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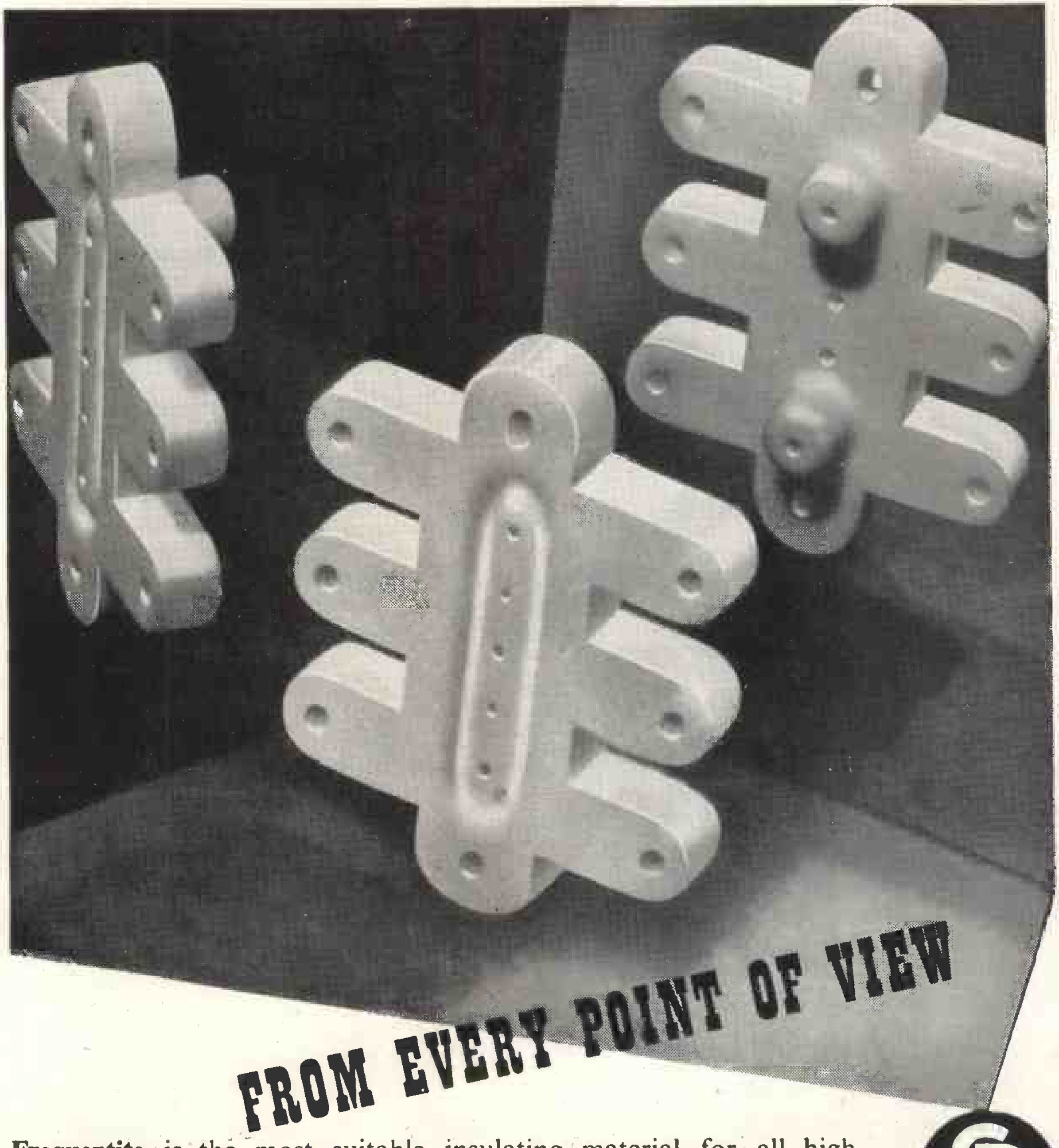
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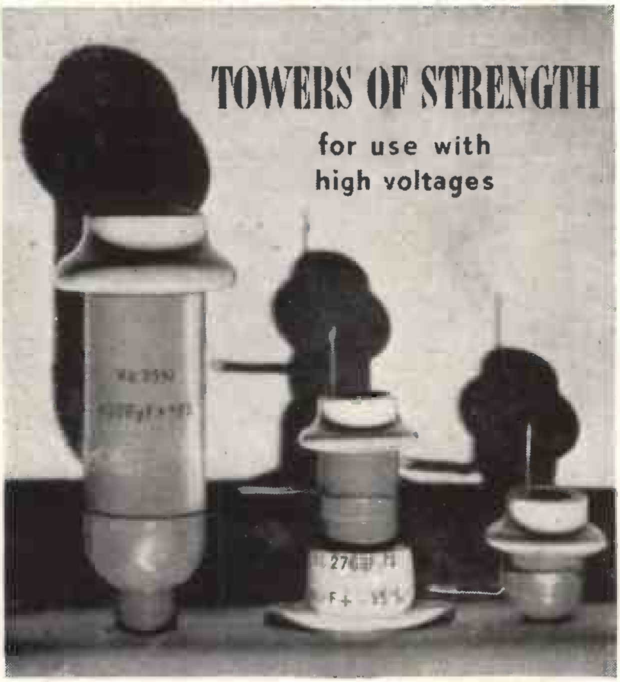
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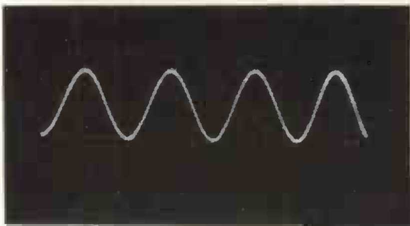

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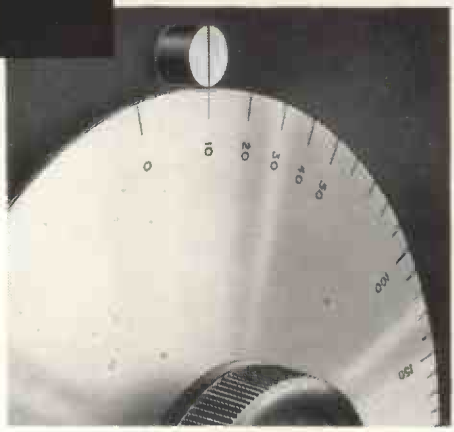

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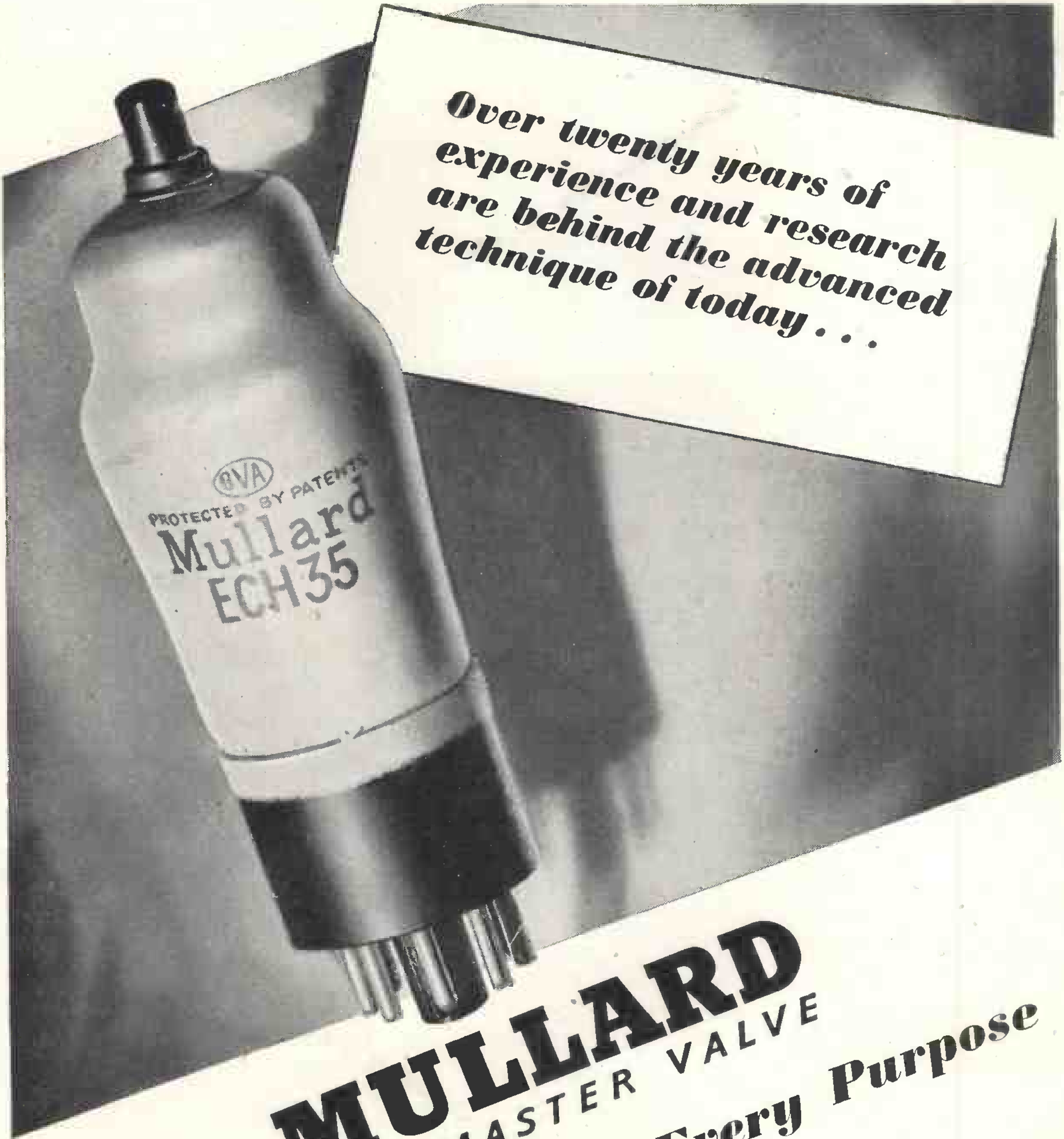
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WIRELESS ENGINEER

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VOL. XXI MARCH, 1944 No. 246

Editorial

A Problem of Two Electrons and Newton's Third Law

A PHYSICIST recently propounded a problem which appeared to cast doubts on the validity of Newton's third law. If two electrons or other charges are moving as shown in Fig. 1 at a given moment, the left-hand one *A* will act as current-carrying element and produce a magnetic field at *D*. The electron *D* is equivalent to a current-carrying element and will experience a mechanical force which an application of the left-hand rule shows to be in the direction indicated. Surely, one is inclined to say, there must be an equal and opposite reaction on the charge at *A*, otherwise Newton's third law is violated. Seeing that *A* is on the line of motion of *D*, the latter cannot possibly produce a magnetic field there, nor is it possible to conceive any way, either magnetic or electric, in which *D* can exert a mechanical force on *A* in the required direction.

Fig. 1.

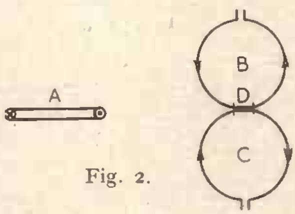


Fig. 2.

A clue to a possible solution of the problem is obtained by considering something more tangible than two fleeting electrons. Fig. 2 shows two coils *B* and *C* in the vertical plane with a short portion *D* common to both, and so arranged that it can move in guides towards or away from the reader. *A* is another coil in the horizontal plane through *D*. Current is supplied to the coils in the directions shown. If free to rotate about a vertical axis, the system *BC* would turn so as to face *A*, and thus increase to its maximum value the magnetic flux linking the three coils. In the position shown the coil *A* will experience a force towards the reader, tending to swing it round in front of *BC*, the torque being, of course, the same as before. The coil *A* produces at *D* an upward magnetic field, as the result of which the conductor *D* experiences a force towards the reader. Where shall we look for the reaction to this force? Certainly not to the coil *A*, since the forces acting on it have a resultant towards and not away from the reader. The answer to this question is seen at once by considering the path of a line of force produced by the coil *A* approximately in the plane of the coils *B* and *C* as shown in Fig. 3. The currents in the coils will distort it so that it passes in front of *C*, behind *D*, and in front of *B*. Hence, although the mechanical force exerted on the conductor *D* is due to its current, i.e. the moving electrons in it, interacting with the magnetic field of the coil *A*, the mechanical reaction of the force does not come on the source of the magnetic field but on other parts of the electric system of which *D* forms an element.

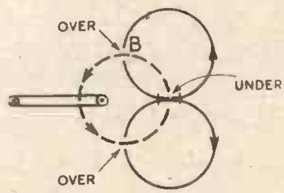


Fig. 3.

The parallel to the case of the two electrons is made much closer by arranging additional coils in a plane at right angles as shown in Fig. 4; another four coils could be inserted at 45 degrees, thus approximating to a toroid, the conductor *D* being common to all the coils. These coils now produce no external magnetic field, and therefore no force whatever on the coil A or on the moving charge A in Fig. 1, although the magnetic field of A causes the force which the conductor D experiences.

If the system of coils be removed and the conductor D replaced by the moving charge as in Fig. 1, the conduction currents of Fig. 4 are replaced by displacement currents the paths of which are very similar to those of the currents in the coils, as can be seen from Fig. 5. These displacement currents must be assumed to produce magnetic fields just as do the conduction currents, and therefore have the same distorting effect on the magnetic field produced by A. The force per cm. on the coil at B in Fig. 3 is simply $B_n I$ dynes if B_n is the component of the magnetic induction normal to the current and I is in absolute units; in the case of the electron the displacement current per square centimetre is $\frac{1}{c}\frac{dD}{dt}$ and the force per cubic centimetre therefore equal to the vector product of $\frac{1}{c}\frac{dD}{dt}$ and B.

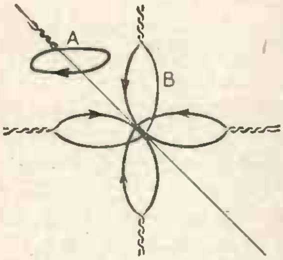


Fig. 4.

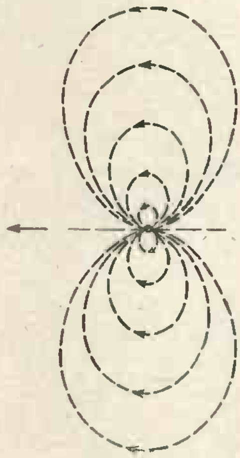


Fig. 5.

It is a simple matter to calculate the magnitude of the displacement current at any point in the plane through the moving charge normal to its motion. If A and B in Fig. 6 represent the positions of a moving positive charge q at two consecutive moments, the electric force $\mathcal{E}$ at P will have changed from Pa to Pb in this interval. This change in $\mathcal{E}$ is represented by the vector ab, which is equal to $Pa \,.\, AB/PA$. If r is the distance of the point P from the moving charge, $Pa = q/r^2$ and the change in $\mathcal{E} = q \,.\, AB/r^3$. This change takes place in the time AB/v; hence $d\mathcal{E}/dt = qv/r^3$ and $dD/dt = qv/4\pi r^3$; this then is the displacement current at P in e.s. units per cm². The total current crossing the normal plane at radii beyond r will be

$$\int_r^\infty \frac{qv}{4\pi r^3} \times 2\pi r \, dr = \frac{qv}{2}\int_r^\infty \frac{dr}{r^2} = \frac{qv}{2r}$$

To calculate the resulting magnetic force H at the point P this is the only current that need be taken into account, since the total toroidal currents may be divided into those which complete their paths inside P and are therefore without effect at P, and those which we have calculated, which embrace P. To find H we therefore have

$$H \times 2\pi r = 4\pi \times \frac{qv}{2r} \times \frac{1}{3 \times 10^{10}}$$

from which

$$H = qv/r^2 \times 1/(3 \times 10^{10})$$

which is the usual formula obtained by regarding the moving charge as a current carrying element. It will be seen that the density of the displacement current varies as $1/r^3$ whereas H varies as $1/r^2$. The displacement current at any point can easily be calculated as follows. Let the coordinates of the point be x and y, the moving charge being taken as the origin; then the distance $r = \sqrt{x^2 + y^2}$, and the electric field at the point is given by the formula

$$\mathcal{E} = \frac{q}{r^2}\left(\frac{x}{r} + j\frac{y}{r}\right)$$

Hence

$$D = \frac{q}{4\pi r^3}\left(x + jy\right)$$

and

$$\frac{dD}{dt} = -\frac{dD}{dx} \times \frac{dx}{dt} = -v\frac{dD}{dx}$$

or

$$= \frac{qv}{4\pi}\left\{\left(\frac{3x^2}{r^5} - \frac{1}{r^3}\right) + j\frac{3xy}{r^5}\right\}$$

The differentiation is with regard to x because the motion is only in this direction, and the minus sign is due to the fact that the motion is that of the origin. This formula was used to determine the shape of the current paths in Fig. 5.

Fig. 6.

Whether the currents are conduction currents as in the coils of Fig. 4, or displacement currents as in Fig. 5, their distorting effect on the magnetic field of the coil or electron A will be very similar, and if the reaction of the mechanical force on D in Fig. 4 is exerted, as it undoubtedly is, on the other parts of the system of which D forms a part, and thence to their supports, it is difficult to avoid the conclusion that the reaction to the force on the moving electron is similarly exerted on the other parts of its electrical system, i.e. on the displacement currents. But to what rigid body or support do the displacement currents transmit the mechanical force? They begin and end on the moving electron and form an inseparable part of its system. If the central element of the system of Fig. 4 is rigidly fastened to the coils, the system as a whole experiences no force. Is the same true in the case of the single moving electron and is the force on the electron due to the magnetic field counterbalanced by the forces transmitted to it along its displacement currents? If so, the electron is in the same position as the man who tries to lift himself by means of his own braces, but this conclusion is so contrary to the accepted view of the action of an electron in such circumstances that one cannot but suspect a flaw somewhere in the argument.

An alternative direction in which to look for a support for the mechanical reaction is along the electric field radiating from the moving charge. If the charge were moving along the axis of a metallic tube, an equal and opposite charge would move along the tube and experience an opposite force to that on the central charge, but as the tube was increased in diameter, the total moving charge would remain the same while the strength of the magnetic field of the coil *A* would fall off as the square of the distance, and with it the force on the outer charge. This provides, therefore, no support for the reaction on the isolated electron.

We are left with three questions; firstly, does the electron *D* in Fig. 1 experience a force?; secondly, is Newton's third law thereby violated?; and thirdly, if not, then where and how is the reaction to the force exerted?

It must be emphasised that we are not here concerned with the forces between moving electrons in general, but only with the special case illustrated in Fig. 1, in which the electron *A* is on the line of motion of *D*, and therefore on the axis of the toroidal system of displacement currents produced by the motion of *D*.

There is one aspect of the problem to which we have not referred, but which must not be overlooked. We have spoken of the motion of the two electrons without specifying the frame of reference. The motion is presumably relative to the electron guns or other apparatus from which the electrons have been ejected. The currents in the coils of Figs. 2, 3 and 4 are beyond question, but unless the frame of reference is specified in Figs. 1 and 5 it is open to an observer who happens to be travelling at the same velocity as the electron *D* to maintain that it is at rest, and that its alleged magnetic field and displacement currents are non-existent. Such an observer would agree that the other electron *A* was moving, but not at right angles to the line joining the two electrons at the moment. He would also not expect the "stationary" electron *D* to experience any force except that due to electrostatic repulsion.

This raises another question, viz., is it possible to answer the three questions set out above without reference to the material or positive charges from which the electrons have been removed, or without reference to the other elements in the electric circuits of which the moving electrons are small elements.

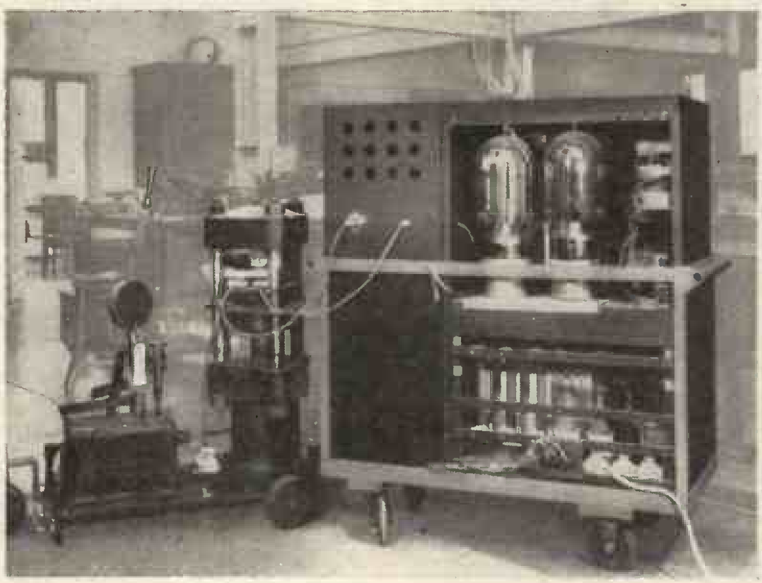
G. W. O. H.

Radio Heating

THE use of power at radio frequencies for purposes other than communication has increased considerably during the war, and it is estimated that in America the RF power used in industry already far exceeds the total power of broadcasting stations.

In this country we have not been slow to take advantage of the new technique which is being applied not only to the eddy current skin hardening of steel, but also to the dielectric preheating of plastic moulding powders and the setting of resin-bonded plywood seams.

The equipment illustrated is a portable experimental radio heater designed by Rediffusion, Ltd., and is seen in use with a hydraulic press for making laminated paper blocks.



Fourier Analysis by Geometrical Methods*

By H. Paul Williams, B.Sc., Ph.D.

1. Introduction

THE use of pulse transmissions has, amongst other things, greatly increased the number of occasions on which an engineer is interested in a Fourier analysis. In such cases it is usual to consult a mathematical textbook where one finds that the theory is developed algebraically. Although algebraic methods are in the long run always more powerful than geometrical methods, the latter have many virtues for the practical engineer. They are usually easier to commit to memory, and often lead to a convenient picture of the effect of variations. In such respects a geometrical approach to Fourier analysis is no exception, and it has indeed been found extremely useful in practice.

It will be noticed that the method outlined is merely the converse of the process of synthesising a complex wave-form—an idea with which we are all familiar. Yet the possibilities in an analytical process are not generally realised by engineers when faced with a Fourier analysis.

In the following article the geometrical aspect is explained with examples after a brief résumé of the normal process of obtaining Fourier coefficients algebraically.

2. Algebraical Fourier Analysis

The theorem which is always associated with Fourier's name arose out of a famous publication in 1822 by Fourier of a thesis entitled "Théorie analytique de la chaleur." The theorem states that a complex wave-form which repeats itself at regular intervals is equivalent to a fundamental sine wave plus harmonics whose amplitudes and phases depend on the shape of the complex wave. If the complex wave has an amplitude which is a function of time and we represent it by $f(\omega t)$ then Fourier's theorem tells us that :—

$$f(\omega t) = a_1 \sin \omega t + a_2 \sin 2\omega t + a_3 \sin 3\omega t + \ldots + b_0 + b_1 \cos \omega t + b_2 \cos 2\omega t + b_3 \cos 3\omega t + \ldots \quad (1)$$

In the above expression the fundamental angular frequency is ω and equals $2\pi f$ where f is the repetition frequency of the complex wave. The other components are harmonics of the fundamental, and their phase and amplitude are governed by the relative values of their respective a and b coefficients. We might equally well have controlled these quantities by expressing the terms in the form $c_n \sin (n\omega t + \phi_n)$ instead of $a_n \sin n\omega t + b_n \cos n\omega t$, but in practice it is best to split each harmonic quantity into sine and cosine components. This is because in a great many cases one of these components can be made zero by the proper choice of the positions which we choose to call the start and finish of a complete period.

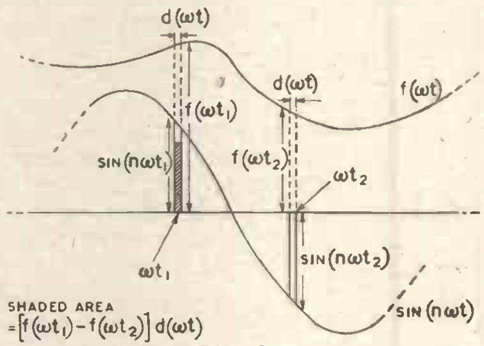


Fig. 1.

Suppose the shape of a complex wave can be represented by some formula connecting amplitude with time, say $f(\omega t)$, then the coefficients may be evaluated in the following manner :—

To find the a_n coefficients we multiply the expansion by $\sin n\omega t$ and integrate over the period 0 to 2π. By doing so the values of all the definite integrals become zero except the term

$$\int_0^{2\pi} a_n \sin^2 n\omega t \, d(\omega t)$$

All the other terms are zero because they are of the form $\int_0^{2\pi} a_m \sin n\omega t \sin n\omega t \, d(\omega t)$ where $m \neq n$

∴ we have

$$\int_0^{2\pi} f(\omega t) \sin n\omega t \, d(\omega t) = \int_0^{2\pi} a_n \sin^2 n\omega t \, d(\omega t) = \pi a_n$$

$$\therefore \quad a_n = \frac{1}{\pi}\int_0^{2\pi} f(\omega t) \sin n\omega t \, d(\omega t) \quad (2)$$

If, therefore, the waveform is such that the algebraical expression for $f(\omega t)$ after multiplying by $\sin(\omega t)$ gives a result which can be integrated, then the coefficient of a_n can be evaluated. In a similar manner we find

$$b_n = \frac{1}{\pi}\int_0^{2\pi} f(\omega t) \cos n\omega t \, d(\omega t) \quad (3)$$

* MS. accepted by the Editor, July 1943.

When $n = 0$, however, we obtain b_0, the D.C. component, by integrating directly thus

$$b_0 = \frac{1}{2\pi}\int_0^{2\pi} f(\omega t)\, \mathrm{d}(\omega t)$$

The method breaks down in practice if we cannot obtain a workable expression for $f(\omega t)$, nor can we obtain in this way a convenient mental picture of what the harmonics are likely to be.

3. Geometrical Fourier Analysis

Examining equation (2) we see that the definite integral represents the summation of elements of area multiplied by $\sin n\omega t$. If we consider a typical strip at ωt_1 then it has a width $d(\omega t_1)$ and a height $f(\omega t_1)$. Its area is therefore $f(\omega t_1)\ d(\omega t_1)$, and this is multiplied by the corresponding value of $\sin n\omega t$, namely $\sin n\omega t_1$. The result is therefore a volume integral which is the summation of triple products of the type $\sin n\omega t_1 \times f(\omega t_1) \times d(\omega t)$. These triple products will be prefixed by positive or negative signs depending on whether the product $\sin n\omega t_1 \times f(\omega t_1)$ is positive or negative.

Now for every positive value of $\sin n\omega t_1$, there will be a corresponding negative value of $\sin n\omega t$ of the same magnitude, for n is an integer so that the number of positive half cycles equals the number of negative half cycles.

In Fig. 1 the negative value of $\sin n\omega t$ corresponding to $\sin n\omega t_1$ is shown as $\sin n\omega t_2$. The product of the latter with $f(\omega t_2)$ may therefore be subtracted from the positive product $\sin n\omega t_1 \times f(\omega t_1)$ by taking the difference in the $f(\omega t)$ values. If $f(\omega t_1)$ and $f(\omega t_2)$ are both positive, the subtraction leads to $\sin n\omega t_1\ [f(\omega t_1) - f(\omega t_2)]$. If they are of opposite signs, the result is an addition of the magnitudes of $f(\omega t_1)$ and $f(\omega t_2)$. In both cases the result must still be multiplied by $d(\omega t)$ to give the triple product.

An alternative way of considering the subtraction is therefore to say that we subtract the strip of area $f(\omega t_2)\ d(\omega t)$ from the strip $f(\omega t_1)\ d(\omega t)$. The result must then be multiplied by $\sin n\omega t_1$ to complete the triple product.

In the case shown in Fig. 1, $f(\omega t_1)$ and $f(\omega t_2)$ are both positive. The shaded area represents $[f(\omega t_1) - f(\omega t_2)]\ d(\omega t)$ which is then to be multiplied by $\sin n\omega t_1$.

To find a_n we sum all products of the type $\sin n\omega t_1\ [f(\omega t_1) - f(\omega t_2)]\ d(\omega t)$ over the positive cycles of $\sin n\omega t$—i.e. over a total range of 0 to π—and then divide the result by π. By performing the subtractions of the type $f(\omega t_1) - f(\omega t_2)$ in such a way as to make the difference constant, the integration is very easily performed. The most convenient subtractions occur when dealing with triangular and rectangular waveforms. With such waveforms an exact solution is often possible.

In the case of waveforms of arbitrary shape, it becomes necessary to use squared paper and to effect the subtraction as accurately as possible by counting the unit squares associated with corresponding positive and negative portions.

Suppose the constant difference is K, then each triple product has the constant factor $Kd(\omega t)$ (taking strips of equal width) whilst the remaining factor is the appropriate value of $\sin n\omega t$. The latter values will have a mean value of $2/\pi$ over the positive half cycles. Furthermore, the total number of all the triple products is such as to include all the strips of width $d(\omega t)$ within a total range of 0 to π, which is the range representing the sum of positive half cycles between 0 and 2π.

Consequently the total sum of all the products is $(2/\pi)\, K\pi$. To obtain a_n we divide this value by π.

$$\therefore \quad a_n = (2/\pi)\, K.$$

The subtraction of strips $f(\omega t_2)\ d(\omega t)$ from $f(\omega t_1)\ d(\omega t)$ to give a constant height K is in many cases not difficult, as will be seen in the examples which are given below.

The argument has been developed above for the sine coefficients. Exactly the same argument may be used for the cosine coefficients. We sketch in the wave $\cos n\omega t$ and then subtract the values of $f(\omega t)$ associated with the negative half cycles from the $f(\omega t)$ values associated with corresponding points on the positive half cycles. If the difference has been made constant, then the value of b_n is $2/\pi$ times this constant height. Should the constant height be negative, the b_n coefficient is also negative, thus indicating a phase difference of π with respect to coefficients which are positive.

If $f(\omega t_1) - f(\omega t_2)$ is constant over only a portion of the required range and zero for the rest, then the average value over the range 0 to π is taken. This average value must be obtained *after* multiplication by corresponding values of $\sin \omega t$ or $\cos \omega t$. Such a case is considered in section 4.1.

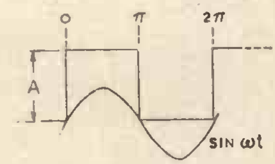


Fig. 2.

Taking the very simple case shown in Fig. 2 as an example, we have

$$a_1 = \frac{1}{\pi}\int_0^{2\pi} A \sin \omega t\, d(\omega t)$$

$$= \frac{1}{\pi}\int_0^{\pi} A \sin \omega t\, d(\omega t) \text{ (since } f(\omega t) \text{ is zero from } \pi \text{ to } 2\pi)$$

$$= \frac{A}{\pi}\Big[-\cos \omega t\Big]_0^{\pi}$$

$$\therefore \quad a_1 = \frac{2A}{\pi}$$

Exactly the same result is obtained if we multiply the constant value of $f(\omega t)$ between 0 and π, namely A, by the mean height of a half sine wave, that is $2/\pi$. There are no subtractions to be made in this case, for $f(\omega t)$ is zero during the negative portion of $\sin \omega t$.

An example in which we have first to subtract the values of $f(\omega t)$ associated with negative half cycles is provided by the saw-toothed wave shown in Fig. 3. Here the coefficient a_1 is found by sketching in a complete sine wave between 0 and 2π. The first half of this fundamental wave gives positive products with the complex wave, whilst the second half gives negative products. The whole of this negative portion may be subtracted from the positive half in the manner shown. This leaves the unshaded area which has a constant height, and therefore does not need any further manipulation.

The height of this portion is $A/2$. Multiplying this by $2/\pi$, the mean height of a sine wave, we obtain A/π, which is therefore the amplitude of the fundamental sine component. The fundamental cosine component will be seen to be zero, since by adding in an appropriate manner the area from 0 to $\pi/2$ with that from $3\pi/2$ to 2π we find that the result will cancel out with the negative area between $\pi/2$ and $3\pi/2$. In a similar manner it will be found that all the harmonics of this cosine wave will also be zero.

The coefficient a_2 is found by sketching in two complete sine waves (shown in Fig. 2 between 2π and 4π). The shaded areas cancel out, leaving a constant height of $A/4$ to be multiplied by the mean value $2/\pi$ of a sine wave. Again the total base line over which the integration is considered is π, thereby making it unnecessary to divide by this factor. Hence the amplitude of a_2 is $A/2\pi$.

The third harmonic is shown sketched in between 4π and 6π and shows us that a_3 is equal to $A/3\pi$. Proceeding in this manner we soon see that the amplitude of the nth harmonic will be $1/n$th of the fundamental. Thus we have

$$f(\omega t) = A/\pi\,(\sin \omega t + 1/2 \sin 2\,\omega t + 1/3 \sin 3\,\omega t + \ldots + 1/n \sin n\omega t + \ldots\ldots)$$

4. Applications of Geometrical Analysis

4.1 *Sharp Rectangular Pulses.* Suppose we have rectangular pulses whose duration is $1/n$th of a complete period, then it will be found that, provided n is large, all the lower harmonics have approximately equal amplitudes of A/n where A is the height of the pulses. Furthermore the nth harmonic will be zero, after which the harmonics increase again but in antiphase with the first group. All multiples of the nth harmonic are also zero, whilst before and after each such multiple there is a phase change of π in the harmonics.

In Fig. 4 a particular case of $n = 32$ is illustrated. It is obvious that the areas under the curves $\cos \omega t$ to $\cos 8\,\omega t$ are all approximately equal. Assuming that the mean height of the cosine curves is unity in each case over the period of the pulse duration, then the product of $\cos \omega t$ times the constant amplitude is A over the range 0 to $\pi/32$. Therefore the average value is $A/32$ over a range of 0 to π. This, then, is the value of b_1, b_2, etc., up to about b_8. Note that we must form the product *before* averaging. We must not multiply the mean sine wave value by the mean height, i.e., $2/\pi$ by $A/32$.

The harmonic $\cos 32\,\omega t$ is obviously zero, since the positive products between 0 and $\pi/64$ balance out with those between $\pi/64$ and $\pi/32$. Furthermore all multiples of 32 have zero amplitude. We also notice that harmonics lying between 32 and 64 have resultant products which are negative, thus indicating a phase difference of π with respect to the lower harmonics.

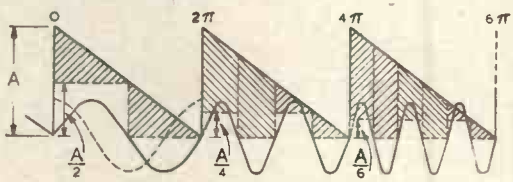


Fig. 3.

The choice of the time axes results in all sine components being zero, since any such sine wave will have products between $63/32\pi$ and 2π which exactly balance out with those between $\pi/32$ and 0. Had we chosen to make the zero time axis at the *beginning* of the pulse, both components would have appeared. In this case the first zero cosine component would have been $\cos 16\omega t$, not $\cos 32\omega t$. This does not contradict the previous result, however, for now there would be a $\sin 16\omega t$ component to allow for.

4.2 *Other Sharp Pulses.*—(*a*) Suppose we have a pulse shaped as shown in Fig. 5 (*a*) which is similar to a Gaussian error curve. Then the graphical method immediately indicates that all the lower harmonics again have equal amplitudes. Since the lower cosine curves approximate to unity over the period of pulse duration, the actual amplitude of these harmonics will bear the same ratio to those of the rectangular pulse as the area of the pulses do to each other (i.e., if $\cos n\omega t$ is constant over the range, then the average height $f(\omega t)$ can be taken; this is equivalent to reversing the roles of $f(\omega t)$ and $\cos n\omega t$.

By inspection of the $\cos 32\omega t$ curve we see that its amplitude will approximate to zero, thereby resembling the rectangular pulse case.

(*b*) A triangular pulse as shown in Fig. 5 (*b*) will not have zero amplitude for the 32nd harmonic. Not until we reach the 64th harmonic do the positive and negative products balance out. Also all integral multiples of the 64th harmonic are zero. An interesting feature is that, after the 64th harmonic, the phases of the harmonics do not change by π with respect to the first group.

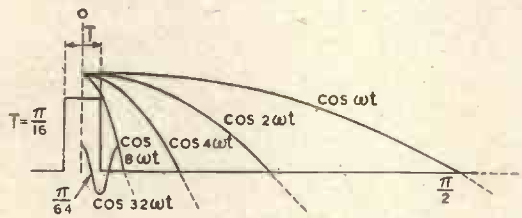


Fig. 4.

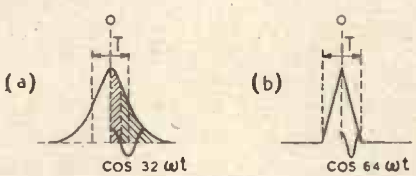
This absence of phase change is due to the fact that the positive area under the first quarter of any harmonic we choose to sketch in can never be more than only just counterbalanced by the negative portions of harmonic. It does not matter how many cycles we include in the base of the triangle or whether the number of quarter wavelengths is non-integral.

In both the above examples, the choice of the origin of time results in zero sine components.

4.3. *Pulses varying their relative positions.*—Suppose we have a train of pulses as shown in Fig. 6 (*a*). Then the fundamental frequency has a periodicity equal to the time interval between two successive pulses. One cycle of this fundamental frequency is shown between 0 and 2π in Fig. 6 (*a*) and is marked cos ωt. As in the previous example, we shall choose the origin of time to give zero sine components.

If the pulses are caused to come together in pairs (keeping the same interval of time between alternate pulses) then the fundamental frequency is obviously halved, for the waveform repeats itself only after each group of two pulses.

Fig. 5.



An example of such "grouping in pairs" is shown in Fig. 6 (*b*). In this figure it will be seen that pulses $p1$ and $p2$ (also $p3$ and $p4$) have moved towards each other, but that the intervals $p1$ to $p3$ and $p2$ to $p4$ have been kept constant. The new fundamental frequency is represented by the curve cos $\omega t/2$.

It will be found that the amplitude of the cos ωt component, and indeed of any of the higher harmonics, varies considerably with the degree of grouping. For instance in Fig. 6 (*b*) where the pulses $p1$ and $p2$ are at $\pm\pi/2$, the amplitude of the cos ωt component is actually zero. With such a spacing this component will have zero amplitude whatever the shape of the pulse may be—provided only that it is symmetrical about its centre.

The higher harmonics will also have zero amplitude whenever the centre of the pulse coincides with a crossing of the axis by the corresponding cosine wave. For in each such case the positive products on one side of this crossing will have corresponding negative products on the other side. It is easily found that in between the grouping positions at which a particular harmonic has zero amplitude, the amplitude of the harmonic will vary sinusoidally. If we then calculate the maximum amplitude of the harmonic we have all the data for constructing a graph of harmonic content versus "grouping effect."

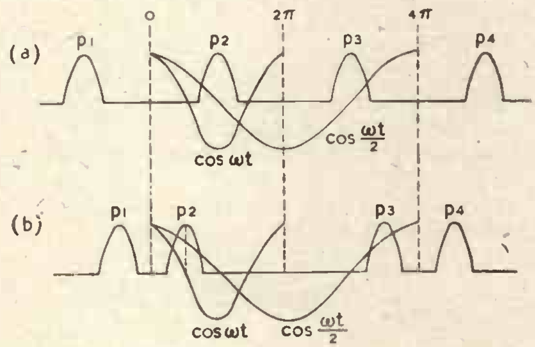


Fig. 6.

The above problem is quoted because it occurred in a practical case. It was, in fact, in dealing with this problem that the geometrical technique described in this article was evolved. In this way a very good grasp of the essential features of the problem was obtained, in particular the results of variations in pulse shape could be directly appreciated.

5. Conclusions

A geometrical outlook on Fourier analysis can be made an exceptionally useful weapon of attack; in many cases the answer can be obtained immediately by suitable subtraction of the negative portions from the positive.

The method also has its uses when experimenting with wave shapes to give the maximum value of some harmonic component. In both types of problem we are led to a convenient picture of the effect of changes in either shape or position of a complex wave.

A Note on

Frequency Modulation*

With Particular Reference to Standard-Signal Generators

By F. M. Colebrook, B.Sc.

(Radio Department, National Physical Laboratory)

ABSTRACT.—The paper is concerned with the significance of unwanted frequency modulation in amplitude-modulated standard-signal generators, particularly at very high frequencies. It is shown that, at very high frequencies, such unwanted frequency modulation is liable to be of large "modulation index," and that it dominates the spectrum to such an extent that the amplitude modulation has practically no significance except as the cause of the frequency modulation. It is shown that frequency modulation of large index dissipates the total energy over a wide band, equal practically to twice the frequency excursion, with a tendency to increase of energy density towards the outer extremes. In combined amplitude and frequency modulation, the spectrum is very unsymmetrical about the carrier frequency, the maximum energy density tending to be at one or other extreme of the band. Experimental vertification is given. The use of 100% square wave modulation is recommended as a possible means of avoiding unwanted frequency modulation in high-frequency standard-signal generators.

1. Object and Scope

It is well known that the amplitude modulation of valve oscillators is liable to give rise to some degree of frequency modulation. The object of the present note is to call attention to some of the consequences of this frequency modulation, particularly in the case of short-wave standard-signal generators, where the "index" of the frequency modulation may be very large.

2. The Spectrum of Pure Frequency Modulation

The frequency-modulated e.m.f.

$$e = \hat{e}_0 \sin\left(\omega t + \frac{\delta\omega}{p}\sin pt\right) = \hat{e}_0 \sin(\omega t + m \sin pt) \quad \ldots \quad \ldots \quad (1)$$

can be expressed in the form

$$e = \hat{e}_0 J_0(m) \sin \omega t + \hat{e}_0 \sum_{n=1}^{n=\infty} J_n(m) \{\sin(\omega + np)t + (-1)^n \sin(\omega - np)t\} \quad \ldots \quad \ldots \quad (2)$$

where $J_n(m)$ is the Bessel function of the first kind, argument m order n.

(The expansion given by Roder[1] on p. 2149 of *Proc. Inst. Rad. Eng.*, Vol. 19, differs from this and is not correct.)

It is important to notice that the spectrum represented by (2) is unsymmetrical, the successive side-waves being all of the same sign for the upper side-waves but of alternating sign for the lower side-waves. On the other hand, the frequency-modulated e.m.f.

$$e = \hat{e}_0 \sin(\omega t \pm m \cos pt) \quad \ldots \quad \ldots \quad (3)$$

gives a symmetrical spectrum, i.e.

$$\hat{e}_0 \sin(\omega t \pm m \cos pt) = \hat{e}_0 J_0(m) \sin \omega t + \hat{e}_0 \sum (-1)^n J_{2n}(m) \{\sin(\omega + 2np)t + \sin(\omega - 2np)t\} + \hat{e}_0 \sum (-1)^{n-1} J_{2n-1}(m) \{\cos(\omega + \overline{2n-1}p)t + \cos(\omega - \overline{2n-1}p)t\} \quad (4)$$

the summations being from $n = 0$ to $n = \infty$ in both cases.

It is at first sight surprising that a frequency-modulated e.m.f. can give either a symmetrical or unsymmetrical spectrum as far as the side-wave phases are concerned, but it should be noted that there is an important physical distinction between the two types of e.m.f. In (1) the momentary frequency, defined by

$$\frac{\partial}{\partial t}\left(\omega t + \frac{\delta\omega}{p}\sin pt\right) = (\omega + \delta\omega \cos pt) \quad \ldots \quad (5)$$

is such that the frequency variation is in quadrature with the e.m.f., whereas in (4) it is in phase or anti-phase with it. The mode of generation will decide which type is produced. Further, though the asymmetry concerned is merely one of phase, it has important consequences in the combination of amplitude and frequency modulation.

3. Significant Band-width

The general character of the frequency-modulation spectrum is well described by Van der Pol,[2] but his description is limited to relatively small values of the "modulation index" m. In the case of ultra-high-frequency oscillators, m may reach three- or four-figure values. For instance, if $\omega = 2\pi \times 300 \times 10^6$ $\delta\omega$ may be as much as

* MS. accepted by the Editor, December, 1943.

$2\pi \times 5 \times 10^5$ and, with $p = 2\pi \times 400$, m is 1250. We may therefore be concerned with Bessel functions of very large argument and very large order. They have not been tabulated in these ranges, but the nature of their variation is known and a general idea of the corresponding frequency-modulation spectra can therefore be deduced.

As a function of n, $J_n(m)$ is oscillatory in character for real values of m over most of its range, the oscillatory period approximating to 2π. The maximum values are always less than 1 and increase slowly up to the last maximum value which occurs when n is approaching m. Beyond the last maximum $J_n(m)$ falls very steeply to exceedingly small values and is practically zero when n exceeds m by four or five. For example, $J_n(13)$ is about 0.21 when $n = 0$, and oscillates with increasing amplitude up to a final maximum of about 0.3 when $n = 11$, and thereafter falls to practically zero when $n = 17$ and higher.

For large values of m, therefore, the frequency-modulation spectrum, though theoretically doubly infinite in extent, is practically confined to the first m side waves on each side, but the remoter side waves will actually tend to increase in amplitude up to the cut-off frequency. As already stated, $J_n(m)$ is oscillatory in character, and for any given value of m it may be small or zero for certain values of n. Thus certain of the side-waves and even the carrier itself may be small or zero. The general character of the spectrum is therefore as shown diagrammatically in Fig. 1, individual

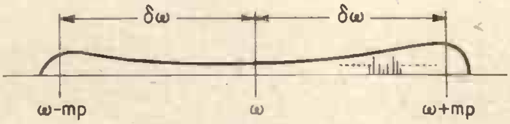


Fig. 1.

side waves having any magnitude inside the envelope, as indicated by the few examples drawn. (If sign also were considered, the envelope would be mirrored in the axis, since the Bessel functions concerned are oscillatory about zero). The frequency-spread on either side is thus, for large m, approximately $m \times p = \delta\omega$, and the determination of the side-wave spread, by heterodyning against an adjustable local oscillator, is therefore a simple means of measuring $\delta\omega$.

The increase of amplitude towards the outer ends of the spectrum is understandable on physical grounds, since the extreme side waves correspond to the maximum frequency excursion, where there is momentarily a zero rate of change of frequency. That is to say, the function lingers on the frequencies represented by the extremes of the band.

4. Energy in Amplitude- and Frequency-Modulated Waves

The amplitude-modulated wave

$$e = \hat{e}_0\{1 + \sum a_n \cos (npt + \theta_n)\} \sin \omega t \quad (6)$$

has a spectrum of the form

$$e = \hat{e}_0 \sin \omega t + \tfrac{1}{2} \sum \hat{e}_0 a_n \{\sin (\omega + np)t + \sin(\omega - np)t\} \quad .. \quad .. \quad (7)$$

and, putting E^2 for the mean square value

$$E^2 = \frac{\hat{e}_0{}^2}{2} + \frac{\sum \hat{e}_0 a_n{}^2}{2} = E_0{}^2 (1 + \sum a_n{}^2) \quad (8)$$

This shows that amplitude-modulation increases the energy in the wave by the amount of the energy in the side waves.

Consider, however, the frequency-modulated wave represented by (2). The mean-square value is

$$E^2 = E_0{}^2 \{J_0{}^2(m) + 2 \sum J_n{}^2(m)\} \quad .. \quad (9)$$

It is known as a property of Bessel functions that the quantity inside the brackets is equal to unity, therefore

$$E^2 = E_0{}^2 \quad .. \quad .. \quad .. \quad (10)$$

Thus the total energy is not changed by frequency modulation. The effect of frequency modulation is therefore to spread the original energy over the whole spectrum, with a tendency to favour the outer regions of the band. This is in marked contrast with the spectrum that would arise from pure amplitude modulation of the same frequency and would produce a correspondingly marked difference in the response of a receiver, particularly if of narrow band-width.

5. Combined Amplitude and Frequency Modulation

As already pointed out, a combination of amplitude and frequency modulation is particularly likely in the case of ultra-short-wave oscillators. This is chiefly due to the fact that interelectrode capacitance varies appreciably with the potentials applied to the electrodes concerned. Moreover, when, as in ultra-short-wave oscillators, the interelectrode capacitances are a large proportion of the total tuning capacitance, the extent of the frequency modulation may be very considerable. This is true, for example, of certain ultra-short-wave standard-signal generators.

From the mode of generation it may be expected that the maximum frequency-excursion is likely to coincide with the maximum change of amplitude. Neither amplitude nor frequency modulation is likely to be purely sinusoidal, but an analysis of this simplest case will serve to bring to light the most important features. The e.m.f. to be considered will therefore be written

$$e = \hat{e}_0 (1 + k \cos pt) \sin (\omega t + m \sin pt) \quad (11)$$

in which the momentary frequency, given by

$$\frac{\partial}{\partial \omega} (\omega t + m \sin pt) = \omega + \delta\omega \cos pt \quad .. \quad (12)$$

is in phase with the amplitude modulation.

Multiplying (2) by $(1 + k \cos pt)$ and summing all terms of like frequency gives rise to a series of side-waves with coefficients of the form

$$J_n(m) \pm \frac{k}{2} \{J_{n-1}(m) + J_{n+1}(m)\} \quad .. \quad (13)$$

to which can be applied the formula

$$J_{n-1}(m) + J_{n+1}(m) = \frac{2n}{m} J_n(m) \quad .. \quad (14)$$

The expansion is

$$\begin{aligned} e &= \hat{e}_0 (1 + k \cos pt) \sin (\omega t + m \sin pt) \\ &= \hat{e}_0 J_0(m) \sin \omega t \\ &\quad + \hat{e}_0 J_1(m) \{(1 + \frac{k}{m}) \sin (\omega + p)t \\ &\qquad - (1 - \frac{k}{m}) \sin (\omega - p)t\} \\ &\quad + \hat{e}_0 J_2(m) \{(1 + \frac{2k}{m}) \sin (\omega + 2p)t \\ &\qquad + (1 - \frac{2k}{m}) \sin (\omega - 2p)t\} \\ &\quad + \hat{e}_0 J_3(m) \{(1 + \frac{3k}{m}) \sin (\omega + 3p)t \\ &\qquad - (1 - \frac{3k}{m}) \sin (\omega - 3p)t\} + \text{etc.} \quad (15) \end{aligned}$$

Thus the spectrum is asymmetrical in both phase and amplitude. If, as will often be the case, k is very small compared with m, the asymmetry will not be very pronounced in the neighbourhood of the carrier frequency, but the nth side waves have coefficients $(1 + kn/m)$ and $(1 - kn/m)$ respectively, which become $(1 + k)$ and $(1 - k)$ when $n = m$. The envelope of the spectrum as illustrated in Fig. 1 will therefore be changed to something like Fig. 2, where k has been taken to be about 50 per cent.

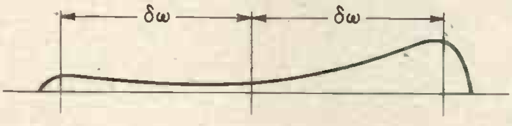


Fig. 2.

As in the case of pure frequency modulation, the nature of the spectrum due to combined frequency and amplitude modulation will depend on the phase relationships of the constituent variations. Thus, for $\hat{e}_0 (1 - k \cos pt) \sin (\omega + m \sin pt)$, the energy will be displaced to the lower side-waves. On the other hand, the systems $(1 + k \sin pt) \sin (\omega t \pm m \sin pt)$ and $(1 + k \cos pt) \cos (\omega t \pm m \cos pt)$ give spectra which are symmetrical in amplitude, the latter being symmetrical in phase as well.

The case considered in detail, however, is the most likely to occur in practice, and the most important feature of the result is that where frequency modulation of large index occurs in combination with amplitude modulation, the resulting spectrum is completely different from that which would arise from amplitude modulation alone. The amplitude modulation contributes a pronounced degree of asymmetry, but apart from this the situation is completely dominated by the frequency modulation.

6. Experimental Observations

No systematic quantitative experimental work has been carried out, but two commercial makes of ultra-short-wave standard-signal generator were examined qualitatively by listening to the heterodyne note produced by interaction with another calibrated oscillator of variable frequency. In both cases the amplitude modulation was obtained by variation of anode potential, and it was found that the values of $\delta\omega$ deduced from the heterodyne observations were in approximate agreement with those produced by static changes of anode potential corresponding to the stated amplitude modulation percentages. In one case, where the frequency modulation index was very large (over 1000) the asymmetry of the heterodyne output, corresponding to the asymmetry of the spectrum, was very marked indeed. These observations were made before the foregoing theory had been worked out, and were not fully understood at the time, and there has been no subsequent opportunity for a more systematic examination. They serve, however, to give qualitative confirmation of the main conclusions.

7. Practical Conclusions Relating to Standard-Signal Generators

It will be seen from the foregoing analysis and observations that when any appreciable degree of frequency modulation exists as an unwanted accompaniment of intended amplitude modulation in a standard-signal generator, it cannot be regarded as a mere imperfection which can be allowed for in using the generator for testing receivers. On the contrary, such frequency modulation dominates the output spectrum, and the amplitude modulation is no longer significant except as the cause of the frequency modulation. It appears, therefore, that the elimination of frequency modulation is essential. The familiar technique of master-oscillator and amplifier is a possible means, but presents special difficulties at ultra-high frequencies, particularly where a wide range of frequencies is desired. An alternative, which has not so far been fully exploited, is to replace the conventional modulating mechanism by some form of audio-frequency on-and-off switching, giving, in effect, 100 per cent. square-wave modulation.

8. Acknowledgments

The work described above was carried out as part of the programme of the Radio Research Board, to whom this paper was first circulated as a confidential report in June 1941. It is now published by permission of the Department of Scientific and Industrial Research.

The author is indebted to his colleagues, Mr. Essen and Mr. Gainsborough, for the experimental observations referred to in Section 6.

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[1] H. Roder. "Amplitude, Phase and Frequency Modulation," *Proc. Inst. Rad. Eng.*, 1931, Vol. 19, p. 2145.

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Power Loss in Deflecting Condensers*

By D. Gabor, Dr.-Ing., F.Inst.P.

(*British Thomson Houston Co. Research Laboratory*)

THE first attempt to calculate the power dissipated in a deflecting condenser was made in 1929 by Sven Benner[1], who produced an incorrect but singularly hard-dying formula[2]. The correct result was first derived by Recknagel[3] and by Hollmann and Thoma[4], but by rather unconvincing methods which were criticised by Colebrook and Vigoureux[5]. As in 1939, Benham[6] gave a new derivation of Benner's formula and insisted on its correctness, it may not be superfluous to derive Recknagel's result again, by a method which is of general applicability to transit-time problems.

An electric field vector **E** acting on convection currents with density i produces an input density **i.E**. The input is obtained by integrating this over the vacuum space of the device in question. Assuming that **E** can be derived from a scalar potential ϕ †, i.e., $\mathbf{E} = -\operatorname{grad} \phi$, the input can be transformed by Gauss's formula as follows:

$$\int \mathbf{i}.\mathbf{E}\, dv = -\int \mathbf{i}.grad\, \phi\, dv = \int \phi\, div\, \mathbf{i}\, dv + \int \phi i_n dS \quad \ldots \quad (1)$$

where S is a surface, forming the boundary of the space in question, and i_n is the current component at right angles to it, counted positive for currents flowing inwards.

We now restrict ourselves to periodic phenomena, and to the calculation of the average input over a whole cycle. Moreover, we assume that the electron current i passes through the boundary S at a constant potential ϕ_0, a condition which is fulfilled in the case of deflecting condensers. Denoting averages as usual with bars we obtain now

$$\int \overline{\phi i_n}\, dS = \phi_0 \int \overline{i_n}\, dS = 0 \quad \ldots \quad (2)$$

as during a complete cycle as much current flows into as out of the boundary S. The input is now represented by the first term of Eq. 1, which may be called the "transit power" T. Using the continuity equation

$$\dot{\rho} + div\, \mathbf{i} = 0$$

where ρ is the space charge density, and the dot represents as usual the operator $\partial/\partial t$, we can write T in either of the alternative forms :—

$$T = \int \overline{\phi div \mathbf{i}}\, dv = -\int \overline{\dot{\rho}\, \phi}\, dv = \int \overline{\rho\, \dot{\phi}}\, dv \quad (3)$$

Which of these three expressions is preferable depends on the problem. In the case of longitudinal velocity modulation the first form is the most convenient, whereas symmetrically operated deflecting condensers are best treated by using the third expression.

Let X be the condenser axis, Y the direction of deflection, Z the direction at right angles to both. We assume a narrow beam with a cross section $\Delta Y \Delta Z$, describing some curve $y = y\,(x,t)$. We can at once carry out the integration over Y and Z by putting $\rho = i_x/v_x$, where v_x is the velocity in the X-direction, and introducing the total current $I_x = i_x \Delta Y \Delta Z$.

$$T = \iiint \overline{\rho \dot{\phi}}\, dxdydz = \int \overline{(i_x \Delta Y \Delta Z / v_x)\, \dot{\phi}}\, dx$$
$$= \int \overline{(I_x/v_x) \dot{\phi}}\, dx \quad \ldots \quad (4)$$

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* MS. accepted by the Editor, January, 1944.

† This is equivalent to the assumption that the vector potential can be neglected. For the justification of this assumption, *cf.*, a paper by the author on "Energy Conversion in Electron Valves," which is to appear shortly in the *Journal of the Institution of Electrical Engineers*.

In the case of symmetrically operated deflecting condensers there is no longitudinal field on the axis where the beam enters the deflecting system, nor between the condensers, where the field is almost entirely in the Y-direction. Hence v_x, and consequently also I_x remain constant over almost the whole length of the deflectors, and we can put $I_x/v_x = I_0'/v_0$ before the integration sign. An error arises only by the velocity modulation in the exit region of the system. We can take this into account by extending the integral over a length L which may be slightly different from the length of the deflector plates.

The potential ϕ can be written in the form

$$\phi = \phi_0 - [E(x)y - \tfrac{1}{6}E''(x)y^3 + \ldots] \sin \omega t \quad (5)$$

which fulfils the Laplace equation. $E(x)$ is the field intensity at the axis, in the Y-direction. If we restrict ourselves to small deflections we can neglect the terms from the third onwards, and if the condenser plates are sufficiently long in relation to their distance we can consider $E(x) = E =$ const. The correction can be again included in the integration length L. We put therefore

$$\dot{\phi} = -\omega E y \cos \omega t \quad \ldots \quad \ldots \quad (6)$$

and have to calculate

$$T = -(\omega I_0 E/v_0) \int_0^L \overline{y \cos \omega t}\, dx \quad \ldots \quad \ldots \quad (7)$$

The solution of the dynamical problem gives for the *trajectory*

$$y(x, t, t_0) = \frac{e}{m}\frac{E}{\omega_2}[\sin \omega t - \sin \omega t_0 - \omega(t - t_0) \cos \omega t_0] \quad \ldots \quad \ldots \quad (8)$$

and putting $t_o = t - x/v_0$ we obtain the equation of the *beam*

$$y(x, t) = \frac{e}{m}\frac{E}{\omega^2}[\sin \omega t - \sin \omega\,(t - x/v_0) - (\omega\, x/v_0) \cos \omega(t - x/v_0)] \quad \ldots \quad (9)$$

Substituting this into Eq. 7 and introducing the transit angle $\omega\, L/v_0 = \tau$ we obtain the input

$$T = (eI_0E^2L^2/2mv_0^2)\,[(4 \sin^2 \tau/2 - \tau \sin \tau)/\tau^2] \quad (10)$$

This is the result of Recknagel, and of Hollmann and Thoma.

If the deflectors are not symmetrically operated, so that there is an oscillating potential difference at the entrance, velocity modulation will occur. We can conveniently express the potential on the axis by the distance y_0 of the axis from the oscillation node, i.e., we write it $Ey_0 \sin \omega t$. The calculation which is carried out elsewhere* gives an additional input

$$T' = (eI_0E^2y_0^2/2mv_0^2)\, \tau \sin \tau \quad \ldots \quad \ldots \quad (11)$$

Under certain conditions this correction may become quite noticeable. For small transit angles

$$T + T' = (eI_0E^2/24mv_0^2)\,(L^2 + 12y_0^2)\,\tau^2 \quad (12)$$

Combination terms between deflection and velocity modulation do not arise in this approximation.

I thank the directors of the British Thomson Houston Co. for permission to publish this note.

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[5] F. M. Colebrook and P. Vigoureux, *Wireless Engineer*, Vol. 15, pp. 442, Aug., 1938.

[6] W. E. Benham, *Wireless Engineer*, Vol. 16, pp. 598, December, 1939.

Note added February 12th, 1944.—Benham has corrected the slip which caused his error in *Wireless Engineer*, Vol. 18, p. 277, July 1941. *Cf.* also the letter of S. Rodda in the February issue, 1941, which contains a similar slip, and was rectified in the April issue of the same year. This proves how much the subject is in need of clear general principles.

* *Cf.* "Energy Conversion in Electron Valves."

Index and Binding Case

We are advised by our Publishers that a few copies of the 36-page Subject and Author Index to the Abstracts and References published in *Wireless Engineer* during 1943, are still available. The price is 2s. 8d. including postage.

Binding cases for Volume XX of *Wireless Engineer*, January to December, 1943, are now available and cost 3s. (postage 3d.). It is understood arrangements can be made to bind readers' copies at an inclusive cost of 10s., plus 9d. to cover the postage when returning the bound volume.

Book Received

Testing Radio Sets (Fourth Edition). By J. H. Reyner, B.Sc. In the preface to the recently published fourth edition of this well-known book the author states: "The complete change in radio technique in the twelve years since this book was first written has necessitated a major operation in preparing this fourth edition. The testing of receivers is now a highly specialised business, usually carried out in well equipped workshops. Even the individual service-man . . . has to-day, to be equipped with a variety of instruments such as signal generators and output meters if he is to operate efficiently. The distinction between the service-room and the designs laboratory becomes increasingly difficult to define, and in consequence the former division of the book into Fault Testing and Laboratory Testing has been abandoned. This may mean that the laboratory worker will find descriptions of methods in which he is not interested." The subjects covered by the thirteen chapters include generators and indicators, meters, C.R. oscillographs, A.F. and R.F. tests, and testing components and mains apparatus. Three appendices on time constant, resistance-condenser networks and negative feed-back are included. Pp. 215. 144 photographs and diagrams. Chapman & Hall, Ltd., 11, Henrietta Street, London W.C.2. Price 15s.

Audio-Frequency Mixers*

By M. F. Cooper

THE design of audio-frequency mixing units although straightforward, is not quite the simple problem sometimes imagined and rarely seems to be understood by manufacturers of such components as constant impedance faders if one may judge by the circuit diagrams some publish.

To be satisfactory, a mixer unit must fulfil the following requirements:

(a) It must have a negligible effect on the audio-frequency currents it is handling other than that of attenuation.

(b) It must have a negligible effect on the performance of the devices that feed it or are fed by it.

(c) It must, to this end, present a substantially constant impedance at any setting of its faders both to the incoming lines to be mixed and to the overall output line.

(d) Its input and output circuits must correctly match the characteristic impedances of the incoming and outgoing lines respectively.

(e) The operation of each of its faders must have no effect on the functioning of any other.

(f) It must have the least possible insertion loss.

Mixer units may be designed to handle any number of incoming lines, but it is rare to construct one to handle more than six. In the motion picture studio, it is usual to employ four channel mixers. When more circuits than this have to be mixed, a second complete mixer unit may be used. The incoming lines may originate in microphones, re-recording sound-heads, gramophone pick-ups, land-lines, or a mixture of these sources. The most common mixer output impedance is 500 ohms, but the input impedance to the unit's channels is usually smaller than this according to the type of microphone favoured, 250 ohms being a value frequently met with in practice.

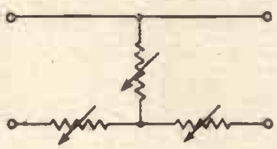


Fig. 1. *"T" fader.*

The input circuits may be connected in parallel, in series, or in series-parallel as in Figs. 5, 7, and 8. The faders used must be of the constant impedance variety and also fall into three main types—the "T" (Fig. 1), the bridged "T" (Fig. 2) and the ladder type (Fig. 3.) The first two are the more constant as far as impedance is concerned. The "T" type requires three sets of contacts, the bridged "T" type two sets, while the latter type requires only one set of contacts. The ladder type has the disadvantage of possessing a larger insertion loss.

The performance of one commercially available ladder-type fader is given in Fig. 4 where the broken line curve gives the value of the output impedance with the input impedance correctly matched, and the solid line curve indicates the input impedance when the output load is correctly matched.

It will be noticed that the output impedance differs from that of the input by some eighty ohms when the fader is set to zero attenuation; also that the input impedance mismatches the line feeding the fader as the setting approaches maximum attenuation. This, however, is likely to be of small importance as this part of the range is mostly used for "fading out." Over the working part of the range between attenuations of 10 db. and 45 db., both the input and the output impedances are sufficiently near their rated values for all practical purposes.

In designing a mixer unit, it is important to remember that the faders themselves are merely attenuators inserted in the various incoming or outgoing lines, and that, apart from their being designed to operate in a line of a specified impedance, they must play no part in the mixing of the various circuits. For example when a "T" type of fader is set at its zero attenuation position, its series arms are short-circuited, and its shunt arm open-circuited so that in effect it is completely out of the circuit. Accordingly one designs a mixer first without its faders and then inserts them merely as volume controls in their respective lines.

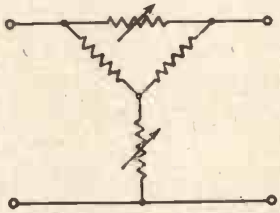


Fig. 2. *Bridged "T" fader.*

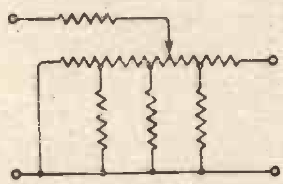


Fig. 3. *Ladder type fader.*

* MS. accepted by the Editor, September, 1943.

The following precaution in the manner of using mixer units should be observed in practice. When a constant impedance type of fader is set at its position of infinite attenuation, it bridges the line with a load equal to the characteristic impedance. In its position of zero loss, it is, as stated above, virtually out of the circuit. When, therefore, a

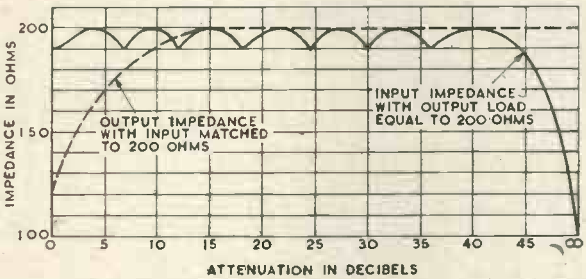


Fig. 4. *Curves showing deviation from constant impedance experienced with a ladder-type fader rated at 200 ohms.*

mixer unit has a number of input circuits not in use and not connected to dummy loads, it is important that those faders not in use be turned to their position if infinite impedance. The reason for this will become more apparent later in this paper.

Parallel Mixers

The basic circuit of a parallel mixer is given in Fig. 5. where A is the output impedance of the microphone pre-amplifier or other device feeding the mixer input circuit and C is the input impedance of the amplifier or line which the mixer feeds. At this stage in the design the faders are omitted as they play no part in the actual mixing of the circuits. Bearing in mind the principle of impedance matching, it is important that any

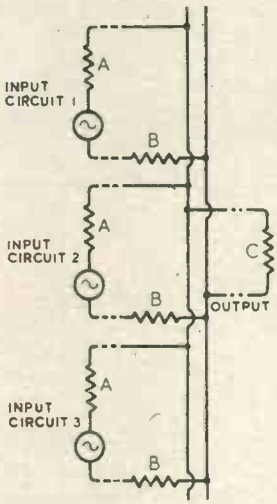


Fig. 5. *Basic circuit of parallel mixer with faders omitted. A is the output impedance of the device feeding the mixer, B the compensating resistance, and C the input impedance of the amplifier, etc., being fed.*

one of the impedances A should see a resistance equal to itself despite the fact that a number of other circuits of the same impedance are in parallel with it. Similarly it is important that the amplifier input impedance C looking back into the mixer circuits should also see an impedance equal to itself. In order to achieve this it is necessary to insert a compensating resistance B in series with each input circuit in the manner shown in Fig. 5. The above two requirements may now be expressed mathematically for n circuits. For convenience Fig. 5 is re-arranged in Fig. 6.

As the output impedance A of the device connected to the input circuit has to see a resistance equal to itself, the following equation may be formulated :—

$$A = B + \frac{C\left(\frac{A+B}{n-1}\right)}{C + \left(\frac{A+B}{n-1}\right)} \quad \ldots \quad \ldots \quad (1)$$

In the same way, looking back from the input impedance of the amplifier which the mixer feeds, a second equation is apparent :—

$$C = \frac{A+B}{n} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

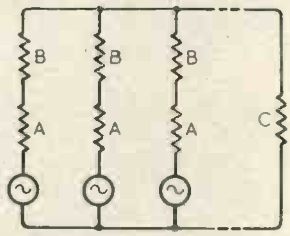


Fig. 6. *Circuit of parallel mixer of Fig. 5 redrawn.*

Solving these equations simultaneously gives :—

$$A = \frac{n}{n-1} B \quad \ldots \quad (3)$$

$$B = \frac{n(n-1)}{2n-1} C \quad (4)$$

$$A = \frac{n^2}{2n-1} C \quad \ldots \quad (5)$$

Series Mixers

For series mixers, it is necessary to place the compensating resistance B in parallel with the input circuit, as shown in Fig. 7.

Looking into the mixer through one of the input circuits gives rise to :—

$$\frac{AB}{A+B} = \frac{C}{n} \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

Looking back into the mixer from the output circuit gives :—

$$A = \frac{B\left\{(n-1)\frac{AB}{A+B} + C\right\}}{B + C + (n-1)\frac{AB}{A+B}} \quad \ldots \quad (7)$$

Solving these equations simultaneously gives :—

$$A = \frac{n-1}{n} B \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

$$A = \frac{2n-1}{n^2} C \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

$$C = \frac{n(n-1)}{2n-1} B \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

It will be noted that these equations differ from those for the parallel type of mixer in that the factor involving n is inverted.

Series-Parallel Mixers

Under certain conditions to be explained later, a series-parallel type of circuit of the form shown in Fig. 8 is sometimes desirable. Here again, A is the output impedance of the device feeding the

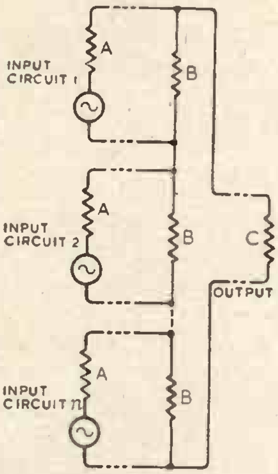


Fig. 7. *Basic circuit of series type mixer. A is the output impedance of the device feeding the mixer, B the compensating resistance, and C the input impedance of the amplifier, etc., being fed.*

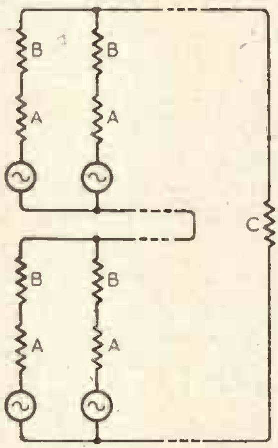


Fig. 8. *Basic circuit of series-parallel type of mixer. A is the output impedance of the device feeding the mixer, B the compensating resistance, and C the input impedance of the amplifier, etc., being fed.*

mixer input circuit, B is the compensating resistance, C is the input impedance of the line or amplifier which the mixer is feeding, and n is the *total* number of input circuits. Looking into the mixer through one of the input circuits gives :—

$$A = B + \frac{\left(\frac{A+B}{0.5n-1}\right)\left(C + \frac{A+B}{0.5n}\right)}{\frac{A+B}{0.5n-1} + C + \frac{A+B}{0.5n}} \quad (11)$$

Looking back into the mixer from the output circuit gives :—

$$C = \frac{A+B}{0.5n} + \frac{A+B}{0.5n} = \frac{4\cdot(A+B)}{n} \quad \ldots \; (12)$$

Solving these equations gives :—

$$A = \left(\frac{n}{n-3}\right)B \quad \ldots \; (13)$$

$$A = \frac{n^2}{4\,(2n-3)}C \quad \ldots \; (14)$$

$$C = \frac{4(2n+3)}{n\,(n-3)}B \quad \ldots \; (15)$$

Mixer Insertion Loss

A series mixer circuit may also be redrawn as in Fig. 9. Clearly when the device at A sees a shunt resistor B and a series one consisting of $(n-1)\,A$ and $(n-1)\,B$ in parallel, the current I will undergo attenuation before reaching its load C.

As both A and C each look into an impedance equal to themselves, the circuit may be regarded as a minimum loss taper network whose attenuation loss is

$$20 \log_{10}\left(\sqrt{\frac{C}{A}} + \sqrt{\frac{C}{A} - 1}\right) \text{db.} \quad \ldots \; (16)$$

Since $A = \dfrac{2n-1}{n^2}C$ $\quad \ldots \; (9)$

this becomes

$$20 \log_{10}\left(\sqrt{\frac{n^2}{2n-1}} + \sqrt{\frac{n^2}{2n-1} - 1}\right) \text{db.} \; (17)$$

which simplifies to

$$10 \log_{10}(2n-1) \text{ db.} \quad \ldots \; (18)$$

Choice of Mixer Circuit

For a better understanding of the application of each of the three types of mixer circuit, it is helpful to draw up a Table, such as that given below, in which either A or C is made equal to unity.

No. of Input Circuits (n)	Parallel Mixer			Series Mixer			Series—Parallel		
	A	B	C	A	B	C	A	B	C
1	1.000	0.000	1.000	1.000	∞	1.000	—	—	—
2	1.333	0.667	1.000	1.000	2.000	1.333	1.000	* —	1.000
3	1.800	1.200	1.000	1.000	1.500	1.800	1.000	0.000	1.333
4	2.286	1.714	1.000	1.000	1.333	2.286	1.000	0.250	1.250
5	2.778	2.222	1.000	1.000	1.250	2.778	1.000	0.400	1.120
6	3.273	2.727	1.000	1.000	1.200	3.273	1.000	0.500	1.000

* The value of B is here negative.

A is the output impedance of the device feeding the mixer input circuit. B is the value of the compensating resistance. C is the input impedance of the device which the mixer feeds.

From this Table, the following design rules become apparent :—

(1) When the impedance of the input circuit is required to be higher than that of the output circuit, a parallel mixer should be used.

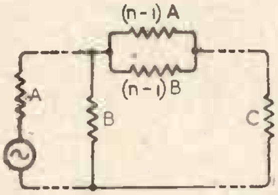


Fig. 9. *Series type of mixer redrawn and regarded as a "minimum loss" taper network.*

(2) When the impedance of the output circuit is required to be higher than that of the input circuit, a series mixer should be used.

(3) When the input and output circuits are required to be of nearly the same impedance, a series parallel arrangement is indicated.

The Table also makes clear the fact that the impedance of the input circuits bears a fixed relation to that of the output circuit, according to the number of input circuits decided upon. Furthermore, it by no means follows that this relation will be a convenient one unless a further impedance matching network or transformer is used.

Example of Design of Mixer Unit. It is required to design a mixer with four input circuits each to match 250-ohm lines and to feed its combined output into a 500-ohm line.

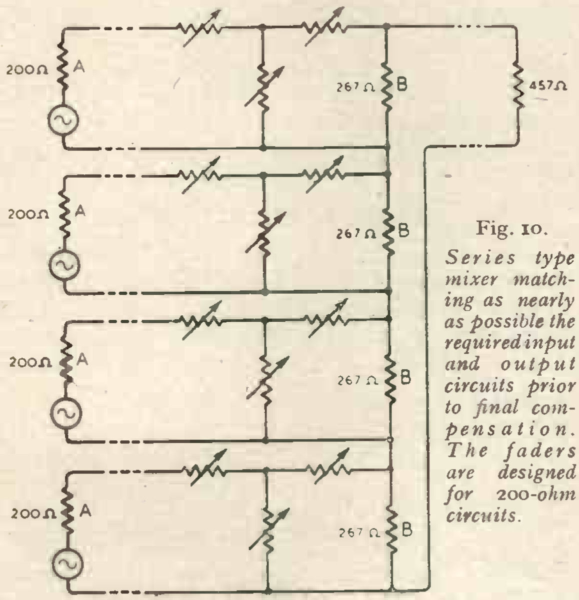


Fig. 10. *Series type mixer matching as nearly as possible the required input and output circuits prior to final compensation. The faders are designed for 200-ohm circuits.*

As the output circuit is to match a higher impedance than that of the input circuits, a mixer of the series type must be used.

From the Table it will be noted that the ratio of the input impedances to the output impedance for a four-way mixer is 1 : 2.286. It is thus not possible exactly to match both input and output circuits by means of the mixer network alone.

Before going any further, it is necessary to decide upon the type and impedance of fader to be used. One reliable product is available in values of 200 ohms and 500 ohms only. In order to avoid the tedious business of re-winding four

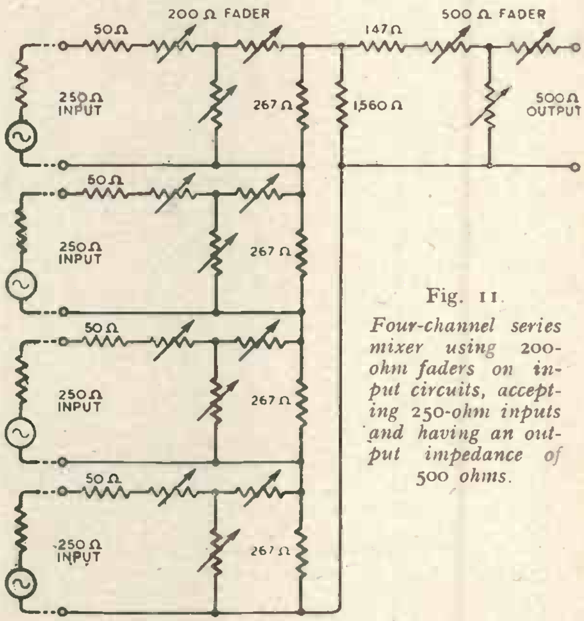


Fig. 11. *Four-channel series mixer using 200-ohm faders on input circuits, accepting 250-ohm inputs and having an output impedance of 500 ohms.*

sets of fader impedances or of introducing matching networks after the faders, the value 200 ohms can in this case be adopted. This means that the output circuit will have an impedance of 200 × 2.286 = 457 ohms, which is fairly near to the required 500 ohms. Ideally for such a mixer, the faders should have a value of 500/2.286 = 219 ohms, but faders of such impedances are not readily available.

Accordingly, the mixer circuit has now arrived at the state shown in Fig. 10. The compensating resistance B will have a value of $B = \frac{4}{3}A$ (see equation (8)) which is 267 ohms.

It would be possible to design a taper network for the input circuit to match the incoming 250-ohm line to the 200-ohm fader and mixer circuit, but in this case, such a complication is hardly necessary and the insertion loss would amount to 4.2 db. A simpler way and one which has an insertion loss of only 2 db. is to put a 50-ohm resistance in series with the incoming line. This ensures that the line is correctly loaded, while the impedance seen by the output circuit looking back into the mixer is not appreciably affected.

It remains to adjust the impedance of the output circuit by means of a taper network. Such a network can be calculated from the following formulae :

$$Z_A = \sqrt{Z_1(Z_1 - Z_2)}$$

$$Z_C = \frac{Z_1 Z_2}{\sqrt{Z_1(Z_1 - Z_2)}}$$

$$\text{Loss} = 20 \log_{10}\left(\sqrt{\frac{Z_C}{Z_A}} + \sqrt{\frac{Z_C}{Z_A} - 1}\right) \text{db.}$$

where (referring to Fig. 12) Z_A is the series impedance and Z_C is the shunt impedance. Z_1 and Z_2 are the impedances of the incoming and outgoing lines respectively which in this case are $Z_1 = 457$ ohms and $Z_2 = 500$ ohms. Solving these equations gives $Z_A = 146.7$ ohms and $Z_C = 1{,}560$ ohms. The insertion loss amounts to 2.6 db. It is now possible to complete the mixer circuit as shown in Fig. 11.

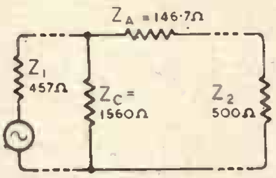


Fig. 12. *Taper network designed to match* 457 *ohms to* 500 *ohms.*

Provided that high quality " T " faders are used such a circuit will comply with the requirements set out at the beginning of this paper.

The total insertion loss which such a mixer network produces is :—

(a) Due to 50-ohm input circuit matching resistors	2.0 db.
(b) Due to mixer circuit itself 10 log $(2n - 1)$	8.4 db.
(c) Due to output circuit taper pad ..	2.6 db.
Total loss	13.0 db.

As a matter of interest it may be added that, had faders of an impedance of 219 ohms each been available for controlling the input circuits, no output taper pad would have been necessary and the insertion loss would have been as follows :—

(a) Due to a 31-ohm input circuit matching resistor	1.1 db.
(b) Due to mixer circuit itself ..	8.4 db.
Total loss	9.5 db.

In all other respects there would be nothing to choose between the two designs.

"Radio Data Charts"

Revised and Enlarged Third Edition

A REVISED new edition of the well-known collection of abacs by the late Dr. R. T. Beatty, published under the title of " Radio Data Charts " from the offices of our associated journal *Wireless World*, has been issued. The revision was undertaken by J. McG. Sowerby, B.A., who is a frequent contributor of abacs to *Wireless World*.

In addition to the ten new charts included in this edition, which brings the total to forty, eleven of the original abacs have been redrawn to extend their range or otherwise bring them up to date.

The change of coil inductance and R.F. resistance due to screening, the design of transmission lines, loudspeaker dividing networks, multi-ratio output transformers for supplying simultaneously loudspeakers of different impedances with different powers, are among the subjects covered by the new abacs. Charts covering the routine work in designing coils, chokes, mains transformers, etc., which were an essential part of the original series, are also included. The price of the new edition, which is obtainable from our Publishers, Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S.E.1, is 7*s.* 9*d.* by post.

Institution of Electrical Engineers

A DISCUSSION on the " Treatment and Tests for Extreme Climatic Conditions " will be opened by E. M. Lee, B.Sc., at a meeting of the Wireless Section of the Institution of Electrical Engineers on March 21st. Dr. D. Gabor will deliver a paper on " Energy Conversion in Electron Valves " at the meeting of the Section on April 5th. Both meetings will begin at 5.30.

A provisional committee has been set up by the I.E.E. for the formation of a Wireless Group in Cambridge and district. The chairman of the committee is C. R. Stoner, B.Sc. ; vice-chairman, B. J. Edwards, and Hon. Secretary, D. I. Lawson, M.Sc. On March 6th at 5.30 at the Cambridgeshire Technical School, Collier Road, Cambridge, C. P. Edwards, M.Sc., will speak on " Enemy Airborne Radio Equipment." On March 30th at 8.15 at the University Engineering Department, Trumpington Street, Cambridge, R. H. Angus, M.A., will deliver a paper on " Transients on Transmission Lines."

Institution of Electronics

THE DESIGN and application of thermionic valve rectifiers will be dealt with by F. E. Henderson of the G.E.C. when he addresses a meeting of the Institution of Electronics on March 18th at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, at 3 o'clock. Applications for tickets should be made to Alexander H. Hayes, 64 Winifred Road, Coulsdon, Surrey.

Brit. I.R.E.

A DISCUSSION on the " High-fidelity Reproduction of Music," which will be opened by Dr. N. Partridge, has been arranged by the Brit. I.R.E. for March 10th. Dr. Malcolm Sargent will be the principal speaker. The meeting will be held at the Institution of Structural Engineers, 11 Upper Belgrave Street, London, S.W.1, at 6.30.

GOODS FOR EXPORT

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export.

Attenuator Design*

By R. F. Blackwell, B.Sc., A.R.C.S., and T. A. Straughan, B.Sc., A.Inst.P.

(*Murphy Radio Ltd.*)

Introduction

IT is sometimes necessary to design attenuators having unequal steps of attenuation; it is convenient to use such an attenuator when checking the frequency response (bandwidth) of an amplifier or receiver, where measurements are required at, say, − 6 db. and − 40 db.

The usual method of doing this is:

(*a*) to calculate each section separately and combine them, or

(*b*) to calculate each element in sequence by the repeated application of simple circuit theory.

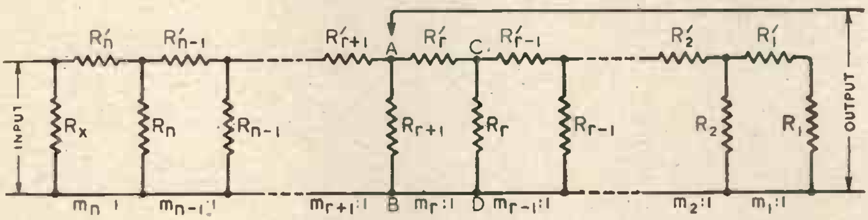
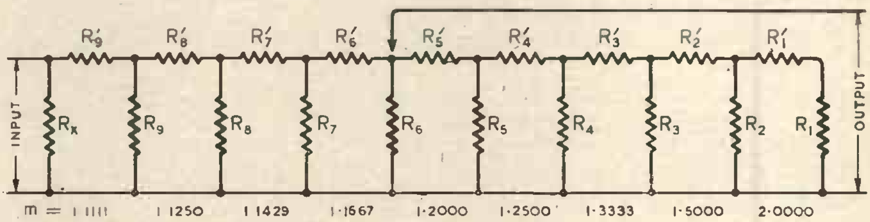


Fig. 1 (*Above*).

Fig. 2 (*Right*).



The method to be described is a generalisation of the second of these two and has the advantage of lending itself to tabulation.

Theory

In Fig. 1, let R_o be the output resistance,

(R_r, R_r') the r-th section of the attenuator,

m_r the voltage ratio across the r-th section, i.e. $\dfrac{\text{voltage across } R_{r+1}}{\text{voltage across } R_r}$

S_r the resultant of R_r shunted by the network to its right, and

T_r the resultant of R_{r+1} shunted by the network to its left.

Consider the r-th section:

The condition for a voltage ratio m_r is

$$R_r' = (m_r - 1)S_r \qquad (1)$$

The condition for a resistance R_o from A to B is

$$R_o = \frac{T_r(R_r' + S_r)}{T_r + R_r' + S_r} \qquad (2)$$

Substituting in (2) for R_r' from (1),

$$R_o = \frac{T_r \,.\, m_r \,.\, S_r}{T_r + m_r \,.\, S_r} \qquad (3)$$

Similarly, the condition for a resistance R_o from C to D is

$$R_o = \frac{S_r[(m_r - 1)S_r + T_r]}{T_r + m_r \,.\, S_r} \qquad (4)$$

Equating (3) and (4),

$$T_r \,.\, m_r \,.\, S_r = S_r[(m_r - 1)S_r + T_r]$$

$$\therefore \quad S_r = T_r \qquad (5)$$

Substituting in (4) from (5) and rearranging,

$$S_r = \frac{m_r + 1}{m_r} \,.\, R_o \qquad (6)$$

Substituting in (1) from (6),

$$R_r' = \frac{m^2_r - 1}{m_r} \,.\, R_o \qquad (7)$$

By definition, S_r is made up of R_r shunted by $(R_r'_{-1} + S_{r-1})$,

$$\therefore \quad S_r = \frac{R_r(R_r'_{-1} + S_{r-1})}{R_r + R_r'_{-1} + S_{r-1}}$$

and re-arranging,

$$R_r = \frac{S_r(R_r'_{-1} + S_{r-1})}{R_r'_{-1} + S_{r-1} - S_r} \qquad (8)$$

This expression becomes indeterminate for the 1-st section ($r = 1$), but in this case, it follows from the definition that

$$R_1 = S_1 \qquad (9)$$

* MS. accepted by the Editor, November 1943.

If the input resistance is to be equal to the output resistance R_0, it follows that

$$R_x = T_n = S_n \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

The method of using the results obtained in equations (6), (7), (8), (9) and (10) is best shown by means of an example, which is given below.

Example

It is required to calculate an attenuator of output resistance 100 ohms, giving outputs in the ratios 1.0 : 0.9 : 0.8 . . . . . 0.1

* * *

Fig. 2 shows the nine stages of attenuation, together with the value of m_r for each stage.

The calculations are given in the table below.

From equation (10), $R_x = S_9 = 190$ ohms.

The complete circuit of the attenuator is shown in Fig. 3.

* * *

In conclusion, the authors wish to thank Murphy Radio Ltd., for permission to use the results of work done in their Test Instruments Laboratory.

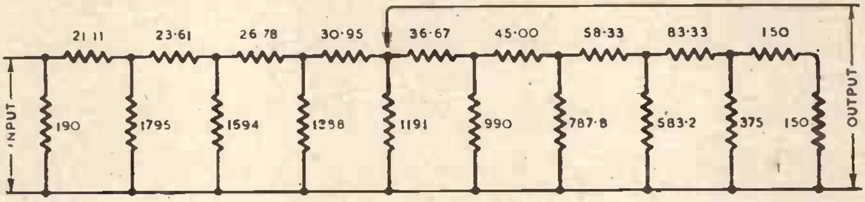


Fig. 3.

r	m_r	$m_r - 1$	$m_r + 1$	$m_r^2 - 1$	$R_r' = \frac{m_r^2 - 1}{m_r} R_0$	$S_r = \frac{m_r + 1}{m_r} R_0$	$R'_{r-1} + S_{r-1}$	$R'_{r-1} + S_{r-1} - S_r$	R_r
1	2.0000	1.0000	3.0000	3.0000	150.00	150.00	—	—	150.0
2	1.5000	0.5000	2.5000	1.2500	83.33	166.67	300.00	133.33	375.0
3	1.3333	0.3333	2.3333	0.7778	58.33	174.98	250.00	75.02	583.2
4	1.2500	0.2500	2.2500	0.5625	45.00	180.00	233.31	53.31	787.8
5	1.2000	0.2000	2.2000	0.4400	36.67	183.33	225.00	41.67	990.0
6	1.1667	0.1667	2.1667	0.3611	30.95	185.68	220.00	34.32	1190.5
7	1.1429	0.1429	2.1429	0.3061	26.78	187.50	216.63	29.13	1387.7
8	1.1250	0.1250	2.1250	0.2656	23.61	188.89	214.28	25.39	1593.8
9	1.1111	0.1111	2.1111	0.2346	21.11	190.00	212.50	22.50	1794.5

Book Review

Wave Filters

By L. C. Jackson, M.Sc.(Lond.), D.Sc.(Leiden). Pp. vii + 107. 64 Diagrams. Methuen & Co., Ltd., 36, Essex Street, London, W.C.2. Price 4s. 6d.

This book is an addition to a well-known series of physical monographs, and has many of the virtues and some of the faults found when a large subject is compressed into a small compass. The opening chapter briefly mentions some filter applications, and this is followed by two chapters on constant-*k*, and *m*-derived and composite filters. Crystal and coaxial filters are described in rather general terms, as is the effect of resistive losses in components. Some notes on practical filter construction are then followed by a brief delineation of the application of filter theory to mechanical and acoustical problems, with some examples.

In such a brief text as is necessary in a book of this size it is difficult to avoid falling into the pitfalls of extreme compression (when the result is often incomprehensible to those not already familiar with the subject), or alternatively incomplete and unsatisfactory treatment. The author has successfully avoided these two extremes by omitting more advanced theory, and covers the fundamentals of T and π structures lucidly in chapters two and three. The section on the effect of resistive losses would have been improved by a larger and more accurate version of Fig. 46 which would have been of more practical use, and the descriptions of crystal and coaxial filters form but an incentive to further study. The interesting section on acoustical and mechanical applications of filter theory is more detailed, but is inevitably rather incomplete.

The filter specialist will find little with which he is not already familiar in this book, but specialists in other spheres will find it a useful general survey, or alternatively a sound introduction to a larger treatise. Students preparing for the I.E.E. (communications) or similar examination will doubtless derive benefit from the clear exposition of essential theory.

Faults are few: in Chapter I ripple and mains frequencies in rectifier circuits are confused, and the surface noise from records extends much below 4000 c/s. In Chapter III the explanation of the terms mid-series and mid-shunt iterative impedance will not be immediately clear to all students. Several diagrams do not correspond exactly with the text, but the discrepancies are obvious. These are, however, but minor blemishes on an otherwise useful monograph.

J. McG. S.

The Slide Rule*

A Method of Obtaining Increased Accuracy in Reading and Setting

By G. A. Hay, B.Sc.

THE application of the slide rule to the calculation of experimental results is so universal that the following method of attaining greater precision of reading and setting might be found useful in increasing its scope still further. The method is not original, but does not seem to be generally known: a mathematical proof is given in the appendix.

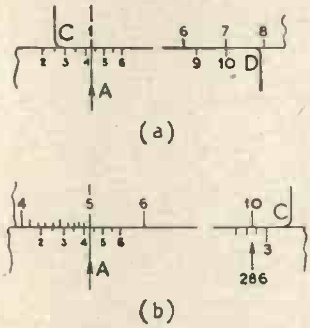


Fig. 1.

It is generally accepted that the accuracy of the normal ten-inch slide rule of good make ranges from four to three significant figures on the *C* and *D* scales, depending on the exact position of the result on the scale. It is commonly thought that this limit is set by the errors inherent in the mechanical design of the rule, such as thickness and inaccuracy of graduations, thickness of hair-line, etc. The success of the method described below, however, seems to show that the accuracy of *setting* and *reading*, i.e., estimating fractions of a division, is the limiting factor. It is possible to increase precision of setting and reading by a method similar to the common vernier.

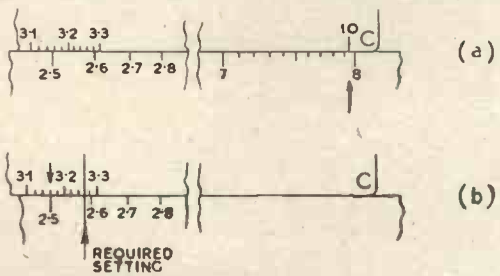


Fig. 2.

In Fig. 1a, the result of a series of operations is shown on the *D* scale at *A*. From this the figures 1.42 . . . can be read off with no ambiguity, but the next figure would normally have to be estimated as 8 or 9. The next step in reading this would be to set the cursor accurately at *A*, and then move the slide until a position is found where two graduations differing by 0.1 on the *C* scale exactly fit between 1.4 on the *D* scale and the cursor, in this case 4.9 and 5.0. The *C* index will then indicate the next three significant figures, of which only two are reliable. This is shown in Fig. 1b, the figures being . . . 286. The final result is thus 1.4286. Calculation gives the actual result (of 10/7) as 1.42857 . . . Practice may be had with similar examples which can easily be evaluated, such as 13/7, 13/9, 17/13, etc.

The method can also be applied to setting the scales, provided the quantity required comes on the *D* scale. (It is possible by a round-about process to transfer a setting to the *C* scale, but it is likely that the accuracy of setting will be lost in the extra operations involved.) Let us assume that a setting of 2.5793 is wanted on the *D* scale. The

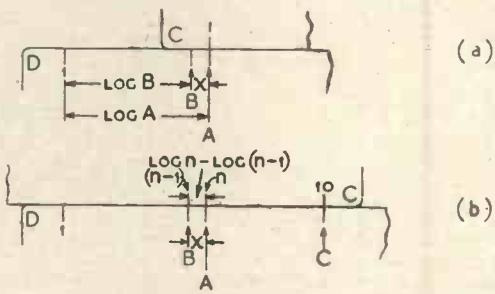


Fig. 3.

cursor is set to 2.57 approximately, then the *C* index moved to the figures . . . 793 as in Fig. 2a. No mark on the *C* scale corresponds with 2.5 on the *D* scale, so the slide is moved so that the nearest graduation comes against 2.5, in this case 3.16. Against the graduation 3.26 on the *C* scale will be the required setting, as in Fig. 2b.

It will be seen from the above brief description that the method is definitely limited in its scope and does not compare at all with a set of seven figure tables. Moreover, a first-class rule used in a good light is essential. Bearing these limitations

* MS. accepted by the Editor, July, 1943.

in mind, however, it is possible to get results under certain conditions which would otherwise be impossible of attainment.

APPENDIX

In Fig. 3a, which represents the setting of the rule after a calculation has been done, A is the result of the calculation, and B the quantity read off directly, which falls short of A by a numerical amount C.

hence $A = B + C$ .. .. .. (1)

also $\log A - \log B = x$ .. .. .. (2)

from (1) $\log A = \log (B + C) = \log B + x$

hence $x = \log (B + C) - \log B = \log \left(\frac{B + C}{B}\right)$ .. .. (3)

Fig. 3b represents the second stage in evaluating the result; $(n - 1)$ and n are the two consecutive divisions which fit the interval B to A, i.e., the distance x, such that $x = \log n - \log (n - 1)$

i.e. $x = \log \left(\frac{n}{n - 1}\right)$ .. .. .. (4)

from (3) and (4) $\log \left(\frac{B + C}{B}\right) = \log \left(\frac{n}{n - 1}\right)$

i.e. $B + C = \frac{nB}{n - 1}$

whence $C = \frac{B}{n - 1}$

This is the result indicated by the index at C, i.e., the result of dividing B by $(n - 1)$.

Wireless Patents

A Summary of Recently Accepted Specifications

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

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

556 051.—Class-B amplifier in which the gain is maintained constant, irrespective of impedance variations in the output or load.
The British Thomson-Houston Co. Convention date (U.S.A.) 22nd May, 1941.

556 137.—Diaphragm mounting designed to reduce peak resonance in loudspeakers and microphones.
K. H. Schmidt. Application date 27th May, 1942.

556 340.—Regenerative repeater system for code telegraphy, with preset locked relays to avoid the use of " spacing " distributors.
Standard Telephones and Cables (assignees of W. B. Martin). Convention date (U.S.A.) 25th February, 1941.

556 369.—Trunk telephony system with by-pass circuits at the repeating stations to divide the speech frequencies from the control and calling currents.
Standard Telephones and Cables (communicated by Western Electric Co.). Application date 22nd May, 1942.

556 568.—Circuit for eliminating " hum " from a photoelectric cell which is excited by an A.C.-operated lamp.
Radio Corporation of America. Convention date (U.S.A.) 31st July, 1941.

556 762.—Circuit for converting tone-to-tone A.C. telegraph signal into double-current D.C. signals.
S. N. Watson and T. Worswick. Application date 17th April, 1942.

556 850.—Receiving relay or " counter " responsive to a series, or code, of electric pulses.
Standard Telephones and Cables (communicated by Western Electric Co. Inc.). Application date 24th September, 1942.

AERIALS AND AERIAL SYSTEMS

555 735.—Frame aerial with a magnetic-core coupling designed to cover a wide range of frequencies.
Johnson Laboratories Inc. (assignees of W. A. Schaper). Convention date (U.S.A.) 8th March, 1941.

556 055.—Construction and support of a two-part aerial of the rigid pole or rod type.
Constructors, Ltd., and W. C. Scrivener. Application date 22nd June, 1942.

556 067.—Construction and support of a rigid rod or pole aerial with tapered ends.
Constructors, Ltd., and W. C. Scrivener. Application date 22nd June, 1942.

556 093.—Dipole aerial systems in which an inner conductor is capacitance coupled at both ends to an external tubular conductor.
Standard Telephones and Cables (assignees of A. Alford). Convention date (U.S.A.) 9th April, 1941.

556 592.—Loop aerial made in segments arranged in the same plane to form a substantially-circular outline, in one plane, particularly for use on aircraft.
Standard Telephones and Cables (assignees of M. A. Rote). Convention date (U.S.A.) 12th April, 1941.

DIRECTIONAL WIRELESS

555 968.—Arrangement for providing two degrees of sharpness of directivity, one for homing, and the other for taking bearings, in a directional system of the switched cardioid type.
Marconi's W.T. Co.; C. S. Cockerell; J. D. Brailsford; and M. H. Cufflin. Application date 23rd February, 1940.

556 324.—Radio-navigational aerial system which is screened against local re-radiation of undesired polarity.
Standard Telephones and Cables and A. J. Maddock. Application date 27th March, 1942.

556 476.—Radio beacon station transmitting a wave with a progressively-varying phase for direction-finding purposes.
Standard Telephones and Cables and C. W. Earp. Application date 3rd April, 1942.

556 614.—Radio-navigational beacon transmitter with means for preventing or neutralizing the emission of misleading parasitic signals.
Standard Telephones and Cables and A. J. Maddock. Application date 9th April, 1942.

556 899.—Dipole aerial with an intermediate grounded screen for transmitting blind-landing signals to an aviator.

Aga-Baltic Akt. Convention date (Sweden) 13th January, 1941.

556 967.—Rotary direction-finding aerial with two symmetrical auxiliary loops which serve to correct quadrantal and like errors.

Marconi's W.T. Co. and J. H. Moon. Application date 27th March, 1942.

557 017.—Remote control system for varying the angular setting of a rotatable aerial, and for indicating its prevailing orientation.

E. H. Robinson. Application date 28th April, 1942.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

555 900.—Combination control system, particularly for the local oscillator, and the high-frequency gain control, of a superheterodyne receiver.

Rediffusion Ltd.; R. P. Gabriel; and G. B. Ringham. Application date 21st July, 1942.

555 942.—Stabilizing means for negative feed-back amplifiers in which the gain is adjusted by varying the loss in the feed-back path.

Standard Telephones and Cables; A. H. Roche; and H. G. Kidner. Application date 10th March, 1942.

555 959.—Means for testing the signal-to-noise ratio of radio receivers.

Manufacturing R.A.P. and J. F. Gowar. Application date 6th July, 1942.

556 171.—Frequency-dividing network and amplitude limiter for receiving frequency- or phase-modulated signals.

Marconi's W.T. Co. (assignees of M. G. Crosby). Convention date (U.S.A.) 20th March, 1941.

556 319.—Safeguarding device for an automatic SOS alarm to maintain its efficiency when the ship's operator is off-duty.

Standard Telephones and Cables and J. D. Holland. Application date 27th March, 1942.

556 404.—Two-way telephone installation also adapted to serve as a radio receiver for broadcast programmes.

B.G. (London), Ltd. (trading as The Dulci Co.); W. Barr; and M. E. Angel. Application date 25th June, 1942.

556 724.—Valve "chopper" circuit for detecting frequency-modulated signals.

Marconi's W.T. Co. (assignees of C. W. Hansell). Convention date (U.S.A.) 17th June, 1941.

556 774.—Suppressing image frequencies in a superheterodyne receiver with permeability tuning.

Johnson Laboratories Inc. (assignees of F. N. Jacob). Convention date (U.S.A.) 13th May, 1941.

556 798.—Frequency converter, with transmission-line type of tuning, for use in the reception of ultra-short-wave signals.

The British Thomson-Houston Co. Convention date (U.S.A.) 12th March, 1940.

556 992.—Receiver for frequency-modulated signals in which a single multi-grid valve allows the usual discriminator network to be eliminated.

Marconi's W.T. Co. (assignees of F. B. Stone). Convention date (U.S.A.) 31st July, 1941.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

556 320.—Television system in which a different characteristic frequency is associated with each scanning point.

J. N. M. Howells. Application date 27th March, 1942.

556 430.—Amplifier and relay system for transmitting wide-band television signals over a coaxial cable.

Standard Telephones and Cables (assignees of L. W. Morrison, Junr.). Convention date (U.S.A.) 10th January, 1941.

557 000.—Inter-coupled pair of pentode valves serving to mask or "quash" transmitted television signals at the end of each scanning line.

A. C. Cossor; W. H. Stevens; and L. H. Bedford. Application date 27th May, 1940.

557 001.—Cathode-ray tube with piezo-electric control for reproducing a sequence of television signals at definite time intervals along the front of a ribbon-like electron stream.

B. C. Fleming-Williams. Application date 12th June, 1940.

TRANSMITTING CIRCUITS AND APPARATUS

(*See also under Television*)

555 750.—Radio transmitter, the frequency of which can be controlled, at will, either by a stabilised piezo-electric crystal, or by an adjustably-tuned circuit.

Rediffusion, Ltd., and E. W. Rogers. Application date 29th May, 1942.

555 925.—Frequency- or phase-modulating system of the kind in which short "time-modulated" pulses form an intermediate stage of the final signal [addition to 551 282].

Standard Telephones and Cables (assignees of L. R. Wrathall). Convention date (U.S.A.) 4th November, 1941.

555 999.—Pendulum-controlled coding device utilising the start-stop principle, particularly for operating a teleprinter, or for transmitting standardised orders.

Standard Telephones and Cables; G. C. Hartley; and W. J. Reynolds. Application date 13th March, 1942.

556 054.—Minimising the effect of inter-electrode capacitance in power amplifiers designed to handle wide bands of ultra-high frequencies.

Standard Telephones and Cables (assignees of W. H. Doherty). Convention date (U.S.A.) 21st June, 1941.

556 057.—Frequency monitoring device comprising a transformer and rectifier combination for supervising the performance of an F.M. broadcast transmitter.

The British Thomson-Houston Co. (communicated by General Electric Co.). Application date 7th July, 1942.

556 208.—System for converting frequency modulation to phase modulation as a step in the production of an F.M. signal having a wide excursion or range of swing.

Standard Telephones and Cables and C. W. Earp. Application date 25th April, 1941.

556 331.—Facsimile telegraph system with an "advanced" auxiliary scanner for increasing the speed of transmission.

Standard Telephones and Cables (assignees of E. Bruce and W. Herriott). Convention date (U.S.A.) 31st October, 1940.

556 757.—Circuit arrangement for stabilising the amplitude of a valve generator at different selected frequencies.

Standard Telephones and Cables and M. M. Levy. Application date 17th April, 1942.

556 769.—Means for increasing the inductance of the internal conductors of a valve power-amplifier for very high frequencies.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 4th September, 1941.

556 852.—Piezo-electric-crystal-controlled valve for producing frequency-modulated signals.

Marconi's W.T. Co. (assignees of G. L. Usselman). Convention date (U.S.A.) 2nd October, 1941.

556 855.—Means for stabilising the frequency and phase of a " slave " oscillation relatively to a " master " oscillation, particularly for controlling a common-wave broadcasting system.

R. Calvert. Application date 31st March, 1942.

556 930.—Short-wave oscillation generator with a transmission line feed-back circuit serving to apply a predetermined phase shift.

Marconi's W.T. Co. and D. A. Bell. Application date 30th August, 1939.

557 023.—Magnetic keying device for inducing signal impulses, say in a field telegraph, without the use of a battery.

G. G. Glanville. Application dates 23rd July and 25th September, 1942.

SIGNALLING SYSTEMS OF DISTINCTIVE TYPE

555 993.—Multi-channel radio signalling system in which timed pulses are applied to predetermined phases of a single carrier-wave.

Standard Telephones and Cables ; P. K. Chatterjea and L. W. Houghton. Application date 12th March, 1942.

556 001.—Signalling system in which the band-width of the transmitted frequencies is modulated in accordance with the amplitude of the signal.

Standard Telephones and Cables ; P. K. Chatterjea and D. M. Ambrose. Application date 13th March, 1942.

556 079.—Multiplex signalling system in which the frequency separation of the different signals is determined by the repetition frequency of a series of pulses.

Standard Telephones and Cables ; P. K. Chatterjea and L. W. Houghton. Application date 12th March, 1942

556 081.—Signalling system in which a central station radiates a plurality of single-side-band messages to a number of sub-stations.

Standard Telephones and Cables ; P. K. Chatterjea and L. W. Houghton. Application date 13th March, 1942.

556 231.—Attenuation equaliser for a multi-channel carrier-wave telephony transmission line.

Standard Telephones and Cables (assignees of W. P. Mason). Convention date (U.S.A.) 27th September, 1941.

556 745.—Electric signalling system in which trains of impulses of varying length and polarity are utilized particularly for remote control purposes.

Standard Telephones and Cables ; H. M. M. d'A. Fonseca and H. J. Ward. Application date 14th April, 1942.

556 875.—Radio-frequency wired wireless broadcasting system in which frequency modulation is utilised to minimise distortion due to the non-linear characteristics of the distributing network.

Re-diffusion and P. Adorjan. Application date 10th July, 1942.

556 923.—Multi-channel signalling system utilising rhombic aerials for single-side-band transmission at optimum frequency for the prevailing atmospheric conditions.

Standard Telephones and Cables (communicated by Western Electric Co. Inc.). Application date 21st April, 1942.

557 028.—Negative feed-back repeater in which temperature-compensating impedances are included in series and in shunt with the feed-back couplings.

Standard Telephones and Cables (assignees of M. K. Zinn). Convention date (U.S.A.) 30th September, 1941.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

555 827.—Electrode arrangement for increasing the intensity of the electron stream generated in a cathode-ray device of the velocity-modulating type. [*Addition to* 541 271.]

The British Thomson-Houston Co. Convention date (U.S.A.), 26th July, 1940.

556 046.—Arrangement of the gun and focusing electrodes of a cathode-ray tube for producing a clearly-defined " cross-over " in the electron stream.

A. C. Cossor and H. Moss. Application date 14th March, 1942.

556 118.—Electrode assembly of a multi-grid valve, particularly suitable for switching operations.

Standard Telephones and Cables (assignees of A. M. Skellett and H. W. Weinhart). Convention date 17th May, 1941.

556 211.—Electrode arrangement for velocity modulating the electron beam of a cathode-ray tube.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 17th November, 1941.

556 280.—Construction and assembly of the heavy cup-like electrodes of a voltage-regulating device of the stabilovolt type.

Marconi's W.T. Co. and G. N. Dyson. Application date 24th March, 1942.

556 305.—Electrode construction and assembly to facilitate the mass production of multi-grid valves.

B. Erber. Application dates 26th January and 28th February, 1942.

556 372.—Electrode system for focusing an electron stream, particularly for microscopy.

The British Thomson-Houston Co. Convention date (U.S.A.), 2nd July, 1941.

556 427.—Electrode arrangement for a thermionic valve with a low " mu " or amplification factor, and a sharp cut-off characteristic.

Hazeltine Corporation (assignees of R. C. Hergenrother). Convention date (U.S.A.), 8th March, 1941.

556 461.—Two-group electrode arrangement for eliminating undesired space-charge and inductive effects in a multi-grid " mixer " valve.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 28th January 1942.

556 505.—Directly-heated valve cathode designed to ensure a high order of insulation and a low magnetic field, and to emit a plane wave of electrons.

Westinghouse Electric International Co. Convention date (U.S.A.) 24th June, 1941.

556 530.—Arrangement of the focusing and control electrodes in an electron-discharge tube of the velocity-modulating type.
Standard Telephones and Cables (assignees of F. Gray). Convention date (U.S.A.) 4th April, 1941.

556 565.—Method of depositing powdered fluorescent material on the surface of a cathode-ray tube.
Standard Telephones and Cables (assignees of J. F. Rutledge). Convention date (U.S.A.) 5th July, 1941.

556 662.—Cathode-ray tube in which a rotary motion is imparted to the electron stream in order to generate oscillations of very high frequency.
Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 3rd November, 1941.

556 957.—Arrangement of the "gun" assembly in a cathode-ray tube for producing a hollow electron beam of high density.
Western Electric Co. Inc. Convention date (U.S.A.) 7th May, 1941.

557 005.—Arrangement of auxiliary electrodes for reducing undesired damping effects in order to allow a valve having a comparatively large transit time to be used for handling ultra-short waves.
Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 5th June, 1941.

557 041.—Electron discharge tube in which an electron beam is formed and cyclically deflected from its normal axis in order to deliver power at a constant rate to a load circuit.
Standard Telephones and Cables (assignees of R. V. L. Hartley). Convention date (U.S.A.) 28th March, 1941.

557 076.—Construction and assembly of a metal-to-glass seal, particularly for the metal container or shell of an electron-discharge tube.
Marconi's W.T. Co. (assignees of D. W. Power). Convention date (U.S.A.) 30th April, 1941.

SUBSIDIARY APPARATUS AND MATERIALS

555 749.—Construction of flexible conduit or screen designed to shut-out radio frequencies.
E. L. W. Byrne [communicated by Titeflex Metal Hose Co.]. Application date 18th May, 1942.

555 779.—Mounting a piezo-electric crystal so that the area of contact is surrounded by a pressure-relieving groove to prevent damping.
Marconi's W.T. Co. (assignees of P. D. Gerber). Convention date (U.S.A.) 1st July, 1941.

555 825.—Electron-discharge device for developing a rotating magnetic field for the purpose of controlling the propagation characteristics of a wave-guide.
The British Thomson-Houston Co. Convention date (U.S.A.) 25th April, 1940.

556 118.—Electron valve circuit for transmitting energy to a load through capacity storage devices.
The British Thomson-Houston Co. Convention date (U.S.A.) 20th March, 1941.

556 152.—Thallium counter electrode for a rectifier of the selenium type.
Westinghouse Brake and Signal Co.; L. E. Thompson; and A. Jenkins. Application date 17th March, 1942.

556 167.—Variable condenser arrangement for tuning a hollow resonator of the "open box" type as used for very high frequencies.
Kolster-Brandes and D. N. Corfield. Application date 20th March, 1942.

556 175.—Photo-electric relay, responsive to the earth's magnetic field, for controlling the steering of mobile craft.
D. C. Gall. Application date 14th March, 1942.

556 310.—Counter-electrode, made wholly or substantially of silver, to improve the characteristic of a rectifier of the selenium type.
Westinghouse Brake and Signal Co.; L. E. Thompson; and A. Jenkins.

556 510.—Construction and processing of carbon variable resistances of the pressure-controlled type.
The Plessy Co. Convention date (U.S.A.) 1st October, 1941.

556 526.—Dielectric paper containing the vegetable substance lignin, particularly for condensers.
Standard Telephones and Cables (assignees of D. A. McLean). Convention date (U.S.A.) 9th January, 1941.

556 545.—Construction and assembly of the stack of electrodes in a dry-plate rectifier.
Standard Telephones and Cables (assignees of C. A. Clarke) Convention date (U.S.A.) 16th June, 1942.

556 641.—Method of generating a desired and precise frequency by "beating" the products of at least three associated harmonic-producers.
H. J. Finden and The Plessy Co. Application date 11th March, 1942.

556 643.—Magnetic means for reducing the damping effect of the Earth's gravitational field on the operation of electric measuring instruments.
Standard Telephones and Cables and J. Handley. Application date 10th April, 1942.

556 655.—Quadrant voltmeter designed to register on an evenly-graduated (instead of a logarithmic) scale.
Standard Telephones and Cables and J. Handley. Application date 11th May, 1942.

556 860.—Selective relays or switches responsive to sequences of pulsed signals.
Automatic Telephones and Electric Co. and G. W. Thompson. Application date 22nd April, 1942.

556 886.—Plating and processing the electrodes of copper-oxide rectifiers.
The British Thomson-Houston Co. Convention date (U.S.A.) 4th October, 1941.

556 997.—Method of sealing the ends of a fixed condenser comprising a series of folded or interleaved elements.
British Insulated Cables; W. C. Handley; J. C. Quayle; United Insulator Co.; and N. G. Westcombe. Application date 15th August, 1942.

557 027.—Relay circuit in which pulsed signals of a desired frequency are distinguished from others by a local modulator.
Standard Telephones and Cables (assignees of M. A. Logan). Convention dates (U.S.A.) 23rd August and 4th December, 1941.

557 062.—Construction and assembly of the electrodes and counter-electrodes of a dry-contact rectifier.
Standard Telephones and Cables (assignees of C. A. Kotterman). Convention date (U.S.A.) 28th March, 1942.

557 091.—Construction of high-voltage fixed condensers comprising two or more "cupped" ceramic elements.
British Insulated Cables; J. C. Quayle; and W. C. Handley. Application dates 22nd May and 29th July, 1942.

Abstracts and References

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For the information of new readers it is pointed out that the length of an abstract is not necessarily an indication of the importance attached to the work concerned. An important paper in English, in a journal likely to be readily accessible, may be dealt with by a square-bracketed addition to the title, while a paper of similar importance in German or Russian may be given a long abstract. In addition to these factors of difficulty of language and accessibility, the nature of the work has, of course, a great influence on the useful length of its abstract.

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PROPAGATION OF WAVES

728. ELECTROMAGNETIC WAVES IN A HOLLOW GUIDE WITH TAPERING CROSS-SECTION.—N. N. Malow [Malov]. (*Journ. of Phys.* [of USSR], No. 5, Vol. 4, 1941, pp. 473–478 : in German.)

Analysis of the field distribution in a guide with tapering rectangular cross-section shows that such a guide can be used for the concentration of energy : feeding would take place at a point of large cross-section, and a narrow slot at the tapered end would act as aerial. "Some interesting results arise from an investigation of the standing waves in a conical guide : this will be reported on in a later paper."

729. THE WAVE-GUIDE OF CIRCULAR CROSS-SECTION WITH LAYERED DIELECTRIC INSERT.—H. Buchholz. (*Ann. der Phys.*, 23rd Oct. 1943, Vol. 43, No. 5, pp. 313–368.)

The criterion for the limiting wavelength for a guide with a perfectly conducting metal wall and a homogeneous dielectric, derived from eqn. 1,1, shows that this critical wavelength can, within certain limits, be increased by the use of a dielectric with a dielectric constant ϵ_0 greater than that of a vacuum ϵ. But since all dielectric materials have a loss angle which is not equal to zero, such a step is always accompanied by an increase in attenuation. Eqn. 1,3e for the minimum dielectric attenuation β_D shows that even for the moderate case of $\tan \delta = 10^{-4}$ the value of β_D for a guide having an outer radius $b = 2.5$ cm amounts already to $4j$ N/km ; that is, in the most favourable case of the TE_{11} wave (where $j = j'_{11} = 1.84118$, the lowest possible value), to 7.365 N/km. For a ratio ϵ_0/ϵ of 16 this minimum dielectric attenuation occurs for a vacuum-wavelength $\lambda = 24.1306$ cm. So by filling the guide completely with the dielectric in question, the critical wavelength would indeed be raised to $24.1306 \times \sqrt{2}$, that is to 34.1259 cm, but such a considerable additional attenuation would result that the advantage of the decreased critical frequency would be rendered illusory.

There is, however, the possibility of arriving at a satisfactory compromise between the contradictory requirements of an increased critical wavelength and a low attenuation, by filling the guide only partially with the loss-producing dielectric. Compared with the complete filling, this will reduce the attenuation while at the same time reducing the increase of the critical wavelength : but a balance of advantage remains, since the two changes occur to a different extent. To avoid a special fixing arrangement for the dielectric, it is generally desirable to use a ring-shaped insert fitting the metal tube. The alternative plan, in which the insert takes the form of a dielectric central conductor, is chiefly of theoretical interest, since such a structure obviously resembles the system of a dielectric wire in free space, whose theory has already been given by Hondros & Debye in the 1909/10 *Annalen der Physik* : the only difference being the presence of the concentric metal sheath. But since the treatment of this case differs from that of the ring-shaped insert chiefly in the numerical working-out, it is included in the present work.

By the middle of Section 5 the writer has arrived at eqns. 5,3 and 5,6 for the wave-attenuation due to dielectric losses, for the two axially symmetrical wave-types, the TM_{n0} and TE_{n0} waves. They are derived on the assumption that both dielectrics in the guide have losses ; the formulae for the simpler cases when only the inner dielectric (eqn. 5,3a) and only the outer (eqn. 5,3b) show losses are derived from eqn. 5,3 for the TM_{n0} wave : for the TE_{n0} wave they can be derived from the simpler eqn. 5,6, but this is not actually done. The section ends by considering some alternative forms for eqns. 5,3 and 5,6, and also some approximate formulae of limited range of application. For example, eqn. 5,10β gives a simple approximate formula for the TM_{n0}-wave dielectric-attenuation on the assumption that only one dielectric has losses and that one dielectric constant is much larger than the other ; and eqn. 5,10α does the same thing for the attenuation minimum.

The total attenuation of a guide with dielectric insert is given sufficiently accurately by the simple addition of the attenuation due to dielectric loss, thus obtained, to the attenuation due to thermal losses in the walls, derived in Section 6. Finally, Section 7 applies the results to the calculation of the total attenuation of a *TE* wave in a guide of given dimensions, when the dielectric insert takes the form first of a central conductor and secondly of a dielectric bushing. The calculations cover the TE_{10} and TE_{20} waves and lead to Figs. 16–19, which give the two attenuation components, and also the total attenuation, as functions of the frequency. For previous work, which includes a long bibliography, *see* 2402 of 1941.

730. SHOULD ONE SPEAK OF THE CHARACTERISTIC IMPEDANCE OF A PLANE WAVE OR A TUBULAR LINE? [Discussion, and a Tabulated Comparison between the Formulae for a Two-Strip Line & a Rectangular-Section Guide (H_{01} Wave)].—W. Dällenbach. (*Hochf:tech. u. Elek:akus.*, June 1943, Vol. 61, No. 6, pp. 167–171.)

"Recently the conception of characteristic impedance has been applied in different ways to plane waves in free space and to electromagnetic waves in tubular lines. It has, for instance, been stated that the characteristic impedance of a plane wave in free space is

$$\sqrt{\Pi/\Delta} = \sqrt{4\pi \cdot 10^{-9}/10^{9}/4\pi c^2} = 120\pi = 377 \text{ (ohms)},$$

while for a tubular line of rectangular cross-section the characteristic impedance for an H_{01} wave is calculated (as the ratio of the electric field strength to the magnetic, in a plane at right angles to the tube axis) as

$$\sqrt{\Pi/\Delta} \cdot v/c = \sqrt{\Pi/\Delta} \cdot 1/\sqrt{1-(\lambda/2b)^2}$$

where λ is the vacuum-wavelength in free space and b the length of the side of the rectangular cross-section in the direction of the electric field.

"It is not desirable to speak of the characteristic impedance of a plane wave, particularly of any wave progressing in free space, since when the term impedance is used one has the right to demand information as to voltage and current, as one could reasonably do in the case of waves guided by a line. Also, one comes into conflict with the characteristic impedance $W = \sqrt{\Pi/\Delta} \cdot s/b$ (ohms: eqn. 3) of a uniform idealised two-strip line (Fig. 1), where b represents the width of the parallel strips and s the spacing between them. The two-strip line is merely idealised to the extent that eqn. 3 holds good only if (as in dealing with the ideal plate condenser or solenoid) the field-drop towards the edges, and the stray field outside the prismatic space between the two strips, are neglected. Eqn. 3 gives the characteristic impedance as dependent on the geometrical dimensions s/b of the line, and thus as by no means identical with the field-strengths ratio $\sqrt{\Pi/\Delta}$, though this is certainly common to the two-strip line and to the plane wave progressing in free space.

"The relations for the definite types of electromagnetic waves which propagate in tubular lines are not quite so simple. In the following pages it will be own, by taking as an example the H_{01} wave . . . in a homogeneous loss-free tubular guide of rectangular section and in a vacuum ($\epsilon = 1$), that it is possible to define the characteristic impedance W, the inductance L and capacitance C per unit length, and the instantaneous values of voltage u and current i at any cross-section, in such a way that along the homogeneous loss-free tube exactly the same current and voltage equations (and thus also the same wave equation) hold good as in a loss-free double line *in vacuo*, except that the velocity of light c is replaced by the propagation velocity v characteristic of the tube guide in its steady state of excitation, and dependent on the width b of the guide. The definitions given have a definite physical significance in that they are based on the conservation laws of electric charge and energy (continuity equations of current and power).

"The characteristic impedance thus obtained does not coincide, even in the case of a tube guide of square cross-section, with the field-strengths ratio, but is greater than this by the factor $\pi^2/8$ [the equation for the rectangular tube, of sides s and b, is

$$W = \sqrt{\Pi/\Delta} \cdot \pi^2/8 \cdot s/b/\sqrt{1-(\lambda/2b)^2},$$

compared with eqn. 3 for the two-strip line, above]. The electromagnetic field energy per unit length of line, expressed in the terms here introduced, is not the same for the tube guide as for the two-strip line: for the former an expression is found which is dependent on v/c, and which for $v/c = 1$ simplifies down to the two-strip expression. The results obtained can be extended without difficulty to tube guides of circular section or with dielectric constants other than unity."

731. PRINCIPLES OF MICRO-WAVE RADIO [Cavity Resonators: Transmission Lines].—E. U. Condon. (*Reviews of Mod. Phys.*, Oct. 1942, Vol. 14, No. 4, pp. 341–389.)

From the Westinghouse laboratories. Originally meant to be published as a text-book, this material is presented as a review article chiefly because it appeared desirable "to give the completed portion of the manuscript wide circulation now."

732. TRANSMISSION-LINE THEORY AND ITS APPLICATION [to Calculation of Efficiency of Transmission, Standing-Wave Ratio & Spacing of Dielectric Supports, Design of Impedance Transforming & Matching Sections and Insulating Stubs, and to Measuring Technique: a General Definition of Impedance, and Extension of Formulae & Experimental Methods to Wave-Guides].—R. King. (*Journ. Applied Phys.*, Nov. 1943, Vol. 14, No. 11, pp. 577–600.)

"In Part I [Theory] several forms of the solution of the transmission-line equations are discussed, including in particular a completely hyperbolic one in which the over-all attenuation and phase-shift of the terminal impedances are expressed in a form involving terminal functions which simplify the analysis of many complex problems. . . ." It is this form that is employed in Part II (Applications): "it makes the general case, which is excessively intricate in the exponential or conventional hyperbolic form, practically as simple as the special cases" which alone are simple in those forms.

733. "Q" FOR UNLOADED CONCENTRIC TRANSMISSION LINES.—Miedke. (*See* 764.)

734. A MILES-PER-WATT RECORD [for Frequency-Modulated 1000 Watt Stations] OF 0.82 CLAIMED BY W75C OF CHICAGO.—(*Electronics*, Sept. 1943, Vol. 16, No. 9, p. 154: paragraph only.) Based on report of "fairly regular reception" in Greenville, Rhode Island.

735. ASTRONOMY AND AMATEUR RADIO.—H. M. French. (*QST*, Nov. 1943, Vol. 27, No. 11, pp. 17–20.) Subsequent articles will deal with "Aerology and v.h.f. wave propagation" and "The influence of topography on v.h.f.–to–s.h.f. communications."

736. CONCERNING PHASE SELECTIVITY [given by Receiving Circuit with Periodic Parameter].—Gorelik. (*See* 799.)

737. ON THE REFRACTIVE INDICES OF MEDIA WITH BOUND AND WITH FREE ELECTRONS [Discussion of Simple Fictitious Proton–Electron Model shows Difference in Behaviour to be conditioned by Difference in

Time of Stay of Electron within Proton].—L. I. Mandelstam. (*Journ. of Phys.* [of USSR], No. 1/2, Vol. 4, 1941, pp. 9–11 : in German.)

Darwin (1934 Abstracts, pp. 606–607) arrived at the correct conclusion, that for a medium with free electrons the formula to be used is Sellmeier's and not that of Lorentz–Lorenz. But his treatment, in Mandelstam's opinion, was not a lucid one, so that the present simple consideration of the problem appears desirable. *Cf.* 738, below.

738. The Refractive Index of an Ionised Medium: II [Confirmation & Clarification of Result in I (1934 Abstracts, pp. 606–607) where Correctness of Use of Sellmeier Formula in place of Lorentz Formula was established].—C. G. Darwin. (*Proc. Roy. Soc.*, Series A, 16th Dec. 1943, Vol. 182, No. 989, pp. 152–166.)

"The earlier paper [*cf.* Mandelstam, 737, above] fell into two parts. Its first six sections were a critique of the older methods and aimed at showing how unreliable such methods were. Only negative conclusions were reached, and to overcome the difficulties a new method was introduced in the later sections which avoided them. This method justified the use of the *S* formula for an ionised medium, and while no claim could be made for the sort of rigour that appeals to the pure mathematician, the demonstration was at least as good as many that have to be accepted in the more difficult branches of physics. The present note returns to the point of view of the first half of the paper, and shows that from such a starting point the same result is obtained. The previous criticism, which was negative, in that it only pointed out fallacies in the argument favouring *L*, is now turned into a positive confirmation for *S*. The ideas behind the present work are largely contained in §§ 4–6 of the earlier one."

A direct analysis is made of the effects of collisions between free electrons and positive ions. It is shown that the perturbation of the electron's path by the incident light has a secondary effect during a collision, so that if before entry into collision its position was displaced sideways, it will emerge from the collision with a changed velocity. The average effect of such changed velocities is equivalent to an acceleration, which reduces the effective force on the electron from $E + 4\pi/3 \cdot P$ to E. "This result is proved first for a positive ion composed of a uniform spherical charge, then for a proton, and finally for any centrally symmetrical distribution of charge. Though it has not been proved for a system of unsymmetrical charges arbitrarily orientated, such as ionised molecules, there can be little doubt that the result is general." If the theorem represented by eqn. 11.1 could be established, the proof would be complete: "however, it is already quite clear what the value of the refractive index must be, and the whole subject perhaps hardly merits much further intensive study."

739. The Relation between the "Effective" Ground Conductivity [as obtained by the Dipole Measuring Method] and the Attenuation of Propagation.—J. Grosskopf & K. Vogt. (*Hochf: tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, pp. 14–15.)

"It was shown in a previous paper (1361 of 1943) that the so-called 'effective' conductivity which can be derived from the parameters of the Zenneck rotating-field ellipse, and the frequency-dependence of which (for instance in the case of stratified ground) yields values for the electrical constants of the different layers (376 of 1942), was also a measure of the propagation-attenuation of a transmitting station. This 'effective' conductivity (1833 of 1941) is a quantity which involves the conductivities and thicknesses of the individual strata, and is related to the ellipse parameters by the equation $\sigma_{eff} = \frac{1}{4}f(a/b)^2$ e.s.u., where f is the frequency in c/s and a and b are the major and minor axes of the ellipse.

"The following measurements show that the 'effective' conductivities enable a quantitative determination of the curve of field-strength drop to be made. In Fig. 1 the variation of the product field-strength × distance is given for a frequency of 1360 kc/s. The measurements were made over flat ground free from obstacles [distances up to 3500 m]. Curve 1 of Fig. 2 shows, for the same frequency, the course of the 'effective' conductivity as measured by the dipole method, while curve 2 does the same for a frequency of 191 kc/s. Comparison between curves 1 and 2 shows that near the transmitter the 'effective' conductivity for the higher frequency is lower than for the lower frequency, so that a stratification with a poorly conducting top layer may be deduced here (*see* last two references). At greater distances from the transmitter the ratio of conductivities reverses in favour of the shorter wave [the curves cross at a distance of about 3000 m]. It is to be noticed further, in curve 1, that the conductivity rises in a ratio of 1 : 8 in a range of distance of about 3 km.

"The problem now is to derive, from the conductivity curve 1 of Fig. 2, the field-strength-drop curve of Fig. 1. For this construction the expression [eqn. 2] derived for the attenuation function $S(\rho)$ by van der Pol from the Sommerfeld function (1931 Abstracts, p. 375, r-h column) is taken as a basis." This equation (in which the dielectric constant is assumed to be negligibly small) is only valid for a constant conductivity, independent of the distance. For the present case of an 'effective' conductivity dependent on distance the writer, as an approximation, replaces the simple expression for the numerical distance ρ (eqn. 4) by the integral

$$\rho = \int \{(2\pi \cdot 1/\lambda)/2 \cdot 2\sigma(r)/f\} \cdot dr \quad \ldots \text{eqn. } 5.$$

"The correctness of this not obvious construction, and of the use therein of the 'effective' resistance, is established by the good agreement with measured results."

In Fig. 3 the little circles represent the experimental values of the field-strength-drop curve of Fig. 1, converted by division by the field-strength value at zero distance extrapolated on that curve. The curve ρ in Fig. 3 shows the variation of the numerical distance ρ with the actual distance r, as calculated from eqn. 5, above. The curve $S(\rho)$ represents the resulting dependence of the attenuation factor, over inhomogeneous ground, on the actual distance. It is seen that the attenuation values obtained by the field-strength measurements agree extremely well with the attenuation curve calculated from the 'effective' conductivity values. The three remaining curves (straight lines) in Fig. 3 are the field-strength-drop curves for homogeneous ground of three different conductivity values.

The writer concludes: "The above measurements, and other experiences, show that the expression for the numerical distance (eqn. 5) and the use of the 'effective' conductivity for determining the curve of field-strength drop are both justified. The values of 'effective' conductivity obtained by the dipole method thus provide the basis necessary for the calculation of the propagation-attenuation."

740. The Effect of a Conducting Semiplane on the Field of a Point Charge.—Grünberg & Tsukkerman. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 12, 1942, pp. 36–44.)

In a previous paper by Grünberg (*Journ. Exp. & Theoret. Phys.*, No. 9/10, Vol. 10, 1940, p. 1087 onwards: and *cf.* 378 & 2957 of 1942) the following case was considered:—A "wedge" consisting of two conducting planes at an angle δ is introduced into a field in which a point charge is present (Fig. 1). A method was indicated for determining the potential due to the wedge under these conditions. From this the final potential can be calculated. This is done in the present paper for the case when $\delta = 2\pi$. The solution obtained is identical with that derived by Sommerfeld in 1899. At the same time it is pointed out that the formula given on p. 283 of Jeans's book—" The Mathematical Theory of Electricity and Magnetism" (Cambridge 1915)—is incorrect. For Grünberg's paper on coastal refraction *see* 1830 of 1943.

741. CORRECTION TO " A NOTE ON FIELD STRENGTH OF DELHI 3 AND DELHI 4 AT CALCUTTA DURING THE SOLAR ECLIPSE OF SEPTEMBER 21ST, 1941 " [2636 of 1943].—S. P. Chakravarti. (*Proc. I.R.E.*, Nov. 1943, Vol. 31, No. 11, p. 643.)

742. ECLIPSE OF THE SUN, 21ST SEPT. 1941, IN THE U.S.S.R. [Short Survey of Four Papers written before the Eclipse].—A. Michailov & others. (*Nature*, 4th Dec. 1943, Vol. 152, No. 3866, p. 658.) For the note on results, mentioned here at the end, *see* 1368 of 1943.

743. FLUCTUATIONS OF SOLAR RADIATION, FROM THE VIEWPOINT OF TERRESTRIAL MAGNETISM.—J. Bartels. (*Hochf:tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, pp. 25–26.)

Summary of a 59-page Prussian Academy paper under the same title as the short survey, a very brief summary of which was dealt with in 1627 of 1943. For an earlier paper, in English, *see* 12 of 1941. " In that part of the solar radiation which is absorbed in the ionosphere, and which therefore cannot be observed directly at the ground, the variations in time of the earth's magnetic field enable one to distinguish two types, which will be referred to as *W* and *P*. *W* ionises the daytime side of the ionosphere, and is presumably a wave radiation ; *P* consists of corpuscles (particles) which are, at any rate in part, electrically charged and, being deflected by the earth's magnetic field, penetrate particularly into the auroral zones and reach the night side of the ionosphere." *W* displays itself most clearly in the quiet-day magnetic variations S_q and L_q ; *P* produces the magnetic disturbances *D*. The aim of the present exhaustive work is to derive, from geomagnetic records, two homogeneous series stretching over many years (actually back to 1872) for *W* and *P* and to compare these with direct solar observations (namely the Zurich relative sunspot numbers *R*) in order to derive a relation between the variations δW of *W*, and also between the variations δP of *P*, and the variations δR of *R*. " As Fig. 1 shows, the relations are linear, provided that the quantities δW, δP, and δR are expressed in a suitable way (' normalised '). Thus from the magnetically determined values of δW one can draw conclusions as to the variations of the wave radiation, and from the magnetically measured disturbances δP conclusions as to the variations of the corpuscular radiation."

Regarding the relation between δW and δR, the writer remarks that it is the closest of any hitherto found between any phenomenon on the sun, expressed in monthly or yearly means, and a similarly expressed phenomenon on the earth. He considers that δW is a more faithful measure for the variations of the wave radiation than δR itself, especially at sunspot minima. For the corpuscular radiation *P*, he points out, the Potsdam " reduced " three-hourly characteristic numbers constitute a specially useful measure. They were introduced by the writer into the practice of geomagnetic research and were adopted for all observations by the " International Society for Geomagnetism and Atmospheric Electricity " at their 1939 Assembly.

744. RADIO FADE-OUT ON FEBRUARY 10TH, 1943 [Hermanus Magnetic Observatory Records, in reply to Request from O.E.H. Rydbeck].—A. Ogg : Rydbeck. (*Nature*, 4th Dec. 1943, Vol. 152, No. 3866, p. 664.)

There was an interval of 17 hours before the beginning of the magnetic storm, indicating a speed of about 1500 miles per second for the transmission of impulses from the sun. For the characteristic magnetic behaviour at the time of a radio fade-out *see* also 2065 of 1943, and for Rydbeck's original letter reporting an oblique-incidence double pulse apparently reflected from the region of abnormal ionisation below the regularly reflecting layer, see *Nature*, 19th June 1943, Vol. 151, No. 3842, p. 700. The magnetograms showed no conspicuous change at the time of the fade-out, but the Prague Observatory reported strong, brilliant sunspot eruptions on that day.

745. SOLAR PROMINENCES [Classification according to Association with Sunspots, Origin, Motion, & Structure].—E. Pettit. (*Nature*, 1st Jan. 1944, Vol. 153, No. 3870, p. 29 : short summary, from *Astrophys. Journ.*)

746. MEASUREMENTS ON THE LATERAL AND VERTICAL MOVEMENTS OF CHROMOSPHERIC ERUPTIONS.—M. A. Ellison. (*Nature*, 11th Dec. 1943, Vol. 152, No. 3867, p. 697 : summary, from *Mon. Not. Roy. Astron. Soc.*, Vol. 103, 1943.)

747. THE SOLAR CORONA AND GEOMAGNETISM [Light thrown on the Problem of those Recurrent Magnetic Storms which seem to be as Unconnected with Chromospheric Activity as with Photospheric : the " C-Regions " of the Corona, and Their Bursts of Activity].—M. Waldmeier. (*Nature*, 10th July 1943, Vol. 152, No. 3845, p. 44.) *See* also 2639 & 3259 of 1943.

748. TEMPERATURE OF THE SOLAR CORONA.—V. Vand. (*Nature*, 26th June 1943, Vol. 151, No. 3843, p. 728.)

" It is quite possible that a temperature of the order of 2 300 000° K, mentioned in Dr. A. Hunter's article on this subject, may be maintained in the solar corona by collisions of atoms, accelerated from distant regions by the gravitational field of the sun. . . . Radiation losses increase with the [coronal] density and might be considerable in the inner corona, and equipartition of the energy might not be reached, so that the ionisation maintained in the inner corona might be of the correct order, as required by Edlén's proposals ; but there is a possibility that in a more distant region there will be a layer of higher kinetic temperature, and that the temperature decreases to that of the surface of the sun, as the sun is approached.

" The question arises whether the sun is trapping enough matter to produce the observed density in the corona. According to my investigations, there might be an appreciable evaporation of finely divided interplanetary matter in the vicinity of the sun. Under gravitational force only . . . very little matter would be trapped . . . As the magnetic field of the sun is fairly strong in its vicinity, it seems possible that the amount of matter so trapped would be sufficient to produce the observed density of the corona.

" The variations in the shape and intensity of the corona and its line spectrum, which closely follow the sunspot cycle, may be explained tentatively by the variation of the sun's magnetic field over sunspot regions, and so by the amount of matter trapped. There might be a marked escape of high-speed electrons from the corona, and considerable electric fields may develop. These, together with the forces due to the diamagnetism of the ions, may complicate considerably the theory of the corona. More detailed results will be published elsewhere."

749. The Coronal Line Spectrum.—P. Swings: B. Edlén. (*Nature*, 25th Dec. 1943, Vol. 152, No. 3869, p. 754.) Summary of a note by Swings on a paper by Edlén: *cf.* 2949 of 1943.

750. The Light of the Night Sky [including Comparison of the Short-Wave Region of Its Spectrum with That of Polar Aurora: Variations of Intensity with Season & with Magnetic Conditions: etc.].—C. T. Elvey. (*Sci. Abstracts*, Sec. A, May 1943, Vol. 46, No. 545, p. 104.) From *Reviews of Mod. Phys.*, April/July 1942. *See* also 2955 of 1943, and *Astrophys. Journ.*, Jan. 1943, pp. 65–71.

751. Hitherto Unidentified Absorption Bands of Water Vapour [in particular, a Band centred about 1.455μ].—T. G. Cowling. (*Nature*, 11th Dec. 1943, Vol. 152, No. 3867, p. 694.)

752. New Bands in the First Negative (or Visible) O_2^+ Band-System [excited by 750–850 kc/s Discharge].—N. L. Singh & L. Lal. (*Sci. & Culture* [Calcutta], Aug. 1943, Vol. 9, No. 2, p. 89.)

753. Origin of Cosmic Rays [Summary of the Five-Band, Atom-Annihilation Hypothesis (2609 of 1942 and 1836 & 2303 of 1943)].—R. A. Millikan, H. V. Neher, & W. H. Pickering. (*Nature*, 12th June 1943, Vol. 151, No. 3841, pp. 663–664.)

754. The Production of Penetrating Showers [and the Part played by Non-Ionising ("N") Radiation, More Penetrating than Photons, and suggested to consist of Neutrons].—L. Jánossy & G. D. Rochester. (*Proc. Roy. Soc.*, Series A, 16th Dec. 1943, Vol. 182, No. 989, pp. 180–188.)

755. Seeing through Fog [with Formulae for Visibility-Range of a Light in a Night Fog & in a Day Fog, and of an Illuminated Object in a Night Fog].—J. G. Holmes. (*Sci. Abstracts*, Sec. A, May 1943, Vol. 46, No. 545, p. 104.)

756. The Scattering of Light in a Turbid Medium [where Scattering & Absorption occur Simultaneously].—V. A. Ambartsumian. (*Journ. of Phys.* [of USSR], No. 1, Vol. 5, 1941, p. 93: summary only, in English.)

757. Relaxation in Liquids and Scattering of Light [and the Connection between Double Refraction due to Flow of Liquid, Relaxation Time, & Depolarisation of the Scattered Light].—M. Leontovich. (*Journ. of Phys.* [of USSR], No. 6, Vol. 4, 1941, pp. 499–514: in English.)

758. On the Penetration of Totally Reflected Light into the Less Dense Medium [Experiments with Two Touching Prisms].—Goos & Hänchen. (*See* 1097.)

759. A Mathematical Proof of Stokes's Reversibility Principle [First Direct Proof, on Assumption of Validity of Fresnel's Equations].—A. I. Mahan. (*Journ. Opt. Soc. Am.*, Nov. 1943, Vol. 33, No. 11, pp. 621–626.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

760. Thunderstorms and Their Electrical Effects: Second Charles Chree Address.—B. F. J. Schonland. (*Proc. Phys. Soc.*, 1st Nov. 1943, Vol. 55, Part 6, No. 312, pp. 445–458.)

761. Atmospherics and Meteorological Conditions at Madras.—T. K. Lakshmanan. (*Sci. & Culture* [Calcutta], Sept. 1943, Vol. 9, No. 3, pp. 128–129.)

The writer concludes: "It would appear from the above that thunderstorms provide a great majority, if not all, of atmospheric disturbances, and that local and nearby thunderstorms play the greatest part in their production. The high rate of production of atmospherics seems to suggest that lightning phenomena alone may not be sufficient to cause so many atmospheric disturbances. All tropical thunderstorms are heat thunderstorms and they occur with the greatest frequency in summer and during the afternoon on moist land areas. Thunderstorms, therefore, follow temperature variation roughly, and hence the correlation between the occurrence of atmospherics and local temperature [Figs. 1, 2] becomes clear."

PROPERTIES OF CIRCUITS

762. Microwave Plumbing [with Particular Reference to Transmission Lines, Wave-Guides, Aerial Systems, & Oscillators: Equipment for Laboratory Instruction at Cruft Laboratory, Harvard University].—D. D. King. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 116–119 and 276: Oct. 1943, No. 10, pp. 118–121 and 180.)

763. Principles of Micro-Wave Radio [Cavity Resonators: Transmission Lines].—Condon. (*See* 731.)

764. "Q" for Unloaded Concentric Transmission Lines [Nomogram for Q and Z_0 for Copper Concentric Cables of Optimum Conductor Ratio ($b/a = 3.6$), with Curves giving Multiplying Factor for Other Ratios: for Lines used as Transformers, Filters, or Transmission Networks, and either an Odd Number of Wavelengths long, Short-Circuited at Receiving End, or an Even Number, Open at Receiving End].—R. C. Miedke. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 139–140.)

765. Transmission-Line Theory and Its Application [using the "Completely Hyperbolic" Solution].—King. (*See* 732.)

766. A Dissipative Resistance for Very High Frequencies.—W. Burkhardtsmaier. (*Hochf:tech. u. Elek:akus.*, May 1943, Vol. 61, No. 5, p. 159, Fig. 15.)

A Telefunken patent, D.R.P.728 126. A coaxial-line section, closed at one end, with a length at most 1/10th of the shortest working wave, and with a characteristic impedance (assuming complete absence of loss) of about $1/\sqrt{5}$ times the d.c. resistance, has in series with it an inductance of about 2/3rds of the total static inductance of the double conductor.

767. Brownian Motion and Resistance Noise.—H. F. Mataré. (*Ann. der Phys.*, 17th Sept. 1943, Vol. 43, No. 4, pp. 271–278.)

"It is shown that the so-called 'Nyquist formula' for resistance noise is already derivable from a calculation of the spontaneous electron-motion (Brownian motion) in a conducting network [*L*, *C*, *R*], as carried out by de Haas-Lorentz [in 1913: ref. "3"], and also from Einstein's generalised fluctuation formula" [in 1922: ref. "2"]. *Cf.* Surdin, and Campbell & Francis, 2090 and 2091 of 1943.

768. VOLTAGE FLUCTUATIONS IN SEMICONDUCTORS.—B. I. Davydov & B.Kh. Gurevich. (*Journ. o Tech. Phys.* [in Russian], No. 1, Vol. 12, 1942 pp. 31–35.)

It is pointed out that the mechanism of voltage fluctuations in semiconductors is similar to the shot effect in valves, the difference being that electrons are liberated by thermal movement not only on a cathode, but along the whole length of the semiconductor, and that these electrons travel only short distances. A mathematical discussion of the phenomenon is presented. It is shown that when no current passes through the semiconductor the mean square of the fluctuations can be determined from the well-known formula (1) for the Johnson effect. When a small current passes through the semiconductor this value rises in proportion to the square of the current for small currents and in proportion to the current for larger currents. These conclusions are broadly in accordance with experimental results. It was assumed in the discussion that Ohm's law remains valid for the phenomena under consideration.

769. FLUCTUATIONS IN AN AUTO-OSCILLATING SYSTEM AND THE DETERMINATION OF THE NATURAL LIMIT OF THE FREQUENCY-STABILITY OF A VALVE GENERATOR.—I. Berstein. (*Journ. of Phys.* [of USSR], No. 1/2, Vol. 4, 1941, pp. 113–122: in German.)

The Russian original was dealt with in 1649 of 1942. In his treatment of the possibility of an experimental testing of the results, the writer gives his general equation for the result of the detecting process on a continuous frequency-spectrum (eqn. 67, simplified to eqn. 69, or for a limited region to eqn. 70: *cf.* 1658 of 1942): he also calculates the order of amplification necessary for the experimental demonstration, and arrives at the reasonable value of 2000. "It should be noted that with so high an amplification a voltage of other origin may appear at the amplifier output. Such an origin might well be the heterodyning of fluctuations in the grid circuit of the detector valve by the voltage under investigation." Care would therefore have to be taken to separate the two sets of noise.

770. ENERGETIC TREATMENT OF AUTO-OSCILLATING SYSTEMS OF THE THOMSON TYPE.—K. F. Teodortschik. (*Journ. of Phys.* [of USSR], No. 1/2, Vol. 4, 1941, pp. 39–44: in German.)

One of the papers specially written for the 60th birthday of N. D. Papalexi. For previous abstracts on the same general subject *see* 1365 & 2538 of 1940 and 32 of 1942. The present treatment includes as one example the application of the "energy cycle" technique to the calculation of the parametric excitation of a non-linear system: *see* for example Papalexi, 430 of February, and *cf.* Barrow, 1934 Abstracts, pp. 204–205.

771. ENERGY RELATIONS IN OSCILLATORY SYSTEMS, AND PARAMETERS OF RADIATING SYSTEMS.—Kessenich. (*See* 816.)

772. FREQUENCY-TRIPLING CIRCUIT USING A DISTORTING, NON-LINEAR FOUR-TERMINAL NETWORK.—W. Benz. (*Hochf:tech. u. Elek:akus.*, June 1943, Vol. 61, No. 6, p. 191.) An A.E.G. patent, D.R.P. 729 192. A bridge network is used, so balanced that over a definite working region the relation between the input and output voltages is approximately represented by $u_2 = \frac{3}{4}ku_1 - ku_1^2$, k being a constant.

773. FREQUENCY-DOUBLING BY A MAGNETOSTRICTIVE ROD [with Free End forming Plate of Condenser: Doubled Frequency taken from Coil surrounding Rod].—J. Rode. (*Hochf:tech. u. Elek:akus.*, May 1943, Vol. 61, No. 5, p. 157, Fig. 5.) D.R.P. 727 879.

774. POWER-TUBE PERFORMANCE IN CLASS C AMPLIFIERS AND FREQUENCY MULTIPLIERS, AS INFLUENCED BY HARMONIC VOLTAGE.—Sarbacher. (*See* 826.)

775. ON MEASURING INDUCTANCE COILS WITH ELECTROSTATIC SHIELDS.—Zelyakh. (*See* 865.)

776. CORRECTION TO EQUATION 38 IN "NETWORK THEORY, FILTERS, AND EQUALISERS: PART II" [2086 of 1943].—F. E. Terman. (*Proc. I.R.E.*, Oct. 1943, Vol. 31, No. 10, p. 582.)

777. BAND-PASS WAVE-FILTER UNITS: ANALYSIS ON THE BASIS OF BISECTABLE SYMMETRICAL CIRCUIT ARRANGEMENTS.—E. S. Purington. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 126–129.) For previous work *see* 1044, 1645, & 3311 of 1943.

778. "INTRODUCTION TO CIRCUIT ANALYSIS" [Book Review].—A. R. Knight & G. H. Fett. (*Proc. I.R.E.*, Oct. 1943, Vol. 31, No. 10, p. 587.)

779. METHOD FOR THE SOLUTION OF TRANSIENT CIRCUITS WHOSE STEADY STATE CAN BE WRITTEN BY MILLMAN'S NETWORK THEOREM [338 of 1941: for Networks & Amplifiers, including Negative Feedback].—N. E. Polster: Millman. (*Proc. I.R.E.*, Nov. 1943, Vol. 31, No. 11, p. 647.)

780. SOME NEW APPLICATIONS OF CHAIN CIRCUITS.—L. I. Gutenmacher. (*Journ. of Tech. Phys.* [in Russian], No. 2/3, Vol. 12, 1942, pp. 85–94.)

In measuring and automatic-control circuits it is often necessary to control the speed of the variation of the current. In this paper a method of retardation is proposed based on the use of a chain circuit consisting of a number of series-connected T or pi-type elements (Fig. 2). The operation of the circuit is discussed with a number of oscillograms and curves, and design methods are indicated. A circuit (Fig. 11) is also described for retarding the current vector with respect to the voltage vector.

781. THE USE OF THE RETARDATION EFFECT IN A CHAIN CIRCUIT FOR IMPROVING DIRECTIONAL PROTECTION [and a New Design of Relay].—L. I. Gutenmacher & A. D. Drozdov. (*Journ. of Tech. Phys.* [in Russian], No. 2/3, Vol. 12, 1942, pp. 95–101.)

Directional relays are often used in protective circuits, but their operation is not always reliable. Accordingly a new type of relay was developed in which use is made of a chain circuit. The relay is described and its operation discussed. Various applications are considered and results of tests are given. It is claimed that this relay possesses a large torque, is quick-acting, and has no dead position.

782. A Bridge-Controlled Relay Circuit [primarily for Automatic Control of Humidity (using the Dunmore Lithium-Chloride Hygrometer) but useful in Many Other Applications: Circuit using Type 6V6 Amplifier controlling Type 884 Grid-Controlled Gaseous-Discharge Tube]. — H. L. Andrews. (*Review Scient. Instr.*, Sept. 1943, Vol. 14, No. 9, p. 276.)

TRANSMISSION

783. The Theory of the Klystron [Application of Theory of Parametric Excitation: Klystron as a System with Periodically Varying Capacitance: Formula for Calculation of Steady Amplitude: Suggested Replacement of Large Opening in Resonators (for Passage of Beam) by a Light Grid].—V. Guljaev [Gulyaev]. (*Journ. of Phys.* [of USSR], No. 1/2, Vol. 4, 1941, pp. 143–146: in English.) The Russian original was dealt with in 674 of 1942.

784. On the Theory of the "Density-Modulated" Electron Beam with Finite Current Density [Examination of the Influence of Space-Charge Forces in a Velocity-Modulated (and therefore Density-Modulated) Beam].—F. Borgnis & E. Ledinegg. (*Ann. der Phys.*, 17th Sept. 1943, Vol. 43, No. 4, pp. 296–312.)

Further development of the work dealt with in 1638 [and 2387] of 1941 and 2109 of 1943, where the electric and magnetic forces in the beam were neglected. "It may well be expected, however, that the 'merit' of the [phase-] focusing will be specially affected by the space-charge effect, that is the repulsive forces of the electrons in the beam at high current densities. The following investigations give an insight into the effectiveness of the forces arising from the space charge. A sinusoidally modulated lens is assumed." The radially expanding action of the repulsion is not considered, since the plane problem only is dealt with—*i.e.* the beam is assumed to be infinitely extended in planes at right angles to its direction of motion: this action in any case can be eliminated by electric or magnetic lenses. The effect considered is the axial decompression due to electric forces, an effect which cannot be avoided by any means. The effect of the magnetic forces (which oppose the electrostatic) is neglected.

From the authors' summary:—"At the points of 'overtaking,' the current density becomes infinite; the electrons concerned are 'focused' there. The repulsive electric forces in the beam oppose such a focusing; nevertheless for small current densities a focusing effect does occur. There is however a 'critical current-density' j_k: if this is exceeded, the space-charge forces completely prevent a mutual 'overtaking' of the electrons. At densities above the critical value no focusing occurs in the usual sense.

"For the infinitely extended plane electron flow, and for the case of very small field strengths at the modulating lens, the critical current density j_k for a sinusoidal modulating voltage is found

[eqn. 14c: $j_k = 13.27 \cdot \alpha^2/(1-\alpha)^{3/2} \cdot U_0^{\frac{1}{2}}/\lambda^2$,

where α is the degree of modulation (eqn. 8): thus for an accelerating potential $U_0 = 1600$ v, $\lambda = 20$ cm, and $\alpha = 0.1$, the critical density works out at 15.6 mA], and also a formula for estimating the current density at which the space-charge forces may be neglected [eqn. 18: $j_0 \ll 13.27 \cdot \alpha^2 U_0^{\frac{1}{2}}/\lambda^2$]. For current densities below j_k the focusing relations are investigated. For densities above j_k the Fourier analysis, in time, of the current density for small modulations gives a picture of the spatial distribution of the amplitudes of the fundamental and harmonics of the current density beyond the modulating lens: position and magnitude of the maxima of the amplitudes are given."

785. Method of Amplifying or Generating High-Frequency Oscillations with the Help of Gas- or Vapour-Discharge Tubes [Use of a Grid Control Voltage of Distorted Shape (*e.g.* a Saw-Tooth Voltage) having a Steeper Slope than a Sinusoidal Voltage of Equal Amplitude].—W. O. Schumann. (*Hochf:tech. u. Elek:akus.*, June 1943, Vol. 61, No. 6, p. 190.) D.R.P.728 475.

786. Plasma Phenomena on the Application of Sudden Pulses [when the Anode is Very Suddenly made Negative to the Cathode, or a Negative Potential is Suddenly Applied to an Electrode in the Plasma, so that the Electrons are set in Motion while the Positive Ions remain Still].—W. O. Schumann. (*Ann. der Phys.*, 23rd Oct. 1943, Vol. 43, No. 5, pp. 369–382.)

For experimental results *see* Engelbrecht, 2795 of 1943. In the section on periodic oscillations, pp. 378–280, the phenomena occurring when a negative bias is applied to a plasma-electrode and is superposed by a small a.c. voltage are dealt with only briefly, since they have been already considered (for cylindrical systems) in the paper dealt with in 680 of 1942. The present treatment considers plane parallel electrodes. The two "preferred" wavelength regions of the normal plasma are 30–50 cm and 3–5 m. *Cf.* 785, above.

787. Circuit for the Control and Frequency-Multiplication of Decimetric Waves, using a Magnetron [with Positive Grid and Split End-Plates]. —W. Groos. (*Hochf:tech. u. Elek:akus.*, May 1943, Vol. 61, No. 5, p. 157, Fig. 6.) D.R.P.727 935.

788. Stabilisation of Magnetron Oscillators [Choke in A.C. Filament-Heating Circuit, with Core Nearly Saturated by Constant D.C. in One Winding: Anode D.C. in Another Winding completely or partially Removes the Saturation and Increases the Choking Action].—O. Walter. (*Hochf:tech. u. Elek:akus.*, June 1943, Vol. 61, No. 6, p. 190.) D.R.P.728 730. In this way the anode current can rise without the cathode emission increasing.

789. Stability in High-Frequency Oscillators [around 100 Mc/s: Theoretical & Experimental Investigation of Frequency-Stability with Change in Anode Voltage: Optimum Conditions usually obtained by Fortuitous Circuit Adjustment, and by Use of Concentric-Line or other Low-Inductance Form in Attempt to get a High Q (Useless in Itself), thus leading accidentally to the Low L/C Ratio which is really Needed: Improvement in Q alone may give Poorer Stability: Best Results are with High Q combined with Low L/C and Slight Circuit Adjustments, and Loose Coupling].—R. A. Heising. (*Proc. I.R.E.*, Nov. 1943, Vol. 31, No. 11, pp. 595–600.)

790. Fluctuations in an Auto-Oscillating System and the Determination of the Natural Limit of the Frequency-Stability of a Valve Generator.—Berstein. (*See* 769.)

791. Thermal Frequency-Drift Compensation.—Bushby. (*See* 804.)

792. Voltage-Stabilised Bias Supply for Power Tubes [with Improved Performance].—G. E. Pihl. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 160..165.)

RECEPTION

793. Preventing Re-Radiation from Superheterodyne Receivers [especially for Waves below 1 m].—W. Dällenbach & others. (*See* " Enemy-owned patents," 1010, below.)

794. Superheterodyne Receiver for Ultra-Short Waves [with Magnetron as Mixing Valve].—K. Fritz & R. Kretzmann. (*Hochf:tech. u. Elek:akus.*, June 1943, Vol. 61, No. 6, p. 192.) A Telefunken patent, D.R.P.728 774: Fig. 12.

795. Mixing Circuit for Ultra-Short-Wave Superheterodyne Receivers [using a Double-Diode Valve, Lecher-Wire System, and Push-Pull Connection].—K. Lämmchen. (*Hochf:tech. u. Elek:akus.*, May 1943, Vol. 61, No. 5, p. 158, Fig. 14.) A Blaupunkt patent, D.R.P.727 992.

796. Arrangement for Converting a Frequency-Modulated Oscillation into an Amplitude-Modulated One [using a Frequency-Dependent Resistance, particularly a Conductor of High Permeability (Fe–Ni Alloy) in which Skin Effect produces the Frequency-Dependence].—W. Bürck & G. Vogt. (*Hochf:tech. u. Elek:akus.*, June 1943, Vol. 61, No. 6, p. 192.) A Telefunken patent, D.R.P.729 111.

797. Some Aspects of Radio Reception at Ultra-High Frequency: Part IV.—General Superheterodyne Considerations at Ultra-High Frequencies [including Mixing-Stage Noise and Gain, Feedback in Triode Mixers, Image Frequencies and the Choice of the Intermediate Frequency, R.F. Amplification *versus* Conversion in First Stage, Application of Secondary Emission]: Part V—Frequency Mixing in Diodes [including Derivation of Equivalent Symmetrical Pi Circuit and Its Use to find Conversion Loss (with & without Input-Circuit Loss), the Impossibility of attaining Condition of No Conversion Loss, the Over-All Signal/Noise Ratio (Reasons for Impossibility of Accurate Prediction: Method of Approximate Estimation), etc.].—L. Malter: E. W. Herold. (*Proc. I.R.E.*, Oct. 1943, Vol. 31, No. 10, pp. 567–575: pp. 575–582.) In the series dealt with in 3357 of 1943.

798. The Sensitivity of Ultra-High-Frequency Receivers, *and* The Sensitivity of Ultra-High-Frequency Receivers: a Supplement to Wilke's Paper.—R. Wilke: E. Huber. (*Bull. Assoc. Suisse des Élec.*, 14th July 1943, Vol. 34, No. 14, pp. 402–405: 6th Oct. 1943, No. 20, pp. 615–616: both in German.)

(i) Long summary (with diagrams) of the paper dealt with in 3241 of 1942. (ii) Huber discusses Wilke's expression for the receiver sensitivity: " the calculated noise-ratio s_ν does, it is true, give the correct dependences of the sensitivity of receivers, *but it should never be considered as an absolute measure of that sensitivity.* It is *one* criterion for the sensitivity, but a measure of sensitivity is only provided by the *audible* and measurable noise ratio at the *output* of a receiver. The relation between the calculable noise ratio at the receiver input and the audible and measurable noise ratio at the output is governed by the design of the receiver, above all by its non-linear components (detector) and filters."

The quantity q, the measurable noise ratio at the receiver output, must be defined as the ratio of the effective values of signal-voltage plus noise-voltage to noise-voltage, since the a.f. signal cannot be measured apart from the noise. In other words, q is the total output voltage in the presence of a modulated signal divided by the total output voltage in the presence of an unmodulated signal: it is the absolute measure for the sensitivity of the receiver. The relation between s_ν and q has been exhaustively investigated, above all in two places, Fränz's paper (3026 of 1941) and a publication by the present writer " The relations between signal voltage and noise voltage in the frequency conversions of wireless multi-channel telephony " (Zurich, 1943). In the present note, therefore, only a simple example of the calculation is given, a square-law conversion being assumed in both frequency-changing stages, the mixing stage and the final rectifying stage. The expression arrived at for the relation between s_ν and q is $q^2 = \{2s_\nu^4M^2(1 + M^2/16) + 2ks_\nu^2(1 + M^2/2) + k^2\}/(2ks_\nu^2 + k^2)$; for a large s_ν this reduces as a first approximation to $q^{2\prime} = s_\nu^2M^2/k$ (actually, the equations as given here are not as printed in the article, but are taken from a correcting note in the issue for 20th October, No. 21, p. 652). Thus it is seen that the sensitivity, when s_ν is large, can be improved by the factor $\sqrt{1/k}$ by a reduction of the band-width in the i.f. circuit, and that on the other hand it is proportional to the degree of modulation, M. The factor $\sqrt{1/k}$ may exceed the value 10 in an u.s.w. receiver, and thus plays an important part in the sensitivity.

For a small s_ν the relations are rather more complicated, but can easily be derived from the full equation given above. An equation for q can be found by the same method for c.w. and tone-frequency telegraphy.

799. Concerning Phase Selectivity [Theoretically Infinite Phase Selectivity (towards Suitable Non-Sinusoidal Waves) given by a Receiving Circuit with a Periodic Parameter].—G. Gorelik. (*Journ. of Phys.* [of USSR], No. 1/2, Vol. 4, 1941, pp. 57–58: in French.) The Russian original was dealt with in 627 of 1942.

800. Automatic Tuning of Direct Amplification Stages [for Signals whose Frequency varies over a Wide Range, as in the Mandelstam–Papalexi Distance-Measuring Process].—V. I. Yuzvinski. (*Journ. of Phys.* [of USSR], No. 1/2, Vol. 4, 1941, pp. 147–150: in English.) The Russian original was dealt with in 1703 of 1942.

801. Arrangement for Improving the Rectification in the Audion [Leaky-Grid Detector].—E. Prokott & H. Bohnenstengel. (*Hochf:tech. u. Elek:akus.*, June 1943, Vol. 61, No. 6, p. 191.)

The h.f. voltage to be rectified is applied to the oscillatory circuit " 5 " (Fig. 8) connected to the anode or to a positively-biased auxiliary electrode: from this circuit part of the voltage is back-coupled in reverse phase to the un-tuned grid circuit.

802. A Multiplicative Demodulator [using a Valve with Two Control Grids separated by a Screen Grid, One being modulated Linearly, the Other Over-Modulated].—O. Tüxen. (*Hochf:tech. u. Elek:akus.*, May 1943, Vol. 61, No. 5, p. 159.) A Telefunken patent, D.R.P.728 327.

803. On the Theory of Diode Detection.—V. A. Lasarev [Lazarev]. (*Journ. of Phys.* [of USSR], No. 6, Vol. 4, 1941, pp. 523–527: in English.)

The Russian original was dealt with in 693 of 1942. Conclusions are reached as to the approximate choice of the parameters R and C: thus "in order to guarantee good reception" the value of the ratio $2\pi \cdot RC/T(1 + Rs_1)$ should not exceed 20–25%: here T is the smallest period of all possible l.f. oscillations.

804. THERMAL FREQUENCY-DRIFT COMPENSATION [particularly in Superheterodyne Receivers].—T. R. W. Bushby. (*A.W.A. Tech. Review*, Aug. 1943, Vol. 6, No. 3, pp. 143–160.) "This paper was originally published in *Proc. I.R.E.* (1030 [and 2100] of 1943: for Discussion *see* 3295 of 1943). The notation and some of the text have since been revised."

805. AUTOMATIC BAND-WIDTH CONTROL OF BAND-PASS FILTERS IN RECEIVERS.—H. Pitsch. (*Hochf:tech. u. Elek:akus.*, May 1943, Vol. 61, No. 5, p. 159, Fig. 16.)

A Telefunken patent, D.R.P.728 328. The feedback or negative-feedback current used for the control is taken from the anode circuit of the control valve "2" at the output end of the band-pass filter (consisting of an odd number of directly coupled circuits) and is fed back, without phase displacement, to the filter input.

806. AUTOMATIC BAND-WIDTH CONTROL BY FIELD STRENGTH [I.F. Band-Pass Filter detuned by Positive-Temperature-Coefficient Condenser in One Circuit and Negative in the Other, with Heating Coils traversed by Anode D.C. of A.V.C. Valves]. —R. Hildebrandt. (*Hochf:tech. u. Elek:akus.*, June 1943, Vol. 61, No. 6, p. 192.) A Telefunken patent, D.R.P.728 881.

807. LESS RADIO NOISE [in All-Metal Aircraft: by Approach to Problem from Engineering Standpoint: Large Proportion of Conduits may be Eliminated: etc.].—F. Foulon. (*Sci. News Letter*, 11th Sept. 1943, Vol. 44, No. 11, p. 167.) Douglas Aircraft Company's new concepts.

808. REMOTE CONTROL OF CRYSTAL-LOCKED RECEIVERS [Fixed-Channel Communication Receivers tunable over Narrow Band: Discussion of Various Methods of Remote Control: System using Three Control Tones (Middle One as Pilot-Tone to compensate Line-Attenuation Changes) over Single-Pair Non-Loaded Telephone Line with Earth Return: giving Fine Tuning over $\pm$ 5 kc/s, Smooth Control of R.F. Gain, and On/Off Control for C.W. Reception: Over-All Band-Width about 2.2 kc/s]. —J. E. Benson & A. G. Brown. (*A.W.A. Tech. Review*, Aug. 1943, Vol. 6, No. 3, pp. 161–175.)

809. "PRINCIPLES AND PRACTICE OF RADIO SERVICING" [Book Review].—H. J. Hicks. (*Proc. I.R.E.*, Oct. 1943, Vol. 31, No. 10, p. 587.)

810. "RADIO TROUBLESHOOTER'S HANDBOOK: THIRD EDITION" [Book Review].—A. A. Ghirardi. (*Proc. I.R.E.*, Nov. 1943, Vol. 31, No. 11, pp. 648–649.)

The reviewer concludes: "It might be a good thing if this handbook became required reading for those design engineers and others involved in the production of sets that have the worst case histories, for pointing out how *not* to do things, in order to improve a receiver's reliability in the future."

AERIALS AND AERIAL SYSTEMS

811. ELECTROMAGNETIC WAVES IN A HOLLOW GUIDE WITH TAPERING CROSS-SECTION.—Malow. (*See* 728.)

812. MICROWAVE PLUMBING [with Particular Reference to Wave Guides, Aerial Systems, etc.].—King. (*See* 762.)

813. COUPLED ANTENNAS AND TRANSMISSION LINES [Non-Mathematical Discussion, confirmed by Experiments on a 1 m Wavelength].—R. King. (*Proc. I.R.E.*, Nov. 1943, Vol. 31, No. 11, pp. 626–640.)

Coupled aerials (and the reasons why the input impedance of a driven aerial in the presence of a coupled aerial is different from its self-impedance when isolated: equations for input impedance for one driven and one parasitic element: etc.): mutual impedance (usual assumption so far from being correct that results based on it may often not be even rough approximations): coefficient of coupling: transmission lines (and the coexistence of "transmission-line currents" and "antenna currents": behaviour of a coaxial line used as a shielded loop aerial): coupling of aerials and transmission lines: the collinear array as a coupled circuit (and the use of phase-reversing and detuning "stubs"): the coaxial collinear array (and the use of phase-reversing sleeves): the end-coupled half-wave aerial: asymmetrical aerials and arrays (and the asymmetry produced by the use of a coaxial line instead of a parallel-wire feeder): transmission-line feeders (and the advantages and disadvantages of the non-resonant line): antenna currents on lines (and the use of detuning stubs and sleeves). For a paper by D. D. King on the special demonstration and laboratory equipment (Cruft Laboratory) *see* 812, above.

814. THE "TUBE WIRE" [Concentric Cable with Solid Dielectric] AS A HIGH-FREQUENCY LINE [with Particular Reference to Oppanol-Insulated Cables for Frequencies up to 1000 Mc/s, and a Comparison with the Use of Cogaffin (Synthetic Hard Paraffin)]. —L. Rohde. (*Hochf:tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, pp. 1–6.)

The three synthetic materials with specially good dielectric properties at very high frequencies are the polystyrols ("trolitul" or "styroflex"), the polyisobutylene "oppanol," and paraffin wax. These dielectrics all have small dielectric constants and low dielectric losses. Their dielectric properties vary so much with the degree of purity and (particularly in the case of oppanol) with the method of preparation that samples obtained from different makers were found to differ very much. In Fig. 3, showing the variation of the loss-factor with frequency (from 100 c/s to 1000 Mc/s) for all three types of materials, the upper and lower limits of variation are given in addition to the average values. The three curves for oppanol, in particular, show a range of variation so wide that it would be impossible to arrive at consistent values for frequency-dependence, and so on, from the results of different writers.

Compared with about unity for the paraffin, the loss-factor for the polystyrol materials averages about 2, for oppanol about 5. But oppanol has rubber-like properties and is thus specially suitable for the present purpose, to give a cable capable of being bent into shape but thereafter kept fixed. Synthetic paraffins, suitably blended, can also be made to be soft over a wide range of temperatures, but this development is not yet completed. Mixtures of oppanol with trolitul or paraffin are also possible. The present measurements are confined to the oppanol-insulated wire, except for those on cogaffin in Figs. 4

and 10. The characteristic impedance, Z of such a cable lies between 25 and 100 ohms (taking ϵ as 2.3). For a definite Z the only way to vary the attenuation is to change the diameters, keeping the ratio constant: external diameters between 4 and 20 mm are practicable, so that an attenuation range of 1 : 5 is available. The contribution of the outer conductor to the attenuation is small compared to that of the inner, owing to its diameter being so much larger, so that aluminium or zinc can be substituted for copper here without a great rise in attenuation (Fig. 5 shows a 25% increase for zinc over copper, for an 8 mm-external-diameter cable). On the other hand, at the higher frequencies practically only the inner skin of the outer conductor is in action, so that a thin copper-foil coating inside the zinc tubing (Fig. 7) would bring about a marked improvement (Fig. 6). Among other points discussed in the paper are:—the effect of the nature of the outer conductor on the coupling resistance, and the relation between this latter quantity and the dissipative impedance of the cable (including the behaviour of braided coverings): maximum permissible loading: irregularities of Z, and the sharpest permissible bend for the cable, without causing an irregularity (Figs. 12, 14): the continuous-dielectric cable *versus* the air-space type with trolitul insulators: etc.

815. SIMPLE METHOD FOR INVESTIGATING PERFORMANCE OF 112 Mc/s ANTENNAS [using the Very Minute Signals radiated from a Wire held in Hand and Scraped at Its End with a Piece of Metal].—W. E. Bradley. (*QST*, Nov. 1943, Vol. 27, No. 11, pp. 55 and 80.)

816. ENERGY RELATIONS IN OSCILLATORY SYSTEMS, AND PARAMETERS OF RADIATING SYSTEMS [Networks, Radiating Wires, Spherical & Conical-Horn Acoustic Radiators].—V. Kessenich. (*Journ. of Phys.* [of USSR], No. 1/2, Vol. 4, 1941, pp. 123–142: in English.) The Russian original was dealt with in 705 of 1942.

817. THE DISTRIBUTION OF CURRENT ALONG A SYMMETRICAL CENTRE-DRIVEN ANTENNA.—R. King & C. W. Harrison, Jr. (*Proc. I.R.E.*, Oct. 1943, Vol. 31, No. 10, pp. 548–567.)

This is the paper referred to in 2721 of 1943: for another recent paper (mentioned in the present work) *see* 423 of 1943. "The formulation leads directly to the integral equation obtained [in a somewhat different way] by Hallén (2763 of 1939), rather than to that derived by L. V. King (959 of 1938). The solution of this equation will be described only briefly because it differs in no essential way from that carried out by Hallén. Since Hallén's paper is not readily available it seems desirable to provide at least an outline of the analysis" [Appendix II]. The first-order solution gives eqn. 39 for the current I_z at the cross-section z: in a special notation this reduces to eqn. 43, or in amplitude/phase-angle form to eqn. 44. The curves of Figs. 7 to 18, together with eqns. 43, 44, completely characterise the distribution of current along a typical centre-fed aerial of circular cross-section, with radius a and length h. "The conventionally assumed sinusoidal distribution of current is shown to be a fair approximation for extremely thin aerials and for thicker aerials which do not greatly exceed $\lambda/2$ in length." The final section deals with the calculation of radiation resistance for aerials with non-sinusoidal distribution.

818. MACHINE FOR CALCULATING POLAR DIAGRAMS [of Arrays of Vertical Aerials].—H. P. Williams. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 196..201.) Based on the paper dealt with in 3000 of 1943.

VALVES AND THERMIONICS

819. AMPLIFIER VALVES FOR ULTRA-SHORT WAVES [and the Proportioning of the Various Inter-Electrode Capacitances to avoid Interaction between Output and Input Circuits].—W. Kleen. (*Hochf:tech. u. Elek:akus.*, June 1943, Vol. 61, No. 6, p. 192.) A Telefunken patent, D.R.P.728 755.

820. MAGNETRON FOR RECEPTION [Special Type, with Screening Electrodes situated in the Anode Slits, for Use as Detector].—A. Lerbs & K. Lämmchen. (*Hochf:tech. u. Elek:akus.*, June 1943, Vol. 61, No. 6, pp. 192–193.) A Blaupunkt patent, D.R.P.729 147: Fig. 14.

821. ON THE THEORY OF DIODE DETECTION.—Lasarev. (*See* 803.)

822. EMISSIVE PLATES FOR PENTODES [Performance of Suppressor Grid, when in Shape of Open-Pitched Spiral, improved by coating Plate & Screen-Grid with (*e.g.*) Caesium Oxide: Secondary Electrons More in Number, but Fast-Moving Content is Reduced].—Philips Company. (*Electronics*, Sept. 1943, Vol. 16, No. 9, p. 202: from *Wireless World* patent summary.)

823. THE PREPARATION OF PHOTOCATHODES [and Secondary-Emission Surfaces] OF THE COMPOSITION [Ag]–Cs_2O, Ag–Cs.—Hartmann. (*See* 853.)

824. EXPERIMENTAL CONTRIBUTIONS TO THE SPACE-CHARGE THEORY FOR ELECTRONS WITH HOMOGENEOUS INITIAL VELOCITY.—A. Haug. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 24, 1943, pp. 143–145.)

This theory has been developed for a plane electrode system by Plato, Kleen, & Rothe (3772 of 1936, 2167 & 2575 of 1937, and book, 2721 of 1941). The most notable point about it is, that as a result of the increasing space charge as the current increases, first a potential minimum occurs between the two electrodes and then, from a definite value of the space charge onwards, a "virtual cathode" ("v.K."); that is, a point where both $U = 0$ and $dU/dx = 0$, the potential U being given by the electron velocity expressed in volts. No longer do all the electrons reach the anode, some of them return to the cathode. The formation of this virtual cathode occurs discontinuously: the anode current varies in jumps, and the potential minimum between the two electrodes springs suddenly from a minimum value ($U_{min} > 0$) to zero. If the space charge is then diminished (*e.g.* by reducing the emission current) the dissipation of the virtual cathode takes place at a point different from that at which it was formed—the characteristic curve shows a "hysteresis loop."

No measurements on plane systems have so far been published, no doubt because it was considered that the conditions would be too severely distorted by edge effects. With cylindrical arrangements the writers mentioned above obtained some good results, which to a great extent confirmed the theory, qualitatively at any rate; but the plotted characteristic curves were somewhat muddled at the critical points. In particular, the sudden change in the current distribution could only be observed in special circumstances; as a rule it degenerated in a steep but continuous transition.

In the present writer's experiments the valve used was a triode, with an oxide-coated cathode and an anode of 5 cm² surface; the grid/anode gap was 1.2 cm. The grid took the place of the cathode in the theoretical case and in the experiments mentioned above: the "input" current J, accelerated in the grid/anode space, was calculated from the emission current J' with the help of a factor depending on the grid absorption, and determined from the values of the grid current before the formation of the virtual cathode.

Representing the anode potential by U_2, the grid potential by U_1, the anode current by J_2, and the normal space-charge current (calculated from the theory by the equation on p. 144, l-h column) by J_n, Fig. 1 shows the variation of the "relative" anode current J_2^* $(= J_2/J_n)$ with varying "relative" input current J^* $(= J/J_n)$, for two different ratios of potential, $U_2/U_1 = 0.5$ and 1.0, U_1 being actually 50 v. "Noteworthy are the linear rise before the formation of the virtual cathode (J_2 being about equal to J), the sudden change in the current distribution, the almost constant anode current after the formation of the virtual cathode, and the hysteresis loop (though the latter, it is true, is not recognisable for the 0.5 potential-ratio)." Other curves are shown and discussed: definite quantitative discrepancies between the experimental and the theoretical results are revealed. Many of these are explained as due to simplifying assumptions in the theory, but some remain (particularly at large values of J^*) which are not yet fully understood. Further tests, however, suggest that they are due to the electron beam, at the higher current values, spreading considerably in the neighbourhood of the virtual cathode as a result of the strong space charge: actually, the concentration of the beam by a magnetic field brought about a distinctly better agreement with the theory.

825. On the Refractive Indices of Media with Bound and with Free Electrons, *and* The Refractive Index of an Ionised Medium: II.—Mandelstam: Darwin. (*See* 737 & 738.)

826. Power-Tube Performance in Class C Amplifiers and Frequency Multipliers, as Influenced by Harmonic Voltage [leading to the Obtaining of Substantial Increases in Power Output & Efficiency].—R. I. Sarbacher. (*Proc. I.R.E.*, Nov. 1943, Vol. 31, No. 11, pp. 607–625.)

It is shown that the most favourable path of operation for the valve (seen to be different from that obtained in the normal operation of Class C amplifiers) can be obtained to a good approximation by the introduction of the second- or third-harmonic voltages, in the proper phase, into the plate circuit of the amplifying system. When these harmonics were introduced into the grid circuit, the path of operation was only slightly improved: fourth and higher-order harmonics were at best of little value in either circuit, and in most cases were detrimental. The insertion of parallel resonant circuits tuned to the second or third harmonic into the grid circuit develops harmonic voltages in the wrong phase to improve the performance: the harmonic power must therefore be supplied by auxiliary equipment. This applies also to the plate circuit, except in one special case [bottom of pp. 615, 616]. The power consumed by the auxiliary oscillator has, however, only a small effect on the over-all increase in efficiency.

In frequency doublers the third-harmonic voltage introduced into the grid circuit in the proper phase raises the efficiency to that obtained in ordinary Class C amplification, even when the auxiliary power is included: this represents an even greater improvement than that obtained for the amplifier. For frequency triplers, also, a high efficiency is given by this method.

A general warning is given that care must be taken to avoid excessive momentary space currents, in order that reasonable filament-life may not be impaired.

827. Power-Tube Protective Circuit [against Failure of Fixed-Bias System: Use of Auxiliary Self-Biasing Resistor shorted by 125 mA Littelfuse].—H. G. Kuhn. (*QST*, Nov. 1943, Vol. 27, No. 11, p. 54.)

828. Spaghetti at War [Use as Support to Filament during Welding saves 75% of Usual Time of Assembly].—(*Sci. News Letter*, 25th Sept. 1943, Vol. 44, No. 13, p. 199: photograph & caption only.)

829. Zirconium a Dangerous Metal when in Powdered Form [Spontaneous Combustion & Explosion at Room Temperatures].—U.S. Bureau of Mines. (*Sci. News Letter*, 6th Nov. 1943, Vol. 44, No. 19, p. 292.)

DIRECTIONAL WIRELESS

830. A Single-Turn Goniometer for Ultra-Short Waves, giving Sine-Law Coupling.—R. Hardy & P. de Maertelaere. (*See* "Enemy-owned patents," 1010, below.)

831. Concerning Phase Selectivity, *and* Automatic Tuning of Direct Amplification Stages [for Signals whose Frequency varies over a Wide Range, as in the Mandelstam–Papalexi Distance-Measuring Process].—Gorelik: Yuzvinski. (*See* 799 & 800.)

832. Electronic Instrument Indicator Aids Pilots [Four-Trace Cathode-Ray "Flightray" Indicator].—F. Q. Gemmill: Sperry Gyroscope Company. (*Sci. News Letter*, 13th Nov. 1943, Vol. 44, No. 20, p. 313.) Referred to in 563 of 1939.

833. Revolutionary Compass developed for Airplanes ["Gyro Flux Gate Compass" (Gyroscope used only for Stabilisation)].—W. A. Reichel: Bendix Corporation. (*Sci. News Letter*, 23rd Oct. & 13th Nov. 1943, Vol. 44, Nos. 17 & 20, pp. 268 & 307.)

ACOUSTICS AND AUDIO-FREQUENCIES

834. Energy Relations in Oscillatory Systems, and Parameters of Radiating Systems.—Kessenich. (*See* 816.)

835. A Method for calculating Sound Fields formed by Distributed Systems of Radiators.—L. D. Rosenberg. (*Journ. of Tech. Phys.* [in Russian], No. 2/3, Vol. 12, 1942, pp. 102–148.)

See 3077 of 1943. It is pointed out that the usual method for determining the sound potential of a point by summing (vectorially) the amplitudes of the oscillations coming from all sources is not suitable for calculating sound fields since, apart from mathematical difficulties, the results so obtained are at variance with reality. It is suggested that a much closer approximation to real conditions is obtained if instead of the amplitudes, the average energies radiated from all sources are summed. The method is discussed in detail and then applied to the cases when radiators are uniformly distributed (a) along a straight line, (b) along a circumference, (c) along the sides of a square, (d) on a circle, (e) on a spherical surface, (f) on a cylindrical surface, and (g) in space.

836. The Calculation of the Sound Field of Circular Piston Diaphragms [King's Expressions for

Velocity Potential (1934 Abstracts, p. 622, r-h col.) are Identical with Those of Author and of Stenzel (1930 Abstracts, pp. 458–459: 1478 of 1935) which can readily be obtained by King's Very Simple Treatment: His Criticism of Backhaus's Series Development is therefore Unjustified].—H. Backhaus. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 24, 1943, pp. 75–78.)

837. Diving Amplifier [providing Two-Way Communication with Tender: Loudspeakers serve also as Microphones: Amplifier & Control Circuits].—D. W. Gellerup. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 170..174.)

838. New Record-Marking Device [the "Spot-O-Graph": for Broadcasting & Recording, Foreign-Language Instruction, etc.].—(*Electronics*, Sept. 1943, Vol. 16, No. 9, p. 264.) For selecting particular parts on a record.

839. Re-Use of Home Recording Discs [Method of Heating just enough to allow Cutting Lines to run together].—R. K. Holsinger. (*QST*, Nov. 1943, Vol. 27, No. 11, p. 54.)

840. Hearing-Aid Circuits [Two Circuits for connecting a Hearing-Aid Amplifier to a Brush "Bimorph" Rochelle-Salt Earphone Unit].—Brush Development. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 165..168.)

841. On Propeller Noise.—L. Ya. Gutin: B. P. Konstantinov. (*Journ. of Tech. Phys.* [in Russian], No. 2/3, Vol. 12, 1942, pp. 76–83: p. 84.)

The first paper is a further development of a theory of propeller noise proposed by the author in 1936 (1861 of 1936). A brief survey of the papers on the subject published in the intervening years is given and some of the criticisms of the author's theory are answered. In the second paper a few remarks are made on Gutin's paper. It is stated that attempts to obtain a general solution of the equation determining the noise field of a rotating propeller are futile, and reference is made to another approximate method which, it is claimed, is more logical and accurate than the one proposed by Gutin.

842. The Stapedius Muscle as a Damping Agent protecting against Excessive Noise.—E. G. Wever & C. W. Bray. (*Science*, 31st July 1942, Vol. 96, No. 2483, Supp. p. 8.) *See* 1427 of 1942. A certain minimum amount of noise would apparently aid the hearing of some tones, such as those used in speech.

843. Investigation of the Resistance of Frictional Layers for Sound-Absorbing Systems.—S. N. Rschevkin & S.T. Terossipjantz. (*Journ. of Phys.* [of USSR], No. 1/2, Vol. 4, 1941, pp. 45–56: in English.) The Russian original was dealt with in 1414 of 1942.

844. Sound Absorption in Dielectrics [including a Section on the Criterion for the Applicability of the Conception of Phonons to Low Frequencies].—I. J. Pomeranchuk. (*Journ. of Phys.* [of USSR], No. 6, Vol. 4, 1941, pp. 529–436: in English.)

845. The Resolution of Boundary-Value Problems by means of the Finite Fourier Transformation: General Vibration of a String.—Kapfel Brown. (*See* 973.)

846. Historic Firsts: the Thermophone.—H. D. Arnold & I. B. Crandall, with E. C. Wente. (*Bell Lab. Record*, Nov. 1943, Vol. 22, No. 3, p. 105.)

847. Precision Stroboscopic Frequency-Meter [with Direct-Reading Range 32–4000 c/s, Accuracy within 0.05%: primarily for Musical Pitch Investigations, Piano & Organ Tuning, etc: Fork-Controlled Electronic Generator adjusted till One of 84 Rotating Patterns appears Stationary when illuminated by Discharge Tube fed with Amplified Signal].—E. L. Kent. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 120–121.) Made by C. G. Conn, Ltd.

848. An Oscillographic Method for the Determination of the Velocity of Sound ["Similar in Principle to That used by Colwell (1115 of 1941) but considered to be Capable of Greater Accuracy"].—J. M. A. Lenihan. (*Nature*, 4th Dec. 1943, Vol. 152, No. 3866, p. 662.) *Cf.* Knowles, 507 of February.

849. The Biological Application of Focused Ultrasonic Waves.—J. G. Lynn, R. L. Zwemer, & A. J. Chick. (*Science*, 31st July 1942, Vol. 96, No. 2483, pp. 119–120.) *See* also 514 of February.

PHOTOTELEGRAPHY AND TELEVISION

850. Three Years of Television Relaying [History of Development of the New-York/Schenectady Transmissions *via* the Helderberg Relay Station (*see* for example 2331 of 1939 and text of 3087 of 1940), and Results].—R. L. Smith. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 122–125 and 277.)

851. Optical-Storage Method of Large-Screen Projection.—H. Strubig. (*See* "Enemy-owned patents," 1010, below.)

852. The Origin and the Complications of Electric Double Refraction and of Electric Dichroism in Dilute Dispersed Systems [Kerr Effect, Electroosmotic & Electrophoretic Double Refraction, D.R. due to Orientation caused by Polarisation of Electrostatic Double Layer, etc.].—W. Heller. (*Reviews of Mod. Phys.*, Oct. 1942, Vol. 14, No. 4, pp. 390–409.)

853. The Preparation of Photocathodes [and Secondary-Emission Surfaces] of the Composition [Ag]–Cs_2O, Ag–Cs.—W. Hartmann. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 24, 1943, pp. 111–123.)

In view of the great importance of these photocathodes (the development of high-quality television with moderate illumination, for instance, became possible only with their development), and the large number of papers and patents concerning methods of preparing them, "it seems desirable to give a survey of the various possible processes and to weigh their advantages and disadvantages according to the present state of the technique, at any rate so far as the experiences, spread over many years, of the Fernseh A.G. can provide the data . . . As is well known, a photoelectric layer of this type can also be used as a good secondary-emission cathode, though the maximum output is then given with a slightly different caesium content (see section on 'the forming process' [especially p. 119, r-h column: the optimum structure of the layer is different for the two mechanisms, the photocathode requiring more caesium per unit of surface than the s.e. cathode: also the best 'forming" temperatures are different, over 200° C being good for high emission from s.e. cathodes, whereas photosensitivity is improved by the use of a lower temperature]. The preparation of such s.e. cathodes is gone into here only so far as is necessary to make clear the relations in tubes which contain both photocathode and electron-multiplier."

The survey deals in turn with the preparation of the under-layer (for transparent and non-transparent cathodes); the oxidation process; the setting-free of the alkali metal; the forming process; the sealing-off; and the physical data of the layers, including curves for spectral-sensitivity distribution (for comparison, a curve of an antimony–caesium cathode is also given) and for the dependence of s.e. output on primary-electron velocity. The final paragraphs of this last section consider the question of the maximum permissible loading (depending largely on the constructional conditions as regards the carrying away of heat) and the effect of the thermal "dark" current on the shot-effect noise level (silvering should be employed as much as possible to reduce this "dark" current. Even when voltage and temperature at the tube are kept constant, fluctuations of this current still remain to an extent of some 10%, owing to flicker effect). The paper ends with a list of 98 literature and patent references, the former including many Russian contributions (up to 1939).

854. ANTIMONY–CAESIUM PHOTOCELLS.—N. S. Khlebnikov. (*Izvestiya Elektroprom. Slab. Toka*, No. 12, 1940, pp. 65–70.)

A general survey is given of the properties of the Sb–Cs photocells. Their physical structure is discussed and spectral as well as volt/ampere characteristics are plotted for photocells in which the cathode is deposited (a) directly on the glass envelope (Fig. 3a) and (b) on a conducting base, usually silver (Fig. 3b). The fatigue of the cells is also considered and curves are plotted (Fig. 6) giving a comparison between this type of cell and the Cs_2O–Ag type. Among other advantages of the Sb–Cs type over the other is the possibility it provides of obtaining a one-colour reproduction of a multi-coloured image. This is illustrated by Fig. 7, in which one-colour reproductions of multi-coloured strips, as obtained respectively with the two types of cell, are shown.

855. MILITARY FACSIMILE [from Scout Planes].—(*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 108–109: photographs & captions only.)

856. SENDING TRAIN ORDERS BY FACSIMILE TELEGRAPHY.—Western Union. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 148..154.) From the paper dealt with in 3080 of 1943.

MEASUREMENTS AND STANDARDS

857. STABILITY IN [Ultra-] HIGH-FREQUENCY OSCILLATORS.—Heising. (*See* 789.)

858. CIRCUIT FOR THE GENERATION OF HARMONICS WITH HIGH CONSTANCY OF FREQUENCY [using Crystal oscillating in Series-Resonance].—R. Bechmann & others. (*Hochf:tech. u. Elek:akus.*, May 1943, Vol. 61, No. 5, p. 157, Fig. 7.) D.R.P.727 940.

859. CONDUCTIVITY AND DIELECTRIC CONSTANT OF AN AQUEOUS SOLUTION OF POTASSIUM CHLORIDE OF NORMAL CONCENTRATION IN THE VERY-HIGH-FREQUENCY FIELD [measured by the Thermometric Method].—M. Divilkovsky & D. Masch. (*Journ. of Phys.* [of USSR], No. 1/2, Vol. 4, 1941, pp. 59–65: in French.) The Russian original was dealt with in 2771 of 1941. For later work, on solid dielectrics, *see* 3082 of 1943.

860. FRICTIONAL DISPERSION OF THE DIELECTRIC CONSTANTS OF ORGANIC LIQUIDS AT COMPARATIVELY LONG WAVELENGTHS [15, 60, & 109 m].—P. Mehler. (*Ann. der Phys.*, 17th Sept. 1943, Vol. 43, No. 4, pp. 225–243.)

Extension, to longer waves, of the researches of Plötze (60 cm waves: 703 & 1718 of 1939) and Odenwald (15 cm waves: 353 of 1940), keeping to the lines laid down by the former worker, namely weak solutions (to avoid complications due to intermolecular forces), simple molecules (such as nitrobenzol), and measurements closely spaced over the frequency range, so as to yield a true frequency-dependence. The measuring method chosen was the resonance one, using the Lecher-wire system with hydraulic control of the variable cylindrical condenser and automatic recording indicated in Fig. 1. The temperature range covered was from 8° to 50° C. Results are summarised on p. 242.

861. "TEMPIL" PELLETS [Temperature Indicators: extending Range of "Tempilsticks" (125–700° F) to 750–1600° F, in Steps of 50°: Melting Point within 1% of Stated Temperature: Distinctive Colours].—Fisher Scientific. (*Review Scient. Instr.*, Sept. 1943, Vol. 14, No. 9, p. 280.) *Cf.* 167 of January and back references.

862. A SENSITIVE CATHODE-RAY VOLTMETER [Failure of Electrometer-Valve Methods at Radio & Ultra-High Frequencies: C.R. Technique which can give Sensitivity of 0.01 V and Immeasurably High Input Resistance, using Microscope (× 900) to Observe when Beam touches Edge of a Bright Grain (chosen as Reference Grain) on Screen, Compensating Potential being measured by Millivoltmeter].—Z. V. Harvalik. (*Review Scient. Instr.*, Sept. 1943, Vol. 14, No. 9, pp. 263–265.)

"If specially designed tubes with excellent vacuum and low anode potentials could be used, the sensitivity could be increased at least to 0.001 volt": actually a commercial tube (RCA oscilloscope 913) was employed, with added external deflection plates.

863. A VACUUM-TUBE VOLTMETER FOR A.C. AND D.C: A SIMPLE UNIT EASILY CONSTRUCTED FROM AVAILABLE PARTS.—A. D. Mayo. (*QST*, Nov. 1943, Vol. 27, No. 11, pp. 36–38.)

864. A VERSATILE "Q" METER [based on Variation of Voltage-Gain in Series-Resonant Circuit with the "Q" of That Circuit: Direct-Reading Instrument, applicable also to Measurement of Distributed Capacitance of Coils, Dielectric-Loss & Core-Permeability Measurements, etc.].—F. E. Planer. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 190..196.) For previous work *see* 1921 of 1943.

865. ON MEASURING INDUCTANCE COILS WITH ELECTROSTATIC SHIELDS.—E. V. Zelyakh. (*Izvestiya Elektroprom. Slab. Toka*, No. 12, 1940, pp. 58–60.)

An inductance coil in an electrostatic shield is a three-pole passive system (Fig. 1) in which two poles (*e.g.* 1 and 2) correspond to the ends of the coil winding and the third pole (*e.g.* 3) to the shield. A three-pole passive system can be replaced by an equivalent triangle with impedances Z_{12}, Z_{13} and Z_{23} connected between the apices (Fig. 2). Of these impedances, Z_{12} is inductive and Z_{13} and Z_{23} are capacitive. It is stated that so far as is known to the author no method for direct measurement of Z_{12}, Z_{13} and Z_{23} has yet been described in the technical literature. Accordingly, a method is proposed in which the above values are measured on an a.c. bridge with inductive ratio arms having variable mutual inductance. The necessary formulae are derived, and the effect of Z_{13} and Z_{23} on the accuracy of the measurement of Z_{12} is taken into account. The method has been used for measuring coils in the crystal filters of a 12-channel telephone equipment.

866. TEMPERATURE-COMPENSATED WAVEMETER COIL [for Army & Navy Transmitter-Adjustment: with Inductance-Varying Ring rotated by Bimetallic Spiral].—E. O. Thompson: Philco Corporation. (*Electronics*, Sept. 1943, Vol. 16, No. 9, p. 148.) *See* also 282 of January and back reference.

867. A JUNK-BOX FREQUENCY METER FOR 112 Mc/s: A HETERODYNE-TYPE UNIT WITH HAM-BAND CRYSTAL CHECKS.—W. Adams. (*QST*, Nov. 1943, Vol. 27, No. 11, pp. 30–33.) For WERS purposes.

868. AN INTERPOLATION OSCILLATOR: AN AID TO FREQUENCY MEASUREMENT WITH A 100 kc/s STANDARD.—F. H. Mills. (*QST*, Nov. 1943, Vol. 27, No. 11, pp. 46–50.) "Makes it possible to attain an accuracy within less than one cycle in measurements of any frequency between 100 c/s and 7 Mc/s or even higher."

869. ON THE INVESTIGATION OF THE OSCILLATIONS OF PIEZO-QUARTZ PLATES BY THE INTERFERENCE METHOD.—M. L. Kotliarewsky & E. J. Pumper. (*Journ. of Phys.* [of USSR], No. 1/2, Vol. 4, 1941, pp. 67–78: in German.) The Russian original was dealt with in 1451 of 1942.

870. A VARIABLE FREQUENCY ELECTRONIC GENERATOR [giving 1400 W over Range 300–3500 c/s, Frequency Stability better than 2%: Output Voltage adjustable between 85 & 125 V R.M.S, with Regulation better than 1% from No Load to Full Load: Substantially Sinusoidal Wave-Form: Many Applications, including Testing of Radio & Radar Apparatus].—D. A. Griffin. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 130–132 and 278..280.)

871. STANDARD-FREQUENCY BROADCASTS.—Nat. Bur. of Standards. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 228..232: *Proc. I.R.E.*, Nov. 1943, Vol. 31, No. 11, pp. 642–643.)

872. SHORT-PERIOD ERRATICS OF FREE-PENDULUM [Shortt] AND QUARTZ CLOCKS.—W. M. H. Greaves & L. S. T. Symms. (*Nature*, 27th Nov. 1943, Vol. 152, No. 3865, p. 633: summary only.)

873. REMOTE ADJUSTMENT OF SYNCHRONOUS CLOCKS.—A. Leeman. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 158 and 160.)

874. INSTRUMENT TRANSFORMERS [Summary of I.E.E. Paper on Ratio & Phase-Angle Errors, Means of obtaining Increased Accuracy, etc.].—A. Hobson. (*Nature*, 11th Dec. 1943, Vol. 152, No. 3867, pp. 696–697). *See* also 543 of February.

875. THE TECHNIQUE OF MATERIALS TESTING: V—CHEMICAL AND ALLIED TESTS.—W. D. Owen. (*BEAMA Journal*, Dec. 1943, Vol. 50, No. 78, pp. 386–391.) For this series *see* 532 of February.

876. A NEW METHOD OF ELECTRICAL TESTING, APPLIED TO INSULATED WIRES [especially Enamelled Wires, liable to give Premature Breakdown under Standard Method applied at Rising Temperatures: Use of Automatic Voltage Control given by Test Transformer with Very Poor Regulation: Double-Beam Cathode-Ray Oscillograph].—H. A. Macdonald & E. C. R. Scarfe. (*Nature*, 10th July 1943, Vol. 152, No. 3845, pp. 51–52.) From the Henley's laboratories.

877. "METALLISCHE ELEKTRISCHE WIDERSTANDSWERKSTOFFE" [Resistance Materials: Book Review].—A. Schulze. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 24, 1943, p. 124.) By the writer of papers dealt with in 1721 of 1941, 2034/5 of 1942, and 1199 of 1943.

878. A SOURCE OF ELECTROMOTIVE FORCE OF HIGH CONSTANCY [New, Specially Compact, Convenient, & Shock-Proof Form of Weston Standard Cell, suitable for Many Uses].—A. Leinen & H. W. Straub. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 24, 1943, pp. 145–147.)

Sources of e.m.f. with high constancy in time and only slight dependence on temperature are frequently needed both in research and in practical use. The current output required is in most cases so small that the cell capacity is of subordinate importance. Examples of the application of such sources are for the negative grid bias of amplifiers for measuring purposes, the auxiliary potentials of sensitive electrometers, the supply potentials for ionisation chambers, and so on. For such purposes a long-term constancy at least within 1‰ is desirable. The Weston cell is perfectly satisfactory in this respect, but its H-shape makes it susceptible to shock and easily broken: it could hardly be built up into batteries of high e.m.f., and moreover its construction in large quantities presents difficulties, especially because of its need for platinum-wire leads and the purest of materials.

After many unsuccessful attempts the writers have evolved a design which eliminates all these difficulties and allows the cells (each in a transparent-plastic cylinder of 16 mm length and 10 mm diameter) to be mounted as self-supporting components which can be connected in series to form batteries. The e.m.f. when no current is being taken is $1.0180 \pm 1.5 \times 10^{-3}$ v (as measured on several hundred specimens), its variation over half a year is at most $\pm 1 \times 10^{-3}$ v, and the mean temperature-coefficient between 0° and 50° is $+ 8 \times 10^{-5}$ v/°C. The internal resistance is around 150 ohms. Tests on continuous load are now in progress and will last several months: since the cell has shown such a constancy when no current was being taken, and since in most applications no or very little current is required, the writers think it desirable to publish the design of this new and useful component.

Fig. 1 shows a longitudinal section of the cell. The cylindrical space, terminated by the sealing caps 8,8, is divided into four compartments 4,5,6,7 by the three "diaphragms" 3,3,3, held in position by the ring-shaped distance-pieces 2,2. The caps 8,8 are sealed-in hermetically; they carry the lead-in wires 9,9, of a "special iron alloy" which has proved particularly suitable for the purpose, and are filled with the electrode metals mercury and Cd-amalgam (in compartments 4 and 7 respectively). Compartments 5 and 6 hold the Hg_2SO_4 "paste" and the the saturated $CdSO_4$ solution (with a few $CdSO_4$ crystals) respectively. The "diaphragms" (no details are given) keep the various chemicals, "especially the amalgam, which is liquid at the higher temperatures," in their places, so that the cell is quite insensitive even to severe shaking. The quantities are so chosen that after a shelf-life of six months a continuous drain of about 10^{-6} A can be taken for another six months. The thick iron-alloy lead-in wires render the unit self-supporting: if, in mounting, they are heated too long, they will conduct enough heat to damage the points where they are sealed into the end caps; time-controlled spot welding is the best method to use.

SUBSIDIARY APPARATUS AND MATERIALS

879. A Source of Electromotive Force of High Constancy [New Form of Weston Cell, suitable for providing Grid Bias, Electrometer or Ionisation Chamber Potentials, etc.].—Leinen & Straub. (*See* 878.)

880. Plasma Phenomena on the Application of Sudden Pulses.—Schumann. (*See* 786.)

881. Recording Cathode-Ray-Oscillograph Traces [Papers at Meeting of Association for Scientific Photography (2288 of 1943)].—Nethercot: Hendry. (*Nature*, 4th Dec. 1943, Vol. 152, No. 3866, pp. 656–657: summaries only.) For previous work by Nethercot *see* 2194 of 1943.

882. "Reference Manual—Cathode-Ray Tubes and Instruments" [Book Review].—DuMont Laboratories. (*Proc. I.R.E.*, Nov. 1943, Vol. 31, No. 11, p. 648.)

883. Experimental Contributions to the Space-Charge Theory for Electrons with Homogeneous Initial Velocity.—Haug. (*See* 824.)

884. New Mathematical Tables [including MT17 (Planck's Radiation Functions: Electron Velocity, Path-Curvature, etc.): Note on Series dealt with in 3187 of 1943].—Nat. Bur. of Standards. (*Electronics*, Sept. 1943, Vol. 16, No. 9, p. 202.)

885. Fluorescence of Organic Molecules.—Weiss. (*Nature*, 14th Aug. 1943, Vol. 152, No. 3850, pp. 176–178.)

886. On the Law of Decay of Luminescence of Complex Molecules [including a Chapter on the Construction & Theory of Fluorometers].—Tumerman. (*Journ. of Phys.* [of USSR], No. 1/2, Vol. 4, 1941, pp. 151–166: in English.) The Russian original was dealt with in 3086 of 1942.

887. An Oil-Diffusion Pump with High Evacuating Speed and Wide Range of Action.—Jaeckel & Schröder. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 24, 1943, pp. 69–72.) A final paragraph compares results with those of other recent pumps: *e.g.* Hickman, 4409 of 1940.

888. On a Measuring Device for High and Low Gas Pressures, using Semiconducting Resistances.—Weise. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 24, 1943, pp. 66–69.)

Improvement of the "semiconductor" Pirani manometer dealt with in 677 of 1938. By increasing the surface of the semiconducting resistance to about 10 cm² (the thickness of the magnesium–titanium spinel being about 20μ) the pressure range has been considerably extended and the control current increased up to 100 mA, so that it can be used for the direct control of recording or regulating systems. Thus the device can be employed for the automatic maintenance of a given low vacuum (Fig. 9).

889. Voltage Fluctuations in Semiconductors.—Davydov & Gurevich. (*See* 768.)

890. The Sixth Conference on Semiconductors [including Rectifiers, Photocells (Silver-Sulphide/Antimony Rectifier-Photocell, Geichman & Soroka: Sulphur/Thallium Photocells in Sound-on-Film, Kolomiez), Phosphors, etc.].—Joffe & others. (*Journ. of Phys.* [of USSR], No. 1/2, Vol. 4, 1941, pp. 169–175: summaries only, in English.) Already referred to (Russian summaries) in 1517 of 1942.

891. The Effect of Admixtures to Copper on the Electrical Properties of Copper-Oxide Rectifiers.—Sharavski. (*Journ. of Tech. Phys.* [in Russian], No. 2/3, Vol. 12, 1942, pp. 149–168.)

The following admixtures to copper were experimented with: Be, Al, Si, P, Mn, Fe, Co, Ni, Zn, As, Ag, Cd, Sn, Sb, Au, Ti, Pb, and Bi. The experiments are described in detail and the results are tabulated. The main conclusions reached are as follows: (a) the above admixtures can be divided into two groups: those which increase the forward resistance and decrease the backward resistance, and those which increase the resistance in both directions; (b) from the second group, admixtures can be chosen which leave the forward resistance practically unaltered but increase the backward resistance (Sb and Pb); (c) rectifiers prepared from copper containing definite amounts of admixtures (*e.g.* Cu—99.78%, Sb—0.1%, Pb—0.1%) possess better electrical characteristics than those made from ordinary commercial copper; (d) a negative effect of one admixture can be compensated by the positive effect of another admixture.

At the end of the paper the effect of admixtures on the structure of copper oxide is discussed with a number of photographs. A short theoretical discussion of the rectification process is also included.

892. Improvised Memorising Machine [for Study of Ignitron Arc-Back].—Westinghouse. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 156 and 158.) *Cf.* Pakala, 723 of 1939, and Hull & Elder, 2082 of 1942.

893. A New Type of Ignitron.—Shereshevski. (*Izvestiya Elektroprom. Slab. Toka*, No. 12, 1940, pp. 52–57.)

The operation of ignitrons is described and their advantages over hot-cathode gas-filled rectifier valves are pointed out. A description is then given of a G.E.C. water-cooled ignitron for 135 A at 700 V, and the following disadvantages of this type are pointed out:—(1) The anode voltage must not exceed 700 V; (2) h.f. heating of the anode during evacuation is impossible; (3) the high cost of the materials used (stainless steel); and (4) a complicated and expensive equipment is necessary for their manufacture. Accordingly a new type (Fig. 3) has been developed in Russia obviating the above objections and possessing a number of other advantages. The new ignitron consists essentially of a cathode container made of an alloy of 73% Fe and 27% Cr, and an anode container made of special glass. The ignitron is provided with water-cooling and is capable of operating with voltages up to 10–15 kV. Models for rectified currents of from 30 to 100 A have been made and successfully tested.

The constructional features of the new type are described, and the distribution of temperatures and mercury-vapour densities in the various parts of the ignitron is discussed in detail.

894. Afterglow in High-Pressure Gaseous Discharges [Experiments using Electron Multiplier & C.R.O: Technique applicable also to Study of

Leader-Stroke Development].—Meek & Craggs. (*Nature*, 6th Nov. 1943, Vol. 152, No. 3862, pp. 538–539.)

895. BREAKDOWN OF COMPRESSED GAS WITH REVOLVING ELECTRODES.—Rzjankin. (*Journ. of Phys.* [of USSR], No. 1/2, Vol. 4, 1941, pp. 79–83: in English.) The Russian original was dealt with in 811 of 1942. The tests were made with Papalexi's capacitative parametric generator (*cf.* 430 of February), which is described.

896. BREAKDOWN OF COMPRESSED GASES IN INHOMOGENEOUS FIELDS.—Hochberg & Oksman. (*Journ. of Phys.* [of USSR], No. 1, Vol. 5, 1941, pp. 39–46: in English.) The Russian original was dealt with in 1501 of 1942.

897. AN INVESTIGATION OF THE ELECTRICAL STRENGTH OF GASES.—Hochberg & Sandberg. (*Journ. of Tech. Phys.* [in Russian], No. 2/3, Vol. 12, 1942, pp. 65–75.)

The electrical strength of various (mainly electrically strong) gases was investigated experimentally and preliminary measurements were made of the first ionisation coefficient α for air and SF_6. The results obtained are discussed in the light of the modern theory of the breakdown of gases. One of the conclusions reached is that the breakdown of various gases occurs at almost the same value of α. The latter is reached at a different field intensity for each gas, which serves as a criterion of the strength of the gas.

898. HIGH VOLTAGE CONDENSERS WITH GAS INSULATION UNDER PRESSURE.—Hochberg, Reynov, & Glikina. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 12, 1942, pp. 8–13.)

A description is given of gas-filled condensers, developed in Russia, suitable for operation at high frequencies and under high voltages. Condensers of this type with fixed capacities of 300, 600, 1200, 2400 and 4000 $\mu\mu F$ were tested at frequencies up to 1.2 Mc/s and voltages up to 40 kv (peak). These condensers were filled with nitrogen under pressures of from 15 to 18 kg/cm² and SF_6 under pressures from 8 to 9 kg/cm². The tests, which are fully reported, have shown that by using SF_6 in place of N either the gas pressure or the over-all dimensions of the condenser can be reduced, or alternatively the capacity can be raised. Under heavy loads, *e.g.* up to 2000 kVA for a capacity of 1200 $\mu\mu F$, the stable temperature of the condenser rises without forced cooling to 70° C approx. for an ambient temperature of about 20° C. It is considered that SF_6 is quite suitable for condensers of the type described.

899. CERAMIC CAPACITORS [" Disc Ceramicons," Basic Types 160 & 170], *and* TWO-TERMINAL OIL CAPACITORS [Both Lugs Insulated].—Erie Resistor: Aerovox. (*Electronics*, Sept. 1943, Vol. 16, No. 9, p. 260: p. 268.) *Cf.* 2224 of 1943 for the ceramic series.

900. ON THE ABNORMAL DEPENDENCE OF THE IONIC OR ELECTRONIC CONDUCTIVITY OF CERTAIN SOLUTIONS [Oxides of Alkali Metals in Glasses, Impurities in Semiconductors, etc.].—Frenkel. (*Journ. of Phys.* [of USSR], No. 1, Vol. 5, 1941, pp. 31–38: in English.)

901. DIELECTRIC LOSSES AT HIGH FREQUENCIES [Wavelength 106 m] IN GLASS FABRIC.—Skanavi. (*Journ. of Phys.* [of USSR], No. 1/2, Vol. 4, 1941, pp. 85–87: in English.) An abstract was referred to in 1971 of 1943. Among other results, it is shown that $\tan\delta$ for a thin glass fabric can be calculated approximately from $\tan\delta$ of the glass and the percentage of the glass content.

902. FLEXIBLE FIBRE-GLASS SLEEVING [New Type, Extremely Flexible & Non-Fraying].—Bentley, Harris Mfg. Company. (*Review Scient. Instr.*, Sept. 1943, Vol. 14, No. 9, p. 280.)

903. PHOTO-ELASTIC INVESTIGATIONS OF STRUCTURAL CHANGES IN PLASTIC MATERIALS [Polythene, Nylon, Methyl Methacrylate Polymer, & Polystyrene].—Kolsky & Shearman. (*Proc. Phys. Soc.*, 1st Sept. 1943, Vol. 55, Part 5, No. 311, pp. 383–395.)

904. THE ELECTRON DIFFRACTION BY AMORPHOUS POLYMERS [leading to a Discussion of the Elastic Properties of the Polyvinyl Acetate and the Acrylate & Methacrylate Polymers: the Occurrence of High Elasticity].—Coumoulos. (*Proc. Roy. Soc.*, Series A, 16th Dec. 1943, Vol. 182, No. 989, pp. 166–179.)

905. STERIC HINDRANCE AND HEATS OF FORMATION [in Polymerisation].—Evans & Polanyi. (*Nature*, 25th Dec. 1943, Vol. 152, No. 3869, pp. 738–740.)

906. MOLECULAR ORIENTATION IN MOULDED PLASTICS [Preliminary Diffraction Studies of Molecular Alignments produced by Injection Moulding & Other Mechanical Working, and affecting the Strength, etc.].—Baker. (*Bell Lab. Record*, Nov. 1943, Vol. 22, No. 3, pp. 119–122.)

907. RADIO-FREQUENCY HEATING SPEEDS PLASTIC MOULDING [reduces Curing Time, eliminates Breakage of Inserts & Pins, minimises Gassing Problems, reduces Pressure required].—Taylor. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 102–107 and 204..210.)

908. LIGNIN, A NEW PLASTIC USED FOR TELEPHONE PARTS TO SAVE PHENOL FIBRE.—Western Electric. (*Electrician*, 26th Nov. 1943, Vol. 131, No. 3417, p. 542.) *See* also 2502 of 1943.

909. SYNTHETIC RUBBERS AND PLASTICS: IV—THE APPLICATION OF SYNTHETIC RUBBERS FOR CABLES.—Evans. (*Distribution of Electricity*, Jan. 1944, Vol. 16, No. 153, pp. 208–213.)

910. " MANUAL ON LUCITE " [Book Notice].—du Pont de Nemours. (*Review Scient. Instr.*, Oct. 1943, Vol. 14, No. 10, p. 326.)

911. THE DEVELOPMENT IN TIME OF THE THERMAL BREAKDOWN OF SOLID INSULATORS.—Grünberg & others. (*Journ. of Phys.* [of USSR], No. 5/6, Vol. 5, 1941, pp. 339–356: in German.) The Russian original was dealt with in 3147 of 1941.

912. SOUND ABSORPTION IN DIELECTRICS.—Pomeranchuk. (*See* 844.)

913. FRICTIONAL DISPERSION OF THE DIELECTRIC CONSTANTS OF ORGANIC LIQUIDS AT COMPARATIVELY LONG WAVELENGTHS.—Mehler. (*See* 860.)

914. THE EFFECT OF PRESSURE UPON THE DIELECTRIC CONSTANTS OF LIQUIDS.—Owen & Brinkley. (*Phys. Review*, 1st/15th July 1943, Vol. 64, No. 1/2, pp. 32–36.)

915. ON ELECTROSTATIC GENERATORS.—Joffe & others. (*Journ. of Phys.* [of USSR], No. 1/2, Vol. 4, 1941, pp. 167–168 : in English : summaries only.)

Difficulties and future prospects : capacity of an electric source of energy ultimately determined by $SvF \cos \alpha$, and deductions from this fact (Kapitza) : superheated compressed steam as insulating and ventilating medium (Papalexi) : etc.

916. ELECTROSTATIC HIGH-VOLTAGE GENERATOR WITH A GROUNDED METAL AXIS.—Joffe & Hochberg. (*Journ. of Phys.* [of USSR], No. 5, Vol. 4, 1941, pp. 389–391 : in English.) The Russian original was referred to in 2799 of 1942.

917. ON THE CAUSE OF THE HIGH PERMEABILITY OF ALLOYS Fe–Si–Al ("SENDUST" [*see* for example 1577 & 3517 of 1937]).—Zaimovsky & Selissky. (*Journ. of Phys.* [of USSR], No. 6, Vol. 4, 1941, pp. 563–565 : in English.)

" It is shown that the high permeability of the Fe–Si–Al system is in close connection with the very small values of magnetostriction and magnetic anisotropy constant, and thus the theory of Fe–Ni–permalloy may be generalised on the Fe–Si–Al alloys." A paper by the second author, " High permeability and superstructure in the Fe–Si–Al alloys, ' Sendust ' type," follows on pp. 567–568, also in English.

918. ON THE TEMPERATURE-DEPENDENCE OF MAGNETIC PERMEABILITY IN WEAK FIELDS [with μ/T Curves for Many Alloys : Anomalous Behaviour of Fe–Si–Al Alloys, and Its Great Interest].—Zaimovsky. (*Journ. of Phys.* [of USSR], No. 6, Vol. 4, 1941, pp. 569–572 : in English.)

919. A MIXTURE OF AMBER AND TROLITUL AS BINDING MATERIAL FOR H.F. IRON CORES.—Lorenz Company. (*Hochf:tech. u. Elek:akus.*, June 1943, Vol. 61, No. 6, p. 192.) D.R.P. 729 004.

920. THE EFFECT OF ELASTIC STRESSES ON MAGNETISATION PROCESSES IN FERROMAGNETICS IN WEAK FIELDS.—Drozhzhina & Shur. (*Journ. of Phys.* [of USSR), No. 5, Vol. 4, 1941, pp. 393–399 : in English.) The Russian original was dealt with in 216 of 1943.

921. SENSITIVE ELECTRONIC RELAY [No. 99780 Cenco-Gilson Electronic Relay : " Hair-Trigger Sensitivity and Non-Chatter Features "].—Central Scientific. (*Review Scient. Instr.*, Sept. 1943, Vol. 14, No. 9, p. 279.)

STATIONS, DESIGN AND OPERATION

922. FREQUENCY-MODULATION TRANSMITTER AND RECEIVERS FOR STUDIO-TO-TRANSMITTER RELAY SYSTEM [in 330.4–343.6 Mc/s Band : Reasons for Adoption of ± 75 kc/s Swing only : Design of Transmitter & Receiver : Aerial (entirely enclosed in Airtight Herkolite Insulating Tubing) : etc.].—Goetter. (*Proc. I.R.E.*, Nov. 1943, Vol. 31, No. 11, pp. 600–606.) Simplicity and ease of maintenance and operation have been specially kept in mind.

923. PLANNING A VERY-HIGH-FREQUENCY COMMUNICATIONS SYSTEM [including Details of Massachusetts State Police System].—Doremus. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 96–101 and 178, 180.)

924. ON THE SPOT WITH A WALKIE-TALKIE : THE PACK SET IN WERS OPERATION.—Burkle. (*QST*, Nov. 1943, Vol. 27, No. 11, pp. 23–25.)

925. CD-WERS, 1944 STYLE : A MODERN MOBILE EMERGENCY TRANSMITTER-RECEIVER. — Long. (*QST*, Nov. 1943, Vol. 27, No. 11, pp. 11–16.)

926. PATENT ON SECRET-COMMUNICATION SYSTEM.—Tenenbaum. (*See* " Enemy-owned patents ", 1010, below.)

927. USING 'PHONE LINE FOR REMOTE INDICATION OF OVER-MODULATION [Single Monitor indicates in Studio as well as at Transmitter].—Leeman. (*Electronics*, July 1943, Vol. 16, No. 7, pp. 144 . . 148.)

GENERAL PHYSICAL ARTICLES

928. CHANCE, FREEWILL, AND NECESSITY IN THE SCIENTIFIC CONCEPTION OF THE UNIVERSE : TWENTY-SEVENTH GUTHRIE LECTURE.—Whittaker. (*Proc. Phys. Soc.*, 1st Nov. 1943, Vol. 55, Part 6, No. 312, pp. 459–471.)

929. METAPHYSICAL ELEMENTS IN PHYSICS.—Margenau. (*Reviews of Mod. Phys.*, July 1941, Vol. 13, No. 3, pp. 176–189.)

What is metaphysics ? General framework of physical methodology. Reality. The logical positivists. The metaphysics of symbolic construction. Methodological changes entailed by quantum mechanics.

930. ON THE DIMENSIONS OF PHYSICAL MAGNITUDES (THIRD PAPER : ELECTRIC & MAGNETIC MAGNITUDES) [Correction of Error in Earlier Paper, and More Complete Development of the Theory].—Dingle. (*Phil. Mag.*, Sept. 1943, Vol. 34, No. 236, pp. 588–599.) For the preceding papers *see* 2541 & 3765 of 1942.

931. THE EFFECT OF A CONDUCTING SEMIPLANE ON THE FIELD OF A POINT CHARGE.—Grünberg & Tsukkerman. (*See* 740.)

932. NOTE ON THE INTERACTION OF TWO POINT CHARGES [Simplified Version of Derivation of Integrals of " Energy " & " Angular Momentum," as found in Recent Series of Papers (2246 of 1943)].—Milne. (*Phil. Mag.*, Oct. 1943, Vol. 34, No. 237, pp. 712–716.)

933. DEFINITION AND MEASUREMENT OF ABSOLUTE ELECTRODE POTENTIALS [Potential of Isotropic Conductor defined as Potential of a Point in a Cavity within the Conductor].—Grahame. (*Phys. Review*, 1st/15th June 1943, Vol. 63, No. 11/12, p. 458 : summary.) " Its particular advantage is that it makes possible an experimental determination of the electrostatic potential difference between two phases . . ."

934. THE ORIGIN AND THE COMPLICATIONS OF ELECTRIC DOUBLE REFRACTION AND OF ELECTRIC DICHROISM IN DILUTE DISPERSED SYSTEMS.—Heller. (*See* 852.)

935. ON THE DISPERSION OF MAGNETIC DOUBLE REFRACTION. — Servant. (*Comptes Rendus* [Paris], 7th/21st Dec. 1942, Vol. 215, No. 23/25, pp. 574–576.)

" I have proposed (ref. " 1 ") to represent the dispersion of electric or magnetic double refraction by the simple formula $C = c \cdot \lambda/(\lambda^2 - \lambda_0^2)$ . . . I have given the interpretation of this in the case of the Kerr effect (ref. " 2 ") ; it can be extended to the Cotton–Mouton effect . . ."

936. THE PROPERTIES OF FLUIDS—Bradford. (*Phil. Mag.*, July 1943, Vol. 34, No. 234, pp. 433–471.)

" In this series of papers, a general theory of the properties of fluids has been developed, in which molecular attraction plays a rôle, identical with that of gravitation in astronomy . . . The new theory is at once a confirmation of the dynamical theory of gases and an extension of it to the liquid state."

937. A DISCOVERY IN PHYSICS : PURE MAGNETIC CURRENT [Disclosure in New York " of what appears to be a discovery in physics ranking in importance with the discovery of the principle of the dynamo . . ." : Demonstration to Am. Phys. Soc. at Columbia University].—Ehrenhaft. (*The Times*, 17th Jan. 1944, p. 3.) *See* also 2175 & 3622/3 of 1940 ; 11, 221/2, 675 (with back references to 1931, etc.) & 1304 of 1941 ; 18, 888, 1889, & 3408 of 1942 ; 226 & 2867 of 1943 ; and 623 of February.

938. " A TREATISE ON PHYSICAL CHEMISTRY : VOL. 1—ATOMISTICS AND THERMODYNAMICS " [Book Review].—Taylor & Glasstone (Edited by). (*Nature*, 21st Aug. 1943, Vol. 152, No. 3851, pp. 200–202.) Reviewed by R. H. Fowler.

939. PROBABILITY ERRORS AND ERROR LIMITS IN APPLICATION TO THE PROBLEM OF THE ATOMIC CONSTANTS.—Stille. (*Zeitschr. f. Phys.*, 6th April 1943, Vol. 120, No. 11/12, pp. 703–719.)

940. ELEMENTARY PARTICLES OF PHYSICS [the New " Building Blocks of the Universe "].—Stranathan. (*Electronics*, Aug. 1943, Vol. 16, No. 8, pp. 122–126 and 272..275.) For a book by the same writer *see* 2863 of 1943.

941. PROPOSALS FOR NEW BASIC PHYSICAL POSTULATES.—Townsend. (*Nature*, 11th Sept. 1943, Vol. 152, No. 3854, p. 308 : summary only.)

" The ultimate force quantum is the dynamion, which on coming in contact with an ultimate mass particle or akinesion at once imparts to it an ultimate energy quantum or kinesion, resulting in an actinion . . ." The equivalent of the motion of 546 actinions constitutes a photon.

942. ON THE " RADIUS " OF THE ELEMENTARY PARTICLES.—Landau. (*Journ. of Phys.* [of USSR], No. 6, Vol. 2, 1940, pp. 485–487 : in English.) English version of the paper dealt with in 1522 of 1941.

943. THE FUNDAMENTAL EQUATIONS OF ELECTRON MOTION (DYNAMICS OF HIGH-SPEED PARTICLES).—MacColl. (*See* 3525 of 1943.)

944. ON THE CAPTURE OF A SLOW-MOVING DIRECTED ELECTRON IN A COULOMB FIELD OF FORCE.—Morgans. (*Phil. Mag.*, Aug. 1943, Vol. 34, No. 235, pp. 537–549.)

945. A LINEAR THEORY OF THE ELECTRON : II.—Bopp. (*Ann. der Phys.*, 13th May 1943, Vol. 42, 1942/3, No. 7/8, pp. 573–608.) For Part I *see* 927 of 1941.

946. NUCLEAR SCATTERING OF ELECTRONS IN THIN METALLIC FILMS : I [Measurements on 40–120 ekV Electrons agree with Mott's Theory : Neher's Results completely Inexplicable].—Petukhov & Vyshinsky. (*Journ of Phys.* [of USSR], No. 3, Vol. 4, 1941, pp. 235–246 : in English.)

947. AN INVESTIGATION OF THE RADIATION LOSSES OF ELECTRONS BY THE CALORIMETRIC METHOD [Agreement with Calculated Results by Bethe–Heitler Theory].—Ivanov & others. (*Journ. of Phys.* [of USSR], No. 4, Vol. 4, 1941, pp. 319–334 : in English.)

948. RÉSUMÉS OF RECENT RESEARCH : ELECTRON POLARISATION.—(*Journ. Applied Phys.*, June 1943, Vol. 14, No. 6, pp. 271–272.) *See* also 1783/5 of 1943.

949. RÉSUMÉS OF RECENT RESEARCH : HIGH CENTRIFUGAL FIELDS AND RADIOACTIVE DECAY.—Freed & others. (*Journ. Applied Phys.*, June 1943, Vol. 14, No. 6, p. 271.)

950. THE BLACKBODY : PART II [Summation of Radiation, Brightness & Colour Temperatures, Pressure of Radiation, Blackbody as Quanta Generator, and Efficiency of Radiation].—Benford. (*Gen. Elec. Review*, Aug. 1943, Vol. 46, No. 8, pp. 433–440.) For Part I *see* 3179 of 1943 : corrections are to be found on p. 440.

951. THE RAMAN EFFECT.—Glockler. (*Reviews of Mod. Phys.*, April 1943, Vol. 15, No. 2, pp. 111–173.)

MISCELLANEOUS

952. A NOTE ON THE EVALUATION OF RIEMANN'S ZETA FUNCTION.—Healey & Mackenzie. (*A.W.A. Tech. Review*, Aug. 1943, Vol. 6, No. 3, pp. 125–141.)

Authors' summary :—" An expression, equation 28, is obtained that allows rapid and accurate computation of $\zeta(x) = \sum_{n=1}^{\infty} (1/n^x)$, $x > 1$; this expression having the important property of applying equally well for $x = 1 + \delta$, $\delta \ll 1$, as for larger values of x. In addition, a formula for evaluating Euler's constant is deduced from eqn. 28 by considering its behaviour as $x \to 1$."

953. ON SAMPLING IN UNKNOWN FIELDS [and the Proposed Use of an " H " Model (Equal Regular Hexagonal Cells in Bee-Hive Pattern) instead of Usual " S " Model (Equal Squares)].—Ghosh. (*Sci. & Culture* [Calcutta], Sept. 1943, Vol. 9, No. 3, pp. 129–130.)

954. THE APPROXIMATE MATHEMATICAL METHODS OF APPLIED PHYSICS AS EXEMPLIFIED BY APPLICATION TO SAINT-VENANT'S TORSION PROBLEM [Ritz's, Galerkin's, Graphic, & Other Methods : with Many Literature References].—Higgins. (*Journ. Applied Phys.*, Sept. 1943, Vol. 14, No. 9, pp. 469–480.)

955. THE THREE INFINITE HARMONIC SERIES AND THEIR SUMS (WITH TOPICAL REFERENCE TO THE NEWTON AND LEIBNITZ SERIES FOR π).—Soddy. (*Proc. Roy. Soc.*, Series A, 16th Dec. 1943, Vol. 182, No. 989, pp. 113–129.)

956. " VECTOR AND TENSOR ANALYSIS " [Book Review].—Craig. (*Review Scient. Instr.*, Oct. 1943, Vol. 14, No. 10, pp. 317–318.)

957. " DIE MATHEMATIK DES NATURFORSCHERS UND INGENIEURS : BAND I—DIFFERENTIAL UND INTEGRALRECHNUNG " [Book Review].—Baule. (*E.T.Z.*, 3rd June 1943, Vol. 64, No. 21/22, p. 310.) First of six volumes.

958. "*Quarterly of Applied Mathematics*" [Short Review of the First Two Issues of the Periodical referred to in 2878 & 3284 of 1943].—(*Proc. I.R.E.*, Nov. 1943, Vol. 31, No. 11, pp. 647–648.)

959. "*Mathematical Tables and Aids to Computation*" [Review of First Two Issues (Jan. & April 1943) of New Quarterly issued by National Research Council, U.S.A.].—Archibald (Edited by). (*Phil. Mag.*, Nov. 1943, Vol. 34, No. 238, p. 794.) For the National Bureau of Standards' series of Tables *see* 3187 & 3579 of 1943, and 960, below.

960. NEW MATHEMATICAL TABLES [including MT17 (Planck's Radiation Functions: Electron Velocity, Path-Curvature, etc.): Note on Series dealt with in 3187 & 3579 of 1943].—Nat. Bur. of Standards. (*Electronics*, Sept. 1943, Vol. 16, No. 9, p. 202.)

961. "TABLES OF FUNCTIONS WITH FORMULAE AND CURVES" [1943 Edition (under authority of Alien Property Custodian): Book Reviews].—Jahnke & Emde. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 298 and 299: *Review Scient. Instr.*, Oct. 1943, Vol. 14, No. 10, p. 319: *Proc. I.R.E.*, Oct. 1943, Vol. 31, No. 10, p. 587.)

962. "TABLES OF LEGENDRE ASSOCIATED FUNCTIONS" [Book Notice].—Mursi. (*Phil. Mag.*, Oct. 1943, Vol. 34, No. 237, p. 722.) From the Fouad I University, Cairo.

963. "EMPIRICAL EQUATIONS AND NOMOGRAPHY" [Book Review].—Davis. (*Review Scient. Instr.*, Oct. 1943, Vol. 14, No. 10, pp. 315–316.)

964. "WHAT IS MATHEMATICS?" [Book Review].—Courant & Robbins. (*Distribution of Electricity*, Jan. 1944, Vol. 16, No. 153, pp. 225–226.) "Readers will learn that Mathematics is as fascinating as Music or Literature. They may even come to look upon unfamiliar ideas with sympathy."

965. SOME NEW IDEAS IN MATHEMATICS.—Turnbull. (*Distribution of Electricity*, Oct. 1943, Vol. 16, No. 152, pp. 194–195.)

966. "MATHEMATISCHE INSTRUMENTE" [from the Slide Rule, through Pantographs, Curve-Drawing Devices, Simple Instruments for Approximate Integration, etc., to the Differential Analyser: Book Review].—Meyer zur Capellen. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 24, 1943, p. 95.)

967. ELECTRICAL ANALOGIES TO PHYSICAL PHENOMENA, AND THEIR APPLICATION TO THE SOLUTION OF CERTAIN PROBLEMS OF MATHEMATICAL PHYSICS.—Gutenmacher. (*Journ. of Tech. Phys.* [in Russian], No. 2/3, Vol. 12, 1942, pp. 47–64.)

Supplementing previous papers in other journals, the following method is discussed for representing by electrical analogies complex processes taking place in space and time:—the body in which the processes are taking place is regarded as made up of a large, but finite, number of particles. Each particle and its interaction with other particles is represented by an electric circuit having R, L, and C. The properties of the circuit are mathematically similar to those of the particle under consideration. Thus models can be built up of processes represented by differential equations with partial derivatives and with any number of variables. After the discussion a description is given of an electro-integrator used for solving certain concrete problems.

968. INTEGRATING MACHINES [Survey].—Willers. (*Arch. f. Tech. Messen*, April 1943, Part 142, J081-11, Sheets T47–48.)

969. MECHANICAL INTEGRATION IN ELECTRICAL PROBLEMS [Thirty-Fourth Kelvin Lecture].—Hartree. (*Journ. I.E.E.*, Part I, Oct. 1943, Vol. 90, No. 34, pp. 435–442) Summaries were referred to in 2014 & 2531 of 1943.

970. AN ELLIPTOGRAPH, WITH SUPPLEMENT ON THE EVOLUTE OF THE ELLIPSE AND THE ELASTICA.—Boys. (*Proc. Phys. Soc.*, 1st Nov. 1943, Vol. 55, Part 6, No. 312, pp. 471–481.)

971. DYNAMICAL TRAJECTORIES IN A RESISTING MEDIUM, *and* DYNAMICAL TRAJECTORIES OF THE CURVATURE TYPE.—Kasner: DeCicco. (*Proc. Nat. Acad. Sci.*, Sept. 1943, Vol. 29, No. 9, pp. 263–268: pp. 268–270.) For a combined paper by the two authors on "Union-preserving transformations of differential-elements" *see* pp. 271–275.

972. RELAXATION METHODS APPLIED TO ENGINEERING PROBLEMS: VIII—PLANE-POTENTIAL PROBLEMS INVOLVING SPECIFIED NORMAL GRADIENTS.—Southwell & Vaisey. (*Proc. Roy. Soc.*, Series A, 16th Dec. 1943, Vol. 182, No. 989, pp. 129–151.) For Southwell's book *see* 1028 of 1941.

973. THE RESOLUTION OF BOUNDARY-VALUE PROBLEMS BY MEANS OF THE FINITE FOURIER TRANSFORMATION: GENERAL VIBRATION OF A STRING [Theory of Ordinary Differential Equations applied to Boundary-Value Problems by means of the Finite Sine Transformation & the Finite Cosine Transformation: Applicability to Other Engineering Problems].—Kapfel Brown. (*Journ. Applied Phys.*, Nov. 1943, Vol. 14, No. 11, pp. 609–618.)

974. THEORY OF VIBRATIONS: FORCED MOVEMENTS OF AN OSCILLATOR SUBMITTED TO A FORCE DERIVED FROM A POTENTIAL, TO A RESISTANCE WHICH IS A PASSIVE FUNCTION OF VELOCITY, AND TO AN EXCITATION WHICH IS A SINUSOIDAL FUNCTION OF TIME.—Brard. (*Comptes Rendus* [Paris], 7th/21st Dec. 1942, Vol. 215, No. 23/25, pp. 521–523.) With primary application to the rolling of a ship in a swell.

975. THE TRANSIENT STATE AND THE ANALYSIS OF SHOCK-EXCITATION [with Special Reference to the Applicability of the Fourier Method to the Approximate Shock-Excitation at Ignition in I.C. Engines].—Manley. (*Engineering*, 22nd Oct. & 5th Nov. 1943, Vol. 156, Nos. 4058 & 4060, pp. 321–322 & 361–362.) *See* also a letter from the same writer, on the accuracy of numerical harmonic analysis, *ibid*, 22nd Oct. 1943, p. 335; and correspondence in the issues for 5th & 19th November.

976. PRINCIPLES OF MICRO-WAVE RADIO.—Condon. (*See* 731.)

977. "RADIO ENGINEERS' HANDBOOK" [Book Review].—Terman. (*Proc. I.R.E.*, Nov. 1943, Vol. 31, No. 11, p 649.) Preprints of certain sections were dealt with in 2086 & 2667 of 1943. "Recommended to every radio engineer who is alert to the advances

in his profession and who is anxious to accomplish the best work within limited time."

978. "SCHRIFTEN DER DEUTSCHEN AKADEMIE DER LUFTFAHRTFORSCHUNG" [Nos. 1–53 : Book Review].—(*Zeitschr. f. tech. Phys.*, No. 5, Vol. 24, 1943, p. 123.)

979. "WISSENSCHAFTLICHE VERÖFFENTLICHUNGEN AUS DEN SIEMENS-WERKEN" [Vols. XIX & XX : Book Review].—Siemens Company. (*Naturwiss.*, 21st May 1943, Vol. 31, No. 21/22, pp. 252–254.) All the appropriate papers have been dealt with in past abstracts (between 1940 and 1943).

980. "KURZES LEHRBUCH DER PHYSIK" [Book Review].—Stuart. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 24, 1943, p. 123.) For previous work by this writer *see* 3422 of 1941.

981. "THE AMATEUR SCIENTIST" [with an Appendix on Specimen Projects, including Radio-Ionosphere Research (S.A. Korff) : Book Review].—Thomas. (*Review Scient. Instr.*, Oct. 1943, Vol. 14, No. 10, pp. 298–299.)

982. "PRACTICAL RADIO FOR WAR TRAINING," *and* "BASIC ELECTRICITY FOR COMMUNICATION" [Book Reviews].—Beitman : Timbie. (*Proc. I.R.E.*, Nov. 1943, Vol. 31, No. 11, p. 648 : p. 648.)

983. "FIRST PRINCIPLES OF RADIO COMMUNICATIONS" : *also* "A COURSE IN RADIO FUNDAMENTALS" : *and* "ELEMENTS OF RADIO" [Book Reviews].—Morgan : Grammer : Marcus. (*Proc. I.R.E.*, Oct. 1943, Vol. 31, No. 10, p. 585 : p. 586 : p. 586.)

984. WIRELESS BADGES : RADIO INSIGNIA IN THE FORCES [British & American].—(*Wireless World*, Oct. 1943, Vol. 49, No. 10, pp. 293–296.)

985. THE JAPANESE MORSE RADIOTELEGRAPH CODE : WHAT IT IS AND HOW IT IS TRANSCRIBED.—Holden. (*QST*, Oct. 1943, Vol. 27, No. 10, pp. 30–33.) For severe criticism *see* November issue, No. 11, pp. 56–57.

986. COMMUNICATION AND INVASION.—(*Bell Lab. Record*, Nov. 1943, Vol. 22, No. 3, pp. 123–126.)

987. HOW ELECTRONIC EQUIPMENT AIDS INVASION FORCES [based on Experience in Sicily].—U.S. Signal Corps. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 212..220.)

988. RADIO PRODUCTION FOR THE ARMED FORCES [including the Very Special Requirements and the Reason for the More Elaborate Specifications & the Strict Standardisation : the Rôle of Research : etc.].—Hooper. (*Proc. I.R.E.*, Nov. 1943, Vol. 31, No. 11, pp. 640–642.) "In the first World War our radio and sound production just about equalled one week's production in World War II."

989. SEA-RESCUE TRANSMITTER ["Gibson Girl" Outfit of Hand-Powered Unit, etc.].—Bendix Aviation. (*Electronics*, Sept. 1943, Vol. 16, No. 9, Cover : *see* also p. 209.)

990. DIVING AMPLIFIER [for Communication with Tender].—Gellerup. (*See* 837.)

991. ELECTRONIC PRODUCTION IDEAS WIN WPB AWARDS [Gadget to prevent Breakage of Transmitting Valves during Assembly : Fibre-Glass Sleeves to prevent Burn-Out of Induction-Heating Coils : etc.].—(*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 224 and 226.)

992. STALIN PRIZES [1941 Awards].—(*Journ. of Phys.* [of USSR], No. 6, Vol. 4, 1941, pp. 573–574 : in English.) In the "inventions" category, second prizes were awarded for an "aeroplane detecting device" and "a new type of thermic direction finder." For 1942 Awards *see* 2266 of 1943.

993. THE WAY AND SPIRIT OF SCIENCE [Abridged Translation of Address posted in Chinese Government Laboratories & Workshops].—Generalissimo Chiang Kai-Shek. (*Nature*, 14th Aug. 1943, Vol. 152, No. 3850, pp. 180–182.)

994. INITIATIVE IN RESEARCH [illustrated by the History of the Development of Dumet Wire as Substitute for Platinum Leading-In Wire, etc.].—Fink. (*Science*, 9th July 1943, Vol. 98, No. 2532, pp. 28–31.)

995. COOPERATION IN SCIENTIFIC RESEARCH IN THE BRITISH EMPIRE [Leading Article on the Report of the British Commonwealth Science Committee : including the Question of the Rationalisation of Scientific Abstracting].—(*Nature*, 10th July 1943, Vol. 152, No. 3845, pp. 29–31.)

996. INDUSTRY, RESEARCH AND EDUCATION IN GREAT BRITAIN [Leading Article on Recent Debate, Memorandum, Articles, etc.].—(*Nature*, 20th Nov. 1943, Vol. 152, No. 3864, pp. 579–581.)

997. THE ORGANISATION OF POST-WAR ELECTRICAL RESEARCH : INCORPORATING A SUGGESTED OUTLINE OF A BRITISH ELECTRICAL RESEARCH BOARD.—I.E.E. Post-War Planning Committee. (*Journ. I.E.E.*, Part I, July 1943, Vol. 90, No. 31, pp. 261–263.) *Cf.* 2620 of 1943.

998. SCIENTIFIC PERSONNEL IN INDUSTRY [Leading Article on F.B.I. Report, Courtauld's *Times* Article, etc.].—(*Nature*, 1st Jan. 1944, Vol. 153, No. 3870, pp. 3–5.)

999. THE FREEDOMS OF SCIENCE [and the Need for More Central Planning of Science for Peace].—Watson-Watt. (*Nature*, 6th Nov. 1943, Vol. 152, No. 3862, pp. 543–544 : summary of address.)

1000. "THE PLANNING OF SCIENCE" [Conference Report : Book Review].—Assoc. of Scientific Workers. (*Proc. Phys. Soc.*, 1st Nov. 1943, Vol. 55, Part 6, No. 312, p. 514.)

1001. RESEARCH LABORATORIES IN INDUSTRIES.—Buckley. (*Science*, 31st July 1942, Vol. 96, No. 2483, pp. 100–102.) From the President, Bell Telephone Laboratories.

1002. SCIENCE IN TWO COUNTRIES : A NEW ALLIANCE—IMPERIAL COLLEGE AND "M.I.T."—Southwell. (*The Times*, 14th Jan. 1944, p. 5.) A leader is on the same page.

1003. RESEARCH IN THE UNITED STATES [Summary of Statement to Parliamentary & Scientific Committee].—Simon. (*Nature*, 19th June 1943, Vol. 151, No. 3842, p. 693.)

1004. ORGANISATION OF SCIENTIFIC AND INDUSTRIAL RESEARCH IN INDIA [Summary of Two Articles in *Science & Culture*, July 1943, Vol. 9, No. 1].—(*Nature*, 27th Nov. 1943, Vol. 152, No. 3865, p. 639.) Defects of the present organisation and proposals for reform.

1005. RESEARCH: A GENERAL SURVEY.—Roskill. (*Engineering*, 1st, 8th, 15th, 22nd, & 29th Oct. and 5th & 12th Nov. 1943, Vol. 156, Nos. 4055/4061, pp. 263 etc.) For a leading article on this, on Hartley's brochure, on the Larke Committee pamphlet, and on the Parliamentary & Scientific Committee's proposals, *see* issue of 29th October, pp. 351–352.

1006. RESEARCH: A GENERAL SURVEY [Letter on the Need for Drastic Overhaul of Income-Tax Law regarding Research Expenditure & "Unearned" Royalty Income].—Hajnal-Kónyi. (*Engineering*, 12th Nov. 1943, Vol. 156, No. 4061, p. 394.) Prompted by the statement in 1005, above, that "a drastic overhaul of the existing patent law is required," and pointing out what may be a still more adverse influence on research. Cf. *Nature*, 15th Jan. 1944, Vol. 153, p. 76.

1007. INVENTION OR RESEARCH?—Macdonald. (*Engineer*, 19th Nov. 1943, Vol. 176, No. 4584, p. 409.) "The principal inventions upon which modern industrial development is founded were all made independently of scientific research" (Hatfield).

1008. INVENTORS AND EMPLOYERS [Report adopted by Council of the Chartered Institute of Patent Agents].—(*Engineering*, 5th Nov. 1943, Vol. 156, No. 4060, pp. 375–376.)

1009. PATENT SITUATION [Urgent Need for Prolongation of Period to 17 Years, for Patents issued before & during the War].—Holtzman. (*Electronics*, Sept. 1943, Vol. 16, No. 9, p. 304.)

1010. ENEMY-OWNED PATENTS [available to American Industry].—Chireix & others. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 182..188.)

(i) Land-mine locator (H. Chireix): (ii) v.h.f. coupling device giving sine-law coupling with one-turn stator and rotor, for d.f., attenuators, etc. (R. Hardy & P. de Maertelaere: rotor consists of two cut-away hemispherical shells): (iii) secret communication (B. Tenenbaum: several frequencies, quartz-controlled, in succession: particularly suitable for waves below 1 m, when special Lecher systems, of concentric type, are used): (iv) preventing re-radiation from superheterodynes (W. Dällenbach, A. Allerding, & E. Huttmann: balanced mixing-valve coupling method for waves below 1 m): (v) large-screen television projection (H. Strubig: optical storage method, based on colour-changes in alkaline-earth halides under electron-beam irradiation: intermediate-film renewed by image-cancellation: and a variant resembling the Skiatron—3501 of 1940).

1011. THE BRITISH SCIENTIFIC INSTRUMENT INDUSTRY [Leading Article on Handbook of the Scientific Instrument Manufacturers' Association of Great Britain].—(*Nature*, 18th Dec. 1943, Vol. 152, No. 3868, pp. 704–706.)

1012. INSTITUTION OF ELECTRICAL ENGINEERS: NEW SCHEME OF INVITATIONS TO MEETINGS FOR NON-MEMBERS.—"Diallist." (*Wireless World*, Dec. 1943, Vol. 49, No. 12, p. 382.)

1013. A NATIONAL HEADQUARTERS FOR PHYSICISTS: THE AMERICAN INSTITUTE OF PHYSICS BUILDING [Martin Erdmann Residence, New York City].—(*Journ. Applied Phys.*, Oct. 1943, Vol. 14, No. 10, pp. 499–509.)

1014. FUTURE OF TECHNICAL COLLEGES.—Lowery. (*Nature*, 21st Aug. 1943, Vol. 152, No. 3851, p. 218.)

1015. THE FUTURE OF TECHNICAL COLLEGES [Leading Article on Recent Correspondence & Publications], *and* A TECHNOLOGIST LOOKS AT THE FUTURE [Address by C. R. Burch].—(*Nature*, 6th Nov. 1943, Vol. 152, No. 3862, pp. 519–520: pp. 523–525.)

1016. THE ROYAL OBSERVATORY, GREENWICH: ANNUAL REPORT [Summary].—(*Nature*, 11th Dec. 1943, Vol. 152, No. 3867, pp. 700–701.)

1017. HISTORIC FIRSTS: LONG-DISTANCE RADIO TELEPHONY [Arlington/Paris, 1915].—(*Bell Lab. Record*, Sept. 1943, Vol. 22, No. 1, p. 5.)

1018. DID MARCONI INVENT RADIO? [Supreme Court's Decision of June 1943 did Not affect Basic Patent].—Stewart. (*QST*, Oct. 1943, Vol. 27, No. 10, pp. 64 and 84..88.) Prompted by an article in the August issue.

1019. ARCHITECTURAL THREAT TO AMATEUR RADIO [No Aerials permitted in Model City of Greenbelt].—Versace. (*QST*, Oct. 1943, Vol. 27, No. 10, pp. 62–63.) Prompted by a publication of the International Congress of Modern Architecture.

1020. THE COMING-OF-AGE OF BROADCASTING.—Hibberd. (*Journ. Roy. Soc. Arts*, 24th Dec. 1943, Vol. 92, No. 4655, pp. 46–54: Discussion pp. 54–55.)

1021. PROGRAMME QUALITY ANALYSER [Listeners' Reactions studied by testing Six or more Groups of 10 "Typical" Listeners provided with "Good" & "Bad" Push-Buttons: Psychological Analysis of Recorded Curves].—Columbia Broadcasting System. (*Electronics*, Sept. 1943, Vol. 16, No. 9, p. 168.)

1022. INK *versus* PENCIL TRACINGS [Successful Use of Pencil Tracings: Offer of Information].—Worthington Pump & Machinery. (*Engineering*, 29th Oct. 1943, Vol. 156, No. 4059, p. 355.) *See* also issues for 3rd and 17th December, pp. 454 & 494.

1023. MICROFILMING TECHNICAL LITERATURE [with Particular Reference to the British Council's Service for China].—British Council. (*Engineer*, 29th Oct. 1943, Vol. 176, No. 4581, p. 347.)

1024. THE COMPILATION OF TECHNICAL PAPERS AND LECTURES.—Wilson. (*BEAMA Journal*, Sept. 1943, Vol. 50, No. 75, p. 263: summary only.)

1025. "THE READER OVER YOUR SHOULDER: A HANDBOOK FOR WRITERS OF ENGLISH PROSE" [Book Review].—Graves & Hodge. (*Nature*, 4th Dec. 1943, Vol. 152, No. 3866, pp. 645–647.)

1026. NEED FOR TECHNICAL CORRECTION [Hopes for a Post-War Committee for Prevention of "Gaffes" and Ugly & Unnecessarily Complicated Technical Terms].—"Supervisor." (*Electrician*, 3rd Dec. 1943, Vol. 131, No. 3418, pp. 562–563.)

1027. SCIENTIFIC TERMINOLOGY IN INDIAN LANGUAGES [and the Madras Committee].—(*Current Science* [Bangalore], Oct. 1941, Vol. 10, No. 10, pp. 425–431.)

1028. AN INTERNATIONAL INFORMATION COUNCIL [Substance of a Paper on "A Plan for Mobilising Bibliographical References to the Contents of the World's Non-Fiction Literature"].—Pollard. (*Nature*, 6th Nov. 1943, Vol. 152, No. 3862, pp. 541–542.)

1029. THE IMPERIAL AGRICULTURAL BUREAUX [an Example of Cooperation: Leading Article].—(*Nature*, 25th Dec. 1943, Vol. 152, No. 3869, pp. 731–733.)

1030. ACTION BY THE JOINT COMMITTEE ON INDEXING AND ABSTRACTING IN THE MAJOR FIELDS OF RESEARCH.—(*Science*, 19th June 1942, Vol. 95, No. 2477, p. 622: paragraph only.)

1031. TRANSLITERATION OF ENGLISH NAMES INTO RUSSIAN—Krotkov. (*Science*, 15th Oct. 1943, Vol. 98, No. 2546, pp. 344–345.) For previous correspondence *see* 647 of February: *also* issue for 1st Oct. 1943, p. 302.

1032. "GERMAN FOR THE SCIENTIST (CHEMIST AND PHYSICIST)" [Book Review].—Wiener. (*Nature*, 10th July 1943, Vol. 152, No. 3845, p. 35.) "Intended to enable the science student to acquire a reading knowledge of scientific German in a short time."

1033. "THE PUBLIC LIBRARY SERVICE: ITS POST-WAR REORGANISATION AND DEVELOPMENT" [Book Review].—Library Association. (*Nature*, 25th Dec. 1943, Vol. 152, No. 3869, pp. 733–734.)

1034. SOME NOTES ON THE ENGINEER-IN-CHIEF'S LIBRARY.—Wright. (*P.O. Elec. Eng. Journ.*, Oct. 1943, Vol. 36, Part 3, pp. 71–75.)

1035. RADIO *versus* INDUSTRIAL SYMBOLS ["Failure to Standardise on One Set of Symbols for both Communications & Industrial Gear will Multiply the Possibilities of Error": Editorial].—(*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 94–95.)

1036. ELECTRONIC APPLICATIONS.—Gillmor. (*Proc. I.R.E.*, Oct. 1943, Vol. 31, No. 10, p. 527.)

From the President of the Sperry Gyroscope Company. "We never entered the electronic business as a distinct field. Electronics, on the other hand, entered our business, and our products have been vastly improved by its applications. We see no end in sight of utilising more and more applications of this new tool. . . ." *See* for example 1041, below.

1037. SOME COMMENTS ON POST-WAR ELECTRONICS.—Billings. (*Proc. I.R.E.*, Nov. 1943, Vol. 31, No. 11, pp. 592–593.)

"With sane and sensible planning . . . it will not be necessary to curtail either personnel or existing facilities." "Navigational aids and equipment have received a tremendous impetus." "Industrial electronics have just begun to scratch the surface." "The strictly communication field has been greatly expanded." From the President, Belmont Radio.

1038. ANALYSIS OF THE RADIO-AND-ELECTRONIC FIELD [Future Developments in Communication, H.F. Heating, Telemetering & Other Carrier-Current Applications, Dynetic Balancing, Mass Spectrometers, Micrometers, Industrial X-Rays, etc.].—Madsen. (*Proc. I.R.E.*, Nov. 1943, Vol. 31, No. 11, pp. 644–645: extracts only.)

From the Westinghouse Company. "It is important that we 'keep our feet on the ground' lest the electronic field again be smothered by adverse publicity caused by misapplication."

1039. ELECTRONICS IN MODERN ENGINEERING: PARTS I AND II.—Blakey. (*BEAMA Journal*, Dec. 1943, Vol. 50, No. 78, p. 402: summary only.) "It became obvious [to the author, after many conversations with engineers in many industries] . . . that a fundamental approach must be made to the problem and couched in terms and language understandable to engineers. . . ."

1040. "APPLIED ELECTRONICS" [Book Review].—Staff of M.I.T. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 284..286.) For a previous review *see* 3195 of 1943: and *see* also *Journ. Applied Phys.*, Nov. 1943, Vol. 14, No. 11, pp. 565–566.

1041. ELECTRONIC INSTRUMENT INDICATOR AIDS PILOTS [Four-Trace Cathode-Ray "Flightray" Indicator].—Gemmill: Sperry Gyroscope. (*Sci. News Letter*, 13th Nov. 1943, Vol. 44, No. 20, p. 313.) Referred to in 563 of 1939.

1042. SENDING TRAIN ORDERS BY FACSIMILE TELEGRAPHY.—Western Union. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 148..154.) From the paper dealt with in 3080 of 1943.

1043. NEW TEST OF FATIGUE [primarily for Pilots: Neurometer consisting of Specially Designed Tuning Fork held against Finger Tips].—Roth. (*Sci. News Letter*, 16th Oct. 1943, Vol. 44, No. 16, p. 245.)

1044. ELECTRONIC CONTROL OF D.C. MOTORS: PARTS IV AND V [Starting, Filtering, Anti-Hunting, Reversing, Regeneration by Inverter Action, etc.].—Moyer. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 133–138 and 281..283: Oct. 1943, No. 10, pp. 128–133 and 312..316.) For previous parts *see* 343 of January.

1045. SOME NEW APPLICATIONS OF CHAIN CIRCUITS [for Retardation in Measuring & Automatic-Control Circuits], *and* THE USE OF THE RETARDATION EFFECT IN A CHAIN CIRCUIT FOR IMPROVING DIRECTIONAL PROTECTION [and a New Design of Relay with Several Advantages].—Gutenmacher: Gutenmacher & Drozdov. (*See* 780 & 781.)

1046. FRICTIONAL PHENOMENA: XVI—TECHNICAL APPLICATIONS OF EXTERNAL FRICTION OF SOLIDS [including Clutches, Dampers, the Bowing of a Violin, and the Elimination of Relay Chatter (*cf.* "Bounceless Ball," 1499 of 1943)].—Gemant. (*Journ. Applied Phys.*, Oct. 1943, Vol. 14, No. 10, pp. 510–521.)

1047. WELDING MONITOR [for training Welding Students in judging Correct Arc Length].—(*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 142 and 146, 148.)

1048. "ELECTRONIC CONTROL OF RESISTANCE WELDING" [Book Review].—Chute. (*Review Scient. Instr.*, Oct. 1943, Vol. 14, No. 10, pp. 312–313.)

1049. A SIMPLE TEMPERATURE CONTROL FOR LABORATORY ELECTRIC FURNACES.—Hirst & Cannon. (*Journ. of Scient. Instr.*, Aug. 1943, Vol. 20, No. 8, pp. 129–132.)

1050. A BRIDGE-CONTROLLED RELAY CIRCUIT [for Control of Humidity and Many Other Applications].—Andrews. (*See* 782.)

1051. Remote Adjustment of Synchronous Clocks.—Leeman. (*Electronics*, Sept. 1943, Vol. 16, No. 9, pp. 158 and 160.)

1052. A Variable-Frequency Electronic Generator [giving 1400 W over Range 300–3500 c/s: Many Applications, including Testing of Radio & Radar Apparatus].—Griffin. (*See* 870.)

1053. An Electrical Tube Gauge [Electro-Magnetic Device for Semi-Skilled Testing of Air-Heater Tubes in Boiler-House Operation].—Fawssett. (*Engineering*, 15th Oct. 1943, Vol. 156, No. 4057, pp. 301–302.) *Cf.* 3636 of 1943.

1054. Electro-Magnetic Concrete Elongation Meter and Earth-Pressure Pick-Up [Portable Equipment].—Fuchs. (*Elektrot. u. Masch:bau*, 9th May 1941, Vol. 59, No. 19/20, pp. 224–226.)

1055. The Measurement of Rapidly Varying Mechanical Quantities [Survey of Vibrometers, Engine Indicators, etc.].—Geiger. (*Elektrot. u. Masch:bau*, 25th April 1941, Vol. 59, No. 17/18, pp. 190–201.)

1056. Recording Audio Analyser [Western Electric Model RA-281 (for Frequencies 10–9500 c/s) for Noise & Vibration Study].—Western Electric. (*Electronics*, July 1943, Vol. 16, No. 7, pp. 100–103 and 210.)

1057. The Design of Vibration Pick-Up Units [R.A.E. Vibrograph, Sperry and Mullard Pick-Ups, and a Suggested Improved Design using Much Higher Damping Factor & Natural Frequency].—Postlethwaite. (*Engineering*, 5th Nov. 1943, Vol. 156, No. 4060, pp. 362–364.)

1058. A Hydrostatically Supported Cloud Chamber of New Design for Operation at High Pressures.—Johnson & others. (*Review Scient. Instr.*, Sept. 1943, Vol. 14, No. 9, pp. 265–271.)

1059. Use of Radon to Trace the Flow Pattern of Gases in Furnaces.—Mayorcas & Thring. (*Nature*, 18th Dec. 1943, Vol. 152, No. 3868, pp. 723–724.)

1060. Mass Spectrometer for Butadiene Analysis.—Hipple. (*Electronics*, Sept. 1943, Vol. 16, No. 9, p. 142.) *See* also 2280 of 1943.

1061. A New Method of Recording Gas Analysis with the Help of the Absorption of Infra-Red Rays without Spectrum Analysis [making Use of the Selective Heating of the Gas to operate a Capacity-Change Pick-Up and thereby the Recording Instrument].—Luft. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 24, 1943, pp. 97–104.)

1062. Certain Germs [feeding on Hydrocarbons, and detected by Spectrum Analysis] help in locating Oil Deposits.—Blau: Standard Oil Development. (*Sci. News Letter*, 2nd Oct. 1943, Vol. 44, No. 14, p. 217.)

1063. "Bibliography of the Dropping Mercury Electrode" [Book Review].—Leeds & Northrup Company. (*Electronics*, Sept. 1943, Vol. 16, No. 9, p. 188.)

1064. The Barnstead Purity Meter [for Distilled Water].—Fisher Scientific. (*Review Scient. Instr.*, Sept. 1943, Vol. 14, No. 9, p. 279.) *Cf.* the Dec. 1943 *Scientific American*, p. 258.

1065. Zinc-Oxide Smoke as a Reference Standard in Electron Wavelength Calibration [in Electron-Diffraction Investigations].—Lu & Malmberg. (*Review Scient. Instr.*, Sept. 1943, Vol. 14, No. 9, pp. 271–273.)

1066. Divergent-Beam X-Ray Photography [and Its Possible Applications, including Rapid Selection of Diamonds].—Lonsdale. (*Nature*, 1st Jan. 1944, Vol. 153, No. 3870, pp. 22–23.)

1067. X-Rays from Radio Tubes [Effective Apparatus assembled at Cost of Six or Seven Dollars].—Brinker. (*Science*, 19th June 1942, Vol. 95, No. 2477, p. 634.)

1068. Stable Self-Quenching Geiger-Müller Counters containing Organo-Metallic Compounds [particularly Tetramethyl Lead Vapour: with Wide Voltage Ranges where Count is practically Independent of Voltage].—Keston. (*Review Scient. Instr.*, Oct. 1943, Vol. 14, No. 10, pp. 293–295.)

1069. Radio-Frequency Heating speeds Plastic Moulding.—Taylor. (*See* 907.)

1070. Radio "Nails" in the Assembly of Plywood [Intense Heat in Narrow Beam of Pistol-Shaped "Radio Nailer" melts Glue between Sheets, producing Spots that hold like Pins].—(*QST*, Nov. 1943, Vol. 27, No. 11, p. 52.)

1071. Better Food Dehydration through Use of Radio-Frequency Energy [Moisture Content reduced to 1%].—Sherman. (*Sci. News Letter*, 28th Aug. 1943, Vol. 44, No. 9, p. 132.) *See* also 711 of February and back references.

1072. Radio-Frequency Heating applied to Wood Gluing [Introduction: Thermosetting Glues: Dielectric Heating (with Formulae): Wood as a Dielectric (and Simplified Approximate Formulae and Curves): Coupling Problems (Electrode Arrangements, Coupling Networks to Reduce the Effects of Load Variations, Elimination of Standing Waves on Large Presses): Measurement of Temperature at the Glue Line].—Bierwirth & Hoyler. (*Proc. I.R.E.*, Oct. 1943, Vol. 31, No. 10, pp. 529–537.) From the R.C.A. Laboratories.

1073. Heat-Conduction Problems in Presses used for Gluing of Wood [a Theoretical Investigation: the Differential Equation of Heat Conduction: the Case of Hot-Plate Presses: Solution of Heat-Flow Equations when Heat is Generated within the Wood: Conclusions].—Brown. (*Proc. I.R.E.*, Oct. 1943, Vol. 31, No. 10, pp. 537–548.) A companion paper to 1072, above.

1074. The Biological Application of Focused Ultrasonic Waves.—Lynn, Zwemer, & Chick. (*Science*, 31st July 1943, Vol. 96, No. 2483, pp. 119–120.) *See* also 514 of February.

1075. Effect of Frequency on Let-Go Currents, *and* Effect of Wave-Form on Let-Go Currents.—Dalziel & others. (*Elec. Engineering*, Aug. 1943, Vol. 62, No. 8, p. 376: p. 376: summaries only.) For earlier work *see* 289 of 1943.

1076. Accidents due to Electricity, in Switzerland during 1942.—Sibler. (*Bull. Assoc. Suisse des Élec.*, 16th June 1943, Vol. 34, No. 12, pp. 329–335: in French.)

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1078. LOCATING BURIED CABLES ELECTRICALLY [before Ploughing to lay Shield Wires: the Cable-Depth Indicator].—Greenidge. (*Bell Lab. Record*, Nov. 1943, Vol. 22, No. 3, pp. 106–109.)

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1080. THE PERIODIC VARIATIONS OF THE GRAVITATIONAL FORCE [Recorded Curves compared with Those obtained from Calculations on a Rigid-Earth Theory: Possible Interpretations of the Differences].—Lockenvitz. (*Geophysics*, July 1943, Vol. 8, No. 3, pp. 325–326: short summary only.)

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1084. ESSENTIALS OF WALKING ARE STUDIED WITH OSCILLOGRAPH [by Pressure-Responsive Resistance Discs & Twelve-Element Mirror-Type Oscillograph (which has also been used for Muscle Action-Current Curves)].—(*Electronics*, June 1943, Vol. 16, No. 6, pp. 264 and 266.)

1085. MEASURING ROTATIONAL SPEEDS WITH STROBOSCOPIC PATTERNS.—MacInnes. (*Electronics*, April 1943, Vol. 16, No. 4, pp. 166 and 168.) Summarised from *Review Scient. Instr.*, Jan. 1943.

1086. PRECISION STROBOSCOPIC FREQUENCY-METER [primarily for Piano & Organ Tuning, etc.].—Kent. (*See* 847.)

1087. A PHOTOELECTRIC TORSIOGRAPH [on Stroboscopic Principle, with C.R.O. Observation of Phototube Current].—Spillmann. (*Journ. Roy. Aeron. Soc.*, Dec. 1943, Vol. 47, No. 396, pp. 689–690: an R.T.P.3 Abstract.) *See* also 269 of 1943.

1088. AN INEXPENSIVE STROBOSCOPE [Edgerton Type] FOR HIGH-SPEED PHOTOGRAPHY [Rates up to 300 per Second], *and* HIGH-SPEED FLASHLIGHT [for One-Millionth-Second Exposures: *see* also 381 of January].—Silverman & Warhus: General Electric. (*Review Scient. Instr.*, Sept. 1943, Vol. 14, No. 9, pp. 273–275: pp. 278–279.)

1089. PHOTOGRAPHIC ANALYSIS OF MOTION [Substance of R.I. "Friday Discourse"], *and* FASTAX: AN ULTRA-HIGH-SPEED MOTION-PICTURE CAMERA [Continuous-Motion Type with Rotating Prism: Time-Magnifications up to 500 : 1 when projected at 16 Pictures per Second: 8-mm and 16-mm Models].—Davies: Smith. (*Nature*, 4th Sept. 1943, Vol. 152, No. 3853, pp. 261–264: *Bell Lab. Record*, Sept. 1943, Vol. 22, No. 1, pp. 1–4.)

1090. NOTE ON IMAGE FORMATION BY ROTATING MIRRORS.—Smith. (*Proc. Phys. Soc.*, 1st May 1943, Vol. 55, Part 3, No. 309, pp. 210–214.)

1091. PHOTOGRAPHY AS A SCIENTIFIC INSTRUMENT [Summaries of Papers at First Meeting of the Association for Scientific Photography (2288 of 1943)].—(*Nature*, 26th June 1943, Vol. 151, No. 3843, pp. 718–721.)

1092. "WISSENSCHAFTLICHE PHOTOGRAPHIE" [Third Edition: Book Review].—von Angerer. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 24, 1943, p. 95.) The importance of this work is indicated by the appearance of this new edition in spite of the war.

1093. PRINCIPLES OF THE USE OF NON-REFLECTING FILMS IN OPTICAL INSTRUMENTS.—Greenland. (*Nature*, 11th Sept. 1943, Vol. 152, No. 3854, pp. 290–292.)

1094. OPTICAL PHYSICS IN THE U.S.S.R.—Frisch. (*Journ. Opt. Soc. Am.*, Nov. 1943, Vol. 33, No. 11, pp. 637–639.)

Including the discovery of the Raman effect, simultaneously with Raman, by Mandelstam & Landsberg; Vavilov's work on fluorescence, its extinction, and its polarisation; also on weak light streams and their fluctuations; and Cherenkov's discovery of a new kind of light radiation [*cf.* Ginsburg, 620 of February, and back references].

1095. INFRA-RED RADIATION [including Short Sections on Liquid Helium as a Generator of 2–10 mm Microwaves (and Its Limitations), Transmission through Fog, Power from Ice Water, etc.].—Beese. (*Science*, 19th June 1942, Vol. 95, No. 2477, pp. 614–617.)

1096. THE PHOSPHORESCENCE MICROSCOPE OPENS A NEW FIELD OF RESEARCH.—Harvey & Chase. (*Sci. News Letter*, 13th Nov. 1943, Vol. 44, No. 20, p. 309: *Science*, 22nd Oct. 1943, Vol. 98, No. 2547, Supp. p. 8.)

1097. ON THE PENETRATION OF TOTALLY REFLECTED LIGHT INTO THE LESS DENSE MEDIUM [Experimental Investigation of a Plane Right-Angled Prism touching the Slightly Convex Surface of Another Right-Angled Prism: Disappearance of Newton's Rings at Total Reflection, and Formation of a "Central Spot," much Larger than the Surface of Contact: Investigation of This Spot: an Interference Effect].—Goos & Hänchen. (*Ann. der Phys.*, 23rd Oct. 1943, Vol. 43, No. 5, pp. 383–392.) For the use of an arrangement somewhat resembling this, for "speech-on-light" signalling, *see* 3613 of 1943.

1098. SEEING THROUGH FOG.—Holmes. (*See* 755.)

1099. GROUND-GLASS DISCS [and the Relations between Diameter & Curvature of the Granulations and the Optical Properties, etc.].—Hansen. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 24, 1943, pp. 104–111.) From the Zeiss laboratories.

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