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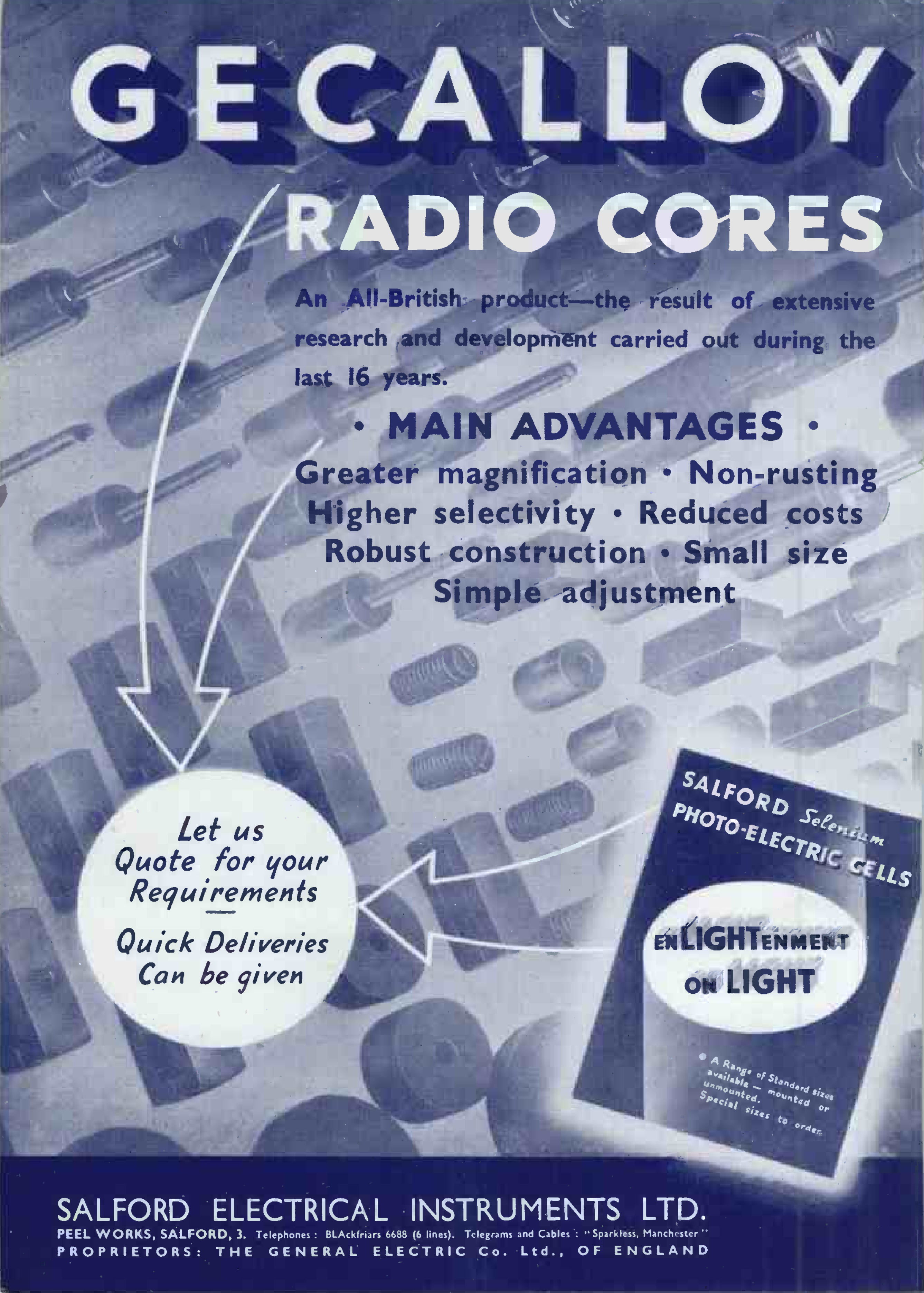
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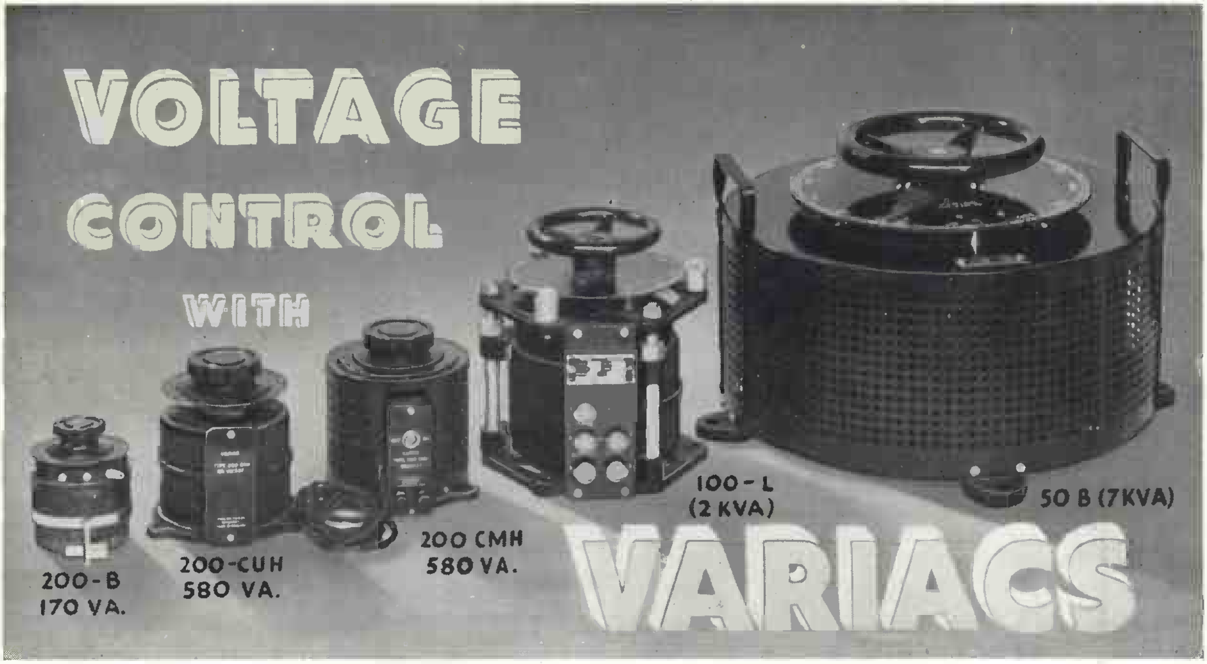
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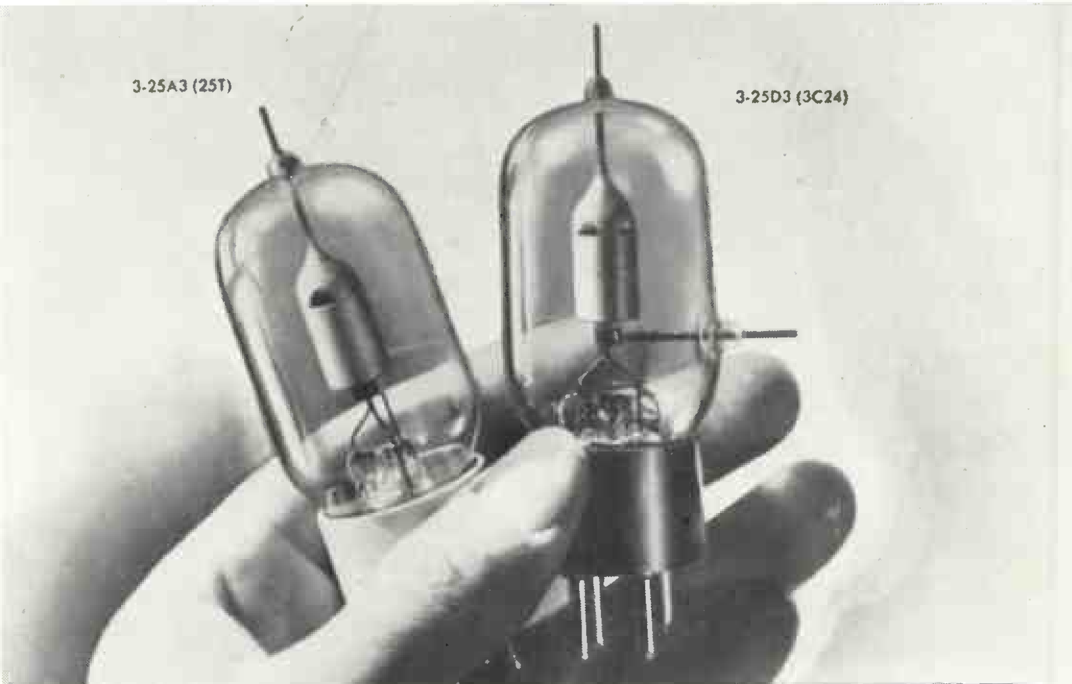
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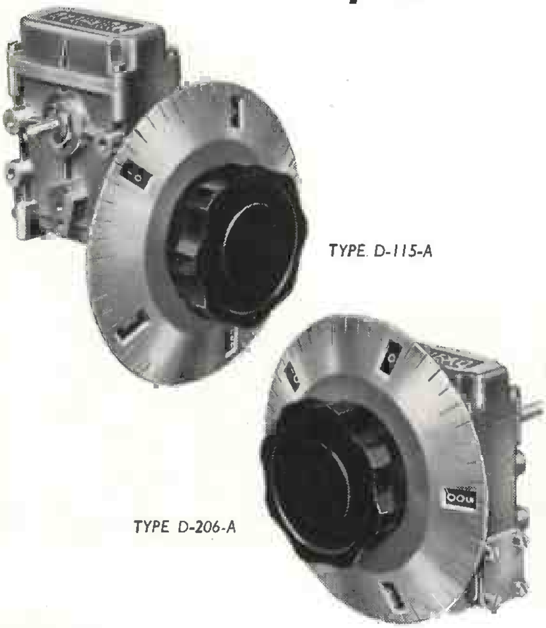

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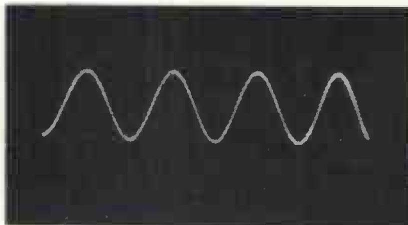

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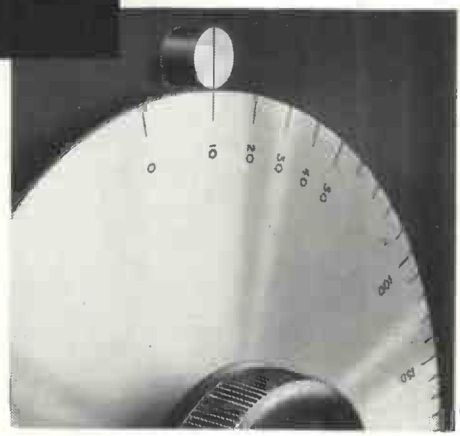

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WIRELESS ENGINEER

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

VOL. XXI OCTOBER, 1944 No. 253

Editorial

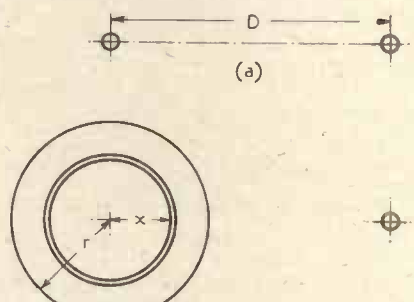
The Inductance of a Circuit Consisting of Two Parallel Wires

A New Treatment of the Problem

IN connection with the formula $L = \left(4 \log_e \frac{D}{r} + 1\right) 10^{-9}$ for the inductance in henries per cm. of length of an overhead line consisting of two parallel wires of radius r at a distance D (measured between centres), one often finds an element of doubt expressed as to whether it is rigorously correct for conductors of considerable size, even at very low frequencies, when skin effect is negligible and uniform current density can be assumed.

In Vol. 1 of Alex. Russell's *Alternating Currents* five or six pages are devoted to a rigorous proof of the formula ; Moullin gives the correct formula in his *Principles of Electromagnetism*, but says that " the exact solution will not be attempted " ; in Dover's *Theory and Practice of Alternating Currents*, a common mistake is made in one of the limits of integration, with the result that $(D - r)/r$ appears instead of D/r, and it is then stated that it becomes D/r when D is large in comparison with r. Why $D - r$ was preferred to $D + r$ it is difficult to see.

We propose now to explain a simple way of arriving at the formula and showing that it is rigorously correct whatever the size of the conductors. We consider in the first place two very fine filaments (Fig. 1a) carrying unit current in opposite directions. The magnetic field of the left-hand conductor (shown magnified in Fig. 1b) will be in concentric circles around it. Within the conductor at a distance x from the centre, the current linked will be x^2/r^2, and the line integral of H around the circle must be 4π times this ; hence $H \times 2\pi x = 4\pi x^2/r^2$ and $H = 2x/r^2$. In a ring of radial thickness dx and 1 cm. long the magnetic flux will be $2xdx/r^2$, and this links the current x^2/r^2, giving a linkage of $2x^3dx/r^4$, the integral of which from 0 to r is $\frac{1}{2}$, and is thus independent of the size of the conductor.



(b) Fig. 1.

Outside the conductor $H = 2/x$ and the whole current is linked until $x = D - r$. As x increases from $D - r$ to $D + r$ the total current linked by the flux decreases from unity to zero. For greater values of x the linkage is zero and the flux can therefore be neglected. If r is small compared with D, both $D(1 - r/D)$ and $D(1 + r/D)$ approximate to D, and the total linkage due to the external flux will be the integral of $2dx/x$ from r to D which is $2 \log_e D/r$. The total linkage will thus be $2 \log_e D/r + \frac{1}{2}$ due to the flux of the one conductor; that due to the flux of the other conductor will be the same, giving a total linkage per cm. length of the circuit of $4 \log_e D/r + 1$ for unit current, and therefore an inductance of $(4 \log_e D/r + 1)10^{-9}$ henries per cm.

If the radii of the conductors are not so small as to make r/D negligible some uncertainty arises as to the linkage of the flux of one conductor with the current of the other conductor. As x increases from $D - r$ to $D + r$ the flux lines link a gradually increasing fraction α of the cross-section of the conductor, represented by the gibbous cross-hatched area in Fig. 2, so that the total linkage is $1 - \alpha$. Russell integrates this across the conductor, and finds that the result is ultimately the same as if the field $H = \frac{2}{x}$ were assumed to link unit current and simply integrated to the centre of the wire. It can, however, be shown that this is necessarily so. Let it be assumed that the integral linkage is the same as if the field $H = \frac{2}{x}$ were integrated to some other point to the left or right of the centre by some fraction of the radius, that is, that $L = 4 \log_e D'/r + 1$ where D' is not quite the same as D.

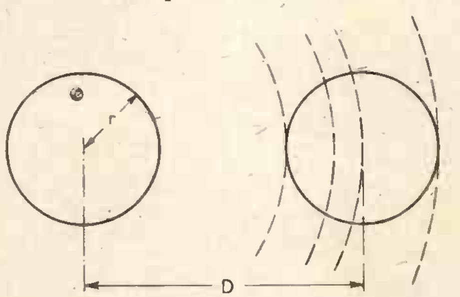


Fig. 2.

Now when the two conductors are carrying equal currents in opposite directions, the e.m.f. induced in each conductor will be $I\omega(2 \log_e D'/r + 1)$ and the magnetic field will be as shown in Fig. 3. The flux to the left of the central plane links the left-hand conductor and that to the right links the right-hand conductor. It is important to notice, however, that *this central plane and the flux to the left of it are entirely unaffected by changes in the size of the right-hand conductor, so long as its centre remains fixed.* Hence the e.m.f. $I\omega(2 \log_e D'/r + 1)$ induced in the left-hand conductor remains unchanged even if the right-hand conductor becomes a fine filament, in which case D' has no option but to become equal to D. Hence the e.m.f. induced in the left-hand conductor is always $I\omega(2 \log_e \frac{D}{r} + 1)$ whatever the size of the right-hand conductor, and if the

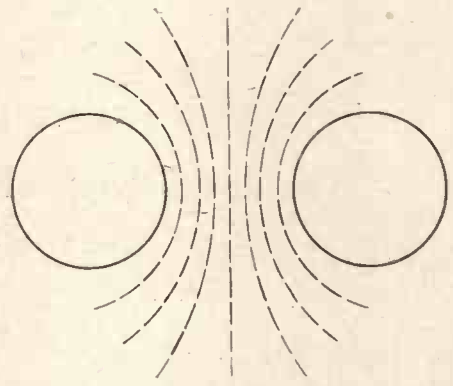


Fig. 3.

transmission line consist of two wires of different radii r_1 and r_2, the inductance $L = 2 \log_e \frac{D}{r_1} + 2 \log_e \frac{D}{r_2} + 1$ and the e.m.f. induced in one wire is given by the formula $I\omega(2 \log_e \frac{D}{r_1} + \frac{1}{2})10^{-9}$ or $I\omega(2 \log_e \frac{D}{r_2} + \frac{1}{2})10^{-9}$ volts per cm. irrespective of the size of the other wire.

The question may arise as to the exact meaning of the induced e.m.f. calculated by the formula $I\omega(4 \log_e \frac{D}{r} + 1)$, since it is obvious that the e.m.f will vary from point to point in the cross-section of the conductor. We have assumed uniform current distribution, hence it is immaterial whether we integrate over the current or over the cross-section. If we integrate the flux over the current linked we obtain the inductance; if we integrate the flux over the area linked we obtain the average value of the induced e.m.f. over the area, or something proportional to it. Hence with uniform current distribution the inductance obtained by integrating the flux-current linkages is that which gives the average e.m.f. over the cross-section. Variations from this average are the cause of circulating currents, i.e. skin effect, but we have assumed that these are negligibly small, a state of affairs rarely met with in radio work.

A somewhat similar but much simpler problem is the calculation of the force exerted on a long conductor of large cross-section due to the magnetic field of a fine wire running parallel to it. One could, of course, expend much mathematics on integrating the force over the cross-section of the large conductor, but it is hardly necessary seeing that the force on the fine wire in the magnetic field of the large wire must be equal and opposite and can be written down straight away. Since the magnetic field of either wire is independent of its size, the force for given circuits is also independent of the size and dependent only upon the distance between centres. G. W. O. H.

GEOMETRY OF PUSH-PULL AMPLIFICATION*

By R. L. Russell, M.Sc., Grad. I.E.E.

(Robert Gordon's Technical College, Aberdeen)

SUMMARY.—It is usual to regard the mutual conductance characteristics for valve amplifiers below saturation as consisting of two parts. The upper part is sufficiently nearly linear to be treated as such for quantitative work, and it is almost universal to take the initial part as being of parabolic shape. There seems to be little justification for this assumption, (except over small ranges) and in any event the discontinuity of treatment is not satisfactory. On the supposition that the curves are more nearly hyperbolic, a geometrical explanation for push-pull amplification is obtained. It is further shown that for such a shape of valve characteristic, and for a particular value of bias, there is complete freedom from distortion over an indefinite range. Experimental results are quoted and methods described by which this special shape can be identified. From the analysis emerges an algebraic expression which may be regarded as an approximation to the mutual conductance curves over ordinary working ranges.

Introduction

It is unfortunate for many purposes that all thermionic valves should have characteristics which are non-linear over some part of their range. One of the most troublesome consequences is that valve amplification is accompanied by distortion, and the problem in practice is to reduce the percentage distortion to a figure which is below some predetermined level. This figure is quite often determined in audio equipment, for instance, by the amount of distortion which can be tolerated without the output being rendered objectionable, but for many types of scientific apparatus this criterion may not be sufficient. For example, amplifiers employed in the cathode-ray oscillograph should have linear characteristics for all frequencies to be indicated. Frequently it is desirable to secure an adequate power output with only a tolerable amount of distortion and it is for this purpose that the push-pull system is most often employed. Provided that the two valves in this arrangement have identical characteristics and behave in exactly the same way, no even harmonics can be present in the output. This follows at once from considerations of symmetry and the situation is often briefly summarised by stating that the even harmonics cancel and the odd ones are additive. This suggests that the cause is inherent in the nature of the valve characteristics. It is comparatively rarely remarked that the amounts of odd harmonics are also dependent on the grid bias and that they can be reduced to a minimum by choice of a suitable value. The author shows in this paper that all distortion can be avoided if valves which have dynamic characteristics of hyperbolic shape are employed together with a particular bias. The asymptotes consist of the V_g axis and

* MS. accepted by the Editor, July 1944.

the line to which the $I_A - V_g$ characteristic approaches as V_g increases, within normal working ranges, and which in practice may be taken as the straight part of the characteristic.

1. Combined Characteristic

Since the anode currents for the two valves in push-pull flow in opposite directions through the anode load, it is convenient for graphical work to regard one of them as positive and draw the $I_A - V_g$ curve in the usual way, and invert the other as in Fig. 1. It is clear that the relative

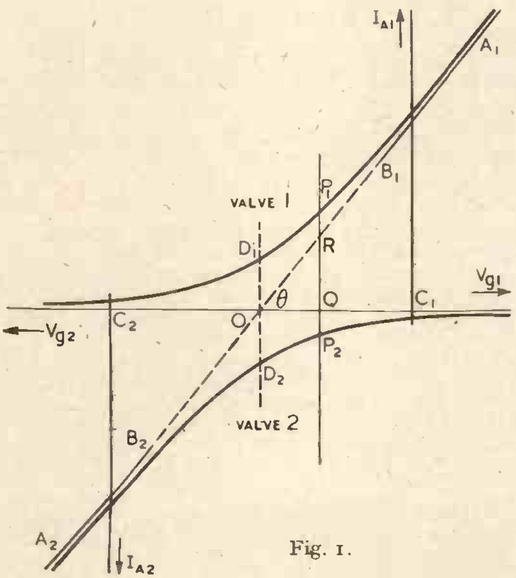


Fig. 1.

position of the curves with respect to one another is dependent on the common grid bias, and one is led to consider the situation when a value of bias ($OC_1 = OC_2$) is applied such that the curves occupy a position as shown. Below saturation, A_1O is the limiting line to which the upper curve is tending as V_g increases, and it will also be approached by the overall characteristic for the pair, since the effect of the second valve, for which the grid voltage is becoming more negative, will be diminished. The line A_2O is defined in a similar way, and providing the valves are identical A_1OA_2 will be straight. Now, for an ideal system, in which no distortion is introduced, the combined characteristic would be linear throughout, and in particular, in the intermediate range would follow the dotted line B_1B_2. A signal voltage of amount $2.OQ$ applied symmetrically between the grids in the usual way, would then correspond ideally to an anode current QR. In actual fact, the anode current will be QP_1 for one of the valves and QP_2 for the other. The net load current therefore will be $(QP_1 - QP_2)$, there being no significance in the order of subtraction. In order that this should be the same as in the ideal case, it is necessary that $(QP_1 - QP_2)$ should be equal to QR. That is,

$$RP_1 = QP_2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Moreover, this condition should be satisfied not only for one, but for all positions of Q, excepting of course for the limitation imposed for large grid swings by valve saturation. With this reservation, the problem ceases to be a physical one and may be treated as a proposition in pure geometry. There may be several solutions, but the one quoted is thought to correspond best with the behaviour of actual valves.

As shown in Appendix I, the condition laid down in (1) is in fact satisfied for a hyperbola. In order therefore to obtain an approximate theory of push-pull amplification it is convenient, and not unreasonable, to suppose that the valve characteristics are hyperbolic, with the voltage axis and A_1OA_2 as asymptotes. The degree of artificiality thereby introduced is at least comparable with that of the customary parabolic representation, and to the extent therefore that the curves in practice approximate to a hyperbolic shape, and providing always that the correct bias is employed, the combined characteristic will approach the ideal line.

2. Analytical Treatment

This result can be represented analytically by writing down the equation to the hyperbola, referred most naturally to axes V_g and a line D_1OD_2 through O parallel to I_A. As shown in Appendix II this equation is,

$$\frac{I_A^2}{\tan\theta} - I_A V_g - K \cdot \sin\theta = 0 \quad \ldots \quad (2)$$

where $\tan\theta$ is the slope of the dynamic curve, which is the line $A_1 O A_2$ in Fig. 1, and K is mathematically a positive quantity. The quantity V_g is now a half the signal voltage, and if it is represented as $V \cdot \sin\phi$, then (2) becomes a quadratic in I_A, the roots of which will give the contribution due to each valve. If the roots of this equation are I_{A1} and I_{A2}, then by ordinary quadratic theory, we have,

$$(I_{A1} + I_{A2}) = V \,.\, \sin\phi \,.\, \tan\theta \quad .. \quad (3)$$

These roots have opposite signs, and therefore $(I_{A1} + I_{A2})$ which represents the algebraic sum of the currents, is numerically equal to the difference. The above result shows that the output is an undistorted copy of the input. As the voltage across the load resistance is $(V \,.\, \sin\phi \,.\, \tan\theta \,.\, R)$ which is equal to $(m \,.\, V \,.\, \sin\phi)$, the stage gain (m) for the system is the same as that of a single valve working under "Class A" conditions.

This may be taken as establishing a condition under which freedom from distortion can be expected, and shows the importance of employing the correct bias. It is unlikely that a particular valve will have properties of precisely the special type required, but the closeness or otherwise of the approximation to a hyperbola is to some degree under control, because the curvature at the foot of the $I_A - V_g$ curve can be varied. Thus a more complete investigation would hope to show that the harmonic content in the output was reduced to a minimum for some particular value of H.T. supply, anode load, and screen voltage. It will be appreciated that the foregoing arguments are applied to resistances and cannot be taken as referring without question to all types of load. By using resistances in the anode circuits, one of the main advantages normally claimed for the push-pull system, namely high power output, is lost, but there are many applications in which this is only of minor consideration, but in which freedom from distortion is of great importance.

3. Practical Tests

That these conclusions are at least close to the truth was illustrated on the cathode-ray tube. The method was the usual one (*see* Fig. 2) of supplying a 50-cycle per second A.C. signal to the valves, and also to the tube, so as to deflect the spot horizontally. The vertical deflections were made proportional to the anode current by connecting the appropriate deflector plates across the anode load. By this means, the overall characteristic curve was traced out on the screen, and since resistances were employed throughout, troublesome effects due to phase shift were avoided. As a matter of detail, a separate winding on the input transformer was employed for the horizontal deflection, to avoid a short circuit of the H.T. supply via a common earth on the cathode-ray tube. Care was taken to match the valves and adjust the loads so that the valve slopes were equal.

The following procedure was adopted as a preliminary to testing. With all the supplies switched on, what is approximately part of the characteristic curve for each valve in turn can be obtained by using a bias which cuts off the other valve. When using a bias of value intermediate between these extremes, it is found that the general symmetry of the trace about the centre point can be improved by altering the tapping on the resistance R. The purpose of this

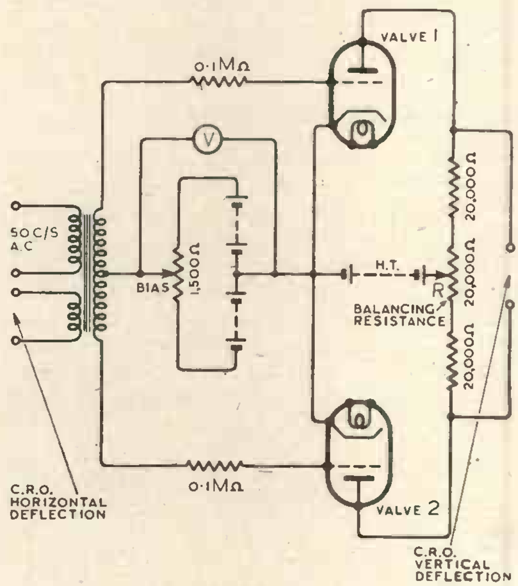


Fig. 2.

adjustment is to equalise the valve slopes. The effect of varying the grid bias was then readily observed and traces of the shape shown in Fig. 3 were obtained.

These could have been predicted from a consideration of the curves for the separate valves. By using a bias sufficient to cause cut-off, the effect shown in A can of course be exaggerated, but without going to these limits, the presence of third harmonics, which will usually predominate, is sufficiently well marked. The third harmonic in C is not such as to affect the wave shape so obviously. It is interesting to note that, broadly speaking, in A the harmonic is "antiphase" and in C "in phase" with the fundamental. The output wave shape was good, and the characteristic appeared to be linear, at a bias of -4.5 volts. Tests were made with a harmonic analyser of the output wave shape, and a minimum value of third harmonic occurred at approximately this value of grid bias.

It would be an impossible task in practice to identify a line as an asymptote in the strict mathematical sense, and it would be laborious if the correct value of bias could only be found by the methods described. Fortunately, it will be sufficient in most cases merely to align the straight parts of the respective curves rather than the asymptotes as is theoretically required. The standing common bias will then be given by the common point in which both linear portions of the characteristic curve, when produced, meet the V_g axis.

4. Tests of Hyperbolic Shape

Although the practical $I_A - V_g$ curve is capable of modification, it cannot be expected that the methods suggested will be sufficiently flexible in effect to transform any shape into one of the desired kind. Plainly, some types of valve will approach the ideal more closely than others, and some test is required which will enable those which are most suitable to be selected. For this purpose the results quoted in the appendices may be employed.

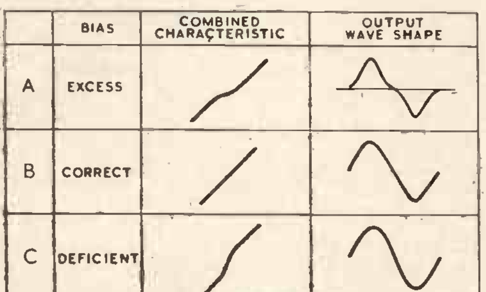


Fig. 3.

One method which is crude, but has the merit of simplicity, would be to draw lines such as $LMNK$ across the $I_A - V_g$ curve in a number of positions of which one is shown in Fig. 4. For all such transversals the intercepts LM and NK should be equal. All that is required is that the curve shall be drawn with reasonable accuracy and on a fairly large scale, and that the lines selected shall not approach either the V_g axis or OA_1, otherwise the lengths cannot be measured with precision.

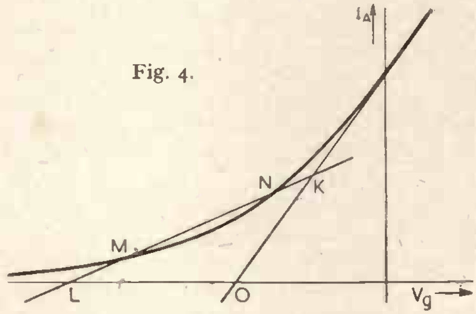


Fig. 4.

Alternatively (*see Fig.* 6) use may be made of the fact that for any point on a hyperbola, the product of the coordinates, in general oblique, measured parallel to the asymptotes from their point of intersection is constant. The test therefore consists of comparing the products XY for a number of positions of P.

As a further development from the original assumptions, it is shown in Appendix III that the equation

$$I_A = \frac{\tan\theta}{2}\left(V_g + \sqrt{V_g^2 + 4K\cos\theta}\right)$$

represents the mutual conductance characteristic for a single valve. This is of interest since it is valid not only over the curved part, but also over that portion of the characteristic which is sensibly linear when, as V_g increases, the expression reduces approximately to $I_A = V_g \tan\theta$.

Acknowledgment

The author's thanks are due to Professor G. H. Rawcliffe who read the manuscript and offered many suggestions in connection with the work.

APPENDIX I

The equation to a hyperbola referred to the principal axes takes the familiar form,

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1 \qquad \text{(4}$$

Let the equation to any line $EFGH$ or $E'F'G'H'$ (*see Fig.* 5) be,

$$y = mx + c \qquad (5)$$

Eliminating y between (4) and (5), a quadratic is obtained giving the values of x for the points of intersection G and F.

$$x^2(b^2 - a^2m^2) - x(2m \cdot c \cdot a^2) - a^2(c^2 + b^2) = 0 \quad \text{(6)}$$

If the roots of (6) are x_F and x_G, then,

$$x_F + x_G = \frac{2 \cdot m \cdot c \cdot a^2}{b^2 - a^2 \cdot m^2}$$

It follows that the value of x for the mid point of FG is,

$$\frac{x_G + x_F}{2} = \frac{m \cdot c \cdot a^2}{b^2 - a^2 \cdot m^2}$$

Similarly, the values of x for E and H are obtained by eliminating y between $y = mx + c$ and the joint equation to the asymptotes, which is, $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 0$, giving,

$$\frac{x_E + x_H}{2} = \frac{m \cdot c \cdot a^2}{b^2 - a^2 \cdot m^2}$$

It follows that the centre of EH and FG are one and the same point and that therefore $EF = GH$.

In applying this general geometrical result to the analysis of the push-pull system (as in Fig. 1) a line of the type $E'F'G'H'$, intersecting both branches of the hyperbola is required. In testing a valve characteristic as described in Section 4, a line of the type $EFGH$, intersecting one branch in two places is employed.

APPENDIX II

One method of finding the equation to a hyperbola referred to axes ox and oy, (*see Fig.* 6), would

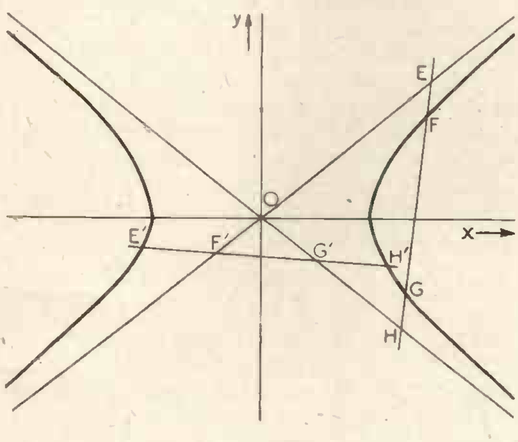


Fig. 5.

be to take the standard form (4) as in Appendix I and convert by direct substitution. A simpler method assumes the result (proved in most books on coordinate geometry), that the equation referred to the asymptotes as axes is,

$$X \cdot Y = K \quad \text{(7)}$$

where K is a positive constant. If P is any point X, Y the relation between the two systems of coordinates is,

$$x = Y \cdot \cos\theta - X \qquad y = Y \cdot \sin\theta$$

Substituting in (7), $\left(\frac{y}{\sin\theta}\right) \cdot \left(\frac{y \cdot \cos\theta}{\sin\theta} - x\right) = K$ (8)

Converting now to the scales of anode current and grid voltage, x is replaced by V_g which is the magnitude of the grid voltage for either valve, or half the signal voltage, and y is replaced by I_A. Tan θ becomes, strictly, the slope of the asymptote or, approximately, of the straight part of the $I_A - V_g$ dynamic characteristic which is given from ordinary valve theory by

$$\frac{\mu}{R + R_A}.$$

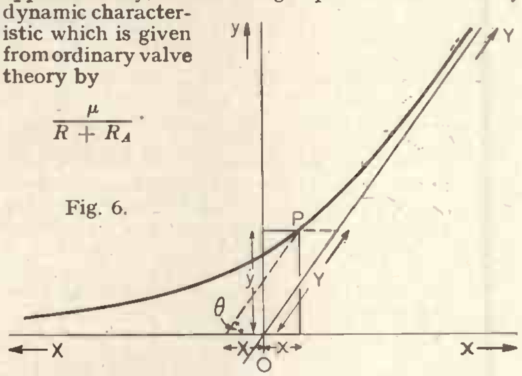


Fig. 6.

We have, therefore,

$$\frac{I_A{}^2}{\tan\theta} - I_A V_g - K \cdot \sin\theta = 0 \quad \text{(9)}$$

as the equation to the hyperbola in terms of I_A and V_g. It may be noted that $K \cdot \sin\theta$ is a positive quantity, and that therefore the roots of this equation regarded as a quadratic in I_A will always be real and of opposite sign. This must necessarily be so from a consideration of the circuit conditions which the equation represents.

APPENDIX III

The expression (9) regarded as a function of I_A and V_g is the combined equation to the characteristics of the push-pull system. For any particular value of V_g, say V'_g, it is a quadratic in I_A whose two roots are,

$$I'_{A_1} = \frac{\tan\theta}{2}\left(V'_g + \sqrt{V'_g{}^2 + 4 \cdot K \cdot \cos\theta}\right),$$

$$I'_{A_2} = \frac{\tan\theta}{2}\left(V'_g - \sqrt{V'_g{}^2 + 4 \cdot K \cdot \cos\theta}\right)$$

where I'_{A_1} and I'_{A_2} are the corresponding anode currents for valve 1 and valve 2 respectively (*see Fig.* 1). Remembering that these relations will be true for any value of V'_g, and confining attention to valve 1 only, the $I_A - V_g$ equation for a single valve is seen to be,

$$I_A = \frac{\tan\theta}{2}\left(V_g + \sqrt{V_g{}^2 + 4 \cdot K \cdot \cos\theta}\right) \quad \text{(10)}$$

As the curve tends to approach its asymptote OA_1 it can be represented approximately as,

$$I_A = V_g \cdot \tan\theta \quad \text{(11)}$$

since the error in neglecting the term $4 \cdot K \cdot \cos\theta$ in (10) diminishes as V_g increases. From (11), since $m = \frac{dV_A}{dV_g} = \frac{d(I_A R)}{dV_g}$, the standard result $m = \frac{\mu R}{R + R_A}$ is obtained.

Performance of COUPLED AND STAGGERED CIRCUITS in Wide Band Amplifiers*

By D. Weighton, M.A.

SUMMARY.—Solutions are presented for coupled and staggered circuits in amplifiers for which the gain is limited by the band width requirements. Expressions are derived for stage gain in terms of band width, tuning capacitances and the parameters of the response curve which define its shape. In certain cases these expressions are shown to reduce to simple forms which are convenient for design calculations. The effects of mistuning and unequal Q in the coupled circuit amplifier are considered with particular reference to practical difficulties of alignment. For comparison of performance it is not sufficient to consider single stages alone since the response curves are not of identical form and the results will therefore depend on the gain ratio at which the band width is defined. The results are therefore presented in terms of an amplifier of any number of stages having constant band width at 3 db. points on the overall response. These curves form a convenient basis for the rapid estimation of the performance of particular amplifiers. It is concluded that coupled circuits may be made to give an improvement over staggered circuits both in uniform and composite amplifiers which varies from 1.5 to 3 db. per stage according to the tolerances in variation of the response within the pass band and the apparatus available for carrying out the trimming operations.

CONTENTS

1. Introduction

THE general solution of coupled and staggered circuits has been derived by a number of authors [1,2] and considerable literature exists on the application of these results to the design of narrow band amplifiers usually required to tune over a wide range of frequencies[3,4,7]. In comparing the performance of various types of circuit the problems which have received most attention are those of selectivity, frequency stability and the maintenance of a uniform characteristic over the tuning range. For the wide band amplifier, however, these factors are of less importance, and the relative merits of different types of circuit cannot readily be assessed from the results of the investigations quoted above. In particular selectivity is of minor importance since the gain requirement usually necessitates more than the number of circuits needed for adequate discrimination against signals lying outside the band. With certain reservations in the first and last stages of an amplifier where the design may be modified by considerations of noise and detector loading the problem reduces to one of maximum gain per stage for a given overall band width.

Wheeler[9] has shown that there exists a theoretical limit to the gain band width attainable in any one stage of an amplifier whether it be designed to have low pass or band pass characteristics. For an ideally terminated dead end filter the maximum gain may be represented by

$$\frac{g}{\pi B C}$$

where g is the mutual conductance, B the cut off frequency, and C the total capacitance across which the load impedance must be developed. A similar expression for a four-terminal coupling network is

$$\frac{g}{\pi B\sqrt{C_1 C_2}}$$

where C_1 and C_2 are the capacitances across input and output terminals of the filter. The gain of any practical arrangement will be lower than that of either of these two expressions by an amount which is in general less for circuits of increasing complexity.

The object of the present paper is to show

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

that the stage gain obtained with certain practical band pass circuits may be written in terms of the limiting theoretical gain derived by Wheeler. This form is particularly suitable both for comparison of circuits of various types and for rapid estimation of the performance of particular amplifiers. Two modifications are, however, necessary. The expression must be sufficiently general to enable B to be defined for a complete amplifier of any number of stages, and a form factor will be introduced in those cases where the response curve may exhibit two or more humps.

For simplicity uniform amplifiers are considered first, i.e. those in which the same means of coupling are employed throughout so that the analysis may be limited to a single stage or in the case of staggered tuning a two-stage unit in which the circuits are symmetrically disposed. The uniform amplifier has certain advantages in simplicity of design and alignment, but is in practice frequently deferred to some combination of stages with different circuits or of the same type with different parameters. Such an amplifier will be described as composite. Typical combinations have been dealt with generally by Ho Shou Loh,[7] Uehling[8] and others, and are compared below within the special limitations of the present investigation.

To facilitate the calculation a number of approximations are made. These depend for the most part on the neglect of second order terms in half band width as a fraction of the resonant frequency. This approximation sets the upper limit of the band width of amplifiers to which the results will apply with sufficient accuracy. The lower limit is reached when the circuit Q for optimum gain demanded by the band width requirement is greater than that which can be achieved in practice. Under these conditions the amplifier may be designed with a response wider than that required or the gain may be reduced by the addition of tuning capacitance. The analysis will, of course, be generally applicable to this latter condition, but the conclusions are primarily concerned with amplifiers lying between the above limits.

2. Uniform Amplifiers

For completeness and as an illustration of the method we shall consider first an amplifier in which the coupling impedances consist of single resonant circuits tuned to a common frequency. The method will then be extended to the staggered amplifier in which the circuits of alternate stages are tuned to different frequencies, the difference being of the same order as the band width; and the coupled circuit amplifier in which two tuned circuits are employed in each stage.

2.1. *Isochronous Single Circuits*

One stage of an amplifier of this type is shown in Fig. 1, from which blocking and

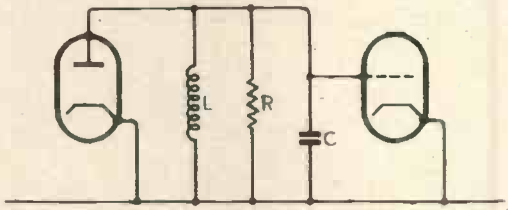


Fig. 1.

decoupling impedances have been omitted. The load consists of an inductance L, capacitance C and resistance R, representing the total losses associated with the circuit, including the output resistance of the preceding value.

The gain of one stage is then given by gZ, where g is the mutual conductance and Z the load impedance.

Now $$\frac{1}{Z} = j\omega C + \frac{1}{j\omega L} + \frac{1}{R}$$

or $$\frac{1}{Z} = j\omega_0 C\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right) + \frac{1}{R}$$

where ω_0 is the resonant angular frequency. writing

$$\alpha = \frac{\omega - \omega_0}{\omega_0}$$

then $$\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right) = \left(1 + \alpha\right) - \left(1 + \alpha\right)^{-1}$$

Since we are concerned only with frequencies close to resonance, α is small compared with 1, and approximately

$$\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right) = 2\alpha$$

or $$\frac{1}{Z} = \frac{1}{R}\left(1 + 2j\omega_0 CR\alpha\right)$$

But $\omega_0 CR$ is the magnification Q of the tuned circuit

$$\therefore \quad Z = R(1 + 2j\alpha Q)^{-1}$$

Writing $G(\alpha)$ for the stage gain at a frequency defined by α

$$|G(\alpha)| = gR(1 + 4\alpha^2Q^2)^{-\frac{1}{2}} \quad .. \quad (1)$$

or $\quad n = (1 + 4\alpha^2Q^2)^{\frac{1}{2}}$

Where n is defined by the ratio

$$n = \frac{|G(o)|}{|G(\alpha)|} \quad .. \quad .. \quad .. \quad (2)$$

Rearranging this expression

$$\alpha = \sqrt{n^2 - 1}/2Q$$

The band width between points at which the gain is $1/n$th of the gain at the centre of the band is therefore

$$B = \frac{\alpha\omega_0}{\pi} = \omega_0\sqrt{n^2 - 1}/2\pi Q$$

Setting $\alpha = o$ in equation (1) and substituting for Q from above.

$$|G(o)| = \frac{g}{\pi BC} \cdot \tfrac{1}{2}\sqrt{n^2 - 1} \quad .. \quad (3)$$

The gain at the centre of the band is here expressed in terms of the quantity $g/\pi BC$ and the ratio n which may be chosen so that B denotes the band width at any required attenuation. In particular for the band width between 3 db. points the gain is very nearly $\frac{1}{2}g/\pi BC$ (v. Strutt[5]).

(2.2) *Amplifier with Staggered Circuits*

For reasons of symmetry the smallest unit of a staggered amplifier which may be considered is of two stages, and the overall response may be made up from that of a number of such units. This is not strictly a uniform amplifier, but is considered in this section since it represents the simplest arrangement of staggered circuits which may be employed.

If ω_1 and ω_2 are the angular resonant frequencies of the two circuits we shall write

$$\delta_1 = \frac{2(\omega_1 - \omega_0)}{\omega_0}$$

$$\delta_2 = \frac{2(\omega_2 - \omega_0)}{\omega_0}$$

and $\quad \alpha = \dfrac{\omega - \omega_0}{\omega_0}$

where ω_0 is the angular frequency of the centre of the band. By analogy with the preceding analysis the gain of one stage is then

$$|G_1(\alpha)| = \frac{gQ_1}{\omega_0 C_1}\left[1 + 4\left(\alpha + \frac{\delta_1}{2}\right)^2 Q_1^2\right]^{-\frac{1}{2}} \quad .. \quad .. \quad (4)$$

Where C and Q have the same connotation as in (2.1) and the suffixes 1 and 2 relate to the two staggered circuits.

The overall gain is then

$$|G_1(\alpha)||G_2(\alpha)| = \frac{g^2Q_1Q_2}{\omega^2C_1C_2}$$

$$\left[\left\{1 + 4\left(\alpha + \frac{\delta_1}{2}\right)^2 Q_1^2\right\}\left\{1 + 4\left(\alpha + \frac{\delta_2}{2}\right)^2 Q_2^2\right\}\right]^{-\frac{1}{2}} \quad .. \quad .. \quad (5)$$

For a symmetrical response the coefficients of α^3 and α must vanish in the expansion of the quantity in the square bracket, from which we obtain

$$\delta_1 + \delta_2 = 0$$

and

$$Q_1 = Q_2$$

For symmetry the circuits must therefore have equal Qs, but not necessarily equal dynamic impedance.

The condition $\delta_1 + \delta_2 = 0$ indicates that the response is symmetrical about a frequency midway between the tuning points of the two circuits.

Writing $\quad n^2 = \dfrac{|G_1(o)|}{|G_1(\alpha)|} \cdot \dfrac{|G_2(o)|}{|G_2(\alpha)|}$

From (5)

$$16\alpha^4Q^4 + 8\alpha^2Q^2(1 - \delta^2Q^2) + (1 - n^4)(1 + \delta^2Q^2)^2 = 0 \quad .. \quad (6)$$

The condition for the appearance of double peaks is therefore

$$\delta Q > 1$$

and the "transitional" stagger is defined by

$$\delta_T = \frac{1}{Q}$$

The term transitional will be used generally to denote the condition in which the number of peaks on the response curve passes from one to more than one (v. Aiken[6]).

The position of the humps is found by putting $\dfrac{dn}{d\alpha} = 0$ in equation (22), whence

$$\alpha = \pm\tfrac{1}{2}\sqrt{\delta^2 - \delta_T^2} \quad .. \quad .. \quad (7)$$

Substituting in equation (6), the ratio of peak to trough n_1 is given by

$$n_1^4 = \frac{4\delta^2\delta_T^2}{(\delta^2 + \delta_T^2)^2} \quad .. \quad .. \quad .. \quad (8)$$

or $\quad \delta^2 = \delta_T^2\dfrac{1 + \sqrt{1 - n_1^4}}{1 - \sqrt{1 - n_1^4}} \quad .. \quad .. \quad (9)$

A general expression for band width is

obtained by substituting this value of δ in the solution of equation (6)

$$4\alpha^2Q^2 = 2\frac{\sqrt{1-n_1^4}+\sqrt{n^4-n_1^4}}{1-\sqrt{1-n_1^4}}$$

or $$\frac{Q}{\omega_0} = \frac{1}{\sqrt{2}\pi B}\left[\frac{\sqrt{1-n_1^4}+\sqrt{n^4-n_1^4}}{1-\sqrt{1-n_1^4}}\right]^{\frac{1}{2}} \quad \ldots \quad \ldots \quad (10)$$

The gain at the centre of the band is found by putting $\alpha = 0$ in equation (5)

$$\sqrt{|G_1(0)||G_2(0)|} = \frac{gQ}{\omega_0 C}\left[1+\delta^2Q^2\right]^{-\frac{1}{2}}$$

substituting for $\frac{Q}{\omega_0}$ from equation (10) and for $(1+\delta^2Q^2)$ from equation (9)

$$\sqrt{|G_1(0)||G_2(0)|} = \frac{g}{2\pi B\sqrt{C_1C_2}}\left[\sqrt{1-n_1^4}+\sqrt{n^4-n_1^4}\right]^{\frac{1}{2}} \quad \ldots \quad \ldots \quad (11)$$

or if the two circuits have equal tuning capacitances

$$C_1 = C_2 = C$$

$$\sqrt{|G_1(0)||G_2(0)|} = \frac{g}{\pi BC}\cdot\frac{1}{2}\left[\sqrt{1-n_1^4}+\sqrt{n^4-n_1^4}\right]^{\frac{1}{2}} \quad (12)$$

and in the special case of transitional stagger

$$\sqrt{|G_1(0)||G_2(0)|} = \frac{g}{\pi BC}\cdot\frac{1}{2}(n^4-1)^{\frac{1}{4}} \quad (13)$$

Equations (12) and (13) relate to the mean gain per stage, and may therefore be compared with equation (3) for the isochronous amplifier. If B be defined for points of 3 db. attenuation per stage, then the mean gain per stage for an overall transitional response is approximately $0.66g/\pi BC$, an improvement of 2.4 db. over the isochronous case.

(2.3) *Amplifier with Coupled Circuits*

A simplified equivalent circuit in which the coupling impedance is π connected and the generator is treated as an infinite impedance source has been adopted for the purpose of the calculation (Fig. 2). In practice the arrangement may have a variety of forms according to

(*a*) the method of coupling adopted.

(*b*) the distribution of losses which will in general include both series and parallel resistance, and

(*c*) the generator impedance.

The various forms of coupled circuit may, however, be reduced to the desired equivalent by a simple transformation, and the results are therefore generally applicable provided that in the case of a π connection the tuning capacitance of each circuit is made to include the coupling reactance. The transformation of coupled circuits has been discussed in detail by Aiken.[6]

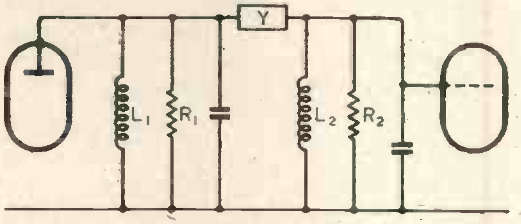


Fig. 2.

The calculation is limited to a coupling impedance which has no real component and does not change appreciably over the frequency band of the amplifier. No restriction is placed on the ratio of tuning capacitance, Q or resonant frequency of the coupled circuits except that the detuning is assumed to be small compared with the mean frequency.

If Y_1 and Y_2 are the admittances of the primary and secondary circuits, and Y the admittance of the coupling reactance, then the stage gain is

$$G = \frac{gY}{Y_1Y_2 + Y(Y_1+Y_2)}$$

writing $y_1 = Y_1 + Y$

and $y_2 = Y_2 + Y$

$$G = \frac{gY}{y_1y_2 - Y^2} \quad \ldots \quad \ldots \quad (14)$$

If ω_1 and ω_2 are the resonant angular frequencies of the primary and secondary circuits, and

$$\delta = \frac{\omega_1 - \omega_2}{\omega_0}$$

then neglecting second order terms in α

$$\left.\begin{aligned} y_1 &= \frac{1}{R_1}\left[1+2jQ_1\left(\alpha-\frac{\delta}{2}\right)\right] \\ y_2 &= \frac{1}{R_2}\left[1+2jQ_2\left(\alpha-\frac{\delta}{2}\right)\right] \end{aligned}\right\} \quad \ldots \quad (15)$$

The suffixes 1 and 2 relate to primary and secondary circuits respectively.

Inserting these values in (14) and rationalising

$$|G(a)| = gs\sqrt{R_1R_2}\Big[16\alpha^4Q_1^2Q_2^2 - 4\alpha^2\{2Q_1Q_2(1 + s^2 + \delta^2Q_1Q_2) - (Q_1 + Q_2)^2\} + 4\alpha\delta(Q_2^2 - Q_1^2) + \{\delta^2(Q_2 - Q_1)^2 + (1 + s^2 + \delta^2Q_1Q_2)^2\}\Big]^{-\frac{1}{2}} \quad \ldots \ldots \ldots (16)$$

where s is the coupling index defined by

$$s^2 = R_1R_2Y^2 = Q_1Q_2k^2$$

where k is the coupling factor.

Since the expression in the square bracket contains a term in α the response curve will in general be unsymmetrical about the centre frequency ω_0. The term vanishes in two particular cases

when $Q_1 = Q_2$

and when $\delta = 0$

Thus if the circuits are tuned to the same frequency, the Qs may be different without causing asymmetry. It is shown below that this leads to some advantage in gain. If, however, the circuits are staggered the Qs must be made equal (not necessarily the dynamic impedances R_1 and R_2). Since we are only concerned with symmetrical curves, the equation may be written

$$|G(\alpha)| = gs\sqrt{R_1R_2}\Big[16\alpha^4Q_1^2Q_2^2 + 4\alpha^2(Q_1^2 + Q_2^2) - 8\alpha^2Q_1Q_2p^2 + (1 + p^2)^2\Big]^{-\frac{1}{2}} \quad \ldots \ldots \ldots (17)$$

where $p^2 = s^2 + \delta^2Q_1Q_2$

Putting $\alpha = 0$, the gain at the centre of the band is

$$|G(0)| = g\sqrt{R_1R_2}\frac{s}{1 + p^2} \quad \ldots (18)$$

and $16\alpha^4Q_1^2Q_2^2 - 8\alpha^2Q_1Q_2(p^2 - \frac{1}{2}\overline{Q_1^2 + Q_2^2})$
$- (1 + p^2)^2(n^2 - 1) = 0 \quad \ldots \ldots (19)$

where n is defined as in equation (2).

At the peaks of the response curve $dn/d\alpha = 0$, i.e. from (19)

$$\alpha\sqrt{Q_1Q_2} = \tfrac{1}{2}\sqrt{p^2 - \tfrac{1}{2}\left(\frac{Q_1}{Q_2} + \frac{Q_2}{Q_1}\right)} \quad (20)$$

and the condition for the appearance of double peaks is therefore

$$p^2 = \tfrac{1}{2}\left(\frac{Q_1}{Q_2} + \frac{Q_2}{Q_1}\right)$$

This expression is similar to that derived by Aiken for the transitional coupling except that in place of the coupling index s we have a composite index p which includes the effects of coupling and staggering in one factor. The value of p determines the shape of the curve and the ratio of trough to peak. Writing p_T for the transitional index and substituting for α in (19) and (20)

$$p^2 = \frac{p_T^2 + \sqrt{1 - n_1^2}}{1 - \sqrt{1 - n_1^2}} \quad \ldots \ldots (21)$$

where n_1 is the ratio of peak to trough.

Solving equation (19)

$$\alpha^2Q_1Q_2 = \frac{1}{4}\Big[(p^2 - p_T^2) \pm \sqrt{(p^2 - p_T^2)^2 + (p^2 + 1)^2(n^2 - 1)}\Big] \quad \ldots \ldots (22)$$

The positive sign is taken since we are concerned with the overall band width.

Substituting for p^2 from (21)

$$\alpha^2Q_1Q_2 = \frac{1 + p_T^2}{4}\cdot\left[\frac{\sqrt{1 - n_1^2} + \sqrt{n^2 - n_1^2}}{1 - \sqrt{1 - n_1^2}}\right] \quad \ldots \ldots (23)$$

but $B = \dfrac{\alpha\omega_0}{\pi}$

$$B = \frac{1}{2\pi\sqrt{R_1R_2C_1C_2}}\left[\frac{(1 + p_T^2)(\sqrt{1 - n_1^2} + \sqrt{n^2 - n_1^2})}{1 - \sqrt{1 - n_1^2}}\right]^{\frac{1}{2}} \quad \ldots \ldots (24)$$

Substituting in equation (18) for $\sqrt{R_1R_2}$ from (24) and for p^2 from (21)

$$|G(0)| = \frac{gs}{2\pi B\sqrt{C_1C_2}}\left[\frac{(1 - \sqrt{1 - n_1^2})(\sqrt{1 - n_1^2} + \sqrt{n^2 - n_1^2})}{(1 + p_T^2)}\right]^{\frac{1}{2}} \quad \ldots \ldots (25)$$

It is convenient at this point to distinguish two cases:

(*a*) $\delta = 0$ and Q_1 is not in general equal to Q_2, i.e. the circuits are tuned to the same frequency but may have different Qs.

(*b*) $Q_1 = Q_2$ and δ is not in general equal to o, i.e. the circuits are not necessarily tuned to the same frequency but have equal Qs.

Both conditions give rise to symmetrical resonance curves as shown above.

Case (a) $p = s$ and $p_T = s_T$

Then s may be substituted in the equation for gain, using the relation (20)

$$|G(o)| = \frac{g}{2\pi B\sqrt{C_1C_2}} \left[\frac{(s_T^2+\sqrt{1-n_1^2})(\sqrt{1-n_1^2}+\sqrt{n^2-n_1^2})}{1+s_T^2}\right]^{\frac{1}{2}} \quad \ldots \quad (26)$$

Case (b) $Q_1 = Q_2$ and $p_T = 1$

$$|G(o)| = \frac{g}{2\pi B\sqrt{C_1C_2}} \cdot \frac{s}{\sqrt{2}} \cdot \left[(1-\sqrt{1-n_1^2})(\sqrt{1-n_1^2}+\sqrt{n^2-n_1^2})\right]^{\frac{1}{2}} \quad \ldots \quad (27)$$

These equations are now in a form suitable for comparison with other types of circuit since the gain is expressed in terms of the response curve parameters and valve slope and capacitances only. It is, however,

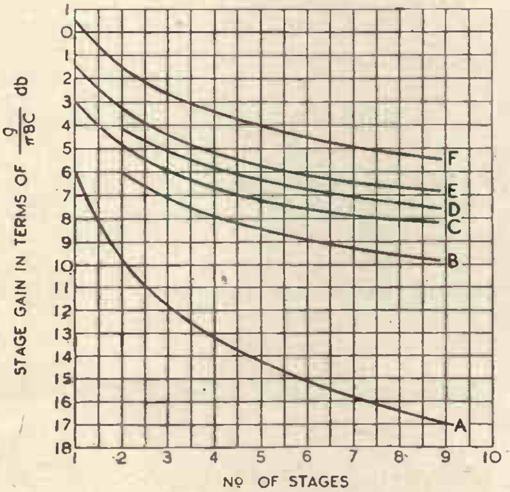


Fig. 3.—*Each curve relates to an amplifier of constant overall band width. A, isochronous single circuits; B, staggered circuits (transitional); C, coupled circuits (transitional equal Q); D, staggered circuits (1db. peaks); E, coupled circuits (transitional $Q_1 = 5Q_2$); F, coupled circuits (1db. peaks. $Q_1 = Q_2$).*

necessary to make some assumption relating C_1 and C_2 the tuning capacitances of the coupled circuits with C the total tuning capacitance of the single circuit amplifiers. Neglecting any small differences in stray capacitances with the two arrangements

$$C = C_1 + C_2$$

Provided the ratio of C_1 to C_2 lies between $\frac{1}{2}$ and 2, the error involved in writing $\sqrt{C_1 C_2} = \frac{1}{2}C$ will be less than 2 per cent. and is therefore adopted as a basis of comparison. The expressions for stage

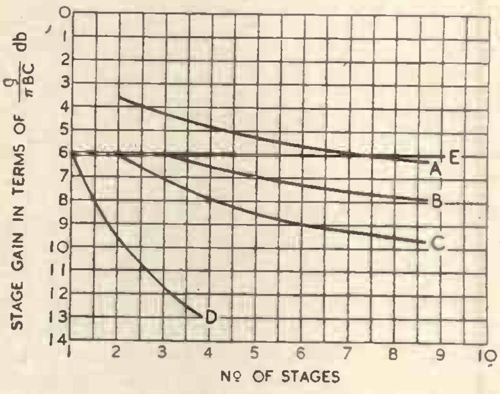


Fig. 4.—*Each curve relates to an amplifier of constant overall response. A, amplifier of two-stage units comprising coupled and single tuned circuits (no peaks) ($Q_1 = Q_2$); B, amplifier of three-stage units of staggered circuits, one central and one each side (no peaks); C, amplifier of two-stage units of staggered circuits (no peaks); D, amplifier of isochronous single circuits; E, staggered amplifier of optimum design (all stages different).*

gain in terms of band width may now be written in terms of $\frac{g}{\pi BC}$ for all types of circuit. The result are presented in the form of curves relating stage gain to the number of stages in an amplifier of given overall response (Fig. 4.) The band width B is defined at 3 db. points overall so that the factors n and n_1 are calculated from

$$n = \frac{1.41}{y}$$

and $$n_1 = \frac{x}{y}$$

where x is the ratio of peak to trough on the overall response curve and y the number of stages.

It appears from these curves that the differences in gain for various arrangements of staggered and coupled circuits change only slowly with the number of stages, provided there are more than 3 or 4. The figures for gain with 6 stages have therefore been extracted in the table below and apply with fair accuracy for any number between about 3 and 10. The figure for transitionally coupled circuits of equal Q is normalised at zero db.

Coupled Circuits	db. gain (normalised) per stage
Equal Qs no humps	0
,, Qs 1 db. humps	3.08
$Q_1 = 5Q_2$ no humps	1.58
Staggered circuits	
No humps	− 1.38
1 db. humps	0.86

(2.3.2.) *Anachronous Coupled Circuits*

The effect of mistuning with circuits of equal Q is contained in equation (27). If the coupling is reduced and the form of the response curve maintained constant by retuning, the gain falls in proportion to the coupling index (and coupling impedance since the Qs do not change). The optimum performance is therefore obtained when the circuits are isochronous. There may be some practical advantage in using mistuned circuits and looser coupling since the trimming procedure is simplified by a reduction of interaction between the two circuits when each one is tuned. The advantage would not, however, be appreciable at a point where the gain is less than that of a staggered single circuit amplifier, which would therefore be preferred.

(2.3.3.) *Coupled Circuits of Unequal Q*

It appears from equation (26) that the gain increases when s_T is greater than one, i.e. when the primary and secondary circuits are of unequal Q (not necessarily unequal dynamic impedance). The effect has been described by Ho-Shou Loh[7] for the case of a three-circuit amplifier. When there are no peaks on the response curve (transitional coupling) the improvement in gain per stage approaches $\sqrt{2}$ or approximately 3 db. as the ratio of Q_1/Q_2 becomes very large (or very small). If, however, the response curve is desired to have humps the advantage of using unequal Qs is less than this figure. A ratio of about 5 for Q_1/Q_2 might be attained in practice and gives a calculated improvement of 1.5 db. per stage.

There are, however, certain difficulties in trimming circuits of this type without the aid of a frequency modulated source. A common method of alignment which gives correct results for circuits of equal Q is as follows. A signal generator is set at any frequency reasonably close to the desired operating frequency and both circuits are peaked for maximum output. The resulting response curve is then explored and the separation of the peaks measured. If this separation is y cycles per second, the generator is now set at $y/2$ cycles from the desired centre frequency and the circuits reset for maximum output. The method depends on the peaks of the response curve having maximum amplitude when the circuits are tuned to the same frequency. That this condition is satisfied when the circuits have equal Qs is seen by examination of equation (17) which may be written

$$|G(\alpha)| = gs\sqrt{R_1R_2}\left[16\alpha^4Q^4 - 8\alpha^2Q^2(p^2-1) + (1+p^2)^2\right]^{-\frac{1}{2}}$$

Substituting the value of αQ at the frequency of the peak

$$\alpha Q = \tfrac{1}{2}\sqrt{p^2-1}$$

$$|G(\alpha)|_{max} = \frac{gs\sqrt{R_1R_2}}{2p}$$

and since $\quad p^2 = s^2 + \delta^2 Q_1 Q_2$

$$|G(\alpha)|_{max} = \frac{gs\sqrt{R_1R_2}}{2\sqrt{s^2+\delta^2Q_1Q_2}}$$

Hence $|G(\alpha)|$max. is greatest when δ vanishes.

When the Qs are unequal, the equations for the peak amplitude do not admit of a simple solution in the general case. The effect of detuning may, however, be derived as follows. From equation (16)

$$|G(\alpha)| = gs\sqrt{R_1R_2}\Big[16\alpha^4Q_1^2Q_2^2 - 8\alpha^2Q_1Q_2(p^2-p_T^2) + \alpha\delta(Q_2^2-Q_1^2) + (1+p^2)^2 + \delta^2(Q_2-Q_1)^2\Big]^{-\frac{1}{2}}$$

Differentiating with respect to δ, and setting $\delta = 0$

$$\left[\frac{\partial|G(\alpha)|}{\partial\delta}\right]_{\delta=0} = -\frac{|G(\alpha)|^3(Q_2^2-Q_1^2)}{gs\sqrt{R_1R_2}}\alpha_1 \qquad \ldots \ldots (28)$$

$\left[\frac{\partial|G(\alpha)|}{\partial\delta}\right]_{\delta=0}$ is therefore of opposite sign for any pair of points on opposite sides of the centre frequency and in particular at the frequencies at which the peaks occur when $\delta = 0$. The effect of detuning is therefore initially to increase one peak and depress the other. Since δ has been defined as positive when the primary circuit is tuned to the higher frequency, equation (28) indicates that the peak will rise on the side to which the circuit of higher Q is tuned (irrespective of whether it be primary or secondary). In general the maximum value of the peak response will occur at some value of detuning other than zero, and the trimming procedure described above will therefore lead to a detuned and unsymmetrical condition except in the particular case of equal primary and secondary Qs.

3. Composite Amplifiers

In the above calculations we have considered only amplifiers consisting of identical stages or pairs of stages throughout, so that the overall response curve is the mth power of that of one stage, where m is the number of stages. There is often some advantage in combining stages of different circuits or circuits of the same type with different parameters, usually one or more stages with a double humped response and a single peaked stage designed to compensate the central dip and produce a sensibly flat overall characteristic. It is evident that for an amplifier of about 5 or more stages there is a very large number of ways in which coupled, staggered and single circuit stages may be combined. The number of possible arrangements is however limited by the necessity for maintaining a symmetrical response, and for practical reasons the use of many differently designed stages is undesirable, particularly in a coupled circuit amplifier. For the staggered amplifier the optimum combination is achieved with less complexity since the differences may occur only in the trimming operations.

We shall consider first the general cases of staggered and coupled circuit amplifiers of any number of stages designed to have optimum performance with a transitional overall response, and certain simple applications of the general formulae will then be made.

(3.1). *Staggered Circuit Amplifier*

For a staggered amplifier of y stages the number of different frequencies to which the circuits are tuned may have any even value from 2 to y when y is even, or any odd value from 1 to y when y is odd. The particular cases of one and two tuning points have already been dealt with under (2.1) and (2.2) above, and the general case will now be considered where each stage is tuned to a different frequency and the circuit parameters selected to produce a transitional overall response. From equation (i) the gain of the mth stage may be written

$$|G_m(\alpha)| = \frac{g\,Q_m}{\omega_0 C_m}\left[1 + 4\left(\alpha + \frac{\delta_m}{2}\right)^2 Q_m^{\,2}\right]^{-\frac{1}{2}} \quad \ldots \quad \ldots \quad (29)$$

where the nomenclature is similar to that used in (2.2) above. The overall gain for y stages is then

$$\Pi|G_m(\alpha)| = \frac{g^y\,\Pi\,Q_m}{\omega_0^{\,y}\,\Pi\,C_m}\cdot\Pi\left[1 + 4\left(\alpha + \frac{\delta_m}{2}\right)^2 Q_m^{\,2}\right]^{-\frac{1}{2}} \quad \ldots \quad \ldots \quad (30)$$

where the product in each case has factors from $y = 1$ to $y = m$.

For the transitional condition in which the response curve becomes single peaked, the coefficients of all terms except those in α^{2y} and α^0 (in the expansion of (30)) must vanish. It is therefore possible to derive $(2y - 1)$ equations relating $2y$ quantities, the δ and Q of each circuit. These quantities may therefore be chosen to make the coefficients vanish, and a remaining condition satisfied in which the overall band width has the desired value. Equation (30) then becomes

$$\Pi|G_m(\alpha)| = \frac{g^y\,\Pi Q_m}{\omega_0^{\,y}\,\Pi\,C_m}\left[(4\alpha^2)^y\,\Pi Q_m^{\,2} + \Pi(1 + \delta_m^{\,2}Q_m^{\,2})\right]^{-\frac{1}{2}} \quad \ldots \quad \ldots \quad (33)$$

writing

$$n = \frac{\Pi\,|G_m(o)|}{\Pi\,|G_m(\alpha)|}$$

$$\frac{\Pi Q_m}{\Pi(1 + \delta_m^{\,2}Q_m^{\,2})^{\frac{1}{2}}} = \frac{\sqrt{n^2 - 1}}{(2\alpha)^y}$$

As before $\quad B = \dfrac{\alpha\omega_0}{\pi}$

and

$$\frac{\Pi Q_m}{\Pi(1 + \delta_m^{\,2}Q_m^{\,2})^{\frac{1}{2}}} = \frac{\omega_0^{\,y}\sqrt{n^2 - 1}}{(2\pi B)^y\,\Pi\,C_m} \quad \ldots \quad (34)$$

substituting in equation (31)

$$\Pi|G_m(o)| = \frac{g^y\sqrt{n^2 - 1}}{(2\pi B)^y}$$

and the mean gain per stage is then

$$G = \frac{g(n^2 - 1)^{\frac{1}{2y}}}{2\pi B(\Pi C_m)^{1/y}} \quad \cdots \quad (35)$$

or if the tuning capacitances of each stage are equal

$$G = \frac{g}{\pi BC} \cdot \tfrac{1}{2}(n^2 - 1)^{\frac{1}{2y}} \quad \cdots \quad (36)$$

When y is put equal to 1 or 2 in this expression we obtain the formulae derived above for single isochronous circuits and the two stage staggered unit, remembering that n here refers to the overall response. If n is put equal to 3db. then $(n^2 - 1)$ is very nearly equal to one and the gain per stage is therefore independent of the number of stages. To determine the stagger and Q of each circuit required to produce this optimum condition for any number of stages it is necessary to solve the relations obtained from (30) by equating coefficients to zero. For three stages the solution is very simply obtained and leads to the following results.

$$\left.\begin{array}{l} \delta_1 = -\delta_2, \quad \delta_3 = o \\ Q_1 = Q_2 = 2Q_3 \\ \delta^2 Q_1^2 = \delta^2 Q_2^2 = 3 \end{array}\right\} \quad \cdots \quad (37)$$

Two stages are therefore of equal Q symmetrically staggered on each side of the centre of the band, and the third is of half the Q centrally tuned.

The results derived from equation (36) are shown in Fig. 4 (curves B, C and D) in the form of curves for stage gain for any number of stages in an amplifier of constant band width at 3 db. points.

(3.2) *Coupled Circuit Amplifier*

In the general case of a composite coupled circuit amplifier the coupling index and Q product of each stage are different. As before, the gain will be determined for the condition in which these parameters are selected to produce a transitional overall response. From equation (17) the gain of the mth stage may be written

$$|G_m(\alpha)| = \frac{g s_m \sqrt{Q_{m1}Q_{m2}}}{\omega_0\sqrt{C_{m1}C_{m2}}}\Big[16\,\alpha^4 Q_{m1}^2 Q_{m2}^2 - 8\alpha^2 Q_{m1}Q_{m2}(s_m^2 - s_{Tm}^2) + (1 + s_m^2)^2\Big]^{-\frac{1}{2}} \quad \cdots \quad (38)$$

and for an amplifier of y stages the total gain is

$$\Pi|G_m(\alpha)| = g^y \Pi\left[\frac{s_m\sqrt{Q_{m1}Q_{m2}}}{\omega_0\sqrt{C_{m1}C_{m2}}}\Big\{16\,\alpha^4 Q_{m1}^2 Q_{m2}^2 - 8\alpha^2 Q_{m1}Q_{m2}(s_m^2 - s_{mT}^2) + (1+s_m^2)^2\Big\}^{-\frac{1}{2}}\right] \quad \cdots \quad (39)$$

Using a method similar to that applied to the staggered amplifier above the mean gain the transitional condition is given by

$$G = \frac{g(n^2 - 1)^{\frac{1}{4y}}}{2\pi B(\Pi\sqrt{C_{m1}C_{m2}})^{1/y}}\left[\Pi\frac{s_m}{\sqrt{1 + s_m^2}}\right]^{1/y} \quad \cdots \quad (40)$$

If the tuning capacitances of each stage are equal

$$(\Pi\sqrt{C_{m1}C_{m2}})^{1/y} = \sqrt{C_1C_2}$$

An approximation must now be made similar to that discussed under (2.3) above, where

$$\sqrt{C_1C_2} = \tfrac{1}{2}C$$

Equation (40) then becomes

$$G = \frac{g}{\pi BC}(n^2 - 1)^{\frac{1}{4y}}\left[\Pi\frac{s_m}{\sqrt{1 + s_m^2}}\right]^{1/y} \quad \cdots \quad (41)$$

Unlike the corresponding expression for staggered circuits, the calculation of gain for any particular case involves the solution of the equations derived from (38) by equating coefficients to zero. The result for two stages is of interest since it may be compared with the arrangement described in (3.3) below. When $y = 2$, it is found that

$$s_1^2 = 5.8$$

and $s_2^2 = 0.18$

Then $|G| = 0.59\dfrac{g}{\pi BC}$

or 4.5 db. below $\dfrac{g}{\pi BC}$

There is therefore an advantage of only 0.5 db. per stage in this arrangement over two identical stages each transitionally coupled to give a similar overall response.

(3.3) *Coupled and Single Circuits*

We shall consider here the simplest case of a composite amplifier of this type, i.e. one made up of two stage units comprising a coupled and a single circuit. The expression for overall gain may be written

$$|G_1(\alpha)|\,|G_2(\alpha)| = \frac{g^2 s\sqrt{Q_1Q_2}\cdot Q}{\omega_0^2\sqrt{C_1C_2}\cdot C}\Big[(1+4\alpha^2Q^2)\big\{16\alpha^4Q_1^2Q_2^2 - 8\alpha^2Q_1Q_2(s^2-s_T^2)+(1+s^2)^2\big\}\Big]^{-\frac{1}{2}} \quad \ldots \quad (42)$$

For the transitional condition, the coefficients of α^4 and α^2 must vanish in the expansion of the quantity within the square bracket. Solving these equations we find

$$s^2 = 1 + 2s_T^2 \quad \ldots \quad (43)$$

and $Q_1Q_2 = 2(1+s_T^2)Q^2$ .. .. (44)

Inserting these conditions in equation (42) and writing B for the band width between points at which the overall gain of the two stages is $\frac{1}{n}$th of the gain at the centre of the band.

$$64(\pi B)^6 Q_1^2Q_2^2Q^2 = \omega_0^6(1+s^2)^2(n^2-1) \quad \ldots \quad (45)$$

Writing $\alpha = 0$ in equation (42)

$$|G_1(o)|\,|G_2(o)| = \frac{g^2Q\sqrt{Q_1Q_2}}{\omega_0^2C\sqrt{C_1C_2}}\cdot\frac{s}{1+s^2} \quad \ldots \quad (46)$$

Substituting for s, Q and Q_1Q_2 from equations (43), (44) and (45) the mean gain per stage is

$$G = \frac{g}{\pi BC}\cdot(n^2-1)^{\frac{1}{6}}\left\{\frac{1+2s_T^2}{8(1+s_T^2)}\right\}^{\frac{1}{6}} \quad (47)$$

When the Qs of the coupled circuits are equal $s_T = 1$

and $\left\{\frac{1+2s_T^2}{8(1+s_T^2)}\right\}^{\frac{1}{6}} = -3.6$ db.

When the ratio Q_1/Q_2 becomes very large or very small

$$\left\{\frac{1+2s_T^2}{8(1+s_T^2)}\right\}^{\frac{1}{6}} = -3.0\text{ db.}$$

Thus a combination of coupled circuit and single circuit stages gives greater gain than a combination of two coupled circuit stages, and since the arrangement has also practical advantages it would in every case be preferred.

The performance of composite amplifiers designed on this basis is shown in curve A of Fig. 4.

4. Conclusions.

The design of any amplifier for any particular requirement will depend on the actual value of $\frac{g}{\pi BC}$ which can be attained, since economy in stages may have to be balanced against the disadvantage of complex circuits and trimming procedure. Certain general conclusions may, however, be drawn from examination of the curves in Figs. (3) and (4).

For a uniform amplifier with no humps on the overall response curve, the coupled circuit has an advantage of approximately 1.5 db. per stage over staggered circuits. The improvement rises to about 2 db. per stage when the overall response has 1 db. humps, and up to 3 db. per stage in both cases if the coupled circuits may have unequal Qs. These figures are generally applicable to any amplifier satisfying the requirements set out in the introduction.

A composite amplifier has a useful advantage over a uniform amplifier for both types of circuit. In the simplest case in which double and single peaked stages are combined to give a flat response, the mean stage gain improves by nearly 1.7 db. for staggered circuits and 2 db. for coupled circuits (6 stages). The difference is 1.7 db. per stage or rather more than 2 db. when the coupled circuits may have unequal Qs. Thus in all cases the improvement obtained by using coupled circuits lies between 1.5 and 3 db. per stage.

An example of the application of the curves to the estimation of performance of a particular amplifier is given below.

If $B = 3$ Mc/s, $g = 4.5$ milliamps per volt, and $c = 30$ pF, then $\frac{g}{\pi BC}$ is 24 db.

Referring to the curves for uniform amplifiers.

6 stages staggered in pairs (no humps) $24 - 9 = 15$ db. per stage or 90 db. total.

5 stages coupled circuits (no humps, equal Qs), $24 - 7.2 = 16.8$ db. per stage or 84 db. total, etc.

Acknowledgment

The Author is indebted to Mr. E. J. Cope for help and advice and to Messrs. Pye Limited for permission to publish this work.

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BOOK REVIEWS

Physics and Radio

By M. NELKON. Pp. 388 + VIII, with 507 Figs. Edward Arnold and Co., Ltd., 41, Maddox Street, London, W.1. Price 8s. 6d.

This is an excellent elementary text-book intended for (i) Radio Mechanics and Wireless Operators who require an exposition of the fundamental physical principles of Radio, (ii) students taking the City and Guilds first examinations in Technical Electricity and those who intend to proceed to Radio, and (iii) students of School Certificate or Matriculation Standard who desire a knowledge of Basic Radio. The author states that he has taught all these classes of students at Northampton Polytechnic and the book certainly suggests it.

The first two hundred pages are devoted to electricity and magnetism and elementary electrical technology; the remainder is devoted to radio work including chapters on sound leading to waves and aerials, and on light leading to refraction in the ionosphere. The final chapter deals with cathode-ray tubes, thyratrons, time-bases, etc. Every chapter concludes with a number of exercises. Mathematics is reduced to a minimum, e.g. in dealing with a condenser charged through a resistance, it is stated that the charge reaches 63 per cent. of its final value after $C \times R$ seconds, but "the proof of these statements requires the use of the calculus, and is beyond the scope of this book."

We have rarely come across a book in which such meticulous care appears to have been taken in the choice of symbols, nomenclature, and diagrams, although in some cases the symbols are not exactly those recommended by the British Standards Institution, e.g. K for kilo instead of k, and k for susceptibility instead of κ, and the author uses "capacity" throughout, but refers in a footnote to the fact that it is now being replaced by "capacitance." The author distinguishes carefully between a potential divider and a potentiometer (although they get mixed up in the index), two things that are often confused. The properties and various applications of diodes, triodes, tetrodes and pentodes are fully discussed. Several chapters are devoted to A.C. circuit theory and its application to resonance, filters, etc.

This is a book that can be unreservedly recommended to anyone studying the subject.

G. W. O. H.

Heaviside's Operational Calculus Made Easy

By Dr. T. H. TURNEY. Pp. 96 + VII, with 32 Figs. Chapman and Hall, 11, Henrietta Street, London, W.C.2. Price 10s. 6d.

The prices of books seem to differ in a strange way; the book by Nelkon *reviewed above*, contains nearly 400 closely packed pages and costs 8s. 6d., whereas this book by Turney of about a quarter of the size costs 10s. 6d.; presumably the anticipated circulation plays a large part in the matter.

This book deals with a very important mathematical tool devised by Heaviside for the solution of problems of great complexity in a relatively simple manner. Recent advances in radio telegraphy have led to a greatly increased interest in the transmission of pulses and transients, and any attempt to explain Operational Calculus in a simple manner is to be welcomed. A general idea of the contents can be formed from the titles of the seven chapters; (i) How differential calculus comes into electrical problems; (ii) Heaviside's operator; (iii) Expansion theorem; (iv) Waves on cables; (v) Distortionless cable; (vi) Relation between Heaviside and Fourier; (vii) Justification of Heaviside's methods by the use of the exponential.

Something seems to have gone wrong with the final paragraph of the introduction, which reads as follows: "Sometimes the currents and voltages are both known, and one wants to know what *circuit* to use in order to get such and such a current when such and such a voltage is applied. Heaviside called his 'Operational Calculus.'" His what?

On the very first page one is struck by the author's little regard for recognised symbols or for consistency in such matters, for having applied a voltage E across an inductance, he finds a "back voltage of strength V induced by the changing current"; on p. 6 it becomes a back e.m.f. but is still V and equal to $-LdI/dt$ and not to $-Ldi/dt$. For microfarad the author uses μf, mf and mfd indiscriminately, but never by any chance μF, and it is probably true to say that wL occurs more frequently than ωL; to all of which the author would probably reply "what does it matter so long as we are having a jolly time?"

The author's method of simplification involves such devices as taking "just a wee bit" of the cable where more stodgy writers take a short length. Similar simplification could be introduced into books on veterinary science by referring to horses and dogs as gee-gees and bow-wows. Another of the simplifications consists in writing things out in full either instead of, or in addition to, the symbols, e.g. "$F'(x)$ that is Eff — dashed — ecks" (the *ff* in italics to give a fortissimo effect). Other examples of this method of simplification are "$\frac{dV}{dx} = minus \sqrt{LC}\frac{dV}{dt}$" and "If it were V at x miles = sent voltage *times* ½ *times* the translation operator, then the ½ would indicate only half voltage there, but there is no half, and the full voltage is measured in this ideal case of no R and G." One cannot but wonder if this sort of thing really makes it any simpler.

The sections dealing with infinite and distortionless cables are perhaps the best in the book, but the author confuses conductance and admittance on p. 58 where he refers to $G + Cp$ as the "conductance." On p. 59 we read "If a battery is put on a condenser, then you take it off and short the ends, you get a discharge or *reverse* current." His treatment of the battery is in keeping with his treatment of the English language. It is very annoying to come across a sentence such as "What you do is to work with jw instead of p and so you use a *bt* of j's and w's." After trying for some time to make sense of this, the poor reader may have a brainwave and guess that *bt* is a *simplified* way of writing "lot"; he may also guess that *w* should be *ω*.

Reference should perhaps be made to the plate of photographs of coils and condensers beautifully reproduced; they involuntarily carried one's thoughts to the flowers that bloom in the spring.

The general conversational style of the book is well illustrated by a remark on the last page: "Now we have come to the end of the book. I hope you have liked it and found it interesting. Do not work too hard at it."

G. W. O. H.

B.R.E.M.A.

At the annual general meeting of the Equipment Makers' Section of the Radio Manufacturers' Association it was decided to dissolve the Section and to establish a new autonomous association to be known as the British Radio Equipment Manufacturers' Association. The new association will replace its predecessor on the Radio Industry Council.

Officers of the new association are:—Chairman, G. Darnley-Smith; Vice-Chairman, A. McVie; Trustees, E. K. Balcombe, L. D. Bennett and L. McMichael.

The offices are temporarily at Century House, Shaftesbury Avenue, W.C.2. Tel: Gerrard 7777.

Technical Data on "Chance" Sealing Glasses

A brochure has been issued by Chance Bros. Ltd., of Smethwick, giving technical details of six types of sealing glass which they manufacture to meet the needs of those industries which use glass bulbs or tubes as vacuum containers. Each glass is available in rod, tubing and in bulbs which can be blown to any required shape.

The compositions of the six glasses are given in Table I, and their principal properties in Table II.

It would be possible to increase the number of types, but the practical and desirable policy, both from the points of view of the manufacturer and user, is to select the smallest number of different types which can satisfactorily meet each main group of requirements and then to standardise on these and to supply them in good quality and of constant properties. The last column of Table II shows that these six types give the designer the choice of any of the metals usually employed for sealing into glass.

To distinguish between the various glasses one can observe either the specific gravity, the fluorescence, or the colour, or a combination of these properties. The different types are given pale distinctive colours which can be detected by examining the edge. In addition to the softening temperature given in Table II, the brochure gives particulars of the upper and lower annealing temperatures, Young's modulus, the stress-optical coefficient and thermal endurance figures for each type.

Hysil GH1 has the lowest expansion coefficient possible in commercial manufacture. It has very high thermal, chemical and electrical stability, and can be used when the most exacting degassing is called for. If it is required to seal in larger tungsten wires or molybdenum, Intasil GS1 must be used as an intermediate. For Kovar or Fernico two or three intermediates are necessary depending on the complexity of the seal. The controlling factor in such cases is, of course, the coefficient of linear expansion.

G. W. O. H.

TABLE I

	SiO_2	B_2O_3	Na_2O	CaO	K_2O	Al_2O_3	BaO	Sb_2O_3	PbO
Chance GH1 Hysil	80.4	12.4	4.2	0.3	—	2.7	—	—	—
Chance GS1 Intasil	74.5	13	5	0.5	—	4	3	—	—
Chance GS4	76	10.5	6	0.5	—	4	3	—	—
Chance GS3	67	21	3	—	4.5	4	—	0.4	—
Chance GW1 Soda-lime ..	74	—	16	7	—	1	—	1.3	—
Chance GW2 Lead glass ..	60	—	8	—	5	0.1	—	0.6	26

TABLE II

	Sp. Gr.	T_s	α	For direct sealing of
Chance GH1 Hysil ..	2.24	780° C.	33.6×10^{-7}	Hard bulb glass only
Chance GS1 Intasil ..	2.30	780	38.7	Tungsten
Chance GS4	2.32	760	45	Molybdenum
Chance GS3	2.23	710	49	Kovar-Fernico type alloys
Chance GW1 Soda-lime	2.49	640	87	Chrome Iron, Platinum, Dumet or copperclad
Chance GW2 Lead-glass	2.99	610	86	(as above)

T_s = softening temperature. α = Linear expansion coefficient.

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

"The Non-reflecting Termination of a Concentric Line"

To the Editor, "Wireless Engineer"

SIR,—The Editorial of your September number on "The Non-reflecting Termination of a Concentric Line" is a very helpful addition to the discussion of our recent I.E.E. paper. In it you refer to the length of short-circuited line which must extend beyond a graphite film of resistance equal to Z_0 in order that the termination so formed may be non-reflecting. In this connection we should like to mention that the $0.88\lambda/4$ length of extension line employed for this purpose was not based on a calculation, but was the length which *experimentally* provided the closest approach to the non-reflecting condition. The discrepancy between this length and $\lambda/4$ was attributed by us to the presence of the supporting disc of bakelite—though our remarks on the point are not as clear as they should have been. This accords with your statement that "If the disc (resistive film) is backed with an appreciable thickness of dielectric of higher permittivity (than air), the correct length of the short-circuited end piece will be somewhat reduced (from $\lambda/4$)." The capacitive shunt reactance of 400 $\mu\mu$F which we associated with the disc related to this bakelite support, and not to any stray capacitance associated with an open-ended line, such as you discuss.

Although no excuse for lack of clarity, our inability to state the wavelengths of measurement made discussion of the experimental results more difficult than is normally the case.

WILLIS JACKSON.
Manchester. L. G. H. HUXLEY.

"Deflected Electron Beams"

To the Editor, "Wireless Engineer"

SIR,—In his letter in the August issue, Mr. Benham asks me to explain why his calculation in *Wireless Engineer*, Vol. 16, No. 598, December, 1939, led to Benner's formula for the power loss in a deflecting condenser, while in the June issue Mr. Harries obtained Recknagel's result, starting from the same premissae. Mr. Benham's question is already partly answered by the letter from Mr. J. A. Jenkins in the August issue. Both Mr. Benham and Mr. Harries have started from the same *wrong* form of Ramo's formula for the induced current, as given by Jenkins' eqn. (1), instead of from the correct form (2). (First stated correctly by Recknagel, *Zeitschr. f. tech. Phys.*, 1938, p. 74.) From this wrong starting point Benham proceeded correctly, and arrived at Benner's formula, while Harries made a slip in the integration (in the middle term of his eqn. 3.1, *Wireless Engineer*, June, 1944), and derived Recknagel's result. I must therefore somewhat qualify my statement on Harries' admirably concise derivation, though it would deserve the epithet with the two slight corrections applied. As it stands, the correct result is obtained by two compensating errors, one in the premissae, the other in the calculation. Benham on the other hand, made an error only in his premissae.

By now readers of *Wireless Engineer* might well be somewhat bewildered by so many slips, errors and corrections. Those who might find my own derivation on p. 115 of the March issue too condensed or unfamiliar, may be referred to a fairly simple proof of Recknagel's formula by L. Malter in *RCA Review*, Vol. 5, No. 439, April, 1941.

Regarding Mr. Harries' letter in the September issue, neither I nor any of the other authors who have derived Recknagel's formula have assumed an abruptly terminating field. It has been merely assumed that the exit region is short as compared with the wavelength and with the length of the plates. Both assumptions are justified at not too high frequencies, and deflector plates closely spaced in relation to their length.

There is no essential difference between Lamont's formula (5.10) on p. 74 of "Wave Guides" and my formula (4b). Lamont's formula refers to a field terminated by two parallel plates at right angles to the z-direction, while I gave the formula for the case in which this extension is infinite. In both cases *curl E* is different from zero, and in both cases there exist special modes in which there is no x-directed field. But Mr. Harries will easily convince himself that also in the case of the H_{101} mode, which he mentions as an instance, there exists a magnetic field, transverse to any plane in which E_y is sinoidal and different from zero, hence the objection voiced at the end of my letter in the July issue still applies.

Rugby. D. GABOR.

I.E.E. Radio Section

THE opening meeting of the 1944–45 Session of the Radio Section of the Institution of Electrical Engineers will be held on Wednesday, October 11th, when the new chairman, H. L. Kirke, will deliver his inaugural address. Mr. Kirke has been head of the Research Department of the B.B.C. since 1925. He was in Marconi's Wireless Telegraph Company prior to joining the Corporation in 1924.

It will be recalled that the name of the Section has been changed to that of Radio Section, and the rule of the Institution governing the Section's scope modified to read : "The Section shall include within its scope all matters relating to the study, design, manufacture or operation of apparatus for communication by wave radiation, for high-frequency and electronic engineering, or for the electrical recording or electrical reproduction of sound."

On Wednesday, October 25th, Prof. Willis Jackson and J. S. A. Forsyth will deliver a joint paper on "The Development of Polythene as a High-Frequency Dielectric."

Two papers dealing with aerials will be delivered at the meeting on Wednesday, November 1st. The first is by Dr. E. B. Moulin, and is entitled "Theory and Performance of Corner Reflectors for Aerials" and the second, by H. Page, on "The Measured Performance of Horizontal-Dipole Transmitting Arrays."

At an informal meeting of the Institution arranged for Monday, October 23rd, the recently elected president, Sir Harry Railing, will open a discussion on "The Engineer's Part in Certain Post-war Problems."

All the above meetings will be held at the Institution, Savoy Place, Victoria Embankment, London, W.C.2, and will begin at 5.30.

Brit. I.R.E.

THE annual general meeting of the London Section of the British Institution of Radio Engineers will be held at the Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1 on Thursday, October 19th, at 6.0 when the president-elect, Leslie McMichael, will deliver his presidential address.

At the meeting of the Midlands Section of the Institution on October 25th at the University of Birmingham Dr. Hilary Moss will deliver a paper on "The Electron Gun of the Cathode-Ray Tube."

The next meeting of the North-Western Section will be held at the University of Liverpool on October 27th.

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

561 855.—Transformer casing in which provision is made to tolerate variations in the thickness of the laminae forming the magnetic core.
F. H. Haynes. Application date 2nd December, 1942.

562 217.—Automatic gain regulators in an audio-frequency amplifier for reproducing simultaneously different signals from a photo-electric sound record.
Radio Corporation of America. Convention date (U.S.A.) 30th March, 1940.

562 286.—Two-way supervisory signalling system in which low-frequency or sub-audio-frequency circuits are transmitted over a line wire.
Standard Telephones and Cables (communicated by International Standard Electric Corporation). Application date 22nd January, 1943.

DIRECTIONAL WIRELESS

562 284.—Radio beacon for blind landing wherein the equi-signal glide path is formed by phase-differentiated lobes radiated from low-lying antennae.
Standard Telephones and Cables (assignees of A. G. Kandoian). Convention date (U.S.A.) 19th January, 1942.

562 305.—Cathode-ray indicator for determining distance and direction of underwater bodies by means of reflected pressure-waves of supersonic frequency. [Addition to 542 634.]
H. F. Rost and P. H. E. Claesson. Application date 14th April, 1942.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

561 954.—Frequency discriminator for detecting frequency- or phase-modulated signals, comprising a piezo crystal which applies control voltages in phase-quadrature to two grid-controlled rectifiers.
Marconi's W. T. Co. and H. R. Cantelo. Application date 4th December, 1942.

562 258.—Combination of a capacitance and inductance for use as an aerial substitute in broadcast reception.
P. and D. and J. Westwood (trading as Westwood Bros.). Application date 5th January, 1943.

562 315.—Receiver for frequency- or phase-modulated signals wherein undesired amplitude variations are removed by a pair of limiting detectors arranged in push-pull.
Marconi's W. T. Co. (assignees of C. W. Hansell). Convention date (U.S.A.) 22nd December, 1941.

562 325.—Arrangement of the mixer valve in a superhet receiver so as to permit the intermediate frequency to be varied over a given range with the minimum of tuning readjustments.
Standard Telephones and Cables; C. M. le G.

Eyre; and J. O. Gilderdale. Application date 1st February, 1943.

562 340.—Negative feed-back amplifier in which two oppositely-poled rectifiers are used in the output circuit to maintain a strictly linear response.
Standard Telephones and Cables and A. W. Ewen. Application date 23rd December, 1942.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

561 926.—Television system wherein a light beam is controlled by passing it through a viscous liquid which is subjected to periodic deformation by the action of a modulated electron beam. [Addition to 543 485].
Ges. Zur Forderung &c. Technischen Hochschule. Convention date (Switzerland) 28th August, 1940.

562 113.—Coloured television system in which phasing signals are utilised to ensure the sychronisation of rotating colour filters.
Marconi's W. T. Co. (assignees of G. L. Beers). Convention date (U.S.A.) 28th June, 1941.

562 149.—Means for securing a high "gamma" or contrast effect in the television signals generated in a cathode-ray tube of the Iconoscope type when using a low-velocity scanning beam.
Marconi's W. T. Co. (assignees of G. A. Morton and L. E. Flory). Convention date (U.S.A.) 29th August, 1941.

562 168.—Colour television system in which two or more light-sensitive screens giving distinctive hues are separately scanned by different electron beams in the same cathode-ray tube, and the resulting images are superposed.
J. L. Baird. Application date, 25th July, 1942.

562 334.—Colour television system in which provision is made for avoiding the long repetition frequency that normally occurs when the scene to be reproduced happens to consist largely of one colour.
J. L. Baird. Application date 10th October, 1942.

TRANSMITTING CIRCUITS AND APPARATUS

(See also under Television)

561 977.—Automatically adjusting the circuits of a radio transmitter to a given frequency in two successive steps, the first giving rough tuning and the second an accurate setting.
Standard Telephones and Cables and W. A. Gold. Application date 8th December, 1942.

561 993.—Generating frequency-modulated signals by means of an inductance with two coils, one of which is controlled by the audio-frequency, the fields from both coils being at right angles to each other.
Aga-Baltic Akt. Convention date (Sweden) 3rd June, 1941.

562 329.—High-frequency oscillation generator in which a valve operating as a Class C amplifier generates harmonics from an applied frequency and feeds back the primary frequency.
Siemens Brothers & Co.; M. Reed; and S. H. Moss. Application date 16th February, 1943.

562 342.—Construction of a send-receive switch, say for an aircraft set, or for other circuits carrying high-potential radio-frequency currents.
Standard Telephones and Cables and S. H. Towner. Application date 23rd December, 1942.

SIGNALLING SYSTEMS OF DISTINCTIVE TYPE

562 276.—Electro-magnetic relay for rapidly switching a number of input circuits in an anti-fading or "diversity" system of radio reception.
Marconi's W. T. Co. (assignees of De W. R. Goddard). Convention date (U.S.A.) 20th December, 1941.

562 341.—Switching device comprising a gas-filled relay for generating electric pulses and for varying the ratio between make and break independently of the switch repetition frequency.
Standard Telephones and Cables; F. H. Bray; and F. E. Newton. Application date 23rd December, 1942.

562 381.—Selective receiver for remote control systems in which a desired operation is effected by the interval between successive impulses.
The British Thomson-Houston Co. Convention date (U.S.A.) 28th November, 1941.

562 392.—Arrangement for ensuring the stable operation of two parallel-connected negative feed-back amplifiers when switching a multi-channel H.F. transmission line.
Standard Telephones and Cables; A. H. Roche; and T. W. Elliott. Application date 24th December, 1942.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

561 905.—Discharge tube with means for imparting an axial rotation to the electron stream so that it impacts in sequence upon a number of different anodes.
Western Electric Co. Inc. Convention date (U.S.A.) 29th October, 1941.

561 910.—Discharge tube for velocity modulation in which the electrons are forced to take a helical path near the anode, so as to provide an output circuit of low impedance, for broad-band operation.
Marconi's W.T. Co. (assignees of L. S. Nergaard). Convention date (U.S.A.) 30th October, 1941.

561 911.—Velocity-modulation tube in which the fast and slow moving electrons are separated to move along paths at different radial distances from the axis of the tube, both streams delivering energy simultaneously to the anode.
Marconi's W. T. Co. (assignees of W. A. Zalesak). Convention date (U.S.A.) 30th October, 1941.

562 211.—Valve in which a number of co-planar grids are arranged between a single cathode and a common anode in order to mix the different

wave forms in a multi-channel communication system.

B. J. Edwards and Pye Ltd. Application date 18th December, 1942.

562 270.—Composition of luminescent material or phosphor for use in cathode-ray tubes, wherein the deleterious effect of de-oxidation is minimised.

Marconi's W. T. Co. (assignees of H. Nelson). Convention date (U.S.A.) 30th October, 1941.

562 274.—Cooling arrangement for the anode of an electron discharge device wherein provision is made for keeping the electrode at a somewhat higher temperature than the cooling medium, if and when desired.

Standard Telephones and Cables (assignees of C. V. Litton). Convention date (U.S.A.) 7th February, 1942.

562 298.—Electron discharge tube in which a one-turn spiral chamber serves as a resonator for bunching or modulating the electron stream in the process of generating short-wave oscillations.

A. G. Fraser-Nash and A. Whitaker. Application date 18th July, 1940.

562 299.—Electron multiplier in which grouping or bunching electrodes are disposed between the secondary-emission cathodes in order to velocity-modulate the electron stream.

F. J. G. van den Bosch and Vacuum-Science Products. Application date 5th September, 1940.

562 300.—Electron multiplier comprising means for first velocity-modulating the electron stream, and then converting that change into a density modulation.

F. J. G. van den Bosch and Vacuum-Science Products. Application date 5th September, 1940.

562 302.—Velocity-modulating discharge tube in which a control electrode is provided in the drift space for regulating the transit time of the electrons without affecting their linear distribution along the stream.

Standard Telephones and Cables (communicated by International Standard Electric Corporation). Application date 24th November, 1941.

562 306.—High-frequency generator of the beam-deflection type, wherein a hollow resonator chamber is formed between, and integrally with, the two alternative target anodes.

A. C. Cossor; L. Jofeh; and B. C. Fleming-Williams. Application date 7th May, 1941.

SUBSIDIARY APPARATUS AND MATERIALS

561 816.—Valve-controlled motor for accelerating electrons or other charged particles in order to secure impact effects.

The British Thomson-Houston Co. Convention date (U.S.A.) 13th January, 1942.

561 872.—Design, construction, and processing of the coated discs for a rectifier of the selenium type.

Standard Telephones and Cables; E. A. Richards; L. J. Ellison; and F. Gray. Application date 3rd December, 1942.

561 873.—Preventing damage to the coated discs during the manufacture of rectifiers of the selenium type.

Standard Telephones and Cables and A. M. Searle. Application date 3rd December, 1942.

561 889.—Assembling and centring the coated discs of a selenium-type rectifier.

Standard Telephones and Cables; E. A. Richards; L. J. Ellison; and F. Gray. Application date 3rd December, 1942.

562 032.—Piezo-electric oscillator held between spring-pressed rollers to minimise the effect of mechanical vibration when used on an aeroplane or other mobile craft.

Marconi's W. T. Co. and C. S. Cockerell. Application date 10th November, 1942.

562 034.—Precision control of the spacing between a crystal oscillator and its electrode in order to secure a fine adjustment of the operating frequency.

B. Tenenbaum. Application date 11th November, 1942.

562 145.—Arrangement for measuring inductance and capacitance comprising a crystal-controlled oscillator valve with a variably-tuned output circuit and a cathode-ray indicator of the magic-eye type.

R. H. Streete and W. Whitticase. Application date 15th December, 1942.

ABSTRACTS AND REFERENCES

Compiled by the Radio Research Board and published by arrangement with the Department of Scientific and Industrial Research

Comparative Length of the Abstracts.—*It is explained to new readers that the length of an abstract is no sign, by itself, of the importance of the work concerned. An important paper in English may be dealt with by a short abstract, or even, if it is in a journal readily obtainable, by a square-bracketed addition to the title; while a paper of similar importance in a language other than English may be given a long abstract. In addition to these questions of language and accessibility, the nature of the work has, of course, a great effect on the useful length of its abstract.*

PROPAGATION OF WAVES

3081. MEASUREMENT OF THE ELECTRIC FIELD IN THE INTERIOR OF AN ELECTROMAGNETIC GUIDE [with Special Reference to the Magnetic Type H_0 Wave in a Wave-Guide of Rectangular Cross Section].—H. Gutton & J. Ortusi. (*Comptes Rendus* [Paris], 5th/26th July 1943, Vol. 217, No. 1/4, pp. 18–20.)

"The determination of the electric field at a point in the guide leads to the knowledge, for a progressive wave, of the values of the electric and magnetic vectors at all points, and consequently to the knowledge of the value of the energy circulating in the guide. We have measured this field by determining the current induced in a wire of very small diameter placed parallel to the electric vector and connected to the two faces of the guide. The calculation of the radiation of the wire to the interior of the guide allows the relation to be determined between the current of circulation in the wire and the electric field in the neighbourhood of the wire."

In order to carry out this calculation, the writers first study the radiation from a conducting wire connected to two infinite conducting planes, assuming that the current is uniform along the wire. A cylindrical wave radiated by such a wire is defined by the component E_z of its electric vector, and this E_z is given by eqn. 1, which can be solved with the help of tables of Hanckel functions. To calculate the impedance E_z/I of the wire inside the guide, eqn. 1 must be replaced by one which takes into account the field reflected by the two faces of the guide which are parallel to the electric vector. This field can be calculated from a series of terms representing the radiation from the electrical images of the wire in the two infinite plane mirrors formed by these two faces: this series is divergent only in the very special case where the wire is at a distance equal to $\lambda/4$ or $3\lambda/4$ from the two faces: in all other cases it is calculable. Modifying eqn. 1 by introducing the sum A of the terms of this series, eqn. 2 if obtained for E_z.

If the guide is terminated at both ends by two elements with complex reflection-coefficients R_1, R_2, eqn. 2 must be modified to give eqn. 3 by adding to A a number B representing, at the point where the wire lies, the infinite succession of electric fields of the waves successively reflected by the two terminating elements. This number B can be calculated as a function of R_1 and R_2 and of the distances from the wire of the two terminations.

The h.f. current I in the wire is found by measuring the heating of the latter, which is formed of two 0.03 mm-diameter wires, of alloy "BTE" and "CTE" respectively, soldered to form a thermoelectric junction. Each wire is connected to a thicker copper wire, one of which goes to one face of the guide while the other goes to one plate of a plane condenser whose second plate is the other surface of the guide, separated from the first plate by a thin sheet of mica: this condenser has a very small impedance at ultra-high frequencies. The thermojunction is enclosed in a small evacuated bulb. The arrangement is calibrated at 50 c/s; correction for the change of resistance of the wire at u.h.f. is made. The apparatus has been employed to measure the coefficients of reflection of H_0 waves at discontinuities in the cross section of the guide: and also to measure the useful power, and efficiency, of the generators producing the waves.

3082. ELECTROMAGNETIC FILTERS [Study of Filter Action inside Wave-Guides].—Gutton & Ortusi. (*See* 3107.)

3083. "PROBLÈMES DE PROPAGATION GUIDÉE DES ONDES ÉLECTROMAGNÉTIQUES" [Book published in 1941].—L. de Broglie. (Referred to by Gutton & Ortusi, 3082, above.)

3084. Network-Analyser Studies of Electromagnetic Cavity Resonators.—J. R. Whinnery, C. Concordia, W. Ridgway, & G. Kron. (*Proc. I.R.E.*, June 1944, Vol. 32, No. 6, pp. 360–367.)

This is the "third" paper mentioned at the beginning of 2838 of September. Equivalent circuits for the Maxwell field equations were set up for a rectangular two-dimensional cavity, a cylindrical cavity, and an L-shaped two-dimensional cavity. "Comparisons made between the known theoretical results and the field distributions measured from the equivalent circuits are used for verification of the equivalent circuits, for evaluation of the usefulness of present network analysers in high-frequency-field problems, and for suggestions of desirable features for analysers constructed especially for the study of field problems."

3085. The Maxwell Laboratory at the University of Moscow [and Its Work on the Development of the Fundamental Principles of the Electromagnetic Theory].—Arkadiev. (*See* 3327.)

3086. Principles, Theory—and Practice: Early Ideas on Wave Propagation.—G. W. O. Howe. (*Wireless World*, July 1944, Vol. 50, No. 7, pp. 194–195: address to Wireless Section, I.E.E.)

3087. The Angle of the Inverted Cone Transmission Line which Simulates the Radio Waves.—G. W. O. H. (*See* 3156.)

3088. "Radio Waves and the Ionosphere" [Book Notice].—Bennington. (*See* 3330.)

3089. The Magmatic Phenomena and the Theories of the Electromagnetic Quantum [with Special Reference to the Writer's Electromagnetic Theory of Gravity: ending with an Explanation of Wireless Transmission Phenomena without calling upon the Help of Ionospheric Layers].—C. L. Sagui. (78-page Pamphlet, in French, pub. by Ayzac Frères, Avignon, France, in 1941.)

The theory, as applied to wireless propagation, does not deny the existence of upper-atmospheric ionisation, only of the various layers. Among the phenomena explained, by associating the electromagnetic gravitation with the pressure of light and the ionisation of the air, are Kiebitz's entrenched-aerial results, sunset and sunrise effects, night fading, seasonal variations, and the directional action of the inverted-L aerial. *See* also Sauty, 3090, below.

3090. The Ancient and Modern Theories of Gravitation, *and* Concerning the Constants of Weiss, Rydberg, and Planck.—L. Sauty. (30-page Pamphlet, in French, pub. by Ayzac Frères, Avignon, France, in 1941.)

Special attention is given to Sagui's various papers (*see* 3089, above), one of which, the "Theory of the Magnetic Nature of Gravity," appeared in *Phys. Review* of 1927. If it is agreed, with Sagui, that gravitation is of electromagnetic nature, there is no need for the geometries of Einstein and of Weyl in order to show that gravitation and the electromagnetic field are the same thing, though different in their intimate structure. In fact, if Sagui's contention that the gravitational field acts on light by changing its wavelength as a function of the movement of the field, there is no reason for the limited theory of relativity to survive: it will only retard progress.

3091. The Longest Way Round [Postcript to "Equatorial Radio Girdle: Avoiding Zones of Ionosphere Disturbance"].—Cable & Wireless, Ltd. (*See* 3281.)

3092. Atmospheric-Electric Observations at Huancayo, Peru, during the Solar Eclipse, January 25th, 1944.—Jones & Giesecke: Gish. (*See* 3104.)

3093. An Estimate of the Trend of Solar Activity, 1944–50 [based on Brunner's Recently Derived Empirical Formulae].—A. H. Shapley. (*Terr. Mag. & Atmos. Elec.*, March 1944, Vol. 49, No. 1, pp. 43–45.) *See* also 3094, below.

3094. Next Sunspot Cycle: Low Maximum Activity Predicted.—A. H. Shapley. (*Wireless World*, July 1944, Vol. 50, No. 7, p. 214.) A note by T.W.B. on Shapley's paper, 3093, above.

3095. Atomic Nitrogen in the High Atmosphere [Presence of λ3466.5 in Aurora but Not in Night Sky: etc.].—R. Bernard. (*Terr. Mag. & Atmos. Elec.*, June 1944, Vol. 49, No. 2, p. 128: summary only.)

The reviewer mentions incidentally that "in another paper not available here, Dufay, Gauzit, & Tcheng Mao-Lin announce the observation of the λ5200 line in the high atmosphere," contrary to one of Bernard's conclusions. For another Dufay–Tcheng paper on atomic nitrogen *see* 1890 of 1942.

3096. The Geographic Incidence of Aurora and Magnetic Disturbance, Northern Hemisphere.—E. H. Vestine. (*Terr. Mag. & Atmos. Elec.*, June 1944, Vol. 49, No. 2, pp. 77–102.)

Introduction: the isochasms of Fritz: the effect of cloudiness and daylight-conditions on the observed frequency of aurora in high latitudes: correction of observed data on auroral frequency for seasonal inequalities in duration of night: tables of auroral frequencies: isochasms based on standard frequencies, high latitudes: isochasms, northern hemisphere: isomagnetic lines of geomagnetic disturbance: references: bibliography.

3097. On the Magnetic Disturbances of Sudden Onset in the Paris Region: Annual and Diurnal Distribution of the Sudden Onsets [based on Observations over 60 Years].—C. Maurain. (*Comptes Rendus* [Paris], 5th/26th July 1943, Vol. 217, No. 1/4, pp. 8–10.) For a supplementary Note *see* pp. 57–59.

3098. Cosmic Rays [Lecture to Electronics Group, Institute of Physics, London].—L. Jánossy. (*Electronic Eng:g*, April 1944, Vol. 16, No. 194, pp. 449–452 and 466.)

3099. "A New Cosmic-Ray Recorder and the Air-Absorption and Decay of Particles": Correction ["μ = 22.8%" should read

"2.28%"].—A. Duperier. (*Terr. Mag. & Atmos. Elec.*, June 1944, Vol. 49, No. 2, p. 138.) *See* 2492 of August.

3100. "WEATHERWISE: ENGLAND'S WEATHER DURING THE PAST THIRTY YEARS" [Book Review].—J. H. Willis. (*Nature*, 24th June 1944, Vol. 153, No. 3895, pp. 756–757.)

3101. THE PROPAGATION OF WAVES ALONG TRANSMISSION LINES, AND THE CALCULATION OF THE RESULTANT WAVE AFTER SUCCESSIVE REFLECTIONS AT THE ENDS [Carson's Solution, and a New Solution expressed in Series-Development Form which lends Itself readily to Calculation].—Bayard. (*Bull. Soc. Franc. des Élec.*, March 1943, Vol. 3, p. 98 onwards.) Short summary in *Bull. Assoc. Suisse des Élec.*, 23rd Feb. 1944, Vol. 35, No. 4, p. S.7.

3102. PROBLEMS OF THE TRANSMISSION OF LIGHT THROUGH TISSUES AND SOME OTHER MEDIA [primarily in connection with Living Tissues & the Measurement of the Oxygen Content of Blood, but applicable to Any Medium of Two Constituents, the Second of Which is distributed throughout the First in the Form of a Series of Vessels of Varying Sizes, etc.].—D. S. Evans. (*Phil. Mag.*, May 1944, Vol. 35, No. 244, pp. 300–314.)

3103. SCALAR POLARISATION FRINGES PRODUCED BY THE SUPERPOSITION OF CRYSTALLINE PLATES [with Equations & Photographs].—B. H. Billings. (*Journ. Opt. Soc. Am.*, May 1944, Vol. 34, No. 5, pp. 267–269.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

3104. ATMOSPHERIC-ELECTRIC OBSERVATIONS AT HUANCAYO, PERU, DURING THE SOLAR ECLIPSE, JANUARY 25TH, 1944.—M. W. Jones & A. A. Giesecke: O. H. Gish. (*Terr. Mag. & Atmos. Elec.*, June 1944, Vol. 49, No. 2, pp. 119–122.)

The chief effects associated with this partial eclipse were:—"The potential gradient decreased in value during the eclipse: the positive and negative conductivity increased: air–earth current density, as computed from values of the potential gradient and conductivity, increased: the nuclei count of the atmosphere decreased. These effects are attributed to corresponding variations in the solar heating of the lower strata of the atmosphere". The paper is followed (pp. 123–124) by a discussion of it by O. H. Gish: effects like those reported, "despite their dependence upon restricted local conditions, are, however, of interest because a study of them leads to a better conception of the factors which produce departures from the universal component of diurnal variation in potential gradient, and, to a lesser extent, in air–earth current".

PROPERTIES OF CIRCUITS

3105. ON ELECTRICAL RESONANCE [in a Coaxial Line & a Dipole Aerial].—Collie. (*See* 3155.)

3106. NETWORK ANALYSER STUDIES OF ELECTROMAGNETIC CAVITY RESONATORS.—Whinnery & others. (*See* 3084.)

3107. ELECTROMAGNETIC FILTERS [Study of the Problems of Filter Action inside Wave-Guides with Conducting Walls].—H. Gutton & J. Ortusi. (*Comptes Rendus* [Paris], 5th/26th July 1943, Vol. 217, No. 1/4, pp. 67–69.)

For other work on wave-guides *see* 3081, above. "Let us consider a progressive incident wave U_i of a given type circulating in the interior of a guide. Let us suppose that there is a discontinuity of section which provokes a reflection, and let U_r be the reflected wave; we will suppose it to be of the same type as the incident wave. These two waves interfere in front of the discontinuity. From the knowledge of the maximum and minimum amplitudes, the modulus of the coefficient of reflection is obtained. The position of the nodes and antinodes measures the variation of the phase of the reflected wave. The modulus and the phase define a complex coefficient of reflection R such that $U_r = RU_i$. We will define also a complex coefficient of transmission T, such that the transmitted wave $U_r = TU_i$.

"The principle of the conservation of energy provides a relation between the moduli of R and T; the energy of the incident wave is equal to the sum of the reflected and transmitted energies in the case where the losses by conduction current in the walls are negligible. Suppose the guide to be separated into three parts, A, B, C, by two discontinuities 1 and 2. The filter cell thus constituted has coefficients of reflection R and transmission T which are calculable as functions of the coefficients of transmission and reflection, and the transit angle θ, of the wave between 1 and 2: $R = R_1 + R_2T_2T_3e^{-2i\theta}/(1 - R_2R_3e^{-2i\theta})$ and $T = T_1T_2e^{-i\theta}/(1 - R_2R_3e^{-2i\theta})$. These results are obtained by taking the sum of the series of reflections between 1 and 2; R_1 and T_1 are the coefficients of reflection and transmission at the passage through the discontinuity 1 from A towards B, R_2 and T_2 are those at the passage from B towards C, and R_3 and T_3 those at the passage from B towards A.

"The modulus of the transmission coefficient of the filter cell is $|T| = |T_1||T_2|/\{1 - 2|R_2||R_3| \cos (2\theta - \phi_2 - \phi_3) + |R_2|^2|R_3|^2\}^{\frac{1}{2}}$, where ϕ_2 and ϕ_3 are the arguments of R_2 and R_3. The transmission coefficient is a maximum when $\cos(2\theta - \phi_2 - \phi_3) = 1$, which is the condition of resonance of the cell: it is a minimum for $\cos(2\theta - \phi_2 - \phi_3) = -1$.

"To obtain a good filtering effect, the transmission coefficient of the cell must be small for all frequencies differing from the pass frequency. The denominator is a function of θ, minimum at resonance. If R_1 and R_2 are near to unity, the modulus of the transmission coefficient is near to unity for the resonance frequency. For $T_1 = T_2$ and $R_2 = R_3$, the transmission coefficient is then $t = |T|^2/(1 - |R|^2)$. But the principle of the conservation of energy gives the relation $|T|^2 = 1 - |R|^2$; hence the transmission coefficient of the cell at resonance is equal to unity. The function $t = (1 - |R|^2)/\{1 - 2|R|^2 \cos (2\theta - \phi_2 - \phi_3) + |R|^4\}^{\frac{1}{2}}$ gives the variation of the transmission coefficient as a function of θ.

"This process of calculation can be applied to a succession of filter cells formed by a series of discontinuities, thus leading to a network, in the interior of a guide, analogous to the filter networks of the telephonists. It is possible to foresee band-pass filters. We have carried out experiments in the case of a guide whose section was rectangular with 30 cm and 4 cm sides, inside which a magnetic wave type H_{01} was circulating. The electric vector for this type of wave is polarised parallel to one of the sides of the cross section. The reflecting discontinuities were formed by two conducting diaphragms each placed in a cross section and pierced by a slit of 1 mm width: the electric field was perpendicular to the edges of the slit. We have plotted the transmission curve of the cell as the distance between the two slits was varied. The calculated curve agrees well with the experimental. The modulus of the transmission coefficient at resonance was found to be exactly unity.

"This calculation is applicable to the transmission of the incident energy of a wave at a receiver producing a reflection coefficient R of the incident wave. It is necessary, in order to consume all the energy incident on the receiver, to add in front of the receiver a discontinuity having the same coefficient of reflection (in modulus) as the receiver, and placed at such a distance that the cell thus formed shall be in resonance."

3108. BAND FILTER FOR ULTRA-SHORT WAVES [General Considerations: the Use of Cavity Resonators (Pot Type): a Four-Circuit Filter with Alternate Capacitive & Inductive (Holes in Dividing Wall) Coupling: an Experimental Amplifier with Two Amplifier Stages & Three 2-Circuit Inductively Coupled Band Filters with Adjustable Coupling, for a 1.7 m Wave, Amplification 300: Self-Supporting Construction: Transmission Curves of Such a Filter compared with Those of a Broadcast-Band Filter & a Bridge-Type Quartz Filter].—A. de Quervain. (*Bull. Assoc. Suisse des Élec.*, 8th March 1944, Vol. 35, No. 5, pp. 109–111: in German.)

3109. FLUCTUATION PHENOMENA AS LIMITS OF AMPLIFICATION AND RECEPTION [Fluctuation Sources in Amplifiers & Receivers: Aerial Noise: Resistance Noise: Valve Noise: the Limiting Sensitivity of Amplifiers & Receivers].—W. Kleen. (*E.T.Z.*, 9th Sept. 1943, Vol. 64, No. 35/36, p. 473 onwards.) A 6-page paper, mentioned in *Bull. Assoc. Suisse des Élec.*, 19th April 1944, p. S.12.

3110. RESPONSE OF A LINEAR RECTIFIER TO SIGNAL AND NOISE.—W. R. Bennett. (*Bell S. Tech. Journ.*, Jan. 1944, Vol. 23, No. 1, pp. 97–113.) Already dealt with in 1883 of June.

3111. TEMPERATURE COMPENSATION: AN ANALYSIS OF AN UNCOMPENSATED TEMPERATURE ERROR OCCURRING IN VARIABLE-FREQUENCY TANK CIRCUITS EMPLOYING CERAMIC CAPACITORS FOR COMPENSATION.—H. Sherman. (*Electronics*, April 1944, Vol. 17, No. 4, p. 125.)

The development of the variable-temperature-coefficient ceramic capacitor to the point where well-controlled mass production is possible has increased the use of such capacitors for the temperature compensation so essential for military equipment. "The extensive use of this type of compensation has introduced an uncompensated error in variable-frequency circuits which appears at all frequencies except the one for which the ceramic-capacitor t.c. is chosen [*see* eqn. 9] . . . The necessity for compensating inductance changes by equivalent inductance changes rather than by capacitance changes has been indicated in an article by Thompson entitled 'Temperature-Compensated Wavemeter Coil'" [866 of March].

3112. TEMPERATURE COEFFICIENT OF AIR-CORED SELF-INDUCTANCES: THE CASE OF A "THIN" CURRENT-CARRYING LAYER.—A. Bloch. (*Wireless Engineer*, Aug. 1944, Vol. 21, No. 251, pp. 359–367.)

Author's summary:—"In § 1 a simple first approximation for the value of the internal self-inductance of the coil is derived from the assumption that the electromagnetic field enters the conductor like a plane electromagnetic wave, an assumption which is always justified when the current-carrying layer is thin compared with the dimensions of the conductor. In this case it follows most easily from Howe's 'transmission-line treatment' of wave propagation that the reactive power 'consumed' by the internal reactance must be equal to the real power consumed, *i.e.* that the internal reactance ωL_i must equal the loss resistance R_i of the coil, or $L_i \approx L/Q$, where L = total inductance of coil and 'Q' refers to the copper losses only.

"As the skin thickness, and therefore the losses, vary as the square root of the resistivity of the conductor-material, it follows that the t.c. of the internal inductance equals half the t.c. of the resistivity (*i.e.* in the case of copper conductors it will be 2100×10^{-6}). If the variation of the internal inductance were the only change to be reckoned with, the coil as a whole would then possess a t.c. of self-inductance equal to $2100 \times 10^{-6}/Q$. This result is valid for all kinds of conductor cross-sections, and includes the effect of copper shielding cans. It is easily generalised to take account of different conducting materials in the field of the coil.

"In § 2 it is shown . . . that for the case of a circular conductor the result obtained in § 1 includes the influence of the field-penetration on the external field of the coil. In § 3 the case of additional geometrical changes of the coil dimensions is dealt with, including the case where the diameter of the coil-wire expands at a rate different from that of the over-all coil-dimensions. Appendix I derives a simple formula for the copper losses and the Q value of an inductance coil. An example shows quite clearly that the opinion of previous investigators as to the negligible influence of the proximity effect on the internal inductance requires revision. For the sake of completeness, Appendix II derives some skin-effect formulae from transmission-line considerations, including that for Wheeler's equivalent-magnetic-skin thickness."

3113. A NOMOGRAM FOR THE CALCULATION OF SINGLE-LAYER CYLINDRICAL COILS [with the Added Simplicity, compared with Previous Types, of giving the Required Information in a Single Process, with the help of a Cross-Line Reading Device indicating Four Points Simultaneously]—J. Seebe. (*Funktech. Monatshefte*, June 1943, No. 6, p. 67.)

3114. EFFECT OF STRAY CAPACITANCE ON COUPLING COEFFICIENT [is to Increase, Decrease, or leave it Unaffected, according to Connections & Way the Coils are wound.].—G.W.O.H.

(*Wireless Engineer*, Aug. 1944, Vol. 21, No. 251, pp. 357–358.) Sequel to the Editorial dealt with in 2157 of July.

3115. OPERATING CONDITIONS OF ACTIVE ELECTRICAL TRANSDUCERS: ANALYSIS AND DESIGN BY MEANS OF A VOLTAGE RATIO [instead of the Usual Impedance Ratio], AND APPLICATION TO THERMIONIC-VALVE CIRCUITS.—B. M. Hadfield. (*Wireless Engineer*, Aug. 1944, Vol. 21, No. 251, pp. 368–376.)

The writer concludes: "It should be clear from the above that the general and specific design of circuits comprising a source of energy and a load, whether the operation be such as never to attain, or just to attain, the circuit voltage and current limits, and whether the design be for volt-ampere output, for efficiency, or for voltage transfer-ratio, is expressed most directly and usefully by means of a ratio between the load and source voltages. It is most direct, because the required conditions cannot be stated generally without use of such a ratio: and most useful for design purposes, because the circuit conditions can be stated in terms of the required practical values of voltage and current.

"Furthermore, as the volt-ampere efficiency and voltage transfer are intimately related to this ratio, and maxima of these quantities should be the ultimate aim of the designer, expression by means of this ratio makes for a rapid and successful design procedure." Application of the method to thermionic-valve circuit design (triode, tetrode, pentode) is outlined, and a simple and flexible method of stating the over-all gain is proposed which enables the design of amplifying stages to be performed explicitly in terms of the required circuit voltages and currents.

3116. NODE EQUATIONS.—M. B. Reed. (*Proc. I.R.E.*, June 1944, Vol. 32, No. 6, pp. 355–359.)

Author's summary:—"The node equations are shown to be Kirchhoff's current equations expressed in terms of circuit admittances and voltages from all network junctions or nodes to the reference node (node at which a current equation is not written). A method of writing these node equations directly from a network is presented. This method is given in such a form that it applies to any network, even though mutual magnetic induction, regulated generator voltages, and given input currents are included", which was not the case with methods previously given (refs. "1," "2"): thus it "places the node-equation technique where it belongs, on an entirely equal footing with the mesh equations as a complementary scheme of writing network equations".

It is pointed out that the theorem suggested by Millman (338 of 1941) "is actually a node equation with only passive elements in the branches connected to the node. The method given here, therefore, extends Millman's theorem to any node in any network".

3117. A METHOD OF SOLVING CERTAIN NON-LINEAR CIRCUIT PROBLEMS [limited to Circuits containing Non-Reactive Elements].—W. H. B. Cooper. (*Wireless Engineer*, July 1944, Vol. 21, No. 250, pp. 323–326.)

"When the law of a non-linear device can be expressed in the form of a simple 'analytic' function over its entire range, then there is, generally speaking, no difficulty in obtaining a solution to the problem. In practice, however, the problem cannot often be solved in this simple way, but the law of the device in question can usually be represented by taking a sufficient number of terms of a power series. In those cases where the law can be expressed by means of, say, two 'artificial' functions, then these two functions can be combined by a Fourier series, resulting in one expression which will hold over a limited, but controllable, range. An answer is produced in a form which is particularly useful for ascertaining the magnitudes of specific distortion (modulation) products." Four examples of the application of the method are worked out, including the case of a voltage limiter.

"It will be appreciated that this method of solution is of real value when two or more sinusoidal input signals are applied simultaneously. . . ." For Bennett's earlier work, mentioned on p. 323, *see* 1933 Abstracts, p. 389.

3118. OPTIMUM WORKING CONDITIONS FOR THE TRANSMITTING VALVE WITH AN OSCILLATORY CIRCUIT HAVING LOSSES, *and* THE VALIDITY OF THE EQUIVALENT PLATE-CIRCUIT "THEOREM" FOR POWER CALCULATIONS.—Hülster: Stockman. (*See* 3168 & 3169.)

3119. "OPTIMUM LOAD" [Letter on Sturley's Article (2159 of July): an Alternative Explanation which has been found Acceptable to Students].—W. H. Date: Sturley. (*Wireless World*, July 1944, Vol. 50, No. 7, p. 222.)

3120. A NEW TREATMENT OF THE WHEATSTONE BRIDGE NETWORK.—Wey. (*See* 3215.)

3121. THE FREQUENCY SPECTRUM OF PERIODIC PULSES [Square-Wave & Saw-Tooth].—Filipowsky. (*See* 3200.)

3122. STABILITY OF REGENERATION: THE DAMPING OF THE MULTIVIBRATOR CIRCUIT.—Eisenmann. (*Funktech. Monatshefte*, April/May 1943, No. 4/5, pp. 53–55.)

The usual mathematical treatment of regeneration involves two generally complex quantities, the amplification V and the back-coupling K. A method of calculation which, without involving the latter quantity, would give a direct account of the mutual effects between the input and output circuits would be useful, but as a generalised method applicable to all theoretical cases would be very complex and difficult to carry through. In most practically important cases, however, the back-coupling process can be reduced to two conditions following one another in rapid or infinitely rapid succession. In the one condition (represented by the subscript m) the quantity carrying out the regeneration (current value, for inductive coupling; voltage for capacitive coupling; represented in either case by X) forms with the grid voltage (at first taken as arbitrary) of the back-coupled valve a pure linear function involving only the outside voltage e_1 but no dependent voltage or current values; whereas the other, immediately preceding condition, $m - 1$, represents the dependence of the grid voltage on this quantity X. The conjunction of the two conditions leads to a recursion formula representing the actual condition of the back-coupling process and giving the value of X as well as the condition for stability or instability of the process. The paper shows that this treatment leads to precise and simple solutions, in which the internal resistance of the back-coupled valve is represented by $r = 1/SD$.

Through the action of X a voltage e is impressed on the grid: if $e/D = a$, the m-condition is represented by $X_m = A' + h.a$. But the arbitrary value $e = aD$ (D is the value of "durchgriff" or penetration coefficient) is actually produced by the quantity X_{m-1} of the immediately preceding condition, so that $a = B + k . X_{m-1}$. Thus the recursion formula for calculating X is

$$X_m = (A' + hB) + hk . X_{m-1} = A + c . X_{m-1}$$

where A ($= A' + hB$) and c ($= hk$) are constants which contain only the outside voltage e_1. The development of the formula gives

$$X_m = A . (1 + c + c^2 + \ldots c^n . X_{m-n}).$$

Now X_m represents the final value X after m conditions in rapid succession and in infinite number, so that m must be put at ∞ and X_o at zero: in order that X_m may have a definite final value, the geometrical series $1 + c + c^2 + \ldots$ must converge. Therefore the convergence of this series represents the condition for the stable working of the regenerative process.

The series is in general made up of complex terms $c = x + j . y$; such a series always converges if the real geometrical series formed from the absolute terms of the series, $1 + |c| + |c|^2 + \ldots$, converges. The convergence condition of the complex series, and therefore the stability condition, is thus in general $|c| = \sqrt{x^2 + y^2} < 1$. But in the case of convergence the complex geometrical series can be replaced by the finite expression $1 + c + c^2 + \ldots = 1/(1 - c)$, so that finally $X = A/(1 - c)$. The application of these general equations is first illustrated by the case of the regeneration of the circuit of Fig. 1, where the outside excitation e_1 is applied to the anode oscillatory circuit: the stability condition is found to be given by eqn. 11, the value of X by eqn. 14. The application to more complicated circuits is illustrated by the case of Fig. 2, where the outside excitation e_1 controls the input valve 1, with its parallel ohmic resistance w forming one arm of a bridge circuit beyond which there are two valves 2, 4, capacitively back-coupled in a multivibrator-type connection. In the bridge-diagonal $D_{12} - D_{34}$ there is a compound resistance R_d made up of three paralleled resistances, the ohmic resistance R, the inductive ωL, and the capacitive $1/\omega C$.

The treatment in question is used to show that it is the choice of the values R, L, and C, forming the diagonal resistance R_d, that determines the stability or instability of the whole arrangement. The X in this case is the differential effect V between the diagonal-points of the bridge; eqn. 18 gives the stability condition, eqn. 19 the value of V. For special cases simpler equations, 21, 23 and 20, 22, are obtained. The stabilised differential effect V can obviously be amplified and used for indicating.

3123. Stabilising Electronic Circuits.—M. Lévy. (*Journ. British I.R.E.*, March/May 1944, Vol. 4, No. 1, pp. 48–74.)

Part I—Some Problems concerning Selective Amplifiers & Oscillators (use of negative feedback to increase the stability of selective amplifiers [*see* also 2327 of 1943], and a convenient bridge circuit developed by the writer and produced commercially by "Secla," Ltd., in 1932: an output-voltage stabiliser for variable-frequency oscillators, British Patent of 1942, with shunting triode instead of diode [*see* also 2332 of 1943]: an output-current stabiliser for variable-frequency oscillators (meter-control unit, *e.g.* for stabilising the h.f. current produced by the oscillator of a Q-meter, variations of more than 100% being reduced to below 3%: coupling coils carried on pointer of meter: British Patent of 1943).

Part II—Some Problems concerning Instabilities produced by Mains-Voltage Variations (method of total compensation: of individual compensation: method of compensation for non-linear elements, and application to voltmeter circuits: a simple h.t. stabiliser circuit for pentodes—"the usual electronic stabiliser circuits usually increase greatly the load on the h.t. supply source and are for some applications very uneconomical. In these cases, and particularly when it is intended to supply pentode valves, a simple stabilising circuit can be used"). In his reply to the Discussion the writer agrees that Miller's double-triode circuit (2314 of 1942 [and Williams, 2525 of August]) is very suitable for small voltages, as in biological studies. He also discusses the Partridge control circuit (Fig. 27) for the screen-grid voltage for power pentodes, and the Arguimbau–Groszkowski stabilising circuit (dynatron controlled by diode) of Fig. 28.

3124. The Stability Factor of Negative Feedback in Amplifiers.—S. Becker. (*Proc. I.R.E.*, June 1944, Vol. 32, No. 6, pp. 351–353.)

"There are many means of obtaining negative feedback, and since these are adequately covered in the literature, specific circuits will not be given here. It is intended, rather, to develop a set of equations which will enable the engineer to design negative-feedback amplifiers for various applications"; determining the increase in stability caused by negative feedback when it is known how much gain may be sacrificed; the effect on gain and stability of a given amount of negative feedback; and how much gain must be sacrificed in order to obtain a certain stability. Other advantages of negative feedback are briefly dealt with at the end by literature references.

3125. Negative Feedback in Audio-Frequency Amplifiers.—Chang-Ly Lee. (*Cambridge Dissertations*, 1942/3 [Abstracts of], pub. 1944, p. 24.)

"The amplification factor $A_o = A|\gamma|(1 - A\beta e^{j\phi})$ is worked out by a new method, and it is concluded that the amplification will approximate to $-|\gamma|\beta e^{j\phi}$ when a very large amount of feedback is applied to the amplifier. A systematic mathematical derivation is used to show that the distortion is reduced by a factor of $1/(1 - A\beta)$ in negative-feedback amplifiers. In voltage-feedback amplifiers the ratio of the amplitudes of second harmonic contained in the output voltage to the fundamental is reduced by the same factor as the amplification of the fundamental.

"By use of Terman's relative amplification theory at low and high frequencies, two tables are obtained and are used for the comparison of the frequency-response of an amplifier without or with different amounts of feedback. An example is given to show that negative feedback in some cases makes the frequency-response worse instead of improving it." A 5 kw transmitter, with negative feedback applied to improve its qualities, was designed and tested, with satisfactory results.

3126. [NEGATIVE-] FEEDBACK AMPLIFIER FOR CATHODE-RAY OSCILLOSCOPES.—G. R. Mezger. (*Electronics*, April 1944, Vol. 17, No. 4, pp. 126–131 and 254.)

"It would appear, therefore, that some method for reduction of the output impedance, which would not sacrifice load-circuit impedance and thereby transfer the power-dissipation of the circuit to the plate of the vacuum tube, would prove of value. In special cases, where wide frequency-range is of prime importance, cathode-followers have been employed for the deflection of c.r. tubes. The low limit on the output potential available from the cathode-follower, however, has precluded its general adoption for such purposes. . . ." On the other hand, "the reduction of impedance level of the output circuit . . . by the use of negative voltage feedback can be greater than 90% of the value without feedback. This fact is further developed in the Appendix. Such a method, therefore, is of particular interest in the case of c.r. tube deflection-amplifiers. . . ." The theory and design of such an amplifier are given. The advantages made possible by the proper combination of positive current feedback and negative voltage feedback (Mayer, 2721 of 1939) are touched on.

3127. THEORETICAL TREATMENT OF THE PUSH-PULL CLASS AB SYSTEM WITH CATHODE-CIRCUIT RESISTANCES.—Kauffeldt. (*See* 3136.)

3128. ON THE MODE OF ACTION OF THE "CATHODE" AMPLIFIER.—R. Wunderlich. (*Bull. Assoc. Suisse des Élec.*, 8th March 1944, Vol. 35, No. 5, pp. 124–125: long illustrated summary, in German, of the paper dealt with in 36 of 1943.)

3129. RADIO-FREQUENCY PENTODES AS AUDIO-FREQUENCY AMPLIFIERS: ADVANTAGES OVER TRIODES IN EARLY STAGES.—Amos. (*See* 3171.)

3130. RADIO DATA CHARTS: NO. 16—VOLTAGE GAIN OF RESISTANCE-COUPLED AMPLIFIERS.—J. McG. Sowerby. (*Wireless World*, July 1944, Vol. 50, No. 7, pp. 209–211.)

3131. EQUALISER DESIGN: ATTENUATION AND PHASE FUNCTIONS OF FREQUENCY–TRANSMISSION CHARACTERISTICS IN CIRCLE DIAGRAMS, FOR DETERMINING PERFORMANCE AND SELECTING CIRCUIT CONSTANTS OF "CONSTANT-RESISTANCE" AND OTHER CONVENTIONAL TYPES.—M. J. Di Toro. (*Electronics*, April 1944, Vol. 17, No. 4, pp. 118–120.)

TRANSMISSION

3132. THE GENERATION OF DECIMETRIC WAVES WITH DIODES.—J. Menke. (*Bull. Assoc. Suisse des Élec.*, 3rd May 1944, Vol. 35, No. 9, pp. 253–255: summary, from *Funktech. Monatshefte*, No. 11/12, 1942: in German.)

If the same demands are to be made, as regards constancy of frequency, on waves below 1 m as on broadcasting waves, then they must be generated by frequency-multiplication of a lower-frequency master-oscillator. In the construction of the multiplier, where the "valve" action of thermionic tubes is employed, the electron transit time of the valves plays an important part. An oscillatory circuit can be excited by a thermionic tube (acting as a controlled "valve") only if the anode current, and therefore the charge within the electrode space, alters in the rhythm of the frequency: this is possible only if the phase angle ϕ is smaller than 2π, *i.e.* is less than the duration of a period. The anode current begins to flow so soon as the electrons from the cathode enter the discharge space, and not, as is sometimes assumed, only when they impinge on the anode. If the transit time is equal to the length of the period ($\phi = 2\pi$), the average space charge remains constant and a direct current flows in the anode circuit, all control action ceasing. The same thing happens if ϕ is a whole multiple of 2π. Fig. 1 show show ϕ affects the current in the anode circuit: as ϕ increases, the ratio between output power and control power grows steadily worse and finally becomes less than unity.

Since ϕ increases with increasing cathode/anode gap, an obvious plan is to replace triodes by diodes (Fig. 3); for the power amplification in any case is less than unity, and higher voltages can be applied to a diode without fear of breakdown. Assuming a straight-line characteristic, an equation is found for the mean value of the anode current over a period: $\bar{I} = K \cdot (u + u_o) \cdot (\sin\delta - \delta\cos\delta)/\pi(1 - \cos\delta) = i_s \cdot \psi(\delta)$, where i_s is the peak current: δ is the current-flow angle, the time (expressed in angular measure) for which the anode current flows during a half-period. This equation helps to design the cathode so that the peak value of the current remains below the saturation current. Even though the characteristic of the diodes used may be a space-charge curve instead of a straight line, the deviations from the above equation are insignificant up to current-flow angles of 120°.

The experimental circuit is seen in Fig. 5: the master-oscillator had a maximum output of 20 w, its frequency was 300 Mc/s. The two diodes shown were actually combined in a duo-diode valve: the connections to the common cathode and the two anodes were made in the form of a Lecher system (Fig. 6) acting as the oscillating circuit of the 600 Mc/s output stage. A rotor of dumb-bell form between the shaped ends of this Lecher system served to tune the symmetrical valve capacitances C', C'', while the tuning condenser C_1 of the output stage (*see* equivalent circuit) was varied by screwing the disc C_1 nearer to or further from the lower, double Lecher strip [in Fig. 5 the anodes are shown as common, the cathodes being led out separately, whereas Fig. 6 shows the duo-diode with its common cathode and the separately led-out anodes: there is no appreciable difference in the functioning].

"An interesting construction is also obtained if instead of the Lecher system a pot circuit is used; this serves at the same time as the valve container. The equivalent circuit would be something like Fig. 8. Owing to the improved electrical construction and the better matching, the output obtained is larger. Both systems, Lecher-pair and pot-circuit, provide better matching of the transmitter to the external circuit than is given by ordinary circuits," which for various reasons (valve capacitances, skin effect, decrease of sharpness of resonance, etc.) have a reduced resonance resistance as the frequency is increased: thus for good matching the external resistance must be reduced and the valve becomes incompletely controlled. This may happen by a reduction of the anode voltage, combined with a raising of the saturation current: the electron transit time will be increased, with consequent disadvantages. The summary ends with a few data for the two arrangements.

3133. A COUPLED-CIRCUIT FREQUENCY MODULATOR [using a Condenser Microphone].—E. J. O'Brien. (*Proc. I.R.E.*, June 1944, Vol. 32, No. 6, pp. 348–350.)

"The capacitance variation in a condenser microphone, when connected in the tank circuit of an oscillator, will produce frequency modulation of an oscillator. In fact, this method has been used to explain the theory of operation of a simple frequency modulator. However, since only a small frequency deviation is possible, the method is not practical. This paper shows that by certain circuit modifications, wide-band frequency modulation can be accomplished in a single-tube transmitter, using a signal-operated condenser as a modulator . . . High-fidelity frequency modulation is possible for the coupled-circuit modulator when the microphone has a change in capacitance that is proportional to the sound pressure and independent of the frequency of the signal wave. This condition is met in the ideal microphone and reasonably so for commercial microphones."

3134. NEW VALVE-OSCILLATOR CIRCUIT [of High Frequency-Stability & Low Harmonic Content, without Critical Adjustments and operating over a Wide Range of Frequencies: based on Use of Properties of a Half-Wave Artificial Line, with Lumped Inductance & Capacitance].—F. Butler. (*Wireless Engineer*, July 1944, Vol. 21, No. 250, pp. 317–319.)

Applications include its use as the basis of a stable heterodyne frequency meter; in a beat-frequency oscillator where one of the r.f. sources is required to be free from harmonics; in the production of a circular time-base of variable frequency (making use of the fact that the mid-shunt and terminal voltages are in phase-quadrature); and as a neutralised amplifier. "Further sections of artificial line may be added at the output end of the circuit for the purpose of impedance matching or additional filtering": *e.g.* for the energising of a low-impedance aerial. The writer concludes: "At high frequencies the artificial line may be replaced by a section of actual transmission line having distributed constants, but in this case the electrical performance is largely modified and controlled by the inter-electrode capacitances of the valve. This is particularly so if a triode is used."

3135. TEMPERATURE COMPENSATION [especially in Military Transmitters: an Uncompensated Error in Compensation by Ceramic Capacitors].—Sherman. (*See* 3111.)

3136. THEORETICAL TREATMENT OF THE PUSH-PULL CLASS AB SYSTEM WITH CATHODE-CIRCUIT RESISTANCES.—A. Kauffeldt. (*Telefunken-Röhre*, Feb. 1943, No. 27/28, p. 22 onwards: a 20-page paper.) A short summary is given in *Bull. Assoc. Suisse des Élec.*, 5th April 1944, Vol. 35, No. 7, p. S 10.

3137. HISTORIC FIRSTS: HIGH-EFFICIENCY AMPLIFIER FOR RADIO TRANSMITTERS.—W. H. Doherty. (*Bell Lab. Record*, May 1944, Vol. 22, No. 9, p. 386.)

3138. MILITARY TRANSMITTER IN MASS PRODUCTION [Successful Application of Assembly System similar to Those used in Pre-War Manufacture of Radio Receivers, to the Heavier, Much More Complicated BC-610-E (Hallicrafter Pre-War HT-4 Transmitter)].—C. T. Read. (*Electronics*, April 1944, Vol. 17, No. 4, pp. 121–124.)

RECEPTION

3139. MECHANICAL MODELS OF FREQUENCY CONVERTERS.—Stockman. (*See* 3166.)

3140. FLUCTUATION PHENOMENA AS LIMITS OF AMPLIFICATION AND RECEPTION.—Kleen. (*See* 3109.)

3141. RESPONSE OF A LINEAR RECTIFIER TO SIGNAL AND NOISE.—W. R. Bennett. (*Bell S. Tech. Journ.*, Jan. 1944, Vol. 23, No. 1, pp. 97–113.) Already dealt with in 1883 of June.

3142. DISCUSSION ON "THE RECTIFYING PROPERTY OF CARBORUNDUM" [Kendall, 1913 of June].—A. Fairweather: J. T. Kendall. (*Proc. Phys. Soc.*, 1st July 1944, Vol. 56, Part 4, No. 316, pp. 270–271.)

Classification (colour *versus* crystal structure): criticism and defence of the fused-contact technique: the phenomena at high voltages.

3143. MAGNETOSTRICTION NOISE FROM TELEPHONE WIRES [Steel or Copper–Steel, vibrated by Wind, etc: 1942/3 Tests on Magnitude & Frequency-Distribution: the $f = 7 \times v/d$ Relation: Method of Damping].—M. T. Dow. (*Bell Lab. Record*, June 1944, Vol. 22, No. 10, pp. 421–424.)

3144. THE INTERFERENCE WITH BROADCAST RECEPTION CAUSED BY TROLLEY-BUS SYSTEMS.—W. Gerber & J. Meyer de Stadelhofen. (*Bull. Assoc. Suisse des. Élec.*, 5th April 1944, Vol. 35, No. 7, pp. 161–167: in German.)

Results of a statistical investigation by the Swiss P.O., as regards medium and long waves. The paper begins with the representation of a trolley-bus system as a high-frequency circuit (equivalent-circuit diagram: impedance of two-wire and four-wire lines [*cf.* work on tramway systems, 1407 of 1938]: attenuation along the lines). It continues with a discussion of the effects on the neighbouring receivers (near field of the interference-carrier: the more complicated fields in the actual presence of the trolley-bus itself: percentages of receivers seriously affected [*cf.* 4333 of 1938]), and ends with an examination of the steps that have been taken to reduce the trouble. The carbon contact introduced some years ago was a great improvement: other measures include a spring-mounted carrier for the contact-shoe (Fig. 12) and a special filter mounted on the roof of the bus at the base of the collector arm (Fig. 13). For specially bad conditions such a filter can be modified so as to give additional protection, concentrated on one particular wavelength.

3145. HIGH-FREQUENCY THERAPY [and the Screening of Interference].—Oliphant. (In paper dealt with in 3372, below.)

3146. RADIO HEATING EQUIPMENT: IV—INTERFERENCE PROBLEMS: IMPORTANCE OF EFFICIENT SCREENING.—L. L. Langton. (*Wireless World*, July 1944, Vol. 50, No. 7, pp. 212–213.) For previous parts *see* 2818 of August.

3147. NON-INTERFERING A.C. MOTORS: THE INDUCTION TYPE AND ITS LIMITATIONS [Reply to Suggestions such as 2187 of July].—N. F. T. Saunders. (*Wireless World*, July 1944, Vol. 50, No. 7, pp. 206–208.) For "Diallist's" comments *see* August issue, p. 254

3148. POST-WAR DEVELOPMENT IN RADIO ENGINEERING [Points from Report: including Recommendation of Government Control of Transmissions of "Accidental Type"].—British I.R.E. (*Wireless World*, July 1944, Vol. 50, No. 7, p. 215.) For an Editorial note *see* p. 193. For views on television *see* 3195, below.

3149. R.M.A. REPORT: NEW REPRESENTATION OF THE INDUSTRY [and Other Points (including Post-War Employment of Technicians of Various Grades, Civilian Receivers, etc.)].—R.M.A. (*Wireless World*, July 1944, Vol. 50, No. 7, p. 219.)

3150. TRACKING IN SUPERHETERODYNE RECEIVERS: PART II [Padder Method: Analysis of Three-Point Tracking].—S. W. Amos. (*Electronic Eng:g*, April 1944, Vol. 16, No. 194, pp. 460 and 465–466.) For Part I *see* 2553 of August. "The subject is discussed fully in a forthcoming book, 'Radio Receivers and Transmitters,' by S. W. Amos & F. W. Kellaway, to be published by Messrs. Chapman & Hall."

3151. THE DETERMINATION OF THE OPTIMUM TRACKING POINTS IN SUPERHETERODYNE RECEIVERS.—O. Meisinger. (*Funktech. Monatshefte*, June 1943, No. 6, pp. 67–68.)

"In two previous papers [one of which was referred to in 1569 of May], formulae, tables, and curves were obtained for calculating the series and parallel capacitances in the oscillator circuit from three given frequencies at which the tracking is to be perfect. An analytical calculation of the three optimum Δf null-points (tracking points) can hardly be possible, or at any rate the resulting formulae would scarcely be suitable for numerical working-out. It has been found possible, however, to arrive by methods of 'practical mathematics' at a quite simple way of determining the three unknowns quickly.

"Fundamentally, the process might be as follows: keeping the two end null-points fixed, say at 500 and 1500 kc/s, the internal Δf null-point is supposed to shift, and the corresponding series and parallel capacitances are calculated: from these the Δf-curves are plotted, and the one with the two maxima equally large is selected. This gives the optimum position of the middle tracking frequency; it is assumed that the optimum Δf-curve has equal absolute deviations at the four points (the two ends and the two maxima), giving the so-called 'Tschebyscheff approximation,' as opposed to the 'Gaussian'. Then, on the curve-portions to right and left, which pass rapidly away from the zero line, the frequencies are found at which the absolute error is the same as for the two maxima. These graphically-obtained values can be improved at will by a numerical method: by dividing the two new outer limiting frequencies, a frequency-ratio is obtained for which the optimum Δf null-points have been found. By repeating the process for a series of different frequency-ratios, and making a suitable graphical representation and interpolation between the calculated points, the optimum position of the null-frequencies for each frequency-ratio can be read off.

"But the calculation of the many curves for the shifting middle null-frequency involves so much work that some method of simplification is very desirable. A surprisingly good solution is at hand: from any arbitrary calculated Δf-curve a new curve, for which the two maxima are equally large, can be constructed by a simple shifting and rotation of the zero line to form a 'shearing' line. For the Δf-curve is a difference-curve of two frequencies, the 'desired' and the 'actual'. If, in the input circuit, the self-inductance is variable, such variation will not affect the frequency-ratio of the circuit, which depends only on the root of the C-ratio: only the tracking is detuned, in proportion to the signal frequency; for instance, three times as much as 1500 kc/s as at 500 kc/s. Thus the construction of the desired 'shearing' line follows directly: rotation of the zero line about the point 'zero kc/s' in the extension of the zero line.

"This construction is carried out in Fig. 1 for null-frequencies of 500, 1000, and 1500 kc/s. From the diagram I have obtained the following values: end-frequencies 440 and 1580 kc/s, giving a range of 1140 kc/s; over-all frequency-ratio $Q^* = 1580/440 = 3.59$; Δf null-points at 0.053, 0.49, and 0.93 of the over-all range": the latter being $1850 - 440$ or 1140 kc/s, these decimal fractions should give 60.42, 558.60, and 1060.20 kc/s respectively, but in his tabulated results on p. 68 the writer for some reason takes slightly different decimal fractions which yield 70, 520, and 1090 kc/s respectively. Adding these difference-frequencies in turn to the lower end-frequency of 440 kc/s, he obtains as the three tracking points the frequencies 510, 960, and 1530 kc/s, the upper end-frequency being, as already stated, 1580 kc/s.

He deals similarly with a curve for $Q^* = 1500/550 = 2.73$ of a previous paper, and combines the two sets of results in Fig. 2, interpolating a line for $Q^* = 3.0$ on the assumption of linear interpolation. He ends by pointing out two defects of his method: they can be corrected, but such correction should be hardly necessary.

3152. "RECEIVER SPECIFICATIONS AND PRICES" [Broadcast Receivers manufactured between 1935 & 1940, for Identification of Sets and Determination of Second-Hand Prices: Notice of Booklet].—(*Wireless World*, July 1944, Vol. 50, No. 7, p. 215.)

3153. SERVICEMEN'S GUILD [Note on Formation of the "Guild of Radio Service Engineers"].—

J. H. Corbett & others. (*Wireless World*, July 1944, Vol. 50, No. 7, p. 218.) *Cf.* 2194 of July.

3154. Aesthetics of Sound Reproduction: High Fidelity or Judicious Distortion?—Hartley. (*See* 3178.)

AERIALS AND AERIAL SYSTEMS

3155. On Electrical Resonance [in a Coaxial Line & a Dipole Aerial: Treatment by Elementary Method based upon Damped Waves].—C. H. Collie. (*Proc. Phys. Soc.*, 1st July 1944, Vol. 56, Part 4, No. 316, pp. 255–262.)

"Intended for men hitherto trained as physicists who but for the war would have completed their undergraduate course without any quantitative study of radio problems. Such men should be well acquainted with the general properties of waves, and the treatment given makes as much use as possible of the concept of the plane wave": thus the resonant aerial is treated essentially as a problem in the diffraction of such a wave.

"The chief attraction of the treatment . . . is that it enables the main phenomena of resonance to be treated by a single elementary method. All the difficulties inherent in a strict treatment based on Maxwell's theory are segregated by making use of Hertz's well-known calculation of the radiation resistance of a dipole . . . It is believed that the results obtained are nearly true, but the direct experimental evidence is meagre.

"The weakness of this method of obtaining the approximate current-distribution in an aerial lies in the fact that it does not inherently lead to an estimate of the magnitude of the possible error. However, some idea of the error involved can be obtained by comparing the value of the resonant current i, adjusted to give the correct dissipation of energy, with the value calculated from the known value of i_0, the current induced in an infinite aerial," using Nicholson's (1910) equation. This comparison is carried out: "actually the formulae developed represent the experimental results much more accurately than this, because, as is easily shown by graphical integration, minute changes in the distribution of the current produce large changes in the component of the electric field parallel to the axis of the aerial. Hence a current-distribution which satisfies Maxwell's equations for a very thin wire will also very nearly satisfy them for a thicker wire. The best experimental evidence available for this statement is the general agreement between the values of radiation resistance obtained directly from transmitting aerials and indirectly from receiving aerials . . ."

3156. The Angle of the Inverted-Cone Transmission Line which Simulates the Radio Waves [Discussion of the Effect of an Approximation (made in the Writer's 1913 British Association Paper) on the Calculated Angle, prompted by an American Suggestion].—G. W. O. H. (*Wireless Engineer*, July 1944, Vol. 21, No. 250, pp. 305–307.)

3157. Receiving Aerials [a Survey].—O. Schäfer. (*Funktech. Monatshefte*, April/May 1943, No. 4/5, pp. 41–53.)

Simplified presentation of the theoretical foundations: application of line theory to aerials. The "short" (vertical) aerial: the top-loaded "short" aerial: the quarter-wave aerial and its lengthening and shortening: the "long" vertical aerial and its modifications; "wave" aerials (long-wire aerials, Kiebitz, Beverage): frame and loop aerials, including the shielded loop (Goldman, 143 of 1939): the "earth" aerial and its advantages on occasion (Kiebitz, and Schäfer, 4425 of 1939): matching to the receiver, for one frequency: for a wide frequency range: the screened down-lead: broad-band (including community) aerials and their matching (Arnous & Hormuth, 3936 of 1938: Moebes, 2768 of 1939): elimination of "sheath" waves by auxiliary aerials at the cable input end (Roosenstein, 4421 of 1939, for television). There are 18 literature references in all, chiefly German.

3158. "Screened Loop Aerials" [2564 of August]: Correction to Typographical Error.—R. E. Burgess. (*Wireless Engineer*, Aug. 1944, Vol. 21, No. 251, p. 358.)

3159. Development of the General Antenna-Array Equation.—W. T. Thomson. (*Journ. Applied Phys.*, May 1944, Vol. 15, No. 5, pp. 420–422.)

"In literature dealing with the subject, reference is often made to the general equation for the directive antenna array developed by G. C. Southwell. The purpose of this paper is to present an alternate and somewhat simpler derivation of the same equation by the use of exponential operators."

Author's summary:—"Interference patterns resulting from a system of orderly arranged sources, whether they be radio, light, or sound waves, can be conveniently analysed by the use of the exponential operator e^j. This paper illustrates the application of the exponential operator in the development of the equation for the general antenna array."

3160. Rhombic Aerials [Characteristic Diagrams: Termination: Radiation Resistance: Feeders: Measurements & Results of Tests].—J. Grosskopf. (*E.T.Z.*, 12th Aug. 1943, Vol. 64, No. 31/32, p. 415 onwards.) An 8-page paper, mentioned in *Bull. Assoc. Suisse des Élec.*, 19th April 1944, p. S.12.

3161. Historic Firsts: the Horizontal Rhombic Antenna.—E. Bruce. (*Bell Lab. Record*, June 1944, Vol. 22, No. 10, p. 440.)

3162. Swiss Army Regulations for the Prevention of Accidents due to Electric Currents [including Regulations on the Installation of Wireless Aerials & Counterpoise Earths].—(*Bull. Assoc. Suisse des Élec.*, 22nd March 1944, Vol. 35, No. 6, pp. 154–155: in French.)

VALVES AND THERMIONICS

3163. The Energy and Permittivity of Electron Space Charges [Treatment of Idealised Diode leading to Results with Practical Application to Study of Cathode/Grid Space of Any Hard Thermionic "Polyode" whose Geometry does Not depart Too Markedly from Plane Parallel: the Statical *versus* Dynamical Derivation of ϵ].—W. E. Benham. (*Wireless Engineer*, July 1944, Vol. 21, No. 250, pp. 320–322.)

"It is to-day seen to be more accurate to say that one can indeed obtain a correct value for the permittivity on quasi-statical considerations, especially when guided by the knowledge that the dynamical method gives this value; namely the assumed value under eqn. 9 [$\epsilon = 3/5$]. For, by writing W_1 as the difference between W_σ (the gross energy required to charge the condenser) and $(9/15)W_0$ (the energy which is to be regarded as stored, or potential, energy, $(8/15)W_0$ of which is immediately realised as kinetic energy of the electron stream and $(1/15)W_0$ is realisable only if the cloud is permitted to scatter to great distances), we see that instead of the single step represented by eqn. 12 we should have the double step $W_1 = (5/3 - 3/5)W_0 = (16/15)W_0$ . . . eqn. 12a. We infer from eqn. 12a that ϵ has the value of 3/5, the value it has hitherto been with certainty known to possess only by a dynamical analysis involving transit-time considerations . . ." [on the following line the first W_0 should read W_σ].

The simultaneous derivation, from eqn. 12a, of the same value for ϵ from energy considerations is based on a new definition of capacitance as (twice the electronic energy stored per electron transit)/(square of anode potential), and the second main object of the paper is to call attention to this new definition, as applied to the Child–Langmuir diode. In other, " more primordial " examples the classic $\frac{1}{2} QV$ also fails to give the whole energy.

3164. CORRESPONDENCE ON " DEFLECTED ELECTRON BEAMS " [Harries, 2576 of August].—D. Gabor: W. E. Benham: J. A. Jenkins: Harries. (*Wireless Engineer*, July & Aug. 1944, Vol. 21, Nos. 250 & 251, pp. 327–328 & 358.)

(i) From Gabor's long letter:—" what Mr. Harries calculates is in fact the transit power. I will try once more to explain why in a calculation which is based on the transit power (or its equivalent) it is not necessary to take account of the exit field, provided that it is short against the plate length and against the length traversed by an electron in a cycle . . . " " Though he mentions x-directed fields and their effects, he thinks he can exclude them from his analysis. He is, of course, free to do so, but in this case he is not justified in calling the quantity which he calculates ' the power used to deflect the beam ' . . ." (ii) Benham's short letter deals more with Gabor's remarks (in (i) and in 2575 of August) than with Harries's paper. (iii) Jenkins criticises the calculation by which Harries obtained his new expression for the current in a length o to l: he gives " the correct form of Ramo's equation " for this length: it applies even if l is less than the deflector-plate length.

3165. ANALYSIS OF THE OPERATION OF DOUBLE-CONTROL-GRID TUBES [and the Calculation of Conversion Transconductance, Modulation Distortion, Cross-Modulation, Modulation Trim & Converter Whistles, from Empirically Found Static Characteristics].—G. L. Hamburger. (*Journ. British I.R.E.*, March/May 1944, Vol. 4, No. 1, pp. 4–36.)

" Whilst it is not anticipated that in practice the above-mentioned effects should really be evaluated along the lines indicated in the following, *viz.* from he static characteristics, the theory thus elaborated offers a clear view and understanding of the manner in which these effects are brought about. Also, the theory suggests directions of improving the operational qualities of such a tube by indicating the desirable features of the characteristics. . . ."

3166. MECHANICAL MODELS OF FREQUENCY CONVERTERS.—H. Stockman. (*Journ. Applied Phys.*, May 1944, Vol. 15, No. 5, pp. 438–445.)

Following on the writer's paper on converter terminology (1567 of May). " The action of modern frequency converters can be lucidly and accurately described by easily-built mechanical models, which for a chosen type of operation record the output wave as function of input amplitudes and input frequencies."

3167. THE MAGNETICALLY FOCUSED RADIAL-BEAM VACUUM TUBE [Design & Applications].—A. M. Skellet. (*Bell S. Tech. Journ.*, April 1944, Vol. 23, No. 2, pp. 190–202.)

Author's summary:—" A new type of vacuum tube is described in which a flat radial beam of electrons in a cylindrical structure may be made to rotate about the axis. Features of the tube are its absence of an internal focusing structure and resultant simplicity of design, its small size, its low voltages, and its high beam currents [5 mA and more with only 50 V on the anodes, in the smaller tubes: 50 mA and more in the larger, with 100 V or less]. The focusing of the beams and their directional control are accomplished by the magnetic fields in small polyphase-motor stators. A time-division multiplex signalling system for 30 channels using these tubes is briefly described."

As an electronic commutator a practical limit to its speed is set primarily by the a.c. losses in the stator. This limit is estimated to be about 10 kc/s for ordinary stator and tube designs. The highest cyclic speed for a stator that has been used at present is 600 c/s, which with both beams employed gave an effective cyclic frequency of 1200 c/s. The simplest tube structure is seen in Fig. 1; this is sufficient for some applications. Fig. 4 shows a more complex tube, with a cylindrical screen element just inside the cylindrical individual-anodes system; " suppressor grids " (each a pair of paraxial wires) in front of each of the anodes; and a control grid closely surrounding the cathode. Such a tube may be used for amplification.

3168. OPTIMUM WORKING CONDITIONS FOR THE TRANSMITTING VALVE WITH AN OSCILLATORY CIRCUIT HAVING LOSSES.—F. Hülster. (*Telefunken-Röhre*, Feb. 1943, No. 27/28, p. 42 onwards.) Short summary in *Bull. Assoc. Suisse des Élec.*, 22nd March 1944, Vol. 35, No. 6, p. S.9.

3169. THE VALIDITY OF THE EQUIVALENT PLATE-CIRCUIT " THEOREM " FOR POWER CALCULATIONS [Protest against Recent Statements that This Equation can Not be used for Power Calculations, especially when Plate Dissipation is concerned].—H. Stockman. (*Proc. I.R.E.*, June 1944, Vol. 32, No. 6, p. 373.)

3170. " OPTIMUM LOAD " [Letter on Sturley's Article (2159 of July)].—Date: Sturley. (*See* 3119.)

3171. RADIO-FREQUENCY PENTODES AS AUDIO-FREQUENCY AMPLIFIERS: ADVANTAGES OVER TRIODES IN EARLY STAGES [and Some

Important Points which must be Attended to in the Design of Such Amplifiers].—S. W. Amos. (*Wireless World*, July 1944, Vol. 50, No. 7, pp. 196–197.)

3172. CONSERVING SMALL TUBES IN AUDIO SERVICE.—C. A. Rackey. (*Electronics*, April 1944, Vol. 17, No. 4, pp. 140–142 and 393, 394.)

"In war-time, the broadcast station operating engineer must devise means for dealing with initial variations in characteristics, and methods of ensuring maximum life. Practical suggestions for achieving small-tube economies are given."

3173. VARIABLE-MU OR VARIABLE-μ? [Letter on Subject dealt with in 2582 of August: *Both* Terms are Perfect Examples of Jargon: Suggested Alternative].—H. Morgan. (*Wireless World*, July 1944, Vol. 50, No. 7, p. 222.)

3174. THERMIONIC EFFECTS OF THIN FILMS OF ALKALINE-EARTH OXIDES ON METALS.—G. E. Moore & H. W. Allison. (*Phys. Review*, 1st/15th April 1944, Vol. 65, No. 7/8, p. 254: summary only.)

"Data are presented which indicate that approximately 0.001 monomolecular layer of alkaline-earth oxide adsorbed on tungsten or molybdenum filaments produces optimum thermionic emission which is approximately the equivalent of that obtained with conventional oxide-coated cathodes, using the same oxide . . . A theory involving oriented adsorption is proposed which appears to account for the observed phenomena. The work suggests possible modifications in existing theories of the oxide-coated cathode."

3175. ELECTRODES WITH HIGH SECONDARY-ELECTRON EMISSION [French Patent No. 862 488].—(*E.T.Z.*, 9th March 1944, Vol. 65, No. 7/10, p. 81.)

Using alloys of copper and one or more metals of the light-metal class, *e.g.* aluminium or magnesium. A duralumin alloy is given as an example, containing 95% Al, 4% Cu, 0.5% Mn, 0.5% Mg, and traces of Fe. The proportions can be varied over a wide range without the number of electrons set free being altered. Well purified and cleaned electrodes of such metals have a s.e. factor of 2.3 to 3 for a primary-electron voltage of about 300 v. According to the invention, these plates are heated for about 45 minutes in an oxygen-containing atmosphere (*e.g.* pure oxygen or air) by resistance or h.f. heating, or by electric discharge using an auxiliary electrode. They are heated to such a temperature that the structure becomes granular. The resulting surfaces have a s.e. factor of 10 for a primary-electron voltage of 400 v. Subsequent heatings up to 400° have no effect on the factor.

3176. THE TECHNIQUE OF GLASS MANIPULATION.—G. A. Percival. (*Electronic Eng'g*, April & May 1944, Vol. 16, Nos. 194 & 195, pp. 453–457 & 500–504.)

ACOUSTICS AND AUDIO-FREQUENCIES

3177. THE DISCERNIBILITY OF CHANGES IN PROGRAMME BAND WIDTH [in connection with High-Fidelity Broadcasting].—D. K. Gannett & I. Kerney. (*Bell S. Tech. Journ.*, Jan. 1944, Vol. 23, No. 1, pp. 1–10.)

A report prepared before work non-productive to the war effort was suspended. For the material and the experienced group of observers employed, the curves lead to the following conclusions:—(1) Increases in band width can be detected up to 15 kc/s for both music and speech. "The fact that this is true for speech is rather surprising. However, above about 5 kc/s, changes in band width are twice as readily detectable on music as on speech." (2) It requires an increase in band width from 8 to 15 kc/s to be as readily detected as an increase from 5 to 8 kc/s, for both speech and music. (3) The following intervals correspond to one "liminal unit" (top of p. 4) and are thus just discernible half of the time to the observers: speech—5 to 8, 8 to 15 kc/s: music—5 to 6½, 8–11, 11–15 kc/s.

The results are compared with Snow's paper on the audible frequency ranges of music, speech, and noise (1932 Abstracts, pp. 98–99). Among other things, this comparison suggests the interesting hypothesis that the relations at the lower end of frequency spectrum (not dealt with in the present measurements) are probably the same as at the upper end, one liminal limit for music corresponding to about 80 c/s, two to about 150 c/s.

3178. AESTHETICS OF SOUND REPRODUCTION: PART I—HIGH FIDELITY OR JUDICIOUS DISTORTION? PART II—DESIGNING A RADIO-GRAMOPHONE FOR MUSICAL SYNTHESIS.—H. A. Hartley. (*Wireless World*, July 1944, Vol. 50, No. 7, pp. 198–202: Aug. 1944, No. 8, pp. 236–239.)

(i) "I am no longer an exponent of plain, unadulterated high-fidelity reproduction . . . My own experiments have tended to prove that the keenest artistic enjoyment is to be secured when the response curve has been 'doctored'. I find that the doctoring has to be varied according to the nature of the thing one is listening to, and the doctoring has to be done with a fine sense of artistic discretion . . . I have found, by comprehensive experimenting over a long period, particularly on records, that while the ear is acutely sensitive to peaks on the response curve it does not appear to notice the presence of valleys, or at any rate of canyons and gorges. If, however, these canyons and gorges can be introduced in certain variable ways (for the ways must be variable according to the effect desired) a good deal of the noticeable imperfections in musical reproduction can be taken out without in any way spoiling the musical quality of the instruments . . ." The writer's results appear to line up with Dr. Malcolm Sargent's contentions (in a British I.R.E. address in March, 1944) that "truth is not necessarily beauty, that high fidelity is to be avoided if you wish to be artistic, that beauty begins where utility ends".

(ii) "Nowadays, it is rather a waste of time to try to perfect the radio receiver, as so many of the B.B.C. programmes consist of home-made recordings of execrable quality compared with direct studio transmissions. However, the simple arrangement shown gave excellent results in pre-war days . . ." Bass compensation: ". . . impossible to recommend any circuit which includes inductances": it is necessary "to waste the middle and top somewhere and push up the over-all amplification . . ." Pick-ups: "by hook or by crook the reader should try to get one of the light-weight sort, using miniature needles or a jewelled stylus . . . Fibre needles are a snare and a delusion . . . Ideally, the friction between the needle and the record should be non-existent, and the nearest approach to this is reached by a well-polished jewel . . ." The main amplifier (" fairly conventional ") and the loadspeaker (including its situation, and the placing of the second loud-speaker to improve " depth and realism "). Concluding remarks.

3179. MUSIC WHILE YOU WORK [Notes on a U.S.A. Report on Music in relation to Repetitive Manual Work].—American War Production Board. (*Wireless World*, July 1944, Vol. 50, No. 7, p. 208.)

3180. THE LOW-FREQUENCY POWER AMPLIFIER AND ITS BEHAVIOUR TO SPEECH AND MUSIC [including the Effects of Form Factor & Contrast: Practical Conclusions & New Measuring Methods].—K. Steimel. (*Telefunken-Röhre*, Feb. 1943, No. 27/28, p. 7 onwards.) A fifteen-page paper, mentioned in *Bull. Assoc. Suisse des Élec.*, 19th April 1944, p. S.12.

3181. THE *Wireless World* QUALITY AMPLIFIER WITH CATHODE FOLLOWER [Letter describing Application of Cathode-Follower Output Stage, prompted by Mitchell's Paper (2227 [and 2228] of July): Resulting Improvement (" All-Round Sense of Realism which is Entirely New to Me . . .")].—A. C. Robb. (*Wireless World*, July 1944, Vol. 50, No. 7, pp. 221–222.)

3182. NEGATIVE FEEDBACK IN AUDIO-FREQUENCY AMPLIFIERS.—Chang-Ly Lee. (*See* 3125.)

3183. THE ELECTROACOUSTICAL EQUIPMENT FOR THE CONTINUOUS RECORDING AND REPRODUCTION OF GRAMOPHONE RECORDS IN BROADCASTING STUDIOS.—W. A. Gunther. (*Schweiz. tech. Z.*, 30th Sept. 1943, No. 39, p. 545 onwards.) An 11-page paper, mentioned in *Bull. Assoc. Suisse des Élec.*, 19th April 1944, p. S.12.

3184. POLARISATION AND SPECIFIC HEAT OF KH_2PO_4, *and* EFFECT OF ELECTRIC FIELD STRENGTH ON THE RESONANCE FREQUENCIES OF THE PIEZOELECTRIC CRYSTALS AKIN TO ROCHELLE SALT.—A. von Arx & W. Bantle: W. Bantle & others. (*Sci. Abstracts*, Sec. A, April 1944, Vol. 47, No. 556, p. 82 : p. 82 : from *Helvet. Phys. Acta*, 1943.) For other work *see* 2904 of September.

3185. INDICIAL RESPONSE OF TELEPHONE RECEIVERS [Instantaneous Response to Suddenly Applied Electromotive Force: of Particular Fundamental Interest in connection with Response to Speech Waves: Method of Analysis of Receiver Characteristics, with Oscillograms: Comparison with Steady-State Response Characteristics].—E. E. Mott. (*Bell S. Tech. Journ.*, April 1944, Vol. 23, No. 2, pp. 135–150.)

" From the standpoint of most faithfully reproducing transients, indicial response data indicate that a receiver having a limited range of frequency response should have a frequency-response characteristic which droops gradually rather than abruptly near the upper end of the range."

3186. A PRACTICAL BEAT-FREQUENCY OSCILLATOR [Range 25–13 000 c/s: the 6K8G (Triode-Pentode) as Oscillator & Isolator, the 6J8G as a Double-Grid Triode Mixer: Three Methods of Calibration (including Use of Mains Frequency as Standard): etc.].—V. Dalton-Hall. (*Bull. Inst. Rad. Eng. Australia*, B6–3/44, pp. 9–14.)

3187. A TRANSATLANTIC WIDE-BAND CABLE FOR TELEPHONE TRAFFIC [with 47 Submerged Repeaters].—(*Bull. Assoc. Suisse des Élec.*, 19th April 1944, Vol. 35, No. 8, pp. 229–230: summary, from *NZZ*, 21st Dec. 1943.) *Cf.* 2618 of August.

3188. " CLINICAL AUDIOMETRY " [Book Review].—C. C. Bunch. (*Science*, 26th May 1944, Vol. 99, No. 2578, p. 431.)

3189. THE FIGHT AGAINST MACHINE-MADE NOISE [Its Importance (American Results on Improvement of Typists' Output, etc.): the Success of the " Gartenmann " Sound-Consuming Plates for Walls & Ceilings].—(*Schweizer Arch. f. angew. Wiss. u. Tech.*, March 1944, Vol. 10, No. 3, Supp. pp. 1–3: in German.)

3190. THE REDUCTION OF NOISE FROM AIR-CONDITIONING SYSTEMS.—A. J. King. (*Engineering*, 30th June 1944, Vol. 157, No. 4094, pp. 501–504.) From the Met.-Vick. Research Department.

3191. DEVELOPMENT OF THE GENERAL ANTENNA-ARRAY EQUATION [and the Use of Exponential Operators].—Thomson. (*See* 3159.)

3192. VARIATION, WITH TEMPERATURE, OF SUPERSONIC VELOCITIES IN WATER/ALCOHOL MIXTURES [in connection with Light-Modulating Devices].—Goudet. (*See* 3201.)

3193. CRACK DETECTION IN LARGE METAL CASTINGS, BY SUPERSONIC WAVES.—A. Behr: Shrayber. (*Journ. Applied Phys.*, May 1944, Vol. 15, No. 5, p. 457: paragraph only, on two papers.) *Cf.*, for example, 904 of 1942 and 515 of February. " The distribution of the transmitted beam is measured directly with a piezoelectric detector or can be inferred from the standing waves formed on the surface of an oil bath in which the specimen is immersed."

3194. DETECTING FLAWS [in Sheet] WITH U.H.F. SOUND WAVES, *and* A POSSIBLE APPLICATION OF ULTRASONICS [Treatment of Small Melts, Grain-Refining & Improving the Properties of the Weld Metal: Application to Spot Welding is Very Promising].—A. Trost: A. Behr. (*Sci. Abstracts*, Sec. B, April 1944, Vol. 47, No. 556, p. 61: Sec. A, April 1944, No. 556, p. 76.) The first paper seems to be an English version of the one dealt with in 515 of February.

PHOTOTELEGRAPHY AND TELEVISION

3195. TELEVISION *Status Quo?* [Note on R.M.A. Recommendations and British I.R.E. Views (in Report dealt with in 3148, above): the United States R.T.P.B. Recommendation].—

(*Wireless World*, July 1944, Vol. 50, No. 7, p. 216.)

3196. Automatic Radio Relaying: Some General Considerations.—D. A. Bell. (*Wireless World*, July 1944, Vol. 50, No. 7, pp. 203–204.) *See* also "Diallist," on pp. 204–205.

3197. A.T. & T. announces Coaxial Programme: Facilities planned to meet Requirements for Inter-City Telephone Circuits may also be used for Television.—A.T. & T. (*Bell Lab. Record*, May 1944, Vol. 22, No. 9, pp. 392–395.) For a preliminary note *see* 2751 of August.

3198. Television Broadcast Coverage: presenting Multi-Path Distortion Data obtained by an Exhaustive Survey in the New York City Area.—A. B. Du Mont & T. T. Goldsmith, Jr. (*Proc. Radio Club of Am.*, Jan. 1944, Vol. 21, No. 1, pp. 1–13.) Already dealt with in 2631 of August.

3199. The General Electric Television Film Projector.—E. D. Cook. (*Journ. Soc. Mot. Pic. Eng.*, Oct. 1943, Vol. 41, p. 273 onwards.)

3200. The Frequency Spectrum of Periodic Pulses [Square-Wave & Saw-Tooth: Mathematical & Graphical Determination of the Information required for the Fourier-Series (Superposition) Method of calculating the Behaviour of a Channel to Such Pulses].—R. Filipowsky. (*Funktech. Monatshefte*, June 1943, No. 6, pp. 57–65.)

3201. Variation, as a Function of Temperature, of the Velocity of Sound in Mixtures of Water and Methyl Alcohol [in connection with Supersonic Light-Modulating Devices].—G. Goudet. (*Comptes Rendus* [Paris], 5th/26th July 1943, Vol. 217, No. 1/4, pp. 65–66.)

For such devices (*see* for example 487 of 1942) it is desirable, for reasons of stability, to find a liquid in which the supersonic velocity v varies as little as possible with the temperature θ. This variation may be characterised by the coefficient $\mu = -(1/v) \cdot (dv/d\theta)$, which is positive for all liquids except water. Thus a mixture of water and another liquid can give a μ which is zero at a given temperature, and the writer has therefore studied experimentally various mixtures of water and methyl alcohol at temperatures around 30°. The technique is described and the results are shown in a curve: the test frequency was 9.56 Mc/s, corresponding to wavelengths of about 0.158 mm and 0.114 mm in pure water and alcohol respectively. The curve cuts the zero line at the point 0.23, representing a mixture of 30 volumes of alcohol to 100 of water. "Experimentally, no variation in the amplitude of the standing wave is observed when the temperature of this mixture varies from 26° to 31°, whereas for pure water a variation of 0.05° produces an easily observable effect."

3202. Electric Birefringence of Colloidal Solutions.—B. W. Sakmann. (*Phys. Review*, 1st/15th April 1944, Vol. 65, No. 7/8, p. 254: summary only.)

"However, the direct part of the birefringence of sols of *small* particle size and *high* concentration cannot be explained by the orientation of anisotropic particles in the electric field. Measurements of the concentration-dependence of the electric birefringence of those solutions indicate that part of the double refraction is due to an interaction between the micelles."

3203. Inner Photoelectric Effect of Selenium in the Infra-Red [with Curves showing Photoelectric Effect as function of Wave Number: Critical Point in Infra-Red, akin to already-known Critical Point near Red End of Visible Spectrum].—I. Weibull. (*Sci. Abstracts*, Sec. A, Vol. 47, No. 556, p. 78: from *Ark. Mat. Astr. Fys.*, 29B, 1943.)

MEASUREMENTS AND STANDARDS

3204. Measurement of the Electric Field in the Interior of an Electromagnetic Guide.—Gutton & Ortusi. (*See* 3081.)

3205. Methods for the Investigation of the Properties of Liquids at Ultra-High Frequencies.—G. Williams. (*Phil. Mag.*, May 1944, Vol. 35, No. 244, pp. 283–296.)

In a recent paper (1255 of April) the author developed a method for the measurement of impedance (using Lecher wires or coaxial tubes) in which errors due to oscillator-output fluctuations were eliminated. In the theory there given, the characteristic impedance of the wires was assumed to be the same at all points. It is not, however, always possible when constructing the apparatus to make the characteristic impedance between the bridges the same as that between Z_2 and Z (Fig. 1), owing to the fact that the bridges have to be rigidly connected together ("tandem bridge"). The present paper begins by showing how the theory may be modified to include this case: the final equations remain unchanged. It is assumed that the construction is such that the line losses between the bridges are not appreciable.

The paper then deals with special points connected with the method, such as the experimental determination of the characteristic impedance of the Lecher system when this is constructed, for the necessary rigidity and uniform separation, of angle brass or otherwise so that the characteristic impedance cannot easily be calculated; and the elimination of end effect. It then passes on to deal briefly with the use of the method for the investigation of the properties of liquids in which the losses are negligible. The procedure is more complicated (pp. 288–292, for coaxial lines) when the losses cannot be neglected. Another method, in which the whole of the coaxial tube is filled with the liquid, is discussed at the end of the paper, and an Appendix describes two quite different methods involving the measurement of constant fractions of the currents actually flowing at various points in the lines themselves, not in the bridges.

3206. Dielectric Constants and Power Factors at Centimetre Wavelengths [22.5 & 10 cm].—C. R. Englund. (*Bell S. Tech. Journ.*, Jan. 1944, Vol. 23, No. 1, pp. 114–129.)

"Under the conditions encountered in this work, the coaxial line appeared to have the practical superiority, down to something like 10 cm wave-length, anyway. Below this, the wave-guide is very manageable and has several advantageous features." Author's summary :—"The theory underlying the measurement of dielectric constants and power factors, by means of resonant lengths of coaxial transmission line, is developed, apparatus used for such measurements is illustrated, and the measurement routine described. A table of typical results is appended [the materials include BTL F3 Mg. Silicate type ceramic with (at 22.5 cm) an ϵ of 5.83 and a p.f. of 0.00023, various glasses, polystyrene (worst, most common, and best), styralloys and styramic E1689, and some waxes] together with an '$X \tan X$' table for aid in the calculations."

The writer begins by discussing the definition of Q (the quantity selected for measurement) for his purposes: the $\omega L/R$ definition employed at low frequencies is better replaced by a definition in terms of the detuning process itself. The theory of measurement is then developed. It applies to the $\lambda/4$ line, which is a rather difficult practical one: it is best to add another $\lambda/4$ line to make a $\lambda/2$ resonator, shorted at both ends, with the dielectric placed exactly at the centre.

The expressions used in the work, for ϵ and p.f., are given in eqn. 15. "There are several short-comings affecting this theory. The Q of the un-loaded line depends partly on metal power loss along the line. When the line is shortened by the dielectric plug, part of this loss disappears and part is transferred to the dielectric plug. Fortunately these losses are small, since they are metal losses at a current node, but for long dielectric plugs or plugs of high dielectric constant the need for correction can arise. The necessary calculations have not been reduced to a simple form."

Further, the calculation of $\lambda/2$ results by $\lambda/4$ theory is safe only with high Q values. Experiment shows that the maximum line shortening occurs with the plug exactly centred, "but the calculated power factor is not a maximum here, as might be expected". But experience shows that "results can be duplicated from day to day and at other frequencies, and that over a reasonable range of plug thickness no change in d.c. and p.f. values, greater than the unavoidable errors of measurement, is obtained". The apparatus, with its vernier-indicating plunger, is described and illustrated, and hints on maintenance are included.

3207. A Note on Impedance Measurements at [Ultra-] High Frequencies, with Special Reference to Impedance Matching [Extension of Barrow's "Three Voltmeter" Method (using Networks simulating Lines: 3592 of 1935) to Ultra-High Frequencies, replacing Network by Actual Coaxial-Line Sections].—P. J. Kibler. (*Proc. I.R.E.*, June 1944, Vol. 32, No. 6, pp. 354–355.)

The limited application of the original method still holds: the region of greatest accuracy is seen to lie in the region of $Z_r = (0.6 - j.4)\ Z_0$, and the different lengths of measuring line required at various frequencies are inconvenient; work, however, is usually centred on one or more discrete frequencies in a given range and the disadvantage is not too serious. Considerable use has been made of the method in matching various aerial loads to coaxial cables at frequencies from 200 to 350 Mc/s: as a good match is approached the accuracy improves. A special probe (Fig. 3) for use with the valve voltmeter is described; it replaced the usual banana plug and the capacitance between the two studs composing it was adjusted to about 0.4 μμF. *Cf.* 3209, below.

3208. Indirect Current-Measurement at High [and Ultra-High] Frequencies by the Measurement of Voltage.—A. Klemt. (*Funktech. Monatshefte*, June 1943, No. 6, pp. 68–70.)

The difficulties of direct measurement of current, and the desirability of utilising the ease of voltage-measurement by diode or triode. The method of introducing the known resistance, in the earthed or in the voltage-supplying lead: a two-diode bridge circuit for measuring difference-voltages. Reasons for use of carbon resistances: the proportioning of the resistance to the resistance of the circuit. Measurement by means of resonant circuits (only when the whole measuring equipment can be connected into the earth side of the circuit). Current/voltage conversion by transformers: use of parallel-resonance on the secondary side: linearisation of the conversion for a frequency band: the effect of leakage: use of toroidal transformers: a practicable current/voltage transformer unit for 10–100 Mc/s, with cable lead to voltmeter (the linearising resistance on the secondary side helps here, being split into two equal terminating resistances, one at each end of the cable).

3209. Ultra-High-Frequency Probe [*e.g.* for use with Valve Voltmeter Model VM-27E: Cone-Shaped, with Its "High" Terminal in the Nose, permitting Extremely Close Connection: moulded in Low-Loss Material].—A. W. Barber Laboratories. (*Gen. Elec. Review*, May 1944, Vol. 47, No. 5, p. 50.)

3210. Pentode–Diode Valve Voltmeter [Correction to Value of "R16"].—T. A. Ledward. (*Wireless World*, July 1944, Vol. 50, No. 7, p. 223.) *See* 2664 of August.

3211. High-Potential Vacuum-Tube Voltmeter [Principles of "Inverted" Valve (Terman, 1928 Abstracts, p. 348) applied to give Valve Voltmeter for High Potentials (0–2000 Volts) with High Input Impedance (1.5×10^8 to 5×10^9 Ohms, according to the Grounding of the Potential Source under Test): using a Type 57 Pentode, with Neon Tube to warn against Wrong Polarity: Milliammeter in Grid-Current Circuit may be replaced by Indicator Tube for Rapid Rough Checking].—P. B. Weisz. (*Proc. I.R.E.*, June 1944, Vol. 32, No. 6, pp. 338–339.)

3212. New Valve-Oscillator Circuit [of High Frequency-Stability & Low Harmonic Content].—Butler. (*See* 3134.)

3213. A Resistance–Capacitance Signal Generator.—A. Klemt. (*Arch. f. Tech. Messen*, June 1943, Vol. 13, Part 144, Z42-5, T72.) For the range 100 c/s to 100 kc/s.

3214. Steady-State Testing with Saw-Tooth Waves [and Their Advantages over Square Waves].—D. L. Waidelich. (*Proc. I.R.E.*, June 1944, Vol. 32, No. 6, pp. 339–348.)

"This paper will show that if the response of an amplifier [or other network] to a saw-tooth is known, the response to any other steady-state wave of the same fundamental frequency may be obtained from the saw-tooth response without resorting to a Fourier analysis and synthesis [by means of eqn. 10, " having the same significance in steady-state work that Duhamel's theorem has in transient studies," : except for the d.c. term, " which is usually zero in practical cases, but if it is not zero, it may almost always be neglected since it does not affect the wave form "]. Furthermore, it is possible to show that in steady-state work the response to a saw-tooth wave has the same significance as the response to the unit function (indicial admittance) has in transient work.

" The saw-tooth wave has all of the harmonics, both odd and even, present in it, and hence, in testing, the response to a saw-tooth wave will give all the information necessary. The response to the square wave will be shown to be a special case of the response to a saw-tooth wave. If the impressed steady-state voltage has no even harmonics, either the saw-tooth or the square-wave response may be used in obtaining the output wave [using eqn. 15, similar to eqn. 10]. If, however, the impressed voltage has some even-harmonic components, the saw-tooth wave must be used . . ." The response curves of several circuits to the saw-tooth wave are obtained, and several experimental oscillograms are reproduced and discussed. For previous work *see* 1039/40 of 1943.

3215. A NEW TREATMENT OF THE WHEATSTONE BRIDGE NETWORK [to facilitate Calculations of Galvanometer Current (in Sensitivity Determinations) and Design-Calculations for Network having Any Desired Characteristic Curve of Galvanometer Current & Variable-Arm Resistance].—R. J. Wey. (*Wireless Engineer*, July 1944, Vol. 21, No. 250, pp. 308–317.)

" It is shown that the characteristics of all Wheatstone bridge networks, either with or without appreciable battery internal resistance, can be represented by a single curve of the form $f = g/(1 + g)$, it being merely necessary to choose appropriate scales for galvanometer current (f) and variable-arm resistance (g). Variation in the bridge constants has the effect of varying the position of the apparent point of balance on the curve.

" Furthermore, the characteristics of any bridge may be specified completely by two constants, the ' null-point sensitivity ' S and the ' equivalent null-point ' a_e. Simple formulae are derived for calculating these constants from the bridge resistance values. To facilitate the calculation of characteristic curves, particularly when the range, and hence the curvature, is small, the results are expressed in terms of deviation from a straight line tangential to the curve at the null-point."

3216. THE MEASUREMENT OF DIELECTRIC CONSTANT [Introduction of Wheatstone-Bridge Circuit into Gardiner's Arrangement, to increase Sensitivity & to allow Looser Coupling].—P. H. Amphlett. (*Sci. Abstracts*, Sec. B., April 1944, Vol. 47, No. 556, p. 66 : from *Journ. Soc. Chem. Ind.*, 1944.)

3217. A NOMOGRAM FOR THE CALCULATION OF SINGLE-LAYER CYLINDRICAL COILS.—Seebe. (*See* 3113.)

3218. TEMPERATURE COEFFICIENT OF AIR-CORED SELF-INDUCTANCES : THE CASE OF A "THIN" CURRENT-CARRYING LAYER.—Bloch. (*See* 3112.)

3219. FREE VIBRATIONS OF AEOLOTROPIC BODIES [Frequencies & Modes of Crystal Vibrations obtained by Approximation Method similar to Perturbation Theory of Quantum Mechanics : Confirmation by Frequencies & Powder-Patterns of Quartz & Tourmalin Plates].—H. Ekstein. (*Phys. Review*, 1st/15th April 1944, Vol. 65, No. 7/8, pp. 254–255 : summary only.)

3220. THE ETCH FIGURES OF BASAL SECTIONS OF QUARTZ : THEIR USE IN THE ORIENTATION OF WATER-WORN CRYSTALS [which Cannot be used for Piezoelectric Purposes unless the Positions of the Prism Faces are known Reasonably Accurately : Investigation to find Method dispensing with Use of X-Rays].—F. N. Hanlon. (*Journ. & Proc. Roy. Soc. New South Wales*, 31st March 1944, Vol. 77, Part 2, pp. 40–51.)

Author's summary :—" Basal sections of quartz, etched with hydrofluoric acid, were rotated on the stage of a microscope and obliquely illuminated. The position of the sections that gave the maximum reflected illumination through the microscope was determined. This position varied with the duration of etching, and a curve showing this variation was constructed.

" While unknown sections of untwinned or electrically twinned crystals could be orientated by obtaining their curves, the process is long and tedious and the order of accuracy to be expected is not closer than to within a few degrees. If the etching on opposite sides of such a slab could be assumed to have simultaneously reached the same stage of development, it could be orientated after one period of etching to within $\pm 2°$. When optical twinning is present, and this is the case with some portion or most crystals, an unknown section can be orientated to within $\pm 1°$."

3221. USE OF THE ETCH TECHNIQUE FOR DETERMINING ORIENTATION AND TWINNING IN QUARTZ CRYSTALS.—G. W. Willard. (*Bell S. Tech. Journ.*, Jan. 1944, Vol. 23, No. 1, pp. 11–51.)

Chapter 5 of the series dealt with in 1282/3 of April and 3222/4, below. Introduction (the various methods of investigating the structure orientation) : twinning, electrical & optical : nature of etch pits : optical effect of etch pits : the reflection method : the transmission method : the pin-hole transmission method : etch-figure instruments (reflection " Oriascope " & " Twinoriascope " : pin-hole Oriascope [*cf.* 2264 of July]) : the process of etching (and Egerton's preliminary reports on his investigation of the chemical process) : effect of twinning in the finished plate (including " combined " twinning) : conclusions.

3222. MODES OF MOTION IN QUARTZ CRYSTALS, THE EFFECTS OF COUPLING, AND METHODS OF DESIGN [Chapter 6 of Series].—R. A. Sykes. (*Bell S. Tech. Journ.*, Jan. 1944, Vol. 23, No. 1, pp. 52–96.)

" It is the intention of this chapter to present a physical picture of the manner in which quartz crystals vibrate in their simplest forms and then to show what has been learned from these simple forms that will apply to the more complex combinations of motion. . . ." The discussion of coupling effects shows "that a single theory that would relate all the now known resonances in quartz plates together with the effects of coupling would be prodigious indeed. In order to reduce the design of quartz plates to a simple engineering basis it is necessary to take specific examples and investigate the region in the vicinity of the frequency to be used based on general theory and then apply approximations that fit the specific case." This leads to the final sections, on methods for obtaining isolated modes of motion: *GT*, *BT*, and *AT* crystals. Special attention is given to the *BT*-type crystals, and Fig. 6.23 includes certain discrete frequencies as well as frequency ranges which have been found to result in crystal units having no serious dips in activity over a wide range in temperature (Thurston, Schramm). An appendix gives the equation of elastic and piezoelectric constants for rotation of axes about the *X* axis.

3223. THEORETICAL ANALYSIS OF MODES OF VIBRATION FOR ISOTROPIC RECTANGULAR PLATES HAVING ALL SURFACES FREE.—H. J. McSkimin. (*Bell S. Tech. Journ.*, April 1944, Vol. 23, No. 2, pp. 151–177.)

Chapter 7 of the series dealt with in 3221/2, above. "The comparatively recent advent of crystal-controlled oscillators and of wave filters employing piezoelectric elements has resulted in an extensive study of the ways in which plates made of elastic materials such as quartz or Rochelle salt can vibrate. Of special interest have been the resonant frequencies associated with these modes of motion. As will be indicated in subsequent paragraphs, the general solution to the problem of greatest interest is quite complex, and has not been forthcoming (*i.e.*, as applied to rectangular plates completely unrestrained at all boundary surfaces). For this reason numerous approximate solutions have been developed which yield useful information in spite of their limitations. Several of these solutions will be discussed in the following sections. The three general types of modes (*i.e.*, the extensional, shear, and flexural) will be analysed in some detail. Also, as a preliminary step, the formulation of the general problem along classical lines will be developed.

"For the most part, the solutions obtained here are limited to those for an isotropic body. However, such solutions provide considerable guidance for the modes of motion existing in an aeolotropic body such as quartz . . . Because of their great utility, simplified formulae have been derived for the resonant frequencies associated with long, narrow bars vibrating longitudinally, thin plates with extensional motion along the thickness dimension, and thin plates vibrating with shearing motion at right angles to the thickness. Exact solutions for the infinite strip have been derived, and used in obtaining the displacements and resonant frequencies for flexural and longitudinal modes. Such solutions take account of the fact that the width of the plate may become appreciable . . ." For Chapter 8 *see* Sykes, 3224, below.

3224. PRINCIPLES OF MOUNTING QUARTZ PLATES [Chapter 8 of Series dealt with in 3221/3, above].—R. A. Sykes. (*Bell S. Tech. Journ.*, April 1944, Vol. 23, No. 2, pp. 178–189.)

Clamp-type supports (pressure mounting and its limitations: the cantilever-support mounting): wire-type supports (soldered lead with bell-shaped solder cone, and solder ball as clamp for wire: "headed-wire" mounting and its advantages): air-gap-type supports (and the effect of air-gap thickness on frequency).

3225. FLATNESS AND PARALLELISM IN QUARTZ PLATES [Latest Lapping Machine avoiding the Various Causes of Uneven Grinding].—G. M. Thurston. (*Bell Lab. Record*, June 1944, Vol. 22, No. 10, pp. 435–439.) *See* also 3226, below.

3226. HAND LAPPER FOR QUARTZ CRYSTALS [for Final "Finishing" Laps, replacing Finger-Pushing Procedure: "has Greatly Expedited the Finishing Process," gives Greater Precision, & reduces Training Time].—G. M. Thurston. (*Bell Lab. Record*, July 1944, Vol. 22, No. 11, pp. 452–453.) To go with the latest machine lapper, 3225, above.

3227. QUARTZ CRYSTAL MODEL [Two Feet High, illustrating the Various Cuts for Training Purposes, etc.].—F. Caroselli. (*Bell Lab. Record*, May 1944, Vol. 22, No. 9, pp. 409–412.)

3228. POLARISATION AND SPECIFIC HEAT OF KH_2PO_4, *and* EFFECT OF ELECTRIC FIELD STRENGTH ON THE RESONANCE FREQUENCIES OF THE PIEZOELECTRIC CRYSTALS AKIN TO ROCHELLE SALT.—von Arx & Bantle: Bantle & others. (*See* 3184.)

3229. STABILITY OF REGENERATION: THE DAMPING OF THE MULTIVIBRATOR CIRCUIT.—Eisenmann. (*See* 3122.)

3230. STANDARD FREQUENCY SOURCE: CONVENIENT AND ACCURATE STANDARD FOR USE IN LABORATORY AND TEST OPERATIONS CALLING FOR PRECISE TIME, SPEED, OR FREQUENCY MEASUREMENTS [Unit comprising 60 c/s Oscillator (controlled by Maginvar Tuning Fork), Amplifier, & Voltage Regulator].—H. L. Clark & H. Johnston. (*Gen. Elec. Review*, May 1944, Vol. 47, No. 5, pp. 42–46.)

For papers on allied subjects *see* 122 & 3476 of 1943. The special property of maginvar (spelt throughout this article as "magnivar") is that (unlike ordinary invar materials, which have low expansion/temperature coefficients but not necessarily low frequency/temperature coefficients) it has its coefficients of expansion and stiffness so balanced that its frequency/temperature coefficient is within ± 4 parts per million per degree centigrade: *see* also 223 of January.

3231. TUNING-FORK STANDARDS FOR FREQUENCY-METER CALIBRATION [Installation comprising 15 Tuning-Fork Electronic Oscillators, with Stroboscopic Standardisation].—D. E. Anderson. (*Electronic Eng:g*, April 1944, Vol. 16, No. 194, p. 480: summary, from *Elec. World*.)

3232. UNITED NATIONS STANDARDS [Establishment of United Nations Standards Coordinating Committee, as Temporary Measure].—(*Wireless Engineer*, July 1944, Vol. 21, No. 250, p. 329.)

3233. Specific Resistance, Volume Resistivity, and Mass Resistivity [Reply to Correspondence on the Editorial dealt with in 2661 of August: and the Ambiguous & Dangerous Use of the Word "per" in "Ohms per cm per cm²" and elsewhere].—G. W. O. H. (*Wireless Engineer*, July 1944, Vol. 21, No. 250, p. 307.) *See* also August issue, p. 358.

3234. Nomenclature of Dielectric Properties.—C. F. Brockelsby. (*Wireless Engineer*, July 1944, Vol. 21, No. 250, p. 328.)

A letter raising a subject related to that of the Editorials referred to in 3233, above. "The nomenclature in this field is far from satisfactory; since many of the quantities have no names at present [K, K' y, $|y|$, and δ], it does not seem unreasonable to hope that a discussion of suitable terms may prove fruitful": this letter begins such a discussion.

3235. A Precision Apparatus for the Rapid Determination of Indices of Refraction and Dispersion by Immersion [employing the Double-Diaphragm Method for securing Oblique Illumination: Max. Error about $\pm 5 \times 10^{-5}$].—C. A. Faick & B. Fonoroff. (*Journ. of Res. of Nat. Bur. of Stds.*, Feb. 1944, Vol. 32, No. 2, pp. 67–75.)

3236. The Absolute Measurement of Large Magnetic Fields by a Null Method [Field calculated in terms of a Capacitance, a Voltage, a Resistance, & an Area].—H. Mikhail & Y. L. Yousef. (*Proc. Phys. Soc.*, 1st July 1944, Vol. 56, Part 4, No. 316, pp. 249–250.) The discharge from the condenser counterbalances the effect of cutting the magnetic field by the search coil. No quivering of the fluxmeter-pointer is produced, such as was found with Nettleton & Sudgen's method.

3237. The A_L Measuring Equipment, a Permeability-Testing Apparatus for Transformer Cores.—M. Bidlingmaier. (*Bull. Assoc. Suisse des Élec.*, 3rd May 1944, Vol. 35, No. 9, p. S.13: list of sections in paper in *Siemens Zeitschr.*, July/Sept. 1943, Vol. 23, p. 53 onwards.)

3238. Permanent Magnet Measurements.—E. M. Underhill. (*Electronics*, April 1944, Vol. 17, No. 4, pp. 135–139 and 385..390.)

Concluding article of the series on permanent magnets (1700 of May, 2744 of August); it gives procedures for using the ballistic galvanometer (an analysis of these instruments is given in an Appendix), fluxmeter, magnetometer, and permeameter, to determine if sample magnets confirm the accuracy of design calculations and produce the required results.

SUBSIDIARY APPARATUS AND MATERIALS

3239. The Magnetically Focused Radial-Beam Vacuum Tube [and Its Use as an Electronic Commutator, etc.].—Skellet. (*See* 3167.)

3240. Correspondence on "Deflected Electron Beams". [Harries, 2576 of August].—(*See* 3164.)

3241. Negative-Feedback Amplifier for Cathode-Ray Oscilloscopes. — Mezger. (*See* 3126.)

3242. The Frequency Spectrum of Periodic Pulses [Square-Wave & Saw-Tooth].—Filipowsky. (*See* 3200.)

3243. New Valve-Oscillator Circuit [of High Frequency-Stability & Low Harmonic Content: suitable for Variable-Frequency Circular Time-Base].—Butler. (*See* 3134.)

3244. Some Unusual Applications of the Double-Beam Cathode-Ray Oscillograph [Phase-Angle Measurement: Determination of Distortion: Comparison of Frequencies: Checking Equality of Signals in Push-Pull Amplifiers].—Patchett. (*Electronic Eng:g*, April 1944, Vol. 16, No. 194, pp. 467–468 and 470.) For previous papers *see* 2425 of July.

3245. On the Greinacher Voltage-Multiplying Circuit and Its Use for the Production of High Constant D.C. Voltages [for X-Ray Equipments, Atomic Disintegration, etc: Advantages of the Liebenow–Greinacher Connection, etc.].—Mehlhorn. (*E.T.Z.*, 9th March 1944, Vol. 65, No. 7/10, pp. 80–81: summary, from *Wiss. Veroff. Siemens-Werken*, 1943, p. 1 onwards.). *Cf.* 3252, below.

3246. Progress in Electron-Microscopy, *and* New Results with the Siemens Electron-Microscope.—(*See* 3376.)

3247. Electron-Microscopic Determination of Surface Elevations and Orientations [especially the Stereoscopic Method: including a New Cartridge for obtaining Stereo Micrographs at an Angle of 10°: Thicknesses as Small as 150 ± 50 AU are measured, using This]. — Heidenreich & Matheson. (*Journ. Applied Phys.*, May 1944, Vol. 15, No. 5, pp. 423–435.)

3248. Application of the "Memnoscope" to Rectifier Study.—Pakala & Wouk. (*Proc. I.R.E.*, June 1944, Vol. 32, No. 6, pp. 336–338.)

Authors' summary:—"The 'memnoscope' is a device employing rotating condensers for studying randomly occurring electrical phenomena (723 of 1939). This paper describes some records obtained . . . when studying arc-backs in shielded mercury-arc rectifiers. It has been found that arc-backs may occur on the shield, without a cathode spot forming on the anode and without resultant disturbances in the external electrical circuits". The writers end: "Other methods of recording random phenomena with long-persistence cathode-ray tubes are used (Hull, 2356 of 1936 and back references). For studying more than two or three wave-forms simultaneously, and if detail not better than 2 or 3 degrees of a 60-cycle wave is desired, the 'memnoscope' is an excellent device for the purpose."

3249. Use of the Ionisation Gauge on Systems Evacuated by Oil Diffusion Pumps [Unless Certain Precautions are taken, Observed Ionisation Current may be as Small as One Hundredth of That corresponding to the Vapour Pressure of the Pump Fluid, owing to Consumption of Vapour].—Blears. (*Nature*, 1st July 1944, Vol. 154, No. 3896, pp. 20–21.) From the Met.-Vick. laboratories.

3250. STABILISING ELECTRONIC CIRCUITS.—Lévy. (*See* 3123.)

3251. INVESTIGATIONS ON CURRENT-SUPPLY INSTALLATIONS FOR TELEGRAPHY.—Schmidl. (*T.F.T.*, Nov. 1943, Vol. 32, No. 11, pp. 239–244: to be concluded.)

3252. THE VILLARD VOLTAGE-DOUBLING CIRCUIT, TREATED ON THE LINES OF RECTIFIER TECHNIQUE [Villard Condenser, Charging & Discharging Processes: Conversion of Villard Potential into D.C. Potential: etc.].—Verse. (*Elektrot. u. Masch:bau*, 11th June 1943, Vol. 61, No. 23/24, p. 265 onwards.) *Cf.* 3245, above.

3253. RESISTORS FOR HIGH-VOLTAGE CIRCUITS AND HIGH AMBIENT TEMPERATURES [using Minimum of Critical Materials: formed of Pressed & Sintered Ring Segments connected Non-Inductively].—Sprague Electric. (*Gen. Elec. Review*, May 1944, Vol. 47, No. 5, p. 50.)

3254. THERMAL AND ELECTRICAL CONDUCTIVITY OF GRAPHITE AND CARBON AT LOW TEMPERATURES [Measurements between − 191°C & 100°C: including the Unexplained Anisotropy of Acheson Graphite].—Buerschaper. (*Journ. Applied Phys.*, May 1944, Vol. 15, No. 5, pp. 452–454.)

3255. DISCUSSION ON "THE RECTIFYING PROPERTY OF CARBORUNDUM."—Fairweather: Kendall. (*See* 3142.)

3256. THE TECHNIQUE OF GLASS MANIPULATION.—Percival. (*Electronic Eng:g*, April & May 1944, Vol. 16, Nos. 194 & 195, pp. 453–457 & 500–504.)

3257. DIELECTRIC CONSTANTS AND POWER FACTORS AT CENTIMETRE WAVELENGTHS [22.5 & 10 cm: Results for Various Glasses & Other Materials].—Englund. (*See* 3206.)

3258. NOMENCLATURE OF DIELECTRIC PROPERTIES.—Brockelsby. (*See* 3234.)

3259. THE ESTABLISHMENT OF A DIVISION OF HIGH-POLYMER PHYSICS IN THE AMERICAN PHYSICAL SOCIETY.—(*Science*, 19th May 1944, Vol. 99, No. 2577, pp. 401–402.)

3260. PLACE-EXCHANGE THEORY OF PLASTIC FLOW, AS APPLIED TO POLYMERS.—Eley & Pepper. (*Nature*, 8th July 1944, Vol. 154, No. 3897, p. 52.)

3261. "PLASTICS: SCIENTIFIC AND TECHNOLOGICAL" [Book Review].—Fleck. (*Engineering*, 9th June 1944, Vol. 157, No. 4091, p. 443.) "The formidable task of critically surveying the science and technology of plastics for the benefit of both users and producers has been undertaken by Mr. Fleck with a combination of thoroughness and competence that commands admiration. . . ."

3262. THERMAL CONDUCTION WITH RADIO HEATING [of Plastics, etc.], *and* WELDING OF THERMOPLASTIC MATERIALS BY MEANS OF RADIO-FREQUENCY CURRENTS.—Herne: Zade. (*See* 3369 & 3370, below.)

3263. PHENOLIC LAMINATES AS INSULATING MATERIALS.—Rulon. (*Sci. Abstracts*, Sec. B, April 1944, Vol. 47, No. 556, p. 64: from *Elec. World*, 1943.) For another paper *see* Caldwell, 2967 of September.

3264. CORROSION OF LIGHT-ALLOY SCREWS AND BOLTS IN PHENOLIC PLASTICS [after 6–12 Months: Investigation of Cause: Suggested Preventive Surface-Treatment].—Geier & Reschke. (*E.T.Z.*, 9th March 1944, Vol. 65, No. 7/10, pp. 76–77.)

3265. MACHINE SCREWS: FASTENING STRENGTH IN VARIOUS MATERIALS [Tests to fill Gap in Knowledge, particularly Serious in view of Use of Substitute Materials].—Millard. (*Bell S. Tech. Journ.*, Jan. 1944, Vol. 23, No. 1, p. 132: summary only.)

3266. A TOOL FOR CUTTING CIRCULAR WASHERS OR BOBBIN CHEEKS [Materials from Sixteenth to Quarter Inch of Thickness].—Drury. (*Journ. of Scient. Instr.*, July 1944, Vol. 21, No. 7, p. 125.)

3267. DEVELOPMENTS IN INSULATING MATERIALS [Short Survey, with Table of Some Natural Materials & the Roughly Corresponding Synthetic Substitutes: including Trolitul, Lupolen, Clophen, Oppanol, Lignofol, Perlonseide, & Luvican].—Wall. (*Engineering*, 23rd June 1944, Vol. 157, Nos. 4093, pp. 482–483.)

3268. INSULATING VARNISHES: A GUIDE TO SELECTION AND APPLICATION.—McGill. (*Elec. Review*, 18th Feb. 1944, Vol. 134, No. 3456, pp. 238–240.) By the Managing Director, Sterling Varnish Company.

3269. GUTTA PERCHA AND BALATA, WITH PARTICULAR REFERENCE TO THEIR USE IN SUBMARINE-CABLE MANUFACTURE [including a Comparison with Polyethylene].—Dean. (*Journ. Roy. Soc. Arts*, 23rd June 1944, Vol. 92, No. 4668, pp. 368–382: Discussion pp. 382–386.)

3270. CONTRIBUTION TO THE STUDY OF THE MECHANISM OF THE ELECTRICAL BREAKDOWN OF CABLES [the Thermal-Breakdown Theory: the Ionisation-of-Vacuoles Theory: a New Theory fitting in with All the Facts, and involving a Tendency of the Electric Field to Expel the Impregnating Matter].—Borel. (*Bull. Assoc. Suisse des Élec.*, 3rd May 1944, Vol. 35, No. 9, pp. 239–243: in French.)

3271. "BIBLIOGRAPHY AND ABSTRACTS ON ELECTRICAL CONTACTS" [Book Review].—Am. Society for Testing Materials. (*Proc. I.R.E.*, June 1944, Vol. 32, No. 6, pp. 374–375.)

3272. THE ASEA "SCHUB" [Shove] TRANSFORMER [Free from Defects of Previous Designs with Continuously Variable Transformation Ratio].—Olson. (*Elektrot. u. Masch:bau*, 18th Feb. 1944, Vol. 62, No. 7/8, pp. 95–98: long summary.)

3273. PERMANENT MAGNET MEASUREMENTS.—Underhill. (*See* 3238.)

3274. THE MAXWELL LABORATORY AT THE UNIVERSITY OF MOSCOW.—Arkadiev. (*See* 3327.)

3275. MAGNETOSTRICTION NOISE FROM TELEPHONE WIRES.—Dow. (*See* 3143.)

3276. "MAGNETOCHEMISTRY" [Book Review].—Selwood. (*Phil. Mag.*, May 1944, Vol. 35, No. 244, p. 353.)

3277. GYRO MOTORS [including Bantam Types].—Westinghouse. (*Journ. Applied Phys.*, May 1944, Vol. 15, No. 5, p. 458.)

STATIONS, DESIGN AND OPERATION

3278. GERMAN VERY-HIGH-FREQUENCY COMMAND SET [Type FUG-16, for Ships, Tanks, Aircraft, etc: 38–42 Mc/s: Transmitter–Receiver, believed to be of 1935 Design: Good & Bad Points].—Gordon. (*Electronics*, April 1944, Vol. 17, No. 4, pp. 132–134 and 300.)

3279. A.T. & T. ANNOUNCES COAXIAL PROGRAMME: FACILITIES PLANNED TO MEET REQUIREMENTS FOR INTER-CITY TELEPHONE CIRCUITS MAY ALSO BE USED FOR TELEVISION.—A.T. & T. (*Bell Lab. Record*, May 1944, Vol. 22, No. 9, pp. 392–395.) For a preliminary note *see* 2751 of August.

3280. AUTOMATIC RADIO RELAYING: SOME GENERAL CONSIDERATIONS.—Bell. (*Wireless World*, July 1944, Vol. 50, No. 7, pp. 203–204.) *See* also "Diallist," on pp. 204–205.

3281. THE LONGEST WAY ROUND [Postscript to "Equatorial Radio Girdle: Avoiding Zones of Ionosphere Disturbance" (2345 of July): the Principle as employed by Cable & Wireless, Ltd.].—Cable & Wireless. (*Wireless World*, July 1944, Vol. 50, No. 7, p. 202.)

3282. MULTI-CHANNEL RADIO TELEPHONE SPANS THE CHESAPEAKE ENTRANCE [Cape-Henry/Cape-Charles Twelve-Channel Link (25 Miles) avoids a 400-Mile Route: Pilot-Frequency Gain Control: etc.].—Peterson. (*Bell Lab. Record*, May 1944, Vol. 22, No. 9, pp. 387–390.)

3283. HISTORIC FIRSTS: THE RADIO LINK ["First Time that Reliance had been placed on Radio to give Regular Day-In Day-Out Public Telephone Service": the 30-Mile Emergency Link between the "Magic Isle" of Catalina & the Mainland, after the Los Angeles Earthquake, 1920].—(*Bell Lab. Record*, July 1944, Vol. 22, No. 11, p. 451.)

3284. GOVERNING PRINCIPLES OF FREQUENCY ALLOCATION [Monthly Commentary prompted by Certain Suggested Principles mentioned in "International Telecommunications" (Mance: *see* 3285, below)].—(*Wireless World*, July 1944, Vol. 50, No. 7, p. 193.)

3285. "INTERNATIONAL TELECOMMUNICATIONS" [a Chatham House Publication].—O. Mance. (Mentioned in 3284, above.)

3286. ENGINEERING WORK OF THE FEDERAL COMMUNICATIONS COMMISSION: I—GENERAL INTRODUCTION (E. K. Jett): II—TIMELY BROADCAST MATTERS (G. Adair): III—POLICE, AVIATION AND MARITIME SERVICES (W. N. Krebs): IV—INTERNATIONAL POINT-TO-POINT AND ALLOCATION PROBLEMS (P. F. Siling).—Jett & others. (*Proc. I.R.E.*, June 1944, Vol. 32, No. 6, pp. 317–330.)

Among various points, I—"We are fortunate in having a temporary respite to do the necessary planning for the technical future of radio . . . If we do a reasonably good planning job now, there will be room for at least the minimum frequency requirements of all legitimate radio services." II—"What variation of the root-sum-square method should be made and what allowance should be made for other factors? . . . Are the present night-time propagation curves of the Commission satisfactory or should these be modified, and furthermore, what consideration should be given to F-layer or multiple E reflections in determining sky-wave interference?" III—"Engineers who have an interest in this service are urged to give more attention to the practical application of frequencies above 30 Mc/s for short-distance telephony in the maritime services." IV—"The past system of channeling, on a percentage basis, may now be outmoded . . . It might be possible [in the future] to assign for particular purposes a channel whose width would be determined by the requirements of the circuit and adjacent assignments . . ." The "equatorial radio girdle" (2345 of July, and 3281, above) is mentioned.

3287. RADIO FOR RAILROADS [Survey of Past Difficulties & Recent Development].—Halstead. (*Electronics*, April 1944, Vol. 17, No. 4, pp. 92–95 and 210..214.)

"The accelerated technological progress resulting from war research, the practical benefits afforded by the use of railway radio communication in ordnance plants, and the improved financial condition and progressive spirit of the railroad industry have combined fortuitously at this time and should facilitate rapid growth of this new field . . ." *Cf.* 3288, below.

3288. RADIO DIRECTION ON RAILWAYS [Announcement of Completion of Building-Up of Radio Network, by the Four Main-Line Companies].—(*Engineer*, 23rd June 1944, Vol. 177, No. 4615, p. 477.) *Cf.* 3004 of September.

GENERAL PHYSICAL ARTICLES

3289. "EXPERIMENT AND THEORY IN PHYSICS" [Book Review].—Born. (*Proc. Phys. Soc.*, 1st July 1944, Vol. 56, Part 4, No. 316, pp. 291–292.) Tracing "the mutual relationship between theory and experiment in the actual historical development of science, with special emphasis on modern progress . . ." For a long review by Dingle see *Nature*, 15th July 1944, Vol. 154, No. 3898, pp. 65–67.

3290. ON HELMHOLTZ'S ELECTRODYNAMICAL POTENTIAL AND THE INDUCTION COEFFICIENTS OF UNCLOSED CURRENTS IN QUASI-STATIONARY PROCESSES.—da Silveira. (*Phil. Mag.*, May 1944, Vol. 35, No. 244, pp. 346–351.)

Incidentally, "for open currents the contribution of this term [the additional term, in eqn. 23, relative to each filament of current] is smaller in proportion as the extremities of the currents are closer. For example, in the case of the discharge of a plane condenser with a small thickness of dielectric, the contribution is very small, and the magnetic energy has more or less the same value as in a closed current."

3291. GRAVITATION, ELECTROMAGNETISM, AND QUANTUM THEORY [Summary of "The Theory of Indeterminate Space-Time," by F. R. Saxby].—Piaggio: Saxby. (*Nature*, 15th July 1944, Vol. 154, No. 3898, p. 94.) "There is great danger that what is apparently an investigation of great importance may be missed by physicists . . ."

3292. THE MAGMATIC PHENOMENA AND THE THEORIES OF THE ELECTROMAGNETIC QUANTUM, *and* THE ANCIENT AND MODERN THEORIES OF GRAVITATION.—Sagui: Sauty. (*See* 3089 & 3090.)

MISCELLANEOUS

3293. A NEW APPROACH TO THE DYNAMICS OF SYSTEMS WITH GYROSCOPIC COUPLING TERMS. —Bloch. (*Phil. Mag.*, May 1944, Vol. 35, No. 244, pp. 315–334.)

"Passive electrical networks and 'ordinary' mechanical systems have in common that mutual impedances (admittances) are symmetrical: $Z_{ik} = Z_{ki}$. This is basic for the use of electrical analogies. In mechanical systems with gyroscopic couplings this symmetry gives place—in part—to a skew symmetry: and, so far as the author is aware, such systems have for this reason not been treated by means of electrical analogies . . . It is shown that, when the method [developed in the present paper] becomes inapplicable, it leads to the finding of a class of mechanical systems which possess asymmetrical impedance properties, corresponding to electrical systems containing valves. A simple example of such a system is given, and a representative electrical circuit is developed which contains only passive elements."

3294. SOME NEW METHODS IN MATRIX CALCULATION.—Hotelling. (*Sci. Abstracts*, Sec. A, April 1944, Vol. 47, No. 556, p. 69.)

3295. KINEMATICAL PROBABILITY ["As an Inversion of Quantum-Mechanical Ideas, a Calculus is proposed in which the Density of Solutions of a Differential Equation is sought rather than the Solutions Themselves"].—Liebowitz. (*Phys. Review*, 1st/15th April 1944, Vol. 65, No. 7/8, p. 255: summary only.) For other work by the same writer *see* 1102 of April.

3296. ON THE APPLICATION, TO A CRITERION OF INDEPENDENCE, OF THE COUNTING OF THE NUMBER OF INVERSIONS PRESENTED BY A PERMUTATION.—Ville. (*Comptes Rendus* [Paris], 5th/26th July 1943, Vol. 217, No. 1/4, pp. 41–42.) When a number of tests in succession have given a series of values for a variable X, and it is required to make sure that the tests have been truly independent and that the law of probability of X has remained constant during the tests.

3297. RELATIONS BETWEEN STATISTICS: THE GENERAL AND THE SAMPLING PROBLEM WHEN THE SAMPLES ARE LARGE.—Geary. (*Sci. Abstracts*, Sec. A, April 1944, Vol. 47, No. 556, pp. 72–73.)

3298. A SAMPLING INSPECTION PLAN FOR CONTINUOUS PRODUCTION.—Dodge. (*Bell S. Tech. Journ.*, Jan. 1944, Vol. 23, No. 1, p. 130: summary only.)

"It differs from others which have been published in that it presumes a *continuous flow* of *consecutive articles* or *consecutive lots* of articles offered to the inspector for acceptance in the order of their production. It is accordingly of particular interest for products manufactured by conveyor or other straight line continuous processes. In operation, the plan provides a corrective inspection, serving as a partial screen for defective units. . . ."

3299. THE EFFICIENT USE OF GAUGES IN [Statistical] QUALITY CONTROL.—Tippett. (*Engineer*, 23rd June 1944, Vol. 177, No. 4615, pp. 481–483.)

3300. ARE GAUGES REALLY NECESSARY? [Feats of Blind Inspectors].—(*Electronic Eng:g*, April 1944, Vol. 16, No. 194, p. 477: paragraph only.)

3301. "REPORT ON THE TEACHING OF MATHEMATICS TO PHYSICISTS" [Book Review].—Joint Committee, Mathematical Assoc. & Institute of Physics. (*Journ. of Scient. Instr.*, July 1944, Vol. 21, No. 7, p. 127.)

3302. "MATHEMATICS OF RADIO COMMUNICATIONS" [Book Review].—Wang. (*Proc. I.R.E.*, June 1944, Vol. 32, No. 6, p. 375.)

3303. "CALCULATIONS FROM DRAWINGS" [Book Review].—Holliday. (*Engineering*, 9th June 1944, Vol. 157, No. 4091, p. 443.)

3304. TRIMETIC PROJECTION.—Metropolitan-Vickers. (*Electronic Eng:g*, April 1944, Vol. 16, No. 194, p. 478: summary.) Another summary was dealt with in 2390 of July.

3305. NOMOGRAMS [particularly the Parallel-Line Logarithmic Type for Problems involving Multiplication, Division, Powers, or Roots: Construction of Nomograms for Equations with 3, 4, & 5 Variables].—Nachod. (*Gen. Elec. Review*, May 1944, Vol. 47, No. 5, pp. 13–20.)

3306. "SIGNALS FOR THE HOME GUARD" [Book Review].—Whitehouse. (*Electronic Eng:g*, April 1944, Vol. 16, No. 194, p. 482.)

3307. MILITARY TRANSMITTER IN MASS PRODUCTION [Successful Application of Assembly System].—Read. (*See* 3138.)

3308. ENGINEERING WORK OF THE FEDERAL COMMUNICATIONS COMMISSION.—Jett & others. (*See* 3286.)

3309. R.M.A. REPORT: NEW REPRESENTATION OF THE INDUSTRY [and Other Points (including Post-War Employment of Technicians of Various Grades, Civilian Receivers, etc.)].—R.M.A. (*Wireless World*, July 1944, Vol. 50, No. 7, p. 219.)

3310. Post-War Development in Radio Engineering [Points from Report].—British I.R.E. (*See* 3148.)

3311. Post-War Development: Reports on the Industry and Radio Engineering [Extracts from Annual Report, R.M.A., and "Post-War Development in Radio Engineering" (British I.R.E.)].—R.M.A: British I.R.E. (*Wireless Engineer*, July 1944, Vol. 21, No. 250, p. 329.)

3312. A Proposal recommending the Formation of a British Radio Research Institute, submitted to the Radio Industry and Government of Great Britain as a Contribution toward Post-War Prosperity.—British I.R.E. (*Journ. British I.R.E.*, March/May 1944, Vol. 4, No. 1, pp. 37–45.) The full text of the proposal dealt with in 2084 of June.

3313. A Ministry of Science? Does the Nation need Such a Ministry, and if so, Who should take Charge of It?—Randell. (*BEAMA Journal*, June 1944, Vol. 51, No. 84, p. 202: summary, from *Electrical Industries*, May 1944.)

3314. Society for Freedom in Science [Note on Recent Statement of Purpose & Aims: the Approaching Period of Reconstruction & Its Dangers].—(*Nature*, 8th July 1944, Vol. 154, No. 3897, p. 48.)

3315. An International Federation of Engineers [Note on Recent Meeting at Burlington House].—(*Engineer*, 23rd June 1944, Vol. 177, No. 4615, p. 477.)

3316. The Coordination of Allied Professions.—Crampton. (*Engineer*, 16th June 1944, Vol. 177, No. 4614, p. 468.) "At the present rate of progress it would take a millennium to unify or federate them all. Is it not clear that an arbitration tribunal should give a final and binding decision on such questions?"

3317. Organisation of Physics in America [Leading Article on Harnwell's Editorial (*Review Scient. Instr.*) urging that Some Concrete Step must be taken to bring about Greater Unity].—Waterfall & Hutchisson. (*Journ. Applied Phys.*, May 1944, Vol. 15, No. 5, pp. 407–409.)

"The American Institute of Physics, through its members and affiliated societies, has a fair but not complete coverage of the field of physics, but it appears that a considerable modification of its present organisation may be necessary to enable it to perform satisfactorily the functions of a strong central organisation to unify physics. Traditions of individual societies may have to be broken. Compartmentalisation of interests within the Institute, without unnecessary overlapping, should make for a strong and smooth-working organisation which would attract to it newly-forming groups and older established groups which recognise their logical connection with physics. . ."

3318. Discussion of Closer Cooperation between the I.E.E. Wireless Section and the Institute of Radio Engineers [at I.R.E. Board of Directors' Meeting].—(*Proc. I.R.E.*, June 1944, Vol. 32, No. 6, p. 371.)

3319. I.E.E. Wireless Section changes Its Name to Radio Section, and Modifies the Rule dealing with Its Scope.—I.E.E. (*Wireless Engineer*, Aug. 1944, Vol. 21, No. 251, p. 382.)

3320. Proposed Constitutional Amendments in the Institute of Radio Engineers [particularly the Montreal Amendment (3053 of September) and the Proposed Increase of Subscriptions].—I.R.E. (*Proc. I.R.E.*, June & July 1944, Vol. 32, Nos. 6 & 7, pp. 369–370 & 436.)

3321. How Can We Develop Inventors?—Kettering. (*Engineer*, 9th June 1944, Vol. 177, No. 4613, pp. 443–444.) Excerpts from a paper in *Mechanical Eng:g*. The writer is the Director of Research, General Motors Corporation. For a leading article *see* pp. 446–447.

3322. Inquiry into Research [Letter prompted by Remark in Leading Article of 26th May ("Indeed, there seems something higher and greater than research—the heaven-sent gift of imagination")].—Ferguson. (*Engineer*, 9th June 1944, Vol. 177, No. 4613, p. 447.) For further correspondence *see* issues for 16th & 23rd June, pp. 467–468 & 487.

3323. Physics and the Scientific Instrument Industry.—Philpot. (*Proc. Phys. Soc.*, 1st July 1944, Vol. 56, Part 4, No. 316, pp. 263–270.)

"The man to whom physics appears as a heap of dry bones, the precise dimensions of which are to be carefully measured and memorised," may do well in the examination room, but "the makings of the true experimental physicist are in the man who sees in the dry bones the possibilities of articulation, mentally clothes them with flesh, and gives to them life and movement". In the Discussion, F. Twyman mentions as further uses for physicists the finding of new markets for existing products, of fresh instruments to make ("the instruments made by scientific men for their own researches form a rich field for exploitation . . ."), and of instruments used in classical experiments, so that copies could be made available for educational purposes.

3324. Progress in Engineering Knowledge during 1943.—Alger & Stokley. (*Gen. Elec. Review*, Feb. 1944, Vol. 47, No. 2, pp. 9–29 and 33..49.) With a very long list of literature references.

3325. Research Work for 1944 in the Academy of Sciences of U.S.S.R.—Bach. (*Nature*, 1st July 1944, Vol. 154, No. 3896, p. 32.)

3326. History and Activities of the U.S.S.R. Academy of Sciences during the Past Twenty-Five Years.—Brasch. (*Science*, 2nd June 1944, Vol. 99, No. 2579, pp. 437–441.)

3327. THE MAXWELL LABORATORY AT THE UNIVERSITY OF MOSCOW.—Arkadiev. (*Nature*, 29th July 1944, Vol. 154, No. 3900, p. 157.)

Subjects touched on include "styctography" (1820 of 1943 and back references); radioscopy by radio waves, using screens luminescent under the action of centimetric waves; a comprehensive theory of "passive" spectra and the application of spectral analysis to the study of magnetisation processes; "the theory of passive spectra has been applied to the behaviour of matter of every description, beginning with the ionosphere and gases . . ."; general equations "representing a scheme of the behaviour of matter along the entire scale of electromagnetic waves" (Debye dispersion, magnetic properties of ferromagnetic bodies in the region of ultra-Hertzian waves, etc.).

3328. THE SCIENTIFIC OUTLOOK AND ITS PRESENTATION BY FILMS.—Bell. (*Nature*, 29th July 1944, Vol. 154, No. 3900, pp. 155–157.)

3329. SCIENCE AND BROADCASTING [Article on "Reshaping Man's Heritage: Biology in the Service of Man" (Book) but particularly on the Original Series of Broadcast Talks: Reactions of an Army Listening Group: Suggestions for Increasing the Appeal of Science Topics].—Hawkins. (*Nature*, 8th July 1944, Vol. 154, No. 3897, pp. 39–40.)

3330. "RADIO WAVES AND THE IONOSPHERE" [Book Notice].—Bennington. (*Wireless Engineer*, July 1944, Vol. 21, No. 250, p. 319.)

"Believed to be the only publication of its kind." The author states: "It is not a text-book. It contains no mathematics. It merely aims to explain the phenomena [of propagation] in as simple language as is possible."

3331. THE PAPER SHORTAGE AND SCIENTIFIC PUBLICATIONS [and Some Suggestions].—Griggs. (*Science*, 26th May 1944, Vol. 99, No. 2578, pp. 428–430.)

"If editors would publish 'Advance Abstracts of Papers Received and Available in Microfilm' in every issue of their journals, I venture to predict that readers would habitually turn to this section of the journal before reading anything else . . . If one takes the trouble to compare the abridged articles of the *Reader's Digest* with their originals, he finds not only that often nothing has been lost by abbreviation, but that frequently something has been gained. Could research papers be improved by similar treatment? For the most part, I believe that they could, except for the few investigators in cognate fields who must have detail. Skilful editing by one closely in touch with the science concerned could solve the problems of many a journal . . ."

3332. *Portugaliae Physica* [Notes on First Issue of New Lisbon Journal].—(*Nature*, 15th July 1944, Vol. 154, No. 3898, p. 79: *Journ. of Scient. Instr.*, July 1944, Vol. 21, No. 7, p. 128.) *See*, for example, 2766 of August.

3333. *Die Naturwissenschaften*: REPLACEMENT OF COPIES OF DOUBLE NUMBER 47/48 DESTROYED BY ENEMY ACTION.—(Inset in *Naturwiss.*, 3rd [18th on Cover] Dec. 1943, Vol. 31, No. 49/50 [49/52 on Cover].)

3334. "THE SUBJECT INDEX TO PERIODICALS, 1942" [Book Review].—Library Association. (*Nature*, 27th May 1944, Vol. 153, No. 3891, p. 635.)

3335. PROPOSED AMERICAN STANDARD PRACTICE FOR MICROFILMS, Z38.7.8, AND STANDARD SPECIFICATIONS FOR MICROFILM READERS, Z.38.7.9.—American Standards Association. (*Journ. Opt. Soc. Am.*, April 1944, Vol. 34, No. 4, pp. 243, 244.) Published for trial and criticism.

3336. SAFEGUARDING OF ESSENTIAL RECORDS BY PHOTOGRAPHY [the Kodak "Recordak" System, the Williamson Mfg Company's "Reprograph" & Its P.O. Modification, and the Littlejohn Copying Camera for Linen Records].—Wickens. (*P.O. Elec. Eng. Journ.*, April 1944, Vol. 37, No. 1, pp. 17–21.)

3337. "THE THEORY OF THE PHOTOGRAPHIC PROCESS" [Book Review].—Mees. (*Nature*, 27th May 1944, Vol. 153, No. 3891, pp. 632–633.) For another review *see* 1454 of April.

3338. INFLUENCE OF PNEUMATIC PRESSURE ON THE PHOTOGRAPHIC SENSITIVITY.—Choong Shin-Piaw. (*Journ. Opt. Soc. Am.*, May 1944, Vol. 34, No. 5, pp. 285–289.)

3339. A MEAN SCOTOPIC VISIBILITY CURVE [giving the Reciprocals of the Relative Energies of Different Wavelengths required to produce a Given Visual Effect on the Retinal Rods].—Stiles & Smith. (*Proc. Phys. Soc.*, 1st July 1944, Vol. 56, Part 4, No. 316, pp. 251–255.)

3340. SENSITIVITY OF THE HUMAN EYE.—Hecht. (*Nature*, 1st July 1944, Vol. 154, No. 3896, p. 13: summary of lecture based on original researches.) *See* also 1576 of 1941.

3341. ON A GENERAL STIMULUS/RESPONSE LAW IN BIOLOGY [including, as Approximations over Certain Limited Ranges, the Weber & Weber–Fechner Laws].—de Rudder. (*Naturwiss.*, 3rd [18th on Cover] Dec. 1943, Vol. 31, No. 49/50 [49/52 on Cover], pp. 577–584.)

3342. NEW CATADIOPTRIC MENISCUS SYSTEMS [eliminating the Chief Defects of Reflector & Refractor Systems].—Maksutov. (*Journ. Opt. Soc. Am.*, May 1944, Vol. 34, No. 5, pp. 270–284.) For finders, spectrograph cameras, finders of comets, meteor cameras, etc.

3343. COMBINATION OF PRISMS WITH CONSTANT DEVIATION FOR THE VISIBLE, INFRA-RED, AND ULTRA-VIOLET SPECTRA.—Picard. (*Comptes Rendus* [Paris], 2nd/30th Aug. 1943, Vol. 217, No. 5/9, pp. 139–141.)

3344. THE NEW LIGHT EFFECT: INTENSITY VARIATION BY DIRECT PHOTOELECTRIC MEASUREMENTS [Results confirming Joshi's View that the Phenomenon can Not be identified with Negative Photoelectric Effect].—Deo. (*Current Science* [Bangalore], Feb. 1944, Vol. 13, No. 2, p. 44.) *See* 2291 of 1943 and 2445 of July, and 3345, below.

3345. LIGHT-EFFECT IN CHLORINE UNDER ELECTRICAL DISCHARGE: CHANGE OF THE WAVE FORM DUE TO IRRADIATION.—Joshi. (*Nature*, 29th July 1944, Vol. 154, No. 3900, p. 147.) *See* also 3344, above.

3346. VARIATION, WITH TEMPERATURE, OF SUPERSONIC VELOCITIES IN WATER/ALCOHOL MIXTURES [in connection with Light-Modulating Devices].—Goudet. (*See* 3201.)

3347. ELECTRIC BIREFRINGENCE OF COLLOIDAL SOLUTIONS.—Sakmann. (*See* 3202.)

3348. PROBLEMS OF THE TRANSMISSION OF LIGHT THROUGH TISSUES AND SOME OTHER MEDIA [primarily in connection with the Measurement of the Oxygen Content of Blood].—Evans. (*See* 3102.)

3349. A FINE MECHANICAL ADJUSTMENT OF VARIABLE SENSITIVITY [primarily for adjusting the Tilt of a Mirror to an Accuracy within 0.1″: Reliable Minification of 25 000 or More].—Perfect. (*Journ. of Scient. Instr.*, July 1944, Vol. 21, No. 7, pp. 123–124.)

3350. "OPTICAL WORKSHOP PRINCIPLES" [Book Review].—Dévé. (*Engineering*, 30th June 1944, Vol. 157, No. 4094, p. 504.) Translated from the French.

3351. PHOTOELECTRIC INDUSTRIAL CONTROLS.—Hague. (*Electronics*, April 1944, Vol. 17, No. 4, pp. 114–117.)

"Rugged construction has taken the electronic equipment out of the experimental stage and made it an important industrial tool. The principles of operation of gas- and vacuum-type phototubes and the use of accessories are described." From the Westinghouse Company.

3352. ELECTRICITY AND SPORT [including Photoelectric Measurement of Times, Counting Devices, & Communications]. — Janicki. (*Bull. Assoc. Suisse des Élec.*, 3rd May 1944, Vol. 35, No. 9, pp. 248–252: in German.)

3353. INVESTIGATIONS ON OSCILLATIONS IN PNEUMATICALLY CONTROLLED VALVES FOR LIQUIDS UNDER HIGH PRESSURE [using Electric & Photoelectric Methods].—Hoppe. (*Zeitschr. V.D.I.*, 5th Feb. 1944, Vol. 88, No. 5/6, pp. 84–85.)

3354. THE UNDAËR SYSTEM, A NEW DEVELOPMENT IN INSTALLATION TECHNIQUE [Press-Button Air-Pressure-Wave Generator connected by 2 mm Tubing to Electro-Pneumatic Switch: Various Applications].—Roth: Lüthi. (*Bull. Assoc. Suisse des Élec.*, 8th March 1944, Vol. 35, No. 5, pp. 117–120: in German.)

3355. SOLAR SEARCHLIGHT: SIGNALLING MIRROR ACCURATELY DIRECTS HIGH-INTENSITY SUNBEAM: ITS BRILLIANT FLASHES ATTRACT RESCUERS.—Potter. (*Gen. Elec. Review*, May 1944, Vol. 47, No. 5, pp. 7–9.)

3356. SPECTRAL BLACKOUTS [War-Time Applications, including Use of Didymium-Glass Windows with Sodium-Vapour Lamps].—(*Journ. Applied Phys.*, May 1944, Vol. 15, No. 5, p. 458.)

3357. RADIATION RECEIVER WITH REDUCED SENSITIVITY TO THE POSITION OF THE SOURCE [in connection with a Method of determining the Difference in Thickness of Metallic Tube Walls from the Absorption of Gamma Rays].—Dobrotin & Frank. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 20th April 1943, Vol. 39, No. 2, pp. 49–52: in English.)

For instance, "radioactive sources of gamma rays frequently differ from one another considerably in form, and this is bound to affect the results of measurements, because their distance from the ionisation chamber cannot be made so large as to be incomparable with their dimensions."

3358. RADIATION MEASUREMENT SET [Small Portable Geiger–Müller Instrument for Detection & Measurement of Alpha Particles, Weak Beta-Radiation, Ultra-Violet Light, etc.].—Herbach & Rademan Company. (*Review Scient. Instr.*, March 1944, Vol. 15, No. 3, pp. 74–75.)

3359. "THE APPLICATION OF RADIANT HEAT TO METAL FINISHING" [Book Notice].—Nelson & Silman. (*Journ. of Scient. Instr.*, July 1944, Vol. 21, No. 7, p. 126.)

3360. FUTURE PROSPECTS OF RADIO-PROSPECTING BY REFLECTION.—Fritsch. (*E.T.Z.*, 9th March 1944, Vol. 65, No. 7/10, p. 81: summary only.) A French summary was dealt with in 2455 of July.

3361. WATER FINDING BY WIRELESS PROSPECTING [Propagation Measurements: Resistance Method: Capacitance-Substitution Method: Possibilities of Error: etc.]. — Fritsch. (*Wasserkr. u. Wasserwirtsch.*, 15th Sept. 1943, Vol. 38, No. 9, p. 209 onwards.) A 7-page paper, mentioned in *Bull. Assoc. Suisse des Élec.*, 19th April 1944, p. S.12.

3362. ELECTROMAGNETIC-WAVE CRYSTALS [Possibility of producing Artificial Diamonds, etc., by causing Crystallisation to proceed in Space filled with Standing Waves with Nodal Points corresponding to Positions of Atoms in the Crystal].—Japolsky. (*Nature*, 1st July 1944, Vol. 154, No. 3896, p. 20.)

"It seems that in this way any feasible atom lattice can be realised, for it can be shown, on the lines which I used for determining stable positions of a rotating electron beam [ref. "2"], that these nodal points will also be the points of maximum stability of corpuscles." The stationary waves can be produced by interference of monochromatic beams of X-rays or by using electron diffraction.

3363. PAPERS ON THE USE OF SUPERSONIC WAVES IN FLAW-DETECTION AND METALLURGY.—Behr: Shrayber: Trost. (*See* 3193/4.)

3364. MAGNETIC DEFECTOSCOPE [for Rails, at Speeds up to 15 m.p.h: Sensitive to Defects amounting to a Few Tenths of One per Cent. of Total Section of Rail].—Gorelik & others. (*Journ. Applied Phys.*, May 1944, Vol. 15, No. 5, p. 457: summary, from *Vestnik Metalloprom.*, 1939.) *See* also 2467 of July, and Mee, 3622 of 1943.

3365. A NEW DESIGN OF RADIO-FREQUENCY CRACK-DETECTOR FOR FERROUS OR NON-FERROUS METALS.—Salford Elec. Instruments. (*Electrician*, 14th July 1944, Vol. 133, No. 3450, p. 33: paragraph only.)

3366. HEATING GEARS FOR HARDENING BY HIGH-FREQUENCY INDUCTION.—Curtis. (*Sci. Abstracts*, Sec. B, April 1944, Vol. 47, No. 556, p. 68: from *Machinery*, 1944.)

3367. ELECTRONIC-HEATING DESIGN CHART ["Choice of Over-All Circuit Constants for Induction & Dielectric Heating Applications can be made Directly from the Chart. Their Limitations & Dependencies are Visualised"].—Fields. (*Electronics*, April 1944, Vol. 17, No. 4, pp. 143–144 and 395, 396.)

3368. FABRICATING WOOD AIRCRAFT "SKINS" [with the Help of Radio-Frequency Heating].—Taylor. (*Electronics*, April 1944, Vol. 17, No. 4, pp. 102–107 and 391, 392.) With nine references to recent literature.

3369. THERMAL CONDUCTION WITH RADIO HEATING.—Herne. (*Wireless Engineer*, Aug. 1944, Vol. 21, No. 251, pp. 377–382.)

"So far, the two major uses are in the heating and curing of large blocks of thermo-setting plastics and in the heating of large composite sections of wood to accelerate the hardening of the glue in the joints. As a rough guide, the method is of value when the moulding is thicker than about one inch and when the composite wood board is thicker than about two inches. The whole problem of developing the technique then becomes one of obtaining a uniform temperature-rise in all the material at once. This problem separates itself into two parts: firstly the body must be studied to determine the general time/temperature relationships for various rates of generation and loss of heat: and secondly the electrodes must be so shaped as to produce that electric-field intensity at every point which will then give a uniform temperature-rise. The following is intended as a contribution to the first half of this problem."

Beginning with a short review of the literature (Brown's paper, 1073 of March, "is by far the most valuable contribution to the subject"), the writer then gives the general equation of heat conduction and obtains its solution for the one-dimensional case (on certain simplifying assumptions) first by a simple and direct method and then by a more powerful method depending on the superposition theorem and involving the temperature-distribution equation (11) due to Duhamel. Extensions of the Duhamel's-theorem method are indicated and a practical problem is worked out numerically.

3370. WELDING OF THERMOPLASTIC MATERIALS BY MEANS OF RADIO-FREQUENCY CURRENTS.—Zade. (*Plastics*, March 1944, Vol. 8, No. 82, p. 100.) Mentioned in Herne's paper, 3369, above, for its bibliography of recent developments in heating by dielectric hysteresis.

3371. RADIO HEATING EQUIPMENT: IV—INTERFERENCE PROBLEMS: IMPORTANCE OF EFFICIENT SCREENING.—Langton. (*Wireless World*, July 1944, Vol. 50, No. 7, pp. 212–213.) For previous parts *see* 2818 of August.

3372. HIGH-FREQUENCY THERAPY: PART VIII—THERAPY MACHINE OPERATION, CONTINUED [including Screening, Interference with Telecommunications, & Inductothermic Therapy].—Oliphant. (*Electronic Eng:g*, April 1944, Vol. 16, No. 194, pp. 472–474.) For previous parts *see* 2822 of August.

3373. MEDICAL ELECTRONIC PRACTICE AND RESEARCH [Basic Principles of Bioelectricity, Survey of Present Techniques, & Predictions of Future Progress, with Emphasis on Electro-Shock Therapy, Electrical Anaesthesia, Brain-Wave Recording, Determination of Ovulation Time, & Measurements on Living Tissues].—Goodell. (*Electronics*, April 1944, Vol. 17, No. 4, pp. 96–101 and 356..372.)

3374. BIOELECTRIC-RESEARCH APPARATUS.—Goldberg. (*Proc. I.R.E.*, June 1944, Vol. 32, No. 6, pp. 330–336.)

From the author's summary:—"Three independent amplifying channels, working into a three-trace cathode-ray tube, allow the recording of three, independent, simultaneous phenomena. The three traces may be partially or wholly superimposed, as desired . . . All channels operate from a common battery and power-line supply [the latter for the three output stages]. Cathode-ray-tube sweep circuits are direct-current-coupled and entirely power-line-operated. Individual control of centering and sweep-speed for each trace is provided. An associated stimulating circuit, synchronised with the sweep, provides stimuli for biologic specimens . . . A maximum voltage gain of 125 db may be obtained with a response flat within 1 db from 0 to 14 k/s. The sweep amplifiers provide an undistorted output of approx. 500 v . . . Sweep frequencies range from 1 per minute to 20 000 per second."

3375. SWISS ARMY REGULATIONS FOR THE PREVENTION OF ACCIDENTS DUE TO ELECTRIC CURRENTS.—(*See* 3162.)

3376. PROGRESS IN ELECTRON-MICROSCOPY, *and* NEW RESULTS WITH THE SIEMENS ELECTRON-MICROSCOPE.—(*Schweizer Arch. f. angew. Wiss. u. Tech.*, March 1944, Vol. 10, No. 3, pp. 86–88: p. 88.)

(i) Including Tiselius & Sard's work on the poliomyeletis virus, Ruska's on bacteriophages, Müller's stereoscopic technique without movement of the object (the direction of the ray being altered), etc. (ii) The above-mentioned work on infantile paralysis.

3377. SOME UNUSUAL APPLICATIONS OF THE DOUBLE-BEAM CATHODE-RAY OSCILLOGRAPH.—Patchett. (*See* 3244.)

3378. HIGH-FREQUENCY ELECTRODYNAMIC VIBRATION MOTOR WITH ELECTRONIC POWER SUPPLY [for Tests on Large Turbines].—(*Gen. Elec. Review*, Feb. 1944, Vol. 47, No. 2, p. 29.) In the long survey of progress referred to in 3324, above.

3379. MAGNETOSTRICTION NOISE FROM TELEPHONE WIRES.—Dow. (*See* 3143.)

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