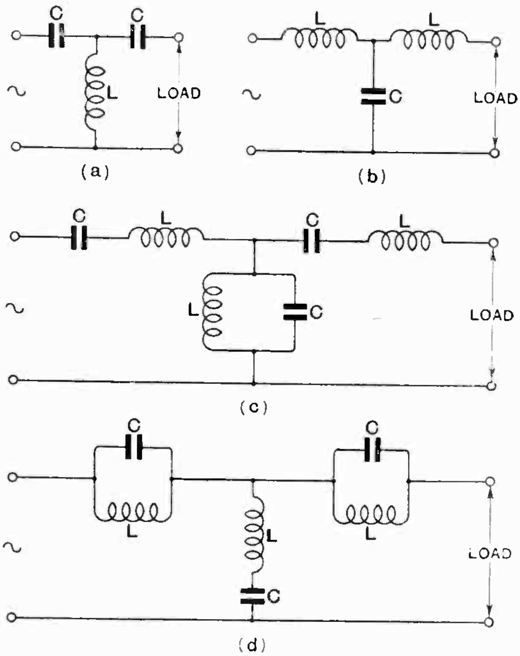


Fig. 22.—*Various types of symmetrical T-filter.*

§33. Analytical Expressions for Filter Reactance.

The component values being thus all represented by the quantities L and C, we now define f_0 or $\frac{\omega_0}{2\pi}$ to be that frequency to which L and C are resonant. It is worth noting that while $\omega_0 L$ is numerically equal to $\frac{1}{\omega_0 C}$, and may be substituted for it wherever it occurs, the separate reactances of L and C at frequency f_0 are of opposite sign—a point on which confusion is often liable to arise. Next let f denote any other frequency, ω being as usual $2\pi f$. If the symbol p be taken to represent the ratio f/f_0, it becomes an easy matter to express the reactances P and Q of Fig. 21(c) for the four different cases shown in Fig. 22. This done,

TABLE.

Filter-Type.	P	Q	A	B
(*a*) High-Pass	$-\frac{\omega_0 L}{p}$	$p\omega_0 L$	$1-\frac{1}{p^2}$	$-\frac{\omega_0 L}{p}\left(2-\frac{1}{p^2}\right)$
(*b*) Low-Pass	$p\omega_0 L$	$-\frac{\omega_0 L}{p}$	$1-p^2$	$p\omega_0 L\,(2-p^2)$
(*c*) Band-Pass	$\left(p-\frac{1}{p}\right)\omega_0 L$	$-\frac{\omega_0 L}{\left(p-\frac{1}{p}\right)}$	$1-\left(p-\frac{1}{p}\right)^2$	$\left(p-\frac{1}{p}\right)\omega_0 L\left\{2-\left(p-\frac{1}{p}\right)^2\right\}$
(*d*) Band-Stop	$-\frac{\omega_0 L}{\left(p-\frac{1}{p}\right)}$	$\left(p-\frac{1}{p}\right)\omega_0 L$	$1-\frac{1}{\left(p-\frac{1}{p}\right)^2}$	$-\frac{\omega_0 L}{\left(p-\frac{1}{p}\right)}\left\{2-\frac{1}{\left(p-\frac{1}{p}\right)^2}\right\}$

† See "Filters," by P. K. Turner, *E.W. & W.E.*, August, 1925. The present article was, of course, written before the author had had the advantage of studying Mr. Reed's treatment of "Electrical Wave Filters" in recent issues.—W. A. B.

the values of A and B may be readily set down from equations (33) as in the Table given on the preceding page.

Let us now consider the effect of introducing these filters between a source of e.m.f.s and a reactive load. This load, which may, of course, be any combination of inductance and capacity, will here for simplicity be assumed to be a pure inductance. It will be convenient to define this inductance by its ratio to the value L of the inductive components of the filter. We shall define the load, therefore, as an inductance kL, where k is a proportional constant.

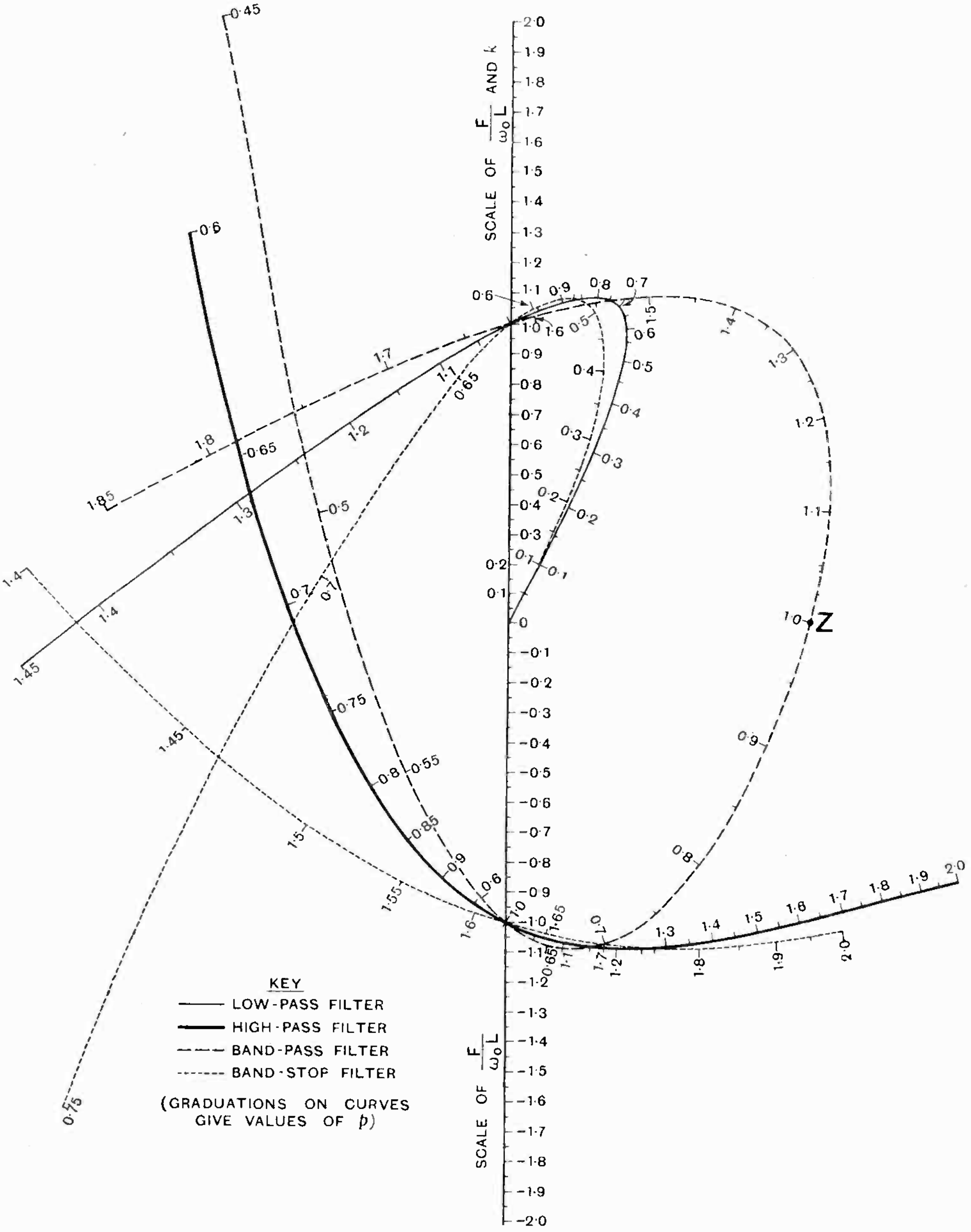


Fig. 23.—*Alignment chart for various types of symmetrical T-filter—all used with inductive load kL.*

Then, since the reactance W of the load at frequency f may be written $p\omega_0 kL$, equation (32) gives us the following relations:

(*a*) High-pass filter

$$\frac{F}{\omega_0 L} = \left(p - \frac{1}{p}\right)k - \frac{2}{p} + \frac{1}{p^3} \quad \cdots \quad (34)$$

(*b*) Low-pass filter

$$\frac{F}{\omega_0 L} = (p - p^3)\,k + 2p - p^3 \quad \cdots \quad (35)$$

(*c*) Band-pass filter

$$\frac{F}{\omega_0 L} = \left\{p - p\left(p - \frac{1}{p}\right)^2\right\}k + 2\left(p - \frac{1}{p}\right) - \left(p - \frac{1}{p}\right)^3 \quad \cdots \quad (36)$$

(*d*) Band-stop filter

$$\frac{F}{\omega_0 L} = \left\{p - \frac{p}{\left(p - \frac{1}{p}\right)^2}\right\}k - \frac{2}{\left(p - \frac{1}{p}\right)} + \frac{1}{\left(p - \frac{1}{p}\right)^3} \quad \cdots \quad (37)$$

Equations (34) to (37) enable us to compute the filter reactance F for various loads at different values of frequency. As these equations are complicated, it will be found convenient where a fair amount of work is being done to use the Parallel Alignment Chart of Fig. 23, which has been designed to evaluate the above expressions at sight. To use this Chart a set-square or other device for obtaining parallels is necessary, and in this respect the method of using differs slightly from the usual alignment procedure. It will, however, be found exceedingly simple.

§34. Parallel Alignment Chart for Symmetrical T-Filters with Inductive Loads.

Let the point Z on the right of Fig. 23 be joined to the given value of k taken on the upper half of the central vertical scale. Then, selecting the curve appropriate to the filter being considered, let lines be drawn through the various values of p shown on this curve, all such lines being parallel to the fixed Z-k line previously found. The several points in which these parallels meet the vertical scale will give values of the ratio $\frac{F}{\omega_0 L}$ for the corresponding values of p. In practice, none of these parallels need actually be drawn on the chart, it being sufficient to maintain the parallel condition by means of a

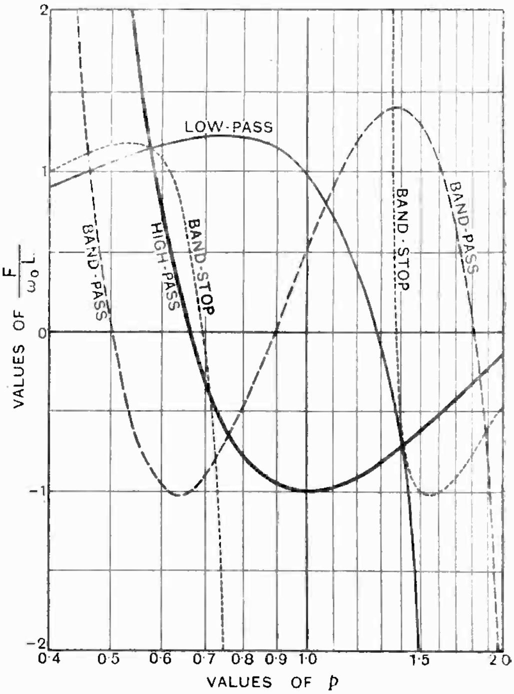


Fig. 24.—*Response curves of symmetrical T-filters of Fig. 22; all used with inductive load* 0.5 *L*.

set-square when $\frac{F}{\omega_0 L}$ is rapidly read off as p is varied on the particular filter curve. Since the denominator $\omega_0 L$ of this ratio is constant for any given filter, the values of $\frac{F}{\omega_0 L}$ may be plotted against values of p to show the relative fluctuations in F. It will be seen that the effect of increasing or diminishing the load is to increase or diminish the slope of the parallel index-lines. The effect of varying this load on the filter response curves is thus rapidly and conveniently estimated over a wide band of frequencies for the particular filter concerned.

§35. An Example.

As an example, the response curves of the four filters of Fig. 22 when used with an inductive load have been plotted in Fig. 24. In order to preserve the true proportions on a frequency basis, the values of p along the abscissa are taken to a logarithmic scale. The point $p = 2$ corresponding to $f = 2f_0$ is thus equidistant with $p = 0.5$, corresponding to $f = 0.5f_0$. In the example illustrated, the load was assumed to have a value 0.5 times the component inductances of the filter, i.e., $k = 0.5$. The actual estimations of the values of $\frac{F}{\omega_0 L}$ for values of p were obtained by the Alignment Chart in a matter of seconds, and the plotting of Fig. 24 was more or less automatic.

It is hardly necessary to mention that the sign of $\frac{F}{\omega_0 L}$ is of no importance to the filtering effect. It might, indeed, have been better to treat all values of $\frac{F}{\omega_0 L}$ as though they had been positive, since it is only with the absolute magnitude of the filtering effect that we are concerned. What value of $\frac{F}{\omega_0 L}$ shall be regarded as the minimum above which the signals are held to be filtered out must be a matter of taste conditioned by the needs of the particular problem considered. For the response curves of Fig. 24 we might, for example, assign the absolute value

$$\frac{F}{\omega_0 L} = 1.5$$

—an arbitrary choice. This figure entails the cutting off by the high-pass filter of all frequencies below $0.55f_0$, and the cutting off

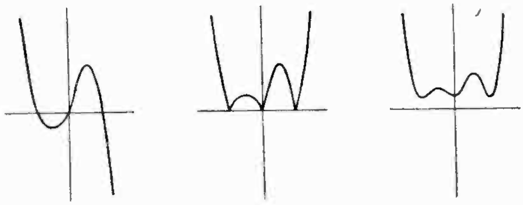


Fig. 25.—*Effect of resistance on ideal reactive filter curve.*

by the low-pass filter of all frequencies above $1.47f_0$. Similarly the band-pass filter will allow the passage of all frequencies from $f = 0.45f_0$ to $f = 1.95f_0$, while the band-stop excludes all within the range from $f = 0.73f_0$ to $f = 1.35f_0$. It is, of course, one of our main objects to arrive at values of these "cut-off" frequencies and it may be pointed out that to obtain these it will not in general be necessary to plot out the curves of Fig. 24. Having assigned the value of the cut-off ratio $\frac{F}{\omega_0 L}$, the corre-

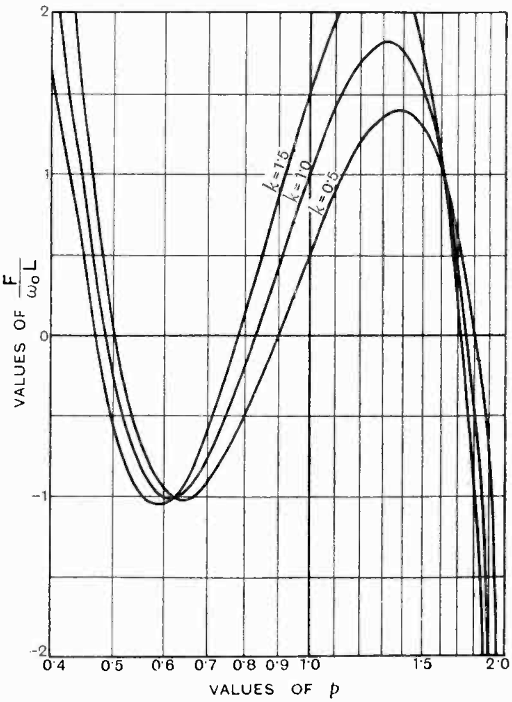


Fig. 26.—*Response curves of band-pass symmetrical T-filter of Fig. 22 (c), used with various inductive loads.*

sponding cut-off frequency may be read off directly from the Alignment Chart by drawing a parallel to Z-k through $\frac{F}{\omega_0 L}$ to meet the appropriate curve in the cut-off value of p required. Indeed, it is possible to plot graphs showing the relation between the cut-off ratio $\frac{F}{\omega_0 L}$ and cut-off frequency for various loads. Other interesting deductions might be made from the Alignment Chart of Fig. 23, but considerations of space forbid.

§36. Effect of Resistance in Filter Components.

If we return to the suggestion made in the last paragraph, and replot the response curves of Fig. 24 making all the ordinates positive, we should obtain curves similar to that of Fig. 25(b), which has been drawn to illustrate the effect of this process on the curve Fig. 25(a). It will be seen that the true filter response curve meets the zero axis in a series of sharp cusps, but this, it must be remembered, is for the ideal reactive filter. In any practical case, a slight modicum of resistance will operate in quadrature with the reactive elements of the filter, and the effect of this on the response curve is to flatten it out. The ratio $\frac{F}{\omega_0 L}$ is always prevented from ever actually attaining the zero value, and hence the cusps tend to be smoothed over, as in Fig. 25(c). Thus, the response curves of the purely reactive filters already considered are in fact norms to which the curves of practice approximate.

§37. Band-Pass Filter with Various Inductive Loads.

In order further to demonstrate the utility of the Chart of Fig. 23, response curves were obtained from it for the band-pass filter of Fig. 22(c) using three different inductive loads, $k = 0.5$, $k = 1.0$, and $k = 1.5$. These are reproduced in Fig. 26, and show clearly how the values of the cut-off frequencies depend on the load.

(*To be concluded.*)

Book Reviews.

NATIONAL PHYSICAL LABORATORY. COLLECTED RESEARCHES. Vol. XXI. 1929, pp. iv. + 449. His Majesty's Stationery Office, Adastral House, Kingsway, London, £1 2s. 6d.

The volume contains 22 papers, all but one of which have already been published elsewhere, the exception being the paper by Dye and Hartshorn on a Primary Standard of Mutual Inductance for presentation to the Imperial Government of Japan. This replaces the one described by Dr. Dye in Vol. XVIII of the Collected Researches which was destroyed in the earthquake of 1923. It is of the Campbell type and is very similar to the N.P.L. 1907 standard. Its construction and calculation is described in the paper together with the experimental tests which showed that the units realised by the two standards differ by a few parts in a million.

Of the reprinted papers, three are by Dye, six by Hartshorn, three by Wilmotte, one by the two last-named jointly, five by Smith-Rose and Barfield, two by Hollingworth, and one by Webb. They are all on electrical subjects and twelve of them on radiotelegraphy. It is hardly necessary to say that they are all of a very high standard of excellence. To anyone interested in accurate electrical measurements it will be a great convenience to have these otherwise scattered papers bound up in a single volume.

MEASURING-DIAGRAMS FOR FINDING ISO-AZIMUTHS FOR SHORT AND MIDDLE DISTANCES FROM RADIO-BEACONS—WITH DIRECTIONS FOR USE. By Prof. Immler. Pub. by M. Krayn, Berlin. Sole agents in the British Isles: Stobart & Son, 8–11, Paternoster Row, London. 5s. 6d.

This book comprises seven sheets of curves, two pages of tables and four of explanatory text, two in German and two in English. It is intended for the use of those on board ship who, having taken the bearings of a radio transmitter of known position and obtained from the navigation officer the approximate position of the ship, wish to determine the position line and the actual position of the ship. From the worked examples it is obvious that the tables and curves enable this to be done very readily by those familiar with the subject. We must confess that to anyone who, like ourselves, is unfamiliar with the subject, the description of the principles involved is not quite so clear as it might be. It is a pity that the English translation was not made or corrected by someone more familiar with the language. The tables and curves are well printed and we have no doubt that the book will prove very useful to the increasing number of those who use radio bearings in connection with navigation.

REPORT OF THE RADIO RESEARCH BOARD FOR THE PERIOD ENDED 31ST MARCH, 1929. Pp. iv. + 166. His Majesty's Stationery Office, Adastral House, Kingsway, London. 3s. 6d.

This is a general review of the work carried out under the auspices of the Board since its establishment in 1920. The extent of this work is indicated by the fact that the bibliography of papers published in connection therewith, which forms Appendix 1 of the Report, contains 106 items.

The first twenty pages give a general account of the establishment of the Board and the development of its activities. Then follow detailed sections dealing with the Propagation of Waves, Directional Wireless, Atmospherics, Radio-frequency Standards and Precision Measurements, Antennæ, Amplifiers, Interference and Short Waves, concluding with a number of notes on miscellaneous matters such as Cathode-ray oscillographs, and high-vacuum pumps.

A perusal of the Report cannot but impress one with the large amount of useful work of a fundamental nature carried out under the auspices of the Board. We welcome this well-arranged and very readable account of a number of long-sustained attacks on some of the most interesting problems in radio science.

G.W.O.H.

Electrical Wave Filters.

By M. Reed, M.Sc., A.C.G.I., D.I.C.

(*Continued from page 261 of May issue.*)

Section D.

Wave Filters Using Mutual Inductance.

Before commencing the study of wave filters containing mutual inductance, some properties of simple circuits containing mutual inductance must first be considered.

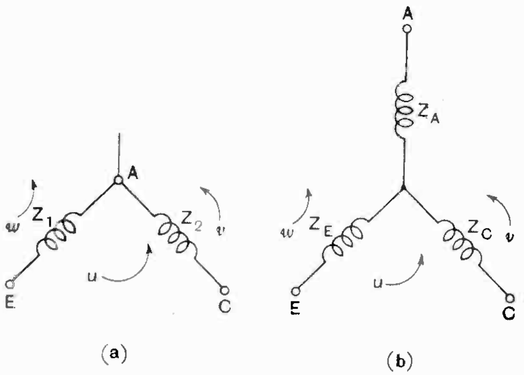


Fig. 31.

In Fig. 31(a) two coils having impedances Z_1 and Z_2, respectively, form branches of a network. Let m be the mutual impedance between them, so that $m = j\omega M$, where M is the value of the mutual inductance between them. Assume that the currents in the branches are as indicated above. The equations for the potential differences between the points CA and EA will be :—

$$e_{CA} = (Z_2 + m)u - Z_2 v - mw \quad .. \quad (58)$$

$$e_{EA} = -(Z_1 + m)u + mv + Z_1 w \quad .. \quad (59)$$

Now if the two impedances of Fig. 31(a) are replaced by three impedances connected together as in Fig. 31(b), and suppose further that the values of these impedances Z_A, Z_C and Z_E, respectively, are such that the potential differences and the currents remain unaltered.

The equations now become :—

$$e_{CA} = Z_C u - (Z_A + Z_C)v + Z_A w \quad .. \quad (60)$$

$$e_{EA} = -Z_E u - Z_A v + (Z_A + Z_E)w \quad .. \quad (61)$$

Comparing coefficients of equations (58) and (60) we have :—

$$Z_A = -m \quad .. \quad .. \quad (62)$$

$$Z_C = Z_2 + m \quad .. \quad .. \quad (63)$$

From equations (59) and (61)

$$Z_E = Z_1 + m \quad .. \quad (64)$$

Therefore a pair of mutually coupled coils can be replaced by a star connected system of three impedances without mutual inductance.

Now when two impedances which are mutually coupled are connected in series, it is possible for the vector impedance of the combination to be greater or less than the vector sum of the component impedances. In the first case the coils are said to be connected in "series aiding" and the sign of the mutual inductance is taken as positive. In the latter case the coils are said to be connected in "series opposing" and the sign of the mutual inductance is taken as negative.

It follows from equation (62), (63) and (64) that the structure of Fig. 32(b) is equivalent to the two coils of Fig. 32(a) where inductance is L_1 and L_2, respectively, and which are coupled by a mutual inductance M whose sign may be positive or negative.

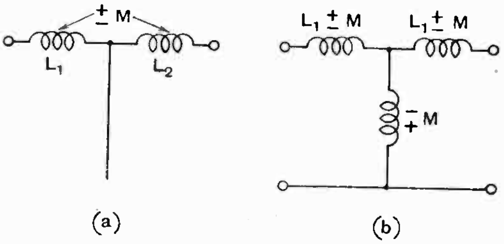


Fig. 32.

As an extension to the above we have the case of the T network of Fig. 33(a) which consists of three coils with mutual inductance between all the elements. The T network of Fig. 33(b) is equivalent to the network of Fig. 33(a), the formulæ governing their equivalence being :—

$$L_A = L_1 + M_{12} + M_{13} - M_{23}$$
$$L_B = L_2 + M_{12} - M_{13} + M_{23}$$
$$L_C = L_3 - M_{12} + M_{13} + M_{23}$$

In these formulæ, the signs correspond to the case where M is positive between all

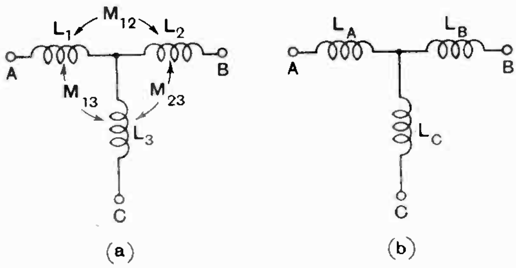


Fig. 33.

pairs of coils. When the mutual inductance between any two coils changes sign, the signs accompanying that mutual inductance in the above formulæ are reversed.

Application to Filter Circuits.

To illustrate the use of mutual inductance in filter circuits, a low pass and a band pass filter similar to those already considered will be investigated. Consider the circuit of Fig. 34(a) ; this structure may be regarded as equivalent to the structure of Fig. 34(b) or of Fig. 34(c) depending on whether the sign of M is positive or negative, respectively.

Now it is seen that if we put

$$L_1/2 = L/2 - M \text{ and } L_2 = M,$$

then the filter of Fig. 34(c) is the same as that of Fig. 21, therefore this filter has exactly the same characteristics as the low pass filter which has already been considered. Hence filters of this type which contain mutual inductance of negative sign are equivalent to the ordinary low pass filter without mutual inductance. There is one point of difference which should be noted. The filter of Fig. 34(c) has only an hypothetical mid-shunt characteristic impedance because point P is not physically accessible.

Consider now the filter of Fig. 34(b). If we put

$$L_1/2 = L/2 + M \text{ and } L_2 = M,$$

this filter reduces to the structure of Fig. 35 which can be regarded as the simplest type of a low pass filter containing negative inductance. This filter will now be considered in detail.

Low Pass Filter Containing Negative Inductance.

From Fig. 35 we have that :—

$$Z_1 = j\omega L_1 \quad \ldots \quad \ldots \quad (65)$$

$$Z_2 = -j(\omega L_2 + 1/\omega C_2) \quad \ldots \quad (66)$$

$$\therefore \quad Z_1/Z_2 = -\frac{\omega^2 L_1 C_2}{(\omega^2 L_2 C_2 + 1)} \quad \ldots \quad (67)$$

The cut-off frequencies are obtained by equating Z_1/Z_2 to 0 and -4, respectively. By putting $Z_1/Z_2 = 0$, it is seen that we have as the lower cut-off frequency $f_1 = 0$. From $Z_1/Z_2 = -4$ we have the upper cut-off frequency given by :—

$$\frac{\omega_c^2 L_1 C_2}{(\omega_c^2 L_2 C_2 + 1)} = 4 \quad \therefore \quad \omega_c^2 = \frac{4}{C_2(L_1 - 4L_2)}$$

$$\therefore \quad f_c = \frac{1}{\pi\sqrt{C_2(L_1 - 4L_2)}} \quad \ldots \quad (68)$$

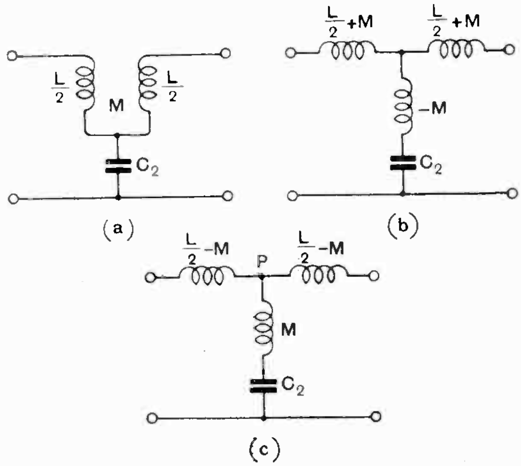


Fig. 34.

Fig. 35 therefore represents a low pass filter whose cut-off frequency is given by equation (68).

Now we have infinite attenuation when the value of Z_1/Z_2 is infinite. From (66) it is seen that this would be the case if

$$\frac{\omega^2 L_2 C_2 + 1}{\omega C_2} = 0.$$

The frequency of infinite attenuation would then be given by

$$f_{\infty} = \frac{1}{2\pi\sqrt{-L_2C_2}},$$

which is an imaginary quantity. Therefore it is impossible to have a frequency such that

$$\frac{\omega^2 L_2 C_2 + 1}{\omega C_2} = 0,$$

hence the filter of Fig. 35 can never have infinite attenuation. We use, therefore, as a convenient parameter the frequency where Z_2 is a minimum. If we denote this frequency by f_r, then it can be seen by differentiating equation (66) and solving $dz/d\omega = 0$, that :—

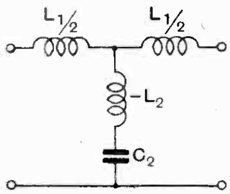


Fig. 35.

$$f_r = \frac{1}{2\pi\sqrt{L_2C_2}} \quad \ldots \quad \ldots \quad (69)$$

From equation (68) we have that :—

$$\frac{\omega_c^2}{4} = \frac{1}{L_1C_2 - 4L_2C_2} = \frac{1}{L_1C_2 - 4/\omega_r^2}$$

$$\therefore \quad L_1C_2 = [1 + (\omega_c/\omega_r)^2]4/\omega_c^2 \quad \ldots \quad (69a)$$

Substituting the value of L_1C_2 from equation (69a) and the value of L_2C_2 from equation (69), equation (67) becomes :—

$$Z_1/Z_2 = -\frac{4(\omega/\omega_c)^2}{(\omega/\omega_r)^2 + 1}[1 + (\omega_c/\omega_r)^2]$$

$$= -\frac{4(f/f_c)^2}{(f/f_r)^2 + 1}[1 + (f_c/f_r)^2] \quad \ldots \quad (70)$$

If we denote the mid-series characteristic impedance of the filter by Z_K, then we have from equation (1) that :—

$$Z_K^2 = Z_1Z_2(1 + Z_1/4Z_2)$$

By multiplication, we have from equations (65) and (66) that :—

$$Z_1Z_2 = \omega L_1\left[\frac{\omega^2L_2C_2 + 1}{\omega C_2}\right]$$

$$= L_1/C_2[(f/f_r)^2 + 1] \quad \ldots \quad (71)$$

Employing equations (70) and (71), the series characteristic impedance is given by :—

$$Z_K^2 = L_1/C_2(f^2/f_r^2 + 1)\left[1 - \frac{f^2/f_c^2 + f^2/f_r^2}{f^2/f_r^2 + 1}\right]$$

$$= L_1/C_2(1 - f^2/f_c^2) \quad \ldots \quad (71a)$$

Now the nominal impedance Z_0 has been defined as the value of the series characteristic impedance at the mid-frequency. In the case of a low pass filter the mid-frequency is zero (see page 257), hence for the filter under consideration, the value of Z_0 is equal to $\sqrt{L_1/C_2}$ (from equation (71a)). The series characteristic impedance is therefore given by :—

$$Z_K = \sqrt{L_1/C_2}\sqrt{1 - (f/f_c)^2} = Z_0\sqrt{1 - (f/f_c)^2} \quad \ldots \quad \ldots \quad (72)$$

It is seen that the value of impedance as given by equation (72) is the same as the value of the series characteristic impedance for the simple low pass filter of Fig. 22. That this should be so follows from the fact that the filter of Fig. 35 can be regarded as being derived from the filter of Fig. 22. Comparing Figs. 15(a) and 15(b) with the corresponding filters of Figs. 22 and 35, it can be seen that the elements of the last two are related by the following equations :—

$$L_1 = m_1L_0 \quad \ldots \quad \ldots \quad \ldots \quad (73)$$

$$L_2 = -\frac{1 - m_1^2}{4m_1}L_0 \quad \ldots \quad \ldots \quad (74)$$

$$C_2 = m_1C_0 \quad \ldots \quad \ldots \quad \ldots \quad (75)$$

Equations (68), (70), and (72) could have been obtained more easily by employing the relations of (73), (74) and (75) combined with the corresponding formulæ for the simple filter of Fig. 22.

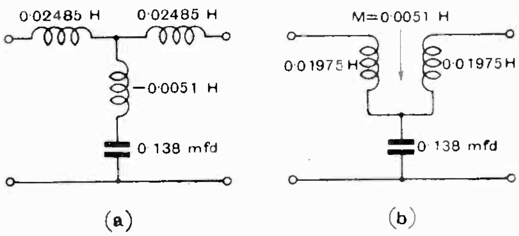


Fig. 36.

By comparing (11), (12) and (13) with equations (73), (74) and (75) it is seen that if we write m_1 for m in equations (11) and (13) and $-m_1$ for m in equation (12), we obtain equations (73), (75) and (74), respectively. Hence the values for the elements of the filter of Fig. 35 can be obtained from equations (29), (30) and (31), by writing m_1 for m in the first and third of these equations, and $-m_1$ for m in the second equation.

The values of the elements of the filter of Fig. 35 are therefore given by :—

$$L_1 = \frac{Z_0 m_1}{\pi f_c} \quad \cdots \quad (76)$$

$$L_2 = -\frac{Z_0}{\pi f_c} \times \frac{1 - m_1^2}{4m_1} \quad \cdots \quad (77)$$

$$C_2 = \frac{m_1}{\pi f_c Z_0} \quad \cdots \quad (78)$$

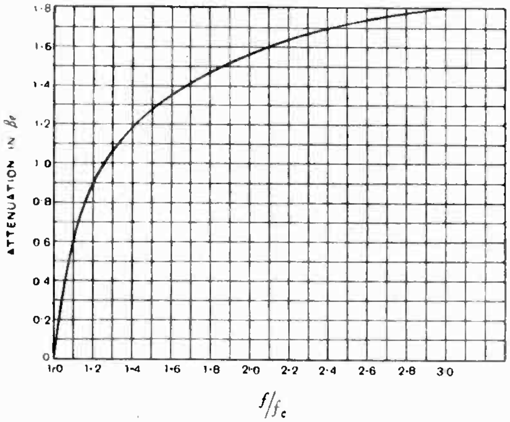


Fig. 37.—*Attenuation characteristic of low pass filter with mutual inductance.*

From equations (77) and (78) we have by multiplication :—

$$L_2 C_2 = -\frac{1 - m_1^2}{4\pi^2 f_c^2 Z_0} = \frac{1}{4\pi^2 f_r^2} \text{ from equation (69)}$$

$$\therefore \quad m_1^2 = 1 + (f_c/f_r)^2 \quad \cdots \quad (79)$$

Substituting this value for m_1 in equation (70) we have :—

$$Z_1/Z_2 = -\frac{4m_1^2(f/f_c)^2}{1 + (f/f_r)^2} \quad \cdots \quad (80)$$

Example.

As a numerical example of the above type of filter, assume that it is required to design a low pass filter whose cut-off frequency is 5,000 cycles per second and whose frequency, where the impedance of the shunt arm is a minimum, is 6,000 cycles per second. Assume further that the terminal impedances are 600 ohms.

We have therefore that

$$f_c = 5{,}000 \quad f_r = 6{,}000$$
$$Z_0 = 600$$

From equation (79) $m_1 = 1.3$.

From equation (76)

$$L_1 = \frac{600 \times 1.3}{\pi \times 5{,}000} = 0.0497 \text{ henrys.}$$

From equation (77)

$$L_2 = \frac{-600}{\pi \times 5{,}000} \times \frac{-0.69}{5.2} = 0.0051 \text{ henrys.}$$

From equation (78)

$$C_2 = \frac{1.3}{\pi \times 5{,}000 \times 600} = 0.138 \text{ mfd.}$$

The filter is therefore as shown in Fig. 36(a), which is equivalent to the filter of Fig. 36(b).

The attenuation and phase constant characteristics can be obtained from equation (80) and from Figs. 6 and 7, respectively. These characteristics are shown in Figs. 37 and 38, respectively. Reference to Fig. 37 shows that the attenuation characteristic is unique in that the attenuation constant is finite at all frequencies. The curve is only drawn for frequencies up to 15,000 cycles per second ; after this frequency the curve becomes almost flat and at infinite frequency the attenuation is only $2\beta l$. The phase constant characteristic of Fig. 38 is of somewhat similar shape to that of Fig. 25, although the phase shift at any frequency is different for the two filters.

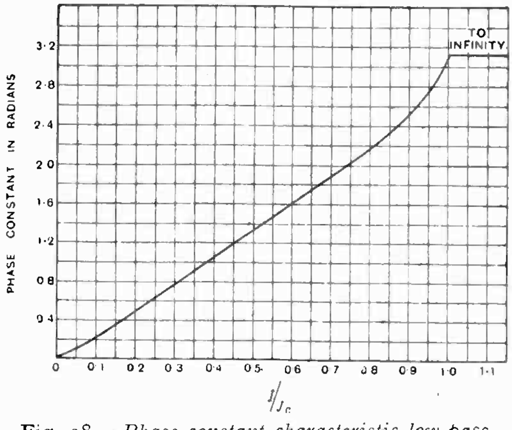


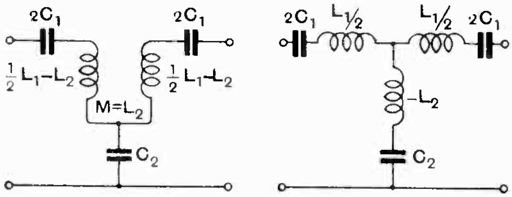
Fig. 38.—*Phase constant characteristic low pass filter with mutual inductance.*

Also for the filter of Fig. 35, the phase shift remains constant at 3.14 radians for frequencies above the cut-off frequency, whereas the filter of Fig. 21 has a change in phase shift of 3.14 radians at the frequency of infinite attenuation.

The characteristics of Figs. 37 and 38 have been drawn for the ideal filter, *i.e.*, for the filter without dissipation. The corresponding characteristics for the dissipative case can be obtained by employing the methods of page 261.

Band Pass Filter Containing Mutual Inductance.

A band pass filter containing mutual inductance and corresponding to the one of Fig. 21 will now be considered.



(a) (b)

Fig. 39.

The structure of Fig. 39(a) in which the mutual inductance is positive and equal in magnitude to L_2 can be regarded as equivalent to the filter of Fig. 39(b).

In the structure of Fig. 39(b) :—

$$Z_1 = j(\omega L_1 - 1/\omega C_1) \quad \ldots \quad (81)$$

$$Z_2 = -j(\omega L_2 + 1/\omega C_2) \quad \ldots \quad (82)$$

$$\therefore \quad Z_1/Z_2 = C_2/C_1 \frac{1 - \omega^2 L_1 C_1}{1 + \omega^2 L_2 C_2} \quad \ldots \quad (83)$$

As before the cut-off frequencies are given by equating Z_1/Z_2 to 0 and -4, respectively.

From the first condition, the lower cut-off frequency is given by :—

$$f_1 = 1/2\pi\sqrt{L_1 C_1} \quad \ldots \quad \ldots \quad (84)$$

From the second condition the upper cut-off frequency is given by :—

$$f_2 = 1/2\pi\sqrt{\frac{C_2 + 4C_1}{C_1 C_2 (L_1 - 4L_2)}} \quad \ldots \quad (85)$$

From (83) it is seen that Z_2 can never be zero since there is no frequency which will satisfy the condition

$$\frac{\omega^2 L_2 C_2 + 1}{\omega C_2} = 0.$$

Therefore the filter of Fig. 39(b) is similar to that of Fig. 35 in that it can never have infinite attenuation. As in the case of the previous filter, let f_r be the frequency at which the value of Z_2 is a minimum, then :—

$$f_r = 1/2\pi\sqrt{L_2 C_2} \quad \ldots \quad (86)$$

By substituting the above values of f_1, f_2, and f_r, in formula (83) we obtain, by methods similar to those employed on page 258, the following expression for Z_1/Z_2 :—

$$Z_1/4Z_2 = \frac{1 - (f/f_1)^2}{1 + (f/f_r)^2} \cdot \frac{(f_2/f_r)^2 + 1}{(f_2/f_1)^2 - 1} \quad \ldots \quad (87)$$

Since the filter of Fig. 39(b) can be considered as derived from the filter of Fig. 27, therefore its series characteristic impedance will be the same as it is for this filter, and hence its value will be given by equation (42).

It can easily be seen that the filters shown in Fig. 39(b) and Fig. 27 are related by the following equations :—

$$L_1 = m_1 L_0 \quad \ldots \quad \ldots \quad \ldots \quad (88)$$

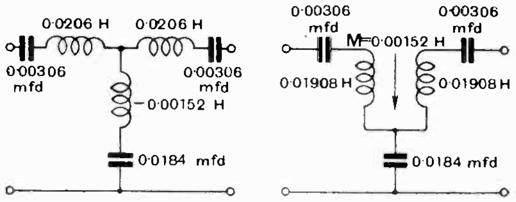
$$C_1 = C_0/m_1 \quad \ldots \quad \ldots \quad \ldots \quad (89)$$

$$L_2 = -\left[\frac{1 - m_1^2}{4m_1}\right] L_0 \quad \ldots \quad (90)$$

$$\frac{1}{C_2} = \frac{1}{m_1}\left[\frac{1 - m_1^2}{4C_0} + \frac{1}{C}\right] \quad \ldots \quad (91)$$

where m_1 is given by equation (96).

By comparing equations (88) to (91) with those of (32) to (35) and substituting in equations (49), (50), (51) and (53), it is seen



(a) (b)

Fig. 40.

that the values of the elements in the case of the filter of Fig. 39(b) are given by :—

$$L_1 = Z_0 m_1/\pi(f_2 - f_1) \quad \ldots \quad \ldots \quad (92)$$

$$C_1 = (f_2 - f_1)/4\pi f_1^2 Z_0 m_1 \quad \ldots \quad \ldots \quad (93)$$

$$L_2 = \frac{-Z_0}{\pi(f_2 - f_1)} \times \frac{1 - m_1^2}{4m_1} \quad \ldots \quad \ldots \quad (94)$$

$$C_2 = \frac{(f_2 - f_1)m_1}{(f_2^2 - m_1^2 f_1^2)\pi Z_0} \quad \ldots \quad \ldots \quad (95)$$

By multiplying (94) and (95) and substituting for L_2C_2 from (86), the value of m_1 is given by :—

$$m_1 = \sqrt{1 + \frac{(f_2/f_1)^2 - 1}{(f_r/f_1)^2 + 1}} \qquad .. \quad (96)$$

Example.

We shall take as a numerical example the case of a filter similar to the one considered in the case of the band pass filter without mutual inductance.

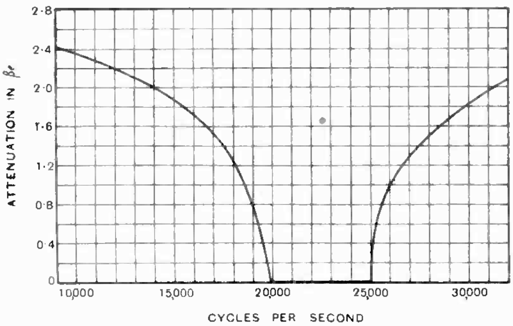


Fig. 41.—*Attenuation characteristic for band pass filter containing negative inductance.*

Assume that the lower and upper cut-off frequencies are respectively 20,000 and 25,000 cycles per second, and that the value of the series characteristic impedance at the mid-frequency is to be 600 ohms. Assume further that the value f_r is to be 30,000 cycles per second.

We have therefore that

$$f_1 = 20{,}000 \quad f_2 = 25{,}000$$
$$f_r = 30{,}000 \quad Z_0 = \quad 600$$

$\therefore$ from (96) $m_1 = 1.083$

Hence from (84) $L_1 = 0.0412$ henrys.

,, (89) $C_1 = 0.00153$ mfd.

,, (90) $L_2 = 0.00152$ henrys.

,, (91) $C_2 = 0.0184$ mfd.

The required filter is therefore as shown in Fig. 40(a), which is equivalent to the structure of Fig. 40(b).

If the sign of M had been negative, then it follows from page 316 that the structure would reduce to a band pass filter whose characteristics would be identical with those of the filter shown in Fig. 26.

The attenuation and phase constant characteristics for the above filter are obtained from equation (87) and these are shown in Figs. 41 and 42, respectively. The corresponding characteristics for the dissipative case could be obtained by the methods already indicated.

From Fig. 41 it is seen that in this case, as in the case of the low pass filter of Fig. 36(b), the attenuation is finite at all frequencies.

From Fig. 42 it is seen that the phase shift for this filter is the same at the cut-off frequencies as for the filter of Fig. 28, although the phase shift characteristic is of somewhat different character during the non-attenuating range. There is, of course, no change of 3.14 radians in the phase constant at 30,000 cycles per second, as there was in the case of the band pass filter without mutual inductance of positive sign.

Wave Filters Containing Mutual Inductance in General.

In the two cases of filters containing mutual inductance that have been considered, the attenuation characteristic is unique in that the attenuation is always finite. It must not be assumed, however, that all filters which contain mutual inductance (of either sign) never have infinite attenuation. To illustrate this point a few examples of filters which contain mutual inductance but which nevertheless have infinite attenuation are given n Fig. 43.

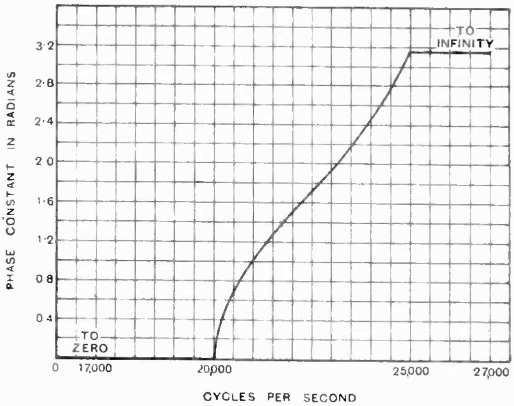


Fig. 42.—*Phase constant characteristic band pass filter containing negative inductance.*

Certain other characteristics peculiar to filters which contain negative inductance are illustrated in this figure. For example, Figs. 43 (a) and 43 (b) show filters which have two frequencies of infinite attenuation, located on one side of the pass band. The attenuation constant is, in general, finite at zero and infinite frequencies. Fig. 43 (c) shows a filter which has only one frequency of infinite attenuation, namely, at zero frequency. Finally, Fig. 43 (d) shows a filter which has only one frequency of infinite attenuation and the attenuation is finite at zero and infinite frequency.

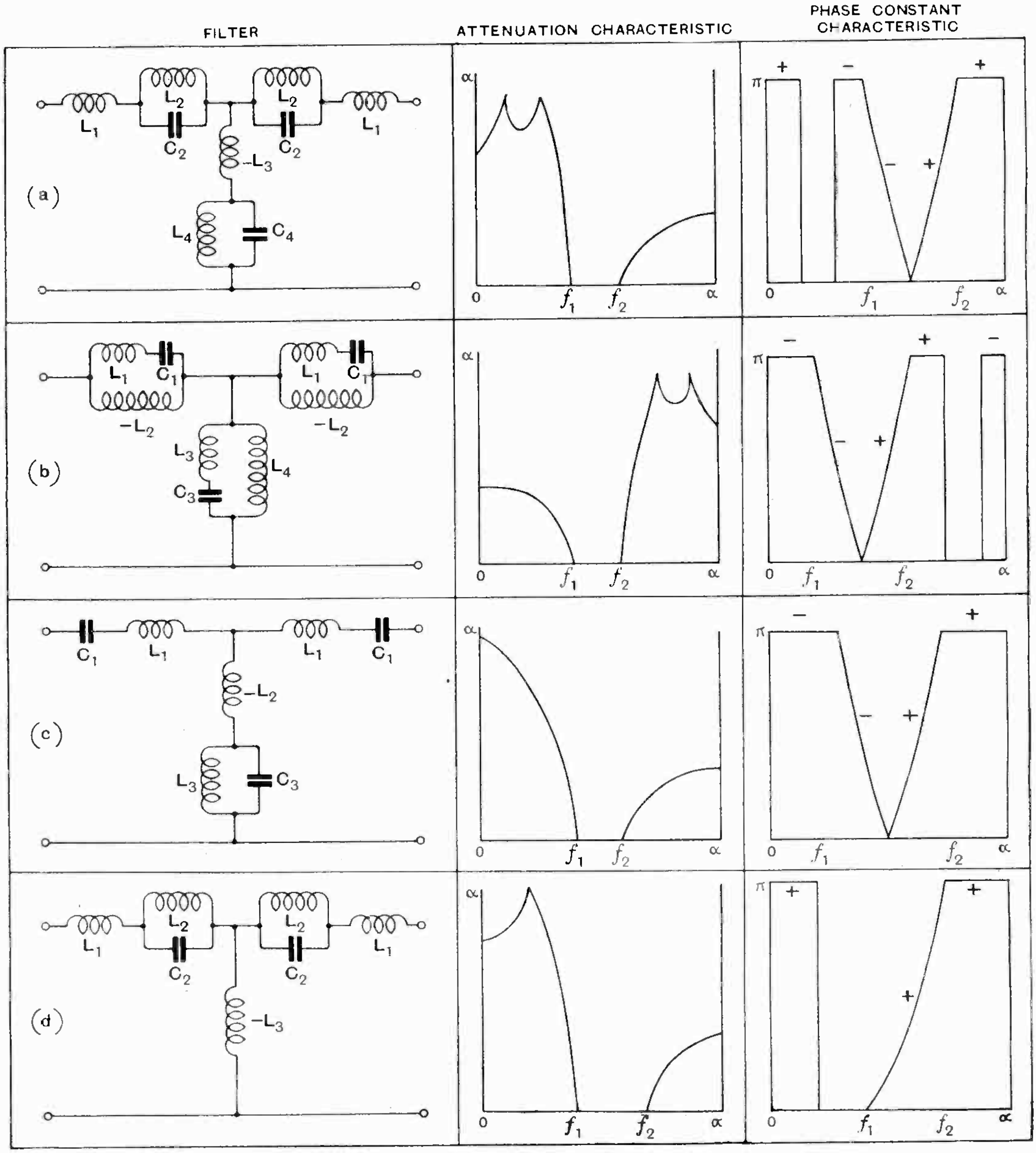


Fig. 43.—*The characteristics are given in a schematic form only, and no attempt is made at an accurate reproduction of the actual characteristic.*

Generally, the phase constant characteristics for filters containing negative inductance are similar to the corresponding filters which do not contain negative inductance, although the characteristics of the former within the pass bands are, in general, of a different character than those of the latter. The phase characteristics of the filters shown in Figs. 43 (a) and 43 (b) are unique, for band pass filters, in that the phase undergoes a change in sign within one attenuation band. Fig. 43 (d) shows a filter whose phase constant is of the same sign throughout the entire frequency range.

With respect to impedance characteristics, it is to be noted that these are in no way different for filters with and without negative inductance. Similar filters have the same series characteristic impedance in the two cases because they can be regarded as derivations of the same simple filter (see pages 317 and 319). This is a very important property as it permits composite filters (see below) to be formed which combine filters containing negative inductance with those which do not contain negative inductance.

(To be continued.)

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.

A "Synchronising Wave."

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

SIR,—Recent papers disclose the great importance of fixing the wavelengths of transmitting stations very accurately and of the difficulties encountered even when quartz crystals or tuning forks are used for the purpose. Modern methods of transmitting involving the suppression of the carrier wave and its re-introduction at the receiving end accentuate the difficulties, while interference among broadcast stations is of everyday occurrence.

It occurred to the writer that all such difficulties would immediately disappear if a long wavelength high power station were continuously to transmit a "standardising wave" of a certain fixed frequency. Every station in the world would use this wave to synchronise a master oscillation, a particular harmonic of which would be used to drive the transmitting valve system. In this way, even if the frequency of the standard wave did vary, all other waves would vary with it, and no ill effects would be observed. If one standardising wave were not sufficient to meet all requirements two or even more might be transmitted, the frequency of all, however, being determined by the same tuning fork.

Here at last is a use for Rugby!

E. MALLETT.

Relation between Electric and Magnetic Fields.

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

SIR,—I have read your timely editorial on "The relation between electric and magnetic fields" with much interest. It appears to me, however, that while you have assisted in clearing away one misconception you have helped to establish another, *i.e.*, that a space may be screened against the electric or the magnetic "component" of a wave.

I know that this viewpoint (or I would prefer to term it this nomenclature) has been in vogue for some time, particularly since the experimental work of Mr. Barfield in 1924. However, I quite fail to see that it rests on physical reality. Certainly a space may be screened from the results of the "vertical effect," but are we right in postulating that the "vertical effect" in the two arms of a frame aerial is due solely to the electric component of the wave? I think not. It is usually a "capacitative" mode of operation of the system which produces unwanted voltages at the receiver, these voltages being independent of the direction of the frame; but may I suggest that it is equally correct to say that it is produced by the magnetic "component" of the wave. As stated in your editorial, "it is immaterial whether we regard the e.m.f. induced in the aerial (whether in the capacitative system or the inductive frame system—to coin terms: E.H.R.G.) as due to the vertical electric field or the horizontal magnetic field. They are simply two ways of looking at the same thing." Undoubtedly it is possible to neutralise a receiver from the effects of this mode of operation of the receiving system (commonly called the vertical effect). The receiver is thus no longer affected by any currents except those circulating in the frame aerial; and these latter, note, may be considered as due to the electric "component" of the wave cutting the two vertical sides of the frame with a slight phase difference. In other words, there is still an electric "component" in the space which is claimed to be screened therefrom!

I note that you admit the presence of these "electric forces" in the screened space, but only as resultant effects of the magnetic flux. I must say, however, that I fail to understand on what grounds we are justified in viewing the current in a screened frame as *primarily* due to the magnetic "component" of the wave, rather than to the electric "component."

True, we must consider the resultant effect of the radiation from the screen and the received wave, but this is itself the means whereby the receiving system is neutralised as regards the undesired mode of operation (or vibration) be that mode of operation capacitative to earth, say, or circulative in the inductive frame aerial.

Your final paragraph is so insistent on the fact that the two "components," so-called, cannot be viewed as in any way physically distinct—being only convenient viewpoints of a common wave—that I am further perplexed at your explanation of screening. Why not view the problem with "two eyes" all the time, and replace our misleading terminology—using such terms as "neutralising" and "modes of operation of the system" instead of "screening" and "components of the wave"?

E. H. R. GREEN.

Wellington, New Zealand.

On 30th April we sent the following letter to Mr. Green:

We thank you for your interesting letter of 17th March. A letter on somewhat similar lines from Mr. Burnett is being published in the May number, and in the Editorial we are dealing with the subject in some detail. The difference between us is largely but not entirely one of nomenclature. As you say, the vertical effect, whether in an open aerial or coil may be equally well regarded as due to the magnetic component of the wave, *assuming that the aerial or coil is exposed to the action of the wave.* It is merely a matter of convenience to refer to the electric field in the case of an open aerial and to the magnetic field in the case of the coil, although in the latter case many prefer to consider the two electric fields slightly out of phase. In the screened space, one can assume either that the electric field of the wave is still there, but neutralised by the superposition of another vertical electric field produced by the screen, or that the space is completely screened against the former field. In either case one still has the spatial variation or curl of the electric field within the screened space, in one case regarded as an unneutralised remnant of the original field, and in the other, as due to the magnetic field; as we said in the Editorial, the electric field in the screened space is that associated with any alternating magnetic flux. We think, however, that there is some justification for regarding the current in a screened frame as due *primarily* to the magnetic component of the wave, which passes horizontally through the space between a metal roof and floor, and is supported by external magnetomotive forces. This appears to us to be preferable to the assumption that some of the vertical electric field gets through the metal roof and floor, and unless it does, one is hardly justified in calling it the electric field of the wave, or in referring at all to a wave within the screened space.

G.W.O.H.

"Threshold Howl."

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

SIR,—We have been much interested in Mr. Alder's article on "Threshold Howl" in the April issue of *E.W. & W.E.* and in Mr. Scroggie's letter on this subject in the May issue. They have a very close bearing on the phenomenon of "Interrupted Triode Oscillations" which we have discussed in the current number of the *Proc. Camb. Phil. Soc.* [XXVI., 236 (1930)]. In this paper we have shown that periodic cessation of high frequency oscillations can be obtained when an oscillating valve circuit is coupled to a circuit containing a non-linear resistance (a rectifier) and a piece of apparatus having a time-constant. Oscillographic investigations have shown that the circuit works as follows. The non-linear resistance rectifies the oscillatory e.m.f., but the time-constant apparatus delays the growth of the rectified current. During the establishment of this current the working point moves along the rectifier characteristic, thus causing a change in the effective H.F. resistance of the rectifier. Because of the coupling, this entails a change in the effective resistance of the main oscillating circuit, which change is sufficient to stop the oscillations.

The circuit described by Mr. Scroggie, in which a tuned anode high frequency amplifier is followed by a rectifier (presumably with a transformer or telephones in its anode circuit) is identical with that which led us to the investigation of this phenomenon. It appears that in this case the "howl" is produced in the following way. The H.F. amplifier is in an oscillating condition, due to stray magnetic or capacity coupling between its grid and anode circuits. It thus plays the part of an oscillating triode coupled to a circuit containing a rectifier and a time constant device, as described above. The fact that, in Mr. Scroggie's case, the howl ceased when screening was complete, indicates that the oscillations in the H.F. amplifier were due to stray magnetic coupling. This explanation is also in keeping with the fact that the howl could be started and stopped by altering the relative positions of the input and output H.F. circuits.

Mr. Alder's explanation of the more ordinary threshold howl may be thought of in the same way, if we consider the triode of his circuits (Figs. 1 and 3 of his paper) to act simultaneously as the generator of oscillations, and as the rectifying device coupled to the oscillatory circuit.

J. A. RATCLIFFE.
L. G. VEDY.

Cavendish Laboratory,
Cambridge.
8th May, 1930.

Books Received.

ELECTRICAL WIRING AND CONTRACTING. Vol. IV. Edited by H. Marryat, M.I.E.E., M.I.Mech.E.

Comprising: Motor Starters and Regulators, Private Power Plant, Electric Signs and Estimating, the sections being written respectively by H. Cotton, G. A. Wedge, and H. R. Taunton. Published by Sir Isaac Pitman & Sons, Ltd., London. Price 6s. net.

A FIRST ELECTRICAL THEORY FOR SCHOOLS. By H. W. Heckstall-Smith, M.A.

A text-book covering the School Certificate, Matriculation and 1st M.B. Examinations, including Electrostatics, Electromagnetism, Electrolysis, Dynamos and Motors, Discharge Tubes, Valves, X-rays, Radioactivity, etc. Pp. 372, with 135 illustrations and diagrams. Published by J. M. Dent & Sons, Ltd., London and Toronto. Price 4s. net.

A Wireless Broadcasting Transmitting Station for Dual Programme Service.

(Paper by P. P. Eckersley, M.I.E.E., and N. Ashbridge, B.Sc., read before the Wireless Section I.E.E., on 7th May, 1930.)

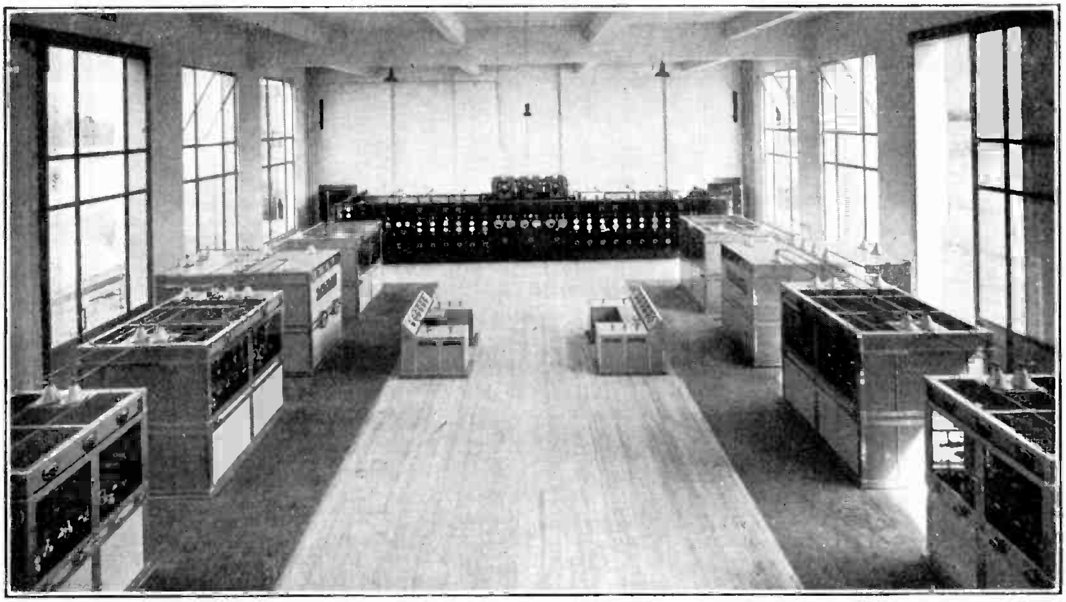
ABSTRACT.

THE paper provides a general description of the "twin" broadcasting station at Brookmans Park, near London, the first of the twin transmitting stations basic to the so-called "Regional Scheme" of the B.B.C. The general implications of the Regional Scheme are first reviewed, when the authors turn to discussion of the choice of site for this particular station. On review of the district to be served, it is stated that a northern location on the periphery of London seemed in all the circumstances to be the best. The site was additionally recommended inasmuch as the telephone cables were found to be most suitable in a northerly direction. Water, which is required at the maximum rate of 10,000 gallons per day for the cooling of power-valve anodes, was also available from the main supply.

A general description and block plan of the site are given. Before purchase the site was tested for its electrical properties as they have a bearing upon the aerial system. A 1 kw. mobile transmitter was erected on the site, and it appeared from the experiments made that the site behaved normally as regards effective height, etc. This transmitter served the further useful purpose of giving a forecast of the expected field-strength in and around the London area. A motor van with measuring apparatus travelled some 10,000 miles round the site and plotted field-strength contours from the temporary transmitter.

It was thought advisable to install a self-contained generating plant and not to use public supply mains. It is interesting to note that "shut-downs" of considerable duration have frequently been due to failure of the public supply mains.

Diesel-engine power units were accordingly chosen, generating direct current, so that a storage battery could be used. The station building is so planned that there is a progressive evolution from the crude oil which feeds the Diesel engines to the transmitters which supply the aerials with modulated high-frequency currents. The power-house contains four Diesel engines each driving a d.c. generator of 200 kw. output at 200–260 volts. The output of the generators is floated across a 2,000-ampere-hour battery. Three engines running are thus sufficient for the normal maximum load of about 514 kw., the fourth being in reserve. The main power load is 200 kw. to each of the main high-tension motor generators and 35 kw. to each of the main motor generators giving 22 volts output for the lighting of all filaments except that of the master oscillator. Grid voltages are also derived from motor generator sets, while another set supplies anode power to the master oscillator,



A general view of the Brookmans Park station interior.

separator and modulated amplifier on the low-power section of the transmitter.

In a previous paper† one of the authors discussed the comparison of h.t. machine as against valve rectification for anode supply, and expressed a preference for the h.t. generator. The generators used for the new station are therefore of some interest, and a lengthy description of them is given in the paper. The machines were specially made for the purpose by the English Electric Coy., and incorporate features to give protection against the so-called "Rocky Point" effect of "flash-over," which has been described by various authors in connection with water-cooled valves. One protective feature is that the machines are heavily decompounded with their own current, while smoothing chokes in series help to keep down sudden increase of current due to "flash-over." Details of load characteristics with various degrees of decompounding are given in the paper. Three of these machines are installed, each enclosed in a separate iron grille which cannot be opened without closing down the machine. The main smoothing chokes, one for each machine, are of 5 henrys inductance and are also housed in these compartments.

The various other motor generators already referred to are also described in the paper.

The authors then proceed to describe the Transmitter-Room equipment. It is stated in the paper that it was not thought necessary to include a full description of the transmitters because otherwise the paper would be too long, but it is anticipated that a further paper will be written on this subject.

The transmitter room is 74 ft. long and 60 ft. wide. The two transmitters face one another, leaving a large space in the middle of the room. The switchboard is at right-angles to both transmitters. A vault runs under each transmitter so that there is a corridor-shaped space below transmitters and switchboard for accommodation of wiring, etc.

The paper by one of the authors, already cited, outlined the reasons for the adoption by the B.B.C. of what is known as "low power" rather than "high power" modulation for the transmitters themselves.

† *Cf. Journal I.E.E.*, 1928, Vol. 66, p. 501; and *E.W. & W.E.*, 1928, Vol. 5, p. 189.

Each transmitter proper contains four units as follows:—

Unit *A* for the production of modulated and relatively low-power oscillations of sensibly constant mid (carrier) frequency.

Unit *B* increases the power of these oscillations.

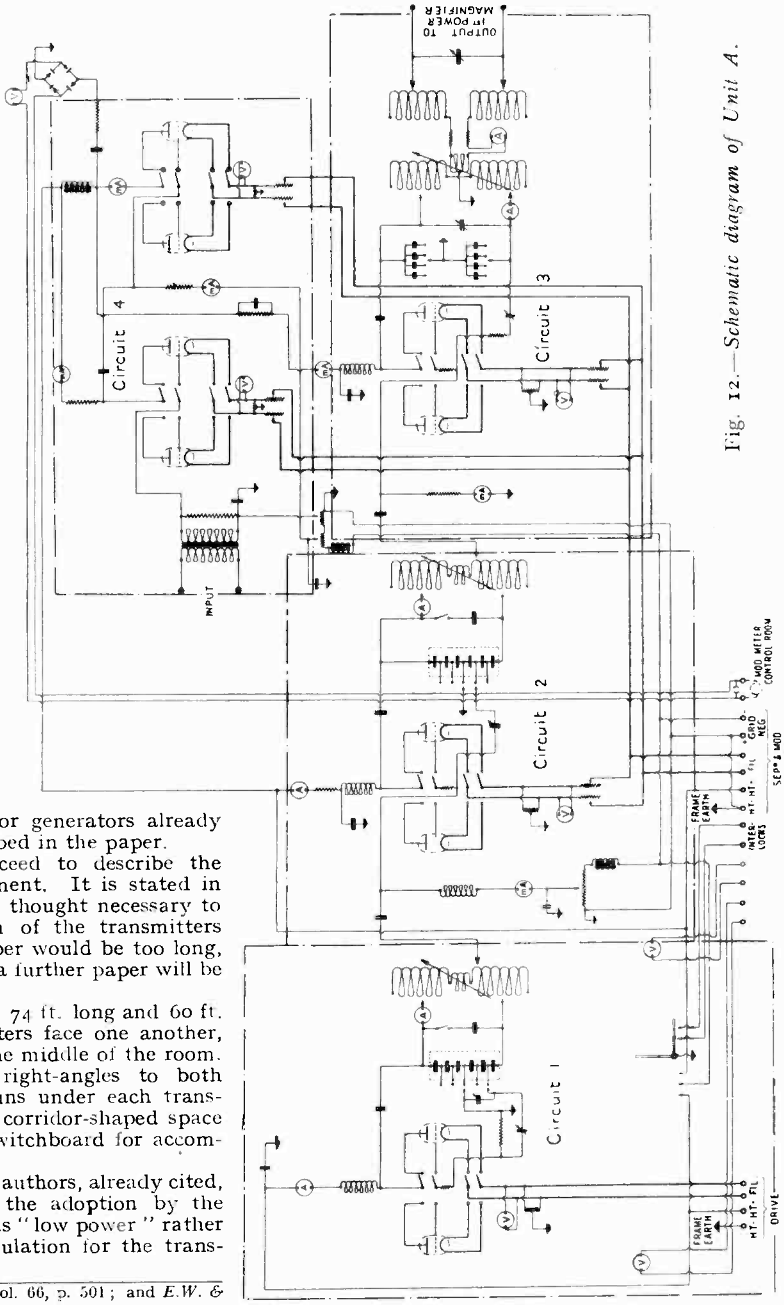


Fig. 12.—*Schematic diagram of Unit A.*

Units *C* and *D* comprise apparatus which increases the output of the *B* unit to the value required for radiation.

Unit *A* contains four separate shielded circuits, the drive, separator, modulated oscillation amplifier and modulator. The connections of this unit are shown in Fig. 12.* Circuit 1 is a conventional valve generator, developing the carrier frequency. To prevent change of frequency, the drive circuit works into the constant load of the "separator," Circuit 2. The output of Circuit 2 energises Circuit 3, the modulated oscillation generator. This latter acts to magnify the oscillations passed on to it from the separator. The modulator, Circuit 4, follows the conventional choke or Heising system and modulates the intensity of these oscillations in sympathy with the low-frequency currents of modulation fed to it from the local control room.

The output from unit *A* is passed to unit *B*, which contains a push-pull connection of two water-cooled valves, designed to magnify the modulated high-frequency currents fed to it from unit *A*. The output of unit *B* is passed on to the identical units C_1 and C_2. These contain banks of water-cooled valves, each unit taking one side of a push-pull circuit. Unit *D* contains a closed circuit consisting of inductance and capacity, which is set into full-power oscillation by connection to the valves in units C_1 and C_2. Arrangements are made for neutrodyning the various circuits in the *B* and *C* units. The output of the last stage is passed to the aerials via feeder lines.

The transmitters were designed by the B.B.C. and constructed by Marconi's Wireless Telegraph Coy., Ltd. They are based on data obtained by the design and operation of Daventry Experimental, 5GB. Particular attention has been paid to combining accessibility with safety of operating personnel. Great precautions have also been taken to ensure reliability of performance. To this end, where there is one particular valve which, if it failed, would put the rest of the apparatus out of action, arrangements have been made for throwing in a spare valve without cutting off the power from the particular unit. If, for instance, either valve in the *B* unit fails, the operator of the station can bring a new valve into operation in 15 seconds or less. A switch is arranged so that when the spare valve filament is brought up to full brightness, a spring switch is released which connects the anode and grid of the spare valve. The method of quick valve replacement is applied to all units.

Each transmitter has a remote-control table in the centre of the room, so that the engineer sitting at this desk may keep a continuous watch on the various measuring instruments located not only on the set but also immediately to his eyes on the table itself.

The actual valve-cooling water is fed into the valves by gravity from a roof tank. The conventional method is used of running the water into the valves through a coil of large rubber pipe and of forming an exit for the water in the same manner. There is, with this system, some d.c. loss due to conduction of current to earth via the water, and there is also some loss due to high frequency currents feeding into the pipes as a capacity to earth. Neither trouble is, however, serious.

Four masts are provided, placed as far as possible from each other and from the building. The Air Ministry considered that, in view of the amount of flying in the district, it would be dangerous to build masts higher than 200ft. Each aerial is therefore supported on two masts 600ft. apart and with a distance of 900ft. between aerials. The masts are insulated from earth chiefly to give flexibility of adjustment so that a mast can be insulated or earthed, depending upon the wavelength used and the amount of distortion of the polar diagram found in practice. An example is shown in Fig. 18, which shows the present polar diagram of the 261-metre transmitter. The diagram can be varied by different methods of earthing the masts. Work on this problem is still proceeding, but the conditions of working at the time of writing the paper are as shown. The aerial power in this case was 45 kw.

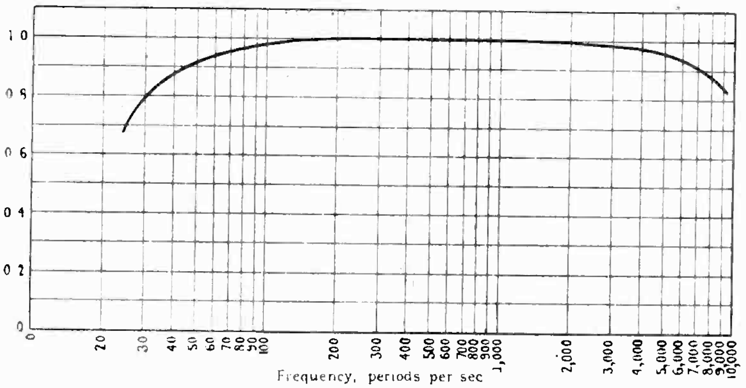


Fig. 17.—*Overall response curve of* 356 *m. transmission.*

A small room has been equipped with the necessary apparatus for taking definite measurements of the performance of either transmitter. The intention is that such measurements should be made once a week, or more often, if necessary.

Five telephone cables come in from Savoy Hill, four being unloaded and suitable for music transmission, while the fifth is lightly loaded and is intended mainly for communication purposes. Two control rooms are provided to house the necessary amplifiers, check receiver and switchgear for controlling and checking the audio-frequency input to the transmitters. In each room

* The authors' original figure numbers are adhered to throughout this abstract.

the actual control position consists of a small mahogany desk upon which are mounted the volume-control potentiometers, monitoring meters, operating keys, etc. Each control room is provided with a single "A" and two "B" amplifiers. The former is used in connection with the local studio equipment, which is provided for emergency or test purposes. Normally, the output of a "B" amplifier is connected to the input of the transmitter, while its input is derived from the incoming cable line from the studio at Savoy Hill. Each

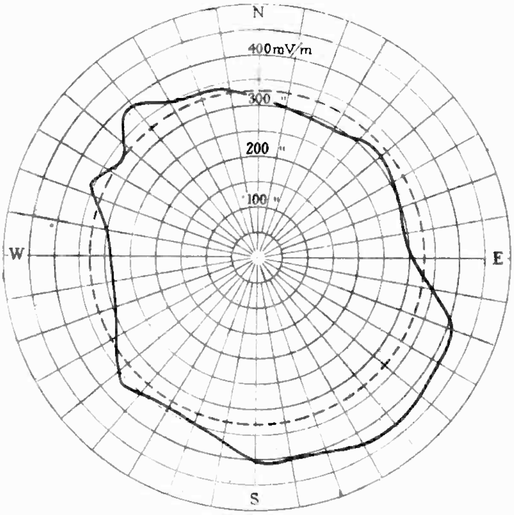


Fig. 18.—*Present polar diagram of 261 m. transmitter.*

control room is also provided with a high-quality and high-selectivity receiver for checking the transmission by wireless reception.

It is stated that during the design stage, it was anticipated that some difficulty would be experienced from "cross-talk" between the two programmes. There was, of course, the possibility that there might be mutual high-frequency effects between the transmitters and between the feeder lines and aerial system, but this effect was found to be absent to a rather remarkable extent.

The overall frequency response curve of the 356-m. transmitter, including the "B" amplifier, transmitter and aerial, is shown in Fig. 17. The response of the transmitter to varying amplitudes of audio-frequency input at a given frequency is sensibly flat up to full 100 per cent. modulation.

Discussion.

The discussion which followed the reading of the paper was relatively short.

COL. A. S. ANGWIN, who spoke first, noted some essential differences between the practice of Brookmans Park and that for commercial point-to-point working. A striking feature was the suggestion of great finality about the station. This finality had reflected on the matter of power supply, where their (Post Office) experience had been different on the comparison of mains supply or independent generation. He also questioned the statement of lengthy breakdowns due to failure of mains supply. Discussing the insertion of guard resistances in the anodes, he asked how much they could afford to waste in this way as compared with valve life. With reference to the frequency stability (quoted as 300 cycles on the 261.4 m. wave), he pointed out that the C.C.I. Radio hoped shortly to bring this down to 50 cycles. Was it then proposed to control by means of oscillator or tuning fork ?

MR. J. E. CALVERLEY (who designed the H.T. motor generators) discussed various points in the design of these machines. Those at Brookmans Park represented great advances over the first of such machines, designed twenty years ago for wireless telegraph stations. He was interested to know how much more development of the H.T. generator would be needed in the next few years. The limit of this type of machine was not yet in sight.

MR. E. H. SHAUGHNESSY was interested to note that the B.B.C. had reverted to the conventional closed water system for valve cooling, as at Rugby. He was also glad to know that H.T. machines were being used. At Rugby each machine gave 250 kw. on each commutator at 3,000 v., so that the two machines gave 6,000 v.

MR. P. K. TURNER referred to the very satisfactory audio-frequency response curve, suggesting it would have been better shown in transmission units. He also asked what is the mean modulation when something consistent in volume is being sent out.

Replying to the discussion, MR. P. P. ECKERSLEY said they did not think it likely that there would be any changes in the immediate future. As regards anode resistances, it was hoped that these might be removed with improvements in the valves. The closed circuit, as master drive, could no doubt be made better than the 300 cycles quoted, possibly between 100 and 200, but the fork could certainly do within 50 cycles as their experience of common-wavelength working had shown.

MR. N. ASHBRIDGE dealt with the matter of cost of supply. Their cost per unit appeared to be just about equal to that of purchase from supply authority. This represented an actual gain since an independent and self-contained transmitter would still have been necessary as a stand-by.

On the motion of the Chairman (Capt. C. E. Kennedy-Purvis, R.N.) the authors were cordially thanked for their paper.

This meeting terminated the session of the Wireless Section.

Abstracts and References.

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PROPAGATION OF WAVES.

EINE METHODE ZUR UNTERSUCHUNG VON ECHOS BEI DER AUSBREITUNG ELEKTROMAGNETISCHER WELLEN IN DER ATMOSPHÄRE (A Method of Investigation of Echoes in the Propagation of Electromagnetic Waves in the Atmosphere).—G. Goubau. (*Physik. Zeitschr.*, 1st April, 1930, Vol. 31, No. 7, pp. 333–334.)

A short account of a method for the investigation of atmospheric echoes of wireless signals in the form of short pulses of radio-frequency energy. The emitter consists of a regulated oscillator ("Steuersender") and a neutralised high-frequency amplifier. The short impulses, which serve to modulate the oscillations from the emitter, are produced by means of a highly saturated iron-cored choke, connected in a condenser circuit which is fed from a 500-period generator. The grids of the high-frequency amplifier valves have a negative bias of sufficient magnitude to prevent anode current (and therefore antenna current) flowing when the system is not oscillating. The choke is connected in the grid lead, and with sufficiently large negative grid bias the anode current can be prevented from flowing except in short periods of less than 10^{-5} seconds, the wavelength generated being about 500 metres. The form of the antenna current is shown in a photograph taken with a Braun tube (Fig. 1). In order to obtain a stationary image on the screen of the tube a horizontal sinusoidal deflection [time base] is produced by the magnetic action of the current from a condenser circuit which was also fed from a 500-period generator. The vertical deflection, which gives the form of the antenna current, was produced electrostatically by direct induction from the antenna.

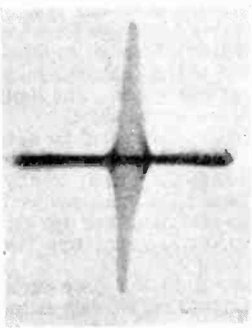


Fig. 1.

The first part of the receiver is designed to receive, amplify and detect the signals as far as possible without broadening them. The second part of the receiver consists of a valve generator, which provides the 500-period current for the magnetic deflection in the Braun tube. This must be synchronised with the fundamental period of the impulse from the emitter and this synchronisation is effected by receiving the signals, amplifying them and using them to guide the 500-period valve generator.

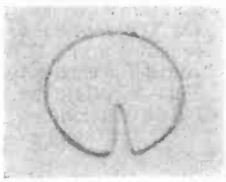


Fig. 2.

A photograph is shown of the pattern on the screen of the Braun tube when only the signal is received and a circular rotating magnetic field is used to provide the time-base (Fig. 2). Photographs with an elliptical rotating magnetic field showing the presence of one (Fig. 3) and two (Fig. 4) echoes are also given; they were taken at a distance of 50 km. from the emitter and show that the resolving power of the apparatus is sufficient to separate two signals whose path difference is approximately 30 km.

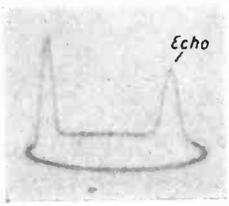


Fig. 3.

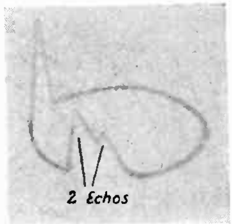


Fig. 4.

The apparatus is said to be simple and easily handled; aperiodic signals such as atmospherics are not observed so long as they remain below a certain limit. The time of exposure required is about 0.5 sec. and during this time the echoes are, in general, constant.

IONIZATION IN THE UPPER ATMOSPHERE; VARIATION WITH LONGITUDE.—E. O. Hulbert. (*Phys. Review*, Feb. 1st, 1930, Series 2, Vol. 35, No. 3, pp. 240–247.)

Author's abstract:—Continuing a former paper (*Phys. Rev.*, Vol. 34, p. 1167, 1929; *cf.* 1929 Abstracts, p. 627) the present paper gives theoretical calculations of the changes in the ionization in the upper atmosphere with longitude. The electrical conductivity of the upper atmosphere is about 1.4×10^{-5} at noon equinox at the equator and an order of magnitude less at night. The maximum density of electrons y_m varies with the latitude θ and longitude ψ, measured from noon equinox at the equator according to $y_m = 3.14 \times 10^5 \cos\theta$ $(0.18 \sin\psi + \cos\psi)$ for the daylight hours. At night the expression is more complex. The values of y_m yield skip distances of short wireless waves roughly in accord with observation in the day but somewhat too great at night. The theory puts the shortest skip distance at 40 minutes past noon and observation in temperate zones gives 2 p.m.; the agreement is good but not perfect.

SUR LES PROPRIÉTÉS DES GAZ IONISÉS DANS LES CHAMPS ÉLECTROMAGNÉTIQUES DE HAUTE FRÉQUENCE (The Properties of Ionised Gases in High Frequency Electromagnetic Fields).—C. Gutton. (*Comptes Rendus*, 7th April, 1930, Vol. 190, pp. 844–847.)

In his experiments on this subject, H. Gutton placed a glass tube, containing the rarefied gas, in the space between two copper plates which served as the plates of a condenser supplied with high frequency. His results led him to conclude the existence of an oscillation period for the electrons and of resonance phenomena when the frequency of the field coincided with that of these oscillations: *see* many past abstracts. Pedersen, on the other hand, explained Gutton's results along the lines of Eccles' theory, by regarding his plates and tube as two condensers in series, one having air as dielectric and the other having the ionised gas. When the gas is sufficiently ionised it has a negative dielectric constant and behaves as an inductance (*cf.* Pedersen, March Abstracts, p. 152). Thus the plates and tube are equivalent to a circuit of inductance and capacity, and it was the resonance of this circuit which Gutton observed.

If this view-point were correct, the resonant point should depend, within wide limits, on the distance between the plates and the tube. Gutton did not notice any influence of the dimensions of his apparatus on the value of ionisation corresponding to a given frequency. The present writer has now investigated the resonance ionisation values for varying distances between plates and tube. With a 2.76 m. wave, *variations of distance from 2 to 12 mm. caused no change in the resonance ionisation.* "This remains independent of the dimensions of the apparatus, and is, in very fact, due to a period of oscillation of the electrons of the gas."

In the course of these tests, the writer was able to obtain evidence of this resonance by a more direct process, not involving the capacity of a condenser. A valve oscillator circuit was so oriented that its electric field was parallel to the axis of the tube. Starting with a low ionisation, the conductivity C_0 was measured, the oscillator set going and the new conductivity C measured. The procedure was then repeated for increasing values of C_0. For a very well-defined value of C_0, the oscillations produced a sudden increase of conductivity and of luminosity. The conductivity *after* the sudden increase was the same as that which, in the previous experiments, corresponded to resonance. The experiment was repeated for varying distances of the nearest part of the oscillator circuit from the tube.

The writer explains the result as follows:—as, with increasing ionisation, the period of the electronic oscillations approaches the resonant period, the amplitude of these oscillations increases: this produces an increased ionisation, which in its turn approaches resonance. It is only when this last is reached that a stable condition can be established. The phenomenon can be demonstrated in various ways:—thus if the tube, in the neighbourhood of the oscillator, has its ionisation slowly increased, it is found that as the resonant point is passed through, the current in the oscillator circuit drops—the tube absorbs the energy like a tuned circuit.

"All these results confirm the explanation given by H. Gutton to his researches. As he has shown, the resonance phenomena intervene in the propagation of waves in the upper atmosphere and explain many of the facts ascertained by radio-telegraph workers. They necessitate a modification of the Eccles formula and the theories arising from it."

DIE ABSORPTION DES WELLENZUGES IM DIELEKTRIKUM (The Absorption of a Wave Train in a Dielectric).—G. Kreutzer. (*Zeitschr. f. Phys.*, 18th March, 1930, Vol. 60, No. 11/12, pp. 825–844.)

A theoretical investigation of the absorption of a finite sinusoidal electromagnetic signal—a wave train—on its entry into a dispersive and absorptive medium. The absorption coefficient is shown to differ markedly from the value given by classical Optics; this agrees with the practical results of other workers (*e.g.*, Colley). The character of these discrepancies is examined, also the dependence of the absorption on the depth of penetration, on the frequency, and on the length of the train.

Results may be summed up as follows:—(1) The absorption constant is not constant for a given wave train, but varies with the depth of penetration. (2) The constant corresponding to a definite depth is *smaller* than that given by classical theory, for frequencies in the neighbourhood of the natural frequencies of the molecular resonators; and *greater*, for very small and very large frequencies. (3) The curve showing the change with frequency of the absorption constant is similar to a classical absorption curve with one maximum. The displacement of the maximum, if it exists, can only be very unimportant. (4) For short trains the departure from the classical values amounts to several per cent.; thus it is 5.3 per cent. for a train of 6 complete waves, and a rapid fall of absorption to zero seems suggested for still shorter trains.

The writer's theoretical results are confirmed by tests on ethyl alcohol.

WORLD WIDE COMMUNICATIONS WITH SHORT WIRELESS WAVES.—T. L. Eckersley and K. W. Tremellen. (*Marconi Review*, Feb., 1930, pp. 1–17; abstract in *World Engineering Congress Abstracts*, 1929, Paper 124.)

(1) A summary of modern transmission theory: the use of Shadow Charts and Map: direction finding and scattering. (2) Experimental results obtained from a 12-months' interception of short wave wireless signals: intensity curves (N. York, Melbourne, Cape Town): effect of light and dark: quick echoes: signal strength within the skip: magnetic storms, sun spots and fading—"the services appear to be affected [by fading] in a degree proportional to the nearness of their paths to the magnetic poles, where magnetic storm effects are most intense." (3) Practical application of the results obtained from the above to the projection of new services.

SHORT WAVE RADIO COMMUNICATION.—T. Nakagami. (*World Engineering Congress Abstracts*, 1929, Paper 65.)

This paper was referred to in April Abstracts, p. 207. Good communication has been maintained from Osaka to Geltow since 1927, by using two independent transmitters of different frequencies, manipulated by a common key; signals were received at Geltow by selecting the better wave or by combining both waves. For economic reasons this arrangement was replaced by a crystal-controlled transmitter with two tuned circuits in the plate circuit of the power amplifier valve, these circuits being adjusted to resonate to two suitable harmonics of the crystal frequency.

The writer then deals with fading elimination by (*a*) combinations of vertical and horizontal aerials, and (*b*) spaced aerials. Instead of heavily shielding the separate receivers, or placing them at a distance, the writer uses a method by which any desired number of receiving sets are fed by *one common heterodyne oscillator through one-way coupling valve units.* No troublesome interferences are experienced during the adjustment or working of the set. Another method is to use superheterodyne receivers whose intermediate frequencies are chosen so as to have a different band, with a few kilocycles separation, on successive receivers.

Finally the writer deals with the alternative use of a large single aerial and one receiver, which will generally give a useful signal in spite of fading, etc. But in this case it is essential, at any rate for high-speed working, to use an amplitude limiter.

METEOROLOGICAL INFLUENCES ON LONG-DISTANCE, LONG-WAVE RECEPTION.—E. Yokoyama and T. Nakai. (*World Engineering Congress Abstracts*, 1929, Paper 386.)

Summarised results:—(1) The received field intensity was less affected by the meteorological elements round the transmitting stations than by those round the receiving station. (2) Field intensities for both daylight and night reception varied inversely with the changes of atmospheric temperature and absolute humidity on the receiving side—in agreement with the daylight results of Austin and Minohara. (3) The intensity/pressure relation was not found to be so apparent as in the case of (2), though in the monthly average variation the field intensity seemed to have a direct relation with atmospheric pressure in summer, and an inverse relation in winter. (4) The influence of weather on the field intensity was found to be still less clear than in the cases of the three above-mentioned meteorological elements.

THE VARIATION OF THE RESIDUAL IONIZATION WITH PRESSURE AT DIFFERENT ALTITUDES, AND ITS RELATION TO THE COSMIC RADIATION.—W. F. G. Swann. (*Journ. Franklin Inst.*, Feb., 1930, Vol. 209, No. 2, pp. 151–200.)

REFLECTIE VAN ELECTROMAGNETISCHE GOLVEN AAN MEDIA MET VERANDERLIJKE DIËLECTRISCHE CONSTANTE (Reflection of Electromagnetic Waves by Media with Variable Dielectric Constant).—G. J. Elias and C. Th. F. van der Wijck. (*Tijdschrift Nederlandsch Radiogenootschap*, March, 1930, Vol. 4, No. 4, pp. 79–85.)

A mathematical study of the Maxwellian theory of the reflection of electromagnetic waves by a medium whose dielectric constant ϵ is given by

$$\epsilon = e^{-kz},\ z > 0;\ \epsilon = 1,\ z < 0,$$

while the electrical conductivity $g = 0$ and the permeability $\mu = 1$. The problem is reduced to the solution of a differential equation of Bessel's form and it is found that the amplitude of the reflected wave is equal to that of the incident wave. An expression is given for the phase difference of the two waves.

REFLECTIE VAN ELECTROMAGNETISCHE GOLVEN AAN MEDIA MET VERANDERLIJK GELEIDINGSVERMOGEN EN DIËLECTRISCHE CONSTANTE (Reflection of Electromagnetic Waves by Media with Variable Conductivity and Dielectric Constant).—G. J. Elias. (*Tijdschrift Nederlandsch Radiogenootschap*, March, 1930, Vol. 4, No. 4, pp. 86–103.)

The method adopted is the same as in the foregoing paper (see above Abstract), the electrical conductivity g being now also assumed to vary according to the law $g = \frac{\omega}{4\pi} e^{kz}$. A solution is again obtained in terms of Bessel functions and expressions are found for the amplitudes and phases of the reflected and refracted waves in terms of those of the incident waves.

THE RELATION BETWEEN ELECTRIC AND MAGNETIC FIELDS.—C. R. Englund. (*E.W. & W.E.*, April, 1930, Vol. 7, pp. 204–205.)

A long letter questioning the accuracy of G.W.O.H.'s editorial on this subject (April Abstracts, p. 208), particularly the passages "ascribing E.M.F.s as due to magnetic fields" and speaking of "alternating fields of one kind without the presence of fields of the other kind." The writer recalls that while the open aerial operates on the electric field, the closed (loop) aerial acts on the rate of space change of electric field. "I know of no radio reception to date which has derived from the magnetic field component of the radiation; there is a possibility that some magnetostriction effect, or accessory action in high permeability alloys (permalloy) may make magnetic field reception possible some time; such apparatus would very likely be useful in studying non-transverse radiation fields such as the Zenneck-Sommerfeld 'ground wave' . . . Under no circumstances, in a stationary situation, can magnetic or electric fields vary *in any manner* without being accompanied by electric and magnetic fields respectively."

On p. 179, G.W.O.H. replies. He may have followed the usual convention of ascribing the induced E.M.F. in a coil to the changing magnetic field without going through the intermediate explanation of how the varying magnetic flux induces an electric field which acts upon the electrons, but of this he is quite unrepentant. His editorial clearly stated that although you may, by screening, alter the relation existing between the electric and magnetic fields in the wave outside the screen, you cannot have one field without the other inside the screen.

DIE SIGNALGESCHWINDIGKEIT EINER FREIEN ELEKTROMAGNETISCHEN WELLE IN EINEM BEWEGTEN MITTEL NACH DER THEORIE VON MINKOWSKI: NACH DEN ELEKTRODYNAMIKEN VON COHN, LORENTZ UND ABRAHAM (The Group Velocity of a Free Electromagnetic Wave in a Medium in Motion, according to Minkowski's theory: according to the Electrodynamics of Cohn, Lorentz and Abraham).—K. Uller. (*Ber. d. Oberhess. Ges. f. Natur- u. Heilkde, zu Giessen*, Vol. 12, 1928/1929, pp. 18–29 and 161–183: long abstracts in *Physik. Ber.* 15th Feb., 1930, Vol. 11, pp. 343–344.)

ÜBER DEN ZUSAMMENHANG ZWISCHEN INTENSITÄT UND ABLENKUNGSWINKEL BEI MOLEKULARER LICHTZERSTREUUNG (On the Connection between Intensity and Angle of Deflection in the Molecular Dispersion of Light).—G. I. Pokrowski. (*Zeitschr. f. Phys.*, 18th March, 1930, Vol. 60, No. 11/12, pp. 850–855.)

It is shown that in the case of light dispersion through great compressions (or rarefactions) in the dispersive medium, an asymmetrical distribution of the dispersed light—with respect to the angle of incidence—must ensue. This theoretical conclusion is compared with observations on dispersion in the atmosphere: satisfactory agreement is found.

SUR LE PROBLÈME DE LA SYNTHÈSE ASYMMETRIQUE, ET SUR LES ACTIONS COMBINÉES DE LA LUMIÈRE POLARISÉE ET D'UN CHAMP MAGNÉTIQUE SUR CERTAINES PLAQUES PHOTOGRAPHIQUES (The Problem of Asymmetrical Synthesis, and the Combined Actions of Polarised Light and a Magnetic Field on Certain Photographic Plates).—A. Cotton. (*Comptes Rendus*, No. 18, Vol. 189, pp. 657–660.)

In this note concerning the results of Zocher and Coper on the optically asymmetrical effects apparently produced on certain photographic plates by a circularly polarised ray of light, the writer refers to Lindmann's experiments with Hertzian waves passing through an insulating medium containing a large number of resonators, each consisting of a curl of copper wire shaped like the arc of a helix. Such a medium behaves, in its rotatory power and dichroism, exactly as solutions of double coloured tartrates behave to light rays.

SUR LA TRANSPARENCE DE LA BASSE ATMOSPHÈRE (On the Transparency of the Lower Atmosphere).—H. Buisson, G. Jausseran and P. Rouard. (*Comptes Rendus*, 31st March, 1930, Vol. 190, pp. 808–810.)

MÉSURES DIRECTES DE L'ABSORPTION ATMOSPHÉRIQUE (Direct Measurements of Atmospheric Absorption).—Link and Hugon. (*Comptes Rendus*, 31st March, 1930, Vol. 190, pp. 810–813.)

RECENT RESULTS IN THE REGION OF ULTRA-SHORT WAVES.—Hahnemann. (*See* under "Transmission.")

HERTZIAN AND INFRA-RED RAYS AS A MEANS OF COMMUNICATION.—F. Schröter. (*See* under "Transmission.")

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

LA NOUVELLE MÉTHODE DE SONDAGE ÉLECTROMAGNÉTIQUE VERTICAL ET QUASI-HORIZONTAL DE L'ATMOSPHÈRE (The New Method of Electromagnetic, Vertical and Quasi-horizontal Exploration of the Atmosphere).—J. Lugeon. (*Arch. sc. phys. et nat.*, Sept./Oct., 1929, Vol. 11, pp. 239–259: abstract in *Physik. Berichte*, 1st April, 1930, Vol. 11, p. 719, and in *Science Abstracts*, A, March, 1930, p. 314.)

For previous papers by the same author, see 1929 Abstracts, pp. 444 and 502. Beginning at sunrise, no sudden change in field (as shown by atmospherics) is to be observed, but as soon as the sun is high enough for its rays to be tangential to the highest ionised layer a sudden change in field is produced. These sudden changes occur every time the rays become tangential to an ionised layer, so that the state of the atmosphere at sunrise may thus be examined. From the results, an empirical evaluation of the inversion temperatures can be obtained. From quasi-horizontal testing, a measure of the latitude and longitude of the points of production of the meteorological disturbances can be found.

L'HIVER DE 1930 ET L'ACTIVITÉ SOLAIRE (The Winter 1929–1930 and Solar Activity).—H. Mémery. (*Comptes Rendus*, 31st March, 1930, Vol. 190, pp. 807–808.)

SPECTRUM OF THE SUNLIT AURORAL RAYS.—C. Störmer. (*Nature*, 1st March, 1930, Vol. 125, p. 305.)

Further investigation of the spectrum of sunlit auroral rays tends to strengthen the conclusions in the letter referred to in 1929 Abstracts, p. 569.

ÜBER BESTÄNDIGKEIT UND KOAGULATION VON NEBEL UND WOLKEN (On the Permanence and Coagulation of Mist and Clouds).—A. Wigand and E. Frankenberger. (*Physik. Zeitschr.*, 1st March, 1930, Vol. 31, No. 5, pp. 204–215.)

ZUR BLITZFORSCHUNG (On the Investigation of Lightning Discharges).—O. Prochnow. (*Physik. Zeitschr.*, 1st April, 1930, Vol. 31, No. 7, pp. 335–338.)

A defence of the authenticity of certain pictures of globular lightning in the author's book "Erdball und Weltall," Vol. II.

GLOBULAR LIGHTNING.—W. C. Reynolds. (*Nature*, 15th March, 1930, Vol. 125, p. 413.)

An account of a case of globular lightning inside a room in which it seems probable that both induction and stationary waves were concerned with the phenomena.

LIGHTNING FLASH ENERGY.—W. Feld. (Abstract in *Physik. Ber.*, 15th Feb., 1930, Vol. 11, p. 395.)

Observations on a kite wire melted by lightning led to an estimate of about 9,500,000 calories for the heat required to produce the effect.

LA MISE À LA TERRE DES PARATONNERRES (The Earthing of Lightning Conductors).—V. Schaffers. (*Comptes Rendus*, 17th March, 1930, Vol. 190, pp. 669–670.)

So far as its behaviour as an earth for a lightning conductor is concerned, a material should be tested by a condenser discharge rather than by (say) a bridge measurement of ohmic resistance. The writer's preliminary tests with a spark gap buried in turn in water and dry sand indicate that though damp earth is to be preferred to dry earth, there is not much to choose between the two, and it is more important to reduce the resistance and inductance of the path leading to earth.

THYRITE: A NEW MATERIAL FOR LIGHTNING ARRESTERS.—K. B. McEachron. (*Gen. Elec. Review*, Feb., 1930, Vol. 33, pp. 92–99.)

The full paper, a summary of which was dealt with in May Abstracts, p. 270.

LA CONCEPTION DE STEPHEN GRAY SUR L'IDENTITÉ DE LA FOUDRE ET DES ÉTINCELLES DES MACHINES ÉLECTRIQUES (The Suggestion of Stephen Gray as to the Identity of Lightning and the Sparks of Electrical Machines).—E. Mathias. (*Comptes Rendus*, 7th April, 1930, Vol. 190, pp. 847–849.)

The writer shows that the identity between lightning and the laboratory spark, although roughly correct, fails at close quarters. He quotes Walter's results on the structure of the spark from an induction coil, which may be put briefly as follows:—the spark is formed of two discharges, proceeding with different velocities in opposite directions. In the case of lightning, Walter found the same "preliminary" and "principal" discharges that he found in the induction coil spark; but in lightning the preliminary discharges *started always and only from the positive* pole.

Thus lightning, contrary to the artificial spark, has a definite sense; Simpson has shown that it always carries positive electricity only. The writer mentions that this failure of identity between the two phenomena accounts for Flammarion's observation that animals killed by electric spark decompose more quickly than those killed by lightning; in the former case "the animals are killed both by the positive spark and by the negative spark; there is a double destruction of the tissues."

PROPERTIES OF CIRCUITS.

AU SUJET DE LA MULTIPLICATION DES FRÉQUENCES PAR LES TRIODES (Frequency Multiplication by Triodes).—R. Mesny. (*L'Onde Élec.*, January, 1930, Vol. 9, pp. 18–22.)

Referring to Marique's method of calculating the working conditions in frequency-multiplying triode circuits (1929 Abstracts, p. 325), the present writer shows how the calculations may be shortened. Like Marique, he assumes rectilinear plate-current/grid-potential characteristics, and he considers only the case of frequency doubling.

THEORIE DER ZWEIELEKTRODENRÖHREN UND ERZEUGUNG ELEKTRISCHER SCHWINGUNGEN VON EXTRA NIEDRIGER FREQUENZ (The Theory of the Two-Electrode Valve and the Generation of Extra Low Frequencies).—Y. Ito. (*Zeitschr. f. Hochf. Tech.*, Feb., 1930, Vol. 35, pp. 67–75.)

This second part of the paper referred to in May Abstracts, p. 272, deals with the generation of oscillations. The reaction between the anode circuit and the heating circuit can be accomplished in various ways:—by an iron-cored transformer, by inductive voltage-dividing (potentiometer) connections, or even by a relay. The equation for self-excitation shows that with such a back-coupled diode the setting in of oscillation is always harsh; if the anode supply is made too high, this may easily burn out the valve.

Amplitude and frequency can be kept constant. The frequency obtainable is limited by the heat capacity of the filament. In the tests described, the highest frequency reached was 72 p.p.s. with the transformer reaction, but with the relay reaction a frequency of over 800 was obtained. The lowest frequency reached with either circuit was 0.05 p.p.s.

On p. 75 some errors in Part I are corrected.

MAXIMUM UNDISTORTED OUTPUT OF A TRIODE.—A. Forstmann. (Summary in *L'Onde Élec.*, Feb., 1930, Vol. 9, p. 13A.)

The writer considers that the usual calculated values are too low. "If the anode voltage and load impedance are increased simultaneously, with output transformers and a push-pull connection, the full power which the valve can dissipate can be reached." *Cf.* same writer, Abstracts, 1928, p. 343 and 1929, p. 148.

MAXIMUM POWER OUTPUT OF AMPLIFIERS.—M. v. Ardenne. (Short summary in *L'Onde Élec.*, Jan., 1930, Vol. 9, p. 5A.)

"Variations on a known theme . . . The author's calculations lead him to the following rule:—the power furnished without distortion is at its maximum one seventh or one twelfth of the power provided by the battery at rest."

APPLICATIONS OF THE METHOD OF ALIGNMENT TO REACTANCE COMPUTATIONS AND SIMPLE FILTER THEORY.—W. A. Barclay. (*E.W. & W.E.*, April, 1930, Vol. 7, pp. 180–189.)

Continuation of the paper referred to in April Abstracts, p. 210. The present instalment deals with single stage filters along the lines of the Alignment Method. "A filter must always be considered in combination with its working load, and what might be a 'high-pass' filter when used with a certain load might operate in an entirely different manner when used with a load of different type . . . The only safe plan is to draw out the curve of filtering effect over a range of frequencies. The arithmetical calculations involved in this work would normally be prohibitive; with the simplifications introduced by the use of the Alignment Principle, they become quite possible and even easy. There is great need, however, for a simple means of calculating the constants of a filter which shall cut off a certain band of frequencies when used with a given load. The writer must admit that so far the general solution of this problem has evaded him. But he has been able to provide the next best thing, *viz.*: a rapid means of estimating the performance of any given filter under given conditions, so that the action of different filters may be readily compared, and from the numerical results that filter selected which approximates most nearly to the desired effect."

In the next part it will be shown how the performance of a compound filter of several similar stages may be rapidly derived from that of a single stage.

NEGATIVE IMAGE IMPEDANCE: A HYPERBOLIC THEORY OF TRANSMITTING NETWORKS.—K. Nagai. (*World Engineering Congress Abstracts*, 1929, Paper 134: for the complete Paper, see *Tech. Rep. Tôhoku Univ.*, No. 1, Vol. 9, 1929, pp. 69–85 and plates.)

"To specify the characteristics of a 4-pole transmitting network, the author proposes to use a term, $\epsilon^{2\theta}$, where θ is the hyperbolic angle of the network. In a 4-pole transmitting network there are two image impedances at each end of the network. They differ in sign from each other, but their absolute values are equal. The correspondence of image impedances, Z_{01} and Z_{02}, is considered briefly and the frequency continuations of these impedances are studied, using the Riemann surface having two sheets. The expressions of image impedances, attentuation constant, phase constant, and are $\epsilon^{2\theta}$ derived in the general case and in dissymmetrical T and π lines. Furthermore the special case where each element is composed of pure reactances is studied, and the characteristic properties of such a network are described." The values of the various expressions, including the cut-off frequencies, in some of the simple cases are calculated and given in the form of tables.

SU UNA TEORIA DEI CIRCUITI RADDRIZZATORI (On a Theory of Rectifying Circuits).—G. Sacerdote. (*L'Elettrotec.*, 15th Nov., 1929, Vol. 16, No. 32, pp. 718–723.)

A theoretical investigation of the action of a rectifying circuit, under the assumption that the rectifying element consists of two ohmic resistances ρ_1 and ρ_2, the first inserted for positive values of the impressed E.M.F. and the second for negative values. The efficiencies of various circuits (Graetz bridge, monophase rectifier) are calculated. The case of a polarised rectifier is also considered.

EIN BEITRAG ZUR THEORIE DER RÜCKKOPPLUNGEN IN ZWEIDRAHTLEITUNGEN (Contribution to the Theory of Reaction in Two-Wire Lines).—W. Weinitschke. (*E.N.T.*, No. 10, Vol. 6, pp. 399–418.)

THE SUPERPOSITION OF STRONG AND WEAK FIELDS IN MAGNETIC MATERIALS: THE REGION OF VALIDITY OF THE RAYLEIGH-JORDAN RELATIONS.—Goldschmidt: Jordan. (*See* under "Subsid. App. and Materials.")

TRANSMISSION.

NEUERE RESULTATE AUF DEM GEBIETE DER ULTRA KURZEN WELLEN (Recent Results in the Region of Ultra-Short Waves).—W. Hahnemann. (*E.N.T.*, Jan., 1930, Vol. 7, No. 1, pp. 15–24.)

A description of recently developed apparatus and experimental results relating to the transmission of messages by ultra-short waves, principally in the region from 6 m. to 0.5 m. Emitters and receivers of waves about 3 m. in length can be used for steady communication over distances of 20 to 30 km., their height above the earth's surface being the factor determining the range. Further useful developments depend on the possibility of modulating the waves at very high frequencies and of concentrating them in narrow beams. Examples of the application of ultra-short waves to navigation and of the transmission of signals to great distances by means of relay towers are given. Pictures of ultra-short wave apparatus show the present state of development.

HERTZSCHE UND INFRAROTE STRAHLEN ALS NACHRICHTENMITTEL (Hertzian and Infra-Red Rays as a Means of Communication).—F. Schröter. (*E.N.T.*, Jan., 1930, Vol. 7, No. 1, pp. 1–14.)

A general account of the means of production, properties and use of "quasi-optical" or "ultra-short" waves of lengths between 8 m. and 0.7μ. Known methods of production are given in tabular form. Waves of length less than 1 m. are specially considered; methods of production of undamped waves by means of electron tubes (Barkhausen-Kurz oscillations) and of damped waves by means of spark discharges are described. Beam emission of very short, quasi-optical waves by means of paraboloidal reflectors, and receivers suitable for these wave-lengths, are shortly discussed. The application of the "optical path" transmission to telephony over short distances, and to navigation, is indicated.

The properties of infra-red rays are described; they may be used with advantage for signalling over short distances when fog is present.

INTEGRAPH SOLUTIONS OF ELECTRON ORBITS IN THE BARKHAUSEN-KURZ EFFECT.—F. W. Sears. (*Journ. Franklin Inst.*, April, 1930, Vol. 209, No. 4, pp. 459–472.)

Author's summary:—The Continuous Integraph has been used to trace the orbits of an electron oscillating within the filament-plate space of a three-electrode vacuum tube, such oscillations being presumably the origin of the Barkhausen-Kurz effect. The effects of space charge, initial velocity of emission, and amplitude of oscillations are considered. The results check and extend those of Kapzov found by other methods.

ULTRA SHORT RADIO WAVES.—W. H. Moore. (*Journ. Franklin Inst.*, April, 1930, Vol. 209, No. 4, pp. 473–483.)

An account of the known methods of producing radio waves of lengths of the order of one metre or less, including that of the magnetron vacuum tube. Frequency determination methods and the amount of power available are also discussed.

WIRELESS TELEPHONY BY MEANS OF ULTRA SHORT WAVES.—S. Chiba. (*World Engineering Congress Abstracts*, 1929, Paper 682.)

A Barkhausen-Kurz oscillator is used for generating 80 cm. waves. The Lecher wire system is connected at its current nodes to a number of radiating dipoles; or the French saw-tooth type of array can be used. In the writer's set the whole antenna system (with wire reflectors) measures less than 2in. × 1in. × 0.5in, and has a directive property of "remarkable sharpness." Modulation is by audio-frequency voltage applied to the plate circuit. A linear modulation characteristic is ensured by suitable plate potential applied by a potentiometer.

The same apparatus may be used for receiving, by decreasing the filament current till the oscillations, becoming weaker and weaker, reach a certain strength at which the triode becomes a very efficient detector (presumably regenerative). Further increase of sensitivity may be obtained by impressing a high frequency oscillation (*e.g.*, 1000 m. wavelength) on the plate, thus getting a super-regenerative effect.

With the system described, telephony can be carried out over several kilometres when no obstacles intervene: longer distances can be obtained by raising the stations higher above the ground. Except in front of the aerial, the radiated wave is weak and the speech distorted. Higher secrecy can be secured by using two aerial systems, radiating waves whose planes of polarisation are at right angles; by alternately modulating these two waves (or by alternately feeding the modulated wave to the two aerial systems) a modulated wave is obtained whose plane of polarisation is continually being changed.

AN ELECTROLYTIC OSCILLATOR. · (*Wireless World*, 5th March, 1930, Vol. 26, pp. 251–252.)

Describing a modification by the Russian physicist, W. M. Schulgin, of the Wehnelt interruptor, which consists of a platinum point (+) and a lead plate (−) immersed in dilute sulphuric acid. By reversing the polarity, Schulgin obtains oscillations of a much higher frequency than those of the original device. The functioning of this high frequency generator is to be investigated in the near future with the aid of an oscillograph or similar means. For Schulgin's own papers, *see* 1929 Abstracts, pp. 42 and 508; for more on the subject *see* Nilsson, *Wireless World*, 9th April, 1930, p. 398.

THE PHYSICAL REALITY OF SIDEBANDS.—E. V. Appleton. (*Wireless World*, 19th March, 1930, Vol. 26, pp. 299–300.)

"A reply to the heretics" who dispute the accuracy of the sideband theory of wireless telephony (*see* 1930 Abstracts, pp. 212, 275 and 276). "Of the physical reality of sidebands there is not the slightest doubt. . . . *Three* chirps are to be heard as the frequency of an oscillating receiver is made to vary through that of 2LO when this station is emitting a tuning note. . . . If a telephony station emitting a constant modulation frequency is tuned-in carefully with a very selective receiver, three distinct maxima of signal intensity can be recorded." The writer disposes of the "heretics'" argument that reception on a harmonic should yield distortion and a raising of pitch if the sideband theory were correct.

As regards the "Stenode Radiostat" system (March Abstracts, p. 159), the writer considers that it is not fair to the inventor to discuss that system until full technical details are published. "It is probable that we have still much to learn concerning the properties of highly selective receivers when used with quenching devices. . . . The correctness of the sideband theory of wireless telephony can hardly be, in this connection, the question at issue."

THE "WAVE-BAND" THEORY OF WIRELESS TRANSMISSION.—E. H. Linfoot, A. A. Newbold, J. A. Fleming. (*Nature*, 1st March, 1930, Vol. 125, pp. 306–307.)

A continuation of the discussion referred to in May Abstracts, pp. 275–276.

UNTERSUCHUNGEN ÜBER QUARZGESTEUERTE SCHWINGVORGÄNGE (Investigations of Quartz-Regulated Oscillations).—P. von Handel. (*E.N.T.*, January, 1930, Vol. 7, No. 1, pp. 30–33.)

A discussion of some special problems occurring in the frequency regulation of wireless emitters by means of quartz crystals. The equivalent electric circuit of the oscillating quartz crystal is first described and the simplest circuit for a quartz-regulated emitter is given. In this circuit the oscillating crystal must act as an inductance in series with an ohmic resistance. Circuits with additional reaction for long waves (above 200 m.) and for short waves are given and the question of the possibility of excitation of disturbing waves in these circuits is discussed; prevention of these disturbing waves in quartz-regulated circuits is generally possible.

MARCONI TUNING FORK CONTROL FOR TRANSMITTERS.—(*See* under "Stations, D. & Operation.")

THE THEORY OF THE TWO-ELECTRODE VALVE AND THE GENERATION OF EXTRA LOW FREQUENCIES.—Ito. (*See* under "Properties of Circuits.")

RECEPTION.

AIRCRAFT ENGINE IGNITION SHIELDING.—(*Bur. of Stds. Tech. News Bull.*, March, 1930, pp. 22–23; also *Bur. of Stds. Journ. of Res.*, March, 1930, Vol. 4, pp. 415-424.)

Three shielding assemblies are described; the first two were satisfactory from a receiving point of view, but practical difficulties arose—*e.g.*, magneto and spark plugs were insufficiently protected against rain, deterioration of rubber cable due to the abrasive action of the metal braid on the lacquer finish on the rubber. The third system promises to fulfil all requirements; it uses liquid-tight flexible metal tubing with a surrounding layer of copper braid to ensure efficient shielding.

THRESHOLD HOWL IN REACTION RECEIVERS.—L. S. B. Alder. (*E.W. & W.E.*, April, 1930, Vol. 7, pp. 197–200.)

In a reaction receiver with a leaky grid detector coupled by a transformer to one or more l.f. stages, it frequently happens that as the reaction is increased up to the oscillating point a l.f. oscillation or modulation appears to start simultaneously with the r.f. oscillation, and to continue with a rise in pitch as the reaction is increased, until with a still greater increase in reaction the l.f. modulation dies out, leaving a pure r.f. oscillation.

In a short wave receiver used for Morse reception, whether C.W. or I.C.W., it is just at this point where threshold howl appears that the greatest sensitivity is looked for; but the smoother the reaction control and the better the adjustment of grid bias for good detection, the worse is the howl likely to be.

The present paper investigates the origin of this threshold howl, beginning by contrasting it with the somewhat similar "squegger" howl produced in a circuit of the same kind by making a large increase in reaction beyond the oscillating point: in this case the frequency of the self-quenched oscillations depends on the values of the grid condenser and its leak, the usual values for good detection giving a very high-pitched self-quenching note, whereas the threshold howl is generally a note of low pitch and is unchanged by changing the value of the leak.

The writer recalls that the conditions which correspond to good autodyne detection are those which give a large change in anode current as reaction is increased just beyond the oscillating point; for a leaky grid detector the change is a decrease, for an anode bend detector it is an increase. Taking the former case, he shows how the effect of this decrease, combined with an external impedance which is inductive, is to cause successive amplitudes above and below the stable value: these swings are generally damped out before any effect can be noticed in the telephones, but under certain conditions, particularly when the anode inductance is large and capable of storing and restoring considerable energy, they may continue to follow one another at definite intervals, producing the threshold howl.

The frequency of this depends on the time constant L/R of the anode circuit, R including the valve impedance; the rise in pitch as the reaction is increased being due to an increase in the mean value of R as the grid becomes more negative. The writer confirms his reasoning by applying it to an anode bend detector, having a capacity shunted across a resistance in its anode circuit. The threshold howl was even more intense and persistent than with the leaky grid arrangement.

A detector which may be perfectly quiet before oscillations start often becomes extremely microphonic when oscillating. This is an example of the fact that even if threshold howl is not noticed as such, transient impulses may often produce it momentarily and cause the receiver to appear noisy in operation. The writer considers the most satisfactory solution to be a leaky grid detector with a resistance-capacity coupling to the first l.f. stage, keeping the inductance value of reaction coil, r.f. choke, etc., down to that necessary for satisfactory reaction control.

ON THE RECEPTION OF EXTREMELY SHORT WAVES.—S. Uda. (*World Engineering Congress Abstracts*, 1929, Paper 81.)

See April Abstracts, pp. 212–213. The present paper gives a new range result: telephonic communication with 50 cm. waves was successfully carried out over 10 km., with the same transmitter (10 mA. in the aerial) but with a new receiver using a Cymotron 199 as the detector valve.

RECTIFICATION OF ULTRA-SHORT WAVES.—(*German Pat.* 487452, Esau, pub. 10th December, 1929.)

Tests with very short waves (2–30 m.) have shown that the usual detector-materials give no or very little rectification, even when a d.c. polarising voltage is supplied. The invention describes the use of an alternating voltage of about 10,000 to 20,000 p.p.s. as a biasing potential, which allows good rectifying effects to be obtained; probably by causing canals of polarisation by which the high frequency currents can enter without having to change the material—which may be beyond their powers, since the time of a half oscillation may easily be less than the time necessary for polarising the material.

HOCHFREQUENZVERSTARKUNG KURZER WELLEN (High-Frequency Amplification of Short Waves).—W. Runge. (*E.N.T.*, Jan., 1930, Vol. 7, No. 1, pp. 30–33.)

Author's summary:—It is shown that the amplification of frequencies from 10^4 to 3×10^4 kc/s with normal single-grid valves is quite possible. It is only necessary to build oscillatory circuits with sufficiently high fly-wheel resistance. The shunt effects of the capacities between the electrodes can be rendered harmless by simple means. Four-stage amplifiers produced commercially give total amplification factors of from 600 to 10,000.

ON THE AMPLIFICATION AND DETECTION OF VERY [ULTRA] SHORT ELECTRIC WAVES WITH DIODE, ETC.—K. Okabe. (*World Engineering Congress Abstracts*, 1929, Paper 615.)

A paper covering the same ground as that dealt with in April Abstracts, p. 213.

PROGRESS IN RADIO RECEIVING DURING 1929.—A. N. Goldsmith. (*Gen. Elec. Review*, January, 1930, Vol. 33, pp. 69–79.)

In this survey, various types of "Radiola" broadcast receivers, "Radiotron" valves, loud speakers, the RCA Theremin musical instrument

(" music from the air"), etc., etc., are described and illustrated.

WIRELESS TELEPHONY BY MEANS OF ULTRA SHORT WAVES.—Chiba. (*See* under " Transmission.")

ERGEBNISSE DER IM APRIL 1929 BEI DEN BERLINER RUNDFUNKTEILNEHMERN GEHALTENEN UMFRAGE ÜBER DIE EMPFANGSVERHÄLTNISSE (Results of the Enquiry as to Reception Conditions among Receivers of Broad-Cast Wireless Programmes in Berlin in April, 1929).—F. Kiebitz. (*E.N.T.*, January, 1930, Vol. 7, No. 1, pp. 24–30.)

METEOROLOGICAL INFLUENCES ON LONG-DISTANCE, LONG-WAVE RECEPTION.—Yokoyama and Nakai. (*See* under " Propagation of Waves.")

AERIALS AND AERIAL SYSTEMS.

A VECTOR SOLUTION OF SHORT WAVE FEEDER PROBLEMS.—E. Green. (*Marconi Review*, February, 1930, pp. 18–23.)

Development of a vector diagram showing how the voltage and current at a given point in a feeder are related to the voltage and current at any other point.

PRACTICAL DETERMINATION OF THE TERMINAL IMPEDANCE OF SHORT WAVE FEEDERS.—L. T. Bird. (*Marconi Review*, February, 1930, pp. 24–29.)

Referring to the vector diagram dealt with in Green's paper (see above abstract), the writer shows how it may be completely determined in a practical case from the three current readings normally taken on a standard feeder system, and that the fine adjustment to be made at the last feeder junction, to reduce reflection to the practical minimum, may be found in this way.

UEBER DIE SENDECHARAKTERISTIK VON FLUGZEUGSCHLEPPANTENNEN (On the Transmitting Characteristic of the Trailing Aircraft Aerial).—G. Sudeck. (*Zeitschr. f. Hochf. Tech.*, March, 1930, Vol. 35, pp. 89–98.)

An Adlershof investigation, theoretical and experimental, into the directional characteristics of the standard 70 m. trailing aerial, especially in the case of modern all-metal aeroplanes. It was prompted by frequent reports, in practice, of bad effects due to this directional property. Summarised results are given below :—

(1) Theory and practice agree in showing that the standard 70 m. trailing aerial, with the body of the aeroplane as counterweight, and for a relative speed of 140 km. per hour, can be replaced by an equivalent dipole inclined at an angle α, of 16° to 18°, to the horizontal.

(2) The aerial has a very irregular characteristic in the case where the sight angle β (angle of elevation of the aeroplane at the receiving station) is approximately equal to, or greater than, the angle α defined above. In the case of greatest importance in practice, where β is small, *the aerial gives no directional effect.*

(3) If, however, owing to the imperfect conductivity of the earth, the electric field vector makes an angle with the perpendicular, then according to theory marked directional effects should appear even for very small values of β. This has not been experimentally confirmed up to the present.

The wavelength used throughout was 450 m.

VALVES AND THERMIONICS.

BEITRAG ZUR PRIMÄREN ELEKTRONENSTROMVERTEILUNG IN TECHNISCHEN DREIELEKTRODENRÖHREN BEI POSITIVEN POTENTIALEN BEIDER KALTEN ELEKTRODEN GEGEN DIE KATHODE (Contribution to the Study of the Distribution of the Primary Electronic Current in Technical Triodes when Both Cold Electrodes are at Positive Potentials relative to the Cathode).—J. E. Scheel. (*Archiv für Elektrot.*, 26th Feb., 1930, Vol. 23, No. 4, pp. 383–412.)

Author's summary :—After a short discussion of the results obtained in typical papers on the subject of current distribution, a combined analytical and graphical approximation method is given for the quantitative determination of the electron paths up to the point where they cross the circle defined by the grid wires, for cylindrical tubes with grids composed of cylindrical wires arranged parallel to the filament at the corners of a regular polygon, in active regions free of space charge.

Starting from Abraham's expression for the approximate value of the potential in the plane of cross-section of the tube, the limiting values of the errors in Abraham's formulæ for the partial capacities and the amplification factor are first determined. It is found that the error limits in Abraham's equation for the amplification factor only depend on the quotient

$$\frac{nc}{a}\left(=\frac{\text{Total circumference of the } n \text{ grid wires}}{\text{Circumference of the grid circle}}\right),$$

where c = radius of one grid wire, a = radius of circle passing through grid wires. The error limits are given in graphical form for the interval

$$0 < \frac{nc}{a} < 0.8.$$

The initial equations for the approximate determination of the electron paths are derived from the first fundamental law of general mechanics and Abraham's potential function.

Considerations of the geometrical positions of the maxima and minima of the radial and circular components of the field of force in the cross-section of the tube enable the exactitude of the paths deduced to be controlled, and lead to a method for a second approximation.

The limiting case of grid screening (in which the greatest number of electrons are absorbed by the grid), which is the characteristic property by which the grid is judged, is discussed on the basis of three examples, with reference to an undisturbed initial transition of electrons towards the anode (no disturbing to-and-fro oscillations), in the case of equality of cathode and anode potentials with arbitrary positive potential of the grid relative to the anode. Among other effects it is shown that, in the case of equal geometrical screening (shadow effect) of the grids employed, the angles of the paths at the points where they are tangential to the grid wires and the percentage by which the grid screening actually occurring preponderates over the geometrical value are approximately inversely proportional to the number of grid wires of the set of valves.

Transformation equations and deductions therefrom are given for application of the method to other working voltages between the electrodes.

A comparison of the results of Abraham's approximation equations for pure current distribution with the corresponding portions of the results of this paper shows qualitative agreement.

SULLA EMISSIONE ELETTRONICA IN UN TUBO A VUOTO (On Electronic Emission in a Vacuum Tube).—L. Tieri and V. Ricca. (*Nuovo Cim.*, Dec., 1929, pp. 381–392.)

Authors' summary :—The paper describes an experimental study of the relation connecting variations $\triangle i$ of the electronic current i from an incandescent filament in vacuo and variations $\triangle I$ of the filament heating current I and $\triangle E$ of the potential difference E between the ends of the filament when I remains constant. It is found that the form of the functions $\triangle I = f(i)$ and $\triangle E = \phi(i)$ depends on the mode of connection of the anode to the filament. The precise results are: when the anode is connected (*a*) to the negative end of the filament, $\triangle I$ is positive for very small values of anode potential and therefore of i, and negative for greater values of the anode potential: analogous results are found for $\triangle E$ except that the sign is changed ; (*b*) to the positive end of the filament, and (*c*) to the mid-point of a filament shunt resistance, $\triangle I$ is always positive and $\triangle E$ always negative. The values obtained with arrangement (*c*) are the arithmetic means of those found with (*a*) and (*b*). The difference between the values of $\triangle I$ obtained in cases (*a*) and (*b*) (for the same values of I and i) is given in absolute value by $i\frac{I\frac{dr}{dI}}{R}$ (r resistance of filament for current I, R whole resistance of filament circuit) ; the difference between the values of $\triangle E$ is equal to ir. The functions $\triangle I = F(V)$ and $\triangle E = \phi(V)$ obtained in case (*a*) [V anode potential] show a maximum for $V = V_m$ and become zero for $V = V_s$, and the values of V_m and V_s are, over a wide range, independent of the value of I. It is further found that the interpretation of the existence and constancy of V_m and V_s depends on a knowledge of the law of distribution of the electronic emission from the various points of the filament.

THE EMISSION OF POSITIVE IONS FROM TUNGSTEN AND MOLYBDENUM.—L. P. Smith. (*Phys. Review*, Feb. 15th, 1930, Series 2, Vol. 35, No. 4, pp. 381–395.)

Author's abstract :—An examination of the positive ion emission from tungsten and molybdenum has been made in which it was sought to determine the following points :

(1) The nature of the ions emitted at various temperatures ;

(2) the temperature variation of the positive ion current ;

(3) the theory of positive ion emission with regard to where and how the ions are formed ;

(4) the positive ion work function for these metals ;

(5) whether the work function, determined by experiment, checks with that calculated by a simple cyclic process involving the thermionic work function, the ionizing potential and the latent heat of evaporation of the metal.

The mass spectrum for tungsten and molybdenum filaments taken at moderate temperatures (1,700° to 2,000° K) has shown that the emitted ions consist of sodium, the two isotopes of potassium, and aluminium. At high temperatures these impurities disappear and finally both tungsten and molybdenum filaments yield positive ions of their own metal. The latter confirm a report by Wahlin. The temperature variation of the positive ion current at high temperature yields a value of 6.55 volts for the positive ion work function of tungsten and 6.09 volts for that of molybdenum. These values disagree widely from the values 10.88 volts and 9.26 volts calculated from the simple cyclic process mentioned above. This suggests that the ions are formed as a by-product of an irreversible recrystallisation of the metal. Theoretical considerations show that the ions are emitted from the metal and are not formed after a neutral atom evaporates.

SCHOTTKY EFFECT AND CONTACT POTENTIAL MEASUREMENTS ON THORIATED TUNGSTEN FILAMENTS.—N. B. Reynolds. (*Phys. Review*, Jan. 15, 1930, Series 2, Vol. 35, No. 2, pp. 158–171.)

Author's abstract :—The Schottky effect for thoriated tungsten filaments is investigated and Schottky's relation that log $i \propto (V)^{\frac{1}{2}}$ is verified at high fields, but fails at gradients below 10,000 volts/cm., even for fully activated surfaces. This lack of saturation at low fields is accentuated by the effect of bombardment with high velocity positive ions, such bombardment apparently producing a surface-roughening and consequently increased fields in local areas. Investigation with low accelerating and retarding voltages, while varying the temperature and state of activation of the filament, allows a comparison of the contact potential and the work function at the absolute zero of temperature (ϕ_0) for the thoriated surface. The two values (contact potential and ϕ_0) are found to vary with a one-to-one correspondence if ϕ, the work function at the temperature of measurement, be allowed a temperature coefficient. This coefficient is much larger than can be attributed to the specific heat of the electrons in the metal. The electrons with high velocities show a Maxwellian velocity distribution. Near the zero of potential there are certain anomalous effects and a "patch surface" is postulated which, in a qualitative manner, explains this behaviour and the lack of current saturation with voltage gradients below a limiting value.

THE EFFECT OF END LOSSES ON THE CHARACTERISTICS OF FILAMENTS OF TUNGSTEN AND OTHER MATERIALS.—I. Langmuir, S. MacLane and Katharine B. Blodgett. (*Phys. Review*, Mar. 1st, 1930, Series 2, Vol. 35, No. 5, pp. 478–503.)

The leads of a tungsten filament in vacuo cool the ends of the filament and so affect the voltage, candle power, electron emission and other properties of the filament. In this paper the temperature distribution near the lead is derived for long filaments, where there is a central portion at a uniform temperature T_m. A method is given for determining T_0, the temperature of the lead-filament junction. Tables and formulæ are presented which allow ready calculation of the effect of the leads on the properties of any long tungsten filament for which the current and diameter are known.

Part II of the paper gives figures from which may be found the properties of filaments so short that the first theory does not apply. Some experimental checks of the theory are given.

For a short filament with leads cooled in liquid air a negative slope of the volt-ampère characteristic is observed when the central temperature is much smaller than T_m.

A TUNGSTEN FILAMENT ALLOYED WITH THORIUM.—K. Nishimoto. (*World Engineering Congress Abstracts*, 1929, Paper 484.)

To avoid the " off-setting " of tungsten (reversion to the hard, brittle condition, with irregular thickening) the writer alloys it with thorium ; a solid solution is formed which is said to possess great advantages.

VOLFRAMOVII KATOD (The Tungsten Filament).—S. I. Zilitinkevitch. (*T.i T.b.p.*, Leningrad, December, 1929, Vol. 10, pp. 626–639.)

In Russian. A detailed discussion on investigations on the subject by H. A. Jones and I. Langmuir (*Gen. El. Rev.*, Vol. 30, 1927). Tables and curves showing the resistance and temperature coefficient of a tungsten filament at different temperatures are given. The effect of non-uniform heating of a filament and the cooling effect of the lead-in conductors are discussed. A few numerical examples relating to the design of the tungsten filament are added.

DETERMINATION OF THORIA IN THORIATED WIRE BY ITS RADIOACTIVITY.—T. Sasahara. (*World Engineering Congress Abstracts*, 1929, Paper 368.)

" Heretofore, the thoria content in the thoriated wire has been determined only by chemical analysis, but the operation is quite laborious and the wire is wasted and cannot be used again as filament wire. If the radioactivity of the thoriated wire is easily measured, the thoria content of the wire will be determined with much less labour and cost." The process recommended uses an ionisation chamber and Shimizu's electrometer.

THE SURFACE HEAT OF CHARGING.—K. F. Herzfeld. (*Phys. Review*, Feb. 1st, 1930, Series 2, Vol. 35, No. 3, pp. 248–258.)

Author's abstract :—In recent papers by Bridgman, Langmuir and Tonks, and the author, the deviation of the constant A of *thermionic emission* from the theoretical value has been linked with the surface heat of charging and the *temperature variation of the photo-electric threshold*. In the present paper, at least a part of this effect is explained by the heat expansion of the material together with the dependency of the *work function* on the volume. Numerical calculations both for the deviations of A and for the temperature change of the threshold are made and compared with experiments. Before deciding whether the explanation given in this paper is complete, it will be necessary to calculate the space-charge effect of the electrons in the transition layer on the surface of the metal.

SECONDARY EMISSION FROM METALS BY IMPACT OF METASTABLE ATOMS AND POSITIVE IONS.—W. Uyterhoeven and M. C. Harrington. (*Phys. Review*, Feb. 15th, 1930, Series 2, Vol. 35, No. 4, pp. 438–439.)

1929 VALVES, GERMAN AND OTHERWISE.—F. Kunze. (*Funk-B.*, 22nd March and 20th Sept., 1929 ; summary in *L'Onde Élec.*, Feb., 1930, Vol. 9, p. 15A.)

A survey and table of receiving valves on the German market and a few others. " Several types are interesting ; *e.g.*, Siemens' valves with a slope of 4 and 12mA. per volt."

DIRECTIONAL WIRELESS.

ZUR FRAGE DER STANDORTSBESTIMMUNGEN AUS DREI FUNKPEILUNGEN (On the Question of Determination of Position from Three Wireless Bearings).—P. Duckert. (*E.N.T.*, Jan., 1930, Vol. 7, No. 1, pp. 15–18.)

An investigation of the possibility of deducing a ship's true position, or of estimating the maximum error involved in given procedures for determining it, from bearings subject to errors. The tendency in practice to regard the size of the error triangle [" cocked hat "] as an indication of the exactness of the measurements is wrong in principle, as is also the rule generally adopted of regarding the in-centre of the error triangle as the most probable position of the ship. The cases of random and systematic errors are considered separately, and reference is made to an apparatus for searching mechanically for the true position.

RADIO DIRECTION-FINDING BY TRANSMISSION AND RECEPTION.—R. L. Smith-Rose. (*Nature*, 5th April, 1930, Vol. 125, pp. 530–532, and 12th April, 1930, Vol. 125, pp. 568–569.)

Abstracts of a lecture delivered at the Royal Institution on 6th February, 1930. A general account of methods of radio direction-finding, dealing first with the rotating closed loop direction-finder and the errors to which it is subject. The elimination of night errors by the Adcock system is shortly described, and also the alternative method of direction-finding, in which the directional part of the wireless system is transferred from the receiving to the transmitting end, as in the rotating loop beacon system.

IMPROVEMENTS IN VISUAL INDICATOR FOR AIRCRAFT RADIOBEACON.—(*Bur. of Stds. Tech. News Bull.*, March, 1930, pp. 23–24.)

The useful range has been increased to about 250 miles (as compared with 175 miles) by improvements in design of the permanent magnet used for polarising the reed. Flying directly over a second station (transmitting aural signals on a frequency separated by 60 kc. from that of the guiding station 170 miles away) no effect on the reed deflections was found. The sharpness of the beacon course at that distance was 2½ miles—slightly better than $\pm 1°$.

Further increases in sensitivity are expected from the use of a nickel-steel alloy for the reed, having greater permeability than elinvar, previously used. Research is in progress to make this alloy, if possible, to have zero temperature coefficient and other desirable properties.

Increase of sensitivity increases not only the range but also the number of available reed frequencies (at present limited to 65–120 p.p.s.) by raising the upper limit.

APPLYING THE VISUAL DOUBLE-MODULATION TYPE RADIO RANGE TO THE AIRWAYS.—H. Diamond. (*Bur. of Stds. Journ. of Res.*, Feb., 1930, Vol. 4, pp. 265–287.)

Author's abstract:—This paper deals with methods for aligning the courses of the visual radio range with the fixed airways. It has previously been shown that the courses of the aural radio range may be shifted by the use of a vertical wire antenna in conjunction with the transmitting loop antennas or by varying the relative power in the two antennas [Kear and Jackson, March Abstracts, p. 161]. These methods are, in part, applicable to the visual system. In the aural system the goniometer primaries are excited alternately. This permits independent consideration of the field patterns due to the primaries. In the visual system this is not the case, as both goniometer primaries are excited all the time. Two cases present themselves, the condition when the currents in the primaries are in time phase and the condition when they are in quadrature time phase. The former condition results in two beacon courses which are 180° apart and can not be shifted from this relationship. The latter condition yields four beacon courses. A mathematical analysis is made of this case, and the amounts of angular variation possible using several methods of attack are tabulated.

A method of obtaining small amounts of shift by an adjustment of the receiving equipment aboard the airplanes is also described; one of the reeds is shunted by a suitable resistance in order that the reeds will vibrate equally when on one side of the equisignal zone. This method permits of great flexibility in securing a desired course and is suitable only for employment with the visual system. Sample calculations are made for actual airway routes to demonstrate the several methods of attack.

FLYING AN AIRPLANE IN FOG.—J. H. Doolittle. (*Soc. Autom. Eng. Journ.*, March, 1930, Vol. 26, pp. 318–320 and 345.)

This article describes tests with the "localizer beam" from a wireless transmitter on the ground. Starting from the neighbourhood of the transmitter, the beam "was followed for about 4 miles. During this time the airplane was gradually climbed to about 1,000ft. A 180-deg. turn was made at this point and the beam followed to the beacon. As the beacon was approached, the beam became narrower and, while it was more difficult to follow, the course became much more exact. The visual type indicator, consisting of two vibrating reeds, indicated to the pilot his position with respect to the beam centre. . . . At the exact moment of passing over the beacon house, the reeds stopped momentarily and then started to vibrate again in the opposite direction. . . ."

In another flight, where the aeroplane descended to 400ft., "the course was held by the directional gyroscope and the necessary slight changes in course made from time to time. In this case, knowing the exact direction of the beam facilitated the work, as it was immediately known when a wrong direction was being flown, even though the reed indicator showed that the pilot was on his course. . . . In previous tests where the directional gyroscope was not employed, we found that following the beam into the field was extremely difficult, as the tendency when the beam narrowed down was to fly out of the beam continually on one side or the other, and difficulty was always experienced in getting back on the beam without completely crossing it."

FOG-LANDING DEVELOPMENTS BY THE BUREAU OF STANDARDS.—Bureau of Standards, Washington. (*Bur. of Stds. Tech. News Bull.*, Feb., 1930, No. 154, pp. 10–11.)

A note devoted chiefly to the arrangement referred to in the previous abstract as the "localizer beam." Details of the shape of a particular beam are given: at 3 miles its height above ground is 2,000ft., decreasing to 85ft. at half a mile and to 5ft. at 500ft. The slope of the path decreases as the pilot approaches the ground, thus facilitating a proper landing.

MISTSIGNALANLÄGGNING MED RADIOFYR VID TRÄLLEBORG (Fog Signalling Equipment with Radio-beacon at Trälleborg).—I. Billing. (*Teknisk Tidskr.*, April, 1930, Vol. 60, pp. 61–65.)

ACOUSTICS AND AUDIO-FREQUENCIES.

THE IMPOSSIBILITY OF STEREOSCOPIC RECEPTION.—H. V. Hartel. (Summary in *L'Onde Élec.*, Feb., 1930, Vol. 9, p. 15A.)

"Without doubt, if a dialogue is transmitted through two loud speakers, each of which is exclusively reserved to one speaker, the impression of reality is greatly increased. But the movement of one person between two microphones gives no good result at all: if the microphones are close to each other, the effect is as if there were only one; if they are more than a metre apart, the auditors certainly get the impression that the sound ' turns,' but that it ' turns ' too quickly and without naturalness. The desired stereoscopic effect is by no means obtained."

KRASCHETU AKUSTICHESKOI CHASTI TELEFONA (On the design of the telephone receiver).—N. N. Andreev and N. N. Riabinina. (*T.i T.b.p.*, Leningrad, December, 1929, Vol. 10, pp. 551–571.)

In Russian. A method is given for the theoretical determination of the natural frequency of a telephone diaphragm from its geometrical and physical constants. While this method is based chiefly on the investigations of Rayleigh (Theory of sound, London, 1926) and Kennely (Electrical Vibration Instruments, N.Y., 1923) particular attention is given to (*a*) the effect of different methods of clamping on the vibration of the diaphragm, and (*b*) the change of the natural frequency of the diaphragm produced by the air cushion under it and by the ear cap. The conclusions arrived at have been experimentally verified at the State Laboratory of Physics by the glass particle method (March Abstracts, p. 162). Some of the curves thus obtained are shown.

ÜBER DIE BERECHNUNG UND BEWERTUNG DER FREQUENZKURVEN VON MEMBRANEN (On the Calculation and Evaluation of the Frequency Curves of Membranes [Application to Frequency Characteristic Curves of Loudspeakers]).—H. Stenzel. (*E.N.T.*, March, 1930, Vol. 7, No. 3, pp. 87–99.)

Author's summary :—It is explained that, in judging a loud speaker [frequency characteristic] curve, the influence of the directional effect on the distortion is of particular importance, so that a loud speaker cannot be judged when only the frequency curve for points on the central axis is available. Judgment first becomes possible when the frequency curves for several different angles are known. Such frequency characteristics are given for different types of plane rigid membranes and combinations of them, using a formula given by Rayleigh.

The same formula can also be used to calculate the curves for three-dimensional rigid membranes when the [equations for the] field of radiation can be completed by the condition $\frac{d\phi}{dn} = 0$ [ϕ velocity potential, n direction of normal to membrane]. Such calculations are performed for simple rigid three-dimensional membranes. It is shown that the frequency curve of the Rice-Kellogg loud speaker can also be calculated in this way by replacing the cone by plane surfaces. The calculated curve agrees well in essentials with the measured one. In particular, the striking maxima and minima of the frequency curves of cone loud speakers are explained thereby.

MAGNETIC DAMPING OF THE MOVING COIL.—N. W. McLachlan. (*Wireless World*, March 5th, 1930, Vol. 26, pp. 243–245.)

Explaining how natural oscillations of the cone are curbed by electro-magnetic damping. The author, however, shows mathematically that it is fallacious to suppose that when the motion of the cone is aperiodic owing to electromagnetic damping, the resonance effect of the surround does not exist. Resonance, however, is less conspicuous as electro-magnetic damping increases.

ON THE FREE PERIODS OF RESONATORS.—E. J. Irons. (*Phil. Mag.*, March, 1930, Vol. 9, —No. 57, pp. 346–360.)

SCHALLDRUCKMESSUNGEN AN MIKROPHONEN, TELEPHONEN UND IM FREIEN SCHALLFELD (Measurements of Sound Pressure in Microphones, Telephones and in Free Space).—C. A. Hartmann. (*E.N.T.*, March, 1930, Vol. 7, No. 3, pp. 100–107.)

Author's summary :—An electrostatic compensation method for the measurement of sound pressure is described. Some applications of the method to the procedure and arrangements for the determination of the efficiency of transmission of sound by electrical apparatus (microphones, telephones and loud speakers) and to the measurement of acoustic fields are sketched and compared with other methods of sound measurement.

THE HYPERBOLIC PARAMETERS OF THE HORN AND THE ACOUSTIC TRANSFORMER, A WORKING THEORY OF THE SOUND COLLECTOR, THE GENERAL CONSIDERATION AND DESIGN OF ACOUSTIC AND ELECTRO-ACOUSTIC TRANSMITTING SYSTEMS.—K. Kobayasi. (*World Engineering Congress Abstracts*, 1929, Paper 190; for the complete Paper, see *Tech. Rep. Tôhoku Univ.*, No. 1, Vol. 9, 1929, pp. 87–148.)

AN IMPROVED CONDENSER MICROPHONE FOR SOUND PRESSURE MEASUREMENTS.—D. A. Oliver. (*Journ. Scient. Instr.*, April, 1930, Vol. 7, pp. 113–119.)

Aldridge (1928 Abstracts, p. 688) pointed out that the " free air " curves obtained by the Rayleigh disc are radically different from the " actual pressure " curves obtained with the Wente microphone, the difference in the main being due to (*a*) diffraction of sound by the microphone as an obstacle in the sound field, and (*b*) acoustic resonance of the cavity in front of the diaphragm in the standard type of microphone. (*a*) can be allowed for by Ballantine's calculations. The present paper deals with the construction and performance of a microphone primarily designed to overcome the effects of the recessed diaphragm of the Wente design, and thus to avoid (*b*).

THE ABSORPTION OF SOUND AT OBLIQUE ANGLES OF INCIDENCE.—P. R. Heyl, V. L. Chrisler, and W. F. Snyder. (*Bur. of Stds. Journ. of Res.*, Feb., 1930, Vol. 4, pp. 289–296.)

Authors' abstract :—The absorption of sound at oblique angles of incidence has up to the present been purely a matter of theory, no experimental work having been published on the subject. Theoretical discussions have been given, which appear to be in error in an essential point, namely, the overlooking of the probable existence of rotational motion in the region of absorption.

This paper describes experiments made to investigate this question. It is found that the absorption varies with the angle of incidence, but not according to the law which has been deduced from purely theoretical considerations.

As a consequence of the experiments described in this paper, the conclusion has been reached that the tube method of measuring absorption is limited in its application to relative comparison of samples of similar nature, and that for absolute values of absorption the reverberation method is the only trustworthy one.

Acoustical Analysis of Auditoriums by Optical Treatments in Models.—T. Satow. (*World Engineering Congress Abstracts*, 1929, Paper 113.)

The model space is walled by metallic mirrors. The sound source is replaced by a lamp specially designed so as to radiate a few separated beams in any desired direction. The space is filled with smoke, and the beams can be observed directly or photographed transversely. A special prism is used to detect the direction of each beam falling on any auditor in the space.

The Two Fundamental Functions of the Vibrometer and its Applications in Electro-Acoustics.—K. Kobayasi: Nukiyama and Matsudaira. (*World Engineering Congress Abstracts*, 1929, Paper 189.)

The vibrometer is essentially a moving-coil type of telephone receiver with two moving coils, wound on a bobbin and able to vibrate with the same velocity in a magnetic field; the mutual impedance between them is compensated by other, stationary, coils. One moving coil, the "driving coil," exerts a vibro-motive force proportional to the current flowing through it; the other, the "measuring coil," exerts an electromotive force proportional to the velocity of the coil system. If, therefore, the coil system is provided with a diaphragm of known effective area, the volume velocity of this can be known from the e.m.f. induced in the measuring coil; also the sound pressure acting on the diaphragm can be found from the current which must be sent into the driving coil in order to bring the diaphragm to rest. If a rigid piston diaphragm is used, the two functions may be greatly simplified.

On Sound-Waves due to prescribed Vibrations on a Spherical Surface in the presence of a rigid and fixed Spheroidal Obstacle.—H. Sircar. (*Tôhoku Math. Journ.*, No. 3/4, Vol. 31, pp. 251–265.)

Gramophone Pick-ups Tested.—(*Wireless World*, March 26th and April 2nd, 1930, Vol. 26, pp. 321–328 and 356–362.)

Tests and measurements of the frequency characteristics of the leading makes.

Correct Pick-up Alignment.—E. A. Chamberlain. (*Wireless World*, March 26th, 1930, Vol. 26, pp. 339–340.)

The author shows that deviations from the tangential can be reduced by moving the swivelling point nearer the turntable so that the needle path is advanced past the centre. But the ideal amount of advancement cannot be attained in practice owing to the increase in dragging effect towards the centre.

An Electrical Frequency Analyzer.—M. Kobayashi. (*World Engineering Congress Abstracts*, 1929, Paper 126.)

A rotation of 180° of the dial of an oscillator gives a frequency range from 7,530 to 14,530 p.p.s. The output is passed into a modulator where it is modulated by the current whose wave form is to be analysed. The three frequencies thus produced (F, $F+f$ and $F-f$) pass through a filter circuit into a tuned vibrator (two conductors stretched across a magnetic field and carrying a mirror) which has two natural frequencies, *e.g.*, 5,820 and 7,530 p.p.s., one of which is the resonance frequency of the filter. The vibrator will then only oscillate vigorously for a current of this frequency, *e.g.*, 7,530 p.p.s.; hence by changing F over its full range, currents from 0 to 7,000 p.p.s. can be analysed. The light beam reflected from the mirror is projected on to a film on a drum, which is coupled by a belt or other means to the oscillator dial, so as to make one complete revolution when the dial is turning through 180°. Oscillations pictured on the film thus represent the spectrum of the frequencies in question.

PHOTOTELEGRAPHY AND TELEVISION.

Wie kann man feststellen, ob ein Empfänger für Fernsehzwecke geeignet ist? (How can one tell whether a Receiver is suitable for Television?) (*Die Sendung*, 18th April, 1930, Vol. 7, p. 271.)

A number of defects in the picture produced are mentioned, together with the causes producing them. Thus a harsh picture in which dark edges are followed ("followed" as regards the direction of scanning) by lighter shadows, giving a "plastic" or relief effect, is attributed to the receiver exaggerating the high frequencies (in the 300–6,500 p.p.s. range) at the expense of the low. The reverse propensity on the part of the receiver produces a faint picture, wavering at the edges. In a head, for instance, the eyes and mouth are hardly visible.

Shadows similar to those in the first case, following the dark edges but separated from them by a light space, are attributed to stray reaction coupling in the amplifier. Other defects are similarly treated, the last being the appearance of transitory dark streaks—caused by over-control of the glow lamp due to too much output from the receiver and too little initial voltage on the lamp.

Baird Television Receiver Tested.—(*Wireless World*, 12th March, 1930, Vol. 26, p. 277.)

An account of a practical test with the first commercial model of a Baird television receiver. The results "will interest the enthusiast."

ELECTRICITY FROM THE SUN: THE LANGE PHOTO-ELECTRIC CELL.—[B. Lange.]

A popular paragraph on the "semi-conductor" cell described in May Abstracts, p. 283. The possibility of "running motors with electricity from sunlight" is envisaged. Advantages here claimed for the cell, in addition to those mentioned in that abstract, are:—it does not show fatigue and can be operated indefinitely without loss of efficiency: for photometry, its current is directly proportional to the light, over a long range of brightness.

SCATTERING OF LIGHT BY KERR CELL.—A. Bramley. (*Phys. Review*, No. 7, Vol. 34, p. 1061.)

An investigation with frequencies corresponding to 1–6 m. wavelengths. *See also* Abstracts, 1929, pp. 114 and 463.

THE PHOTO-ELASTIC PROPERTIES OF GLASS.—F. C. Harris. (*Journ. Soc. Glass. Techn.*, Trans., No. 51, Vol. 13, 1929, pp. 213–219.)

A survey of present knowledge on the double refraction in glass produced by mechanical deformation, and its relation to the piezo-optical effect and the chemical composition of the glass. *Cf.* Siemens and Halske patent for photoelectric relay, 1929 Abstracts, p. 158.

ABSOLUTE RETARDATIONS IN DOUBLE REFRACTION CAUSED BY DEFORMATION.—Henriot and Marcelle. (*See* under "Miscellaneous.")

For the use of this effect as a photoelectric relay, *see* Siemens and Halske patent, 1929 Abstracts, p. 158.

MEASUREMENTS AND STANDARDS.

LA FORMULATION DE L'EFFET KELVIN (Formulæ for the Kelvin Effect).—E. Fromy. (*L'Onde Élec.*, Feb., 1930, Vol. 9, pp. 69–74.)

An enthusiastic appreciation of Levasseur's new formulæ (Feb. Abstracts, p. 110), of which the generalised, practical form, for conductors of cross section of any shape, is

$$K = \sqrt[6]{0.17798 + \left(\frac{2\pi S\sqrt{\mu cf}}{p}\right)^6} + 0.25$$

where S is the sectional area, p the perimeter, c the conductivity, μ the permeability and f the frequency: c.g.s. electromagnetic units being used.

NEW BASIS FOR ELECTRICAL UNITS.—Notes from the U.S. Bureau of Standards.—(*Journ. Franklin Inst.*, January, 1930, Vol. 209, No. 1, pp. 109–111.)

A very short abstract from the minutes of the 1929 session of the International Committee of Weights and Measures.

THE CALCULATION OF THE COEFFICIENTS OF SELF INDUCTION OF IRON-CORED COILS IN COMMUNICATION TECHNIQUE.—G. Lohrmann. (*Elektrot. u. Masch:bau*, 11th August, 1929, Vol. 47, pp. 689–690.)

See also 1929 Abstracts, p. 643.

NOMOGRAMS FOR THE CALCULATION OF ELECTROMAGNET WINDINGS FOR COMMUNICATION PURPOSES.—W. M. Denissoff; M. G. Zimbalisty; J. S. Lewieff. (*Transactions Elec. Lab. Leningrad*, No. 6, 1927, 59 pp.)

Four papers, in Russian with German summary.

A PRECISION METHOD OF CALIBRATING A TUNING FORK BY COMPARISON WITH A PENDULUM.—C. Moon. (*Bur. of Stds. Journ. of Res.*, Feb. 1930, Vol. 4, pp. 213–219.)

Author's abstract:—A photographic method for determining the relative frequency of a tuning fork and pendulum is described in which no energy is drawn either from the fork, the pendulum, or from the fork-driving circuits. A photographic record is obtained from which the frequency of the fork, the amplitude of the fork, and the amplitude of the pendulum are obtained. The accuracy of the timing is such that the time interval for an integral number of fork vibrations can be determined to 20 microseconds. If the pendulum is timed over an interval of one second, the error in frequency will be $\pm$ 0.002 per cent. If the time interval is increased to n seconds, the error will be $\pm \frac{1}{n} \times 0.002$ per cent.

Irregularities in relative frequency have been found which are thought to be due to a variable rate of the pendulum caused by microseismic movements of the building. Curves are given showing the frequency amplitude relation for two forks (one of steel and one of elinvar) when vibrating freely.

THE ESTABLISHMENT OF THE RADIO FREQUENCY STANDARD.—Y. Namba. (*World Engineering Congress Abstracts*, 1929, Paper 399.)

The abstract gives a short description of the equipment set up at the Electrotechnical Laboratory of the Ministry of Communications, Japan.

ON THE DETERMINATION OF THE PIEZO-ELECTRIC CONSTANT OF A QUARTZ RESONATOR AT HIGH FREQUENCY.—T. Fujimoto. (*World Engineering Congress Abstracts*, 1929, Paper 369.)

"Never has the measurement of the constant been attempted under dynamical conditions." The writer measured the various constants in the right hand side of Cady's formula $\epsilon = \frac{\omega_0 N}{2b}\frac{\chi_0}{V_0}$; ω_0 ($= 2\pi f_0 =$ frequency constant at resonance of the quartz rod) by a micrometer-condenser; N by means of Cady's formula $N = 2\pi M(f_1 - f_2)$; χ_0 (max. displacement of end of rod) by interferometer; and V_0 (corresponding max. voltage across rod) by thermionic voltmeter. The quartz rod vibrating freely in air-gaps between electrodes "gave rise to enormously large applied voltage so that the value χ_0/V_0 was small and the value of ϵ was found to be only 1/7th of the commonly accepted value." Elimination of the air-spaces only increased ϵ by 22 per cent. *See* also same writer, 1928 Abstracts, p. 227.

ON THE PROPERTIES OF TOURMALINE CRYSTALS USED AS PIEZOELECTRIC RESONATORS.—J. T. Henderson. (*Trans. Roy. Soc. Canada*, No. 1, Vol. 22, Sec. III, 1928, pp. 127–131.)

ROCHELLE SALT AS A DIELECTRIC.—C. B. Sawyer and C. H. Tower. (*Phys. Review*, 1st Feb., 1930, Series 2, Vol. 35, No. 3, pp. 269–273.)

Authors' abstract :—Both saturation and hysteresis appear in Braun tube oscillograms made at various temperatures with a condenser whose dielectric consists of Rochelle salt slabs cut perpendicular to the a-axis. The dielectric constant for such slabs may reach a value of 18,000. Curves are also given, showing the variation in mechanical and electrical saturation with temperature. These correspond in only a general way to the piezo-electric constant's variation with temperature. Certain marked peculiarities are noted in the resulting mechanical deformation when Rochelle salt is excited with alternating potentials. Clear Rochelle salt half-crystals have been produced up to 45 cm. in length.

DIE SCHWINGUNGEN DER QUARZLAMELLE (The Vibrations of Quartz Lamellæ).—A. Lissütin. (*Zeitschr. f. Phys.*, 2nd January, 1930, Vol. 59, No. 3/4, pp. 265–273.)

A mathematical investigation of simultaneous vibrations *in two directions* in a rectangular quartz lamella.

THE VALVE-MAINTAINED QUARTZ OSCILLATOR.—J. E. P. Vigoureux. (*Journ. I.E.E.*, Feb., 1930, Vol. 68, pp. 265–295.)

Neglecting temperature effects, the writer investigates the variation of frequency caused by variations of (i) air-gaps, (ii) constants of the plate circuit, and (iii) inter-electrode capacities and conductances. In the theoretical treatment, the quartz is replaced by its equivalent electrical circuit (Dye) : the combination of quartz resonator, valve and plate circuit is represented by a network of admittances, from which three circuit equations are obtained ; to these is added the fundamental equation of the valve, and these four equations yield a single linear differential equation of the fifth order, with constant coefficients. Considering only the frequency and amplitude of the oscillations after the latter have reached a constant amplitude, the writer reduces this equation to one of the same type but of the second order : and from this he develops formulæ for the changes of frequency produced by the several variations mentioned above.

Formulæ are also developed giving the conditions for the maintenance of oscillations, and an investigation is made of the variations of amplitude with variations in (*a*) capacity in the plate circuit, (*b*) resistance in the plate circuit, and (*c*) grid conductance. *Cf.* Terry, 1929 Abstracts, p. 109, and Wright, pp. 217–218. An experimental investigation is then described ; the theoretical and experimental results agree, for both types of connection (plate-to-grid and filament-to-grid), except that it was found in practice that the addition of a grid leak of a suitable value may increase the amplitude of oscillations ; perhaps because it tends to keep the mean potential of the grid at the most favourable point on the valve characteristic.

The curves obtained showing the relation between power dissipated and the resistance of the oscillatory circuit indicate very clearly the difference between the two types of connection. In the filament-to-grid type, the maximum total power is in some cases higher than the corresponding power for the plate-to-grid type. In *all* cases, however, the curve is sharper and the maximum power corresponds to a smaller total resistance than with the plate-to-grid type ; the latter is therefore preferable, since it is advantageous to dispose of approximately maximum power over as wide a range of current as possible. Another advantage of the plate-to-grid type is that subsidiary resonances of the quartz plate, in the neighbourhood of the main resonance frequency, do not produce secondary oscillations as readily as with the filament-to-grid connection.

ÜBER DIE STABILITÄT VON QUARZOSZILLATOREN (The Stability of Quartz Oscillators).—N. Titow and A. Weinberg. (*Journ. App. Phys.*, Moscow, No. 5, Vol. 6, 1929, pp. 75–86.)

The effects of changes in anode and filament voltages, the detuning of the oscillatory circuit, and the pressure on the crystal, were all found to be very small, both for transverse and longitudinal modes of vibration ($\lambda = 770$ and 1,852 m.). 40 or 50 minutes' wait is needed for a steady state to be reached.

INVESTIGATIONS OF QUARTZ-REGULATED OSCILLATIONS.—v. Handel. (*See* under " Transmission.")

SOME DEVELOPMENTS OF THE PIEZO-ELECTRIC CRYSTAL AS A FREQUENCY STANDARD.—H. J. Lucas. (*E.W. & W.E.*, April, 1930, Vol. 7, pp. 201–203.)

Summary of an I.E.E. (Wireless Section) paper read on 5th March. From the precision standpoint, the longitudinal mode has the advantage of a temperature coefficient about 1/20 that of the transverse mode. To avoid variations in the behaviour of crystal resonators traced to friction at the mount, the writer grips the quartz firmly between cork at a nodal point of mechanical displacement for the longitudinal mode, *i.e.*, in the centre of its length (*cf.* Mögel, May Abstracts, p. 284). This remedies the short-period variations of frequency, but long-period variations of the order of 1 in 10,000 remain ; these are traced to changes in atmospheric humidity and are removed by evacuating the air—which gives also an improvement in decrement by the removal of air-loading.

The paper describes the development of the Lucas-Sullivan Quartz Crystal Standard (the effects of humidity led to the use of the valve type LS5D, in which the grid connection is made to a terminal on the glass envelope, thus eliminating the valve holder and cap from the grid circuit) ; the author's H.F. Multivibrator (the impedances are designed for 50 kc., the frequency of the crystal control : no difficulty has been experienced in working down to the 120th harmonic—6,000 kc.) ;

and a low frequency Multivibrator using the same crystal-drive principle.

A suggestion is dealt with, made by B. Williams, to employ a quartz drive at 50 kc. to control two multivibrators and thus to obtain a 5-cycle beat (counted electrically by photographic records at definite time intervals) which should provide a simple and direct reference to the time standard. This method was demonstrated.

ACCURACY OBTAINABLE WITH PIEZO OSCILLATORS.—Bureau of Standards, Washington. (*Bur. of Stds. Tech. News Bull.*, Feb., 1930, No. 154, pp. 9–10.)

Tabulated results of prolonged tests on a number of quartz oscillators roughly similar in design but differing in the design of the plate holder. The maximum variations, in parts per million, ranged from ± 3 to $+ 23$; the worst being provided by a design in which the electrodes were sputtered on to the quartz, but here " the change in frequency was continuous and appears to be approaching a constant value. Change indicates that sputtered electrode is dropping off the plate."

NOTE SUR LES QUARTZ PIÉZO-ÉLECTRIQUES. (Note on Piezoelectric Quartz).—M. Cosyns and R. Moens. (*Bull. de Belg.*, No. 5, Vol. 15, pp. 479–487.)

An investigation into the limits of accuracy of a quartz frequency standard, and into the various factors affecting the constancy. The form of the curve representing the effect of the distance between quartz surface and electrode suggests the superposition of two phenomena, one electrical, the other mechanical: the first being the variation, with the distance, of electrode-to-quartz capacity: the second being the effect of the layer of air. The experimental curve shows discontinuities, interpreted as due to the interaction of the two phenomena.

A PORTABLE CONSTANT OUTPUT TONE GENERATOR AND VALVE VOLTMETER: FREQUENCY RANGE 20 TO 10,000 CYCLES PER SECOND.—C. G. Kemp. (*Marconi Review*, March, 1930, pp. 17–25.)

HIGH-FREQUENCY RESISTANCE MEASUREMENT BY THE USE OF A VARIABLE MUTUAL INDUCTANCE.—W. Jackson. (*Journ. I.E.E.*, Feb., 1930, Vol. 68, pp. 296–304.)

The usual " resistance-variation " method gives the *combined* resistance of the coil under measurement and the variable tuning condenser, so that for accurate measurement this latter must be of a known power factor. To avoid this necessity, the writer uses a method suggested by Moullin, by which the coil resistance can be determined independently by the use of a variable mutual inductance. The errors likely to occur are considered, and results obtained are compared with values arrived at by calculation and by the " resistance-variation " method. The application of the method to condenser resistance measurement is described.

A REMOTE READING DEVICE FOR USE WITH THERMOJUNCTIONS.—(*Journ. Scient. Instr.*, April, 1930, Vol. 7, pp. 135–136.)

When measuring current in an aerial at very high frequencies by means of the usual arrangement of a heater, thermojunction and galvanometer, the capacity to earth of the galvanometer is in parallel with half the heater resistance. The calibration of the junction and galvanometer, usually carried out with d.c., is thus altered, and errors will be appreciable if the capacity to earth of the galvanometer and leads is large.

The Radio Research Station, Slough, uses the following arrangement, which permits of the leads being of any length, and of measurements of current being made even at a point having a potential above that of the ground, with the galvanometer at earth potential. The aerial branches and is connected through two thermocouples to two condensers (of low impedance at the working frequency) and so to earth. The galvanometer is connected to the lower ends of the thermojunctions, which are connected so that the thermo-e.m.f.s are added. The capacity to earth of the galvanometer does not affect the measurement. Calibration must be carried out with a.c. of any frequency, or—if there is doubt as to equal distribution of r.f. current in the two thermojunctions—at the working frequency.

STUDIES AND APPLICATIONS ON THE THERMO-ELECTRIC PROPERTIES OF INORGANIC COMPOUNDS.—K. Fujii. (*World Engineering Congress Abstracts*, 1929, Paper 603.)

Researches leading to the design of thermojunctions and thermopiles formed of compounds (*e.g.*, Cu_2S and PbS) in place of the usual metals. Sensitivities 2–6 times greater than those of metal-to-metal combinations are obtained.

STANDING WAVES AND RESONANCE CURVES.—R. King. (*Review of Scient. Instr.*, March, 1930, Vol. 1, pp. 164–180.)

For an abstract of a preliminary paper on the same subject, *see* April Abstracts, p. 225. In the present paper the special Lecher wire apparatus used is described and illustrated: the writer gives his conclusions as follows:—" The nature of the waves induced in a pair of parallel wires depends upon the frequency or frequencies impressed, and on the linear phase relations between the inducing and resonating systems. Resonance curves are symmetrical and uniform if the parallel wire system is completely tuned to a monochromatic frequency and its natural phase corresponds to the induced phase. That is, the positions of natural loops on the tube system coincide with the points at which the induced oscillation can set up maximum current loops. If the natural phase does not coincide with the induced phase, the amplitude of natural oscillations in a circuit consisting of a part of the tube system may be increased or brought completely to zero by tuning the remaining coupled circuit to reflect the induced wave more or less favourably." The writer hopes that his results will serve to throw light on the electromagnetic waves which Kessenich believes affect the shape of the resonance curves in an inexplicable manner (*see* Jan. Abstracts, p. 51.)

ÜBER DIE FEHLER DER SCHEITELSPANNUNGSMESSUNG VERMITTELST ROHRENGLEICHGERICHTETEM KONDENSATORSTROM (Errors in Peak Voltage Measurements using Valve-rectified Condenser Currents).—H. König. (*Helvet. Phys. Acta*, No. 6, Vol. 2, 1929, pp. 357–410.)

The substitution of valve technique for the old mechanical synchronous rectifier has made the method far more convenient but is liable to introduce its own sources of error, which are here very thoroughly investigated.

A NEW TYPE OF SELF-BALANCING [RECORDING] POTENTIOMETER.—F. Moore. (*Review of Scient. Instr.*, March, 1930, Vol. 1, pp. 125–139.)

Description of the Wilson-Maeulen potentiometer recorder "which has remarkable precision in recording changes of temperature." It is of rugged design and construction.

SENSITIVITY OF A GALVANOMETER AS A FUNCTION OF ITS RESISTANCE.—H. B. Brooks. (*Bur. of Stds. Journ. of Res.*, Feb., 1930, Vol. 4, pp. 297–312.)

The writer shows that both Maxwell's and Ayrton and Perry's statements, as to the conditions for maximum sensitivity, are correct for their respective assumptions, but that the sensitivity function in each case is very flat near the maximum. Apart from considerations of damping, the user has a wide range of choice of galvanometer resistance with relatively small loss of sensitivity; and when critical damping is considered, he can in fact sometimes obtain much better sensitivity with moving-coil galvanometers by departing from the theoretical optimum value of resistance.

A NEW METHOD OF USING THE CO-ORDINATE A.C. POTENTIOMETER UPON [VALVE] CIRCUITS OF SMALL POWER.—D. C. Gall. (*Journ. Scient. Instr.*, March, 1930, Vol. 7, pp. 103–104.)

SUR LA MESURE DE L'INTENSITÉ EFFICACE DES COURANTS DE HAUTE FRÉQUENCE (The Measurement of the Effective Strength of H.F. Currents). — H. Mutel. (*Comptes Rendus*, 7th April, 1930, Vol. 190, pp. 860–862.)

It is often found that two hot-wire ammeters of differing design, graduated with d.c., do not agree, when used on frequencies of some millions, even if corrections are made for skin effect. The writer has set out to find the chief causes of these discrepancies, by tests on a differential hot-wire thermometer and a final comparison of this with a hot-wire ammeter of the ordinary type.

His conclusions are that for wavelengths of 10 m. and downwards [the only longer wavelength mentioned was 70 m., and for this the particular effect in question—the correction for skin effect—was negligible] the losses due to dielectric hysteresis in the containers of hot-wire ammeters may introduce great inaccuracies, and that containers of insulating material are not necessarily better than those of metal. For these frequencies, hot-wire ammeters can only give satisfactory results if allowance is made for skin effect and if the container walls are sufficiently far from the hot-wire. The writer has obtained good results with a wooden case $24 \times 22 \times 5$ cm. in dimensions. He concludes: "For [ultra] short wavelengths, the circuit is the seat of stationary waves; the intensity is not the same at all points; we have always introduced the instruments under comparison at the mid-point of the coil of the oscillating circuit, near where the current is a maximum."

EIN NEUES HOCHSPANNUNGSELEKTROMETER (A New High Voltage Electrometer).—T. Wulf. (*Physik. Zeitschr.*, 1st April, 1930, Vol. 31, No. 7, pp. 315–323.)

SUBSIDIARY APPARATUS AND MATERIALS.

AUSSENAUFNAHME SCHNELLER KATHODENSTRAHLOSZILLOGRAMME DURCH LENARDFENSTER (The External Recording of Rapid C.-R. Oscillograms by the use of a Lenard Window).—M. Knoll and B. v. Borries. (*Zeitschr. f. tech. Phys.*, April, 1930, Vol. 11, No. 4, pp. 111–112.)

By introducing a Lenard window into a tube hitherto used for internal recording, designed for prolonged runs at 80 kv. exciting potential, the writers have increased the photographic recording speed from 20 m./sec. (*see* Knoll and Stoerk, 1929 Abstracts, p. 341) to values up to 120 km./sec. The window is of aluminium foil 0.007 mm. thick. A special design of "scaffolding" (to support the window against atmospheric pressure) allows the records to be practically free from breaks and shadows: the main scaffolding is made of steel strips on edge, 10 mm. apart and of cross section 0.3×4.0 mm^2., and it is supplemented by a phosphor-bronze netting. The image of this netting can only be seen on the record by means of a magnifying glass; the squares of the steel band structure are visible to the eye as faint white lines. [For a window formed by a bubble of glass, *see* 1929 Abstracts, pp. 163 and 341.]

THE APPLICATION OF HIGH POTENTIALS TO VACUUM-TUBES.—M. A. Tuve, G. Breit and L. R. Hafstad. (*Phys. Review*, 1st Jan., 1930, Series 2, Vol. 35, No. 1, pp. 66–71.)

Authors' abstract: A brief progress-report is made on the results so far obtained in the development of vacuum-tubes to which the very high voltages produced by Tesla coils (greater than 10^6 volts) can be applied. One cascade tube has been constructed which withstood repeatedly a voltage of 1,400,000 volts, and others have been used at lower voltages. This method, originally developed by Coolidge, gives promise of being suitable for voltages of several million, and eventually perhaps even higher. No effort has been made so far to use these tubes with a definite and controlled emission, since experience has shown that single-section tubes operated at several hundred kilovolts have approximately the same voltage limitation with or without hot cathodes. The chief difficulty with very high-voltage tubes is that of preventing the uncontrollable (cold-cathode) emission which limits the voltage which can be applied. An electrodeless tube which withstood 1,000,000 volts is briefly described.

A NEW DESIGN OF CATHODE-RAY OSCILLOGRAPH AND ITS APPLICATIONS TO PIEZO-ELECTRIC MEASUREMENTS.—S. Watanabe. (*Scient. Pap. Inst. Phys. Chem. Res.*, Tokyo, No. 212, Vol. 12, 1929, pp. 82–98.)

The oscillograph, specially designed with a view to piezo-electric methods of research, has a hot cathode; special flexible joints for cathode and anode, for adjusting the ray coaxially with the tube axis; a Wehnelt cylinder round the cathode, magnetic concentrating coils between anode and screen, and deflecting plates externally adjusted (conical bearings, mercury sealed). Voltage is 5–10 kv., the maximum recording speed is about 1 km. per sec. Various applications are given, such as the investigation of the explosion pressure in an internal combustion motor.

A DEVICE FOR AUTOMATIC CONTROL OF THE VACUUM IN A SHEARER X-RAY TUBE.—T. N. White. (*Journ. Scient. Instr.*, March, 1930, Vol. 7, pp. 99–100.)

"The device described enables the conditions to be kept constant automatically within a few per cent. and for an indefinite period." *Cf.* Haworth, Feb. Abstracts, p. 114.

OSZILLOGRAPHEN (Oscillographs).—(*Zeitschr. V.D.I.*, 22nd Feb., 1930, Vol. 74, pp. 239–242.)

An illustrated survey of modern types of oscillograph, about half being devoted to the cathode ray type. Most of the references have been dealt with in these Abstracts.

A STUDY IN CONDENSATION PUMPS.—K. C. D. Hickman and C. R. Sanford. (*Review of Scient. Instr.*, March, 1930, Vol. 1, pp. 140–163.)

"Recommendations and Summary:—Very small condensation pumps have been shown to be useful for most laboratory purposes. *N*-butyl phthalate and benzyl-butyl phthalate have been recommended as efficient substitutes for mercury where a trap immersed in refrigerant is not desirable." Some 30 references are listed.

THE SURFACE-CHARGE FIGURE AND SOME APPLICATIONS.—Y. Toriyama and U. Shinohara. (*Mem. Fac. Engineering, Hokkaido Univ.*, No. 2, Vol. 2, 1929, pp. 21–34 and 35–48.)

The surface charges produced on an insulating plate (*e.g.*, vulcanite) between point-and-plate electrodes are investigated. They can be made visible by scattered powders (sulphur and lead oxide) and can be used to reveal, for example, the potential distribution along a helix produced by a surge.

A LABORATORY METHOD OF PRODUCING HIGH POTENTIALS.—G. Breit, M.A. Tuve and O. Dahl. (*Phys. Review*, 1st Jan., 1930, Series 2, Vol. 35, No. 1, pp. 53–65.)

Authors' abstract:—Details are given of the experimental arrangement by which, using Tesla coils in oil, very high potentials have been produced and measured. Excited at the rate of 120 sparks per second, Tesla coils have been operated at 3,000,000 volts in ordinary transformer oil at atmospheric pressure. In oil under a pressure of 500 pounds per square inch, voltages as high as 5,200,000 have been produced with intermittent excitation. These voltages (peak values) are measured by a simple capacity-potentiometer, in which an insulated electrode "picks up" a known fraction of the total voltage, this fractional voltage being measured by means of a sphere gap. Measurements are given of the voltage distribution along Tesla coils. Calculations and measurements of the efficiency and power-output of such coils show that at 120 sparks per second, a coil operating at 5,000,000 volts provides sufficient power, if used to accelerate helium nuclei in a suitable vacuum-tube, to yield the equivalent of about 2,600 grams of radium.

LES REDRESSEURS À VAPEUR DE MERCURE À HAUTE TENSION CONTINUE. APPLICATION À L'ALIMENTATION DES POSTES ÉMETTEURS DE T.S.F. (H.T. Mercury Vapour Rectifiers, and their Use for the Supply of Power to Wireless Transmitters).—M. Demontvignier. (*L'Onde Élec.*, Feb., 1930, Vol. 9, pp. 45–68.)

"The mercury vapour rectifier, properly adapted, constitutes actually the best means of anode supply for valve transmitters of medium and high power." The various requirements of such transmitters are discussed and compared with the properties of these rectifiers: *e.g.*, to prevent damage by the "Rocky Point" Effect (name given in America to sudden internal short-circuit of one valve of a number in parallel), the short-circuit should be limited—*e.g.*, to 6 or 7 times the working current: the writer shows how this limitation can be obtained by a suitable arrangement of rectifiers. He goes on to describe various rectifying plants already installed, including four at the Eiffel Tower station: one of 100 kw., 13,000 v., a three-twelve-phase rectifier in oil, and three (100, 30 and 6 kw. respectively) in air, single-phase connected as voltage doublers.

ZUM MECHANISMUS DER RICHTWIRKUNG IN KUPFEROXYDULGLEICHRICHTERN (On the Mechanism of the Rectifying Action of Copper Oxide Rectifiers).—W. Schottky and W. Deutschmann. (*Physik. Zeitschr.*, No. 22, Vol. 30, 1929, pp. 839–846.)

SUR LE REDRESSEUR À OXYDE DE CUIVRE (On the Copper-Oxide Rectifier).—H. Pélabon. (*Comptes Rendus*, 10th March, 1930, Vol. 190, pp. 630–632.)

The writer gives an explanation of the exact action of this rectifier which reconciles certain contradictory facts. It involves the combined action of three different bodies, CuO, Cu_2O and a very conductive, granular substance (made up of 96.5 per cent. Cu and 3.5 per cent. Cu_2O), together with the pure copper itself.

HIGH-VOLTAGE MERCURY VAPOUR ARC RECTIFIERS FOR CURRENT SUPPLY OF RADIO STATIONS.—V. P. Vologdin. (*World Engineering Congress Abstracts*, 1929, Paper 695.)

"The U.S.S.R. is the only country in which the high-voltage mercury arc rectifiers have been successfully applied in numerous powerful high tension installations for many a year past." Recent Russian researches have elucidated the various complex phenomena involved in the working of these rectifiers, and the writer outlines the economic advantages of such a rectifier over a Kenotron equipment, each giving 36 kVA. at 12,000 v.

HOT CATHODE MERCURY VAPOUR RECTIFIERS FOR ANODE SUPPLY.—(*Gen. Elec. Review*, Jan., 1930, Vol. 33, pp. 40–41.)

The largest set so far constructed gives 50 A. at 15,000 v. It uses 18 tubes in three independent channels, each channel being provided with a separate surge reactor which keeps the load equalised and also assists in the reduction of the 300-cycle ripple (line frequency being 50 cycles). A common high-voltage condenser bank completes the smoothing, the d.c. output having a ripple component of the order of 0.05 per cent.

Each channel is connected in the "3-phase full-wave connection," so that there is no d.c. component in the plate transformer windings. The conversion efficiency at full load is about 96 per cent.; the overall regulation from no load to full load is about 8.6 per cent.

GLIMMENTLADUNG AN HOHLKATHODEN (Glow Discharge with a Cathode consisting of Two Opposed Parts each surrounded by a Hollow Anode).—A. Güntherschulze. (*Zeitschr. f. tech. Phys.*, Feb., 1930, Vol. 11, pp. 49–54.)

Very high current densities can be obtained in the glow discharge with this arrangement, when gaps and gas pressure are suitably adjusted.

THE THEORY OF THE GRID-GLOW TUBE.—D.D. Knowles. (*Electric Journ.*, February, 1930, Vol. 27, pp. 116–120.)

First part of a series of articles.

A SELECTIVE CALLING DEVICE FOR TELEGRAPHS.—S. Tanaka. (*World Engineering Congress Abstracts*, 1929, Paper 53.)

A condenser in the local circuit of the line relay is charged through a very high resistance at every marking stroke and discharged through the winding of a sensitive discriminating relay at every spacing stroke of the line relay. The various parts are so proportioned and adjusted that the discriminating relay operates only by the discharge of the condenser when its charging lasts longer than the longest dash used in the ordinary telegraphic working. When the relay does operate it connects a selecting apparatus which finally rings a bell.

WIRELESS REMOTE CONTROL.—H. Yagi. (*World Engineering Congress Abstracts*, 1929, Paper 172.)

Trigger valve circuits, to act as the connecting device between an electric oscillation and a mechanical relay, may be broadly divided into two classes, non-oscillatory and oscillatory. Nukiyama utilises secondary emission in his "jumper," working in conjunction with his "amplifilter" (*see* under "Miscellaneous") to form a new system of multiplex telegraphy and a system of submarine acoustic remote control. He has also devised some non-oscillatory triggers.

Chiba and the writer have developed a remote control system suitable for use with a short wave beam. The writer also has a system with a rotating switch, using a single wavelength. Each signal is preceded by a special starting signal. He states that neon glow lamps with two or three electrodes are very well suited for trigger relays, and will be extensively employed in the future. "The design of wireless control is now well within the power of engineers, and the time is ripe for its application to civil services."

TEFAG-RISTOW WIRELESS CALL.—A. Ristow. (*Génie Civil*, 15th Feb., 1930, Vol. 96, p. 167.)

Short description of the call device dealt with in March Abstracts, p. 169.

A PORTABLE TRANSIENT INDICATOR.—(*World Power*, December, 1929, Vol. 12, p. 529.)

A highly sensitive warning device depending on the properties of a low voltage glow tube which has a breakdown pressure of about 120 v. d.c. and yet gives no discharge on 110 v. until a third or trigger electrode allows the current to pass. A klydonograph is necessary, however, to indicate the actual voltage present, since the glow tube gives no such indication; it must, moreover, be re-set by external means, since the current once started continues to flow at 110 v.

DIE UNTERSUCHUNG DER PERMEABILITÄT DER FERROMAGNETIKA IN DEN HOCHFREQUENTEN MAGNETFELDERN (The Permeability of Ferromagnetic Materials in H.F. Magnetic Fields).—N. N. Malov. (*Journ. App. Phys.*, Moscow, No. 5, Vol. 6, 1929, pp. 26–38.)

The wave-range used was 50–140 m. Among the chief results obtained, the permeabilities of nickel and iron wires ($a = 0.1$ and 0.043 mm.) were found to decrease gradually with the wavelength, by an amount up to 15 to 20 per cent.

NEW NICKEL-IRON ALLOY: REMARKABLE MAGNETIC PROPERTIES OF PERMALLOY "C."—(*Electrician*, 14th March, 1930, Vol. 104, pp. 330–331.)

ÜBER DEN DIAMAGNETISMUS FERROMAGNETISCHER MEDIEN (On the Diamagnetism of Ferromagnetic Media).—R. Gans. (*Naturwiss.*, 21st Feb., 1930, Vol. 18, No. 8, pp. 184–185.)

Under the influence of strong magnetic fields (*e.g.*, those greater than 8,000 Gauss) certain materials, ferromagnetic under the action of weaker fields, become diamagnetic, a phenomenon already predicted by Wilhelm Weber.

FERROMAGNETISCHE MISCHKÖRPER (Ferromagnetic Mixtures).—W. Doebke. (*Zeitschr. f. tech. Phys.*, Jan., 1930, Vol. 11, pp. 12–16.)

A theoretical investigation, the results of which are confirmed by experiment into the effective permeability of such mixtures.

ZUR ÜBERLAGERUNG STARKER UND SCHWACHER FELDER IN MAGNETISCHEN MATERIALEN (The Superposition of Strong and Weak Fields in Magnetic Materials).—R. Goldschmidt. (*Zeitschr. f. tech. Phys.*, Jan., 1930, Vol. 11, pp. 8–12.)

ZUM GULTIGKEITSBEREICH DER RAYLEIGH-JORDANSCHEN BEZIEHUNGEN (The Region of Validity of the Rayleigh-Jordan Relations).—H. Jordan. (*Zeitschr. f. tech. Phys.*, Jan., 1930, Vol. 11, pp. 2–8.)

An investigation of the relations between permeability increase and increase in loss-angle, for increasing amplitudes of weak sinusoidal fields. Rayleigh's equations are found to be only approximately accurate; the introduction of two independent constants in place of his single hysteresis constant is recommended. The implications of this are discussed.

SUR UN PROCÉDÉ PERMETTANT LA DÉTERMINATION DES PROPRIÉTÉS MAGNÉTIQUES DES TOLES AUX FAIBLES INDUCTIONS EN COURANT ALTERNATIF (A Process for the Determination of the Magnetic Properties of Iron Sheets for Weak Inductions in A.C.).—R. Jouaust and P. Waguet. (*Bull. d. l. Soc. franç. d. Élec.*, Dec., 1929, Vol. 9, pp. 1293–1297.)

SUR L'AIMANTATION À SATURATION DES FERRO-COBALTS ET LES MOMENTS ATOMIQUES DU FER ET DU COBALT (Magnetisation to Saturation of the Ferro-Cobalts, and the Atomic Moments of Iron and Cobalt).—P. Weiss and R. Forrer. (*Comptes Rendus*, 28th October, 1929, Vol. 189, pp. 663–666.)

For similar treatment of the Nickel-Cobalts, *see* same journal, 12th Nov., 1929, pp. 789–791.

EINE VERBESSERUNG AN THERMOSTATEN MIT ELEKTRISCHER HEIZUNG (An Improvement in Thermostats with Electric Heating).—L. Hock and C. L. Nottebohm. (*Zeitschr. f. Elektrochem.*, No. 7, 1929, Vol. 35, p. 458.)

A modified design of Duane and Lori's thermostat gives a very high constancy of temperature. Details are promised later.

MELTING, MECHANICAL WORKING, AND SOME PHYSICAL PROPERTIES OF RHODIUM.—Wm. H. Swanger. (*Bur. of Stds. Journ. of Res.*, Dec., 1929, Vol. 3, pp. 1029–1040.)

THE HALL EFFECT, ELECTRICAL CONDUCTIVITY, AND THERMOELECTRIC POWER OF THE LEAD-ANTIMONY SERIES OF ALLOYS.—E. Stephens. (*Phil. Mag.*, April, 1930, Vol. 9, No. 58, pp. 547–560.)

STEADYING FREQUENCY: NEW INSTRUMENT FOR USE ON LARGE POWER SYSTEMS.—(*Electrician*, 27th Dec., 1929, Vol. 103, p. 831.)

Illustrated description of the new Italian "C.G.C. Frequencygraph." *See* also *Engineer*, 17th Jan., 1930, p. 73.

DIE MEHRPHASIGEN KOLLEKTOR- UND INDUKTIONSMASCHINEN ALS SONDERFALL DES "ALLGEMEINEN TRANSFORMATORS" (The Multiphase Collector- and Induction-Machines as a Special Case of the "General Transformer").—M. P. Kostenko. (*Archiv. f. Elektrot.*, 26th Feb., 1930, Vol. 23, No. 4, pp. 413–434.)

A theoretical investigation of the action of various types of transformers.

THE "YOUNG" ACCUMULATOR.—(*Electrician*, 28th March, 1930, Vol. 104, p. 409.)

Paragraph on the orders given by the French railways to the British firm manufacturing this accumulator, "the principle of which has not been divulged. It is said to effect a useful saving of weight and to eliminate sulphating. It is claimed that the accumulator can be fully charged in an hour and a half, instead of the usual ten hours, and that it has resisted drastic tests, such as continuous short circuiting."

A FORMULA FOR THE RELATION BETWEEN THE CAPACITY AND THE TEMPERATURE AND DISCHARGING CURRENT OF THE LEAD STORAGE BATTERY.—S. Nakamura. (*World Engineering Congress Abstracts*, 1929, Paper 473.)

A NEW ULTRA-SPEED KINEMATOGRAPHIC CAMERA TAKING 40,000 PHOTOGRAPHS PER SECOND.—T. Suhara. (*World Engineering Congress Abstracts*, 1929, Paper 735; also *Génie Civil*, 5th April, 1930, Vol. 96, p. 346.)

Reproduction of these photographs at the normal rate of 16 pictures per second gives an apparent reduction of 2531.

A NOTE ON THE MOUNTING OF QUARTZ SUSPENSION FIBRES.—D. R. Barber. (*Journ. Scient. Instr.*, March, 1930, Vol. 7, pp. 105–106.)

"It is often necessary to mount a number of similar suspension fibres, each having the same degree of tension, but this is not an easy matter when the diameters are 10 μ or less. The following method, however, gives satisfactory results."

SOME EXPERIMENTS WITH CARBON LINE RESISTANCES.—J. B. Seth, C. Anand and G. L. Puri. (*Phil. Mag.*, March, 1930, Vol. 9, No. 57, pp. 415–422.)

See also 1929 Abstracts, p. 228.

A PROCESS FOR MANUFACTURING MANGANESE DIOXIDE, AND ITS ELECTROCHEMICAL PROPERTIES.—Y. Kato and T. Matsuhasi. (*World Engineering Congress Abstracts*, 1929, Paper 56.)

INSULATOR DESIGN: BRITISH PATTERN TO RESIST SALT FOGS.—Messrs. Bullers. (*Electrician*, 31st January, 1930, Vol. 104, p. 133.)

FURTHER EXPERIMENTS ON MICA INSULATION.—J. M. Macaulay and D. Carson. (*Journ. Roy. Tech. Coll.*, Glasgow, Jan., 1930, Vol. 2.)

An investigation of Rayleigh's discovery that a freshly split mica surface becomes a fairly good conductor and recovers its insulating properties on exposure to air. Based on some old experiments of Bunsen, a general explanation of the results encountered is suggested in terms of a temporary and a permanent layer formed on the mica surface.

DIELECTRIC LOSSES AND BREAKDOWN IN POROUS MATERIALS: TESTS ON THE PROPERTIES OF INSULATING MATERIALS.—A. Gyemant: O. R. Randall. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 10, 1929, pp. 328–334: *Engineering*, 15th and 22nd Nov., 1929, Vol. 128, pp. 657–659 and 689–690.)

ÜBER DIE DURCHSCHLAGSFESTIGKEIT EINIGER FESTER ISOLIERSTOFFE BEI BEANSPRUCHUNGEN VON LANGER BIS ZU GANZ KURZER DAUER (The Resistance to Breakdown of some Solid Insulating Materials in Testing Periods of Long to Very Short Duration).—R. Jost (*Archiv für Elektrot.*, 18th Jan., 1930, Vol. 23, No. 3, pp. 305–322.)

UNTERSUCHUNGEN ÜBER DIELEKTRISCHE VERLUSTE BEI DAUERBEANSPRUCHUNG UND VERSCHIEDENEN TEMPERATUREN (Investigations on Dielectric Losses under Prolonged Test and Various Temperatures).—H. W. L. Brückman. (*E.T.Z.*, 26th December, 1929, Vol. 50, pp. 1873–1875.)

ÜBER DAS DIELEKTRISCHE VERHALTEN VON NIEDERSPANNUNGSKONDENSATOREN MIT GESCHICHTETER PAPIERISOLATION (The Behaviour of Dielectrics in Low Voltage Condensers with Layered Paper Insulation).—F. A. Schäfer. (*Archiv. für Elektrot.*, 18th Jan., 1930, Vol. 23, No. 3, pp. 351–380.)

MOULDED INSULATING COMPOSITIONS.—A. R. Dunton and A. W. Muir. (*Electrician*, 14th Feb. and 14th March, 1930, Vol. 104, pp. 192–194 and 326–329.)

REINIGUNG VON ISOLATOREN MITTELS STAHLWOLLE (Cleaning Insulators with Steel Wool).—(*E.T.Z.*, 12th Dec., 1929, Vol. 50, p. 1814.)

The glaze of insulators is not scratched by medium coarse steel wool, which makes a very good cleaner. Pumice is used in conjunction with the wool, but more as a lubricant for the rubbing process than as a cleaning agent.

PORZELLANISOLATOREN UND ISOLATORENPORZELLAN (Porcelain Insulators and Insulator Porcelain).—W. Weicker: S. Velander. (*E.T.Z.*, 19th Dec., 1929, Vol. 50, p. 1852.)

Review of a brochure, by Velander, "of exceptional importance to the whole question of insulators." For a long English summary, *see Electrician*, 31st Jan., 1930, pp. 129–132.

IONIZATION CURRENTS AND THE BREAKDOWN OF INSULATION.—J. J. Torok and F. D. Fielder. (*Journ. Am. I.E.E.*, Jan., 1930, Vol. 49, pp. 46–50.)

SUSPENSION INSULATORS WITHOUT METAL JOINTS.—M. Iwatake. (*World Engineering Congress Abstracts*, 1929, Paper 54.)

STATIONS, DESIGN AND OPERATION.

PREMIÈRE RÉUNION DU COMITÉ CONSULTATIF INTERNATIONAL DE RADIOÉLECTRICITÉ (First Meeting of the CCIR).—(*L'Onde Élec.*, Jan. and Feb., 1930, Vol. 9, pp. 23–44 and 75–92.)

Among the many questions dealt with at the Hague meeting were the following:—(1) definition of the "power" of a transmitter, for telegraphy and for telephony; (2) the definition of ultra-short, short, medium and long waves; (3) the method of designating a short wave station—the method agreed can be illustrated by the following example:—12 kw.; $DR\ 160° + 160°$; $n = 24$; $l = (3/2)$; $\beta = 11\frac{1}{2}$; $h_1 = \frac{1}{2}$; $\theta = 90°$. This represents a transmitter giving 12 kw. in the aerial, with a directive aerial (D) and reflector (R), which can transmit either in the direction 160° or in the direction 160° + 180°; the effective number of wires is 24, each of length equal to $1\frac{1}{2}$ wavelengths; the breadth of the directive system is $11\frac{1}{2}$ wavelengths, the height above the ground of the lowest point is $\lambda/2$, and the wires are vertical.

(4) Frequency meters; control of frequencies; admissible tolerances. (5) Band width. (6) Separation of channels. (7) The allocation of the Ultra-short waves to national services. These and many other questions are reported in the January number. The February instalment is given up to a memorandum from the British G.P.O. on modern practice in preventing the emission of harmonics, etc., from arc and coupled-circuit valve transmitters; to an appendix on the co-ordination of radio-telephony and ordinary telephony in the international telephone service; and to another appendix on the regulation of amateur licences.

HIGH BROADCAST POWER. (*Science*, 14th March, 1930, Vol. 71, pp. xii and xiv.)

WGY, the G.E.C. station at Schenectady, started test broadcast transmissions on 200 kw. on 9th March. Six 100 kw. valves are used, each 5 ft. long (plus water-jacket, $7\frac{1}{2}$ft.), incorporated in a 200 kw. linear power amplifier, driven by a 5 kw. intermediate power amplifier. Piezoelectric frequency control is employed, the wavelength being 379.5 m. Aerial current is 92 A. See also *Sci. News-Letter*, 15th March, 1930, p. 167.

NAVAL WIRELESS TELEGRAPH COMMUNICATIONS.—G. Shearing and J. W. S. Dorling. (*Journ. I.E.E.*, Feb., 1930, Vol. 68, pp. 237–264.)

The full paper (with its subsequent discussion) an abstract of which was referred to in March Abstracts, p. 174. Part 1 is historical; Part 2 deals with the requirements to be filled by a Naval W/T System; Part 3 deals with offices and apparatus, a large number of connection and other diagrams being included; while Part 4 treats briefly the Organization and Development procedure.

THE PROVISION OF RADIO FACILITIES FOR AIRCRAFT COMMUNICATION.—E. L. Nelson and F. M. Ryan. (*Soc. Autom. Eng. Journ.*, March, 1930, Vol. 26, pp. 326–334 and 340.)

A fully illustrated article based on aircraft equipment recently developed by the Bell Telephone Laboratories for receiving weather reports and beacon signals and for two-way telephonic communication between air and ground. Information regarding shielding, bonding and installation is given.

THE MARCONI RADIO TELEPHONE TERMINAL EQUIPMENT.—G. A. Mathieu. (*Marconi Review*, March, 1930, pp. 1–11.)

An article describing the Marconi equipment to enable two-way communication to be carried on over a combined radio and land-line link, under commercial conditions. It consists essentially of a "hybrid" (bridge) circuit for passing from the 4-wire radio system to the 2-wire land-line system, receiving and transmitting echo suppressors, receiving and transmitting repeaters, and monitoring arrangements, together with the necessary switches. The transmitter echo suppressor is blocked by the receiving echo suppressor, by heavily biasing the first grid of the former by the rectified current of the diode rectifier of the latter; this action is instantaneous in comparison with that of the mechanical relay and prevents both suppressors from working simultaneously.

A CONSTANT FREQUENCY CONTROL FOR BROADCAST TRANSMITTERS: EXTENSION OF RANGE. (*Marconi Review*, March, 1930, p. 12.)

With regard to the previous article (Feb. Abstracts, p. 115) it is pointed out that the range there mentioned can be extended above and below by the suitable choice of tuning forks and by the use of frequency doubling circuits.

A TUNING FORK CONTROL FOR SHORT WAVE TRANSMITTERS.—F. M. G. Murphy. (*Marconi Review*, March, 1930, pp. 13–16.)

An article describing the extension of the control equipment for broadcast transmitters (Feb. Abstracts, p. 115) to the control of transmitters working on short waves, such as 25 m. The fork frequency is about 1,439 p.p.s., and 13 doubling stages are used.

MOTOR LORRY WIRELESS SETS FOR EGYPT. (*Engineer*, 14th March, 1930, Vol. 149, p. 299.)

The Marconi Company is supplying the Egyptian State Telegraph Department with sets (½ kw. medium wave and 100 w. short wave) mounted on lorries, for linking up, at short notice, areas not supplied by the ordinary telephone and telegraph system.

WIRELESS EQUIPMENT IN GREECE. (*Engineering*, 11th April, 1930, Vol. 129, p. 487.)

The Greek islands are to be linked up with Athens and the mainland by wireless telephone and telegraph services. Four stations are being supplied by the Marconi Company.

GENERAL PHYSICAL ARTICLES.

ÜBER DIE RICHTUNG DER ENERGIESTRÖMUNG IN EINER ZYLINDERWELLE (On the Direction of Energy Flow in a Cylindrical Wave).—J. Picht. (*Ann. der Physik*, Series 5, 1930, Vol. 4, No. 2, pp. 273–284.)

ZUR THEORIE DER ELEKTRISCHEN UND THERMISCHEN LEITFÄHIGKEIT VON METALLEN (On the Theory of the Electrical and Thermal Conductivity of Metals).—R. Peierls. (*Ann. der Physik*, Series 5, 1930, Vol. 4, No. 2, pp. 121–148.)

IONIC MOBILITIES IN Cl_2 AND IN Cl_2-AIR MIXTURES.—L. B. Loeb. (*Phys. Review*, 15th Jan., 1930, Series 2, Vol. 35, No. 2, pp. 184–192.)

ELECTRON VELOCITIES IN A HIGH FREQUENCY DISCHARGE IN HYDROGEN.—C. J. Brasefield. (*Phys. Review*, 1st Jan., 1930, Series 2, Vol. 35, No. 1, pp. 92–97.)

SECONDARY ELECTRONS OF HIGH VELOCITY FROM METALS BOMBARDED WITH CATHODE RAYS.—P. B. Wagner. (*Phys. Review*, 1st Jan., 1930, Series 2, Vol. 35, No. 1, pp. 98–106.)

DE INVLOED DER ENERGIEVERLIEZEN BIJ ELASTISCHE BOTSINGEN IN DE THEORIE DER ELECTRONENDIFFUSIE (The Influence of the Energy Losses by Elastic Impact in the Theory of Electronic Diffusion).—M. J. Druyvesteyn. (*Physica*, Feb., 1930, Vol. 10, No. 2, pp. 61–70.)

ÜBER DIE ZÄHIGKEIT DER ELEKTROLYTLÖSUNGEN (On the Viscosity of Electrolytic Solutions).—B. N. Finkelstein. (*Physik. Zeitschr.*, 1st Feb., 1930, Vol. 31, No. 3, pp. 130–135.)

A generalisation of Einstein's theory (*Ann. der Phys.*, (4), Vol. 19, 1906, and Vol. 34, 1911, p. 591) to the case where the dissolved substance is a strong (binary) electrolyte and the solvent a dipole liquid (*e.g.*, water).

ÜBER DEN MECHANISMUS DER ENTMAGNETISIERUNG (The Mechanism of Demagnetisation).—Helene Trosien. (*Ann. der Physik*, January, 1930, Series 5, Vol. 4, No. 1, pp. 109–120.)

EIGENSCHAPPEN VAN FERROMAGNETISCHE KRISTALLEN (Properties of Ferromagnetic Crystals).—G. J. Sizoo. (*Physica*, January, 1930, Vol. 10, No. 1.)

Author's summary :—A short description of Weiss' theory of ferromagnetism is followed by an account of the results of the author's experiments on the influence of the size of the grain on the magnetic properties of iron and nickel, on the magnetisation diagram of single crystals and on the Barkhausen effect. The results support Weiss' theory of the spontaneous magnetisation connected with a preferential crystallographic direction.

BEMERKUNGEN ZUM SOGENANNTEN "BAROMETER-EFFEKT" DER HÖHENSTRAHLUNG (Remarks on the "Barometer Effect" of Cosmic Rays). —W. Kaufmann. (*Zeitschr. f. Phys.*, 21st Jan., 1930, Vol. 59, No. 9/10, pp. 573–578.)

THE VARIATION OF THE RESIDUAL IONIZATION WITH PRESSURE AT DIFFERENT ALTITUDES, AND ITS RELATION TO THE COSMIC RADIATION.—W. F. G. Swann. (*Journ. Franklin Inst.*, February, 1930, Vol. 209, pp. 151–200.)

ON THE APPLICATION OF THERMODYNAMICS TO THE THERMO-ELECTRIC CIRCUIT : ON THE NATURE OF THE TRANSVERSE THERMO-MAGNETIC EFFECT AND THE TRANSVERSE THERMO-ELECTRIC EFFECT IN CRYSTALS.—P. W. Bridgman. (*Proc. Nat. Acad. Sci.*, Oct., 1929, Vol. 15, pp. 765–768 and 768–773.)

DIE CHEMISCHEN WIRKUNGEN DES LICHTS (The Chemical Effects of Light).—M. Bodenstein. (*Naturwiss.*, 11th October, 1929, Vol. 17, pp. 788–795.)

PELTIER AND THOMSON EFFECTS FOR BISMUTH CRYSTALS.—H. D. Fagan and T. R. D. Collins. (*Phys. Review*, 15th Feb., 1930, Series 2, Vol. 35, No. 4, pp. 421–427.)

Authors' abstract :—The Peltier and Thomson effects are directly measured (the former against copper) in single crystal rods almost covering the entire orientation range. For the first effect the Voigt-Thomson symmetry relation is definitely not substantiated, while for the latter the data do not provide an adequate test, though it appears likely that there is a deviation here also.

The following values are found : at a temperature of 27° C., $\pi(\| \text{ vs } \perp) = 13.8$, $\pi(45° \text{ vs } \perp) = 8.6$ microvolts ; at a temperature of 48.5° C., $\sigma_{\|} - \sigma_{\perp} = 43$, $\sigma_{45} - \sigma_{\perp} = 26.5$ microvolts/° C. These values are all in fair agreement with values deduced from thermal e.m.f. temperature data of the writers and of previous observers.

THE ROTATING ELECTRON IN A BEAM OF LIGHT.—B. M. Sen. (*Phil. Mag.*, Nov., 1929, Vol. 8, No. 52, pp. 690–697.)

THE QUANTUM THEORY AS A PROBLEM IN LINES OF FORCE.—C. D. Niven. (*Phil. Mag.*, October, 1929, Vol. 8, No. 51, pp. 491–504.)

"The wave mechanics method has introduced new hypotheses ; working from these, results have been obtained agreeing excellently with experiment and the reality of the quantum theory has been more firmly established than ever. Unfortunately, the new hypotheses do little to elucidate the physical meaning of the quantum theory. In the following paragraphs an attempt is made to attach a physical meaning to . . . a few of the most fundamental principles of the quantum theory, but this does not express a disbelief in the wave mechanics. . . ." The phenomena dealt with are :—the emission of light from a discharge tube, thermal radiation, the photoelectric effect, and conduction.

MESSUNGEN DES BEI DER TOTALREFLEXION IN DAS ZWEITE MITTEL EINDRINGENDEN LICHTES (Measurements of the Light entering the Second Medium at Total Reflection).—O. Stasiw. (*Ann. der Phys.*, 8th Oct., 1929, Series 5, Vol. 3, No. 2, pp. 209–228.)

STUDY OF ELECTRIC OSCILLATIONS BY MEANS OF A DISCHARGE TUBE : RECTIFICATION OF H.T. ALTERNATING CURRENT.—Y. Ikeda, E. Kato, M. Mori. (*Proc. Imp. Acad.*, Tokyo, June, 1929, Vol. 5, pp. 227–229 and 230–232.)

APPEARANCE OF NOBLE GASES IN VACUUM TUBE DISCHARGES : THE DISAPPEARANCE OF HYDROGEN IN DISCHARGE TUBES.—D. Dooley : R. Delaplace. (*Nature*, No. 3123, Vol. 124, p. 372 ; *Comptes Rendus*, No. 21, Vol. 189, pp. 849–850.)

ÜBER KONTAKTPOTENTIALE ZWISCHEN GLEICHEN METALLEN (On Contact Potentials between Like Metals).—W. Ende. (*Physik. Zeitschr.*, No. 15, Vol. 30, 1929, pp. 477–480.)

To reduce the contact potential as much as possible between two pieces of the same material, the surfaces should be cleaned by sawing, turning, scraping or sand-blasting (p.d. down to below 0.05 v.), whereas treatment by washing, acids, and particularly by sand-paper, may put the p.d. up to 0.5 v.

ON THE FREE PERIODS OF RESONATORS.—E. J. Irons. (*See* under "Acoustics.")

A SUPERCONDUCTOR, CONSISTING OF TWO NON-SUPERCONDUCTORS.—de Haas, van Aubel and J. Voogd. (*Proc. Amsterdam*, 1929, Vol. 32, No. 6, pp. 724–730.)

A rather long abstract is to be found in *Physik. Berichte*, 15th November, 1929, p. 2095.

SUR L'INTERPRÉTATION DE LA VARIABILITÉ DE LA RÉSISTANCE OHMIQUE AVEC LA FRÉQUENCE (The Interpretation of the Variability of Ohmic Resistance with the Frequency).—A. Perrier. (*Helv. Phys. Acta*, No. 3, 1929, Vol. 2, pp. 148–150.)

The writer interprets the frequency-dependence in the case of bismuth, antimony and tellurium according to his theory of metallic conduction.

Recent Progress in the Dual Theory of Metallic Conduction.—E. H. Hall. (*Proc. Nat. Acad. Sci.*, Jan., 1930, Vol. 16, pp. 45–55.)

Statistical Theories of Matter, Radiation and Electricity.—K. K. Darrow. (*Bell. Tech. Journ.*, Oct., 1929, Vol. 8, pp. 672–748.)

"The atomic or 'kinetic' theory of gases, with its interpretations of such qualities as temperature, pressure, viscosity, and conductivity, has ranked for more than half a century as a very important part of theoretical physics. A corresponding theory for radiation and for negative electricity is much to be desired, since it is known that in many ways each of these entities behaves as though it were atomic. There are, however, differences among the three, and only within the last five years have these been formulated suitably. This article is devoted to the resulting statistical theories."

Electro-Physics.—D. Owen. (*Journ. I.E.E.*, January, 1930, Vol. 68, pp. 132–138.)

A review of progress during the past few years.

Ist das kontinuierliche Spektrum des Unterwasserfunkens Temperaturstrahlung? (Is the Continuous Spectrum of the Underwater Spark a Temperature Radiation?).—B. Wrede. (*Ann. der Phys.*, 4th Dec., 1929, Series 5, Vol. 3, No. 6, pp. 823–839.)

Über Wellengeschwindigkeit und Flussgeschwindigkeit ("Korpuskulargeschwindigkeit") einer Welle (Wave Velocity and Flow—"Corpuscular"—Velocity of a Wave).—W. Alexandrow. (*Zeitschr. f. Phys.*, Sept., 1929, Vol. 57, No. 5/6, pp. 380–386.)

Zur Quantentheorie der Wellenfelder (The Quantum Theory of Wave Fields).—W. Heisenberg and W. Pauli. (*Zeitschr. f. Phys.*, 2nd January, 1930, Vol. 59, No. 3/4, pp. 168–190.)

Wave Mechanics and the Dual Aspect of Matter and Radiation.—A. M. Mosharrafa. (*Proc. Roy. Soc.*, 2nd December, 1929, Vol. 126A, pp. 35–40.)

Cf. January Abstracts, p. 54.

Note on the Theory of the Interaction of Field and Matter.—J. R. Oppenheimer. (*Phys. Rev.*, 1st March, 1930, Series 2, Vol. 35, No. 5, pp. 461–477.)

Author's abstract:—The paper develops a method for the systematic integration of the relativistic wave equations for the coupling of electrons and protons with each other and with the electromagnetic field. It is shown that, when the velocity of light is made infinite, these equations reduce to the Schrödinger equation in configuration space for the many body problem. It is further shown that it is impossible on the present theory to eliminate the interaction of a charge with its own field, and that the theory leads to false predictions when it is applied to compute the energy levels and the frequency of the absorption and emission lines of an atom.

Modern Concepts in Physics and their Relation to Chemistry.—I. Langmuir. (*Science*, 25th Oct., 1929, Vol. 70, pp. 385–396.)

Electron Waves.—C. J. Davisson. (*Journ. Franklin Inst.*, Nov., 1929, Vol. 208, pp. 595–604.)

A short review of the experimental work of the last two years, with a few suggested paths for future research.

Ether Drift Experiments in 1929, and Other Evidences of Solar Motion.—Dayton C. Miller. (*Science*, 6th Dec., 1929, Vol. 70, pp. 560–561.)

On the Production of X-Radiation, according to Wave Mechanics.—A. Sommerfeld. (*Journ. Franklin Inst.*, Nov., 1929, Vol. 208, pp. 571–588.)

Über die effektive und die reversible Permeabilität (On Effective and Reversible Permeability).—G. J. Sizoo. (*Ann. der Phys.*, 8th Oct., 1929, Series 5, Vol. 3, No. 2, pp. 270–276.)

Magnetochemie der Dia- und paramagnetischen Metalle und Legierungen (Magnetochemistry of the Dia- and Paramagnetic Metals and Alloys: a Comprehensive Review).—H. J. Seemann. (*Zeitschr. f. tech. Phys.*, Oct., 1929, Vol. 10, No. 10, pp. 399–408.)

Einleitung in eine Theorie der Magnetooptischen Erscheinungen in Kristallen (Introduction to a Theory of the Magneto-optical Phenomena in Crystals). — J. Becquerel. (*Zeitschr. f. Phys.*, 24th Oct., 1929, Vol. 58, No. 3/4, pp. 205–216.)

Ionisation fester Dielektriken durch Röntgen-strahlen (The Ionisation of Solid Dielectrics by Röntgen Rays).—D. Nasledow and P. Scharawsky. (*Ann. der Physik.*, 2nd Oct., 1929, Series 5, Vol. 3, No. 1, pp. 63–90.)

Der elektrische Durchschlag und Townsends Theorie (Electric Breakdown and Townsend's Theory).—A. v. Hippel and J. Franck. (*Zeitschr. f. Phys.*, 3rd October, 1929, Vol. 57, No. 9/10, pp. 696–704.)

A reconciliation of Townsend's theory with the results of Rogowski, on the assumption that the building-up of the space charge is to be regarded primarily as an electron collision phenomena, ionic mobility playing only a secondary part.

Dissoziation durch Stoss positiver Ionen (Dissociation of Positive Ions by Collision).—A. Leipunsky and A. Schechter. (*Zeitschr. f. Phys.*, 29th Jan., 1930, Vol. 59, No. 11/12, pp. 857–863.)

The writers have experimentally established the existence of activation by collision: hydrogen molecules were dissociated by the impact of fast positive ions (the first step being probably the excitation of the H_2 molecule, with dissociation as a secondary process).

EINE METHODE ZUR BESTIMMUNG VON KONTAKTPOTENTIALEN (A Method of Determining Contact Potentials—Volta Potentials).—E. Patai. (*Zeitschr. f. Phys.*, 21st Jan., 1930, Vol. 59, No. 9/10, pp. 697–699.)

Author's summary :—" The characteristic curves of a triode show a parallel displacement if sodium is introduced electrolytically (Tangl). The reason for this is the change of the contact-potential difference between cathode and grid. On the basis of this phenomenon, a general method for the determination of the contact-potentials of metals can be founded." In the tests quoted, the parallel displacement (*i.e.*, the contact P.D. between sodium and molybdenum) was slightly smaller than the difference between the work functions. *Cf.* Sixtus, March Abstracts, p. 160 (under " Valves "). See also Lange, 1928 Abstracts, p. 400.

ENERGY LOSSES OF ELECTRONS IN MERCURY VAPOUR.—D. C. Rose. (Supplement to *Nature*, March 22nd, 1930, Vol. 125, pp. 460, 461.)

A study of the effects of collisions with mercury atoms of electrons of energies of 8, 18.4, 34.6 and 49 volts.

BESTIMMUNG DES ELEKTRISCHEN MOMENTES EINES MOLEKÜLS AUS DEM TEMPERATURVERHALTEN DER DIELEKTRIZITATSKONSTANTEN (Determination of the Electric Moment of a Molecule from the Variation with Temperature of the Dielectric Constant).—R. Sänger. (*Physik. Zeitschr.*, 1st April, 1930, Vol. 31, No. 7, pp. 306–315.)

EFFETS D'IONISATION PAR L'ACTION SOLAIRE (The Ionising Effects [on Lead, etc.] of Solar Action).—A. Nodon. (*Comptes Rendus*, 7th April, 1930, Vol. 190, pp. 882–884.)

THE BEHAVIOUR OF ELECTRONS IN MAGNETIC FIELDS.—V. A. Bailey. (*Phil. Mag.*, April, 1930, Vol. 9, No. 58, pp. 560–567 and 625–628.)

An account of theory and experiments on the determination of the drift velocity of electrons in gases in uniform electric fields by a method which makes use of the reduction of the divergence of an electronic stream which occurs when a uniform magnetic field is applied in the same direction as the electric field.

ON THE ORIGIN OF THE ELECTRODELESS DISCHARGE.—K. A. MacKinnon. (*Phil. Mag.*, November, 1929, Vol. 8, No. 52, pp. 605–616.)

Hittorf and J. J. Thomson have always maintained that this discharge is due to electromagnetic induction, but Townsend and Donaldson (*ibid.*, January, 1928) assert that electrostatic forces are largely responsible for it, pointing out that theoretically the electrostatic intensity between the end of a solenoidal coil of ordinary dimensions is more than thirty times the electromagnetic intensity around a ring inside the coil. The work here described indicates that the *ring* type of discharge (to which Thomson's work was confined) is undoubtedly of electromagnetic origin, whilst the *glow* is largely or entirely electrostatic.

ON THE " FLASH " IN THE AFTER-GLOW OF THE ELECTRODELESS DISCHARGE WITH CHANGE OF PRESSURE.—C. T. Knipp and L. N. Scheuerman. (*Phil. Mag.*, Nov., 1929, Vol. 8, No. 52, pp. 684–689.)

THE POTENTIAL DISTRIBUTION ACROSS THE CATHODE DARK SPACE.—W. L. Brown and E. E. Thomson. (*Phil. Mag.*, Dec., 1929, Suppy., No. 53, Vol. 8, pp. 918–942.)

EINFLUSS DER ENTGASUNG DER KATHODE AUF DEN KATHODENFALL (Influence of Out-gassing of the Cathode on the Cathode Drop).—G. Barth. (*Ann. der Phys.*, 8th Oct., 1929, Series 5, Vol. 3, No. 2, pp. 253–269.)

ON CONDITIONS NEAR THE CATHODE OF A GLOW DISCHARGE.—N. M. Carmichael and K. G. Emeléus. (*Phil. Mag.*, Dec., 1929, Suppy. No. 53, Vol. 8, pp. 909–918.)

THE DISCHARGE THROUGH RAREFIED GASES UNDER THE INFLUENCE OF HIGH FREQUENCY CURRENTS.—Y. Asami. (*World Engineering Congress Abstracts*, 1929, Paper 75.)

MISCELLANEOUS.

TRANSMISSION SIMULTANÉE DE DEUX COMMUNICATIONS TÉLÉPHONIQUES SECRÈTES (Simultaneous Transmission of Two Secret Telephonic Communications).—G. Fayard. (*Bull. d. l. Soc. franç. d. Élec.*, No. 98, Vol. 9, pp. 1146–1157.)

From the whole band of frequencies in the speech to be transmitted, only the band 300–2300 p.p.s. is preserved. In the case of one of the two simultaneous communications, this whole band is transposed by subtracting each frequency from a frequency of 2600 p.p.s. Thus the two extreme frequencies 300 and 2300 p.p.s. become 2600–300 and 2600–2300 ; *i.e.*, 2300 and 300 p.p.s. respectively, with the result that the low frequencies become transformed to high and vice versa. Thus changed, the speech (called the " inverted speech ") is quite unintelligible.

The second communication, on the other hand, has the frequency 2600 added to each component in its band ; so that the extremes (300 and 2300) become 2900 and 4900 p.p.s. respectively. This, the " high speech," is equally unintelligible.

The processes are carried out by a combination of frequency-transposing valve modulators and Chireix triode-coupled filter stages (each stage comprising a resonant shunt and an anti-resonant circuit, both tuned to the geometrical mean of the extreme frequencies of the band to be passed).

SECRET COMMUNICATION.—T. Kujirai and I. Koga. (*World Engineering Congress Abstracts*, 1929, Paper 141.)

"Special simple and reliable means for secret communication were realised." Four methods were used :—(1) transmission by abrupt change in carrier frequency in quite irregular time intervals, and reception by their synthesis ; (2) extra high speed transmission with a photoelectric cell, and reception by a special electro-mechanical recorder ; (3) transmission by extremely slight frequency modulation, and its detection by a bridge containing a regenerative circuit, or by a combination of multivibrator and a heterodyne receiver ; and (4) transmission by the reversal of an alternating current, and detection by a combination of full-wave rectifier and frequency demultiplier.

THE RADIO RESEARCH BOARD.—(*Engineering*, 11th April, 1930, Vol. 129, pp. 467–468.)

Review of the recently published Report of the Radio Research Board. Hitherto, the work of this Board has been summarised in the Annual Report of the Department of Scientific and Industrial Research, but the published results of the Board's work are attracting so much attention that it is now thought desirable to issue an annual report as a separate publication. The report here dealt with is the first of these.

THE TWENTIETH ANNUAL EXHIBITION OF THE PHYSICAL AND OPTICAL SOCIETIES.—(*Journ. Scient. Instr.*, Feb., 1930, Vol. 7, pp. 33–78.)

ACTION OF LOW VELOCITY ELECTRONS ON MICRO-ORGANISMS.—D. A. Wells. (*Nature*, 28th Dec., 1929, Vol. 124, pp. 983–984.)

Staphylococcus albus can be killed by the action of low-velocity electrons : under the conditions of the tests described, the lethal action is a function of the energy of the individual electrons : the percentage killed at constant electronic energy is a function of the total energy of exposure. Little or no killing was found below 25 v., though the total energy per unit area was constant at 13×10^7 ergs.

A NEW SYSTEM OF AUDIO-FREQUENCY CARRIER TELEGRAPHY.—H. Nukiyama and K. Nagai. (*World Engineering Congress Abstracts*, 1929, Paper 135.)

A system based on a combination of the "Ampli-Filter" (an amplifier with very sharp selectivity), the "Triode Jumper" (a new high-speed valve relay—*see* 1929 Abstracts, p. 399), and the "Filter-oscillator" (an oscillator having no higher harmonic and a high constancy of frequency under a change of load).

TELEFONIA OTTICA MEDIANTE RADIAZIONI ULTRA-VIOLETTE OD ULTRAROSSE (Optical Telephony by Ultra-violet or Infra-red Rays).—Q. Majorana. (Summary in *Nuovo Cim.*, Jan., 1930, Vol. 7, p. XXIII.)

TALKING ALONG A BEAM OF LIGHT.—C. O. Browne. (*Wireless World*, 5th March, 1930, Vol. 26, pp. 240–242.)

THE CHEMICAL EFFECTS OF HIGH FREQUENCY SOUND WAVES. II—A STUDY OF EMULSIFYING ACTION.—W. T. Richards. (*Journ. Am. Chem. Soc.*, No. 6, 1929, Vol. 51, pp. 1724–1729.)

MESURE DIRECTE DU RAPPORT DES RETARDS ABSOLUS DANS LA BIRÉFRINGENCE PAR DÉFORMATION (The Direct Measurement of the Ratio of the Absolute Retardations in Double Refraction by Deformation).—E. Henriot and A. Marcelle. (*Comptes Rendus*, 31st March, 1930, Vol. 190, pp. 791–793.)

DAS "ELEKTRISCHE AUGE" BEI DER SELBSTTÄTIGEN VERKEHRSREGELUNG (The "Electric Eye" in Automatic Traffic Control).—(*E.T.Z.*, 26th December, 1929, Vol. 50, p. 1883.)

American practice, in automatic control of cross roads, is for the light signals to change automatically in a certain cycle. To avoid unnecessary delays on a main road, however, a further refinement is being tried in Pittsburgh ; a photoelectric cell device is used to retain the "all clear" for the main road unless a vehicle is approaching along the less important road.

AN IMPROVED FILM PHONOGRAPH.—C. W. Hewlett. —(*Gen. Elec. Review*, January, 1930, Vol. 33, pp. 38–39.)

A 50-watt incandescent lamp is used for recording : the light passes a straight-edge close to the lamp, is condensed and focused on the mirror of an ordinary oscillograph ; the mirror reflects the straight-edge diagonally on the physical slit, and a microscope objective focuses this slit on the film with ten-fold diminished linear dimensions. At present nine tracks are recorded side by side on the film [width unspecified] and a 400-ft. roll plays for about 80 minutes ; but it is hoped to increase the number of tracks to 15. To avoid reversing, the ends of the film are sealed, thus giving a continuous band, and the scanning spot is shifted 2.5 mm. from one sound track to the next by an electrical device (a small metal tab on the edge of the film completing an electric circuit). No further description is given of the reproducer.

PAPER-WEIGHT, UNBREAKABLE [DURIUM] PHONOGRAPH RECORDS.—(*Scient. American*, April, 1930, Vol. 86, pp. 307–308.)

This record consists of a coating of Durium (April Abstracts, p. 233) six or eight thousandths of an inch thick, on a heavy fibre paper. A thin film of Durium can scarcely be broken with a hammer and is almost as flexible as paper. The writer has "listened in amazement" to the perfect tones of a record already played more than 200 times. Violent hammering and scratching apparently has no effect on the quality.

ELECTRICITY FROM THE SUN (The Lange Photoelectric Cell).—(*See* under "Phototelegraphy.")

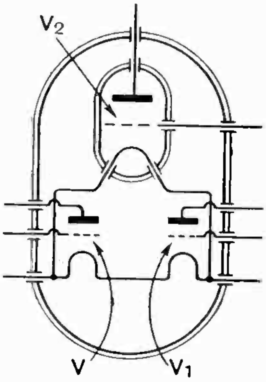
Some Recent Patents.

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 1s. each.

MULTI-STAGE VALVES.

Convention date (Germany), 29th October, 1927. No. 299707.

In a multiple valve comprising say three stages of low-frequency amplification, one stage is separated from the other two by being enclosed within an inner bulb. As shown in the Figure the three-electrode systems *V* and *V*1 are resistance-coupled voltage amplifiers, the coupling-elements being housed in the outer bulb (but not shown), whilst the stage *V*2 is a power amplifier and is contained in a separate bulb with a higher degree of vacuum. The arrangement prevents undesirable reaction between the electron streams of the different systems.



No. 299707.

Patent issued to S. Loewe and E. Roemhild.

BALANCING INTERELECTRODE CAPACITY.

Convention date (U.S.A.), 20th July, 1927. No. 294200.

In order to neutralise capacity coupling between the electrodes of a valve amplifier, the output inductance is coupled to a winding forming the input to the succeeding valve but divided into two parts. One part is more or less closely coupled, reversely, to the output winding, whilst the other part has no magnetic coupling with either of the other two windings. The balancing feed-back voltage is taken back to the grid of the first valve from a point between the two windings forming the input to the next valve. The arrangement is applicable to screened-grid amplifiers.

Patent issued to Radio Frequency Laboratories Inc.

REACTION CIRCUITS.

Application date 28th September, 1928. No. 322271.

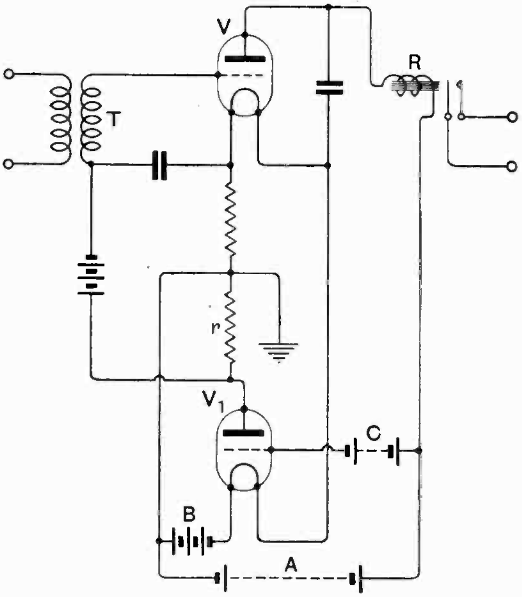
In order to apply reaction to a two-grid amplifier the plate circuit comprises part of a choke-coil, the lower end of which is connected through a coupling-condenser to the grid of the next valve. The outer grid of the tetrode is connected to an adjustable tapping on the aforesaid choke, the tapping point being located beyond the point at which the H.T. supply is fed through the choke. Alternatively the extended portion of the choke may be shunted by a potentiometer resistance, to which the tapping from the outer grid is taken. Or a separate loop-circuit may be coupled to the choke, and tapped to the outer grid.

Patent issued to Igranic Electric Co., Ltd., and A. D'A. Hodgson.

VALVE RELAYS.

Application date, 1st September, 1928. No. 321490.

Provision is made to compensate for the falling voltage of a high-tension battery supplying a valve relay. As shown in the Figure, a valve *V* is fed from an input *T* to operate a relay *R* in the output circuit. An auxiliary valve *V*1 is used to maintain the sensitivity of the relay action in spite of any diminution in the high-tension supply. Both valves are fed from a common L.T. battery *B*. The service H.T. battery is shown at *A*. A standard constant-voltage battery *C* is applied in opposition to the battery *A* to the grid of the valve *V*1. As the voltage of battery *A* falls, the battery *C* imposes a larger negative bias on the grid of valve *V*1.



No. 321490.

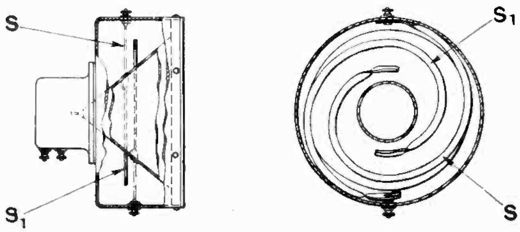
The plate current of this valve falls off, accordingly and the voltage drop across the resistance *r* diminishes. This, in turn, lessens the normal negative bias applied to the grid of the main valve *V*, and so restores the normal value of the plate current of that valve.

Patent issued to General Electric Co., Ltd., and E. P. L. Westell.

LOUD SPEAKERS.

Application date, 31st October, 1928. *No.* 321806.

The diaphragm of a loud speaker is suspended by one or more spiral springs *S*, *S*1, one end of each spring being attached to the diaphragm and the other end to the casing or other fixed part. The springs are rectangular in cross section, the longer axis of the cross-section being set in the radial direction of the diaphragm. This gives a greater



No. 321806.

freedom of vibration to the diaphragm in the axial than in the radial direction, and ensures a relatively large measure of rigidity in the latter direction. To ensure a true balance the supporting-springs encircle the diaphragm in the radial plane that contains the centre of gravity of the vibrating parts.

Patent issued to C. French.

Application date, 10th December, 1928. *No.* 323620.

In general, with mixed sounds, vibrations of high frequency are chiefly produced near the centre of the diaphragm, the lower frequencies occurring towards the outer edges. The invention provides two separate channels for the high and low frequencies, viz. : a central air column for the former and an annular outer passage for the latter. Or the central tube may be surrounded by a series of separate air columns. The two channels combine some distance beyond the diaphragm. It is stated that this arrangement gives greater volume and clearer detail than usual.

Patent issued to M. Benjamin.

Application date, 21st June, 1929. *No.* 324608.

In a four-pole magnetic system the armature is mounted upon a frame which is connected to the diaphragm. The frame is carried upon a lever which does not vibrate with the transmission, but which can be adjusted about a fulcrum so as to regulate the armature setting without varying the stress in the frame.

Patent issued to C. A. and A. C. Gardner.

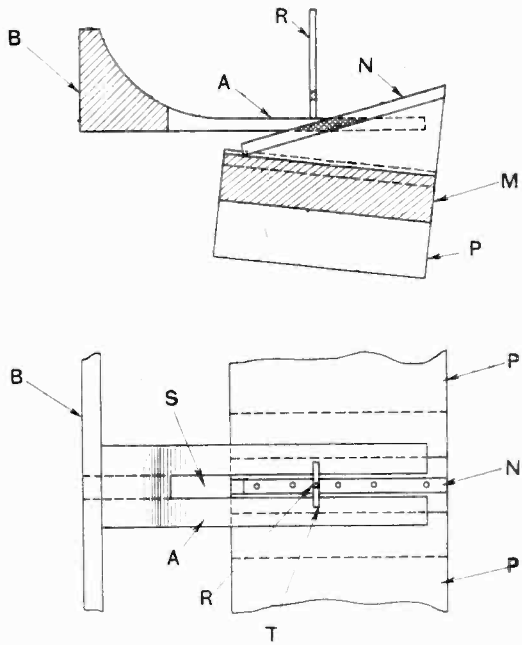
Convention date (*Germany*), *29th December*, 1927. *No.* 303175.

Instead of using an ordinary diaphragm, the amplified speech frequencies are applied directly to an ionised layer of air so as to cause the latter to vibrate and set up a train of sound waves. Such a system is free from the resonance effects invariably associated with a disc, cone, or similar mechanical vibrator. The ionised layer of air is produced inside two perforated disc electrodes by means of an X-ray tube or by a pair of small arc lamps. The inner surfaces of the electrodes may be coated with a radio-active substance.

Patent issued to S. Loewe.

Application date, 8th November, 1928. *No.* 321327.

Relates to speaker-movements of the kind in which, as the reed armature approaches the magnet poles, the centre of attraction moves away from the free end towards the fixed end of the armature, so as to maintain a constant response over a wide range of frequencies. According to the present invention the effective shortening of the armature leverage is emphasised by the provision of a flux-guiding member. As shown in the Figures, the armature *A* is carried by a flexible cross-bar *B* and is slotted at *S*. The magnet pole *P* carries a member *M* of non-magnetic material on which is mounted a strip *N* of magnetic material inclined to the pole. As the armature vibrates, the strip *N* moves to and fro along the slot *S*. The magnetic flux is mainly concentrated in the gap between the armature and strip, as shown by the cross-hatched portion, so that the effective leverage of the magnet force on the armature is lessened as the armature



No. 321327.

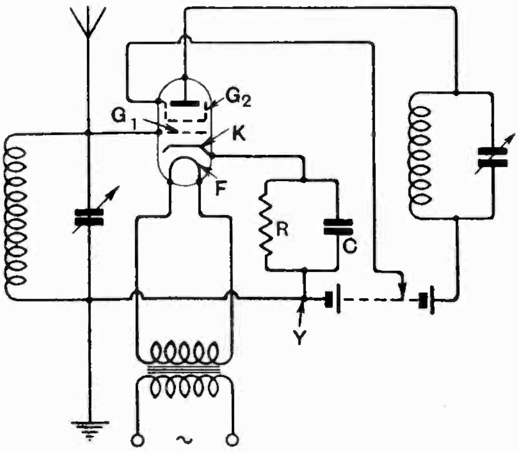
moves downwards towards the pole-piece, and vice versa. The diaphragm is impulsed by a rod *R* carried by a bridge-piece *T* connected across the split in the armature.

Patent issued to Wireless Music, Ltd., and M. Trouton.

AUTOMATIC GRID BIAS.

Convention date (Netherlands), 4th December, 1928. *No.* 323424.

In order to impose a negative grid bias in a screened grid equipotential-cathode amplifier, the cathode K is connected to the common junction Y through a resistance R shunted by a condenser C.



No. 323424.

The whole of the anode current, as well as that flowing from the screening grid G_2, passes through the resistance R to the cathode. If the input grid G_1 is now connected to the common junction point Y it will receive a negative bias corresponding to the potential drop across R. The condenser C is stated to prevent hum.

Patent issued to N. V. Philips Gloeilampen-Fabrieken.

SUPERSONIC RECEIVERS.

Application date, 12*th November,* 1928. *No.* 321560.

In a supersonic set in which the intermediate frequency amplifiers are of the screened-grid type, the difficulty of matching the tuned-transformer impedance between the detector and the first S.G amplifier is overcome by providing one or more tapping points on the primary of the coupling transformer. In this way only a portion of the total primary impedance is included in the plate circuit of the first detector, which has normally a much lower AC resistance than the subsequent S.G amplifiers.

Patent issued to S. G. S. Dicker.

LOW-FREQUENCY AMPLIFIERS.

Application date, 16*th November,* 1928. *No.* 322081.

The anode current of the amplifier valve is passed through the primary winding of the coupling transformer, whilst the secondary winding is traversed by both A.C. and D.C. components. The magnitude of the two D.C. components in primary and secondary, respectively, are so adjusted that the resultant steady flux in the transformer core is substantially zero. The method is particularly useful in making sound reçords upon a photographic film.

Patent issued to the Gramophone Co., Ltd., and C. O. Browne.

MINIMISING FADING.

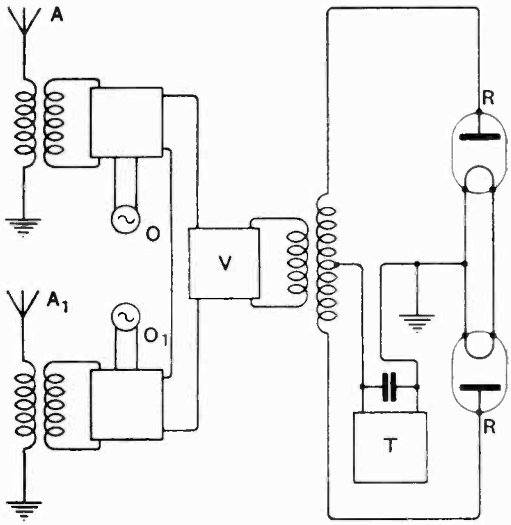
Application date, 26*th November,* 1928. *No.* 323331.

The effect of fading is reduced by using two directed rays simultaneously, the angle of each ray to the horizontal plane being maintained constant but being different from that of the other. Preferably the aerials are of the type in which radiation from alternate half wave-lengths is suppressed, and they are located inside a parabolic screen. For transmission on a 15 metre wavelength over a distance of 8,000 miles one ray is directed at 40° and the other at 80° to the horizontal.

Patent issued to S. G. S. Dicker.

Convention date (U.S.A.), 15*th March,* 1928. *No.* 307894.

When using two or more spaced aerials in reception, with the object of eliminating the effects of fading, it is found impossible to combine the aerial pick-up voltage directly in a common receiver owing to continual fluctuations in phase. According to the invention this difficulty is overcome by coupling a local oscillator O, O_1 to each of the receiving aerials A, A_1 so as to produce slightly different supersonic beat frequencies which



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are then fed to an intermediate-frequency amplifier V. The resulting audible or difference beat note is separated in a full-wave rectifier R and fed to the telephones T or other recording device.

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

AERIAL FEED LINES.

Convention date (U.S.A.), 23rd March, 1928. No. 308664.

A balanced-impedance coupling, specially suitable for supplying sleet or ice melting current to a transmitting aerial, consists in the simplest form of a linear oscillator. The two lines to be coupled are tapped at selected points on each side of the rod oscillator so that the impedance between these points has the value desired. As coupling does not comprise the usual lumped impedances, it may be left exposed to severe climatic conditions without injury.

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

PUSH-PULL AMPLIFIERS.

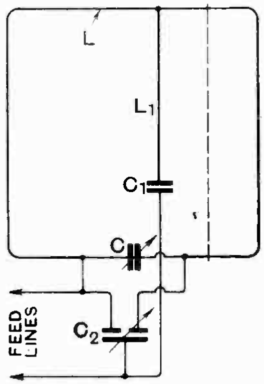
Application date, 22nd November, 1928. No. 324464.

In order to compensate for any asymmetry in the characteristics of the valves, such as might tend to create " hum " in a mains-fed set, a variable resistance is inserted in the anode circuit of each valve. Each resistance is adjusted independently until a correct balance is secured. The primary winding of the output transformer is also tapped at several points to provide further facilities for balancing.

Patent issued to S. G. S. Dicker.

DIRECTIONAL AERIALS.

Convention date (U.S.A.), 21st February, 1928. No. 306487.



No. 306487.

Directional effects are secured by the use of an aerial system comprising a loop L tuned by a condenser C and having an intermediate limb L_1 connected across the loop at a point slightly nearer one end than the other. By means of condensers C, C_1, C_2, the phase relation of the currents flowing in the three upright limbs is adjusted so as to neutralise radiation in one direction along the plane of the aerial, and to concentrate it along the other.

Patent issued to Brandes, Ltd.

IDENTIFYING STATIONS.

Application date, 23rd July, 1928. No. 323245.

In order to afford a listener the opportunity of dentifying the particular station to which he is listening at any time, a slight variation is imparted to the frequency of the transmitted carrier-wave so as to impose a constantly-repeated characteristic C.W. note. The listener, by momentarily throwing his set into oscillations, can thus pick up the identification signal even during the transmission of a programme item, instead of waiting for the usual interval sign. Prolonged self-oscillation is discouraged by the fact that the C.W. identification signal drowns out the ordinary programme transmission.

Patent issued to O. Tants.

VARIABLE INDUCTANCES.

Convention date (U.S.A.), 28th October, 1927. No. 299731.

A variable inductance, which in one form is constructed as a loop or frame aerial, comprises several similar coils or sections, the ends of which are each connected to one of a set of fixed plug contacts mounted on a suitable base-plate. A number of separate switch blocks, corresponding to the lower, medium, and high wavelength ranges to which the aerial or inductance is to be tuned, are adapted to be plugged in to the base, so as to connect all the coil sections in parallel, series, or series parallel according to the wave band required.

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

THERMIONIC VALVES.

Application date, 4th December, 1928. No. 324175.

In order to reduce the internal grid-anode capacity the electrodes are arranged as follows: The anode is innermost and consists of a cylinder of nickel mounted on a central glass stem. Wound spirally about the anode is a wire cathode of tungsten coated with platinum, upon which an alkaline earth oxide has been deposited. The grid lies outermost and consists of a cylinder of nickel. In another arrangement the central anode is a flattened oval, and is surrounded first by a slotted screening-grid and then by a rectangular-shaped anode, the cathode wires being arranged between the slot in the screening grid and the outer anode.

Patent issued to P. Freedman.

COMPOSITE TUNING-UNITS.

Application date, 4th February, 1929. No. 324246.

A cylindrical former is wound externally with primary and secondary windings, separated by suitable spacing-pieces. A second cylindrical former, set at right angles to the first and mounted inside it, carries loading coils for the primary and secondary windings. Change-over from short to long wavelengths is effected by means of a push-pull switch, which in one position short-circuits the loading-coils, and in the other inserts them in series with the transformer windings. The same switch may be rotated simultaneously over a rheostat so as to serve as a volume control.

Patent issued to V. G. van Colle.