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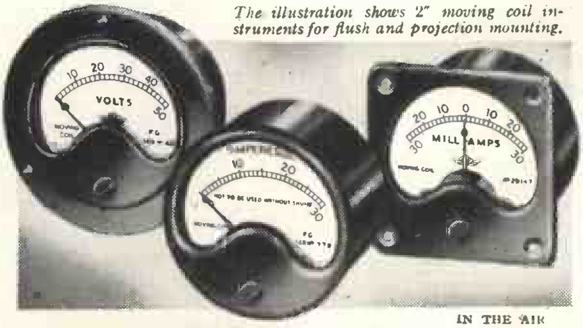

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electronic briefs: FM

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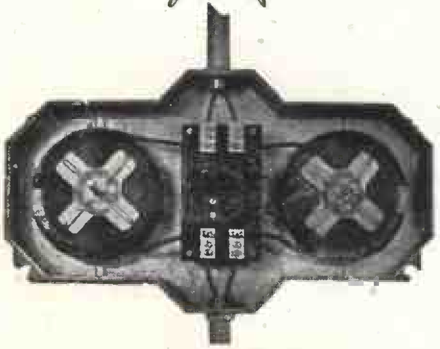

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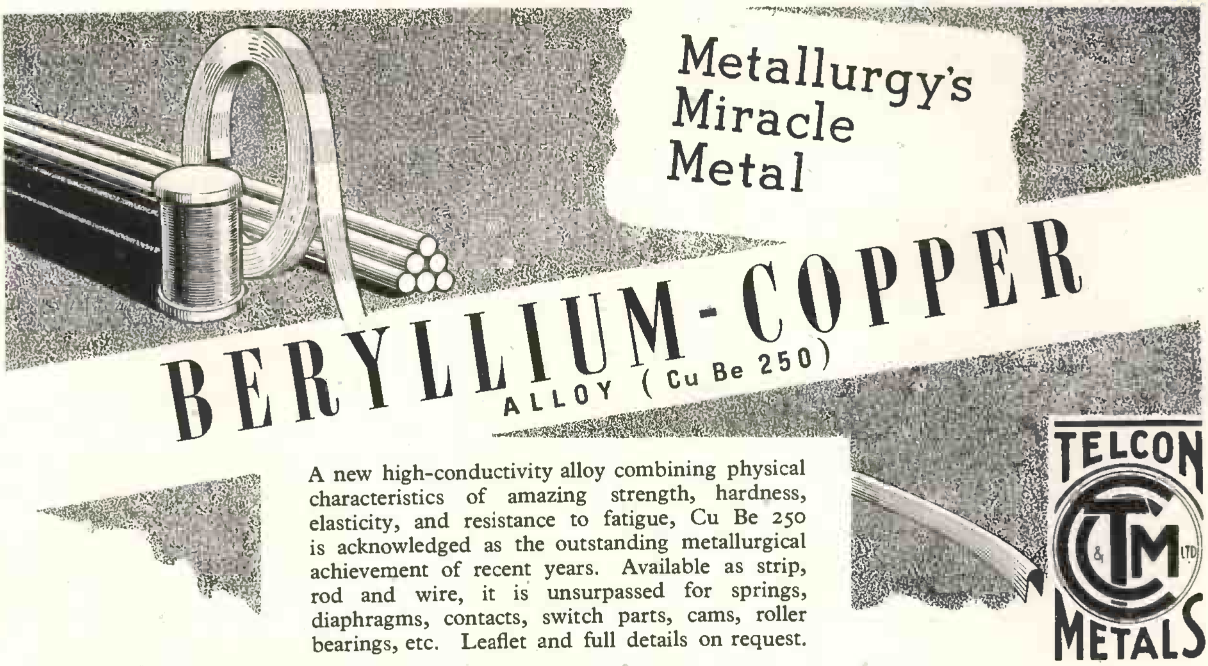

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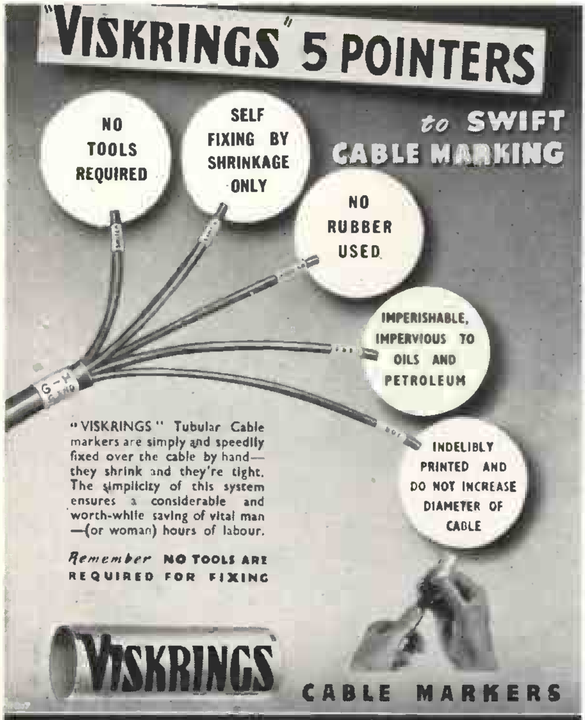
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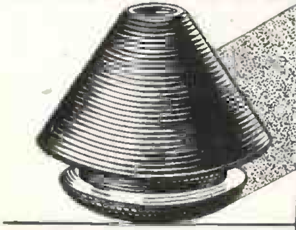


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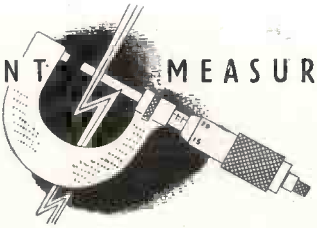

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WHY THEY USE CORED SOLDER

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.

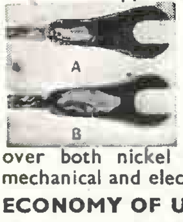
WHY THEY PREFER MULTICORE SOLDER. 3 Cores—Easier Melting Multicore Solder wire contains 3 cores of flux to ensure flux continuity. In Multicore there is always sufficient proportion of flux to solder. If only two cores were filled with flux, satisfactory joints are obtained. In practice, the care with 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 33¹/₃%, 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 OCTOBER, 1943 No. 241

Coercive Force

IN the *Philosophical Transactions of the Royal Society* of 1885* Hopkinson wrote: "I propose to call *OA* the 'Coercive Force' of the material, and define it as that reversed magnetic force which just suffices to reduce the induction to nothing after the material has been submitted temporarily to a very great magnetising force. It is the figure which is of greatest importance in short permanent magnets." It is to be noted that it is the induction *B* and not the intensity of magnetisation *J* that is to be reduced to nothing.

In the preface to "Magnetic Induction in Iron and Other Metals," written in 1891, Ewing says, "Throughout this book the author has endeavoured to familiarise the student with the notion of intensity of magnetisation (*J*) as well as the notion of magnetic induction (*B*). It has been urged by some writers that the alternative which is in this way offered is unnecessary and confusing, and that if we keep '*B*' we may dispense with '*J*.' The scientific value and the practical utility of '*B*' are so obvious that no one proposes to avoid using that. It is '*J*' that we are told must go. In this cry the author is by no means disposed to join. It is not too much to say that in stating the magnetic qualities of a metal the quantity '*J*' is of primary importance. The facts of saturation, the molecular theory, and the phenomena of magneto-optics, all demonstrate its physical reality and its fundamental interest." Then on p. 52 he says: "In Fig. 20 a curve showing the relation of the magnetising force of the solenoid to *J* is drawn from the above table . . . This residual magnetism is, however, very feebly held. Applying a reverse magnetic force quickly removes it, and a force, *OD*, of −2.75 C.G.S. units suffices to destroy it altogether. This force *OD* may be said to measure the degree of stability with which the residual magnetism is held, and accordingly Dr. Hopkinson calls it the 'coercive force,' thus giving an exact and very useful meaning to an old loosely applied term."

This appears to be where the trouble started, for as we saw above, Hopkinson specifically gave the name to something different from that to which Ewing here attached it, with the result that, notwithstanding Ewing's expressed intention of distinguishing between *B* and *J*, the term "coercive force" continued to be loosely applied.

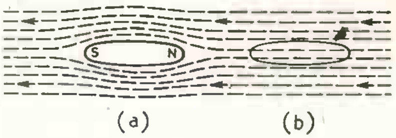

Fig. 1.

The question is, whether the coercive force is the value of the reverse *H* required to *counterbalance* exactly the forward magnetomotive force of the material, thus giving zero magnetic induction, as shown in Fig. 1*a* for an ellipsoidal permanent magnet, or whether it is the still greater reverse *H* required to *destroy* the forward magnetisation as shown in Fig. 1*b*, thus giving a reverse *B* equal to the reverse *H*, as would be the case if the material were non-magnetic. Hopkinson adopted the former and Ewing the latter definition.

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* Vol. 176, p. 455. The modern symbol *J* has been substituted for *I* for the intensity of magnetisation in the various quotations.

In the case of ordinary iron and steel the differences between the two definitions is quite immaterial, but in the case of some magnetic alloys it is the greatest importance and may lead to serious misconceptions. Fig. 2 shows how small the difference is even in a material with a permeability of about 10. The dotted line is drawn for unit permeability, i.e., a non-magnetic material. If the reverse H is increased to 10 we reach point X and $B = 0$; if H is now very slightly increased we reach the point Y for which $-B = -H$ and $J = 0$. For the ordinary ferromagnetic materials, the scale of H is in units and that of B in thousands, with the result that the slope of the dotted line for unit permeability would be greatly reduced so that it would be hardly distinguishable from the horizontal. Under these circumstances, the points X and Y would almost coalesce, and, moreover, Y would be almost vertically below X. Under such circumstances there is no point in attempting to discriminate between the two definitions of coercive force.

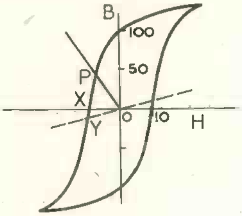

Fig. 2.

Let us now turn to another magnetic material, investigated some years ago and recently utilised in the construction of ammeters by the General Electric Company of America.

In 1931 H. H. Potter* described experiments made with an alloy of silver, manganese and aluminium having the following composition Ag. 86.9, Mn. 8.8, Al. 4.3 per cent., which corresponds approximately to the formula Ag_5MnAl. Magnetic induction is not mentioned in the Paper, all the results being expressed in terms of intensity (or rather as the author mistakenly calls it, " intensity per unit volume "). Fig. 3 is reproduced from Fig. 2 of the Paper and gives the results of the application and reversal of a magnetising force of about 14 000 oersteds. Even at this enormous value of H the alloy is not saturated, but J has reached a value of about 60. The reverse H necessary to reduce J to zero is 5700, which, according to the Ewing definition, is the coercive force. The residual intensity is about 37, corresponding to an induction B of 465. These values can be compared with those for tungsten steel with a H_c of about 70 and a B_r of 11 500, or with those of Ticonal No. 3 with a H_c of 600 and a B_r of 12 700, or with those of Ticonal 2*A* with a H_c of 950 and a B_r of 6000.

If, however, Fig. 3 be replotted with ordinates representing the induction B as is usual in electrical engineering work, Fig. 4 is obtained.

The difference between Figs. 3 and 4 shows how careful one must be in forming opinions as to magnetic properties from a cursory glance at a hysteresis loop. The same scales are employed in Fig. 4 for both H and B, and the dotted line drawn at 45° is the magnetisation curve for a non-magnetic material. For $B = 0$ the reverse H is seen to be 465 which, according to the Hopkinson definition, is the coercive force H_c The Ewing coercive force corresponds to the point where the curve cuts the 45° line, since the alloy then acts as a non-magnetic material. According to this definition the coercive force is 5700.

Two engineers of the General Electric Co. of America have recently described† " A New Moving-Magnet Instrument for Direct Current " in which use is made of this alloy. The authors refer to the Paper by Potter, and state that the alloy used has a coercive force (${}_jH_c$) of 6000 oersteds and a residual induction of 610 gausses. They say " it is unique among permanent magnet materials in having a coercive force of this high value. The high coercive force enables the control magnets, which are in the form of thin strips, to be magnetised in the direction of their thickness." The symbol (${}_jH_c$) suggests that the authors are probably aware that the coercive force quoted is that for which the intensity J is zero. The important

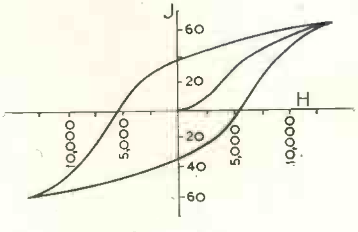

Fig. 3.

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* *Phil. Mag.*, XII. p. 255.

† H. T. Faus and J. R. Macintyre, *Electrical Engineering* (New York), August, 1942, p. 586.

point that now arises and needs to be definitely settled is which of the two coercive forces 465 or 5700 is to be taken as a measure of the suitability of the alloy as a permanent magnet material. For all ordinary purposes there is no doubt that the smaller figure is the true criterion. In the symposium on Magnetism issued by the Institute of Physics in 1938, there is a paper on Permanent Magnets by D. A. Oliver of the Permanent Magnet Association, Sheffield. Except for the formula, $B = \mu_o H \times 4\pi J$, the intensity is never mentioned, and the coercive force employed in all the diagrams and formulae is that which reduces B to zero. The problem of designing a magnet to obtain the optimum field energy is confined entirely to the second quadrant of the B-H loop. This can be seen most simply by considering a toroidal magnet with a small air gap, for which magnetic leakage may be neglected. When the magnetising ampere turns are reduced to zero, $\int H\,dl$ around the magnetic circuit must also vanish i.e., $H_a l_a + H_i l_i = 0$ where a and i refer to air and iron respectively. Hence $\frac{B}{\mu_a} l_a + \frac{B}{\mu_i} l_i = 0$ and $l_i/l_a = -\mu_i/\mu_a$.

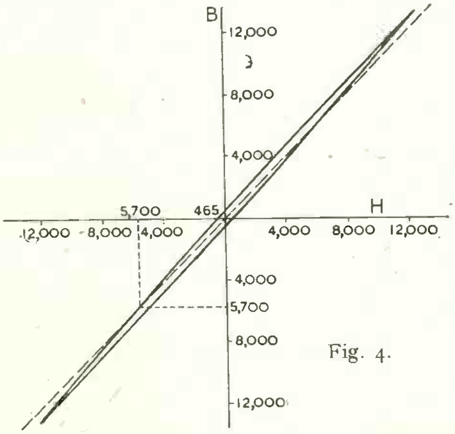


Fig. 4.

Putting $\mu_a = 1$, we see that B must decrease and H become increasingly negative until a point P (Fig. 2) is reached for which $B/-H = l_i/l_a$. The magnet is usually so designed that this working point P gives approximately the maximum value of the product BH. If, however, the shape of the magnet, and therefore the ratio l_i/l_a, is prescribed by other considerations, the direction QP in Fig. 2 is fixed, and one must seek a material to give this line the greatest length, since the product BH will be proportional to OP^2. The energy in the air-gap of the magnet will be equal to $Al_a.B^2/8\pi$; putting $l_a = \frac{H}{B}.l_i$, this may be written $Al_i.BH/8\pi$. Hence the magnetic energy in the gap is proportional to the volume of the magnet and to the product BH.

Hence the only properties concerned in the ordinary design of permanent magnets are B_r, H_c, and the shape of the B-H curve between these two points, since on this depends the maximum value of BH. From this point of view the alloy under consideration is very inferior to such materials as Ticonal, since its $(BH)_{\max}$ is only 54 000 as compared with 4.8×10^6 for Ticonal No. 3. Why then is it used? The answer to this question is probably concerned with a quality which is usually ignored but which may be of great importance, namely, the ability to withstand extraneous temporary demagnetising forces. In a material with a B-H curve like Fig. 2. the dimensions of the permanent magnet may be such that P is the stable point. If now an extraneous demagnetising force is added to that of the magnet itself, it is obvious that the value of B will fall very rapidly and reverse. If the point Y is reached the material is completely demagnetised, J being reduced to zero. With ordinary tungsten steel and with materials like Ticonal, a relatively small additional demagnetising force would accomplish this, but in Figs. 3 and 4 it requires a very large demagnetising force to diminish appreciably the intensity of magnetisation, and a reverse H of nearly 6000 to demagnetise the material completely. It is true that B is reversed by a relatively small reverse H, but this magnetic induction is driven through the material against its permanent magnetisation without destroying it.

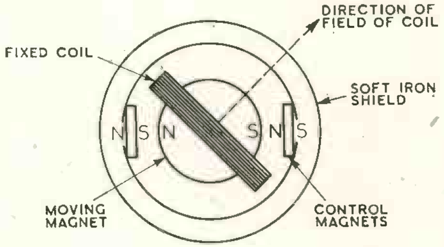


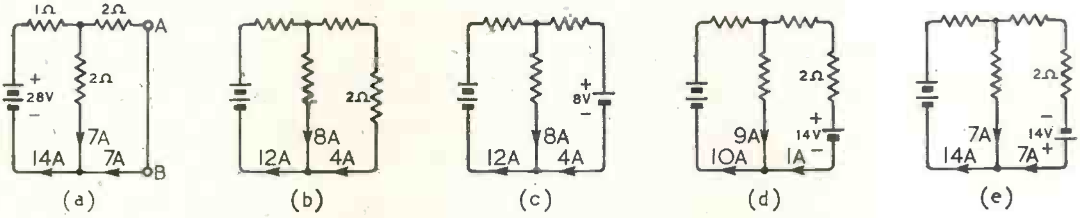
Fig. 5.

As already mentioned, thin strips of this alloy, magnetised in the direction of their thickness, are used as control magnets in the new type of ammeter (Fig. 5). It can be seen that an excessive current flowing momentarily through the fixed coil would tend to demagnetise these thin control magnets. The moving magnet is in the form of a solid cylinder, magnetised along a diameter. Here again an unusual material is employed, viz., a mixture of iron and cobalt oxides with a coercive force of 950 (which of the two is not stated) and a residual induction of 2200. $(BH)_{\max}$ is stated to be about 10^6; $(BH)_{\max}$ of Ticonal No. 3 is about 4.8×10^6, but the oxide magnet has a specific gravity of about half that of steel, and it is important to keep the weight of the moving element as small as possible.

It is evident that in the design of permanent magnets for special purposes, consideration must be given to other factors than those usually regarded as controlling the design, and that the term " coercive force " needs to be carefully defined. G. W. O. H.

The Network Theorem of Pleijel

IN our discussion of the make and break network theorem of Helmholtz in the July Editorial we referred to an article published by Pomey in 1919 entitled " The theorem of Pleijel." This theorem was stated by Pomey in the following terms: " Si une résistance η sans capacité est inserée dans l'une des branches d'un réseau complex, l'augmentation de l'intensité dans une branche quelconque devient la même que celle que produirait une force électromotrice placée au même point, qui est égale à ηi quand i est le courant qui se trouve dans la branch considérée *avant* le chargement. La force électromotrice ηi devra être dirigée *vers* le courant i."



On p. 487 of this issue we publish a letter from Dr. J. H. Mole in which it is shown that this is incorrect if interpreted to mean that the e.m.f. inserted " au même point " is inserted in place of the added resistance η, as we assumed in translating this phrase. It is correct, however, if interpreted to mean that the e.m.f. is inserted in addition to the resistances η, as we assumed in the proof given in the Editorial. If, on inserting the resistance η, the current decreases from i to i' then the e.m.f. which, if introduced instead of the resistance would cause the same change of current throughout the network is equal to $\eta i'$ and not ηi. This e.m.f. must be directed against the current as Pomey says, but for " *avant* " in his statement one must then substitute " *après*." This is illustrated in the adjoining Figures. With a 28 volt battery the currents in (*a*) will be as shown. On inserting a 2 ohm resistance between *A* and *B*, the currents will be as shown in (*b*), but the same change of currents throughout the network is obtained in (*c*) by inserting the e.m.f. of 8 volts, i.e., $2\ \Omega \times 4A$ in opposition to the current. If, however, the added resistance is left in the branch, then the e.m.f. necessary to produce an equal change of current is $2\Omega \times 7A$, i.e., 14 volts as shown in (*d*). If the e.m.f. is reversed so as to flow in the same direction as the current, it annuls the effect of the resistance, and the current distribution as shown in (*e*) is the same as in (*a*). Dr. Mole sets out these two alternative interpretations of Pleijel's theorem quite clearly in his letter.

G. W. O. H.

Coupled Circuit Filters

By K. R. Sturley, Ph.D., M.I.E.E.

(Marconi School of Wireless Communication)

[Concluded from page 434 of the September issue]

6. Extended Applications of the Curves

IT is clear from the analysis given in the first instalment of this article that generalised selectivity, phase shift, and peak and trough transfer impedance curves can be developed for any pair of dissimilar tuned circuits having a common resonant frequency and coupled by mutual inductance.

Examination of other types of shunt* and of series couplings between dissimilar tuned circuits shows that the curves have much wider application. Two cases of common resonant frequency arise in both forms of coupling.

(1) The resonant frequency of the primary and coupling is equal to that of the secondary and coupling. For shunt coupling the circuit not being considered is on open circuit and for series coupling it is short circuited.

(2) The resonant frequencies of the primary and secondary circuits, in the absence of coupling, are equal. This is the more common in practical circuits.

Case 1

(a) Shunt Inductance Coupling

The circuit is that shown in Fig. 8 and the analysis yields results identical with that for mutual inductance coupling if L_1, L_2 and M are replaced by $(L_1 + L_3)$, $(L_2 + L_3)$ and L_3 respectively. The curves are obviously applicable to this circuit.

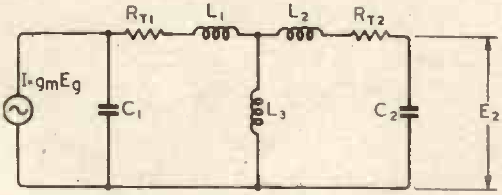


Fig. 8.—*Tuned circuits with shunt inductance coupling.*

(b) Shunt Capacitance Coupling

Fig. 9 gives the circuit for shunt capacitance coupling.

For mutual and shunt inductance coupling the coupling coefficient is defined as

$$k = \frac{\text{coupling reactance}}{\text{geometric mean of coupling + primary reactance of same kind and coupling + secondary reactance of same kind.}} \quad (24)$$

i.e., if the coupling reactance is inductive or capacitive the primary or secondary inductive or capacitive (respectively) reactance must be considered.

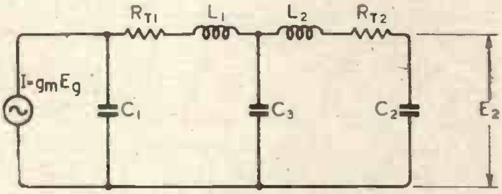


Fig. 9.—*Tuned circuits with shunt capacitance coupling.*

Hence in this instance

$$k = \frac{\dfrac{1}{\omega_m C_3}}{\sqrt{\dfrac{C_1 + C_3}{\omega_m C_1 C_3} \cdot \dfrac{C_2 + C_3}{\omega_m C_2 C_3}}} = \sqrt{\frac{C_1 C_2}{(C_1 + C_3)(C_2 + C_3)}} \quad \ldots \quad \ldots \quad (25)$$

$$f_m = \frac{1}{2\pi\sqrt{\dfrac{L_1 C_1 C_3}{C_1 + C_3}}} = \frac{1}{2\pi\sqrt{\dfrac{L_2 C_2 C_3}{C_2 + C_3}}}$$

$$Q_1 = \frac{\omega_m L_1}{R_1 + \dfrac{1}{(\omega_m C_1)^2 R_a}};$$

$$Q_2 = \frac{\omega_m L_2}{R_2 + \dfrac{1}{(\omega_m C_2)^2 R_g}}$$

---

* The term " shunt " denotes that the coupling forms a shunt or parallel arm of a T network and " series " that it forms the series arm of a π network.

The resistances R_a and R_g are in parallel with C_1 and C_2, and their series equivalents are therefore as indicated. Analysing as for mutual inductance gives

$$Z_T = \frac{j\dfrac{\omega_m{}^3}{\omega^3}\sqrt{R_{D1}\,.\,R_{D2}}\,\sqrt{Q_1Q_2}\,k\,\dfrac{C_3{}^2}{(C_1+C_3)(C_2+C_3)}}{1 + Q_1Q_2\left(k^2\dfrac{\omega_m{}^2}{\omega^2} - F^2\right) + j\,(Q_1+Q_2)\,F} \qquad \ldots \quad \ldots \quad (26)$$

which reduces to expression (5b) $\times \dfrac{-C_3{}^2}{(C_1+C_3)(C_2+C_3)}$, if $\dfrac{\omega_m}{\omega}$ is assumed to be unity.

It is therefore evident that the generalised selectivity curves are applicable and the parameter

$$\sqrt{Q_1Q_2}\,k = \frac{\text{coupling reactance}}{\text{geometric mean of primary and secondary total series resistances.}}$$

as was noted for mutual inductance coupling.

The phase shift curves may also be used by reading from the right-hand vertical scale B, i.e., $\phi = 90°$ at $\Delta f = 0$ and $-90°$ at $\Delta f = +\infty$. For negative off-tune frequencies the phase angle varies from 90° through 180° to 270° at $\Delta f = -\infty$ and the right-hand vertical scale A is used.

The peak and trough transfer impedance curves require $\sqrt{R_{D1}R_{D2}} \times \dfrac{C_3{}^2}{(C_1+C_3)(C_2+C_3)}$ to be registered with $\dfrac{\sqrt{Q_1Q_2}\,k}{1 + Q_1Q_2\,k^2} = 1$

The factor $\dfrac{C_3{}^2}{(C_1+C_3)(C_2+C_3)}$ occurs because the capacitive arms of the primary and secondary circuits consist of C_1 or C_2 in series with C_3. The result is a reduction of the voltage across C_2.

(*c*) *Series Inductance Coupling* (*Fig.* 10)

The expression for Z_T is different from that for shunt coupling as shown by the detailed analysis of Appendix I, but if certain assumptions (justifiable in almost all practical circuits) are made, the expression for $|Z_T|$ is identical with that of (5a). Hence all the generalised curves are applicable. The left-hand vertical scale B of the phase shift curves is the correct one for positive off-tune frequencies. Two points of interest arise from the analysis. The coupling coefficient is now defined as follows:

$$k = \sqrt{\frac{L_1L_2}{(L_1+L_4)(L_2+L_4)}}$$

$$= \frac{\text{coupling susceptance}}{\text{geometric mean of coupling + primary susceptance of same kind and coupling + secondary susceptance of same kind.}} \qquad \ldots \quad \ldots \quad (27)$$

(note coupling plus primary susceptance $= \dfrac{1}{X_c} + \dfrac{1}{X_p}$) i.e., it is the same definition as for shunt coupling except for the substitution of susceptance for reactance. The parameter $\sqrt{Q_1Q_2}\,k$ is also similar, with susceptance and conductance substituted for reactance and resistance, thus

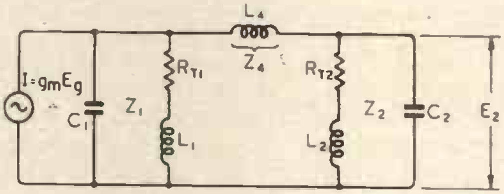


Fig. 10.—*Series inductance-coupled tuned circuits.*

$$\sqrt{Q_1Q_2}\,k = \frac{\text{coupling susceptance}}{\text{geometric mean of primary and secondary total parallel conductances.}} \qquad \ldots \quad \ldots \quad (28)$$

$$f_m = \frac{1}{2\pi\sqrt{\dfrac{L_1L_4C_1}{L_1+L_4}}} = \frac{1}{2\pi\sqrt{\dfrac{L_2L_4C_2}{L_2+L_4}}}$$

$$Q_1 = \frac{\omega_m\dfrac{L_1L_4}{L_1+L_4}}{R_1 + \dfrac{1}{(\omega_mC_1)^2R_a}};$$

$$Q_2 = \frac{\omega_m\dfrac{L_2L_4}{L_2+L_4}}{R_2 + \dfrac{1}{(\omega_mC_2)^2R_g}}$$

(*d*) *Series Capacitance Coupling*

The circuit is shown in Fig. 11 and

$$f_m = \frac{1}{2\pi\sqrt{L_1(C_1+C_4)}} = \frac{1}{2\pi\sqrt{L_2(C_2+C_4)}}$$

$$k = \frac{C_4}{\sqrt{(C_1 + C_4)(C_2 + C_4)}}$$

$$Q_1 = \frac{\omega_m L_1}{R_1 + \dfrac{1}{[\omega_m(C_1 + C_4)]^2 R_a}}$$

$$Q = \frac{\omega_m L_2}{R_2 + \dfrac{1}{[\omega_m(C_2 + C_4)]^2 R_g}}$$

Note that R_a and R_g are effectively in parallel with $(C_1 + C_4)$ and $(C_2 + C_4)$. By assuming in the numerator of Z_T that Q_1 and $Q_2 \gg 1$ and in the denominator that $-\dfrac{C_4^2}{C_1C_2}[1 + j(Q_1 + Q_2)\dfrac{\omega}{\omega_m}]$ can be neglected, it is found that the denominator is equal to

$$\frac{C_4^2}{C_1C_2k^2}\left[(1 + jQ_1F)(1 + jQ_2F) + Q_1Q_2k^2\frac{\omega^2}{\omega_m^2}\right],$$

and

$$Z_T = \frac{j\dfrac{\omega}{\omega_m}\sqrt{R_{D1} \,.\, R_{D2}}\,\sqrt{Q_1Q_2}\,k}{1 + Q_1Q_2\left(k^2\dfrac{\omega^2}{\omega_m^2} - F^2\right) + j(Q_1 + Q_2)F} \quad \ldots \ldots \quad (29)$$

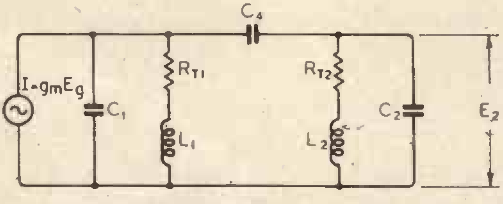


Fig. 11.—*Series capacitance-coupled tuned circuits.*

If $\dfrac{\omega}{\omega_m}$ is assumed to be unity, expression (29) is the same as (5b).

Again all the generalised curves are applicable but for the phase shift the right-hand vertical scales must be employed, i.e., as for shunt capacitance.

(e) *Shunt Inductance and Capacitance Coupling*

The circuit is illustrated in Fig. 12 and analysing by normal procedure gives

$$Z_T = \frac{-j\sqrt{R_{D1} \,.\, R_{D2}}\,\sqrt{Q_1Q_2}\left(k_{L3}\dfrac{\omega_m}{\omega} - k_{C3}\dfrac{\omega_m^3}{\omega^3}\right)\dfrac{C_3^2}{(C_1 + C_3)(C_2 + C_3)}}{1 + Q_1Q_2\left[\left(k_{L3}\dfrac{\omega}{\omega_m} - k_{C3}\dfrac{\omega_m}{\omega}\right)^2 - F^2\right] + j(Q_1 + Q_2)F} \quad \ldots \ldots \quad (30)$$

where

$$k_{L3} = \frac{L_3}{\sqrt{(L_1 + L_3)(L_2 + L_3)}} \qquad k_{C3} = \sqrt{\frac{C_1C_2}{(C_1 + C_3)(C_2 + C_3)}}$$

$$f_m = \frac{1}{2\pi\sqrt{(L_1 + L_3)\dfrac{C_1C_3}{C_1 + C_3}}} = \frac{1}{2\pi\sqrt{(L_2 + L_3)\dfrac{C_2C_3}{C_2 + C_3}}}$$

$$Q_1 = \frac{\omega_m(L_1 + L_3)}{R_1 + \dfrac{1}{(\omega_m C_1)^2 R_a}} \qquad Q_2 = \frac{\omega_m(L_2 + L_3)}{R_2 + \dfrac{1}{(\omega_m C_2)^2 R_g}}$$

Provided $\omega_m L_3$ does not approach $\dfrac{1}{\omega_m C_3}$, i.e., the series resonant frequency of the shunt arm is well outside the normal frequency range of the coupled circuits, all the generalised curves are applicable. The capacitive factor $\dfrac{C_3^2}{(C_1 + C_3)(C_2 + C_3)}$ must be included for the trough and peak transfer impedance, and the effective coupling coefficient is the difference between the inductive and capacitive coefficients. The left-hand vertical scales are used for the phase shift curves if the inductive coupling coefficient is the

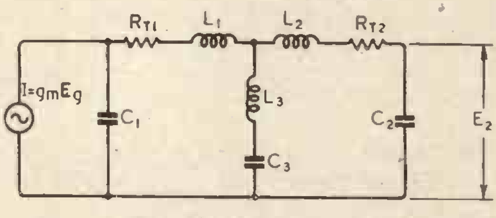


Fig. 12.—*Shunt inductance- and capacitance-coupled tuned circuits.*

greater, and the right-hand if the capacitive coupling coefficient is greater.

(*f*) *Series Inductance and Capacitance Coupling*

Fig. 13 gives the circuit and it is found that the generalised curves are all applicable provided parallel resonance of the series coupling arm is not approached. All the remarks in (*e*) also apply here, but there is no capacitive factor.

$$f_m = \frac{1}{2\pi\sqrt{\dfrac{L_1L_4}{L_1+L_4}(C_1+C_4)}}$$

$$= \frac{1}{2\pi\sqrt{\dfrac{L_2L_4}{L_2+L_4}(C_2+C_4)}}$$

Type of Coupling	f_m	k	$\sqrt{Q_1Q_2}\,k$
1. Mutual Inductance	$\frac{1}{2\pi\sqrt{(L_1C_1}}$	$\frac{M}{\sqrt{L_1L_2}}$	$\frac{\omega_m M}{\sqrt{R_{T1}\cdot R_{T2}}}$
2. Shunt Inductance	$\frac{1}{2\pi\sqrt{(L_1+L_3)C_1}}$	$\frac{L_3}{\sqrt{(L_1+L_3)(L_2+L_3)}}$	$\frac{\omega_m L_3}{\sqrt{R_{T1}\cdot R_{T2}}}$
3. Shunt Capacitance	$\frac{1}{2\pi\sqrt{L_1\frac{C_1C_3}{C_1+C_3}}}$	$\sqrt{\frac{C_1C_2}{(C_1+C_3)(C_2+C_3)}}$	$\frac{\frac{1}{\omega_m C_3}}{\sqrt{R_{T1}R_{T2}}}$
4. Series Inductance	$\frac{1}{2\pi\sqrt{\frac{L_1L_4}{L_1+L_4}C_1}}$	$\sqrt{\frac{L_1L_2}{(L_1+L_4)(L_2+L_4)}}$	$\frac{\frac{1}{\omega_m L_4}}{\sqrt{\frac{R_{T1}(L_1+L_4)^2}{(\omega_m L_1L_4)^2}\;\frac{R_{T2}(L_2+L_4)^2}{(\omega_m L_2L_4)^2}}}$
5. Series Capacitance	$\frac{1}{2\pi\sqrt{L_1(C_1+C_4)}}$	$\frac{C_4}{\sqrt{(C_1+C_4)(C_2+C_4)}}$	$\frac{\omega_m C_4}{\sqrt{\frac{R_{T1}}{(\omega_m L_1)^2}\cdot\frac{R_{T2}}{(\omega_m L_2)^2}}}$

$$Q_1 = \frac{\omega_m \dfrac{L_1 L_4}{L_1 + L_4}}{R_1 + \dfrac{1}{[\omega_m (C_1 + C_4)]^2 R_a}}$$

$$Q_2 = \frac{\omega_m \dfrac{L_2 L_4}{L_2 + L_4}}{R_2 + \dfrac{1}{[\omega_m (C_2 + C_4)]^2 R_g}}$$

Q_1	R_{T1}
$\dfrac{\omega_m L_1}{R_{T1}}$	$R_1 + \dfrac{1}{(\omega_m C_1)^2 R_a}$
$\dfrac{\omega_m (L_1 + L_3)}{R_{T1}}$	$R_1 + R_3 + \dfrac{1}{(\omega_m C_1)^2 R_a}$
$\dfrac{\omega_m L_1}{R_{T1}}$	$R_1 + R_3 + \dfrac{1}{(\omega_m C_1)^2 R_a}$
$\dfrac{\omega_m \dfrac{L_1 L_4}{L_1 + L_4}}{R_{T1}}$	$R_1 + \dfrac{1}{(\omega_m C_1)^2}\left(\dfrac{1}{R_a} + \dfrac{1}{R_4}\right)$
$\dfrac{\omega_m L_1}{R_{T1}}$	$R_1 + \dfrac{1}{\omega_m^2 (C_1 + C_4)^2}\left(\dfrac{1}{R_a} + \dfrac{1}{R_4}\right)$

The effective coupling coefficient is the difference between the inductive and capacitive coefficients.

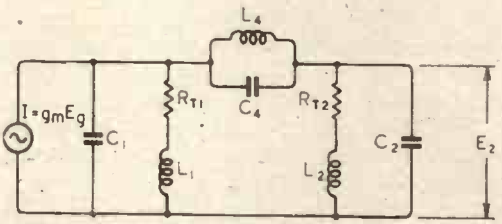


Fig. 13.—*Series inductance- and capacitance-coupled tuned circuits.*

To facilitate reference, the above results for (*a*), (*b*), (*c*) and (*d*) are set out in the form of a table (see Table 1) of mid frequency, coupling coefficient, the frequency and constant factors associated with

$$\sqrt{R_{D1} \cdot R_{D2}} \cdot \sqrt{Q_1 Q_2}\, k$$

in the numerator of Z_T, the frequency factor multiplying k^2 in the denominator, Q_1, Q_2, R_{T1} and R_{T2}. The frequency factors allow a

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TABLE I. $L_1C_1 = L_2C_2$

$$Z_T = \frac{-jA\sqrt{R_{D1} \cdot R_{D2}}\,\sqrt{Q_1 Q_2}\,k}{1 + Q_1 Q_2 (k^2 D - F^2) + j(Q_1 + Q_2)F}$$

$A = \dfrac{\omega_m}{\omega}$ for couplings 1, 2 and 4

$= \dfrac{\omega}{\omega_m}$ for coupling 5

$= -\dfrac{\omega_m^3}{\omega^3}\dfrac{C_3^2}{(C_1 + C_3)(C_2 + C_3)}$ for coupling 3

$D = \dfrac{\omega^2}{\omega_m^2}$ for couplings 1, 2 and 5

$= \dfrac{\omega_m^2}{\omega^2}$ for couplings 3 and 4

R_3 = equivalent series resistance of the shunt coupling arm.

R_4 = equivalent parallel resistance of the series coupling arm.

$R_{D1} = Q_1 \omega_m L_1$ for capacitive couplings.

$= \dfrac{Q_1}{\omega_m C_1}$ for inductive couplings.

R_{D2} is defined similarly by replacing suffix 1 by 2.

An alternative expression for f_m, and the expressions for Q_2 and R_{T2} are found by replacing the suffix 1 in the f_m, Q_1 and R_{T1} columns by the suffix 2, and replacing R_a in the R_{T1} column by R_g.

rapid estimate of the modification likely to occur in the symmetry of the curves about f_m. The frequency factor in the numerator is of much greater importance than that multiplying k^2 in the denominator. Thus for shunt inductance and mutual inductance coupling there is a tendency for $|Z_T|$ at a given negative off-tune frequency ($f < f_m$) to be greater than $|Z_T|$ at the same positive off-tune frequency. This tendency is greatly exaggerated in the case of shunt capacitance but is in the reverse direction with series capacitance ($|Z_T|$ is greater at a positive off-tune frequency). The additional equivalent series resistances inserted in the primary and secondary circuits due to the parallel external resistances R_a and R_g are, for all except series capacitance coupling, $\frac{1}{(\omega_m C_1)^2 R_a}$ and $\frac{1}{[\omega_m C_2]^2 R_g}$ respectively. For series capacitance coupling they are $\frac{1}{[\omega_m(C_1 + C_4)]^2 R_a}$ and $\frac{1}{[\omega_m(C_2 + C_4)]^2 R_g}$.

Case 2. $L_1C_1 = L_2C_2$

(a) *Shunt Inductance Coupling*

A complete analysis of this condition is given in Appendix II, where it is shown that

$$Z_T = \frac{-j\dfrac{\omega_m}{\omega}\sqrt{R_{D1}\,.\,R_{D2}}\sqrt{Q_1Q_2}\,k\,\dfrac{2\sqrt{L_1L_2}}{L_1+L_2}}{1 + Q_1Q_2\left(k^2\dfrac{\omega^2}{\omega_m^2} - F^2\right) + j(Q_1+Q_2)F} \qquad \ldots \quad \ldots \quad (31)$$

Apart from the factor $\frac{2\sqrt{L_1L_2}}{L_1+L_2}$ it is identical with expression (5b) for mutual inductance coupling. Hence the generalised selectivity and phase shift curves are applicable as are also the trough and peak transfer impedance curves if $\sqrt{R_{D1}\,.\,R_{D2}}\,\frac{2\sqrt{L_1L_2}}{L_1+L_2}$ is registered with $\frac{\sqrt{Q_1Q_2}\,k}{1+Q_1Q_2k^2} = 1$.

The values of Q_1, Q_2, f_m and k are different from those found for case 1 but it is worth noting that k can be defined in a very similar manner.

$$k = \frac{\text{coupling reactance}}{\text{geometric mean of coupling reactance} + \left(\dfrac{2L_2}{L_1+L_2} \times \text{primary reactance of same kind}\right) \text{ and coupling reactance} + \left(\dfrac{2L_1}{L_1+L_2} \times \text{secondary reactance of same kind.}\right)} \qquad \ldots \quad \ldots \quad (32a)$$

The two factors represented in the denominator are actually equal so that the definition can be simplified to

$$k = \frac{\text{coupling reactance}}{\text{coupling reactance} + \left(\dfrac{2L_2}{L_1+L_2} \times \text{primary reactance of same kind}\right).} \qquad \ldots \quad \ldots \quad (32b)$$

but the correspondence between the definitions for cases 1 and 2 is then less marked.

$\sqrt{Q_1Q_2}\,k$ is also amenable to simple definition and is the same as that set out in case 1(a) except for a factor $\frac{L_1+L_2}{2\sqrt{L_1L_2}}$ multiplying the coupling reactance in the numerator

$$\text{i.e.} \quad \sqrt{Q_1Q_2}\,k = \frac{\text{coupling reactance} \times \dfrac{L_1+L_2}{2\sqrt{L_1L_2}}}{\text{geometric mean of primary and secondary total series resistances.}} \qquad \ldots \quad \ldots \quad (33)$$

(b) *Shunt Capacitance Coupling.*

The method of procedure is the same as for shunt inductance coupling.

$$f_m = \frac{1}{2\pi\sqrt{\dfrac{L_1\dfrac{C_1 2aC_3}{1+a}}{C_1 + \dfrac{2aC_3}{1+a}}}} = \frac{1}{2\pi\sqrt{\dfrac{L_2C_2\dfrac{2C_3}{1+a}}{C_2 + \dfrac{2C_3}{1+a}}}}$$

where $a = \frac{L_2}{L_1} = \frac{C_1}{C_2}$

$$k = \sqrt{\frac{C_1C_2}{\left(C_1 + \dfrac{2a}{1+a}C_3\right)\left(C_2 + \dfrac{2}{1+a}C_3\right)}}$$

The definitions for k and $\sqrt{Q_1Q_2}\,k$ are exactly as set out in (a) above.

$$Q_1 = \frac{\omega_m L_1}{R_1 + \dfrac{1}{[\omega_m C_1]^2 R_a}}$$

and

$$Q_2 = \frac{\omega_m L_2}{R_2 + \dfrac{1}{(\omega_m C_2)^2 R_g}}$$

If $\dfrac{\omega_m}{\omega}\,\dfrac{(a-1)C_1(Q_1-Q_2)}{(1+a)C_1+2aC_3}$

$$= \frac{\omega_m}{\omega}\,k\,\frac{a-1}{1+a}(Q_1-Q_2)$$

in the denominator is assumed to be negligible.

$$Z_T = \frac{j\dfrac{\omega_m^{\,3}}{\omega^3}\sqrt{R_{D1}\,.\,R_{D2}}\,.\,\sqrt{Q_1Q_2}\,k\,\dfrac{2\sqrt{L_1L_2}}{L_1+L_2}\,\dfrac{C_3^{\,2}}{\left(\dfrac{1+a}{2a}C_1+C_3\right)\left(\dfrac{1+a}{2}C_2+C_3\right)}}{1+Q_1Q_2\left(k^2\dfrac{\omega_m^{\,2}}{\omega^2}-F^2\right)+j(Q_1+Q_2)F} \quad .. \quad (34)$$

By assuming $\dfrac{\omega_m}{\omega} = 1$, the generalised curves can be employed. The right-hand vertical scales are the correct ones for the phase shift curves and

$$\sqrt{R_{D1}\,.\,R_{D2}}\,\frac{2\sqrt{L_1L_2}}{L_1+L_2}\,\frac{C_3^{\,2}}{\left(\dfrac{1+a}{2a}C_1+C_3\right)\left(\dfrac{1+a}{2}C_2+C_3\right)}$$

is registered with $\dfrac{\sqrt{Q_1Q_2}\,k}{1+Q_1Q_2\,k^2} = 1$ on the trough and peak transfer impedance curves. The capacitive factor in the above expression arises from the reduction of voltage due to the shunt capacitance already discussed in case 1(b).

(c) *Series Inductance Coupling.*

The analysis of this type of coupling is detailed in Appendix III, and after certain, usually justifiable, assumptions have been made the expression for $|Z_T|$ is identical with that of case 2(a) except that the frequency factor multiplying k^2 is inverted. Since this factor is assumed to be unity it is clear that all the generalised curves are applicable.

(d) *Series Capacitance Coupling.*

For series capacitance coupling

$$f_m = \frac{1}{2\pi\sqrt{L_1\left(C_1+\dfrac{1+a}{2}C_4\right)}} = \frac{1}{2\pi\sqrt{L_2\left(C_2+\dfrac{1+a}{2a}C_4\right)}}$$

$$k = \frac{C_4}{\sqrt{\left(\dfrac{2C_1}{1+a}+C_4\right)\left(\dfrac{2aC_2}{1+a}+C_4\right)}} = \frac{C_4}{\dfrac{2C_1}{1+a}+C_4}$$

The definitions for k and $\sqrt{Q_1Q_2}\,k$ are as follows:

$$k = \frac{\text{coupling susceptance}}{\text{geometric mean of coupling susceptance} + \left(\dfrac{2L_1}{L_1+L_2}\times\text{primary susceptance of same kind}\right)\text{ and coupling susceptance} + \left(\dfrac{2L_2}{L_1+L_2}\times\text{secondary susceptance of same kind.}\right)} \quad .. \quad .. \quad (35)$$

and

$$\sqrt{Q_1Q_2}\,k = \frac{\text{coupling susceptance}\times\dfrac{L_1+L_2}{2\sqrt{L_1L_2}}}{\text{geometric mean of primary and secondary total parallel conductances.}} \quad .. \quad .. \quad (36)$$

$$= \frac{\omega_m C_4\,\dfrac{1+a}{2\sqrt{a}}}{\sqrt{\omega_m^{\,2}\left(C_1+\dfrac{1+a}{2}C_4\right)^2 R_{T1}\,.\,\omega_m^{\,2}\left(C_2+\dfrac{1+a}{2a}C_4\right)^2 R_{T2}}} \quad .. \quad .. \quad (37)$$

$$Q_1 = \frac{\omega_m L_1}{R_1 + \dfrac{1}{[\omega_m(C_1 + \frac{1+a}{2}C_4)]^2 R_a}}$$

$$Q_2 = \frac{\omega_m L_2}{R_2 + \dfrac{1}{[\omega_m(C_2 + \frac{1+a}{2a}C_4)]^2 R_g}}$$

By assuming that Q_1 and $Q_2 \gg 1$ in the numerator of Z_r and that in the denominator

$$-\frac{C_4^2(1+a)^2}{4aC_1C_2}\left[1 + \frac{2\omega_m}{\omega}\,\frac{(Q_2 + aQ_1)}{1+a}\right]$$
$$-j\left[\frac{C_4^2(1+a)^2}{4aC_1C_2}(Q_1+Q_2)F + \frac{C_4(1-a)}{2C_1}\frac{\omega_m}{\omega}(Q_2 - Q_1)\right]$$

Type of Coupling	f_m	k	$\sqrt{Q_1Q_2}\,k$
1. Shunt Inductance	$\dfrac{1}{2\pi\sqrt{\left(L_1+\frac{1+a}{2a}L_3\right)C_1}}$	$\dfrac{L_3}{\sqrt{\left(\frac{2aL_1}{1+a}+L_3\right)\left(\frac{2L_2}{1+a}+L_3\right)}}$	$\dfrac{\omega_m L_3 \cdot \frac{L_1+L_2}{2\sqrt{L_1L_2}}}{\sqrt{R_{T1} \cdot R_{T2}}}$
2 Shunt Capacitance	$\dfrac{1}{2\pi\sqrt{\dfrac{L_1C_1\frac{2aC_3}{1+a}}{C_1+\frac{2a}{1+a}C_3}}}$	$\sqrt{\dfrac{C_1C_2}{\left(C_1+\frac{2aC_3}{1+a}\right)\left(C_2+\frac{2C_3}{1+a}\right)}}$	$\dfrac{\frac{1}{\omega_m C_3}\;\frac{L_1+L_2}{2\sqrt{L_1L_2}}}{\sqrt{R_{T1}\;R_{T2}}}$
3. Series Inductance	$\dfrac{1}{2\pi\sqrt{\dfrac{\frac{L_1 2L_4}{1+a}C_1}{L_1+\frac{2}{1+a}L_4}}}$	$\sqrt{\dfrac{L_1L_2}{\left(L_1+\frac{2L_4}{1+a}\right)\left(L_2+\frac{2aL_4}{1+a}\right)}}$	$\dfrac{\frac{1}{\omega_m L_4}\;\frac{L_1+L_2}{2\sqrt{L_1L_2}}}{\sqrt{\dfrac{R_{T1}\left(L_1+\frac{2L_4}{1+a}\right)^2}{\left[\omega_m\frac{L_1 2L_4}{1+a}\right]^2}\;\dfrac{R_{T2}\left(L_2+\frac{2aL_4}{1+a}\right)^2}{\left[\omega_m\frac{L_2 2aL_4}{1+a}\right]^2}}}$
4. Series Capacitance	$\dfrac{1}{2\pi\sqrt{L_1\left(C_1+\frac{1+a}{2}C_4\right)}}$	$\dfrac{C_4}{\sqrt{\left(\frac{2C_1}{1+a}+C_4\right)\left(\frac{2aC_2}{1+a}+C_4\right)}}$	$\dfrac{\omega_m C_4\frac{L_1+L_2}{2\sqrt{L_1L_2}}}{\sqrt{\left[\omega_m\left(C_1+\frac{1+a}{2}C_4\right)\right]^2R_{T1}\cdot\left[\omega_m\left(C_2+\frac{1+a}{2a}C_4\right)\right]^2R_{T1}}}$

is negligible, the denominator of Z_T becomes

$$\frac{(a+1)^2C_4^2}{4aC_1C_2k^2}\left[(1+jQ_1F)(1+jQ_2F)+Q_1Q_2k^2\frac{\omega^2}{\omega_m^2}\right]$$

and

$$Z_T=\frac{j\frac{\omega}{\omega_m}\sqrt{R_{D1}\,.\,R_{D2}}\sqrt{Q_1Q_2}\,k\,\frac{2\sqrt{L_1L_2}}{L_1+L_2}}{1+Q_1Q_2\left(k^2\frac{\omega^2}{\omega_m^2}-F^2\right)+j(Q_1+Q_2)F} \quad \ldots \quad (38)$$

Q_1	R_{T1}
$\dfrac{\omega_m\left(L_1+\frac{1+a}{2a}L_3\right)}{R_{T1}}$	$R_1+R_3+\dfrac{1}{(\omega_mC_1)^2R_a}$
$\dfrac{\omega_mL_1}{R_{T1}}$	$R_1+R_3+\dfrac{1}{(\omega_mC_1)^2R_a}$
$\dfrac{\omega_m\dfrac{L_12L_4}{1+a}\Big/\left(L_1+\dfrac{2L_4}{1+a}\right)}{R_{T1}}$	$R_1+\dfrac{1}{(\omega_mC_1)^2}\left(\dfrac{1}{R_a}+\dfrac{1}{R_4}\right)$
$\dfrac{\omega_mL_1}{R_{T1}}$	$R_1+\dfrac{1}{\left[\omega_m\left(C_1+\frac{1+a}{2}C_4\right)\right]^2}\left(\dfrac{1}{R_a}+\dfrac{1}{R_4}\right)$

Apart from the positive sign and the frequency factors, this is identical with cases 2(a) and (c) so that the generalised curves again may be used though it should be noted that the right-hand vertical scales on the phase-shift curves must be used.

(e) *Shunt Inductance and Capacitance Coupling*

As in case 1(e) the generalised curves may be employed provided parallel resonance of the coupling arm is not approached. The equivalent coupling coefficient is the difference between the inductive and capacitive, the phase-shift scale to be used being determined by whichever is the greater. For the trough and peak transfer impedance curves

$$\sqrt{R_{D1}\,.\,R_{D2}}\,.\,\frac{2\sqrt{L_1L_2}}{L_1+L_2}\,\frac{C_3^2}{\left(\frac{1+a}{2a}C_1+C_3\right)\left(\frac{1+a}{2}C_2+C_3\right)}$$

TABLE II. $\mathbf{L_1C_1 = L_2C_2,\ \frac{L_2}{L_1} = \frac{C_1}{C_2} = a}$

$$Z_T=\frac{-jA\sqrt{R_{D1}\,.\,R_{D2}}\sqrt{Q_1Q_2}\,k}{1+Q_1Q_2(k^2D-F^2)+j(Q_1Q_2)F}$$

$$A=\frac{\omega_m}{\omega}\cdot\frac{2\sqrt{L_1L_2}}{L_1+L_2}$$ for couplings 1 and 3

$$=\frac{\omega}{\omega_m}\cdot\frac{2\sqrt{L_1L_2}}{L_1+L_2}$$ for coupling 4

$$=-\frac{\omega_m^3}{\omega^3}\cdot\frac{2\sqrt{L_1L_2}}{L_1+L_2}\,\frac{C_3^2}{\left(\frac{1+a}{2a}C_1+C_3\right)\left(\frac{1+a}{2}C_2+C_3\right)}$$ for coupling 2

$$D=\frac{\omega^2}{\omega_m^2}$$ for couplings 1 and 4

$$=\frac{\omega_m^2}{\omega^2}$$ for couplings 2 and 3

R_3, R_4, R_{D1} and R_{D2} are as defined in Table I.

An alternative expression for f_m and the expressions for Q_2 and R_{T2} are found by replacing the suffix 1 by 2, $\frac{L_3}{a}$ by L_3, aC_3 by C_3, L_4 by aL_4, C_4 by $\frac{C_4}{a}$, and R_a by R_g in the expressions for f_m, Q_1 and R_{T1} given above.

is located with

$$\frac{\sqrt{Q_1 Q_2}\, k}{1 + Q_1 Q_2\, k^2} = 1.$$

$$f_m = \frac{1}{2\pi\sqrt{\dfrac{\left(L_1 + \dfrac{1+a}{2a} L_3\right)\dfrac{2aC_1C_3}{1+a}}{C_1 + \dfrac{2aC_3}{1+a}}}}$$

$$= \frac{1}{2\pi\sqrt{\dfrac{\left(L_2 + \dfrac{1+a}{2} L_3\right)\dfrac{2C_2C_3}{1+a}}{C_2 + \dfrac{2C_3}{1+a}}}}$$

(f) *Series Inductance and Capacitance Coupling*

The curves may be used for this type of coupling, $\sqrt{R_{D1} . R_{D2}} . \dfrac{2\sqrt{L_1L_2}}{L_1 + L_2}$ being registered with $\dfrac{\sqrt{Q_1Q_2}\, k}{1 + Q_1Q_2\, k^2} = 1$ on the trough and peak transfer impedance curves. The coupling coefficient is the difference between the inductive and capacitive coefficients and

$$f_m = \frac{1}{2\pi\sqrt{\dfrac{\dfrac{L_1 2L_4}{1+a}}{\left(L_1 + \dfrac{2L_4}{1+a}\right)}\left(C_1 + \dfrac{(1+a)C_4}{2}\right)}}$$

$$= \frac{1}{2\pi\sqrt{\dfrac{\dfrac{L_2 2_a L_4}{1+a}}{L_2 + \dfrac{2a}{1+a} L_4}\left(C_2 + \dfrac{(1+a)C_4}{2a}\right)}}$$

All the above results for (a), (b), (c) and (d) are summarised in Table II. The frequency factors in numerator and denominator of Z_T affect the symmetry of the selectivity curves about f_m in exactly the same manner as for case 1.

7. Resistance in the Shunt or Series Coupling Arms

When the resistance in the shunt or series coupling arms is the resistance of the coupling element only, it is generally small or large respectively in comparison with the reactance of the coupling element. Its effect on coupling coefficient is therefore negligible but there is a reduction in the Q of the primary and secondary circuits. Thus if in a shunt coupling arm there is a resistance R_3 in series with the inductive or capacitive arm, this resistance must be added to that of the series resistance of both primary and secondary circuits. For a series coupling arm consisting of a resistance R_4 in parallel with the reactance element, this resistance must virtually be considered as in parallel with both primary and secondary circuits and it therefore acts as if it were in parallel with both external resistances R_a and R_g. If the series coupling arm consists of a resistance in series with a reactance, the series circuit should be converted to its equivalent parallel circuit and the resistance so calculated taken as in parallel with R_a and with R_g.

8. Mistuned Coupled Circuits

In special cases the generalised curves can be used for dissimilar coupled circuits not having a common resonant frequency, i.e., the primary circuit is mistuned from the secondary. The analysis of Appendix IV shows that it is possible when Q_1 is equal to or nearly equal to Q_2. The effect of mistuning is to increase the coupling coefficient to $\sqrt{k^2 + (F')^2}$, where k is the normal coefficient as defined in the sections above and F' is the ratio of the frequency difference $(f_1 - f_2)$ between the primary and secondary resonances to the mid-frequency f_m.

As a method of increasing the equivalent coupling coefficient (i.e. widening the pass-band) it is uneconomical because the trough and peak transfer impedances are less than for the same pass-band obtained by increased coupling.

Appendix IV shows that f_m is a function of f_1 and f_2, and any change in the resonant frequency of primary or secondary circuits affects the peak frequency nearest its resonant frequency and has practically no effect on that furthest from it. Thus by increasing the resonant frequency of the primary, f_1, the high frequency peak is raised to a higher frequency. At the same time the amplitudes of both peaks decrease. Decrease of

f_2 reduces the frequency of the lower peak and also reduces the amplitude of both. These conditions are illustrated in Fig. 14a.

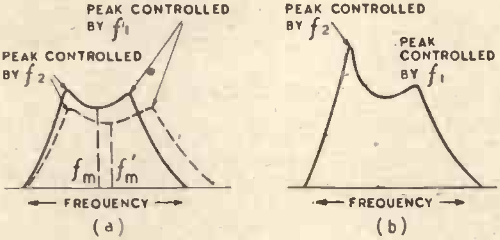


Fig. 14.—*Mistuned coupled circuits.*
(a) $Q_2 \simeq Q_1$ *primary resonant frequency increased.*
(b) $Q_2 \ll Q_1$.

If Q_2 is appreciably greater than Q_1, the amplitude of the peak controlled by f_2 (in this instance the lower frequency) is much greater than the other peak, selectivity on the lower frequency side is much sharper, and the generalised curves cannot be used. This is shown in Fig. 14b.

9. Conclusion

The above analysis shows that Beatty's original generalised selectivity curves are not confined to circuits of identical L, C and Q values, but can be applied to all the simpler forms of coupling between two circuits of differing values of L, C and Q, having a common resonant frequency. They can be applied to mistuned coupled circuits when Q_2 is equal to, or very nearly equal to Q_1, and also to circuits with combined series and shunt couplings, though the author has not yet succeeded in developing simple and accurate expressions for the coupling coefficient, k, and parameter $\sqrt{Q_1Q_2}\,k$ in the latter case.

The important parameters for determining selectivity and phase-shift are shown to be

$$\sqrt{Q_1Q_2}\,k \quad \text{and} \quad \frac{2\sqrt{Q_1Q_2}}{Q_1+Q_2}\cdot\sqrt{Q_1Q_2}\,F$$

where $F = \dfrac{2\Delta f}{f_m} = \dfrac{2 \times \text{off-tune frequency}}{\text{mid-frequency}}$,

and the former lends itself to the following simple definitions in terms of the coupling reactance or susceptance and the primary and secondary total series resistances or parallel conductances.

For shunt coupling and a common primary and secondary resonant frequency in the absence of coupling

$$\sqrt{Q_1Q_2}\,k = \frac{\text{coupling reactance}}{\text{geometric mean of primary and secondary total series resistances.}}$$

Susceptance and parallel conductances are substituted for reactance and series resistance in order to obtain the definition applicable to series coupling.

A multiplying factor $\dfrac{L_1+L_2}{2\sqrt{L_1L_2}}$ must be inserted in the numerator to cover the second case of common resonant frequency.

It has been shown that the maximum value of maximum transfer impedance occurs when $\sqrt{Q_1Q_2}\,k = 1$ and double peaks appear when $\sqrt{Q_1Q_2}\,k$ exceeds $\sqrt{\tfrac{1}{2}\left(\dfrac{Q_1}{Q_2}+\dfrac{Q_2}{Q_1}\right)}$. Maximum transfer impedance for a given selectivity characteristic is realised by making $Q_1 = Q_2$ and the ratio of total primary inductance to total secondary inductance (including the coupling inductance, if any) equal to the ratio of primary external damping resistance to the secondary external damping resistance.

In conclusion the author wishes to thank Marconi's Wireless Telegraph Company for permission to publish the results.

APPENDIX I

Series Inductance Coupling.

$$\left[\textit{Case } 1. \quad \frac{L_1L_4}{L_1+L_4}C_1 = \frac{L_2L_4}{L_2+L_4}C_2\right]$$

The transfer impedance is given by (see Fig. 10.)

$$Z_T = \frac{Z_1Z_2}{Z_1+Z_2+Z_4}$$

where $$Z_1 = \frac{R_{T_1}+j\omega L_1}{j\omega C_1\left[R_{T_1}+j\omega L_1+\dfrac{1}{j\omega C_1}\right]}$$

$$Z_2 = \frac{R_{T_2}+j\omega L_2}{j\omega C_2\left[R_{T_2}+j\omega L_2+\dfrac{1}{j\omega C_2}\right]}$$

$$Z_4 = j\omega L_4$$

Coupling coefficient $k = \dfrac{\text{coupling susceptance}}{\text{geometric mean of coupling + primary susceptance of same kind and coupling + secondary susceptance of same kind.}}$

$$= \sqrt{\frac{L_1L_2}{(L_1+L_4)(L_2+L_4)}}$$

$$f_m = \frac{1}{2\pi\sqrt{\dfrac{L_1L_4}{L_1+L_4}C_1}} = \frac{1}{2\pi\sqrt{\dfrac{L_2L_4}{L_2+L_4}C_2}}$$

$$Q_1 = \frac{\omega_m \dfrac{L_1L_4}{L_1+L_4}}{R_1 + \dfrac{1}{(\omega_m C_1)^2 R_a}}\ ; \quad Q_2 = \frac{\omega_m \dfrac{L_2L_4}{L_2+L_4}}{R_2 + \dfrac{1}{(\omega_m C_2)^2 R_g}}\ ;$$

$$R_{D1} = Q_1\omega_m \frac{L_1L_4}{L_1+L_4}\ ; \quad R_{D2} = Q_2\omega_m \frac{L_2L_4}{L_2+L_4}$$

$$Z_1 = \frac{\dfrac{R_{T_1}}{j\omega C_1}\left(1 + j\dfrac{\omega L_1}{R_{T_1}}\right)}{R_{T_1}\left(1 + \dfrac{j}{R_{T_1}}\left(\omega L_1 - \dfrac{1}{\omega C_1}\right)\right)}$$

$$= \frac{\dfrac{1}{j\omega C_1}\left(1 + j\dfrac{\omega}{\omega_m}Q_1\dfrac{L_1+L_4}{L_4}\right)}{1 + jQ_1\left(\dfrac{\omega}{\omega_m}\dfrac{L_1+L_4}{L_4} - \dfrac{\omega_m}{\omega}\right)}$$

$$= \frac{\dfrac{1}{j\omega C_1}\left(1 + j\dfrac{\omega}{\omega_m}Q_1\dfrac{L_1+L_4}{L_4}\right)}{1 + jQ_1\left(F + \dfrac{\omega}{\omega_m}\dfrac{L_1}{L_4}\right)}$$

Similarly

$$Z_2 = \frac{\dfrac{1}{j\omega C_2}\left(1 + j\dfrac{\omega}{\omega_m}Q_2\dfrac{L_2+L_4}{L_4}\right)}{1 + jQ_2\left(F + \dfrac{\omega}{\omega_m}\dfrac{L_2}{L_4}\right)}$$

$$Z_T = \frac{-\dfrac{1}{\omega^2C_1C_2}\left(1 + jQ_1\dfrac{\omega}{\omega_m}\dfrac{L_1+L_4}{L_4}\right)\left(1 + jQ_2\dfrac{\omega}{\omega_m}\dfrac{L_2+L_4}{L_4}\right)}{\begin{array}{c}\dfrac{1}{j\omega C_1}\left(1 + jQ_1\dfrac{\omega}{\omega_m}\dfrac{L_1+L_4}{L_4}\right)\left(1 + jQ_2\left(F + \dfrac{\omega}{\omega_m}\dfrac{L_2}{L_4}\right)\right) + \dfrac{1}{j\omega C_2}\left(1 + jQ_2\dfrac{\omega}{\omega_m}\dfrac{L_2+L_4}{L_4}\right)\left(1 + jQ_1\left(F + \dfrac{\omega}{\omega_m}\dfrac{L_1}{L_4}\right)\right)\\ + j\omega L_4\left(1 + jQ_1\left(F + \dfrac{\omega}{\omega_m}\dfrac{L_1}{L_4}\right)\right)\left(1 + jQ_2\left(F + \dfrac{\omega}{\omega_m}\dfrac{L_2}{L_4}\right)\right)\end{array}}$$

Assuming that in the numerator Q_1 and $Q_2 \gg 1$ and in the denominator

$$-(1 + jQ_2F)\left(\frac{\omega_m^2}{\omega^2}\frac{L_1}{L_1+L_4} + \frac{L_1}{L_4} + \frac{L_1L_2}{L_4^2}\right)$$

$$-(1 + jQ_1F)\left(\frac{\omega_m^2}{\omega^2}\frac{L_2}{L_2+L_4} + \frac{L_2}{L_4} + \frac{L_1L_2}{L_4^2}\right)$$

$$-\frac{L_1L_2}{L_4^2}\left(1 + j\frac{\omega_m}{\omega}\right)\left(\frac{Q_2}{L_1+L_4} + \frac{Q_1}{L_2+L_4}\right)$$

is negligible compared with

$$\frac{L_1L_2}{k_2L_4^2}\left[(1 + jQ_1F)(1 + jQ_2F) + Q_1Q_2k^2\frac{\omega_m^2}{\omega^2}\right]$$

$$Z_T = \frac{-j\dfrac{\omega_m}{\omega}\dfrac{Q_1Q_2(L_1+L_4)(L_2+L_4)k^2L_4^2}{\omega_m^3C_1C_2L_4^3L_1L_2}}{1 + Q_1Q_2\left(k^2\dfrac{\omega_m^2}{\omega^2} - F^2\right) + j(Q_1+Q_2)F}$$

$$\doteq \frac{-j\dfrac{\omega_m}{\omega}R_{D1}Q_2k\sqrt{\dfrac{(L_1+L_4)L_2}{(L_2+L_4)L_1}}}{1 + Q_1Q_2\left(k^2\dfrac{\omega_m^2}{\omega^2} - F^2\right) + j(Q_1+Q_2)F}$$

or

$$|Z_T| \simeq \frac{R_{D1}Q_2k\sqrt{\dfrac{C_1}{C_2}}}{\sqrt{[1 + Q_1Q_2(k^2 - F^2)]^2 + (Q_1+Q_2)^2F^2}}$$

$$\simeq \frac{\sqrt{R_{D1}\,.\,R_{D2}}\sqrt{Q_1Q_2}\,k}{\sqrt{[1 + Q_1Q_2(k^2 - F^2)]^2 + (Q_1+Q_2)^2F^2}}$$

APPENDIX II

Shunt Inductance Coupling [*Case* 2. $L_1C_1 = L_2C_2$]

The method of finding coupling coefficient k and mid frequency f_m has been previously established* and is as follows. In the absence of resistance two peak frequencies are obtained.

$$f_1 = \frac{1}{2\pi\sqrt{L_1C_1}} = \frac{1}{2\pi\sqrt{L_2C_2}} \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

$$f_2 = \frac{1}{2\pi\sqrt{(L_1 + bL_3)C_1}} = \frac{1}{2\pi\sqrt{\left(L_2 + \dfrac{bL_3}{b-1}\right)C_2}} \quad (2)$$

For the second frequency L_3 is divided between the primary and secondary circuits in such a way that bL_3 in parallel with $\dfrac{b}{b-1}L_3$ results in L_3

From (2) $\quad bL_3C_1 = \dfrac{b}{b-1}L_3C_2$

or $\quad b = \dfrac{1+a}{a} \quad$ where $\quad a = \dfrac{L_2}{L_1} = \dfrac{C_1}{C_2}$

Coupling coefficient

$$k = \frac{f_1^2 - f_2^2}{f_1^2 + f_2^2} = \frac{L_3}{\left(\dfrac{2a}{(1+a)}L_1 + L_3\right)}$$

$$= \frac{L_3}{\left(\dfrac{2}{1+a}L_2 + L_3\right)}$$

$$= \frac{L_3}{\sqrt{\left(\dfrac{2a}{1+a}L_1 + L_3\right)\left(\dfrac{2}{1+a}L_2 + L_3\right)}}$$

$$f_m = f_1\sqrt{1-k} = f_2\sqrt{1+k}$$

$$= \frac{1}{2\pi\sqrt{\left(L_1 + \dfrac{1+a}{2a}L_3\right)C_1}}$$

$$= \frac{1}{2\pi\sqrt{\left(L_2 + \dfrac{1+a}{2}L_3\right)C_2}} \quad \ldots \quad (3)$$

---

* "Analysis of Frequency in Oscillating Circuits," Howe, *Electrical World*, August 19th, 1916, p. 368.

$$Z_T = \frac{Z_1 Z_3 Z_5}{(Z_1 + Z_2 + Z_3)(Z_3 + Z_4 + Z_5) - Z_3^2}$$

$$Z_1 Z_2 Z_3 = \frac{-j\omega L_3}{\omega^2 C_1 C_2} = -j\frac{\omega_m}{\omega} \cdot \frac{\omega_m^2 C_1 L_3 \sqrt{\dfrac{C_2}{C_1}}\, R_{T1} \,.\, R_{T2}}{\sqrt{\omega_m^2 C_1^2 R_{T1}}\,\sqrt{\omega_m^2 C_2^2 R_{T2}} \,.\, \sqrt{\omega_m C_1 R_{T1}} \,.\, \sqrt{\omega_m C_2 R_{T2}}}$$

$$= -j\frac{\omega_m}{\omega}\sqrt{R_{D1} \,.\, R_{D2}} \,.\, \sqrt{Q_1 Q_2}\, k \,.\, \frac{2\sqrt{a}}{1 + a} R_{T1} \,.\, R_{T2}$$

for from (3)

$$\omega_m^2 C_1 = \frac{1}{L_1 + \dfrac{1 + a}{2a} L_3}$$

$$R_{D1} = Q_1 \omega_m \left(L_1 + \frac{1 + a}{2a} L_3\right)$$

$$R_{D2} = Q_2 \omega_m \left(L_2 + \frac{1 + a}{2} L_3\right)$$

$$Q_1 = \frac{\omega_m \left(L_1 + \dfrac{1 + a}{2a} L_3\right)}{R_1 + \dfrac{1}{[\omega_m C_1]^2 R_a}};$$

$$Q_2 = \frac{\omega_m \left(L_2 + \dfrac{1 + a}{2} L_3\right)}{R_2 + \dfrac{1}{(\omega_m C_2)^2 R_g}}$$

$$Z_1 + Z_2 + Z_3 = R_{T1} + j\left(\omega(L_1 + L_3) - \frac{1}{\omega C_1}\right)$$

$$= R_{T1}\left(1 + jQ_1\left(\frac{L_1 + L_3}{\left(L_1 + \dfrac{1 + a}{2a} L_3\right)} \cdot \frac{\omega}{\omega_m} - \frac{\omega_m}{\omega}\right)\right)$$

$$= R_{T1}\left(1 + jQ_1\left(F + \frac{(a - 1)L_3}{2aL_1 + (1 + a)L_3} \cdot \frac{\omega}{\omega_m}\right)\right)$$

Similarly

$$Z_3 + Z_4 + Z_5$$

$$= R_{T2}\left(1 + jQ_2\left(F + \frac{(1 - a)L_3}{2L_2 + (1 + a)L_3} \cdot \frac{\omega}{\omega_m}\right)\right)$$

$$\therefore \quad (Z_1 + Z_2 + Z_3)(Z_3 + Z_4 + Z_5)$$

$$= R_{T1} R_{T2}\Big[(1 + jQ_1 F)(1 + jQ_2 F)$$

$$+ \frac{Q_1 Q_2 \omega^2 (a - 1)^2 L_3^2}{\omega_m^2 (2aL_1 + (1 + a)L_3)(2L_2 + (1 + a)L_3)}$$

$$+ \frac{\omega \,.\, L_3(a - 1)(Q_1 - Q_2)}{\omega_m(2aL_1 + (1 + a)L_3)}\Big]$$

for $\quad 2aL_1 + (1 + a)L_3 = 2L_2 + (1 + a)L_3.$

The factor

$$\frac{\omega}{\omega_m} \frac{L_3(a - 1)(Q_1 - Q_2)}{(2aL_1 + (1 + a)L_3)} = \frac{\omega}{\omega_m} \frac{a - 1}{a + 1}(Q_1 - Q_2)\, k$$

may be neglected in comparison with the other factors.

$$Z_3^2 = \left[\frac{\omega^2}{\omega_m^2} \cdot \frac{\omega_m^2 L_3^2}{R_{T1} \,.\, R_{T2}}\right] R_{T1} \,.\, R_{T2}$$

$$= \frac{\omega^2}{\omega_m^2} Q_1 Q_2 \frac{4aL_3^2\, R_{T1} \,.\, R_{T2}}{(2aL_1 + (1 + a)L_3)(2L_2 + (1 + a)L_3)}$$

$$\therefore \quad (Z_1 + Z_2 + Z_3)(Z_3 + Z_4 + Z_5) - Z_3^2$$

$$= R_{T1} \,.\, R_{T2}\left[(1 + jQ_1 F)(1 + jQ_2 F) + \frac{\omega^2}{\omega_m^2} Q_1 Q_2 k^2\right]$$

Thus

$$Z_T = \frac{-j\dfrac{\omega_m}{\omega}\sqrt{R_{D1} \,.\, R_{D2}}\sqrt{Q_1 Q_2}\, k \dfrac{2\sqrt{L_1 L_2}}{L_1 + L_2}}{1 + Q_1 Q_2 \left(k^2 \dfrac{\omega^2}{\omega_m^2} - F^2\right) + j(Q_1 + Q_2)F} \qquad (4a)$$

$$|Z_T| \simeq \frac{\sqrt{R_{D1} \,.\, R_{D2}}\sqrt{Q_1 Q_2}\, k \dfrac{2\sqrt{L_1 L_2}}{L_1 + L_2}}{\sqrt{[1 + Q_1 Q_2 (k_2 - F^2)]^2 + (Q_1 + Q_2)^2 F^2}} \qquad (4b)$$

It may be noted that the coupling coefficient is defined as follows :

$$k = \frac{\text{Coupling reactance}}{\text{geometric mean of coupling reactance} + (\dfrac{2L_2}{L_1 + L_2} \times \text{primary reactance of same kind) and coupling reactance} + (\dfrac{2L_1}{L_1 + L_2} \times \text{secondary reactance of same kind).}}$$

APPENDIX III

Series Inductance Coupling [*Case* 2. $L_1 C_1 = L_2 C_2$]

The two peak frequencies are

$$f_1 = \frac{1}{2\pi\sqrt{\dfrac{L_1 C_1 b L_4}{L_1 + bL_4}}} = \frac{1}{2\pi\sqrt{\dfrac{L_2 C_2 (1 - b) L_4}{L_2 + (1 - b) L_4}}} \quad \ldots \quad \ldots \quad (1)$$

$$f_2 = \frac{1}{2\pi\sqrt{L_1 C_1}} = \frac{1}{2\pi\sqrt{L_2 C_2}} \quad \ldots \quad \ldots \quad (2)$$

The inductance L_4 is divided between the two circuits so that bL_4 in series with $(1 - b)L_4$ results in L_4.

Combining (1) and (2).

$$b = \frac{1}{1 + a} \quad \text{where} \quad a = \frac{L_2}{L_1} = \frac{C_1}{C_2}$$

$$k = \frac{L_1}{L_1 + \dfrac{2}{1 + a} L_4} = \frac{L_2}{L_2 + \dfrac{2a}{1 + a} L_4}$$

$$= \sqrt{\frac{L_1 L_2}{\left(L_1 + \dfrac{2}{1 + a} L_4\right)\left(L_2 + \dfrac{2a}{1 + a} L_4\right)}}$$

For definition purposes the third expression for k is best.

$$k = \frac{\text{coupling susceptance}}{\text{geometric mean of coupling susceptance} + (\dfrac{2L_1}{L_1 + L_2} \times \text{primary susceptance of same kind) and coupling susceptance} + (\dfrac{2L_2}{L_1 + L_2} \times \text{secondary susceptance of same kind).}}$$

$$f_m = \frac{1}{2\pi\sqrt{\dfrac{L_1\dfrac{2L_4}{1+a}}{L_1+\dfrac{2L_4}{1+a}}C_1}} = \frac{1}{2\pi\sqrt{\dfrac{\dfrac{L_2 2aL_4}{1+a}}{L_2+\dfrac{2a}{1+a}L_4}C_2}}$$

$$Q_1 = \frac{\omega_m\dfrac{\dfrac{L_1 2L_4}{1+a}}{L_1+\dfrac{2L_4}{1+a}}}{R_1+\dfrac{1}{(\omega_m C_1)^2 R_a}}\ ;\quad Q_2 = \frac{\omega_m\dfrac{\dfrac{L_2 2aL_4}{1+a}}{L_2+\dfrac{2aL_4}{1+a}}}{R_2+\dfrac{1}{(\omega_m C_2)^2 R_g}}\ ;$$

$$R_{D1} = Q_1\omega_m\frac{\dfrac{L_1 2L_4}{1+a}}{L_1+\dfrac{2L_4}{1+a}}\ ;\quad R_{D2} = Q_2\omega_m\frac{\dfrac{L_2 2aL_4}{1+a}}{L_2+\dfrac{2a}{1+a}L_4}\ ;$$

$$Z_1 = \frac{\dfrac{1}{j\omega C_1}\left(1+jQ_1\dfrac{\omega}{\omega_m}\dfrac{(1+a)L_1+2L_4}{2L_4}\right)}{1+jQ_1\left(F+\dfrac{\omega}{\omega_m}\dfrac{(1+a)L_1}{2L_4}\right)}$$

$$Z_2 = \frac{\dfrac{1}{j\omega C_2}\left(1+jQ_2\dfrac{\omega}{\omega_m}\dfrac{(1+a)\,L_2+2aL_4}{2aL_4}\right)}{1+jQ_2\left(F+\dfrac{\omega}{\omega_m}\dfrac{(1+a)L_2}{2aL_4}\right)}$$

$$Z_4 = j\omega L_4$$

$$Z_T = \frac{Z_1 Z_2}{Z_1+Z_2+Z_4} = \frac{-\dfrac{1}{j\omega^3 C_1 C_2 L_4}\left(1+jQ_1\dfrac{\omega}{\omega_m}\dfrac{(1+a)L_1+2L_4}{2L_4}\right)\left(1+jQ_2\dfrac{\omega}{\omega_m}\dfrac{(1+a)L_2+2aL_4}{2aL_4}\right)}{\begin{aligned}&-\frac{1}{\omega^2 C_1 L_4}\left(1+jQ_1\frac{\omega}{\omega_m}\frac{(1+a)L_1+2L_4}{2L_4}\right)\left(1+jQ_2\left(F+\frac{\omega}{\omega_m}\frac{(1+a)L_2}{2aL_4}\right)\right)\\&-\frac{1}{\omega^2 C_2 L_4}\left(1+jQ_2\frac{\omega}{\omega_m}\frac{(1+a)L_2+2aL_4}{2aL_4}\right)\left(1+jQ_1\left(F+\frac{\omega}{\omega_m}\frac{(1+a)L_1}{2L_4}\right)\right)\\&+\left(1+jQ_1\left(F+\frac{\omega}{\omega_m}\frac{(1+a)L_1}{2L_4}\right)\right)\left(1+jQ^2\left(F+\frac{\omega}{\omega_m}\frac{(1+a)L_2}{2aL_4}\right)\right)\end{aligned}}$$

Making the assumption in the numerator that Q_1 and $Q_2 \gg 1$ and in the denominator that

$$\begin{aligned}-&\left[\frac{L_1(1+a)}{L_4}+\frac{\omega_m^2}{\omega^2}\frac{4L_1(1+a)}{(1+a)L_1+2L_4}\right]\\-j&\left[\frac{L_1(1+a)}{2L_4}(Q_1+Q_2)F\right.\\&+\frac{\omega_m}{\omega}\frac{(a-1)L_1}{2L_4}(Q_1-Q_2)\\&+\frac{\omega_m}{\omega}\frac{(1+a)L_1^2(Q_1 a+Q_2)}{aL_4((1+a)L_1+2L_4)}\\&\left.+\frac{\omega^2_m}{\omega_2}\frac{2L_1(Q_1 a+Q_2)}{(1+a)L_1+2L_4}F\right]\end{aligned}$$

is negligible,

i.e. denominator =

$$\frac{(1+a)^2 L_1 L_2}{4aL_4^2 k^2}\left[(1+jQ_1F)(1+jQ_2F)+Q_1Q_2k^2\frac{\omega_m^2}{\omega^2}\right]$$

$$Z_T = \frac{-j\dfrac{\omega_m}{\omega}\sqrt{R_{D1}\,.\,R_{D2}}\,.\,\sqrt{Q_1Q_2}\,k\dfrac{2\sqrt{L_1L_2}}{L_1+L_2}}{1+Q_1Q_2\left(k^2\dfrac{\omega^2_m}{\omega^2}-F^2\right)+j(Q_1+Q_2)F} \quad \ldots \quad \ldots \quad (3a)$$

or

$$|Z_T| \bumpeq \frac{\sqrt{R_{D1}\,.\,R_{D2}}\sqrt{Q_1Q_2}\,k\,.\,\dfrac{2\sqrt{L_1L_2}}{L_1+L_2}}{\sqrt{[1+Q_1Q_2(k^2-F^2)]^2+(Q_1+Q_2)^2F^2}} \quad \ldots \quad \ldots \quad (3b)$$

APPENDIX IV

Mistuned Mutual Inductance Coupled Tuned Circuits.

Suppose the resonant frequencies of the primary and secondary circuits of a mutual inductance coupled filter are f_1 and f_2 respectively, f_1 being greater than f_2.

$$Z_T = \frac{-j\dfrac{M}{\omega C_1 C_2}}{\left[R_{T1}+j\left(\omega L_1-\dfrac{1}{\omega C_1}\right)\right]\left[R_{T2}+j\left(\omega L_2-\dfrac{1}{\omega C_2}\right)\right]+\omega^2M^2}$$

Let $f_m = \dfrac{f_1+f_2}{2}$ and $\Delta f' = \dfrac{f_1-f_2}{2}$

i.e., $f_1 = \dfrac{1}{2\pi\sqrt{L_1C_1}} = f_m + \Delta f'$

and $f_2 = \dfrac{1}{2\pi\sqrt{L_2C_2}} = f_m - \Delta f'$

The first part of the denominator of Z_T may be written

$$R_{T1}\,.\,R_{T2}\left[1+jQ_1\left(\frac{\omega}{\omega_1}-\frac{\omega_1}{\omega}\right)\right]\left[1+jQ_2\left(\frac{\omega}{\omega_2}-\frac{\omega_2}{\omega}\right)\right]$$

where

$$Q_1 = \frac{\omega_1 L_1}{R_{T1}} \text{ and } Q_2 = \frac{\omega_2 L_2}{R_{T2}}$$

Now

$\dfrac{\omega}{\omega_1}-\dfrac{\omega_1}{\omega} \bumpeq \dfrac{2\Delta f_1}{f_1}$ where Δf_1 is referred to f_1 as origin.

However, it is necessary to refer not to f_1 but to the mid-frequency f_m and since $f_1 > f_m$

$$\Delta f_1 = \Delta f - \Delta f'$$

where Δf = the off-tune frequency from f_m

$$\therefore\quad \frac{\omega}{\omega_1}-\frac{\omega_1}{\omega} \bumpeq \frac{2(\Delta f-\Delta f')}{f_1} \bumpeq \frac{2(\Delta f-\Delta f')}{f_m} = F - F'$$

Similarly $\frac{\omega}{\omega_2} - \frac{\omega_2}{\omega} = F + F'$. The denominator of Z_T therefore becomes

$$= R_{T1} \,.\, R_{T2}\left[(1 + jQ_1(F - F')(1 + jQ_2(F + F')) + \frac{\omega^2 M^2}{R_{T1} \,.\, R_{T2}}\right]$$

$$= R_{T1} \,.\, R_{T2}\left[(1 + jQ_1(F - F')(1 + jQ_2(F + F')) + Q_1 Q_2\, k^2 \frac{\omega^2}{{\omega_m}^2}\right]$$

$$= R_{T1} \,.\, R_{T2}\left[1 + Q_1 Q_2(k^2 \frac{\omega^2}{{\omega_m}^2} + (F')^2 - F^2) + j[(Q_1 + Q_2)F + (Q_2 - Q_1)F']\right]$$

and
$$|Z_T| = \frac{\sqrt{R_{D1} \,.\, R_{D2}}\,\sqrt{Q_1 Q_2}\,k}{\sqrt{[1 + Q_1 Q_2(k^2 + (F')^2 - F^2)]^2 + [(Q_1 + Q_2)F + (Q_2 - Q_1)F']^2}}$$

This expression is identical with expression (5d) except for the factor $(Q_2 - Q_1)F'$ and the increase in the equivalent coupling coefficient from k to $\sqrt{k^2 + (F')^2}$. Provided Q_2 is very nearly equal to Q_1 the generalised curves for selectivity and phase shift can be applied when the coupling coefficient is taken as $\sqrt{k^2 + (F')^2}$. It may be noted that when $Q_1 = Q_2$ the curves may be used without errors from this source. Differentiating the denominator of $|Z_T|$ with respect to F and equating to O gives

$$F \doteqdot \pm \sqrt{k^2 + (F')^2 - \tfrac{1}{2}\left(\frac{1}{{Q_1}^2} + \frac{1}{{Q_2}^2}\right)}$$

so that $|Z_T|_{\max}$

$$= \frac{\sqrt{R_{D1} \,.\, R_{D2}} \,.\, \sqrt{Q_1 Q_2}\,k}{\sqrt{1 - \frac{({Q_1}^2 + {Q_2}^2)^2}{4{Q_1}^2{Q_2}^2} + (Q_1 + Q_2)^2(k^2 + (F')^2)}}$$

Comparing this with (6) shows that $|Z_T|$ max. for the same selectivity characteristic is reduced in relation to that obtained with coupled circuits having the same resonant frequency. Mistuning as a means of obtaining a given band width as compared with coupling methods is therefore inefficient.

Correspondence

Letters of technical interest are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

Theorem of Pleijel

To the Editor, "Wireless Engineer."

SIR,—It seems to me that this theorem as stated by you in the July Editorial is incorrect. I submit that it can be stated in either of two forms :

The change of current in any branch of a network due to the insertion of a resistance η in a branch A is equal to the current due to E.M.F.s e_1 or e_2 in that branch where

(*a*) $e_1 = \eta i_1$ where i_1 is the *original* current in the branch A and the resistance η *is still present*, or

(*b*) $e_2 = \eta i_2$ where i_2 is the *new current* in the branch and the E.M.F. is applied *in place of* η.

The proof of the theorem which you give leads directly to my statement (*a*). You have shown that an E.M.F. $e = i\eta$ in series with η gives the original current. (This is evident since the voltage drop across e and η is zero so that we have effectively the original circuit.) If e is removed the new current distribution will be obtained. Hence the change of current (calculable in the absence of the original sources) is the current due to e *in the network containing* η.

My statement (*b*) follows from the identity of the potential drops across η carrying i_2 and across the E.M.F. e_2. It is easily deduced that if R_0 is the Thévenin impedance at the point of insertion of η then

$$e_2 = i_2\eta = \frac{i_1\eta}{1 + \eta/R_0}$$

Your form (*a*) can also be deduced from this.

Application of the theorem to a series circuit of a 10-volt battery, 10-ohm resistance and 15-ohm added resistance shows clearly the differences between the methods and the incorrect answer (neg 0.5A) given by application of the theorem as stated by you.

Which of the forms (*a*), (*b*) is the best to use depends on circumstances. If η is small both lead to the form given by you as an approximation.

I should also like to point out that this theorem is a direct application of the superposition principle, and that, as I have shown above, it is most easily proved without any reference to Thévenin's Theorem.

JOHN H. MOLE.

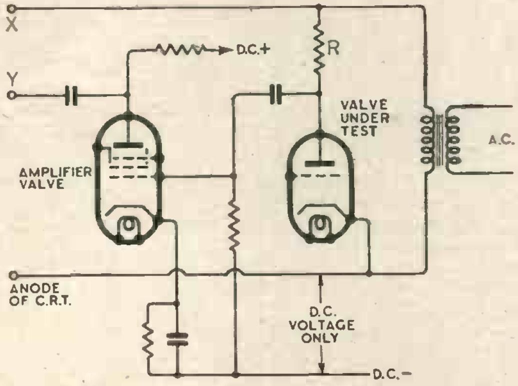
Dewsbury.

[Dr. Mole's criticism is fully justified. Pomey's statement of the theorem, a translation of which was included in the Editorial, is not very clear on the point. The matter is further discussed on p. 472.—ED.]

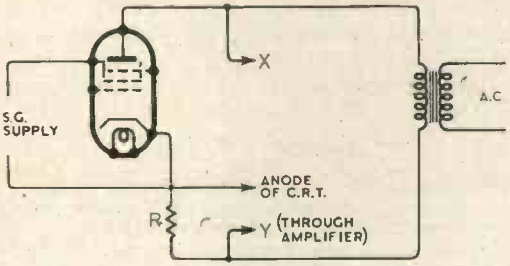
"Tracing Valve Characteristics"

To the Editor, "Wireless Engineer."

SIR,—I was very interested in an article by Geoffrey Bocking with the above title published in *Wireless Engineer* for December 1942. At the time of publication I read through this article but did not go into the details of the circuits. A few weeks ago I thought of making a device similar to the test set, the circuit of which is given in Fig. 9 of the article. On going into more detail as to the operation of the circuit I discovered a very serious error. With the switches in the E_a/I_a position the schematic circuit (omitting details of the grid circuit) is as shown in Fig. A. In order to show E_a/I_a characteristics the X deflection should be proportional to E_a. This condition is fulfilled in the circuit shown, assuming the drop across R to be small compared with the anode voltage. The Y deflection should be proportional to I_a. In the circuit shown this is not so, since the voltage applied between the grid and cathode of the amplifier valve is the A.C. supply voltage to the anode (about 350 volts A.C.), less the small drop (proportional to I_a) across R. Obviously the amplifier will be badly overloaded if not damaged, and even if this were not so, the result would not be correct. The only ways of connecting the cathode-ray tube are as shown in Fig. 1b of the article, when the use of an amplifier on the Y plates is difficult, or as shown in Fig. B. The only difficulty with the latter method is that, if a multi-electrode valve is being tested, a separate supply must be used for each electrode as shown in Fig. B, so that only I_a flows through the resistance R. I have made a test set on these lines which works successfully, but is rather expensive, due to the separate power supplies. I would be pleased to let you have further particulars of this set if you are interested.



(A)



(B)

The error in Fig. 9 cannot, I think, be a printing error as there seems no way of overcoming the difficulty without major alterations to the circuit. Apparently the author cannot have built this test set, as otherwise he would have found out this mistake.

I would like to apologise for referring to an article published so long ago, but it is an error which is not obvious at a first glance.

The circuit appears to be correct when switched to show the E_g/I_a characteristics, as the supply to the anode is then D.C.

G. N. PATCHETT.

Eccleshill, Bradford.

I.E.E. Meetings

THE first meeting of the 1943/44 session of the Institution of Electrical Engineers will be held on Thursday, October 7th, when Col. Sir A. Stanley Angwin will give his inaugural address as president.

On Wednesday, October 13th, T. E. Goldup, the new chairman of the Wireless Section, will deliver his inaugural address.

At an Informal Meeting of the Institution on Monday, October 25th, the president will open a discussion on "How Far is International Standardisation in the National Interest?"

All the above meetings commence at 5.30.

Brit. I.R.E.

"COLOUR and Stereoscopic Television" is the subject of the paper to be delivered by John L. Baird at the meeting of the British Institution of Radio Engineers arranged for 6.30 on October 28th. It will be held at the Institution of Structural Engineers, 11 Upper Belgrave Street, London, S.W.1.

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.

A Valve-Oscillator Theorem*

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

A GREAT variety of methods has been used for the analysis of valve-oscillator circuits. The valve-oscillator may be regarded as an amplifier which has sufficient anode-grid circuit coupling to enable it to produce its own input voltage; or it may be regarded as a regenerative amplifier whose feed-back ratio has been increased to the critical value which makes the voltage-amplification infinite; or it may be regarded as a passive oscillatory circuit having zero total resistance (and hence zero decrement) as a result of the cancellation of the positive resistance of the circuit by the negative resistance of the valve. Each outlook leads to its particular method of analysis—aimed at deducing the frequency of oscillation and the "maintenance condition" (a necessary relation between the valve parameters and circuit constants if self-oscillation is to occur). Some oscillator circuits are best treated using one outlook, some using another. In the present paper it is intended to present, in the form of a theorem, a single procedure applicable to all orthodox negative-grid oscillator circuits; and also, by the application of this theorem to one well-known class of oscillators, to prove certain general rules of behaviour for such oscillators.

Theorem

In any negative-grid valve oscillator circuit the following relation must be satisfied

$$Z + \frac{r_A}{1 + \mu N} = 0 \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where r_A = Valve Impedance (anode incremental resistance)

μ = Valve amplification factor

N = Complex ratio V_g/V_a, i.e. the ratio of the grid and anode voltage vectors

Z = Impedance of the whole external circuit connected between anode and cathode.

Using conventional symbols for A.C. vectors and adopting the valve equivalent circuit† shown in Fig. 1, we see that

$$V_a = r_A I_a - \mu V_g$$

If, by means of the external circuit connected to the valve, V_g be maintained equal to NV_a where N is any complex number, we have

$$V_a = r_A I_a - \mu N V_a$$

whence $$V_a/I_a = \frac{r_A}{1 + \mu N} \quad \ldots \quad \ldots \quad (2)$$

This is therefore the vector impedance which the valve will present, between anode and cathode, when the circuit is such as to maintain V_g/V_a equal to N. For example, if N be made real and negative and larger than $1/\mu$ (i.e. if a voltage greater than $1/\mu$ times the anode voltage be fed back to the grid circuit 180 degrees out of phase with the anode voltage) the valve would function as a pure negative resistance. (In general, as we shall see, an oscillator valve does not function as a *pure* negative resistance, but has also reactance).

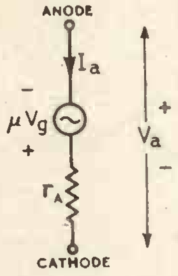


Fig. 1.

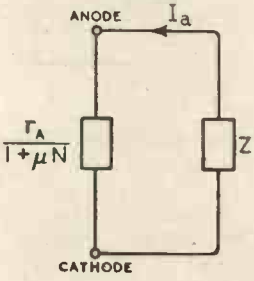


Fig. 2.

If Z represent the vector impedance of the whole external circuit connected between anode and cathode (a quantity which can

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* MS. accepted by the Editor, July 1943.

† In assuming the valve equivalent circuit we are inherently assuming linear characteristics. In assuming A.C. vectors we are inherently assuming sinusoidal oscillation. The above may not, therefore, be regarded as a proof of the existence of sinusoidal oscillations in any oscillator circuit, but merely as the deduction of certain conditions which must be satisfied if sinusoidal oscillation does occur.

usually be easily written down by the use of the rules for series and parallel impedances) the whole circuit becomes as shown in Fig. 2. The application of Kirchhoff's second law to this circuit gives

$$I_a\left(Z + \frac{r_A}{1 + \mu N}\right) = 0$$

so that either the alternating anode current, I_a, must be zero (in which case there is no self-oscillation) or else equation (1) must be satisfied.

Examples of the Application of this Theorem

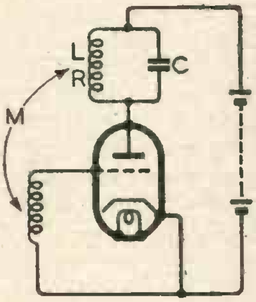

Fig. 3.

The method of determining the oscillation frequency and the maintenance condition by the use of this theorem may be illustrated by reference to the tuned anode oscillator (Fig. 3) and the Colpitts oscillator (Fig. 5). The A.C. equivalent circuit of the tuned anode oscillator is shown in Fig. 4, and it will be seen that

$$Z = \frac{(R + j\omega L)(1/j\omega C)}{R + j\omega L + 1/j\omega C}$$

Moreover the grid voltage vector is given by $j\omega M I_L$, where I_L denotes the vector for the current through the coil L. The alternating voltage across this coil is clearly equal to $-V_a$, and hence

$$I_L = -V_a/(R + j\omega L)$$

and $\quad V_g = j\omega M I_L$

so that $N = -j\omega M/(R + j\omega L)$

Substitution of these expressions for N and Z into equation (1) gives

$$r_A(R + j\omega L + 1/j\omega C) + (R + j\omega L)(1/j\omega C) - \mu M/C = 0$$

Separation of this identity into its real and imaginary parts then gives the oscillation frequency and the maintenance condition as follows:—

$$\omega = \sqrt{\frac{1 + R/r_A}{LC}}$$

$$M = (L + r_A RC)/\mu$$

The equivalent A.C. circuit of the Colpitts oscillator is shown in Fig. 6, and it will be seen that this is an example of the class of oscillators which we shall call "closed circuit oscillators," i.e. oscillators which consist of a closed circuit (in this case $L\,C_1\,C_2$) with the valve's anode, cathode and grid tapped on to this closed circuit. It will be convenient to denote the impedances which make up the closed circuit by vectors $Z_1\,Z_2\,Z_3$, where Z_1 is the impedance between cathode and grid, Z_2 is that between cathode and anode, and Z_3 is that between anode and grid. From Fig. 6 we see that

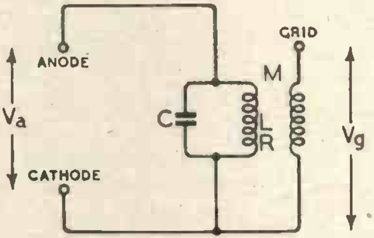

Fig. 4.

$$Z = \frac{Z_2(Z_1 + Z_3)}{Z_1 + Z_2 + Z_3}$$

and

$$N = Z_1/(Z_1 + Z_3)$$

Substitution of these values into equation (1) gives

$$\frac{r_A}{Z_1 + \mu Z_1 + Z_3} = \frac{-Z_2}{Z_1 + Z_2 + Z_3} \quad \ldots \quad \ldots \quad (3)$$

For the Colpitts oscillator Z_1, Z_2 and Z_3 are respectively $1/j\omega C_1$, $1/j\omega C_2$ and $(R + j\omega L)$. Substitution of these expressions into equation (3) and separation into real and imaginary parts gives

$$\omega = \sqrt{\frac{1/C_1 + (1 + R/r_A)/C_2}{L}}$$

and

$$R r_A + L/C_1 = (1 + \mu)/\omega^2 C_1 C_2$$

The first of these gives the oscillation frequency; and if R is small with respect to r_A, as is usual, the oscillation frequency is seen to be very nearly equal to the frequency of resonance of the closed circuit. The second of the above equations gives the maintenance condition; and becomes simply a relation between the valve parameters and circuit constants (as required) if the value of ω be substituted from the first equation.

Closed Circuit Oscillators in General

Many important oscillators are of this type, including the tuned-anode tuned-grid and the commonest crystal controlled oscillator. For oscillators of this type the above theorem reduces to equation (3).

In the majority of closed circuit oscillators (the Colpitts oscillator is the notable exception) the impedance Z_3 between anode and grid is a capacitance, often formed simply of the grid-anode capacitance of the valve. We may derive the following general properties of such oscillators (i.e., where Z_3 is a capacitance) from consideration of equation (3). (The derivation of these properties is given in an appendix.)

(i) Both Z_1 and Z_2 must have inductive reactance at the frequency of oscillation. In the case of the tuned-anode tuned-grid oscillator, in which Z_1 and Z_2 are each parallel L–C circuits, this means that the frequency of oscillation is lower than the resonance frequency of either L–C circuit, since a parallel L–C circuit has inductive reactance only at frequencies below resonance. In the case of oscillators having a piezo-electric crystal between grid and cathode, it follows that the oscillation frequency must lie in the narrow range of frequencies for which the equivalent circuit of the crystal has an inductive reactance.

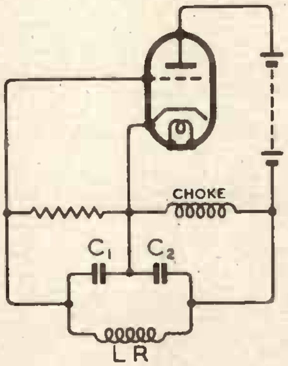

Fig. 5.

(ii) The oscillation frequency differs from the resonance frequency of the closed circuit by a small amount which tends to zero as the resistive components of Z_1 and Z_2 tend to zero.

(iii) At the frequency of oscillation the total reactance of the closed circuit is negative (i.e. capacitive). The magnitude of this capacitive reactance tends to zero as the resistive components of Z_1 and Z_2 tend to zero. This provides us with a rule for determining, for any given oscillator, whether the oscillation frequency is greater or less than the resonance frequency.

(iv) At the frequency of oscillation the reactance component of Z_1 must exceed $1/\mu$ times that of Z_2 by an amount which depends upon the resistive components of Z_1 and Z_2. This enables us to write down an approximate Maintenance Condition for any given oscillator.

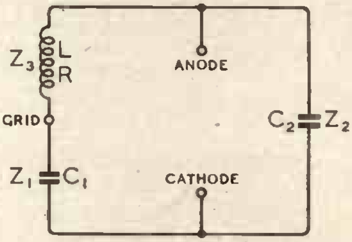

Fig. 6.

APPENDIX

Derivation of the above properties of closed circuit oscillators in which Z_3 is a pure capacitance.

Let $Z_1 = a + jb$; $Z_2 = c + jd$; $Z_3 = -jk$

where a, b, c, d and k are all real, and a, c and k are positive. Substituting these expressions into equation (3), cross-multiplying and separating into real and imaginary parts, we have

$$d(b + \mu b - k) = r_A(a + c) + ac(1 + \mu) \quad .. \quad (4)$$

$$r_A(b + d - k) = -ad(1 + \mu) - c(b + \mu b - k) \quad (5)$$

These may be abbreviated to

$$Abd - kd = B$$

$$Cb + Dd = kE$$

where A, B, C, D and E are all positive. Eliminating d between these equations we have

$$b^2(AC) - b(AE + C)k + (k^2E + ED) = 0$$

which shows that b must be positive. Similarly it may be shown that d is positive. Since b and d denote the reactive components of Z_1 and Z_2 it follows that these reactances must be inductive at the frequency of oscillation, which is the frequency at which equation (3) holds good.

Next, it will be seen that the right-hand side of equation (4) is positive; it follows that $(b + \mu b - k)$ is positive. Hence equation (5) shows that $(b + d - k)$ is negative. This last quantity is the total reactance of the closed circuit, and will be zero at the resonance frequency of the closed circuit. It follows that the oscillation frequency differs from the resonance frequency of the closed circuit.

If, however, the resistive components a and c are zero, equations (4) and (5) become

$$(b + \mu b - k) = (b + d - k) = 0$$

showing that in this event the oscillation frequency is the same as the resonance frequency of the closed circuit, and that at this frequency the reactance, b, of Z_1 is equal to a fraction of $1/\mu$ of the reactance, d, of Z_2. In a practical case a and c are not zero, and we see that the reactive term $(b + \mu b - k)$ is positive, while $(b + d - k)$ is negative. It follows that in practice b must exceed a fraction $1/\mu$ of the reactance d.

The behaviour of closed circuit oscillators in which Z_3 is a pure inductance may be investigated simply by changing the sign of k in the above.

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

553 677.—Construction and arrangement of a microphone which is operated by contact with the throat muscles of the user.

Standard Telephones and Cables and J. S. P. Roberton. Application date 28th November, 1941.

553 997.—Sound-wave transmitter or receiver with means for eliminating the effect of any movement of the device through the medium.

T. J. R. Bright. Application date 20th December, 1941.

554 043.—Means for controlling the lamp used to energise the photo-electric pick-up of a radio-phonograph combination.

Philco Radio and Television Corporation (assignees of M. L. Thompson). Convention date (U.S.A.), 13th December, 1940.

DIRECTIONAL WIRELESS

553 970.—Preventing the radiation of waves having undesired polarity, say from a radio beacon station of the overlapping-beam type.

Standard Telephones and Cables and A. J. Maddock. Application date 9th December, 1941.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

553 671.—Automatic gain control system applied to a spaced arrangement of receivers for counteracting selective fading.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 31st October, 1941.

553 786.—Wireless receiver with press-button tuning means for controlling the setting of a number of movable condensers.

The General Electric Co. and W. R. Rose. Application date 25th April, 1941.

553 847.—Broad-band amplifier comprising two or more distinct paths for applying stabilising feedback to different portions of the frequency range.

Standard Telephones and Cables (assignees of H. W. Bode). Convention date (U.S.A.) 28th December, 1940.

TELEVISION CIRCUITS AND APPARATUS

FOR TRANSMISSION AND RECEPTION

553 851.—Television scanning system with means for automatically controlling or stabilising the " aspect ratio " of the two deflecting fields applied to the electron stream of a cathode-ray tube.

Hazeltine Corporation. Convention date (U.S.A.) 1st July, 1941.

TRANSMITTING CIRCUITS AND APPARATUS

(*See also under Television*)

553 738.—Construction of a portable radio transmitter adapted to be brought into operation in an emergency.

F. B. Dehn (communicated by Wells-Gardner & Co. and Gardwell Co. Inc.). Application date 1st September, 1941.

553 838.—Short-wave generator or amplifier having a " suction " or positively-biased grid which is connected through two distinct leads in order to reduce damping of the input circuit.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 11th December, 1941.

553 967.—Automatic safeguard against the breakdown of any one of several power amplifiers connected in parallel to a common load, such as a transmitting aerial.

Standard Telephones and Cables and A. J. Maddock. Application date 9th December, 1941.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

553 181.—Electrode arrangement for increasing the gain or sensitivity of a multiple-anode valve utilising deflection control.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 12th November, 1941.

553 182.—Construction and arrangement of a metal-to-glass seal in which the component parts have different coefficients of expansion.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 19th November, 1941.

553 746.—Process for making a glass seal, say, between the bulb and base of a thermionic valve, without setting-up undesirable strains.

Marconi's W. T. Co. (assignees of H. R. Seelen). Convention date (U.S.A.) 30th November, 1940.

553 755.—Electron-optical arrangement for producing from a heated cathode an electron beam of uniform density in cross-section.

Ges. zur Forderung & Technischen Hochschule. Convention date (Switzerland) 29th January, 1941.

553 774.—Arrangement of the striking-electrodes in a gas-filled electron-discharge tube.

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

553 787.—Press-button tuning system wherein one of the operating links comprises an electromagnetically-operated pawl-and-ratchet device.

The General Electric Co. and W. R. Rose. Application date 25th April, 1941.

553 805.—Construction and sealing of a radio transmitter tube of the de-mountable and water-cooled type.

"Patelhold" Patentverwertungs and Elektro-Holding Akt. Convention date (Switzerland), 30th December, 1940.

553 832.—Process for coating refractory wire, such as tungsten, with separate metallic layers and rare-earth compounds, for use as thermionic cathodes.

F. Barton. Application date, 3rd December, 1941.

553 841.—Electrode structure designed to facilitate the deposition of a sensitive coating in the manufacture, say, of a photo-electric cell.

Western Electric Co., Inc. Convention date (U.S.A.), 25th January, 1941.

553 846.—Electrode structure designed to reduce input damping in a discharge tube of the electron-beam type coupled to a coaxial-line feeder.

Standard Telephones and Cables (communicated by Western Electric Co., Inc.). Application date, 28th March, 1942.

553 943.—Cathode-ray tube in which a thin beam of electrons is maintained in focus by a magnetic field throughout the range of deflection applied to the beam by a superposed electric field.

Standard Telephones and Cables (assignees of A. M. Skellett). Convention date (U.S.A.), 27th June, 1940.

554 004.—Construction and sealing of the lead-in wires to the electrodes of an electron-discharge tube.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 11th February, 1942.

SUBSIDIARY APPARATUS AND MATERIALS

553 723.—Voltage-converting arrangement comprising a number of thermionic tubes connected in series, so that each of the cathodes has a different operating potential.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 16th February, 1942.

553 828.—Arrangement of multi-vibrator with a Class-B amplifier for generating stabilised oscillations for frequency or phase modulation.

Marconi's W. T. Co. (assignees of J. Evans). Convention date (U.S.A.), 1st June, 1940.

553 845.—Combination of a gas-filled discharge tube and condenser to control the timing of a slow-operation relay.

Standard Telephones and Cables (assignees of B. J. Bjornson). Convention date (U.S.A.), 23rd October, 1940.

553 852.—Electron-discharge system for generating high-frequency oscillations from A.C. mains, and for providing flexible control of the output supplied to a variable load.

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

553 866.—Electron-beam oscillation generator in which the electron stream is made to oscillate in the Barkhausen-Kurz manner across a resonant arrangement of electrodes.

Standard Telephones and Cables (assignees of J. A. Morton. Convention date (U.S.A.), 5th July, 1940.

553 884.—Input circuit for controlling and improving the frequency response of an amplifier of the kind in which negative feed-back is applied through a cathode load impedance.

Marconi's W. T. Co. (assignees of J. L. Hathaway). Convention date (U.S.A.), 7th January, 1941.

553 966.—Arrangement of shunt elements for reducing the residual inductive effects of a precision wire-wound resistance.

Standard Telephones and Cables and W. Kram. Application date, 9th December, 1941.

553 971.—Valve frequency-doubling circuit in which no potentials of the doubled frequency are allowed to appear across the input circuit.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 11th December, 1941.

553 973.—Low-powered "pilot" or starting-up device for a high-powered frequency-converter system of the magnetic-flux type.

Telephone Manufacturing Co. and L. H. Paddle. Application date, 24th December, 1941.

554 003.—Arrangement and impulsing of a two-stage cross-coupled valve relay having two alternate states of stability.

J. H. Reyner and F. R. Milsom. Application date 5th February, 1942.

554 074.—Means for preventing "flash-over" between the insulating spacers and the stranded-wire inner core of a coaxial high-frequency cable. [Addition to 533 982.]

Telegraph Construction and Maintenance Co. and E. W. Smith. Application date, 15th December, 1941.

554 092.—Wave transmission network of the bridged-T type comprising variable attenuation and phase-shifting elements.

Standard Telephones and Cables (assignees of A. W. Clement). Convention date (U.S.A.), 23rd August, 1941.

554 116.—Glow-discharge relay comprising thermo-expansive electrodes for closing a contact for a predetermined time.

Westinghouse Electric International Co. Convention date (U.S.A.), 23rd October, 1941.

554 117.—Variable-impedance network comprising an element with a negative temperature coefficient for stabilising the working characteristic of a high-frequency transmission-line.

Standard Telephones and Cables (Assignees of P. G. Edwards and R. K. Bullington). Convention date (U.S.A.), 9th September, 1941.

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

2625. THE EXPERIMENTAL DETERMINATION OF THE RESONANCE RESISTANCE OF RESONATORS IN THE CENTIMETRIC-WAVE BAND.—Borgnis. (*See* 2755.)

2626. THE RADIATION OF ELECTROMAGNETIC ENERGY THROUGH APERTURES [and the Conception of a "Diffraction" Aerial].—Neyman. (*See* 2715.)

2627. THE SUPPRESSOR ACTION OF CONCENTRIC LINES WITH LONGITUDINALLY LAYERED DIELECTRIC IN THE DECIMETRIC-WAVE BAND [Coaxial Cables with Disc Insulation].—Riedel. (*See* 2716.)

2628. THE IMPEDANCE OF HOLLOW WAVE-GUIDES.—H. T. Flint & L. Pincherle. (*Proc. Phys. Soc.*, 1st July 1943, Vol. 55, Part 4, No. 310, pp. 329–338.)

"Maxwell's equations for the electromagnetic field in the space containing a dielectric bounded by a conductor can be expressed in a form identical with the equations which apply to parallel wires or to concentric cables. This leads to the application of the concept of impedance in the case of wave-guides similar to that applied in the case of parallel wires or cables. Schelkunoff has extended the concept of impedance to a variety of problems, and in particular to the case of wave-guides. It is the purpose of this paper to bring out the close analogy which exists between the two types of guides, so that well-known results in one case can be used in the consideration of the other. It will appear in this way that knowledge of the relation between current and potential in the case of parallel guides, and of the reflecting properties of impedances placed across them, can be used in the solution of questions relating to wave-guides."

The writer deals first with transverse magnetic waves (E-waves) beginning with the infinitely long tube and the effect of a dielectric slab placed within it, and continuing with the calculation of the impedance of hollow tubes with different terminations. Transverse electric waves (H-waves) are then considered (reflection at the boundary separating two dielectrics: reflection at a dielectric slab and at a slab terminated by a hollow tube of length l with a perfectly reflecting end). On the basis of these results, methods are outlined, analogous to those used for Lecher wires (*see* Flint & Williams, 780 of 1942), for measuring the impedances of hollow guides, and hence the dielectric constant and absorption of materials which can be introduced into the guide. Finally, the present treatment is applied to the case considered by Lamont (3281 of 1940 [and not as quoted here: *see* also 4373 of 1940]), and the relation obtained by him, and used as the basis of his method of measuring dielectric constants, is thus found again.

2629. ARRANGEMENT FOR COUPLING A WAVE-GUIDE TO AN ELECTRICAL APPARATUS.—P. G. Violet. (*Hochf:tech. u. Elek:akus.*, Jan. 1943, Vol. 61, No. 1, p. 31.)

A Telefunken patent, D.R.P. 722 612. "Since the optimum coupling possibilities are only encountered with guide waves of the lowest order (E_{01}, H_{01}), the coupling of an electrical apparatus to a guide excited to a wave of higher order (say E_{11} wave) is carried out by branching the end of the guide into several parts, which are joined in pairs to form a loop in which waves of lower order (E_{01} for instance) are formed, and in which an aerial [for the latter wave: with terminals outside the loop: *see* Fig. 17] is provided for coupling purposes". For previous work *see* 3563 of 1942.

2630. Ultra-High Frequencies [Summary of Paper at Joint Meeting of I.R.E. & A.I.E.E. on 28th January].—G. C. Southworth. (*Bell Lab. Record*, March 1943, Vol. 21, No. 7, pp. 194–196.) Including a table of comparative attenuations for ½-inch and 3-inch coaxials and a 3-inch wave-guide.

2631. Correction to "The Reciprocity Theorem of the Electromagnetic Field" [Omission of Factor in Calculation of Integral for Cavity Line].—W. Dällenbach. (*Arch. f. Elektrot.*, 30th Sept. 1942, Vol. 36, No. 9, p. 572.) *See* 3260 of 1942.

2632. Ultra-Short Electromagnetic Waves: I—Electromagnetic Theory: II—Transmission-Line Theory.—E. Weber: J. R. Ragazzini. (*Elec. Engineering*, March & April 1943, Vol. 62, Nos. 3 & 4, pp. 103 & 159 onwards.) *See* also 2633 & 2693, below.

2633. Ultra-Short Electromagnetic Waves: IV—Guided Propagation [Treatment by Transmission-Line Theory & Optical Analogy: including a Section on Cavity Resonators].—S. A. Schelkunoff. (*Elec. Engineering*, June 1943, Vol. 62, No. 6, pp. 235–246.)

2634. Radio Research on Metre Waves [Note on Papers by Members of Staff of Radio Department, N.P.L., dealt with in 1823, 1918, & 1822 of July].—(*Nature*, 17th July 1943, Vol. 152, No. 3846, pp. 83–84.)

2635. Measurement of the Angle of Downcoming Waves from Indian Regional Short-Wave Stations.—M. R. Rao. (*Indian Journ. of Phys.*, Dec. 1942, Vol. 16, Part 6, pp. 347–367.)

Author's summary:—"Results of the measurements of downcoming angles carried out at Delhi on signals radiated from the Bombay and Madras broadcasting stations of All-India Radio are given and discussed. Close agreement has been found between the experimental and the theoretical values. Use of pulse signals radiated from these stations not only helped to overcome difficulties of agitation and haphazard rotation of the patterns on the screen, but also made it possible to resolve the downcoming waves into their component waves and to determine the downcoming angles of each. The results provide an interesting study of the importance of the various parameters which may control propagation under given conditions. The rôle of the intervening ionised strata such as the E layer is also analysed and discussed." The set-up was essentially the same as that used by Chamanlal (360 of 1942) based on the method developed by the Radio Research Board in England. The wide-band characteristic necessary for the reception of the pulses used in the present experiments (50 per second, each about 0.0004 second in length) was achieved by introducing resistances in the tuned circuits of the i.f. stages.

A section on pp. 359–361 deals with "the virtual height paradox": "in a multi-hop transmission, the virtual height of the layer from which reflections take place would increase as the order of the hop increases, as shown in Fig. 8. The results on Bombay and Madras stations working in the 90 m band usually conformed to this. However, at the beginning of April an unusual phenomenon was observed on the Bombay pulse-patterns . . . the first hop is reflected from a virtual height of 500 km, the 2nd hop from 440 km, and the third hop from 393 km. This is in variance with the established notions. As an explanation it is suggested that a deflecting layer in the transmission path, such as the residual E layer that could have been present at the time of measurement, would be responsible for such a phenomenon," as shown in Fig. 9: the greater the obliquity of the incident ray the greater the deviation by the intervening layer, and the greater, therefore, the virtual height. "Another effect of the intervening layer is its effect on the energy distribution in the various component rays": the same record for 10th April showed that the first four hops were of the same order of amplitude, instead of the first hop being, as it was normally, much weaker than the second or third.

2636. A Note on Field Strength of Delhi 3 and Delhi 4 at Calcutta during the Solar Eclipse of September 21st, 1941.—S. P. Chakravarti. (*Proc. I.R.E.*, June 1943, Vol. 31, No. 6, Part I, pp. 269–270.)

The distance is about 900 miles. The relative values of the horizontally (abnormally) polarised component of the electric-field intensity were observed ordinarily every minute, and at certain times every 5 or 10 seconds, during and just after the eclipse. Over the greater part of the period the average signal intensity from both stations was higher than the average "non-eclipse" intensity, falling towards the end of the period almost to (or temporarily below) that level. Delhi 3 (19.62 m) shows several cases of quick fading (10–30 seconds period) during the first 45 minutes, the intensity sometimes varying from half or full "non-eclipse" value to over twice or three times that value. During the second 45 minutes the record shows slow fadings (1–3 minutes) from about full "non-eclipse" value to two or three times that value. Delhi 4 (25.36 m), on the other hand, shows its slow fadings in the first 45 minutes and its quick fadings in the earlier part of the second 45 minutes (from full or 1½ times to 3½ or 4 times the average "non-eclipse" value).

2637. The Molecular Structure of Ozone [as obtained by Electron-Diffraction Investigation].—W. Shand, Jr., & R. A. Spurr. (*Sci. Abstracts*, Sec. A, June 1943, Vol. 46, No. 546, p. 122.)

2638. New Sunspot Cycle [First Group photographed at Naval Observatory].—(*Sci. News Letter*, 29th May 1943, Vol. 43, No. 22, p. 339.)

2639. Coronal Intensity and Geomagnetism.—M. Waldmeier. (*Sci. Abstracts*, Sec. A, June 1943, Vol. 46, No. 546, p. 107.)

The appearance at the Sun's limbs of "*C*-regions" is correlated with the occurrence about 7.4 days later (E limb) or 6.2 days earlier (W limb) of geomagnetic disturbances. Various conclusions are drawn. For recent work by this writer *see* 2277, 2604, 2945, & 2948 of 1942.

2640. "Die erdmagnetische Aktivität in Sodankylä in den Jahren 1914–1934" [Book Review].—E. Sucksdorff. (*Terr. Mag. & Atmos. Elec.*, June 1943, Vol. 48, No. 2, pp. 113–114.)

2641. List of Geomagnetic Observatories and Thesaurus of Values.—J. A. Fleming & W. E. Scott. (*Terr. Mag. & Atmos. Elec.*, June 1943, Vol. 48, No. 2, pp. 97–108.)

2642. Archaeologica Geomagnetica : II, *and* Some Early Contributions to the History of Geomagnetism : II and III.—S. Chapman : H. D. Harradon. (*Terr. Mag. & Atmos. Elec.*, June 1943, Vol. 48, No. 2, pp. 77–78 : pp. 79–91.) For I *see* 2070 of August.

2643. "Heat Transfer by Infra-Red Radiation in the Atmosphere" [Book Review].—W. M. Elsasser. (*Journ. Applied Phys.*, July 1943, Vol. 14, No. 7, p. 367.) Also *Science*, 2nd July 1943, pp. 17–18.

2644. "Methoden und Probleme der dynamischen Meteorologie" [Notice of Reprinting].—H. Ertel. (*See* 2898.) For recent work by this author *see* 3490 of 1942.

2645. Note on the Transmission of Radio Waves through the Earth.—D. Silverman & D. Sheffet. (*Geophysics*, Oct. 1942, Vol. 7, No. 4, pp. 406–413.)

"Transmission is known to be a function of the properties of the earth and of the frequency and, in general, improves with increase in earth resistivity and with decrease in frequency. For all but the lowest frequencies the attenuation is considered to be high enough to assign a very low probability to the transmission of radio waves to any useful depth. In contrast with the pessimistic nature of these data are experiments such as those reported [the only paper quoted is that of Eve, Keys, & Lee, 1930 Abstracts, p. 153, r-h column, & back reference : no reference is made to Fritsch's work, such as that dealt with in 4271 of 1936 and back references] in which radio signals were received in caverns and mines after transmission through considerable thicknesses of rock . . . The apparent exceptions provided by these examples have kept the question open and have undoubtedly inspired similar though unreported measurements of the transmission of radio waves through the ground to mines and caves." The present measurements were made in an active coal mine at depths of 65 and 75 feet below the surface and at 50 and 1100 feet, respectively, horizontally from a vertical entrance shaft. Regular broadcast transmissions were used (690, 1170, and 1430 kc/s). At the second receiving position it appeared that something of the order of 90% of the total signal came directly through the earth, the remainder arriving by way of the vertical and horizontal shafts. The circles in Fig. 3 show the observed attenuations, the curve being extended by Eve's formula (ref. "3") to higher and lower frequencies. The theoretical attenuation at this location is seen to be only 4 : 1 at 50 kc/s as compared with 1500 : 1 at 1400 kc/s. "This report is admittedly incomplete, in many respects, and particularly as to the effect on attenuation of the proximity of the transmitter and the directivity of the antenna system . . ."

2646. Open-Wire Radio-Frequency Transmission Lines.—Laport. (*See* 2724.)

2647. Reflection of Light by a Periodically Stratified Medium.—G. N. Ramachandran. (*Sci. Abstracts*, Sec. A, June 1943, Vol. 46, No. 546, p. 114.)

2648. The Mathematics of Turbid Media [Primary Scattering : Secondary Scattering : the Integral Equation Method : the Differential Equation Method].—S. Q. Duntley. (*Journ. Opt. Soc. Am.*, May 1943, Vol. 33, No. 5, pp. 252–257.) For previous work *see* 936 of 1942.

2649. Papers giving an Analytical Solution of the Problem of the Wave Motion generated in an Elastic Medium by Application of a Pressure of Arbitrary Form to the Interior Surface of a Spherical Cavity [of Importance in Seismic Prospecting].—J. A. Sharpe. (*Geophysics*, April & July 1942, Vol. 7, Nos. 2 & 3, pp. 144 and 311 onwards.) Discussed in a letter from G. B. Lamb in the Oct. 1942 issue, No. 4, p. 419.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2650. Sunrise Maxima in the Intensity of Distant Atmospherics received in Medium-Frequency Channels.—S. R. Khastgir & R. G. Basak. (*Current Science* [Bangalore], Oct. 1942, Vol. 11, No. 10, pp. 392–393.) *See* also 1379 of May, and *cf.* 2651, below.

2651. Investigations on Atmospherics in High-Frequency Channels [2–20 Mc/s : with Particular Attention to Sunrise & Sunset Periods].—S. R. Khastgir & Md. I. Ali. (*Indian Journ. of Phys.*, Dec. 1942, Vol. 16, Part 6, pp. 399–419.)

Dacca investigations (by the "peak" method) during the monsoon time of 1940. A general explanation of the observed maximum (occasionally two maxima) before ground sunrise, and of the maximum just after (occasionally at the same time as) ground sunset, is given on the main lines of Khastgir's paper dealt with in 1379 of May, but with the addition of a rôle played by the absorbing D layer, appearing after sunrise and disappearing after sunset. According to this theory, "the position of the maximum in respect of time would give an indication of the location of the source of atmospherics. If the time of occurrence of the maximum is less than 4ϕ minutes [ϕ is the angle ACG in Fig. 5] before ground sunrise or after ground sunset, it is evident that the disturbance is coming from the west, and if it is more than 4ϕ minutes, the disturbance may come either from the east or from the west. It is possible to draw a curve showing the position of the maximum with reference to the ground sunrise or sunset and the approximate location of the disturbance in miles. . . . If the double sunrise peak is to be associated with the E-layer and F-layer reflections respectively, it is possible also to calculate approximately the separation in time between the two intensity maxima. The observed values of this time difference for some typical cases are given in Table II. The theoretical values which would give approximate agreement for suitable values of the reflection height are also shown in the table. The results of similar experiments by R. G. Basak on 800 kc/s (*Current Science* [Bangalore], Oct. 1942) are also incorporated in this table. Considering the uncertainty in the actual reflection height the agreement can be regarded as satisfactory."

Observations on the frequency-distribution of the atmospheric field strengths were taken on the 2–5 Mc/s and 10–20 Mc/s bands. For distant atmospherics during the day, plotted against $1/f^2$ the field strengths E gave an approximate straight line in one case only; in the others, the curve was straight over a limited range only. During the night, when the sky waves predominated, in both frequency bands E decreased exponentially with increase of f. Atmospherics due to local thunderstorms gave the relation $E = A + B/f$ in both bands, and the same was given by "rain statics" (during prolonged drizzle with slight flashes but no thunder). Each of these cases is considered theoretically (pp. 412–418). The final section deals with an estimation of the signal-strength values for good reception at Dacca on 5 and 10 Mc/s, for morning, afternoon, and night during May and June.

2652. On the Present Position of Lightning Research [Survey].—K. Berger. (*Bull. de l'Assoc. Suisse des Élec.*, 19th May 1943, Vol. 34, No. 10, pp. 269–275: in German.) Dealing more particularly with work in South Africa and U.S.A. A further paper on Swiss results (1936–1938), not yet published, is promised.

2653. Dielectric-Recovery Characteristics of Large Air Gaps [under Conditions pertaining to Multiple Lightning Strokes: Experimental Investigation].—G. D. McCann & J. J. Clark. (*Elec. Engineering*, Jan. 1943, Vol. 62, No. 1, Transactions pp. 45–52.)

2654. Ignition-Channel Cross Section and the Ignition Process with [Ultra-Violet] Irradiation of Limited Cross Section.—W. Fucks & H. Bongartz. (*Zeitschr. f. Phys.*, 25th March 1943, Vol. 120, No. 7/10, pp. 468–475.)

The "ignition channel" is to be distinguished from the "electron channel": it is the region important for the initiation of the discharge, at the moment of instability. It appears never to have been dealt with theoretically: the present paper describes an experimental investigation, in which (in air at atmospheric pressure) its radial extension is measured by a procedure utilising the ignition-potential decreases produced by irradiating a gradually increased amount of cathode surface. The ignition-channel cross section is found to increase with the gap-length: with increasing gap-length the "relative channel-diameter" (ratio of channel-diameter to gap-length) diminishes. The measured relative ignition-channel cross sections are from one to two orders of magnitude greater than the calculated electron-channel cross sections. Implications of the results, as regards lightning-flash mechanism, are envisaged in the final paragraph.

2655. Application of Lightning-Protective Devices in Wartime [Possible Saving in Critical Materials & Man-Hours].—I. W. Gross. (*Elec. Engineering*, Jan. 1943, Vol. 62, No. 1, p. 34: summary only.)

2656. Voltage Surge and Fourier Spectrum in High-Voltage Engineering [and the Distortions produced by Retarding Cables, etc.].—H. Samulon. (*Bull. de l'Assoc. Suisse des Élec.*, 19th May 1943, Vol. 34, No. 10, pp. 279–291: in German.)

2657. An Improved Cosmic-Ray Radio Sonde [with Scaling-Down performed at Ground Station instead of at Transmitter as in Original Design (2305 of 1942): Pulses only about 1/10 000 s, Minimum Spacing about Twice This: Special Method of Keying: Superheterodyne Reception (with Tuned Lines for R.F. Tuning)].—W. H. Pickering. (*Review Scient. Instr.*, June 1943, Vol. 14, No. 6, pp. 171–173.)

PROPERTIES OF CIRCUITS

2658. The Experimental Determination of the Resonance Resistance of Resonators in the Centimetric-Wave Band.—Borgnis. (*See* 2755.)

2659. "Communication Circuits" [Transmission Lines & Wave Guides: Book Review].—L. A. Ware & H. R. Reed. (*QST*, July 1943, Vol. 27, No. 7, p. 34.) "Prerequisites being ordinary calculus and elementary a.c. theory . . ."

2660. Résumés of Recent Research: Cylindrical Cavity Resonators containing Several Dielectric Media.—D. Middleton. (*Journ. Applied Phys.*, July 1943, Vol. 14, No. 7, p. 363.) *See* 2661, below.

2661. Ultra-High-Frequency Oscillations of Cylindrical Cavity Resonators containing Two and Three Dielectric Media.—D. Middleton. (*Phys. Review*, 1st/15th May 1943, Vol. 63, No. 9/10, pp. 343–351.)

"The results indicate a new and convenient absolute method for the measurement of dielectric constants of good dielectrics, for wavelengths around 10 cm [differing from the methods of King and Lamont in that a single resonance position is determined with the sample under test at one end of the resonator; it is simpler, and more convenient in the case of fluids, but less sensitive because the maximum-shift conditions are not necessarily satisfied]. They show also that the resonator behaves like a band-transmission filter for the particular mode excited, and further the analysis yields formulae involving the resonant lengths and frequencies which, it is hoped, may be of use in future experimental measurements and in the design of tunable u.h.f. resonators. The theory applies generally for all modes and resonant dimensions of a tube containing three different dielectrics. Specifically, we will discuss the E_{011} and H_{111} modes and corresponding resonant lengths" of resonators of fixed and variable over-all lengths containing a movable dielectric slab, and of a resonator of variable total length with a slab at one end. It is shown that modes of the form E_{np0} and H_{np0} are not excitable if there is more than one dielectric present in the resonator. Confirmatory experiments on 3070 Mc/s are described.

2662. Concerning the Roots of $J'_n(x)N'_n(kx) - J'_n(kx)N'_n(x) = 0$ [Relation arising in Certain Problems of Resonant Cavities with Cylindrical Symmetry].—R. Truell. (*Journ. Applied Phys.*, July 1943, Vol. 14, No. 7, pp. 350–352.)

From the R.C.A. Laboratories. "The first roots of this relation are presented here as a function of k for $n = 1, 2, 3, 4$. The M'Mahon relation does not allow calculation of the first roots, despite statements to the contrary in several places. It is shown that the functions $J'_n(x)/N'_n(x)$ have relative maxima at $x = n$ except for $n = 0$".

2663. Corrections to "Transformation Elements [Quarter-Wavelength Lines] with Lowest 'Ballast' on the Oscillating Field Energy".—W. Dällenbach. (*Hochf:tech. u. Elek:akus.*, March 1943, Vol. 61, No. 3, p. 83.) *See* 1844 of July.

2664. The Question of the Use of Lumped-Constant or Distributed-Constant Tuning Elements for Ultra-High Frequencies: and a Special Variable Inductance for 260–350 Mc/s.—Summerhayes. (In paper dealt with in 2855, below.)

2665. A Cathode-Follower Stage [for Television].—Kreuzer. (*See* 2752.)

2666. A Self-Balancing Phase-Inverting Circuit and Its Design.—V. S. Kobylyantsev. (*Izvestiya Elektroprom. Slab. Toka*, No. 6, 1940, pp. 44–49.)

Phase-inverting circuits are used for transforming an asymmetrical voltage into a voltage symmetrical with respect to earth. The simplest example of such a circuit is a transformer in which the middle point of the secondary winding is earthed. In this paper a theoretical discussion is presented of the operation of a circuit employing two triodes I and II (Fig. 1) of which I receives the asymmetrical voltage and II automatically acquires the necessary excitation for balancing the output of I. Conditions for correct operation of the circuit are established and methods for designing the circuit discussed. Results of an experimental investigation, including frequency characteristics of the circuit, are also given.

2667. Network Theory, Filters, and Equalisers: Part III [M-Derived (Ladder) Filters: Lattice Filters: Relation between Ladder and Lattice Structures: Equalisers: Dividing Networks].—F. E. Terman. (*Proc. I.R.E.*, June 1943, Vol. 31, No. 6, Part I, pp. 288–302.) Three corrections to Part I (2086 of August) are given at the end.

2668. Arrangement for the Production of a Direct Voltage proportional to Frequency [but Independent of Amplitude].—Brown Boveri. (*Hochf:tech. u. Elek:akus.*, Jan. 1943, Vol. 61, No. 1, p. 31.)

Swiss Patent 218 680. "The d.c. indicating instrument 7 (Fig. 16) is supplied, every time the a.c. changes its sign, with current pulses of opposite direction by the action of a transformer 5 with saturation characteristic and another 6 without such a characteristic, or a condenser."

2669. Notes on Inverse Feedback: Characteristics, Circuits, and Design Considerations.—P. C. Erhorn. (*QST*, June 1943, Vol. 27, No. 6, pp. 13–17.)

2670. Variable-Frequency Bridge-Type Frequency-Stabilised Oscillators [for High and Low Frequencies].—W. G. Shepherd & R. O. Wise. (*Proc. I.R.E.*, June 1943, Vol. 31, No. 6, Part I, pp. 256–268.)

Functioning "in a manner similar to those described by Meacham (263 of 1939: bridge-stabilised oscillators embodying a thermal element as amplitude control) but employing electrical-frequency-determining networks better adapted to the necessity of covering a range of frequencies . . . The circuits employed are two examples of bridged-T and parallel-T circuits whose advantages have been discussed recently by Tuttle and Honnell (1549 and 2368 [and 3111] of 1940). One of the circuits employed is particularly applicable to low frequencies because only capacitances and resistances are employed" [the l.f. model described had a range of 14 c/s to 50 kc/s in four steps: in the h.f. model (bridged-T) the four-step range was from 12 kc/s to 6 Mc/s].

2671. A Different Negative-Resistance Oscillator: Utilising Screen Voltage Regulation for producing Negative Resistance [Special Pentode Circuit].—W. Davidon. (*QST*, July 1943, Vol. 27, No. 7, pp. 25 and 74.)

"The suppressor-grid voltage varies the plate resistance from a positive value when the suppressor is either zero or close to it, through infinity and to the negative value already discussed . . ." The value of the negative resistance is low, about 5000 ohms, "permitting a low L/C ratio to be used in the oscillator circuit and thus further improving the output wave-form. This low value of negative resistance might also be used to good advantage to satisfy the need for a ' pliodynatron ' of low negative resistance for a resistance-tuned amplifier (Cabot, 1934 Abstracts, p. 497 [not Sewall, as in ref. " 2 "]) . . . For oscillator operation in the audio frequencies, a resistance–capacity network can be used instead of a tuned circuit, as demonstrated in Fig. 4."

2672. Sweep Oscillators.—M. M. Finkel'shteyn [Finkelstein]. (*Izvestiya Elektroprom. Slab. Toka*, No. 6, 1940, pp. 58–61.) The theory and applications of oscillators with continuously varying frequency and constant output voltage are discussed.

2673. An Electrical Transducer Circuit for Use with Capacity Pick-Up Devices [primarily for Seismic Work & Study of Mechanical Vibrations in General, Dilatometers, etc : a Coupled-Oscillator Transducer with Mains Supply : Many Advantages, including Simplicity in Operation, Practically Constant Sensitivity (depending on Absolute rather than Percentage Changes in Capacitance) from Zero to Several Hundred Kc/s, and Freedom from Interference].—E. V. Potter. (*Review Scient. Instr.*, May 1943, Vol. 14, No. 5, pp. 130–135.)

Utilising the current changes in a circuit tightly coupling two similar oscillators, when a change in the natural frequency of the one oscillator circuit tends to alter its oscillating frequency, and power has to be transferred (*via* the coupling circuit) in order to maintain the two circuits in synchronism (" Ziehen " effect : Appleton, ref. " 5 ".)

2674. Electrical Circuit Analysis of Torsional Vibrations [of Multi-Cylinder Engines, Continuous Shafts, etc.]—Pipes. (*See* 2907.)

2675. Transient Analysis of Linear Systems [and Its Application to Mechanical & Acoustical Problems].—M. F. M. Osborne. (*Journ. Applied Phys.*, April 1943, Vol. 14, No. 4, pp. 180–184.)

From the Naval Research Laboratory. " The response *versus* frequency curve is the more commonly accepted criterion of performance of an electrical system, although many properties of a circuit can be read directly from its square-wave response (refs. " 2 " to " 6 "). The methods of square-wave analysis have not been generally applied to mechanical systems owing to the difficulty of producing a mechanical square wave . . ." Author's summary :—" A method is suggested for determining either the indicial admittance of a linear system, when the response to a known transient is observed, or the shape of the transient, when the admittance is known. A method is also outlined for obtaining the impedance operators, and in particular the impedance coefficients (stiffness, resistance, and inertia). Corrections due to the reaction of the instrument used in measuring the response of the system, or of a restraint to insure stability of the system, can be taken into account when appreciable. Suggested applications are to acoustical and aerodynamical problems."

2676. A Comparison of the [Amount of Arithmetical Computation required to determine Transient Currents by the] Transform and Classical Methods.—W. V. Lyon. (*Elec. Engineering*, May 1943, Vol. 62, No. 5, pp. 198–203.) *See* also 726 of March : and *cf.* Pipes, *ibid.*, July 1943, Vol. 62, No. 7, pp. 326–327, on Duncan & Collar's introduction of the matrix method.

2677. On the Theory of the Distortion of Telegraph Signals in the High-Frequency Circuits of Radio Apparatus.—I. S. Gonorovski. (*Izvestiya Elektroprom. Slab. Toka*, No. 6, 1940, pp. 16–27.)

In high-speed telegraphy, and especially in picture telegraphy when approximately 2000 signals per second are transmitted, the time necessary for building up and falling off of a signal (time constant) becomes of great importance. In this paper a mathematical discussion is presented in which methods are indicated for determining the time constant of a high-frequency channel consisting of *n* stages with tuned circuits (Fig. 1). The cases of a channel with and without frequency multipliers are considered separately. A numerical example is added.

2678. Surge-Generator Circuits [Development of Formulae for Free Periods and Damping Factors of High-Voltage Surge-Generator Circuits in Discharge, containing Large Number of Meshes : Approximations based on Actual Case].—E. Fisher. (*Journ. Applied Phys.*, July 1943, Vol. 14, No. 7, pp. 341–342.)

2679. The " Mitnahme " [Pulling-into-Tune] of Self - Excited Oscillations, and Its Technical Utilisation.—F. Kirschstein. (*E.N.T.*, Feb. 1943, Vol. 20, No. 2, pp. 29–38.)

A few years ago the term " mitnahme " was practically limited in its use to the pulling into tune of the local-oscillator oscillations by the signal waves received by the aerial, in heterodyne reception, or the mutual pulling into tune of the two h.f. oscillations in a beat-note generator when low beat frequencies were required : that is to say, it referred to unwanted and troublesome effects of only nuisance importance. Recently, however, a whole series of circuits have been developed in which, just as in the earlier arrangements, the frequency of a controlled oscillation is brought into coincidence with that of a controlling oscillation, and which can therefore be spoken of as " mitnahme " circuits. They serve the most varied practical purposes, and the " mitnahme " effect has become a useful tool of an importance already considerable and likely to increase in the future. The present writer, after a short treatment of the classical effect in heterodyne reception, describes some of these " mitnahme " circuits in which the effect is used deliberately.

The first of these is the arrangement used by Kaden (736 of 1940) in his " frequency meter on the compensation principle ", Fig. 2. This frequency meter has the disadvantage over other types of direct-reading meters, such as that of the A.E.G., of having a comparatively narrow frequency range, namely that corresponding to the " mitnahme " region. On the other hand it has the advantage that the indicating current is comparatively large and allows fluctuations of the frequency under measurement to be followed rapidly. The time constant of the iron-cored choke, which prevents sudden changes in the d.c. biasing current I, can easily be brought down to a few milliseconds, for note-frequencies, by a suitably large ohmic resistance in the magnetising current circuit, and will fall still lower in the measurement of higher frequencies owing to the decreasing coil inductance. Hence by registering the current I it is possible not only to record the time-characteristic of rapidly altering frequencies, rather as in pitch measurements in acoustics, but also to deal with periodic fluctuations of the frequency under measurement, such as occur in a frequency-modulated oscillation. " The ' mitnahme ' frequency meter thus becomes an important demodulating device for frequency-modulated oscillations ".

Working fundamentally in the same way as this Kaden " mitnahme " circuit is the de Reynauld arrangement of Fig. 5, covered by a U.S.A. patent. This has the advantage of following even more rapid fluctuations of the incoming frequency ω_f, owing to the absence of a time constant for the biasing of the magnetic core. In its place there is the time constant of the parallel connection of R and C; but this time constant can be made the smaller, the higher the frequency ω_g of the local oscillations, since the object of this RC circuit is to prevent the supply voltage U from fluctuating in the rhythm of ω_g. Thus the de Reynauld circuit is particularly good for the demodulation of frequency-modulated oscillations at high modulating frequencies.

The above two arrangements are typical of the " mitnahme " circuits, having the two essential features of these : namely a self-excited oscillating stage whose frequency can be varied within certain limits by some controlling quantity (the current I in Fig. 2, the voltage U in Fig. 5), and a device in which the phase angle between the " pulled-in " oscillation and the " pulling-in " oscillation is established and converted into a controlling quantity : in Fig. 2 the device takes the form of a Graetz circuit, in Fig. 5 it is a valve rectifier. The " mitnahme " effect can also be regarded as a regulating process in which the frequency of the " pulled-in " oscillation is continually controlled in such a way that a definite phase angle between it and the controlling oscillation remains constant throughout : Urtel's paper, 1399 of 1939, is referred to in this connection.

In Section 3 the two " essential " features for a " mitnahme " action, mentioned above, are identified in the case of the classic effect in heterodyne reception (Fig. 6) : the " controlling quantity " here is seen to be the phase angle ϕ_k of the retroaction factor $\mathfrak{K} = -\mathfrak{U}_g/\mathfrak{U}_a$, and the limits of the " mitnahme " zone are reached when ϕ, the phase angle between the retroaction voltage U_k and the incoming voltage U_f, is $+90°$ and $-90°$. For when ϕ exceeds either of these values the special relation between ϕ and ϕ_k, necessary for the correct adjustment of the frequency ω_g, ceases.

Section 4 deals with the " specially important application of ' mitnahme ' to frequency-division ", as in quartz clocks. The particular circuit for this purpose shown in Fig. 8 differs from that of Fig. 6 only in that the LC circuit is tuned to a frequency which is an nth part of the controlling frequency ω_f, and in having also a combination RC' in the grid circuit with a time constant about equal to the period of the controlling frequency ω_f (*see* Hudec, 3490 of 1938). The synchronising action in this circuit of Fig. 8 is discussed ; it is satisfactory over long periods for frequency ratios of 3 : 1 or 5 : 1 ; a modified form of Fig. 6 is used by Siemens & Halske for larger ratios, such as in obtaining a 4 kc/s oscillation from a 60 kc/s quartz, for multiple carrier-telephony. The use of " mitnahme " in the single-sideband transmission of music (with carrier-suppression) is illustrated in Fig. 11.

Section 5 describes the frequency division used by Rohde & Schwarz in their transportable quartz clock [*see* 1956 of 1941] and Section 6 the use of " mitnahme " by the C. Lorenz Company in common-wave broadcasting. Finally, the long Section 7 deals with the arrangement developed by the writer for the exact speed regulation of an axle driven by a d.c. motor : this has already been described at length in 1484 of May. In the last two paragraphs the writer points out that the extremely important subject of the synchronisation of free relaxation oscillations by control oscillations does, according to the above ideas, also involve " mitnahme " action, for the " kipp " frequency depends on the phase angle between the controlled and controlling oscillations, and for certain phase angles frequency-equality sets in as a stable condition. There are, however, certain differences between the two cases, and the term " synchronisation " is used for the relaxation-oscillation arrangements, while " mitnahme " is reserved for those involving harmonic oscillations.

2680. SOME ASPECTS OF COUPLED AND RESONANT CIRCUITS.—J. B. Sherman. (*Proc. I.R.E.*, Nov. 1942, Vol. 30, No. 11, pp. 505–510.)

" An analysis is presented of the coupled impedance and its components in the two-mesh inductively coupled circuit with a tuned secondary. A similar analysis is made of the impedance and its components in the parallel-resonant circuit having dissipation in the inductive branch."

2681. A METHOD FOR DETERMINING THE NORMAL MODES OF FOSTER'S REACTANCE NETWORKS [Series Combinations of Antiresonant Circuits or Parallel Combinations of Resonant Circuits].—W. R. Le Page. (*Elec. Engineering*, June 1943, Vol. 62, No. 6, p. 267 : summary only.)

2682. THE LOCUS CIRCLE LAW [including Its Application to A.C. Bridge Balancing].—J. Basch. (*Arch. f. Elektrot.*, 31st Oct. 1942, Vol. 36, No. 10, pp. 623–628.)

" The law is proved that for any arbitrary network consisting of a source with sinusoidal e.m.f. with constant frequency, and of linear load elements, all possible ratios of the type 'element-voltage or -current/element-voltage or -current', or of the type 'Σ element-voltages or -currents/Σ element-voltages or -currents' will move along circles as locus curves, when the dissipative resistance or the reactance, or the impedance (the latter in the case of unchanged phase angle) of any one load element is varied." The law can be applied also to conductances.

2683. ELEMENTARY A.C. MATHEMATICS: PART VI—PARALLEL CIRCUITS.—G. Grammer. (*QST*, July 1943, Vol. 27, No. 7, pp. 42–48 and 58.)

2684. THE OBTAINING OF FOUR-TERMINAL NETWORKS WITH THE SAME ITERATIVE IMPEDANCES [but Different Attenuation Characteristics in the Suppression Region] BY MATRIX TRANSFORMATION.—G. A. Usunoff. (*Arch. f. Elektrot.*, 30th Nov. 1942, Vol. 36, No. 11, pp. 687–692.)

Further development of the work dealt with in 3227 of 1942. "It is known that the roots of the characteristic equation of a matrix remain invariant in face of the so-called 'similarity' transformation $Z' = S^{-1} . Z . S$. It follows from this that if this type of transformation is applied to the impedance matrix of a four-terminal network, new impedance matrices are obtained whose characteristic equations have the same roots as the original matrix. These new matrices may have new four-terminal networks corresponding to them. The finding of such new quadripoles, with equal iterative impedances, has a well-defined importance for the theory of filters, since in this way it is possible to arrive at definite cascade combinations of quadripoles which will possess prescribed attenuation characteristics."

The method is applied first to a T network and then to a bridged-T network. The transformation matrix S is of the form $S = \begin{Vmatrix} m & n \\ p & q \end{Vmatrix}$, but since in each case only a symmetrical matrix (giving a symmetrical quadripole) is considered, q is taken as equal to m and n to p. Thus, for the quadripole of Fig. 3a (already shown on pp. 689–690 to be a band-stop filter), use of eqn. 12 gives as the attenuation function (iterative transmission coefficient) of the "transformed" quadripole of Fig. 3b the expressions for g'_K found on p. 692. The limiting frequencies are the same as those of the original quadripole, but the frequencies for which the attenuation becomes infinitely large are given by the equation just below Figs. 4, 5, involving the quantity T, which is $4mp/(m + p)^2$ and depends only on the ratio p/m. "In this case it is possible to calculate a large number of quadripoles all having the same limiting frequencies but different attenuations in the suppression region": in a numerical example f_1 is taken as 3000 c/s and f_2 as 5000 c/s, and the small table on p. 692 gives the calculated frequencies $f_{\infty 1}$ and $f_{\infty 2}$ at which the attenuation becomes infinitely great, for four values of p/m from 0.23 to 0.38. For the value 0.23 the two frequencies are the same (3873 c/s), as is seen by the bottle-neck attenuation curve of Fig. 5, which also shows the double-peak curve for $p/m = 0.3$.

2685. EQUIVALENT CIRCUITS FOR OSCILLATING SYSTEMS AND THE RIEMANN-CHRISTOFFEL CURVATURE TENSOR.—Kron. (*See* 2905.)

2686. SOME APPLICATIONS OF NON-LINEAR CURRENT/POTENTIAL CHARACTERISTICS.—E. E. Shelton. (*Sci. Abstracts*, Sec. B, June 1943, Vol. 46, No. 456, p. 119.) From *Electronic Eng:g*, Jan. 1943.

2687. ESTIMATION OF HARMONICS IN D.C.-POLARISED IRON-CORE CHOKES [Treatment by Use of Taylor's Series as in H.F. Investigation of Valve Characteristics: Simple Practical Application of Results].—W. Hartel. (*Arch. f. Elektrot.*, 30th Sept. 1942, Vol. 36, No. 9, pp. 556–572.)

2688. SUMMATION CIRCUITS WITH CURRENT TRANSFORMERS [for dealing with the Sum of the Currents in Two or More Circuits].—Edler. (*See* 2779.)

2689. RECTIFICATION WITH IMPERFECT RECTIFIERS.—H. Sattler & W. Zwiesler. (*Hochf:tech. u. Elek:akus.*, March 1943, Vol. 61, No. 3, pp. 71–74.)

"For the charging of a condenser from an alternating-voltage source with the help of a rectifier there is a whole series of mathematical and graphical approximate solutions, obtained for various purposes. Those solutions which have as their object the calculation of mains rectifiers assume an ideal rectifier with complete blocking action, and calculate the d.c. voltage at the condenser, and its ripple, for various loads, either with the help of greatly simplifying assumptions as to the voltage characteristic (refs. '1' to '3'), or by an integrating method ('4', '5') or by Fourier analysis of the rectified voltage ('6', '7').

"The object of the present work is to determine by a mathematical-graphical method the voltage characteristic at a condenser connected through an 'imperfect' rectifier to an alternating-voltage source, and to give the rectified voltage at the condenser, and its ripple, in a simple form as a function of the dimensions of the rectifier circuit. This aim is accomplished, mathematically, exactly, without approximation, and is confirmed by experiment": Fig. 6, where a type AZ1 rectifier is provided with suitable shunt and series resistances to fulfil the introductory assumptions of the physical approximation to an "imperfect" rectifier, namely that in the pass direction it should have a constant pass resistance R_d independent of voltage, and in the blocking direction a larger constant blocking resistance R_s: in these resistances the internal resistance of the alternating-voltage source can be included additively. This physical approximation has already been used by Papalexi (1912) in investigations on electrolytic-valve cells, and by Jolley in his book (ref. "9"), for the investigation of the current in a capacitively loaded rectifier circuit.

2690. SKIN EFFECT IN BIMETALLIC CONDUCTORS [*e.g.* Copper-Covered Steel Lines for Carrier Currents up to 160 kc/s: General Equations: Experimental Determination].—B. R. Teare, Jr., & Josephine R. Webb. (*Elec. Engineering*, June 1943, Vol. 62, No. 6, Transactions pp. 297–302.) *See* also 2093 of August.

2691. The Impedance of a Grounded Wire [as in Geophysical Prospecting].—A. Wolf. (*Geophysics*, Oct. 1942, Vol. 7, No. 4, pp. 414–418.)

"The impedance of an insulated wire stretched along the surface of the earth, regarded as a homogeneous conductor, is a function of frequency and of the conductivity of the earth. Formulas are given for the inductance and resistance of such a wire which are applicable under conditions met with in geophysical prospecting."

2692. Papers on Formulae relating to Rectangular Tubular Conductors.—Higgins. (*See* 2761 & 2762.)

TRANSMISSION

2693. Ultra-Short Electromagnetic Waves: III—Generation.—I. E. Mouromtseff. (*Elec. Engineering*, May 1943, Vol. 62, No. 5, pp. 206–215.) One of a series originally presented as a lecture to a Basic Science group of the A.I.E.E: *see* also 2632/3, above.

2694. Arrangement for the Generation of Ultra-Short Waves by Frequency-Multiplication.—R. Forberger. (*Hochf: tech. u. Elek:akus.*, Jan. 1943, Vol. 61, No. 1, p. 29.)

A Telefunken patent, D.R.P. 721 599. Several streams of electrons, proceeding from a common cathode to a common anode but separated by partitioning walls, are simultaneously modulated by a common grid *G* (Fig. 1). In the different channels the disposal and potentials of the various electrodes (such as the secondary-electron-emitting surfaces *V*) are such that the various path-times are different, and the electrons reach the anode at a multiplied frequency.

2695. Magnetron or Retarding-Field Valve Arrangement.—K. Fritz. (*Hochf:tech. u. Elek:akus.*, Jan. 1943, Vol. 61, No. 1, p. 29.)

A Telefunken patent, D.R.P. 722 246. The electrode near the cathode *K* is emissive of secondary electrons and is divided into a number of parts $P_1 \ldots P_4$ (Fig. 4), which are at such potentials that they deliver electrons in the correct rhythm for the working electron flow proceeding to the anodes $A_1 \ldots A_4$."

2696. An Analytical Demonstration of Hartley-Oscillator Action [emphasising the Regions of Amplification & Non-Amplification of the Oscillation, and Their Relation to the Action of the Circuit: including Numerical Comparison between Values of Oscillation-Amplitude thus calculated (by Guillemin's Method: 2697, below) and Those obtained by the "Average g_m" Method].—F. A. Record & J. L. Stiles. (*Proc. I.R.E.*, June 1943, Vol. 31, No. 6, Part I, pp. 281–287.)

2697. An Analytical Method of predetermining the Behaviour of a Vacuum-Tube Oscillator, which yields Regions of Oscillation and Non-Oscillation, the Amplitude of Oscillation, and Wave Form.—E. A. Guillemin. (*Harvard University paper*, 1935: mentioned in 2696, above.)

2698. A 250-Watt C.W. Transmitter using Receiving-Type Tubes: 6L6Gs in a Simple Two-Stage Rig [One 6L6G driving (Link-Coupled) Two in Push-Pull, the Latter on 1125 Volts].—B. C. Barbee. (*QST*, July 1943, Vol. 27, No. 7, pp. 30–32.) "With a little intelligent handling, however, they'll take it and like it."

2699. Automatic Off-Frequency Prevention: Construction of a Gravity-Operated Circuit-Breaking Relay.—"Sourdough." (*QST*, June 1943, Vol. 27, No. 6, pp. 28 and 38.) To work with the relay-closing device described in the May issue.

RECEPTION

2700. Arrangement for the Reception of Ultra-Short Waves [by a Magnetron].—C. Lorenz A.G. (*Hochf:tech. u. Elek:akus.*, Jan. 1943, Vol. 61, No. 1, p. 30.)

D.R.P. 722 472. The diameter of the split anode *A* (Fig. 10) is larger than the critical diameter at which the anode is grazed by the electrons, and the steady magnetic field is of the resonance-field value for the signal frequency. The anode polarisation is so low that no anode current flows through the indicator *T* in the absence of incoming signals.

2701. Circuit for Ultra-Short-Wave Reception [by a Magnetron].—E. Habann. (*Hochf:tech. u. Elek:akus.*, Jan. 1943, Vol. 61, No. 1, p. 30.)

A C. Lorenz patent, D.R.P. 722 733. "The receiving valve is traversed by a constant magnetic field of such strength that the rotation time of the electrons coincides with a period of the signal oscillation; it contains, in addition to the multi-segment perforated electrode 2, which surrounds the cathode 3 (Fig. 13) and to which the incoming signals are led in push-pull, a further, outer cylindrical collector electrode 4 with positive bias, from which the demodulated voltage is taken."

2702. Damping-Circuit Arrangement using Two Absorbing Valves in Push-Pull, particularly for obtaining Super-Regenerative Reception [or for Modulating].—H. G. Möller & K. H. Schwarz. (*Hochf:tech. u. Elek:akus.*, Jan. 1943, Vol. 61, No. 1, pp. 30–31.) D.R.P. 722 902. *See* Fig. 14.

2703. The Behaviour of Mixing Diodes at Low and High Frequencies.—H. Meinke. (*E.N.T.*, Feb. 1943, Vol. 20, No. 2, pp. 39–48.)

From the Telefunken laboratories. "The special relations in the treatment of diode problems are determined by the following facts :—the anode of the diode, acting as the input (control) electrode, takes up the whole diode current ; an appreciable amount of power is consumed in the control process, and the input admittance is fairly large compared with that of grid-controlled valves. As the output electrode, the anode has a ' durchgriff ' of unity, so that the output admittance also is large. All the voltages involved occur at the same electron space, so that in the passage of the modulated flow of electrons retroactive effects occur between the input and output sides of the diode. It is already known that with a diode acting as rectifier the load resistance on the rectified-current side influences the input resistance on the alternating-current side, and also that the internal resistance of the a.c. source influences the internal resistance of the diode on the d.c. side (*see* Hollmann's " Elektronenröhren ", and Rothe & Kleen, 3263 of 1942). Similar effects occur in the rectification of a modulated a.c., in which the load resistance for the modulation frequency, on the output side of the diode, retroacts on the input (Rothe & Kleen, *loc. cit* : Urtel, 1933 Abstracts, p. 623 [and not as in ref. " 3 "] : Wilhelm, 1365 of 1937). The same causes produce the retroactive effects between the input and intermediate-frequency systems in diode-mixing, calculated by Strutt [& van der Ziel (for decimetric waves) : *see* 2362 of September].

" The principle of diode-mixing has been described so often that I may refer to the literature on the subject (Strutt, *loc. cit.* and 1448 of 1936, and his book, 2975 of 1940 : Rothe & Kleen's book, 3053 of 1941). The basic circuit is seen in Fig. 4a " : the process is summarised on p. 39, the signal frequency, heterodyning frequency, and intermediate frequency being represented as angular frequencies h, $\ddot{u}$, and z in order to simplify the formulae. The importance of the image frequency is brought out : " in the reception of high frequencies with low intermediate frequencies, there is so little difference between $\ddot{u} + z$ and $\ddot{u} - z$ that the receiving circuit [h.f. input circuit] represents for both frequencies an impedance which does not vanish." The image-frequency currents occurring on mixing thus produce image-frequency voltages in this circuit, and these retroact on the mixing process. " In the present paper it is shown that an extension of the existing rectification theory of the diode can deal with all the actions occurring in the mixing process. The method can be extended directly to diodes with transit-time effects. The diode, in analogy to the amplifying triode, is represented by diagrams of characteristics [two papers by the present writer, in *Telefunken-Röhre*, Vol. 6, 1941, pp. 250 & 297, are here referred to] : the retroactive effects mentioned are explained with the help of ' working curves ' superposed on these curve families. The connection between the formulae obtained and the usual derivation of the conversion conductance, from the course of the instantaneous slope of the diode without transit-time effects, is given in Section v," where it is stated that methods for the simple calculation of the conversion conductances from the diode characteristics were described in the writer's papers just mentioned : *see* also Mataré, 2705, below. Section vi deals with the effects of electron inertia : the simplifying assumptions made are the same as in the first of the previous papers and in Megaw's paper dealt with in 1546 of 1936, namely parallel plane electrodes at a distance small in comparison with their size ; space charge and initial electron velocity neglected. Measurements show that the effect of the inertia is rather less than that calculated in this way. " A further paper will deal with a bringing together of theory and experiment by the consideration of hitherto neglected influences ". The present simplified theory leads to eqns. 57 to 59, from which the mixing process in transit-time diodes can be calculated in the most general case, as it could be (when transit-time effects were absent) by eqns. 26 to 28. The whole paper should be read in conjunction with that of Mataré, just quoted.

2704. THE RECTIFICATION CHARACTERISTIC FIELD OF A DIODE AT LOW AND HIGH FREQUENCIES, *and* THE POWER BALANCE OF A DIODE AT LOW AND HIGH FREQUENCIES.—H. Meinke. (*Telefunken-Röhre*, No. 21/22, 1941, p. 250 onwards : No. 23, 1941, p. 315 onwards.) The first of these is referred to in 2703, above : both are referred to in 2705, below.

2705. INPUT AND OUTPUT RESISTANCES OF MIXING DIODES [including the Case of Ultra-High Frequencies].—H. F. Mataré. (*E.N.T.*, Feb. 1943, Vol. 20, No. 2, pp. 48–59.)

" In connection with Meinke's paper (2703, above), in which the resistance relations in diode-mixing were considered in the most general way, the present work will discuss some special problems and experimental results. On the basis of the working characteristic of the diode, the experimentally found interactions can be explained easily. Calculations and measured results for various cases are compared [Sections iii & iv]. Further, it will be shown that it is possible, in principle, to make such admittance determinations also by noise measurements [Section v].

" In the decimetric-wave region a case of special interest is that in which the h.f. input circuit represents an appreciable impedance for the image-frequency wave also. The resistance relations here are closely examined [Section vi]. On the grounds of constancy of frequency the mixing with harmonics is often of special importance. It is therefore investigated thoroughly here [Section vii]. The influence of electron inertia will be estimated and discussed " [Section viii].

Section iii, " on the calculation of the admittances by means of reduced functions ", starts off with eqns. 49 & 50, derived in Meinke's paper for the h.f. and i.f. admittances of the diode in the case where the h.f. circuit represents no resistance for the image frequency : it is mentioned that these equations (eqns. 2 & 3 of the present paper) were first given by Strutt (2362 of September). They simplify down to eqn. 3a when the h.f. and i.f. circuits are tuned, and the treatment of this equation, and of the quantities S_g and S_c (the mean mutual conductance—rectifying-characteristic slope—and the conversion conductance), is facilitated by the introduction of the use of " reduced functions," denoted by an asterisk : thus the " reduced function " S_g^* is the ratio $S_g/k\mathfrak{U}^{n-1}$, and $S_c^* = S_c/k\mathfrak{U}^{n-1}$, where k and n are taken from the equation of the characteristic, $J = kU^n$. Introducing these "reduced functions" into eqn. 3a gives eqn. 3b for the "reduced" h.f. and i.f. admittances of the diode, namely $\mathfrak{G}^*_{Dh} = \mathfrak{G}^*_{Dz} = \mathfrak{G}^*_D = S^*_g - S^{*2}_c/S^*_g$, and Fig. 3 gives the curves for $\mathfrak{G}^*_D$ for various values of n from 1 to 2 as a function of U^*_0, the "reduced" d.c. voltage $U_o/\mathfrak{U} = -\cos\theta$. These "reduced" quantities can still be used with advantage even when the conditions of eqn. 3a are not fulfilled, that is when $\mathfrak{G}_h$ and $\mathfrak{G}_z$ are not zero, and Fig. 4 (based on eqn. 3c) gives the "reduced" admittances $\mathfrak{G}^*_{Dz}$ (and $\mathfrak{G}^*_{Dh}$), as functions of U^*_0, with various values of $\mathfrak{G}^*_h$ (and $\mathfrak{G}^*_z$) as parameter, for the case when $n = 1.35$.

Section IV describes the experimental determination of the diode i.f. real admittance G_{Dz} by means of measurements of the damping of the i.f. circuit, first for a single-diode arrangement and then for push-pull arrangements using a duo-diode. In all the examples given the measured points fall well on the calculated curves. In the "noise-measurement" method described in Section V, the valve-noise currents of known value (the equations employed have already been found satisfactory: *see* 391 of February) are generated by the use of a "noise" diode, a directly heated diode working in the saturation region. Fig. 11 shows the circuit for the determination of the i.f. admittance of the diode under test: the noise-generating diode is labelled "Rauschdiode." Two different procedures are described.

The calculation of the input and output resistances of the diode superheterodyne arrangement, as given in Section III, no longer holds good if the image-frequency wave $h_2 = \ddot{u} + z$ is also found in the reception channel, as is frequently the case in decimetric wave reception, and Section VI deals with this case, equation (24) being found for G'_{Dz}. Comparison with eqn. 3 shows that when the image frequency also produces a voltage in the receiver circuit the retroaction term in the expression is multiplied by a factor of 2: this is explained at the top of p. 54, together with the appearance in eqn. 24 of a new conversion conductance S_{c2}, concerned with the second harmonic of the heterodyning wave. On the simplifying assumption that G_h is zero, eqn. 24 becomes eqn. 30, and Fig. 13 gives, for various values of $\mathfrak{U}$ from 2 to 10 v, curves of G_{Dz} for $G_h = \infty$, for $G_h = 0$, and for the case where the image frequency is involved according to eqn. 30.

The question of mixing with harmonics frequently arises in the decimetric-wave region, where the requirement of great stablity of the heterodyning generator is difficult to fulfil. Section VII therefore examines how the diode input and output resistances behave in this case, and pays special attention to the question of conversion amplification, of such importance in determining the sensitivity of a receiver. Fig. 18 shows the curves for S^*_{cm}/S^*_g, of great significance in connection with the conversion amplification, for values of m (the order of the harmonic) from 1 to 4: n (*see* above) is taken as 1.5 throughout. The ratio is plotted against values of the "reduced" working voltage U^*_0. Strutt & van der Ziel (*loc. cit.*) have already shown that for extremely small values of θ (the current-flow angle) S_{cm} approaches the value $(1/\pi)S_{\max} \,.\, \theta/2$ for all values of m, and this is seen in Fig. 18, where all the curves converge as U^*_0 approaches the value $-\cos\theta$. Thus for extreme Class C working it is of no importance which harmonic is used, but this working is difficult to obtain in practice. Figs. 14–16, however, giving the conversion conductances for the 1st to 5th harmonics as a function of U^*_0 for $n = 1, 1.5$, and 2 respectively, show that maxima and minima occur in the S_c curves at definite working conditions, differing for the various harmonics. Use should therefore be made of this fact by choosing the optimum conditions: experimental tests on the sensitivity confirm this point.

The final Section VIII, on the influence of electron inertia on the input and output diode admittances, extends Meinke's work in certain directions and applies the results to the case of an LG1 diode with a cathode/anode gap of 0.15 mm, working on a 50 cm wavelength. Among other results, it is seen that the decrease of the output admittance through retroactive effects is diminished by the action of electron inertia: as the frequency increases, the transit-time effect acts the more strongly to increase the admittance, in opposition to the retroactive action.

2706. The Dynamic Sensitivity of Radio-Telegraph [and Phototelegraph] Receivers.—M. L. Volin. (*Izvestiya Elektroprom. Slab. Toka*, No. 6, 1940, pp. 38–44.)

The sensitivity of a radio-telegraph receiver is determined as follows:—when no signal is received the amplification of the receiver is raised to a maximum possible value beyond which false operation of the receiver begins, due to internal noises: the output of an oscillator is then applied to the receiver and raised to a maximum value E at which there will be no false operation of the receiver, but d.c. impulses free from interference will be obtained at the output when E is switched on and off. E is a measure of the (static) sensitivity of the receiver. It is pointed out that for high-speed telegraphy or picture transmission E has to be raised to a value E_1, which is a measure of the dynamic sensitivity for a given speed and quality of transmission. In the present paper the relationship between E and E_1 is established, and the effect of the frequency bandwidth passed by the receiver on E_1 is discussed. Methods are also indicated for determining the bandwidth necessary for satisfying the required conditions. The paper ends with a report, with a number of oscillograms, on an experimental investigation which was undertaken to verify the theoretical discussion.

2707. Oscillators for Testing Radio Receivers in Association with a Cathode-Ray Oscillograph.—Dubenetski. (*See* 2765.)

2708. Effect of Radio Frequencies of a Power System on Radio-Receiving Systems [R. F. Measurements to determine Correlation: Results useful for Approximate Calculation of Interference].—C. V. Aggers, W. E. Pakala, & W. A. Stickel. (*Elec. Engineering*, Jan. 1943, Vol. 62, No. 1, p. 28: summary only.) *Cf.*, for example, 1659, 1956, 2346, and 3573 of 1942.

2709. Measurements pertaining to Coordination of Radio Reception with Power

Apparatus and Systems [Radio Noisemeter Calibrations: Relations of Apparatus Noise-Levels to Radio-Receiver Interference: Radio-Influence Voltage for Apparatus: etc.].—C. M. Foust & C. W. Frick. (*Elec. Engineering*, June 1943, Vol. 62, No. 6, Transactions pp. 284–291.)

2710. Circuit for the Elimination of Interference on a Neighbouring Frequency [a Two-Aerial, Three-Circuit Arrangement producing a Cancelling-Out of the Interference Frequency].—R. Feld. (*Hochf:tech. u. Elek:akus.*, Jan. 1943, Vol. 61, No. 1, p. 31, Fig. 15.) A Telefunken patent, D.R.P. 723 205.

2711. Generation of Electric Charges by Moving Rubber-Tired Vehicles.—S. S. Mackeown & V. Wouk. (*Elec. Engineering*, May 1943, Vol. 62, No. 5, Transactions pp. 207–210.) *See*, for example, 697 of 1942. A summary was referred to in 2042 of July.

2712. Alternative Materials [Note on "Metrelite," for Screening of Interference, etc: Metal-Sprayed Synthetic-Resin-Bonded Boards & Similar Materials].—Runcolite, Ltd. (*Sci. Abstracts*, Sec. B, June 1943, Vol. 46, No. 546, p. 105.)

2713. The Development and Present Position of the Broadcast Receiver Industry of the World [including the Differences in European & American Technique & Price Levels].—W. F. Ewald. (*E.T.Z.*, 6th May 1943, Vol. 64, No. 17/18, pp. 243–247: to be concluded.)

2714. Unitized-Construction Radio Receivers [built up from Three Basic "Cells," and using only One Type of Valve in Entire Circuit, regardless of Its Complexity: 95% of Usual Connecting-Wire eliminated].—Harvey Machine Company. (*QST*, July 1943, Vol. 27, No. 7, p. 51: paragraph only.)

AERIALS AND AERIAL SYSTEMS

2715. The Radiation of Electromagnetic Energy through Apertures [and the Conception of a "Diffraction" Aerial].—M. S. Neyman. (*Izvestiya Elektroprom. Slab. Toka*, No. 6, 1940, pp. 1–16.)

The problem discussed is as follows:—a metallic envelope totally encloses a space in which electromagnetic waves of constant amplitude are excited (endovibrator: *see* 2081 of August). An aperture is made in the envelope, and it is required to formulate laws determining the radiation of electromagnetic energy through the aperture. It is pointed out that an exact solution of the problem would be too complicated and therefore, without impairing the accuracy required for practical purposes, a number of simplifications are made. A general formula (1) determining the power radiated through the aperture is derived, and the effects of the size of the aperture, and its position with respect to the current antinode, on the radiation resistance of the aperture are discussed. The discussion leads to the conception of a "diffraction" aerial (endovibrator with an aperture), and it is shown that this type of aerial can be used with advantage for reception and transmission on decimetric and centimetric waves. The possible application of the discussion to the theory of electromagnetic screening is briefly indicated. The paper is concluded by a report on an experimental investigation confirming the theoretical results obtained. Polar diagrams of a diffraction aerial are shown.

2716. The Suppressor Action of Concentric Lines with Longitudinally Layered Dielectric in the Decimetric-Wave Band [*e.g.* Concentric Cable with Trolitul Discs supporting the Central Conductor].—H. Riedel. (*Hochf:tech. u. Elek:akus.*, March 1943, Vol. 61, No. 3, pp. 65–70.)

Since the dielectric losses increase linearly with the frequency, and in the decimetric-wave band are already of the same order of magnitude as the eddy-current losses, the tendency is to reduce them to a minimum by keeping down the number of discs as much as is practicable from mechanical considerations. But electrical considerations also come into the question, for if the spaces between the discs are of the same order as the wavelength to be transmitted, reflections will occur which in the most unfavourable conditions will add up from disc to disc and cause a severe loss of energy. A thorough investigation of this question from the theoretical standpoint has already been carried out by Buchholz (1302 of 1940), and the theoretical section II of the present paper is based on his calculations.

Section III describes experiments on a 2 m-long cable section of the disc-insulated type, with a slit along its outer conductor so that the disc-spacing could be varied: the disc-material was also changed. Measurements were carried out on two fixed wavelengths (31.5 and 20 cm), varying spacings (and consequently varying numbers of discs) and different dielectric constants, to find the disc-spacing for which no appreciable ill effect on the transmission of energy through the cable could be detected. For the shortest working wavelength used, $\lambda = 20$ cm, a cable with 3 mm trolitul discs at distances from 30 to 60 mm was found to be satisfactory (Fig. 10): though the curve was already dropping between 40 and 60 mm, the drop at 60 mm was only a fraction of the big drop between 90 and 100 mm, and actually so little difference was found in the attenuations of two longer lengths of works-made cable (3 mm trolitul discs), with spacings of 30 and 60 mm respectively, that the latter spacing was finally adopted. The attenuation curve of the resulting A.E.G. cable, with aluminium outer conductor and 5.5 mm copper-plated aluminium central wire, is seen in Fig. 11: "it brings out the suitability of this cable for wavelengths down to 20 cm." The curves (frequenta and trolitul discs) of Figs. 3–10 show the correctness of the plan adopted, of making the measurements with the cable terminated by its average characteristic impedance Z_m (eqn. 8), the final disc being kept at a distance of a half-spacing from the end.

Section IV points out that while so far a rejector action is concerned the frequency range of a cable can be increased towards higher frequencies by reducing the spacing of the discs, the resulting increase of the number of discs not only raises the dielectric losses but provides more points of reflection whose additive effect will, beyond a certain limit, cause a falling-off of the transmitted energy. It then goes on to discuss attempts to improve the transmission by making the characteristic impedance inside the discs equal to that in the spaces between them: this can be attempted, as in Fig. 12, by increasing the diameter of the outer conductor just at each disc position, so that Z (in the discs themselves) becomes equal to Z_0 (in the spaces) for the particular dielectric constant in question. This plan has the disadvantage of a sudden transition, for the outer conductor, from one diameter to another: the lines of force from the (uniform) central conductor tend to concentrate at the sharp corner of the expansion, few of them reaching the extreme diameter: the result is once more a change of characteristic impedance at this point. On Zinke's suggestion the change from one outer-conductor diameter to another was made gradual by the use of conical sleeves (Fig. 13): the tube-lengths between the disc positions were made telescopic so that the disc-spacings could be varied. Curve 1 of Fig. 14 shows again the characteristic on a 31.5 cm wave of an ordinary cable length, already given in Fig. 5, with curve 2 for the new design superposed on it: the complete absence of the deep trough at the 150 mm spacing is obvious. The slight waviness of the curve is attributed partly to the slight diameter-differences of the telescoping tubes and partly to not quite perfect matching at the discs. On the whole a distinct step towards improving the performance of the cable is indicated. A final experiment, with the discs removed from the new-type cable and replaced by a longitudinally uniform dielectric, showed that the periodic changes in the diameter of the outer conductor produced suppressor action analogous to that due to the discs in an ordinary cable: Fig. 15 illustrates this, the deep trough occurring when the spacing of the conical expansions is no more than 140 mm (the wavelength is presumably again 31.5 cm). This emphasises the necessity, in a cable for a very wide frequency band, of an extremely uniform characteristic impedance throughout its length.

2717. ARRANGEMENT FOR COUPLING A WAVE GUIDE TO AN ELECTRICAL APPARATUS.—Violet. (*See* 2629.)

2718. CORRECTION TO "THE RECIPROCITY THEOREM OF THE ELECTROMAGNETIC FIELD" [Omission of Factor in Calculation of Integral for Cavity Line].—W. Dällenbach. (*Arch. f. Elektrot.*, 30th Sept. 1942, Vol. 36, No. 9, p. 572.) *See* 3260 of 1942.

2719. CORRECTIONS TO "TRANSFORMATION ELEMENTS [Quarter-Wavelength Lines] WITH LOWEST 'BALLAST' ON THE OSCILLATING FIELD ENERGY."—W. Dällenbach. (*Hochf: tech. u. Elektakus.*, March 1943, Vol. 61, No. 3, p. 83) *See* 1844 of July.

2720. A NOTE ON THE MUTUAL IMPEDANCE OF ANTENNAS.—C. W. Harrison, Jr. (*Journ. Applied Phys.*, June 1943, Vol. 14, No. 6, pp. 306–309.)

"Recent research at this Laboratory demonstrates that whereas the assumption of a sinusoidal distribution of current is satisfactory for calculating the distant field of an isolated centre-driven antenna of non-vanishing radius [ref. "3"], this distribution is in reality only the leading term in a complicated series involving powers of the small quantity $1/\Omega$, where Ω is defined by $2 \log_e 2h/a$, and a is the radius of the antenna wire [ref. "4"]. When a parasitic element is placed in proximity to a driven antenna, there is no reason to suppose that the distribution given by (1) is still the leading term in the correct current distribution along the driven antenna. Additionally, the writer can see no reason for assuming that (1) also applies to the parasitic radiator, when it is remembered that this element is immersed in a field of varying amplitude and phase over its entire length. If a rigorous solution is desired for the mutual impedance of antennas, the problem is a boundary-valued one. The case of two antennas can be handled if one is willing to cope with simultaneous integral equations involving the unknown current distributions under the integral signs . . ."

Author's summary:—"An expression is derived for the mutual impedance of a symmetrical centre-driven antenna in proximity to an untuned parasitic element, when the wires are parallel, and are not displaced in length. An integral, frequently occurring in antenna problems, is evaluated graphically over the range required in the present analysis." The input impedance to the driven aerial is dealt with in an appendix.

2721. THE RADIATION FIELD OF A SYMMETRICAL CENTRE-DRIVEN ANTENNA OF FINITE CROSS SECTION, *and* THE DISTRIBUTION OF CURRENT ALONG A SYMMETRICAL CENTRE-DRIVEN ANTENNA.—C. W. Harrison, Jr., & R. King. (Referred to in 2720, above.) Appearing in *Proc. I.R.E.*

2722. AN ELECTROMECHANICAL CALCULATOR FOR DIRECTIONAL-ANTENNA PATTERNS.—C. E. Smith & E. L. Gove. (*Elec. Engineering*, Jan. 1943, Vol. 62, No. 1, p. 28: summary only.) Already referred to in 2018 of July.

2723. A METHOD OF MEASURING THE EFFECTIVENESS OF ELECTROSTATIC LOOP SHIELDING [as used for Noise Reduction in Broadcast Reception: Effectiveness determined as Ratio of Effective Heights of Loop as Magnetic-Field & Electric-Field Collector: Method selected as Best of Five tried for Laboratory Determinations].—D. E. Foster & C. W. Finnigan. (*Proc. I.R.E.*, June 1943, Vol. 31, No. 6, Part I, pp. 253–255.)

Using a short rod aerial connected to a standard-signal generator and projecting above an artificial ground plane below which all the apparatus, except it and the loop itself, is located.

2724. OPEN-WIRE RADIO-FREQUENCY TRANSMISSION LINES [Method of Logarithmic Potentials used to derive Design Formulae for Various Balanced and Unbalanced Lines:

and a Note on the Application to the Design of Low-Frequency Aerials (*e.g.* Cage Aerial, Multi-Wire Flat-Top Aerial)].—E. A. Laport. (*Proc. I.R.E.*, June 1943, Vol. 31, No. 6, Part I, pp. 271–280.) *Cf.* Frankel, 2304 of September.

2725. CHARACTERISTICS OF UNBALANCED OVERHEAD TRANSMISSION LINES [with Details of Attenuation and Radiation, Data on Three Common Types, etc.].—G. H. Brown. (*Broadcast News*, May 1941.) Referred to in 2724, above.

VALVES AND THERMIONICS

2726. PATENTS ON ULTRA-SHORT-WAVE GENERATING DEVICES.—Forberger: Fritz. (*See* 2694 & 2695.)

2727. PAPERS ON THE ACTION OF A DIODE AT LOW AND HIGH FREQUENCIES [including Frequency-Conversion].—Meinke. (*See* 2703/4.)

2728. INPUT AND OUTPUT RESISTANCES OF MIXING DIODES.—Mataré. (*See* 2705.)

2729. CALCULATIONS ON THE USE OF STATIC SECONDARY-ELECTRON MULTIPLIERS.—G. Maurer. (*Arch. f. Elektrot.*, 31st Oct. 1942, Vol. 36, No. 10, pp. 608–614.)

Author's summary:—"The calculation of the multiplying properties of an electron-multiplier is carried out particularly simply if the multiplier characteristic curve log V as a function of U is chosen as the characterising curve [V is the over-all multiplication, U the total voltage used for the n multiplying stages, omitting the collector voltage of the non-multiplying output stage]. In determining the number of stages necessary to obtain a desired multiplication it is advantageous to use the stage characteristic log v as a function of the voltage-per-stage u, if the quality of the various stages is equal and independent of the number of stages. The fluctuations of multiplication produced by fluctuating voltage can also be determined quickly and easily by the use of such a characteristic."

As examples of the method, the writer works out some practical examples, of which the first is the calculation of how high the over-all voltage must be, and how many stages are required, in order to obtain a 10^6 multiplication with the smallest possible over-all voltage. The last, more complex example is the case where, for a similar 10^6 multiplication, the multiplier is required to be so worked that it has a high resolving power for a close series of pulses (that is, that the 10^6 secondary electrons produced by a single primary shall reach the final anode as simultaneously as possible, their path times suffering as little scattering as possible). To attain this it is necessary to use a minimum number of stages each with as high a stage-voltage as possible. An over-all voltage of 2500 v is available. How many stages, and what stage-voltage should be chosen?

The writer refers to Schnitger's paper dealt with in 2718 of 1941, but no mention is made of the same worker's papers dealt with in 451 and 1692 of 1942, the first of which deals specially with the use of a logarithmic measuring scale for the multiplication.

2730. THE EFFECT OF THE MAGNETIC FIELD OF THE CATHODE ON THE ANODE CURRENT OF A CYLINDRICAL DIODE.—A. M. Bliznyuk. (*Izvestiya Elektroprom. Slab. Toka*, No. 4/5, 1940, pp. 43–47.)

The magnetic field of a filament current is usually so weak that its effect on the inter-electrode space charge, and therefore on the anode current, can be neglected. If, however, an a.c. filament supply is used, the small anode-current variations so produced may cause the appearance of noise in the loudspeaker. In this paper the cases of a cylindrical anode with (a) a single filament along its axis, and (b) a U-shaped heater are discussed, and for each case formulæ (25–28) are derived for determining the average equivalent increase (correcting potential) which should be added to the anode voltage to maintain the anode current unchanged when the magnetic field is introduced.

2731. FILAMENT CONTROL AND ITS TUBE-LIFE EFFECT [including Rules for Tungsten, Thoriated, & Coated Filaments: Effect of Mains Fluctuations: Optimum Stand-By Conditions].—D. W. Jenks. (*Sci. Abstracts*, Sec. B, June 1943, Vol. 46, No. 546, p. 116.) From *Communications*, Dec. 1942.

2732. SURFACE AREA OF OXIDE-COATED CATHODES DEDUCED BY ADSORPTION OF GAS AT LOW PRESSURES.—L. A. Wooten & C. Brown. (*Sci. Abstracts*, Sec. B, June 1943, Vol. 46, No. 546, p. 116.)

2733. THE EFFECT OF HIGH ELECTROSTATIC FIELDS UPON THE VAPORISATION OF MOLYBDENUM [and Platinum], *and* THE EFFECT OF HIGH ELECTROSTATIC FIELDS UPON THE VAPORISATION AND RESISTANCE OF MOLYBDENUM FILAMENTS.—G. B. Estabrook: W. P. Reid. (*Phys. Review*, 1st/15th May 1943, Vol. 63, No. 9/10, pp. 352–358: pp. 359–366.)

2734. NEW ORE DEPOSITS OF TANTALUM IN NEW MEXICO.—(*Science*, 14th May 1943, Vol. 97, No. 2524, Supp. p. 12: paragraph only.)

2735. GLASS STRAIN: EXAMINATION OF FAILURES IN LAMP AND ELECTRONIC DEVICES.—H. J. Nolte. (*Electrician*, 9th July 1943, Vol. 131, No. 3397, pp. 31–33.) From the paper dealt with in 2396 of September.

DIRECTIONAL WIRELESS

2736. RADAR: STATEMENT ISSUED BY WESTERN ELECTRIC FOR INFORMATION OF ITS EMPLOYEES [with Historical Sketch].—Western Electric. (*Bell Lab. Record*, June 1943, Vol. 21, No. 10, pp. 362–363.) *See* also Buckley, on p. 333: and *cf.* Army–Navy statement, *QST*, June 1943, p. 51: also 2896, below, and *Wireless World*, Aug. 1943, p. 245.

2737. METHOD OF DETERMINING THE DIRECTION OF MOTION AND THE SPEED OF AN OBJECT MOVING IN A ROAD OR CHANNEL.—H.

Scharlau. (*Hochf:tech. u. Elek:akus.*, Jan. 1943, Vo. 61, No. 1, p. 32.)

A Telefunken patent, D.R.P.722 630. "On either side *a,b* (Fig. 19) of the roadway, transmitters G_a, G_b are erected, working with receivers F_a, F_b opposite to them [three receivers are shown on either bank]. From the sequence in time of the breaks in reception caused at the points *A,B* . . . by the craft *V* moving on the course *P*, the direction of the motion is obtained, and from the ratio of the time-differences between the indications *AC* and *BC*, and *CE* and *CD*, the distance from the banks is derived, and from this (combined with the time observations) the speed is calculated. By choosing different modulations, errors due to the (dotted-line) reflected rays are eliminated."

2738. METHOD OF DISTANCE DETERMINATION ON THE REFLECTED-RAY PRINCIPLE.—H. Gutton. (*Hochf:tech. u. Elek:akus.*, Jan. 1943, Vol. 61, No. 1, p. 32.)

D.R.P.723 075. "Transmitter and receiver are controlled by a variable modulation frequency in such a way that the receiver is blocked during transmission times and open during pauses in transmission: the distance of the reflecting object is found by measuring the difference between the modulation frequencies given by two neighbouring reception-minima."

2739. ULTRA-SHORT-WAVE SIGNAL ARRANGEMENT FOR SAFETY OF CRAFT IN CONDITIONS OF POOR VISIBILITY [Provision of Transmitter, Receiver, & "Reflecting Surfaces" of Special Design (Multiple Dipoles on Rhythmically Swung Axes)].—J. Pintsch Company. (*Hochf:tech. u. Elek:akus.*, Jan. 1943, Vol. 61, No. 1, p. 32.) D.R.P.723 207.

2740. METHOD OF DETERMINING THE POSITION OF AN AIRCRAFT WITH RESPECT TO FIXED POINTS OF A LANDING GROUND [Two Aerials radiating Same Power & Frequency but Different Modulations: Ratio of Received Intensities (indicated by Quotient-Meter in Aircraft) gives Position relative to the Two Aerials].—S.F.R. Company. (*Hochf:tech. u. Elek:akus.*, Jan. 1943, Vol. 61, No. 1, p. 32.) D.R.P.723 206.

2741. AUTOMATIC DIRECTION FINDER [Rotating-Frame Type, with Direct-Reading Arrangement].—R. Weber. (*Hochf:tech. u. Elek: akus.*, Jan. 1943, Vol. 61, No. 1, pp. 31–32, Fig. 18.) A Löwe Radio patent, D.R.P. 722 193.

ACOUSTICS AND AUDIO-FREQUENCIES

2742. TRANSIENT ANALYSIS OF LINEAR SYSTEMS [Methods applicable to Acoustical & Aerodynamical Problems].—Osborne. (*See* 2675.)

2743. AN APPARATUS FOR THE INVESTIGATION OF ECHO PHENOMENA IN CLOSED SPACES [Greatly Simplified Equipment].—B. Burger. (*Hochf:tech. u. Elek:akus.*, March 1943, Vol. 61, No. 3, pp. 75–82.)

Arguing on the lines that as a general rule an acoustical investigation of a room is only needed when its acoustical properties are bad and require improvement, and that in such a case it is only necessary to find out which particular parts of the walls are producing troublesome reflections, the writer has cut out all oscillographic recording and reduced his equipment to a special warble-tone generator of constant intensity, a directive receiver of constant sensitivity, and an indicator giving the relative intensities of the arriving waves.

The development of the warble-note generator is discussed in detail: the method using the inductance-variation of an iron-cored choke, produced by passing an alternating current through an auxiliary winding, was adopted as preferable to all the other methods tried (described in the full Dissertation of which this is an abridged version). The warble-frequency was chosen as 10 c/s, and since an oscillatory circuit for this frequency would require a rather heavy iron-cored choke, and the whole equipment was intended to be easily portable, it was decided to use a relaxation-oscillator which (as Lattmann & Salinger have shown: 2972 of 1936) can be made to give sinusoidal waves. The complete circuit is seen in Fig. 16.

The receiver was a piezoelectric microphone provided with an exponential horn, feeding a two-stage resistance-coupled amplifier and a rectifier with a milliammeter in its anode circuit. A compensation method (p. 80, r-h column) was employed to make the readings proportional to sound pressures. All the supply voltages were taken from small batteries to avoid mains noises and long leads.

2744. SWEEP OSCILLATORS [Theory & Applications].—Finkelstein. (*See* 2672.)

2745. VARIABLE-FREQUENCY BRIDGE-TYPE FREQUENCY-STABILISED OSCILLATORS.—Shepherd & Wise. (*See* 2670.)

2746. LOUDSPEAKER WITH ACOUSTIC GUIDES, IN SUNK BOX, PROJECTING THE SOUND ABOVE GROUND AT ANGLE TO HORIZONTAL [gives Better Coverage than Vertical Radiation, and Better High-Note Reproduction than Horizontal].—L. Bialk & H. Benecke. (*Hochf:tech. u. Elek:akus.*, Jan. 1943, Vol. 61, No. 1, p. 32, Fig. 22.) A Telefunken patent, D.R.P.722 046.

2747. THE MIRROPHONE: MAGNETIC SOUND-RECORDER AND REPRODUCER.—(*Bell Lab. Record*, Sept. 1941, Vol. 20, No. 1, pp. 2–5 and 8.) *See* 2153 of 1941.

2748. PROTECTION FOR WORKERS IN NOISY INDUSTRIES: A "LUCITE" EAR-MOULD.—D. A. McCoy. (*Science*, 28th May 1943, Vol. 97, No. 2526, Supp. p. 12.)

PHOTOTELEGRAPHY AND TELEVISION

2749. TELEVISION PROSPECTS.—W. R. G. Baker. (*Proc. I.R.E.*, June 1943, Vol. 31, No. 6, Part I, p. 305.) Summary of address.

2750. A KINESCOPE FOR A TABLE TELEVISION RECEIVER.—A. S. Buchinski & A. G. Yakovlev. (*Izvestiya Elektroprom. Slab. Toka*, No. 4/5, 1940, pp. 52–54.)

A cathode-ray tube developed in Russia for mass production is described. The main data of the kinescope are as follows :—anode voltage 3500 V ; modulating voltage (swing), 30 V ; filament voltage, 2.5 V ; average blocking voltage, 35 V ; maximum working current of the ray, 125 μA ; over-all length of the tube, 353 mm ; screen diameter, 172 mm ; colour of fluorescence, white.

2751. CALCULATIONS ON THE USE OF STATIC SECONDARY - ELECTRON MULTIPLIERS. — Maurer. (*See* 2729.)

2752. A CATHODE-FOLLOWER STAGE.—V. L. Kreytser [Kreuzer]. (*Izvestiya Elektroprom. Slab. Toka*, No. 4/5, 1940, pp. 54–64.)

In television amplifiers cathode-follower stages are often used (Fig. 1). In this paper a mathematical discussion of the operation of such a stage is discussed under the following headings :—amplification factor ; equivalent amplifier (with an anode load) and its characteristics ; frequency and phase characteristics of a stage without correcting circuits ; input capacity of the stage ; a stage with both anode and cathode loads. In conclusion it is pointed out that the circuit is particularly suitable for use at the output of a multi-stage amplifier.

2753. ON THE THEORY OF THE DISTORTION OF TELEGRAPH [and Phototelegraph] SIGNALS IN THE HIGH-FREQUENCY CIRCUITS OF RADIO APPARATUS.—Gonorovski. (*See* 2677.)

2754. THE DYNAMIC SENSITIVITY OF RADIO-TELEGRAPH [and Phototelegraph] RECEIVERS. —Volin. (*See* 2706.)

MEASUREMENTS AND STANDARDS

2755. THE EXPERIMENTAL DETERMINATION OF THE RESONANCE RESISTANCE OF RESONATORS IN THE CENTIMETRIC-WAVE BAND.—F. Borgnis. (*Naturwiss.*, Vol. 31, 1943, p. 20 onwards : summary in *E.T.Z.*, 6th May 1943, Vol. 64, No. 17/18, p. 249.)

A two-page article with 4 diagrams. The impossibility of measuring the resonance resistance of the cavity and concentric-line resonators used in the centimetric-wave band by the methods employed in the short-wave band is first discussed. Then it is mentioned that the resonance resistance can be defined from the energy standpoint, just as in the case of quasistationary circuits, as the ratio $R_p = U^2/N_w$, where U is the effective voltage at R_p, and N_w is the true power ; but in doing this it must be stated to what point of the resonator the resonance resistance is referred. Whereas, in the quasistationary circuit, the damping d and the resonance resistance are connected by the relation $dR_p = \sqrt{L/C}$, this is not so in the non-quasistationary circuit, so that it is impossible to get at the resonance resistance by way of the measurement of the damping (which can be accomplished well even in the centimetric wave region : a summary or paper in *E.T.Z.*, Vol. 64, 1943, p. 18, is here referred to), since the usual conceptions of concentrated capacitance and inductance are not valid here.

A measurement of the resonance resistance becomes, however, possible if a known ohmic resistance is connected in parallel with the resonator at an appropriate point, without appreciably altering the field, and the decreased deflection of an indicating instrument is simultaneously noted. A circular-sectioned cylindrical cavity resonator such as that of Fig. 2, excited to its fundamental oscillation, has its strongest electric field along its axis of rotation between the points A, B, and this field sinks to zero towards the outer jacket according to a Bessel function. To determine the resonance resistance at the point of strongest field, a thin dielectric rod C is introduced between A and B, having a known dielectric constant ϵ and loss angle $\tan\delta$: this rod acts as a pure ohmic resistance R'_p connected in parallel with the resonator without affecting the character of the field distribution. Keeping the excitation coupling constant, the resulting smaller deflection α' is measured on a square-law indicator. With the same test wavelength another reading α'' is taken with a different rod.

" Since the relative wavelength-change $\Delta\lambda/\lambda$ of a cavity resonator on the introduction of a dielectric rod of radius ρ is equal to $1.86\ (\epsilon - 1)\rho^2/R^2$ [this is the result given at the end of 2306 of 1942], the two rods must be chosen so that $\rho^2\ (\epsilon - 1)$ has the same value in each case. The conductance of such a rod is $G'_p = (\rho^2\pi/2)\ .\ \omega\epsilon\epsilon_0\ \tan\delta\ (\epsilon_0 = 0.886 \times 10^{-13})$. From the ratio of the two deflections, putting $k = \sqrt{\alpha'/\alpha''}$, and with the known conductances G'_p and G''_p of the two rods, the resonance resistance is obtained from the easily derived formula $R_p = (1 - k)/(kG'_p - G''_p)$. Measurements with $\lambda = 14$ cm on a box-shaped cavity of length 100 mm and diameter 107 mm gave resonance-resistance values of 6.0, 6.0, and 6.3×10^6 ohms when measured with the rod combinations quartz-ardostan, calit-ardostan, and quartz-calit respectively. The theoretical value for this resonator was $R_p = 8.6 \times 10^6$ ohms.

" If the above method, illustrated by application to a circular-sectioned cylindrical cavity resonator, is applied to a concentric-tube line closed at both ends, thin dielectric circular discs are introduced between the inner and outer conductors at the point of measurement."

2756. THE IMPEDANCE OF HOLLOW WAVE-GUIDES [and Its Measurement : and the Measurement of Dielectric Constants & Absorption]. —Flint & Pincherle. (*See* 2628.)

2757. A METHOD OF DIELECTRIC-CONSTANT MEASUREMENT AT WAVELENGTHS AROUND 10 CM. —Middleton. (In paper dealt with in 2661, above.)

2758. THE MEASUREMENT OF ANOMALOUS DISPERSION IN OPAQUE DIELECTRICS [by determining Brewster's Angle by Reflection of Polarised Light from a Polished Surface : Constant-Deviation Optical System & Integrating Photoelectric Device (Multiplier-Photocell controlling Multivibrator) making Ultra-Violet Measurements possible (in contrast to Pfund's Method, 651 of 1942)]. —A. W. Lawson. (*Review Scient. Instr.*, Feb. 1943, Vol. 14, No. 2, pp. 38–43.)

2759. Determination of Optical Constants [Conductivity & Dielectric Constant] of Metals by Reflectivity Measurements [using the Electromagnetic Equations to yield Graphical Method of Working Out.]—J. R. Collins & R. O. Bock. (*Review Scient. Instr.*, May 1943, Vol. 14, No. 5, pp. 135–141.)

2760. Determination of the Coefficients of Self and Mutual Inductance of Coils by the Steady-Deflection Method, using the Rotating Commutator [Self-Inductance of 1 mH measured within about 1%].—A. V. Telang. (*Sci. Abstracts*, Sec. B, June 1943, Vol. 46, No. 546, p. 108.)

2761. New Formulas for Calculating Short-Circuit Stresses in Bus Supports for Rectangular Tubular Conductors, *and* New Formulas for the Inductance and Reactance of Square Tubular Conductors.—T. J. Higgins. (*Journ. Applied Phys.*, March 1943, Vol. 14, No. 3, pp. 151–154: April, No. 4, pp. 185–187.) *See* also 2762, below.

2762. Formulas for the Geometric Mean Distances of Rectangular Areas and of Line Segments ["Seemingly Not to be Found in the Existent Literature"].—T. J. Higgins. (*Journ. Applied Phys.*, April 1943, Vol. 14, No. 4, pp. 188–195.)

2763. 260- to 350-Megacycle Converter Unit for General Electric Frequency-Modulation Station Monitor.—Summerhayes. (*See* 2855.)

2764. Standard-Signal Generator [Type 805–A: 16 kc/s to 50 Mc/s: primarily for Use in Quantity Production of Receivers for Armed Forces: Ruggedness combined with High-Quality Performance]. — General Radio. (*Review Scient. Instr.*, Feb. 1943, Vol. 14, No. 2, pp. 53–54.)

2765. Oscillators for testing Radio Receivers in Association with a Cathode-Ray Oscillograph.—V. G. Dubenetski. (*Izvestiya Elektroprom. Slab. Toka*, No. 4/5, 1940, pp. 24–32.)

The operation of the R.C.A. type T.M.V. frequency-modulated oscillator for testing amplifiers with band-pass filters is discussed. A similar oscillator, type G.S-1, developed in Russia is also described.

2766. Variable-Frequency Bridge-Type Frequency-Stabilised Oscillators. — Shepherd & Wise. (*See* 2670.)

2767. Force-Constants and Normal Modes of the Totally Symmetric Vibrations in α-Quartz at Room Temperature.—B. D. Saksena. (*Sci. Abstracts*, Sec. A, June 1943, Vol. 46, No. 546, p. 112.)

2768. The "Mitnahme" [Pulling-into-Tune] of Self-Excited Oscillations, and its Technical Utilisation [in Various Synchronising Arrangements].—Kirschstein. (*See* 2679.)

2769. Arrangement for the Production of a Direct Voltage proportional to Frequency [but Independent of Amplitude].—Brown Boveri. (*See* 2668.)

2770. A Method of Measuring the Effectiveness of Electrostatic Loop Shielding.—Foster & Finnigan. (*See* 2723.)

2771. The Microlineometer.—E. F. Travis. (*Gen. Elec. Review*, June 1943, Vol. 46, No. 6, pp. 345–348.)

"*Micro* from microseconds, *line* from linearity, plus *meter* gives *microlineometer*—a crystal-controlled frequency standard and square-wave generator designed primarily for the production testing of servo sweep generators in wide-band cathode-ray oscilloscopes, but also having many other applications": such as the measurement (in conjunction with a servo sweep generator) of the time delay in transmitting a pulse through a transmission line: in solving the problem of terminating a transmission line correctly: etc. A particular "servo sweep generator" (sweep generator synchronised with a short-duration phenomenon which is recurrent but not necessarily with a constant recurrent rate) is shown in Fig. 3.

2772. Insulation Testing of Electric Windings [with Description of Equipment].—C. M. Foust & N. Rohats. (*Elec. Engineering*, Jan. 1943, Vol. 62, No. 1, p. 30: summary only.)

2773. Voltage Surge and Fourier Spectrum in High-Voltage Engineering [and the Distortions produced by Retarding Cables, etc.].—H. Samulon. (*Bull. de l'Assoc. Suisse des Élec.*, 19th May 1943, Vol. 34, No. 10, pp. 279–291: in German.)

2774. On the Voltage Distortion in High-Voltage Test Equipment [and the Frequent Errors due to Its Neglect: Method of Testing the Suitability of Generators].—K. Andresen. (*Arch. f. Elektrot.*, 30th Sept. 1942, Vol. 36, No. 9, pp. 541–555.)

2775. Two New Electrostatic Voltmeters for High and Low Voltages [*e.g.* Ranges of 13–15 kV and 0–300 or 500 V].—M. Nacken. (*Arch. f. Elektrot.*, 30th Nov. 1942, Vol. 36, No. 11, pp. 678–686.)

In a previous paper (2055 of 1939) the effectiveness of electrostatic and electrodynamic restoring forces was reported on in connection with a method of linking to the voltage standard, without recourse to any absolute mechanical comparison procedure, measurements of voltages of arbitrary height; and of doing this with extremely high sensitivity and with an accuracy in accordance with that of the most sensitive measuring methods. Owing to the changes in the course of the lines of force involved in any movement of the system, the electrostatic controlling forces cannot be represented in a simple and clear form, and methods of approximation are therefore called in. A much employed method, consisting in the development of the capacitance change into a power series, yields the value of voltage at which the electrometer system becomes unstable. Another method of approximation, developed in the present paper, gives not only the voltage value for instability but also the corresponding pointer position, which is found to bear an unvarying relation to the electrode spacing.

De-stabilising controlling forces acting on a moving system in opposite directions lead to a distortion of the scale which yields an extensive compression of the bottom-of-the-scale deflection and a high sensitivity for small voltage-differences. This property is made use of in the instrument shown in part in Fig. 9; the symmetrical horizontal arm, carrying a circular flat disc at either end, is suspended at the mid-point of a stretched vertical ribbon: one disc moves in a damping cylinder, the other between two flat plates, electrically connected, whose opposed actions on the moving disc are discussed (with the help of Fig. 6) on pp. 682–683. The resulting curve is shown in Fig. 10, in comparison with that of a square-law instrument: a deflection of 2 cm (mirror and light-spot indication) is only reached at 13 kv, the full-scale deflection of 30 cm at 15 kv: at the higher voltages a difference of 1 volt can be read. Both the outside electrodes can be adjusted so as to vary the range and scale-character of the instrument. "The apparatus can perform good service in the sensitive monitoring of voltage-constancy in high-voltage systems, and in combination with photoelectrically controlled devices constitutes a high-voltage relay of high sensitivity. In the laboratory, too, it has many uses for precise measurements in the neighbourhood of some fixed voltage, for example in the determination of striking-voltage fluctuations."

On the other hand, a superposition of the stabilising and de-stabilising controlling forces can be employed to produce a linear scale, and this (with the accompanying high initial sensitivity) is used in the instrument illustrated in Figs. 11–14. Here again the horizontal arm carrying a disc at either end is suspended by a stretched vertical ribbon: but in this design each of the discs moves in a hollow cylinder, closed at one end and insulated from the base-plate, which is itself insulated in the earthed metal case seen in Fig. 13. Mirror and light-spot indication is again employed. "The calibration curves of instruments with the range 0–300 v and 0–500 v are shown in Fig. 14. The range can be extended by the factor $\sqrt{2}$ by the use of only one half of the system, the design being symmetrical. The second instrument [0–500 v; curve "a"] shows a completely linear scale, apart from a narrow region at the lower end. The arrangement of the discs in the hollow cylinders gives such an effective air damping that the movement of the system is aperiodic. Because of its simple construction and the comparatively large forces involved, the instrument indicates with great accuracy. The spot comes to rest in less than one second."

2776. AN [Electronic] INSTRUMENT FOR THE DETERMINATION OF CONTACT MAKING AND BREAKING TIME.—W. Richter & W. H. Elliott. (*Elec. Engineering*, Jan. 1943, Vol. 62, No. 1, Transactions pp. 14–16.)

2777. A SIMPLE DEVICE FOR MEASURING THE TIMES OF OPERATION AND RELEASE OF A RELAY.—B. S. Sotskov. (*Izvestiya Elektroprom. Slab. Toka*, No. 6, 1940, pp. 64–67.)

In this device a circuit in which a condenser C charging through a resistance R serves as a time-measuring element, and a neon lamp as an indicator. R and C are so adjusted as to prevent the lamp from striking, and from these values the time constants can be determined. The accuracy of the device is of the order of 1 msec.

2778. NOTE ON "THE TESTING OF MAGNETIC MATERIALS, USING A CATHODE-RAY OSCILLOGRAPH WITH ELECTROSTATIC DEFLECTION ONLY" [3664 of 1942].—K. Kreielsheimer. (*Journ. of Scient. Instr.*, Feb. 1943, Vol. 20, No. 2, p. 32.)

2779. SUMMATION CIRCUITS WITH CURRENT TRANSFORMERS [in Measuring Technique, for dealing with the Sum of the Currents in Two or More Circuits: Calculation of the Current & Phase Errors as Functions of the Errors of the Individual Transformers].—H. Edler. (*Arch. f. Elektrot.*, 31st Dec. 1942, Vol. 36, No. 12, pp. 743–750.)

2780. THE LOCUS CIRCLE LAW [including Its Application to A.C. Bridge Balancing].—Basch. (*See* 2682.)

2781. AN A.C. BRIDGE [with Balance Equation $L = CR^2$, at All Frequencies, including Zero].—B. Petree. (*Elec. Engineering*, Jan. 1943, Vol. 62, No. 1, p. 49.)

2782. RAPID NON-DESTRUCTIVE MATERIAL TESTING [Bridge for detecting Slight Differences in Magnetic, Conductive, & Dielectric Properties of Two Samples placed in Inductance Coils].—W. A. Knoop. (*Sci. Abstracts*, Sec. B, June 1943, Vol. 46, No. 546, p. 110.)

2783. A VARIABLE-RATIO-ARM CONDUCTIVITY BRIDGE [Accuracy within about 0.01% over a Range of One Million Ohms (extensible to Ten Million with only Slight Loss in Accuracy)].—W. F. Luder. (*Review Scient. Instr.*, Jan. 1943, Vol. 14, No. 1, pp. 1–3.)

2784. A NEW CONDUCTIVITY BRIDGE [Range in Ohms 0.2–250 000: primarily for Plant-Research Liquids].—Fisher Scientific. (*Review Scient. Instr.*, Feb. 1943, Vol. 14, No. 2, pp. 52–53.)

2785. A VERSATILE OIL-TESTING CELL OF NOVEL DESIGN [Inexpensive Cell for Routine Determinations of Electrical Properties of Oils, Liquid Dielectrics, Plasticizers, etc.].—T. Hazen. (*Review Scient. Instr.*, May 1943, Vol. 14, No. 5, pp. 141–143.) Fulfilling, for routine purposes, the duties of the more expensive precision-type cells (*e.g.* the Hartshorn–Rushton design, 753 of 1940).

2786. A Tuned Null-Detector [eliminating Volume Adjustment by compressing a Volume Range of over 100 db into the Variation of the Reading of a Simple Milliammeter, and with Simple Tuning without Calibration Charts or Curves).—F. B. Anderson. (*Bell Lab. Record*, June 1943, Vol. 21, No. 10, pp. 347–351.)

2787. Note on a Method for Measuring Small Electric Charges [of order of 1.5×10^{-11} Coulomb, with Probable Error of about 1%: primarily for Measurements of Ionisation in Air produced by X-Rays].—R. M. Showers. (*Review Scient. Instr.*, Feb. 1943, Vol. 14, No. 2, pp. 35–37.) At higher sensitivities (about 10^6 electrons instead of the above 10^8) the accuracy is within about ± 20%.

2788. "Elektrische Messgeräte: Genauigkeit und Einflussgrössen" [Electrical Measuring Instruments: Accuracy & the Factors affecting It (Temperature, Stray Fields, etc.): Book Review].—R. Langbein & G. Werkmeister. (*Bull. de l'Assoc. Suisse des Élec.*, 19th May 1943, Vol. 34, No. 10, p. 304.) An enthusiastic review.

2789. Terminal Corrections for Temperature Tests on Short Conductors.—W. N. Goodwin, Jr: Bauer & Taylor. (*Elec. Engineering*, Jan. 1943, Vol. 62, No. 1, p. 49.) Bauer & Taylor's method (838 of March) is only correct for sufficiently long conductors: Goodwin quotes the full equation from his paper on "The Compensated Thermocouple Ammeter" (1543 & 2338 of 1936).

2790. Standards for Thermo-Elements and Their Accessories [for Temperature Measurement: Agreement between German Manufacturers].—C. Sieber. (*E.T.Z.*, 22nd April 1943, Vol. 64, No. 15/16, pp. 226–228.)

2791. Observational Standards [for Glossiness of Surface, Flaws & Coverage of Finish on Resistors & Condensers, etc.].—T. C. M. Woodbury. (*Bell Lab. Record*, Sept. 1941, Vol. 20, No. 1, pp. 13–14.)

2792. Proposal for the Extension of Our System of Mensuration ["*qD*" as Unit of Length].—Bingham. (*See* 2881.)

SUBSIDIARY APPARATUS AND MATERIALS

2793. On Dioptric Electron-Optical Apparatus with Arbitrarily Curved "Optical" Axes.—Wendt. (*Zeitschr. f. Phys.*, 6th April 1943, Vol. 120, No. 11/12, pp. 720–740.)

"There are already a few electron-optical devices in which the 'optical' axis is not straight (as for a series of centred lenses with rotational symmetry) but curved: for instance the Coeterier–Teves arrangement ["image converter," 1045 of 1937], in which the object and image planes are at right angles, and the mass spectograph. Except for the latter, which requires no stigmatic and geometrically correct image formation, electron-optical devices with curved axes have attained little importance. This may well be attributed chiefly to an at present incomplete mastery of the image-formation laws of such arrangements. A theory would seem to be needed which would allow the design of the image-forming organ, necessary for the production of a distortionless image, to be determined in a simple manner; which would cover the dioptric laws of such an image-formation; and which would calculate the cardinal quantities [focal lengths, principal planes, etc.] and give information as to the aberrations occurring. The setting-up of such a theory is the object of the present work, though the calculation of the aberrations will be left to a later paper."

2794. New Oscilloscope with Wide Frequency-Range for Industrial Measurements [Frequency Response ± 3 db from 20 c/s to 2 Mc/s: Linear Sweep from 50 c/s to 350 kc/s].—Radio City Products. (*Scient. American*, April 1943, Vol. 168, No. 4, pp. 184–185.)

2795. Rapid Processes in the Mercury-Vacuum Arc, measured with a Newly Developed High-Voltage Cathode-Ray Oscillograph [Full Description of the Munich Oscillograph with a Max. Recording Speed ($S = 0.04$) of about 70 000 km/s: with 0.5 mm Spot Diameter, Resolving Power (given by Number of Trace-Widths per Second) 14×10^{10}/s: Application to Extension of Mierdel's Work, 1165 of 1937].—Engelbrecht. (*Arch. f. Elektrot.*, 30th Sept. 1942, Vol. 36, No. 9, pp. 515–540.)

2796. Three New Cathode-Ray Tubes.—R.C.A. (*Journ. Applied Phys.*, April 1943, Vol. 14, No. 4, p. 200.)

2797. The Cathode-Ray Oscillograph applied to Long-Time Switching Transients [Development of Simple & Inexpensive Portable Equipment with Two Low-Voltage Tubes, Film Drum, etc.].—Dunlap & Rohats. (*Elec. Engineering*, May 1943, Vol. 62, No. 5, Transactions pp. 231–234.)

2798. A "Memory" Unit for Use with an Oscillograph for studying Arc-Backs in Ignitrons [Small Motor converted into a Capacitive Charge-Storer to repeat the Ignitron Actions to Oscillograph already set into Operation].—Pakala. (*Journ. Applied Phys.*, July 1943, Vol. 14, No. 7, p. viii.) Note on a Westinghouse device: *cf.* 2082 of 1942.

2799. The Latest in Magnetic Oscillographs [General Electric Type PM-10-B2, with Six or More Galvanometer Elements].—Geiser & Hancock. (*Gen. Elec. Review*, May 1943, Vol. 46, No. 5, pp. 289–294.)

2800. Electrostatic Electron-Microscopy : III [Illustration of Principles set out in Preceding Parts by Description of a Permanently Aligned Simplified Instrument with External Photography and a Resolving Power of about 200 AU].—Bachman & Ramo. (*Journ. Applied Phys.*, April 1943, Vol. 14, No. 4, pp. 155–160.) Final part of the series dealt with in 1950 of July : *see* also 1218 of April.

2801. Some Applications of the High Resolving Power of the Electron Microscope [including a Discussion of the " Four Arguments " against the Gain given by the Apparatus (" Unnatural State " indicated by Absence of Brownian Motion ; Depth of Focus ; etc.) : Some Comparisons with Photomicrographs]. — Green & Fullam. (*Journ. Applied Phys.*, July 1943, Vol. 14, No. 7, pp. 332–340.)

2802. Interpretation of Electron Micrographs of Silica Surface Replicas [also Formvar Replicas : the Great Value of Stereo-Pictures : Resolution (and the " Shape Limitation Factor ") : etc.].—Heidenreich. (*Journ. Applied Phys.*, July 1943, Vol. 14, No. 7, pp. 312–320.) For previous work *see* 543 of February.

2803. On Some Problems relating to Crystal Phosphors and Insulators.—Birus, Möglich, & Rompe. (*Physik. Zeitschr.*, 25th March 1943, Vol. 44, No. 6, pp. 122–129.)

" The quantum output of a crystal phosphor, given by the ratio of the number of light quanta re-emitted to the number absorbed, is characteristic of its luminescent activity. For a good phosphor it attains a value of 0.5 to 0.7, for a poor one it has a very low value. The study of the quantum output of a crystal phosphor can provide important information as to the structure of the luminophor in question. The fact, for instance, that the quantum output is of the order of magnitude of unity, and yet differs considerably from one, appears to prove that it is closely linked to the phosphor structure : in what manner, will be dealt with (together with other questions [such as the comparative importance of the rôles played by single and multiple collisions, and the decrease in quantum output with increased activator content]) in the following pages."

2804. The Mechanism of Luminescence of Phosphors [Measurements on Alkali-Halide Phosphor of Potassium Chloride activated by Thallium].—Antonov-Romanovskij. (*Journ. of Phys.* [of USSR], No. 3/4, Vol. 6, 1942, pp. 120–140 : in English.)

" The measurements of the decay law were carried out for a very prolonged (' complete ') and for a very short excitation, with various intensities of the exciting light. The influence of ' red ' light on the law of decay was also investigated. The results of the measurements show conclusively that, contrary to the current view [the 1938 Oxford Conference is cited here], the radiation of these phosphors is of a recombination and not of metastable character [so that alkali-halide phosphors do not, as usually accepted, represent a separate class of metastable phosphor but must be referred to the same class as the alkaline-earth phosphors]. Depending on the conditions of excitation, the decay can proceed, in general, either according to the bimolecular or the monomolecular scheme." Among the results of the tests with red light, the effect of such irradiation, in producing a quenching effect when applied in the initial stages of decay and an acceleration of the process of luminescence (increased brightness) when applied in the later stages, is brought out definitely.

2805. On the Luminescence of Fluor-Spars [Measurements, in the Ultra-Violet & Visible Regions, of the Fluorescent Spectra of Various Natural CaF_2 Crystals, at Room Temperature & at + 180°C (to increase Radiation) : Decay Characteristic is Hyperbolic].—Rwatschew. (*Journ. of Phys.* [of USSR], No. 3/4, Vol. 6, 1942, pp. 141–144 : in German.)

The fluorescence in the ultra-violet spectrum was measured by a special cylindrical light counter whose " dark " pulses did not exceed one per minute on the average. Excitation was by X-rays. " The hyperbolic law of the decay of fluorescence of fluorspar leads to the conclusion, according to Antonov-Romanovskij's ideas, that the photochemical reaction is a bimolecular one."

2806. The Microlineometer [for the Production Testing of Servo Sweep Generators for Wide-Band Cathode-Ray Oscillographs].—Travis. (*See* 2771.)

2807. A Synchronised Calibrator for Sweep and Gain in Cathode-Ray Recording [particularly for Periodic Single or Independent Multiple Sweeps : primarily for Nerve-Potential Study].—Talbot. (*Review Scient. Instr.*, June 1943, Vol. 14, No. 6, pp. 184–186.)

" A circuit is described comprising an *RC* oscillator and multivibrator which generate three timing scales suited to calibrate a wide range of sweep speeds. In addition, a square pulse with adjustable duration is provided to calibrate the gain and to record the frequency characteristics of an amplifier. Both calibrations are synchronised with the sweep."

2808. A Thyratron Commutator for Cathode-Ray Oscillographs.—Gordienko. (*Izvestiya Elektroprom. Slab. Toka*, No. 6, 1940, pp. 50–58.)

An equipment is described for obtaining on the screen of a cathode-ray tube the image corresponding to a number of simultaneous oscillatory processes. It consists essentially of the following three parts :—(1) Input amplifier valves (one per channel ; Fig. 1). The valves have a common anode-resistance across which the complex voltage is developed. At any instant only one valve is operating, the others being locked by grid bias. (2) A thyratron " ring," similar to that proposed by Wynn-Williams (1931 Abstracts, p. 572) for controlling the amplifier valves : each valve is controlled by a separate thyratron. (3) Relaxation oscillator for controlling the thyratron ring. The operation of the set is discussed and a description is given, including a circuit diagram, of a model for four channels (Figs. 7 and 8). Several possible applications of the apparatus are suggested and a number of experimental oscillograms are shown.

2809. Surge-Generator Circuits [Development of Formulae].—Fisher. (*See* 2678.)

2810. Voltage Stabiliser for Electron-Diffraction Power Supply.—Bauer & others. (*Review Scient. Instr.*, Feb. 1943, Vol. 14, No. 2, pp. 30–32.) Circuit and performance of a stabiliser slightly modified from that of Parratt & Trischka (1489 of 1942).

2811. An Electromagnetic Voltage Regulator Independent of Frequency Variations.—Nikiforov. (*Izvestiya Electroprom. Slab. Toka*, Nos. 4/5 & 6, 1940, pp. 72–78 & 61–62.)

An analysis is given of the operation of the existing types of electro-magnetic voltage regulators using a saturated choke and a condenser, and it is shown that their operation is greatly affected by the frequency variations of the supply. Consequently a new circuit is proposed employing essentially two series-connected circuits of which the first consists of a capacity C_1 connected in parallel with an inductance L_1 (non-saturated choke with an air gap) and the other of a capacity C_2 connected in parallel with an inductance L_2 (saturated choke) followed by a resistance R (Fig. 4). The windings L_1 and L_2 are wound in opposition. The operation of this regulator is analysed and it is shown that if the frequency of the supply varies by ± 4% the regulated voltage will vary by from ± 0.1% to ± 0.2%. The discussion includes the operation of the regulator with a rectifier. A practical circuit for the regulator (Fig. 11) is also suggested.

2812. A New Laboratory Cement [High-Pyseal, companion to Pyseal (developed to replace Picein)].—Fisher Scientific. (*Review Scient. Instr.*, May 1943, Vol. 14, No. 5, p. 154.)

2813. Ignition-Channel Cross Section and the Ignition Process with Irradiation of Limited Cross Section.—Fucks & Bongartz. (*See* 2654.)

2814. Papers on the Effect of High Electrostatic Fields upon the Vaporisation of Molybdenum and Platinum Filaments.—Estabrook: Reid. (*See* 2733.)

2815. On Certain Peculiarities of the Operation of an Oxide Cathode in Mercury Vapour.—Ivanov. (*Izvestiya Elektroprom. Slab. Toka*, No. 4/5, 1940, pp. 39–42.)

Continuing 2221 of August, a report is presented on an experimental investigation in which various measures for preventing the crumbling of the oxidised layer were tested. It is stated in conclusion that while the phenomenon cannot be prevented altogether, a considerable improvement can be achieved if certain precautions are taken in the manufacture and operation of this cathode.

2816. Rectification with Imperfect Rectifiers.—Sattler & Zwiesler. (*See* 2689.)

2817. Discussion on "The Characteristics and Applications of the Selenium Rectifier."—Richards. (*Journ. I.E.E.*, Part II, Aug. 1942, Vol. 89, No. 10, pp. 371–372.) Continued from 3704 of 1942.

2818. Instrument Rectifiers [New Series of Selenium Rectifiers in 20 Sizes, Output 1 to 130 mA].—Selenium Corporation. (*Review Scient. Instr.*, April 1943, Vol. 14, No. 4, p. 119.)

2819. Semiconducting Properties of Stannous Sulphide [Experimental Investigation].—Clark & Anderson. (*Nature*, 17th July 1943, Vol. 152, No. 3846, pp. 75–76.)

2820. Frictional Phenomena: XIII—Internal Friction in Solids [Quantitative Definition of Internal-Friction Losses: Experimental Determination & Some Results: Chief Mechanisms leading to Internal Friction (Thermal & Plastic Processes): Behaviour of Losses as Function of Vibration Frequency, and Its Physical Basis].—Gemant. (*Journ. Applied Phys.*, May 1943, Vol. 14, No. 5, pp. 204–216.) *See* also 2821, below.

2821. Frictional Phenomena: XIV—Technical Applications of the Internal Friction of Solids [including a Section on the Correlation between Internal Friction & Dielectric Losses in Insulating Materials, and a Comparison with the Cole and Wagner Viewpoints].—Gemant. (*Journ. Applied Phys.*, June 1943, Vol. 14, No. 6, pp. 258–270.) For some previous parts *see* 2166 of August, and 2820, above.

2822. Breakdown and Time-Lag of Dielectric Materials.—Attwood & Bixby. (*Journ. Franklin Inst.*, March 1943, Vol. 235, p. 259 onwards.)

2823. The Control, Specialised Testing, and Use of Some Modern Insulating Materials.—Dunton. (*Electrician*, 23rd April 1943, Vol. 130, No. 3386, pp. 422–423.) Summary of I.E.E. paper and Discussion.

2824. The Fundamental Problem of the Theory of Viscous Fluids, *and* The Viscosity of Dilute Solutions of Long-Chain Molecules: V—Dependence on the Solvent.—Putman: Huggins. (*Journ. Applied Phys.*, May 1943, Vol. 14, No. 5, pp. 244–245: pp. 246–248.)

2825. Investigations on the Mechanical Strength of Moulded Synthetic Materials, *and* On the Influence of Production Conditions on the Structure and Tearing Strength of Moulded Parts of Synthetic Materials.—Frischmuth: Grimm. (*Schweizer Arch. f. angew. Wiss. u. Tech.*, Jan. 1943, Vol. 8, No. 1, pp. 24–35: Feb. 1943, No. 2, pp. 55–59: both in German.)

2826. Organic Plastics as Insulating Materials [New Types & Improved Manufacturing Techniques of Older Types have Increased Their Importance : Electrical Characteristics].—Delmonte. (*Elec. Engineering*, Jan. 1943, Vol. 62, No. 1, pp. 19–23.)

2827. Recent Developments in Organic Plastics for Electrical Insulation.—Hazen. (*Elec. Engineering*, May 1943, Vol. 62, No. 5, pp. 191–197.)

2828. Extruded Plastic Tubing [Various "Tulox" Types, " free from Longitudinal Strain " and therefore giving Screw Machine Parts superior to Those made by Injection Moulding].—(*Review Scient. Instr.*, May 1943, Vol. 14, No. 5, pp. 154–155.)

2829. The Spots on Mica (Muscovite) and Their Effect on Its Electrical Properties.—Golovinskaya & Mikhaylov. (*Izvestiya Elektroprom. Slab. Toka*, No. 4/5, 1940, pp. 67–71.) A report with tables and graphs on tests on different kinds of mica.

2830. Pyrex Brand Multiform Glassware [with Various Data & Comparison with Other Insulating Materials].—Corning Glass. (*Review Scient. Instr.*, May 1943, Vol. 14, No. 5, pp. 155–156.) *See* also 2497 of September.

2831. Ceramics for High-Frequency Insulation [Advantages of Steatite Ceramics].—Rigterink. (*Bell Lab. Record*, May 1943, Vol. 21, No. 9, pp. 290–293.) For a long paper *see* 839 of 1942.

2832. A Ceramic " Replacement " Material [Advantages of " Prestite " in Various Applications].—Westinghouse. (*Review Scient. Instr.*, May 1943, Vol. 14, No. 5, p. 155.) *See* also 2390 of September.

2833. Investigation of Ceramic Materials by Optical and X-Ray Analysis.—Rosenthal. (*Sci. Abstracts*, Sec. A, June 1943, Vol. 46, No. 546, p. 123.) From *Electronic Eng:g*, Jan. 1943.

2834. Insulating Materials for Very High Voltage Cable Technique [Papers & Oils : a Survey].—Wallraff. (*E.T.Z.*, 19th Nov. 1942, Vol. 63, No. 45/46, pp. 539–544.)

2835. The Electrical Breakdown in Insulating Oil [Comparison at 165 kc/s and 50 c/s : Influence of Electrode Gap, Temperature, Vertical or Horizontal Electrode Arrangement, and Time : Discussion of the Various Breakdown Theories].—Hähnel. (*Arch. f. Elektrot.*, 31st Dec. 1942, Vol. 36, No. 12, pp. 716–734.)

Among other results, " it was found, contrary to expectation, that the breakdown strength of oil under h.f. voltage was greater, for small electrode gaps, than under 50 c/s voltage. The gap length at which the h.f. breakdown voltage was the same as the 50 c/s voltage became larger as the temperature was lowered."

2836. Three New Insulating Alternates for Varnished Silk [Varnished Rayon, Cotton Cloth, & Nylon].—(*Journ. Applied Phys.*, April 1943, Vol. 14, No. 4, p. 199.)

2837. The New Test Procedures for Enamelled Wire : an Introduction to D.I.N. E 92 112 [made necessary by New Types of Enamel due to War Conditions].—Crebert. (*E.T.Z.*, 2nd Oct. & 5th Nov. 1942, Vol. 63, Nos. 41/42 & 43/44, pp. 503–504 & 528.)

2838. Symposium on Protective Finishes for Scientific Instruments and Apparatus : Foreword : Protective Chemical and Surface Finishes : The Anodic Oxidation of Aluminium and Aluminium Alloys : Protective Paints and Varnishes.—Philpot : Sutton : Bovey : Wornum. (*Journ. of Scient. Instr.*, June 1943, Vol. 20, No. 6, pp. 85–102.)

2839. " Surface Finish " [Book Review].—Schlesinger. (*Journ. of Scient. Instr.*, June 1943, Vol. 20, No. 6, pp. 102–103.) " It is understood that the British Standards Institution will shortly issue a specification for measuring surface finish based on this report."

2840. Conservation of Defence Materials in the Bell System.—(*Bell Lab. Record*, Sept. 1941, Vol. 20, No. 1, pp. 9–12.)

2841. Alternative Materials [Note on " Metrelite," for the Screening of Interference, etc.].—Runcolite, Ltd. (*See* 2712.)

2842. The Utilisation of Aluminium in Electrical Engineering [including " Cupal "].—Streiff. (*Sci. Abstracts*, Sec. B, June 1943, Vol. 46, No. 546, p. 104.) For the use of Cupal in u.h.f. technique and elsewhere *see* 3745 of 1942.

2843. Indium [Its Properties & Uses : Electrical Contacts : Brazing & Soldering Alloys : etc.].—(*Review Scient. Instr.*, June 1943, Vol. 14, No. 6, pp. 191–192.) One of the five " unrestricted " metals.

2844. New Stackpole Iron Cores for Use up to 150–175 Mc/s [Moulded Cores with Permeabilities of about 5 and High " Q "].—Stackpole Carbon. (*Review Scient. Instr.*, Feb. 1943, Vol. 14, No. 2, p. 53.)

2845. Fer-Ha, a New Swiss Product [to overcome Difficulties in importing Compressed-Powder Cores].—Hasler Company. (*Bull. de l'Assoc. Suisse des Élec.*, 19th May 1943, Vol. 34, No. 10, p. 301.) No details are given.

2846. REGIMENTING ATOMS: IN SEARCH FOR BETTER TRANSFORMER CORES [Westinghouse Researches].—Siegel. (*Scient. American*, Feb. 1943, Vol. 168, No. 2, p. 60.)
Continuation of the work which resulted in the development of Hipersil.

2847. THE USE OF ELECTROLYTIC METHOD IN STUDYING MAGNETIC FIELDS.—Lukoshkov. (*Izvestiya Elektroprom. Slab. Toka*, No. 4/5, 1940, pp. 32–38.)

It is shown that if the equipotential lines and lines of force of a system consisting of two conductors and two insulators are plotted with the aid of an electrolytic bath, then the same diagram will apply if the conductors and insulators are interchanged, except that the equipotential lines will become the lines of force and *vice versa* (Figs. 1 and 2). The proof is extended to cover the case of a system consisting of three conductors and three insulators (Figs. 3 and 4), but could be shown to hold good for any system of *n* conductors and insulators. On the basis of this discussion, methods are proposed for studying magnetic fields and determining (by using models) the current distribution on the surface of conductors in a h.f. furnace. As an example, a cylinder surrounded by a ring through which the h.f. current is passed (Fig. 7) is considered. The methods proposed can be used for determining the shape of induction elements necessary for obtaining the desired current distribution on the surface of conductors.

2848. A NEW METHOD FOR THE THEORETICAL INVESTIGATION OF THE MAGNETIC FIELD OF ELECTROMAGNETS [primarily for Electromagnetic Separators].—Sotchnev [Sochnev]. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 10th Oct. 1941, Vol. 33, No. 1, pp. 24–27: in English.)

" The existing methods . . . are either very complicated, or their application is connected with a series of *a priori* and not always adequate assumptions, owing to which they often fail to give reliable and practically applicable results . . . The method proposed by the writer is to a great extent free from the drawbacks of the old methods." The primary application is to multipolar magnets, but magnets in which one pole face is "rifled," and the other either smooth or with hollows under the rifling ridges, are also considered. *See* also 3603 of 1936 and 260 of 1942.

2849. ESTIMATION OF HARMONICS IN D.C.-POLARISED IRON-CORE CHOKES.—Hartel. (*See* 2687.)

2850. FACTORS AFFECTING THE DESIGN OF D.C. MAGNETS.—Rader. (*Elec. Engineering*, June 1943, Vol. 62, No. 6, Transactions pp. 307–310.)

The new requirements imposed by the present vital use of d.c. controls in mobile equipment (*see* for example Russell & Charbonneau, *Elec. Engineering*, July 1943, p. 316) is stressed, together with the lack of assistance in design in the literature. " The usual types of steel used are briefly discussed, including their influence on 'sticking' or residual forces. Calculated curves are presented which show the influence of pole-face area on the force developed by the magnet. Flux measurements on a number of magnets show that theoretical calculations are often in great error because of factors such as leakage and saturation which are usually neglected. Data show that the flux in a d.c. magnet with a small air-gap may vary by as much as 300% between one part of the circuit and another." There is a best pole-face area for max. pull, varying with the air-gap and applied ampere-turns. The use of a ballistic galvanometer for d.c. design is urged.

2851. AN IMPROVED FORM OF SENSITIVE RELAY [Limitation on Performance, by Force required to Separate the Contacts, removed by Provision of Alternative Path for Relayed Current, when Relay closes, and by Periodic Separation of Contact Points].—Legallais. (*Review Scient. Instr.*, Feb. 1943, Vol. 14, No. 2, pp. 51–52.)

2852. NEW LITTLEFUSE INDICATOR OPERATES BY REFLECTED LIGHT [Solenoid-Operated "Signalette" (indicating by Reflected Light, "Black" Light, & Fluorescence) takes 1.5 W compared with 4.5 W of Usual Indicator Lamps: primarily for Aircraft].—(*Proc. I.R.E.*, May 1943, Vol. 31, No. 5, p. xlii.) *See* also p. lxii.

2853. "ACCUMULATOR CHARGING: EIGHTH EDITION" [Book Notice].—Ibbetson. (*Wireless World*, July 1943, Vol. 49, No. 7, p. 211.)

STATIONS, DESIGN AND OPERATION

2854. SKIN EFFECT IN BIMETALLIC CONDUCTORS [*e.g.* Copper-Covered Steel Lines for Carrier Currents up to 160 kc/s].—Teare & Webb. (*See* 2690.)

2855. 260- TO 350-MEGACYCLE CONVERTER UNIT FOR GENERAL ELECTRIC FREQUENCY-MODULATION STATION MONITOR.—Summerhayes. (*Proc. I.R.E.*, June 1943, Vol. 31, No. 6, Part I, pp. 249–253.)

For converting the u.h.f. signals down to 5.4 Mc/s for measurement and indication by the already existing f.m. monitor designed for use in the 42–50 Mc/s u.s.w. broadcasting band. The service record of the units already installed has been entirely satisfactory.

" There is a border line of frequency somewhere in the region of 30 to 300 Mc/s where it becomes uncertain for any particular application as to which type of structure, lumped constant or distributed constant, may be used to the best advantage. In this paper an application is described in which especially designed lumped-constant variable inductors are used to tune a 260–350 Mc/s mixing circuit. This application represents a border-line case where it is felt that the lumped-constant elements have been pushed to the maximum frequency of their usefulness and yet where they still exhibit the advantage of small size and ease of tuning over a range, as compared with transmission-line structures." The inductors consist essentially of a standard variable air condenser in which the central portion of the stator plates has been removed, leaving only the outer edges, so that each stator plate forms a one-turn coil (Fig. 3); the inductance is progressively reduced by turning the rotor plates to increase the coupling, thereby introducing in effect a short-circuited secondary turn on each side of the inductance turn. Stator turns may be connected in series or parallel, or disconnected.

2856. The Possibility of using Frequency-Modulated Ultra-Short Waves for Radio Broadcasting.—A. D. Knyazev. (*Izvestiya Elektroprom. Slab. Toka*, No. 6, 1940, pp. 27–37.)

The difficulties in serving radio listeners in densely populated and industrial centres with a number of broadcasting programmes are pointed out and the possibility of using frequency-modulated ultra-short waves for this purpose is investigated. The peculiarities of ultra-short-wave transmission are considered and the applications of frequency-modulation technique to transmission and reception described. The advantages of frequency modulation over amplitude modulation are discussed. In conclusion it is stated that the method proposed ensures high-quality reliable reception with a choice of several programmes. This paper opens a discussion on the subject.

2857. Arrangement for Duplex Communication on Directed Short or Ultra-Short Waves.—Kriebel. (*Hochf:tech. u. Elek:akus.*, Jan. 1943, Vol. 61, No. 1, p. 29.)

A Telefunken patent, D.R.P.722 165. "When at least one station is mobile, and the position of the other station has to be determined by direction-finding before the establishment of communication, a longer wave (say 4 m) is sent out from an all-round aerial for this purpose, with a frequency differing from that of the service wave (say 50 cm) by the amount of the i.f. of the frequency-changing receiver which is used for both waves."

2858. Rebuilding TR-4s [Abbott TR-4 Transmitter–Receiver] for Non-Priority Tubes: Solving the Replacement Problem with Standard Receiving Types.—Mix. (*QST*, July 1943, Vol. 27, No. 7, pp.17–18 and 32.)

2859. An Economical Transmitter–Receiver for WERS.—Magee. (*QST*, June 1943, Vol. 27, No. 6, pp. 32–34.)

2860. CD–WERS in the State of Maryland: an Example of Centralisation of CD–WERS Activities at a State Headquarters.—McNulty. (*QST*, June 1943, Vol. 27, No. 6, pp. 25–27 and 78.) For a warning of the danger of interference by WERS signals with aircraft communications *see* Tilton, p. 90.

2861. German Radio Equipment [Series of M. A. P. Reports].—(*Sci. Abstracts*, Sec. B, June 1943, Vol. 46, No. 546, p. 118.)

2862. Coastal Radio Telephone Systems.—Pruden. (*Bell Lab. Record*, March 1943, Vol. 21, No. 7, pp. 183–187.) For an earlier paper *see* 3402 of 1942.

GENERAL PHYSICAL ARTICLES

2863. "The 'Particles' of Modern Physics" [Book Review].—Stranathan. (*Journ. Applied Phys.*, July 1943, Vol. 14, No. 7, pp. 365–366.)

2864. Relativistic Field Theories of Elementary Particles [with a Section on Applications (Bremsstrahlung, Pair Generation, Compton Effect, etc.)].—Pauli. (*Reviews of Mod. Phys.*, July 1941, Vol. 13, No. 3, pp. 203–232.)

2865. "Miscellaneous Physical Tables—Planck's Radiation Functions and Electronic Functions" [Book Review].—(*Journ. Applied Phys.*, July 1943, Vol. 14, No. 7, p. 369.) Sponsored by the National Bureau of Standards.

2866. Stochastic Problems in Physics and Astronomy [including a Chapter on Brownian Motion and a Section on the Escape of Particles over Potential Barriers].—Chandrasekhar. (*Reviews of Mod. Phys.*, Jan. 1943, Vol. 15, No. 1, pp. 1–89.)

"A common characteristic of all these problems is that interest is focused on a property which is the result of superposition of a large number of variables, the values which these variables take being governed by certain probability laws . . ."

2867. Further Facts concerning the Magnetic Current.—Ehrenhaft. (*Sci. News Letter*, 26th June 1943, Vol. 43, No. 26, p. 405: summary only.) An American Physical Society paper: for previous work *see* 1889 & 3408 of 1942 and 226 of January.

2868. A Theory of Gravitation ["making It a Push instead of a Pull, thus Avoiding the Bugbear of Action at a Distance: Core of the Earth as an Electronic Gas (explaining why It does Not transmit Transverse Earthquake Waves): Future Possibility of Prediction of Earthquakes].—Shneiderov. (*Science*, 7th May 1943, Vol. 97, No. 2523, Supp. p. 10.)

MISCELLANEOUS

2869. Concerning the Roots of $J'_n(x)N'_n(kx) - J'_n(kx)N'_n(x) = 0$.—Truell. (*See* 2662.)

2870. A Comparison of the Transform and Classical Methods.—Lyon. (*See* 2676.)

2871. On the Iterative Solution of Linear Simultaneous Equations [and Its Advantages: Schmidt's Method (566 of 1942) & a Suggested Alternative Process].—Freeman. (*Phil. Mag.*, June 1943, Vol. 34, No. 233, pp. 409–416.)

2872. Linear Partial Differential Equations with Analytic Coefficients [with Special Reference to the Uniqueness of Solutions of the Cauchy Problem, & to the Functional Character of the Solutions].—John. (*Proc. Nat. Acad. Sci.*, March/April 1943, Vol. 29, No. 3/4, pp. 98–104.)

2873. A Note on the Integration of Linear Second-Order Differential Equations by Means of Punched Cards.—Kormes. (*Review Scient. Instr.*, April 1943, Vol. 14, No. 4, p. 118.)

2874. Notes on a Controlled Type of One-Dimensional Motion: Solution of Second-Order Non-Linear Differential Equation, *and* Determination of Most Favourable Interval for the Numerical Integration of Systems of Differential Equations [of Importance as regards Interpolation Processes].—Bilharz: Collatz. (*Journ. Roy. Aeron. Soc.*, June 1943, Vol. 47, No. 390, pp. 295–296: p. 296.) R.T.P.3 Abstracts.

2875. A Method of Interpolation [applicable to Construction of a Cubic Curve to pass through Four Given Points].—Fry. (*ASTM Bulletin*, May 1943, No. 122, pp. 29–30.)

2876. "Table of the Coefficients of Everett's Central Difference Interpolation Formula" [Book Review].—Thompson. (*Phil. Mag.*, June 1943, Vol. 34, No. 233, pp. 431–432.) No. V of "Tracts for Computers."

2877. "Seven-Place Values of Trigonometric Functions for Every Thousandth of a Degree" [Book Review].—Peters. (*Journ. Applied Phys.*, May 1943, Vol. 14, No. 5, pp. 222–223.)

2878. Establishment of the *Quarterly of Applied Mathematics*, sponsored by Brown University.—(*Journ. Applied Phys.*, June 1943, Vol. 14, No. 6, p. 310.) The first issue is that of April 1943.

2879. The Application of Statistical Methods to the Quality Control of Materials and Manufactured Products [Symposium].—Belz, Cornish, & Stewart. (*Journ. Inst. Eng. Australia*, March 1943, Vol. 15, No. 3, pp. 53–62.)

2880. Increased Production through the Correct Organisation of the Work.—Böhrs. (*Zeitschr. V.D.I.*, 1st May 1943, Vol. 87, No. 17/18, pp. 233–239.)

2881. Proposal for the Extension of Our System of Mensuration [to cover Range from Microscopic Lengths to Astronomical: "qD" (on Analogy to "pH"), the Logarithm of the Length expressed in Centimetres, as Unit of Length: Application to Wire Gauges, etc.].—Bingham. (*Journ. Applied Phys.*, April 1943, Vol. 14, No. 4, pp. 196–198.)

The Angstrom unit thus becomes $\bar{8}.0000\ qD$, while the velocity of light is $10.4768\ qD/s$ and the distance of the Andromeda nebula is $23.833\ qD$.

2882. Rutherford: Life and Work to the Year 1919, with Personal Reminiscences of the Manchester Period [First Rutherford Memorial Lecture of the Physical Society].—Robinson. (*Proc. Phys. Soc.*, 1st May 1943, Vol. 55, Part 3, No. 309, pp. 161–182.)

2883. Why do Scientists and Philosophers so often Disagree about the Merits of a New Theory?—Frank. (*Reviews of Mod. Phys.*, July 1941, Vol. 13, No. 3, pp. 171–175.)

". . . This disagreement arises with necessity, for the 'established philosophical principles' are mostly 'petrifactions' of physical theories which are no longer appropriate to embrace the facts of our actual physical experience."

2884. The Fortieth Anniversary of the First Radio Link in Russia.—Petrovski. (*Izvestiya Elektroprom. Slab. Toka*, No. 4/5, 1940, pp. 78–79.)

"After the inventor of radio communication, Prof. A. S. Popov, made a report on his investigations to the Physico-Chemical Society of Petersburg on 5th May 1895 (Marconi's first patent application, No. 12039, is dated 2nd June 1896), no further developments took place for several years, mainly because the Russian Government was not interested in the invention." In December 1899, however, owing to a navigational error the battleship "Admiral Apraksin" ran aground near the island of Hokhland. In order to refloat the ship it was essential to establish telegraph communication with Kronstadt. The nearest telegraph station was at Kotka on the Finnish shore, 44 km away, and under the direction of Popov radio-communication was put into service between Hokhland and Kotka over the ice-bound sea. The first official telegram transmitted over the link, on 6th February 1900, was an order to the icebreaker "Ermak" to assist in the rescue of 50 fishermen stranded on a floating iceberg. "Ermak" ultimately succeeded in taking off 27 men.

2885. Science in Chungking.—Needham. (*Nature*, 17th July 1943, Vol. 152, No. 3846, pp. 64–66.)

2886. Maintain Post-War Research at War-Time Level.—Hooper. (*Proc. I.R.E.*, July 1943, Vol. 31, No. 6, Part I, p. 247.) An Editorial note calls attention to the importance of Admiral Hooper's recommendations.

2887. Radio Engineering in Wartime [including the Story of "Radio Timor"].—Fly. (*Proc. I.R.E.*, June 1943, Vol. 31, No. 6, Part I, pp. 303–304.)

2888. Address to the I.R.E. Conference.—Ashbridge. (*Proc. I.R.E.*, June 1943, Vol. 31, No. 6, Part I, pp. 302–303.)

2889. Correspondence concerning Proposed Constitutional Amendments to the I.R.E. [2268 of August].—(*Proc. I.R.E.*, June 1943, Vol. 31, No. 6, Part I, pp. 307–308.)

2890. Inventions, Patents, and the Engineer [with Special Reference to the U.S. Patent Laws, and the Accusation of Suppression of Patents].—Crawford. (*Elec. Engineering*, Jan. 1943, Vol. 62, No. 1, pp. 10–16.)

2891. The Kilgore Senate Bill [" Mobilisation of Science " : Further Criticism].—Egloff. (*Science*, 14th May 1943, Vol. 97, No. 2524, pp. 442–443.) *See* 2548 of September : for the American Institute of Physics' resolution *see* issue of 28th May, No. 2526, pp. 482–483 (and *see* pp. 486–487 and 488). *See* also 21st May, 4th & 25th June, pp. 461, 508–511, & 577–579.

2892. Science and Politics [Criticism of Editorial].—West. (*Review Scient. Instr.*, June 1943, Vol. 14, No. 6, pp. 188–189.)

" Physicists must avoid the error of yielding leadership to men who are merely well-known as scientists . . . A union is a specialised tool for economic or social action, as a technical society is a specialised tool for the improvement of the standards and techniques of a particular science, and neither can be used very effectively for other purposes."

2893. Toward an Improved Professional Spirit among Industrial Physicists [and the Steps taken by the American Physical Society].—(*Journ. Applied Phys.*, March 1943, Vol. 14, No. 3, p. 103.)

2894. American Institute of Physics : Report for 1942 [condensed : including Some Data on Journals].—(*Review Scient. Instr.*, May 1943, Vol. 14, No. 5, pp. 148–151.)

2895. Library Stocks of Periodicals [Need for a Decision, on a National Scale, by a Representative & Impartial Body, regarding the Allocation of Available Copies : Part of a Larger Scheme of Survey & Assessment of Needs].—Barnard. (*Nature*, 24th July 1943, Vol. 152, No. 3847, p. 106.)

2896. Science and the Censor [Excerpt from *New York Times* prompted by Army & Navy " Radar " Statement : Imperfect Coordination between British & American Officers of Censorship, etc.].—(*Science*, 14th May 1943, Vol. 97, No. 2524, p. 443.) For the statement mentioned *see* 2736, above.

2897. [The Word] " Electronics " *versus* " Radionics " : Correspondence.—(*QST*, June 1943, Vol. 27, No. 6, pp. 56–57.) *See* also *Wireless Engineer*, Sept. 1943, p. 437, where the original letter is reprinted, with an Editorial comment.

2898. Republication of Technical Books of Axis Origin [Announcement].—(*Review Scient. Instr.*, May 1943, Vol. 14, No. 5, p. 158.) *See* also p. viii, where among others Ertel's " Methoden und Probleme der dynamischen Meteorologie " is offered.

2899. Suggestions from the Office of Scientific Personnel of the National Research Council [regarding the Demand for Teachers of Physics & of Mathematics].—(*Review Scient. Instr.*, Feb. 1943, Vol. 14, No. 2, pp. 29–30.) *See* also p. 58.

2900. The Training of Engineers in the Electrotechnics Division in Technical Colleges, *and* The Training of Probationers.—Nipper : Siebelist. (*E.T.Z.*, 22nd April 1943, Vol. 64, No. 15/16, pp. 209–212 : pp. 212–215). *See* also summaries of other papers on similar subjects, on pp. 217–222.

2901. Training Technical Personnel for War Industry [the ESMWT Programme].—White. (*Elec. Engineering*, June 1943, Vol. 62, No. 6, pp. 247–250.)

2902. *QST* visits Camp Hood : Radio in the Tank Destroyers, *and* Radio Training at Camp Hood.—De Soto. (*QST*, July 1943, Vol. 27, No. 7, pp. 9–13 : pp. 14–16 and 82..90.)

2903. " Airwomen's Work " [in the W.A.A.F : Book Notice].—Taylor. (*Wireless World*, July 1943, Vol. 49, No. 7, p. 211.)

2904. The " Mitnahme " [Pulling-into-Tune] of Self-Excited Oscillations, and Its Technical Utilisation [in Various Synchronising Arrangements].—Kirschstein. (*See* 2679.)

2905. Equivalent Circuits for Oscillating Systems and the Riemann–Christoffel Curvature Tensor [in connection with Hunting of Selsyn Systems, etc.].—Kron. (*Elec. Engineering*, Jan. 1943, Vol. 62, No. 1, Transactions pp. 25–31.)

2906. Transient Analysis of Linear Systems [Methods applicable to Acoustical & Aerodynamical Problems].—Osborne. (*See* 2675.)

2907. Electrical Circuit Analysis of Torsional Vibrations [of Multi-Cylinder Engines, Continuous Shafts, etc.].—Pipes. (*Journ. Applied Phys.*, July 1943, Vol. 14, No. 7, pp. 352–362.)

" The results may be applied by a mere change in notation to the analysis of the longitudinal oscillations of linear spring and mass systems as well as to that of the longitudinal oscillations of prismatic bars."

2908. An Electrical Transducer Circuit for Use with Capacity Pick-Up Devices [for Seismic & Vibration Investigations, Dilatometers, etc.].—Potter. (*See* 2673.)

2909. Papers on a Solution of the Wave Motion generated in an Elastic Medium by a Pressure at the Interior Surface of a Spherical Cavity [of Importance to Seismic Prospecting].—Sharpe. (*See* 2649.)

2910. A Study of Electrical Earth Noise.—Neuenschwander & Metcalf. (*Sci. Abstracts*, Sec. A, July 1943, Vol. 46, No. 547, p. 151.)

2911. Note on the Transmission of Radio Waves through the Earth [into a Coal Mine].—Silverman & Sheffet. (*See* 2645.)

2912. The Impedance of a Grounded Wire [as in Geophysical Prospecting].—Wolf. (*See* 2691).

2913. The Geiger-Müller Counter in the Service of Mining [Prospecting for Radium-Bearing Earths: with Descriptions of Special Counter with Spherically Symmetrical Sensitivity, and Pot-Type Directional Counters: the Complete "Bore-Hole" Equipment].—Rajewsky. (*Zeitschr. f. Phys.*, 25th March 1943, Vol. 120, No. 7/10, pp. 627–638.) For previous papers *see* 2220 & 2921 of 1942.

2914. A Synchronised Calibrator for Sweep and Gain in Cathode-Ray Recording [of Nerve Potentials, etc.].—Talbot. (*See* 2807.)

2915. Nerve Conduction as an Alternating-Action Effect in the Albumen Chain [Formulation of a Complete Mechanism which is an Example of Energy Migration in Nonconductors (*e.g.* Phosphors)].—Schmidt. (*Physik. Zeitschr.*, 25th March 1943, Vol. 44, No. 6, pp. 139–150.) For work by other writers *see*, for example, 997, 2320, & 3215 of 1941 and 2207/9 of 1942: also many references at end of present paper.

2916. Light Muscular Exercise may Reduce the Time for Adapting Eyes to Dark.—Kekcheyev. (*Nature*, 29th May 1943, Vol. 151, No. 3839, pp. 617–618.) Following on previous work on the speeding of dark-adaptation by exciting other sense organs (*cf.* Margolin, 2608 of September).

2917. Joining Thermoplastic Fabrics with a Sewing Machine using Radio-Frequency Current instead of Needle and Thread.—Brown: R.C.A. (*Sci. News Letter*, 12th June 1943, Vol. 43, No. 24, p. 372: photograph and caption only.)

2918. Generation of Electric Charges by Moving Rubber-Tired Vehicles.—Mackeown & Wouk. (*See* 2711.)

2919. Rapid Non-Destructive Material Testing [Bridge for detecting Slight Differences in Properties of Two Samples].—Knoop. (*See* 2782.)

2920. Detector for Under-Surface Flaws in Steel [Heat-Treated Parts (Bearing Races): Magnetic Method using Cathode-Ray Oscillograph].—Brace & Williams. (*Sci. Abstracts*, Sec. B, June 1943, Vol. 46, No. 546, p. 109.)

2921. Dry Grain separated from Wet by Electric Condenser.—Oxley & Henderson. (*Sci. News Letter*, 5th June 1943, Vol. 43, No. 23, p. 361.) From *Nature*.

2922. "Audio Scale" may open War Work to Blind [Accurate & Rapid Weighing by Headphone Indications ("Interlocked Signals" Principle as in Radio Beacon)].—Toledo (Ohio) Scale Company. (*Elec. Engineering*, Jan. 1943, Vol. 62, No. 1, p. 40.)

2923. An Electrostatic Voltmeter for Use with a Photoelectric Device as a Highly Sensitive High-Voltage Relay.—Nacken. (In paper dealt with in 2775, above.)

2924. Automatic Apparatus [with Photoelectric Controls] Tests Single Textile Fibres.—Harris & others. (*Sci. News Letter*, 5th June 1943, Vol. 43, No. 23, p. 361.)

2925. New Investigations on Lubricating Oils [and the Use of "Clouding" Curves plotted from a Photoelectric Measuring Equipment].—Stäger & Künzler. (*Schweizer Arch. f. angew. Wiss. u. Tech.*, Jan. 1943, Vol. 8, No. 1, pp. 15–24: in German.)

2926. Photoelectric Glossmeter.—Photovolt Corporation. (*Review Scient. Instr.*, April 1943, Vol. 14, No. 4, p. 119.)

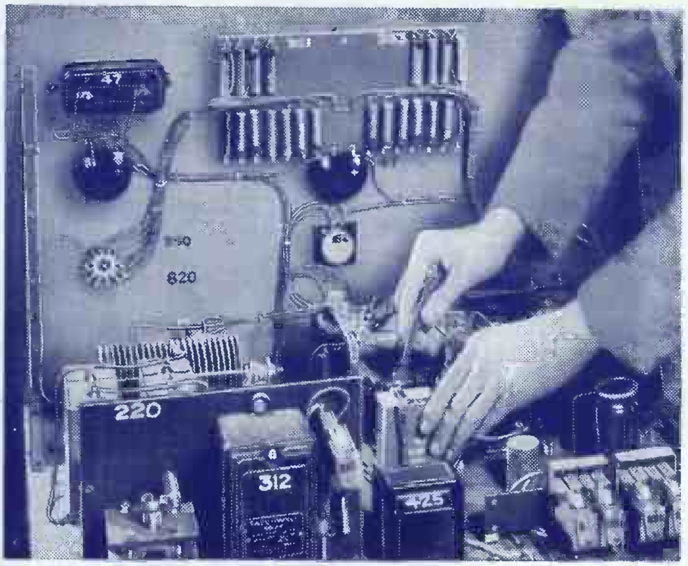
2927. A Two-Cycle Flasher [High-Flux Light-Valve providing Single Flashes of 3 msec. or longer, operated & controlled Electronically: Loudspeaker Movements driven by Thyratrons, and driving Two Vanes: Two-Shutter Principle applicable to More Refined System for Higher Frequencies].—Talbot. (*Review Scient. Instr.*, June 1943, Vol. 14, No. 6, pp. 181–184.)

2928. The Limit of Visual Resolution [Experimental Investigation].—Selwyn. (*Proc. Phys. Soc.*, 1st July 1943, Vol. 55, Part 4, No. 310, pp. 286–291.)

2929. Recent Optical Materials and their Possible Applications, *and* Plastics and the Optical Industry [with Table of Typical Plastics, showing Various Properties, Not only Optical].—Johnson: Wearmouth. (*Proc. Phys. Soc.*, 1st July 1943, Vol. 55 Part 4, No. 310, pp. 291–300: pp. 301–313.) Followed by H. H. Emsley (pp. 314–321) on "Plastic Spectacle Lenses".

2930. Perspective Drawing Made Easy by Photography.—Wheeler. (*Journ. of Scient. Instr.*, July 1943, Vol. 20, No. 7, pp. 115–116.)

2931. The Giant Camera [for photographing Tracings, Prints being then made from the Oiled Haloid Paper Negatives instead of from the Actual Tracings: consists of Two Rooms with Lens in Separating Wall].—Haard. (*Bell Lab. Record*, June 1943, Vol. 21, No. 10, pp. 356–360.)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