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CONTENTS

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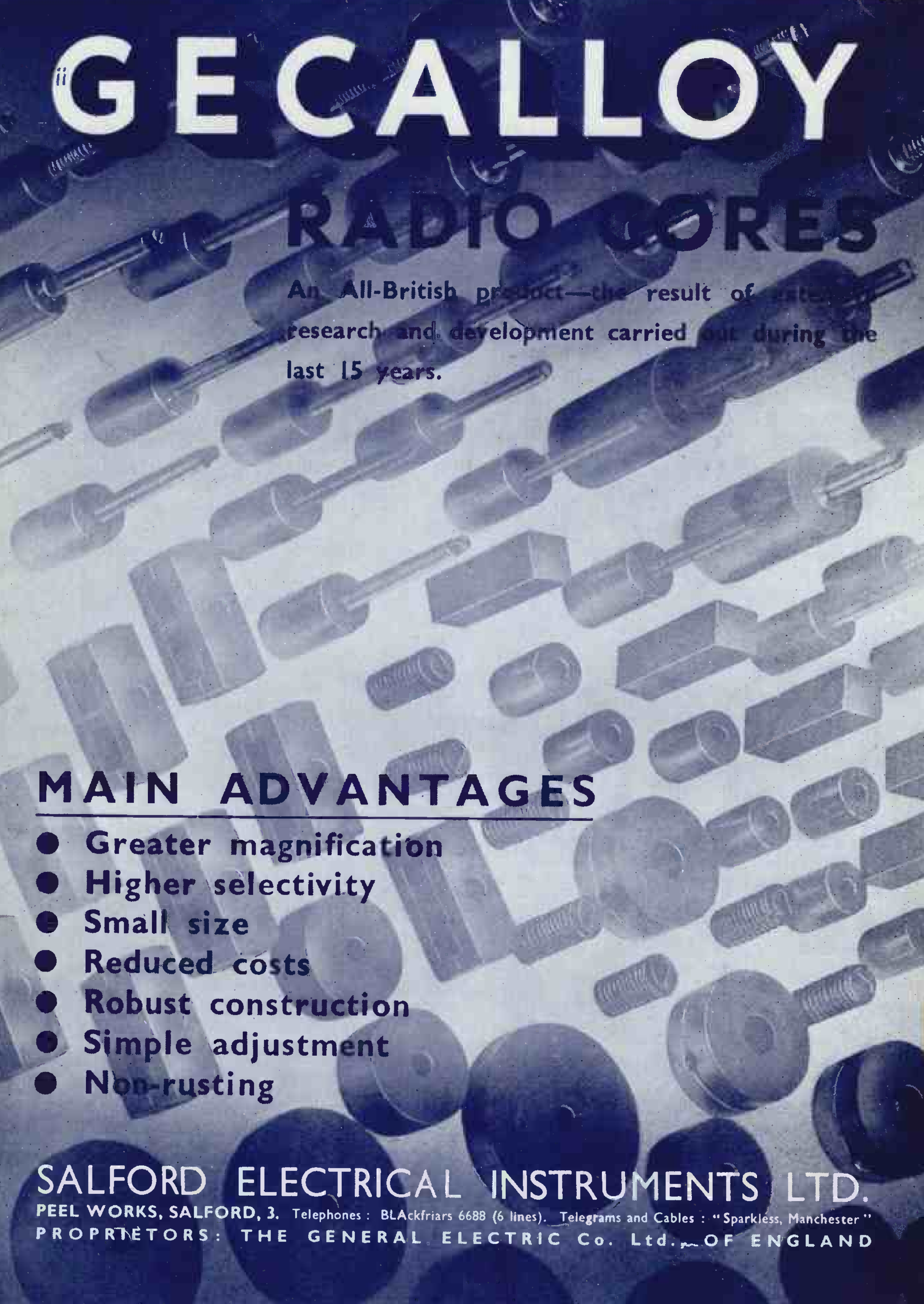
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WHY ERSIN MULTICORE

the Solder wire with 3 cores of non-corrosive **ERSIN FLUX** is preferred by the majority of firms manufacturing the best radio and electrical equipment under Government Contracts.

WHY THEY USE CORED SOLDER

Cored solder is in the form of a wire or tube containing one or more cores of flux. Its principal advantages over stick solder and a separate flux are:

(a) it obviates need for separate fluxing (b) if the correct proportion of flux is contained in cored solder wire the correct amount is automatically applied to the joint when the solder wire is melted. This is important in wartime when unskilled labour is employed.

WHY THEY PREFER MULTICORE SOLDER. 3 Cores—Easier Melting
Multicore Solder wire contains 3 cores of flux to ensure flux continuity. In Multicore there is always sufficient proportion of flux to solder. If only two cores were filled with flux, satisfactory joints are obtained. In practice, the care with which Multicore Solder is made means that there are always 3 cores of flux evenly distributed over the cross section of the solder, so making thinner solder walls than single cored solder, thus giving more rapid melting and speeding up soldering.

ERSIN FLUX

For soldering radio and electrical equipment non-corrosive flux should be employed. For this reason either pure resin is specified by Government Departments as the flux to be used, or the flux residue must be pure resin. Resin is a comparatively non-active flux and gives poor results on oxidised, dirty or "difficult" surfaces such as nickel. The flux in the cores of Multicore is "Ersin"—a pure, high-grade resin subjected to chemical process to increase its fluxing action without impairing its non-corrosive and protective properties. The activating agent added by this process is dissipated during the soldering operation and the flux residue is pure resin. Ersin Multicore Solder is approved by A.I.D., G.P.O., and other Ministries where resin cored solder is specified.

PRACTICAL SOLDERING TEST OF FLUXES

The illustration shows the result of a practical test made using nickel-plated spade tags and bare copper braid. The parts were heated in air to 250° C, and to identical specimens were applied ½" lengths of 14 S.W.G. 40/60 solder. To sample A, single cored solder with resin flux was applied. The solder fused only at point of contact without spreading. A dry joint resulted, having poor mechanical strength and high electrical resistance. To sample B, Ersin Multicore Solder was applied, and the solder spread evenly over both nickel and copper surfaces, giving a sound mechanical and electrical joint.

ECONOMY OF USING ERSIN MULTICORE SOLDER

The initial cost of Ersin Multicore Solder per lb. or per cwt. when compared with stick solder is greater. Ordinary solder involves only melting and casting, whereas high chemical skill is required for the manufacture of the Ersin flux and engineering skill for the Multicore Solder incorporating the 3 cores of Ersin Flux. However, for the majority of soldering processes in electrical and radio equipment Multicore Solder will show a considerable saving in cost, both in material and labour time, as compared either with stick solder or single cored solder. Cored solder ensures that the solder and flux are put just where they are required, and by choice of suitable gauge, economy in use of material is obtained. The quick wetting of the Ersin flux as compared with resin flux in single core resin solder ensures that with the correct temperature and reasonably clean surface, immediate alloying will be obtained, and no portions of solder will drop off the job and be wasted. Even an unskilled worker, provided with irons of correct temperature, is able to use every inch of Multicore Solder without waste.

ALLOYS

Soft solders are made in various alloys of tin and lead, the tin content usually being specified first, i.e. 40/60 alloy means an alloy containining 40% tin and 60% lead. The need for conserving tin has led the Government to restrict the proportion of tin in solders of all kinds. Thus, the highest tin content permitted for Government contracts without a special licence is 45/55 alloy. The radio and electrical industry previously used large quantities of 60/40 alloy, and lowering of tin content has meant that the melting point of the solder has risen. The chart below gives approximate melting points and recommended bit temperatures.

ALLOY Tin Lead	Equivalent B.S. Grade	Solidus C.°	Liquidus C.°	Recommended bit Temperature C.°
45/55	M	183°	227°	267°
40/60	C	183°	238°	278°
30/70	D	183°	257°	297°
18.5/81.5	N	187°	277°	317°

VIRGIN METALS—ANTIMONY FREE

The wider use of zinc plated components in radio and electrical equipment has made it advantageous to use solder which is antimony free, and thus Multicore Solder is now made from virgin metals to B.S. Specification 219/1942 but without the antimony content.

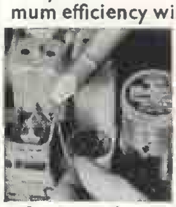
IMPORTANCE OF CORRECT GAUGE

Ersin Multicore Solder Wire is made in gauges from 10 S.W.G. (.128″—3.251 m/ms) to 22 S.W.G. (.028″—.711 m/ms). The choice of a suitable gauge for the majority of the soldering undertaken by a manufacturer results in considerable saving. Many firms previously using 14 S.W.G. have found they can save approximately 33⅓%, or even more by using 16 S.W.G. The table gives the approximate lengths per lb. in feet of Ersin Multicore Solder in a representative alloy, 40/60.

S.W.G.	10	13	14	16	18	22
Feet per lb.	23	44.5	58.9	92.1	163.5	481

CORRECT SOLDERING TECHNIQUE

Ersin Multicore Solder Wire should be applied simultaneously with the iron, to the component. By this means maximum efficiency will be obtained from the Ersin flux contained in the 3 cores of the Ersin Multicore Solder Wire. It should only be applied direct to the iron to tin it. The iron should not be used as a means of carrying the solder to the joints. When possible, the solder wire should be applied to the component and the bit placed on top, the solder should not be "pushed in" to the side of the bit.



ERSIN MULTICORE SOLDER WIRE is now restricted to firms on Government Contracts and other essential Home Civil requirements. Firms not yet using Multicore Solder are invited to write for fuller technical information and samples.

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WIRELESS ENGINEER

Editor HUGH S. POCOCK, M.I.E.E. Technical Editor Prof. G. W. O. HOWE, D.Sc., M.I.E.E

VOL. XX AUGUST, 1943 NO. 239

An Instrument for Direct Measurement of the Travelling Wave Coefficient in Feeders

If a feeder is correctly matched at its termination there is no reflected wave. If the matching is not correct, a backward travelling wave of amplitude V_b is superposed upon the forward travelling wave of amplitude V_f, the ratio V_b/V_f giving the magnitude or modulus ρ of the reflection coefficient. There will now be nodes and antinodes, or points of minimum and maximum amplitude on the feeder, and if we put k for the ratio of the minimum to the maximum we have

$$k = \frac{V_f - V_b}{V_f + V_b} = \frac{1 - \rho}{1 + \rho}.$$

In an article in the Russian journal, *Elektrosvyaz*, No. 4, Vol. IX, April 1941, p. 9,* Pistolkors and Neumann describe a device which they call a feeder reflectometer for the direct measurement of k, which they call the travelling wave coefficient. Two wires

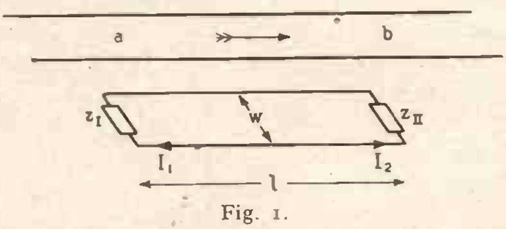

Fig. 1.

are arranged parallel to the feeder and joined at each end through loads Z_I and Z_{II} as shown in Fig. 1. This constitutes a secondary transmission line of length l and width w. The electromagnetic wave travelling from left to right along the feeder will induce electromotive forces in the end connections of length w as it sweeps past

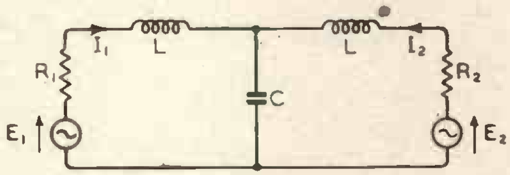

Fig. 2.

them. Neglecting any loss in the feeder, the electromotive forces will be equal but differ in phase by βl where $\beta = 2\pi/\lambda$. Any reflected wave on the feeder will also induce electromotive forces having the same phase difference but in the opposite direction. The magnitudes of the electromotive forces will be proportional to the magnitudes of the respective waves on the feeder.

As we are only interested in the currents at the ends of the line we can replace it by the equivalent T as in Fig. 2. If the losses in a line are negligible, its characteristic impedance $Z_0 = R_0 = \sqrt{(L/C)}$, each half of the top of the T is a purely inductive reactance $\omega L = R_0 \tan \frac{\beta l}{2}$ and the upright of the T is a purely capacitive reactance $1/(\omega C) = R_0/\sin \beta l$. It is assumed in Fig. 2 that the loads Z_I and Z_{II} are non-inductive resistances R_1 and R_2. Putting Z_1 for $R_1 + j\omega L$, Z_2 for $R_2 + j\omega L$ and Z_3 for $1/j\omega C$, the e.m.f. E_1 produces a current

* R.T.P. Translation No. 1525, issued by the Ministry of Aircraft Production.

I'_1 at the left-hand end and a current I'_2 at the right-hand end, where

$$I'_1 = E_1 \frac{Z_2 + Z_3}{Z_1Z_2 + Z_2Z_3 + Z_3Z_1}$$

and

$$I'_2 = E_1 \frac{Z_3}{Z_1Z_2 + Z_2Z_3 + Z_3Z_1}$$

Similarly the e.m.f. E_2 produces a current I''_2 at the right-hand end and a current I''_1 at the left-hand end, where

$$I''_2 = E_2 \frac{Z_1 + Z_3}{Z_1Z_2 + Z_2Z_3 + Z_3Z_1}$$

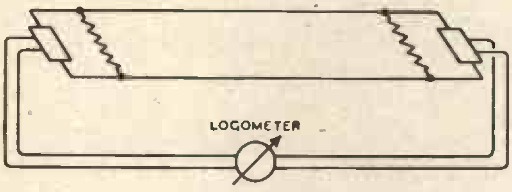

Fig. 3.

and

$$I''_1 = E_2 \frac{Z_3}{Z_1Z_2 + Z_2Z_3 + Z_3Z_1}$$

Hence the resultant currents at the two ends are

$$I_1 = I'_1 - I''_1 = \frac{E_1(Z_2 + Z_3) - E_2Z_3}{Z_1Z_2 + Z_2Z_3 + Z_3Z_1}$$

and

$$I_2 = I''_2 - I'_2 = \frac{E_2(Z_1 + Z_3) - E_1Z_3}{Z_1Z_2 + Z_2Z_3 + Z_3Z_1}$$

If the numerator of either of these expressions is zero the corresponding current will be zero.

Now if R_1 and R_2 are made equal to the characteristic resistance R_0 so that

$$Z_1 = Z_2 = R_0 + j\omega L = R_0(1 + j \tan \beta l/2),$$

the numerator of the expression for I_2 becomes

$$E_2R_0\left(1 + j \tan \beta l/2 - j\frac{1}{\sin \beta l}\right) + E_1R_0 j\frac{1}{\sin \beta l}$$

For a wave travelling along the feeder from left to right E_2 will lag behind E_1 by an angle βl; hence we can write

$$E_1 = E_2 e^{j\beta l} = E_2(\cos \beta l + j \sin \beta l).$$

Substituting these values for E_1 and E_2 the numerator of I_2 becomes

$$E_2R_0(1 + j \tan \beta l/2 - j\,1/\sin \beta l + e^{j\beta l} j\,1/\sin \beta l).$$

Putting $\beta l/2 = x$, the quantity in brackets may be written

$$1 + j \tan x - j\frac{1}{\sin 2x} + j\frac{(\cos 2x + j \sin 2x)}{\sin 2x}$$

$$= j\left(\tan x - \frac{1}{\sin 2x} + \frac{\cos 2x}{\sin 2x}\right)$$

$$= j\left(\tan x - \frac{1 - \cos 2x}{2 \sin x \cos x}\right)$$

$$= j\left(\tan x - \frac{2 \sin^2 x}{2 \sin x \cos x}\right) = 0$$

Hence if $R_1 = R_2 = R_0$, a wave travelling from left to right produces no current I_2 at the right-hand end of the secondary line and similarly a wave travelling from right to left, that is, a reflected wave in the feeder, produces no current I_1 at the left-hand end of the secondary line. The reason for this can be easily seen by considering a pulse travelling from left to right along the feeder. As it passes the left-hand end it will produce a pulse of current which will travel with it along the line and arrive at the right-hand end just as the feeder pulse produces an equal and opposite current at the right-hand end, thus giving zero resultant current.

The currents or potential differences at

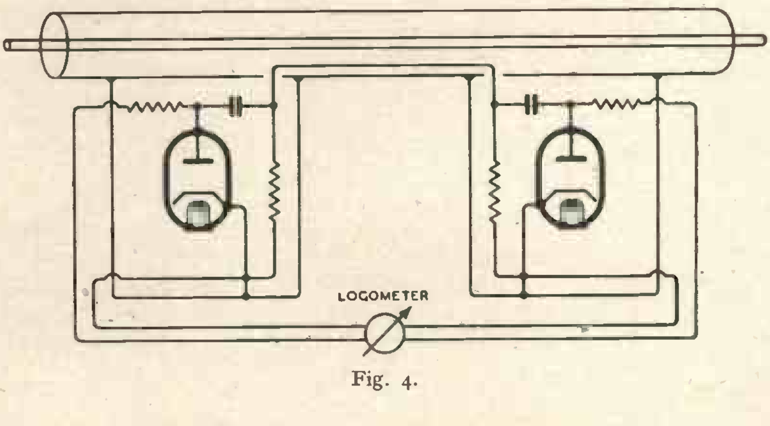

Fig. 4.

the two ends operate thermocouples, detectors, or rectifiers, and the resultant direct currents are conveyed as shown in Fig. 3 to an instrument called a logometer which indicates the ratio of the currents. This instrument can be situated at any convenient point such as a desk in a neighbouring control room; its readings are independent of the frequency and of the strength of the current in the feeder, since they depend solely on the ratio ρ of the forward and backward waves. It can be calibrated so as to read the value of the coefficient k.

Fig. 4 shows the application of the same principle to a concentric feeder; the outer conductor forms one conductor of the secondary circuit, the other being a wire inside the feeder parallel to the axis, and brought out at two convenient points as shown.

The sensitivity of the logometer should be such that the coupling between the feeder and the reflectometer circuit can be made so weak that the reaction on the feeder is negligible.

It is stated that tests have confirmed the theoretical conclusions and shown that the feeder reflectometer can be effectively used in practice as a direct-reading instrument for the determination of the travelling wave coefficient in feeders.

G. W. O. H.

Correspondence

"The Make and Break Network Theorem of Helmholtz"

To the Editor, "Wireless Engineer."

SIR,—May I be permitted to add to your historical survey on Helmholtz's Make and Break Theorem?

It would seem worth while to state the two main theorems which Helmholtz derives in his classical paper and of which the "M. and B. Theorem" is merely a special application.

The first theorem which Helmholtz himself calls the "Theorem of the Electromotive Surface," says:

"For every [solid] conductor A which contains in its interior sources of E.M.F. of any distribution it is possible to determine a 'sheath' containing a certain distribution of E.M.F.s which produces in any other conductor B brought into contact with A the same distribution of currents as the original E.M.F.s contained in A."

The distribution of E.M.F.s referred to is to be found by isolating the conductor A from its surroundings. Helmholtz calls this distribution the "positive" distribution to distinguish it from the "negative" distribution which is obtained by reversing the signs of these surface E.M.F.s.

Helmholtz's simple proof of the theorem runs as follows: If we surround the isolated conductor by a sheath with a certain distribution of E.M.F.s we can arrange that no current will pass to a conductor B, wherever it touches A. The current distribution in A will therefore be the same as it was in its isolated state, and we see that the distribution of E.M.F.s required in the sheath is just the one which cancels the distribution found on the isolated conductor, *i.e.* it is the "negative" distribution.

According to the principle of superposition the zero current in B is the result of adding to the currents produced by the original E.M.F.s in A the currents produced by the negative distribution. The negative distribution is, therefore, able to produce a current distribution in any conductor B which is, apart from its sign, exactly equivalent to the distribution produced by the original E.M.F.s, and we need only change over to the positive distribution in order to produce a current and voltage distribution in B which is the exact counterpart of the distribution caused by the original E.M.F.s.

The second theorem of Helmholtz says that the currents and voltages inside A are the sums of those produced by the internal E.M.F.s when the body is isolated from its surroundings and those produced by the positive surface distribution.

The proof is also based on the principle of superposition. If W_0 is the voltage produced at some point inside A when A is isolated, W_1 the voltage when A is connected to B, $+P$ the voltage when only the positive surface distribution is active and $-P$ when only the negative surface distribution is active, then we have

$$W_0 = W_1 - P,$$

for we have seen that the superposition of the original E.M.F.s with the negative surface distribution has the same effect as the isolation of the body (no currents in B and therefore no change in the current distribution if B is brought into contact). From the last equation follows, however,

$$W_1 = W_0 + P,$$

which is just what the theorem says regarding the voltages. From the voltage distribution follows the current distribution.

A network of "linear" conductors is, of course, only a special form of the solid conductor which Helmholtz has in mind; the electromotive surface distribution shrinks in this case to "spots" of E.M.F. placed in the access leads of the network. The "Make and Break" Theorem follows, if we specialise this network to a two terminal one, replacing the actual network inside the electromotive surface (which is now a purely passive network) by an equivalent resistance.

A. T. Starr published in the *I.E.E. Journal* of September, 1933, a paper extending "Thévenin's" Theorem to the case of a three terminal network, replacing the actual network between the terminals by an equivalent network. It will be noticed that, apart from this addition of the equivalent, 3-terminal network Helmholtz had anticipated the extension by 80 years.

It also does not seem to have been noticed at the time that Strecker and Feldtkeller had restated in *Electrische Nachrichten Tecknik*, 1929 (in their paper on the matrix treatment of 4-terminal networks) Helmholtz's Theorem as applied to an *n*-terminal network, giving Helmholtz as source and using his method of proof given above. This paper mentions also the possibility of replacing the actual network "inside" the terminals by an equivalent network. Furthermore, it states in a separate section the dual counterpart of the Theorem (with dual proof). For the principle of duality, which they use as guide, they refer to their own investigation in *Archiv für Electrotechnik*, 1922, in which they trace back this principle to Russell.

No claim is made as to the originality of this dual theorem, and no claim can indeed be made, for in *Telegraphen und Fernsprechtechnik*, 1926, H. F. Mayer had published an equivalent circuit for an electronic valve which uses the constant current generator shunted by the internal impedance of the network. The editor of that journal pointed out in a long note that this mode of representation had advantages beyond this special application and gave a few examples.

Wide publicity has also been given to both theorems by Barkhausen's book on electronic valves, which includes in its third edition (Vol. 1, p. 142, published 1931) a treatment of the active 2-terminal network in which both methods of representation are described in admirable clarity.

To the readers (and the Editor) of *Wireless Engineer* it may be of interest that the September 1930 issue of this Journal contained a short note by N. R. Bligh giving the equivalent valve circuit with the constant current generator, which also points out the general possibility of using this method of presentation. In a footnote the author adds that he has since become aware of Mayer's paper.

There remains the problem of naming the counterpart of Helmholtz's original theorem. That such a counterpart existed was clear from the moment Russell had drawn attention to the principle of duality. If it had not been used as a means of reasoning and simplification, it was due mainly to the fact that engineers were not accustomed to think in terms of "controlled" currents. This was changed with the advent of the radio valve, and we see that roughly about the same time the theorem was announced or used in various places.

To attach to the theorem the names of all the investigators who formulated it explicitly, is an obvious impossibility, and would also be doubtful justice. It seems that "Helmholtz-Russell" Theorem, though perhaps not ideal, might be accepted as a fair solution.

A. Bloch.

Wembley Park, Middlesex.

[We are indebted to Dr. A. Bloch for his informative letter. The contribution of Russell to which reference is made will be found in Vol. 1 of his "Treatise on the Theory of Alternating Currents," Chapter XVII of which opens with a section on the method of duality. He says "the method of reciprocating a theorem may be called the method of duality."

A reader has kindly drawn attention to the fact that on p. 526 of the 1892 edition of Kempe's "Handbook of Electrical Testing" it is stated that Pollard's Theorem of a shunted battery is that "a battery having a resistance r and shunted by a shunt S is equivalent to a battery of E.M.F. $ES/(S + r)$ and internal resistance $Sr/(S + r)$." This is, of course, a very simple example of Helmholtz's theorem.

In the July Editorial, p. 321, 2nd column. "Jenkin" was a misprint for "Genkin."—G.W.O.H.]

The Place of Scientists in the Community

To the Editor, "Wireless Engineer."

Sir,—Most scientists find themselves in agreement with the pleas which are now being made that the scientific effort, so effective in the war, shall not be allowed to cease when peace returns, but shall be applied to the serious problems which will arise during reconstruction, and after. It is certain that if, in this small island with its limited material resources, we are to maintain our existing population with its present standard of living, scientific and technological research will be required on a scale not yet envisaged. Many responsible scientists, however, view with concern exaggerations which often accompany reasonable claims. From time to time, statements are made by individuals or by organisations, professing to speak for Science, that if some fraction of the national income were allocated to scientific research, and if men of science were given a position of authority in the affairs of the State, the community would find itself in what is usually described as "an age of plenty." It is unfortunate that such exaggerations should be disseminated when schemes for future reorganisation are being discussed. To mislead the community as to its available resources can only foster illusions and bring disappointments which may be disastrous both for it and for science. While we may hope that the improvement in our material comforts, which has marked the past fifty years, will be continued by further applications of scientific methods, the fruits of research sometimes ripen slowly and our material resources during the post-war period cannot be vastly greater than those we now possess. Because of the time-lag in the application of research, it is important that immediate preparation be made for reconstruction.

The claim that the scientist, as scientist, is entitled to some position of exceptional authority in deciding the policies of governments, is one which cannot and should not be accepted in a democratic community. Social problems are too complex to be solved by any one type of mind. The man of science can give valuable assistance in solving problems facing a society by searching out the facts and, on the basis of the facts, suggesting remedies. He could profitably be consulted more frequently than has been the case. When, however, his advice has been given, his duty *as a scientist* is at an end. No social problem can be solved solely by the methods of science; not only material but other values are involved, and it is for the community, of which the scientist is a member, to weigh the different factors and make a decision. A scientific and soulless technocracy would be the worst form of despotism.

Robert H. Pickard, Chairman, Joint Council of Professional Scientists.

Alexander Findlay, President, The Royal Institute of Chemistry.

W. L. Bragg, President, The Institute of Physics.

Reactance-valve Frequency Modulator*

By Emrys Williams, Ph.D., B.Eng., A.M.I.E.E.

1. General Theory

THE well-known reactance-valve circuit, used for frequency modulation, is a valve circuit whose input impedance is required to be purely reactive, and to be variable by varying the grid-bias voltage (and hence the mutual conductance) of a variable-mu valve. The connection of such a variable reactance in parallel with the *L–C* circuit of an oscillator makes possible that variation of oscillation frequency which constitutes frequency modulation.

Fig. 1 illustrates the principle of the reactance valve. In essence it is simply a two terminal network, the two terminals (AA) being the anode and cathode terminals of a valve. In Fig. 1 a hypothetical A.C. generator, V, is shown connected across AA for the purpose of determining the input impedance. The input impedance vector will then be given by V/I.

Now the current I is dependent upon both the anode voltage and the grid voltage. The former is simply V. The latter is here derived from V by a phase-splitting circuit connected across V, and not shown in Fig. 1. We shall denote this alternating grid-voltage by $nVe^{j\theta}$, indicating that its magnitude is a fraction n of that of V, and that it leads V by an angle θ. Clearly θ may be made positive or negative by the use of appropriate phase-splitting circuits.

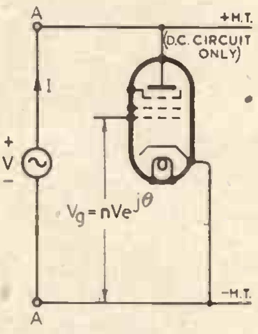

Fig. 1.

Fig. 2 shows the equivalent A.C. circuit and gives the input impedance vector as

$$Z_{in} = V/I = \frac{r_A}{1 + \mu n e^{j\theta}} \quad \ldots \quad \ldots \quad (1)$$

Now for the input impedance to be purely reactive this expression for Z_{in} must be a pure imaginary. To secure this it is usual to choose a phase-splitting circuit which makes θ either $\pi/2$ or $-\pi/2$. Equation (1) then becomes

$$Z_{in} = \frac{r_A}{1 \pm j\mu n} \quad \ldots \quad \ldots \quad (2)$$

$$= \frac{r_A}{1 + \mu^2 n^2}(1 \mp j\mu n)$$

This will approximate to a pure reactance if n be made sufficiently large for μn to be large with respect to unity, in which case equation (2) becomes

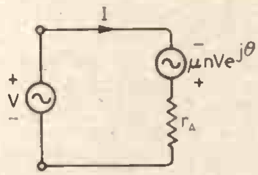

Fig. 2.

$$Z_{in} = \text{approx.} \frac{r_A}{\pm j\mu n} = \mp j/ng_m \quad \ldots \quad (3)$$

The ratio of reactance to resistance will be seen to be μn, i.e.,

$$Q = \mu n \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

2. Particular Case

Suitable phase-splitting circuits are

(*a*) A series combination of resistance R and capacitance C.

(*b*) A series combination of resistance and inductance.

Fig. 3 shows a complete reactance-valve circuit using (*a*) above. For this circuit θ can be made approximately $\pi/2$ by making

$$R \gg 1/\omega C \quad \ldots \quad \ldots \quad \text{(condition } A\text{)}$$

in such a case the value of n will be $1/\omega CR$. The condition that μn shall be large with respect to unity thus becomes

$$1/\omega C \gg R/\mu \quad \ldots \quad \ldots \quad \text{(condition } B\text{)}$$

To satisfy both conditions A and B it is clearly necessary that μ shall be large, and a suitable compromise is to make

$$1/\omega C = R/\mu^{\frac{1}{2}} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

* MS. accepted by the Editor, March 1943.

The input impedance Z_{in} is then very nearly equal to

$$j\omega CRr_A/\mu \quad \ldots \quad (6)$$

so that the circuit behaves as a constant inductance of magnitude CRr_A/μ, or CR/g_m. Equation (5) enables us to assess the value of this inductance *for a given valve operating at a given carrier frequency*, for the combination of equations (5) and (6) gives

$$Z_{in} = jr_A/\mu^{\frac{1}{2}}$$

whence L effective $= r_A/(\omega\mu^{\frac{1}{2}})$

The value of Q for the input impedance may be derived from equation (4), giving

$$Q = \mu/\omega CR$$

so that, if equation (5) is complied with,

$$Q = \mu^{\frac{1}{2}}$$

3. Design Procedure

If the basic requirement is to secure, as far as is possible, a purely reactive variable input impedance, a design procedure may be based on the above, and will be as follows:

(i) When the reactance-valve circuit is connected across the L–C circuit of an oscillator, the phase-splitting circuit will also be connected across the L–C circuit. The impedance of the phase-splitting circuit in the case considered above is approximately a pure resistance R, and hence a minimum

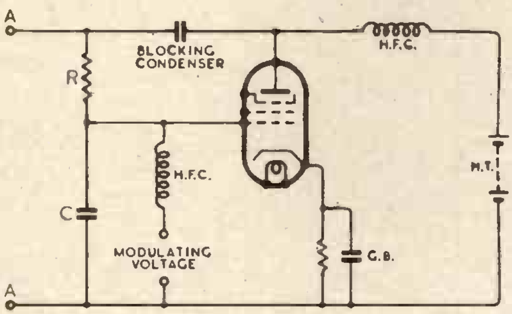

Fig. 3.

permissible value of R is dictated by the properties of the oscillator. For reasons given under (ii) below, it will usually be advisable to use this minimum permissible value.

(ii) Knowing the resistance R, the carrier frequency and the valve parameters, equation (5) gives the value of C. Examples will show that for normal carrier frequencies the resulting value of C is impracticably small unless R is kept low. For example, with ω equal to 5×10^7 second^{-1}, R equal to 10^5 ohms and μ equal to 1000, the value of C given by equation (5) is only $6\,\mu\mu F$, which is of the same order as a grid-cathode capacitance.

(iii) The input inductance is then given by equation (6) and its value of Q will be approximately equal to the square root of the amplification factor.

4. Possible Circuit Modifications

4.1. We may examine equation (1) to find what circuit-modifications would improve the value of Q, i.e., make the phase angle of equation (1) more nearly equal to $\pi/2$. The phase angle of Z_{in} is given by

$$\tan^{-1} \frac{\mu n \sin \theta}{1 + \mu n \cos \theta}$$

For this angle to be $\pi/2$ we must therefore have

$$\theta = \cos^{-1} (-1/\mu n)$$

This value of θ lies outside the ranges (0 to $\pi/2$) and (0 to $-\pi/2$) and can therefore not be secured with simple phase-splitting circuits, though it could be secured by making use of the phase change in a valve stage, i.e., by interposing one or more valve stages between the phase-splitting circuit and the grid of the reactance-valve.

4.2. An interesting modification is the addition of a reactance X in series with the anode circuit. This gives

$$Z_{in} = \frac{r_A + jX}{1 + \mu n e^{j\theta}} \quad \ldots \quad (7)$$

With θ equal to $-\pi/2$ (as in the particular case considered above) this becomes

$$Z_{in} = \frac{r_A + jX}{1 - j\mu n}$$

There will be some value of X which makes this expression a pure imaginary. We wish to determine this value of X and also the resulting reactance of Z_{in}. Denoting the latter by b, we have

$$\frac{r_A + jX}{1 - j\mu n} = j\,b$$

Solving for b and X we have the somewhat surprising result that

$$b = X = 1/ng_m$$

In other words, the impedance of a two-terminal network consisting of two elements in series (viz., the reactance X and the valve) is equal to the impedance of one of them alone (viz., the reactance X). The explanation of this apparent paradox is, of course, that the two-terminal network is not a passive network but includes an e.m.f. μV_g. The practical importance of this result is that we have here a method of producing a reactance having an infinite value of Q—though unfortunately the required series reactance, X, is a function of g_m, which varies in the course of frequency-modulation. So far as frequency-modulation is concerned, therefore, this circuit modification is of academic interest only.

4.3. The possibility of producing an input impedance with *any* desired phase angle (even with a negative component of resistance) is apparent from equation (7). The phase angle of the expression for Z_{in} will be the difference of the phase angle of the numerator and that of the denominator. Provided that μn exceeds unity, the denominator can be given *any* desired phase angle by suitable choice of θ, the phase-splitting angle. It is clearly possible to make the *total* input impedance (i.e., taking account of the shunt impedance of the phase-splitting circuit across the input terminals) purely reactive by this means. A limit is set by the danger of self-oscillation arising from a negative resistance component of input impedance.

4.4. Finally, it is of interest to note that the reactance-valve circuit may be used to provide the inverse impedance of any two-terminal network of impedance Z, by making the phase-splitting circuit a series combination of a resistance R and the two-terminal network of impedance Z. The input impedance vector will then be given by equation (1), which reduces to $R/g_m Z$, provided that $|Z|$ be small with respect to R and large with respect to R/μ. The constant of inversion is thus R/g_m which is conveniently variable.

I.E.E. Officers

THE nominees announced last month to fill the vacancies which will occur on the Council of the Institution of Electrical Engineers on September 30th, have been duly elected. The following, therefore, constitute the Council for the 1943/44 session :—President, Col. Sir A. Stanley Angwin; vice-presidents, T. G. Haldane and Dr. E. B. Moullin; hon. treasurer, E. S. Byng; ordinary members, Brig. F. T. Chapman, J. Hacking, A. L. Lunn, Dr. J. L. Miller, J. S. Forrest, E. C. S. Megaw and E. Leete.

The ballot for members to fill the vacancies occurring on the Committee of the Wireless Section on September 30th, having been held, the following were elected :—Chairman, T. E. Goldup; vice-chairman, Prof. Willis Jackson; immediate past chairman, Dr. R. L. Smith-Rose; ordinary members of the committee: F. P. Best, Capt. C. F. Booth, C. W. Cosgrove, W. T. Gibson, H. G. Hughes, H. L. Kirke, E. C. S. Megaw, O. S. Puckle, J. A. Smale, Dr. H. A. Thomas, T. Wadsworth and Dr. R. C. G. Williams.

I.E.E. and Prisoners of War

AS a result of arrangements made with the British Red Cross Society, prisoners of war in Germany may sit for the Associate Membership Examination of the Institution of Electrical Engineers. Of the nineteen candidates who took last year's examination, or parts thereof, eleven were successful in passing Parts 1 and 2.

A special concession granted to prisoners of war allows them to take one subject at a time if they so desire. Five candidates passed single subjects last year.

The commendably high standard of marks gained by the candidates is noted by the Institution.

A further seventeen prisoners of war in Germany entered for the May examinations this year, the results of which have not yet been announced.

Book Salvage

THE recent drive for books in the London area resulted in the collection of more than 5 million volumes. The salvaged volumes will be graded, some of them being used to replace those destroyed or damaged in libraries during air raids, while others will be utilised for the Forces, the remainder being sent for re-pulping.

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.

Magnetic Induction Field of Air-core Coils*

Its Application to High-frequency Heating in Valve Manufacture

By C. B. Kirkpatrick, B.Sc.

ABSTRACT.—Expressions are derived for the axial components of the magnetic induction field of both three-dimensional and two-dimensional coils; in particular the Helix, the Spirals $r = k\theta$ and $r = r_0 e^{k\theta}$, and the simple Circular Coil are investigated.

Efficient heating by a high-frequency induction field, and the design of heater coils such as those used in valve manufacture, are discussed in some detail.

1. Introduction

VERY little information is available about the magnetic field associated with linear circuits† or coils, in comparison with the numerous formulae which have been worked out for their inductance. Most text books confine themselves to a study of the solenoid and the simple circular coil, and determine the magnetic field for a solenoid by assuming each turn to be a closed circular circuit.

In the first part of this paper, a general vector method for determining the magnetic induction field of a linear circuit is outlined and is applied to the axial field of the helix, the simple circular coil, and two types of spirals. It is shown that the well-known formula for the axial field of a solenoid (closely wound helical coil) is correct for any helical coil however loosely wound. This is an important result for application to high-frequency circuits in which a helical coil of a few turns is not uncommon. An optimum value is derived for that radius of a helical coil which gives a maximum field at a given distance along the axis of the coil.

As far as the author can ascertain, there is no record of this work elsewhere, apart from the well-known formulae for the circular coil and the solenoid.

Stuhlman and Githens have made a detailed investigation of the magnetic field in the neighbourhood of the helical coil (1932) and the spiral coil (1933) under radio-frequency excitation by a search coil method. They concluded that a radio-frequency current with a symmetrical wave form gives an induction field similar to that obtained by direct current excitation. Experimental curves for the field distribution along the axis of the helix and the spiral are given by them and are of similar form to the corresponding theoretical curves of Fig. 7 in the present paper.

In the second part of the paper is discussed the design of high-frequency induction heater coils used in valve manufacture for degassing valve components (chiefly the anode) and for flashing the getter during the exhaust process. The induction field is the main factor to be considered in the design of such coils.

For a " Sealex " machine or an exhaust bench, the typical heating system consists of a number of heater coils of copper tubing connected in series in the tuned circuit of a triode power oscillator. At the Amalgamated Wireless Valve Company, Sydney, these power oscillators operate at a nominal frequency of 225 or 300 kc/s, and the coil design will be considered for radio frequencies of this order. It will be assumed that the heater coils are linear circuits to which the expressions derived for the magnetic field are applicable, and the effects of the leads to the coils will be neglected.

In general, heater coils are made of tubing, wire or strip, and the high-frequency voltages required are produced by valve oscillators, spark gaps and occasionally high-frequency alternators. The valve oscillator has the advantage of high overall efficiency and uniform control of power.

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* Reprinted from *A.W.A. Technical Review*, 1941, Vol. 5, No. 6, by arrangement with Amalgamated Wireless (Australasia) Ltd.

† The term " linear circuit " implies that the cross-sectional area of the conductor comprising the circuit is everywhere small compared with its length.

2. General Theory

A consequence of Maxwell's equation for the electro-magnetic field is that, if a variable electromotive force is applied to an electric circuit, the magnetic field, produced by the current flowing in any element, consists of an induction field in time phase with the current and a radiation field in time quadrature with the current. The amplitude of the radiation field diminishes as the distance and is proportional to the frequency. The amplitude of the induction field diminishes as the square of the distance and is independent of the frequency. Thus the induction field predominates in the immediate region of the circuit, and the radiation field may be neglected for distances small compared with the wavelength.

A current of instantaneous value i flowing in a circuit element **ds** at a distance d from any point P in free space, produces at P an induction field,

$$\mathbf{dH} = i\mathbf{ds} \times \nabla\left(\frac{1}{d}\right) \quad .. \quad (1)$$

The gradient $\nabla\left(\frac{1}{d}\right)$ * is related to the vector **d** by the identity,

$$\nabla\left(\frac{1}{d}\right) = \frac{1}{d^3}\mathbf{d}$$

Hence,

$$\mathbf{dH} = \frac{i}{d^3}\mathbf{ds} \times \mathbf{d} \quad .. \quad (1a)$$

Referred to rectangular co-ordinates, X, Y, Z, whose origin is o and in which the field point P has the co-ordinates x, y, z, and **ds** has co-ordinates X, Y, Z,

$$\mathbf{OP} = \mathbf{i}x + \mathbf{j}y + \mathbf{k}z \quad .. \quad .. \quad (2a)$$

$$\mathbf{ds} = \mathbf{i}dX + \mathbf{j}dY + \mathbf{k}dZ \quad .. \quad .. \quad (2b)$$

$$\mathbf{d} = \mathbf{i}\,(x - X) + \mathbf{j}(y - Y) + \mathbf{k}(z - Z) \quad (2c)$$

Applying (2a) and (2b) to the vector product on the right hand side of (1a), the components of **dH** are easily shown to be

$$dH_x = \frac{i}{d^3}\,(z - Z)dY - (y - Y)dZ \quad (3a)$$

$$dH_r = \frac{i}{d^3}\,(x - X)dZ - (z - Z)dX \quad (3b)$$

$$dH_z = \frac{i}{d^3}\,(y - Y)dX - (x - X)dY \quad (3c)$$

where

$$d = \sqrt{(x - X)^2 + (y - Y)^2 + (z - Z)^2} \quad (3d)$$

The co-ordinates X, Y, Z can be expressed in terms of a suitable parameter (for example a polar co-ordinate). Denoting this parameter by u, substituting in (3) reduces these equations to the forms,

$$dH_x = \phi(u)du$$
$$dH_r = \psi(u)du$$
$$dH_z = \chi(u)du$$

which are suitable for integration.

The total field produced at P by the elements ds between the limits u_1 and u_0 is therefore,

$$H_x = \int_{u_0}^{u_1} \phi(u)du$$

$$H_r = \int_{u_0}^{u_1} \psi(u)du,$$

$$H_z = \int_{u_0}^{u_1} \chi(u)du.$$

The theory thus provides a general method for investigating the induction field arising from currents flowing in linear circuits or coils, whose circuit elements ds lie on algebraic curves.

2.1. The Circular Helix

The general theory is readily applied to the helix. A circular helix is defined as a curve on the surface of a circular cylinder of radius r, such that its direction makes a constant angle β with the axis of the cylinder.

Consider the case where the coil is wound clockwise and the rectangular co-ordinates, (X, Y, Z), are chosen so that the origin is at the axial field point P and the Z axis is the axis of the cylinder (Fig. 1).

Then, by definition, the cylindrical co-ordinates Z, r, θ are related by the equation

$$dZ = r \cot \beta \,.\, d\theta \quad .. \quad .. \quad (4)$$

---

* $\nabla = \mathbf{i}\frac{\delta}{\delta X} + \mathbf{j}\frac{\delta}{\delta Y} + \mathbf{k}\frac{\delta}{\delta Z}$.

and the parametric equations may be written

$$X = r \,.\, \cos\theta$$
$$Y = r \,.\, \sin\theta$$
$$Z = r \,.\, \theta\cot\beta$$

The number of turns per unit increment of Z is given by

$$n = \frac{1}{2\pi}\int_0^1 \frac{d\theta}{dZ}\,.\,dZ$$

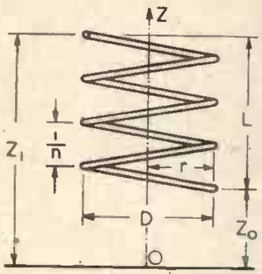

Fig. 1.—*Diagram of a helical coil whose axis is OZ and whose ends are distant Z_0 and Z_1 from the field point O. One turn occupies a length $\frac{1}{n}$ along the Z-axis, and the number of turns, N, is given by $N = nL$.*

Hence, from (4),

$$\tan\beta = 2\pi nr$$

Applying (2) and (3),

$$\mathbf{ds} = \mathbf{i}dX + \mathbf{j}dY + \mathbf{k}dZ$$
$$\mathbf{d} = -\mathbf{i}X - \mathbf{j}Y - \mathbf{k}Z$$
$$dH_x = \frac{i}{d^3}(YdZ - ZdY)$$
$$dH_y = \frac{i}{d^3}(ZdX - XdZ)$$
$$dH_z = \frac{i}{d^3}(XdY - YdX)$$
$$d = (Z^2 + r^2)^{\frac{1}{2}} = r\left\{1 + \left(\frac{\theta}{2\pi nr}\right)^2\right\}^{\frac{1}{2}}$$

The axial field components are therefore,

$$H_x = \frac{i}{2\pi nr^2}\int_{\theta_0}^{\theta_1} \frac{(\sin\theta - \theta\cos\theta)}{\left\{1 + \left(\frac{\theta}{2\pi nr}\right)^2\right\}^{3/2}}\,.\,d\theta \qquad (5a)$$

$$H_y = \frac{i}{2\pi nr^2}\int_{\theta_0}^{\theta_1} \frac{-(\cos\theta + \theta\sin\theta)}{\left\{1 + \left(\frac{\theta}{2\pi nr}\right)^2\right\}^{3/2}}\,.\,d\theta \quad \ldots \quad \ldots \quad (5b)$$

$$H_z = 2\pi ni\int_{Z_0}^{Z_1} \frac{r^2}{(Z^2 + r^2)^{3/2}}\,.\,dZ \quad \ldots \quad (5c)$$

Plotting the integrands of H_x and H_y, and evaluating the nett area between these curves and the θ — axis, has shown H_x and H_y to be small compared to H_z.

Integrating (5c),

$$H_z = 2\pi ni\left[\frac{Z}{\sqrt{Z^2 + r^2}}\right]_{Z_0}^{Z_1} \text{ (see Appendix)}$$

$$= 2\pi ni\left(\frac{Z_1}{\sqrt{Z_1^2 + r^2}} - \frac{Z_0}{\sqrt{Z_0^2 + r^2}}\right) \qquad (6)$$

Therefore,

$$H_z = 2\pi ni\,(\cos\psi_1 - \cos\psi_0) \text{ oersted,}$$

where $\cos\psi = \dfrac{Z}{\sqrt{Z^2 + r^2}}$

i = current in e.m.u.,
n = number of turns per cm.

Clearly from Fig. 1, the overall length of the helix is

$$L = Z_1 - Z_0,$$

and the centre of the helix is the point $\{0,\ 0,\ \tfrac{1}{2}(Z_0 + Z_1)\}$. Thus, when the field point (and hence the origin) is at the centre of the coil,

$$Z_1 = -Z_0 = \tfrac{1}{2}L,$$

and the field at the centre is therefore,

$$H_{Z_c} = \frac{4\pi nLi}{\sqrt{D^2 + L^2}} \qquad (6a)$$

where D is the diameter.

The differential coefficient $\dfrac{dH_Z}{dr}$ vanishes when

$$\frac{Z_0}{(Z_0^2 + r^2)^{3/2}} = \frac{Z_1}{(Z_1^2 + r^2)^{3/2}}$$

It readily follows that, for fixed values of Z_0 and Z_1, the optimum value of r is

$$r_{opt} = (Z_0Z_1)^{1/3}(Z_0^{2/3} + Z_1^{2/3})^{\frac{1}{2}} \quad \ldots \quad (7)$$

The curves in Fig. 2 show how r_{opt} varies for a coil of given length as the field point moves along the axis.

From (5c) it is seen on writing dH_Z in the form,

$$\frac{2\pi r^2}{(Z^2 + r^2)^{3/2}}\,.\,(nidZ)$$

that the current element *ids* of a helical coil produces the same normal component as a circular coil of radius r carrying a current *nidZ*. This assumption is made, when n is large, in the method usually adopted for determining H_Z for a solenoid.

However, in high-frequency induction heating, the coils used are characterised by comparatively small values of n, with the result that the validity of the above statement is then by no means obvious.

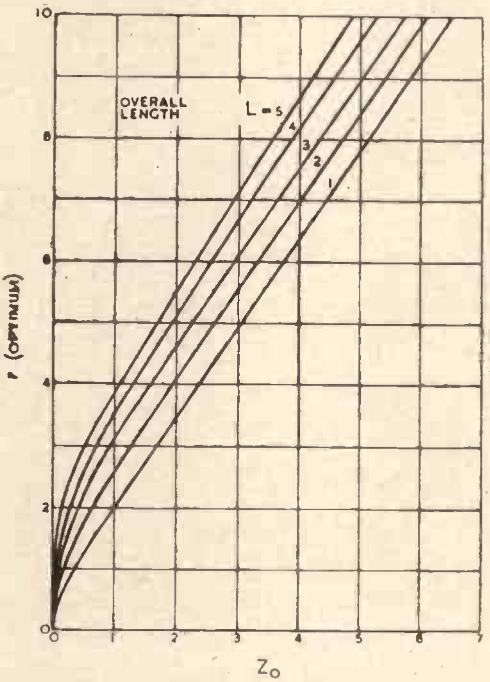

Fig. 2.—*Curves giving the optimum value of r as the field point moves along the axis of a helical coil of overall length L.*

2.2. The Axial Field of Plane Coils

Consider a coil confined to the XY plane with the origin O as its centre. Let the field point P lie on its axis OZ. Equations (2) and (3) now become

$$\begin{aligned}
\mathbf{OP} &= \mathbf{k}z \\
\mathbf{ds} &= \mathbf{i}dX + \mathbf{j}dY \\
\mathbf{d} &= -\mathbf{i}X - \mathbf{j}Y + \mathbf{k}z \\
dH_X &= \frac{zi}{d^3}\,.\,dY \\
dH_Y &= -\frac{zi}{d^3}\,.\,dX \\
dH_Z &= \frac{i}{d^3}\,.\,(XdY - YdX) \\
d &= (X^2 + Y^2 + z^2)^{\frac{1}{2}}
\end{aligned}$$

If (r, θ) are the polar co-ordinates of any point (X, Y) on the two dimensional coil, whose shape is described by the equation

$$r = f(\theta)$$

and, if t is the tangent of the angle ϕ between the radius vector and the tangent at the point (X, Y), then

$$\begin{aligned}
X &= r\cos\theta \\
Y &= r\sin\theta \\
t &= r\frac{d\theta}{dr} = \tan\phi
\end{aligned}$$

so that

$$\begin{aligned}
dX &= (\cos\theta - t\sin\theta)\,dr \\
dY &= (\sin\theta + t\cos\theta)\,dr \\
XdY - YdX &= t.r.dr = r^2 d\theta \\
d &= (z^2 + r^2)^{\frac{1}{2}}
\end{aligned}$$

It follows, on integration, that

$$H_X = zi\int_{r_0}^{r_1}\frac{(t\cos\theta + \sin\theta)}{(z^2 + r^2)^{3/2}}\,dr \quad .. \quad (8a)$$

$$H_Y = zi\int_{r_0}^{r_1}\frac{(t\sin\theta - \cos\theta)}{(z^2 + r^2)^{3/2}}\,dr \quad .. \quad (8b)$$

$$H_Z = i\int_{r_0}^{r_1}\frac{t.r.dr}{(z^2 + r^2)^{3/2}} \quad .. \quad .. \quad (8c)$$

At the centre of the coil ($z = 0$),

$$H_X = zi\int_{\theta_0}^{\theta_1}\frac{(t\cos\theta + \sin\theta)}{r^3}\,dr = 0$$

$$H_Y = zi\int_{\theta_0}^{\theta_1}\frac{(t\sin\theta - \cos\theta)}{r^3}\,dr = 0$$

$$H_Z = i\int_{\theta_0}^{\theta_1}\frac{r^2 d\theta}{r^3} = i\int_{\theta_0}^{\theta_1}\frac{d\theta}{f(\theta)}$$

Writing the integrals in the form,

$$H_X = \int_{\theta_0}^{\theta_1} F(\theta, \sin\theta)\,.\,d\theta$$

$$H_Y = \int_{\theta_1}^{\theta_1} G(\theta, \sin\theta) \,.\, d\theta$$

$$H_Z = \int_{\theta_0}^{\theta_1} H(\theta) \,.\, d\theta$$

it is seen that the field may be computed by plotting the functions F, G, and H against θ, and measuring the nett positive area enclosed by these curves. The functions F and G exhibit a variable periodicity for

$F = 0$, whenever $\theta = 2\pi m - \phi$

$G = 0$, whenever $\theta = 2\pi m + \phi$

where m is any integer.

Further,

$$dH_X = F(\theta, \sin\theta) \,.\, d\theta = \frac{z}{r}(\cos\theta + \sin\theta \cot\phi) dH_Z$$

$$dH_Y = G(\theta, \sin\theta) \,.\, d\theta = \frac{z}{r}(\sin\theta - \cos\theta \cot\phi) dH_Z$$

so that, for any element ds, the field components in the plane parallel to the coil, are proportional to the axial distance z and the normal component dH_Z. In most cases a rough investigation as indicated above shows that H_X and H_Y are small compared with H_Z.

The integration,

$$H_Z = \int_{r_0}^{r_1} \frac{tr}{(Z^2 + r^2)^{3/2}} \,.\, dr$$

is easy to perform in the case of the simple circular coil, the spiral of Archimedes and the equiangular spiral.

The axial field of these coils is now briefly considered.

2.3. The Simple Circular Coil

Let a be the radius so that

$$dr = 0$$

$$t = r^2 \,.\, d\theta = a^2 \,.\, d\theta$$

and

$$H_X = zi \int_0^{2\pi} \frac{a \cos\theta \,.\, d\theta}{(z^2 + a^2)^{3/2}} = 0$$

$$H_Y = zi \int_0^{2\pi} \frac{a \sin\theta \,.\, d\theta}{(z^2 + a^2)^{3/2}} = 0$$

$$H_Z = i \int_0^{2\pi} \frac{a^2 d\theta}{(z^2 + a^2)^{3/2}} = \frac{2\pi i a^2}{(z^2 + a^2)^{3/2}}$$

At the centre of the coil ($z = 0$),

$$H_X = 0$$

$$H_Y = 0$$

$$H_Z = \frac{2\pi i}{a}$$

As a varies, the condition for H_Z to be a maximum is

$$\frac{dH_Z}{da} = 0$$

This is so when $a = \sqrt{2} \,.\, z$

2.4. The Spiral of Archimedes or Equidistant Spiral

The radial distance r increases uniformly with θ so that the polar equation is

$$r = \text{const} \,.\, \theta = \frac{\theta}{2\pi n} \quad \ldots \quad (9)$$

where n is the number of turns corresponding to unit increase in r. The total number of turns is given by

$$N = \frac{\theta_1 - \theta_0}{2\pi}$$

Also
$$t = \frac{r \,.\, d\theta}{dr} = \theta$$

The field components are therefore, from the equations (8),

$$H_X = \frac{i}{2\pi n z^2} \int_{\theta_0}^{\theta_1} \frac{\theta\cos\theta + \sin\theta}{\left\{1 + \left(\frac{\theta}{2\pi n z}\right)^2\right\}^{3/2}} \,.\, d\theta$$

$$H_Y = \frac{i}{2\pi n z^2} \int_{\theta}^{\theta_1} \frac{\theta\sin\theta - \cos\theta}{\left\{1 + \left(\frac{\theta}{2\pi n z}\right)^2\right\}^{3/2}} \,.\, d\theta$$

$$H_Z = 2\pi n i \int_{r_0}^{r_1} \frac{r^2}{(z^2 + r^2)^{3/2}} \,.\, dr$$

At the centre of the coil, provided $r_0 \neq 0$

$$z = 0,\ H_X = 0,\ H_Y = 0$$

$$Hz = 2\pi ni \int_{r_0}^{r_1} \frac{dr}{r} = 2\pi ni \left[\log_e r\right]_{r_0}^{r_1}$$

When $z \neq 0$,

$$Hz = 2\pi ni \left[\log_e \left\{\frac{r + (z^2 + r^2)^{\frac{1}{2}}}{z}\right\} - \frac{r}{(z^2 + r^2)^{\frac{1}{2}}}\right]_{r_0}^{r_1}$$

(see Appendix).

Writing dH_Z in the form $\frac{2\pi r^2}{(z^2 + r^2)^{3/2}} \cdot (nidr)$, it is seen that the element ds produces the same normal component as a circle of radius r carrying a current $(nidr)$.

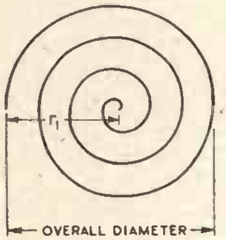

Fig. 3.—*Diagram of an equidistant spiral coil in which* $\theta_0 = 0$, $\theta_1 = 7\pi$ *and the number of turns* N *is* 3.5.

2.5. The Equiangular Spiral

The tangent at any point of the equiangular spiral makes a constant angle α with the radius vector, so that

$$r\frac{d\theta}{dr} = \tan\alpha \quad \ldots \quad \ldots \quad (10)$$

Integrating,

$$r = r_0 e^{\theta \cot \alpha} \quad \ldots \quad \ldots \quad (10a)$$

Writing $\theta = 2\pi N$, where N is the number of turns, and taking logs, we have

$$\log_e r = \log_e r_0 + 2\pi N \cot\alpha$$

If $\triangle r$ is the increase in r per unit turn,

$$\triangle r = \int_0^1 \frac{dr}{dN} \cdot dN$$

and

$$\log_e (r + \triangle r) = \log_e r_0 + 2\pi (N+1) \cot\alpha$$

Therefore,

$$\log_e \left(1 + \frac{\triangle r}{r}\right) = 2\pi \cot\alpha$$

$$\frac{\triangle r}{r} = e^{2\pi \cot\alpha} - 1 = C$$

where C is a constant.

It follows that

$$\cot\alpha = \frac{1}{2\pi}\log_e (1 + C), = \frac{\log_{10}(1 + C)}{2.729}$$

and the spiral is described by the equation,

$$r = r_0 (1 + C)^N$$

The axial field components are given by (8) and (10), and are found to be

$$H_X = zi \int_{r_0}^{r_1} \frac{(\cos\theta \tan\alpha + \sin\theta)}{(z^2 + r^2)^{3/2}} \cdot dr$$

$$H_Y = zi \int_{r_0}^{r_1} \frac{(\sin\theta \tan\alpha - \cos\theta)}{(z^2 + r^2)^{3/2}} \cdot dr$$

$$H_Z = i \tan\alpha \int_{r_0}^{r_1} \frac{r}{(z^2 + r^2)^{3/2}} \cdot dr$$

The normal component becomes, on integration (see Appendix),

$$H_Z = i \tan\alpha \left[(z^2 + r_0^2)^{-\frac{1}{2}} - (z^2 + r_1^2)^{-\frac{1}{2}}\right] \text{ oersted}$$

where $i \doteq \frac{1}{10} \times$ current in amperes;

$$\tan\alpha = \frac{2.729}{\log_{10}(1 + C)}$$

At the centre of the coil ($z = 0$),

$$H_X = 0,\ H_Y = 0,$$

$$H_Z = i \tan\alpha \left[\frac{1}{r_0} - \frac{1}{r_1}\right] \quad \ldots \quad (11)$$

If $\alpha \to 90°$, $\cot\alpha$ is small so that, expanding (10a),

$$r \doteq r_0 (1 + \theta \cot\alpha),$$

and $$r - r_0 \doteq \text{const. } \theta.$$

In this case, the equation for an equiangular spiral is of nearly the same form as that of an equidistant spiral and consequently their induction fields should also be very nearly the same.

In the region $z > r_1$, expansion of the expression for H_Z gives

$$H_Z \doteqdot \frac{i \tan \alpha \, (r_1^2 - r_0^2)}{2z_3}$$

so that H_Z falls off very nearly as the cube of the distance in this region.

3. Induction Heater Coil Design

In high-frequency induction heating, a uniform induction field is desirable in order to obtain uniform heating. On the grounds of efficiency, the coupling between heater coil and load should be as close as possible, and the energy dissipated as heat in the coil circuit, as electromagnetic radiation, and by induction heating of other neighbouring conductors, should be as small as possible.

As a high-frequency current flows in a thin layer at the surface of a conductor (skin effect), the resistance and inductance of the coil and the load are not the same as for steady currents, but depend upon the frequency. Furthermore, the induced currents at the surface of the load considerably weaken the field within, so that induction heating is limited by the depth of penetration of the induction field.

In order to obtain an approximate picture of induction heating, consider the load as an electric circuit of inductance L_2 and resistance R_2 coupled to the heater coil (L_1, R_1) by a mutual inductance M.

If ω is the frequency in circular measure, it will be seen from Fig. 5 that

$$(L_1\omega j + R_1)i_1 + M\,\omega j \,.\, i_2 = e_1$$

$$(L_2\omega j + R_2)i_2 + M\,\omega j \,.\, i_1 = 0$$

Eliminating i_2, and writing,

$$Q = \frac{L_2\omega}{R_2}, \quad k = \frac{Q^2}{Q^2 + 1} \cdot \left(\frac{M}{L_2}\right)^2$$

the above equations reduce to

$$[(L_1 - kL_2)\omega j + (R_1 + kR_2)]i_1 = e_1$$

The load is therefore equivalent to a resistance kR_2 and negative inductance kL_2 in the heater coil circuit. R_1 and R_2 are the "high-frequency resistances" of the coil and the load.

Now the high frequency resistance of a conductor is proportional to the factor $\sqrt{f\mu\rho}$, where

f = frequency in cycles per second
μ = permeability
ρ = specific resistance

and μ and ρ are measured at the temperature of the conductor.

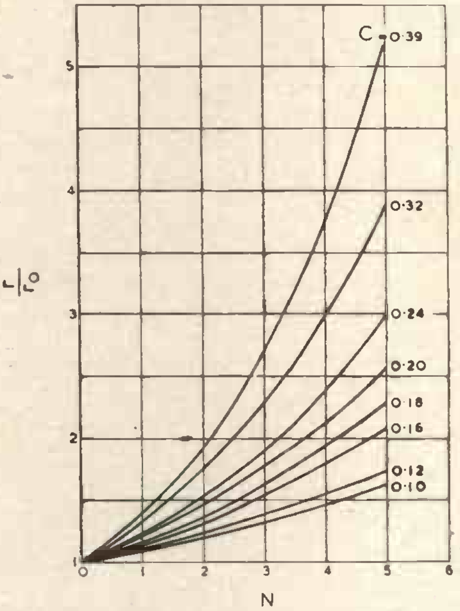

Fig. 4.—*Curves giving the ratio of the radial co-ordinate to the initial radius for the spiral* $r = r_0 (1 + C)^N$, *where C is a constant and N is the number of turns.*

If I is the r.m.s. value of the heater coil current,

$$\text{Power Input} = I^2(R_1 + kR_2)$$

$$\text{Useful Output} = I^2 \,.\, kR_2$$

$$\text{Efficiency} = \frac{kR_2}{R_1 + kR_2}$$

The efficiency increases as R_1 decreases and the specific resistance of the coil should therefore be small. It is also clear that high efficiency entails a large value of k. In fact, a reasonable criterion for satisfactory efficiency in induction heating is that the Q of the load (and consequently the frequency) is large enough for k to approach its asymptotic value, $\left(\frac{M}{L_2}\right)^2$.

Thus if $Q > 3$,

$$0.9\left(\frac{M}{L_2}\right)^2 < k < \left(\frac{M}{L_2}\right)^2$$

and for all practical purposes k may be taken equal to $(M/L_2)^2$.

On the other hand, unduly increasing the frequency increases the radiation loss and lowers the efficiency of the power oscillator or spark gap supplying the high frequency energy.

The heat absorbed by the load may now be written as

$$W = \left(\frac{MI}{L_2}\right)^2 . R_2 \text{ watts}$$

If the induction field through the load is uniform,

$MI \propto H$, where H is the r.m.s. value of the induction field and as already stated,

$$R_2 \propto \sqrt{f\mu\rho}$$

so that $W = \text{const. } H^2 . \sqrt{f\mu\rho}$ watts (12)

where the constant is a function of the dimensions of the load.

The depth of penetration of the field that defines the region heated by induction, is proportional to the factor $\sqrt{\frac{\rho}{f\mu}}$

If the heat absorbed by the load is dissipated as radiation,

$$W = 5.57 \times 10^{-12} T^4 \text{ watts,}$$

where T is the "black" temperature as read directly by a pyrometer.

Although the constant in (12) is not in general easily evaluated, the formulae are useful for comparative purposes.

For example, $\left(\frac{T_1}{T_2}\right)^2 = \frac{H_1}{H_2}$

Further if δf and δH produce the same increase δW in W,

$$\frac{\delta f}{f} = 4 \cdot \frac{\delta H}{H}$$

In practice, μ may be set equal to unity as the temperature T almost always exceeds the magnetic conversion point (Ni 360°C, Fe 770°C) of the load. A high μ value at the commencement of heating only tends to shorten the time taken to attain the final temperature.

It is now clear that the essential requirements of a heater coil are :

(i) small high-frequency resistance.
(ii) maximum coupling with the load,
(iii) a fairly uniform induction field in the space occupied by the load.

Owing to the skin effect associated with high-frequency currents, it is economical to use coils made of tubing, which has the additional advantage of being easily cooled by a stream of water or compressed air while in operation. The material used to wind the coil is usually copper. Annealed copper tubing is used, as it is easier to wind and has a lower ohmic resistance than hard copper. Cooling of the coil prevents any excessive increase in resistance owing to increase in temperature.

Maximum coupling is attained by making the coil as compact as possible, and is limited by

(i) coil diameter,
(ii) tubing diameter and spacing between turns.

The coil diameter must be large enough to prevent arc-over or contact with the load. In heating the metal parts of valves, there is also the danger of high-frequency puncture of the glass bulb, but this trouble is not likely to occur if a strip of mica is inserted between the coil and the bulb. Tubing diameter may be effectively decreased by flattening the tubing, and the spacing between turns may be reduced by inserting thin strips of mica between each turn and binding the turns together with cord.

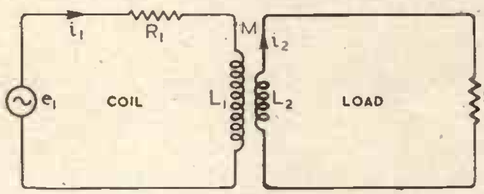

Fig. 5.—*Equivalent circuit diagram of induction-heater coil and load.*

A number of specially shaped coils have been developed to meet the requirements of modern valve manufacture. One such is the bonnet coil illustrated in Fig. 6. This coil is used for heating flat components, such as certain valve anodes, by orienting the magnetic field at right angles to the plane of the anode. Other coils used are the helical, spiral, oval and elliptical types.

As helical coils can be used efficiently for heating the anodes of most valve types, a "Sealex" machine, designed for the high speed exhausting of large quantities of valves, usually incorporates a number of helical coils for the discontinuous heating during the exhaust process, and a helix or a spiral for flashing the getter. All the coils are in series and have a common excitation current. If the getter-flashing coil is made too large, it will heat the anode to a high temperature and may thus evolve more gas than the getter flash can deal with. Thus, if the r.m.s. value of the excitation current is reduced to prevent excessive anode temperature during exhaust, a poor getter flash may occur because of the limitation to the size of the getter coil. In this case, a separate source of power for the getter coil would be a decided advantage.

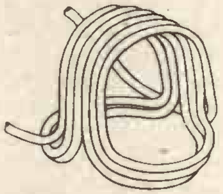

Fig. 6.—*Diagram of a bonnet coil.*

A few factors in the design of helical and spiral coils are now briefly considered.

3.1. Helical Coils

The helix is particularly suited for heating cylindrical loads and produces a fairly uniform field in the required region, provided the overall length of the coil is not less than that of the load.

Assuming the field is uniform, equation (6a) gives

$$H = \frac{4\pi nLA}{10\sqrt{(D^2 + L^2)}}$$

where A = r.m.s. current in amperes,
L = overall length of helix,
D = internal diameter of helix.

If N is the total number of turns, then $N = nL$, and NA is the ampere-turns of the coil.

The induction field is therefore,

$$H = \frac{2\pi NA}{5\sqrt{(D^2 + L^2)}} \text{ oersted}$$

and the heat absorbed by the load is therefore proportional to $\frac{(NA)^2}{(D^2 + L^2)}$.

Table I gives values of this heating factor for A equal to 100 amperes, with typical values of N, L, and D, the latter being expressed in sixteenths of an inch. D is usually made $\frac{5}{16}$in. greater than the bulb diameter to allow sufficient clearance for the bulb.

The power absorbed by a solid cylinder (or by a hollow cylinder with a wall-thickness exceeding the depth of penetration of a high frequency field), of the same length as the heater coil is

$$W = 2.81 \times 10^{-6}\, G(NA)^2\sqrt{f\mu\rho} \text{ watts,}$$

where G is a constant depending upon D, L and the diameter of the cylinder d, and ρ is expressed in ohms. mm^2 per metre. This expression, together with curves for G, is given by Espe and Knoll (1936). An investigation of these curves shows that G is not very different from the form

$$\frac{d^2 \times \text{const.}}{D^2 + L^2}$$

for any given value of $\frac{d}{L}$.

The length of tubing required to wind a helix (N, D, L) is given by the relation

$$S = \sqrt{\pi^2 D^2 N^2 + L^2}$$

TABLE I

		L					
N	*D*	15	16	17	18	19	20
2.5	33	47.5	46.5	45.4	44.2	43.1	42.0
2.5	29	58.6	57.0	55.4	53.6	52.0	50.4
3.5	33	93	91	89	87	84	82
3.5	29	114	112	108	105	102	99
4.5	33	154	150	147	144	140	136
4.5	29	190	185	180	174	169	163

which is derived in the appendix to this paper.

3.2. Spiral Coils

In practice, spiral heater coils seldom have more than three or four turns and are closely wound. Under these circumstances, the equiangular spiral and the equidistant (Archimedes') spiral are of very nearly the same shape.

The expression for the axial field of the equiangular spiral is by far the easier to evaluate and is, consequently, the better one to use. A very accurate formula is included in the appendix for the length of tubing required to wind an equidistant spiral. This formula is scarcely necessary in the design of heater coils, but may be of practical value to the designer of large spiral inductances.

Inspection of equation (11) shows, that at small distances from the centre of a spiral coil, the field depends mainly on the diameter of the first turn. This turn should therefore be as small as possible, if the centre of the coil is very close to the load. At large distances, the field is very nearly proportional to the inverse cube of the distance (see Section 2). Fig. 7 shows how

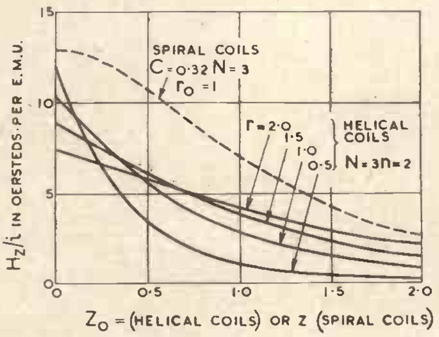

Fig. 7.—*Curves illustrating the way in which the field falls off along the axis of spiral and helical coils.*

the axial field of an equiangular spiral falls off with the distance. Clearly, the field produced by two similar coaxial spirals excited in phase may be made very uniform by spacing the coils correctly.

4. Mathematical Appendix

The following relations are set out for reference.

$$\int \frac{u\,du}{(a^2 + u^2)^{3/2}} = -(a^2 + u^2)^{-\frac{1}{2}}$$

$$\int (1 + u^2)^{\frac{1}{2}} \,.\, du = \log_e\{u + (1 + u^2)^{\frac{1}{2}}\} + u(1 + u^2)^{\frac{1}{2}}$$

$$\int \frac{u^2 du}{(a^2 + u^2)^{3/2}} = \log_e\left\{\frac{u + (a^2 + u^2)^{\frac{1}{2}}}{a}\right\} - u(a^2 + u^2)^{-\frac{1}{2}}$$

$$\int \frac{a^2 du}{(a^2 + u^2)^{3/2}} = u \,.\, (a^2 + u^2)^{-\frac{1}{2}}$$

Proof of the Formula

$$S = \sqrt{\pi^2 D^2 N^2 + L^2}$$

for the Periphery of a Helix

The element $ds = \sqrt{dX^2 + dY^2 + dZ^2}$

$$= \sqrt{(r d\theta)^2 + dZ^2}$$

From (4) and (4a),

$$r d\theta = 2\pi n r \,.\, dZ$$
$$= \pi D n \,.\, dZ.$$

Therefore,

$$ds = \sqrt{(\pi^2 D^2 n^2 + 1)} \,.\, dZ.$$

The periphery is therefore,

$$S = \sqrt{(\pi^2 D^2 n^2 + 1)} \int_{z_0}^{z_1} dZ$$

$$= \sqrt{(\pi^2 D^2 n^2 + 1)} \,.\, (Z_1 - Z_0).$$

Therefore,

$$S = \sqrt{\pi^2 D^2 N^2 + L^2},$$

since $N = nL$ and $L = Z_1 - Z_0$.

Proof of the Formula $S \doteqdot \pi D N + \dfrac{D}{4N}$ *for the Periphery of an Equidistant Spiral*—From (9), the element of length is given by

$$ds = \sqrt{(r d\theta)^2 + dr^2}$$

$$= \frac{1}{2\pi n} \sqrt{1 + \theta^2}\, d\theta.$$

Therefore,

$$S = \int_{\theta_0}^{\theta_1} \frac{1}{2\pi n} \sqrt{1 + \theta^2} \,.\, d\theta$$

$$= \frac{1}{2\pi n}\Big[\theta\sqrt{1+\theta^2} + \log_e(\theta + \sqrt{1+\theta^2})\Big]_{\theta_0}^{\theta}.$$

In the case $\theta_0 = 0$,

$$\theta_1 = 2\pi N, \text{ where } N > 1,$$

and use of the binomial expansion gives

$$S \doteqdot \frac{1}{n}\left\{2\pi N^2 + 0.37 \log_{10} N + 0.483\right\}.$$

In the table below, Sn is compared with $(2\pi N^2 + 0.5)$ for various values of N.

N	$2\pi N^2 + 0.5$	Sn
1	6.78	6.77
2	25.63	25.72
3	57.05	57.21
4	101.0	101.2
5	157.6	157.8
10	628.8	629.2

Now, if D is the overall diameter, the number of turns per unit increment of the radius is

$$n = \frac{2N}{D}.$$

It is now clear from the table that, for all practical purposes

$$S = \pi DN + \frac{D}{4N}.$$

References

1932. Stuhlman, O. and Githens, S. *Rev. Sci. Inst.*, 3, 561.
1933. Stuhlman, O. and Githens, S. *Rev. Sci. Inst.*, 4, 542.
1936. Espe, W. and Knoll, M. "Werkstoffkunde der Hochvakuumtechnik," Berlin : Julius Springer, 128.

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

551 954.—Piezo-electric crystal, mounted in a semi-solid mass of insulating material, and coupled say to a gramophone pick-up.

Radio Corporation of America. Convention date (U.S.A.) 31st January, 1941.

552 019.—Construction of a compact photo-electric pick-up for phonographs.

Philco Radio and Television Corporation (assignees of E. O. Thompson). Convention date (U.S.A.) 18th September, 1940.

552 222.—Preventing refraction effects in profile-cut optical sound reproducing films (addition to 484 374).

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 14th June, 1941.

552 315.—Moving-coil magnetic system for a sound-recorder of the optical type.

G. E. M. Corin and N. Ericsson. Application date, 30th June, 1941.

552 328.—Method of centering the moving coil in the magnetic system of a loudspeaker.

Reslo (Sound Equipment) and L. W. Murkham. Application date 4th December, 1941.

552 331.—Portable valve amplifier, particularly for hearing aids, in which variable reaction is utilised to offset increasing battery resistance.

Western Electric Co., Inc. Convention date (U.S.A.), 24th December, 1940.

552 676.—Watertight cover for protecting the apertures of microphones, loudspeakers, anp the like.

D. H. Marlow and British Rola. Application date, 16th September, 1941.

552 724.—Electro-optical pick-up and coupling circuit for a constant-velocity type of phonograph.

Philco Radio and Television Corporation (assignees of M. L. Thompson and E. O. Thompson). Convention date (U.S.A.) 19th October, 1940.

DIRECTIONAL WIRELESS

552 046.—Directional system for locating a source of infra-red rays.

A. Graves; R. E. Prichard; and Alltools. Application dates, 1st November, 1940, and 25th September and 10th October, 1941.

552 260.—Means for improving the aerial efficiency of a radio altimeter, or distance indicator, when operating on a wide frequency sweep.

Standard Telephones and Cables and E. O. Willoughby. Application date 26th September, 1941.

552 497.—Oscillator circuit for automatically switching or reversing the cardioid field characteristic of a direction-finding system.

Marconi's W. T. Co.; C. S. Cockerell; J. D. Brailsford; and M. H. Cufflin. Application date, 23rd February, 1940.

552 891.—Cathode-follower coupling arrangement for the field coils of a radiogoniometer direction finder for multi-channel working.

Marconi's W. T. Co.; J. D. Peat; and J. Vickers. Application date 24th September, 1941.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

551 951.—Selective circuit for comparing the amount of energy received within two different frequency bands, and for controlling a relay accordingly.

Standard Telephones and Cables; F. Fairley; and R. Walsh. Application date, 15th September, 1941.

551 970.—Circuit for detecting frequency-modulated signals and for simultaneously developing a voltage suitable, say, for automatic gain control.

Hazeltine Corporation (assignees of L. M. Hershey). Convention date (U.S.A.), 13th November, 1940.

551 981.—Valve circuit in which secondary emission is utilised to develop a control voltage suitable for A.V.C. or for automatic band-width or frequency control.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 29th July, 1941.

552 224.—Remote control for presetting the tuning of a wireless receiver and for muting the set during the change-over.

E. F. McDonald, Junr. Convention date (U.S.A.) 25th July, 1940.

552 395.—Remote tuning control of a wireless set by a wholly-electrical linkage which ensures a precise step-by-step adjustment.

Standard Telephones and Cables and G. Newton. Application date 30th September, 1941.

552 403.—Inductance-capacitance combination arranged to give normal and band-spread tuning over a wide range of operation.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 3rd October, 1941.

552 426.—Amplifier in which a variable grid-bias is utilised to control the secondary emission from an auxiliary electrode, thereby regulating the gain of the valve.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 8th August, 1941.

552 431.—Variable tuning system in which the frequency characteristic is controlled by an indirectly-heated non-ohmic resistance in combination with one or more reactances.

Standard Telephones and Cables and C. W. Earp. Application date 3rd October, 1941.

552 462.—Means for giving an audible indication of the correct tuning adjustment of a receiver for frequency- or phase-modulated signals.

Marconi's W. T. Co. (assignees of D. E. Foster). Convention date (U.S.A.), 25th October, 1940.

552 483.—Minimising the effects of fading by a detecting system which automatically increases the amplitude of the carrier wave relatively to the sideband components.

Hazeltine Corporation (assignees of N. P. Case). Convention date (U.S.A.) 25th February, 1941.

552 486.—Mixing circuit giving a high signal-to-noise ratio when receiving short-wave and ultra-short-wave signals.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 1st January, 1942.

552 492.—Short-wave amplifier wherein the cathode comprises two separate supply conductors which are connected to the control grid and anode respectively.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 13th January, 1942.

552 526.—Push-pull amplifier for ultra-short waves comprising means for reducing damping in the input circuit.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 20th August, 1941.

552 658.—Circuit comprising two heterodyne stages for the detection of frequency-modulated signals.

Marconi's W. T. Co. (assignees of W. van B. Roberts). Convention date (U.S.A.) 26th March, 1941.

552 760.—Push-pull amplifier for ultra-high frequencies wherein the undesirable "noise" currents in the anode and screen-grid circuits are arranged to be in phase opposition. [Addition to 552 526.]

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 10th December, 1941.

552 785.—Arrangement of the coil windings in a ganged system for permeability tuning for a superheterodyne receiver.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 13th January, 1942.

552 807.—Means for increasing the signal-to-noise ratio in a receiver for frequency-modulated signals.

Hazeltine Corporation (assignees of H. A. Wheeler). Convention date (U.S.A.) 12th August, 1940.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

552 005.—Television system in which a piezo-electric generator of supersonic pressure waves serves as a modulator and scanning device.

Western Electric Co., Inc. Convention date (U.S.A.) 11th March, 1941.

552 276.—Television transmission system in which the power amplifier is constantly loaded, the picture signals being applied as a frequency modulation, and the synchronising signals as momentary peaks of amplitude.

Marconi's W. T. Co. (assignees of R. D. Kell). Convention date (U.S.A.) 24th December, 1940.

552 582.—Cathode-ray system of stereoscopic television in which separate images are successively produced for right-eye and left-eye vision, respectively.

J. L. Baird. Application dates 11th July and 6th October, 1941.

552 659.—Colour television system in which two or more different target electrodes in a cathode-ray tube are scanned in such a way as to ensure registration of the differently-coloured images.
Hazeltine Corporation. Convention date (U.S.A.) 28th April, 1941.

TRANSMITTING CIRCUITS AND APPARATUS

(*See also under Television*)

552 039.—Method of operating a two-stage cross-coupled multivibrator as a frequency-modulating device.
Marconi's W. T. Co. (assignees of G. L. Usselman). Convention date (U.S.A.) 30th October, 1940.

552 068.—Short-wave wireless telegraphy system in which frequency-shift keying is used to minimise multi-path distortion.
Marconi's W. T. Co. (assignees of C. W. Hansell). Convention date (U.S.A.) 23rd November, 1940.

552 650.—Neutralising couplings for push-pull amplifiers operating on ultra-short waves at a high level of power.
Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 14th October, 1941.

552 672.—Resonant structure comprising two or more coaxial discs arranged in close proximity to form a high-frequency tank circuit.
The British Thomson-Houston Co. Convention date (U.S.A.), 17th August, 1940.

552 943.—Wave-amplitude limiting device arranged to give a favourable response to the transmission of frequency-modulated signals.
Zenith Radio Corporation. Convention date (U.S.A.), 26th December, 1940.

552 394.—Wave guide for transmitting multiplex television signals in which sections of different transverse dimensions are utilised as filters.
Standard Telephones and Cables (assignees of G. C. Southworth). Convention date (U.S.A.), 4th October, 1940.

552 482.—Arrangement for continuously feeding signals to a transmitter which thereafter radiates them on pulses at a higher level of energy.
Marconi's W.T. Co. (assignees of C. W. Hansell). Convention date (U.S.A.), 27th December, 1940.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

552 173.—Cathode-ray tube in which the fluorescent screen is applied directly to the interior glass wall and is viewed through a transparent conductive layer applied to the external surface of the tube.
Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 14th October, 1941.

552 183.—Method of cooling the anode of a valve which is designed to prevent consequential secondary bombardment of the cathode.
Standard Telephones and Cables (communicated by International Standard Electric Corporation). Application date, 28th November, 1941.

552 389.—Cathode-ray tube in which an electron image is projected on to the same side of a plane screen as a separate scanning stream of electrons.
G. S. P. Freeman and A. F. Henson. Application dates 2nd August, 1941, and 20th February, 1942.

552 459.—Velocity-modulation tubes fitted with removable resonant chambers in order to allow either the operating frequency to be varied, or a faulty chamber to be replaced.
Standard Telephones and Cables (assignees of C. V. Litton). Convention date (U.S.A.), 15th October, 1940.

552 523.—Means for reducing the halation effect, due to internal reflection, on the fluorescent screen of a cathode-ray tube.
Electrical Research Products, Inc. Convention date (U.S.A.), 12th June, 1940.

552 597.—Means for preventing excessive heating of the liquid in a gaseous discharge tube.
Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 26th November, 1941.

552 610.—Velocity-modulation tube with an internal Lecher-wire back-coupling element for generating ultra-high frequencies.
Akt. Brown, Boverie et Cie. Convention date (Switzerland), 20th February, 1940.

552 612.—Cathode-ray tube with magnetic deflecting coils which are closely wound about the glass surface in honeycomb fashion.
Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 29th July, 1941.

552 622.—Cathode-ray tube in which the dimensions and spacing of the tube electrodes are co-ordinated in specified manner with the operating potentials to ensure maximum definition and brightness in television reception.
Standard Telephones and Cables (assignees of S. J. Koch). Convention date (U.S.A.), 12th November, 1940.

552 700.—Method of sealing the lead-in conductors for ultra-high-frequency oscillation valves so that the conductors preserve a constant cross-section throughout their length.
Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 10th December, 1941.

552 718.—A two-grid valve wherein the wires of each grid are wound to the same pitch and wherein the active parts of the rear area are located in line with the centre of the apertures between the wires of the front grid.
Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 14th October, 1941.

552 743.—Cathode-ray tube in which the intensity of the electron stream is controlled by a voltage applied across an impedance located in the cathode lead.
Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 14th October, 1941.

552 791.—Construction and assembly of the component parts of the electrode system of a cathode-ray tube.
The British Thomson-Houston Co. and W. J. Scott. Application date, 5th February, 1942.

SUBSIDIARY APPARATUS AND MATERIALS

551 953.—Construction of multiple-roller condensers for high voltages.
Standard Telephones and Cables; J. A. Leno; and W. J. Stray. Application date, 15th September, 1941.

552 062.—Means for correcting "beginning and end" distortion in the shaped voltage pulses used for operating selective relays.
R. R. Birss. Application date, 23rd September, 1941.

552 098.—Valve circuit in which a variable impedance is utilised to convert a mechanical factor, such as pressure, into an equivalent voltage.
Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 19th September, 1941.

552 109.—Reactance winding, particularly for a polyphase system, designed to have a predetermined sequence of positive and zero impedance values.
The British Thomson-Houston Co. Convention date (U.S.A.), 28th June, 1941.

552 117.—Radio facsimile transmission system utilising frequency-modulated picture signals and amplitude-modulated synchronising impulses.
W. G. H. Finch. Convention date (U.S.A.), 5th April, 1940.

552 179.—Carrier-current system for distributing musical or like programmes over a line network not well adapted for the transmission of high frequencies.
Radio Gramophone Development Co. and H. F. Duffell. Application date, 21st November, 1941.

552 301.—Two-valve relay of the trigger or flip-flop type in which both valves have a common cathode load.
Cinema-Television and T. C. Nuttall. Application date, 29th September, 1941.

552 317.—Synchronising system utilising an harmonic of selected phase which is derived from a fundamental control frequency.
Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 29th July, 1941.

552 351.—Thermionic valve circuit for operating a relay in response to a sound of predetermined or selected frequency.
Hazeltine Corporation (assignees of H. C. Page). Convention date (U.S.A.), 3rd January, 1941.

552 355.—Means for driving a piezo-electric crystal so that it oscillates simultaneously in two uncoupled and independently-controlled ways.
Standard Telephones and Cables (assignees of H. J. McSkimin). Convention date (U.S.A.), 16th November, 1940.

552 386.—Piezo-electric assembly wherein the crystal is supported in a resilient mounting which is made substantially resonant to the fundamental frequency.
F. D. Bliley and C. Colman. Convention date (U.S.A.), 1st July, 1940.

552 414.—Secret system of telegraphy or telephony in which the normal signals are broken up into elements the time-sequence of which is then re-arranged according to a given code.
Akt. Brown Boverie et Cie. Convention date (Switzerland), 14th July, 1939.

552 438.—Circuit arrangement for coupling the second of two oscillation generators to a given load in the event of a breakdown of the first generator.
Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 3rd October, 1941.

552 572.—Condenser constructed to allow of adjustment to compensate for temperature variations whilst maintaining a predetermined capacitance.
The Mullard Radio Valve Co. and C. E. G. Bailey. Application date, 10th October, 1941.

552 635.—Method of measuring the time interval between two recurrent sets of electric impulses, one set being of constant and the other set of variable repetition frequency.
Standard Telephones and Cables (communicated by International Standard Electric Corporation). Application date, 20th March, 1942.

552 670.—Hollow resonator element with two sections having slightly different frequencies and inter-coupling means, the whole arrangement forming a band-pass filter.
Marconi's W.T. Co. (assignees of P. S. Carter). Convention date (U.S.A.), 1st October, 1940.

552 683.—Thermionic valve circuit for metering or detecting variations in the frequency of a source of oscillations.
Sir L. Sterling. Convention date (U.S.A.), 19th October, 1940.

552 688.—Thermionic valve circuit for converting a saw-tooth voltage into a facsimile saw-tooth current for application to the deflecting coils of a cathode-ray tube.
Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 31st October, 1941.

552 794.—Arrangement of the input circuit to a gas-filled discharge tube or inverter.
Allmanna Svenska Elektriska Akt. Convention date (Sweden), 28th February, 1941.

552 819.—Wired wireless distribution network with means for ensuring an optimum adjustment of load to the various subscribers.
Radio Gramophone Development Co. and H. F. Duffell. Application date, 21st November, 1941.

552 835.—Cutting and mounting a piezo-electric crystal so as to ensure a constant frequency of oscillation, free from parasitic frequencies, and independent of temperature changes.
Standard Telephones and Cables (assignees of W. P. Mason). Convention date (U.S.A.), 19th October, 1940.

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.

PROPAGATION OF WAVES

2052. POLYCYLINDRICAL ENDOVIBRATORS.—Neyman. (*See* 2081.)

2053. ELECTROMAGNETIC FIELDS IN RADIO: V—WAVES IN DIELECTRIC MATERIALS: VI—WAVES IN METALS AND THE IONOSPHERE.—M. Johnson. (*Wireless World*, June 1943, Vol. 49, No. 6, p. 178–181: July, No. 7, pp. 208–211.)

2054. SKIP DISTANCE: SIMPLE EXPLANATION OF THE EFFECT.—T. W. Bennington. (*Wireless World*, June 1943, Vol. 49, No. 6, pp. 160–163.)

2055. THE REFLECTION OF ELECTROMAGNETIC WAVES FROM A PARABOLIC FRICTION-FREE IONISED LAYER.—O. E. H. Rydbeck. (*Journ. Applied Phys.*, Sept. 1942, Vol. 13, No. 9, pp. 577–581: *Phil. Mag.*, May 1943, Vol. 34, No. 232, pp. 342–348.)

For other recent papers *see* 7 of January and 1364 of May. "The electron density distribution of the undisturbed F_2 layer of the ionosphere very often is essentially parabolic (23 of 1941 and ref. "2," a 1942 Chalmers University publication), at least at sufficient distances from the equator. It is therefore of general interest to study briefly the reflection of electromagnetic waves from such a layer. We assume that plane waves are transmitted in a direction normal to the ionised layer, the electron density of which is a function of the vertical (normal) distance only. . . ." "The introduction of the collisional frequency actually complicates the numerical calculation very much. A treatment of this case therefore is outside the scope of the present communication: a complete treatment of the dissipative case will appear shortly in the *Transactions of Chalmers University*. It should suffice here to show the numerical results for a fairly thick and a thin layer. By means of (4) and (4a) the corresponding results for layers of other dimensions can be obtained by transformation from the plots in Fig. 2 and Fig. 3. It is shown by Fig. 3 that a considerable collisional frequency is necessary to cause any appreciable reduction in virtual height for a thin layer. . . ."

For a non-dissipative medium the reflection coefficient R is determined by eqn. 9, holding throughout the frequency range. "Fig. 5 shows several plots of R^2 as a function of $(f/fc_m)^2$. The critical wavelength is 30 m as before. The deviation from classical optics is practically noticeable first for a half-thickness of about four to three wavelengths. As the layer becomes even thinner, appreciable reflections appear at frequencies well above the critical frequency. It is obvious that the critical frequency conception is misleading for a very thin layer." "Finally it should be stated that results similar to eqn. 8 have been obtained by Rawer (3879 of 1939) in an excellent paper on the reflection of electromagnetic waves from dissipative Epstein-Layers. A result closely similar to eqn. 9 for the penetration-frequency region has been communicated by Booker to Appleton (886 of 1939)".

2056. THE NEGATIVE IONS OF ATOMIC AND MOLECULAR OXYGEN.—D. R. Bates & H. S. W. Massey. (*Phil. Trans. Roy. Soc.*, Series A, 2nd April 1943, Vol. 239, No. 806, pp. 269–304.)

"The important rôle played by negative ions in upper-atmospheric and many discharge-tube phenomena has been emphasised by various authors. . . . In this connection the negative ions formed by and from atomic and molecular oxygen are of particular importance. We have therefore examined in detail the properties, modes of formation and of destruction of o^- and o_2^- ions. Even though, in the past few years, a considerable body of experimental information relating to these ions has been accumulating, it is necessary to employ quantum theory to a great extent to obtain information as to the importance, under various conditions, of the various phenomena involved. In doing this, however, we have taken account of all the experimental information available. Although it has not been possible to obtain definite results in many cases, we have attempted to enumerate all the possibilities, to point out inconsistencies, and to suggest further necessary lines of research. At all times applications to the theory of the ionosphere have been kept in mind, and it is hoped to consider this in detail in the light of the results and possibilities discussed in this paper. . . . In the first section we discuss the structure, mode of formation and of destruction of the negative ions formed by and from atomic oxygen. In the second section is a corresponding analysis of the ions formed by and from molecular oxygen, while in the third section the formation and mutual neutralisation of pairs of positive and negative ions is considered."

2057. A Method for the Separation of Helium from Neon.—E. K. Gerling & G. M. Ermolin. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 30th Sept. 1941, Vol. 32, No. 9, pp. 641–643: in English.)

"In gas analysis it is customary to estimate the sum of helium and neon, no further separation of these gases being effected. Such a separation is essential, however, for the solution of several geochemical problems. For example, the necessity for this separation arises while studying the geochemistry of neon, or estimating the content of helium in the stratosphere and troposphere . . . Paneth, for instance, in 1935 published the results of an estimation of the helium content of the atmosphere and stratosphere (30 of 1936). Unfortunately, no description of the method employed by that author for the separation of the helium from the neon has been given . . . Our method is based on the absorption of neon by coal at a temperature of $-225°$ C, as discovered by Peters . . . The last estimate in Table 4 was obtained by Paneth, and it can be noticed that it is 10% greater than ours [which is 0.000474%]. It is interesting to note that the content of light inert gases (0.00221%) as obtained by Paneth (ref. "7") is in good accord with the figure obtained by us (0.00224%). If we subtract the helium content . . . the amount of neon in the air, according to the obtained difference, will be 0.00177% . . ."

2058. Exploring the Ionosphere: Progress over a Complete Eleven-Year Cycle.—E. V. Appleton. (*Wireless World*, June 1943, Vol. 49, No. 6, pp. 182–183.) Summary of a "progress report" on the ionospheric research work carried out by the Radio Research Board: lecture before the Wireless Section, I.E.E.

2059. Effects of Solar Activity on the Ionosphere and Radio Communications [I.R.E. Summer Convention Paper, 1942: Survey of Present Knowledge: including a Comparison of Radio Circuits on Great-Circle Maps based on Washington & on San Francisco, in Light of Experience with Communications from These Points (Influence of Distance from Auroral Zones)].—H. W. Wells. (*Proc. I.R.E.*, April 1943, Vol. 31, No. 4, pp. 147–157.) A summary was referred to in 689 of March.

2060. Sunspot Activity should hit Low Point in [Early] 1944.—Elizabeth S. Mulders. (*Sci. News Letter*, 3rd April 1943, Vol. 43, No. 14, p. 218.) Prediction based on Mount Wilson sunspot records since 1933, on supposition that present cycle maintains its similarity to the last two cycles.

2061. First Sunspot of New Cycle has already Appeared? [for One Day only, nearly a Year before End of Present Cycle].—S. B. Nicholson. (*Science*, 26th Feb. 1943, Vol. 97, No. 2513, Supp. p. 12.)

2062. Discovery of Thorium in the Sun [in Ionised State only].—Charlotte E. Moore & A. S. King. (*Science*, 26th Feb. 1943, Vol. 97, No. 2513, Supp. p. 10.)

2063. Committee on Coordination of Cosmic-Ray Investigations [including Extracts from Korff's Memorandum on the Significance of Cosmic Rays in Meteorology, etc: Results & Progress in Year ending June 30th, 1942].—J. A. Fleming. (*Terr. Mag. & Atmos. Elec.*, Dec. 1942, Vol. 47, No. 4, pp. 309–314.)

2064. Further Note on the Effect on Cosmic-Ray Intensity of the Magnetic Storm of March 1st, 1942.—Isabelle Lange & S. E. Forbush. (*Terr. Mag. & Atmos. Elec.*, Dec. 1942, Vol. 47, No. 4, pp. 331–334.)

Extension of 2942 of 1942. "The simultaneous occurrence, on February 28th and March 7th, of two large increases in cosmic-ray intensity at Godhavn, Cheltenham, and Christchurch, suggests that they result from the magnetic effect on cosmic-ray trajectories of an eastward ring-current outside the Earth's atmosphere. Similar, but westward-flowing, ring-currents have been suggested to explain the world-wide decreases in cosmic-ray intensity during many magnetic storms. Such eastward-flowing ring-currents, or their magnetic equivalent, are required to explain the world-wide increase in horizontal magnetic intensity which usually precedes, though only by a few hours, the main phase of magnetic storms. That these eastward currents endure only a few hours, whereas the westward currents may endure several days, also suggests that the former are responsible for the two sharp increases in cosmic-ray intensity of February 28th and March 7th, especially since there is some indication in Fig. 2 of simultaneous increases of horizontal magnetic intensity . . ." Reasons are given against attributing the effects to the Sun instead of to the magnetic-storm field.

2065. SUDDEN-COMMENCEMENT MAGNETIC STORMS IN 1941 [Table of Commencement-Times at Nine Different Observatories, and Discussion of Observations at Hermanus Observatory, South Africa.].—A. Ogg. (*Terr. Mag. & Atmos. Elec.*, Dec. 1942, Vol. 47 No. 4, pp. 329–331.)

"The change of the magnetic field at the time of a chromospheric eruption is evidently due to dynamo-action in one or more of the ionospheric layers ionised by ultra-violet light from the eruption, as the ionising agent travels with the speed of light. These magnetic effects due to chromospheric eruptions, which have been observed at Hermanus Observatory, during daylight hours, are probably due to the greater ion-content over the day hemisphere. Further investigations of the magnetograms at observatories in the night hemisphere would be interesting. Another point of interest is that at the time of the radio fade-out the magnetic effect on the declination is greater than on the horizontal intensity, which is contrary to the usual occurrence at the beginning of a magnetic storm . . ."

2066. MAGNETIC ACTIVITY AT DOMBÅS BASED ON ABSOLUTE STORMINESS FOR THE HORIZONTAL COMPONENT [Statistical Investigation over 11-Year Period 1923/33: Proposed New Index, L, depending on AS'_H, and Comparison with K].—K. F. Wasserfall. (*Terr. Mag. & Atmos. Elec.*, March 1943, Vol. 48, No. 1, pp. 29–39.)

2067. AMERICAN MAGNETIC CHARACTER-FIGURE, C_A, THREE-HOUR-RANGE INDICES, K, AND MEAN K-INDICES, K_A, FOR OCTOBER TO DECEMBER, 1942, AND SUMMARY FOR YEAR 1942.—H. F. Johnston. (*Terr. Mag. & Atmos. Elec.*, March 1943, Vol. 48, No. 1, pp. 19–27.)

2068. SUMMARY OF THE YEAR'S WORK, TO JUNE 30TH, 1942, DEPARTMENT OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTION OF WASHINGTON.—J. A. Fleming. (*Terr. Mag. & Atmos. Elec.*, Dec. 1942, Vol. 47, No. 4, pp. 301–308.) For the previous year's report *see* 2274 of 1942.

2069. "AMERICAN GEOPHYSICAL UNION: TRANSACTIONS OF 1942" [Book Review].—J. A. Fleming (Edited by). (*Terr. Mag. & Atmos. Elec.*, March 1943, Vol. 48, No. 1, pp. 39–40.)

2070. ARCHAEOLOGICA GEOMAGNETICA, *and* SOME EARLY CONTRIBUTIONS TO THE HISTORY OF GEOMAGNETISM: I—THE LETTER OF PETER PEREGRINUS DE MARICOURT TO SYGERUS DE FOUCAUCOURT, SOLDIER, CONCERNING THE MAGNET.—S. Chapman: H. D. Harradon. (*Terr. Mag. & Atmos. Elec.*, March 1943, Vol. 48, No. 1, pp. 1–2: pp. 3–17.)

2071. THE ABSORPTION OF INFRA-RED RADIATION BY WATER-VAPOUR AND CARBON DIOXIDE [Theoretical & Experimental Investigation: the Question of the Validity of Beer's Law].—M. McCaig. (*Phil. Mag.*, May 1943, Vol. 34, No. 232, pp. 321–342.)

2072. THE PROBLEM OF THE SCATTERING AND EXTINCTION OF LIGHT BY A CONGLOMERATION OF SMALL PARTICLES.—E. G. Richardson. (*Proc. Phys. Soc.*, 1st Jan. 1943, Vol. 55, Part 1, No. 307, pp. 48–61). In a paper entitled "Turbidity Measurement by Optical Means." For a Discussion *see* pp. 61–63, and *ibid.*, 1st May 1943, Vol. 55, Part 3, pp. 246–247. *See* also 141 of 1941.

2073. AN APPROXIMATE EXPRESSION OF FRESNEL'S FORMULAE FOR LARGE ANGLES OF INCIDENCE.—A. A. Hershun. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, 30th Aug. 1941, Vol. 32, No. 6, p. 400: in English.)

"Thus, with some approximation, it may be considered that with gliding incidence of light (practically $\alpha < 5°$) the logarithm of the coefficient of reflection is proportional to the angle formed by the ray and the surface."

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2074. THE SEPARATION OF ELECTRICITY IN CLOUDS [Criticism of Paper by J. A. Chalmers (1007 of April)].—G. C. Simpson: Chalmers. (*Phil. Mag.*, April 1943, Vol. 34, No. 231, pp. 285–287.)

2075. MAGNITUDES OF LIGHTNING CURRENTS [Previously Accepted Maximum & Average Current Values of 200 & 20 Kiloamperes are Too High, owing to Erroneous Assumption: New Method of Calculation, based on Quasi-Stationary Determination of Current Distribution, yields 160 & 15 Kiloamperes: Recent Magnetic-Link Records on Single Lightning Conductors are thus Explained].—R. H. Golde. (*Nature*, 10th April 1943, Vol. 151, No. 3832, p. 421.)

2076. LIGHTNING PROTECTION OF HAZARDOUS STRUCTURES.—G. D. McCann. (*BEAMA Journal*, April & May 1943, Vol. 50, Nos. 70 & 71, pp. 111–115 & 147–149.) From a paper in *Elec. Engineering*, Dec. 1942.

2077. THE RELATIONSHIP BETWEEN ATMOSPHERIC-ELECTRICAL PHENOMENA AND CERTAIN METEOROLOGICAL PHENOMENA SUCH AS BAROMETRIC PRESSURE, RELATIVE HUMIDITY, TEMPERATURE, AND SUNSHINE: EXPERIMENTAL INVESTIGATION.—J. F. Mackell. (*Terr. Mag. & Atmos. Elec.*, Dec. 1942, Vol. 47, No. 4, pp. 341–342: paragraph only.) "Data obtained so far [1941] are insufficient for final conclusions but indicate a positive relationship."

2078. Association of Large Ions and Fog.—Marcella L. Phillips. (*Terr. Mag. & Atmos. Elec.*, Dec. 1942, Vol. 47, No. 4, pp. 295–299.)

2079. Effect of Smoke [from Burning of Fields & Brush] on the Atmospheric-Electric Elements at the Watheroo Magnetic Observatory [Increase in Potential-Gradient, Decrease in Sum of Conductivities, Relatively Small Change in Ratio of Positive to Negative Conductivity, Lowering of Air/Earth Current: Discussion of Mechanism: Variation of Amount of Radioactive Matter in Air as a Cause of Variation of Rate of Small-Ion Production through the Day: etc.].—G. R. Wait. (*Terr. Mag. & Atmos. Elec.*, March 1943, Vol. 48, No. 1, pp. 49–63.)

2080. Further Evidence of a Latitude-Effect in Potential-Gradient.—O. H. Gish. (*Terr. Mag. & Atmos. Elec.*, Dec. 1942, Vol. 47, No. 4, pp. 323–324.)

PROPERTIES OF CIRCUITS

2081. Polycylindrical Endovibrators.—M. S. Neyman [Neiman]. (*Izvestiya Elektroprom. Slab. Toka*, No. 2, 1940, pp. 33–38.)

For previous work *see* 455, 1743, and 1744 of 1940. A polycylindrical endovibrator or multiple resonant line consists of a cylinder with two end-plates, inside which are mounted a number of coaxial cylinders. These cylinders are fixed alternately to one or the other end-plate, while the free ends of the cylinders do not quite reach the opposite plate (Fig. 1). The arrangement is equivalent to a number of coaxial lines, connected in series, each of which is formed by the outer surface of a cylinder and the inner surface of the next larger cylinder. The mechanical and electrical advantages of the system over an ordinary resonant line are pointed out, and methods are suggested for designing a system with a given diameter of the outside cylinder so as to obtain the lowest decrement, *i.e.* the greatest stabilising effect.

2082. Transitron Oscillators [Comments on Chambers' Articles (1400 of May & 1657 of June): Doubts on Transitron Mechanism accounting entirely for 60 Mc/s Oscillations: Warnings as to Frequency Stability: Suggested Improved Circuit].—T. J. Rehfisch. (*Wireless World*, June 1943, Vol. 49, No. 6, p. 184.)

2083. Application of the Transformation Law of Loss-Free Quadripoles to the Series Connection of Quadripoles.—A. Weissfloch. (*Hochf:tech. u. Elek:akus.*, Jan. 1943, Vol. 61, No. 1, pp. 19–28.)

Author's summary:—" Starting from the ' transformation law ' developed in my previous paper (711 of March: *see* also 2084, below), which states that every loss-free four-terminal network which fulfils the requirements of the so-called ' inversion ' law can be extended at the input and output by lengths of homogeneous line of suitable length to form an ideal, leakage-free transformer, the paper investigates the connection in series of several such quadripoles.

" The results find rich possibilities of application in the decimetric- and centimetric-wave regions, for example in the compensation of points of irregularity in lines, the design of variable transformers and band filters, and the compensation of the frequency characteristics of frequency-dependent impedances, for instance aerials. The attainable degree of perfection, for example in the pass band of band filters or in the compensation of frequency curves, depends chiefly on the question of the expenditure on materials."

Section II deals with the transformation properties of two loss-free quadripoles in series (Fig. 1). " Without limiting the general nature of the treatment we may assume that the connecting line between the two quadripoles has a constant characteristic impedance Z_3, since the transition from one characteristic impedance to another can be represented as a third quadripole. The series connection of the two quadripoles thus fulfils the requirements of the transformation law, and there will always be a point x_0 behind quadripole I and a point y_0 in front of quadripole II [in all the diagrams the generator is taken as to the left of the quadripole] such that the quadripole lying between x_0 and y_0 has the properties of an ideal transformer with the transformation $\ddot{u} = \sqrt{K}$. Our task is to determine how x_0, y_0, and K can be derived from the values $x_0^{(1)}$, $y_0^{(2)}$, k_1, and k_2 and the distance a between the points $y_0^{(1)}$ and $x_0^{(2)}$. For the case where $a = 0$ or $n.\lambda/2$ (where n is a whole number) it is obvious that $x_0 = x_0^{(1)}$, $y_0 = y_0^{(2)}$, and $K = k_1 k_2$. Also for $a = \lambda/4$ the answer is easy: x_0 is in this case to be chosen at a distance of $\lambda/4$ from $x_0^{(1)}$: an impedance $\mathfrak{R}_2$ connected at x_0 then appears at $x_0^{(2)}$ as $Z_3^2 \mathfrak{R}_2 / k_1 Z_2^2$, and at $y_0 = y_0^{(2)}$ as $\mathfrak{R}_1 = (k_2 Z_3^2 / k_1 Z_2^2) . \mathfrak{R}_2$. In the case where $k_1 = k_2 Z_3^2 / Z_2^2$, therefore, an impedance $\mathfrak{R}_2$ connected at x_0 will appear at y_0 with the same value $\mathfrak{R}_2$: that is, $K = 1$. *This fact, that two quadripoles at a suitable distance can mutually compensate each other in their action, is specially important.* The transformation number K can thus vary between $k_1 k_2$ and 1, according to the distance." The remainder of section II deals with the extension of the calculation of x_0, y_0 and K to the transformation of pure reactive impedances: eqn. 8 is arrived at for the transformation number K for the combined quadripoles. But in many cases the transformation constants are better obtained by graphical methods, especially when the spacing a is the only point of interest.

Section III deals with the series connection of quadripoles and lengths of line with different characteristic impedances. For the special case where $Z_1 = Z_2 = Z$ and $k_1 . Z/Z_3 = k_2 . Z_3/Z = +\sqrt{k_1 k_2} = m$ (including the still more special case where $Z_1 = Z_2 = Z_3$ and $k_1 = k_2 = m$), eqn. 8 for K simplifies to eqn. 11. Under these conditions Fig. 2 gives the curves for the determination of K, x_0, and y_0. A special practical application is to the treatment of a homogeneous line-section whose characteristic impedance Z_3 differs from that of the rest of the line, Z, owing to a difference either in its cross-section (Fig. 3a) or in its dielectric (Fig. 3b). These diagrams show how such arrangements are represented as the series connection of two quadripoles fulfilling the above-specified conditions, so that the curves of Fig. 2 can be used. In the case of the different cross-section, the disturbing effect of the corners is at first neglected, but the question of correction for this effect is discussed at the end of the section.

Section IV describes how the irregularities of behaviour due to mountings, bent sections, transitions from one cross-section to another, etc. (which in the previous paper were seen to be representable as transformers whose input v_0 and output x_0, and transformation ratio $\sqrt{k}$, could be determined experimentally), can be compensated, as indicated above, by a second transformer of identical k connected in the line at a suitable distance. Thus Fig. 4b shows how the disturbance due to a right-angle bend can be compensated by a trolitul disc. Such compensation is only exact at a single frequency. How it can be accomplished for a wide range of frequencies is seen in section V, on variable transformers. It has been seen that by altering the distance between two quadripoles K can be varied within wide limits. If $k_1 = k_2 = k$, the variation can be between $K = 1$ and $K = k^2$ (Fig. 2). In practice the quadripoles can be made from metal, ceramic, or trolitul elements which can be moved along a homogeneous line (Fig. 5).

"If the homogeneous line has a characteristic impedance Z, two such quadripoles with the transformation number k will transform all impedances lying, in the complex-number plane, within the circle through k^2Z and Z/k^2 (Fig. 6), to give, for example, progressive waves. It is only necessary to shift the transformer elements to the correct position along the line. Conversely, a line terminated for progressive waves can be transformed to any other impedance within the circle of Fig. 6." Various practical points are discussed on pp. 23 (r-h column) and 24. Fig. 7 shows as a simple example a terminating resistance constructed for the laboratory, to provide a uniform line of 70 ohms characteristic impedance with a pure progressive-wave termination in the 14 cm-wave region. A semiconductor resistance *a* is used as the attenuating element, but with the values available a wave-ratio U_{min}/U_{max} of 0.7 was the highest that could be reached. By means of a single trolitul disc of accurately determined thickness and position the resistance could be transformed to 70 ohms: the same thing could be done with two trolitul discs (of arbitrary thickness 6 mm) by correct adjustment of their positions. The $\lambda/2$ transformation section seen at *c* in Fig. 7 was for the purpose of correcting the frequency characteristic (*see* section VII).

Another type of variable transformer is the "triple tie-line" illustrated in Fig. 8, mentioned by Meinke (3048 of 1942). The action of this is discussed with the help of Fig. 9. It allows the optimum matching to a transmitter or an aerial to be obtained, and its adjustment is quick and convenient if the output can be read directly, by a bolometer for instance. But when it is necessary to transform to a certain impedance which can only be indicated by the potential distribution along a test line, the previous method with two displaceable transformation sections is much more methodical and quicker. This somewhat complex point is discussed in detail at the end of section V.

Section VI deals with band filters and the compensation of points of irregularity for a wide frequency band. In the simplest types of filter there is, strictly speaking, only one pass frequency, and the steeper the rise of attenuation is made at the flanks of the curve, the narrower becomes the pass band. It is however possible to make filters with a wide pass band and nevertheless steep flanks. Taking two arbitrary frequencies f_1 and f_2, free transmission for both can be obtained by the use of four transformation sections (Fig. 11). Of these, I and II must be so chosen and arranged that they compensate each other for f_1, while III and IV likewise cancel out their actions for the same frequency: thus no matter what the distance between these two "twin groups" may be, progressive waves behind the transformation elements will, for the frequency f_1, yield progressive waves also ahead on the line. For the frequency f_2 the "twin group" made up of I and II would have a transformation number K differing from unity. Elements III and IV must then be so chosen that they have, for f_2, the same transformation number. The simplest way of doing this is to use four equal transformation elements: according to the preceding work, the distance of the twin group I and II from the twin group III and IV can be so chosen that the two groups compensate for each other at the frequency f_2. Then if f_1 and f_2 are not too far apart, the combination should give an attenuation characteristic of the shape of Fig. 12. The slope of the two flanks of the pass band will be the steeper, the larger the transformation numbers of the individual sections. It is obvious that by connecting two such "quad groups" a point of zero attenuation can be obtained for a third frequency f_3, and four zero points for the use of 16 elements, and so on. The measuring methods given in the earlier paper allow a systematic "trimming" of such filters.

Another way of flattening or widening the pass band of a filter containing only two sections is by the use of $\lambda/2$ transformation sections (*cf.* Fig. 7, referred to above): the properties of such a section are shown in Fig. 13, and the discussion of this method occupies the remainder of section VI. "What has been said about the widening of the pass band of filters applies naturally also to the compensation of unavoidable points of irregularity. These can be compensated exactly not merely for one frequency but for any number." The final section VII deals with the correction of frequency characteristics. The use of $\lambda/2$ sections (or sections of a multiple of this length) has already been referred to in connection with Fig. 7. Such a section has its frequency fixed once and for all by its length, and if the same compensating action is required at another frequency the section must be replaced by another. The substitution of a "twin group" (for instance, two discs) for the $\lambda/2$ section introduces the possibility of adjustment for different frequencies, but a "quad group" (Fig. 11) provides the complete solution.

2084. NOTE ON MY PAPER "A TRANSFORMATION THEOREM FOR LOSS-FREE QUADRIPOLES, AND ITS APPLICATION TO THE EXPERIMENTAL INVESTIGATION OF DECIMETRIC- AND CENTIMETRIC-WAVE CIRCUITS".—A. Weissfloch: H. Meinke. (*Hochf:tech. u. Elek:akus.*, Feb. 1943, Vol. 61, No. 2, p. 57.)

Meinke has called the writer's attention to the fact that in the former's paper "A Circle Diagram for the Calculation of the Processes on Lines" (1853 of 1941) relations are established from which a proof of the latter writer's "transformation law" (711 of March: *see* also 2083, above) can be deduced without difficulty. Weissfloch replies that Meinke's procedure, when applied to arbitrarily complex loss-free quadripoles, requires that at least the quadripole constants should be known beforehand, whereas his own treatment starts from such quadripoles whose constants are unknown and as a rule (as his examples show) cannot be calculated, at any rate with any accuracy. "A very simple measurement on the lines of Fig. 2 or 7 of my paper thus always yields curves (Fig. 3 or 4) which allow a very simple and exact estimate of the transformation properties to be obtained. The quadripole between the points x_0 and y_0 behaves as a leakage-free and loss-free transformer, whose transformation ratio can be derived similarly in the simplest way from the measured curves. The difference between the two papers is revealed most clearly of all by the fact that Meinke's preliminary setting-out of the problem could not begin to be applied to the majority of my examples. It is just the fact that my method allows such incalculable points of irregularity to be determined exactly in so simple a manner that gives importance, in my view, to the transformer law which I have formulated", and which had already appeared in 1940 in two patent applications by the writer.

2085. "EINFÜHRUNG IN DIE VIERPOLTHEORIE DER ELEKTRISCHEN NACHRICHTENTECHNIK" [Second Edition: Book Reviews].—R. Feldtkeller. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 23, 1942, p. 319: *Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, p. 178.) Vol. II of Fassbender's series "Physik und Technik der Gegenwart" (Communications Section). This edition has been enlarged and revised.

2086. NETWORK THEORY, FILTERS, AND EQUALISERS: PARTS I AND II.—F. E. Terman. (*Proc. I.R.E.*, April & May 1943, Vol. 31, Nos. 4 & 5, pp. 164–175 & 233–240.)

Portions of a forthcoming book "Radio Engineers' Handbook". Part I contains:—network definitions & theorems: general mesh equations of a network, and their solution: two-terminal reactive networks: inverse or reciprocal impedances: fundamental relations in four-terminal networks: fundamental types of the latter: reactive T, L and π networks for matching impedances. Part II contains:—attenuators: relation between attenuation and phase-shift in four-terminal networks, and application of minimum-phase-shift principles to the design of feedback-amplifier circuits. To be concluded.

2087. THE AMPLITUDE OF NOISE VOLTAGES.—Fränz. (*See* 2124.)

2088. SUPPRESSION OF SPONTANEOUS FLUCTUATIONS IN AMPLIFIERS AND RECEIVERS FOR ELECTRICAL COMMUNICATION AND FOR MEASURING DEVICES.—M. J. O. Strutt & A. van der Ziel. (*Physica*, Vol. 9, 1942, p. 513 onwards.)

2089. SUPPRESSION OF SPONTANEOUS FLUCTUATIONS IN $2n$-TERMINAL AMPLIFIERS AND NETWORKS.—A. van der Ziel & M. J. O. Strutt. (*Physica*, Vol. 9, 1942, p. 528 onwards.)

2090. THE E.M.F. OF THERMAL FLUCTUATIONS IN RESISTANCES.—M. Surdin. (*Nature*, 7th Nov. 1942, Vol. 150, No. 3810, p. 550.)

The formula $e_\nu^2 = 4.R.k.T$ was first derived by Nyquist by thermodynamical reasoning: Bernamont (1715 of 1937) derived it from the corpuscular point of view, using the Lorentz theory of electrons: Bakker & Heller (1842 of 1939) have shown that to specify Boltzmann or Fermi-Dirac statistics (as Bernamont did) is unnecessary, and that the equation can be obtained by application of the most general statistical considerations. "The following derivation of the equation, using macroscopical considerations for conductors satisfying Ohm's law, is based on the equipartition of energy . . .".

2091. VOLTAGE FLUCTUATIONS IN RESISTORS (JOHNSON EFFECT).—N. R. Campbell & V. J. Francis. (*Phil. Mag.*, April 1943, Vol. 34, No. 231, pp. 259–265.)

Authors' summary:—"Gives a proof of Johnson's formula for thermal fluctuations based on the principles of Brownian motion and exhibiting the relation between the Johnson effect in resistors and the shot effect in a saturated electronic current."

2092. THE CALCULATION OF THE ALTERNATING-CURRENT RESISTANCE OF LAYERED CYLINDRICAL CONDUCTORS.—W. Egloff. (*E.N.T.*, Oct. 1942, Vol. 19, No. 10, pp. 191–196.)

"The demand for material economy has recently given repeated rise to the question under what conditions can solid copper wires be replaced by the so-called 'K.P.S.' conductors, iron wires surrounded by a copper sheath [*see*, for example, Klein, 911 of March; Proctor, 1278 of April]. The formal solution for the effective resistance of layered cylindrical conductors has been known for some time (1933 Abstracts, p. 171 [Fischer]: pp. 323–324 [Ekelöf]: p. 269 [Strutt]: and Kruse & Zinke, 698 [and 2224] of 1935), so that to give a derivation here would be superfluous. What will be done here is to make merely a contribution to the surmounting of the great mathematical difficulties which present themselves in the numerical working-out of the general results. The formulae given in this paper allow the entire frequency characteristic of the effective resistance in all cases occurring in practice to be calculated. Without any excessive expenditure in computation the accuracy attained for the final results can be made as high as is desired. . . ."

"From the above-mentioned works, particularly that of Kruse & Zinke, it is easy to see that the effective resistance $R_{a,b}$ of the layered conductor can be written in the form of eqn. 1. The quantities $P_{n,m}$ (az, bz) occurring therein are defined by eqn. 2, where J_n and Y_n are the Bessel or Neumann functions of the nth order. For the effective resistance of the solid round wire of radius b, eqn. 3 is obtained from eqn. 1 by the boundary transition $a \to 0$. Further, the resistance of a tube can be obtained from the general equation 1 by a simple transition: if $\sigma_1 \to 0$ the quotient $\sigma/\kappa = \sqrt{\mu_2\sigma_1/\mu_1\sigma_2}$ becomes zero, and the a.c. resistance of a metal tube with radii a and b, filled with (magnetically unpolarisable) air, is given by eqn. 4."

The main difficulty in the numerical working-out of eqns. 1 and 4 lies in the calculation of the numerical values of $P_{n,m}$. The direct method, using the Jahnke-Emde and Tölke tables, leads to errors. But there is a way in which these errors (arising from the nature of the functions defined in eqn. 2) can be avoided, and the work of calculation simplified more and more the smaller the thickness d of the coating—that is, the smaller the difference the two radii, a and b: these are just the conditions in which the direct-method errors become particularly great. The procedure in question depends on the connection between the quantities $P_{n,m}$ and the hypergeometric series $F(\alpha, \beta, \gamma, \xi)$ of Gauss. This connection was first pointed out, for certain special cases, by Schafheitlin in 1908 (ref. "8"), but the present writer has been unable to find, anywhere in the literature, that use has ever been made of his developments. The general formulae of eqn. 5, now given, are taken from a work on cylinder functions by Buchholz (2599 of 1939). By the use of the theory of hypergeometric functions eqns. 9a, b, and 10 a–c are obtained from this, and their employment (in conjunction with the main equation 8) for the calculation of $P_{n,m}$ is summarised in the last paragraph of section 1.

If the frequency is increased so that the auxiliary variable u (eqn. 11) exceeds the value 2, calculation by means of the series of eqn. 8 becomes laborious, and therefore in section 2 the writer derives, with the help of Hankel asymptotic developments of cylinder functions, an expression for higher frequencies. Thus "for frequencies above the limiting frequency given by eqn. 12a, formulae 20 and 21 ["the final asymptotic formulae for the effective resistance of the layered cylindrical conductor"] allow a direct calculation to be made of the resistance $R_{a,b}$ for any arbitrary values of a, b, μ_1, μ_2, and σ_1, σ_2. The fact that the two methods of calculation possess a fairly wide frequency region common to both allows the numerical results to be checked."

In section 3 the formulae arrived at are applied to calculate the a.c. resistance of a certain copper-coated iron wire, for four values of coating thickness. As independent variable the quantity x is taken, where $x = \sqrt{\pi\mu_2\mu_0\sigma_2} \cdot \sqrt{f} = 4.752 \sqrt{f(\text{kc/s})}$, and the limiting values of x for the satisfactory use of the series of eqn. 8 in section 1 are found for the four thicknesses: thus x must not exceed 52 for the 0.02 cm coating, nor 23 for the 0.05 cm coating: that is, the highest frequency for the thinnest coating is 120 kc/s, and for the thickest, 23 kc/s.

On the other hand, the limits of frequency for the use of the asymptotic formulae of section 2, for the same wires, are that f must not be below 12 kc/s for the thinnest coating or below 18 kc/s for the thickest. Fig. 2 shows the $R_{a,b}$ frequency characteristics from $f = 100$ c/s to $f = 500$ kc/s, for these particular wires, while Fig. 3 gives the $R_{a,b}/R_b$ frequency characteristics over a slightly greater range, up to about 1 Mc/s. The limiting values (for $f = 0$) are introduced into both diagrams. The curves of Fig. 3 show that the ratio $R_{a,b}/R_b$ is smaller than unity at certain frequencies: that is, the resistance of the wire with the poorly conducting iron core may be less than that of the solid copper wire. This result is due to the phase displacement between the magnetic fields in the cylinder surfaces $r = a$ and $r = b$.

2093. Copper-Covered Wire Good for High-Frequency Lines [Research (leading to Practical Formulae) on Wire made by welding Copper Covering on Steel Core: Frequencies up to 150 kc/s].—B. R. Teare, Jr., & Josephine R. Webb. (*Sci. News Letter*, 27th March 1943, Vol. 43, No. 13, p. 207.) From the Carnegie Institute. *Cf.* Klein, 911 of March, and Egloff, 2092, above.

2094. Radio Data Charts: No. 8—Power Dissipated by a Resistance.—J. McG. Sowerby. (*Wireless World*, June 1943, Vol. 49, No. 6, pp. 173–175.)

2095. A Circuit Network for Trebling the Impedance Angle of a Lattice Section, and Its Use for Phase-Correction in Pupinised Lines.—M. Wald. (*E.N.T.*, Oct. 1942, Vol. 19, No. 10, pp. 196–199.)

"We confine ourselves here to lattice sections whose series resistance $R_1 = jX_1$ and shunt resistance $R_2 = jX_2$ are reciprocal to each other, so that the characteristic impedance $\sqrt{R_1R_2} = k$ is independent of frequency, and real. Such sections are characterised by the fact that their attenuation for all frequencies is zero, while their impedance angle (that is, the phase angle between input and output voltages) varies with the frequency. On account of this property the sections are particularly employed in phase-compensating circuits, to eliminate the phase-distortions occurring in transmission systems. For this purpose it is usual to combine several sections into a chain terminated by the common characteristic impedance k, so that the impedance angles of the individual sections are added together. Thus in order to produce a phase displacement corresponding to three times the impedance angle of a single section, it would be necessary to combine three equal sections and to terminate this chain by the characteristic impedance k", as in Fig. 1.

In the present paper an arrangement is described by which the same result is obtained with far fewer components : its fundamental principle is that the lattice section should be terminated at the end not by a real characteristic impedance k but by a pure reactance, so that a reflection occurs here and the reflected wave can be made to combine suitably with the advancing wave, the voltages of the two waves adding and the currents subtracting. The reflected wave has the same amplitude as the advancing wave at all frequencies, but is displaced in phase. If the terminating resistance R $(= jX)$ is chosen so that $R = k^2/\frac{1}{2}R_1 = 2R_2$, that is, so that it equals half the series resistance of the section and twice its shunt resistance, the reflected wave will arrive at the input terminals with the voltage $E_{1r} = E_v \cdot e^{-j3\alpha}$ (eqn. 13), where α is the impedance angle of the section and the subscripts r and v stand for the reflected and advancing waves respectively. Thus the resultant voltage at the input terminals is $E_v + E_v \cdot e^{-j3\alpha}$, which, if the voltage at the input terminals due to the advancing wave, E_v, were suppressed, would be identical with the resultant voltage given by the three-section chain of Fig. 1. It is therefore necessary to suppress this voltage E_v, and this is accomplished by means of the bridge circuit of Fig. 3. Circuits of Fig. 1 and Fig. 3 are therefore equivalent except for the voltage loss of 4 : 1 due to the voltage-dividing action of the bridge circuit : this loss can be made up for by amplification. Then the trebled impedance angle is produced with the help of 5 circuit components instead of the 12 of Fig. 1, a saving of 58%. Fig. 4 and the adjacent text deals with the application of the system to the phase correction of a 140-km length of Pupinised cable.

2096. THE STAGE EFFICIENCY OF AN IMPULSE GENERATOR : A MATHEMATICAL NOTE.—G. H. Rawcliffe. (*Phil. Mag.*, May 1943, Vol. 34, No. 232, pp. 353–359.)

"The prototype impulse generator, from which all impulse generators are derived, is a condenser C charged from an independent direct-current source V and discharged through a resistance R across which the impulse voltage is developed." The time taken for the voltage to fall to half the original value is $CR \log_e 2$ seconds. An impulse voltage wave is defined as a (t_1/t_2) wave, where t_1 is the time to the peak voltage and t_2 is the time to half voltage on the wave tail, both in microseconds. According to this definition the prototype impulse wave is a (Zero/$CR \log_e 2 \times 10^6$) wave.

The paper examines the effect of inductance in the circuit and obtains simple expressions, susceptible of being rapidly evaluated for particular values of the constants concerned, for t_1 and for the ratio of the peak voltage to the voltage to which the condenser is initially charged, this ratio being known as the "stage efficiency of the impulse generator." As an example, the formulae are applied to an actual impulse generator, using the normal Marx circuit.

It is stated that the type of mathematical analysis used can be applied to any physical problem whose mathematical form consists of the difference between two exponential functions of widely different negative indices.

2097. QUARTZ BRIDGE FILTERS WITH VERY NARROW PASS BAND.—E. Hudec. (*E.N.T.*, Sept. 1942, Vol. 19, No. 9, pp. 174–189.)

"In two earlier papers (2626 of 1942), which will be referred to as 'I' and 'II,' quartz bridge filters were calculated on the assumption of negligible losses, and their properties investigated. For a pass-band width of about ± 1.5 kc/s and a middle pass frequency of 100 kc/s, the measured attenuation curves agreed practically completely with the calculated curves (I, Figs. 20a & b). For a middle frequency of 500 kc/s and the same pass-band width, appreciable discrepancies between the measured and calculated attenuation curves begin to appear (II, Figs. 15 & 16) but do not upset things seriously. A further rise in frequency or, equally, a decrease in band width does however soon bring about unwelcome fluctuations of attenuation in the pass-band region. In the present paper it is shown that these fluctuations of attenuation are to be attributed to the losses in the coils, and that they can be reduced to below 0.05 neper per filter-section, for a relative band-width down to as little as 2‰, by suitable design giving a figure-of-merit $1/d = 250$ for the coils."

Author's summary :—"The influence of losses on the shape of the attenuation curves of bridge-type filters is calculated generally and numerically and shown in curves. The losses affect the curve-shapes particularly strongly when the loss-coefficient $R_{10}/\mathfrak{Z}_M$ becomes greater than unity (R_{10} being the active component of a bridge-leg in the middle of the pass-band and $\mathfrak{Z}_M$ the characteristic impedance of the loss-free filter, also in the middle of the pass-band) : the pass-band is narrowed, the steepness of slope of the curve-flanks is diminished, and a rise in attenuation appears in the middle of the pass-band. If the upper resonance frequency f_5 is chosen near the middle pass frequency f_0, a gradual rise in attenuation makes its appearance also from the beginning to the end of the pass-band.

"So long as $R_{10}/\mathfrak{Z}_M < 1$, these effects of losses can be kept small by a suitable design of the terminating resistance and by a suitable choice of the filter constants, especially of the inductance of the quartz crystals and the upper resonance frequency f_5. In Figs. 14 and 15, attenuation curves of loss-free filters and of filters with a loss-coefficient $R_{10}/\mathfrak{Z}_M = 1$ are compared. The losses have a specially unfavourable effect when the quantity λ [*see* eqns. 13a & b] is near its lower limit of 0.5 (*cf.* II, Fig. 3). For $\lambda = 0.55$, for example, the losses make the figure-of-merit G of the filter [*see* eqn. 47] fall from 6.4 nepers to 3.5 nepers ; for $\lambda = 0.625$ it only falls from 6.4 to 4.8 nepers.

"The loss-coefficient $R_{10}/\mathfrak{Z}_M$ depends chiefly on the loss-coefficient d of the oscillatory circuit L_0C_0 and on the relative band width $\Delta f_b/f_0$. It is proportional to d : its dependence on the relative band width is seen in Fig. 4. Since it increases very rapidly with decreasing band width, the losses make themselves particularly felt with narrow pass-bands and with very high middle pass frequencies. For instance with $R_{10}/\mathfrak{Z}_M = 1$ and a middle pass frequency $f_0 = 1.5$ Mc/s, an effective pass-band width is obtained of ± 2 kc/s with a coil figure-of-merit $1/d = 250$.

"A quartz bridge filter can be combined with suitable input and output transformers [section 5] to form a stage in an amplifier with adjustable amplification [Fig. 6 and sections 4, 5]. The attainable amplification per stage is calculated generally, and also with particular attention to the influence of the amplification-control on the attenuation characteristic. If, for example, an attenuation-variation of ± 0.1 neper is permitted in the cut-off region, a filter with a loss-coefficient $R_{10}/\mathfrak{Z}_M = 1$ gives an amplification of 2.5 nepers per amplifying stage. Such a stage was constructed with the above data, balanced [section 8], and its behaviour investigated. The resulting attenuation curves, variation with amplification-regulation, and amplification ratio all agreed with the calculated values."

2098. QUARTZ OSCILLATORS AND RESONATORS IN THE REGION FROM 50 TO 300 KC/S.—Bechmann. (*See* 2187.)

2099. SYNCHRONISING CONTROLS OF HIGH ACCURACY AND RELIABILITY [for Remote Control of Wireless Transmitters, Quartz Clocks, etc: with Particular Attention to the "Pull-In" System].—P. Barkow & A. Lechner. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 23, 1942, p. 296: summary only.) From the State P.O. Research Establishment: a "Postarchiv" of 65 pages.

2100. CORRECTIONS TO "THERMAL-FREQUENCY-DRIFT COMPENSATION" [1030 of April].—T. R. W. Bushby. (*Proc. I.R.E.*, April 1943, Vol. 31, No. 4, p. 232.)

2101. ON THE THEORY OF THE DISCRIMINATOR.—Chistyakov. (*See* 2130.)

2102. A THEORETICAL AND EXPERIMENTAL INVESTIGATION OF THE DOW [Electron-Coupled] CIRCUIT: CORRESPONDENCE.—A. M. Semenov: E. V. Borisov. (*Izvestiya Elektroprom. Slab. Toka*, No. 1, 1940, pp. 63–64.)

A letter from Semenov on Borisov's paper (3085 of 1939). Certain assumptions of the author are queried and a formula corrected. In his reply, Borisov disputes the criticisms but accepts the correction.

2103. AN EXPERIMENTAL INVESTIGATION OF NEGATIVE FEEDBACK IN L.F. AMPLIFIERS.—F. A. Drabkina. (*Izvestiya Elektroprom. Slab. Toka*, No. 2, 1940, pp. 50-52.) A short report on experiments with a two-stage resistance–capacity-coupled amplifier with negative feedback (Fig. 1). A number of experimental curves are shown. A bibliography of 40 items is appended.

2104. APPLICATION OF NEGATIVE FEEDBACK IN DESIGN PRINCIPLES.—S. Hill. (*Electrician*, 4th June 1943, Vol. 130, No. 3392, p. 578: summary of British Inst. Rad. Eng. paper.)

2105. "GRUNDLAGEN DER VERSTÄRKERTECHNIK" [Book Reviews].—H. Bartels. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, pp. 178–179: *Zeitschr. f. tech. Phys.*, No. 12, Vol. 23, 1942, p. 316.) Volume X of the series "Physik und Technik der Gegenwart." The author is chief of the Amplifier Laboratory of Telefunken.

TRANSMISSION

2106. ON THE THEORY OF THE MASS-RADIATOR.—A. A. Glagoleva-Arkadieva. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 20th Sept. 1941, Vol. 32, No. 8, pp. 540–542: in English.)

This source of radiation (first reported on in 1922–24) "consists of a mixture of movable metal particles suspended in a liquid dielectric medium. To this mixture, named the 'vibrational mass,' is conducted high voltage from an inductor. Sparking between the particles gives rise to electrical vibrations in these particles. The frequencies of the vibrations extend far into the region of the infra-red spectrum (3.6×10^{12}H) which is scarcely accessible to any other methods of generation of electrical waves."

The writer concludes the present note as follows: "The comparison of theoretical and experimental curves [the latter obtained from Kalugina's work, refs. "5", "6"] leads us to the following conclusions: (1) The radiation of the mass-radiator is excited by means of numerous small Hertz vibrators, each of which is formed by one pair of metal particles suspended in the dielectric medium. The wavelength of radiation λ_0 is bound up with the length of the particles l by the expression $\lambda_0 = 2lm\sqrt{\epsilon}$, where m is a coefficient equal to 4.5–5.0 for small vibrators (refs. "7", "8") and ϵ is the dielectric constant of the mixture. λ_0 may be termed the 'basic wavelength of the vibrational mass'. (2) The radiation of longer wavelengths (centimetric waves), $\lambda > \lambda_0$, is excited by particles arranged in a chain or otherwise, another kind of each such accumulation acting as a large Hertz vibrator. (3) The shortest, millimetric and hectomicron, waves are radiated by the tiniest particles among the basic particles of the vibrational mixture. It is probable that this radiation is also due to sharp edges of comparatively large particles. (4) The radiation of the mass radiator does not arise from the exterior layer of the radiating region alone, but comes from the interior layers which are under the influence of the discharge. (5) For the energy stored up in the vibrators (pairs of spheres in oil) when the concentration of the mixture is at its maximum $k_{v\,max}$ we can give the following figures, taking as an example spheres with $D = 0.094$ cm: $W_{vk_v\,max} \approx 2.9 \times 10^{-3}$ J in a unit volume of the vibrational mixture; $W_{sk_v\,max} \approx 0.53 \times 10^{-3}$ J in a unit surface of a one-sphere layer; and $W_{lk_v\,max} \approx 0.10 \times 10^{-3}$ J in a unit length of a chain of vibrators. The theoretical values of power for the above-mentioned cases may be obtained if the values of energy are multiplied by pq, where p is the number of current intermittences in a second and q is the number of the partial sparks". *See* also 2107, below.

2107. ON THE METHOD OF RESONANCE THERMOCOUPLES USED FOR THE INVESTIGATION OF

COMPLETE RADIATION IN THE ULTRA-HERTZ BAND.—Glagoleva-Arkadieva & Sokolov. (*See* 2172.)

2108. PHASE-FOCUSING OF HIGHER ORDER BY A TWO-LENS SYSTEM: I AND II.—F. Borgnis & E. Ledinegg. (*Zeitschr. f. tech. Phys.*, Nos. 7 & 9, Vol. 22, 1941, pp. 141 & 239 onwards.) *See* also 2109, below.

2109. THE EFFECT OF A PHASE-FOCUSING OF HIGHER ORDER ON THE FOURIER COMPONENTS OF THE RAY-CURRENT DENSITY.—F. Borgnis & E. Ledinegg. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 23, 1942, pp. 306–312.)

"In previous investigations (1638 & 2387 of 1941, and 2108, above) the conditions were investigated under which a phase-focusing of higher order than the 2nd can be obtained. When originally neighbouring electrons of a velocity-modulated beam meet at a point $n + 1$, this point is designated as focus of order $n (F_n)$. With a single lens with pure sinusoidal modulation-voltage a focus of 2nd order can be obtained. A higher-order focusing is possible in two ways: either by the action on the ray of several lenses in cascade, each modulated with a pure sinusoidal voltage, or by the action of a non-sinusoidal modulating voltage. For example, a 3rd-order focus is given by two sinusoidally modulated lenses or by a single lens whose modulating voltage contains the first harmonic as well as the fundamental: the amplitude of the harmonic must in this case, for low degrees of modulation, be made one-eighth of that of the fundamental.

"The resulting ray-current density is at every point beyond the modulating system a periodic function of time. A focus is characterised by the fact that the current density there theoretically becomes infinite at a certain instant: the higher its order, the higher the rate of approach to infinity, *i.e.* the steeper the rise with time of the current density. For practical purposes, however, the important point is not so much the time characteristic or the rate of approach to infinity, but rather the amplitudes of the Fourier analysis of the current density in time. The amplitudes of the fundamental and of the harmonics are, for instance, of importance in determining the efficiency of the generation of oscillations. It is therefore desirable to clear up the question how a raising of the order of the focus, and the use of several modulating lenses or of non-sinusoidal modulating voltages, affect the Fourier amplitudes of the current density. A general answer to this question meets with serious mathematical difficulties. The object of the present paper is to show for a particular example—the use of a single lens modulated by a fundamental and its first harmonic—that the Fourier amplitudes of the current density [both for the fundamental and for the harmonic] actually are higher than those given by a lens modulated only by the fundamental. Further, the paper will investigate what time-characteristic of the velocity-modulation at the modulating lens will yield the maximum possible Fourier amplitudes."

Among the results of the investigation are the following:—"The theoretical efficiency of oscillation generation . . . can be raised through fourth-order focusing, compared with pure fundamental modulation, from 58% to 65%, or for the first harmonic from 49% to 54%. But there exists also a definite ratio of $k = \alpha'/\alpha$ (depth of modulation of 1st harmonic to that of fundamental, in the modulating voltage at the lens) for which the ideal efficiency can be raised to 74% for the fundamental and to 58% for the first harmonic, in the alternating current-flow. The strongest focusing does not necessarily coincide with the largest alternating current-flow; but the addition of a first harmonic does in principle act favourably on the amplitude of this flow". The time-characteristic of the velocity-modulation at the modulating lens which will produce the greatest possible alternating current-flow is one by which all the electrons of one period are focused at a single point, when the ideal efficiency for fundamental and all harmonics alike reaches 100%. The condition for this is that $v(\tau) = s_F/t_F - \tau$ (eqn. 27), so that $v(\tau)$ has a hyperbolic course: the constants s_F and t_F are the focus-distance and the drift time. "The 'corrected phase lens' (to use the terminology of Brüche & Recknagel), represented by eqn. 27, thus gives the highest possible values of the Fourier components of current density, and equally for all harmonics": as the focus is approached the impulse becomes narrower and higher, the gaps longer, so that at the focus itself the impulse is infinitely high and narrow

2110. METHOD OF GENERATING ULTRA-SHORT-WAVE OSCILLATIONS.—H. E. Hollmann. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, p. 174.)

D.R.P.721 009. An electron beam from cathode K (Fig. 2) enters obliquely, and with high initial velocity, a d.c. retarding field due to the source E_0, and describes therein a parabolic path. In the ascending and descending branches of the parabola, the d.c. field has superposed on it oppositely phased a.c. fields excited, by the resonance voltage at the output circuit LC, between the main plate electrode P_1 and the smaller counter-electrodes P'_1 and P'_2: these fields extract energy from the parabolic beam.

2111. METHOD OF GENERATING ULTRA-SHORT WAVES WITH A MAGNETRON.—Telefunken. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, p. 174.)

D.R.P.721 010. The magnetron has several successive electrodes A (Fig. 3), the inner ones being of grid form so that those electrons which in one a.c. field are of incorrect phase for the generation of oscillations can penetrate into another field of opposite phase to the first, and can give up to that field the energy gained from the first.

2112. ARRANGEMENT FOR THE PRODUCTION OF ULTRA-SHORT WAVES.—K. Fritz. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, p. 175.)

A Telefunken patent, D.R.P.721 363. Linear resonators S are mounted in rows perpendicular to the electron paths from cathode K (Fig. 6) to anode A: they are excited by electrostatic or electromagnetic induction and radiate the energy they take up.

2113. THE GENERATION OF ULTRA-HIGH-FREQUENCY OSCILLATIONS BY MEANS OF A CASCADE ELECTRON-MULTIPLIER.—R. Forberger. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, p. 175.)

A Telefunken patent, D.R.P.721 600. An electrode " 8 " (tubular in the diagram of Fig. 7), playing no part in the multiplying process, is interposed in the path of the electrons and diverts (either directly or by electrostatic induction) a fraction of these, which are applied to the control electrode " 2 " belonging to a previous stage. Here they interrupt or weaken the electron flow: the electrostatic induction at electrode " 8 " ceases, the grid " 2 " becomes positive again, and the process begins afresh.

2114. CORRECTION OF FREQUENCY-MODULATION DISTORTION [Letter on Pieracci's " A Stabilised Frequency-Modulation System " (1644 & 2330 of 1942): Analysis of Distortion-Correcting Scheme, Derivation of Necessary Correction, and Proof that if Correction is properly made for Sinusoidal Input, It is Sufficient regardless of Nature of Applied Signal].—S. Bertram: Pieracci. (*Proc. I.R.E.*, April 1943, Vol. 31, No. 4, p. 186.)

2115. FREQUENCY MODULATION: VI—FUTURE APPLICATIONS OF FREQUENCY MODULATION [Post-War Broadcasting: F.M. and Fading: Limits to the F.M. Band: Television: Bibliography].—C. Tibbs. (*Wireless World*, June 1943, Vol. 49, No. 6, pp. 168–171.)

2116. ON A CERTAIN METHOD OF INCREASING THE EFFECTIVENESS OF WIRELESS COMMUNICATION [Amplitude–Phase Modulation].—S. I. Tetelbaum. (*Izvestiya Elektroprom. Slab. Toka*, No. 1, 1940, pp. 26–35.) A fuller mathematical treatment, with numerical examples, of the subject dealt with in 1244 of 1940.

2117. METHOD AND CIRCUIT FOR THE MODULATION OF POLYPHASE OSCILLATION PROCESSES.—G. Guanella. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, p. 175.)

Swiss Patent 218 502. "The currents and voltages of a first polyphase input system and those of a second are mutually modulated, the modulation products in the output system being so made up that a rotating field is formed there with a rotational frequency equal to the algebraic sum of the frequencies of the input systems and an amplitude equal to the product of the amplitudes of the input rotating fields. As a result, only the summation frequencies are present in the output circuit."

2118. THE THEORY OF THE TRANSMISSION OF FREQUENCIES IN GRID MODULATION.—Z. I. Model'. (*Izvestiya Elektroprom. Slab. Toka*, No. 1, 1940, pp. 7–25.)

For previous work *see* 469 of 1939. The fundamental relationships governing amplitude modulation when this occurs in either grid or anode circuit are established and the peculiarities of grid modulation are pointed out. Equations are derived for determining the resonance curves for the cases when the modulated amplifier is followed by one, two, or three tuned circuits, and also equations for determining the amplitude/frequency and phase/frequency characteristics. A detailed discussion is then given of the operation of a valve under the conditions of over-modulation, *i.e.* when the amplitude of the envelope of the modulated frequency exceeds that of the carrier frequency. Over-modulation is said to be distortionless if no additional sidebands appear (Fig. 11), and conditions necessary for this are formulated. The difficulties in meeting these conditions when modulation is effected at the ultimate stage of the transmitter, especially on long waves (in view of the insufficient damping of the aerial) are pointed out, and methods are indicated for determining the frequency distortion so introduced.

2119. SIDEBAND ASYMMETRY IN AMPLITUDE MODULATION [and Its Importance in Transmitter Design].—Böttcher. (*See* 2127.)

2120. ON THE THEORY OF SIGNAL DISTORTION IN H.F. CIRCUITS OF RADIO TRANSMITTERS.—I. S. Gonorovski. (*Izvestiya Elektroprom. Slab. Toka*, No. 2, 1940, pp. 20–33.)

It is pointed out that the usual method of estimating linear distortion of signals in a radio transmitter, by plotting a frequency-response characteristic, is adequate only in the case of simple periodic signals. If, however, non-periodic signals corresponding to speech, music, etc., are transmitted, the complex variation of the amplitudes of component modulating frequencies is accompanied by non-stationary processes in the transmitting circuits which are not reflected in a frequency-response characteristic. It is, therefore, suggested that a truer picture would be obtained if the variation of the modulated-frequency amplitude corresponding to a given variation of the modulating-frequency amplitude is examined. The above is illustrated by a study of the processes taking place in a circuit both tuned to and de-tuned from the carrier frequency, when a periodically or non-periodically modulated sinusoidal e.m.f. is applied to it. The case of two tightly coupled tuned circuits is also considered.

2121. A HIGH-POWER MODULATING CIRCUIT WITH NEGATIVE FEEDBACK.—S. V. Person, A. I. Lebedev-Karmanov, & A. M. Pisarevski. (*Izvestiya Elektroprom. Slab. Toka*, No. 2, 1940, pp. 4–19.)

For previous work *see* papers by Model', Person, & others dealt with in 97 of 1939 and 1823 of 1940. A detailed report is presented on an experimental investigation of a four-stage modulating circuit with a power output of 14 kw (Fig. 13). Each stage employed two valves in a push-pull circuit and the filaments of the valves were a.c. heated. The negative-feedback voltage was taken off the primary of the modulation transformer and applied through a phase-compensating network to the secondary of the input transformer. The theory of the circuit is discussed and a number of experimental curves are shown. The main conclusion reached is that the efficiency of the circuit is greatly increased by the use of the negative feedback but that, as was expected, the circuit does not compensate for the distortion and parasitic modulation taking place at the modulated amplifier stage. Experiments have shown, however, that under proper operating conditions of the modulated amplifier, non-linear distortion introduced is very small and the "klirr" factor of the aerial current hardly differs from that of the modulating voltage.

2122. Modern Rectifiers for Radio Transmitters.—M. A. Spitsyn. (*Izvestiya Elektroprom. Slab. Toka*, No. 1, 1940, pp. 53–59.)

For previous work *see* 3768 of 1938. The following rectifiers of Russian manufacture are described: (a) 250–750 v copper-oxide rectifiers for grid circuits; (b) mercury-vapour rectifiers for outputs up to 100 kw at 10 kv; a special device for cooling the valves by forcing air of constant temperature round them is described; (c) regulated mercury rectifiers in metallic containers for outputs up to 1000 kw at 11 kv. The regulation of the rectified voltages is discussed and an auto-transformer with a short-circuited moving coil, specially developed for this purpose, is described. The protection of the rectifiers is also considered and a quick acting h.t., d.c. circuit-breaker is described.

2123. Quartz Oscillators and Resonators in the Region from 50 to 300 kc/s.—Bechmann. (*See* 2187.)

RECEPTION

2124. The Amplitude of Noise Voltages.—K. Fränz. (*E.N.T.*, Sept. 1942, Vol. 19, No. 9, pp. 166–173.)

From the Telefunken laboratories. "With the steady increase in our knowledge of sensitivity problems a position has gradually been reached where further progress can often be made only by treatments more exhaustive than can be attained by the use of the ratio of signal voltage to noise voltage as a measure of the 'readability' of signals. This has been made especially clear in cases where the 'readability' has to be compared for various band-widths (1030 of 1942 [for later work *see* 3240 & 3564 of 1942]). Further, American literature shows an increasing number of papers dealing with the ratio of the peak value of a noise voltage to its effective value (Landon, 499 of 1937: Jansky, 1392 of 1940), and with the variations of this quantity in different receiving conditions, for example in frequency modulation as compared with amplitude modulation (Crosby, 2504 of 1937).

"The highest measure of knowledge attainable concerning the course in time of noise voltages is provided by the knowledge of the probability distribution of the amplitudes, corresponding to the statistical character of the noise. If $W(u)$ is the probability-density of the amplitude u, then $W(u) \cdot du$ is, by definition, the relative frequency with which repeated measurements disclose an amplitude in the interval $(u, u + du)$. As regards h.f. technique, such problems were apparently dealt with for the first time in a paper by Landon (2129 of 1941) in which some cases were dealt with quantitatively for Gaussian distributions, while certain other technically interesting distributions were discussed qualitatively. In the present paper, in extension of a previous work (3026 of 1941), we shall obtain in a specially simple way the distributions given by Landon, and discuss quantitatively some more non-Gaussian distributions. In view of the large number of distributions which are of technical importance, we shall, in addition to the treatment of examples, strive above all to formulate general methods by which interesting distributions can be calculated for individual cases. It is to be noted, moreover, that Landon, like other American investigators, at first tried to determine experimentally the ratio of the peak value of a noise voltage to its effective value, only to find a few years later that theoretical considerations would have led him to more correct and much more far-reaching conclusions. As examples we shall calculate the amplitude-distributions in i.f. amplifiers [eqn. 28] and at the output terminals of square-law rectifiers [Figs. 7–9].

"The mathematical method which we shall again employ in this paper has been applied for several decades to thermal noise and also to the shot effect, since the latter was discovered. It consists in the development of these noise-voltages over a suitable time period $2T$ (for example the duration of a measurement) into a Fourier series with a period $2T$. The voltage is completely given by the Fourier coefficients, and from these it is, in principle, possible to obtain all the quantities derivable from the voltage. The probability distributions for the real and imaginary parts of the Fourier components are Gaussian, and each two components (or real and imaginary parts of the same components) fluctuate independently of each other: that is, the probability of meeting with several components within prescribed limits is equal to the product of the probabilities of encountering each individual one, without considering the others, in that prescribed interval. The statistical independence of the Fourier components of thermal noise and shot effect can be arrived at from the fact that the emission of the energy quanta (in thermal agitation) or of the electrons (in the shot effect) occurs in such a way that all time-intervals of equal duration have also equal emission-probability. Most of the methods employed by us were developed in the theory of thermal radiation: see for instance the discussions in von Laue's paper" (reference "7").

Section I deals with the probability-distributions in linear networks: the curve of Fig. 4, for example, represents the probability that the instantaneous value of thermal noise or shot effect will lie below a given multiple of the effective value. The treatment is comparatively simple because in the first place the Gaussian distribution and the independence of the Fourier components can be taken straight from the theory of thermal radiation, and secondly because the distribution of a sum of independent functions with Gaussian distribution is itself a Gaussian distribution: in circuits in which the superposition is linear, summation processes are in general sufficient. In non-linear circuits on the other hand (Section II) it must be possible to form arbitrary powers of voltages. Actually, the simplest case is considered, namely a square-law relation between input and output voltages. In obtaining eqn. 16 giving $W(u_1, u_2)$, the probability that u will remain inside the interval (u_1, u_2), the calculation is simplified by the use of a device described by Markoff and by von Laue: it consists in multiplying the product of the probability-density by a factor which is unity when the interval condition is fulfilled, but otherwise vanishes: such a factor is seen in eqn. 15.

2125. Suppression of Spontaneous Fluctuations in Amplifiers and Receivers for Electrical Communication and for Measuring Devices.—M. J. O. Strutt & A. van der Ziel. (*Physica*, Vol. 9, 1942, p. 513 onwards.)

2126. Suppression of Spontaneous Fluctuations in $2n$-Terminal Amplifiers and Networks.—A. van der Ziel & M. J. O. Strutt. (*Physica*, Vol. 9, 1942, p. 528 onwards.)

2127. Sideband Asymmetry in Amplitude Modulation.—F. Böttcher. (*Hochf:tech. u. Elek:akus.*, Jan. 1943, Vol. 61, No. 1, pp. 12–19).

From the Telefunken Laboratory for Large-Transmitter Development. "The demodulation of an amplitude-modulated high frequency which is modulated by a pure sinusoidal tone will in general, even when the modulation characteristic is strictly linear, yield an audio-frequency current with more or less pronounced distortions. In the receiver (assumed to be an ideally functioning linear rectifier) there will thus appear, in addition to the fundamental frequency of the modulation, high harmonics of this even although the distortionless modulation curve contains only the two sidebands of the fundamental. The causes of the distortions in the receiver are in this case asymmetries of the sidebands. It is known that with pure undistorted amplitude modulation the two conjugate side oscillations are produced with equal amplitudes and with zero relative phase displacement. In the usual vector representation (Fig. 1), in which the carrier vector 1 is taken as stationary while the two side-oscillation vectors u and v rotate in opposite directions with the angular frequency α of the modulating note, an undistorted amplitude modulation is represented by the fact that the two sideband vectors are of the same size and are symmetrical to the carrier vector: that is, that during one modulation period both vectors simultaneously take up the direction of the carrier vector. Thus the susceptibility of amplitude modulation to asymmetries extends to the inequality of the sideband amplitudes as well as to their relative phase displacement. In general, both effects occur together.

"As a source of possible disturbance to the sideband symmetry, each of the elements taking part in the transportation of energy from modulated oscillator to receiver must be reckoned with: first, all the oscillating, filter, matching circuits and feeders on the way to the aerial; then the aerial itself (particularly if this is driven on a steep branch of its reactance and resistance characteristic); and lastly the transmission medium between aerial and receiver, with its sometimes frequency-dependent behaviour. As a result of the differing attenuation and unequal rotation of phase suffered by the two sideband frequencies in passing through the various links, an originally pure amplitude modulation may reach the receiver with its sidebands asymmetrical.

"As a further cause of sideband asymmetry, a frequency or phase modulation may appear as the result of a possible retroaction of the modulated stage on the preceding one, according to whether this retroaction affects the controlling high frequency or the phase condition of the controlling e.m.f. for the modulated stage. As is well known, frequency and phase modulation yield an infinitely extended frequency spectrum in which conjugate sideband frequencies appear, of equal amplitudes as in amplitude modulation, but in alternating pairs with opposed and with identical signs. The sideband frequencies of odd order have opposite signs; consequently the one first-order sideband adds itself to the amplitude modulation, while the other subtracts itself from the corresponding sideband. In this action of frequency or phase modulation it is no longer, it is true, merely a matter of a simple disturbance of sideband symmetry, since side-oscillations of higher order are also produced. But the amplitudes of these higher-order oscillations decay rapidly to zero for a small phase-modulation angle—and this is of necessity kept small: so that to all intents and purposes only the side-oscillations of the first order need be considered in this case also.

"In order to obtain a quantitative estimate of the requirements which should be demanded of a transmitter as regards the symmetrical passage of sidebands and freedom from frequency and phase modulation, it is important among other things to know how the sideband asymmetries in demodulation make themselves felt in the appearance of harmonics. In the following pages the mixture of frequencies in an ideal linear rectifier which follows exactly the envelope of the h.f. oscillations will be calculated, so far as it contributes appreciably to the factor of non-linear distortion."

Section II is devoted to the Fourier development of the low frequencies resulting from demodulation. Section III applies the results to numerical calculations to find the effects of the amplitude-asymmetry w and the phase-asymmetry ψ on the quantities a_0 (arithmetical mean value), μ (degree of modulation of fundamental wave), and k (non-linear-distortion factor). The results are given in the form of curves, which include Figs. 2 a–c for the case of single-sideband modulation.

2128. Fog and Radiation [Query as to Reason why Attenuation of Interference (from Power Lines) is so much Greater in Foggy Weather than in Dry: Letter prompted by Forrest's Article (1876 of July): Forrest's Reply].—R. I. Kinross: J. S. Forrest. (*Wireless World*, June 1943, Vol. 49, No. 6, p. 186.)

2129. On the "1 mV-Limit," *and* The Regulation of the Federal Department of Posts & Railways concerning the Limitation of the Interfering Action of Low-Power Apparatus, to protect Radio Reception.—(*Bull. de l'Assoc. Suisse des Élec.*, 10th March 1943, Vol. 24, No. 5, pp. 118–119: p. 128.) The first article serves as an introduction to the second.

2130. On the Theory of the Discriminator.—N. I. Chistyakov. (*Izvestiya Elektroprom. Slab. Toka*, No. 2, 1940, pp. 47–49.)

It was stated in a previous paper (126 of 1939: *also* 3188 of 1938) that a discrepancy in the self-capacities of the two diodes of the discriminator does not affect the frequency characteristic of the discriminator. Subsequent experiments have shown, however, that this statement is true only within certain limits. A further mathematical investigation of the phenomenon is given which shows that by introducing an artificial asymmetry of the diode capacities the frequency characteristic of the discriminator can be altered. Experiments have fully confirmed the conclusions reached.

2131. Designing Superhets: Circuit-Design Formulae for Minimum Tracking Errors.—J. E. Haworth. (*Wireless World*, June 1943, Vol. 49, No. 6, pp. 163–165.) For two errata in the equations *see* July issue, p. 204.

2132. "Radio-Receiver Design: Part I" [Book Notice].—K. R. Sturley. (*Journ. of Scient. Instr.*, May 1943, Vol. 20, No. 5, p. 83.) For a previous review *see* 1409 of May. The author is associated with the Marconi School of Wireless Communication.

2133. "The Technique of Radio Design" [Book Notice].—E. E. Zepler. (*Wireless World*, June 1943, Vol. 49, No. 6, p. 165.)

2134. "Standardschaltungen der Rundfunktechnik" [Standard Circuits of Broadcast (Receiver) Technique: Book Review].—W. W. Diefenbach. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, p. 180.) For a previous book *see* 432 of 1942.

AERIALS AND AERIAL SYSTEMS

2135. On the Theory of the Mass-Radiator.—Glagoleva-Arkadieva. (*See* 2106.)

2136. Directional Transmitting System for Secret Communication. — Telefunken. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, p. 177.)

D.R.P.721 131. To make the directional radiation "2" (Fig. 19), which carries the signal, receivable only within the narrow sector "3", it has superposed on it another directional radiation "1", modulated by an interfering noise, and having a zero or minimum in the section "3".

2137. Device for the Transmission of Current or Voltage between Two Parts rotatable with respect to Each Other [Substitute for Slip Rings in Rotating Aerials, Goniometers, A.F. Apparatus, etc.].—F. Bergtold. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, p. 175.)

A Telefunken patent, D.R.P.719 954. "The windings W_1, W_2 on the iron cores K_1, K_2 (Fig. 10), the first of which is fixed to the rotating spindle A, are to a great extent enclosed by the screens S_1, S_2 which overlap each other in such a way that the leakage fields which would diminish the coupling are greatly weakened."

2138. Optimum Current Distributions on Vertical Antennas [Tower Aerials].—L. La Paz & G. A. Miller. (*Proc. I.R.E.*, May 1943, Vol. 31, No. 5, pp. 214–232.)

A long summary was referred to in 1052 of 1942. Gehring & Brown showed that the poor radiating characteristics of such aerials, compared with those predicted by elementary theory assuming a sinusoidal distribution of current, were due very largely to the actual non-sinusoidal distributions resulting from the non-uniform cross sections of the aerials. Later investigators each made special studies of some particular current distribution which appeared promising to himself. "Thus, to this day, engineers are still divided in their opinions as to the amount of improvement in antenna performance which may be expected to result from future discoveries of current distributions still more desirable than those now in use. It is clear that the general problem can be bounded only on the basis of the results of a general investigation taking *all possible current distributions* into consideration. Such an investigation is presented in this paper".

The "theoretical optimum current distributions" (giving max. field strength on the horizon) for vertical aerials of given lengths are dealt with by the calculus of variations, and approximate solutions of eqn. 12 are derived for lengths ranging from one-eighth of a wavelength to a full wavelength (eqn. 12 is a linear integral equation of the first kind, and therefore belongs to the class which may have either an infinity of solutions, a unique solution, or no solution at all: *see* refs. "8" to "17"). These distributions are illustrated in Fig. 8, and discussed, in connection with their vertical radiation patterns (Figs. 10–13), in detail on pp. 226–230. "Extremely low radiation resistance is characteristic of all distributions on a ¼-wave antenna giving an antenna performance approaching the optimum performance. With modern ground systems it would probably be best to operate top-loaded ¼-wave antennas with the null in the current loop somewhere between the ground and a point 0.088λ above the ground. A top-loaded 3/8-wave antenna operated with the null in the current loop 0.075λ above the ground gives an antenna performance approximately equivalent to that obtained with the usual ½-wave antenna, has little or no high-angle radiation, and is probably economically realisable as it has a radiation resistance referred to the base of the order of 100 ohms."

2139. THE DESIGN OF TOWER AERIALS: SOME NOTES ON THEIR APPLICATION TO AUSTRALIAN BROADCASTING PRACTICE.—A. L. Dixon. (*Proc. Inst. Rad. Eng. Australia*, March/April 1941, Vol. 4, No. 6, pp. 79–87.)

2140. ON SECTIONALISING THE GUYS OF A MAST RADIATOR.—B. V. Braude. (*Izvestiya Elektroprom. Slab. Toka*, No. 2, 1940, pp. 38–47.) Methods are proposed for calculating the voltages developed across the insulators in the guys, and the effect of the guys on the directive characteristics of the aerial.

2141. ARRANGEMENT FOR INDICATING THE POWER TAKEN UP BY A TRANSMITTING AERIAL OVER A WIDE RANGE OF MEASUREMENT AND INDEPENDENT OF FREQUENCY.—F. Ramert. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, p. 177.)

D.R.P.720 895. A frequency-dependent four-terminal network is coupled to the aerial near its base, and the output voltage taken to a circuit with a variable-mu valve, whose anode d.c. indicator is calibrated logarithmically in units of aerial power.

VALVES AND THERMIONICS

2142. "THERMIONIC TUBES AT VERY HIGH FREQUENCIES" [Book Review].—A. F. Harvey. (*Proc. Phys. Soc.*, 1st May 1943, Vol. 55, Part 3, No. 309, pp. 254–255.)

Based largely on the results of the author's work in the Engineering Laboratory, Oxford, and later in the Cavendish Laboratory. For a previous review *see* 1419 of May.

2143. "GRUNDLAGEN DER VERSTÄRKERTECHNIK" [Book Reviews].—Bartels. (*See* 2105.)

2144. TRIODES FOR GENERATING DECIMETRIC WAVES.—N. D. Devyatkov, E. N. Danil'tsev, & V. K. Khokhlov. (*Izvestiya Elektroprom. Slab. Toka*, No. 2, 1940, pp. 56–61.)

A type of triode suitable for generating waves down to 16 cm is described. The use of the valves with a coaxial oscillating circuit is also described, and a number of experimental curves and tables are shown.

2145. AIR-COOLED VALVES (PENTODES).—S. Zusmanovski, L. Kotomina, & V. Sosunov. (*Izvestiya Elektroprom. Slab. Toka*, No. 1, 1940, pp. 36–47.)

The theory of the operation of pentodes is discussed and their advantages over triodes pointed out. Various types of pentodes of Russian manufacture are described and their constants as well as typical operating data (for telegraph operation) are tabulated. Certain advantages of indirectly heated pentodes over the directly heated type are enumerated. The use of pentodes in oscillating and low-power modulating circuits is discussed and a number of characteristic curves are shown, together with tabulated operating data. Reference is also made to the use of pentodes at frequencies above 30 Mc/s (*see* 137 of 1940).

2146. RETURN TO SIMPLICITY? [Suggestion that Post-War Tendency may well be to Discard the Complex Multi-Electrode Valve in favour of Simpler Types, not more Complicated than the Pentode or Beam Tetrode].—"Diallist". (*Wireless World*, June 1943, Vol. 49, No. 6, p. 188.)

2147. RELATION BETWEEN THE JOHNSON EFFECT IN RESISTORS AND THE SHOT EFFECT IN A SATURATED ELECTRONIC CURRENT.—Campbell & Francis. (In paper dealt with in 2091, above.)

2148. A TEST SET FOR MEASURING THE INTER-ELECTRODE CAPACITANCE OF VALVES.—Levitin. (*See* 2175.)

2149. A NEW METHOD OF MEASURING THE THERMIONIC CONSTANTS OF OXIDE-COATED CATHODES.—S. Sano. (*Electrotech. Journ.* [Tokyo], April 1941, Vol. 5, No. 4, pp. 78–79.)

"The saturation characteristics of oxide-coated cathodes are very imperfect and unstable, therefore the zero-field currents i_0 determined from such saturation characteristics are very inaccurate and difficult to reproduce. Hence for the accurate measurement of the thermionic constants a method that does not necessitate i_0 is desirable.

"To meet this demand, the utilisation of the initial currents is considered. Oxide-coated cathodes are convenient to measure the initial-current characteristics, as they can be made equipotential by heating indirectly . . ." The method is described, with an example of a specimen result. It is hoped to make extensive use of it.

2150. ON CERTAIN PECULIARITIES IN THE OPERATION OF AN OXIDE CATHODE IN MERCURY VAPOUR.—Ivanov. (*See* 2221.)

DIRECTIONAL WIRELESS

2151. DEVICE FOR THE TRANSMISSION OF CURRENT OR VOLTAGE BETWEEN TWO PARTS ROTATABLE WITH RESPECT TO EACH OTHER [Substitute for Slip Rings on Rotating Aerials, Goniometers, A. F. Apparatus, etc.].—Bergtold. (*See* 2137.)

2152. DIRECTION-FINDING FREE FROM NIGHT ERRORS.—W. Runge. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, p. 177.)

A Telefunken patent, D.R.P.720 843. In order to allow an aerial system which only receives the field components with horizontal (or vertical) polarisation, to yield bearings only at times of favourable conditions, an auxiliary aerial is provided which is susceptible to polarisation- and interference-fading, and its signals are made to block the indication of bearings whenever they (the signals) fall below a certain limiting value.

2153. DIRECTION-FINDING SYSTEM WITH OPPOSED SINGLE AERIALS [especially Adcock Aerials].—F. Tischer. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, p. 177.)

A Telefunken patent, D.R.P.720 844. The leads from the aerials to the point where they are opposed take the form of continuous choking coils, to decrease the formation of sheath waves and to be free from any freely-oscillating parts: Fig. 18.

2154. Device for the Correction of Errors in the Readings of Direct-Indicating Direction Finders.—A. Stephan. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, p. 177.)

A Telefunken patent, D.R.P.720 845. "The error-containing oscillographic or stroboscopic bearing image is projected on to a screen by means of an optical arrangement (for example a rotatable or swinging prism system) which is controlled by the correction figure."

2155. Direction Finder with Cardioid Diagram.—F. Bergtold. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, p. 177.)

A Telefunken patent, D.R.P.720 889. "If a directive aerial is employed together with a non-directive auxiliary aerial to yield a cardioid diagram (as for example in a 'flicker' direction finder), the voltage from the auxiliary aerial can, without danger of any error in the reading, be amplified separately and led to the receiver through an arbitrary transmission system producing uncontrolled phase rotations, provided that the 'blurring' voltage of the directive aerial is compensated in the formation of the cardioid."

2156. Arrangement for the Production of a Straight Glide-Path for Aircraft Landing.—E. Kramar & W. Gerbes. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, p. 177.)

A Lorenz-A.G. patent, D.R.P.720 890. Two aerials are erected at different heights above the ground and are connected alternately to a common transmitter (*e.g.* in complementary-signal rhythm): the plane of equal field-strengths between the two lowest lobes forms a straight glide-path.

2157. Arrangement for the Avoidance of Errors in Wireless Navigational Measurements due to the Slanting Position of the Measuring Apparatus.—F. Bergtold. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, pp. 177–178.)

A Telefunken patent, D.R.P.720 893. A gyroscopic device allows the instrument to register only when the ship is horizontal: for d.c. instruments the deflections are stabilised by resistance–condenser combinations with a large time-constant.

2158. Adcock-Aerial System.—A. Gothe & W. Hasselbeck. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, p. 177.)

A Telefunken patent, D.R.P. 721 499. "To reduce the effects produced in the vertical conductors *A* (Fig. 20) of an Adcock aerial by the currents flowing in the horizontal leads *V* and their sheathing *S*, the leads and sheaths are prolonged by the similar extensions *L* and S_L so that on both sides of the junction of the vertical wire equally large currents flow in the horizontal leads, their fields cancelling themselves out in the direction of the vertical conductor."

ACOUSTICS AND AUDIO-FREQUENCIES

2159. Frequency-Modulation Distortion in Loudspeakers.—G. L. Beers & H. Belar. (*Proc. I.R.E.*, April 1943, Vol. 31, No. 4, pp. 132–138.) A summary was dealt with in 800 of March: *see* also 1126 of April.

2160. Some Recent Developments in Record-Reproducing Systems [Frequency-Modulation Pick-Up extends Possible Frequency-Range to 10 or 12 kc/s with "Astonishing Freedom from Surface Noise, Mechanical Noise, and Distortion": etc.].—G. L. Beers & C. M. Sinnett. (*Proc. I.R.E.*, April 1943, Vol. 31, No. 4, pp. 138–146.) A summary was dealt with in 808 of March.

2161. Needle-Armature Pick-Ups [Correspondence prompted by Hay's Article (1905 of July) and Brierley's (3020 of 1942 & 78 of January)].—G. E. Horn & R. H. Thrussell: D. W. Aldous: A. C. Robb. (*Wireless World*, June 1943, Vol. 49, No. 6, pp. 184–186.)

The last letter includes a description of a more elastic and adaptable moving system allowing many sizes of needle to be accommodated.

2162. Static Charges on Records [during Cutting: Resulting Troubles: Glass-Base Blanks now used in U.S.A. have Fibre Insert in Centre-Holes to prevent Them].—(*Wireless World*, June 1943, Vol. 49, No. 6, p. 165: paragraph only.)

2163. The "Magic Brain" Automatic Record Player [with One Motor driving Turntable & Another operating Automatic Mechanism: plays Twelve 12″ Discs on Both Sides without Turning Over].—R. C. A. Victor. (*Journ. Applied Phys.*, Oct. 1941, Vol. 12, No. 10, p. 766.) *See* also 734 of 1942.

2164. An Improved Carbon Microphone.—A. Lauterer. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, p. 178.)

A Lorenz-A.G. patent, D.R.P.721 617. "The main current path from the moving electrode '11' (Fig. 23) to the fixed electrode '7' has in parallel with it a permanent shunt path through the powder, between '11' and a fixed auxiliary electrode '5,' which is perpendicular to the direction of the diaphragm-motion and eliminates 'flutter' effects."

2165. Improved Contact Microphone [with Contact Material (*e.g.* Carbon Powder) between Two Diaphragms having Different Resonant Frequencies and excited in Phase Opposition by Same Sound: Improved Uniform Frequency Response & High Output].—W. Geffcken. (*Hochf:tech. u. Elek:akus.*, Dec.

1942, Vol. 60, No. 6, p. 178.) D.R.P.721 616. The good results are attributed to the formation of coupling resonances and an auxiliary shaking effect.

2166. Frictional Phenomena : III.—Absorption of Sound Waves and of Supersonics : IV — Sound - Absorbing Materials. — A. Gemant. (*Journ. Applied Phys.*, Oct. 1941, Vol. 12, No. 10, pp. 718–724 : pp. 725–734.) For other papers in this series *see* 3103 of 1942.

2167. The Determination of Velocity of Sound by the Employment of Closed Resonators and the Hot-Wire Microphone.—W. S. Tucker. (*Phil. Mag.*, April 1943, Vol. 34, No. 231, pp. 217–235.)

PHOTOTELEGRAPHY AND TELEVISION

2168. New Television Manufacturer [Note on Recently-Formed Scophony Corporation of America : the " Supersonic " System for Large-Screen Projection].—(*Proc. I.R.E.*, April 1943, Vol. 31, No. 4, pp. xxviii and xxx.)

2169. Radio-Frequency-Operated High-Voltage Supplies for Cathode-Ray Tubes [primarily for Iconoscopes, Projection Kinescopes, etc.].—O. H. Schade. (*Proc. I.R.E.*, April 1943, Vol. 31, No. 4, pp. 158–163.)

A summary was dealt with in 1941 of 1941. " The obtainable power output is limited by the oscillator power. This method permits the construction of safe supplies, where the current requirements are not too high. This low-power reserve also protects the kinescope and rectifier in case of spark-over or accidental short-circuits, because of the small short-circuiting current," though safety precautions must be taken if the voltage step-up or oscillator power are such as to produce currents of dangerous magnitude. Cost compares favourably with 60 c/s supplies when the oscillator power is moderate, so that small valves can be used : kinescope supplies up to 30 kv and 50 w are in this range.

2170. A Type of Light Valve for Television Reproduction [Large-Screen Projection : Theory, with Experimental Confirmation, of the " Suspension Cell " Light Valve (*e.g* Graphite Particles in Castor Oil) : Rate of Orientation is Independent of Particle Size, Chief Limitation on which is therefore that Particles should be Small compared to Picture Element : Polarisation Effects & the Resulting Delay in attaining Equilibrium between Valve Response & Applied P.Ds : etc.].—J. S. Donal, Jr., & D. B. Langmuir. (*Proc. I.R.E.*, May 1943, Vol. 31, No. 5, pp. 208–214.)

A summary was dealt with in 3500 of 1940. " Fulfils to a considerable degree the requirements of the ideal light valve in which the opacity of a thin sheet may be varied from point to point to reproduce the lights and shades of a picture . . ." The delay due to polarisation effects " may be expected to be reduced in importance by the fact that the suspension responds to the square of the applied difference in potential ". For a method of cathode-ray control of such a valve *see* 2171, below.

2171. Cathode-Ray Control of Television Light Valves [" Suspension " Type].—J. S. Donal, Jr. (*Proc. I.R.E.*, May 1943, Vol. 31, No. 5, pp. 195–208.)

Referred to in 2170, above. " The effects of polarisation of the light valve, resulting from the comparatively low resistivity of the suspension, are described and explained. It is shown that a suspension of such low resistivity as to be uncontrollable by the other procedures may be made operative when the valve is used in combination with a spatially modulated electron spray and when, in addition, the potential of one wall of the valve is increased and decreased at a moderate frequency. Of the procedures described, the most effective from the practical standpoint is shown to be one in which the light-valve field is developed by a scanning beam, and in which the field is later removed by rescanning with the same beam at a reduced electron velocity. A photograph is shown of a picture reproduced by the light valve when controlled by this method."

MEASUREMENTS AND STANDARDS

2172. On the Method of Resonance Thermocouples used for the Investigation of Complete Radiation in the Ultra-Hertz Band [from the " Mass-Radiator," 2106, above].—A. A. Glagoleva-Arkadieva & N. A. Sokolov. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, 20th Sept. 1941, Vol. 32, No. 8, pp. 543–545 : in English.)

" The results of this work may be summarised as follows : (a) The thermocouples with thin aerials used in this investigation possess sharp resonance curves [they are of " V " type, in vacuum ; the thin aerials are made from the wires of the thermocouple itself (nichrome/constantan) ; the dimensions are 20–30μ diameter, 0.008–3.0 cm length ; the junctions are welded, not soldered]. In virtue of this fact, each thermocouple reacts only to one wavelength on the whole band : in other words, its action is quite similar to a Helmholtz resonator for sound waves. This circumstance is very important, since the use of such resonance thermocouples allows measurements in the ultra-Hertz band to be carried out without additional appliances (refs. " 6 ", " 7 ") for the monochromatisation of the radiation.

" (b) Measurements have been made of the monochromatic waves in the region from 353μ to 6.48 cm. (c) For the given sizes of optical parts of the set and for the given vibrational mixing (ref. " 8 ") the long-wave radiation was measured up to $\lambda = 18.7$ cm [with " A "-type, air-filled thermocouples with soldered junctions]. No radiation with $\lambda \approx 33$ and 39 cm was observed. (d) The analysis of the experimental data in the wavelength interval under examination permits the dependence of λ upon *a* to be established, which has practical importance ": a is the length of the thermocouple aerials, λ the wavelength received by the thermocouples: the λ/a ratio increases as a decreases. A similar dependence between λ/a and a exists with small Hertz vibrators (refs. " 4 ", " 5 ").

2173. On the Measurement of Dielectric Constant in the Centimeter Band [by the "Free-Wave" Method of Velasco & Hutchinson (4066 of 1939)].—A. N. Soos. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 30th Oct. 1941, Vol. 33, No. 3, pp. 210–212: in English.)

"Further development of this method has proved the possibility of applying it to still higher frequencies. The measurements were carried out on the wave $\lambda = 5$ cm" [on methyl metacrylate, styrol, sulphur, rock-salt, and mica: also on pulverised semiconductors and polycrystalline plates of cuprous oxide]. "The experiment has shown that the dependence of the value (rE_r/SE_0) upon the thickness t of the specimen may be considered linear for small t. Therefore, ϵ may be determined from observation by using specimen of only one thickness . . . Further research was designed to extend the application of this method to double layers: this would permit the bringing of liquid dielectrics under the scope of the investigation, for a layer of liquid dielectric while inside a shallow vessel with plane vertical walls may be considered to form, with the walls, a double dielectric layer". Eqn. 5 is give for ϵ' in this case: it is valid if the equivalent thicknesses do not exceed $\lambda/2$. Its correctness was verified by measuring ϵ' for two layers of solid dielectrics (Table 3 gives some results): then the method was applied to some polar and dipole-less liquids placed in a mica pan (Table 4).

2174. A Method of Measuring Complex Admittances in the Decimetric-Wave Region.—K. S. Knol & M. J. O. Strutt. (*Physica*, Vol. 9, 1942, p. 577 onwards.)

2175. A Test Set for measuring the Inter-Electrode Capacitance of Valves.—E. A. Levitin. (*Izvestiya Elektroprom. Slab. Toka*, No. 2, 1940, pp. 53–55.)

A circuit is described in which the two-voltmeter method proposed by Bligh (1929 Abstracts, pp. 451–452) is used. The voltage across the standard condenser is measured by a valve voltmeter with two stages of amplification. The accuracy of the set is 5% approx.

2176. Workshop Impedance Tests [Simple Indirect Methods using Voltmeter & Resistance Units of Known Value].—G. W. Stubbings. (*Electrician*, 4th June 1943, Vol. 130, No. 3392, pp. 575–576.)

2177. A New Method of Measuring the Thermionic Constants of Oxide-Coated Cathodes.—Sano. (*See* 2149.)

2178. An Improved Current Integrator.—J. M. Blair. (*Review Scient. Instr.*, March 1943, Vol. 14, No. 3, pp. 64–67.)

Author's abstract:—" An improved integrator circuit for measuring the ion-beam current used in nuclear research is described. A condenser is allowed to be charged and upon reaching a definite potential is discharged through a thyratron tube. This action is brought about at the proper point by a trip circuit composed of two pentode tubes. The potential between the thyratron-cathode and the trip circuit is accurately controlled by a voltage-regulator network. The action of the circuit proves to be quite linear over a wide range of currents and rates of operation."

2179. The Kilovoltmeter [Consumption Not More than 1 Milliampere: 5, 10, & 15 Kilovolts Ranges in Single Instrument: ± 2% Accuracy at Full Scale: Portable].—Shallcross Mfg. Company. (*Proc. I.R.E.*, April 1943, Vol. 31, No. 4, pp. xxiv and xxvi.)

2180. "Elektrische Messgeräte und Messeinrichtungen" [Second Edition: Measuring Instruments & Equipments: Book Review].—A. Palm. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, p. 179.) The author is the Chief Engineer of Hartmann & Braun: Zenneck reviews the book enthusiastically.

2181. The Measurement of Dynamical Magnitudes.—N. Campbell. (*Proc. Phys. Soc.*, 1st May 1943, Vol. 55, Part 3, No. 309, pp. 204–210.)

Author's summary:—" A discussion is given of the question on what experiments the Newtonian theory of dynamics is most suitably based, and in particular whether quantity of matter, mass and force can be measured independently of that theory."

2182. Measurement of Small Quantities.—E. H. Rayner. (*Electrician*, 28th May 1943, Vol. 130, No. 3391, pp. 548–550: summary of lecture to Measurements Section, I.E.E.)

2183. Errors caused by Harmonics in the Measurement of the Hysteresis Losses of Iron Cores.—E. Istvánffy. (*E.N.T.*, Sept. 1942, Vol. 19, No. 9, pp. 161–166.)

2184. Two Methods for the Determination of the Remanence of Permanent Magnets.—W. Jellinghaus. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 23, 1942, pp. 312–314.)

"Both methods are primarily intended for materials with high coercive force (greater than 100 oersteds). The first measures the true remanence; it is equally well suited to the determination of the properties of the material on laboratory specimens and to measurements on individual completed bar magnets, if these have flat and parallel end surfaces. The other is for measuring the apparent remanence of bar magnets or needles, and thus for the comparison of individual magnets.

"The method for determining the true remanence is a yoke method with ballistic measurement (Fig. 1). The specimen 5 is clamped in a yoke 1, whose one limb 2 is movable, and is magnetised by the winding 4: the magnetising current is then cut off. At the point 6 the soft-iron yoke is bored out and the hole filled with a carefully fitted rotatable iron core with two flats which allow an induction winding 8 to be wound over the cylindrical core. The winding space is restricted to the gaps left by the flats between the core and the yoke, and these segments are kept small, extending at most over only one-sixth of the circumference. If the cylinder, with its winding, is rotated by the crank 7 through 180°, the lines of force penetrating the yoke are cut twice: the resulting time-integral of e.m.f. is measured ballistically. The magnetic state of the specimen is unaltered during or after the test."

This single-measurement process is so convenient, compared with the usual ballistic methods, that it has been extended to measure not merely the remanence, that is the induction for zero external field, but the whole magnetising curve. The double-yoke device for this purpose is shown in Fig. 2.

The second arrangement, for the measurement of apparent remanence, is a modification of McKeehan's iron-free magnetic balance: the force is measured by a photocell arrangement giving the deflection of the balance-beam. The equipment is suitable for use even with very small magnets of less than a cubic centimetre in volume: for one of 0.1 cm^3, with a magnetisation of 500 and a gradient of 1 oersted/cm, the force to be measured amounts to 50 dynes.

2185. Synchronising Controls of High Accuracy and Reliability [for Remote Control of Wireless Transmitters, Quartz Clocks, etc.].—Barkow & Lechner. (*See* 2099.)

2186. Secondary Frequency Standard [Adjustable Output at Intervals of 10, 25, 100, & 1000 kc/s, usable up to 50 Mc/s: GE G–18 Crystal sealed in Helium, with T.C. below 1 Cycle/Mc/°C]. — James Millen Company. (*Review Scient. Instr.*, March 1943, Vol. 14, No. 3, p. 81.)

2187. Quartz Oscillators and Resonators in the Region from 50 to 300 kc/s.—R. Bechmann. (*Hochf:tech. u. Elek:akus.*, Jan. 1943, Vol. 61, No. 1, pp. 1–12.)

"In a previous paper (3332 of 1942) we have described the properties of quartz crystals excited to transverse ('thickness') oscillations. The following report deals with the properties of longitudinally oscillating plates and bars, with particular reference to the technical application of oscillators and resonators. The need for the development of quartz oscillators and resonators for the lower frequencies, suitable for series production, came comparatively late with the application of quartz crystals to purposes of selection. Investigations on the longitudinal vibrations of quartz plates and bars go back, however, to the early days of the piezoelectric resonator. The properties of thin longitudinally-vibrating plates are determined by two dimensions, so that the diversity of the phenomena is considerably greater than with the transverse vibrations, whose properties depend to a great extent on one dimension only, the influence of the two other dimensions being only allowed for as a correction. The region of applicability of longitudinally-vibrating plates and bars can be put at 50 to 300 kc/s, though actually these vibrations can be used up to 400 kc/s and over. As we have brought out before, the limits are flexible and depend on the properties demanded.

"A diagram showing all the most useful cuts for the longitudinal oscillations considered in the present paper is given in Fig. 1. For the sake of completeness the cuts used for transverse oscillations are also shown, and the type designations so much used in foreign literature for the various cuts are included. The shaded areas represent cuts through plates whose surface dimension runs parallel to the natural X axis, the angle δ describing the inclination of the plate surface to the Y axis or of the plate normal to the optical axis: the fully blackened areas represent bars and plates whose largest surface lies in the plane of the diagram. The two faces r and r' indicated by the border lines represent the natural rhombohedral faces, the provision of which determines unequivocally the angle for the orientation of both plates and bars, independent of the sense of rotation of the crystal. To obtain the design rules for the long-wave region, we first consider in particular the data of the electrical equivalent circuit of quartz plates and bars. For indicating the orientation of the plates we employ a system of designation introduced in an earlier paper (1757 of 1942). The measured results described now were obtained by improved methods, and results reached before were checked over anew, so that the repetition of a few already known findings, included here for the sake of completeness, would seem justified."

The report begins with the consideration of bars and plates of the $X_{90°,\psi}$ cut. Fig. 2 shows diagrammatically the orientation of such a bar and the sign of the electrical polarisation produced by pressure on the surfaces on sides, for right-handed and left-handed quartz crystals. A simple way of orienting the bar, for preparation, is thus provided, which is of practical use particularly when the material lacks the natural faces r and r'. The numerical data here given were derived from bars and plates sputtered with a thin film of silver (*see* later). Thin bars are first considered: for longitudinal oscillations they have the frequency formula $N = \nu l = \frac{1}{2}\sqrt{1/\rho s'_{22}}$, where N is the oscillation coefficient, ν the natural frequency, l the bar length, ρ the density of the material, and s'_{22} the elasticity modulus for the axis in the ψ direction (connected with the principal-axis coefficients by eqn. 2). The course of N as a function of ψ, calculated by eqn. 1, is seen in the curve of Fig. 3, where the almost completely coincident dots show the measured values. Figs. 4/6 and the adjacent text refer to the temperature-coefficients of frequency, particularly in the important region $\psi = 95°–97°$, where the coefficient changes its sign at around 50° C, and the two flanking regions between 88° and 106°, where the reversal (and zero point) occurs at lower temperatures. Finally the text adjacent to Fig. 7 deals with the equivalent inductance (eqn. 4), ohmic resistance (eqn. 7), and damping (eqn. 8).

For plates or wider bars the frequency law of eqn. 1 has to be extended; it keeps its form, but s'_{22} is replaced by an elasticity coefficient (derived from more general considerations) which for thin rectangular plates is calculated as the root of a cubic equation representing the interaction of the two longitudinal vibrations and the shear vibration. Also, as Mason found, a coupling between this latter vibration and the second harmonic of the flexural vibration occurs, through which the longitudinal natural oscillation is disturbed within a small range of the ratio breadth/length (Fig. 8). The remainder of section I deals with the temperature coefficients and equivalent inductance of these plates or wide bars.

Section II considers, on similar lines, plates of $Y_{\delta,\psi}$ cut, particularly square plates where ψ is 0° and 45° and circular plates Y_δ, for all three of which the frequency law is given by the same eqn. 10. The specially important cases where $\delta = 38°$ and 128° (or 127°: "DT cut" and "CT cut," in the square version) are given particular attention. As in section I, the equivalent inductance (eqn. 12), ohmic resistance (eqn. 14), and damping are considered for the three types of plate. Particularly with square plates with $\psi = 0$ and with round plates, harmonic vibrations occur whose oscillation coefficients N plotted as a function of ψ show a course similar to that of the fundamental oscillations. For special orientations these harmonics also show small temperature coefficients of frequency.

The short section III deals with the rectangular plate of $Y_{141°\,30',\,45°}$ cut, which for an edge ratio of 0.863 has a frequency independent of temperature over a wide range (Mason's "GT" cut), and section IV with the circular plate X_δ, which around $\delta = 40°$ and 50° had been found to have small temperature coefficients. The new, more accurate measurements show that for $N = 2495$ kc/s . mm the temperature coefficient becomes vanishingly small at $\delta = 41°$, and at $\delta = 49°$ in the case where $N = 3315$ kc/s . mm. Square plates $X_{\delta,\,0°}$ also show null-points. But both these plates have other oscillations, easily excited, close at hand, and are therefore of little practical importance.

Section V discusses the holders for longitudinally vibrating plates and bars, and the effect of the silver layers, as employed by Telefunken, on the electrical properties of the crystal. The values given in the earlier sections were obtained with thin sputtered films: sintered-on films (1–5μ) lowered the frequency by an amount roughly proportional to the ratio of the layer thickness to the plate thickness: in some cases the change in frequency amounted to 4%. The temperature coefficient also was affected: with plates having a parabolic frequency/temperature curve the effect of the film was to displace the vertex towards lower temperatures by an amount depending on the crystal cut and on the ratio layer-thickness/plate-thickness. This influence on the temperature coefficient is discussed in detail on p. 11, l-h column. The soldering-on of the holding-plug (as in the types of mounting shown in Fig. 21) produces a similar effect on a smaller scale. The films also have an effect in raising the inductance of the plates and bars, by an amount which may reach 10%. Freshly silvered and mounted plates are subject to initial changes in their properties, which decrease with time to a limiting value. "By repeated tempering the changes are hastened to a stationary state. This phenomenon depends on various factors, most of all on the method of depositing the film. In some cases frequency rises occur of up to 5×10^{-5}, and resistance and damping decreases up to 40%."

The oscillators and resonators made on the above lines can attain a calibration accuracy of 1 to 2×10^{-5}. The damping in air amounts to 2 to 5×10^{-5}, a value about ten times greater than the best obtained with transverse oscillations. In a vacuum the damping may be reduced to 0.8 to 1×10^{-5}. These figures are found to vary little with the cut and mode of vibration. The longitudinally-oscillating crystals are free from the troubles, so common with the transversely-oscillating types, of multiplicity of oscillations near the working resonance points, and the formation of multiple resonances: this point is discussed at the end of section V. Section VI deals with the piezoelectric coefficients already used in calculating the inductances (eqns. 4–6).

2188. SEARCH FOR CRYSTALS: RADIO-QUALITY QUARTZ NEEDED IN LARGE QUANTITIES FOR WAR PURPOSES.—(*Sci. News Letter*, 10th April 1943, Vol. 43, No. 15, p. 231.)

2189. ELECTRONIC SOLDERING METHOD [Valve-Generated Induction Heat replaces Gas Heat in Soldering of Crystal Units].—J. P. Jordan: General Electric. (*Proc. I.R.E.*, April 1943, Vol. 31, No. 4, p. xl.) For a long paper *see* 975 of March.

2190. X-RAY DIFFRACTION UNIT FOR THE CONTROL OF THE CUTTING OF QUARTZ CRYSTALS.—Victor X-Ray Corporation. (*Journ. of Scient. Instr.*, May 1943, Vol. 20, No. 5, pp. 80–81.)

2191. "GLOSSARY OF TERMS USED IN ELECTRICAL ENGINEERING: B.S. 205–1943" [Book Notice]. — British Standards Institution. (*Journ. of Scient. Instr.*, May 1943, Vol. 20, No. 5, p. 82.)

SUBSIDIARY APPARATUS AND MATERIALS

2192. AN IMPROVED CURRENT INTEGRATOR [for Measurement of Ion-Beam Currents].—Blair. (*See* 2178.)

2193. THE STAGE EFFICIENCY OF AN IMPULSE GENERATOR: A MATHEMATICAL NOTE.—Rawcliffe. (*See* 2096.)

2194. THE PHOTOGRAPHY OF HIGH-SPEED TRANSIENT PHENOMENA WITH THE SEALED-OFF GLASS-TUBE CATHODE-RAY OSCILLOGRAPH.—Nethercot & Beattie. (*Journ. of Scient. Instr.*, May 1943, Vol. 20, No. 5, pp. 75–76.)

Compared with the continuously evacuated, high-voltage tube, the sealed-off tube with accelerating voltage normally not exceeding 5 kv has various advantages: thus the relatively large screen is more convenient for visual examination, and the external photography saves considerable time and trouble. This external photography does, however, impose a serious limitation from the point of view of speed, especially as the luminous trace emitted from the screen is never so sharp as that obtained from a well-focused electron beam impinging directly on a sensitised plate or film. "It is the purpose of this article to describe the photographic technique which the authors have found to give the best results consistent with reasonable trouble and expense."

The matters briefly discussed are the choice of lens and films [" several forms of hypersensitising films have been described in the literature of photography, and the authors have tried some of them, but the increase in sensitivity was not found to be commensurate with the extra complication involved "], development, printing, and intensification [" for this class of work the uranium intensification has no equal "]. Three examples of single-sweep records are given, representing maximum writing speeds of 840, 2300, and 3800 km/s respectively: they show that it would be possible to record a trace of substantially higher writing speed.

2195. Application of the Cathode-Ray Oscillograph to Electric Power Systems.—Forrest. (*See* 2277.)

2196. The Determination of the Mean Image Curvature of Cathode-Ray-Tube Deflecting Coils with Double Symmetry.—Marschall & Schröder. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 23, 1942, pp. 297–306.)

Authors' summary :—" For a magnetic deflecting field symmetrical with respect to two planes at right angles to each other (field with double symmetry) the formulae for astigmatism and image-field curvature, derived from aberration theory, are exhaustively discussed. In particular, the equations for the curves of the tangential, sagittal, and mean image curvature are clearly derived. Whereas, fundamentally, both the first two distortions are avoidable, this is not the case for the mean image curvature: the latter occurs even with deflecting fields free from astigmatism. The mean image curvature of an anastigmatic deflecting coil was measured. For this purpose a cathode-ray tube was used in which the electron source was mounted at the side of the fluorescent screen, so that the beam hit the latter at grazing incidence [Fig. 5]: in this way the image-curvature curve can be made directly visible on the screen, and measured. The mean image curvature for the same deflecting coil was also calculated from aberration theory [this involves a knowledge of the field-strength functions $H_0(z)$ and $H_2(z)$, which can rarely be calculated and which were therefore determined experimentally by a rapid method (refs. " 9," " 2 ")]. By the introduction of a ' chopped-off ' homogeneous equivalent field of a certain length l to replace the given deflecting field, an extremely simple formula for determining the mean image curvature is obtained [connecting mean image curvature with the field-length l and the " pointer " length L (distance between the principal plane of deflection and the screen: Fig. 1a & b): it is $1/\rho_m = 1/L + 1/l$, in the practical case where l is much less than $12L^2$]. The results given by the simple formula agree quite well with the exact calculations and with experiment. Finally, a rule-of-thumb is given for calculating the length of the equivalent field for a few types of deflecting coil."

2197. Discussion about the Aberration Formula of Geometrical Electron Optics [Comparison between Writers' & Scherzer's Methods: " It is an Error to consider that Spherical Aberration can Never be Zero, in Special Cases it Is Zero "].—Kato & Inoue. (*Electrotech. Journ.* [Tokyo], April 1941, Vol. 5, No. 4, pp. 68–71.)

2198. Variation of the Axial Aberrations of Electron Lenses with Lens Strength.—Ramberg. (*Journ. Applied Phys.*, Sept. 1942, Vol. 13, No. 9, pp. 582–594.)

Author's summary :—" The variation of refractive power and spherical aberration with electrode voltages and field strengths is studied for two characteristic unipotential lenses, an immersion lens, and a magnetic lens. Conclusions are drawn herefrom regarding the variation, with lens strength and applied voltage, of the resolving power obtainable with the lens as an electron-microscope objective. Scattered measurements by other authors agree satisfactorily with the results. The ' relativistic aberration ' of the electrostatic unipotential lenses, *i.e.* the effect on the image of fluctuations in the over-all applied voltage, is calculated and shown to be of significance in the electrostatic electron microscope. Furthermore, the axial chromatic aberrations are computed for the four systems, and the question of upper limits of the last two aberrations is discussed." From the R.C.A. Laboratories.

2199. Seeing Ever-Smaller Worlds [R.I. Discourse: including a Section on the Limits of the Resolving Power of the Electron Microscope].—Bragg. (*Nature*, 15th May 1943, Vol. 151, No. 3837, pp. 545–547.)

2200. Determination of Object Thickness in Electron Microscopy [by Measuring the Diminution in Intensity of the Beam, caused by the Object].—Marton & Schiff. (*Journ. Applied Phys.*, Oct. 1941, Vol. 12, No. 10, pp. 759–765.)

A summary was referred to in 2931 of 1941. " Since this method would only be applied to specimens so thin that multiple scattering can be neglected, one need know only the total cross section for single scattering of electrons outside the aperture angle of the electron-microscope objective. These cross sections are calculated for fast electrons (energies greater than 10 000 ev) by means of the Born approximation for several cases of practical interest, and the results are applied to some experimental observations."

2201. A Preliminary Report on the Development of a 300-Kilovolt Magnetic Elec-

TRON MICROSCOPE.—Zworykin, Hillier, & Vance. (*Journ. Applied Phys.*, Oct. 1941, Vol. 12, No. 10, pp. 738–742.) *See* also 2470 of 1942.

2202. A DIFFRACTION ADAPTER FOR THE ELECTRON MICROSCOPE.—Hillier, Baker, & Zworykin. (*Journ. Applied Phys.*, Sept. 1942, Vol. 13, No. 9, pp. 571–577.) The full paper, a summary of which was dealt with in 544 of February.

2203. THE POLARISATION OF FLUORESCENCE AND THE LAW OF ITS DECAY.—Tumerman. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 10th Sept. 1941, Vol. 32, No. 7, pp. 474–477: in English.)

"Thus the obtained results—measurements of polarisation—may be looked upon as an independent confirmation of the correctness of the conclusions discussed above concerning the law of decay of fluorescence and the effect upon this law of small concentrations of quenchers" (*see* ref. "1" and 3086 of 1942].

2204. A NEW FLUORESCENT MATERIAL GIVING A WARM YELLOW RADIANCE [Zinc Oxide & Vanadium Pentoxide, combined by Controlled Low-Temperature Heating Process: Absence of Activating Agent such as Mn: Other Special Properties].—Weyl. (*Science*, 16th April 1943, Vol. 97, No. 2520, Supp. p. 12: paragraph only.)

2205. FLUORESCENCE NOTATION [Suggested Use of Notation $[A]\lambda_{solvent}$ = Fluorescence Colour]. —De Ment. (*Phil. Mag.*, March 1943, Vol. 34, No. 230, p. 212.)

2206. THE "STRAIN-FREE" CEMENTING OF GLASS WINDOWS [in Electro- & Magneto-Optical Investigations: to avoid Double-Refraction Effects].—König & von Rautenfeld. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 23, 1942, pp. 273–277.)

2207. RADIO-FREQUENCY-OPERATED HIGH-VOLTAGE SUPPLIES FOR CATHODE-RAY TUBES. —Schade. (*See* 2169.)

2208. ALTERNATING-CURRENT VOLTAGE STABILISER: A CONSTANT-VOLTAGE SOURCE FOR LABORATORY AND TEST INSTRUMENTS ["Variable-Series-Impedance" Type, using Two Chokes in Parallel with Two Separate D.C. Windings (or Single, embracing Both Cores), Tetrode, & Neon Lamp].—Ledward. (*Wireless World*, June 1943, Vol. 49, No. 6, pp. 166–167.)

2209. NEW VOLTAGE STABILISER [Constant Output of 115 Volts from Circuits varying between 95 and 130 Volts: Insensitive to Load Power Factor: Ratings available from 50 to 5000 Volt-Amperes].—General Electric. (*Proc. I.R.E.*, April 1943, Vol. 31, No. 4, p. xxviii.)

2210. AN AUTOMATIC VOLTAGE REGULATOR.—Katsman & Lozinski. (*Izvestiya Elektroprom. Slab. Toka*, No. 2, 1940, pp. 62–64.)

A description is given of an automatic voltage regulator, rated at 22 kVA and capable of maintaining a single-phase voltage of 220 V within ± 1% when the mains voltage varies ± 15%. The regulator is based essentially on the use of two thyratrons which control the direction of rotation of an asynchronous motor which in turn controls an induction regulator.

2211. SUPPLEMENT to "NOTES ON HIGH-VACUUM TECHNIQUE" [1228 of April: Effect of Cold Trap on "Catalogue" Speed: Probable Size & Rate of Formation of Bubbles due to a Given Leak, in "Compressed-Air-under-Water" Test: etc.].—Burrows. (*Journ. of Scient. Instr.*, May 1943, Vol. 20, No. 5, pp. 77–78.)

2212. "HIGH-VACUUM TECHNIQUE" [Book Review].—Yarwood. (*Elec. Review*, 4th June 1943, Vol. 132, No. 3419, p. 752.)

2213. MACHINING RUBBER ON A LATHE [in fashioning Rubber (or Neoprene) Gaskets, etc: by dipping into Liquid Air].—Weissenburger. (*Review Scient. Instr.*, March 1943, Vol. 14, No. 3, p. 77.)

2214. A SIMPLE HIGH-VACUUM NEEDLE-VALVE [fulfilling the Five Main Requirements for Gas Investigations at Pressures between 1 and 10^{-5} mm Hg].—Krieg. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 23, 1942, pp. 314–315.)

These requirements (including the absence of any thread, etc., in contact with the atmosphere and with the inside of the valve: and the avoidance of mercury, rubber, fixing cements and vacuum grease) were simultaneously fulfilled by not one single design found in the literature or offered by the trade. The device here described was therefore developed at the Berlin valve factory of Telefunken.

2215. THERMAL RADIATION: SURVEY OF THE RADIATION LAWS WHICH ARE IMPORTANT IN PRACTICE [with Practical Formulae & Table of Radiation Indices for Various Metallic & Other Surfaces, valid up to 200° C: etc.]. —Sauter. (*Bull. de l'Assoc. Suisse des Élec.*, 10th March 1943, Vol. 24, No. 5, pp. 107–111: in German.)

2216. LOSSES AND MACHINE DIMENSIONS FOR SHORT AND INTERMITTENT WORKING [and the Possible Increase in Power compared with Continuous Working: Treatment by Use of Two Exponential Heating Curves]. —Schuisky. (*Bull. de l'Assoc. Suisse des Élec.*, 10th March 1943, Vol. 24, No. 5, pp. 111–115: in German.)

2217. A METHOD FOR THE SEPARATION OF HELIUM FROM NEON.—Gerling & Ermolin. (*See* 2057.)

2218. Stepped Discharge in Argon and Helium [Experimental Investigation]. — Nomoto. (*Electrotech. Journ.* [Tokyo], April 1941, Vol. 5, No. 4, pp. 72–74.)

2219. Conditions favouring the Start of an Arc Discharge between Cold Activated Electrodes at 50 Cycles per Second [including the Use of Electrodes comprising a Pellet producing Small Amounts of "Active Barium"].—Pirani. (*Proc. Phys. Soc.*, 1st Jan. 1943, Vol. 55, Part 1, No. 307, pp. 24–34.)

2220. Investigation of Transient Processes in a Low-Pressure Mercury Discharge.—Granovsky & Okhlopkov. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 10th Sept. 1941, Vol. 32, No. 7, pp. 489–491: in English.)

2221. On Certain Peculiarities in the Operation of an Oxide Cathode in Mercury Vapour.—Ivanov. (*Izvestiya Elektroprom. Slab. Toka*, No. 2, 1940, pp. 61–62.)

The oxidised layer of an incandescent cathode operating in mercury vapour is liable to show signs of crumbling-off if the tube is switched on after a long period (several weeks) of disuse. The phenomenon takes place as soon as the cathode is switched on and before the anode voltage is applied. In this paper the phenomenon is described, while the results of an experimental investigation will be published in subsequent instalments.

2222. Sealed-off Ignitrons.—Boldyr'. (*Izvestiya Elektroprom. Slab. Toka*, No. 1, 1940, pp. 47–52.)

The theory of ignitrons (single-anode rectifiers with liquid-mercury cathode and igniter: Fig. 1) is discussed, and ignitrons of Russian manufacture are described including the water-cooled type for 100 A at 3000 V.

2223. Modern Rectifiers for Radio Transmitters [including the Regulation of the Rectified Voltages, and a Special Auto-Transformer with Short-Circuited Moving Coil for This Purpose]. — Spitsyn. (*See* 2122.)

2224. Compact Ceramic Condensers ["Disc Ceramicons," Basic Types 1770 & 170].—Erie Resistor. (*Review Scient. Instr.*, March 1943, Vol. 14, No. 3, pp. 80–81.) *See* also *Proc. I.R.E.*, April 1943, Vol. 31, No. 4, pp. xxvi and xxviii.

2225. Mica Production in Ceylon [Paragraph only].—(*Engineer*, 28th May 1943, Vol. 175, No. 4559, p. 438.)

2226. A New Synthetic Rubber ["Paracon"]. — Fuller & Biggs. (*Science*, 16th April 1943, Vol. 97, No. 2520, Supp. p. 10.) From the Bell Telephone Laboratories. *See* also *Bell Lab. Record*, May 1943, Vol. 21, No. 9, pp. 300–301.

2227. "Kunststoffe" [Synthetic Materials: Types, Properties, & Applications: Book Review].—Krause. (*E.N.T.*, Oct. 1942, Vol. 19, No. 10, p. 218.)

2228. Synthetic Flexible Insulations.—Ross. (*Gen. Elec. Review*, April 1943, Vol. 46, No. 4, pp. 212–218.)

2229. Film protects Radio [Immersion in Vapour of a Methyl-Chlor-Silane (sometimes with Subsequent Treatment with Ammonia Vapour) produces Invisible Wet-Refusing Film on Porcelain Insulators].—Patnode. (*Sci. News Letter*, 27th March 1943, Vol. 43, No. 13, p. 195.) From the General Electric Laboratories. Other applications are anticipated.

2230. Investigations of the Effects of Weather and Climate on Cable Heads and Cable-Head Plates in Telecommunication Plants. — Schulze. (*E.N.T.*, Oct. 1942, Vol. 19, No. 10, pp. 199–218.)

Direct temperature effects: influence of damp on the internal insulation resistance [chiefly of phenoplastics containing sawdust, particularly Type S* materials]: effects of constant relative humidity at room temperatures: of rhythmically fluctuating relative humidity: the same, at different temperatures: results of artificial tropical-climate tests: effects of surface condensation: etc. Tests with Plexiglass as a substitute material for specially bad conditions.

2231. Combination Insulator and Wire Marker [Short Lengths of Extruded Plastic Tubing marked with Letters & Numerals].—(*Review Scient. Instr.*, March 1943, Vol. 14, No. 3, pp. 81–82.)

2232. "Formex Magnet Wire" [Notice of Booklet GEA-3911].—General Electric. (*Proc. I.R.E.*, April 1943, Vol. 31, No. 4, p. liii.) For papers on this wire *see* 3101 of 1942.

2233. An Apparatus for Magnetic Testing at High Magnetising Force: Correction to Abstract 1744 of June.—Sanford & Bennett. (The journal year should read 1933, not 1943.)

2234. Two Methods for the Determination of the Remanence of Permanent Magnets.—Jellinghaus. (*See* 2184.)

2235. The Adiabatic Temperature Changes accompanying the Magnetisation of Iron in Low and Moderate Fields.—Bates & Healey. (*Proc. Phys. Soc.*, 1st May 1943, Vol. 55, Part 3, No. 309, pp. 188–201.)

2236. The Calculation of the A.C. Resistance of Layered Cylindrical Conductors, *and* Copper-Covered Wire Good for High-Frequency Lines.—Egloff: Teare & Webb. (*See* 2092 & 2093.)

2237. "DEGUSSA METALL-BERICHTE" [Book Review].—Fröhlich (Edited by). (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 23, 1942, p. 316.) From the Deutsche Gold- und Silber-Scheide-Anstalt: a collection of papers by various workers.

2238. CABLE-JOINTING SOLDER [Letter on American Practice during War].—Halperin. (*Electrician*, 4th June 1943, Vol. 130, No. 3392, p. 565.)

2239. ENGINEERING PROPERTIES OF "K" MONEL [Non-Magnetic in Almost All Applications: for Coil Springs, Electrical Contact Arms, etc.].—(*Review Scient. Instr.*, March 1943, Vol. 14, No. 3, p. 82.)

2240. MOLYBDENUM IN CANADA [Paragraph only].—(*Engineer*, 28th May 1943, Vol. 175, No. 4559, p. 438.)

2241. MINERAL RESOURCES OF THE U.S.S.R.—Williams. (*Nature*, 7th Nov. 1942, Vol. 150, No. 3810, pp. 539–541.)

STATIONS, DESIGN AND OPERATION

2242. FREQUENCY MODULATION: VI — FUTURE APPLICATIONS OF FREQUENCY MODULATION [Post-War Broadcasting: F.M. and Fading: Limits to the F.M. Band: Television: Bibliography]. — Tibbs. (*Wireless World*, June 1943, Vol. 49, No. 6, pp. 168–171.)

2243. ON A CERTAIN METHOD OF INCREASING THE EFFECTIVENESS OF WIRELESS COMMUNICATION.—Tetelbaum. (*See* 2116.)

2244. THE CALCULATION OF THE A.C. RESISTANCE OF LAYERED CYLINDRICAL CONDUCTORS, *and* COPPER-COVERED WIRE GOOD FOR HIGH-FREQUENCY LINES.—Egloff: Teare & Webb. (*See* 2092 & 2093.)

2245. ALTERNATE-SPEECH ARRANGEMENT [for Short Waves] WITH A SINGLE TRIODE.—Fuhrmann. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, p. 175.)

D.R.P. 721 235. "The oscillatory circuit 1, 2 (Fig. 11), tuned to the working short-wave frequency, lies between the positive anode and the grid, which is kept at about the cathode potential. For the production of the quenching oscillation during reception, a tuned circuit 3, 4, coupled to the grid-circuit coil 5, is connected in series with the condenser 6 (shunted by a choke 7, and serving to adjust the quenching-oscillation amplitude) between the centre-point of the short-wave circuit 1, 2 and the cathode. The signals are taken off the transformer 8."

GENERAL PHYSICAL ARTICLES

2246. RATIONAL ELECTRODYNAMICS: PART IV—THE "RADIUS" OF A POINT CHARGE: PART V—THE NEUTRON AND NUCLEAR DYNAMICS.—Milne. (*Phil. Mag.*, April 1943, Vol. 34, No. 231, pp. 235–258.)

Part IV of this series of papers applies the general theory of electrodynamics developed in Part III (1779 of June) to the interaction of two point charges. New phenomena are shown to come in at distances comparable with the classical "radius of the electron." The apparent force of interaction between two charges, which follows an inverse square law at distances large compared with the classical electron radius, suffers a tremendous increase as the distance of separation passes through values comparable with this classical radius. Further, it appears that like charges and unlike charges behave differently. The attraction of an electron towards a positive massive nucleus is enormously increased over the inverse square attraction at very close distances; thus a cluster of electrons in a nucleus will have a strong cohering effect.

In Part V the theory hitherto developed is applied to the case of an electron of charge $-\epsilon$ and mass m interacting with a proton of charge $+\epsilon$ and mass m_H. "The remarkable effect emerges that, in addition to a set of orbits corresponding very closely to the Keplerian orbits, a new set of orbits appears. When these are quantised in H, it is found that in addition to the Bohr orbits, there exist circular orbits of radius $\frac{1}{2}\epsilon^2/mc^2$, which give systems corresponding to the existence of the neutron." It is shown that the proton appears to possess a potential barrier at the distance $\frac{1}{2}\epsilon^2/mc^2$, though this is a dynamical phenomenon, and not due to any "break-down" of the Coulomb law. The conservation of energy is violated when an electron passes through the apparent potential barrier, a positive energy at infinity being derived from a negative energy for the same electron, in the same orbit, when near the nucleus. Thus energy appears to be generated when a neutron disintegrates.

2247. "CONDENSATION" IN FERMI-DIRAC STATISTICS [Discussion of Possible Existence of a Condensed Phase for a Fermi-Dirac Gas].—Kothari & Nath. (*Nature*, 10th April 1943, Vol. 151, No. 3832, p. 420.) "This condensed phase will obviously be significant for astrophysical applications of the reciprocity theory . . ."

2248. COMMITTEE ON COORDINATION OF COSMIC-RAY INVESTIGATIONS [Results & Progress in Year ending June 30th, 1942].—Fleming. (*See* 2063.)

2249. THE CASCADE THEORY WITH COLLISION LOSS ["A More Accurate Theoretical Treatment of Cascade Processes"]. — Bhabha & Chakrabarty. (*Proc. Roy. Soc.*, Series A, 6th May 1943, Vol. 181, No. 986, pp. 267–303.) "The weakest feature in all the previous treatments has been their very inadequate consideration of the effect of the ionisation or collision loss suffered by the cascade electrons . . ."

2250. Corrections to "The Force required to give a Small Acceleration to a Slowly-Moving Sphere carrying a Surface Charge of Electricity" [918 of March].—Searle. (*Phil. Mag.*, May 1943, Vol. 34, No. 232, p. 360.)

2251. The Single Potential Difference at a Cadmium Electrode.—Chalmers. (*Phil. Mag.*, May 1943, Vol. 34, No. 232, pp. 349–353.)

Author's summary :—" By the method of the scraped electrode, it has been found that the 'null' solution for a cadmium electrode in a solution of cadmium sulphate is of concentration about 1½ N. Cadmium in a normal solution has a single electrode potential of about − 0.005 volt, which can be taken as zero to the degree of accuracy of other results. This value is consistent with the others obtained by the author."

2252. Contact Potentials [Joint Letter concerning Statement in Chalmers' Series of Papers (231 of January)].—Chalmers : Hume-Rothery. (*Phil. Mag.*, March 1943, Vol. 34, No. 230, p. 213.)

MISCELLANEOUS

2253. The Determination of Turning Values by means of Logarithmic Graphs.—Silver. (*Journ. of Scient. Instr.*, May 1943, Vol. 20, No. 5, pp. 76–77.)

" The method is of value in practical work in two respects. First, the calculations required to draw the log-log graph are very often easier and less numerous for cumbrous expressions than those needed to graph the function or solve the equation of the first derivative to zero. The log-log graph can be used to represent the variables, and the turning values immediately spotted by laying a straight-edge to the required slope. Secondly, it may be helpful in interpretation of experimental results to consider turning values of simple products or quotients. If the experimental results are represented in a log-log graph, such values can be obtained directly by using the above proposition."

2254. The Evaluation of the Complex Roots of Algebraic Equations.—Cornock & Hughes. (*Phil. Mag.*, May 1943, Vol. 34, No. 232, pp. 314–320.)

Authors' summary :—" A method is described for the evaluation of the complex roots of algebraic equations in which the roots are evaluated directly from the original equation by a process somewhat akin to Horner's method for real roots."

2255. On the Problem of the Stability of the Solutions of the Limiting Problem for Equations in Partial Derivatives of the Hyperbolic Type, *and* Some New Problems for Equations in Partial Derivatives.—Soboleff. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 10th Sept. 1941, Vol. 32, No. 7, pp. 459–462 : pp. 463–466 : in French.)

2256. Simultaneous Linear Partial Differential Equations of the Second Order.—Ince. (*Proc. Roy. Soc. Edinburgh*, Sec. A, Part 3, Vol. 61, 1942/43, pp. 195–209.)

2257. Some Applications of Marcel Riesz's Integrals of Fractional Order.—Copson. (*Proc. Roy. Soc. Edinburgh*, Sec. A, Part 3, Vol. 61, 1942/43, pp. 260–272.)

" An account is given of Professor Marcel Riesz's generalisation of the Riemann–Liouville integral of fractional order. It is shown that the new ideas introduced by Riesz may prove valuable in the theory of the wave-equation in momentum space." An elementary account of Riesz's method of solving the problem of Cauchy for cylindrical waves was given by Baker & Copson in 1939.

2258. On the Asymptotic Evaluation of the Remainder in the Approximation by means of Fourier Summations, *and* On an Application of the Laplace Transformation to the Summation of Fourier Series and Trigonometrical Interpolation Polynomials.—Nikolsky : Jacob. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 30th Aug. 1941, Vol. 32, No. 6, pp. 386–389 : in French : pp. 390–394: in German.)

2259. On the Laplace Transformation and the Heaviside Operator p.—Kanno. (*Electrotech. Journ.* [Tokyo], April 1941, Vol. 5, No. 4, pp. 79–80.)

" It can, then, be concluded that (i) a transformation which satisfies the relation (3) is the Laplace transformation, and (ii) one of the characteristic properties of the Laplace transformation is to reduce the Heaviside operator p to an algebraic parameter λ."

2260. Statistical Methods : Practical Application in the Factory.—Wharton. (*Elec. Review*, 4th June 1943, Vol. 132, No. 3419, pp. 743–745.) From Philips Lamps, Ltd.

2261. Scientific Publications of the Government [Papers at the January, 1943, Meeting of the Washington Academy of Sciences].—(*Science*, 16th April 1943, Vol. 97, No. 2520, pp. 339–346.)

Including Seidell's " Publications of the U.S. Public Health Service " (and the failure of some papers to reach workers outside the U.S.A.), Mathusa & Gibson's " Publications of the National Bureau of Standards," and Shaw's " Discussion of Some Aspects in the Publication of Government Research."

2262. Utilisation of Man-Power [Extracts from " Manual of Man-Power Procedures "].—Radio & Radar Division, War Production Board. (*Proc. I.R.E.*, April 1943, Vol. 31, No. 4, pp. xxxii..xl.)

2263. Radio Regulation and Radio Design [Full Significance of Relationship between Radio-Equipment Design, Practical Operation of

Radio, & Government Regulation of Radio: Importance for the Future].—Craven. (*Proc. I.R.E.*, April 1943, Vol. 31, No. 4, pp. 124–125.)

2264. WIRELESS AND DEFENCE REGULATIONS: 1914 and 1943 COMPARED [and the Danger of Misplaced Leniency: Editorial].—(*Wireless World*, June 1943, Vol. 49, No. 6, p. 159.)

2265. "RADIO GOES TO WAR" [Book Notice].—Rolo. (*Wireless World*, June 1943, Vol. 49, No. 6, p. 165.) The author was on the staff of the Princetown University "Listening Centre," where foreign broadcasts were recorded which provide him with much of his material.

2266. STALIN PRIZES FOR SCIENCE, INVENTIONS, AND INDUSTRIAL TECHNOLOGY, 1942.—(*Nature*, 10th April 1943, Vol. 151, No. 3832, pp. 425–426.)

2267. ADDRESS OF RETIRING PRESIDENT OF THE INSTITUTE OF RADIO ENGINEERS.—Van Dyck. (*Proc. I.R.E.*, April 1943, Vol. 31, No. 4, pp. 175–178.)

"Many will say that it is presumptuous and egotistical for engineers to talk or think in this way. . . ." But many also have wondered at the remarkable way in which Russia has turned back the German military machine: "Perhaps the secret lies in certain facts revealed in recent studies by the New School for Social Research, which show that the long experimentation of the Soviet in government and industrial methods finally developed from 1936 to 1938 into a plan wherein economic control and industrial management were unified in the hands of young production engineers. This change has gone so far that nearly one third of the government offices are held by engineers. . . ." For the contrary view (Pickard, Findlay, Bragg: *Times* letter) see *Engineering*, 25th June, p. 513, and *Electrician*, 2nd July, p. 16.

2268. PROPOSED CONSTITUTIONAL AMENDMENTS, INSTITUTE OF RADIO ENGINEERS.—(*Proc. I.R.E.*, April 1943, Vol. 31, No. 4, pp. 182–183.) For letters for and against, *see*, May issue, pp. 242–243.

2269. RADIO PROGRESS DURING 1942 [Transmitters, Electronics, Television, Piezoelectricity, I.R.E. Standards Reports: with Literature References].—(*Proc. I.R.E.*, April 1943, Vol. 31, No. 4, pp. 127–132.)

2270. MEMBERSHIP DESIGNATIONS OF TECHNICAL INSTITUTIONS.—(*Engineering*, 21st May 1943, Vol. 155, No. 4036, p. 412.)

2271. THE ESSENTIAL ENDOWMENTS OF A PHYSICIST AND AN ENGINEER [Letter in Discussion on "Science & Politics"].—Weiller. (*Review Scient. Instr.*, March 1943, Vol. 14, No. 3, pp. 78–79.)

"It seems that in our day the schools—and that goes for both high schools and colleges—are making out of science and engineering an esoteric discipline, hidden in the clouds and quite unconnected with the harsh realities of this war and of industrial life".

2272. THE TECHNIQUE OF INSTRUCTING.—Burdett. (*Electrician*, 4th June 1943, Vol. 130, No. 3392, pp. 569–570.)

2273. PRESENTATION OF SCIENCE TO A GENERAL PUBLIC.—Raestad. (*Nature*, 15th May 1943, Vol. 151, No. 3837, pp. 547–548.)

The writer (formerly Minister of Foreign Affairs to the Norwegian Government, and president of a committee of the International Institute of Intellectual Cooperation) ends: "I know that in Great Britain the better dissemination of scientific news by the Press and other popular agencies, and the establishment of a central organisation to deal with the numerous international questions which inevitably arise, have frequently been discussed. Now that the United Nations are taking stock of their opportunities and their obligations, the opportunity should be grasped to make the realisation of these purposes part and parcel of a remodelled and strengthened international cooperation."

2274. "LEHRBUCH DER HOCHFREQUENZTECHNIK: BAND I UND II" [Third Edition: Book Review].—Vilbig. (*Hochf:tech. u. Elek:akus.*, Dec. 1942, Vol. 60, No. 6, pp. 179–180.) An enthusiastic review by Zenneck.

2275. "FUNDAMENTALS OF ELECTRICITY" [Book Reviews].—Mott-Smith. (*Science News Letter*, 17th April 1943, Vol. 43, No. 16, pp. 244 & 256.) A quarter of a million copies are being distributed without charge to the nation's secondary schools by Science Service in cooperation with Westinghouse, as a public service and a contribution to the war effort.

2276. "AIR-AGE EDUCATION SERIES" [Book Reviews].—Wood (Edited by): C.A.A. (*Science*, 26th Feb. 1943, Vol. 97, No. 2513, pp. 201–202.) A scathing article by W. J. Luyten, which is itself denounced equally scathingly by Dean Russell (*ibid.*, 2nd April, No. 2518, pp. 309–311).

2277. APPLICATIONS OF THE CATHODE-RAY OSCILLOGRAPH TO ELECTRIC POWER SYSTEMS.—Forrest. (*Journ. of Scient. Instr.*, May 1943, Vol. 20, No. 5, pp. 69–74.)

"The applications of the high- and medium-voltage tubes have been discussed fairly fully in the literature of the subject, and it is the perhaps less spectacular, but none the less useful, applications of the low-voltage tube [gas-focused or high-vacuum, voltages of order of 1000 v] with which this article is concerned." The writer deals in turn with the investigation of wave-form distortion, switching surges, relay performance, characteristic curves (hysteresis loops, lightning arresters), insulators, noise problems, etc. Some hints on the design of apparatus and suggestions for future development complete the paper: "for example, there is need for an oscillograph which will record automatically the currents and voltages on a power system under abnormal conditions such as are produced by a short circuit. At least six beams or tubes would be required to record adequately the conditions on a three-phase system. Photographic recording would be necessary, and in order to keep the consumption of film within reasonable limits, the recording operation would have to be initiated automatically by the disturbance which it is desired to record. Further, some form of delay or storage would have to be incorporated so that the system conditions just before the commencement of the disturbance would be recorded . . ." *Cf.* Nethercot & Beattie, 2194, above.

2278. A New Type of Microphotometer [showing the Blackening Curve corresponding to the Distribution of Blackening along a Straight Line on a Photographic Film, etc., Instantaneously on Cathode-Ray Oscillograph]. Fürth. (*Proc. Phys. Soc.*, 1st Jan. 1943, Vol. 55, Part 1, No. 307, pp. 34–41.)

2279. A Photoelectric Polarimeter [using Polaroid instead of Nicol Prisms, so that the Larger Apertures available give Amounts of Light adequate for Measurement by "Photronic" or other Photocell: Accuracy equal to that of Standard Half-Shadow Instrument: Applicable in Conditions where Visual Methods fail.].—Willey. (*Journ. of Scient. Instr.*, May 1943, Vol. 20, No. 5, pp. 74–75.)

2280. Gas Analysis with the Mass Spectrometer [including a Section on Applications, which include the Analysis of the Rare-Gas Atmosphere in Sealed-Off Electronic Devices].—Hipple. (*Journ. Applied Phys.*, Sept. 1942, Vol. 13, No. 9, pp. 551–560.) This Special Issue on Mass Spectrometry contains four other papers on the subject by various writers. *See* also 3834 of 1942.

2281. Geiger-Mueller Counter Pulse Size [Description of Apparatus for Measurement of Pulse Size: Results for Various Mixtures of Gases].—Miller. (*Review Scient. Instr.*, March 1943, Vol. 14, No. 3, pp. 68–76.)

2282. The Absorption of Infra-Red Radiation by Water-Vapour and Carbon-Dioxide [Theoretical & Experimental Investigation: the Question of the Validity of Beer's Law].—McCaig. (*Phil. Mag.*, May 1943, Vol. 34, No. 232, pp. 321–342.)

2283. X-Ray Diffraction Unit for the Control of the Cutting of Quartz Crystals.—Victor X-Ray Corporation. (*Journ. of Scient. Instr.*, May 1943, Vol. 20, No. 5, pp. 80–81.)

2284. Beryllium Windows in X-Ray Tubes.—Atlee. (*Gen. Elec. Review*, April 1943, Vol. 46, No. 4, pp. 233–236.) *Cf.* 2304 of 1941 (Klug).

2285. Beryllium Windows for Permanently Evacuated X-Ray Tubes.—Brackney & Atlee. (*Review Scient. Instr.*, March 1943, Vol. 14, No. 3, pp. 59–63.) *See* also 2284, above.

2286. Gamma-Radiography [Advantages over Radiography by X-Rays: Technique: Prospect of Rapid Extension].—Croxson. (*Nature*, 10th April 1943, Vol. 151, No. 3832, pp. 424–425: summary of paper.)

2287. Illuminator for Radiographs ["Industrex" Illuminator with Adjustable Shutters to prevent Small Density Differences from being Missed owing to Glare from Unscreened Opal round Margins of Film: Other Refinements].—Kodak, Ltd. (*Journ. of Scient. Instr.*, May 1943, Vol. 20, No. 5, p. 80.)

2288. The Association for Scientific Photography [Note on Formation, with Names of Committee, etc.].—(*Engineer*, 28th May 1943, Vol. 175, No. 4559, p. 436.) *See* also *Journ. of Scient. Instr.*, June 1943, p. 104.

2289. "Photographic Optics" [Book Review].—Cox. (*Phil. Mag.*, May 1943, Vol. 34, No. 232, p. 360.) In the series "The Manual of Photo-Technique." "The author has collected in one volume a mass of data previously out of reach of the majority of photographers. . . ."

2290. Document-Copying Camera.—Watson & Sons. (*Journ. of Scient. Instr.*, May 1943, Vol. 20, No. 5, pp. 78–79.)

2291. A Light Effect in Chlorine under Electric Discharge: Influence of the Intensity and Frequency [Further Work on the Diminution of Current on Irradiation of Chlorine].—Joshi & Deo. (*Nature*, 15th May 1943, Vol. 151, No. 3837, p. 561.) *See*, for example, 2821 of 1941.

2292. On Sensory Energy, with Special Reference to Vision and Colour-Vision.—Shaxby. (*Phil. Mag.*, May 1943, Vol. 34, No. 232, pp. 289–314.)

Among other things, "the cases of steady stimuli (in the skin senses, smell, etc.) are contrasted with those of periodic stimuli (in hearing and sight). The values of the visibility function for different wavelengths are calculated and shown to agree with the observed values. A theory of colour-vision based on the electronic content of the discharges of action current, and not requiring the retinal triplication of the trichromatic theory, is shown to lead to an equation for a match in colour which is in accord with observed data." An addendum considers briefly one possible way of electron ejection, impact with perfect elasticity between the vibrating particle and the electron.

2293. The Speed of Chemical Reactions [Its Methods of Measurement and Their Application to Physics & Biology: Development of Formulae (by Use of Thermodynamics, Statistical Mechanics, & Quantum Theory) applicable to Velocities of Sound & of Nerve Impulses: etc.].—Eyring. (*Science*, 2nd April 1943, Vol. 97, No. 2518, Supp. pp. 10 and 12: summary of lecture.)

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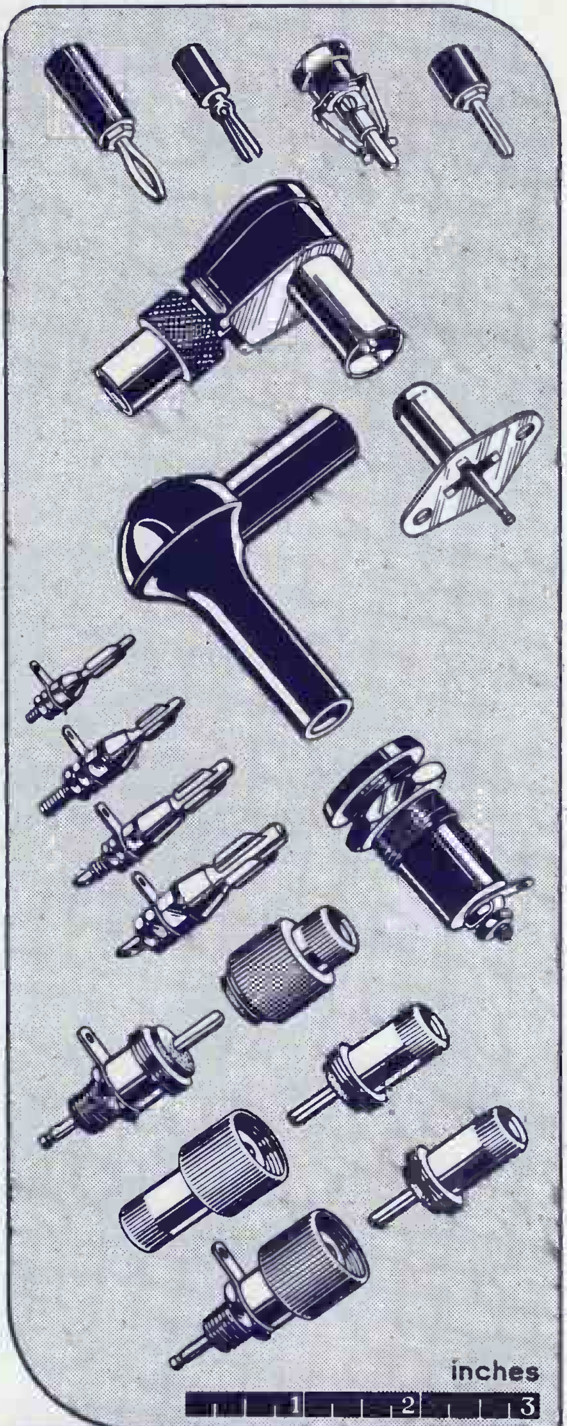

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