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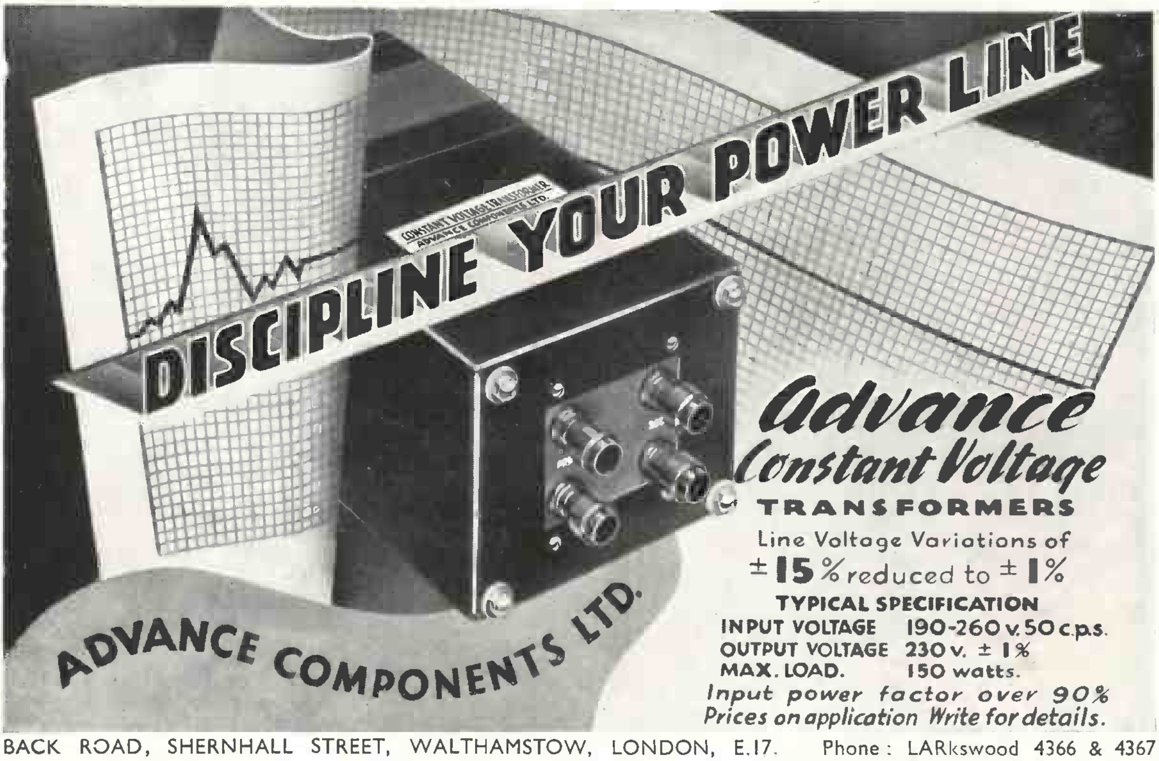
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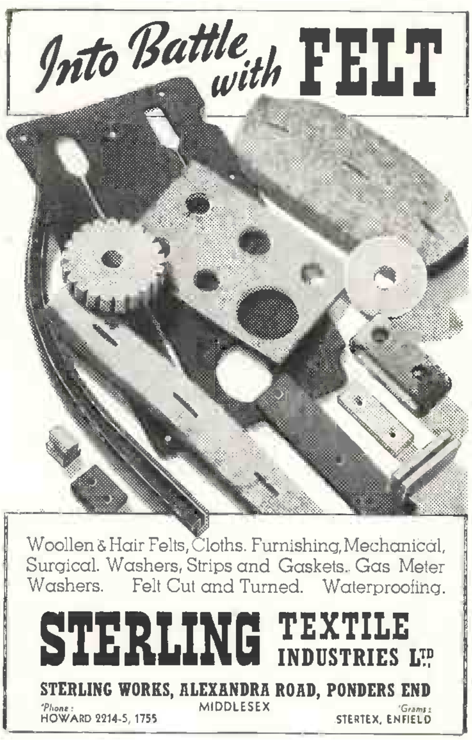
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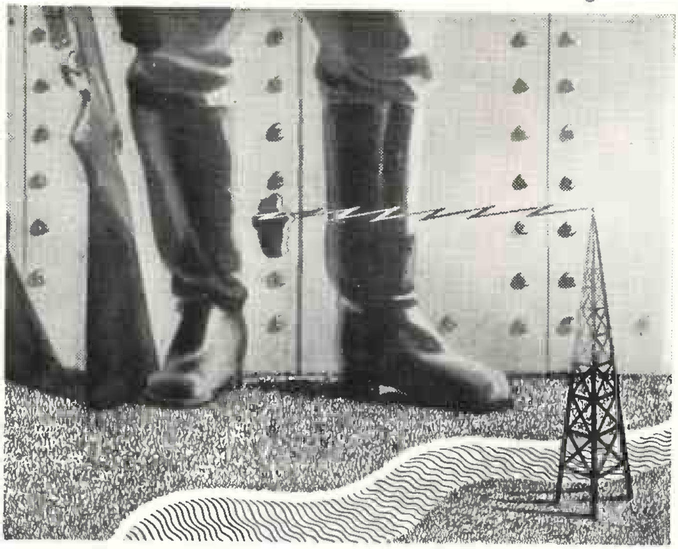

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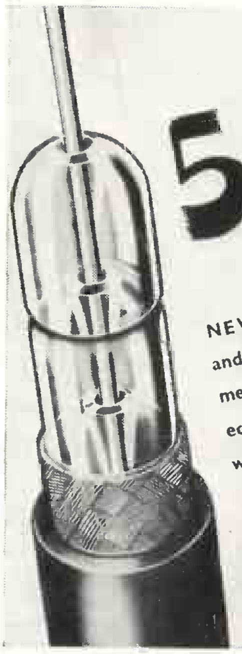

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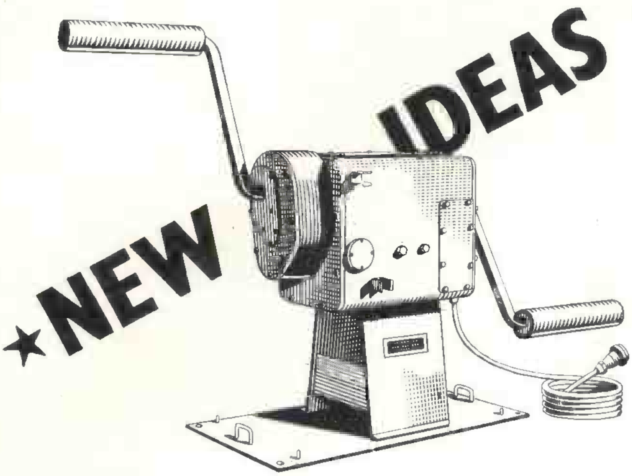

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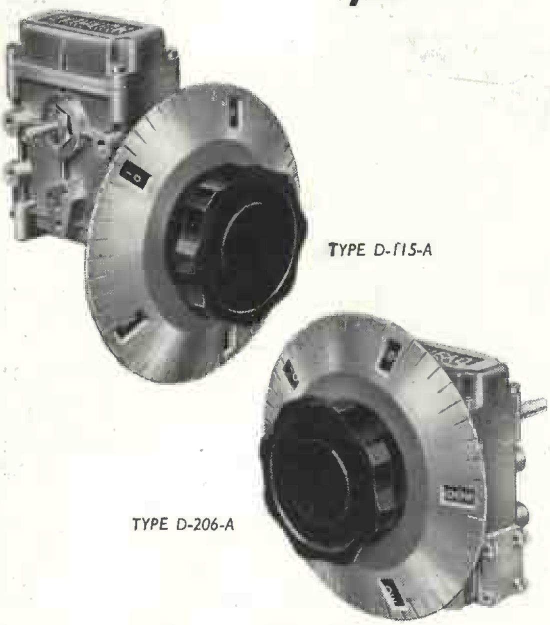

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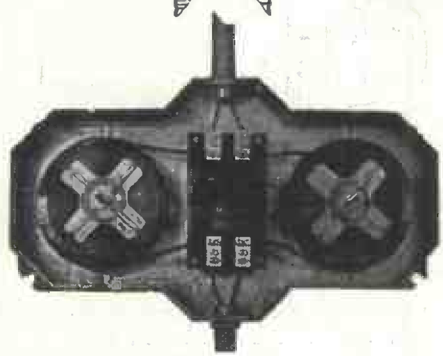

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WIRELESS ENGINEER

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VOL. XXI NOVEMBER, 1944 No. 254

EDITORIAL

Resonance in Quarter-wave Lines

THIS editorial note is prompted by an article recently published in the *Proceedings of the Physical Society* (July 1st, 1944, p. 255) by C. H. Collie entitled simply " On Electrical Resonance." It deals with resonance in a coaxial line and then extends the treatment to a straight wire acting as a receiving aerial. No great novelty is claimed for the methods or results, but it is stated to be an attempt to provide an elementary method of treatment making " the maximum possible use of the student's existing knowledge and experience and introducing the minimum of new material."

The formulae for the quarter-wave coaxial line are established by the summation of the waves continually reflected at the two ends of the line. The line is assumed to be energised, not by an e.m.f. acting at the closed end, but by a probe near the open end. In the following note we consider the same problem from the point of view of the student who is already familiar with the ordinary telephone transmission formulae.

If V_1 I_1 V_2 I_2 are the voltages and currents at the sending and receiving ends of a transmission line, then

$$V_2 = V_1 \cosh Pl - Z_0 I_1 \sinh Pl$$

and $I_2 = I_1 \cosh Pl - \frac{V_1}{Z_0} \sinh Pl$

where, assuming the leakance to be negligible, the characteristic impedance $Z_0 = \sqrt{Z/Y} = \sqrt{\frac{R + j\omega L}{j\omega C}}$, the propagation coefficient $P = \alpha + j\beta$, the attenuation coefficient $\alpha = \frac{R}{2}\sqrt{\frac{C}{L}}$, and the phase-change coefficient β (i.e. the phase change per unit length) $= \sqrt{XB} = \omega\sqrt{LC}$ (assuming R to be small).

If the receiving end is open circuited $I_2 = o$ and we have

$$I_1 = \frac{V_1}{Z_0} \tanh Pl = \frac{V_2}{Z_0} \sinh Pl$$

and $V_2 = V_1\left(\cosh Pl - \frac{\sinh^2 Pl}{\cosh Pl}\right) = \frac{V_1}{\cosh Pl}$

Now

$$2 \cosh Pl = e^{Pl} + e^{-Pl} = e^{\alpha l} \cdot e^{j\beta l} + e^{-\alpha l} \cdot e^{-j\beta l}$$

and if the length of the line be made exactly $\lambda/4$, $\beta l = \pi/2$ and $e^{j\beta l} = j$. We then have

$$2 \cosh P\lambda/4 = je^{\alpha\lambda/4} - je^{-\alpha\lambda/4}.$$

If α is very small, $e^{\alpha\lambda/4} = 1 + \alpha\lambda/4$; $e^{-\alpha\lambda/4} = 1 - \alpha\lambda/4$ and $e^{\alpha\lambda/4} - e^{-\alpha\lambda/4} = \alpha\lambda/2$.

Under these conditions $\cosh P\lambda/4 = j\alpha\lambda/4$ and $V_2 = -j\, V_1/\alpha\lambda/4$

i.e. 90° behind V_1 and $\frac{4}{\alpha\lambda}$ times as great.

Similarly $\tanh P\lambda/4 = 4/\alpha\lambda$ and $I_1 = \frac{V_1}{Z_0} \cdot \frac{4}{\alpha\lambda}$

Hence I_1 is not exactly in phase with V_1 when $l = \lambda/4$; the phase difference can be found as follows, assuming $R/X \ll 1$.

$$Z_0 = \sqrt{\frac{R + j\omega L}{j\omega C}} = \sqrt{\frac{L}{C}}\sqrt{1 - jR/X} = \sqrt{\frac{L}{C}}\sqrt{1 + R^2/X^2}\ \big/ \!\!-R/2X = \left(1 + R^2/2X^2\right)\sqrt{\frac{L}{C}}\ \big/\!\!-R/2X$$

Hence to a high degree of accuracy

$$I_1 = V_1\sqrt{\frac{C}{L}}\cdot\frac{4}{\alpha\lambda}\underline{/R/2X}$$

or, putting $\alpha = \frac{R}{2}\sqrt{\frac{C}{L}}$, $I_1 = \frac{V_1}{\frac{\lambda}{8}R}\underline{/R/2X}$

Since the angle $R/2X$ is very small (about 0.5 minute in the example), I_1V_1 is the power supplied and $\frac{1}{2}I_1^2(R\lambda/4)$ the power dissipated.

Although it is rarely necessary to take the difference into account, it should be noted that β is not exactly $\omega\sqrt{LC}$; to a high degree of accuracy $\beta = \omega\sqrt{LC}(1 + R^2/8X^2)$; in the example the difference is quite negligible.

The example chosen by Collie is a coaxial line of which the inner and outer diameters are 1 cm and 5 cm; the wavelength is 1 metre and the length of the line therefore about 25 cm.

To calculate the attenuation coefficient α, it is necessary to determine the resistance per unit length of the line. It can be shown* that the depth of penetration is equivalent to a uniform distribution of the current over a layer of thickness t where $t = \frac{1}{2\pi}\sqrt{\frac{10^9\rho}{f\mu}}$. For copper $\mu = 1$, $\rho = 1.7 \times 10^{-6}$, and if $f = 300 \times 10^6$ ($\lambda = 1$ metre) $t = 0.38 \times 10^{-3}$cm. If the inner and outer diameters of the dielectric space are 1 cm and 5 cms respectively, the resistance per unit length, go and return, can be calculated from the formula $R = \rho l/A$ and is found to be 1.72×10^{-3}ohm. To find the capacitance per unit length we have

$$C = \frac{1}{2\log_e r_2/r_1}\cdot\frac{1}{9 \times 10^{11}} = 3.46 \times 10^{-13} \text{ farad}$$

and therefore

$$\alpha = \frac{R}{2}\sqrt{\frac{C}{L}} = \frac{RC}{2}\cdot 3 \times 10^{10} = 8.96 \times 10^{-6}$$

Substituting this value in the formula $V_2/V_1 = -j\frac{4}{\alpha\lambda}$ we obtain a voltage magnification of 4400. These values agree exactly with those obtained by Collie.

We have seen that

$$\frac{V_1}{V_2} = \cosh Pl = \cosh(\alpha l + j\beta l).$$

To see clearly how this varies in magnitude and phase as l is varied it is best to consider the equation

$$\cosh(\alpha l + j\beta l) = (e^{\alpha l}\underline{/\beta l} + e^{-\alpha l}\underline{/-\beta l})/2$$

It is seen that the cosh is half the resultant of two vectors starting at unit length from OA for $l = o$ (Fig. 1) and rotating in opposite

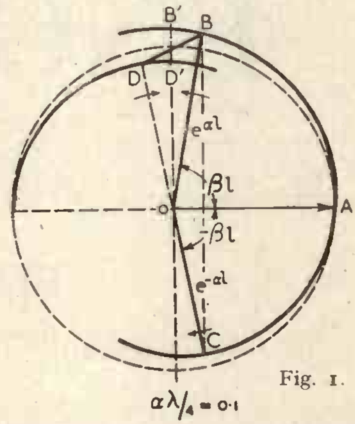


Fig. 1.

directions as the distance l increases so that the angles are always βl and $-\beta l$. The length of the positively (anti-clockwise) rotating vector OB increases exponentially, and the length of the oppositely rotating vector OC decreases reciprocally. As we have seen, for small values of αl the changes are approximately linear. As the length l approaches $\lambda/4$, the angle βl approaches 90° and the resultant DB of the two vectors decreases, until, when $l = \lambda/4$, the resultant is $D'B'$. We then have

$$\frac{V_1}{V_2} = \cosh P\frac{\lambda}{4} = \frac{D'B'}{2\,OA}$$

and to a very close degree of approximation this is the minimum value. If OA represents in magnitude and phase the voltage V_2 at the open end of the line, then $DB/2$ represents the voltage V_1 at the closed end. The line is assumed to be closed through a source of zero impedance having this electromotive force, but exactly the same results are obtained by Collie, who assumes to line to be energised by a probe near the open end.

We have seen that $I_1 = \frac{V_2}{Z_0}\sinh Pl$. It is easily seen that

$$\sinh(\alpha l + j\beta l) = (e^{\alpha l}\underline{/\beta l} - e^{-\alpha l}\underline{/-\beta l})/2$$

and the sinh is therefore represented by half the difference of the two spiral vectors in Fig. 1, that is, by the line $BC/2$, which is not quite perpendicular to OA except in the neighbourhood of A and when $\beta l = \pi/2$. In

* *Journ. I.E.E.*, Vol. 54, p. 473. 1916.

the latter case, although the sinh and the cosh are in phase, I_1 is not quite in phase with V_1 because Z_0 has a small angle; in the example, however, this is negligible.

In order to clarify the Figure it has been drawn for $\alpha\lambda/4 = 0.1$, i.e. for a much greater attenuation than that of our quarter-wave air-line, for which, since $\alpha = 8.96 \times 10^{-6}$ and $\lambda = 100$ cm, $\alpha\lambda/4 = 0.224 \times 10^{-3}$. With such a small attenuation the Figure would have to be drawn to a very large scale in order to distinguish the spirals from the circle. In the Figure the distance between B' and the circle is 0.1 of the radius; if drawn to the proper scale it would only be 0.224×10^{-3} of the radius.

The smaller the distance $D'B'$ the more rapid will be the change of phase, i.e. the angle between $D'B'$ and DB, as the length l departs from $\lambda/4$. In our example a change of length of 1 mm corresponds to a change in βl of $\frac{\pi}{2} \cdot \frac{1}{250}$, i.e. $2\pi \times 10^{-3}$. From Fig. 2 (not drawn to scale) it is seen that this small departure from $\lambda/4$ causes cosh Pl to swing through an angle the tangent of which is $2\pi/0.224 = 28.1$, i.e. an angle of about 88°. This also agrees with the result obtained by Collie, who emphasises this remarkably sharp tuning. A word of warning should, however, be given as to the purely theoretical character of this result. Disappointment awaits anyone who attempts to obtain experimental confirmation of these calculated values. The reasons for this were discussed in the September Editorial.

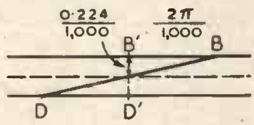


Fig. 2.

The electric field does not suddenly stop at the open end of the line, but fringes out into the surrounding space giving the line an electric length in excess of its physical length, and, moreover, the wave arriving at this open end will not be entirely reflected but will be, to some extent, radiated out into space, thus giving the effect of a dissipative load at the end of the line. With a concentric line 25 cm long and 5 cm diameter working at 300 Mc/s these effects will be quite pronounced and cause the measured characteristics to differ considerably from the theoretical values.

G. W. O. H.

The Problem of Two Electrons and Newton's Third Law

THE March Editorial was devoted to an interesting and somewhat paradoxical problem. It was purposely left rather in the air with the idea of instigating some discussion of the problem. We thought, however, that we had indicated what we considered the solution, but from a reference to the article it appears that this was not made clear. It may be remembered that we considered two electrons A and D moving along paths at right-angles and at the moment when one of them, A, is at the point of intersection of the paths. It will act as an element of current and produce a magnetic field at D which should cause the electron D to experience a force parallel to the path of A. But A cannot experience any reacting force due to D because it is on the line of motion of D. Where, then, is the reaction to the force on D? To answer this one has to consider the network of displacement currents (*see* Fig. 5 of Editorial) that are caused by and accompany the electron D. According to Maxwell's theory these displacement currents act electromagnetically like conduction currents in producing magnetic fields and presumably in experiencing mechanical forces due to magnetic fields. Hence the absence of any reaction on A is due to the fact that its magnetic field causes two equal and opposite forces on the electron D and on its associated network of displacement currents. Since the latter is inseparable from the electron we are justified in regarding them as two parts of a single system, subjected to two equal and opposite forces and therefore experiencing no resultant force. The paradox is thus resolved. Any point on the line of motion of D is completely outside the network of displacement currents. Any other point will be embraced to some extent by the network, and the equality of the two forces will no longer hold when A is at such a point. Anything in the nature of a paradox is due to the neglect of the displacement currents which must be associated with an isolated electron in motion.

G. W. O. H.

TESTING HIGH-FREQUENCY CABLES*

A Resonance Line Method for the Measurement of Characteristics in the Decimetre Wave Range

By F. Jones, B.Sc. (Hons.), A.M.I.E.E., and R. Sear, B.Sc. (Hons.), A.Inst.P.

SUMMARY.—The paper describes a method for the measurement of electrical impedances, and its particular application to the routine testing of cables in the decimetre wave range. Details of the method and the working equations are given, together with a description of the necessary equipment and its operation. Particular attention is paid to difficulties encountered with the measuring line and its detector, the problem of the measuring line calibration, and the effect on measurements of reactive discontinuities at the junction of the line and cable and at the centre line support. The measurement of twin cables with a velocity unbalance is discussed. Full treatment of the theory is given in an appendix.

Introduction

THE necessity arose a few years ago for the rapid determination of the transmission characteristics of cables designed for use at ultra-high frequencies. The method described in this paper was developed and put into use for routine testing during 1941. The method has been in constant use since then and has proved satisfactory. During the last three years, development work has proceeded on the apparatus and the difficulties inherent in the method have been thoroughly investigated.

The majority of methods of cable testing at ultra-high frequencies have as their basis, either the work of R. A. Chipman[1] or that of H. Bruckman[2]. The two methods are fundamentally different, the former utilising resonance phenomena on a transmission line, and the latter the formation of standing waves on a line not terminated by its characteristic impedance. Either method is capable of measuring the input impedance of a given length of cable at a given frequency. They are consequently capable of being adapted for use with the standard low frequency method of measuring cable characteristics[3, 4], in which the measurement is made with the cable in both open circuit and short circuit conditions.

A main difficulty is encountered at some frequency in this method of test even with "lumped circuit" measuring devices[5, 6, 7], due to the inevitable discontinuity at the point of connection of the cable. Such measuring devices are limited to frequencies below 100–150 Mc/s and distributed impedance devices are necessarily used at higher frequencies. A great reduction in the discontinuity at the point of connection of the cable is then possible, but since the effect of a given discontinuity increases with frequency, this factor again becomes a main difficulty above about 300 Mc/s.

In the use of the open and closed circuit method of testing, some special technique has to be used to eliminate this junction effect. A method developed at the National Physical Laboratory[8] consists essentially of measuring the cable in odd multiples of $\frac{1}{8}$ wavelength. Two complete open circuit and closed circuit tests are performed, either on two lengths of cable or on the same length at two different frequencies. Another method involves plotting on cartesian coordinates the conductance and susceptance components of the input admittances of the cable when either the cable length or frequency is varied. A circle, or strictly speaking, a spiral[9], is obtained since the real and imaginary parts of a hyperbolic tangent with complex argument give a circular diagram when plotted on rectangular coordinates. The effect of a reactive discontinuity at the junction of the cable and measuring line is merely to displace the circle centre from the conductance axis. From this diagram all the cable characteristics may be obtained.

Both of these techniques are applicable to either the resonant line or the standing wave methods of test. They are valuable for detailed investigations of cable pro-

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

perties but are too lengthy for the purpose of routine testing, as one sample normally requires a minimum test time of three to four hours.

The method used by the authors, and adapted from an investigation into the effects of junction discontinuities with "lumped circuit" resonance methods[10], is the testing of resonant lengths of cable by the resonant measuring line method. It is shown[10], that the effect of a "lumped" inductive reactance in the cable junction is negligible when the junction is situated at a voltage antinode, and a potential source of error is thus minimised by arranging the cable to be resonant, and with a high input resistance. This involves the use of cable lengths of either an integral number of half wavelengths with the far end open circuited, or an odd number of quarter wavelengths with the far end short circuited. The former condition is used in practice as it permits the cable length to be easily adjusted. The testing time, using this method, is of the order of twenty minutes for each sample. A further advantage is that accurate results are obtainable on shorter lengths of cable than are required for other methods, thus minimising cable wastage.

Notation

The notation is conveniently stated in two parts, one relating to the measuring line and the other to the cable. The units are as indicated except where otherwise stated in the text.

For the measuring line,

L = length from the open end to the detector in cms.
L_0 = value of L for resonance without cable or any form of discontinuity.
L_1 = value of L for resonance with a cable connected.
δL_0 = resonance curve width at half the maximum deflection, in cms., without a cable connected.
δL = resonance curve width at half its maximum deflection with a cable connected.
ΔL = $\delta L - \delta L_0$.
ΔL_0 = value of ΔL for a resonant cable length, when there is zero effect from the cable junction and centre line support.
A = attenuation constant, including the contribution of the detector, in nepers per cm.
λ_a = wavelength in cms.
B = $2\pi/\lambda_a$ = wavelength constant in radians per cm.
c = velocity of propagation in cms. per sec.
Z_0 = characteristic impedance in ohms.
Z_f = impedance of the line and cable at their junction.
P = $A + jB$ = propagation constant.
n' = $2L_1/\lambda_a$ = number of half wavelengths.

For the cable,

l = length in cms.
l_0 = resonant length in cms.
α = attenuation constant in nepers per cm.
λ_c = wavelength in cms.
β = $2\pi/\lambda_c$ = wavelength constant in radians per cm.
v = velocity of propagation in cms. per second.
Z_c = characteristic impedance in ohms.
C = capacitance in farads per cm.
C_t = Cl_0
n = $2l_0/\lambda_c$ = number of half wavelengths.

Also

f = frequency of test in cycles per second.

1. Outline of the Method and Practical Application

(i) *The method*

The characteristics of a transmission cable that are normally required to be determined are the attenuation, characteristic impedance and velocity ratio, the last being the ratio of the velocity of propagation in the cable to that in free space. All these characteristics are capable of being determined by the measurement of a resonant length of cable placed at the end of a measuring line, together with a measurement of the cable capacitance at a low radio or audio frequency.

The general theory of resonant line testing has been developed in the paper by R. A. Chipman,[1] while its application to resonant cable, or pure resistance measurements, is developed in the Appendix. From equation A/30 the attenuation of the cable is given by

$$\alpha = \frac{B\Delta L_0 Z_c}{2Z_0 l_0} = \frac{\pi \Delta L_0 Z_c}{\lambda_a Z_0 l_0} \quad \ldots \quad (1)$$

The validity of this equation depends upon the galvanometer deflection being proportional to the square of the current flowing in the detector, as is the case when a detector of the vacuum thermocouple type is used. It is also assumed that the attenuation of the cable measured is small and its impedance is substantially resistive.

For convenience of working, equation (1) may be written as

$$\alpha = \frac{\pi n}{2Z_0 c} \times \frac{\Delta L_0}{C_t l_0} = \frac{K \, . \, \Delta L_0}{C_t l_0} \text{ nepers/cm.} \quad \ldots \quad (2)$$

where K is a constant for a fixed number of half wavelengths under test. To obtain the result in db/100 ft. the equation becomes

$$\alpha = \frac{868 \, . \, 6 \, . \, K \, . \, \Delta L_0}{C_t l_0} \text{ db/100 ft.} \quad \ldots \quad (3)$$

where the length l_0 is now expressed in feet.

In equation (3) the capacitance of the

total length of cable is required. If, as is the case with polythene or air dielectric cables, the permittivity shows no appreciable change with frequency, then for uniform cables the capacitance required may be obtained by a usual bridge measurement.

The impedance of the cable follows from the relationship

$$Z_c = \frac{1}{\lambda_c f C} = \frac{n}{2fC_t} \quad \ldots \quad \ldots \quad (4)$$

and the velocity ratio is obtained from

$$\frac{v}{c} = \frac{\lambda_c}{\lambda_a} = \frac{2l_0}{n\lambda_a} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

Equations (3), (4), and (5) constitute the working equations used to obtain cable characteristics by the present method.

(ii) *Application*

The apparatus used consists essentially of a generator loosely coupled to a measuring line at its open end. The measuring lines are of two types designed to test coaxial and balanced twin cables. These incorporate a thermocouple detector in conjunction with a sensitive galvanometer. Fuller details of this equipment are given in Section 2.

In order to test a coaxial cable, the line, with the connecting cap in position, is first brought to resonance by adjusting its length, and its length noted. A cable length in excess of an integral number of half wavelengths is connected to the line, and is brought to separate resonance by cutting short lengths from the far end. This is satisfied when resonance of the combined system coincides with the position initially obtained for line resonance without the cable attached. The maximum deflection of the galvanometer spot at resonance is noted. The line is then detuned to give half of this deflection on each side of the peak value, and the corresponding lengths noted. The difference of these readings is the resonance curve width δL. The corresponding value of δL_0 for the measuring line is determined by a previous measurement, and is a constant for constant test conditions. The value ΔL_0 required is then given by $\delta L - \delta L_0$. The capacitance and length of the sample are measured, and knowing the number of half wavelengths from an approximate knowledge of the velocity ratio of the cable, the cable characteristics are obtained from equations (3), (4), and (5).

A similar procedure is followed for the measurement of twin cables, but with one additional step. This is necessitated by the distortion of the normal resonance curve when a cable possesses a velocity of propagation unbalance. Correction of the balance of the system is then necessary, and this is obtained by the use of the small condensers provided at the open end of the lines. Referring to Fig. 1(c), the condenser A is screwed in to contact the line *a*, and the position for resonance of this system is noted. This is repeated with the condenser A fully screwed out and with the condenser B contacting the line *b*. Assuming that the shorter of the two line lengths is obtained with the condenser B contacting the line, condenser A is screwed in to contact the line *a*, and condenser B is adjusted until the line length for resonance coincides with the shorter length. Condenser A is screwed fully out, and the system is then balanced. A symmetrical resonance curve is now obtained and its width is measured as described above. A fuller discussion of the effects of velocity unbalance in twin cables is given in Section 6.

For the purpose of routine cable testing it is convenient to select a standard number of half wavelengths. By this means a standard length of cable can be selected for most cables of similar insulants, and the variety of sample lengths is then reduced to the number of types of insulant used. As an example of this practice, the standard sample length for solid polythene insulated cables of average attenuation may be chosen as about 100 cms., with test frequencies of the order of 200 Mc/s. This gives two half wavelengths as the standard electrical length.

With careful design of the measuring equipment and cable connectors, this method is applicable over most of the decimetre wave range, due attention being paid to the errors, treated in Section 4, arising from the capacitive discontinuity at the line support and the cable junctions.

The accuracy obtained by this method is good, and is within the requirements generally accepted for high frequency cable testing. For attenuation measurements the repetitive accuracy is about 2 to 3 per cent., and the agreement with results by other methods is of the same order. In the measurement of characteristic impedance and velocity ratio accuracies of the order of 1 per cent. and 0.3 per cent. respectively, are obtained. All these values are strictly applicable to uniform cables only, but for the frequencies under discussion, normal cable meets this requirement.

The accuracies stated are capable of improvement, but the meaning of the values obtained becomes indefinite unless strict attention is paid to the cable uniformity. For cables of low attenuation measured at the higher frequencies, increased accuracy of curve width measurement is desirable to keep short sample lengths, while maintaining the accuracy stated. This is obtained by using a micrometer drive in place of the scale and vernier. For normal cables the arrangement can be used to improve the accuracy of 2 to 3 per cent. when this is necessary. In the measurement of velocity ratio the accuracy is a combination of

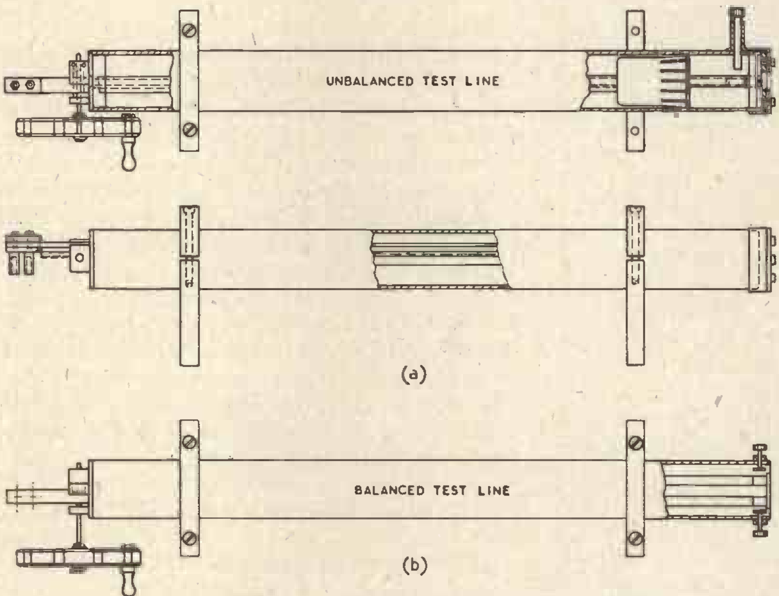
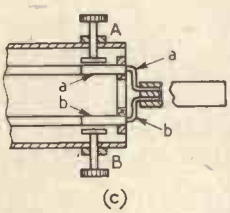


Fig. 1. *Measuring lines.*



that obtained by the wavemeters, and the accuracy of cable wavelength measurement. The former measurement is capable of considerable improvement, as discussed in Section 2 (iv). An improvement in the measurement of cable wavelength is also possible if a longer procedure is adopted. This is similar to that described for a measuring line calibration in Section 3. The cable length used is initially slightly in excess of $n\lambda_c/2$ and the cutting process is followed. This is repeated for a considerably shorter length of cable slightly in excess of $n_1\lambda_c/2$. The curves of line length against cable length are linear and this facilitates the accurate measurement of the distance between the curves at a constant value of line length. The length obtained gives the integral number $(n - n_1)$ of cable half wavelengths. In this way the error of a single measurement is reduced and the effect of the junction of the line and cable eliminated, so that an accuracy of about 1 part in 1000 can be obtained for the cable wavelength.

2. Apparatus

(i) *Measuring lines*

The unbalanced measuring line shown in Fig. 1 (a) consists essentially of a brass outer tube of $1\frac{1}{2}$ inch in internal diameter and a coaxial brass centre line $\frac{1}{4}$ inch in diameter, of lengths slightly longer than a quarter wavelength at the lowest test frequency required. The base of a sliding piston $1\frac{3}{4}$ inch long short-circuits these conductors, and is driven by a rack and pinion. The scale is mounted over and integral with the rack, while a vernier scale is mounted on the pinion bearing piece. A detector of the thermocouple type is mounted with the heater connections across the ends of the sliding piston remote from the short circuit. The couple leads are taken through a small tube integral with the rack and scale to two insulated plug terminals at the scale end. Connections are made from these to a sensitive galvanometer.

The balanced measuring line shown in Fig. 1 (b) is essentially similar, but with two balanced centre lines of $\frac{1}{4}$ inch diameter, and corresponding modification to the piston. The thermocouple in this case is mounted with the heater connections between the two inner line contacts of the piston. At the open ends of the lines, sleeves are sweated to the outer tube to take, with sliding fit, the injection probes from the oscillator. One only is provided on the unbalanced line, while two, vertically in line with the centre conductors, are provided for the balanced line.

To connect the cable to the unbalanced line, caps are provided fitting closely over the end of the line, and with central holes to suit the diameter of the cable dielectric. The cable screen is faced to the outside of the cap and clamped with a flat disc by means of two screws. The centre conductor of the cable is inserted into a small hole in the end of the centre conductor of the measuring line, both surfaces having been previously amalgamated with mercury. For the balanced line no cap is used, the two conductors of the twin cable being connected as for the centre conductor of the unbalanced line, and the screen of the cable left floating.

An additional precaution is necessary in the testing of twin cables, as discussed in Sections 1 and 6. The condensers mentioned in these discussions are two small discs mounted on the screen of the measuring line near the position of the cable connection. These are capable of being screwed in to contact the centre lines by small knurled discs on the outside.

In the lines used initially contact troubles were a main source of difficulty. This was eventually reduced by the piston being provided with spring finger contacts, slightly L-shaped at the ends, and rounded over. These were provided in both the outer skirt and the inner tube. Difficulty was still experienced from oxidation of the contact surfaces, but was cured by silver-plating the relevant surfaces and finishing with rhodium-plating. An appreciable deposit of rhodium was found to be necessary. Adequate springiness of the contacts is achieved by making the piston of phosphor bronze or

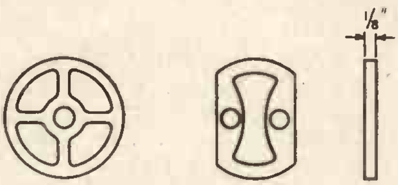


Fig. 2. *Line supports.*

beryllium copper. While rhodium has a much higher resistivity than silver, the usual plating material for this application, the increase in line losses is not appreciable, as the major contribution to them is due to the heater of the thermocouple.

A further initial difficulty with a piston of outside diameter nearly equal to the inside diameter of the outer tube, was due to a slight rocking motion of the piston, particularly with the rack fully extended. This produced a variation in the deflection of the indicating galvanometer. To overcome this effect, the outer piston contact fingers were coned

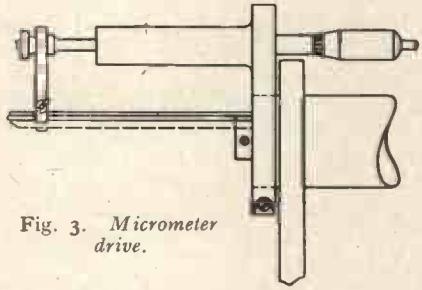


Fig. 3. *Micrometer drive.*

outwards and the body of the piston made of appreciably smaller diameter than the outside tube. The inner contacts were formed on a tube of larger diameter, giving more clearance from the centre line at all positions other than the actual contact points.

A centre line support is necessary at the lower frequencies since even though the lines are short and lend themselves to mechanical stability, some play is experienced at the free end of the centre lines. An investigation of the error in measurement which can arise from this support is discussed in Section 4 (ii). The supports now in use are made of polystyrene and all unessential material has been removed, the shapes finally adopted being shown in Fig. 2. With these supports the errors arising from the discontinuity involved are negligible.

Difficulty was experienced with the connections made by amalgamating the contact surfaces. With brass centre lines " seasoned cracking " was exhibited, and their life was extremely short. A method adopted for reducing this action of mercury was to use copper tips, long enough to provide the contact holes at the end of the brass lines. The action of mercury on copper is comparatively slow, and the life of the tips is satisfactory. The use of tips makes replacement easy.

The accuracy of measurements of the resonance curve widths is limited by the accuracy of reading the scale and its vernier. The need arose for increased accuracy in measurements other than routine testing. This was provided by the addition of a micrometer drive. A sketch of this is given in Fig. 3. The micrometer screw thread and barrel is supported by a clamp mounted on the outer tube of the measuring line. The micrometer barrel screws against a spring-loaded plunger, the other end of which is fitted with a clamp. The rack is capable of operating independently of this drive, but when required the clamp is tightened on to the rack and the whole is driven by the micrometer screw. By this means measurements can be taken to 0.001 cm., in place of the 0.01 cm. obtainable with the scale and vernier.

(ii) *Detectors*

The detectors in use are, as mentioned, thermocouples. These consist of a heater wire and thermocouple maintained in close proximity by a small bead of quartz glass insulation. The whole is mounted in an evacuated glass envelope. They are used without their usual cap mounting. The type adopted has a heater of 3Ω, with a maximum rating of 50 mA, and a couple of resistance approximately 4Ω. These thermocouples are much more convenient than crystal detectors in resonant line measurements, due to the instability of the relationship between the high frequency and rectified voltages obtained with the latter. In cases where the crystal may be calibrated immediately prior to use, as in standing wave equipment, its use offers the advantages of improved sensitivity and quick response. Even so, the necessity of previous calibration and of working to a calibration curve are distinct disadvantages. The lack of easy means of crystal calibration prior to any measurement has led to the almost universal adoption of thermocouples, as detectors for resonant line measurements. Apart from the time delay of the heater-couple system in assuming its equilibrium temperature, a disadvantage of thermocouple usage is the poor sensitivity encountered. Optimum conditions of operation are important and are obtained when the resistance indicating device is matched to that of the couple. Since the thermocouple is connected directly to a galvanometer, this condition is met by the use of a galvanometer coil with resistance of the order of 4Ω.

Thermocouples are usually quite satisfactory in operation, but are liable to three forms of breakdown. These are (*a*) fusing of the heater wire due to overloading, (*b*) direct contact between heater and couple, and (*c*) undue sensitivity to a concentric mode of propagation, as well as the normal twin mode, on balanced lines. An invariable symptom of the first form of breakdown is a decrease in the resonance curve width of the measuring line. This may be accompanied by other effects such as insensitivity, instability, a change in the line length for resonance at a given frequency, and an appreciable galvanometer deflection for all positions of the piston

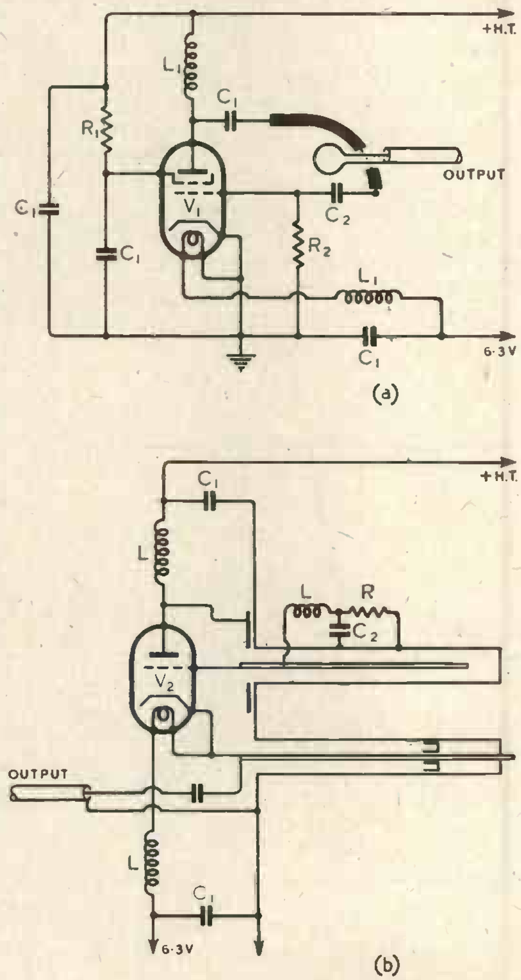


Fig. 4. (a) 200-*Mc/s oscillator.* $R_1 = 10{,}000\Omega$, $R_2 = 5{,}000\Omega$, $C_1 = 100$ *pF*, $C_2 =$ *approx.* 20 *pF*, $L_1 =$ *R.F. chokes*, $V_1 =$ *R.C.A.* 832
(b) 600-*Mc/s oscillator.* $R = 1{,}000\Omega$, $C_1 = 100$ *pF*, $L =$ *R.F. chokes*, $V_2 = E$ 1231

along the line. These latter effects are all very variable in magnitude, and a periodic measurement of the line losses is the best means of checking for an open circuit heater wire. It is usually possible to observe a break in the heater wire through a magnifying lens, but in a doubtful case, the thermocouple heater should be removed from the line and tested for continuity.

The symptoms of the second form of breakdown are an appreciable galvanometer deflection for all positions of the piston, and an enhanced " body movement " effect. In the case of a balanced line, a pronounced double peak instead of a single symmetrical resonance curve is obtained when the injection system is electrically slightly unbalanced. This form of breakdown is easily detected since a low resistance exists between the thermocouple terminals and the rack.

The nature of the third form of breakdown is somewhat obscure. The symptom is again that a double peak is obtained on a balanced measuring line when the injection is unbalanced, while the heater remains insulated from the couple. The effect has

built for fixed frequency operation. Numerous advantages are obtained by this practice. Contacts are minimised by fixing the normally variable components of an ultra-high-frequency oscillator, optimum output can be arranged without utilising variable matching devices from oscillator to load, and higher frequency stability is obtained. The main disadvantage is the multiplication of oscillators for the various test frequencies required.

Two types of oscillator are used, both of the Colpitts type. For the longer wavelengths of the decimetre wave range a " lumped " circuit oscillator is used. While this reduces the available output, the circuit is made compact and easily housed. The oscillatory circuit inductance comprises a quarter loop connected from the valve anode to the grid coupling condenser, and is tuned

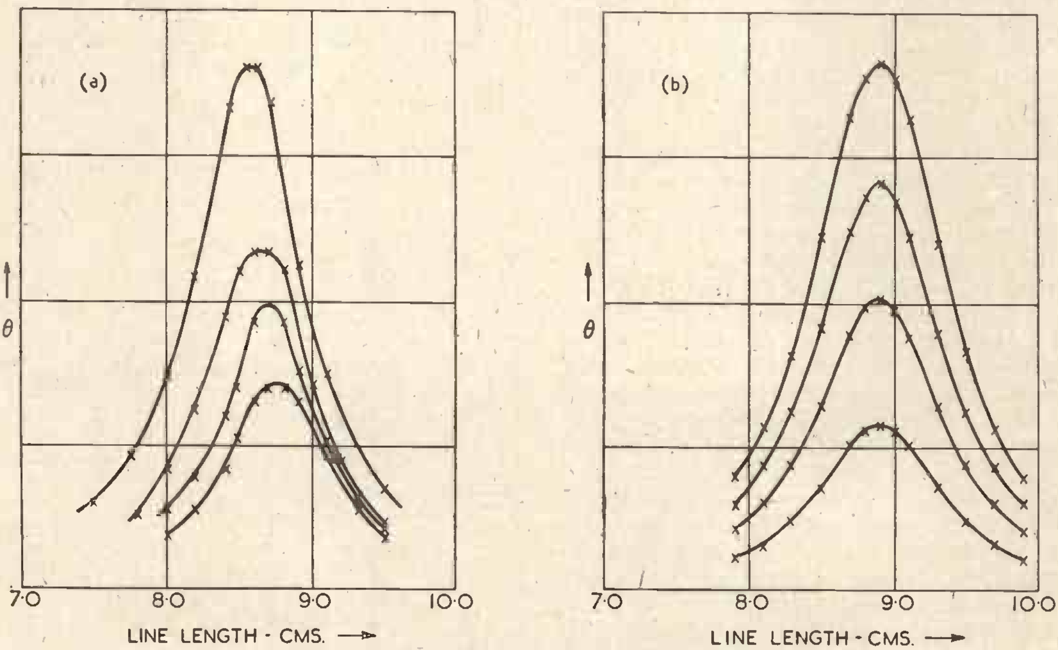


Fig. 5. *Resonance curves :* (a) *with oscillator " pulling " ;* (b) *without oscillator " pulling."*

been attributed to the softening of the insulating bead and a subsequent movement of the heater wire into very close proximity with the couple. This may be regarded as an intermediate breakdown to the second form. An investigation of this effect is discussed in Section 5.

(iii) *Generators*

The generators, shown diagrammatically in Fig. 4, used for test purposes, have been

by the valve interelectrode capacitance. The anode load consists of a choke cut to give optimum conditions and decoupled at the power pack end. Bias is obtained by the usual grid resistor. The output is taken by a single loop coupling to the oscillatory circuit, and feeds into a length of output cable, the combination being adjusted to resonance. This arrangement, using a low loss coaxial feeder, gives good frequency stability.

For the shorter wavelengths, a valve built for operation with a coaxial line oscillatory circuit is used. The line is electrically a half wavelength long, with the outer earthed and connected to the anode via a series condenser, provided to block the anode d.c. potential to earth. The centre line is connected to the valve grid and the grid biassing resistor is tapped to it, through a decoupled choke at the voltage node. The line terminates in an open circuit to minimise contacts, the centre grid line being spaced with a polystyrene washer at the open end. The valve load is provided by a second coaxial line connected between the valve cathode and earth. This is fitted with a short circuit piston for easy adjustment to optimum conditions. The output coaxial feeder is coupled in parallel with the cathode line through a small series condenser and is cut for optimum output, performing the function of a line matching transformer.

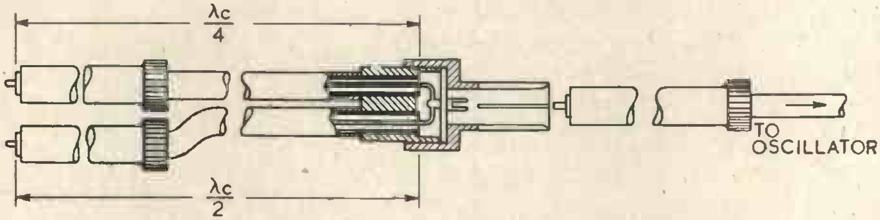


Fig. 6. *Balanced line feeder.*

In both cases the feeders are fitted with probes for connection to the unbalanced measuring lines and a small portion of the bare centre conductor is left protruding to provide capacitive coupling to the measuring line. The capacitance obtained provides sufficient coupling for normal test purposes.

The coupling obtained in this way is very loose. This is a necessary feature, since the measurements made depend on the constancy of the injected voltage while a resonance curve is being traversed. It is advisable to check for "pulling" of the oscillator, and the major symptom of this is that a change of frequency is experienced. There are two methods available for checking frequency changes. The first and most accurate method is to use a heterodyne frequency meter and ensure that no appreciable change of the audio note is experienced on going through a resonance curve. The second method is to plot complete resonance curves with varying amplitudes at resonance and to check that no change in the position for resonance has occurred, while there is also inappreciable change in the curve widths at varying amplitudes. Fig. 5 (a) is an example of the latter method when the oscillator is being badly "pulled," while Fig. 5 (b) shows satisfactory coupling conditions.

The injection to the balanced measuring line is more elaborate. In this case a connector was devised to provide connection between the coaxial oscillator feeder and two coaxial feeders terminating in probes fitting the balanced measuring lines. Details of this arrangement are given in Fig. 6. At the point of connection all three centre conductors are joined as are the outer conductors. The two feeders are then cut to a half wavelength and a full wavelength respectively to provide a phase difference of 180° at the two injection points to the measuring line. No provision has been made to equalise precisely the amplitudes of the injected voltage, but such a feature is desirable in view of the thermocouple difficulties encountered.

(iv) *Wavemeters*

The usual method of wavelength measurement in the decimetre wave range is by the measurement of two resonance positions, which are integral multiples of a half wavelength apart, on a transmission line. At wavelengths below that for which the measuring lines are $3\lambda_a/4$ long, this method is easily applied. The piston is set at approximately $\lambda_a/4$ from the open end of the line, and the positions of the peak of the resonance curve determined. A second measurement is made with the piston approximately $3\lambda_a/4$ from the end of the line, and the difference of the readings gives an almost exact half wavelength. A correction[11] arising from the resistance of the lines can be applied, but the direct measurement is normally sufficiently accurate for test purposes.

This method can be extended to the longer wavelengths by building special wavemeter lines of appropriate length. However, because of the inconvenience of mechanically moving the piston over such long lengths, a wavemeter has been devised operating on the absorption wavemeter principle, and which is capable of providing extreme accuracy of setting. A parallel wire system is employed, open circuited at the input end and short circuited at the far end by a movable bridge, and divided by an intermediate bridge into two circuits which are then capable of being separately resonant. The open-ended circuit contains a detecting device. The intermediate bridge is adjusted to produce resonance or near resonance in this circuit, so that a convenient deflection is obtained with the second circuit detuned. The second circuit is then tuned by means of the far-end bridge, and near its resonance the familiar absorption wavemeter effect is obtained.

Consider two adjacent parallel wire systems of lengths $l = \lambda_a/4 - \delta/\beta$ and $l_1 = \lambda_a/2 + \Delta/\beta$ as shown in Fig. 7. B and C are two movable short circuiting bridges, each of impedance $j\delta Z$. AB is almost a quarter wavelength and BC is almost a half wavelength, so that $\delta \ll 1$ and $\Delta \ll 1$.

Let a voltage E of frequency $\omega/2\pi$ be injected at A through an impedance jZ. Let I_B be the current at B, detected by any suitable means, and α, β, Z_0, be the attenuation in nepers per cm., the wavelength constant in radians per cm., and the characteristic impedance, in ohms, of the line.

Then by consideration of the transmission line equations it can be shown that provided $\alpha l \ll 1$,

$$|I_B|^2 = \frac{E^2}{[(Z_0 - Z\delta) - X(Z/Z_0 + \delta)]^2 + [\alpha l(X+Z)]^2} \quad \ldots \quad (6)$$

Fig. 7.

where X is the combined reactance of the short circuit at B in parallel with the line BC.

Provided $\alpha l_1 \ll 1$, the reactance X is easily shown to be

$$X = \frac{\delta Z(\alpha^2 l_1^2 + \Delta^2 + [3\delta Z/Z_0]\,.\,\Delta + 2\delta Z^2/Z_0^2)}{\alpha^2 l_1^2 + (\Delta + 2\delta Z/Z_0)^2} \quad \ldots \quad (7)$$

The variation of X with Δ is given in Fig. 8. Considering the point A, and putting $X = \delta Z$, then from equation (7) $\Delta = -2\delta Z/Z_0$ and this is the shortening of the line BC from $\lambda_a/2$ for resonance due to the bridges if resonated alone. From equation (6) it is seen that at this point the current I_B is the same as when BC is well off resonance. This

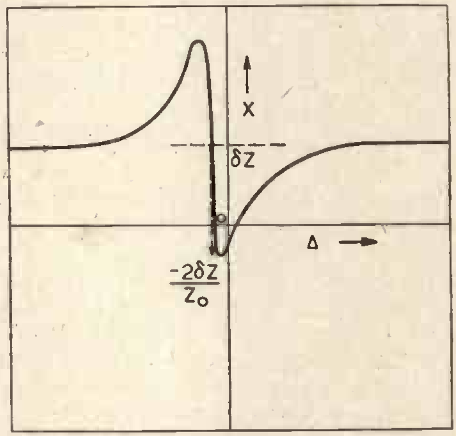


Fig. 8. *Variation of X with Δ.*

point occurs during a rapidly changing period of X, and consequently of I_B with Δ. The position at which the length BC becomes resonant is thus sharply defined.

Utilising this phenomenon for wavelength measurement at fixed frequencies enables apparatus to be made of simple construction, the travel of the short circuit bridges being required only for short distances, thus obviating cumbersome racking devices. The setting of the bridges can be made extremely accurately. With careful construction an accuracy of about 1 part in 500 is obtainable, while greater accuracy is obtained by correcting for the reactance of the bridges. Alternatively, the distance between the bridges may be calibrated against a standard frequency source. The resistance correction already noted may be made negligible by reducing the resistance and radiation losses of the line. (*To be continued.*)

References are given at the foot of page 526.

CATHODE-COUPLED OSCILLATORS*

By F. Butler, B.Sc., A.M.I.E.E.

SUMMARY.—A two-valve network is described which permits the maintenance of sustained oscillations in a parallel-resonant LC circuit without the necessity for coil tappings or reaction windings.

The tuned circuit forms the anode load of an amplifier valve in which the grid is earthed, the driving voltage being applied between earth and cathode. When operated at the frequency of parallel resonance of the coil and condenser combination, the amplifier has the property that the input and output voltages are in phase and self-oscillation is obtained by the use of direct feedback between the anode and cathode circuits without the necessity for phase reversal. Because of degenerative feedback, the input impedance of the earthed grid amplifier is low in value, and it becomes a practical necessity to make use of a cathode follower to supply the driving power while maintaining the requisite phase-relationship between input and output voltages.

Stabilisation of the generated frequency is conveniently obtained by the use of a quartz crystal, which is operated at its frequency of series resonance. Modifications of the basic circuit lead to the dievelopment of a selective amplifier in which the discrimination against unwanted frequences is enhanced by the use of negative feedback.

1. Introduction

REGARDING a triode amplifier stage as a four-terminal active network with pairs of input and output terminals, there are three practicable methods of applying the input voltage and of connecting the load impedance. Corresponding to each arrangement, there exists an equivalent circuit from which may be derived expressions for the input impedance, stage gain, output impedance, phase displacement and power output of the system. In the form most widely used, the cathode of the valve is earthed effectively at signal frequencies, the input being applied between grid and cathode. The output load is joined in series with the anode circuit of the valve. Operating without the flow of grid current and at frequencies low enough to avoid feedback and transit-time effects, the input impedance is infinite and the output resistance, measured between anode and earth, is R_a, the slope resistance of the valve. At higher frequencies, feedback occurs through the anode-grid capacitance (Miller effect), the input impedance changes in a manner depending on the power factor of the anode load and neutralisation may be required to maintain stability.

The next circuit in order of importance is the cathode-loaded amplifier, the so-called cathode follower. In this case the anode of the valve is held at earth potential as regards signal frequencies. The load impedance is connected between cathode and earth and the input voltage applied between grid and earth, or, effectively, between grid and anode. A very high input impedance results from this connection, together with a low output impedance, given approximately by the reciprocal of the mutual conductance of the valve. At high radio frequencies, feedback occurs through the grid-cathode capacitance and self-oscillation can occur for certain values of load impedance and phase angle.

In the third arrangement the amplifier grid is earthed and the input voltage applied between earth and cathode. The load impedance is joined in series with the valve anode circuit. Under these conditions the input impedance is low in value and the output impedance abnormally high. Some feedback occurs between anode and cathode, but because the grid acts as an earthed screen separating these electrodes, the capacitance between them is very small, and neutralisation is not normally required in order to maintain stability, particularly if steps are taken, with indirectly heated valves, to remove the effects of heater-cathode capacitance by the use of R.F. chokes or parallel-tuned circuits in the heater leads. The earthed-grid or inverted amplifier has been employed in high power short wave broadcast transmitters, and more recently has been applied to the design of high frequency receivers, where, under certain conditions, a higher signal to noise ratio is achieved than by use of alternative systems.[1]

Assuming that purely resistive loads are used, the phase relationship between input and output voltage may be deduced by

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

inspection of the amplifier circuits. In the case of the earthed cathode amplifier the two voltages are in antiphase. In both the others they are in phase. The conversion of any amplifier into a self-oscillator requires that the input voltage is derived from the output in the correct phase and in excess of a critical minimum amplitude. The conception of an oscillator as an amplifier which supplies its own input voltage leads at once, with the aid of simple equivalent circuits, to the derivation of the frequency and maintenance conditions for sustained oscillations in each of the three standard circuits.

2. Equivalent Circuits of Valve Amplifiers

The two commonest valve amplifiers and their equivalent circuits are shown in Fig. 1. These are well known, and are included for ease of comparison with the equivalent of the earthed grid amplifier to be discussed later. The meaning of the symbols used will be apparent from the diagrams.

The derivation of both equivalents follows from the principle that an amplifier valve is

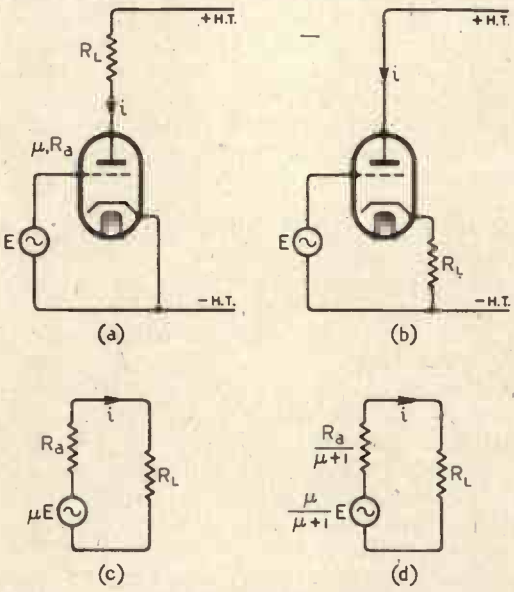


Fig. 1. (a) *Earthed cathode amplifier, and* (b) *cathode follower circuits.* (c) *The equivalent circuits are shown in* (c) *and* (d) *respectively.*

completely simulated by a generator of E.M.F. equal to the grid-cathode voltage multiplied by the amplification factor of the valve, the effective internal resistance being R_a, the anode slope resistance. Under the idealised conditions already postulated, the input impedances of the earthed-cathode and cathode follower amplifiers are virtually infinite and the driving sources are unloaded. The source impedance is thus of no consequence.

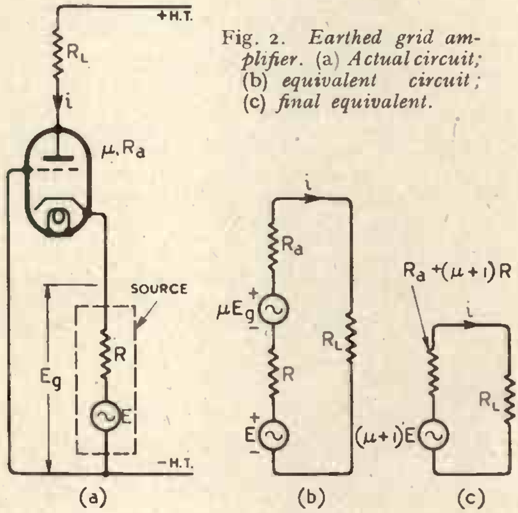


Fig. 2. *Earthed grid amplifier.* (a) *Actual circuit;* (b) *equivalent circuit;* (c) *final equivalent.*

3. Theory of the Inverted Amplifier

The equivalent circuit of the earthed-grid amplifier is rather more difficult to derive, because the source of excitation voltage is called upon to supply energy to the amplifier circuit and it becomes necessary to take into account its internal output impedance. Again making use of the triode equivalent generator principle, the actual amplifier circuit shown in Fig. 2 (*a*) is converted successively into the equivalents shown in Fig. 2 (*b*) and 2 (*c*).

Let μ = amplification factor of valve.
R_a = anode slope resistance.
R_L = load resistance.
R = internal resistance of source.
E = E.M.F. of source.
E_g = effective grid-cathode potential.
i = alternative component of anode current.

From Fig. 2(*b*), taking into account the instantaneous polarities of the various voltages :—

$$i = \frac{E + \mu E_g}{R + R_a + R_L} \quad \ldots \quad \ldots \quad (1)$$

$$E_g = E - iR \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

Hence

$$(\mu + 1)E = \{R_a + R_L + (\mu + 1)R\}i \qquad (3)$$

From this equation the equivalent circuit shown in Fig. 2 (*c*) can be derived. The effective output impedance, looking into the valve network, is $(\mu + 1)R + R_a$ and is considerably higher than in the case of the two amplifiers previously discussed. The input impedance Z_i is the ratio E_g/i. It can be derived by setting $R = 0$, in which case $E_g = E$ and :—

$$i = \frac{(\mu + 1)E_g}{R_a + R_L}$$

$$\therefore \frac{E_g}{i} = Z_i = \frac{R_a + R_L}{\mu + 1} \qquad (4)$$

The abnormally low value of this impedance restricts the uses of the inverted amplifier, although the energy taken from the driving source contributes to the useful output developed in the load resistance.

The output voltage E_0 is given by iR_L, so that the stage gain of the system, from equation (3), is given by :—

$$E_0/E = \frac{(\mu + 1)R_L}{R_a + R_L + (\mu + 1)R} \qquad (5)$$

4. The Earthed-Grid Oscillator

The inverted amplifier can be converted to a self-oscillator by coupling it to a tuned circuit in such a way that the anode and

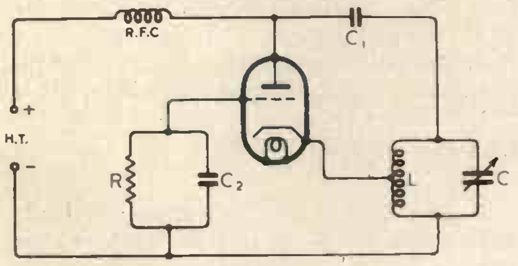


Fig. 3.

cathode potentials are in the same phase. Self-oscillation then occurs if the amplitude of the cathode to earth potential exceeds a certain minimum value. Fig. 3 shows a practical circuit.

Oscillations can be sustained with very low values of the ratio L/C and high stability of frequency is thus attainable. The components R and C_2 serve to provide grid bias by the flow of rectified grid current. The principal disadvantage of the circuit is that there is some loading of the tuned circuit due to the low input impedance of the cathode-earth connection to the valve. The loading is constant, however, and tends to swamp any additional damping due to the flow of grid current ; it can be minimised in any case by correct choice of the cathode tapping point. This disadvantage is less serious than in the case of the so-called electron-coupled oscillator, in which still greater loading is placed on the tuned circuit. The circuit of Fig. 3 has special advantages when used as the primary

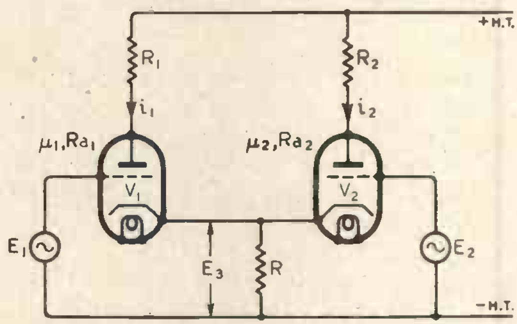


Fig. 4.

oscillator in a frequency-modulated transmitter. Among these are the high effective output impedance, with the fact that the associated reactance modulator can be connected in parallel with the entire tuned circuit, which is not possible with the Hartley or Colpitts circuits commonly employed.

5. Theory of the Cathode-Coupled Amplifier

The problem of supplying the driving power to an inverted amplifier is easily solved by the use of a cathode follower stage. The resulting two-valve circuit becomes almost identical with the cathode-coupled amplifier, of which practical details have already been published.[2] So far as the writer is aware, no complete treatment of this circuit has been given, though the appropriate analysis has been suggested and the equivalent circuit derived.[3]

The most general circuit which can be devised is shown in Fig. 4. For the purpose of analysis, this may be replaced by the equivalent shown in Fig. 5.

Let E_1, E_2 = grid excitation voltages of the valves V_1, V_2 respectively.

Ra_1, Ra_2 = corresponding anode resistances.

R_1, R_2 = load resistances.
μ_1, μ_2 = amplification factors.
i_1, i_2 = alternating anode currents.
R = common cathode coupling resistance.

The circuit equations may be written :—

$$\mu_1(E_1 - E_3) = (Ra_1 + R_1)i_1 + R(i_1 + i_2) \quad \ldots \quad (6)$$

$$\mu_2(E_2 - E_3) = (Ra_2 + R_2)i_2 + R(i_1 + i_2) \quad \ldots \quad (7)$$

$$E_3 = (i_1 + i_2)R \quad \ldots \quad (8)$$

Eliminating E_3 and solving for i_1 and i_2, we have :—

$$\mu_1 E_1\{Ra_2 + R_2 + (\mu_2 + 1)R\} - \mu_2 E_2(\mu_1 + 1)R = i_1\{(Ra_1 + R_1)(Ra_2 + R_2) + (\mu_1 + 1)R(Ra_2 + R_2) + (\mu_2 + 1)R(Ra_1 + R_1)\} \quad \ldots \quad (9)$$

$$\mu_2 E_2\{Ra_1 + R_1 + (\mu_1 + 1)R\} - \mu_1 E_1(\mu_2 + 1)R = i_2\{(Ra_1 + R_1)(Ra_2 + R_2) + (\mu_1 + 1)R(Ra_2 + R_2) + (\mu_2 + 1)R(Ra_1 + R_1)\} \quad \ldots \quad (10)$$

From equations (7) and (8), by setting $E_2 = 0$, an expression can be derived for the input impedance of V_2, ignoring the resistance R. In this case :—

$$E_3/i_2 = Z_i = \frac{Ra_2 + R_2}{\mu_2 + 1}$$

This agrees with the result previously given in equation (4).

The stage gain and output voltage of the amplifier can be derived from equations (9) and (10).

Let E_{01} = output voltage across R_1.
E_{02} = output voltage across R_2.
Then $E_{01} = i_1 R_1$; $E_{02} = i_2 R_2$. .. (11)

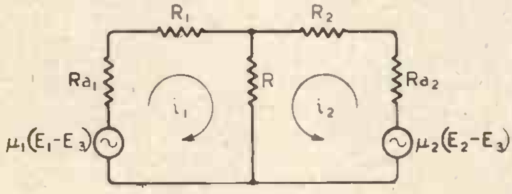


Fig. 5.

Substituting for i_1 and i_2 in equations (9) and (10), an expression can be derived for the output of the amplifier corresponding to the arbitrary input voltages E_1 and E_2.

On setting $E_2 = 0$, the foregoing theory applies to the cathode phase inversion amplifier, which is designed to provide a balanced output from an unbalanced input signal. From equations (9), (10) and (11) the ratio of the two output voltages is given by :—

$$\frac{E_{02}}{E_{01}} = \frac{(\mu_2 + 1)RR_2}{\{Ra_2 + R_2 + (\mu_1 + 1)R\}R_1} \quad \ldots \quad (12)$$

The two voltages may be made equal in amplitude by proper choice of valves or load resistances, or with similar valves and equal loads, by using a sufficiently high value of cathode coupling resistance.

Schmitt has shown[4] that gain control in such an amplifier is conveniently obtained by the provision of separate cathode resistances for each valve, with a variable resistance connected between the cathodes. For the purpose of analysis, the resulting delta of impedances can be converted to the equivalent star formation. It is found that for equal increments of attenuator resistance, the gain falls rapidly at first and then more gradually. This characteristic has some useful applications which will subsequently be discussed.

The general results given in equations (9) and (10) can be applied to the case of a cathode follower driving an inverted amplifier. This particular system requires that $E_2 = 0$ and $R_1 = 0$. Using the above equations and remembering that the output voltage $E_{02} = i_2 R_2$, the stage gain becomes :—

$$\frac{E_{02}}{E_1} = \frac{\mu_1(\mu_2 + 1)RR_2}{Ra_1(Ra_2 + R_2) + (\mu_1 + 1)R(Ra_2 + R_2) + (\mu_2 + 1)RRa_1} \quad \ldots \quad (13)$$

In practice, when R is large (i.e. of the same order as the valve resistances) and μ_1 and $\mu_2 \gg 1$, a rather drastic simplification can be made, which is accurate enough for practical purposes, while giving a clearer physical picture of the effect of changes in the various parameters. Making this simplification, we find that the new stage gain becomes :—

$$\frac{E_{02}}{E_1} = \frac{\mu_2 R_2}{R_2 + Ra_2 + \mu_2/gm_1} = \frac{\mu_2 R_2}{R_1 + Ra_2 + \frac{\mu_2}{\mu_1} . Ra_1} \quad \ldots \quad (14)$$

The composite system is approximately represented by a single valve having the amplification factor of the second valve, with an internal resistance augmented by the amount $\frac{\mu_2}{\mu_1} . Ra_1$.

If this high resistance is objectionable it may be reduced to any desired extent by the use of negative feedback to an earlier amplifier stage, an expedient which will normally be required if the amplifier is to handle a wide range of audio frequencies.

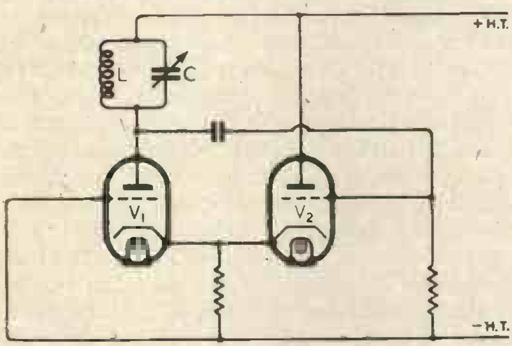


Fig. 6.

6. The Cathode-Coupled Oscillator

Referring to the circuit shown in Fig. 4, the conditions for self oscillation are secured if the grid of V_1 is earthed, the anode of this valve being cross-connected to the grid of V_2. Relaxation oscillations then occur, provided the stage gain of V_1 exceeds a certain critical level. Since V_2 is functioning as a cathode follower, its anode load serves no useful purpose and should be reduced to zero. To obtain a sinusoidal output, R_1 must be replaced by a tuned LC circuit. The basic oscillator circuit then becomes that shown in Fig. 6.

The advantages of this circuit may be summarised as follows :—

(i) Alteration of frequency range can be made by inductance changes, using a single pole switch. No reaction windings or tapped coils are employed.

(ii) The high input impedance of the cathode follower imposes light loading on the main tuned circuit.

(iii) Unity gain in this stage provides ample driving voltage to ensure reliable oscillation up to very high frequencies, even when using tuned circuits of low Q value.

(iv) The series circuit shown can be replaced by its shunt-fed equivalent. In each case, one side of the tuned circuit is earthed as regards R.F. potential.

(v) Triode or pentode valves may be used as desired.

A practical oscillator circuit is shown in Fig. 7.

The theory of the oscillator is contained in equations (9) and (10) in which R_1 is taken as the dynamic resistance at resonance of the tuned circuit. The maintenance of oscillations is controlled by two circuit parameters. These are the cathode coupling resistance and the dynamic load resistance of the amplifier. Their inter-relation is shown below. By setting $E_1 = 0$, $R_2 = 0$ and $E_2 = - i_1R_1$, the circuit of Fig. 4 is transformed to that of Fig. 6 and equation (9) becomes, after reduction :—

$$R\{\mu_2(\mu_1 + 1)R_1 - (\mu_2 + 1)(Ra_1 + R_1) - (\mu_1 + 1)Ra_2\} = (Ra_1 + R_1)Ra_2 \quad .. \quad .. \quad (15)$$

7. Quartz-Crystal Stabilisation

A simple modification of the oscillator circuit shown in Fig. 6 permits the use of a piezo-electric crystal for frequency control. The necessary changes are shown in Fig. 8.

At the frequency of series resonance, the quartz plate is equivalent to a low

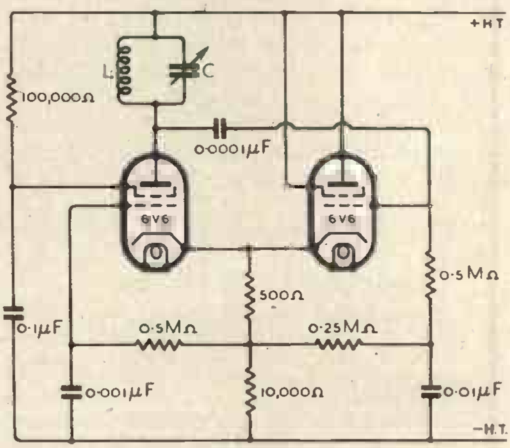


Fig. 7.

resistance. Provided that this resistance is small in comparison with the cathode resistances R, the latter are virtually in parallel and oscillations occur as in the absence of the crystal. Off resonance, the crystal simulates a high reactance. The driving voltage falls off in amplitude and changes rapidly in phase, so that oscillations cease. The more elaborate circuit shown in Fig. 7 can be converted to crystal control on replacing the single cathode load and bias resistance by separate elements as in Fig. 8.

High stability is attained by the operation of the crystal at series resonance, under which condition the holder capacitance has least effect on the generated frequency. The circuit is easily adjusted, since the true tune position corresponds to minimum H.T. feed, whereas in many crystal circuits this

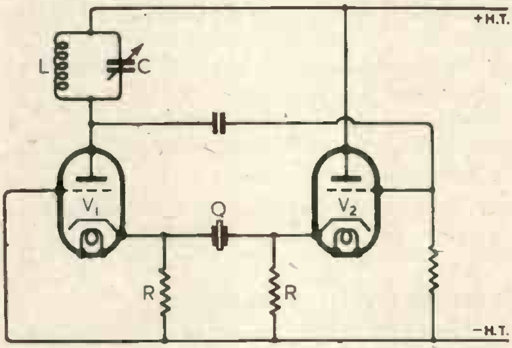


Fig. 8.

last condition is unstable. A large power output can be secured with weak excitation of the crystal, and consequent low heat generation. A short-circuiting switch across the crystal permits self-oscillation if a variable frequency is desired. A series *LC* circuit may be used instead of the quartz plate in cases where low harmonic content is required from the self-oscillator circuit.

Low distortion is also obtained by restricting the amplitude of oscillation. This is readily achieved at audio-frequencies, where the requirements are most severe, by the use of a high resistance (e.g. 0.25 MΩ), in series with the feedback coupling condenser and by the use of separate cathode loads for each valve, coupled at the cathode end by a resistance of the order of 5,000 ohms, which introduces so much attenuation that oscillations are barely maintained.

8. Selective Amplifiers

Referring to the circuit shown in Fig. 4, the amplifier can be made frequency selective by splitting the cathode load as shown in Fig. 8 and by using a series-tuned circuit or a quartz crystal to connect the cathodes. The off-resonance attenuation is greater than for conventional amplifiers, and may be enhanced, if required, by the use of tuned output circuits in place of the load resistances shown.

In recent years, oscillators and selective amplifiers have been developed using bridge or phase-shift networks instead of *LC* circuits. Some of these are adaptable for use with the cathode coupled oscillator.[5] The principal difficulty is to secure enough gain in the amplifiers to make good the attenuation in the phase-shift networks.

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[2] O. H. Schmitt, *Journal of Scientific Instruments*, Vol. 15, p. 136 (1938). *Review of Scientific Instruments*, Vol. 12, p. 548 (1941).

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[5] S. S. West, *Electronic Engineering*, Vol. 17, p. 198 (1944).

November Meetings

AT a meeting of the Radio Section of the Institution of Electrical Engineers to be held on November 21st, P. R. Coursey will open a discussion on "New Aspects of Post-War Interference Suppression." Dr. L. Essen will lecture on "The Measurement of Balanced and Unbalanced Impedances at Frequencies near 500 Mc/s and its Application to the Determination of the Propagation Constants of Cables" at a further meeting of the Radio Section on December 6th. Both meetings will be held at the I.E.E., Savoy Place, Victoria Embankment, London, W.C.2, and will commence at 5.30.

The paper on "The Development of Polythene as a High-Frequency Dielectric," given recently at the London Radio Section by Professor Willis Jackson and J. S. A. Forsyth, will be repeated at a meeting of the North-Western Radio Group to be held at 6 o'clock on November 10th at the Engineers' Club, Albert Square, Mancheser.

The Cambridge Radio Group will hear H. L. Kirke, chairman of the Radio Section, repeat his inaugural address at a meeting at the University Engineering Department, Trumpington Street, Cambridge, at 7 o'clock on November 28th.

TESTING HIGH-FREQUENCY CABLES

(*See* page 512).

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[8] L. Essen, *Journ. I.E.E.*, 1944, Vol. 91, Pt. III, p. 84.

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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.

Reform of Electrical Units

To the Editor, "Wireless Engineer."

SIR,—In the post-war world which appears on our horizon, science in general and electricity in particular will take a prominent place in the education of all, and especially in the education of the practical engineer from whom a higher standard of service will certainly be expected.

We need not expect the practician of the future to take any more kindly to mathematics than he does to-day, but if he acquires an intimate knowledge of the *results* of theory he may safely ignore the methods by which they were obtained.

This will put a heavy tax on his memory. Is that memory to be unnecessarily burdened with the lopsided formulae that disfigure electrical theory to-day? Will the practical man still have the labour of translating from three different systems of units into the practical system in which he makes all his calculations? The answer is yes, unless a change is made in our electric and magnetic units.

I do not here contemplate a change in the practical units volt, ampere, gauss; the call for that would be a cry in the wilderness: there would be no listeners in spite of the fact that the practical system, adopted to provide units of convenient size, entirely fails to justify its existence in "wireless" practice where we work in micro-amps, microvolts, microhenrys and micromicro-farads. Practical units are too cumbersome for use in theory so at least two systems must remain until the practical system dies of senile decay. The three systems of units used in text-books are the electrostatic, electromagnetic and Gaussian systems. In this last purely electric quantities are expressed in electric units based on Coulomb's law of force; purely magnetic quantities are expressed in magnetic units derived from the law of magnetic force. In the Gaussian system Ampère's law becomes "the work done in taking unit magnetic pole once around a wire carrying a current I (the magnetomotive force) is equal to $4\pi I$, divided by c the ratio of the electromagnetic to the electrostatic unit of charge."

Gaussian units are generally used in the treatment of Maxwell's electromagnetic theory and, I hold, as modified by Heaviside, should be the only system appearing in the whole theory of electricity and magnetism.

As predicted by Maxwell and amply verified by experiment, the constant c is equal to the velocity of light in free space :—3×10^{10} cm. per sec. If this had been known soon after Ampère's discovery the electrostatic and electromagnetic systems, as we know them, would probably never have been adopted: there is no justification, except habit, for their employment to-day.

There is a further adjustment of units which I consider advisable in the interests of future generations. When expressed in e.s. or e.m. units the factor 4π appears unexpectedly and inconveniently in many formulae: e.g. that connecting electric induction D (flux per unit area), electric force $\mathcal{E}$ and polarisation P is $D = \mathcal{E}/4\pi + P$. The corresponding formula connecting magnetic induction B, magnetic force and magnetisation J is $B = H + 4\pi J$. The electric and magnetic field energies per unit volume are $D\mathcal{E}/8\pi$ and $BH/8\pi$. The capacitance of a parallel plate condenser is area divided by 4π times the (small) distance between the plates. Gauss' theorem is "the flux through any closed surface is equal to 4π times the charge enclosed."

The way to remove this 4π factor was shown by Heaviside forty years ago. It is by expressing the laws of electric and magnetic forces in the form $F = \frac{e e'}{4\pi r^2}$ and $F = \frac{m m'}{4\pi r^2}$ so that unit charge (magnetic pole) is that which when placed at unit distance from an equal like charge (pole) repels it with a force of $1/4\pi$ dynes.

Pictorially Heaviside's definitions associate one line of force with unit charge and unit magnetic pole instead of 4π lines.

With these definitions the formulae above become $D = \mathcal{E} + P$, $B = H + J$, field energies are $D\mathcal{E}/2$ and $BH/2$, the capacitance of the plate condenser is area divided by separation distance, Ampere's law is :— magnetomotive force is equal to current 3×10^{10} and Gauss' theorem is "the flux (number of lines of force) passing through any closed surface is equal to the charge enclosed," which appears self evident.

In spite of the elegance of formulae expressed in Heaviside units, they have not been adopted in elementary text-books. They are used by a few writers, amongst whom are H. A. Lorentz and Sir Owen Richardson, in somewhat advanced treatises.

The blame for this neglect is on our teachers; the remedy lies in the hands of the teachers. A text-book using Gauss-Heaviside units would have little chance of being recommended to students, and publishers cannot be expected to print books which will not sell.

I discussed this subject with several teachers. Some of them objected that they were used to the old formulae and would find the change too inconvenient. That is, inconvenient for themselves. The convenience of the generations of students who pass through their hands is not considered; a very selfish attitude.

Other teachers, less honest, I think, objected that though π disappears in some places it reappears in others. Of course it does, it appears where we might reasonably expect it. For example, the capacitance of a sphere is 4π times the radius. If by some freak of mind our unit of length were defined as the circumference of a standard circular disc with the consequent appearance of π in all linear measurements, would it be a fair answer to the demand for a change to a linear standard that though π disappears in linear measurement it reappears in the calculation of the circumference of circles?

A third objection, by way of a cold douche, is "after all the units we use are purely a matter of convention." Yes, so are the clothes we wear a fact which is no excuse for slovenliness of dress.

J. J. DURACK.

Rathfarnham, Dublin.

"Deflected Electron Beams"

To the Editor, "Wireless Engineer"

SIR,—Dr. Gabor seems to have shifted his ground as regards his criticisms of the second part of my paper. He said in the July issue that an x-directed electric component necessarily existed in the "sine shaped" electric field used in part of my work. Now that I have pointed out that this is not so, he says that magnetic field components exist in a resonator and affect the results. They do; and some of the effects are computed for this case in my paper; but surely this does not in the least affect the point at issue. It does not invalidate the method I have put forward for finding the deflection power in terms of the difference between the input beam energy and the exit beam energy. For example, my equation (31) gives the beam deflection power rigorously and in terms of d.c. power in the beam and of the tube geometry. My method in general is rigorous, and, of course, implies no violation of the principle of the conservation of energy. Such a violation does result, in my opinion, from the alternative method exemplified by Dr. Gabor's equation (10) (March issue), and I do not think there has been any disproof of my argument (April issue) to this effect.

I regret I did not until to-day see Mr. Jenkins' and Mr. Benham's letters in your August issue. In reply to them, and to Mr. Rodda's letter in your present issue, I would like to point out that the infinite-field deflection power formula was *not* put forward by me (in section (1) of my June paper) as a correct expression. Far from agreeing with this "Recknagel-Hollmann-Gabor" formula, I was at pains to try to show its invalidity; but, incidentally, Mr. Benham and I are quite correct in using Ramo's formula (as far as it goes) as the beginning of a quasi-steady state analysis (*see* Jen, *Proc. I.R.E.*, June 1941, p. 347).

London, S.W.18. OWEN HARRIES.

To the Editor, "Wireless Engineer"

SIR,—I should like to express my entire agreement with Dr. Gabor in his letter to you published in the October issue except in so far as he appears to admit the identity of the Recknagel formula with the formula recently given by Mr. Harries (June issue, p. 268, Equation 4.1). If we adopt as a criterion the fact that the conductance at zero frequency should tend to zero the formula of Benner fails, as I have previously pointed out, and so does the new formula of Harries, except at zero plate length. Both of these formulae should therefore decisively be rejected.

New Barnet, Herts. S. RODDA.

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

562 396.—Multi-line set of microphone amplifiers in which negative feed-back is utilised to control and calibrate the signal strength fed from each line, say, to a broadcast transmitter.

The British Thomson-Houston Co. Convention date (U.S.A.), 31st December, 1941.

562 803.—Gramophone pick-up with a hollow transmission element, which is filled with oil and arranged to convey only rotary movements about its axis.

A Schumann. Application date, 29th January, 1943.

562 812.—Utilising a Thermistor (i.e. an element having a resistance which varies with temperature) for increasing the low-frequency response of an audio-frequency amplifier.

Standard Telephones and Cables; P. K. Chatterjea; L. W. Houghton; and T. C. Scully. Application date, 13th January, 1943.

DIRECTIONAL WIRELESS

562 853.—Switching device for preventing "key clicks" in a radio beacon transmitter of the overlapping-beam type.

Standard Telephones and Cables and L. T. Heaton-Armstrong. Application date, 30th July, 1942.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

562 508.—Superhet receiver in which heterodyne interference is minimised by means of a control voltage derived from the frequency difference between the signal carrier and the interfering wave.

W. S. Percival. Application date, 21st December, 1942.

562 512.—Tuning arrangement for a short-wave receiver in which two concentric windings are variably switched in relative to a single powdered-iron core, to cover two widely-separated wavebands.

Johnson Laboratories Inc. (assignees of F. W.

Edwards). *Convention date* (*U.S.A.*), 5*th January*, 1942.

562 533.—Spade-tuning arrangement comprising small inductance coils and a screw-controlled metal plate, particularly for use where the available space is restricted.

E. K. Cole and A. R. Knipe. Application date, 25*th March*, 1943.

562 553.—Reducing heterodyne interference in a superhet receiver by utilising the frequency modulation products arising from the interference.

Marconi's W.T. Co. (*assignees of M. G. Crosby*). *Convention date* (*U.S.A.*), 25*th November*, 1941.

562 577.—Valve socket and panel arrangement to minimise wiring in wireless receivers of so-called pocket size.

Philco Radio and Television Corporation (*assignees of A. C. Mathews*). *Convention date* (*U.S.A.*), 13*th November*, 1941.

562 702.—Receiver for F.M. signals wherein undesired amplitude variations are separately detected, and applied in phase opposition to counterbalance their effect on the original signal.

Marconi's W.T. Co. (*assignees of M. G. Crosby*). *Convention date* (*U.S.A.*), 25*th October*, 1941.

562 779.—Reducing the effects of frequency-selective fading by differentially manipulating the carrier-wave and side-band frequencies received on a single aerial.

Marconi's W.T. Co. (*assignees of DeW. R. Goddard*). *Convention date* (*U.S.A.*), 12*th September*, 1941.

TELEVISION CIRCUITS AND APPARATUS

FOR TRANSMISSION AND RECEPTION

562 433.—Cathode-ray television receiver in which the incoming picture can be seen, without distortion, either from the back or front of a single fluorescent screen.

J. L. Baird. Application date, 23*rd July*, 1943.

562 482.—Television system wherein a non-linear amplifier is utilised for light and shade, or " gamma " control, without changing the peak-to-peak ratio between input and output signals.

Marconi's W. T. Co. (*assignees of F. J. Somers*). *Convention date* (*U.S.A.*), 27*th December*, 1941.

562 513.—Television system in which synchronising impulses of opposite polarity are applied to the oppositely-inclined slopes of saw-toothed oscillations to control the scanning.

Marconi's W. T. Co. (*assignees of G. L. Fredendall and A. C. Schroeder*). *Convention date* (*U.S.A.*), 31*st December*, 1941.

562 569.—Phase-inverting valves arranged to neutralise " ground " interference induced between the sending and receiving ends of a coaxial transmission line carrying, say, television signals.

Philco Radio and Television Corporation (*assignees of F. J. Bingley*). *Convention date* (*U.S.A.*), 3*rd February*, 1942.

562 707.—Television system in which provision is made for preventing the effect of delayed " echoes " of the horizontal-line synchronising signals.

Philco Radio and Television Corporation (*assignees of F. J. Bingley and W. E. Bradley*). *Convention date* (*U.S.A.*), 6*th March*, 1942.

562 726.—Television system in which provision is made for " locking " the synchronising signals supplied from different studios, or centres of picture production, to a common master oscillator at the main radiating station.

Marconi's W. T. Co. (*communicated by The Radio Corporation of America*). *Application date*, 25*th March*, 1943.

562 794.—Minimising the effect of delayed-echo signals in a television system of the alternate carrier type, i.e., where synchronisation involves changes in frequency.

Philco Radio and Television Corpn. (*assignees of F. J. Bingley*). *Convention date* (*U.S.A.*), 19*th March*, 1942.

562 843.—Television system wherein the scanning is synchronised by using time-bases at the transmitter and receiver which are periodically triggered through control pulses derived from the electric supply mains.

I. L. Maguire. Convention date (*Australia*), 26*th March*, 1940.

TRANSMITTING CIRCUITS AND APPARATUS

(*See also under Television*)

562 672.—Mounting or casing for preventing corona discharge between the elements of an oscillation generator or resonator of the transmission-line or Lecher-wire type.

The General Electric Co.; D. C. Espley; and J. W. Ryde. Application date, 4*th November*, 1940.

562 705.—Generating electric oscillations by utilising the negative-resistance effect of a Thermistor or element having a resistance that varies with temperature.

Standard Telephones and Cables; P. K. Chatterjea; and C. T. Scully. Application date, 8*th January*, 1943.

562 728.—Stabilising the operation of a frequency- or phase-modulating system of the kind in which a pair of heterodyne converters are combined with a master oscillator to generate a range of frequencies.

Marconi's W. T. Co. (*assignees of M. G. Crosby*). *Convention date* (*U.S.A.*), 27*th March*, 1942.

562 791.—Generating impulses of predetermined amplitude and duration by a switching arrangement which charges and discharges a reactance through non-linear circuit elements.

B. M. Hadfield. Application date, 23*rd December*, 1942.

562 676.—Movable short-circuiting device for adjusting the impedance of a coaxial transmission line, or of a wave guide, or of a resonator stub.

J. Collard and H. E. Holman. Application date, 23*rd January*, 1942.

SIGNALLING SYSTEMS OF DISTINCTIVE TYPE

562 422.—Signalling system in which energy pulses of constant amplitude and width are varied in their time phase or repetition frequency to convey intelligence.

Marconi's W. T. Co. (*assignees of W. van B. Roberts*). *Convention date* (*U.S.A.*), 5*th March*, 1942.

562 655.—Multi-stage push-pull amplifier utilising beam power tetrodes and negative feed-back to

reduce spurious oscillation in a multi-channel carrier-wave signalling system.

Automatic Telephone and Electric Co. and J. R. Cannon. Application date, 6th January, 1943.

562 764.—Wireless signalling system in which any one of a number of different receivers can be called-up by the transmission of a predetermined sequence of impulses.

W. H. Norris. Application date, 17th August, 1942.

562 915.—Means for reducing mutual interference in signalling systems of the kind in which two or more different messages are transmitted simultaneously on the same carrier frequency, as by frequency and pulse modulation.

W. A. Beatty. Application date, 16th October, 1942.

562 949.—Method of operating a beam type of deflection valve for receiving signals consisting of periodic pulses of radiated energy.

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

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

562 398.—Cathode assembly for a valve, designed to ensure an equally-distributed temperature, and, therefore, a uniform overall emission of electrons, where indirectly heated.

Standard Telephones and Cables (assignees of C. V. Litton). Convention date (U.S.A.), 6th February, 1942.

562 914.—Construction of an electron-beam deflection valve, suitable for use as a mixer in a superhet receiver.

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

SUBSIDIARY APPARATUS AND MATERIALS

562 531.—High-frequency condensers with a low-loss dielectric consisting solely of polyphenyl compounds, with or without polynuclear aromatic hydrocarbons.

The British Thomson-Houston Co. Convention date (U.S.A.), 31st March, 1942.

562 638.—Voltage regulating arrangement comprising a saturated and an unsaturated transformer, and a rectifier, for supplying a D.C. load from an A.C. source.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 5th September, 1941.

562 667.—Condenser built up of superposed layers of metallic and insulating material and having taps or electrodes which are screened from each other.

British Insulated Cables; J. C. Quayle; E. O. Jones; and F. Moores. Application date, 15th March, 1943.

562 673.—Voltage regulating arrangement comprising a saturated and an unsaturated transformer, and a rectifier, for supplying a D.C. load, such as a buffer battery, from an A.C. source.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 9th September, 1941.

562 696.—Method of preparing lead and barium sulphate crystals for use in the preparation of fluorescent screens, particularly for X-rays. (Addition to 540 252.)

H. S. Tasker and Ilford Ltd. Application date, 7th January, 1943.

562 735.—Magnetometer for automatically recording changes in magnitude or direction of the earth's field, the instrument being free from zero drift.

The British Electrical and Allied Industries Research Association; A. Butterworth; and A. Turney. Application date, 29th March, 1943.

562 741.—Dynamo-electric frequency-changing set with a flexible synchronising control.

The British Thomson-Houston Co. Convention date (U.S.A.), 1st April, 1942.

562 792.—Method of testing for the presence of air in hermetically-sealed bulbs, such as those used for photo-flash lamps.

The British Thomson-Houston Co. Convention date (U.S.A.), 21st January, 1942.

562 811.—Transmission gear for giving a continuous indication at a remote point of an instrument reading.

Standard Telephones and Cables; C. H. Chambers; and P. G. Collier. Application date, 13th January, 1943.

562 817.—Apparatus for analysing wave forms, including a storage device for integrating amplitude data over a predetermined time interval.

W. G. Walter. Application dates, 11th February and 19th July, 1943.

562 848.—Method of assembling and cementing the elements of a copper-oxide or selenium type rectifier.

The General Electric Co.; H. C. Turner; and J. Chamberlain. Application date, 10th July, 1942.

562 862.—Applying and processing the counter electrodes forming part of a dry-plate rectifier.

The General Electric Co.; H. C. Turner; and J. Chamberlain. Application date, 7th 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

3380. TRANSMISSION-LINE THEORY APPLIED TO WAVE GUIDES AND CAVITY RESONATORS: PARTS I & II.—D. Middleton & R. King: D. Middleton. (*Journ. Applied Phys.*, July 1944, Vol. 15, No. 7, pp. 524–535 & 535–544.)

"It is our purpose in this paper, which at least in Part I is to be regarded as a companion piece to the second writer's paper [732 of March], to show in detail that the analysis of transmission circuits constructed of hollow and coaxial conductors may be given in the general hyperbolic form [there discussed] of the ordinary theory, and to apply that theory in a number of practical cases. Specifically we will define and discuss terminal and input impedances of a wave guide and cavity resonator of arbitrary cross section, unrestricted terminations, and driven at some arbitrary point along the tube. A brief discussion of the propagation constant and characteristic impedances will be included, and finally in Part II we will consider a number of experimental examples, and a theoretical treatment of a closed, cylindrical pipe containing several imperfect dielectric media at one end. The great advantage of the analysis lies in the fact that definite and meaningful experimental results may be obtained, for *any* termination, whereas a mathematical treatment of the problem would, in most cases, be quite impractical if not impossible."

3381. THE NON-REFLECTING TERMINATION OF A CONCENTRIC LINE [Editorial on Willis Jackson & Huxley's Paper (1871 of June) and Moullin's Contribution to the Discussion].—G. W. O. H. (*Wireless Engineer*, Sept. 1944, Vol. 21, No. 252, pp. 409–411.)

Including an explanation of the fact that the magnetic field at any point in the cross-section depends only on the current in the core at that cross-section, and is independent of what the current may be at other points along the core. "The experiments of Professor Willis Jackson and Dr. Huxley and the contribution to the discussion by Dr. Moullin constitute a valuable addition to our knowledge of this subject. They have certainly uprooted some very widely held misconceptions."

3382. "HYPER- AND ULTRA-HIGH-FREQUENCY ENGINEERING" [Book Reviews].—R. I. Sarbacher & W. A. Edson. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 334..337: *Review Scient. Instr.*, April 1944, Vol. 15, No. 4, pp. 102–103.) Summarised extracts from this book were dealt with in 63 of January and back reference.

3383. LONG-DISTANCE "BURSTS" CAUSE F.M. INTERFERENCE.—F. C. C. (*See* 3455.)

3384. TROPOSPHERIC FADING ON A 337 Mc/s STUDIO–TRANSMITTER LINK.—Dillon. (In paper dealt with in 3634, below.)

3385. THE USE OF FIELD-INTENSITY MEASUREMENTS FOR COMMERCIAL-COVERAGE EVALUATION [including Survey of North-Eastern States, Sheets of "Complete Spectrum Observations", & Remarks on Correlation between Fading & Barometric Conditions].—Felix. (*See* 3642.)

3386. THEORY OF THE COASTAL REFRACTION OF ELECTROMAGNETIC WAVES.—G. A. Grünberg. (*Journ. of Phys.* [of USSR], No. 5, Vol. 6, 1942, p. 185 onwards.) The paper referred to at the end of 1830 of 1943. A summary is given in *Sci. Abstracts*, Sec. A, June 1944, Vol. 47, No. 558, p. 124.

3387. TWO STRATOSPHERES IN MIDDLE LATITUDES.—H. Arctowski. (*Journ. Franklin Inst.*, April 1942, Vol. 233, No. 4, p. 330: summary, from *Heating and Ventilating*, Vol. 39.) *See* 942 of 1942.

3388. REPORT OF SYMPOSIUM ON COSMIC RAYS [Rio de Janeiro, 1941: Notice of Issue].—Brazilian Academy of Science. (*Journ. Applied Phys.*, June 1944, Vol. 15, No. 6, p. 516.)

3389. THE VARIATION OF MESOTRON INTENSITY WITH ALTITUDE AND LATITUDE, TOGETHER WITH ALLIED PHENOMENA, AND THE BEARING OF THESE MATTERS ON THE NATURE OF THE PRIMARY PARTICLES: PART II.—W. F. G. Swann. (*Journ. Franklin Inst.*, Aug. 1943, Vol. 236, No. 2, pp. 111–139.) Part I was in the July issue, No. 1, p. 1 onwards.

3390. ON WHISTLING METEORS [and Alternative Causes of the Delhi "Whistles"].—Khastgir. (*See* 3408.)

3391. THE DOPPLER AND ECHO DOPPLER EFFECT [including the Derivation of a Combined Formula adaptable to 16 Cases of Doppler Effect involving Motion of Generator, Detector, & Reflector].—J. O. Perrine. (*Sci. Abstracts*, Sec. A, June 1944, Vol. 47, No. 558, p. 116.)

3392. HISTORICAL NOTE ON THE DEFLECTING INFLUENCE OF THE ROTATION OF THE EARTH [including the Work of Coriolis].—E. W. Woolard. (*Journ. Franklin Inst.*, May 1942, Vol. 233, No. 5, pp. 465–470.) *See*, for instance, Michel, 2843 of September.

3393. VELOCITY AND MASS DISTRIBUTIONS RESULTFROM THE LATERAL DIFFUSION OF A CURRENT IN A STRATIFIED MEDIUM ON A ROTATING EARTH.—G. Grimminger. (*Journ. Franklin Inst.*, Nov. & Dec. 1943, Vol. 236, Nos. 5 & 6, pp. 413–443 & 509–520.)

"The most important result of the investigation is to show how the lateral diffusion of currents in the upper atmosphere can produce significant pressure changes at the ground (cyclogenesis and anticyclogenesis) and, most important of all, that these pressure changes are dynamic in origin."

3394. ON A NEW METHOD OF MEASURING THE "MEAN HEIGHT" OF THE OZONE LAYER IN THE ATMOSPHERE: PART II.—K. Watanabe. (*Journ. Franklin Inst.*, Nov. 1943, Vol. 236, No. 5, pp. 461–471.) For Part I *see* J. Strong, 1297 of 1941.

3395. THE DIELECTRIC CONSTANT OF AIR IN VARIOUS CONDITIONS OF DENSITY, HUMIDITY, AND CARBON-DIOXIDE CONTENT.—Eltgroth. (In paper dealt with in 3431, below.)

3396. ACTIVE NITROGEN AND $N_2^+(X')$ IONS [Further Arguments in Support of the Writer's Hypothesis (1109 [ii] of April)].—S. K. Mitra. (*Nature*, 12th Aug. 1944, Vol. 154, No. 3902, pp. 212–213.)

"No other hypothesis so far put forward gives any explanation of the occurrence of ions in active nitrogen, or of the fact that the afterglow and the ionisation in it are not wholly independent": it also gives simple explanations of various other phenomena in active nitrogen, even to small details.

3397. DEVELOPMENT OF δ AND γ BANDS OF NITRIC OXIDE IN ACTIVE NITROGEN, AND LYMAN BANDS IN HELIUM–NITROGEN MIXTURE.—B. M. Anand. (*Indian Journ. of Phys.*, Oct. 1943, Vol. 17, No. 5, pp. 246–251.)

3398. SOLAR FLARES AND MAGNETIC STORMS [Discussion of Relationship between the Less Intense Flares & Geomagnetic Activity].—H. W. Newton. (*Nature*, 19th Aug. 1944, Vol. 154, No. 3903, p. 242: summary, from *Mon. Not. Roy. Astron. Soc.*, Vol. 104, 1944.)

"In a general way the radio fade-out data confirm a small statistical rise of geomagnetic activity within a few days after the mean fade-out. These results are, however, less definite than those from the solar-flare data." For previous work *see* 2128 of July and 2488 of August.

3399. PRELIMINARY NOTE ON THE BEHAVIOUR OF HELIUM IN THE SOLAR ATMOSPHERE [including a Suggestion that a Classification of Solar Flares based on Behaviour of the He Lines would be More Sensitive than the Present Hα Classification].—S. E. A. van Duke. (*Sci. Abstracts*, Sec. A, June 1944, Vol. 47, No. 558, p. 112: from *Astrophys. Journ.*, Jan. 1944.)

3400. THE EARTH'S AND THE SUN'S PERMANENT MAGNETIC FIELDS IN THE UNITARY FIELD THEORY.—E. Schrödinger. (*Sci. Abstracts*, Sec. A, June 1944, Vol. 47, No. 558, pp. 132–133.) For other recent work by the same writer *see* 2764 of August.

3401. SOLAR CYCLE AND WEATHER [and the Relation between Calcium Flocculi (measured at the Observatory del Ebro) & Changes in Solar Constant: Tentative Trial of Solar Forecasting of Temperature Departures at Washington: etc.].—C. G. Abbot. (*Nature*, 19th Aug. 1944, Vol. 154, No. 3903, p. 242.) *See* also 1125 of April.

3402. ULTRA-VIOLET AND DAYLIGHT RAYS IN RELATION TO THE SEASONS AND THE SOLAR CYCLE [Deductions from 11 Years' Observations].—J. R. Ashworth. (*Sci. Abstracts*, Sec. A, June 1944, Vol. 47, No. 558, p. 133.) *See* also 398 of February and back reference.

3403. LUMINOUS EFFICIENCY OF RADIANT ENERGY FROM THE SKY [from Available Data in the Literature: Round Number 100 Lumens per Watt representative of Typical Cloud-Free Sky].—Nat. Bureau of Standards. (*Journ. Franklin Inst.*, Nov. 1943, Vol. 236, No. 5, pp. 490–491.) Compared with 90.2 lumens per watt for the radiant energy scattered in the upper atmosphere.

3404. EXPERIMENTS IN SCATTERED LIGHT: ANGLES OF FIRST MINIMUM [and the Successful Use of Mie's Theory for determining the Size of Droplets in the Range 1–4μ].—R. V. Tamhankar & G. R. Paranjpe. (*Indian Journ. of Phys.*, Oct. 1943, Vol. 17, No. 5, pp. 287–294.)

"Starting with Mie's formula, the distribution of intensity of light scattered in the region of the transmitted direction has been studied theoretically for four drop-sizes of water vapour, *viz.*, $\alpha = 15$, 20, 25, and 30, where α represents the ratio of the circumference of the drop to the wavelength of the light used. The range verified in the present investigations was 150°–180°. The calculations reveal that a sharp minimum of intensity exists in the range considered and that it has to be ascertained very carefully. This minimum, which is here termed 'the angle of the first minimum on Mie's theory', may be correlated with the first-order corona ring for the drop-sizes considered.

"The theoretical results have been verified experimentally for the first time. The scattered intensity has been measured by the use of a photo-electric cell coupled with a suitable amplification arrangement. The results have been compared with Mie's theory and also with the first-order corona rings. A fair agreement is found to exist in the cases considered." It is also concluded that the "circular-disc" theory is certainly not as defective as it was thought to be by Mecke, who considered it to give incorrect results for sizes below 4μ.

3405. Light Scattering in Solutions [in connection with Optical Analysis of Solutions of Polymers].—P. Debye. (*Journ. Applied Phys.*, April 1944, Vol. 15, No. 4, pp. 338–342.) One of the papers in the symposium referred to in 3602, below.

3406. "Propagation ellipsoïdale, Relativité, Quanta" [Book Review].—H. Varcollier. (*Journ. Franklin Inst.*, Dec. 1943, Vol. 236, No. 6, p. 595.)

"An account of experiments based on the theory of the ellipsoidal propagation of light. Whether or not this theory may win final acceptance is for the future to show, but it has attracted the attention of many physicists, especially as an explanation of the Michelson experiment. . ."

3407. The Charles L. Mayer "Nature of Light" Awards [Subjects for Two 2000 Dollar Awards for Contributions submitted before 1st Jan. 1946].—Nat. Science Fund. (*Journ. Franklin Inst.*, May 1944, Vol. 237, No. 5, p. 417: *Journ. Applied Phys.*, July 1944, Vol. 15, No. 7, p. 522.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

3408. On Whistling Meteors [and Alternative Causes of the Delhi "Whistles" (Chamanlal & Venkataraman, 1607 of 1942)].—S. R. Khastgir. (*Indian Journ. of Phys.*, Oct. 1943, Vol. 17, No. 5, pp. 239–245.)

The evidence in support of the meteor/Doppler-effect hypothesis is set out. But if, as is assumed by the previous writers in order to explain those whistles which were observed *beyond* the range of the ground wave, a perceptible amount of ionospheric scattering is recognised, it is evident that the waves returned from the head of the meteor would be only a small fraction of the total scattered radiation reaching the receiver, and would hardly be able to produce a discernible beat-note with the waves scattered by the patchy ionised regions of the ionosphere. "This is indeed a strong argument against the view that the observed whistles are due to Doppler effect. . ."

The writer then points out the striking similarity between these Delhi whistles and the "whistling tones" observed by Barkhausen, Eckersley, and Burton & Boardman in a.f. amplifiers connected to large aerials. "One wonders whether the two phenomena are fundamentally the same or similar. One suggestion would be that the carrier waves were modulated in some way by the a.f. atmospherics which could then be heard in the receiver tuned to the frequency of the carrier waves."

But whereas the Delhi whistles were observed to be coincident with the appearance of meteors, no such correlation was noted by Burton & Boardman (1934 Abstracts, p. 31) for their musical "tweeks" and "swishes". The present writer tentatively suggests (pp. 242–244) that an electrical impulse may be produced by the stoppage of meteors in the ionosphere: its various frequency components would reach the lower fringe of the layer one after another in quick succession, the short wavelengths arriving earlier than the long. The carrier waves scattered from the ionosphere in the same region would be modulated by the a.f. oscillations, the modulation frequency being a function of time, so that the carrier-tuned receiver would reproduce a note of rapidly descending pitch. This would account for some, at any rate, of those Delhi whistles which were of descending pitch. Probably the ascending-pitch whistles were completely unconnected with meteors, being due to similar carrier-modulation by a.f. "tweeks" and "swishes". The above hypothesis of modulation also explains the observed dependence of whistle-pitch on the carrier-wave frequency. Suggestions for some experiments to decide between the alternative explanations are made. Finally, it is admitted, in favour of the Doppler-effect theory, that such a wireless-wave change of frequency has definitely been obtained by Appleton (1363 of 1943).

3409. A Further Study of Atmospherics during the Monsoon Period [Summer & Winter Monsoon Periods contrasted: Meteorological Conditions are Similar, but Electrical Characteristics Differ Greatly: Probable Reasons].—N. S. S. Rao. (*Sci. Abstracts*, Sec. B, June 1944, Vol. 47, No. 558, p. 110.) Following on 3274 of 1943.

3410. The Measurement of Lightning Current in Direct Strokes [over a Five-Year Period: Effect of Object Height on Frequency of Striking & on Character of Discharge: etc.].—G. D. McCann. (*Elec. Engineering*, June 1944, Vol. 63, No. 6, p. 233: summary only.)

3411. Lightning Counter [for Power Company Engineers: Simple Device using Two Strips (One Toothed) of Metal Foil between Plastic Plates].—L. Finzi. (*Electronics*, April 1944, Vol. 17, No. 4, pp. 198 and 202.)

3412. Paper on Four Types of Radio Sonde [and Their Practical Difficulties, particularly regarding the Recording of Relative Humidity: the Need for an Improved Device: Advantages of Frequency Modulation: etc.].—V. E. Suomi. (*Electronics*, April 1944, Vol. 17, No. 4, pp. 188 and 192: summary only.)

PROPERTIES OF CIRCUITS

3413. The Limitations imposed by the Quantum Theory on Resonator Control of Electrons [" Considerations of the Energy Exchange-Rate between Electrons passing through a Resonant Cavity above 300 Mc/s, where the Controlling Field would be of the Order of 100 Micro-Electron-Volts "].—L. P. Smith. (*Electronics*, March 1944, Vol. 17, No. 3, p. 103 : paragraph on a New York Winter Meeting paper.)

" In such cases, the customary concept of the energy-exchange relationship as a continuous effect is contrary to what we know about the quantum theory. Accordingly, the relationship is defined as taking place in definite steps, or jumps, of one quantum at a time. The probability of an exchange of two quanta taking place at a single instant is negligibly small . . . In these days, when the frequency is going higher and higher, we should expect to run into these difficulties, where the results are far different from those expected from classical theory."

3414. The Piston Attentuator.—H. Wheeler. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 103 and 312 : note on a New York Winter Meeting paper.)

Mathematical demonstration of natural or exponential law of attenuation in db in respect to piston displacement : three types—electrostatic, and coaxial and coplanar electromagnetic types, the last being specially recommended for its reliability. " A trick used with it, at higher frequencies, is to provide coupling to the cavity of the signal generator simply by placing the end of the attenuator at a hole in the cavity where the electromagnetic field is maximum."

3415. Cylindrical Cavity Resonators [and the Derivation of Their " Q " Values by Transmission-Line Methods].—C. F. Davidson & J. C. Simmonds. (*Wireless Engineer*, Sept. 1944, Vol. 21, No. 252, pp. 420–424.)

The general expression arrived at by this analysis (using the impedance concept [*cf.* 1740 of 1938]) involves the attenuation of a wave-guide, of the same cross-section, when operating in the same transmission mode ; as well as the surface resistance of the cavity-material, and other quantities which are functions of the cavity-dimensions and operating frequency. Thus for the expression to be of practical use the attenuation must either be calculated (by resort to the field equations) or determined experimentally : in the latter case the expression becomes " of immediate value—the attenuation of a wave-guide could, perhaps, be calculated from the measured Q of a resonator." In any case, the derivation is instructive in that " it leads to some correlation between the familiar ideas of transmission lines and lumped circuits and the seemingly new ideas required in wave-guide technique ".

3416. The Non-Reflecting Termination of a Concentric Line [Editorial on Willis Jackson & Huxley's Paper and Moullin's Contribution to the Discussion].—G. W. O. H. (*See* 3381.)

3417. Demonstrating Transmission-Line Principles : Slow-Motion Models with Exaggerated Circuit Constants.—C. Stokes. (*Wireless World*, Aug. 1944, Vol. 50, No. 8, pp. 250–251.)

3418. Arrangement for Matching by means of Stubs [D.R.P.740 030, applied for 27/2/40].—(*T.F.T.*, Jan. 1944, Vol. 33, No. 1, p. 17.)

No name is mentioned. The distance of the stub from the potential minimum on the feeder bears a definite relation to the length of the stub up to the short-circuiting bridge ; consequently a template may be constructed so that the bridge is correctly shifted when the stub is displaced with respect to the potential minimum. But in this case a separate template is required for each wavelength. On the other hand, if the characteristic impedance of the stub is made equal to half that of the feeder for a parallel connection, or to twice that of the feeder for a series connection, a cog-wheel reduction ratio of 1 : 2 is satisfactory. Whether the stub is to be regarded as a parallel or a series connection for cavity cables depends on the currents flowing on the inner surfaces of the latter.

3419. The Modification of Noise by Certain Non-Linear Devices.—D. O. North. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 312 and 314 : note on a New York Winter Meeting paper.)

Graphical representation of statistical behaviour of noise in passing through a square-law or a linear detector. " The resulting output from the square-law detector, for an idealised rectangular noise-input distribution, was particularly interesting. The audio component became a triangular distribution, of the same band-width, but decreasing proportionately with frequency, while the r.f. distribution became an isosceles triangle whose base was twice the band-width, with the apex at double the carrier frequency."

3420. Experiments relating to the Statistical Theory of Noise.—C. M. Burrill. (*Electronics*, March 1944, Vol. 17, No. 3, p. 314 : note on a New York Meeting paper.)

Following on 3419, above. " Discussion of the proof of the formula $p = \exp.\ (-A^2/BE^2)$, where p is the probability that at any instant the amplitude, or instantaneous value of the noise envelope, will exceed the value A, and E is the instantaneous value of the envelope applying where the noise has been passed through a selective circuit which limits the band of the noise spectrum in respect of its mean value. This leads to the fact that, if the band-width is made sufficiently small, the effect of variation in the envelope is negligible over periods as long as one-eighth of a second. It is consequently possible to perform the measurement of noise in such a narrow band, over this period of time, within accuracies of the order of 1%."

3421. On the Fluctuations produced by Shot Effect in Amplifiers.—A. Blanc-Lapierre. (*Comptes Rendus* [Paris], 5th/26th July 1943, Vol. 217, No. 1/4, pp. 73–74.)

" The fluctuations created in a linear amplifier by shocks which are equal, very short, and random, differ according to whether the mean interval between two consecutive shocks is small or great compared with the time constants of the amplifier. Certain formulae regarding shot effect become, for this reason, inexact for widely spaced shocks or quickly damped amplifiers. It is this fact that I propose to show precisely and quantitatively."

It is assumed that the amplifier is unresponsive to continuous current, and that $qR(t/\tau)$ represents its response to a very short impulse produced by the charge q acting at the instant $t = 0$. Time is represented in the homogeneous form t/τ so that amplifiers having responses of the same form but of varying damping rates may be compared by a variation of τ. Following the classic hypotheses, the distribution of the shocks in time is supposed to obey Poisson's law: i being the mean intensity, there will be $\rho = i/q$ shocks per second. $x(t)$ represents the response of the amplifier subjected to the shocks: $t_1 = \tau\lambda_1$ and $t_2 = \tau\lambda_2$ being two arbitrary instants, the writer sets out to determine first the probability $W(x_1, x_2)dx_1dx_2$ of the satisfaction of the inequalities $x_1 \leq x(t_1) \leq x_1 + dx_1$ and $x_2 \leq x(t_2) \leq x_2 + dx_2$; and also the probability $W'(x_1', x_2')dx_1' dx_2'$ that the reduced variable $x' = x/\sqrt{\rho\tau}$ will satisfy the corresponding inequalities.

An example of the writer's final results is given by eqn. 6 for the case of the square-law detector: $\overline{(x_1^2 - \overline{x^2})(x_2^2 - \overline{x^2})} = 2q^2i^2\mu_{11}^2(\theta) + q^3i\mu_{22}(\theta) = 2F^2(\theta) + q^3i\mu_{22}(\theta)$; this equation yields the results already established, by the use of Fourier series, in the paper referred to in 1630 of May (and *cf.* Fränz, 3026/7 of 1941): namely that the spectrum of the square-law detector is strictly the sum of two spectra: the first, proportional to q^2i^2 and independent of the phase displacement $\phi(\nu)$ of the amplifier, predominates if $\rho\tau$ is large, while the second, proportional to q^3i and dependent on $\phi(\nu)$, predominates if $\rho\tau$ is small.

3422. GROUNDED-GRID RADIO-FREQUENCY VOLTAGE AMPLIFIERS.—M. C. Jones. (*Proc. I.R.E.*, July 1944, Vol. 32, No. 7, pp. 423–429.)

I—Single-stage amplifier (and the relation to the cathode-follower circuit: the latter is a "voltage-follower," the grounded-grid [Strong's "inverted amplifier," 4230 of 1940] is a "current-follower": calculation of gain. II—Tandem circuits. III—Pi-section tandem circuits. IV—Antenna input circuits. V—Noise considerations (measurement of noise factor by the "$4KT$" method: by the "$1KT$" method: by a compromise method, when the internal resistance of the signal generator is less than the input resistance of the receiver, but is still not negligible: calculation of receiver noise and noise factor). VI—Coupling-transformer designs and optimum values for R_L. For Dishal's paper on these amplifiers at u.h.f. *see* 2883 of September.

3423. LETTER ON THE CATHODE-FOLLOWER OUTPUT STAGE *versus* THE USE OF HEAVY NEGATIVE FEEDBACK.—Williamson. (*See* 3508.)

3424. CORRECTIVE NETWORKS FOR [Negative-] FEEDBACK CIRCUITS [to Control the Cut-Off Attenuation Characteristic of the Feedback-Transmission Loop so as to prevent Oscillation].—V. Learned. (*Proc. I.R.E.*, July 1944, Vol. 32, No. 7, pp. 403–408.)

The requirements for stabilising amplifying devices having negative feedback relate to certain necessary conditions of phase shift and attenuation in the amplifier and feedback circuits. Previous writers have shown that to obtain an optimum design satisfying these requirements, definite attenuation characteristics must be followed. To provide a factor of safety, it is customary to require that the cut-off transmission characteristic should not attenuate at a rate of more than 10 db per octave. Corrective networks are described in this paper to achieve this attenuation rate and provide amplifying devices which will approach the optimum characteristics: "they consist of simple circuit-element combinations that are suited for operation in the plate and grid circuits of vacuum-tube amplifiers."

3425. D.C. AMPLIFIER DESIGN TECHNIQUES [Design Equations with Practical Examples: Stabilisation of Negative-Feedback Amplifiers: Cathode-Follower & Phase-Inverter Considerations: Valve-Drift Problems in High-Gain D.C. Amplifiers, & Operation of Multi-Stage Amplifiers from Common Power Supplies].—E. L. Ginzton. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 98–102.)

"A method of directly coupling successive stages of a vacuum-tube amplifier without using a common B-supply has been described by W. M. Brubaker (ref. "1" [and 2205 of 1940]). Except for the verbal description in this note, the circuit does not seem to have appeared in print in spite of its usefulness and simplicity . . ." Modifications of this method are included in the present paper.

3426. AN IMPROVED "ZERO-RESISTANCE" CIRCUIT FOR PHOTOCELL PHOTOMETRY [Modification of Barbrow's Circuit].—Projector & others. (*See* 3766.)

3427. HARMONIC ANALYSIS OF OVER-BIASED AMPLIFIERS ["Quick Graphical Method of determining Harmonic Components up to the Tenth for Voltage or Current in Various Classes of Amplifiers: Amount of Distortion can thus be Predicted"].—U. R. Furst. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 143–144.)

3428. HARMONIC ATTENUATION WITH A PI NETWORK: AN ANALYSIS OF AN APPLICATION IN TRANSMITTERS.—Harrell. (*See* 3451.)

3429. INTERMITTENT BEHAVIOUR OF OSCILLATORS [and the Criterion for Motor-Boating: including a Discussion of Limiting Devices].—W. A. Edson. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 314 and 316: note on a New York Winter Meeting paper.)

"Using the well-known feedback representation of the $\mu\beta$ vector for a closed system, in terms of the vector ratio between output voltage and input voltage (which can be determined experimentally), he first reviewed the criterion that some kind of oscillation will ensue; namely, that the point on the vector plot should include the point 1.0. He then showed that the same criterion applied for whether an oscillating system will behave with intermittent operation, when the vector diagram is plotted for the voltage ratio with a small amount of superimposed modulation transmitted around the loop. When the condition obtains, the modulation envelope is amplified and the system is capable of self-oscillation . . . Three types of limiting devices, the lamp-ballast bridge, the diode rectifier, and the over-loaded gain section, were discussed, with attention on means of establishing the highest conditions of frequency and amplitude stability by proper application of control."

3430. CURRENT STABILISERS [against Line-Voltage Fluctuation or Load-Resistance Variation: for Photometry, Measurement Work, Magnetron Oscillators, as Coupling Device in D.C. Amplifier Work, etc.].—J. N. van Scoyoc & E. H. Schulz. (*Proc. I.R.E.*, July 1944, Vol. 32, No. 7, pp. 415–418.)

Authors' summary:—"The degree of regulation to be expected from several types of current stabilisers is considered. Regulation equations are derived and a graphical-design method is presented. The regulation by a single pentode is much better than that of a single triode. Two cascode-connected pentodes [" the term 'cascode' as distinguished from 'cascade' applies to an amplifier in which the tubes are connected in series to obtain direct coupling "] give a better regulation, but the tube drop is greater and the circuit is more complex. The regulation may be improved by using non-linear resistors in the control circuit."

3431. FREQUENCY-STABILITY OF TUNED CIRCUITS [using Air Capacitors: Action of Variations in Air Density & Humidity such as are encountered in Operation over Wide Range of Altitudes: Data for Change in Dielectric Constant at Various Humidity & Temperature Values and for Varying Carbon-Dioxide Content (Dry-Ice Test Chambers): Effect of Moisture Films and Oil or Grease Films: Wax/Air Interfaces must be kept out of Strong Electric Fields: etc.].—G. V. Eltgroth. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 118–120 and 379, 380.)

Among other points, "recent experimental work has shown that moisture films form on objects situated in moist air even though conditions may be such that no condensation takes place . . ."

3432. *RC*-OSCILLATOR PERFORMANCE [Practical Performance Data on Relaxation, Transitron ("Improved van der Pol"), & Phase-Shift Types: Suggestions for overcoming Difficulties encountered in Production of Sine Waves from Saw-Tooth Waves with the help of Filters: Synchronisation of Oscillators with an External Frequency Source: etc.].—J. H. Newitt. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 126–129 and 252..258.)

3433. SIMPLE *RC* EQUALISER NETWORKS [with Charts: Application to Variable Tone-Control].—Merchant. (*See* 3511.)

3434. CRYSTAL BAND-PASS FILTER [Max. Attainable Band-Widths for Quartz Filters (Theoretical Increase by Auxiliary Coils from 0.8% to 11%, Practical Limit 6% [*cf.* Herzog, 1539/40 of May and 2540 of August]: Rochelle Salt gives 8%, but "Goodness Coefficient" is One Order of Magnitude less than that of Quartz: Advantages of KH_2PO_4 Crystals].—B. Matthias & P. Scherrer. (*Sci. Abstracts*, Sec. B, June 1944, Vol. 47, No. 558, pp. 99–100: from *Helvet. Phys. Acta*, 1943.) For previous work *see* 2904 of September and 3184 of October.

3435. GEOMETRIC SOLUTIONS OF L-TYPE EXCITATION NETWORKS [for the Feeding of Two or More Resistive Loads from a Single Power-Source, at Varying Currents & Phases (as in Directional Aerial Arrays: Duttera, 1042 of 1943)].—R. C. Paine. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 242..250.) "In a specific problem more accurate results can be obtained by graphic solutions, on a sufficiently large scale," than by charts.

3436. FORMULAS FOR THE FOUR-TERMINAL-NETWORK PARAMETERS OF UNIFORM-LADDER NETWORKS.—W. R. LePage. (*Elec. Engineering*, June 1944, Vol. 63, No. 6, p. 227: summary only.)

3437. CORRECTION OF TYPOGRAPHICAL ERRORS IN "IMAGE-REPRESENTATIONS OF LINEAR COMPLEX FUNCTIONS BY THE USE OF THEIR 'FIXED POINTS'" [2542 of August].—H. Schulz. (*T.F.T.*, Jan. 1944, Vol. 33, No. 1, p. 22.)

3438. IMPEDANCE-COMBINING CHART ["Timed Tests indicate that Impedance combined in Series or Parallel may be computed Several Times Faster with the Accompanying Chart than with a Vector Slide Rule"].—G. Muffly. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 134–137.) With several examples, including Scott's "new type of selective circuit," 1802 of 1938.

3439. "GRAPHICAL CONSTRUCTION FOR VACUUM-TUBE CIRCUITS" [Book Review, including a Discussion of the Validity of the Equivalent-Plate-Circuit Theorem (*cf.* 3169 of October)].—A. Preisman. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 338..340.) A favourable review by Stockman. A previous review was referred to in 2517 of August.

3440. OPTIMUM LOAD [Letter on Subject dealt with in 3119 of October: Limitations of the $R_t = 2R_a$ Optimum Relation: Howe's Editorial (1027 of 1943)].—E. F. Good. (*Wireless World*, Aug. 1944, Vol. 50, No. 8, p. 252.)

3441. THE MULTIVIBRATOR: APPLIED THEORY AND DESIGN: PART II [Multivibrator in which the Synchronising Voltage is supplied to Both Valves]: PART III [Synchronisation of only One Valve: Variations in Amplitude of the Synchronising Pulse: Effects of Ripple & Feedback Voltages in Power Supply].—E. R. Shenk. (*Electronics*, Feb. & March 1944, Vol. 17, Nos. 2 & 3, pp. 140–145 and 363..373: pp. 138–142 and 342..353.) For Part I *see* 2536 of August.

3442. A FREQUENCY-MULTIPLYING CIRCUIT [Simple & of High Efficiency].—(*T.F.T.*, Jan. 1944, Vol. 33, No. 1, pp. 16–17, Fig. 4.)

Frequency-multiplying devices such as those based on the generation of harmonics by the use of non-linear distortions, or on a multivibrator circuit, are inefficient, complicated, and costly, and do not give an output of the same wave-form as the original input signal. The present circuit (D.R.P. 738 823, applied for 30/4/41: no name given) avoids these defects. "The fundamental oscillation whose frequency is to be multiplied is led to a doubled push-pull circuit in which the two valves 1 and 2 work normally as Class B amplifiers, while the two others, 3 and 4, are so strongly negatively biased that only the voltage peaks of the fundamental oscillation will open them.

"By counter-phase combination in the anode resonant circuit, tuned to the multiplied frequency, and with the assistance of the joining-up transient processes, a tripling of the fundamental wave occurs, the sinusoidal wave-form persisting. The high efficiency of the circuit is due to the fact that the valves, acting as Class B amplifiers, are used to the full. The same applies to the other two valves, acting as Class C amplifiers."

3443. THE COMPUTATION OF MAGNETIC-FIELD STRENGTH OF ROUND COILS OF SMALL CROSS SECTION [Correction Formulae for Gray–Russell Formulae, to take Account of Effect of Section Dimensions of Length & Thickness].—H. B. Dwight & G. O. Peters. (*Elec. Engineering*, June 1944, Vol. 63, No. 6, p. 227 : summary only.)

3444. FIELD CONCENTRATION NEAR CIRCULAR CONDUCTORS [Problem of Interest in Construction of a Type of Electric Cable].—H. Poritsky. (*Sci. Abstracts*, Sec. A, May 1944, Vol. 47, No. 557, p. 89.)

3445. THE CAPACITANCE OF ARRANGEMENTS WITH PLANES AND CYLINDERS [with Formulae for Various Combinations, with Uniform & Stratified Dielectrics : including Parallel Wires, Wire Grids, etc.].—F. Moeller. (*Arch. f. Tech. Messen*, Sept. 1943, Part 147, Z130-1, Sheets T107–T108.)

3446. ENERGY WASTED IN CHARGING A CONDENSER. —V. Wouk. (*Communications*, April 1944, Vol. 24, No. 4, pp. 48..52 and 88, 89, 90.)

"In this paper it will be shown that whenever a condenser is charged by a constant e.m.f. in a circuit without valve action, an amount of energy equal to the amount finally stored on the condenser is expended in I^2R loss during the charging process. . . If the voltage source varies in magnitude with time, such a simple equivalence of stored and dissipated energy, in general, does not exist."

TRANSMISSION

3447. FREQUENCY MODULATION OF RESISTANCE–CAPACITANCE OSCILLATORS [especially suitable for Sub-Carrier Frequency Modulation in Facsimile Transmission, etc. (720 of 1940, 3344 of 1943)].—M. Artzt. (*Proc. I.R.E.*, July 1944, Vol. 32, No. 7, pp. 409–414.)

"Replaces the beat-oscillator system and has been found to be far more stable and considerably simpler in adjustment. The large frequency swings are obtained directly, without heterodyning, and the frequency drift usually associated with beat oscillators is thus avoided. . . By proper choice of constants and operating conditions the amplitude modulation can be reduced to a negligible amount even with shifts as high as ± 40% of the carrier frequency, and without introducing appreciable harmonic distortion." Modulation of the resistance–capacitance oscillator is accomplished by a pair of control valves so balanced that no transients or components of the original signal appear in the output. The choice of the type of *RC* oscillator having a 180° phase-shift ladder network enables (among other advantages) the unwanted amplitude modulation to be eliminated without resorting to volume controls which would limit the speed of operation of the system : "the speed of operation is apparently instantaneous", and the precise following of a square-wave signal is specially useful for facsimile.

3448. FREQUENCY-STABILITY OF TUNED CIRCUITS [using Air Capacitors : Action of Variations in Air Density & Humidity].—Eltgroth. (*See* 3431.)

3449. A BATTERY-POWERED CAMPER'S COMBINATION : A VERSATILE RADIO TRANSMITTER AND PUBLIC-ADDRESS [or Gramophone] AMPLIFIER.—H. M. French. (*QST*, May 1944, Vol. 28, No. 5, pp. 32–35.)

3450. RADIO BIBLIOGRAPHY : No. 16—TRANSMITTERS [including Transmitting Aerials & Television : from about 1914 to 1943].—F. X. Rettenmeyer. (*Radio* [New York], June 1944, Vol. 28, No. 6, pp. 42..58.)

3451. HARMONIC ATTENUATION WITH A PI NETWORK : AN ANALYSIS OF AN APPLICATION IN TRANSMITTERS [including the Technique of making the "Surprisingly Critical" Adjustments].—O. W. Harrell. (*Communications*, May 1944, Vol. 24, No. 5, pp. 40 and 82, 83.)

3452. TRANSMITTER-BREAKDOWN ALARM [operating Immediately if Carrier is Interrupted, or if Carrier is maintained without Modulation for more than 15 Seconds].—Angus. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 158 and 160.)

3453. SAFETY GROUNDING-SWITCH SYSTEM [for Radio Transmitters : to prevent Accidental Electrocution].—J. Zelle. (*Electronics*, April 1944, Vol. 17, No. 4, pp. 180..188.)

RECEPTION

3454. ARRANGEMENT FOR THE ALTERNATIVE RECEPTION OF AMPLITUDE- AND FREQUENCY-MODULATED SIGNALS [D.R.P.740 120, applied for 20/5/40 : no name mentioned].—(*T.F.T.*, Jan. 1944, Vol. 33, No. 1, p. 18, Fig. 8.)

Previous automatic change-over arrangements have depended on the phase relations between carrier and sidebands, or between carrier and an auxiliary carrier with intermittently changing phase, to carry out the change-over. Such arrangements are liable to be irregular in their working owing to h.f. fluctuations which cause phase variations. According to the invention this trouble is avoided by providing two rectifiers in series, the first with a perfectly linear characteristic and the second acting also as a limiter, and employing the differences between a.m. and f.m. signals after rectification, which are unaffected by h.f. phase conditions, as the criterion for the change-over.

3455. LONG-DISTANCE "BURSTS" CAUSE F.M. INTERFERENCE [Momentary Sharp Increases in Signal Strength, up to Several Hundred an Hour, interfere with Reception, at 300–

1400 Mile Distances, of U.H.F. (including F.M.) Stations: F.C.C. is conducting Tests].—F. C. C. (*Sci. News Letter*, 1st July 1944, Vol. 46, No. 1, p. 14.)

3456. A NOTE ON TWO DEFINITIONS OF NOISE FIGURE IN RADIO RECEIVERS.—D. K. C. MacDonald. (*Phil. Mag.*, June 1944, Vol. 35, No. 245, pp. 386–395.)

"There are known to the writer two definitions of noise figure (or factor of merit as regards signal to noise performance) of which one is in a fundamental form in general terms [$F = (S_i/N_i)/(S_o/N_o)$, where S and N are specially defined "available" signal and noise powers], most likely to appeal to a 'radio physicist,' the other in a form more suited to the ideas of the 'radio engineer' [$F = (e_a^2/e_s^2) . (R_{eq} + R_a)/R_a$, where R_{eq} is the fictitious "noise resistance" in series with the grid circuit, and R_a the radiation resistance of the aerial].

"The purpose of this note is to show that these lead to the same result, but that while the second definition is, in general, more suitable for immediate calculation with the data available to those engaged in radio engineering, yet care is necessary to avoid error in the computation of noise figure for receivers in which an amplifier stage (or stages) after the first is significant. In such cases, the more fundamental form is of value as a check on the work [one particular error, committed more than once in the past, is discussed by way of illustration: it recurs in Herold's "otherwise excellent article", 2336 of 1942]. It should be appreciated that in this note we are only concerned with radio frequencies above the limit where external noise such as 'atmospheric static,' 'ignition noise,' etc., is significant. As a rough guide we may say that above about 70 Mc/s external noise may be neglected."

3457. NOISE FIGURES OF RADIO RECEIVERS.—H. T. Friis. (*Proc. I.R.E.*, July 1944, Vol. 32, No. 7, pp. 419–422.)

"Early in 1942 North (2337 of 1942) suggested the adoption of a standard for the absolute sensitivity of radio receivers which differed by a factor of 2 from the standard used by us at that time. We adopted his standard, since ours was somewhat limited in that it was based on matched impedances in the input circuit of the receiver.

"In this paper a more rigorous definition of the standard of absolute sensitivity, the so-called noise figure, of a radio receiver is suggested. The definition is not limited to high-gain receivers, but can be applied to four-terminal networks in general. It also makes it possible by a simple analysis to give the relationship between the noise figure of the receiver as a whole and the noise figures of its components. In the case of a double-detector receiver these components may be a h.f. amplifier, a frequency converter, and an i.f. amplifier. The paper also gives a brief description of methods of measurement of noise figures . . . The noise figure will be defined in terms of 'available' signal power, 'available' noise power, gain, and 'effective band-width' . . ." These terms are defined. Mis-match relations between the receiver components are discussed ("in amplifier input circuits a mis-match condition may be beneficial, owing to the fact that it may decrease the output noise more than the output signal"). It is the presence of such mis-match conditions in amplifier input circuits that makes it desirable to use the term "available power" in this paper. The paper is the result of many discussions both outside and inside the Bell Telephone Laboratories, and it is hoped that the definitions and symbols suggested will come into general usage.

3458. THE MODIFICATION OF NOISE BY CERTAIN NON-LINEAR DEVICES, *and* EXPERIMENTS RELATING TO THE STATISTICAL THEORY OF NOISE.—North: Burrill. (*See* 3419 & 3420.)

3459. ON THE FLUCTUATIONS PRODUCED BY SHOT EFFECT IN AMPLIFIERS.—Blanc-Lapierre. (*See* 3421.)

3460. "DIE BEZIEHUNG ZWISCHEN NUTZSPANNUNG UND STÖRSPANNUNG BEI DER FREQUENZ-UMSETZUNGEN DER DRAHTLOSEN MEHR-KANALTELEFONIE" [Book Review]. — E. Huber. (*Wireless Engineer*, Sept. 1944, Vol. 21, No. 252, p. 429.) A summary of this Dissertation was dealt with in 2884 of September.

3461. RADIO NOISE FROM FLUORESCENT LAMPS [Notes on a Filter Arrangement for Suppression of Interference from Small Fixtures].—C. S. Young. (*Sci. Abstracts*, Sec. B, June 1944, Vol. 47, No. 558, p. 110.)

3462. DISCUSSION ON "RADIO-NOISE FILTERS APPLIED TO AIRCRAFT" [88 of January (and 1191 of April)].— C. W. Frick & S. W. Zimmerman. (*Supp. to Elec. Engineering, Transactions Section*, Dec. 1943, Vol. 62, pp. 979–980.)

3463. NOISE METER FOR PLANES [Valve Voltmeter indicating Quasi-Peak Value of Noise Signal (since only the Nuisance Value is of Interest): connected to Regular Receiver in the Aeroplane, for Measurement of Interference from Various Sources].—F. Foulon. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 160..164.) From an A.I.E.E. paper on radio-noise elimination in all-metal aircraft: *see* also 87 of January and 807 of March. For the full paper see *Supp. to Elec. Engineering, Transactions Section*, Dec. 1943, Vol. 62, pp. 877–891: Discussion pp. 994–996.

3464. DISCUSSION ON "HIGH-VOLTAGE IGNITION-CABLE DESIGN FOR AIRCRAFT."—H. H. Wermine. (*Supp. to Elec. Engineering, Transactions Section*, Dec. 1943, Vol. 62, pp. 993–994.)

3465. REDUCING MACHINE-MADE INTERFERENCE: THREE-PHASE MOTORS FOR DOMESTIC USE? [Summary of Article dealt with in 2554 of August].—"Supervisor." (*Wireless World*, Aug. 1944, Vol. 50, No. 8, p. 233.) *See* also p. 225.

3466. STUDIES OF ELECTRICAL INTERFERENCE TO RADIO RECEPTION [due to D.C. Fans & Large Motors].—S. C. Majumdar, S. M. Sen, & S. R. Khastgir. (*Indian Journ. of Phys.*, Oct. 1943, Vol. 17, No. 5, pp. 271–282.)

Chakravarty & Dutt (1665 of 1942) found that the frequency distribution of the r.f. interference voltage input to the receiver, investigated over a wide range of wavelengths, revealed a number of maxima. "The cause or causes of these maxima were not, however, explained, and this remained a very intriguing and useful subject for investigation." The present investigations were made in the low, medium, and high broadcast frequency bands, and began with measurements of the r.f. radiation field of the electric noise and of the corresponding a.f. output for different frequencies, followed by a study of the effect of motor-speed variation on these measurements: in general, the noise field decreased with the increase of frequency, except for some maxima, while the corresponding a.f. output increased with frequency, except for some maxima. The maxima for the r.f. noise field and the a.f. output were not always at the same frequencies; the former seemed to depend on the interfering source. The general effect of speed variation was to decrease the field as the speed decreased: the positions of the maxima were not affected.

Prompted by Howe's results on interference from traction systems (3666 of 1937), which suggested that the maxima in the r.f. interference field were connected with the resonance frequency of the armature-sector circuit of the motor [*see* also Khastgir & Sen, 86 of January], the writers then determined the resonance frequencies of the armature-sector coils of the various motors; taking a wide range of frequencies from 0.5 to 22 Mc/s, since it was realised that in service the frequencies set up would depend not only on the coil properties but also on the resistance of the air-gap where the sparking occurred, which would vary between wide limits as the commutator rotated. "The resonance frequencies were obtained and there appeared some correspondence between them and the frequencies corresponding to the observed maxima in the noise field. It was thus conjectured that the quasi-continuous type of r.f. noise component would have its maximum intensity in the region of the resonance frequencies as determined by the *L*, *C*, *R* values of the different armature-sector coils." The investigation ended with some measurements of the vertical and horizontal components of the noise field, and an oscillographic study of the r.f. noise components.

3467. INTERMITTENT BEHAVIOUR OF OSCILLATORS [and the Criterion for Motor-Boating].—Edson. (*See* 3429.)

3468. THREE-POINT TRACKING IN SUPERHETERODYNES: PART II.—K. Fränz. (*Wireless Engineer*, Sept. 1944, Vol. 21, No. 252, pp. 425–429.) Full translation of the paper dealt with in 1920 of June: the translation of Part I is referred to there.

3469. VARIABLE CONTRAST EXPANSION: CONTROL OF CONTRAST RANGE WITHOUT CHANGE OF AVERAGE LEVEL.—Ingham & Foster. (*See* 3510.)

3470. SAFE PILOT-LAMP CIRCUIT [for A.C./D.C. Receivers: avoiding Premature Failure due to High Voltage applied while Valves are Heating-up].—A. C. Miller. (*Electronics*, Feb. 1944, Vol. 17, No. 2, p. 188.) Patent assigned to Philco Company.

AERIALS AND AERIAL SYSTEMS

3471. RHOMBIC TRANSMITTING AND RECEIVING AERIALS IN A 337 Mc/s STUDIO–TRANSMITTER LINK [replacing "Square-Corner" Type of Aerial System].—Dillon. (In paper dealt with in 3634, below.)

3472. A NEW STUDIO ANTENNA [for the 333.4–333.6 Mc/s Schenectady-Studio/Helderberg-Transmitter Link].—M. W. Scheldorf. (*Electronics*, March 1944, Vol. 17, No. 3, p. 103: paragraph only, on a New York Winter Meeting paper.) *See* also 3376 of 1943.

3473. "ERZWUNGENE ELEKTRISCHE SCHWINGUNGEN AN ROTATIONSSYMMETRISCHEN LEITERN BEI ZONALER ANREGUNG" [Book Review].—E. Metzler. (*Wireless Engineer*, Sept. 1944, Vol. 21, No. 252, p. 429.)

In connection with the problem of improving the broadcast distribution over the very difficult Swiss terrain: "insulated towers have been erected at Beromünster with a platform at about two-thirds of the total height, where the tower is interrupted by insulators across which the secondary of the exciting transformer is connected."

3474. MUTUAL AND SELF-IMPEDANCE FOR COUPLED AERIALS.—R. King & C. W. Harrison, Jr. (*Journ. Applied Phys.*, June 1944, Vol. 15, No. 6, pp. 481–495.)

Existing analyses of the self- and mutual impedances of a driven aerial in the presence of a second aerial are based on three assumptions, each of which is valid only under certain special conditions. The true general state of affairs is expressed in the following extract from the first page, in which all three assumptions and their limitations are mentioned:—"Because the distribution of current in an antenna of non-vanishing cross-section changes when a second antenna is brought near it, the self-impedance as well as the mutual impedance is a function of the relative orientation and separation of the antennas. Only if it is assumed that the distribution of current in a driven antenna is unchanged when a second antenna is brought near is the self-impedance constant. This is done in the conventional analysis in which a sinusoidal current is postulated, a distribution that is correct only for an antenna of vanishing radius. Note that even in this over-simplified case *the mutual impedance is not independent of the distributions of current* in the coupled antennas, so that it is *never* correct to 'assume a *convenient* current flowing in one antenna'."

The writers continue: "An electromagnetically correct formulation of the problem of determining the input impedance of a centre-driven antenna in the presence of a second, arbitrarily oriented antenna has been given in terms of the vector potential [reference is to a paper, "The Receiving Antenna," by the same authors, which has been "accepted for publication in the *Proc. I.R.E.*" A paper under this title was dealt with in 1934 of June]. It will now be specialised to two parallel antennas and the analysis carried out approximately."

The present analysis is limited to two parallel antennas, the one centre-driven and the other centre-driven or centre-loaded in an arbitrary way, of the same length and radius. "Extension to more than two antennas is easily formulated, but even the approximate solution of three or more simultaneous integral equations is difficult. The above analysis for two antennas indicates that thin antennas in any number, but all of half-length $h = \lambda/4$, may be analysed roughly for spacings that are not too small by assuming sinusoidal distributions of current in all. For other lengths and thick antennas the sinusoidal distribution is not adequate. An approximate analysis of two antennas of different lengths is in preparation."

3475. An Approximate Representation of the Electromagnetic Field in the Vicinity of a Symmetrical Radiator [of Non-Vanishing Radius].—C. W. Harrison, Jr. (*Journ. Applied Phys.*, July 1944, Vol. 15, No. 7, pp. 544–546.)

"The exceedingly intricate form of the actual current distribution in antennas of finite radius seems to preclude a direct determination of the field. An alternative approach, which is probably satisfactory in practice, is to represent the quadrature components of current along the antenna by simple distribution functions. This is actually possible to a good degree of approximation." The field vectors in the near zone are then determined by carrying out the calculus of the field theory involved. The resulting expressions, while more intricate than existing formulae based on a sinusoidal distribution, represent approximately the field conditions near aerials used in practice.

3476. On Radiation Problems concerning Vertical Antennas.—E. T. Glas. (*Stockholm Dissertation*, 1943: quoted in King & Harrison's paper, 3474, above.) For Brillouin's paper, also quoted, *see* 2899 of September, and for Bouwkamp's *Physica* paper *see* 2197 of July.

3477. Circuit Relations in Directional Broadcast Transmitting Arrays [Theory reduced to Form which can be handled by Ordinary Circuit Analysis, without Advanced Mathematics].—H. E. Ennes. (*Radio* [New York], June 1944, Vol. 28, No. 6, pp. 18–23 and 52.) For instructional purposes; "too awkward for use under practical conditions".

3478. Geometric Solutions of L-Type Excitation Networks [as used in feeding Directional Aerial Arrays].—Paine. (*See* 3435.)

3479. Copper-Covered Steel Wire at Radio Frequencies.—B. R. Teare, Jr., & E. R. Schatz. (*Proc. I.R.E.*, July 1944, Vol. 32, No. 7, pp. 397–403.)

Following on the work dealt with in 2690 of 1943 [and back reference: for German investigations *see* 911 & 2092 of 1943]. "Copper-covered steel conductors are finding increasing use, chiefly in applications that require strength as well as electrical conductance" [they have a tensile strength that may be "as much as 3 times that of solid copper for 30% wire, the magnitude depending on the steel in the core, and may be as much as 2½ times for 40% wire. Thus when mechanical strength is the principal factor determining the size of the conductor, as may well be in the case of antenna installations, adequate strength can be obtained with a smaller size of copper-covered steel than of copper. Because of the smaller diameter, the c-c steel will have a higher resistance, but when mechanical strength and weight of the over-head construction are the determining factors, an increase of resistance may be permissible"].

"In order that the proper conductor may be selected, it is necessary to know the resistance over the frequency range to be employed. Such information has been available only for the very low frequencies and also for the high frequencies where skin-thickness formulas become valid. It is the purpose of this study to determine the resistance of c-c steel wire over the whole range of frequencies and to compare it with the resistance of solid-copper wire" [and also of corresponding tubular copper exteriors: Fig. 2, showing the behaviours of c-c steel and solid-copper wires of equal diameters (No. 18 AWG) to frequencies up to and beyond 20 Mc/s, also shows that the c-c steel wires and the tubular conductors have substantially the same resistance except at low frequencies (below about 100 kc/s): "for many practical problems this last observation suggests a simple means of determining the performance of c-c steel conductors, since data for tubular conductors are available": refs. "3," "4."] The curves of Fig. 2 are also applicable to any other size of conductor, provided that the lower, generalised frequency scale is employed (in conjunction with the chart of Fig. 3): for the frequencies applying to the curves vary with different diameters. Various other relations are shown by other curves: for example, Fig. 7 deals with inductances instead of resistances.

3480. New Antenna Mast Designs: Easily Erected Antenna Supports with Ham Possibilities.—T. A. Garretson. (*QST*, May 1944, Vol. 28, No. 5, pp. 38–40.)

3481. A Hasty Method of Waterproofing Runways [Use of a Resin–Salt Compound to waterproof Soils].—W. R. McCutchen. (*Journ. Franklin Inst.*, June 1944, Vol. 237, No. 6, p. 468: summary, from *Military Engineer*.)

VALVES AND THERMIONICS

3482. The Limitations imposed by the Quantum Theory on Resonator Control of Electrons.—Smith. (*See* 3413.)

3483. Avoidance of Unwanted Couplings between Grid and Anode Circuits of Micro-Wave Valves, due to Nearness of Connections, etc., by building the Electrodes into Two Parallel Wave-Guides, with the Grid in an Opening between Them.—(*T.F.T.*, Jan. 1944, Vol. 33, No. 1, p. 17, Figs. 5, 6.) D.R.P. 740 031, applied for 3/10/37. No name is given. Adjustments are made with iris diaphragms or pistons.

3484. Deflected Electron Beams [Reply to Gabor's Letter, 3164 of October].—J. H. Owen Harries. (*Wireless Engineer*, Sept. 1944, Vol. 21, No. 252, p. 430.)

(i) The statement that Recknagel's formula for infinite deflecting plates represents the "transit power" involves a violation of the principle of the conservation of energy. (ii) The writer's "sine-shaped field" is one possessing curl, such as occurs in a cubical cavity resonating at the H_{101} mode: there is no x-directed component in any part of such a field.

3485. Optimum Load [Letter on Subject dealt with in 3119 of October].—Good. (*See* 3440.)

3486. Graphical Determination of Operating Point of Self-Biased Tube.—A. Schach. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 240 and 242.)

3487. Factors involved in choosing Tube Types: Part II—Practical Considerations in the Selection for Various Applications.—A. C. Matthews. (*Radio* [New York], June 1944, Vol. 28, No. 6, pp. 32–34 and 58: to be concluded.) "The usual data characteristic chart published by the tube manufacturer is entirely inadequate for use by the design engineer. . ."

3488. Joint Army–Navy Tube Standardisation Programme.—C. W. Martel & J. W. Greer. (*Proc. I.R.E.*, July 1944, Vol. 32, No. 7, pp. 430–434.)

3489. United States and Canadian Armed Forces Standardise Radio Tubes.—(*Elec. Engineering*, June 1944, Vol. 63, No. 6, p. 238.)

3490. Vacuum in Tubes [Receiving, Power, & Cathode-Ray, etc: Present Trends].—(*Electronics*, March 1944, Vol. 17, No. 3, pp. 248, 250.)

DIRECTIONAL WIRELESS

3491. The Directional Characteristic of a Half-Wave Doublet Goniometer [H. C. Forbes, U.S. Patent No. 2 320 124].—R. J. Dwyer: Forbes. (*Journ. Applied Phys.*, June 1944, Vol. 15, No. 6, pp. 513–514.)

Author's summary:—"The directional characteristic of a goniometer using two half-wave doublet antennas mounted at right angles is derived. It is shown that, unlike the double loop goniometer, the directional characteristic is not identical with that of single half-wave doublet that can be rotated, though the variation from such a case is very small." Fig. 2 is a graph of θ_{max} against α as obtained from eqn. 5. For values of α that are multiples of 45°, θ_{max} is equal to α, but between these values there is a slight deviation which is shown on an enlarged scale in Fig. 3: the curve is nearly sinusoidal. Values of θ_{min} can be obtained from Fig. 2 by adding 90° to θ_{max}.

3492. Method of Subdividing the Glide Path produced by an Instrument-Landing Transmitter [D.R.P. 738 898, applied for 7/12/39: Improved Plan for Use of One Receiver only].—(*T.F.T.*, Jan. 1944, Vol. 33, No. 1, p. 17.)

No name is mentioned. Hitherto the plan has been to transmit the auxiliary signals on frequencies so near the glide-path frequency that they will come in on the same tuning of the receiver, the separation being carried out in the l.f. circuit thanks to a difference in modulation frequencies. This involves complications to avoid interference by difference frequencies between the carriers. According to the invention, the auxiliary frequencies are sent out unmodulated and of such values that the audible (or inaudible, for secrecy) difference frequencies formed with the glide-path frequency give an indication of the corresponding section-limits. Further, it is suggested that the glide-beam signals should be polarised vertically and the auxiliary signals horizontally.

3493. Flight Paths of Radio Instrument-Landing System [with Photographic Space–Time Records of Approach Paths in 25 Blind Landings: from C.A.A. "Technical Development Report No. 32"].—C.A.A. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 236..240.)

3494. Radio in Aviation [Work of the C.A.A: Application to Post-War Private Flying: the Portable Experimental U.H.F. "Localizer," etc.].—C. I. Stanton. (*Elec. Engineering*, June 1944, Vol. 63, No. 6, pp. 215–217: *Communications*, April 1944, Vol. 24, No. 4, pp. 32–34.)

3495. Post-War Control of Air Traffic [Plans of the C.A.A.].—G. A. Gilbert. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 148..168.)

Radar's main advantage is for detecting objects which do *not* cooperate: future aircraft equipment (collision warning device, automatic position reporter, traffic clearance indicator): ground facilities: etc. Summary of speech to A.I.E.E. in January.

3496. Theory of the Coastal Refraction of Electromagnetic Waves.—Grünberg. (*See* 3386.)

3497. Electronic Radio-Range Monitor [giving Warning of 3° Shift or of Fading below Normal Strength].—Islip Mfg. Company. (*Electronics*, April 1944, Vol. 17, No. 4, pp. 172..180.) *See* also 1438 of 1943.

ACOUSTICS AND AUDIO-FREQUENCIES

3498. Voice-Controlled Devices: Electro-Mechanical Analysis of Words of Command.—Telcs. (*See* 3731.)

3499. A New Crystal Microphone of the Telefunken Company ["Ela M 401/1 & 402/1" (Hand & Table Models), with Practically Spherical Characteristics and a Frequency Range of 50–10 000 c/s, with no Deviation greater than ± 10 db from the 1000 c/s Level: Sensitivity 1 mV/μb: One Dual Rochelle-Salt Plate with Capacitance 2000–300 pF: Housing of 5 cm Diameter].—W. Behringer. (*T.F.T.*, Jan. 1944, Vol. 33, No. 1, pp. 1–2.)

Including a discussion of the action of high temperatures (around 60° C) in depriving the Rochelle salt of its water of crystallisation. In any case the microphone capsule can be easily and quickly replaced. Leads up to 150 m (or, for lower requirements of performance, up to 200 m) can be used, thanks to the design of a special cable, with a capacitance of about 60 pF per metre.

3500. MEASUREMENT OF THE CHARACTERISTIC VALUES OF TELEPHONE TRANSMITTERS [Carbon Microphones : Survey of Basic & Special Tests].—H. Panzerbieter & A. Ueberschuss. (*Arch. f. Tech. Messen*, Jan. & Feb. 1943, Parts 139 & 140, V375-1 & 2, Sheets T4 & T15–T16.)

3501. AIR VENT MAKES HEADPHONES MORE COMFORTABLE [" Big Improvement in Comfort " reported by 20 Hospital Patients as result of Slanting Hole (No. 50 Drill) through Cap].—B. P. Hansen. (*QST*, May 1944, Vol. 28, No. 5, p. 51.)

3502. THE DUPLEX LOUDSPEAKER [Recent Design Work, leading to the Newest Model with Six-Cell High-Frequency Horn mounted on End of Low-Frequency Unit Pole-Piece : the Dividing Network : etc.].—J. B. Lansing. (*Communications*, Dec. 1943, Vol. 23, No. 12, pp. 22–23 and 90.) " At a distance of two feet from the new unit, all frequencies being reproduced appeared to come from a single source."

3503. MATCHING SPEAKERS OF UNEQUAL IMPEDANCE.—R. W. Crane. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 256..260.)

3504. CELLOPHANE TAPE RECORDER [with Permanent Gem Points for Recording & Reproducing].—Fonda Corporation. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 146, 148.) *See* also 2225 of July.

3505. STELLITE ALLOY [for Pivots, Gramophone Needles, etc.].—Haynes Stellite. (*Electronics*, March 1944, Vol. 17, No. 3, p. 288.) *See* also 1693 of May.

3506. A BATTERY-POWERED CAMPER'S COMBINATION : A VERSATILE RADIO TRANSMITTER AND PUBLIC-ADDRESS [or Gramophone] AMPLIFIER.—H. M. French. (*QST*, May 1944, Vol. 28, No. 5, pp. 32–35.)

3507. A HIGH-FIDELITY PEAK-LIMITING AMPLIFIER: A 50-WATT AUDIO UNIT FOR SPEECH OR RECORDING.—C. W. Moorhouse. (*QST*, May 1944, Vol. 28, No. 5, pp. 19–21 and 76.) " Constructed after selecting the best features of several recent designs."

3508. CATHODE-FOLLOWER OUTPUT STAGE [Disadvantages of Circuits used by Mitchell and Baker (2227/8 of July) : Low Output-Resistance (the Cause of the Remarkable Improvement in Quality of Loudspeaker Reproduction) is Better obtained by Negative Feedback].—D. T. N. Williamson. (*Wireless World*, Aug. 1944, Vol. 50, No. 8, p. 252.) *Cf.* Mezger, 3126 of October.

3509. CORRECTIVE NETWORKS FOR NEGATIVE-FEEDBACK CIRCUITS.—Learned. (*See* 3424.)

3510. VARIABLE CONTRAST EXPANSION : CONTROL OF CONTRAST RANGE WITHOUT CHANGE OF AVERAGE LEVEL.—W. E. Ingham & A. Foster. (*Wireless World*, Aug. 1944, Vol. 50, No. 8, pp. 243–244.)

The arrangement has been applied with success to the special contrast-expansion circuit described by Williamson, 3048 of 1943 [and 480 of February].

3511. SIMPLE *RC* EQUALISER NETWORKS [with Charts giving Attenuation & Phase Shift of Networks employing Several Resistors & only One Capacitor : Application to Variable Tone-Control].—C. J. Merchant. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 146–148 and 377, 378.)

3512. NOTES ON TRANSFORMER DESIGN [for the Reduction of Stray Fields producing Extraneous Noise].—Harrison. (*See* 3593.)

3513. TEMPERATURE-COMPENSATED A.F. OSCILLATORS [for Precision Measurements over a 10 : 1 Frequency Range : *RC* Negative-Feedback Oscillator in Temperature-Controlled Chamber].—Electro Products Laboratories. (*Electronics*, April 1944, Vol. 17, No. 4, pp. 202 and 206.)

3514. EVOLUTION OF THE DECIBEL UNIT AND THE VOLUME UNIT [and the Corresponding DB & VU Indicators & Meters].—P. B. Wright. (*Communications*, April & May 1944, Vol. 24, Nos. 4 & 5, pp. 54..60 and 85..91 : pp. 44..50 and 76..81.)

3515. EVALUATING HEARING AIDS [in relation to Specific Categories of Defective Hearing].—B. H. Senturia, S. R. Silverman, & C. E. Harrison. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 250..254 : summary only.)

3516. FUNDAMENTALS OF HEARING-AID DESIGN [including " a Novel Method of obtaining the Required Type of Selective Amplification " : Effect of Room Noise in Limiting the Max. Amplification usable : etc.].—W. D. Penn. (*Elec. Engineering*, June 1944, Vol. 63, No. 6, p. 228 : summary only.)

3517. NEW INSULATING MATERIAL [from Perlite (Volcanic Glass) exploded like Popcorn & forming a Mass which is Lighter than Cork].—L. L. Boyer. (*Journ. Franklin Inst.*, May 1942, Vol. 233, No. 5, p. 464.)

3518. AN UNEXPLORED MUSICAL RESOURCE [" Coincident Metric Patterns " or " Coincident Metres," produced by the Writing of Contrapuntal Lines in Different Time Signatures, in Ratios More Extended than 2 against 3, or 3 against 4].—E. Murray & H. L. Edsall. (*Journ. Franklin Inst.*, June 1944, Vol. 237, No. 6, pp. 451–467.)

3519. THE SONGS OF INSECTS.—G. W. Pierce. (*Journ. Franklin Inst.*, Aug. 1943, Vol. 236, No. 2, pp. 141–146.)

3520. THE DOPPLER AND ECHO DOPPLER EFFECT.—Perrine. (*See* 3391.)

3521. SUPERSONIC FUNDAMENTALS [Survey of Basic Methods of Generation (including Holtzmann's Glass Tube vibrated by Silk-Covered Belts, giving 33 kc/s at Power Level 100 Times that obtainable with Whistle) : Effects : Applications].—V. J. Young. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 122–125 and 204..212.)

PHOTOTELEGRAPHY AND TELEVISION

3522. QUALITY CONSIDERATIONS IN SCREEN-PROJECTION TELEVISION [Technique using Cathode-Ray Tubes working up to 80 kV, projecting on to Screen made up of Large Number of Concave Mirrors: Drawbacks: General Sources of Picture Distortion: the Radically New A.F.I.F. ("Eidophor") Technique (1988 of June)].—W. Amrein. (*Schweizer Arch. f. angew. Wiss. u. Tech.*, Oct. 1943, Vol. 9, No. 10, p. 293 onwards: summary in *Sci. Abstracts*, Sec. B, May 1944, Vol. 47, No. 557, pp. 88–89.)

3523. TELEVISION BROADCASTING: I—TELEVISION TRANSMITTER AND ANTENNA: II—STUDIO–TRANSMITTER LINKS TECHNIQUE, TELEVISION NETWORKS, AND REBROADCASTING.—J. E. Keister: H. D. Fancher. (*Communications*, May 1944, Vol. 24, No. 5, pp. 30–32: p. 32.) Summaries of A.I.E.E.–I.R.E. lectures.

3524. COLOUR IN TELEVISION [Development, and in particular the C.B.S. System].—P. C. Goldmark. (*Communications*, May 1944, Vol. 24, No. 5, pp. 32, 35, and 82.) Summary of A.I.E.E.–I.R.E. lecture.

3525. TELEVISION PRINCIPLES [and History from 1875 (von Carey) & 1896 (Schöffler) onwards].—P. Mertz. (*Communications*, April 1944, Vol. 24, No. 4, pp. 34 and 35.) Summary of A.I.E.E.–I.R.E. lecture.

3526. TELEVISION PICK-UPS.—R. E. Shelby. (*Communications*, April 1944, Vol. 24, No. 4, pp. 36–37 and 81..84.) Summary of A.I.E.E.–I.R.E. lecture.

3527. ORTHICON CAMERAS [ordinarily used for Outdoor Programmes only] IN TELEVISION STUDIO WORK.—H. R. Lubcke. (*Electronics*, March 1944, Vol. 17, No. 3, p. 103: paragraph only, on a New York Winter Meeting paper.) Highly satisfactory, with certain advantages over the iconoscope, though the latter requires less care and adjustment.

3528. TELEVISION PRIORITY [Rehabilitation of the Devastated Countries should have First Call on Our Trained Scientists & Manufacturing Facilities].—D. A. Bell. (*Wireless World*, Aug. 1944, Vol. 50, No. 8, pp. 252–253.)

3529. TELEVISION COURSE FOR N.B.C. ENGINEERS.—N.B.C. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 266, 268.)

3530. TELEVISION BROADCASTERS FORM ASSOCIATION.—(*Electronics*, March 1944, Vol. 17, No. 3, pp. 280, 282.)

3531. ON THE FLUCTUATIONS PRODUCED BY SHOT EFFECT IN AMPLIFIERS.—Blanc-Lapierre. (*See* 3421.)

3532. FREQUENCY MODULATION OF RESISTANCE–CAPACITANCE OSCILLATORS [for Facsimile Transmission, etc.].—Artzt. (*See* 3447.)

3533. THEORY OF THE HALF-TONE PROCESS: III—DOT SIZE AND HALF-TONE DENSITY.—J. A. C. Yule. (*Journ. Franklin Inst.*, Nov. 1943, Vol. 236, No. 5, pp. 473–487.)

3534. CIRCUIT FOR THE SAW-TOOTH TYPE OF ELECTROSTATIC DEFLECTION IN CATHODE-RAY TUBES [giving a Raster of Varying Line-Length, particularly a Trapezoidal Raster, for Television & Other Purposes].—(*T.F.T.*, Jan. 1944, Vol. 33, No. 1, p. 16, Figs. 1–3.) D.R.P. 738 822, applied for 3/3/38. No name is given.

MEASUREMENTS AND STANDARDS

3535. THE PISTON ATTENUATOR.—Wheeler. (*See* 3414.)

3536. V.H.F. COIL CONSTRUCTION [for Standard Inductances, etc.].—Meyerson. (*See* 3620.)

3537. TWO METHODS OF MEASURING ULTRA-HIGH-FREQUENCY ELECTRIC FIELDS [of the order of 10 Volts/Centimetre, at Frequencies up to 500 Mc/s: the "Induced Dipole" & "Dielectric Thermometer" Methods].—K. Rachel Makinson & H. D. Fraser. (*Phil. Mag.*, June 1944, Vol. 35, No. 245, pp. 355–371.)

Such measurements are usually made with a loop aerial and detector: this method, measuring primarily the magnetic flux linkage with the loop, depends on a knowledge of the relation between the electric and associated magnetic fields. "In the field which it was necessary to measure, in connection with work on h.f. discharges in gases, no simple relation was known, the electric field of wavelength 59 cm being produced between two parallel copper plates 4 cm square and 4.6 cm apart, approximately balanced about earth. The field was generated by a coupled pair of magnetrons. Any method of measuring field strengths at these frequencies, when it involves the use of electron tubes, requires very careful consideration of circuits and components if large errors are to be avoided. The two instruments described here were therefore developed to measure this electric field more directly."

An instrument similar to that developed of the "induced dipole" type was used by Zouckermann (3564 of 1940) to measure potential differences at u.h.f. As now designed it consists of copper vane 2 cm long and broad enough to provide the necessary damping, suspended in a glass protecting tube by a quartz fibre from a torsion head, and carrying a little way below it a system of three small mirrors (at 90°, 135°, 135° to each other) each of which is used in turn to reflect a light-beam on to a scale in the process of setting the strip at 45° to the field and carrying out a measurement. Various refinements embodied in the instrument are described.

Dielectric thermometers were used for the same purpose by Divilkowsky & Filippof (264 of 1936 [*see* also 3082 of 1943 and 859 of March, and the many back references there given]). It was found, by comparison with "induced-dipole" measurements, that calibration by means of the values of the complex dielectric constant of *n*-propyl alcohol of unspecified purity measured by Abadie (2723 of 1937) was correct within the limits of experimental error at 136 Mc/s but not at 510 Mc/s. The thermometer was therefore calibrated against the "induced dipole," which is also more sensitive and quicker to use, though less portable.

With higher field strengths, permitting the use of a shorter conducting strip, the dipole method could be extended to still higher frequencies: " it might also profitably be developed to use a conducting strip one half a wavelength long."

3538. THE "PROBE-TYPE" WAVEMETER: A NEW FORM OF ABSORPTION WAVEMETER [with Exploring Coil (representing about 2% of the Total Inductance) on 13 cm Stem plugged in on Top of Instrument by a Concentric Tubular Plug & Socket (enabling Coil to be Rotated): Diode EB11 as Detector, driving an EM11 Tuning Indicator: Range 40 kc/s to 100 Mc/s, with Seven Interchangeable Coils].—H. J. Wilhelmy. (*Arch. f. Tech. Messen*, June 1943, Part 144, V3614-7, Sheet T68.) This is the paper referred to in 1993 of June.

3539. HETERODYNE FREQUENCY METER [Portable, suitable for Field Work: Range 1–60 Mc/s, with Accuracy 0.002 % or Better: Quickly & Accurately Recalibrated while in the Field: Type SR-90].—A. H. Carr. (*Radio* [New York], June 1944, Vol. 28, No. 6, pp. 24–27 and 68.)

3540. A RESONANT-CAVITY METHOD FOR MEASURING DIELECTRIC PROPERTIES AT ULTRA-HIGH FREQUENCIES [using Small Disc Samples inserted between the Flat Ends of the Cylindrical Posts which form a Re-entrant Part of the Cavity: Precision Differential Screw for Varying the Separation of These Ends after Removal of Disc, to restore Resonance: Q greater than 2000, giving Great Sensitivity to Low-Power-Factor Samples].—C. N. Works, T. W. Dakin, & F. W. Boggs. (*Elec. Engineering*, June 1944, Vol. 63, No. 6, p. 232: summary only.)

A frequency range with a ratio of about 1.5 can be dealt with by each cavity. Accuracies within $\pm$ 0.00005 and $\pm$ 1% can be obtained in tan δ and ϵ routine measurements: operation is simple and rapid.

3541. VERY-HIGH-FREQUENCY BEHAVIOUR OF RADIO COMPONENTS [Measurements of Power Factor & Apparent Capacitance for Several Makes of Capacitors, Sockets, Valves, & Concentric Cables, over a Frequency Range 27.5–200 Mc/s, using a High-Frequency Q-Meter: Desirability of Further Work at Other Temperatures & Humidities].—E. L. Hall. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 114–118.)

3542. CHARACTERISTICS OF RADIO ELECTRONIC COMPONENTS.—A. C. Matthews. (*Radio* [New York], July 1943, p. 24 onwards.) Referred to in 3541, above.

3543. EQUIPMENT AND METHOD FOR MEASUREMENT OF POWER FACTOR OF MICA [" the Best Single Electrical Property indicative of the Suitability of the Mica for Use in Radio Condensers "].—E. L. Hall. (*Proc. I.R.E.*, July 1944, Vol. 32, No. 7, pp. 393–396.)

From the Nat. Bureau of Standards. By the old resistance-variation method the time taken for one measurenent and its working-out was at least 15 minutes: with the new equipment it is about 3 minutes. The test procedure consists of three steps: a preliminary capacitance measurement of the mica specimen with the r.f. bridge, an adjustment of the bridge power-factor dial to zero with respect to the standard air-condenser, and measurement of the p.f. of the specimen by means of the p.f. dial of the bridge. Various refinements have been introduced into the equipment, such as slow-motion devices for the adjustments.

Some results on various specimens of mica are discussed, including the effects of temperature and humidity during the tests, and of heating the mica: in two cases this heating *increased* the p.f. values (" an explanation . . . might be made if the chemical and capillary structures of the mica were known. A limited amount of work has been done in seeking to correlate electrical p.f. with other physical measurements and observations, but without marked success"). The effect of inclusions is also discussed. *See* also 3544, below.

3544. MICA AND QUARTZ [Editorial]: *also* SPOT NEWS, MEASURING Q OF MICA: *and* MICA FOR WAR PURPOSES [Given, 565 of February]. —(Mentioned in Hall's Paper, 3543, above.) " Some information has appeared recently concerning a previously confidential study, arranged by the National Research Council, of mica and means to determine rapidly its suitability for various electrical uses."

3545. EXTREME CLIMATIC CONDITIONS: A RÉSUMÉ OF CLIMATIC FACTORS, THEIR INFLUENCE ON RADIO EQUIPMENT AND COMPONENTS, AND OF METHODS OF TESTING [with Special Reference to Service Equipment].—P. R. Coursey. (*Wireless Engineer*, Sept. 1944, Vol. 21, No. 252, pp. 412–420.)

" It is possible to distinguish at least twenty-one different forms of deterioration caused by climatic factors or the extraneous influences consequent upon peculiar climatic conditions ": these are enumerated and discussed. They can give rise to six different types of failure (structural, mechanical, loss of electrical quality, chemical, internal & external electrical failure). To cover absolutely all these factors and effects in testing " would involve such a prolonged series of tests as would render it impossible either to type-approve or to sample in production." Such tests as can be applied must therefore combine some form of acceleration of the testing conditions and effects, and the writer goes on to discuss the various forms of accelerated testing, to represent tropical conditions, which were unified in the W.T. Board Specification No. K110, modified in 1942 and, it is suggested, now require further modifications or alternatives. *Cf.* 3637, below.

3546. OSCILLATORY TOWER [Pivoted 50-Foot Steel Mast, for testing Radio Apparatus under High Centrifugal & Tangential Forces].—Westinghouse. (*Electronics*, March 1944, Vol. 17, No. 3, p. 341: photograph & caption only.)

3547. DESIGN CONSIDERATIONS IN AIRCRAFT INSTRUMENTS TO MEET WAR SERVICE.—C. F. Savage & J. M. Whittenton. (*Elec. Engineering*, June 1944, Vol. 63, No. 6, p. 226: summary only.)

3548. A Unique Moving-Magnet Ratio Instrument [with Characteristics comparing favourably with Those of Moving-Coil Instruments, and with Added Advantages].—F. R. Sias & D. B. Fisk. (*Elec. Engineering*, June 1944, Vol. 63, No. 6, p. 226 : summary only.)

3549. "Maintenance and Servicing of Electrical Instruments" [Book Review].—J. Spencer. (*QST*, May 1944, Vol. 28, No. 5, pp. 31 and 76.)

3550. Sensitive Cathode-Ray Voltmeter [for Very Low Potentials].—Z. V. Harvalik. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 254..256.) Illustrated summary of the paper dealt with in 862 of March.

3551. "Ein Röhrengerät zur Messung von Leistung, Spannung, und Strom" [Book Review].—A. Spälti. (*Wireless Engineer*, Sept. 1944, Vol. 21, No. 252, pp. 429–430.)
With the valve wattmeter described (the measurement of voltage and current is quite secondary), powers as low as 10^{-5} w can be measured over the frequency range 30–5000 c/s.

3552. Correspondence on "Symbols for Meter Dials" [1659 of May].—G. Keinath : Edgcumbe. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 355..357.)

3553. Measuring Instruments with Suppressed Lower-End Readings.—W. Oesinghaus. (*Arch. f. Tech. Messen*, Feb. 1943, Part 140, J015-8, Sheet T20.) Following on 2000 of June.

3554. The Secondary Loading of the Instrument Transformer by the Instrument and the Connecting Leads.—W. Beetz. (*Arch. f. Tech. Messen*, March 1943, Part 141, Z32-1, Sheet T36.)

3555. The Comparative Advantages of Quartz, Rochelle Salt, and KH_2PO_4 Crystals for Band-Pass Filters.—Matthias & Scherrer. (In paper dealt with in 3434, above.)

3556. Rodometric Examination of Quartz Crystals.—G. J. Holton. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 114–117 and 252, 254.)
"A new optical method of determining the positions of the three axes within a fraction of a degree. It involves grinding and etching a small window on the crystal, and observing the characteristic star-and-spots pattern produced at this window by a light beam." A summary is given in *Journ. Franklin Inst.*, June 1944, Vol. 237, No. 6, pp. 504–505.

3557. The Q-Lap : an Automatic Crystal-Lapping Machine [of the North American Philips Company].—T. W. M. Schaffers. (*Communications*, April 1944, Vol. 24, No. 4, pp. 40–42 and 80.)

3558. The Multivibrator : Applied Theory and Design : Parts II & III.—Shenk. (*See* 3441.)

3559. Changes in Standard Frequency Broadcasts [from WWV : 2.5 Mc/s Frequency added to the Three Original Frequencies : Omission of Pulse on 59th Second of Every Minute].—Nat. Bureau of Standards. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 260..264.) With details of the full service.

3560. Current Stabilisers [Comparison of Degree of Regulation obtainable with Different Types].—van Scoyoc & Schulz. (*See* 3430.)

3561. Dual-Purpose Transitron Oscillator, and Its Uses as a Signal Source and for Dynamic Resistance Measurements.—F. P. Williams. (*Wireless World*, Aug. 1944, Vol. 50, No. 8, pp. 241–242.)

3562. Inductance Bridge for Communications Circuits.—E. Mittelman. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 138–139 and 308, 310.)
"Values of inductance . . . may be measured accurately in terms of a calibrated capacitor and electronic resonance indicator. Low cost is a feature of this instrument", which can be constructed out of radio parts.

3563. Measuring Bridges and Compensators : Survey, Part I [Summary of Papers in Past Issues of the Same Journal, on Theory, Design, & Applications].—W. Geyger. (*Arch. f. Tech. Messen*, March 1943, Part 141, J90-1, Sheet T35.)

3564. Field Testing with Equipment Limitations [Various Tests & Measurements carried out in the Field without Any Calibrated Instruments].—O. J. Smith. (*Communications*, May 1944, Vol. 24, No. 5, pp. 28–29 and 86, 89.)

3565. Electrode Shaping to establish a Uniform Electric Field along High-Voltage Resistors [as used, *e.g.*, in H.T. Measuring Technique].—Shallcross. (*See* 3623.)

3566. War Standards, "Power-Type Wire-Wound Rheostats," "Variable Wire-Wound Resistors," and the Testing of Electrical Insulating Materials.—Am. Standards Association. (*Elec. Engineering*, June 1944, Vol. 63, No. 6, p. 241.)

3567. Standardisation of Resistors [Protest against the Division of Range into 12 Parts : Five Definite Advantages of the Adoption of 10 Parts].—W. Bowen. (*Wireless World*, Aug. 1944, Vol. 50, No. 8, p. 253.)

3568. "The Fourteen Systems of Units" [Book Review].—W. R. Varner. (*Review Scient. Instr.*, April 1944, Vol. 15, No. 4, pp. 99–100.)

3569. "Grösse, Masszahl, und Einheit" [Book Review].—M. Landolt. (*T.F.T.*, Jan. 1944, Vol. 33, No. 1, pp. 20–21.)

SUBSIDIARY APPARATUS AND MATERIALS

3570. Photographing Patterns on Cathode-Ray Tubes [Data on Max. Writing Speeds which can be recorded Photographically with *Commercial* Tubes operating at *Low & Medium* Accelerating Potentials: Procedures for obtaining Max. Speed, with Alignment Charts to simplify Calculation].—Feldt. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 130–137 and 262..268.) With bibliography. Speeds up to 1000 km/s can be recorded under these conditions. From the DuMont laboratories.

3571. Wide-Band Oscilloscope [Compact & Portable, 9-Inch Screen: Amplifier Response essentially Flat up to 4 Mc/s: Time-Base driven by Multivibrator: Unusually High Frequency-Stability by Positive Grid-Bias & Negative Feedback: etc.].—Bartelink. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 122–125.) The work was carried out in 1942 at the General Electric Laboratory.

3572. Use of Oscilloscopes at Very High Frequencies [Commercial Oscilloscopes unsatisfactory at Frequencies above 50 Mc/s, owing to Capacitive Coupling between Vertical & Horizontal Deflection Plates: Satisfactory Solution by Connecting the Horizontal to the Vertical Plate through Small Inductance of Correct Value (Transmission-Line Section as Variable Inductance): Excellent Results on 5-Inch Oscilloscope, up to over 150 Mc/s].—Cutler. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 214, 216.)

3573. Deflected Electron Beams [Reply to Gabor's Letter, 3164 of October].—Harries. (*See* 3484.)

3574. Concerning the Division of Electron and Ion Optics of the American Physical Society [177 of January].—Pierce. (*Journ. Applied Phys.*, July 1944, Vol. 15, No. 7, pp. 517–518.)

3575. Future Electron Microscopy [Summaries of Papers at Meeting of Electron Microscope Society of America, in January, held jointly with American Physical Society].—(*Electronics*, March 1944, Vol. 17, No. 3, pp. 240..248.)

3576. Fresnel Diffraction in the Electron Microscope.—Boersch. (*Physik. Zeitschr.*, June 1943, Vol. 44, p. 202 onwards.)

3577. On the Excitation of Luminescent Zinc Sulphide [Experimental Examination of Riehl's Theory (4263 of 1937) of the Excitation of ZnS(Cu) Phosphors: Its Failure for Persistent Phosphorescence: the Writer's Transfer Mechanism].—Curie. (*Comptes Rendus* [Paris], 5th/26th July 1943, Vol. 217, No. 1/4, pp. 110–112.)

3578. "Luminescence of Liquids and Solids and Its Practical Application" [Book Review].—Pringsheim & Vogel. (*Review Scient. Instr.*, April 1944, Vol. 15, No. 4, p. 100.)

3579. Design of a Vacuum Photographic-Plate Chamber [for Electron-Diffraction Cameras: embodying the Wilson Sliding Vacuum Seal, 1753 of 1941].—Schulz. (*Review Scient. Instr.*, April 1944, Vol. 15, No. 4, pp. 78–80.)

3580. Vacuum in Tubes [Receiving, Power, & Cathode-Ray, etc: Present Trends].—(*Electronics*, March 1944, Vol. 17, No. 3, pp. 248, 250.)

3581. A High-Vacuum Connection [Demountable Joint (also successful as Gland for Longitudinal & Rotational Motion) using Standard Cone-Seated Tank Connection and Rubber (or Lead) Ring].—Moore. (*Journ. of Scient. Instr.*, July 1944, Vol. 21, No. 7, pp. 124–125.)

3582. Two Methods of Sealing-Off Large Exhausting Tubes [Sealing-Off Points of Low Pumping Resistance, to avoid Restriction of Pumping Speed].—George. (*Journ. of Scient. Instr.*, July 1944, Vol. 21, No. 7, p. 125.)

3583. Circuit for the Saw-Tooth Type of Electrostatic Deflection in Cathode-Ray Tubes [giving a Raster of Varying Line-Length].—(*See* 3534.)

3584. *RC*-Oscillator Performance [Practical Performance Data on Relaxation, Transitron, & Phase-Shift Types].—Newitt. (*See* 3432.)

3585. Thermionic Rectifier Circuits [of Proved Performance: Argon-Rectifier Bridge Circuit giving 9 A at 90 V: Three Transformerless Anode Supplies with High Current Ratings: High-Voltage Bridge Rectifier, using 8 Receiver-Type Valves, for Cathode-Ray Tubes].—Hitchcock. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 102–105 and 226..230.)

Among the points on which emphasis is placed are the use of inexpensive tubes and components, the attainment of relatively high current output, and light-weight construction. Operation is from 115 v, 60 c/s supply.

3586. Vibrator–Condenser-Type Power Supplies [a Method of D.C. Voltage Transformation "Employed for Many Years in the High-Voltage Field" but completely Neglected by the Communications Engineer: Modification of Anderson's Rotating-Commutator Scheme (3196 of 1936), using Full-Wave Split-Reed Vibrator: Results & Applications].—Honnell. (*Communications*, May 1944, Vol. 24, No. 5, pp. 25–27 and 52, 54, 64.)

3587. Current Stabilisers [Comparison of Degree of Regulation obtainable with Different Types].—van Scoyoc & Schulz. (*See* 3430.)

3588. On the Theory of Electrostatic Generators [Summary of Final, Simplified Form of the General Quantitative Theory progressively developed in Previous Papers from 1924 to 1933, with Detailed Application].—Simon. (*Journ. Franklin Inst.*, March 1944, Vol. 237, No. 3, pp. 177–196.)

3589. Electrostatic Generators [especially the Band Type: History: Working Principles: Classification: Voltage: Current: Characteristic Curves: Designs: Applications].—Neubert. (*Naturwiss.*, 3rd [18th on Cover] Dec. 1943, Vol. 31, No. 49/50 [49/52 on Cover], pp. 584–588.) The work, still proceeding, of Joffe & Hochberg (4459 of 1940) in developing disc-type generators to give large currents is referred to at the end.

3590. A New Portable A.E.G. Universal Recorder, Model RM.—Lingg & Zacher. (*AEG-Mitteilungen*, Sept./Dec. 1942, No. 9/12, pp. 68–70.)

One of the striking properties of the new model, apart from its portability, is its low dependence on frequency. In the 75 v range the error is only 2.5% at 2 kc/s, in the 30 mA range the same error is not reached below 5 kc/s.

3591. Discussion on "Aircraft Contactors" [236 of January].—Russell & Charbonneau. (*Supp. to Elec. Engineering, Transactions Section*, Dec. 1943, Vol. 62, p. 980.)

3592. The Motion at "Break" in Low-Voltage Switching Appliances [Velocity & Time calculated by Graphical Integration: Values of Contact-Arm Mass which Increase & Decrease the Contact Force].—Laig-Hörstebrock. (*E.T.Z.*, 13th Jan. 1944, Vol. 65, No. 1/2, pp. 1–4.)

3593. Notes on Transformer Design [for the Reduction of Stray Fields, producing Extraneous Noise, in Power Transformers, Filter Reactors, & A.F. Transformers: Astatically Balanced Coils, Small Size, High Efficiency: Fully Interleaved Core Assemblies: Shielding: Dessication & Sealing].—Harrison. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 106–109 and 382, 388.) From the Altec Lansing Corporation.

3594. Iron Powder [GAW Carbonyl Iron Powder "L," giving Specially High Permeability, etc.].—General Aniline & Film. (*Review Scient. Instr.*, April 1944, Vol. 15, No. 4, p. 113.)

3595. Mechanical Problems of Permanent-Magnet Design [Alnico Machining Tolerances, Casting Allowances, Choice of Alloys, Cost Factors, etc: Emphasis on Practical Data obtained through Actual Experience].—Underhill. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 126–129 and 374, 376.) In the series dealt with in 3238 of October and back references.

3596. Magnetism in Theory and Practice [Thirty-Fifth Kelvin Lecture].—Stoner. (*Electrician*, 5th May 1944, Vol. 132, No. 3440, pp. 379–381.) *See* also "A General Theoretical Explanation of the Properties of Ferromagnetic Materials", *Elec. Review*, 5th May 1944, Vol. 84, No. 3467, p. 626.

3597. Glass for Precision Gauges [to conserve Steel: Very Definite Advantages].—Hambleton. (*Journ. Franklin Inst.*, Aug. 1943, Vol. 236, No. 2, p. 198: summary only.)

3598. Glass as a Rival to Plastics for Delicate and Precision Parts and Insulators [New Forming Process].—(*Electronics*, Feb. 1944, Vol. 17, No. 2, p. 268: paragraph only.)

3599. Electronics in Plastics Industry [Advantages of H.F. Heating: Four Improvements Still Necessary, including a Better Method of heating Moulded Powder to eliminate Need for Preforms, and an Ideal Moulding Material that will Not Gas or Sweat excessively].—Blessing. (*Electronics*, March 1944, Vol. 17, No. 3, p. 260: summary of address.)

3600. A Study of Organic Insulating Materials [Synthetic Resins & Rubbers: particularly wirh regard to obtaining Best Properties by Control of Form of Macro-Molecule].—Stäger & others. (*Sci. Abstracts*, Sec. B, May 1944, Vol. 47, No. 557, p. 77.) For another paper by Stäger on modern insulating materials *see* 1684 of May.

3601. Symposium on the Physics of Rubber and Other High Polymers [at November, 1943, Meeting of American Physical Society].—(*Journ. Applied Phys.*, April 1944, Vol. 15, No. 4, pp. 293–405.) *See* also below.

3602. Light Scattering in Solutions [in connection with Optical Analysis of Solutions of Polymers].—Debye. (*Journ. Applied Phys.*, April 1944, Vol. 15, No. 4, pp. 338–342.) One of the papers in the symposium referred to in 3601, above.

3603. Elasto-Viscous and Stress-Optical Properties of Commercial Polymerised Methyl Methacrylate as a Function of Temperature.—Robinson & others. (*Journ. Applied Phys.*, April 1944, Vol. 15, No. 4, pp. 343–351.) In the symposium referred to in 3601, above.

3604. Hysteresis Losses in High Polymers [and the Question how far Dielectric & Elastic Behaviour parallel Each Other].—Sack & others. (*Journ. Applied Phys.*, April 1944, Vol. 15, No. 4, pp. 396–397.) In the symposium referred to in 3601, above.

3605. Thermal Expansion and Second-Order Transition Effects in High Polymers: Part I—Experimental Results [on Saran, Polystyrene, & Polystyrene *plus* Polyolefins].—Boyer & Spencer. (*Journ. Applied Phys.*, April 1944, Vol. 15, No. 4, pp. 398–405.) In the symposium referred to in 3601, above.

3606. The Polymerisation of Styrene in the Presence of Nitrothiophene and Chloranil, *and* Chain Transfer in the Polymerisation of Styrene: the Reaction of Solvents with Free Radicals.—Price: Mayo. (*Sci. Abstracts*, Sec. A, June 1944, Vol. 47, No. 558, p. 130: p. 130.)

3607. Polystyrene Globules of High Purity prepared by Suspension Polymerisation [and the Importance of Careful Control of the Hydrodynamic Conditions].—Hohenstein & Mark. (*Journ. Applied Phys.*, June 1944, Vol. 15, No. 6, p. 515 and Cover.)

3608. "ELASTIC AND CREEP PROPERTIES OF FILAMENTOUS MATERIALS AND OTHER HIGH POLYMERS" [Book Review].—Leaderman. (*Review Scient. Instr.*, April 1944, Vol. 15, No. 4, p. 101.) "Fulfils a long-standing need. . ."

3609. CHEMICALLY TRANSMUTED WOOD, *and* TRANSMUTATION OF WOOD.—du Pont de Nemours: U.S. Forest Products Laboratory. (*Journ. Franklin Inst.*, June 1944, Vol. 237, No. 6, pp. 505–506: p. 507.)

Summaries of papers in *Chem. & Eng. News* and *Nature*: (i) the methylolurea treatment (2977 of September): (ii) "It was believed for some years that the use of synthetic resins was essential . . . but only recently the U.S. Forest Products Laboratory has demonstrated that much of what is done by the earlier processes can be achieved through the use of heat and pressure alone."

3610. CYCLEWELD—A NEW BONDING PROCESS [using Cycleweld Cement, a Thermosetting Plastic].—Chrysler Corporation. (*Journ. Franklin Inst.*, March 1944, Vol. 237, No. 3, p. 218: summary, from *Modern Plastics*, Vol. 21.)

3611. SYNTHETIC SHELLAC ["Zinlac"].—Zinsser & Company. (*Review Scient. Instr.*, April 1944, Vol. 15, No. 4, p. 113.) *Cf.* 1691 of May.

3612. DULAC FUNGAS-RESISTANT LACQUER NO. 86 FOR COMMUNICATIONS EQUIPMENT IN THE TROPICS.—Maas & Waldstein Company. (*Radio* [New York], June 1944, Vol. 28, No. 6, p. 39.)

3613. INFLUENCE OF HUMIDITY ON DIELECTRIC PROPERTIES OF HIGH-FREQUENCY CERAMICS.—Hausner. (*Journ. Am. Ceramic Society*, 1st June 1944, Vol. 27, No. 6, pp. 175–181.)

Author's summary:—"The relation between humidity and dielectric properties of ceramics has been shown to be influenced by almost the same factors that determine the dielectric properties themselves. The influence of humidity on dielectric properties depends on the composition of the material, compacting pressure, firing temperature and time, and surface conditions; it is also dependent on the testing frequency, temperature and air pressure, and perhaps many other unknown components.

"It is this great number of variables that . . . offers explanation for the fact that measurements on dielectric properties of ceramic material show entirely different results even though all measurements be made at exactly the same relative humidity."

3614. TALCS FOR USE IN RADIO CERAMIC INSULATORS, *and* PHYSICAL TESTING OF TALC FOR HIGH-FREQUENCY CERAMICS.—Klinefelter & others: Speil. (*Sci. Abstracts*, Sec. B, June 1944, Vol. 47, No. 558, p. 97: p. 97.)

3615. ANOMALIES IN THE CRYSTALLINE STRUCTURE OF MICA [Results of X-Ray Structural Studies on Brazil & Madagascar Micas, before & after Heat Treatment].—Nat. Bureau of Standards. (*Journ. Franklin Inst.*, March 1944, Vol. 237, No. 3, pp. 216–217.)

3616. PAPERS ON THE TESTING OF MICA FOR ITS SUITABILITY FOR USE IN RADIO CONDENSERS, ETC.—Hall & others. (*See* 3543 & 3544.)

3617. RESONANCE IN BY-PASS MICA CAPACITORS [with Chart giving Lead Lengths & Capacitance Values for Series Resonance at Any Frequency from 5 to 800 Mc/s, for Postage-Stamp Mica By-Pass Capacitors with No. 20 Tinned Copper Leads].—Green & McComb. (*Electronics*, March 1944, Vol. 17, No. 3, p. 119.)

3618. NEW MATERIAL FOR CAPACITORS ["Lectrofilm," Synthetic Material prompted by Shortage of High-Grade Mica].—General Electric. (*Electronics*, Feb. 1944, Vol. 17, No. 2, p. 336: paragraph only.)

3619. THE CAPACITANCE OF ARRANGEMENTS WITH PLANES AND CYLINDERS [with Uniform & Stratified Dielectrics], *and* ENERGY WASTED IN CHARGING A CONDENSER.—Moeller: Wouk. (*See* 3445 & 3446.)

3620. V.H.F. COIL CONSTRUCTION [for Standard Inductances & Other Purposes], *and* COIL Q-FACTORS AT V.H.F.—Meyerson. (*Communications*, April 1944, Vol. 24, No. 4, pp. 29–31: May 1944, No. 5, pp. 36–38 and 83, 84.)

(i) "In the course of constructing coils of exacting dimensions for use as standard inductances, and also for investigating Q stability factors, it was found necessary to use wire-sizes from 12 to 18 on lucite and polystyrene coil-forms varying from ½" to 1½" in diameter. The usual problems involved in getting uniform results in winding these heavier wire sizes were encountered, as well as considerable variation in inductance values due to differences of coil-form dielectric constants and variation in wire diameter." The paper deals with the steps taken to overcome these difficulties: they include deep, triangular grooving, the use of a tension flange to secure uniform strain on the wire, and the use of a threaded adjustable core of lucite or polystyrene for compensation. Some typical coil results and Q graphs are included.

(ii) "The original intent of the experiments was to investigate the possible development of some formula that would indicate the effects of varying coil parameters on Q. However, a recapitulation of results showed that it was simpler and more effective to gather all the data within the usable limitations of standard practice, and simply note the trends." Some of these trends are shown graphically, some (including the effect of cotton covering) in tabular form.

3621. VERY-HIGH-FREQUENCY BEHAVIOUR OF RADIO COMPONENTS [Capacitors, Sockets, Valves, & Concentric Cables], *and* CHARACTERISTICS OF RADIO ELECTRONIC COMPONENTS.—Hall: Matthews. (*See* 3541/2.)

3622. THE APPLICATIONS OF STATISTICS TO DIELECTRICS ["bring forth Three Important Engineering Problems which, heretofore, have Not been given the Consideration they deserve"].—Summers & Ross. (*Elec. Engineering*, June 1944, Vol. 63, No. 6, p. 235: summary only.)

3623. Electrode Shaping to establish a Uniform Electric Field along High-Voltage Resistors.—Shallcross. (*Journ. Franklin Inst.*, May 1942, Vol. 233, No. 5, pp. 471–484.)

"An electrode design is developed for the purpose of obtaining a constant potential gradient along the surface of a cylinder. Such a design is important in a high-voltage low-current resistance in order that the voltage drop per unit of resistance be constant. It is found that the dimensions of such a resistor and its associated electrodes can be reduced considerably by the proper electrode design . . . It is thought that an electrode system designed on these principles would simplify the problem of insulation and measurement of high voltages."

3624. Copper-Covered Steel Wire at Radio Frequencies.—Teare & Schatz. (*See* 3479.)

3625. Stainless-Steel-Sheathed Aerial Cable [Experimental Type: Comparison with the Normal Lead-Sheathed Type].—Moffatt. (*P.O. Elec. Eng. Journ.*, Jan. 1944, Vol. 36, Part 4, pp. 107–109.)

3626. Levulinic Acid, derived from Starch, as a Fluxing Agent for Soldering of Steel Parts in Radio Equipment [avoiding the Washing-Off Process necessary with Other Fluxes].—R.C.A. (*Journ. Applied Phys.*, April 1944, Vol. 15, No. 4, p. 406: paragraph only.)

3627. Three Metals Plated Simultaneously [Process developed primarily for Copper or Brass Parts of Aircraft Instruments carrying H.F. Currents, to give High Surface Conductivity & Resistance to Corrosion: Special Plating Anodes of Copper–Tin–Zinc Alloy].—Westinghouse. (*Journ. Franklin Inst.*, April 1944, Vol. 237, No. 4, p. 328: summary, from *Iron Age*, Vol. 153.)

3628. Black Nickel Plating: I & II.—Poor. (*Sci. Abstracts*, Sec. B, April 1944, Vol. 47, No. 556, pp. 67–68.)

3629. Stellite Alloy [for Pivots, Gramophone Needles, etc.].—Haynes Stellite. (*Electronics*, March 1944, Vol. 17, No. 3, p. 288.) *See* also 1693 of May.

3630. Electronic Dew-Point Indicator [for Heat-Treatment Atmospheres: continuously reporting on Unwanted Water-Vapour & Oxygen Content].—Westinghouse. (*Journ. Applied Phys.*, June 1944, Vol. 15, No. 6, p. xviii.) "A tiny stream of the gas mixture is drawn across an electron beam . . ."

3631. Lithium-Controlled Atmosphere [for Metallurgical Processes: using Lithium's Strong Affinity for Oxygen, Water Vapour, and Carbon Monoxide & Dioxide].—Lithium Company. (*Journ. Applied Phys.*, June 1944, Vol. 15, No. 6, p. xviii.)

3632. Cement for Instrument Windows [replacing Putty: Saves Time and Seals More Tightly].—Westinghouse. (*Review Scient. Instr.*, April 1944, Vol. 15, No. 4, p. 113.)

3633. Output of Over-Age Dry Batteries.—Nat. Bureau of Standards. (*Journ. Franklin Inst.*, June 1944, Vol. 237, No. 6, p. 469: paragraph on recent Reports.)

STATIONS, DESIGN AND OPERATION

3634. A 337-Mc/s Frequency-Modulated Studio–Station Link [from Winston-Salem Studios of WMIT to the Transmitter on Clingman's Peak, 116 Miles away].—Dillon. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 104–107.)

At the transmitter, the "square-corner" reflector type of aerial was replaced by a two-wire horizontal rhombic aerial (with a leg-length of 4.2λ) which was found to be consistently better. A single-wire rhombic aerial (with some special constructional details which are described) similarly replaced a square-corner system at the receiving end, and gave increased signals and a reduction of background noise.

Six cases of severe tropospheric fading have occurred in the past seven months, causing a loss of about three hours of air time during that period. "We have been unable to notice any characteristic of weather conditions that occurs coincidentally with the fading, other than the effect of billowy clouds in the path of the signal. The effect of such clouds is not necessarily direct, from what information we have gathered. Fading is apparently due to some condition of humidity or temperature in the air surrounding or immediately adjacent to the cloud layer. With cloud banks low and in the transmission path, the signal may fade. With clouds at a higher level, an exceptionally strong signal rather than a fade is often noticed. It has been noted that when the path between Winston-Salem and Clingman's Peak contains rain or dense clouds over most of its length the signal received is unusually strong, but dense fog or clouds at one end of the circuit only causes no apparent change in signal."

3635. Frequency-Modulation Broadcasters, Incorporated [F.M.B.I.]: Convention at New York Winter Meeting [including Approved Recommendations].—F.M.B.I. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 328..332.)

3636. Watt Power—a Report [Analysis of Arguments *pro & con* a Lower Power Level for Post-War Amateur Operation].—Warner. (*QST*, May 1944, Vol. 28, No. 5, pp. 7–9.) *Cf.* 2353/5 of July.

3637. "Jungle-Proof" Sets [New Zealand Engineers produce Transmitter–Receiver subjected for Six Hours to Temperature of 140°F & Humidity of 100%].—(*Wireless World*, Aug. 1944, Vol. 50, No. 8, pp. 247–248: short summary.)

3638. Modifying Radio Equipment for Military Applications [illustrated by the Conversion of the HT-12 Marine Radio Telephone into the SCR-543].—Hallicrafters Company. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 98–101.) *Cf.* Read, 3138 of October.

3639. Captured Axis Equipment: the German FUG-10 Panel [for Bomber & Reconnaissance Aircraft].—Gordon. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 94–97.) Containing two transmitters and receivers, d.f. and blind-landing gear, and intercom. system. *See* also p. 103 and 326.

3640. RADIO IN AVIATION [Work of the C.A.A: Application to Post-War Private Flying].—Stanton. (*See* 3494.)

3641. RADIO-TELEGRAPH RELAYS: AUTOMATIC RE-TRANSMISSION OF SIGNALS [in the Cable & Wireless Network].—Smale. (*Wireless World*, Aug. 1944, Vol. 50, No. 8, pp. 229–232.) *See* also 3281 of October.

3642. THE USE OF FIELD-INTENSITY MEASUREMENTS FOR COMMERCIAL-COVERAGE EVALUATION [and the Work of the "Radio Coverage Reports" Service].—Felix. (*Proc. I.R.E.*, July 1944, Vol. 32, No. 7, pp. 381–393.)

"The familiar field-intensity survey, showing the 10.0, 2.0, and 0.5 mv/m contours, defining good urban, suburban, and rural service, has not established itself, by more than a decade of general use, as the satisfactory answer to the requirements of the time buyer." A field survey of the north-eastern states, carried out by the Service, proved that no fixed set of standard values "would serve the purposes of commercial evaluation or would be productive of coverage maps tending to coincide with the disclosures of listener station-utilisation findings." The Service therefore developed a system of reporting "complete spectrum observations" (Figs. 2–4), defining "day and night physical delivery" *of every audible station* in cities of over 25 000 population and at intermediate rural points: "as a general rule of thumb, a service is not of outstanding commercial value, regularly and normally capable of retaining a useful proportion of the audience," *if five or more stations* are of substantially higher classification [incidentally, "while Radio Coverage Reports are not directly concerned with the causes of fading, a correlation between barometric conditions and stability of distant services was frequently noted. When the greatest difference in barometric pressure between station and reception point existed, greater stability in reception from distant clear-channel stations was regularly observed; conversely, when the signal path follows a barometric trough, fading tends to be more severe."]

From these investigations the concept of a "prevailing standard" was developed and was found to agree with the results of an extensive "coincidental listener survey" (depending on telephonic enquiries), and the paper's final section deals with "possibilities of mapping station and network areas to 'prevailing service' standard."

3643. "RADIO-AUDIENCE MEASUREMENT" [Book Review].—Chappell & Hooper. (*Proc. I.R.E.*, July 1944, Vol. 32, No. 7, pp. 438–439.) *See* also 3644, below.

3644. PROPOSED NEW SERVICE, "CENTERCASTING".—Goldsmith. (*See* 3680.)

3645. REAL INTERNATIONAL BROADCASTING: PROPOSALS FOR A EUROPEAN ALLIANCE.—Hubert, Eckersley, & Tenenbaum. (*Wireless World*, Aug. 1944, Vol. 50, No. 8, pp. 234–235 and 246.)

3646. CARRIER CURRENT FOR RAILROAD COMMUNICATION [Belvidere–Delaware Branch].—(*Electronics*, April 1944, Vol. 17, No. 4, pp. 146 and 148.) *See* also 2762 of August.

3647. COPPER-COVERED STEEL WIRE AT RADIO FREQUENCIES.—Teare & Schatz. (*See* 3479.)

GENERAL PHYSICAL ARTICLES

3648. SPECIAL THEORY OF RELATIVITY IN HYPERBOLIC FUNCTIONS [including a Demonstration of the Advantages of These Functions in Restricted Relativity, by considering the Theories of the Aberration of Light and of Fizeau's Experiment].—Karapetoff. (*Reviews of Mod. Phys.*, Jan. 1944, Vol. 16, No. 1, pp. 33–52.)

3649. CURVILINEAR PROPAGATION OF ELECTROMAGNETIC ENERGY IN A RIEMANN CONTINUUM.—Dive. (*Comptes Rendus* [Paris], 5th/26th July 1943, Vol. 217, No. 1/4, pp. 104–106.)

3650. ON THE REPRESENTATION OF THE ELECTROMAGNETIC QUANTITIES IN THE QUANTUM THEORY OF FIELDS AND IN THE WAVE MECHANICS OF THE PHOTON.—de Broglie. (*Comptes Rendus* [Paris], 5th/26th July 1943, Vol. 217, No. 1/4, pp. 89–92.)

3651. "ELEMENTARY WAVE MECHANICS: INTRODUCTORY COURSE OF LECTURES" [Book Review].—Heitler. (*Nature*, 22nd July 1944, Vol. 154, No. 3899, p. 101.)

3652. ON THE MOBILITY OF FREE ELECTRONS IN ARGON [Determination of the Transit Speed under the Action of a Uniform Electric Field, by the Author's X-Ray Pulse Method (*cf.* 2850 of September)].—Herreng. (*Comptes Rendus* [Paris], 5th/26th July 1943, Vol. 217, No. 1/4, pp. 75–77.)

3653. THE MOBILITIES OF ELECTRONS IN HELIUM [calculated on Basis of Writer's Electron-Energy-Distribution Formula: Agreement with Measured Values].—Llewellyn Jones. (*Proc. Phys. Soc.*, 1st July 1944, Vol. 56, Part 4, No. 316, pp. 239–248.)

3654. DOPPLER EFFECT IN POSITIVE RAYS OF HYDROGEN, *and* IONISATION POTENTIAL AND DOPPLER EFFECT IN HYDROGEN POSITIVE RAYS.—Dasannacharya & others. (*Nature*, 1st July 1944, Vol. 154, No. 3896, pp. 21–22: pp. 22–23.)

3655. AN INVESTIGATION OF THE EXISTENCE OF "MAGNETIC" CURRENTS.—Millest: Ehrenhaft. (*Phil. Mag.*, May 1944, Vol. 35, No. 244, pp. 342–345.) *See* 3018 of September and back references. Kendall's independent conclusions are supported. For Goldman's account of Westinghouse experiments also leading to rejection of the theory see *Radio* [New York], June 1944, Vol. 28, No. 6, pp. 38 and 58..66.

MISCELLANEOUS

3656. On van der Pol's and Related Non-Linear Differential Equations.—Shohat. (*Journ. Applied Phys.*, July 1944, Vol. 15, No. 7, pp. 568–574.)

"The present paper is closely related to a previous one by the author (1619 of 1943). First, we correct a consequential error in the said paper. Secondly, by a simple application of Parseval's formula we are able to establish directly the following fundamental result:—If the equation $d^2u/dt^2 - \epsilon F(u)(du/dt) + u = 0$—generalisation of van der Pol's equation—has periodic solutions, of period close to 2π, then, under certain general conditions concerning $F(u)$, such a solution $u(t)$ is *strongly dominated* by the first term of its Fourier expansion; that is, not only $u(t)$ but also $u'(t)$, $u''(t)$, $u'''(t)$ can be approximated closely, for all t, by the said first term—simple harmonic oscillation—and its corresponding derivatives. An algebraic equation is set up for the determination of the amplitude A_1 of this harmonic oscillation, and van der Pol's result ($A_1 \sim 2$) is confirmed.

"Thirdly, for van der Pol's equation we set up expansions of $u(t)$ and its frequency ν in power series, in terms of ϵ, $0 < \epsilon \ll 1$. Finally, for the same $u(t)$ and ν we obtain, for the first time, we believe, other series expansions in terms of ϵ, *for all values of* ϵ, *large and small.* The values of ν computed from the first few terms of the new series agree quite well with experimental results. The method employed is applicable to more general equations."

3657. On the Forced Vibrations of Non-Linear Springs.—Wylie. (*Journ. Franklin Inst.*, Sept. 1943, Vol. 236, No. 3, pp. 273–284.)

"The present note is a quantitative study of the problem, and consists of a comparison of several methods of approximate solution in relation to accurate solutions obtained by numerical integration. One of these methods, which incidentally seems to be of rather wide application to problems formulated in terms of non-linear differential equations, or differential equations with periodic coefficients, is found to be of high accuracy over most of the range of the parameters of the problem, and admits, moreover, of a simple graphical representation . . . in the form of a pair of nomograms. . ."

3658. A Rapid Method of Inversion of Certain Types of Matrices [occurring in Vibration Problems, etc.].—Saibel. (*Journ. Franklin Inst.*, March 1944, Vol. 237, No. 3, pp. 197–201.)

3659. Mechanical Vibrations: Their Cause and Prevention [including the "Galloping Wire" Phenomenon in Long-Span Lines under Wind-Action].—Inglis. (*Engineer*, 23rd June 1944, Vol. 177, No. 4615, pp. 489–490.) Extracts from the 50th James Forrest Lecture.

3660. Some Refinements in Methods of Graphical Integration.—Donnell. (*Journ. Franklin Inst.*, April 1942, Vol. 233, No. 4, pp. 331–348.)

3661. Differentiation with the Cinema Integraph [4107 of 1940].—Pekeris & White. (*Journ. Franklin Inst.*, July 1942, Vol. 234, No. 1, pp. 17–29.)

3662. An Extension of Dawson's Table of the Integral of e^{x^2} [involved, for example, in Investigations of Short-Wave Oscillators].—Terrill & Sweeny. (*Journ. Franklin Inst.*, June 1944, Vol. 237, No. 6, pp. 495–497.)

3663. Zeros of Bessel Functions [Tables giving Positive Real Roots between 0 & 25 for Function & First Derivative of Bessel Functions of the First Kind].—Smith & others. (*Journ. Franklin Inst.*, April 1944, Vol. 237, No. 4, pp. 301–303.)

3664. "Tables of the Bessel Functions $J_0(z)$ and $J_1(z)$ for Complex Arguments", *and* "Table of the Reciprocals of the Integers from 100 000 through 200 000" [Book Reviews].—Mathematical Tables Project. (*Phil. Mag.*, May 1944, Vol. 35, No. 244, pp. 353–354: p. 354.)

3665. Some Improvements in Practical Fourier Analysis, and Their Application to X-Ray Scattering from Liquids [dispensing with Mechanical Analyser even when Number of Coefficients is Very Large].—Danielson & Lanczos. (*Journ. Franklin Inst.*, April & May 1942, Vol. 233, Nos. 4 & 5, pp. 365–380 & 435–452.)

3666. Note on the Theory of Series (XXIII): On the Partial Sums of Fourier Series.—Hardy & Littlewood. (*Proc. Cambridge Phil. Soc.*, June 1944, Vol. 40, Part 2, pp. 103–107.)

3667. "Fourier Series" [Book Review].—Hardy & Rogosinski. (*Nature*, 29th July 1944, Vol. 154, No. 3900, pp. 130–131.) No. 38 of "Cambridge Tracts in Mathematics & Mathematical Physics".

3668. The Applications of Statistics to Dielectrics.—Summers & Ross. (*See* 3622.)

3669. "Statistical Adjustment of Data" [Book Review].—Deming. (*Journ. Franklin Inst.*, May 1944, Vol. 237, No. 5, p. 433.)

3670. A Model for Quantitative Statistical Experiments [simulating, for example, Quality-Control Investigations on Production Processes: for Instructional Purposes].—Turner. (*Engineer*, 14th July 1944, Vol. 178, No. 4618, pp. 26–27.)

3671. A Note on Tolerance Limits [and the Quality-Control Problem of the Determination of These Limits when the Variability of the Product is known to be due to Random Factors].—Paulson. (*Sci. Abstracts*, Sec. A, June 1944, Vol. 47, No. 558, pp. 110–111.)

3672. The Industrial Lot and Its Sampling Implications.—Simon. (*Journ. Franklin Inst.*, May 1944, Vol. 237, No. 5, pp. 359–370.)

"It is shown that wrong inferences are drawn from samples because of failure to understand what constitutes a lot and because of failure to verify the existence of a lot in the practically useful sense. Time-tried methods of making valid inferences from samples without increased cost are pointed out."

3673. The Accumulation of Chance Effects and the Gaussian Frequency Distribution.—Silberstein. (*Phil. Mag.*, June 1944, Vol. 35, No. 245, pp. 395–404.)

"It has often been surmised, either quantitatively or in a more or less vague qualitative way, that Gauss's law of error or the so-called normal frequency distribution of deviations from a mean would be produced by the cooperation of a great number of independent causes, if the effect of each of these taken separately is uncertain within some limits. In the research field of photography, this question is of particular interest in connection with the size–frequency distribution among the grains or silver-halide crystals of an emulsion. A clear insight into the *modus operandi* of such a plurality of causes may also be useful in a variety of other situations.

"The object of the present paper is to determine rigorously the probability of any resultant effect of a number *n* of independent causes or processes, as the accumulation of their individual chance effects, and to investigate the limiting form to which this probability tends with increasing *n* . . ." *See* also 1457 of April.

3674. "Mathematics for Engineers," "Physics for Engineers," "Chemistry for Engineers," *and* "Mechanics for Engineers" [Review of Series of Volumes].—Fleming. (*Phil. Mag.*, May 1944, Vol. 35, No. 244, pp. 351–352.)

3675. "Hyper- and Ultra-High-Frequency Engineering" [Book Review].—Sarbacher & Edson. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 334..337.) Summarised extracts from this book were dealt with in 63 of January and back reference.

3676. "Radio Technology" [Book Review].—Weller. (*Wireless World*, July 1944, Vol. 50, No. 7, p. 208.) For another review *see* 1738 of May.

3677. "Basic Radio" [Book Review].—Boltz. (*Proc. I.R.E.*, July 1944, Vol. 32, No. 7, p. 439.)

The reviewer (Preisman) ends by expressing the wish that "elementary engineering texts were written by world-famous engineers who have matured to the point where they have penetrated the jungle of detail and once more see the broad aspects of the subject." For a previous review *see* 2094 of June.

3678. "Practical Radio and Electronics Course, Three Volumes" [Book Review].—Beitman. (*Proc. I.R.E.*, July 1944, Vol. 32, No. 7, p. 439.)

3679. "Radio-Audience Measurement" [Book Review].—Chappell & Hooper. (*Proc. I.R.E.*, July 1944, Vol. 32, No. 7, pp. 438–439.) *See* also 3680, below.

3680. Proposed New Service, "Centercasting."—Goldsmith. (Mentioned in Review, 3679, above.)

In that book review Goldsmith remarks: "Recently there has been brought to the attention of . . . the R.T.P.B. the matter of providing experimental facilities . . . for a new service termed 'centercasting'. This service involves two-way communication between a central transmitting and receiving station, on the one hand, and, on the other, a considerable number of surrounding voter and respondent stations (each also having a transmitter and a receiver). Thus questions can be asked of the audience, and the answers of the listeners can be speedily obtained by radio. The process is applicable not only to broadcasting itself, as is highly appropriate, but also to many commercial, political, and sociological inquiries. Possibly centercasting will find its place in later editions of this book."

3681. Real International Broadcasting: Proposals for a European Alliance.—Hubert, Eckersley, & Tenenbaum. (*Wireless World*, Aug. 1944, Vol. 40, No. 8, pp. 234–235 and 246.)

3682. Twenty Years of German Broadcasting Engineering [from the Date of the First Transmission from the Berlin "Voxhaus", 29th October, 1923].—Meinel. (*T.F.T.*, Nov. 1943, Vol. 32, No. 11, pp. 245–246.)

3683. Newspaper Ownership of Broadcasting Stations [F.C.C. Decision].—F. C. C. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 264, 266.)

3684. School Broadcasting.—Cameron. (*Journ. Roy. Soc. Arts*, 9th June 1944, Vol. 92, No. 4667, pp. 341–347: Discussion pp. 347–349.)

3685. Transcriptions for Schools [available on Loan: selected from "Adventures in Research" (Weekly Radio Feature)].—Westinghouse. (*Electronics*, March 1944, Vol. 17, No. 3, p. 272.)

3686. Radio Division in State Department [Recent Reorganisation of State Department raises Status of Telecommunications Section to a Division].—(*Electronics*, March 1944, Vol. 17, No. 3, p. 260.)

3687. War Facts and Post-War Fancies ["Post-War Prospects for Home Radio, Frequency-Modulation, & Television are Bright: Industrial Electronics is still the Enigma"].—Henney. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 92–93 and 212..224.) For remarks on the chief deterrent to the wider adoption of electronic devices by industry *see* p. 91.

3688. "A Primer of Electronics" [for Salesmen, Workers engaged in Electronic Production, etc: Book Review].—Caverly. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 337, 338.)

3689. Remarks on the Writing of Technical Articles in Plain English and Otherwise.—Ready. (*QST*, May 1944, Vol. 28, No. 5, p. 69.)

3690. The Use of the Term "Potentiometer" to mean "Voltage Divider" [is "on a Very Low Level of Intelligence"].—MacGahan. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 355 and 356.)

3691. Radio *versus* Industrial Symbols [Correspondence prompted by Editorials, 1035 of March & 1771 of May].—(*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 357..360.)

3692. "Illustrated Technical Dictionary" [Book Reviews].—Newmark (Edited by). (*Nature*, 12th Aug. 1944, Vol. 154, No. 3902, p. 193: *Proc. I.R.E.*, July 1944, Vol. 32, No. 7, p. 440.)

3693. Clearing-House for Technical Translations established.—American Documentation Institute. (*Elec. Engineering*, June 1944, Vol. 63, No. 6, p. 238.) With the cooperation of the Office of Alien Property Custodian.

3694. The Decimal System of the *Archiv für Technisches Messen* [Explanation and List of Subjects & Their Subdivisions].—(*Arch. f. Tech. Messen*, Jan. 1943, Part 139, V01-4, Sheets T1–T3.)

3695. Scientific Research [Some Aspects which have Not been Sufficiently Considered in the "Very Interesting & Very Hopeful Discussion" in the Issue for 6th May].—Cockerell. (*Nature*, 12th Aug. 1944, Vol. 154, No. 3902, p. 214.) Including the necessity for provision for adequate publication: *e.g.* of shorter papers to keep the scientific world aware of what is going on, and to encourage cooperation.

3696. Science and the Scheme of Things.—Whitney. (*Journ. Franklin Inst.*, April 1944, Vol. 237, No. 4, pp. 265–270.) "Pure research thus far has been quite personally independent and always unpopular—until after the event . . ."

3697. University Research Fellowships.—I.C.I. (*Wireless Engineer*, Sept. 1944, Vol. 21, No. 252, p. 431.)

3698. The Charles L. Mayer "Nature of Light" Awards.—Nat. Science Fund. (*See* 3407.)

3699. "Report on the Extension of Scientific Research in Manchester University, particularly in Relation to the Industries of Its Area" [Article on].—(*Nature*, 12th Aug. 1944, Vol. 154, No. 3902, pp. 216–217.) "Of much more than local interest . . ."

3700. Industrial Research under Free Enterprise.—Ruthenburg. (*Elec. Engineering*, June 1944, Vol. 63, No. 6, pp. 210–215.)

3701. Stevens Research Foundation [Formation of Non-Profit Corporation in cooperation with Stevens Institute of Technology].—(*Electronics*, March 1944, Vol. 17, No. 3, p. 268.)

3702. Organisation of Physics in America [Correspondence on Editorial, "A More Perfect Union", in February Issue].—Harnwell. (*Review Scient. Instr.*, April 1944, Vol. 15, No. 4, pp. 108–109.) For a leading article on this editorial *see* 3317 of October.

3703. National Electronics Conference [Notice of First Meeting, Chicago].—(*Journ. Applied Phys.*, July 1944, Vol. 15, No. 7, p. 522: *Elec. Engineering*, June 1944, Vol. 63, No. 6, p. 240.)

3704. Concerning the Division of Electron and Ion Optics of the American Physical Society [177 of January].—Pierce. (*Journ. Applied Phys.*, July 1944, Vol. 15, No. 7, pp. 517–518.)

3705. The Organisation, Direction, and Support of Research in the Physical Sciences [Paper at Symposium of American Philosophical Society].—Taylor. (*Science*, 31st March 1944, Vol. 99, No. 2570, pp. 249–256.)

3706. Problems of Scientific Research [Extracts from Pamphlet reporting on Two Nuffield College Conferences].—Nuffield College. (*Engineer*, 7th July 1944, Vol. 178, No. 4617, pp. 8–9.) The pamphlet was signed by nearly a hundred scientists and industrialists. The two extracts are headed "How much should we spend on research?" and "The status of science". *See* also *Journ. of Scient. Instr.*, Sept. 1944, p. 168.

3707. Sessions of the Physico-Mathematical Department of the Academy of Sciences of the USSR [Summaries & Discussions].—(*Journ. of Phys.* [of USSR], No. 5, Vol. 6, 1942, p. 224 onwards: list of contents in *Sci. Abstracts*, Sec. A, May 1944, Vol. 47, No. 557, p. 91.)

3708. Provision of National Research Laboratories in India [Extract from Budget Speech].—Raisman. (*Current Science* [Bangalore], April 1944, Vol. 13, No. 4, p. 112: *see* also pp. 108, 113, & 113–114.)

3709. Peace, War, and the Future Application of Radio in China.—Liang. (*Electronics*, March 1944, Vol. 17, No. 3, p. 326: paragraph on a New York Winter Meeting paper.) After the war 15 000 electrical engineers will be needed for reconstruction in China.

3710. Technical Education in the U.S.S.R.—Tolpin. (*Nature*, 19th Aug. 1944, Vol. 154, No. 3903, pp. 244–245.) By the writer of the article dealt with in 2378 of July.

3711. "Electronics: a Series of Lectures at the Civic Theatre, Indianapolis" [Book Review].—Heyl. (*Electronics*, Feb. 1944, Vol. 17, No. 2, p. 346.)

3712. Making and Presentation of Scientific Films [Account of Joint Meeting of the Assoc. for Scientific Photography & the Scientific Film Assoc.].—(*Nature*, 19th Aug. 1944, Vol. 154, No. 3903, pp. 243–244.)

3713. Importance of Film Records [Reasons why, at present, Valuable Scientific Film Records are Gradually Disappearing: a Suggested Remedy].—Bell. (*Nature*, 12th Aug. 1944, Vol. 154, No. 3902, p. 214.) For previous work *see* 3328 of October.

3714. VECTOGRAPHIC VIEWS [War Uses of (Three-Dimensional) Vectographs for Instructional Purposes: Their Method of Preparation].—Polaroid Corporation. (*Journ. Applied Phys.*, July 1944, Vol. 15, No. 7, p. xvi.)

3715. THE VECTOSCOPE [Device to provide Visual Aid in teaching Vector Representation of Electrical Quantities].—Betz. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 168..180.)

3716. THE THIRD ANNUAL SCIENCE TALENT SEARCH [and the Technique of Selection].—Edgerton & Britt. (*Science*, 21st April 1944, Vol. 99, No. 2573, pp. 319–320.)

3717. MORSE AND PSYCHOLOGY [Note on United States O.W.I. Statement summarising Recent Investigations on the Difficulties experienced by Learners].—O.W.I. (*Wireless World*, Aug. 1944, Vol. 50, No. 8, p. 244.)

3718. "SCIENCE AT WAR" [Book Review].—Gray. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 353 and 354.)

3719. INVENTORS COUNCIL POSES MILITARY PROBLEMS FOR PUBLIC SOLUTION, *and* INVENTIVE PROBLEMS OF MILITARY INTEREST.—National Inventors Council. (*Elec. Engineering*, June 1944, Vol. 63, No. 6, p. 238: *Proc. I.R.E.*, July 1944, Vol. 32, No. 7, p. 438.) Two selections made from a more comprehensive list.

3720. WAR-TIME ELECTRONIC PATENT POOL [Government & Industry, British & American].—(*Electronics*, March 1944, Vol. 17, No. 3, pp. 92–93.)

3721. THE AMERICAN PATENT SYSTEM: REPORT OF THE NATIONAL PATENT PLANNING COMMISSION.—(*Journ. Franklin Inst.*, March 1944, Vol. 237, No. 3, pp. 237–247.)

3722. SCIENCE IN SIGNAL CORPS DEVELOPMENT.—Code. (*Scientific Monthly*, July 1944, Vol. 59, No. 1, pp. 5–8.)

The 1934 Signal Corps budget was about equal to its present annual expenditure on friction tape for insulating its wire-splices . . . Only one of the great number of different radio sets now in production is of pre-war design . . . A few unsolved and urgent problems are mentioned . . . Hitler entered the war "with the idea that he could finish it with the same equipment with which he started. He has learned better, and he now has large numbers of highly efficient people thinking up unpleasant surprises for us. The enemy may spring those surprises up to the last minute, and up to the last minute we must be ready to counter them. Somehow we must find a way to continue to use our scientific man-power with undiminished effectiveness, for it is our one irreplaceable resource for which there is no substitute. We must maintain our research teams until the last shot is fired, and after . . ." Major-General Code is Asst. Chief Signal Officer, U.S. Army.

3723. POST-WAR CONTROL OF AIR TRAFFIC [Plans of the C.A.A.].—Gilbert. (*See* 3495.)

3724. "ELECTRICITY AND ITS APPLICATION TO CIVILIAN AND MILITARY LIFE," *and* "PRACTICAL RADIO FOR WAR TRAINING" [Book Reviews].—Rinde: Beitman. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 340, 341: p. 341.)

3725. THE TRANSMISSION OF ENERGY OVER GREAT DISTANCES [such as Norwegian Water-Power Sources to Central Germany, Victoria Falls to the Rand, etc: Calculation of 1500 km Overhead Line for 400 kV Three-Phase Supply: Comparison with Very High Tension D.C. Line: etc.].—Wist. (*E.T.Z.*, 9th March 1944, Vol. 65, No. 7/10, pp. 65–72: to be concluded.) This first part deals only with the a.c. line.

3726. METEOROLOGICAL SERVICE FOR ELECTRIC-POWER SYSTEMS [Need for Special Forecasts: Effects of Glaze Storms, etc., on Electric Service].—Davison. (*Elec. Engineering*, June 1944, Vol. 63, No. 6, pp. 203–209.) With 63 literature references.

3727. ELECTRICITY AT THE 28TH SWISS "MUSTERMESSE" [Sample Fair] AT BASLE.—(*Bull. Assoc. Suisse des Élec.*, 19th April 1944, Vol. 35, No. 8, pp. 181–208.)

3728. WEST COAST ELECTRONIC MANUFACTURERS ASSOCIATION [Formation of].—(*Electronics*, March 1944, Vol. 17, No. 3, p. 264.)

3729. DISPOSAL OF GOVERNMENT WAR PLANTS AND EQUIPMENT.—McGraw. (*Electronics*, April 1944, Vol. 17, No. 4, facing p. 88.)

3730. SENSITIVE CARRIER-TONE ALARM [unlike "Many of the Circuits that have appeared in Various Publications," in meeting the F.C.C. Specifications as set forth in Restricted Order No. 2].—Appleman. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 154..158.) Satisfactorily used at WACO.

3731. VOICE-CONTROLLED DEVICES: ELECTRO-MECHANICAL ANALYSIS OF WORDS OF COMMAND [Dudley's Voice-Operated Typewriter: Western Electric Automatic Telephone Exchange System: the Writer's Lift-Control Robot: Speech-Sounds Analysis Work of Paget, Crandall, & others].—Telcs. (*Wireless World*, Aug. 1944, Vol. 50, No. 8, pp. 245–246.)

3732. GAMMA-RAY MEASUREMENTS IN OIL WELLS.—Howell. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 130–133 and 286.)

"Information obtained by examining sub-surface structures through which existing wells pass facilitates location of proposed new wells. Electronic method of exploration functions even where metallic casings have been sunk. In addition, radioactivity measurements permit accurate determination of the level of cement as casings are being set."

3733. A NEW TYPE OF COUNTER FOR IONISING PARTICLES [overcoming Two Main Disadvantages of Ordinary Geiger–Müller Counters, Restricted Sensitivity & Absence of Complete Shielding in Anti-Coincidence Work].—McCusker. (*Journ. of Scient. Instr.*, July 1944, Vol. 21, No. 7, pp. 120–122.)

3734. Experiments on, and Theory of, the Action of the Geiger Point Counter.—Morgan & Bohn. (*Journ. Franklin Inst.*, May 1944, Vol. 237, No. 5, pp. 371–384.)

3735. Wind Power Generators [Recent American Designs].—Sholl. (*Electrician*, 17th Dec. 1943, Vol. 131, No. 3420, pp. 602–603.) *Cf.* 292 of 1941, 2832 of 1942, and 940 & 2617/8 of 1943.

3736. A Hasty Method of Waterproofing Runways [Use of a Resin–Salt Compound to waterproof Soils].—McCutchen. (*Journ. Franklin Inst.*, June 1944, Vol. 237, No. 6, p. 468: summary, from *Military Engineer.*)

3737. Extreme Climatic Conditions: a Résumé of Climatic Factors, Their Influence on Radio Equipment and Components, and of Methods of Testing.—Coursey. (*See* 3545.)

3738. "How to Maintain Electric Equipment" [Book Review].—General Electric. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 348–349.)

3739. Ground-Line Treatment of Standing Poles [Preservative Treatment by Combined Use of Sodium Fluoride (or Silicofluoride) & Creosote].—Amadon. (*Bell Lab. Record*, July 1944, Vol. 22, No. 11, pp. 468–471.)

3740. The Acid-Production of Fungi and Its Effect on Wood impregnated with Copper Sulphate.—Kind. (*Bull. Assoc. Suisse des Élec.*, 5th April 1944, Vol. 35, No. 7, pp. 174–176: in German.)

3741. Portable Carrier Telegraph for the Signal Corps [CF-2B Four-Channel System].—Dahlbom. (*Bell Lab. Record*, May 1944, Vol. 22, No. 9, pp. 404–408.)

3742. Application of Carrier to Power Lines [Survey based on 20 Years' Experience], *and* Application of 720-Cycle Carrier to Power-Distribution Circuits.—Rives: Woodworth. (*Supp. to Elec. Engineering, Transactions Section*, Dec. 1943, Vol. 62, pp. 835–844: pp. 903–915.) For Discussions *see* pp. 945–947 & 1003–1006.

3743. Communications in 'Plane Assembly [Portable "Electronic Communicator" (Interphone) between Riveter & Bucker, etc.].—Electronic Speciality. (*Electronics*, April 1944, Vol. 17, No. 4, p. 148.)

3744. Welding Current Regulator.—Cooper. (*Electronics*, April 1944, Vol. 17, No. 4, pp. 150..164.)

For use where the variations in the welding currents occur as a result of impedance or power-factor changes, in addition to possible voltage variations; where the simpler ordinary voltage-regulating compensator is inadequate.

3745. Electronic Control for Burning Machine [cutting & trimming Steel Plates for Ships: Resulting Even Motor Speed increases Rate of Working].—Miller. (*Electronics*, April 1944, Vol. 17, No. 4, pp. 164..172.) With other possible applications.

3746. Measurements of Forces in Mechanical Models of High-Tension Overhead Lines, etc. [using High-Frequency Capacitance-Change Devices and C.R. Oscillograph].—Senn. (*Bull. Assoc. Suisse des Élec.*, 23rd Feb. 1944, Vol. 35, No. 4, pp. 85–90: in German.)

3747. Materials for Resistance-Manometers [with Data on Copper, Gold, & Silver Alloys].—Schulze. (*Arch. f. Tech. Messen*, Nov. 1942, Part 137, J136-9, Sheets T120–T121.)

3748. Recording Devices for Dynamic Extension Measurements, *and* The Dynamic Extensometer of E. Lehr.—Lehr. (*Arch. f. Tech. Messen*, Jan. 1943, Part 139, V91122-8, Sheets T7–T9: Aug. 1943, Part 146, V91122-10, Sheets T93–T94.) Capacitance-change devices are dismissed as having disappointed high hopes.

3749. A New Measuring Device for Slow and Rapid Changes in Length: Applications and Tests.—Theis. (*Arch. f. Tech. Messen*, June 1943, Part 144, V1121-3, Sheet T63.) Following on 353 of January.

3750. The Optical Interferometer Method of measuring Changes in Length, with Moving-Film Recording replacing Visual Observation.—Johnson & Parsons. (*Journ. of Res. of Nat. Bur. of Stds.*, March 1944, Vol. 32, No. 3, pp. 103–104: in a paper on the expansion of concrete aggregates.)

3751. The Bellows Accelerometer [using Metallic Sylphon Bellows as Active Element & to provide Damping].—Shrader. (*Journ. Franklin Inst.*, Sept. 1943, Vol. 236, No. 4, pp. 353–362.)

3752. Electronic Balance for Gyro Rotors [the "Electrodynascope," using Piezoelectric Measurement of Alternating Bearing Forces exerted by the Unbalance].—Sonntag Scientific Corporation. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 196 and 200.)

3753. Measurement of the Impact Times of Bodies with the Help of Automatically Recording Methods: II—"Time Magnifiers" and Oscillographs.—Mintrop. (*Arch. f. Tech. Messen*, June 1943, Part 144, V142-7, Sheets T64–T65.)

3754. Electronic Octane Tester [Direct-Reading, with Pressure-Operated Pick-Up & Integrating Circuit].—Crossley. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 168..180.)

3755. Split-Detector for Tungsten Wire [using Eddy-Current Principle].—O'Dell. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 238 and 240.) Illustrated summary of the paper dealt with in 3411 of 1943.

3756. Filament Temperature Effects [Correspondence prompted by Note dealt with in 2438 of July: Practical Use, to effect Release of Relay 10 Seconds after Energisation: Causes of Filament Failure].—Burton & others: "Diallist". (*Wireless World*, July 1944, Vol. 50, No. 7, pp. 222–223.)

3757. Automatic Pressure Regulation in Vacuum Distillation [using an Electronic Relay].—Coulson & Warne. (*Journ. of Scient. Instr.*, July 1944, Vol. 21, No. 7, pp. 122–123.)

3758. Electronic Dew-Point Indicator [for Heat-Treatment Atmospheres].—Westinghouse. (*See* 3630.)

3759. Novel Dew-Point Recorder [using General Electric Photoelectric Relay] safeguards Natural Gas Line against Freezing.—Beardsley & Carter. (*Journ. Franklin Inst.*, April 1942, Vol. 233, No. 4, p. 364.)

3760. Gravimeters [Part III of Survey, including Askania Type with Photoelectric Indication].—Graf. (*Arch. f. Tech. Messen*, Sept. 1943, Part 147, V651-5, Sheets T103–T104.)

3761. Photoelectric Colour Measurement [of Petroleum Products, Naval Stores Products, Colour Changes in Salmon, etc.].—Seymour. (*Electrician*, 28th July 1944, Vol. 133, No. 3452, pp. 76–79.)

3762. The Drift of Selenium Photoelectric Cells in relation to Their Use in Temperature Measurement.—Hall. (*Sci. Abstracts*, Sec. B, June 1944, Vol. 47, No. 558, p. 104.)

3763. Photoelectric Magnification [Photoelectric Comparator, throwing Image of Precision Gauges used in Fighter-Plane Production, enlarged 62½ Times, on to Screen].—(*Electronics*, Feb. 1944, Vol. 17, No. 2, p. 266: photograph & caption only.)

3764. Phototube tests Fragmentation-Bomb Fuses.—(*Electronics*, Feb. 1944, Vol. 17, No. 2, p. 208.)

3765. Aircraft Signal Systems [Photoelectric Dimming Devices for Cockpit or Control-Room Signal Lamps, to adjust Brilliance to correspond to Natural Light present].—Rugge. (*Electronics*, March 1944, Vol. 17, No. 3, p. 328: note on a New York Winter Meeting paper.) From the Curtiss–Wright Corporation.

3766. An Improved "Zero-Resistance" Circuit for Photocell Photometry [Barbrow's Circuit (2030 of 1941) modified to improve Maintenance of Calibration & to facilitate Measurements in Adverse Conditions].—Projector & others. (*Review Scient. Instr.*, April 1944, Vol. 15, No. 4, p. 107.)

3767. Electronic Control for Constant Illumination [from High-Pressure Mercury-Vapour Lamps for printing Motion-Picture Film, etc.].—Hilliard. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 180..200.)

3768. Luminous Efficiency of Radiant Energy from the Sky.—Nat. Bureau of Standards. (*See* 3403.)

3769. Electronic Devices [in the Textile Industry].—(*Sci. Abstracts*, Sec. B, June 1944, Vol. 47, No. 558, p. 98.)

3770. Mobile Crime Laboratory [in 29-Foot Bus: Statement-&-Confessions Recorder, Lie Detector (Blood-Pressure, Respiration, & Perspiration Recorder), Drunkometer (*cf.* 388 of January), P.A. Equipment, etc.].—Illinois Police Department. (*Electronics*, Feb. 1944, Vol. 17, No. 2, p. 121: photographs & captions only.)

3771. Electronics in the Study of Head Injuries [Apparatus & Technique for Indirect Diagnosis of Brain Damage in Concussion Cases].—Sheer & Lynn. (*Electronics*, Jan. 1944, Vol. 17, No. 1, pp. 112–117 and 338..352.)

3772. Field Distribution in Electronic Heating [primarily in connection with Dosimetry in Medical Diathermy, but of Interest to Designers of Electronic Heating Equipment].—Lion. (*Electronics*, March 1944, Vol. 17, No. 3, pp. 216..234.) Long illustrated summary of the paper dealt with in 706 of February.

3773. Heating of Non-Magnetic Electric Conductors by Magnetic Induction—Longitudinal Flux [Calculations for Solid & Hollow Cylinders, Slabs, etc.].—Baker. (*Elec. Engineering*, June 1944, Vol. 63, No. 6, Transactions pp. 273–278.)

3774. Developments in Riveting [Use of Radio-Frequency Energy to detonate Explosive Rivets].—du Pont de Nemours. (*Journ. Franklin Inst.*, Sept. 1943, Vol. 236, No. 3, p. 312: summary, from *Army Ordnance*.) *See* also 372 of January.

3775. High-Speed Soldering with Radio-Frequency Power [Capacitor Cans carried by Moving Belt, with Bottoms & Rings of Solder in place, are Sealed at rate of 2500 per Hour without Danger to the Capacitor].—Taylor. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 114–117 and 232, 234.)

3776. Symposium on Electronic Heating [Importance of Matching to Load Impedance (especially for Metals changing Their Characteristics at Curie Temperature): Applications of Dielectric Heating: etc.].—Mittelman, Weinmuller. (*Electronics*, April 1944, Vol. 17, No. 4, pp. 192..198: summaries only.)

3777. Electronics in Plastics Industry [Advantages of H. F. Heating: Improvements Still Necessary].—Blessing. (*See* 3599.)

3778. Radio-Frequency Heating of Aircraft Spars and Gas Tanks.—Fairchild Engine & Airplane. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 150..154.)

3779. Electronic Dehydration of Foods [Tests on 29 Mc/s: Less than 100 Watts per Pound of Compressed Food required for Removal of Practically All Water: about 1 Kilowatt-Hour per Pound of Water Removed: Container evacuated to 29 in. of Mercury].—Sherman. (*Electronics*, Feb. 1944, Vol. 17, No. 2, pp. 94–97.) *See* also 1071 of March.

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