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WIRELESS ENGINEER

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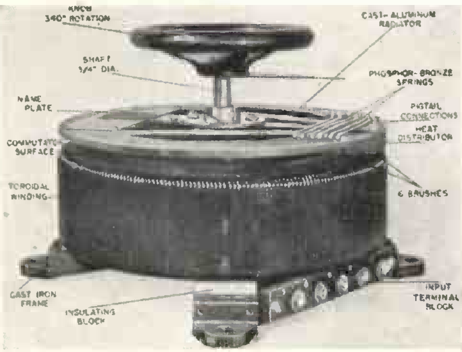

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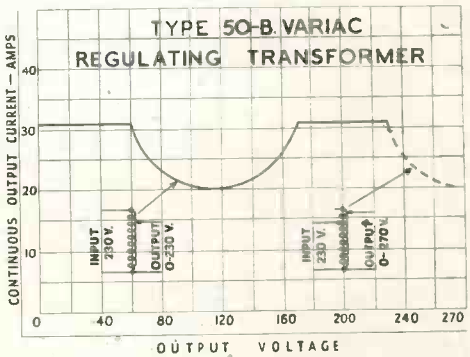

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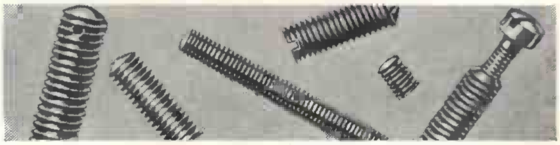

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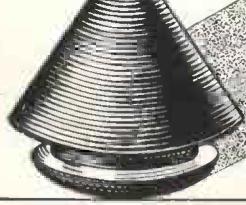

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WHY ERSIN MULTICORE

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

WHY THEY USE CORED SOLDER

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

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

WHY THEY PREFER MULTICORE SOLDER. 3 Cores—Easier Melting

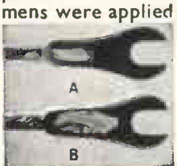
Multicore Solder wire contains 3 cores of flux to ensure flux continuity. In Multicore there is always sufficient proportion of flux to solder. If only two cores were filled with flux, satisfactory joints are obtained. In practice, the care with which Multicore Solder is made means that there are always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

ERSIN FLUX

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

PRACTICAL SOLDERING TEST OF FLUXES

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



ECONOMY OF USING ERSIN MULTICORE SOLDER

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

ALLOYS

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

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

VIRGIN METALS — ANTIMONY FREE

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

IMPORTANCE OF CORRECT GAUGE

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

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

CORRECT SOLDERING TECHNIQUE

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

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

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WIRELESS ENGINEER

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

VOL. XX DECEMBER, 1943 No. 243

Editorial

Phase and Group Velocity in the Ionosphere

A MEDIUM in which the velocity of wave propagation varies with the frequency is called a dispersive medium. The ionosphere is such a medium. The free electrons are caused to oscillate by the electric field of the wave, and when the field strength is a maximum in one direction the electrons have their maximum displacement in the opposite direction, since their acceleration is then a maximum. The electronic displacement is thus in the opposite direction to the Maxwellian vacuum displacement, and reduces the effective dielectric constant below that of a vacuum. The reduction will depend on the frequency of the wave and on the number of electrons; the effective dielectric constant will be $1 - \alpha N/f^2$ where f is the frequency, N the number of electrons per cubic centimetre, and $\alpha = \frac{q^2}{\pi m}$. q, the charge of an electron is 4.803×10^{-10} e.s.u. and m, its mass, is 9.11×10^{-28} gramme, so that $\alpha = 8.1 \times 10^7$. The velocity of an electromagnetic wave is inversely proportional to the square root of κ and consequently the velocity in the ionosphere will be greater than that in a vacuum. At first sight this appears to be contrary to the theory of relativity, but the apparent discrepancy was explained by Sommerfeld in 1907.* The velocity thus calculated is that of a certain phase of a wave of constant amplitude with neither beginning nor end and therefore with no means of measuring its velocity. One is a step nearer the possibility of such a measurement when one considers the superposition of two such infinite waves of slightly different frequency, the resultant of which is an infinite series of beats or groups of waves as shown in Fig. 1. If the velocity in a vacuum be denoted by c the phase velocity v will be given by the formula $v = \frac{c}{\sqrt{1 - \alpha N/f^2}}$.

The upper wave in Fig. 1, having the longer wavelength and consequently the lower frequency, will have the higher phase velocity. At the moment shown A and B coincide and give a group maximum G, but the second wave will gradually fall behind the first until, after a time $(\lambda_1 - \lambda_2)/(v_1 - v_2)$, C will coincide with D and the group maximum G will have fallen back and lost a wavelength compared with either of the constituent waves. During the time $(\lambda_1 - \lambda_2)/(v_1 - v_2)$ the first wave will have travelled a distance $v_1(\lambda_1 - \lambda_2)/(v_1 - v_2)$, and in this time the group will have travelled a distance $v_1(\lambda_1 - \lambda_2)/(v_1 - v_2) - \lambda_1$. For the velocity of the group we therefore have

$$v_g = \frac{v_1(\lambda_1 - \lambda_2)/(v_1 - v_2) - \lambda_1}{(\lambda_1 - \lambda_2)/(v_1 - v_2)}$$
$$= v_1 - \lambda_1(v_1 - v_2)/(\lambda_1 - \lambda_2).$$

Assuming that $dv/d\lambda$ may be assumed constant over the range involved, this may be

* *Phys. Zeitschr.*, Vol. 8, p. 841, 1907, "Ein Einwand gegen die Relativtheorie und seine Beseitigung."

written, $v_g = v_1 - \lambda_1 dv/d\lambda$. During this same time, the second wave will have travelled a distance $v_2\, d\lambda/dv$, and the group will have travelled a distance $v_2 d\lambda/dv - \lambda_2$, which gives $v_g = v_2 - \lambda_2\, dv/d\lambda$. We can therefore write generally $v_g = v - \lambda\, dv/d\lambda$ $= f\lambda - \lambda \dfrac{d(f\lambda)}{d\lambda} = -\lambda^2\, df/d\lambda = df/d(1/\lambda)$.

This can also be obtained from the formula $v_g = v_1 - \lambda_1(v_1 - v_2)/(\lambda_1 - \lambda_2)$ by writing it thus $v_g = \dfrac{v_2\lambda_1 - v_1\lambda_2}{\lambda_1 - \lambda_2}$ which on dividing by $\lambda_1\lambda_2$ gives $v_g = \left(f_2 - f_1\right)\Big/\left(\dfrac{1}{\lambda_2} - \dfrac{1}{\lambda_1}\right)$.

Putting $\omega = 2\pi f$ and $\beta = 2\pi/\lambda$, we have the well-known relationship, $v_g = d\omega/d\beta$.

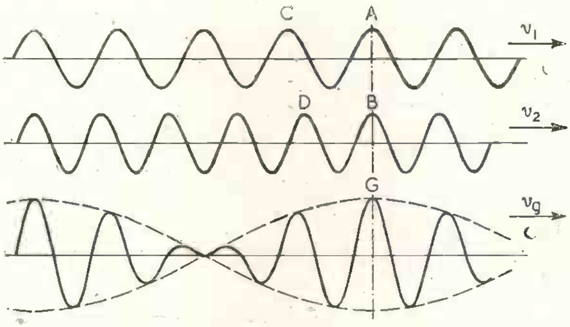

Fig. 1.

In ordinary non-ionised space the two constituent waves would travel with the same velocity $v = c = f\lambda$; $f = c/\lambda$ and $df = cd(1/\lambda)$. Hence $v_g = c$. If the ionisation is slight or the frequency very high, so that $\alpha N/f^2 \ll 1$, then $v \approx c(1 + \alpha N/2f^2)$ and $1/\lambda = f/v \approx f\left(1 - \dfrac{\alpha N}{2f^2}\right)/c$.

Hence $v_g = df/d(1/\lambda) \approx c\left(1 - \dfrac{\alpha N}{2f^2}\right)$.

Hence, under these conditions the group velocity is as much below c as the phase velocity is above it.

If $\alpha N/f^2$ is not small compared with unity, the approximations made above are not permissible; we then have

$$1/\lambda = \frac{f\sqrt{1 - \alpha N/f^2}}{c}$$

$$\frac{d(1/\lambda)}{df} = \frac{1}{c} \cdot \frac{1}{\sqrt{1 - \alpha N/f^2}}$$

and $v_g = c\sqrt{1 - \alpha N/f^2}$. Hence c is the geometric mean of the phase and group velocities. Also $v_g/v = 1 - \alpha N/f^2$ and therefore $v_g = v - \lambda\alpha N/f$, but we have seen that $v_g = v - \lambda\, dv/d\lambda$, and therefore $dv/d\lambda = \alpha N/f$. We assumed that this could be regarded as constant over the difference of frequencies involved in the production of the beats. This assumption is only permissible when this difference is small. The variation of the phase and group velocities with variations in the value of $\alpha N/f^2$ is shown in Fig. 2, where the dotted lines show the approximation for small values of $\alpha N/f^2$.

To show clearly what happens to the groups or beats as they penetrate into the ionosphere we will take a numerical example

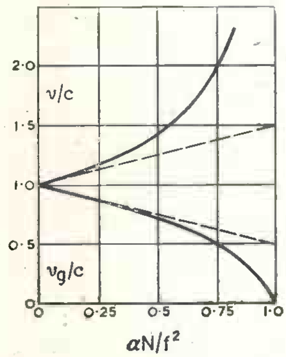

Fig. 2.

and assume that the transmission is vertically upwards and consists of two sustained waves, one having a frequency f_1 of 5.3 Mc/s, and the other a frequency f_2 of 5.4 Mc/s. If the electron density N is 5×10^4 per cm³, $\alpha N/f^2 = 0.1442$*, and $\sqrt{1 - \alpha N/f_1^2} = 0.9251$. This gives a phase velocity v_1 of 3.243×10^{10} and therefore a wavelength λ_1 of 6119 cm. Similarly for the other wave, $\alpha N/f_2^2 = 0.1389$, $\sqrt{1 - \alpha N/f_2^2} = 0.928$, $v_2 = 3.233 \times 10^{10}$ and $\lambda_2 = 5987$ cm. The group velocity $v_g = 3 \times 10^{10} \times 0.9265 = 2.78 \times 10^{10}$. The length of a group will extend from a point where the two waves are in phase to the next point at which this occurs, that is, where $n\lambda_1 = (n + 1)\lambda_2$. This gives $n = 45.3$ and the length of the group is therefore 45.3×6119 or 46.3×5987 i.e.

* Although the value adopted for α does not justify the four figures, such accuracy is essential when dealing, as here, with small differences.

278 000 cm. Taking the mean of 45.3 and 46.3 we can say that the group will contain 45.8 waves.

Similar calculations have been carried out for higher values of electron density, viz. for $N = 15$, 30 and 34×10^4 electrons per cm^3, and the results are given in the Table. The results are also shown strictly to scale in Fig. 3, and they are very striking. As the waves penetrate into regions of the ionosphere where the electron density is greater, the groups not only move more slowly but diminish in length, while the constituent waves increase in velocity and therefore also in length. The result is a very striking decrease in the number of waves per group.

A very slight further increase in N causes a rapid drop of v_g, and when N reaches about 35.35×10^4, v_g falls to zero; the signal is then reflected and returns to earth, going through all the transformations of Fig. 3 in the reverse order.

It must be emphasised that we are throughout this present article neglecting two important things, viz. losses due to energy dissipation in the medium, and the effect of the earth's magnetic field. We feel, however, that it is preferable to obtain a clear picture of the simplified problem before considering the effects of such things as anomalous dispersion.

If a wave is transmitted upward at an angle θ_1 to the vertical, it will be refracted to an angle θ_2 in the ionosphere, where $\sin\theta_1/\sin\theta_2 = v_1/v_2 = \sqrt{\kappa_2/\kappa_1}$ and the numbers 1 and 2 refer to the two media. Putting

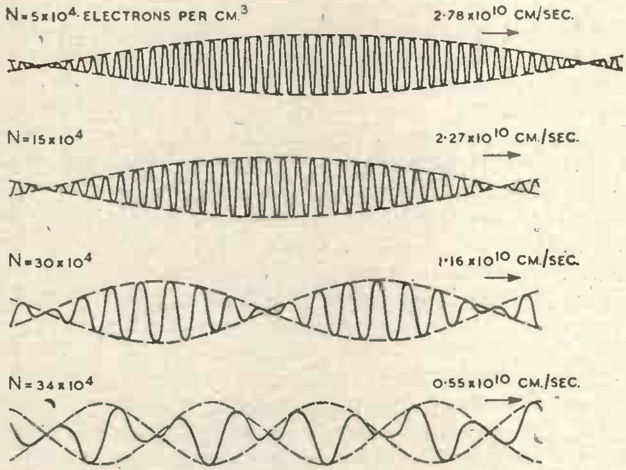

Fig. 3.

$\kappa_1 = 1$ and $\theta_2 = 90°$, i.e. assuming that the wave is refracted until it is moving horizontally, and will therefore return to earth, we have $\sin\theta_1 = \sqrt{\kappa_2}$. As θ_1 is decreased, i.e. the nearer the vertical the original direction of the wave, the smaller must be the value of κ_2 to obtain this result. For vertical transmission $\theta_1 = 0$ and κ_2 must vanish, i.e. $\alpha N/f^2 = 1$; assuming $f = 5.35 \times 10^6$, the mean of the two frequencies considered

	N = Number of Electrons per cm³			
	5×10^4	15×10^4	30×10^4	34×10^4
$\alpha N/f_1^2$	0.1442	0.4326	0.8652	0.9806
$\alpha N/f_2^2$	0.1389	0.4167	0.8334	0.9445
$\sqrt{1 - \alpha N/f_1^2}$	0.9251	0.7532	0.3671	0.1394
$\sqrt{1 - \alpha N/f_2^2}$	0.928	0.7637	0.4082	0.2355
$v_1 = 10^{10} \times$	3.243	3.983	8.172	21.52
$v_2 = 10^{10} \times$	3.233	3.928	7.349	12.74
λ_1 cm	6119	7515	15420	40600
λ_2 cm	5987	7274	13610	23600
$\dfrac{v_1 - v_2}{\lambda_1 - \lambda_2} = 10^6 \times$	0.7575	2.282	4.547	5.165
$v_g = 10^{10} \times$	2.780	2.268	1.161	0.55
Waves in a group	45.8	30.7	8.0	1.89
Length of group in cm	278000	234000	116000	56430

above, and $\alpha = 8.1 \times 10^7$, this gives $N = 35.34 \times 10^4$ electrons per cm^3 as found above. If the wave is modulated in the manner assumed above, the groups will undergo the transformations shown in Fig. 3 in their curved passage through the ionosphere. If the value of N nowhere reaches the density necessary to reduce v_g to zero, the wave will pass right through the ionosphere, the groups gradually regaining their original configuration as they pass out into the atmosphere above the ionospheric layer.

Up to this point we have assumed the transmission to consist of two continuous waves of slightly different frequencies, giving an endless succession of beats. When the signal consists of a pulse or of a short train of waves, the problem becomes much more complicated. It was treated very fully in 1914 by Sommerfeld and Brillouin.* Such a signal consists not of two but of an infinite number of harmonic components, which give zero resultant at every moment except during the signal. The very high frequency components of the signal have phase and group velocities differing very little from c, since $\alpha N/f^2$ is small and κ therefore nearly unity. Although of small amplitude these groups will travel through the ionosphere at the velocity c and thus arrive before the main body of the signal, which, being composed of lower frequency components, will travel at lower group velocities. The arriving signal will therefore consist of a weak forerunner or precursor, undelayed by ionospheric action, of gradually changing amplitude and frequency, which suddenly develops into the delayed main signal ; this will be a distorted version of the original signal. A consideration of Fig. 3, which applies to the ideal case of two harmonic frequencies, indicates that an actual signal of short duration must undergo very striking transformations in its journey through the ionosphere, transformations which are not entirely reversible, with the result that it emerges from the ionosphere in a somewhat modified form. This makes it difficult to define exactly what is meant by its velocity, but neglecting the weak forerunner and changes in the exact outline of the signal, it can be safely said that its velocity is that of the sinusoidal group to which it most closely approximates. G. W. O. H.

* *Annalen der Physik*, Vol. 44, pp. 177, 203. "Über die Fortpflanzung des Lichtes in dispergierenden Medien."

Admission to I.E.E. Meetings

THE Council of the Institution of Electrical Engineers has had under consideration for some time the question of making the technical meetings of the Institution accessible to those who may be interested in the proceedings, but who may consider that their technical experience and educational attainments do not suffice to admit them to any form of Institution membership.

It is understood it has now been decided that a person in the category outlined above, who is interested in the proceedings at Ordinary Meetings, Section Meetings, Local Centre Meetings and Informal Meetings, shall, on the completion of an application form and on payment of a fee of 7s. 6d. to cover administration costs, receive notices of meetings and an invitation card which will serve as a title of admission to the technical meetings of the Institution in London and in the provinces during the forthcoming Session.

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Index to Abstracts

AS announced last month, the index to the Abstracts and References section for the current volume is in course of preparation and will be published separately early in the new year.

Our Publishers ask us to stress that, as supplies will be limited, it will be necessary for those requiring copies to make early application. A charge of 2s. 8d. (including postage) will be made for the index.

As in former years the index to Articles and Authors for the current volume is included in this issue.

Superheterodyne Tracking Charts—III.*

The Padded Signal Circuit

By A. L. Green, Ph.D.

ABSTRACT.—In communication receivers and in bandspread broadcast receivers the problem sometimes arises of reducing the frequency ratio of the signal circuits to a value less than that for which the ganged tuning condenser was originally designed. It is common practice to achieve this result by inserting a fixed padding capacitance in series with the tuning condenser, that is to say by converting the signal circuit to the type customarily used in a superheterodyne oscillator. The present paper introduces the analytical conception of a virtual pilot circuit, with which are tracked both the padded signal circuit and the padded oscillator circuit in a superheterodyne receiver. An advantage of this method of approach to the problem is that the components in both the signal and the oscillator circuits can readily be designed according to superheterodyne tracking charts of the type previously described.

1. Introduction

It is well known that the design of a straight-line-frequency tuning condenser of conventional type depends both on the frequency ratio required in the *LC* circuit and on the minimum capacitance of that circuit. In a practical case the maximum and minimum capacitances of the tuning condenser may be respectively 432$\mu\mu$F and 12$\mu\mu$F, but the shape of the plates is such as to give a linear frequency scale to a circuit having a minimum capacitance much greater than that of the condenser alone. By way of example, a condenser required to give a linear frequency scale in the broadcast band of 550—1,500 kc/s would be designed to operate in a circuit in which the minimum trimming capacitance (T) is

$$T = \frac{432 - 12}{2.727^2 - 1} = 65\mu\mu\text{F} \quad .. \quad (1)$$

since the frequency ratio of the whole circuit is 2.727 : 1†. Mass-produced variable condensers of the type usually available to a receiver designer conform broadly to the example quoted, and it is therefore a matter of convenience to design *LC* circuits in which the frequency ratio is approximately 3 : 1; otherwise the frequency scale tends to depart markedly from linearity.

* Reprinted from *A.W.A. Technical Review*, 1943, Vol. 6, No. 2, p. 97, by arrangement with Amalgamated Wireless (Australasia), Ltd. Parts I and II were published under the same title by Green (1941) and by Payne-Scott and Green (1941) in *A.W.A. Techn. Rev.*, and reprinted in *Wireless Engineer*.

† See Part II of this paper.

Special cases sometimes arise, however, in which it is desirable to reduce the frequency ratio of the receiver to a value much less than 3 : 1, particularly in communication receivers in which ease of tuning is preferable to wide coverage. An example of this tendency was described by Honnor and Mathieson (1941) in connection with a transmitter-receiver equipment for small aircraft. In this design the transmitter frequencies fell within the two bands 2.5—3.5 Mc/s and 6.2—6.7 Mc/s so that it would have been possible to design the corresponding receiver with a single band in the range 2.5—6.7 Mc/s. With a frequency ratio of 2.68 : 1, the frequency scale would have been substantially linear but almost two-thirds of the scale would then have been useless for air-

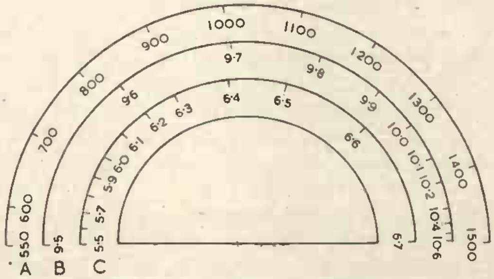

Fig. 1. *Comparison of bandspread frequency scales with the linear scale for which the tuning condenser was originally designed:*

A—linear scale for medium-frequency broadcast band,

B—bandspread scale to give ease of tuning in the 31-metre broadcast band,

C—bandspread scale for an aircraft communication receiver.

craft communication. The receiver was, however, designed for two bands with restricted frequency ratios of respectively 1.4 : 1 and 1.22 : 1, so that both scale linearity and wide coverage were neglected in favour of ease of operation of the equipment within the field for which it was specifically designed.

In Fig. 1 are illustrated three frequency scales, *A* being a linear scale for the broadcast band 550—1,500 kc/s, assuming that the variable condenser has been designed to be used in an *LC* circuit in which the minimum capacitance is 65$\mu\mu$F and the frequency coverage 2.727 : 1. Using the same shape of condenser plate*, scale *C* represents the departure from linearity in one of the bands used by Honnor and Mathieson, assuming that the frequency ratio was reduced to 1.22 : 1 simply by adding trimming capacitance across the tuning condenser. The bandspread action is, however, such that the desired coverage of 6.2—6.7 Mc/s occupies an angular scale length of 126°, whereas the alternative design of a single-band receiver with a frequency ratio of 2.68 : 1 would have compressed this aircraft channel into only 21° of rotation of the tuning condenser.

The remaining frequency scale illustrated in Fig. 1, scale *B*, is of interest in that it is an example of bandspread action in a broadcast receiver. In this design bandspread tuning is effected by inserting, in series with the variable tuning condenser, a small fixed padding capacitance of value 20$\mu\mu$F. The signal circuit then takes the form customarily found in a superheterodyne oscillator, but with markedly different component values. In the example quoted, an object was to cover reception in the 31-metre band, i.e. between 9.5 and 9.7 Mc/s, with much greater ease of tuning than is usual in the 15—45-metre band of a broadcast receiver. By consciously sacrificing both linearity in the tuning scale and wide coverage, it has been possible to expand this band to an angular scale length of 87°, whereas the corresponding figure for the linear scale of frequency ratio 3 : 1 would have been only 3°.

* In order to avoid excessive loss of circuit gain, the maximum capacitance of the tuning condenser was reduced from 432$\mu\mu$F to 77$\mu\mu$F by double-spacing the plates. The corresponding trimming capacitance was 135$\mu\mu$F for a frequency ratio of 1.22 : 1.

A comparison of the three scales illustrated in Fig. 1, emphasises the point that scale linearity is likely to suffer when using a frequency ratio differing widely from that for which the variable condenser was originally designed. Scale C demonstrates that the calibration becomes crowded at the low-frequency end of the band when the parallel trimming condenser is markedly increased above the designed value, while scale *B* shows crowding in the high-frequency region due to the restrictive effect of the small series padding condenser. It is, therefore, not difficult to deduce that there exists a method of decreasing the frequency ratio of a signal circuit, using a combination of increased parallel trimming capacitance and inserted series padding condenser, by which substantial scale linearity is retained. The present paper is concerned with this problem, and with the correlated problem of tracking the oscillator in a superheterodyne receiver with a padded signal circuit, but the solution happens to take a more general form in which the padded signal circuit can be designed to have any specified calibration, not necessarily linear.

2. The Pilot Circuit

In Fig. 2 are illustrated two *LC* tuned circuits of which one, the padded circuit, is of the general oscillator type considered in

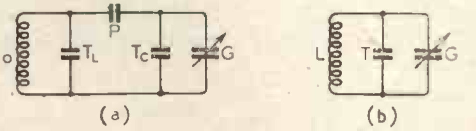

Fig. 2. *Skeleton circuits on which the analysis is based. (a) Padded circuit. (b) Pilot circuit.*

Part II of this paper. The extension of the earlier analysis to that now under consideration involves the use of this type of padded circuit in both the superheterodyne oscillator and in the signal amplifying stages. In the signal circuits it becomes a design problem to select values of the padder *P*, and of the two trimming capacitances, T_L and T_C, such that simultaneously the following three conditions are fulfilled :—

(*a*) The desired frequency ratio is attained ;
(*b*) The scale calibration is substantially

linear, or more generally corresponds with a desired form ; and

(c) The L/C ratio is maintained at a high value in order to achieve adequate gain.

In the oscillator circuit a primary consideration is that it should track with the padded signal circuit ; secondary design criteria are concerned with the distribution of trimming capacitances between T_L and T_C, and the manner in which this distribution affects the oscillator output, the oscillator stability, and the suitability of the circuit for inclusion in a multi-band switched receiver.

The other LC tuned circuit illustrated in Fig. 2 is of the simple type specified for the signal amplifying stages in the earlier paper. It clearly has no existence in a superheterodyne receiver in which both the signal and the oscillator circuits include series padding condensers, but its inclusion in the analysis is of considerable importance. This circuit, which will be referred to as the pilot circuit, determines the form of the scale calibration in a conveniently simple manner and, at the same time, provides a solution to the problem of tracking a padded oscillator circuit with a padded signal circuit. Briefly the conception of the pilot circuit involves the idea of selecting, for the padded circuit, values of the padder P and of the two trimmers T_L and T_C, in a manner such that the real padded circuit is made to track at three frequencies (Sowerby, 1932) with the non-existent pilot circuit. Clearly this process may be applied both to the padded oscillator circuit and to the padded signal circuit, so that a repetition of the design calculations has the effect of aligning each one of the padded circuits in turn to the pilot circuit, and therefore of aligning the two padded circuits the one with the other.

In addition it is easy to see that the form of the calibration curves of the two padded circuits must correspond with that of the pilot circuit, and this will be linear if the frequency ratio of the pilot circuit is that for which the variable tuning condenser was originally designed. At this stage it is convenient to mention that the idea of the pilot circuit necessarily neglects the possibility of serious tracking errors occurring in the two sets of calculations. It is apparent that the calibration scale of the pilot circuit will coincide with those of the padded circuits only at the three selected points of alignment, but the distortion of the scale due to this cause is likely to be very much less noticeable than the departures from scale linearity illustrated in Fig. 1 for other bandspread systems. Again it is clear that it is a particularly simple matter to compute the positions of the calibration marks for the pilot circuit, since only the trimmer T and the variable condenser G are involved in the calculations. At the worst, therefore, relatively little time is lost in using this device as a first approximation to the scale calibration of the padded circuit. At the best, the tracking errors will be negligible and the frequency scale of the receiver can be assumed to be identical with that of the pilot circuit. In many practical cases the frequency scale of the pilot circuit will be adequate for the initial design of the receiver, and the final calibration will be obtained experimentally, as is customary.

The tracking errors occurring in the alignment of the padded signal circuit with the pilot circuit do not, of course, represent any real loss of efficiency in the receiver. Since only the padded signal circuit and the padded oscillator circuit have existence in the equipment, it is the differential error between these two circuits that is of practical significance. By analogy with a somewhat similar problem considered by Builder (1941), in connection with additive frequency scales for a circuit tuned by a variable condenser, it is probable that this differential error will be negligibly small in most practical cases.

A further point of interest in the calibration scale of the pilot circuit, and, therefore, of the padded signal circuit, is that it can readily be designed in a form that is not linear. At first sight there is no point in doing so in a bandspread receiver, particularly since the principal object of the analysis is to avoid serious departures from scale linearity. Detailed calculations show, however, that there is sometimes an advantage to be gained by selecting for the pilot circuit a frequency ratio that is somewhat less than the critical ratio for which the variable condenser was originally designed. This advantage is most likely to be noticeable in circuits in which a considerable reduction of frequency coverage is required, and the practical aspect is that undesirably small values of the padding capacitance can thereby be avoided.

3. Notation

Referring again to Fig. 2, it is apparent that the components illustrated in the pilot circuit correspond exactly, in an analytical sense, with those used in Part II of this paper for the signal circuit. Correspondingly the present padded signal circuit cannot be distinguished from the padded oscillator circuit, which is used in both analyses. An important difference, however, between the two superheterodyne tracking problems is that it is now necessary to visualise a virtual intermediate frequency (ω_j), when considering the combination of the pilot circuit and the padded signal circuit as a virtual superheterodyne receiver. Clearly the true intermediate frequency of the receiver (ω_i) remains the constant frequency difference that must be maintained between the padded signal and oscillator circuits.

At this stage in the investigation it does not seem to be necessary to increase the complexity of the notation by providing independent sets of symbols respectively for the padded signal circuit and for the padded oscillator circuit, even when both circuits exist together in a superheterodyne receiver. As previously explained, the procedure of tracking a padded oscillator circuit to a padded signal circuit merely involves the alignment of each circuit in turn to a pilot circuit. From this point of view it is possible to provide one analytical solution and one set of tracking charts for the following three cases :—

(*a*) The alignment of a padded oscillator circuit to a real parallel-tuned signal circuit;

(*b*) The alignment of a padded oscillator circuit to a virtual pilot circuit; and

(*c*) The alignment of a padded signal circuit to a virtual pilot circuit.

Distinction may be made between the three problems by remembering that case (*a*) involves a real intermediate frequency ω_i, case (*c*) requires the conception of a virtual intermediate frequency ω_j, while case (*b*) utilises a compound intermediate frequency $\omega_j \pm \omega_i$.

The notation used in the following analysis is summarised below :

ω_1 = low-frequency tracking point of the pilot circuit,
ω_2 = high-frequency tracking point of the pilot circuit,
ω_3 = arithmetic-mean tracking point of the pilot circuit,
ω_i = true intermediate frequency of a superheterodyne receiver,
ω_j = virtual intermediate frequency for the combination of a padded signal circuit with a virtual pilot circuit,
α = $\dfrac{\omega_2}{\omega_1}$, frequency ratio of the pilot circuit,
β = $\dfrac{\omega_2 + \omega_j}{\omega_1 + \omega_j}$, frequency ratio of a padded signal circuit,
L = inductance of pilot circuit,
L_o = inductance of padded signal circuit,
G = incremental capacitance of each section of the ganged tuning condensers, measured from its value at frequency ω_2,
G_{max} = value of G at frequency ω_1,
G_3 = value of G at frequency ω_3,
T = total capacitance in pilot circuit at frequency ω_2, i.e. when $G = 0$,
T_L = trimming capacitance across L_o, including self-capacitance of L_o and all strays,
T_C = trimming capacitance across G in the padded circuit, including minimum of tuning condenser and all strays,
P = series padding capacitance,
C = total effective capacitance across L_o,
C_{max} = value of C when $G = G_{max}$.

Some derived symbols are used for convenience in the solution and in the preparation of the charts :

$$\mu = \frac{(1 + \alpha)^3}{1 + 3\alpha} = \frac{G_{max}}{G_3} \quad \ldots \quad (2)$$

$$\mu_o = \frac{(1 + \beta)^3}{1 + 3\beta} \quad \ldots \quad (3)$$

$$\rho = \frac{\mu - 1}{\mu_o - 1} \quad \ldots \quad (4)$$

4. Analysis of the Virtual Tracking Problem

In order to avoid confusion between the three superheterodyne tracking problems mentioned in the previous section, attention will be directed for the moment to the case of aligning a padded signal circuit to a virtual pilot circuit. An important difference, between this virtual tracking problem and the closely corresponding case of aligning a parallel-tuned signal circuit to a padded oscillator circuit, is that the three virtual tracking frequencies in the pilot circuit are not initially specified. The designer is provided with the desired coverage of the padded signal circuit, so that the values of $\omega_1 + \omega_j$, $\omega_2 + \omega_j$, $\omega_3 + \omega_j$, and therefore of β, are known. There is, however, no obvious specification for the virtual intermediate frequency, so that it is not immediately possible to derive the three tracking frequencies (ω_1, ω_2 and ω_3) of the pilot circuit. The only other criterion available is that the frequency ratio (α) of the pilot circuit should be such as to give the desired shape to the calibration curve.

The Pilot Circuit.—As it happens, knowledge of the absolute values of the three tracking frequencies of the pilot circuit is not necessary. It is sufficient that the ratio ω_2/ω_1 be specified and also that ω_3 be the arithmetic mean of ω_1 and ω_2. Correspondingly the inductance (L) of the pilot circuit does not appear in the solution. The three equations for the pilot circuit are

$$L(G_{max} + T)\omega_1^2 = 1 \qquad \ldots \quad \ldots \quad (5)$$

$$LT\omega_2^2 = 1 \qquad \ldots \quad \ldots \quad (6)$$

$$L(G_3 + T)\omega_3^2 = 1 \qquad \ldots \quad \ldots \quad (7)$$

between which it is immediately possible to eliminate L and to solve for T and for G_3 in terms only of the specified quantities α and G_{max}. These solutions are

$$T = \frac{G_{max}}{\alpha^2 - 1} \qquad \ldots \quad \ldots \quad (8)$$

and

$$G_3 = G_{max} \frac{1 + 3\alpha}{(1 + \alpha)^3} \qquad \ldots \quad \ldots \quad (9)$$

the latter being written for convenience

$$\frac{G_{max}}{G_3} = \mu \equiv \frac{(1 + \alpha)^3}{1 + 3\alpha} \qquad \ldots \quad \ldots \quad (10)$$

Of these two solutions, that for G_3 will be required later in the analysis of the padded signal circuit, while T determines the form of the calibration curve.

Frequency scales for the pilot circuit, such as are illustrated in Fig. 3, are derived in the following manner; the general equation for the pilot circuit is

$$L(G + T)\omega^2 = 1 \qquad \ldots \quad \ldots \quad (11)$$

and the combination of this with equation (6) gives

$$\left(\frac{\omega_2}{\omega}\right)^2 = \frac{(G + T)}{T} \equiv 1 + (\alpha^2 - 1)\frac{G}{G_{max}} \qquad \ldots \quad \ldots \quad (12)$$

from which it is possible to compute relative frequency scales for specified values of α. It is, of course, necessary to know the manner in which the capacitance of the tuning condenser varies with respect to angular rotation of the tuning control, or alternatively this fact may be deduced from the knowledge that the frequency scale was originally designed to be linear for a specified frequency ratio and for a specified maximum value of capacitance.

In Fig. 3 it is assumed that the tuning condenser has been designed for a linear calibration over the broadcast band of 550—1,500 kc/s, i.e. for a frequency ratio of 2.727 : 1, and it is known that G_{max} has the value 420$\mu\mu$F. Scale D is for this frequency ratio, and the criterion of linearity

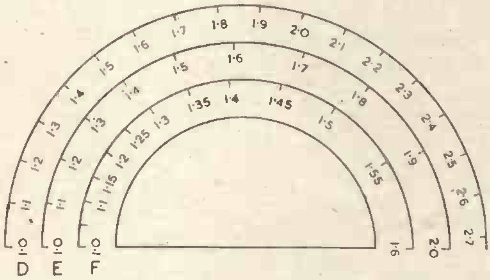

Fig. 3. *Comparison of some permissible calibration scales for the pilot circuit.*

D—frequency ratio for which variable condenser was originally designed,
E—frequency ratio of 2 : 1,
F—frequency ratio of 1.6 : 1.

is sufficient to determine the manner in which the ratio G/G_{max} varies with respect to angular rotation of the moving plates. With this knowledge it was then possible to compute scales E and F, respectively for frequency ratios of 2 : 1 and 1.6 : 1, by using equation (12). The frequency scales illustrated in Fig. 3, therefore, represent samples of permissible calibration forms for the padded signal circuit, neglecting the possibility of noticeable tracking errors occurring between the pilot and the padded circuits. Factors which the designer may consider, when choosing one or other of these scales for the pilot circuit, will be considered later.

The Padded Signal Circuit.—The three alignment equations for the padded circuit of Fig. 2 are

$$L_0\,(\omega_1 + \omega_i)^2 \left[T + \frac{P(G_{max} + T_0)}{P + T_0 + G_{max}}\right] = 1 \qquad \ldots \quad \ldots \quad (13)$$

$$L_0 (\omega_2 + \omega_j)^2 \left[T_L + \frac{PT_C}{P + T_C} \right] = 1 \quad \ldots \quad (14)$$

$$L_0 (\omega_3 + \omega_j)^2 \left[T_L + \frac{P(G_3 + T_C)}{P + T_C + G_3} \right] = 1 \quad \ldots \quad (15)$$

in which the frequencies $\omega_1 + \omega_j$, $\omega_2 + \omega_j$, and $\omega_3 + \omega_j$ are specified, G_{max} is measured experimentally, and G_3 is derived from the solution of the pilot circuit. Solutions are required for the components L_0, P, T_L and T_C, so that, as previously discussed in Part II for the corresponding problem of the padded oscillator circuit, it will be necessary to retain one of these unknown quantities in the solutions for the remainder.

One method of solving these equations is firstly to eliminate L_0 by combining the expressions in pairs, giving

$$T_L + \frac{P(G_{max} + T_C)}{P + T_C + G_{max}} = \beta^2 \left[T_L + \frac{PT_C}{P + T_C} \right] \quad \ldots \quad (16)$$

and

$$T_L + \frac{P(G_3 + T_C)}{P + T_C + G_3} = \frac{4\beta^2}{(1 + \beta)^2} \left[T_L + \frac{PT_C}{P + T_C} \right] \quad \ldots \quad (17)$$

which may be rewritten in a form that is convenient for the elimination of T_L, i.e.,

$$\frac{G_{max} P^2}{(P + T_C)(P + T_C + G_{max})} = (\beta^2 - 1) \left[T_L + \frac{PT_C}{P + T_C} \right] \quad \ldots \quad (18)$$

$$\frac{G_3 P^2}{(P + T_C)(P + T_C + G_3)} = \frac{(\beta - 1)(1 + 3\beta)}{(1 + \beta)^2} \left[T_L + \frac{PT_C}{P + T_C} \right] \quad \ldots \quad (19)$$

Elimination of T_L then leads to the following expression,

$$\frac{G_{max}}{G_3} \cdot \frac{P + T_C + G_3}{P + T_C + G_{max}} = \frac{(1 + \beta)^3}{1 + 3\beta} \quad (20)$$

which is a solution for the pair $P + T_C$ in terms of known quantities. For convenience in the preparation of the charts, introduce the symbol

$$\mu_0 = \frac{(1 + \beta)^3}{1 + 3\beta} \quad \ldots \quad (21)$$

and also substitute for G_3 from equation (10),

$$\frac{G_{max}}{G_3} = \mu = \frac{(1 + \alpha)^3}{1 + 3\alpha}$$

leading to the simplified solution,

$$P + T_C = G_{max} \cdot \frac{\mu_0 - 1}{\mu - \mu_0} \quad \ldots \quad (22)$$

A still further step is taken, in order to correlate the solution for $P + T_C$ with others that are to follow, this being the introduction of the symbol

$$\rho = \frac{\mu - 1}{\mu_0 - 1} = \frac{\alpha^2}{\beta^2} \cdot \frac{3 + \alpha}{3 + \beta} \cdot \frac{1 + 3\beta}{1 + 3\alpha} \quad (23)$$

Finally, therefore, the solution for the pair $P + T_C$ may be stated in the form

$$P + T_C \doteq \frac{G_{max}}{\rho - 1} \quad \ldots \quad (24)$$

demonstrating that only the quantities G_{max}, α and β are required in the preparation of the charts, and that the virtual frequencies of the pilot circuit have disappeared from the solution.

Maximum and Minimum Values of Components—An approach to the problem of obtaining useful solutions for the padded circuit is through the two limiting cases,

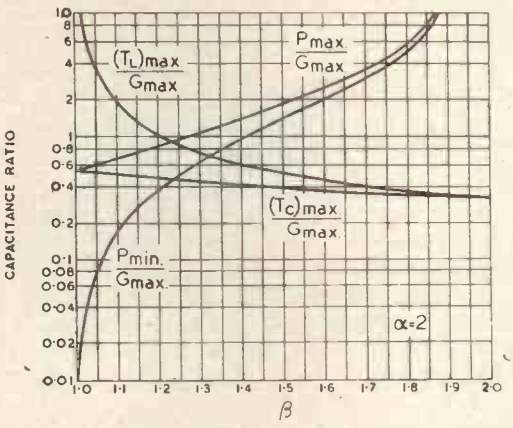

Fig. 4. *A key diagram to the detailed charts that follow, showing the general picture for a pilot-frequency ratio of 2 : 1.*

respectively, when $T_C = 0$ and $T_L = 0$. From expression (24), it is apparent that

$$P + T_C = P_{max} = P_{min} + (T_C)_{max} \quad \ldots \quad (25)$$

in which P_{max} corresponds with the limiting case $T_C = 0$, and P_{min} to the alternative case $T_L = 0$. It follows that P_{max} is given simply by

$$P_{max} = \frac{G_{max}}{\rho - 1} \quad \ldots \quad \ldots \quad (26)$$

As to the values of P_{min} and $(T_C)_{max}$, expression (18) takes the form,

$$\frac{P_{min}}{(T_C)_{max}} = \frac{\rho(\beta^2 - 1)}{\rho - 1} \quad \ldots \quad \ldots \quad (27)$$

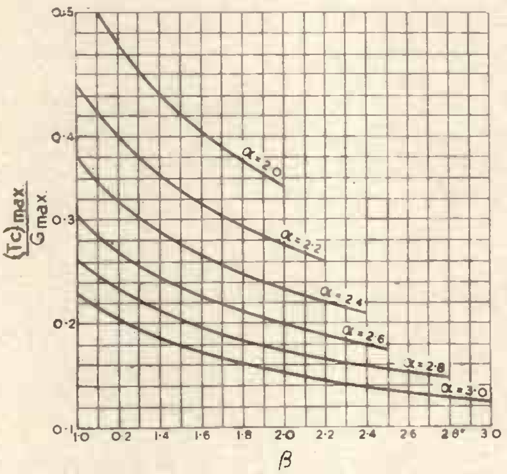

Fig. 5. *Charts of $(T_C)_{max}$ for high values of pilot-frequency ratio.*

when $T_L = 0$, if use be made of (25) and (26). We also have

$$P_{min} + (T_C)_{max} = \frac{G_{max}}{\rho - 1} \quad \ldots \quad (28)$$

from (25) and (26), so that the combination of (27) and (28) gives the required solutions,

$$(T_C)_{max} = \frac{G_{max}}{\rho\beta^2 - 1} \quad \ldots \quad \ldots \quad (29)$$

and

$$P_{min} = G_{max} \cdot \frac{\rho}{\rho - 1} \cdot \frac{\beta^2 - 1}{\rho\beta^2 - 1} \quad \ldots \quad (30)$$

The remaining solution required, that for $(T_L)_{max}$, is readily obtained from (18) by substituting $T_C = 0$ and $P = P_{max}$; it is

$$(T_L)_{max} = \frac{G_{max}}{\rho(\beta^2 - 1)} \quad \ldots \quad \ldots \quad (31)$$

An identity, which will be found useful in some of the transformations that follow, is

$$\frac{P_{max}}{P_{min}} = \frac{(T_L)_{max}}{(T_C)_{max}} \quad \ldots \quad \ldots \quad (32)$$

which follows immediately from (26), (29), (30) and (31).

Case where T_C is Specified.—It is apparent that the designer must estimate the value of one of the components L_0, P, T_C and T_L, in order to determine the others. In practice it is relatively an easy matter to estimate either T_L or T_C, given the maximum values permissible for these components, since they comprise various self and stray capacitances. Assuming, therefore, that T_C has been assigned a value less than the maximum given by (29) above, it follows that

$$P = P_{max} - T_C \quad \ldots \quad \ldots \quad (33)$$

from (25); also from (18), and using solutions already obtained, we have

$$T_L = \frac{P}{P_{min}} \left[(T_C)_{max} - T_C \right] \quad \ldots \quad (34)$$

in which P must first be evaluated from (33) immediately above. Finally, a convenient expression for the inductance is

$$L_0 = \frac{1}{(\omega_1 + \omega_j)^2} \cdot \frac{P_{min}}{P^2} \cdot \frac{1 + P_{max}/G_{max}}{1 + (T_C)_{max}/G_{max}} \quad \ldots \quad \ldots \quad (35)$$

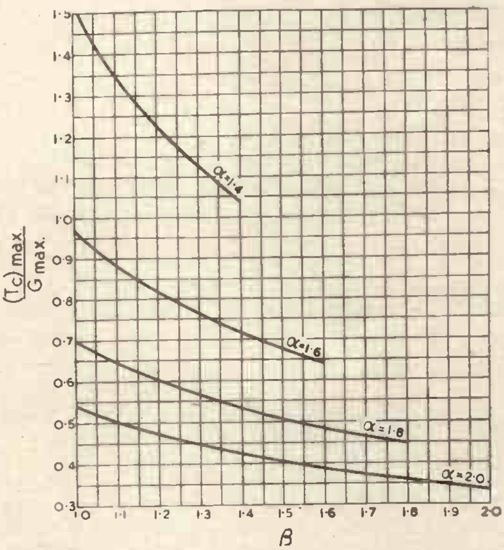

Fig. 6. *Charts of $(T_C)_{max}$ for low values of pilot-frequency ratio.*

in which $(\omega_1 + \omega_j)$ is the low-frequency tracking point of the padded signal circuit and P is obtained, as before, from (33). Expression (35) is derived from (13), with the help of (25) and (34).

Case where T_L is Specified.—The solutions for P and T_O in terms of a specified T_L are a little awkward for numerical computation, except in an approximate form which, how-

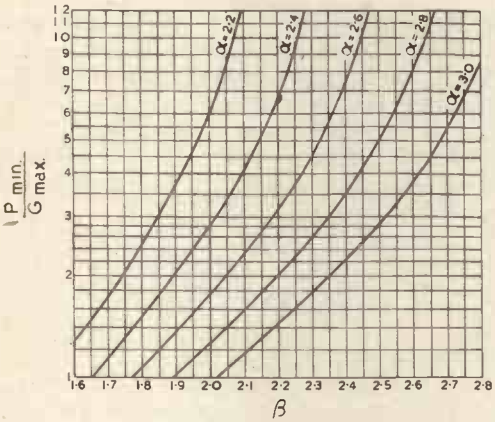

Fig. 7. *Charts of P_{min} for high values of both α and P_{min}.*

ever, is applicable to the numerous practical cases in which T_L comprises only the self-capacitance of the coil. The approximate solution is derived from (34), which may be rewritten as

$$T_O = (T_O)_{max} - T_L \cdot \frac{P_{min}}{P}$$

Clearly when T_L is small, T_O approaches its maximum value so that simultaneously, as indicated by (25), P approaches the value P_{min}. For such cases (34) may be written

$$T_O \simeq (T_O)_{max} - T_L \quad \cdots \quad (36)$$

with little error, and at the same time

$$P \simeq P_{min} + T_L \quad \cdots \quad (37)$$

from (25) and (36).

The exact solutions for P, T_O and L_0, in terms of a specified T_L, are derived from the combination of (33) and (34), and are

$$P = \frac{P_{min}}{2}\left[1 + \sqrt{1 + 4T_L/P_{min}}\right] \quad \cdots \quad (38)$$

and

$$T_O = (T_O)_{max} - T_L \cdot \frac{P_{min}}{P} \quad \cdots \quad (39)$$

The solution for T_O is, of course, dependent on the prior evaluation of P from (38). As to L_0, there seems little point in departing from expression (35), once P has been determined.

Gain of Padded Signal Circuit.—The fact that the padded signal circuit of Fig. 2 contains four disposable components, but that only three tracking frequencies are specified, gives the designer a limited amount of control over the gain of an amplifying stage. To a first approximation the gain is proportional to the resonant impedance (Z) of the circuit, where

$$Z = \frac{Q}{\omega C} \quad \cdots \quad (40)$$

In this expression, Q is the magnification ratio ($\omega L_0/R$) and C is the total effective capacitance across the inductance L_0 at frequency ω, that is to say

$$C = T_L + \frac{P(G + T_O)}{P + G + T_O} \quad \cdots \quad (41)$$

Using the results previously obtained in (25) and (34), we have

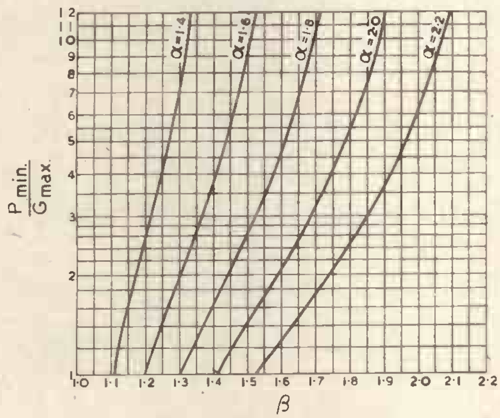

Fig. 8. *Charts of P_{min} for low values of α and high values of P_{min}.*

$$C = \frac{P^2}{P_{min}} \cdot \frac{G + (T_O)_{max}}{G + P_{max}} \quad \cdots \quad (42)$$

and the special case of frequency $\omega_1 + \omega_2$, where $G = G_{max}$ and $Z = Z_{min}$, is

$$C_{max} = \frac{P^2}{P_{min}} \cdot \frac{G_{max} + (T_O)_{max}}{G_{max} + P_{max}} \quad (43)$$

This formula is particularly useful in that it readily covers all cases of distribution of capacitances between T_O and T_L. In the two limiting cases of $T_O = 0$ and $T_L = 0$, the symbol P is to be replaced by P_{max} and P_{min} respectively; for an intermediate case, the value of P is derived from either

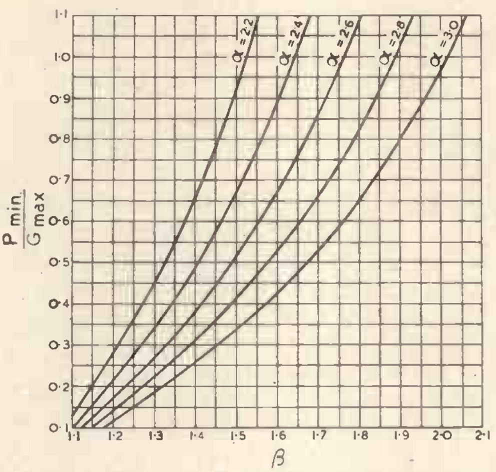

Fig. 9. *Charts of P_{min} for high values of α and medium values of P_{min}.*

(33) or (38), depending on which of the trimmers T_G or T_L is specified.

Tracking of Oscillator and Signal Circuits.—It has been pointed out that this problem resolves itself merely into tracking both of the padded circuits, one after the other, to the pilot circuit. All of the preceding analysis is applicable to the alignment of the padded oscillator circuit to the pilot circuit, it being necessary to remember that the three track-

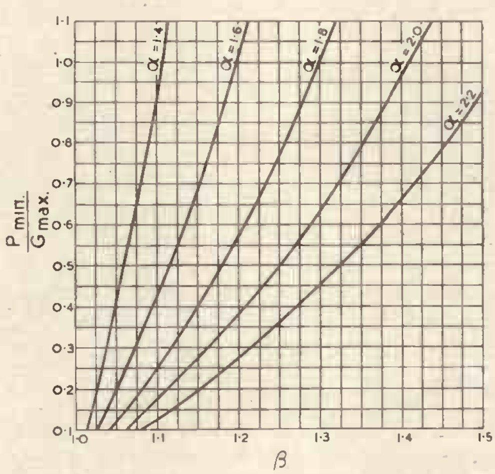

Fig. 10. *Charts of P_{min} for low values of α and medium values of P_{min}.*

ing frequencies are now of the form, $\omega + \omega_j \pm \omega_i$, where $\omega + \omega_j$ represents a known alignment point in the signal circuit. Values of P, T_G and T_L for the oscillator circuit may therefore be obtained from the same charts that have been compiled for the padded signal circuit, provided that the appropriate value of β is used.

As to the oscillator inductance, this is the only component whose solution contains a frequency symbol, and in which confusion is likely to occur between corresponding components in the two padded circuits. For this component, expression (35) must be replaced by

$$(L_0)_{osc} = \frac{1}{(\omega_1 + \omega_j \pm \omega_i)^2} \cdot \frac{P_{min}}{P^2} \cdot \frac{1 + P_{max}/G_{max}}{1 + (T_G)_{max}/G_{max}} \quad \ldots \quad \ldots \quad (44)$$

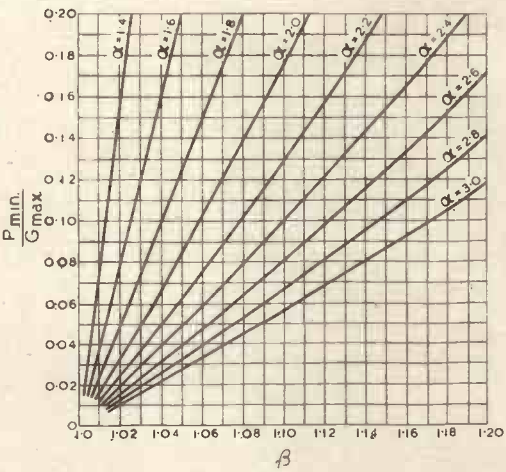

Fig. 11. *Charts of P_{min} for low values of P_{min}.*

in which P, P_{max}, P_{min}, and $(T_G)_{max}$, are evaluated for the particular "β" of the oscillator circuit.

5. Preparation of the Charts

It has been pointed out that, of the four components in the padded signal circuit, only the inductance has a solution in which the frequency specifically appears. The others P, T_G and T_L, can readily be expressed as fractions of the known tuning capacitance G_{max}, and therefore can be specified for frequency ratios of the circuit. Again it is clear, from the results obtained in the previous section, that the most useful quantities for evaluation are P_{min}, P_{max}, $(T_C)_{max}$ and $(T_L)_{max}$. Of these, the first three are so simply inter-related that it is

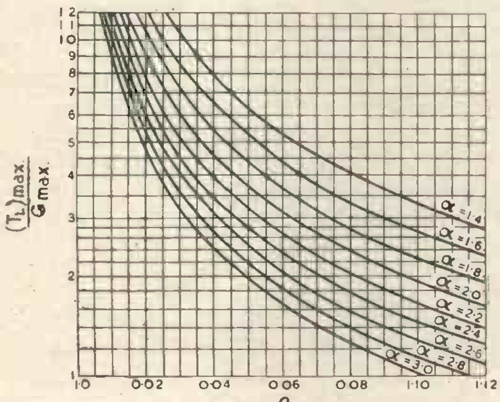

Fig. 12. *Charts of $(T_L)_{max}$ for high values of $(T_L)_{max}$.*

unnecessary to plot more than two, and in practice P_{min} is to be preferred to P_{max} on the score of accuracy in reading the charts. Fig. 4 is a key diagram for the charts that follow, giving a complete picture of the variations of P_{min}, P_{max}, $(T_C)_{max}$ and $(T_L)_{max}$ in padded circuits that are to be tracked with a pilot circuit of frequency ratio 2 : 1; the corresponding calibration scale is marked E in Fig. 3.

An object in the preparation of the charts

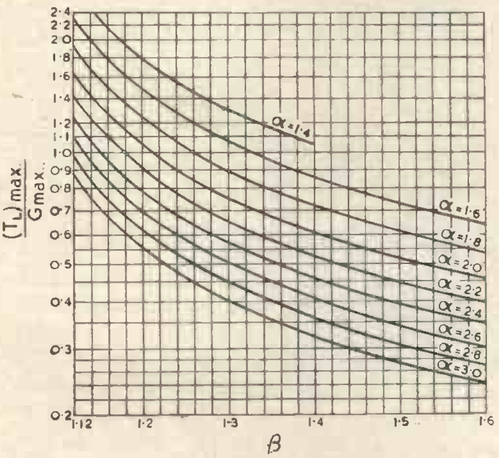

Fig. 13. *Charts of $(T_L)_{max}$ for medium values of $(T_L)_{max}$.*

is to provide sufficient data for the solution of the following three problems:

(*a*) In a padded signal circuit, to determine the values of the components in a manner such that the calibration scale is linear or a near approach to linearity;

(*b*) In a superheterodyne receiver comprising a padded signal circuit and a padded oscillator circuit, to track the two padded circuits;

(*c*) For a superheterodyne receiver comprising a simple parallel-tuned signal circuit and a padded oscillator circuit, to provide charts that extend the range of usefulness of those already given in Part II of this paper. Problems (*a*) and (*b*) could be satisfied by charts in which allowance is made for only two or three values of the frequency ratio (α) of the pilot circuit, say $\alpha = 3$, 2 and 1.5, since the parameter α is only of importance in determining the shape of the calibration

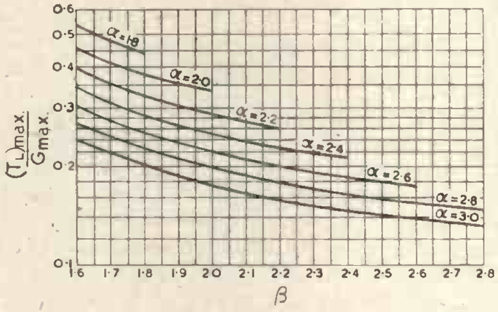

Fig. 14. *Charts of $(T_L)_{max}$ for low values of $(T_L)_{max}$.*

curve. In order, however, to provide for the very commonly required tracking problem of case (c), and therefore to complete the general usefulness of the charts, it is better to plot curves for a much larger number of values of α. Experience with the charts previously provided in Part II of this paper has shown that interpolation between curves for widely spaced values of α should be avoided if reading accuracy is to be maintained at a usefully high level. Accordingly the charts have been drawn for nine values of α between 1.4 and 3.0, at equally spaced intervals of 0.2.

It has already been mentioned that the symbols μ and μ_0 have been introduced into the analysis with the object of facilitating the computations. For each curve in the charts, it is desirable to plot the variation of the required component for values of β, from unity up to a maximum equal to the parametrical value of α assigned to the curve in question. In other words, if values of μ_0 are tabulated against β, then the same table inherently contains the desired value of μ; it is the same as the maximum value of μ_0 for the curve under consideration. The next step is to compute $\rho = (\mu - 1)/(\mu_0 - 1)$, and the remainder of the computations for P_{min}, $(T_C)_{max}$ and $(T_L)_{max}$ do not require comment.

Superheterodyne tracking charts for the component $(T_C)_{max}$ are illustrated in Figs. 5 and 6, P_{min} in Figs. 7—11, and $(T_L)_{max}$ in Figs. 12—14.

6. Application of Charts.

Summary of Formulae.—The following abridged list of formulae is recommended for use with the charts; a list of symbols has been given in Section 3. Numerical examples, using the charts and the formulae, are included in the present section.

Pilot Circuit—

$$T = \frac{G_{max}}{\alpha^2 - 1} \qquad \qquad (8)$$

$$\left(\frac{\omega_2}{\omega}\right)^2 = 1 + (\alpha^2 - 1)\frac{G}{G_{max}} \qquad \qquad (12)$$

Padded Circuit—

$$P + T_C = \frac{G_{max}}{\rho - 1} \qquad \qquad (24)$$

$$(T_C)_{max} = \frac{G_{max}}{\rho\beta^2 - 1} \qquad \qquad (29)$$

$$(T_L)_{max} = \frac{G_{max}}{\rho(\beta^2 - 1)} \qquad \qquad (31)$$

$$P + T_C = P_{max} = P_{min} + (T_C)_{max} \qquad (25)$$

T_C specified—

$$P = P_{max} - T_C \qquad \qquad (33)$$

$$T_L = \frac{P}{P_{min}}\left[(T_C)_{max} - T_C\right] \qquad \qquad (34)$$

where P is first evaluated.

T_L specified—

$$P = \frac{P_{min}}{2}\left[1 + \sqrt{1 + 4T_L/P_{min}}\right] \qquad \qquad (38)$$

$$T_C = (T_C)_{max} - T_L \cdot \frac{P_{min}}{P} \qquad \qquad (39)$$

where P is first evaluated. Approximate formulae, when $T_L \ll P$, are

$$T_C \simeq (T_C)_{max} - T_L \qquad \qquad (36)$$

$$P \simeq P_{min} + T_L \qquad \qquad (37)$$

Effective Capacitance across Inductance—

$$C = \frac{P^2}{P_{min}} \cdot \frac{G + (T_C)_{max}}{G + P_{max}} \qquad \qquad (42)$$

When $G = G_{max}$, then $C = C_{max}$. The value of P is to be obtained from (33) or (38), according as T_C or T_L is specified.

Inductance—

$$L_0 = \frac{1}{(\omega_1 + \omega_j)^2} \cdot \frac{P_{min}}{P^2} \cdot \frac{1 + P_{max}/G_{max}}{1 + (T_C)_{max}/G_{max}} \qquad \qquad (35)$$

in which $\omega_1 + \omega_j$ is the known low-frequency tracking point of a padded signal circuit. For a padded oscillator circuit, replace $\omega_1 + \omega_j$ by $\omega_1 + \omega_j \pm \omega_i$. The value of P can be derived from (33) or (38), according as T_C or T_L is specified. For an unpadded signal circuit,

$$L = \frac{\alpha^2 - 1}{\alpha^2 \omega_1{}^2 G_{max}} \qquad \qquad (45)$$

Selection of Calibration Curve—It has been mentioned that the designer may, on occasions, prefer to use a calibration curve for a padded signal circuit that departs somewhat from linearity. Examples of such frequency scales are illustrated in Fig. 3, and it is a matter of justifying their use. In practice it is sufficient to choose a value of α for the pilot circuit, such that this circuit has the desired shape of frequency scale, and then to confine attention to the corresponding curves in the charts.

By way of example, assume that a superheterodyne receiver with a padded signal circuit is to cover the 31-metre broadcast band, say 9.5—10.5 Mc/s, but that a closer approach to scale linearity is required than is given by the bandspread system illustrated in scale B of Fig. 1. Temporarily, for convenience, assume that β has the value 1.10 (corresponding with a band 9.5—10.45 Mc/s), and read off some trial values from the charts.

For $\beta = 1.10$

α	2.8	2.0	1.8	1.6
P_{min}	0.068	0.177	0.258	0.431
$(T_C)_{max}$	0.246	0.501	0.646	0.887
$(T_L)_{max}$	1.14	1.92	2.26	2.71
P_{max}	0.314	0.678	0.904	1.318
C_{max} for $T_L = 0$	0.064	0.157	0.223	0.351
C_{max} for $T_C = 0$	1.374	2.328	2.735	3.278

In the table, all values represent fractions of G_{max}; also P_{max} is derived from (25) and the two limiting values of C_{max} from (43).

The column for $\alpha = 2.8$ corresponds closely with a linear calibration scale, as illustrated in Fig. 3. The value of 0.068 for the ratio P_{min}/G_{max} involves, however, a padding condenser of less than 30$\mu\mu$F if all of the trimmer is placed across a tuning condenser of conventional capacitance, and this value of padder may be thought to be inconveniently small. The table indicates two ways in which the padder may be increased, while maintaining the desired value of β. One way involves a redistribution of trimming capacitances in the direction of increasing T_L, and the other device requires a shift to a smaller value of α and therefore to loss of scale linearity. It is, however, easy to show that the true compromise involved in this choice is between loss of gain on the one hand, and loss of scale linearity on the other.

A numerical example will make this point clear. The problem is to compare the gains of two padded signal circuits, aligned respectively with pilot circuits for which α has the values 2.8 and 2.0. In one case ($\alpha = 2.0$) the trimming capacitance is to be concentrated in T_C, so that $P = P_{min} = 0.177\ G_{max}$. In the other case ($\alpha = 2.8$) the trimming capacitances are to be distributed between T_C and T_L in such a manner that the padder is increased from its minimum value ($0.068\ G_{max}$) to the value $0.177\ G_{max}$, that is to say to the padder value specified for the other case. Components in the linear circuit are

$$T_C = P_{max} - P \qquad \text{(25)}$$

$$= (0.314 - 0.177)G_{max} = 0.137\ G_{max}$$

and

$$T_L = \frac{P}{P_{min}}\left[(T_C)_{max} - T_C\right] \qquad \text{(34)}$$

$$= \frac{0.177}{0.068}\left[0.246 - 0.137\right] G_{max}$$

$$= 0.284\ G_{max}$$

The maximum capacitance across the inductance in the linear circuit is

$$(C_{max})_{2\cdot 8} = \frac{P^2}{P_{min}} \cdot \frac{1 + (T_C)_{max}/G_{max}}{1 + P_{max}/G_{max}} \qquad (43)$$

$$= \frac{(0.177)^2}{0.068} \cdot \left[\frac{1{,}246}{1.314}\right] G_{max}$$

$$= 0.436\ G_{max}$$

On the other hand, the maximum capacitance in the other circuit is

$$(C_{max})_{2\cdot 0} = \frac{(0.177)^2}{0.177} \cdot \left[\frac{1.501}{1.678}\right] G_{max}$$

$$= 0.158\ G_{max}.$$

The ratio of the two numbers 0.436 and 0.158 immediately indicates that the gain of the non-linear circuit ($\alpha = 2.0$) is greater than that of the linear circuit ($\alpha = 2.8$) by a factor of 2.76. This, then, is the price to be paid for the convenience of approximately doubling the padder capacitance in the linear circuit. In the alternative scheme for increasing the padder capacitance, high gain is achieved at the expense of the relatively unimportant loss of scale linearity illustrated in scale E of Fig. 3.

Tracking of Padded Signal and Oscillator Circuits.—An example of a design problem involving the alignment of a superheterodyne oscillator circuit to a padded signal circuit has already been mentioned, in connection with a transmitter-receiver equipment for light aircraft (Honnor and Mathieson, 1941). The receiver has two bands, 2.5—3.5 Mc/s and 5.5—6.7 Mc/s, and the problem is to achieve a closer approach to scale linearity than is illustrated in the bandspread scale C of Fig. 1.

In order to illustrate some of the possibilities in the application of the tracking charts, two additional design criteria will be imposed, namely :

(*a*) The gains of the two padded signal circuits shall be equalised at the low-frequency limits 2.5 and 5.5 Mc/s respectively ;

(*b*) The band switching in the oscillator circuit shall be such that the one padding condenser must serve both bands.

Initially suppose that the designer has selected a pilot frequency ratio of 2.0, in accordance with the suggestion made in the previous section. A trial set of components from the charts would be :

For $\alpha = 2.0$

Band (Mc/s)	2.5–3.5	5.5–6.7	2.95–3.95	5.95–7.15
β ..	1.4	1.22	1.34	1.20
P_{min} ..	0.963	0.429	0.760	0.383
$(T_C)_{max}$	0.421	0.464	0.434	0.470
P_{max} ..	1.384	0.893	1.194	0.853
$(T_L)_{max}$	0.605	0.966	0.680	1.046

In this table the last two columns are for the padded oscillator circuits, assuming an intermediate frequency of 450 kc/s; the component values are given as fractions of G_{max}.

Taking first the requirement that the oscillator padder shall serve both bands, this is possible if a value be selected between 0.760 and 0.853, since these padder ratios correspond respectively with the minimum permissible value in the medium-frequency band and the maximum permissible value in the high-frequency band. Assume initially that the only contribution to T_L in the medium-frequency oscillator is by the self-capacitance of the inductance, of value 0.02 G_{max}, say 8$\mu\mu$F. Then for the M.F. oscillator circuit we have

$$T_L = 0.02\ G_{max}$$

$$T_C \simeq (T_C)_{max} - T_L \quad .. \quad .. \quad (36)$$

$$= (0.434 - 0.02) G_{max} = 0.414\ G_{max}$$

and $P \simeq P_{min} + T_L \quad .. \quad .. \quad (37)$

$$= (0.760 + 0.02)\ G_{max} = 0.780\ G_{max}.$$

If this padding capacitance is also to be used in the H.F. oscillator circuit, we have for that circuit,

$$T_C = P_{max} - P \quad .. \quad .. \quad (25)$$

$$= (0.853 - 0.780)\ G_{max} = 0.073\ G_{max}$$

$$T_L = \frac{P}{P_{min}}\left[(T_C)_{max} - T_C\right] \quad .. \quad (34)$$

$$= \frac{0.780}{0.383} \cdot \left[0.470 - 0.073\right] G_{max}$$

$$= 0.815\ G_{max},$$

and this value is permissible since it is less than the value (1.046) of $(T_L)_{max}$ for the H.F. band. As to the value (0.073) of T_C in the H.F. oscillator, this represents a capacitance of approximately 30$\mu\mu$F which is realisable if care be taken to reduce stray capacitances. It is apparent, therefore, that the two oscillator circuits can be designed to use a common padder, provided that the trimming capacitances are so located that T_L is negligibly small in the M.F. oscillator, and T_C approaches its realisable minimum value in the H.F. oscillator.

The next problem is to equalise the gains of the two padded signal circuits at their respective low-frequency limits. In practice this involves making a distribution of trimming capacitances in the M.F. band (2.5—3.5 Mc/s) such that less than the maximum possible gain is realised. Considering firstly the H.F. band (5.5—6.7 Mc/s), the greatest gain obtainable at 5.5 Mc/s will be had under the following conditions:

$$T_L = 0$$

$$T_C = (T_C)_{max} = 0.464\ G_{max}$$

$$P = P_{min} = 0.429\ G_{max}$$

$$C_{max} = \frac{(0.429)^2}{0.429} \cdot \left[\frac{1.464}{1.893}\right] G_{max} \quad .. \quad (43)$$

$$= 0.332\ G_{max}.$$

Turning next to the M.F. band, the circuit gain at 2.5 Mc/s can be made equal to that at 5.5 Mc/s in the other band, if the total effective tuning capacitance be adjusted to the value

$$0.322\ G_{max} \cdot \frac{5.5}{2.5} = 0.73\ G_{max}$$

Using expression (43) for the M.F. band, we have

$$C_{max} = \frac{P^2}{P_{min}} \cdot \left[\frac{1 + (T_C)_{max}/G_{max}}{1 + P_{max}/G_{max}}\right] = 0.73\ G_{max}$$

Appropriate values of P_{min}, P_{max} and $(T_C)_{max}$ are given in the first column of the preceding table, so that the expression can be solved for P;

$$P = 1.085\ G_{max}$$

leading to

$$T_C = P_{max} - P \quad .. \quad .. \quad (25)$$

$$= (1.384 - 1.085)\ G_{max} = 0.299\ G_{max}$$

and

$$T_L = \frac{P}{P_{min}}\left[(T_C)_{max} - T_C\right] \quad .. \quad (34)$$

$$= \frac{1.085}{0.963} \cdot \left[0.421 - 0.299\right] G_{max}$$

$$= 0.136\ G_{max}$$

These, then, are the components for the M.F. band to give the same gain as the maximum obtainable in the H.F. band. In practice it will not be possible to achieve the condition

$T_L = 0$ in the H.F. band, but allowance can be made for the self-capacitance of the coil in the same manner as previously indicated. Due, however, to the fact that the gain of the signal amplifying stage depends also on other factors, e.g. the Q of the inductance, it does not seem to be necessary to attempt greater accuracy in the design of the condensers.

Tracking of Oscillator with Simple Parallel-tuned Signal Circuit—This problem is essentially that considered in Part II of this paper. The only point to be remembered is that, in replacing the pilot circuit by a real signal circuit, the virtual intermediate frequency (ω_j) becomes the true intermediate frequency (ω_i) in expressions (13), (14) and (15). Correspondingly, the frequencies ω_1, ω_2 and ω_3 in (5), (6) and (7) become known quantities, so that it is possible to determine the inductance (L) of the signal circuit,

$$L = \frac{\alpha^2 - 1}{\alpha^2 \omega_1^2 G_{max}} \qquad \cdots \quad (45)$$

With this modification, the superheterodyne tracking charts are indistinguishable from those previously published, with the exception that greater reading accuracy is now provided.

Arbitrarily Chosen Tracking Points.—In Part II, allowance has been made for the possibility of reducing superheterodyne tracking errors by using the device introduced by Cocking. (1938). Briefly this involves using outer tracking frequencies (ω_1 and ω_2) that do not coincide respectively with the low-frequency and high-frequency limits of the band. A convenient manner of introducing this idea in the application of the charts is simply to interpret α and β as the frequency ratios of the tracking points, rather than of the band limits. The ratio P_{min}/G_{max} can be read directly from the charts, but $(T_C)_{max}$ and $(T_L)_{max}$ now contain additional contributions from the tuning condenser, due to its rotation from the H.F. band limit to the H.F. tracking point. These contributions can, however, readily be measured or calculated, as can the new value of G_{max} appropriate to the L.F. tracking point.

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A.M.I.E.E. Examination Changes

THE Institution of Electrical Engineers announces the following changes in the examination for Associate Membership, which will become effective in October 1945.

In place of the present Part I a Joint Section A examination will be held in conjunction with the Institution of Civil Engineers. Papers of three hours each will be set in these subjects: English, Mathematics, Principles of Electricity, Applied Mechanics and Applied Heat. Evidence of laboratory work in the subjects of Applied Heat and Principles of Electricity may be called for.

Section B of the examination, which replaces the present Part II, consists of a three-hour paper on Electrical Engineering, and a three-hour paper on one of the following subjects: Electricity Supply, Electrical Measurements, Electrical Installations, Electrical Machinery, Radio Communications or Line Communications. The revised regulations and syllabuses are obtainable from the Secretary, I.E.E., Savoy Place, London, W.C.2.

The Industry

THE London Office of Ferranti, Ltd., has been transferred to 36, Kingsway, W.C.2. Telephone: Temple Bar 6666.

The shares of Hammans Industries, Ltd., manufacturers of insulating materials, have been acquired by De La Rue Plastics, Ltd.

The address of Multicore Solders, Ltd., is now Commonwealth House, New Oxford Street, London, W.C.1. Telephone: Chancery 5171/2.

"Wireless Engineer" Publication Date

PRINTING arrangements have necessitated a change in the publication date of *Wireless Engineer*, which will in future be the sixth of the month.

Brit.I.R.E.

AT the next meeting of the London Section of the British Institution of Radio Engineers, E. L. Gardiner, B.Sc., will read a paper on "Selective Methods in Radio Reception." The meeting, which is arranged for 6.30 on December 15th, will, as usual, be held at the Institution of Structural Engineers, 11, Upper Belgrave Street, S.W.1.

Direct Reading of the Frequency of Resonant Circuits

By W. H. F. Griffiths, F.Inst.P., M.I.E.E.

(Concluded from page 538 of the November issue)

IN the capacitance law, $C = \frac{1}{(a\theta + b)^2}$, which must be satisfied if linearity of frequency scale is to be realised, C must, of course, embrace all components of the residual capacitance, i.e., the total *circuit* capacitance at $\theta = 160$. In estimating this residual an allowance must be made for the effective value of the self-capacitance of the inductance coil of the resonant circuit. If a wide range of frequency is to be provided a number of " range coils " are necessary and these will have widely different values of self-inductance and almost certainly will have different values of self-capacitance in consequence. The best procedure in this case is to base the design law on a mean capacitance, c_s, which is the mean of the self-capacitances of all range coils. The frequency law will then suffer a departure from linearity at the highest and lowest frequency ranges of the circuit.

The change of $df/d\theta$ due to a value of coil self-capacitance c'_s different from c_s may be found in the following manner:

Let f = the frequency which would be obtained if the range coil of inductance L' had a self-capacitance c_s, and f' = that actually obtained by virtue of a self-capacitance c'_s

then
$$f' = f\left\{1 - \frac{\frac{1}{2}(c'_s - c_s)}{C}\right\}$$
$$= \frac{a\theta + b}{2 \times 10^{-6}\pi\sqrt{L}} \left\{1 - \tfrac{1}{2}(c'_s - c_s)(a\theta + b)^2\right\}$$
$$\frac{df'}{d\theta} = \frac{a}{2 \times 10^{-6}\pi\sqrt{L}} \left\{1 - \tfrac{3}{2}(c'_s - c_s)(a\theta + b)^2\right\} \quad (37)$$

Therefore
$$\frac{d^2f'}{d\theta^2} = -\frac{6a^2(c'_s - c_s)}{4 \times 10^{-6}\pi\sqrt{L}}(a\theta + b) \quad (38)$$

It has been shown already that if N is the number of equidistant calibration points, the maximum possible frequency error due to interpolation midway between any two adjacent points
$$= +\frac{3200}{(N-1)^2} \cdot \frac{d^2f}{d\theta^2}$$
$$= -\frac{3200}{(N-1)^2} \cdot \frac{6a^2(c'_s - c_s)}{4 \times 10^{-6}\pi\sqrt{L}}(a\theta + b)$$

Expressed as a fractional part of frequency the interpolation error becomes
$$-\frac{3200 \times 6a^2(c'_s - c_s)(a\theta + b) \times 2 \times 10^{-6}\pi\sqrt{L}}{(N-1)^2 \times 4 \times 10^{-6}\pi\sqrt{L}\,(a\theta + b)}$$
$$= -\frac{9.6 \times 10^3\, a^2(c'_s - c_s)}{(N-1)^2} \quad \ldots \quad (39)$$

which is constant for all values of θ.

As explained previously the interpolation error from any single cause cannot be allowed to exceed one-fifth of the total inaccuracy, α, of the frequency of a resonant circuit. It is seen, therefore, that
$$c'_s - c_s \leqslant \frac{\alpha/5\,(N-1)^2}{9.6 \times 10^3\, a^2} \quad \ldots \quad (40)$$

The evaluation of this expression for the example of the 0.01 per cent. wavemeter already described in which $\alpha = 0.0001$, and $N = 7$ shows that the permissible variation of self-capacitance of the many range coils is $\pm 7\mu\mu F$. It must be remembered, however, that in circuits of lower minimum capacitance, C_{min}, the permissible tolerance would be less.

In the example the assumed value of c_s was 7 $\mu\mu$F. This represented the true condition for a medium frequency range of the order 1 Mc/s. At 100 kc/s a coil of larger self-capacitance (11 $\mu\mu$F) was needed, while at the highest frequencies of 15 Mc/s the self-capacitance of the range coil was only 4 $\mu\mu$F. The curves of Fig. 17 show the percentage change of $df/d\theta$ caused by the change $(c'_s - c_s)$, of self-capacitance occurring at these extreme lower and upper frequencies.

Having dealt with the law complications enumerated as *a*, *b* and *c* early in the article, that enumerated as *d* will now be dealt with briefly—the effect of plate "wobble" together with its accompanying defect, inequality of dielectric gaps.

Because of the inverse law connecting capacitance and dielectric gap distance the equalisation of the gaps on either side of each moving plate is an important feature[1] in the construction of a variable air condenser which is required to be true to any given law. Small general and local irregularities which would produce only negligible deviation from the mean law if the plates were absolutely equidistant will produce law deviations by no means inconsiderable if this initial plate setting has not been effected or insufficient care has been exercised in this operation. In order to illustrate this effect, the case of "wobble" due to a bent moving plate will be considered as an example. The sketch of Fig. 18 shows a moving plate bent to an angle, η, of 9′ in a radial direction at the trailing radial edge. At the leading radial edge the plate is perfectly flat and parallel to the pair of fixed plates between which it interleaves. The degree of wobble at any angular condenser setting θ is shown in the following table—the angular displacement from a plane parallel with the fixed plates is given as η. It is seen that such a wobble causes displacements of a few thousandths of an inch from the mid-position at the peripheral edge of a moving plate of 4 inches radius.

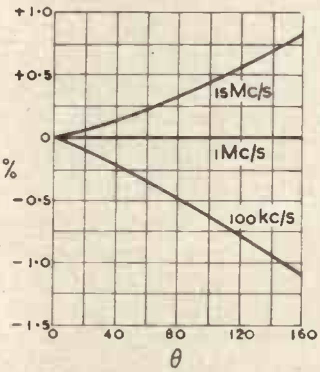


Fig. 17.—*Showing the effect upon $df/d\theta$ of inductances of varying self-capacitances—expressed as a percentage deviation of $df/d\theta$ from a linear law of f.*

θ degrees	η	Peripheral displacement of moving plate due to wobble expressed as a distance	a percentage of $g_1+g_2=0.2$ in.
180	0	0	0
120	3′	0.003 inch	1.6%
60	6′	0.006 inch	3.3%
0	9′	0.01 inch	5%

The curves of Fig. 19 show the percentage deviation of $dC/d\theta$ at any angular setting θ of the condenser if all moving plates were bent in this manner. It is seen that such a wobble would have produced an almost negligibly small effect upon the law of the condenser had there been no initial displacement of the moving plates from their mid-positions between the fixed plates (i.e. $g_1=g_2$).

Had the moving plates been 5 per cent. displaced initially from their mid-positions (i.e. $g_2=\frac{1.1}{0.9}g_1$), however, the same amount of plate wobble would have produced an appreciable deviation from law in the region of the maximum capacitance of the condenser.

The third curve shows that the same amount of wobble produces a serious effect upon the law when the moving plates are displaced initially by 16.7 per cent. ($g_2=2g_1$). In this case the deviation of $dC/d\theta$ reaches 8 per cent. at maximum capacitance. Initial inequality of dielectric gaps of this order are not likely to be experienced in practice with variable condensers of good quality unless such inequality is an intentional feature of design as is the case with a special temperature compensated condenser due to Thomas.[2]

It is unlikely that *all* moving plates would be bent in the same manner and in the same direction, and so the law deviation due to plate bending is unlikely to be as great as that shown in Fig. 19 in accurate variable condensers in which the dielectric air gaps are invariably large. Law deviations of this

[1] This constructional feature is also necessary to ensure the greatest possible calibration permanence of a variable condenser: see an article by the present author "The Accuracy and Calibration Permanence of Variable Air Condensers for Precision Wavemeters". *Wireless Engineer*, Vol. V, No. 52 (Jan. 1928), pp. 17–24.

[2] "The Theory and Design of Valve Oscillators" by H. A. Thomas, p. 228, and "The Temperature Compensation of Condensers" by the present author, *Wireless Engineer*, XIX 222 (March, 1942), p. 108.

order and even greater are experienced, however, in less accurate condensers having smaller dielectric gaps. Moreover, it must be remembered that although, for simplicity of presentation, the plate wobble has been regarded as being caused by bent moving plates, it may also be produced by a variety of other causes such as a bent moving plate spindle. In this latter case all moving plates *would* wobble to the same extent, and the effect upon the law would be much more serious than that produced by one or two distorted plates.

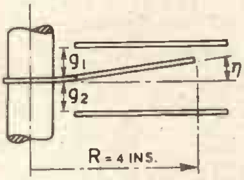


Fig. 18.

As stated in the introduction to this section these effects upon the law of a condenser are due to the inverse law connecting capacitance C and dielectric gap distance g so that if g_1 and g_2 are the gap distances on either side of a moving plate,

$$C \propto \frac{1}{g_1 g_2}$$

In order to make the capacitance independent of the ratio g_1/g_2 the two dielectric gaps must be arranged to be in series electrically instead of in parallel. If this is so *and the gaps are still allowed to be complementary* then

$$\frac{1}{C} \propto \frac{1}{1/g_1} + \frac{1}{1/g_2}$$

$$\propto g_1 + g_2$$

Therefore

$$C \propto \frac{1}{g_1 + g_2} \quad \ldots \quad \ldots \quad (41)$$

which is constant.

A condenser with adjacent dielectric gaps arranged in this manner has been termed by the author[3] a "series-gap variable condenser," and must not be confused with a commercially used variable condenser of the type in which two entire variable condenser units are connected electrically in series by arranging that the moving plates of each unit are mounted on the same metal shaft. Such a condenser[4] is also termed a series-gap condenser, somewhat erroneously and is a design sometimes resorted to at high frequencies merely in order to avoid the use of a "collector" for the moving plate system. It has none of the fine qualities of the author's series-gap condenser. Even the latter will not have complete immunity from the capacitance instability effects caused by variation of the ratio g_1/g_2 unless precautions are taken to shield electrostatically adjacent elements of the complete plate assembly. Moreover, the "law" of the series-gap condenser with all this elaboration is still affected by moving plate "wobble." If the moving plate is not parallel to the adjacent pair of fixed plates, between which it interleaves, the adjacent dielectric gaps may be represented as neighbouring elemental condensers of capacitances C_1, C_2, and C_3, C_4, as in the sketch of Fig. 20. The resultant capacitance of these two elemental sections is

$$C = \frac{(C_1 + C_3)(C_2 + C_4)}{C_1 + C_3 + C_2 + C_4}$$

the value of which will not remain constant unless

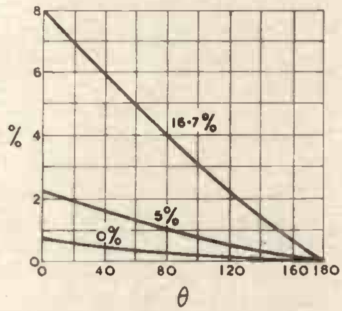
$$C_1 = C_3$$

and

$$C_2 = C_4$$

for all values of C_1 and C_2 even though $g_1 + g_2 = g_3 + g_4$. Thus a wobble of the moving plate will alter the value of $dC/d\theta$ unless the neighbouring elemental sections C_1, C_2, and C_3, C_4, are isolated. This the author has achieved by employing moving plates of glass on which a number of specially shaped metallic areas are deposited to

Fig. 19.—*Showing the percentage increase of $dC/d\theta$ caused by "wobble" for various percentages of initial plate displacement at $\theta = 180$ degrees (see text).*



[3] "Further Notes on the Calibration Permanence and Overall Accuracy of the Series-gap Precision Variable Air Condenser". *Wireless Engineer*, VI 64 (Jan., 1929), pp. 23–30, and VI 65 (Feb., 1929), pp. 77–80 by the present author.

[4] The present author is sorry to find that such an eminent authority as Dr. Hartshorn has termed Fig. 54, p. 117 of his work "Radio-Frequency Measurements by Bridge and Resonance Methods" (Chapman & Hall, 1940), a "*Series-gap Condenser.*"

correspond to the neighbouring elemental sections. The capacitance of C_1 and C_2 in series is now constant irrespective of changes in the position of the moving plate since

$$C = \frac{C_1 C_2}{C_1 + C_2} \propto \frac{1}{g_1 + g_2}$$

and, that of C_3 and C_4 in series being similarly constant, the sum of

$$\frac{C_1 C_2}{C_1 + C_2} \quad \text{and} \quad \frac{C_3 C_4}{C_3 + C_4}$$

must now be constant, irrespective of the relation between C_1 and C_3 or between C_2 and C_4.

Thus it is possible to overcome, to a great extent, irregularities of law due to moving plate wobble by using a series-gap condenser, but the author would not suggest that a variable condenser designed on this principle is necessary in order to obtain strict conformity to law. An ordinary parallel-gap condenser with a dielectric gap as large as possible consistent with reasonably low self-inductance is capable of adjustment to good conformity to its design law, provided that the gap equalisation is effected conscientiously.

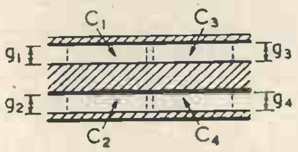


Fig. 20.

Mention of the self-inductance of the condenser introduces the remaining cause of law imperfection—that due to the variation of this inductance with θ.

Unlike the other causes of law imperfection a, b, c and d, this final cause, e, is dependent upon frequency.

The self-inductance of a variable air condenser of the conventional parallel plate design is somewhat variable with θ. Invariably it is found to be a minimum, L_0, at the minimum capacitance setting of the condenser, and a maximum $L_0 + \Delta L_0$ at the maximum capacitance setting. Moreover, it is usually found to vary more or less uniformly throughout the angular rotation of the condenser; this change of self-inductance may be expressed as

$$-\Delta L_0 \left\{\frac{\theta - 160}{160}\right\} \qquad \ldots \quad \ldots \quad (42)$$

for a linear frequency law condenser.*

The effect of such a residual upon the linearity of law is determined as follows:

$$f = \frac{1}{2\pi\sqrt{LC}} = \frac{a\theta + b}{2\pi\sqrt{L}}$$

where a and b are the plate-shape constants already found by expressions (7) and (8) respectively but multiplied by 10^6 in order to effect the change from $\mu\mu$F units of the condenser design formulae to the farad units of the present frequency formulae.

The total inductance, L, of the resonant circuit is given by

$$L = L_1 + L_0 - \frac{\theta - 160}{160}\Delta L_0$$

$$L = L_1 + L_0 + \Delta L_0 - \frac{\Delta L_0}{160}\theta \qquad \ldots \quad (43)$$

and, therefore,

$$f' = \frac{a\theta + b}{2\pi\sqrt{L_1 + L_0 + \Delta L_0 - \frac{\Delta L_0}{160}\theta}} \qquad (44)$$

Working logarithmically to differentiate this expression,

$$\log_e f' = \log_e (a\theta + b) - \tfrac{1}{2}\log_e 4\pi^2\left(L_1 + L_0 + \Delta L_0 - \frac{\Delta L_0}{160}\theta\right)$$

$$\frac{1}{f'} \cdot \frac{df'}{d\theta} = \frac{a}{a\theta + b} - \frac{1}{2}\left\{\frac{-4\pi^2 \Delta L_0/160}{4\pi^2\left(L_1 + L_0 + \Delta L_0 - \frac{\Delta L_0}{160}\theta\right)}\right\}$$

Putting

$$L = L_1 + L_0 + \Delta L_0 - \frac{\Delta L_0}{160}\theta$$

$$\frac{df'}{d\theta} = \frac{a}{2\pi L^{\frac{1}{2}}} + \frac{2\pi^2 \Delta L_0 (a\theta + b)}{1280\,\pi^3 L^{\frac{3}{2}}}$$

$$\frac{df'}{d\theta} = \frac{320\,aL + \Delta L_0(a\theta + b)}{640\pi L^{\frac{3}{2}}} \qquad \ldots \quad (45)$$

Differentiating logarithmically,

$$\log_e \frac{df'}{d\theta} = \log_e\left\{320\,a\left(L_1 + L_0 + \Delta L_0 - \frac{\Delta L_0}{160}\theta\right) + \Delta L_0(a\theta + b)\right\} - \log_e 640\,\pi - \tfrac{3}{2}\log_e\left\{L_1 + L_0 + \Delta L_0 - \frac{\Delta L_0}{160}\theta\right\}$$

* This is probably not true for commercial variable condensers of wide capacitance range in which there exists a large variation of R with θ.

$$\frac{1}{\frac{df'}{d\theta}} \cdot \frac{d^2f'}{d\theta^2} = \frac{-\frac{320\,a}{160}\,\Delta L_0 + a\Delta L_0}{320aL + \Delta L_0\,(a\theta + b)} - \frac{3}{2} \cdot \frac{-\Delta L_0/160}{L}$$

$$\frac{d^2f'}{d\theta^2} = \frac{+\frac{3\Delta L_0}{320}\left\{320\,aL + \Delta L_0(a\theta + b)\right\} - \frac{320\,a}{160}\Delta L_0 L + \Delta L_0 aL}{L\left\{320\,aL + \Delta L_0(a\theta + b)\right\}} \cdot \frac{320\,aL + \Delta L_0(a\theta + b)}{640\pi L^{\frac{3}{2}}}$$

$$= \frac{+\,3\,a\,\Delta L_0\,L + 3/320\,\Delta L_0^2\,(a\theta + b) - 2\,a\,\Delta L_0\,L + a\,\Delta L_0\,L}{640\,\pi L^{\frac{5}{2}}}$$

$$= \frac{\Delta L_0\{aL + 3/640\,\Delta L_0(a\theta + b)\}}{320\pi L^{\frac{5}{2}}} \qquad \ldots \quad \ldots \quad \ldots \quad (46)$$

where

$$L = L_1 + L_0 + \Delta L_0 - \frac{\Delta L_0}{160}\,\theta$$

and the interpolation error is, from (18),

$$+\frac{3200}{(N-1)^2} \cdot \frac{d^2f'}{d\theta^2}$$

which, expressed as a fractional part of f', must not exceed one-fifth of the total inaccuracy of the frequency of the resonant circuit:

$$\frac{3200}{(N-1)^2} \cdot \frac{d^2f'}{d\theta^2} \Big/ f' \leqslant \frac{\alpha}{5}$$

The value of the self-inductance L_0 of a variable air condenser of large dimensions and good design is of the order 0.05 μH. It might be somewhat higher in a condenser of very large dimensions such as would be used for a precise wavemeter or oscillator for frequencies lower than 15 Mc/s or so. On the other hand, the figure might, perhaps, be as low as 0.03 μH in the case of a condenser of smaller dimensions (not midget dimensions) intended for use at higher frequencies.* It is most difficult to predetermine the self-inductance of any particular design of variable condenser, but elementary precautions may be taken to ensure that it does not exceed 0.06 μH.

Fortunately, by far the greater part of L_0 is constant with θ, the total variation, ΔL_0, being of the order 0.005 μH for very large condensers and somewhat less for those of smaller dimensions. The author's experience has shown that ΔL_0 rarely exceeds 0.1 L_0; the reason for this is, of course, that the leads, collector system, framework and other parts of *fixtures* contribute much more self-inductance than does the *variable* plate system itself.

The variation of self-induction ΔL_0 in the case of the variable condenser of the example which has been examined throughout this article was of the order 0.005 μH, and such variation would affect the linearity of the frequency law at high frequencies as shown by the curves of Fig. 21. The expression (45) was used in the computation of $df/d\theta$ from which these curves were plotted. It will be seen that at frequencies lower than 5 Mc/s, corresponding to $L_1 + L_0 \doteqdot 3 \times 10^{-6}$, the variation of self-inductance has no appreciable effect upon the law. As the value of $L_1 + L_0$ is decreased, however, the linearity of the law suffers to an increasing extent.

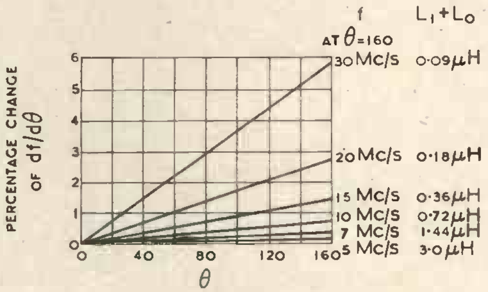


Fig. 21.—*Showing the effect of a given value of ΔL_0 (0.005 μH) upon $df/d\theta$ at various frequencies.*

* It is not an infallible rule that variable condensers of the largest physical dimensions necessarily have the largest values of L_0 and ΔL_0. Some quite small condensers have high self-inductance and vice-versa

The limit to law imperfection is, of course, imposed by the interpolation error permissible which, in the case of the example, is 0.002 per cent. as has been stated previously. The curves of Fig. 22 show, therefore, that the self-inductance $L_1 + L_0$ of the circuit should not be reduced below 0.36×10^{-6} thus limiting the frequency to 15 Mc/s.

This frequency limitation, the curves of Figs. 21 and 22 and, in fact, the whole of the expressions (44), (45) and (46), which have been developed to show the effect of variation of self-inductance, are based upon the assumption that most of the capacitance C_{min} resides in the variable condenser itself; in which case the resonant circuit may be represented by the simplified diagram* of Fig. 23 (a). This is good practice especially for short-wave circuits. If, however, an appreciable part of C_{min} is set up as an independent fixed condenser C_F, the diagram

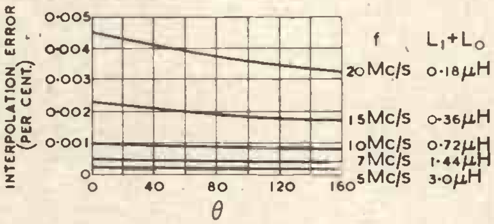


Fig. 22.—*Showing the effect of a given value of* ΔL_0 (0.005 μH) *upon the interpolation error at various frequencies.*

must be changed to that of Fig. 23 (b) in which another component, L_F, of residual self-inductance appears. The influence of the branch circuit $C_F L_F$ upon ΔL_0 may be very appreciable if the value of C_F approaches the order $C_{min} - C_F$. The actual value of ΔL_0 of the variable condenser may, in effect, be augmented greatly in this way. Moreover, such augmentation is not minimised by reducing L_F—this usually aggravates the trouble—as is seen in the curves of Fig. 24. These curves and those of Fig. 25 are applicable to the case of the example which has been referred to throughout the article if $C_F = \frac{1}{2} C_{min}$. Fig. 24 shows the effect of varying the value of L_F while Fig. 25 shows the effect of varying the value of L_0.

It is seen that there are optimum values for both L_F and L_0—values which reduce the change of the effective self-inductance of the circuit to a negligible amount. It would seem that the effect of ΔL_0 upon the linearity of the frequency law of the variable

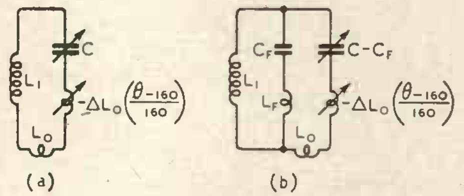


Fig. 23.

condenser may be eliminated by a judicious augmentation of the value of L_F. Obviously, however, such compensation becomes impracticable when the value of L_F demanded ceases to be small compared with that of the total self-inductance of the whole resonant circuit. If a large part of C_{min} resides in a separate fixed condenser it will be seen, from Figs. 24 and 25, that it is possible for the *effective* change of self-inductance with θ to be over 300 per cent. greater than that, ΔL_0, of the variable condenser alone. It is thus possible that the $d^2f/d\theta^2$ values of the curves of Fig. 21 will be raised by over three times by this redistribution of capacitance. On the other hand, due also to this same redistribution of capacitance but with different values of

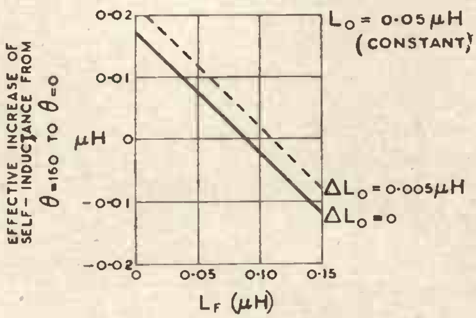


Fig. 24.

residual self-inductances, the $d^2f/d\theta^2$ values may be reduced or actually reversed in algebraic sign. Usually, however, in well-designed circuits, either the greater part of C_{min} resides in the variable condenser or the self-inductances L_0 and L_F are not very

* In the diagrams of Fig. 23 the self-capacitance of L_1, the capacitance of the valve or other circuit attachment and the stray lead capacitances are omitted in the interests of simplification. The inductance of the leads between L_1 and C is included in the value of L_1, and circuit resistance is assumed to be negligible and ignored for simplicity.

different from 0.05 μH. In either of these cases the augmentation of ΔL_0 rarely exceeds 100 per cent. but even this might reduce the upper limit of frequency in the example depicted in Fig. 22 from 15 Mc/s to 10 Mc/s. The curves of Fig. 22 are based upon the actual calibration of seven cardinal frequencies, and if this number is increased on the 15 Mc/s range so as to increase $(N - 1)$ proportionally to the frequency (in this case by $\sqrt{2}$) the effect upon the interpolation error of the 100 per cent. augmentation of ΔL_0 will be nullified.

Thus, if the effect of ΔL_0 itself, or of any augmentation of it due to a branching of the capacitance arm of a resonant circuit,

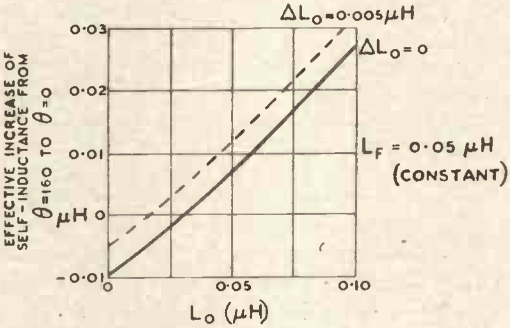


Fig. 25.

is serious upon the extreme (high) frequency ranges, the latter may be calibrated at a number of cardinal frequencies which increases progressively with frequency.

The author feels that it is just possible that the law may deviate from linearity from yet another cause of self-inductance variation with scale angle θ. This possible cause, however, does not reside in the variable or fixed condensers or their circuits. It is due to the frequency characteristic of inductance of the main coil L_1, Fig. 23.

If the frequency at which a coil is used is raised above a certain value there occurs a redistribution of current within the cross-section of the conductor. This is commonly termed the "skin-effect" and is due to the eddy currents induced in the conductor. The change of self-inductance consequent upon such current redistribution is well known—the inductance of a straight conductor or of a coil formed by that conductor decreases with frequency (above a certain value) until a limit is reached when the current is confined to a peripheral strip of the conductor of negligible thickness. A further increase of frequency, beyond this sensibly limiting value, produces no corresponding further reduction of inductance although, of course, the effective resistance of the conductor continues to rise with frequency and has no limit.

It is seen, therefore, that associated with any range coil of a wavemeter or resonant circuit there is a band of frequencies throughout which the internal inductance of the conductor is changing rapidly.

Naturally the effect is more appreciable in coils of large conductor section owing to the correspondingly larger contribution which the internal inductance makes to the total inductance at low frequencies. For this reason the change of inductance with frequency would be expected to be more serious in the highest frequency ranges of a wavemeter—the ranges in which coils of one or two turns of heavy conductor are usually employed.

As an example, the curves of Fig. 26 show the extent of this eddy current effect in single turn coils of 5 cm mean radius. The curves A, B and C, which are for medium, fine and very fine conductors, respectively, show the percentage reduction of total self-inductance due to the gradual loss of the internal inductance component with increasing frequency. The heavier the section of the conductor the lower is the frequency at which the loss of the internal component commences to be appreciable. Thus it is seen that the frequency at which the maximum change in $\Delta L_1/L_1$ occurs may vary from 150 kc/s in the case of the medium conductor, to 15 Mc/s in the case of the very fine conductor.

It should, perhaps, be noted that for a given diameter of turn (given length of conductor) the maximum *fractional* reduction, $\Delta L_1/L_1$, of inductance (at very high frequencies) increases with conductor section. This, obviously, is because a greater percentage of the total magnetic field is within that section, in consequence of which, the maximum inductance (at $f = 0$) is decreased by increasing the conductor section. The maximum reduction of *actual* inductance, ΔL_1, at very high frequencies is independent of conductor section.

In an accurate wavemeter a coil of the

dimensions of the present example would be used at a frequency of the order 10 Mc/s. If the conductor were 0.01 cm diameter (curve *C*) the reduction of effective inductance in the coil would, it is seen, be about 0.4 per cent. for a frequency range

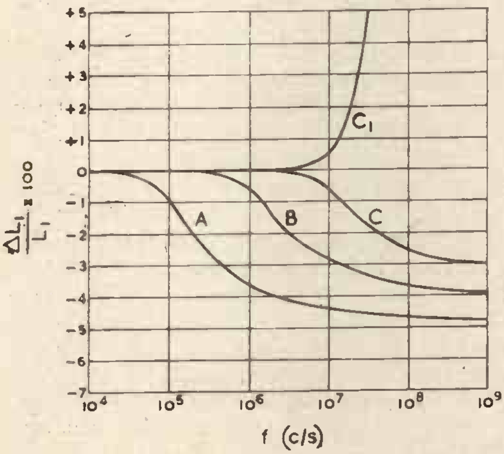


Fig. 26.—*The curves A, B, and C show the percentage reduction of self-inductance of single turn coils due to eddy current effect. The curves relate to copper coils of* 5 *cms mean radius and of conductor diameters of* 0.1 *cm,* 0.03 *cm and* 0.01 *cm respectively. The three coils have low frequency values of* 0.31 μH, 0.38 μH *and* 0.44 μH *respectively and* ΔL_1 *at very high frequencies is the same for all coils,* −0.0155 μH *which corresponds to* percentage *changes of* − 5%, − 4.1% *and* − 3.5% *respectively.*

The curve C_1 *shows the independent change of* effective *inductance of coil C which would be experienced due to self-capacitance under some conditions of use, but which is not experienced in a resonant circuit.*

$f_2/f_1 = \sqrt{2}$, which is the case of the example used throughout this article. The effective circuit inductance would decrease from $\theta = 0$ to $\theta = 160$ by 0.4 per cent. and would thus cause a departure from frequency linearity. The extent of this departure would not be serious—a change of inductance up to 1.5 per cent. could be tolerated in such a case. But it is seen that by increasing the conductor size to 0.03 cm the change of inductance, for the given frequency range, is reduced to 0.2 per cent. and reduced still further to 0.1 per cent. for a conductor size of 0.1 cm—when absolutely no effect upon the frequency law would be experienced.

A brief study of the curves will show, however, that it may not be safe to rely upon the simple expedient of increasing the conductor section in order to reduce the change of inductance for any given frequency range.

In passing it should be remembered that the eddy current effect is dependent upon the resistivity and permeability of the conductor as well as upon its diameter and in the curves of Fig. 26 the resistivity of copper and unity permeability have been assumed.

If for a moment the coil of curve C be considered apart from its use in a resonant circuit, the curve C_1 Fig. 26 shows the increase of effective inductance which for some uses would be caused by the self-capacitance of the coil. In such cases, at frequencies of the order 10 Mc/s the change of inductance due to the eddy current effect would be exactly compensated by that, of opposite algebraic sign, due to the self-capacitance, since both effects are proportional to the square of the frequency.*

Such exact compensation, over an appreciable frequency band, is rather unusual, however, even in cases where the self-capacitance of a coil contributes to its effective self-inductance. But even partial compensation of this nature is *never* possible when the coil is used as a component of a resonant circuit, for then, of course, the self-capacitance merely augments the circuit capacitance, and therefore cannot cause an increase in the effective inductance of the coil.

The effects upon the frequency law of the various causes of non-linearity may be summarised very briefly in the following manner.

(*a*) The edge capacitance effect of the peripheral edge of the moving plates of the variable condenser is generally large enough to cause appreciable errors of interpolation especially at the high frequency end of the scale. The effect becomes more serious as the capacitance ratio C_{max}/C_{min} is increased. The magnitude of the effect may be calculated while the condenser is still in the design stage, and the plate shape corrected by a formula which has been developed in general terms. The effect is independent of frequency, but the efficacy of its correction must be determined at a frequency low

* This is sensibly true of the eddy current effect only at frequencies considerably lower than those at which the value of $\frac{\Delta L_1}{\Delta f} \cdot \frac{1}{L_1}$ is a maximum.

enough to avoid confusion with frequency effects.

(*b*) The edge capacitance effect of the leading and trailing radial edges of the moving plates of the variable condenser are generally serious from $\theta = 0$ to $\theta = 10$ and from $\theta = 130$ to $\theta = 160$. The effect may be overcome by specially shaping the plates throughout these angles. No general procedure can be given for this shaping because the effect depends so much upon the general design of the condenser. This effect and its correction are also independent of frequency, but the former should be determined, and the latter effected, at a frequency low enough to avoid confusion with other causes of law imperfection which may be dependent upon frequency. If this special "end shaping" is not undertaken the frequency range of the condenser must be limited to 120 degrees of the scale ($\theta = 10$ to $\theta = 130$) and the number of ranges (for a given total range of frequency) increased accordingly.

(*c*) The effect of a self-capacitance of range coil different from that used in estimating the minimum capacitance of the variable condenser occurs only where the condenser is associated with a large number of range coils of widely different inductance values in which the self-capacitances are widely different. The magnitude of the effect may be calculated exactly and becomes more appreciable as the value of C_{min} is reduced. This again is an effect which is independent of frequency except inasmuch as the self-capacitance of a range coil usually bears some relation to its inductance value and therefore to the frequency at which it is used. It is practicable to augment the distributed capacitances of all coils until they are sensibly equal to the highest value, but usually this will be found unnecessary in accurate circuits of high C_{min} when air cored inductances of good quality are employed as range coils.

(*d*) The effects of plate "wobble," plate distortion and want of "truth" of rotation are by no means negligible. Such effects may be serious, especially if the dielectric air gaps are too small and if the equalisation of the gaps on either side of all moving plates is not effected with care. These effects may be eliminated almost entirely by the use of a special design of variable condenser in which the dielectric gaps on either side of each moving plate are in series electrically and are complementary. A variable condenser of such design is very elaborate and costly, and the degree of perfection obtained by its use may be approached by the simpler orthodox design which has other advantages.

(*e*) (1). The effect of the varying self-inductance of the variable condenser is appreciable only at the highest frequency ranges of a resonant circuit; it is usually not serious until the inductance value of the range coil is reduced to a fraction of a microhenry. The interpolation error due to this effect is somewhat greater at the low frequency end of the scale than at the high frequency end and may be calculated if a knowledge of the residual self-inductance is first obtained. The effect is overcome by increasing the number of frequency calibration points per range progressively as the frequency is increased in successive ranges. The additional number of calibration points necessary to nullify the effect is readily calculable. The effect, if not completely nullified in this manner, may limit the upper frequency of the circuit.

(*e*) (2). The effect of dividing the capacitance arm of the resonant circuit into two parallel branches by providing independent fixed and variable condensers, may augment the interpolation error due to the effect previously enumerated, (*e*) (1), or it may neutralize it or even introduce a fresh error of opposite algebraic sign. Since this effect may be expressed as an effective variation of the self-inductance of the variable condenser, it may, like that previously enumerated, (*e*) (1), be nullified in the same manner or, likewise, may impose an upper limit to the frequency of the circuit.

(*e*) (3). The possible effect of a variation in the self-inductance of a range coil with frequency and therefore with θ. If present at all, this effect would probably be small especially on all but the very highest frequency ranges. At these highest frequency ranges the effect would probably pass unnoticed by slightly augmenting that due to cause (*e*) (1) since both of these causes tend to produce the same kind of law imperfection.

In conclusion the author would express his thanks to Messrs. H. W. Sullivan, Ltd., for permission to describe and illustrate the scale and scale arrangements of Figs. 1 and 2.

Abstracts and References

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

PROPAGATION OF WAVES

3248. REFLECTION AND TRANSMISSION BY ABSORBING DIELECTRICS OF ELECTROMAGNETIC WAVES IN HOLLOW TUBES.—L. Pincherle. (*Phil. Mag.*, Aug. 1943, Vol. 34, No. 235, pp. 521–532.)

"The purpose of this note is to investigate theoretically the reflection and transmission of the waves at the surface of separation, normal to the axis of the tube, between two different media. We shall consider tubes of rectangular cross-section, and suppose that the walls are infinitely conducting. It will be shown that the formulae obtained for the reflected and transmitted intensities are identical with the usual Fresnel's formulae, for the absorbing case, applied to the component waves [Brillouin's "criss-cross" waves to which the longitudinal component is due]. In Section 2 the expressions for the fields in the absorbing dielectric inside a tube of rectangular cross-section will be given for convenience: they are the natural extension of those valid for the non-absorbing case. In Section 3 the boundary conditions at the separation of two media will be applied to find the reflected and transmitted intensities. In Section 4 formulae relative to a sheet of an absorbing dielectric will be given, as they may be suitable for experimental applications" [for the measurement of refractive and absorptive indices].

3249. WAVE GUIDES IN ELECTRICAL COMMUNICATION.—J. Kemp. (*Journ. I.E.E.*, Part III, Sept. 1943, Vol. 90, No. 11, pp. 90–114.)

"An attempt is here made to survey the state of published knowledge of a branch of electrical engineering that has recently come into prominence, and to present an introduction to it in general terms within a range sufficient to explain the development of what in effect is a new technique and its relation to other branches of electrical engineering. . . ." For previous work *see* 1592 of 1942.

3250. TRANSMISSION THEORY OF CONCENTRIC LINES, *and* TRANSMISSION THEORY OF CYLINDRICAL HOLLOW TUBE GUIDE [and a Comparison between the Two Types of Conductor].—Hsü Chang-Pen. (*Sci. Abstracts*, Sec. B, Nov. 1942, Vol. 45, No. 539, p. 178 : p. 178.) From *Journ. of Math. & Phys.* [of M.I.T.], March 1942, Vol. 21.

3251. LONG-DISTANCE SHORT-WAVE TRANSMISSION: SIMPLIFIED EXPLANATION OF THE BEHAVIOUR OF OBLIQUELY INCIDENT WAVES.—T. W. Bennington. (*Wireless World*, Oct. 1943, Vol. 49, No. 10, pp. 297–300.)

3252. THE IONOSPHERE AND ITS TEMPERATURE.—K. Wegener. (*Gerlands Beiträge z. Geophysik*, No. 3/4, Vol. 59, 1943, pp. 276–282.)

For a previous paper (covering some of the same ground) *see* 991 of April. Vegard & Tönsberg found − 38.7° C. as the mean value over several years for the temperature of the auroral regions. "Since the extreme values fluctuate fairly widely, as may well be understood from the description of the aurora just given [a recapitulation of the writer's Spitzbergen observations in 1912/13, leading, among other conclusions, to 70 km as the minimum height, in agreement with Störmer's value for Norway], we will take the round figure of − 40° C. Now, however, a number of foreign physical chemists, some of them renowned, have found from the conjectured processes in the ionosphere, even for our latitudes, temperatures which fluctuate between + 100 and + 600° C and are incompatible with the results of Vegard & Tönsberg. This discrepancy will here be cleared up as far as possible.

"The highest temperature, for a Boltzmann–Stefan black body—that is a body which reflects no radiation, absorbs all incoming radiation, and emits a radiation $\sigma \cdot T^4$, where σ is the radiation constant and T the Kelvin temperature—is given as + 120° C at the Earth's distance from the Sun by the simple relation solar constant $= \sigma \cdot T^4$. The highest temperature of the stratosphere, which allows the greater part of the solar radiation to pass, must in any case be much lower. A higher temperature than this is only possible on the basis of another law, namely that found by Kirchhoff for the selective absorption and emission of a gas: every gas absorbs and emits on its own particular wavelength. If we replace the atmosphere by a simple gas which absorbs and emits only on very short wavelengths, then the temperature of that gas must be raised by absorption until it is enabled to emit short-wave radiation. In this case very high temperatures become possible. In a mixture of gases, however, any heating-up of a selectively absorbing gas will be communicated by thermal conduction to all the other gases. We must therefore extend the Kirchhoff law for the atmosphere: the mixture of gases in the atmosphere behaves as an ideal gas, which can absorb and emit on all the wavelengths of the individual gases. If short-wave radiation, which can be emitted only at a high temperature, is selectively absorbed by one gas of the mixture, all the other gases will be warmed also, and the longer-wavelength gases will at once emit (since their radiative equilibrium at the lower temperature has been disturbed) the heat which they have received by conduction.

"Thus the deciding factor for the radiative equilibrium of the stratosphere up to the limits of the atmosphere will be the individual gases of the longest wavelengths. But these are present, though in different proportions of volume, right up to the borders of the atmosphere, just as they are at balloon-explored heights. Except by the [restricted] Kirchhoff law the calculated very high temperatures cannot be accounted for. They are mathematical values without real existence. The balloon soundings in our latitudes find the temperature of radiative equilibrium of the stratosphere at heights from 10 to 30 km to be about − 52° C. From the above extended law this is the equilibrium temperature of the whole stratosphere up to its upper border."

The daily variation of the stratospheric temperature has been found to be too small to measure. The yearly variation in our latitudes is about 7°, and is due less to the difference in the height of the Sun than to the difference in the length of the day. Abisko (68°30′N) observations of stratospheric temperature show a June/December variation of 31° at 18 000 m and of 14° at 10 000 m: extrapolation (allowing for half as great a mass of air between 18 000 m and the limits of the atmosphere as between 10 000 and 18 000 m) gives − 35° for continuous illumination und − 73° for continuous darkness (a yearly variation of 38°) for the corresponding temperature at the outer limits of the atmosphere. But since the highest layers above Abisko are excluded from the Sun's rays for a comparatively short time only, the lowest temperature during the true Polar night may well be taken as from − 75° to − 80° C. "The − 40° found by Vegard & Tönsberg for the auroral region therefore indicates that the temperature of the ionosphere in the Polar night is raised about 30–40° by the cathodic radiation strongly concentrated locally by the Earth's magnetic field. The warmed air must rise 3–4 km in the previously roughly isothermal stratosphere, in order to arrive again at static equilibrium. With a band-thickness of 50 km such a rise is too small to have been noticed. There can hardly be a question of more than a local heating, transitory with the inconstancy of the aurora."

The temperature difference between the Polar stratosphere and that in our latitudes indicates that horizontal currents must exist in the stratosphere, reversing from summer to winter, but in the auroral zone weakening in winter. In the Antarctic (which, in contrast to the Arctic, is in perihelion in summer and aphelion in winter) the stratospheric temperature may be expected to be rather higher in summer and lower in winter than the Arctic values.

As regards ultra-violet radiation from the Sun, this has little mechanical energy but great chemical. It is not, like the corpuscular radiation, concentrated in places. How the ionising of the stratosphere and ionosphere is divided between it and the corpuscular radiation is not known. The formation of the ozone in the stratosphere is apparently to be attributed first and foremost to it, while fading and radio-disturbances are clearly dependent on the corpuscular radiation. The regular variations in reception at sunrise and sunset, on the other hand, are presumably ultra-violet effects. Regener's balloon observations at 21 km showed a fairly sudden broadening of the solar spectrum towards the short-wave side: thus there is a short-wave absorption hereabouts, but numerous balloon soundings passing through this level have given no indication of any heating effect. In view of the "extended" Kirchhoff law and of the small mechanical energy of the short-wave radiation, this is understandable. "We have no reason to assume that at greater heights the conditions for the ultra-violet radiation would be changed. An influence of the ultra-violet radiation on the temperature of the ionosphere and stratosphere may thus be doubted."

3253. Height Measurements of the Aurora Borealis of 18th Sept. 1941.—F. W. P. Götz & F. Schmid. (*Hochf:tech. u. Elek:akus.*, April 1943, Vol. 61, No. 4, p. 123: summary only.)

"A still open question is whether auroras which stretch into southern latitudes display any properties different from those whose extent is limited to northern latitudes. A contribution to this problem should be offered by the parallactic measurements carried out by the present writers, the first in Arosa [*see* also 369 of 1942] and the second in Oberhelfenschwil [also in Switzerland] . . . The first of these measurements was of the aurora of 18th/19th Sept. 1941 at $20^{h}\ 43^{min}$ (Central European Time). The very successfully photographed rays reached to 27° and gave a parallactic displacement of 3°. On the average, the calculated height for the top of the rays was 530 km, for the base 230 km, the aurora being sun-lit over its whole extent. Its projection fell on the North Sea. By chance, Prof. Störmer had made photographs of the aurora at the same time, so that for the purposes of comparison the enormous measuring base of 1460 km from Arosa to Oslo was available: a parallactic displacement of 57° to 63° was found. Prof. Störmer calculated from this, for 2^h 27^{min}, a summit height of approximately 800 km.

"It is noteworthy about this aurora that in Arosa and in South France the forbidden line 5199 AU of atomic nitrogen, absent in 'classic' auroras, was observed: probably the Arosa spectrum contained also the NI line 3467 AU. To the question whether and at what height atomic nitrogen is present there is therefore the definite reply that atomic nitrogen is present at any rate above 230 km."

3254. THE AURORAE OF 25TH JAN. 1938 AND 18TH SEPT. 1941 AND THEIR SOLAR ORIGIN.—M. Waldmeier. (*Sci. Abstracts*, Sec. A, Aug. 1943, Vol. 46, No. 548, p. 176.)

"German and Dutch magnetic traces show large deflections in *H* and *D* which occurred simultaneously with outbreaks of luminosity in the 1938 aurora, but the 1941 auroral intensity showed no such correlation with Swiss magnetic records. Both aurorae are ascribed to chromospheric eruptions emitting particles at speeds from 2000 to 750 km/s."

3255. VARIATIONS OF ULTRA-VIOLET AND DAYLIGHT RAYS [Deductions from Daily Record covering the Last Eleven Years: Both Classes of Ray have Max. Intensity at Sunspot Minimum and Min. Intensity at Sunspot Maximum: U.V. Intensities rise & fall More Slowly than Daylight: Graph of U.V./Daylight Intensities agrees well with That of Sunspot Variation and with Appleton's Ionisation Curve).—J. R. Ashworth. (*Nature*, 18th Sept. 1943, Vol. 152, No. 3855, p. 330.)

"It would seem that the large range of variation of ionisation, and properties accompanying it, is set up by the emanation from the sun which is responsible for auroras and geomagnetic phenomena, and the large changes of u.v. and daylight rays are due to effects which accompany ionisation and which behave as a partial shield to the rays. The course of the *daily* and *yearly* variation of both classes of rays, which, however, are due to the changing altitude of the sun, also suggests that they suffer a partial shielding in a similar way . . ."

3256. MEASUREMENTS OF ULTRA-VIOLET SOLAR RADIATION IN WASHINGTON, 1936 TO 1942.—W. W. Coblentz & R. Stair. (*Journ. of Res. of Nat. Bur. of Stds.*, June 1943, Vol. 30, No. 6, pp. 435–447.)

"In the absence of factors for eliminating the effect of atmospheric turbidity and the variability (seasonal and meteorological) of atmospheric ozone, it is impracticable to determine from these data the effect of sunspots upon the amount of ultra-violet emitted. In the few instances when observations could be made near the time when the ionosphere (and radio transmission) was disturbed by large outbursts of sunspots, the ultra-violet intensities showed nothing conspicuously different from the usual values."

3257. THE TOTAL INCOMING RADIATION [from Sun & Sky] IN DAVOS.—F. Prohaska. (*Gerlands Beiträge z. Geophysik*, No. 3/4, Vol. 59, 1943, pp. 247–275.)

3258. INTERACTING SOLAR PROMINENCES [photographed at Mount Wilson Observatory: Indications that Positive & Negative Charges exist within Same Prominence: the Unexplained Abrupt Changes in Speed of Ascent].—E. Pettit. (*Sci. & Culture* [Calcutta], May 1943, Vol. 8, No. 11, p. 445.)

3259. MONOCHROMATIC PHOTOMETRY OF THE SOLAR CORONA, *and* PHOTOMETRY OF THE INNER CORONA.—M. Waldmeier. (*Sci. Abstracts*, Sec. A, Aug. 1943, Vol. 46, No. 548, p. 154: p. 154.) For previous work *see* 2639 of October.

3260. SOLAR DISTURBANCES AND INTERDIURNAL VARIATIONS OF ATMOSPHERIC PRESSURE.—E. Huntington. (*Sci. Abstracts*, Sec. A, Aug. 1943, Vol. 46, No. 548, p. 176.)

3261. SUNSPOTS: CLOSE OF THE PRESENT CYCLE [Note prompted by Nicholson's Report from Mount Wilson Observatory].—(*Wireless World*, Oct. 1943, Vol. 49, No. 10, p. 303.) Over the initials "T.W.B." *See* also 2638 of October.

3262. ZODIACAL LIGHT AT POONA [With Time/Intensity Graph].—J. Singh. (*Current Science* [Bangalore], July 1943, Vol. 12, No. 7, p. 207.) *Cf.* 2299 & 2300 of September, and 4234 of 1938.

3263. SPECTRUM OF ACTIVE NITROGEN IN THE SCHUMANN REGION [Evidence against the Atomic Hypothesis (now generally finding Favour) and supporting the Molecular Nature of the Phenomenon].—B. M. Anand, P. N. Kalia, & M. Ram. (*Indian Journ. of Phys.*, April 1943, Vol. 17, Part 2, pp. 69–78.)

3264. PROFILES IN THE ALPHA BAND OF ATMOSPHERIC OXYGEN.—H. A. A. Panofsky. (*Sci. Abstracts*, Sec. A, Sept. 1943, Vol. 46, No. 549, p. 178.) "The total absorption coefficient of the α-band was computed. The mean molecular diameter for collisions between O_2 molecules and air molecules was estimated to be 5.15×10^{-8} cm".

3265. A NOTE ON THE ELEMENTARY THEORY OF THERMAL DIFFUSION [Elementary Derivation of Coefficient of Thermal Diffusion & Discussion of Its Change of Sign: Comparison with Grew's Experimental Results (3192 of 1942)].—R. N. Rai & D. S. Kothari. (*Indian Journ. of Phys.*, April 1943, Vol. 17, Part 2, pp. 103–106.) "The following mixtures are also expected to show reversals of the type observed by Grew: (i) N_2 and NO, (ii) A and CO_2."

3266. ON THE EQUATION OF DIFFUSION IN A TURBULENT MEDIUM.—W. G. L. Sutton. (*Proc. Roy. Soc.*, Ser. A, 6th Sept. 1943, Vol. 182, No. 988, pp. 48–75.)

3267. MEASUREMENTS OF CASCADE SHOWERS PRODUCED BY IONISING AND NON-IONISING RADIATION IN THE STRATOSPHERE.—J. Tabin & M. Schein. (*Phys. Review*, 1st/15th June 1943, Vol. 63, No. 11/12, p. 462: summary only.) "At a pressure of 3 cm Hg (first radiation unit from the top of the atmosphere) it was found that 71% of the showers below the lead were produced by non-ionising and 29% by ionising radiation."

3268. THE ATMOSPHERIC ABSORPTION CURVES AND THEIR DEPENDENCE ON THE NATURE OF THE PRIMARY COSMIC RAYS.—S. K. Chakrabarty. (*Indian Journ. of Phys.*, April 1943, Vol. 17, Part 2, pp. 121–129.)

"It is the purpose of the present paper to examine whether calculations based on the accurate results of the cascade theory [*see* 2249 of August] can be compared with the observed curves, and thereby to test whether the results of observation can be interpreted in terms of incoming electrons and positrons. Such a comparison will give an idea as to the nature and history of the primary cosmic rays before they enter the earth's atmosphere, which possibly bear the impress of the origin of cosmic rays." The writer concludes: "It is therefore essential that protons, or at least some charged particles other than electrons or positrons, *must* exist in the primary cosmic rays [but "this conclusion will be altered if we assume that electrons can produce mesons or some other particles which require a lower energy to penetrate the atmosphere than by the cascade process"] . . . Whether electrons or positrons do exist at all in the primary cannot, however, be definitely established unless further observational data, taken at closer latitudes, are available . . . The results of the measurements of Neher & Pickering at Agra and Bangalore, however, suggest that even the protons in the primary cosmic rays cannot have a continuous energy spectrum."

3269. EDMOND HALLEY AND GEOMAGNETISM.—S. Chapman. (*Nature*, 28th Aug. 1943, Vol. 152, No. 3852, pp. 231–237.)

3270. A PHYSICAL MECHANISM FOR THE NEBULAR RED SHIFT [explained as Second-Order Effect of Ordinary Coherent Refraction, occurring even in the Approximation of Geometrical Optics].—L. H. Thomas. (*Phys. Review*, 1st/15th June 1943, Vol. 63, No. 11/12, pp. 460–461: summary only.)

3271. NEW CONTRIBUTIONS TO INTERFEROMETRY: PART I—NEW NON-LOCALISED INTERFERENCE FRINGES [produced with an Approximate Point Source & a Fabry–Perot Interferometer: Properties & Possible Applications].—S. Tolansky. (*Phil. Mag.*, Aug. 1943, Vol. 34, No. 235, pp. 555–565 and Plates.) For example, the absence of lenses "leads to a flexibility in dispersion and magnification which is unique in the field of high-resolution instruments . . . So large are the ring diameters that the masking-off of a given ring, or even portion of a ring thickness, is a simple matter. This production of a high degree of monochromatism might have applications. . ."

3272. CALCULATION OF THE SCATTERING OF LIGHT BY "FILAMENT-CHAIN" SOLUTIONS.—Neugebauer. (*See* 3551.)

3273. A NOTE ON THE TRANSMISSION-LINE EQUATION IN TERMS OF IMPEDANCE, *and* NOTES ON TRANSMISSION LINES: USE OF THE GENERAL EQUATIONS IN DETERMINING LINE PROPERTIES.—Pierce: Stewart. (*See* 3289 & 3290.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

3274. ATMOSPHERICS DURING THE MONSOON PERIOD [including the Valuable Information regarding Formation, Location, & Movement of Depressions obtainable with Directional Receivers].—N. S. S. Rao. (*Sci. Abstracts*, Sec. B, Sept. 1943, Vol. 46, No. 549, p. 168.)

3275. RADIO INTERFERENCE AS AN ASTRONOMICAL RESEARCH TOOL [Review of Work on "Interstellar Interference" and "Cosmic Static" by Jansky (1934 Abstracts, p. 31, and 41 of 1936) and Reber (1769 of 1940), and Its Astronomical Interpretation].—V. Hardung. (*Bull. Assoc. Suisse des Élec.*, 16th & 30th June 1943, Vol. 34, Nos. 12 & 13, pp. 348–350 & 371–374: in German.)

3276. GALACTIC GAS CLOUDS: A COMPLEX SYSTEM OF ENORMOUS RAREFIED CLOUDS OF GAS MOVING AT HIGH VELOCITY HAS BEEN DISCOVERED [Mount Wilson Results].—H. N. Russell: Adams. (*Scient. American*, Aug. 1943, Vol. 169, No. 2, pp. 62–63.)

3277. FIELD FLUCTUATIONS OF CLOUD-TO-EARTH AND CLOUD-TO-CLOUD LIGHTNING STROKES.—H. Wichmann. (*Gerlands Beiträge z. Geophysik*, No. 3/4, Vol. 59, 1943, pp. 299–305.)

For previous work *see* 2916 of 1940 and 658 & 3204/5 of 1942. Author's summary:—"Cloud-to-cloud lightning strokes show considerably slower and longer-lasting field-fluctuations than strokes to earth. The rapid fluctuations of less than 0.01 second occurring with strokes to earth either are entirely absent with cloud-to-cloud lighting or may appear weakly towards the end. In the case of interconnected cloud-to-cloud and cloud-to-earth lightning, the component due to the former is clearly visible on the shape of the field-fluctuation curve. Cloud-to-cloud lightning occurs chiefly in thunderstorms of slight intensity, and during times of slight lightning activity and at the end of a thunderstorm."

3278. THUNDERSTORM MEASUREMENTS OF THE YEARS 1936 AND 1937 [on St. Gotthard and Lavorgo–Veveri H.T. Systems: with an Appendix on the Determination of the Surge Velocity along St. Gotthard Line, with a View to Fault Locating with a Cathode-Ray Oscillograph.]—K. Berger. (*Bull. Assoc. Suisse des Élec.*, 30th June 1943, Vol. 34, No. 13, pp. 353–365: in German.) The mean values of velocity over various lengths of line gave 291 $\pm$ 3% m/μs.

3279. THE EFFECT OF LIGHTNING ON RECEIVING AERIALS [Extract from I.E.E. Paper "The Protection of Structures against Lightning"].— J. F. Shipley. (*Electronic Eng:g*, Aug. 1943, Vol. 16, No. 186, p. 107.)

3280. LIGHTNING STRIKING FREQUENCIES FOR VARIOUS HEIGHTS [from 80 to 1250 Feet].— Westinghouse. (*Proc. I.R.E.*, Feb. 1943, Vol. 31, No. 2, p. 79.)

3281. THE PROTECTIVE RANGE OF A LIGHTNING CONDUCTOR.—R. H. Golde. (*BEAMA Journal*, Aug. 1943, Vol. 50, No. 74, pp. 242–245.)

3282. REPORT ON THE WORK CARRIED OUT IN 1941 AT THE ABSROTH LIGHTNING-RESEARCH FIELD [*see* also 2642 of 1941: Damage caused by Obsolete Lightning Conductors: Local Statistics: Measuring Methods & Apparatus for Earthing Resistances (*see* also 3502, below): Results, including Influence of Weather: etc.].—V. Fritsch. (*Gerlands Beiträge z. Geophysik*, No. 3/4, Vol. 59, 1943, pp. 306–330.)

3283. THE RADIO SONDE [Survey, with Special Reference to the Radio Meteorograph (Olland, Diamond–Hinman, Väisälä, & Duckert Types) and the Cosmic-Ray Radio Sonde: Future Applications & Development].—W. H. Pickering. (*Proc. I.R.E.*, Sept. 1943, Vol. 31, No. 9, pp. 479–485.)

"Future developments in radio-sonde techniques, besides involving the application of the technique to specific new problems, will call for the development of more satisfactory light-weight power sources, improvement of operating efficiency for the higher frequencies, development of balloons capable of reaching higher altitudes . . ."

PROPERTIES OF CIRCUITS

3284. THE IMPEDANCE OF A TRANSVERSE WIRE IN A RECTANGULAR WAVE-GUIDE.—S. A. Schelkunoff. (Paper in the first number of *Quarterly of Applied Mathematics*, whose establishment was referred to in 2878 of October.)

3285. THE USE OF THE IRIS-DIAPHRAGM PRINCIPLE FOR VARIABLE TERMINATING OR COUPLING DEVICES FOR CONCENTRIC CABLES.—H. E. Hollmann. (*Hochf:tech. u. Elek:akus*, Oct. 1942, Vol. 60, No. 4, p. 114, Fig. 19.) A Telefunken patent, D.R.P. 720 438.

3286. QUADRIPOLE [Four-Terminal Network] THEORY TREATED BY CIRCLE GEOMETRY, AND ITS IMPORTANCE FOR MEASURING TECHNIQUE AND CIRCUIT THEORY IN THE DECIMETRIC AND CENTIMETRIC WAVE REGIONS.—A. Weissfloch. (*Hochf:tech. u. Elek:akus.*, April 1943, Vol. 61, No. 4, pp. 100–123.)

Further development (generalisation) of the work dealt with in 3287, below, and 711 of March [for later papers *see* 2083/4 of August & 3102 of November]. "Recognition of the fact that with these short waves the conceptions 'inductances,' 'capacitances,' and 'ohmic resistances' become unusable as well-defined building blocks leads to the question whether some other constructional element cannot be found . . . out of which every decimetric- and centimetric-wave circuit can be built up. The answer is in the affirmative: the quadripole conception can be used as such a building block. However complicated a decimetric- or centimetric-wave circuit may be, there are always certain particular points (or the construction can be so designed that such points can be obtained) at which the electromagnetic state can be characterised unequivocally by giving a current and a voltage, or two equivalent quantities". Thus in Fig. 1a the points α and β on the homogeneous coaxial line can be chosen far enough from the point of irregularity to make the undistorted field of a homogeneous line exist at those points, so that current and voltage define the electromagnetic state: other examples are given in Figs. 1 b–d, a cavity interposed in the run of a coaxial line, a coupling loop, and a diode with h.f. connections. Actually, in such cases voltages and currents are difficult to determine (particularly both together), but the impedances at the points selected as beginnings and ends of the quadripoles can always be measured or calculated: thus on homogeneous lines they can be reckoned easily from the potential distribution, which need be determined only relatively. Then the impedance relation of eqn. 3 can be used to replace the voltage and current relation of eqn. 1.

Theoretically, the constants in eqn. 3 can be obtained by three measurements with three different impedances introduced in turn behind the quadripole, measuring the transformation of these by the quadripole and then applying eqn. 4: then, working back through eqns. 3 and 1, the currents, voltages, power, and power losses would all be found. In practice, however, such calculations with complex quantities are too laborious and the results far from clear. This is probably the reason why such quadripole measurements are hardly ever carried out. "It is the purpose of this paper to find methods of determining experimentally the transformation properties of a quadripole in the simplest possible way and to work out the results in a lucid manner," and the circle relations of quadripole theory are employed for this purpose as being extremely helpful: *see* 3287, below.

Section II shows how for any loss-free quadripole a "reactive transformation diagram" (Fig. 6) can be constructed from particularly simple measurements: this diagram is based on the well-known "perspective axis" construction of projective geometry, and allows any transformation of the quadripole to be determined graphically for a given frequency. From such a diagram, geometrical construction yields, for any such quadripole, an "orthogonal-family transformation diagram" which shows the transformation properties still more clearly. There are three types of such a diagram: the elliptic (Fig. 17), the parabolic (Fig. 19), and the hyperbolic (Fig. 20). The elliptic type contains as a special case the well-known circle diagram of the uniform line; the parabolic type, the diagrams of a series and a parallel reactance; the hyperbolic, the leakage-free and loss-free transformer. As regards quadripoles with losses, not hitherto considered, these can be analysed by simple measurements into an equivalent circuit composed of a loss-free and a loss-possessing component: the treatment of the influence of the latter on the transformation properties of the quadripole is considered in section III 8 on p. 117, which deals briefly also with quadripoles containing useful loads (*e.g.* directive aerial arrays, Fig. 33). Section IV deals with the frequency-dependence of the transformation properties and the wide-band resistances of a quadripole.

3287. PAPER ON QUADRIPOLE THEORY TREATED BY CIRCLE GEOMETRY.—A. Weissfloch. (*E.N.T.* Vol. 19, 1942, p. 259 onwards.) Referred to in 3286, above, where the two "main laws" (for loss-free and loss-possessing quadripoles respectively) are reproduced, and further points discussed on the basis of Bieberbach's book on conformal representation and Doehlemann's on projective geometry. The first law states that for every loss-free quadripole there corresponds a circle transformation (of the impedances or admittances) of the right half-plane on itself, and conversely that every transformation of the right half-plane on itself is representable by a loss-free quadripole.

3288. CHART FOR EQUIVALENT SERIES AND PARALLEL CIRCUITS [Semicircle Diagram particularly useful for Design of Matching Networks (Aerial/Feeder, etc.)].—R. Toombs. (*Electronics*, April 1943, Vol. 16, No. 4, pp. 109–110.)

3289. A NOTE ON THE TRANSMISSION-LINE EQUATION IN TERMS OF IMPEDANCE.—J. R. Pierce. (*Bell S. Tech. Journ.*, July 1943, Vol. 22, No. 2, pp. 263–265.)

Based on Schelkunoff's extension of the impedance concept (1740 of 1938). "In treating the transmission line from the impedance point of view, without dealing with currents and voltages, a first-order non-linear differential equation in terms of impedance and distance is obtained. This impedance equation is a Ricatti equation and could be obtained from the usual line equations. It is simpler, however, to derive it directly. As the principal interest of such a treatment lies in the method and in the fact that the line may be tapered, rather than in losses, the derivations will be carried out for loss-less lines. Losses can be taken into account by allowing the inductance per unit length, L, and the capacitance per unit length, C, to become complex quantities". Eqn. 2 is obtained: $R \,.\, dZ/dx = j \,.\, (\omega/v) \,.\, (R^2 - Z^2)$. For the simplest case, that of a uniform line, where R is a constant (R_0), eqn. 2 can be integrated directly, giving $Z/R_0 = \tanh (j\omega x/v + K)$, the familiar result. MacColl has pointed out that eqn. 2 is the same as the electrostatic electron-optical equation for paraxial rays. "It would seem, then, that from each solution of an electron-optical problem, a solution of a tapered-line problem could be found, and *vice versa*. While it cannot be claimed that anything new has entered the transmission-line equation in expressing it in terms of impedance, it does seem that the approach may be stimulating in uncovering hitherto neglected material and analogies."

3290. NOTES ON TRANSMISSION LINES: USE OF THE GENERAL EQUATIONS IN DETERMINING LINE PROPERTIES [with Special Reference to Use of Line Sections as Reactances, Impedance-Matching Transformers, etc.].—H. E. Stewart. (*QST*, Aug. 1943, Vol. 27, No. 8, pp. 25–29 and 102, 104.)

3291. GRAPHICAL-VECTOR SOLUTION AND STUDY OF THE COIL-LOADED LINE [Simple Method of obtaining Single-Frequency Solution by Graphical Construction combined with Slide-Rule Operations: Fundamentally as Rigorous as Campbell's Formulae: leads to Clearer Understanding of Loading Phenomena than is given by Most Methods].—A. K. Robinson. (*Journ. I.E.E.*, Part III, Sept. 1943, Vol. 90, No. 11, pp. 115–128.)

3292. THE CALCULATION OF THE FORCES ON CYLINDRICAL CONDUCTORS IN PLANE ELECTROSTATIC AND ELECTROMAGNETIC FIELDS [by Methods based on Theory of Functions & specially used in Hydrodynamics (Extension of Blasius' Integral, etc.): Wide Applicability of Resulting Formulae: Cylinders of Circular & Elliptical Cross-Section: Superposition of Uniform Magnetic Field on Field due to Two Parallel Linear Currents: etc.].—W. Müller. (*Ann. der Phys.*, 13th May 1943, Vol. 42, 1942/3, No. 7/8, pp. 609–633.)

3293. THE SELF-INDUCTANCE OF CLOSELY WOUND SINGLE-LAYER CYLINDRICAL COILS, *and* THE INDUCTANCE OF ROUND [Air-Cored] COILS.—de Gruyter: Müller. (*See* 3485 & 3486.)

3294. MAGNETIC INDUCTION FIELD OF AIR-CORE COILS: ITS APPLICATION TO HIGH-FREQUENCY HEATING IN VALVE MANUFACTURE.—Kirkpatrick. (*See* 3412.)

3295. THERMAL-FREQUENCY-DRIFT COMPENSATION: DISCUSSION [on Bushby's Paper, 1030 of April (and 2100 of August): Need for Distinction between Lowest Average Percentage Drift and Lowest Average, or Maximum, Absolute Drift: Optimum Condition may be One of Two Choices depending on the Application of the Equipment].—H. Sherman: T. R. W. Bushby. (*Proc. I.R.E.*, July 1943, Vol. 31, No. 7, pp. 385–386.)

3296. ELEMENTARY A.C. MATHEMATICS: PART VII—POWER, POWER FACTOR, LOSSES IN REACTANCES.—G. Grammer. (*QST*, Aug. 1943, Vol. 27, No. 8, pp. 56–59.) For some previous parts *see* 2349 of September and 2683 of October.

3297. CUMULATIVE CORRECTION TABLE FOR DATA SHEETS 1 TO 50 CONTAINED IN VOLS. 14 & 15, *and* INDEX TO DATA SHEETS IN VOLS. 14 & 15.—(*Electronic Eng:g*, July 1943, Vol. 16, No. 185, pp. 65–66: p. 67.)

3298. A PARALLEL CIRCUIT WITH A COUPLING ELEMENT: PART I—RESISTIVE ELEMENTS [Solution by Kirchhoff Currents & by Circuit Transformation: Application of "Thévenin's" Theorem]: PART II—COMPLEX ELEMENTS.—P. F. Soper. (*BEAMA Journal*, Sept. 1943, Vol. 50, No. 75, pp. 285–291.) "It is believed that these aspects of electrical circuit theory, particularly the methods of numerical solution, have not so far received the attention that they so richly deserve."

3299. THE MAKE AND BREAK NETWORK THEOREM OF HELMHOLTZ [and Not of Thévenin or Anybody Else, except perhaps Pleijel, who applied It to Alternating Currents & Transients].—G. W. O. H. (*Wireless Engineer*, July 1943, Vol. 20, No. 238, pp. 319–322.) With a final tilt at the mis-spelling of names [incidentally, "Brainard" on p. 321 should end in "erd"]. For a long letter from A. Bloch giving further information, and in particular stressing the importance of Russell's work drawing attention to the principle of duality, *see* August issue, No. 239, pp. 367–368: the writer suggests that a fair solution would be to speak of the "Helmholtz–Russell" theorem. *See* also 3300, below.

3300. THEOREM OF PLEIJEL [Criticism of Theorem as stated in Editorial, 3299, above].—J. H. Mole: G. W. O. H. (*Wireless Engineer*, Oct. 1943, Vol. 20, No. 241, p. 487.) The point is finally cleared up in a note by G. W. O. H. on p. 472.

3301. ON THE TRANSIENT PROCESSES IN LINEAR CIRCUITS WITH LUMPED PARAMETERS, COUPLED ELECTRICALLY AND MAGNETICALLY.—N. G. Gorodetski. (*Izvestiya Elektroprom. Slab. Toka*, No. 9, 1940, pp. 58–64.)

Two circuits with parameters R_1, L_1 and R_2, L_2 respectively are connected electrically and in addition coupled magnetically. Formulae are derived for determining the currents in the circuits during the transitory period, immediately after the system has been switched on or off. The case of the two circuits connected in series does not present great difficulties, but parallel connection is discussed in detail and the cases when the circuits are excited with sinusoidal and d.c. voltages are considered separately.

3302. A GENERAL REACTANCE THEOREM FOR ELECTRICAL, MECHANICAL, AND ACOUSTICAL SYSTEMS.—D. Y. Maa. (*Proc. I.R.E.*, July 1943, Vol. 31, No. 7, pp. 365–371.)

From the National Tsinghua University, Kunming. Author's summary:—"Foster's reactance theorem for the driving-point impedance of a two-terminal electric network is extended to more general cases comprising mechanical and acoustical as well as electrical systems. The network may contain distributed but finite elements besides the lumped ones. The driving force also may be distributed instead of being concentrated at a point. For the latter case, it is suggested that a quantity 'mass driving-point impedance' is to be introduced, which has properties similar to simple impedance. Applications of the theorem to cases of practical importance [microphone diaphragms, air chambers, electrical systems coupled to mechanical systems, etc.] are discussed." For another paper on Foster's reactance theorem *see* LePage, 2681 of October.

3303. MATRIX ALGEBRA AND THE SOLUTION OF ELECTRICAL NETWORK PROBLEMS.—J. C. Simmonds. (*Electronic Eng:g*, Sept. & Oct. 1943, Vol. 16, Nos. 187 & 188, pp. 160–161 & 212–213.)

3304. DISCUSSION ON "A CONTRIBUTION TO THE THEORY OF NETWORK SYNTHESIS" [347 of February].—E. A. Guillemin: R. A. Whiteman. (*Proc. I.R.E.*, Feb. 1943, Vol. 31, No. 2, pp. 80–82.)

3305. A SIMPLE METHOD OF CALCULATION FOR FREQUENCY-DEPENDENT ATTENUATING NETWORKS [for Distortion Correction between Studio & Transmitter, and for Measuring Technique: Method using Table of "Normalised Frequency" (for Each of Six Different Equalising Networks) and Curve Families].—H. Weber. (*Bull. Assoc. Suisse des Élec.*, 2nd June 1943, Vol. 34, No. 11, pp. 307–310: in German.)

3306. "TRANSFORMED NETWORKS" [Letter on Griese's Paper (350 of February) and Editorial Reply].—Z. Friedberg: Griese. (*Wireless Engineer*, June 1943, Vol. 20, No. 237, p. 303.)

3307. CAUER FILTERS [Outline of Cauer's Method of Filter Design: Application to Simple Low-Pass Filter as Example of Use].—T. H. Turney. (*Strowger Journal*, May 1943, Vol. 5, No. 3, pp. 139–146.)

In conclusion, the writer mentions Cauer's use of mutual inductance to reduce the number of coils in cases where many are required, such as a filter of the higher impedance class belonging also to one of the higher attenuation classes. "The theory of multi-winding transformers seems to be worthy of more attention by British and American designers."

3308. THEORY OF IDEAL FILTERS: THE RELATION OF TRANSIENT RESPONSE TO AN IDEALLY LIMITED FREQUENCY BAND.—D. A. Bell. (*Wireless Engineer*, July 1943, Vol. 20, No. 238, pp. 323–326.)

"It is shown that the conventional method of determining the transient response of an electrical system of finite band-width but unspecified structure, by taking a Fourier integral equivalent to the Heaviside unit function and limiting this infinite series of sinusoidal components to the appropriate frequency band, has two defects: (a) it corresponds to a filter in which the number of sections is a half, and (b) even this requires an unusual form of Fourier equivalent of the Heaviside function."

3309. COUPLED-CIRCUIT FILTERS: GENERALISED SELECTIVITY, PHASE SHIFT, AND TROUGH AND PEAK TRANSFER-IMPEDANCE CURVES [Beatty's Generalised Selectivity Curves (1933 Abstracts, p. 98) extended to Dissimilar Coupled Circuits (having a Common Resonant Frequency) by Suitable Choice of Abscissa Scale: Conditions for Application to Shunt & Series Inductance & Capacitance Couplings, and to Mis-Tuned Coupled Circuits: the Important Parameter $\sqrt{Q_1Q_2}\,k$: etc.].—K. R. Sturley. (*Wireless Engineer*, Sept. & Oct. 1943, Vol. 20, Nos. 240 & 241, pp. 426–434 & 473–487.) For American work referred to in the introduction *see* 2091 of 1937 (Maynard).

3310. NARROW BAND-PASS FILTER PERFORMANCE [with Charts giving Minimum Attenuation, Attenuation at Cut-Off Frequencies, and Actual Curve, for Given Cut-Off Frequencies & Coil "Q": Time spent in Trial Design reduced to a Few Minutes].—H. Holubow. (*Electronics*, May 1943, Vol. 16, No. 5, pp. 104–107.)

3311. LOW- AND HIGH-PASS WAVE-FILTER UNITS: TREATMENT ON THE BASIS OF CONSIDERING THEM AS BISECTABLE SYMMETRICAL CIRCUITS [with Advantages over the Usual Analytical Approaches].—E. S. Purington. (*Electronics*, June 1943, Vol. 16, No. 6, pp. 106–109.)

3312. ON A TYPE OF POLYNOMIAL MET WITH IN THE STUDY OF ELECTRIC FILTERS [Development & Trigonometrical Expression of the Polynomials: Special Relations: Polynomials derived from Continuous Fractions: Polynomials & Hypergeometric Function].—M. Parodi. (*Rev. Gén. de l'Élec.*, Feb. 1942, Vol. 51, No. 2, p. 142 onwards.)

3313. THE QUARTZ CRYSTAL GATE AND THE INTRODUCTION OF HIGHLY SELECTIVE CIRCUITS.—Robinson. (*See* 3360.)

3314. COMPLEX CORRECTION OF WIDE-BAND AMPLIFIERS.—G. V. Braude. (*Izvestiya Elektroprom. Slab. Toka*, No. 9, 1940, pp. 19–32.)

In a previous paper (2337 of 1935) the author proposed a method for determining the parameters of complex correcting circuits by equating to zero the first terms of a Taylor's series representing the frequency characteristic of the circuit. The method has been applied widely both in Russia and abroad, but in the circuits so far proposed correction can take place only with definite ratios of the capacitance elements of the circuit. After an exhaustive analysis of various possible correcting circuits, the author has evolved a universal circuit (Fig. 1) in which correction can take place within the whole possible range of capacitance ratios. The operation of the circuit is discussed in detail and design methods are indicated for obtaining optimum results with regard to frequency and phase distortion. In an appendix the effects of parasitic capacities of the circuit are considered.

3315. ON THE RELATIONSHIP BETWEEN NON-LINEAR DISTORTION AND THE TIME CONSTANTS IN CERTAIN SELF-REGULATING SYSTEMS.—B. S. Gal'perin. (*Izvestiya Elektroprom. Slab. Toka*, No. 9, 1940, pp. 15–19.)

Self-regulation of a valve stage is effected by superimposing on the alternating voltage of the incoming signal a d.c. biasing impulse obtained by rectifying the signal and proportional to it in intensity. The noise due to the pulsation of the rectified impulse cannot be entirely eliminated by smoothing filters, since a decrease in the pulsation means an increase in the time constants of the filter and thus leads to a distortion of signal variations. The operation of the filter with a regulated single-valve or push-pull stage is discussed and the effects of the time constants on the distortion introduced are investigated. The cases of full-wave and half-wave rectification of the signal are considered separately.

3316. NEGATIVE FEEDBACK [Error in Logic makes Formula as generally stated "Entirely Erroneous," though Mathematically Correct: Ratio of Resulting Output Signal to Resulting Noise is Less than without Negative Feedback].—F. S. Macklem. (*Electronics*, April 1943, Vol. 16, No. 4, p. 211.)

3317. COMPARISON OF VOLTAGE- and CURRENT-FEEDBACK AMPLIFIERS: CORRECTIONS.—E. H. Schulz. (*Proc. I.R.E.*, July 1943, Vol. 31, No. 7, p. 384.) *See* 1679 of June.

3318. CATHODE-COUPLED PUSH-PULL AMPLIFIERS [for Time-Base Circuits].—O. S. Puckle. (*Electronic Eng:g*, July 1943, Vol. 16, No. 185, pp. 55–57.) Extract from the book "Time Bases" (3521, below.)

3319. INPUT ADMITTANCE COMPENSATION: APPLICATION OF SOME RESULTS DERIVED FROM THE ARTICLES ON THE CATHODE FOLLOWER [1023 of April].—C. E. Lockhart. (*Electronic Eng:g*, Sept. 1943, Vol. 16, No. 187, pp. 145–147.)

3320. AN AUTOMATIC FREQUENCY-CONTROLLED OSCILLATOR AND AMPLIFIER FOR DRIVING MECHANICAL VIBRATORS.—Potter. (*See* 3450.)

3321. THE SYNCHRONISATION OF OSCILLATORS: PART IV—THE DISCRIMINATION OF A SYNCHRONISED OSCILLATOR AGAINST UNWANTED SIGNALS MIXED WITH THE CONTROL TONE [Analysis & Experiment].—D. G. Tucker. (*Electronic Eng:g*, Aug. 1943, Vol. 16, No. 186, pp. 114–117.) For previous parts *see* 2334 of September.

3322. SYNCHRONISATION OF VALVE GENERATORS [Mathematical Treatment, including the Back-Coupled Generator with Tuned Anode Circuit].—H. Samulon. (*Sci. Abstracts*, Sec. B., Jan. 1943, Vol. 46, No. 541, p. 15.) From *Helvet. Phys. Acta*, No. 4, Vol. 14, 1941, p. 281 onwards.

3323. MORE ACCURATE METHODS FOR DESIGNING SHORT-WAVE MULTIVIBRATORS.—Shteynshleyger. (*See* 3483.)

3324. THE TRANSFORMATION OF A SINGLE-PHASE CURRENT INTO A POLYPHASE CURRENT, AND *vice versa*, BY MEANS OF STATIC DEVICES.—J. Bethenod. (*Génie Civil*, 1st Jan. 1943, Vol. 120, No. 1, p. 10: summary, from *Comptes Rendus* [Paris], 1st June 1942.)

3325. Analysis of Rectifier Operation.—O. H. Schade. (*Proc. I.R.E.*, July 1943, Vol. 31, No. 7, pp. 341–361.)

"General operating characteristics of practical rectifier circuits have been evaluated and used by the writer for design purposes and information since early 1934, but circumstances have delayed publication. Several papers have appeared in the meantime treating one or another part of the subject on the assumption of zero series resistance. Practical circuits have resistance, and may even require insertion of additional resistance to protect the diode and input condenser against destructive currents. The equivalent diode resistance and the emission from oxide-coated cathodes are, therefore, discussed preceding the general circuit analysis. This analysis is illustrated on graphic constructions establishing a direct link with oscillograph observations on practical circuits. A detailed mathematical discussion requires much space and is dispensed with in favour of graphic solutions, supplemented by generalised operating characteristics." "The applications of these principles have often explained large discrepancies from expected results as being caused by series or diode resistance and excessive peak-current demands."

3326. A Vibrographic Study of the Output of a Single-Phase Half-Wave Power Rectifier.—T. Tirunarayanachar. (*Indian Journ. of Phys.*, April 1943, Vol. 17, Part 2, pp. 107–110.)

Author's summary ;—" A simple device for studying the efficacy of design of filter circuits employed in power units is described. Instead of the usual cathode-ray oscillograph and a linear time base, the arrangement consists of an electro-magnetically excited wire, the vibrations being recorded by a vibrograph devised by the author (1933 Abstracts, p. 167). Vibrograms taken in the study of the wave-form and ripple-components of a single-phase half-wave power rectifier output are given in support of the method suggested. The arrangement is specially suited for studying the ripple components in the output [testing the efficiency of smoothing filters for half-wave rectifiers]. The applicability of the method in wave-form investigation is being further studied."

3327. Analysis of Full-Wave Single-Phase Rectifier with Choke Input [together with Means of determining Critical Inductance permitting Continuous Flow of Current: Experimental Confirmation].—L. C. Tillotson & C. M. Wallis. (*Electronics*, April 1943, Vol. 16, No. 4, pp. 94–97 and 120 . . 126.)

3328. The Swinging Filter Choke [with Wide Variation of Inductance as D.C. Component is Varied: used as First Element of Choke Input (Smoothing) Filter for Rectifier Systems: Proper Design & Correct Use].—R. M. Hanson. (*Electronics*, June 1943, Vol. 16, No. 6, pp. 112–116 and 335.)

3329. Vacuum Rectifiers working with Condenser Input: Graphical Assessment of Their Performance.—R. G. Mitchell. (*Wireless Engineer*, Sept. 1943, Vol. 20, No. 240, pp. 424–425.)

"Formulae are derived enabling curves to be drawn which give all the desired circuit data in terms of the known constants for vacuum rectifier circuits working with condenser input, in single and bi-phase circuits." Most previous treatments involve assumptions which greatly reduce the practical utilty of the results.

3330. Operation of Vapour-Tube Rectifier Circuits with Opposing Direct Voltages [as in Accumulator Charging and the Energising of D.C. Motors: Graphical Analysis & Experimental Confirmation].—J. M. Fluke. (*Electronics*, June 1943, Vol. 16, No. 6, pp. 100–103.)

3331. Combining of Phase-Shifted Rectified Sine Waves [Graphical & Analytical Investigation of Wave-Forms: Methods of Producing the Waves in question, in Various Frequency Ranges; Wave-Forms obtained by combining Rectified Pulses with Full Sine Waves].—J. T. Tykociner & L. R. Bloom. (*Electronics*, April 1943, Vol. 61, No. 4, p. 160.) Note on a 54-page Bulletin.

3332. The Diode as a Rectifier and a Detector for Weak Signals [Treatment by Method of Perturbation].—Aharoni. (*See* 3396.)

TRANSMISSION

3333. The Generation and Amplification of Decimetric and Centimetric Waves.—H. E. Hollmann. (*T.F.T.*, March 1943, Vol. 32, No. 3, pp. 65–69.)

Concluded from 2353 of September. The present instalment deals first with the writer's "dynamic transversely-modulated tube with transverse working field" (Fig. 98: *see* also 1859 of 1941) and "with longitudinal working field" (Figs. 100, 101: *see* also 2986 of 1942): "these valves at present possess only theoretical interest, because even with the use of wide flat beams there are difficulties in the way of obtaining, with sufficiently long and sharp beams, the current values necessary on matching grounds."

Part III deals with plasma oscillations: the only references given are to the work of Rompe & Steenbeck (ref. "138," on the plasma régime in gases) and of von Stengel (2566 of 1940, on his investigations of the interference-producing oscillations in sodium-vapour and mercury-vapour lamps). For the natural frequency of electron oscillations in a plasma the writer gives the relation $\omega_0 = \sqrt{4\pi e^2 N/m}$, which for ordinary plasmas works out at wavelengths from decimetric to centimetric: for ion oscillations the relation is $\omega_i = \sqrt{4\pi e^2 N/Mm^H}$, corresponding to wavelengths of 10–100 m up to the acoustic natural wavelength of the discharge tube.

Part IV deals with spark generators. Here the references range from Rhigi (1893) and Lebedew (1895) through Nichols & Tear (1923), Lewitzky (1924–1927), Glagelowa-Arkadiewa ("mass radiator": 1929 Abstracts, p. 508 [and 2106 of August]), Dänzer (1929 Abstracts, p. 500), Pupp (1930 Abstracts, p. 43), Hasselbeck (1932 Abstracts, p. 399) and many others, to Rohde & Schwarz's concentric-line spark oscillator (Fig. 111: 1933 Abstracts, pp. 501–502) and finally to Ludenia's excitation of cavity resonators by saw-tooth oscillations (long abstract, 2641 of 1942).

3334. Arrangement for the Setting-Up of Ultra-High-Frequency Oscillations in a Cavity Resonator by means of a Gaseous-Discharge [Mercury-Vapour] Path.—F. Borgnis. (*Hochf:tech. u. Elek: akus.*, Oct. 1942, Vol. 60, No. 4, p. 112.) A Telefunken patent, D.R.P. 719 654. "In a cylindrical cavity of the cavity resonator 1 (Fig. 3) a gaseous discharge takes place parallel to the electric field E, and excites the resonator to oscillate."

3335. Tubes employing Velocity Modulation [Chapter of Forthcoming Book "Hyper and Ultra-High Frequency Engineering"].—R. I. Sarbacher & W. A. Edson. (*Proc. I.R.E.*, Aug. 1943, Vol. 31, No. 8, pp. 439–452.)

Velocity modulation, nature and production (single-step and two-step methods): utilisation (conversion into intensity-modulated beam: deflection method, conversion by retarding field, conversion by drift). Klystrons (Applegate diagram to elucidate "buncher" action: kinematic "bunching": current relations: phase shift: the Klystron as oscillator: cavity resonators: design and applications of the Klystron: the reflex Klystron). The inductive output amplifier (Haeff & Nergaard) and the Hahn & Metcalf tubes. Conclusions (high cost of associated tuner is the chief drawback to Klystron: "modified designs will be produced which accomplish the same results less expensively").

3336. Impulse Formation and Oscillatory Output for an Electron Flow in the Longitudinal-Field Chamber [of Velocity-Modulated Tubes: "Bunching" for Flows with Homogeneous Entrance-Velocity].—M. Geiger. (*Telefunken-Röhre*, March 1941, No. 19/20, p. 119 onwards: Oct. 1942, No. 24/25, p. 38 onwards.) For other papers *see* 1639 of 1941 and 109 of 1942.

3337. Contribution to the Theory of Velocity-Modulated Tubes and Other Transit-Time Valves.—R. Warnecke & J. Bernier. (*Rev. Gén. de l'Élec.*, Jan. & Feb. 1942, Vol. 51, Nos. 1 & 2, pp. 43 & 117 onwards.)

3338. On the Theory of the Split-Anode Magnetron [and the Essential Packeting Effect due to Phase Focusing, similar to That in the Klystron: Theory & Experimental Confirmation].—F. Lüdi. (*Sci. Abstracts*, Sec. B, Aug. 1943, Vol. 46, No. 548, p. 155: from *Helvet. Phys. Acta*, No. 1, Vol. 16, 1943.)

3339. A Spark-less Relay-Switch for Small Currents and High Voltages [primarily for the Protection of Magnetrons against Damage from Back-Heating].—H. G. Möller. (*E.T.Z.*, 20th May 1943, Vol. 64, No. 19/20, p. 276: summary only.)

If, for instance, a 20 mA current at 1000 V is to be broken quickly and spark-lessly, it is impossible to use a large spark-quenching condenser, because its charging current would itself do the damage. The writer's scheme is seen in Fig. 2, where S represents the apparatus to be protected when the current from the supply battery B_1 grows too large. As soon as this happens the relay-magnet attracts the armature, and in 1/300 s (adjusted by a cathode-ray oscillograph) the upper spring has moved over the gap-length of 0.3 mm and closed the contact C_1 This applies a positive voltage to the left-hand end of S to oppose the positive voltage, from the supply battery, on the right-hand end, and thus puts a brake on the current through S. Almost simultaneously the contact C_2 is opened, breaking the circuit through S spark-lessly. The battery now sends a strong current-pulse through the condenser K and the relay-magnet winding, pulling the armature hard over and opening C_2 fully: the current then sinks to the amount passed by the resistance R shunting K, which is enough to keep the armature held over. On opening the main switch S_2, the armature falls back and the arrangement is re-set. The magnet core is laminated and the pole-pieces are suitably designed, so that the self-inductance is high and the process is not delayed by eddy currents in the iron. The auxiliary battery B_2 is only needed when the device to be protected, S, has considerable inductance; in that case B_2 makes the positive "braking" voltage higher than the supply voltage.

3340. A Three-Phase Rotary-Field Transmitter for Ultra-Short Waves [with Stable Frequency Characteristics: including Tests with Tri-pole Aerial at Top of 50 m Tower (connected by Special Three-Phase Feeder), and Comparison with Theory].—W. Dieterle. (*Sci. Abstracts*, Sec. B, Jan. 1943, Vol. 46, No. 541, pp. 15–16: from *Helvet. Phys. Acta*, Nos. 2 & 3, Vol. 15, 1942, pp. 127 & 199 onwards.) *Cf.* Loyet, 601 of February, and back reference (for broadcasting frequencies).

3341. A Very-High-Frequency Transmitter for Emergency Service: a Simple Stabilised Push-Pull Oscillator Rig [built chiefly from Salvage Parts: Frequency Stability good enough for Superheterodyne Reception].—R. R. Hay & W. A. Harpster. (*QST*, Sept. 1943, Vol. 27, No. 9, pp. 48–49 and 59.)

3342. Reactance-Valve Frequency Modulator [Analysis: the Particular Case where the Phase-Splitting Circuit is a Series Combination of Resistance & Capacitance: Design Procedure: Possible Circuit Modifications to improve Ratio Reactance/Resistance: Possibility of producing an Input Impedance with *Any* Desired Phase Angle (even with Negative Component of Resistance): etc.].—E. Williams. (*Wireless Engineer*, Aug. 1943, Vol. 20, No. 239, pp. 369–371.) For a letter from F. Butler, recalling Sheaffer's methods (1814 of 1940), and discussing the advantages of the cathode-follower connection, *see* November issue, No. 242, p. 539.

3343. "Frequency Modulation" [Book Reviews].—A. Hund. (*Proc. I.R.E.*, Aug. 1943, Vol. 31, No. 8, pp. 455–456.)

A previous review was referred to in 2357 of September. Here, de Mars is extremely critical, particularly of the author's treatment of the difference between frequency- and phase-modulation, and of his "covering up" (or reversal) of the "important lesson" furnished by the history of frequency modulation. The second review, by Austin Bailey, is favourable.

3344. Use of Subcarrier Frequency-Modulation in Communication Systems.—W. H. Bliss. (*Proc. I.R.E.*, Aug. 1943, Vol. 31, No. 8, pp. 419–423.)

Author's summary :—"When subcarrier frequency-modulation [subcarrier wave frequency-modulated by signal material and then used to modulate a primary carrier] having a frequency range of 1600 to 2000 c/s was used for transoceanic facsimile transmission [720 of 1940], pictures were obtained with finer detail and better half-tone quality than those transmitted by previous systems; the speed of transmission could also be increased. An extension of the system to a two-way multiple-channel radio-relay circuit providing teletype service between New York and Philadelphia [in which a signal-level variation of a few decibels caused printer failures] gave improved stability of operation when variations in signal strength occurred" [22 db drop instead of 4 db required to produce failure : preferable to the alternative use of a.v.c.].

3345. An Experimental Investigation of a New High-Efficiency Grid-Modulation System.—N. M. Sankin, I. N. Rubinshteyn, & A. I. Sobolev. (*Izvestiya Elektroprom. Slab. Toka*, No. 8, 1940, pp. 20–27.)

A modification is proposed of the impedance-inversion grid-modulation system first developed by Terman & Woodyard (4300 of 1938 [and 3530 of 1939]). In the new circuit (Fig. 5) valve 1 operates into three inductively coupled tuned circuits, I, II, and III, of which III is the aerial circuit. Valve 2 operates into II and is switched on during the positive half-cycle of the low-frequency modulating voltage; this alters the impedance of II, and therefore of I. The advantages of the new circuit are: simplified tuning, improved frequency characteristic, absence of the impedance-inversion coil, and reduced "klirr" factor at the higher modulating frequencies. A detailed report on an experimental investigation of the new system is given, showing that an efficiency for the final stage of the order of 65–70% can be obtained in this way. These figures can be improved up to modern American standards if negative feedback is used.

3346. The Class B Modulating System.—A. I. Eylenkrig. (*Izvestiya Elektroprom. Slab. Toka*, No. 9, 1940, pp. 1–14.)

It is pointed out that while the high-frequency channel of the Class B modulating system has been extensively studied, the audio-frequency channel of the system has received comparatively little attention. Accordingly a detailed theoretical discussion, supported by experimental results, is given of distortions which may arise in the latter channel. The discussion may be divided into the following parts: push-pull modulating circuit, modulation transformer, modulator valves, sub-modulator circuit, sub-modulating transformer, and sub-modulator valves. A number of practical recommendations are given.

3347. Performance of Self-Biased Modulated Amplifiers.—Sarbacher. (*See* 3402.)

3348. A Valve-Oscillator Theorem.—E. Williams. (*Wireless Engineer*, Oct. 1943, Vol. 20, No. 241, pp. 489–491.)

"In the present paper it is intended to present, in the form of a theorem $[Z + r_A/(1 + \mu N) = 0]$, a single procedure applicable to all orthodox negative-grid oscillator circuits; and also, by the application of this theorem to one well-known class of oscillators, to prove certain general rules of behaviour for such oscillators" ["closed circuit oscillators" such as the Colpitts circuit].

3349. An Investigation of the Effect of the Valve on the Frequency of Oscillations.—G. T. Shitikov. (*Izvestiya Elektroprom. Slab. Toka*, No. 8, 1940, pp. 5–19.)

The operation of the following self-excited oscillators is discussed : (a) Hartley and Dow types, and (b) oscillators with tuned grid and anode circuits inductively coupled. For each group, formulae are derived showing the effect of inter-electrode capacities on the frequency of the oscillations. A report is given on experiments made to verify the theory. One of the conclusions reached is that by suitably selecting the coupling between the valve and the oscillatory circuit, the stability of oscillation, as affected by valve replacements, valve heating, and variations in the power supplies, can be improved by ten or more times.

3350. Quartz Crystal Applications, *and* Methods for Specifying Quartz Crystal Orientations and Their Determination by Optical Means.—W. P. Mason: W. L. Bond. (*Bell S. Tech. Journ.*, July 1943, Vol. 22, No. 2, pp. 178–223 : pp. 224–262.) First two papers of a series "communicating the specialised knowledge acquired at the Bell Telephone Laboratories."

3351. A Mineral Survey for Piezoelectric Materials.—W. L. Bond. (*Bell S. Tech. Journ.*, July 1943, Vol. 22, No. 2, pp. 145–152.)

3352. The Discovery of Quartz Crystal Deposits and New Production Methods.—G. Sonnedecker. (*Science*, 6th Aug. 1943, Vol. 98, No. 2536, Supp. p. 10.)

3353. How Jap Radio Transmitters Work—in U.S. Hands : a Description of Japanese Radio Equipment captured on Guadalcanal [including Some Novel Features in Construction].—J. H. Smith. (*QST*, Sept. 1943, Vol. 27, No. 9, pp. 44–45 and 59.)

3354. A Five-Band Transmitter–Exciter : a 100-Watt Unit of Conservative Design.—C. C. Richelieu. (*QST*, Aug. 1943, Vol. 27, No. 8, pp. 46–49 and 98, 100.)

3355. Automatic Transmitter Protection [from Overloads & Underloads : in Use at WMCA, New York].—F. Marx. (*Electronics*, June 1943, Vol. 16, No. 6, pp. 98–99 and 313.)

RECEPTION

3356. The Precision Tuning Problem in Ultra-High-Frequency Broadcasting [and the Development of a "High-Speed Scanning Receiver" with "Director" locking It on

Desired Carrier, identified by Its Special (Supersonic) Note: Successful Operation already obtained in Mobile & Aircraft Applications].—S. Y. White. (*Electronics*, May 1943, Vol. 16, No. 5, pp. 94–97 and 214.) Four patents have been issued.

3357. Some Aspects of Radio Reception at Ultra-High Frequency: Part I—The Antenna and the Receiver Input Circuits: Part II—Admittances and Fluctuation Noise of Tubes and Circuits: Part III—The Signal-to-Noise Ratio of Radio Receivers.—E. W. Herold & L. Malter. (*Proc. I.R.E.*, Aug. & Sept. 1943, Vol. 31, Nos. 8 & 9, pp. 423–438 & 491–510.) First three of the five parts of a series described editorially as "instructional material of timely interest."

3358. Chart for Radio Noise [Thermal & Shot, and Their Sum: with Suggestions on Its Use].—J. McG. Sowerby. (*Wireless Engineer*, July 1943, Vol. 20, No. 238, pp. 327–330.) For a letter from R. E. Burgess pointing out an error in eqn. 5, and the author's reply, and also an Editorial on the point, *see* the September issue, No. 240, pp. 436 and 413–414.

3359. More Selectivity in WERS Reception: a Super-Regenerative Superhet using Standard Tubes.—G. Grammer. (*QST*, Sept. 1943, Vol. 27, No. 9, pp. 17–22 and 59.)

3360. The Quartz Crystal Gate and the Introduction of Highly Selective Circuits [Letter, prompted by Footnote in Builder & Benson's Paper (1647 of June), on Priority and on the Differences between Marrison's Bridge-Balanced Circuit & Robinson's "Crystal Gate"].—J. Robinson. (*Wireless Engineer*, Sept. 1943, Vol. 20, No. 240, pp. 435–436.)

3361. Intermodulation in Receivers for Amplitude-Modulated Transmitters [Cause, Mathematical Representation, & Graphical Determination].—L. Brück. (*Telefunken-Röhre*, Oct. 1942, No. 24/25, p. 49 onwards.)

3362. On the Influence of Some Back-Couplings on the Sensitivity [Comparison, including Retroaction from Cathode Circuit of Triodes].—K. Fränz. (*Telefunken-Röhre*, Oct. 1942, No. 24/25, p. 35 onwards.)

3363. The Diode as a Rectifier and a Detector for Weak Signals [Treatment by Method of Perturbation].—Aharoni. (*See* 3396.)

3364. A Note on Volume-Rectification of Crystals.—S. R. Khastgir. (*Indian Journ. of Phys.*, April 1943, Vol. 17, Part 2, pp. 111–113.)

Prompted by Sen's statement (1760 of June, following 1610 of 1938) that "volume rectification is not confined to crystals like carborundum, zincite, and silicon alone, which have no centres of symmetry, but that it is also exhibited by crystals like galena, iron-pyrites, and pyrolusite, possessing centres of symmetry," Sen's rectification results with such symmetrical crystals, placed between mercury electrodes of large surface area, merely showed that the surface effects were not eliminated in his experiments. The writer (with Das Gupta: 543 & 1644 [and 2407] of 1935) showed the probability of the existence of volume rectification in polar crystals, and the crucial test was carried out by Deaglio (2408 of 1935): the writer (with Chakravarty; 3476/7 [and 1170] of 1937) carried the matter still further, and Deaglio (3368 of 1938) stated clearly that volume rectification is only a natural consequence of the lack of symmetry in polar crystals.

3365. Surge-Limiting Electrolytic Condensers.—L. N. Zakgeym & G. D. Nikolaeva. (*Izvestiya Elektroprom. Slab. Toka*, No. 9, 1940, pp. 53–57.)

Special electrolytic condensers with a steep volt/ampere characteristic are now used in the filter circuits of many radio receivers to provide load to the mains transformer during the first few seconds after switching-on the receiver, and thus to prevent undesirable surges. A report is given on an experimental investigation undertaken to evolve manufacturing processes necessary to ensure prolonged and stable operation of these condensers. The preparation of the samples and the subsequent tests are described in detail, and a number of experimental tables are shown. One of the conclusions reached is that the best results are obtained with non-etched aluminium electrodes and a working electrolyte consisting of a solution of 110 g of ammonium pentaborate in 1 litre of distilled water.

3366. Radio-Noise Filters for Use in Aircraft.—C. W. Frick & S. W. Zimmerman. (*Sci. News Letter*, 3rd July 1943, Vol. 44, No. 1, p. 8.)

3367. Lapp-Type Insulators [and Their Freedom from Radio Interference].—R. C. Andersen. (*Sci. Abstracts*, Sec. B, Feb. 1943, Vol. 46, No. 542, p. 26.)

3368. Static Electric Problems in Tyres [including Laboratory Testing Machine for evaluating the Static-Generating Properties of Rubber Compounds: Correlation with Resistivity: etc.].—J. W. Liska & E. E. Hanson. (*Sci. Abstracts*, Sec. B, Oct. 1942, Vol. 45, No. 538, p. 160.) *Cf.* 2711 of October.

3369. Three-Point Tracking in Superheterodynes [Translation of Paper referred to in 3575 of 1942].—K. Fränz. (*Wireless Engineer*, July 1943, Vol. 20, No. 238, pp. 331–338.)

"The complicated tracking calculation which formerly had to be performed accurately to 7 places can now be simplified to the point where the required L and C values can be calculated with fully sufficient accuracy by the use of the slide rule . . ."

3370. The Development and Present Position of the Broadcast Receiver Industry of the World.—W. F. Ewald. (*E.T.Z.*, 20th May 1943, Vol. 64, No. 19/20, pp. 271–275.)

Concluded from 2713 of October. The countries covered are Japan, Canada, Australia, New Zealand, the Argentine, China, Holland, England, France, Italy, Hungary, Scandinavia, Belgium, Switzerland, and Russia. The basis is the year before the war. Among the comments on the English industry, illustrative of the contents of this paper, are the following: "the comparative weakness of England in export to Europe is explained on commercial rather than on technical grounds. In spite of American influences the character of English receiver-manufacture is entirely European." The comparatively large number of battery-type receivers "corresponds to the astonishingly backward state of the electrification of the country." In Russia a 4-valve superheterodyne "costs the wages of a highly skilled worker, doctor, or engineer for 6 to 8 weeks."

3371. UNITIZED ELECTRONIC CELLS [Receivers, Remote-Control Units, Transmitters, Alarm Systems, etc.].—Harvey Machine Company. (*Review Scient. Instr.*, Aug. 1943, Vol. 14, No. 8, p. 257.) *See* 2714 of October.

3372. UTILITY SETS [and the Question of High Quality].—"Diallist." (*Wireless World*, Oct. 1943, Vol. 49, No. 10, pp. 316–317.) Reply to a correspondent.

3373. "THE TECHNIQUE OF RADIO DESIGN" [Book Review].—E. E. Zepler. (*Wireless World*, Nov. 1943, Vol. 49, No. 11, p. 331.)

3374. "TESTING RADIO SETS: FOURTH EDITION, REVISED" [Book Review].—J. H. Reyner. (*Electrician*, 1st Oct. 1943, Vol. 131, No. 3409, p. 338.)

AERIALS AND AERIAL SYSTEMS

3375. ARRANGEMENT FOR THE TRANSMISSION OR RECEPTION OF ELECTROMAGNETIC BEAMS.—L. Lipsey & E. Bittera. (*Hochf:tech. u. Elek:akus.*, Feb. 1943, Vol. 61, No. 2, p. 64.)

Swiss Patent 219 529. The aerial *A* (Fig. 19) is embedded in a dielectric *P* of prismatic, conical, or ring form and of triangular cross section, so that the radiation from it is totally reflected by the surfaces passing through two sides of the triangle, and emerges through the third boundary surface.

3376. DIRECTIONAL ULTRA-HIGH-FREQUENCY ANTENNA [for Studio/Transmitter Relay Service on Any of the 23 Assigned Channels centering on 337 Mc/s: mounted on Single Metal Pole].—M. W. Scheldorf. (*Proc. I.R.E.*, July 1943, Vol. 31, No. 7, p. 388.)

3377. THREE-ELEMENT DIRECTIONAL ANTENNA FOR PORTABLE 112-Mc/s WORK [with Plexiglas Insulation for Reflector & Director].—J. H. Jearne. (*QST*, Aug. 1943, Vol. 27, No. 8, p. 65.)

3378. RESONANT CIRCUITS IN ANTENNA SYSTEMS: SOME CIRCUIT FUNDAMENTALS AND THEIR APPLICATION TO AMATEUR PROBLEMS [such as making Multi-Element Arrays work on Two Bands].—D. Espy. (*QST*, Sept. 1943, Vol. 27, No. 9, pp. 32–37.)

3379. DATA SHEETS 51 & 52: AERIAL CHARACTERISTICS AND COUPLING SYSTEMS, *and* DATA SHEET 53: AERIAL CHARACTERISTICS, II—RADIATION RESISTANCE AND POLAR CHARACTERISTICS.—(*Electronic Eng:g*, Aug. 1943, Vol. 16, No. 186, pp. 109–112: Oct. 1943, No. 188, pp. 197–200.)

3380. AN INSTRUMENT FOR DIRECT MEASUREMENT OF THE TRAVELLING WAVE COEFFICIENT IN FEEDERS [the "Feeder Reflectometer"].—G. W. O. H: Pistol'kors & Neyman. (*See* 3470.)

3381. A MONITORING INSTRUMENT FOR MATCHING CONDITIONS IN SHORT-WAVE FEEDER/AERIAL SYSTEMS.—Buschbeck. (*See* paper dealt with in 3471, below.)

3382. A TRIPLE-LOOP SYSTEM FOR TUNING FEEDERS TO TRAVELLING WAVES.—V. V. Tatarinov. (*Izvestiya Elektroprom. Slab. Toka*, No. 8, 1940, pp. 1–4.)

Tuning a feeder to eliminate standing waves by a loop in parallel with the feeder involves adjusting (a) the tapping point and (b) the loop length. The first operation is difficult with screened feeders and a new method is, therefore, proposed in which three loops are used and the feeder can be tuned for any load without these being moved. The loops are connected to the feeder at any points at intervals of $\frac{1}{4}\lambda$. The actual tuning of the feeder is effected by adjusting two adjacent loops, while the third loop is tuned to $\frac{1}{4}\lambda$, which is equivalent to a $\frac{1}{4}\lambda$ displacement of the other two loops in its direction. A mathematical proof of this is given.

3383. LOW-LOSS COAXIAL CABLES [with Solid Flexible Dielectric, "Copolene B", having Electrical Characteristics approximating to Those of Polystyrene Beads: Solid Construction "simplifies Solution of Many H.F. Transmission Problems"].—American Phenolic Corporation. (*Review Scient. Instr.*, Aug. 1943, Vol. 14, No. 8, p. 258.)

3384. DIPOLE AERIALS [Letter on Wells's Paper, 1888 of July].—J. S. McPetrie: Wells. (*Wireless Engineer*, June 1943, Vol. 20, No. 237, p. 303.)

3385. RADIATION FROM VEE ANTENNAS.—C. W. Harrison, Jr. (*Proc. I.R.E.*, July 1943, Vol. 31, No. 7, pp. 362–364.)

Author's summary:—"Certain aspects of the directional qualities of a non-resonant inclined vee antenna are discussed briefly. Formulas, based on the assumption of a perfectly conducting earth, are derived for the radiation intensity in two planes. These relations show that the antenna is unidirectional when centre-driven. Its wide-band performance, combined with ease of erection and low cost, should make it an attractive antenna, particularly for receiving applications." Practical details of such an aerial used by the Mackay Company are added at the end.

3386. ADJUSTMENT OF DIRECTIONAL ANTENNAS [such as the Two-Tower System of WEAF: Resistance & Reactance Values at Radio Frequencies measured while Full Power is being supplied, by Width & Height Measurements of Elliptical Screen-Pattern of Cathode-Ray Oscillograph].—W. S. Duttera. (*Electronics*, April 1943, Vol. 16, No. 4, pp. 91–93.)

3387. Medium- and Long-Wave Aerial System for a Radio Laboratory [for Study of Radio Receivers].—Rymer. (*See* 3492.)

3388. The Effect of Lightning on Receiving Aerials [Extract from I.E.E. Paper "The Protection of Structures against Lightning"].—J. F. Shipley. (*Electronic Eng:g*, Aug. 1943, Vol. 16, No. 186, p. 107.)

3389. "Loop Antennas for Aircraft": Correction to Equation 6.—G. F. Levy. (*Proc. I.R.E.*, July 1943, Vol. 31, No. 7, p. 384.) *See* 1683 of June.

3390. Glass Kite-String used to carry Radio Antenna aloft [for Forced Landings at Sea].—(*Scient. American*, Sept. 1943, Vol. 169, No. 3, pp. 132–133.)

VALVES AND THERMIONICS

3391. Tubes employing Velocity Modulation.—Sarbacher & Edson. (*See* 3335.)

3392. New Receiving Tubes for Very High Frequencies.—Sylvania Electric Products. (*QST*, Aug. 1943, Vol. 27, No. 8, p. 59.)

3393. The Signal Converter: New Thermionic Discharge Tube for the Production of the Time-Base Deflection Potentials of a Cathode-Ray Tube ["Nagard Type I" Deflection-Modulated Cathode-Ray Valve: Greatly Improved Accuracy of Synchronisation in Television & Oscillography: Advantages of Trapezoidal over Saw-Tooth Wave-Form: etc.].—P. Nagy & M. J. Goddard. (*Wireless Engineer*, June 1943, Vol. 20, No. 237, pp. 273–299.) For corrections *see* July issue, No. 238, p. 338.

3394. Discussion on "Fluctuations in Space-Charge-Limited Currents" [Bell, 1894 of July].—J. R. Pierce: D. A. Bell. (*Journ. I.E.E.*, Part III, Sept. 1943, Vol. 90, No. 11, p. 148.)

3395. Space-Current Flow in Vacuum-Tube Structures.—B. J. Thompson. (*Proc. I.R.E.*, Sept. 1943, Vol. 31, No. 9, pp. 485–491.)

Author's summary:—"From well-known formulas for space-current in diodes and for amplification factor in triodes, inter-electrode capacitance, plate current, and potential distribution in triodes and multi-grid tubes are determined through use of the concept of planes of equivalent potential. By the same means, amplification factor in multi-grid tubes is derived." The author claims "little originality and no novelty in this material," but the concepts of valve analysis presented have proved informative and useful to himself in practical valve-design work.

3396. The Diode as a Rectifier and a Detector for Weak Signals [taking Non-Linearity of Characteristic into Account].—J. Aharoni. (*Phil. Mag.*, Aug. 1943, Vol. 34, No. 235, pp. 505–521.)

"In certain types of problems the deviation of the characteristic from a straight line has to be taken into account. In such cases we meet with non-linear differential equations, and the linear circuit theory is of no direct help. In most cases these differential equations are of a complicated nature and methods of approximation have to be applied. It appears that the method of perturbation (applied so much in planetary and atomic problems) offers a convenient approach. The deviation from a straight line may be regarded as a perturbation, and a solution is sought in the form of a power series in the perturbation, and not in the applied signal voltage as in Carson's method."

Part I deals with rectification. "From eqn. 43 it will be seen that the deviation of the characteristic from a straight line makes things slightly worse as regards smoothing proportionately with b" [$i_a = aV + bV^2$: eqn. 2]. Expressions are found for the efficiency of smoothing, given by the percentage ripple, for the fundamental and for the harmonic 2ω. Part II deals with demodulation or detection. Eqn. 64 shows "that the amplitude of the a.f. oscillation, which has been produced by the diode, is proportional both to β, the amplitude of the carrier wave, and to M, the amplitude of the modulation. Hence, to the first order, the diode behaves as an ideal modulator. The proportionality both with β and M makes it clear that it is better to amplify before detection than use the same amplification after detection . . ." "From some text-books the impression is gained that as the rectification is according to a square law so will also be the detection. It is perhaps therefore worth while to show by an elementary consideration that, exactly because of the square-law rectification, the demodulation is linear. . . A linear demodulation would follow, of course, also from a linear rectification." "Eqn. 66 shows that the weaker the signal β, the more will the higher terms in b be negligible, and hence the more will the rectification be according to a square law, and the demodulation linear." "The straightening effect of R must not be made too large. The more fidelity we expect from the rectifier the less efficient it will be. Lack of fidelity will be proportional to ϵ^2, efficiency to ϵ."

3397. The Secondary Electron Emission from Metals in the Low Primary Energy Region [Investigation by Specially Devised Method: Results on Gas-Free Copper with Primary Electrons having Energies down to Lowest Practicable with Tungsten Thermionic Source (about 0.35 eV at 2000°K): Comparison with Theories].—Irena Gimpel & O. Richardson. (*Proc. Roy. Soc.*, Ser. A, 6th Sept. 1943, Vol. 182, No. 988, pp. 17–47.)

From the authors' summary:—"The distribution of energy is analysed both for the primary and the secondary electrons. It is found to be practically the same for both groups for all energies below a few volts. From this we deduce (1) that for these low-energy electrons the secondary electrons are just reflected electrons, and (2) that the coefficient of reflection r varies very little with the energy of the electrons. . . . It is shown that no manipulation with fields can ever reduce the mean energy of electrons from a thermionic source below $2kT$. . . . Many determinations of r have been made from a few volts down to $2kT$, and the average value of r is about 0.24. No variation of r has been established with certainty, but there are indications that it drops a little from the value at $2kT$ to a minimum at about $2kT + 0.5$ ev, then increases slightly."

3398. A General Experimental Solution of Poisson's Equation for Two Independent Variables [by an Electrical Integraph based on the Analogy of a Resistance Network to a Finite-Difference Mesh : Application to the Plotting of Equipotentials in an Electron Multiplier, etc.].—T. K. Hogan. (*Journ. Inst. Eng. Australia*, April 1943, Vol. 15, No. 4, pp. 89–92.)

3399. Physics and the Static Characteristics of Hard Vacuum Valves [and the Limits of the Simple "Continuous Fluid" Theory normally used : Comparison with Rubber-Sheet Results].—J. H. Fremlin. (*Electronic Eng:g*, Aug. 1943, Vol. 16, No. 186, pp. 103–107.) Paper read before Electronics Group, Institute of Physics : for an earlier paper *see* 3166 of 1939 [and 3419 of 1940].

3400. The Current/Voltage Characteristic of an Electron Flow in a Retarding Field between Two Plate Electrodes inclined to One Another [Approximate Determination of Trajectory of an Electron injected into such a Field : Penetration Depth as Function of Angle of Injection : etc.]. — H. Marschall. (*Telefunken-Röhre*, Oct. 1942, No. 24/25, p. 23 onwards.) With nine diagrams.

3401. Letter on "Tracing Valve Characteristics, using the Cathode-Ray Oscillograph" [Assertion of Circuit Error needing Major Alterations to correct]. — G. N. Patchett : Bocking. (*Wireless Engineer*, Oct. 1943, Vol. 20, No. 241, p. 488.) *See* 436 of February.

3402. Performance of Self-Biased Modulated Amplifiers [Procedure for determining Dynamic Characteristics & Optimum Performance : Variation of Polarising Voltages during Operation determined as Function of Bias Resistor & Its Location in Circuit : Ways of obtaining Improved Linearity of Circuit Operation & Reduced Peak Driving Power are indicated by This Analysis].—R. I. Sarbacher. (*Electronics*, April 1943, Vol. 16, No. 4, pp. 99–103 and 128..138.)

3403. Optimum Conditions in Class A Amplifiers : Correspondence prompted by Editorial (1027 of April) on Nottingham's Paper.—W. E. Benham, E. Bradshaw. (*Wireless Engineer*, June 1943, Vol. 20, No. 237, pp. 302–303.) For a letter from A. S. Gladwin, giving a simple approximate method of solving Nottingham's maximum-output equation, *see* September issue, No. 240, p. 436.

3404. The Optimum Conditions for Class C Operation [Editorial on Frommer's Paper, 1107 of April].—G. W. O. H. (*Wireless Engineer*, June 1943, Vol. 20, No. 237, pp. 267–272.)

3405. Rules for Prolonging Tube Life.—H. J. Dailey. (*Electronics*, April 1943, Vol. 16, No. 4, pp. 76–78.) From the Westinghouse Company.

3406. Codes and Conventions in Electronic Apparatus [Resistors, Capacitors, Transformers, Valves : British & American].—G. Parr. (*Journ. of Scient. Instr.*, Aug. 1943, Vol. 20, No. 8, pp. 121–124.)

3407. "Introduction to Valves" [and Cathode-Ray Tubes, etc : Second Edition : Book Review]. — F. E. Henderson. (*Wireless World*, Oct. 1943, Vol. 49, No. 10, p. 309.)

3408. "Rundfunkröhren, Eigenschaften und Anwendung" [Part I—General Treatment of Broadcast-Receiver Valves : Part II—Telefunken Types & Their Performance : Book Review].—L. Ratheiser. (*Hochf:tech. u. Elek:akus.*, Oct. 1942, Vol. 60, No. 4, p. 116.)

3409. The Emissive Power of Typical Grid and Plate Surfaces [Plain, Acid-Etched, Sand-Blasted, Oxidised, Graphite-Coated, Batch- and Strip-Carbonised, etc.].—R. Szymanowitz. (*Electronics*, May 1943, Vol. 16, No. 5, pp. 93 and 178, 180.)

3410. Electronics Mystery, Solved, may lead to Improved Vacuum Tubes [Westinghouse Researches show that Gases dissolve in Some Metals to form Solid Solution : Electron Emission affected by Oxygen in Zirconium, Titanium, & Hafnium as well as in the Usual Thorium, Barium, etc : Possibility of Oxide-Coated Cathodes for High-Voltage Valves].—H. C. Rentschler. (*Scient. American*, July 1943, Vol. 169, No. 1, p. 17.)

3411. Apparatus for the Detection of Splits in Tungsten Wire [Application of Eddy-Current Principle of Crack-Detection in Metals to 20 Mc/s Apparatus for detecting Fine Longitudinal Splits in Wire for Valves : Much More Rapid than Usual Low-Power-Microscope Examination].—D. T. O'Dell. (*Journ. of Scient. Instr.*, Sept. 1943, Vol. 20, No. 9, p. 147.)

3412. Magnetic Induction Field of Air-Core Coils : Its Application to High-Frequency Heating in Valve Manufacture.—C. B. Kirkpatrick. (*Wireless Engineer*, Aug. 1943, Vol. 20, No. 239, pp. 372–382.) Reproduction of the paper dealt with in 1695 of 1942.

DIRECTIONAL WIRELESS

3413. METHOD AND EQUIPMENT FOR DISTANCE DETERMINATION WITH FREQUENCY-MODULATED WAVES.—G. Guanella. (*Hochf:tech. u. Elek:akus.*, Feb. 1943, Vol. 61, No. 2, p. 64.)

Swiss Patent 219 436. "To eliminate large errors due to interference, the determination of the distance of a transmitter from a reflecting surface, by the sending-out and subsequent reception of frequency-modulated waves, is accomplished by varying the frequency of the emitted signal continuously and non-uniformly, in time with a low frequency, and obtaining at the receiver a periodically varying quantity which is proportional to the instantaneous frequency of the beat between the direct and the reflected oscillations, and from which a component is led through frequency-selecting devices to the indicating system." For other patents *see* 3016/7 of November.

3414. ARRANGEMENT FOR THE DETECTION OF A REFLECTING OBJECT MOVING IN THE RADIATION FIELD OF A SHORT-WAVE TRANSMITTER [Omnidirectional Transmitter, Directional Receiver with Minimum in Transmitter Direction: Reflected Energy reaches Receiver in Direction other than Minimum, and produces Indication].—H. Muth & W. Beuermann. (*Hochf:tech. u. Elek:akus.*, Oct. 1942, Vol. 60, No. 4, p. 115.) A Telefunken patent, D.R.P. 718 936, applied for 22/2/1936.

3415. RADAR [Radio - Detection - and - Ranging]: BACKGROUND OF THE WAR'S GREATEST DEVELOPMENT [Work of R.C.A., Westinghouse, Naval Aircraft Radio Laboratory, Irving Wolff, & others].—(*Scient. American*, Aug. 1943, Vol. 169, No. 2, pp. 78–80.) *Cf.* 2736 of October.

3416. CATHODE-RAY DIRECTION FINDER WORKING WITH ROTATING AERIAL AND AN AUXILIARY DEFLECTING FIELD PRODUCING ALTERNATE LEAD AND LAGS IN RAPID SUCCESSION.—R. Kümmich. (*Hochf:tech. u. Elek.akus.*, Oct. 1942, Vol. 60, No. 4, p. 115.)

A Telefunken patent, D.R.P. 719 657. The auxiliary field works so that points on the two directional curves *n* and *o* (Fig. 22) appear alternately on the screen, their point of intersection yielding the correct direction. The original curve, often flattened by blurring, is shown at *p*.

3417. THE PROBLEMS OF NEW SYSTEMS OF RADIO-NAVIGATION [free from Night Effect].—L. E. Shtillerman. (*Sci. Abstracts*, Sec. B, Jan. 1943, Vol. 46, No. 541, p. 17: from *Elektrosvyaz*, No. 5, 1941.) An abstract reticent to the point of dumbness.

3418. ARRANGEMENT FOR GENERATING A MINIMUM-CLEARING VOLTAGE IN A DIRECTION FINDER.—W. Hasselbeck & F. Stein. (*Hochf: tech. u. Elek:akus.*, Feb. 1943, Vol. 61, No. 2, p. 64.)

A Telefunken patent, D.R.P. 723 815. An auxiliary coil is mounted at 90° to the search coil: its signal voltage, displaced by 90°, is taken to circuits which continuously vary its amplitude and suddenly change its phase by 180°, and is then led to the receiving system to act as a clearing voltage.

3419. EQUI-SIGNAL BEACON TRANSMITTER [for improving Reception spoilt by Interference].—Y. Rocard. (*Hochf:tech u. Elek:akus.*, Feb. 1943, Vol. 61, No. 2, p. 64.)

D.R.P. 723 512. A directive system, with a sharp minimum in the course direction, radiates a strongly (100%) modulated wave, while a non-directive aerial, fed with the complementary signals with 180° alternating phase, radiates a wave of the same frequency but more weakly modulated with a high carrier value.

3420. "LOOP ANTENNAS FOR AIRCRAFT": CORRECTION TO EQUATION 6.—G. F. Levy. (*Proc. I.R.E.*, July 1943, Vol. 31, No. 7, p. 384.) *See* 1683 of June.

ACOUSTICS AND AUDIO-FREQUENCIES

3421. MOVING-COIL LOUDSPEAKER GIVING VOLTAGES PROPORTIONAL TO COIL VELOCITY [either for Determination of Radiated Energy or for Production of Negative-Feedback Voltage: by Compensating (by a Bridge Circuit) All Components which are Independent of Coil Velocity (Ohmic & Inductive Voltage-Drops)].—O. Roniger. (*Hochf:tech. u. Elek:akus.*, Oct. 1942, Vol. 60, No. 4, p. 115.) A Telefunken patent, D.R.P. 719 499.

3422. ROCHELLE-SALT CRYSTAL DEVICES OF LOW IMPEDANCE [Search for Satisfactory Method of using Single Plate: the "Monobar" Unit with Bonded Gold Foil Electrode & Spring-Toggle Mechanical Multiplying System ("Bow-&-Frame"): Microphones remarkably free from Harmonic Distortion: Mirror Oscilloscope: Loudspeaker: etc.].—R. W. Tibbetts. (*Electronics*, April 1943, Vol. 16, No. 4, pp. 88–90 and 116, 118.) *See* also 3605, below.

3423. EMERGENCY CIRCUITS FOR LEVEL-EQUALISING AND ANTI-SIDETONE CONTROL.—D. Phillips. (*Sci. Abstracts*, Sec. B, Aug. 1943, Vol. 46, No. 548, p. 154.) Including a method of operating a 3-way telephone conversation with loudspeaker receivers at each point.

3424. PRINCIPLES OF MODERN GRAMOPHONE RECORDING.—N. Banerjee. (*Sci. & Culture* [Calcutta], June 1943, Vol. 8, No. 12, pp. 485–490.) From Hindusthan Musical Products, Ltd., Calcutta.

3425. THE NEW SIEMENS SILVER [-Vapour] PROCESS IN THE MANUFACTURE OF GRAMOPHONE RECORDS.—Siemens & Halske Laboratories. (*T.F.T.*, March 1943, Vol. 32, No. 3, pp. 71–72.) *See* also 2406 of September.

3426. A PEAK-LIMITING AMPLIFIER FOR RECORDING: THE USE OF INSTANTANEOUS AUTOMATIC VOLUME CONTROL TO PREVENT OVER-CUTTING.—R. Lewis. (*QST*, Sept. 1943, Vol. 27, No. 9, pp. 26–27.)

3427. Device for Automatic Reception and Removal of Shavings or Thread in Instantaneous Recording.—R. Sinclair. (*QST*, Sept. 1943, Vol. 27, No. 9, p. 63: paragraph only.)

3428. Pick-Up Mounting: a Simple and Satisfactory Pivoting System for the "Tracking Arm."—A. C. Robb. (*Wireless World*, Oct. 1943, Vol. 49, No. 10, p. 314.) For a reply from D. W. Aldous on the suggested use of "tracking arm" (as an alternative to "carrying arm") to replace the misnomer "tone arm," *see* November issue, No. 11, p. 345.

3429. Contrast Expansion and Distortion [Correspondence prompted by Hughes's Letter, 2987 of November].—C. E. G. Bailey: J. Moir. (*Wireless World*, Oct. 1943, Vol. 49, No. 10, pp. 313–314.)

3430. Sibilant Speech Sounds: the Elimination of Relative Spectral-Energy Distortion in Electronic Compressors.—B. F. Miller. (*Electronic Eng:g*, July 1943, Vol. 16, No. 185, pp. 69–70.)

3431. Remark on the Paper "Theoretical and Experimental Investigations on Telephone Receivers (Magnetic Converters)" [Correction & Author's Acknowledgment].—U. John: K. Braun. (*T.F.T.*, March 1943, Vol. 32, No. 3, pp. 70–71.) *See* Braun, 792 of March.

3432. The Limits of Improvement of Intelligibility in Telephonic Communication [Recent Ideas of Improvement attainable by Use of Wider Frequency Band are Over-Optimistic: Suggested Way of Improvement for Present Band].—K. O. Schmidt. (*T.F.T.*, March 1943, Vol. 32, No. 3, pp. 54–60.)

3433. Transmission Relations in Telephony compared with Natural Hearing [Monaural & Binaural Hearing: Sound-Pressure "Damming" by the Head: Resonance of Ear (Acoustic Resistance depends on Auricle, hardly at all on Auditory Passage): the Primary Calibration Circuit in Paris and Its Duplicates: Conclusions as to Correct Calibration of Telephone Transmitters & Receivers, etc.].—K. Braun. (*T.F.T.*, March 1943, Vol. 32, No. 3, pp. 49–53.)

For example, "it is wrong to measure the frequency characteristics of transmitters on the basis of the sound pressures of the undistorted sound field, as has been done hitherto." For the most natural transmission the frequency curve of the telephone link must not run horizontally but must rise by about 1.4 nepers between about 800 c/s and 4000 c/s. Owing to the character of the microphones employed, the standard calibration circuits show such a characteristic.

3434. New Acoustic Stethoscope [transmitting All Frequencies from 40 to 4000 c/s without Discrimination (Ordinary Stethoscope Range 200–1500 c/s)].—H. F. Olson. (*Proc. I.R.E.*, July 1943, Vol. 31, No. 7, p. 389.) *See* also *Scient. American*, Sept. 1943, Vol. 169, No. 3, pp. 131–132, and *cf.* Donovan, 3435, below.

3435. Discussion on "The Electrical Amplifying Stethoscope and Phono-Electrocardioscope" [2606 of September].—G. E. Donovan. (*Journ I.E.E.*, Part III, Sept. 1943, Vol. 90, No. 11, pp. 149–150.)

3436. Known and Novel Musical Sounds from Electrical Musical Instruments [Hammond Organ, Electrochord, Melodium, etc.].—H. Bode. (*Bull. Assoc. Suisse des Élec.*, 26th Aug. 1942, Vol. 33, No. 17, pp. 479–483: in German.)

3437. Electronic Music Group [Note on Formation].—(*Electronic Eng:g*, Sept. 1943, Vol. 16, No. 187, p. 167.)

3438. "White Noise" [on Analogy of White Light] in Planes [and Suggested Remedies].—L. D. Carson & others. (*Science*, 30th July 1943, Vol. 98, No. 2535, Supp. p. 8.)

3439. Measurement and Analysis of Noises by an Improved Method.—D. S. Elliott & J. L. McLucas. (*Phys. Review*, 1st/15th June 1943, Vol. 63, No. 11/12, pp. 456–457: summary only.)

3440. Characteristics of Decibel Meters [Rectifier/Moving-Coil-Voltmeter Type].—J. H. Jupe. (*Electronic Eng:g*, Sept. 1943, Vol. 16, No. 187, pp. 166–167.)

3441. Steady State of Sound in a Room [Reverberation-Time Formula $T = KE_0V/I$, tested for Constancy of K by Warble-Note Method in Twelve Rooms: Procedure used does Not yield Useful Values of T].—H. P. Knauss & J. G. Woodward. (*Journ. Acous. Soc. Am.*, July 1943, Vol. 15, No. 1, p. 80: summary only.)

3442. Synthetic Reverberation [the "Reverberstat" (M.G.M. Studios), a Device consisting of Oil-Immersed Spiral Springs driven by Loudspeaker and driving a Piezoelectric Transmitter].—D. W. Aldous: J. K. Hilliard. (*Electronic Eng:g*, Aug. 1943, Vol. 16, No. 186, p. 117.)

3443. Studio for the Microphonic Pick-Up of Acoustic Programmes [Three Ordinary Walls, the Fourth forming a Concave Reflector in front of which the Microphone picks up chiefly the Reflected Waves].—H. J. von Braunmühl & W. Weber. (*Hochf:tech. u. Elek:akus.*, March 1943, Vol. 61, No. 3, p. 92.) D.R.P. 725 744, applied for 23/6/40: Fig. 18.

3444. Materials and Construction for Speech Broadcasting Studios, *and* Acoustics for Broadcasting Studios for Speech *versus* Music.—L. Green: E. J. Content. (*Journ. Acous. Soc. Am.*, July 1943, Vol. 15, No. 1, p. 80: p. 80: summaries only.)

3445. Insulating Materials [War-Time Difficulties: the Advantages of Foamed Light-Weight Concrete].—H. R. Fraenkel. (*Journ. Roy. Soc. Arts*, 17th Sept. 1943, Vol. 91, No. 4648, pp. 562–564.)

3446. The Vibration Characteristics of "Free-Free" Circularly Curved Bars.—W. A. Pliskin, J. E. Edwards, & F. P. Bundy. (*Journ. Applied Phys.*, Aug. 1943, Vol. 14, No. 8, pp. 410–417.) Extension of work referred to in 498 of February.

3447. 36 and 72 Ordinate Schedules for General Harmonic Analysis [Corrections].—R. P. G. Denman: F. W. Grover. (*Electronics*, April 1943, Vol. 16, No. 4, pp. 214 and 215.) *See* 1147 of April.

3448. A General Reactance Theorem for Electrical, Mechanical, and Acoustical Systems [Extension of Foster's Reactance Theorem].—Maa. (*See* 3302.)

3449. "Dynamical Analogies" [Book Review].—H. F. Olson. (*Proc. I.R.E.*, Sept. 1943, Vol. 31, No. 9, p. 524.)

3450. An Automatic Frequency-Controlled Oscillator and Amplifier for driving Mechanical Vibrators [specifically, St. Clair's High-Frequency Sound Generator for Industrial Purposes (2455 of 1941), but with Other Applications].—E. V. Potter. (*Review Scient. Instr.*, July 1943, Vol. 14, No. 7, pp. 207–215.)

"The circuit is very effective, changes in either oscillator or vibrator frequency, or both, of approx. 500 c/s in 12 kc/s, being followed automatically so that the oscillator frequency will not deviate from the resonant frequency of the vibrating member by more than 0.1 c/s."

3451. Measuring Shaft Power Output by means of Acoustics.—C. C. Downie. (*BEAMA Journal*, Aug. 1943, Vol. 50, No. 74, p. 255: summary only.)

PHOTOTELEGRAPHY AND TELEVISION

3452. Colour Television: Part II [Improvements in the Columbia Broadcasting System (481 of February and 1161 of April): Improved Receiver-Tube Phosphors & Attendant Changes in Transmitter Colour Characteristics: Automatic Colour Phasing: Sixty-Cycle Interference at Receiver: Colour Television utilising a Wider Band: Projection (Experiments with Various "Diavisor" Systems: the Use of a "Wobbler" Disc)].—P. C. Goldmark, E. R. Piore, J. M. Hollywood, T. H. Chambers, & J. J. Reeves. (*Proc. I.R.E.*, Sept. 1943, Vol. 31, No. 9, pp. 465–478.)

3453. Television after the War [Informal Discussion, Wireless Section I.E.E: Factors determining the Choice of Carrier Frequency for an Improved Television System (and the Question of Multi-Path Interference on a 400 Mc/s Carrier): the Commercial Viewpoint: Picture Format (at present "a Miserable Legacy from the Cinema"): the Case for Multiple Interlacing: etc.].—B. J. Edwards, P. Nagy, & others. (*Electronic Eng:g*, July, Aug. & Sept. 1943, Vol. 16, Nos. 185, 186, & 187, pp. 60–64, 118–120, & 164–165.) *See* also 3454, below.

3454. Discussion on Factors determining the Choice of Carrier Frequency for an Improved Television System [Informal Meeting].—I.E.E. Wireless Section. (*Journ. I.E.E.*, Part III, Sept. 1943, Vol. 90, No. 11, pp. 147–148.)

3455. Television Progress.—A. N. Bhattacharya. (*Sci. & Culture* [Calcutta], May 1943, Vol. 8, No. 11, pp. 431–435.) Continued from 2441 of September. Recent developments in large-screen projection and colour are among the subjects discussed: also the Coronaviser (*see* for example 4202 of 1940.)

3456. The Scophony Telekino Transmitter.—N. N. Blyumental'. (*Izvestiya Elektroprom. Slab. Toka*, No. 8, 1940, pp. 35–40.)

The operation of the system is described, and in conclusion it is asserted that while the system represents an original solution of the problem it cannot yet be regarded as fully developed. In particular the definition of transmission and ease in operating the equipment leave a good deal to be desired.

3457. The Scophony Television Receiver with the Supersonic Light Modulator.—N. N. Blyumental'. (*Izvestiya Elektroprom. Slab. Toka*, No. 9, 1940, pp. 33–41.)

Operation of the original model of the receiver is discussed and a comparison between this type and one using a cathode-ray tube is drawn. In the former type, a black-and-white image of somewhat better quality is obtained and no higher voltages are used. This is off-set by the higher power required for scanning and crystal-excitation, a more complicated optical system, and more difficult adjustments and maintenance. On balance, the writer considers that the new type cannot compete with cathode-ray-tube receivers for screens of the order of from 1 to 2 m^2, and even less for receivers for individual reception. There are possibilities, however, of producing simplified and more effective receivers with supersonic light modulators both for small screens and for screens exceeding 10 m^2.

3458. A New Mechanical-Optical Television System.—O. B. Lur'e. (*Izvestiya Elektroprom. Slab. Toka*, No. 8, 1940, pp. 40–46.)

In the usual disc systems, the image is projected on to the disc and scanned by displacing the apertures on the disc with respect to the image. This is effected by rotating the disc with peripheral speeds of the order of several hundreds of metres per second. In the system developed by the author, the image is displaced by means of rotating mirrors with respect to stationary apertures, and the same definition can be obtained with speeds of rotation several tens of times lower. The design of the optical system is discussed, and a formula (3) is derived for determining the light flux falling on the photocell. Distortions introduced by the system are also discussed in detail. It is pointed out that the system is simple in construction and quite effective for the transmission of cinema films.

3459. A Monoscope for testing Cathode-Ray Tubes [for Television Reception: Method of generating Test Signals greatly Simplified by putting Transparent Test Picture inside

Tube in Optical Contact with Screen: Technique for obtaining Heat-Proof & Perfectly Graded Picture: Performance of a "Fluorescent Monoscope": Other Possible Applications of Technique (*e.g.* Scale in Monitor Tube in Contact with Screen)].—W. Ehrenberg & G. P. Newton. (*Electronic Eng:g*, Sept. 1943, Vol. 16, No. 187, p. 148.) From the E.M.I. Laboratories.

3460. THE SIGNAL CONVERTER: NEW DISCHARGE TUBE [Deflection-Modulated Cathode-Ray Valve] FOR THE PRODUCTION OF TIME-BASE POTENTIALS.—Nagy & Goddard. (*See* 3393.)

3461. LIGHT-BEAM MODULATION BY THE PHOTO-ELASTIC EFFECT IN GLASS [or Transparent Plastics: a Light-Valve based on a Pressure-Applying System: Relation between Light Intensity and Actuating-Coil Current].—W. E. LeClair. (*Electronics*, May 1943, Vol. 16, No. 5, pp. 122..126.)

3462. USE OF SUBCARRIER FREQUENCY-MODULATION IN COMMUNICATION SYSTEMS.—Bliss. (*See* 3344.)

3463. ALLOYS OF GOLD WITH ALKALI METALS.—A. Sommer. (*Nature*, 21st Aug. 1943, Vol. 152, No. 3851, p. 215.)

For previous work *see* 1752 of June. "As was to be expected, the alloys of the Au*M* type are photoelectrically sensitive, but the sensitivity is too low to be of practical importance . . . The visual change from a practically opaque gold layer to the extremely transparent AuCs layer is particularly striking." From Cinema Television, Ltd.

3464. ON THE INERTIA OF THE SETTING-IN OF CURRENT IN THE SELENIUM PHOTOELEMENT.—W. Gurski. (*Licht*, 20th Oct. & 20th Dec. 1942, Vol. 12, Nos. 10 & 12, pp. 176 & 217 onwards.)

MEASUREMENTS AND STANDARDS

3465. A METHOD OF MEASURING VERY SMALL AND VERY LARGE IMPEDANCES IN THE DECIMETRIC AND CENTIMETRIC WAVE REGION.—A. Weissfloch. (Referred to in 3286, above, as about to appear in *E.T.Z.*)

3466. MEASUREMENT OF PERMITTIVITY BY MEANS OF A WAVE-GUIDE [using *H*-Waves in a Rectangular-Sectioned Guide: Phase-Jump observed when Waves are Reflected from Movable Piston carrying Plate of Material].—G. Fejér & P. Scherrer. (*Sci. Abstracts*, Sec. A, Aug. 1943, Vol. 46, No. 548, p. 164.) For previous work *see* 1176 of April.

3467. A CONTRIBUTION TO THE DETERMINATION OF THE DIELECTRIC CONSTANTS OF MIXED BODIES [Powder Aggregates, etc.].—R. Vieweg & Th. Gast. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 24, 1943, pp. 56–62.)

"For calculating the dielectric constants of mixed aggregates there exist mixing formulae with parameters [*see* for example 3372 of 1942] which hold good for definite field conditions, *i.e.* for a given ratio of the dielectric constants and a definite spatial distribution. The present investigation sought to obtain these parameters by variation of the dielectric constant of one component without alteration of the spatial distribution, and by establishing systems of equations with two unknowns. The variation of the dielectric constant was carried out with powder aggregates by compression of the air [treated as the one component, the powder being the other] in the spaces of the powder, and was recorded automatically as a function of the pressure by means of a highly sensitive self-balancing bridge [the circuits and test condensers are described in some detail]. From the dielectric constant of the mixed aggregate, the space proportion of the powder, and the ratio of the variations of the dielectric constants of the compressed air and of the mixture, the dielectric constant of the powder can be calculated." For a long abstract of a paper by Büchner *see* 1806 of 1942.

3468. REFINEMENT OF THE ELECTROSTATIC METHOD OF MEASURING THE DIELECTRIC CONSTANTS OF GASES.—A. van Itterbeek & J. Spaepen. (*Zeitschr. f. Instr:kunde*, May 1943, Vol. 63, No. 5, pp. 167–169.)

Recently the beat-frequency method has replaced the electrostatic, in spite of the good results obtained with the latter method by Boltzmann, and later by Verain. This fact is probably due to the need for the use of an electrometer in this method. On the other hand, the beat-frequency method involves "great difficulties, for too many factors may affect the apparatus. It is thus practically impossible to measure the dielectric constants of non-polar gases at atmospheric pressure by this method." The writers have therefore modified Verain's electrostatic method by replacing the quadrant electrometer by a low-grid-capacity triode and a sensitive galvanometer. Their complete equipment is shown in Fig. 2.

3469. TUNED LECHER WIRES FOR MEASUREMENTS OVER A WIDE RANGE OF FREQUENCIES [Use of Small Variable Condenser at Transmitter End].—E. C. Woodruff. (*QST*, Aug. 1943, Vol. 27, No. 8, p. 64.)

3470. AN INSTRUMENT FOR DIRECT MEASUREMENT OF THE TRAVELLING WAVE COEFFICIENT IN FEEDERS [the "Feeder Reflectometer"].—G. W. O. H: A. A. Pistol'kors & M. S. Neyman. (*Wireless Engineer*, Aug. 1943, Vol. 20, No. 239, pp. 365–367.) Editorial on the paper dealt with in 1046 of 1942.

3471. HIGH-FREQUENCY WATTMETER AND MATCHING-ERROR METER WITH DIRECT INDICATION [*e.g.* for Wave-Range 14–100 m, Carrier Power 50 kW: particularly for the Monitoring of Feeder Conditions].—W. Buschbeck. (*Hochf:tech. u. Elek:akus.*, April 1943, Vol. 61, No. 4, pp. 93–100.)

From the Telefunken Laboratories. There are so many things which may upset matching (detuning by fog or rime, the breaking of an aerial wire, detuning caused by a neighbouring aerial, wrong selection of an aerial, reversal of radiating direction, etc.) that a continuous watch is necessary to ensure the greatest possible reliability of service. The most straightforward way of carrying out such a watch is to arrange a number of rectifiers along a feeder-section of at least $\frac{1}{2}\lambda_{max}$ so as to test the voltage conditions (Figs. 1–3): it is shown that the power passed is proportional to the product of the extreme values of current or voltage on the feeder (assumed to be loss-free: top of p. 94), so that by determining the voltages or currents at nodes and antinodes the power flowing in the aerial is given by the product, as well as the matching conditions by the quotient.

Such an arrangement, however, involves three rectifiers at each measuring point, and since about twenty of these points (which for satisfactory accuracy should not be more than $\lambda/10$ apart) are necessary for a wave-range of (say) 15–60 m, the whole plan becomes unduly complicated. A simpler solution was therefore sought and found, employing only two rectifiers instead of sixty and not requiring access to a $\frac{1}{2}\lambda_{max}$ length of feeder, which is often difficult to arrange. The principle of the method is shown in Fig. 5. A voltage component qU_1 proportional to the input voltage U_1, and a voltage component proportional to, and in phase with, the input current J_1, and of such value that for correct matching it attains the value qU_1, are connected in series and in opposition. The quantities S and D of the vectorial sum and difference thus obtained are measured with the help of linear rectifiers. The sum and difference of these two quantities, namely, $S + D$ and $S - D$, easily obtained by a d.c. bridge, are shown (pp. 95-96) to be proportional to the extreme values along the feeder and can be used, as in the first arranagement, to indicate both the power passing and the matching conditions.

Sufficiently sensitive (iron-free) dynamometers and quotient meters were not available in commercial form, since (as shown in section XI) the method depends on the two rectifiers exerting a negligibly small coupling effect between the "voltage" voltage-component and the "current" voltage component (*see* above) and this means that they must be of very low-capacity type, requiring sensitive measuring instruments (less than 15 mA per coil for full-scale deflection). An instrument with two moving coils and crossed pointers was therefore developed (scale shown in Fig. 12: it shows power, matching error, and maximum cable voltage). Since the one moving-coil system always carries a current which, no matter what the point of its derivation may be, is proportional to the maximum cable voltage at the moment, the instrument can be used directly as an automatic cable protector. And since the power indication has been shown (*see* for instance Fig. 8 and adjacent text), unlike the case of the first arrangement, to be independent of the degree of mis-matching, the instrument can be used quite generally as a simple h.f. wattmeter.

The method, as described above, assumes the possibility of obtaining a "current" voltage component which will be proportional to, and in phase with, the input current J_1. The practical difficulty in doing this, and the frequency-independent compensation of the actual phase error, is discussed in section V. Another practical point, the design of frequency-independent pure ohmic resistances (Fig. 10) is discussed in section IX. Section XII points out that the "difference" rectifier particularly is required to work linearly down to voltages as small as 1 V, so that it becomes necessary to compensate the initial current, which is very sensitive to temperature: this is done by employing a double diode (with common cathode) as rectifier, using the second anode for compensating purposes (Fig. 13).

3472. DIRECT-READING WATTMETERS FOR USE AT RADIO FREQUENCIES.—G. H. Brown, J. Epstein, & D. W. Peterson. (*Proc. I.R.E.*, Aug. 1943, Vol. 31, No. 8, pp. 403–410.)

A summary was dealt with in 1744 of 1942. Both types, the 500–2000 kc/s and the single-frequency (neighbourhood of 50 Mc/s), are on the "paired thermocouples" principle, the difference in the two instruments lying in the method of coupling the thermocouples to the transmission line. Both instruments have been proved conclusively to be accurate: with the second, tests made on frequencies between 40 and 50 Mc/s show that the instrument develops errors of 5% when the carrier frequency is more than 0.5 Mc/s away from the calibrating frequency.

3473. HARMONIC GENERATOR FOR FREQUENCIES ABOVE 100 Mc/s [primarily for the Alignment of Super-Regenerative Receivers with a 10 Mc/s Range about 200 Mc/s: constructed from Simple I.C.W. Transmitter–Receiver which gave R.F. Output extremely Rich in Harmonics.].—W. M. Colles. (*Wireless Engineer*, June 1943, Vol. 20, No. 237, pp. 300–302.)

3474. RADIONIC FREQUENCY METER [Accurate-Frequency Carrier Signals provided Every 10 kc/s & Every 100 kc/s from 100 c/s to 45 Mc/s: also Every 1000 kc/s from 1 Mc/s to 120 Mc/s: Modulated Note at Will: also Special Models for Adverse Conditions].—F. E. Garner Company. (*Journ. Applied Phys.*, Aug. 1943, Vol. 14, No. 8, p. 409.)

3475. CALIBRATING-WAVEMETERS [for Army & Navy Transmitters: a "Weatherproof" Model with Thermostatic Control to give Constant Calibration].—E. O. Thompson & D. Sunstein. (*Proc. I.R.E.*, July 1943, Vol. 31, No. 7, p. 389.) A Philco development.

3476. A NEW METHOD OF FREQUENCY MEASUREMENT ["Super-Sensitive": primarily for Research on Steam-Turbine Governors: Tuning Fork driven by System Frequency].—H. L. Clark & J. E. Hancock. (*Electronics*, May 1943, Vol. 16, No. 5, pp. 148..152: summary, from *Instruments*.)

"In the narrow frequency band surrounding the resonant peak, the phase angle changes rapidly and is proportional to the deviation of the applied frequency from the resonant frequency of the fork."

3477. FREQUENCY METER [Type 500A: 0–50 kc/s: Simple & Accurate].—Hewlett-Packard Company. (*Review Scient. Instr.*, July 1943, Vol. 14, No. 7, p. 225.)

3478. RADIO STATION OF THE NATIONAL BUREAU OF STANDARDS [New, More Powerful Station and Its Transmissions].—Nat. Bur. of Standards. (*Science*, 20th Aug. 1943, Vol. 98, No. 2538, Supp. p. 8.)

3479. QUARTZ CRYSTAL APPLICATIONS, *and* METHODS FOR SPECIFYING QUARTZ CRYSTAL ORIENTA-

TIONS AND THEIR DETERMINATION BY OPTICAL MEANS.—Mason: Bond. (*See* 3350.)

3480. A MINERAL SURVEY FOR PIEZOELECTRIC MATERIALS.—W. L. Bond. (*Bell S. Tech. Journ.*, July 1943, Vol. 22, No. 2, pp. 145–152.)

3481. THE DISCOVERY OF QUARTZ CRYSTAL DEPOSITS AND NEW PRODUCTION METHODS.—G. Sonnedecker. (*Science*, 6th Aug. 1943, Vol. 98, No. 2536, Supp. p. 10.)

3482. THE VIBRATION CHARACTERISTICS OF "FREE-FREE" CIRCULARLY CURVED BARS.—W. A. Pliskin, J. E. Edwards, & F. P. Bundy. (*Journ. Applied Phys.*, Aug. 1943, Vol. 14, No. 8, pp. 410–417.) Extension of work referred to in 498 of February.

3483. MORE ACCURATE METHODS FOR DESIGNING SHORT-WAVE MULTIVIBRATORS.—V. B. Shteynshleyger. (*Izvestiya Elektroprom. Slab. Toka*, No. 8, 1940, pp. 28–34.)

For the practical design of such multivibrators, the method proposed by L. S. Gutkin is normally used in Russia. In this method parasitic (inter-electrode) capacities are taken into account instead of parasitic inductances as proposed by van der Pol. It is pointed out, however, that in Gutkin's method the anode/grid capacity is regarded as an input dynamic capacity and is determined from formulae for sinusoidal currents. This may lead to serious errors, and accordingly a new method is proposed in which the anode/grid capacity is taken into account directly in the derivation of the differential equation of the multivibrator. Further, a condition of self-excitation is derived in which the parasitic capacities are taken into account as well as the anode reaction (variations in the anode voltage due to variations in the drop across the anode resistance, which are in turn caused by variations in the grid voltage). The discussion is applied to the case of an Abraham–Bloch multivibrator (Fig. 1) for $\lambda = 30$ m, and several numerical examples are given.

3484. SYNCHRONISATION OF VALVE GENERATORS [Mathematical Treatment, including the Back-Coupled Generator with Tuned Anode Circuit].—H. Samulon. (*Sci. Abstracts*, Sec. B, Jan. 1943, Vol. 46, No. 541, p. 15.) From *Helvet. Phys. Acta*, No. 4, Vol. 14, 1941, p. 281 onwards.

3485. THE SELF-INDUCTANCE OF CLOSELY WOUND SINGLE-LAYER CYLINDRICAL COILS.—E. de Gruyter. (*Bull. Assoc. Suisse des Élec.*, 1st July 1942, Vol. 33, No. 13, pp. 375–377: in German.)

If in the formula $L = k\pi^2 d^2 n/d_0$, the "compactness" β ($= d/nd_0$: that is, the ratio of coil diameter to coil length) is introduced, then $L = k\pi^2\beta dn^2$: and since k is a function of β, Bergtold groups both quantities together, with the constant π^2, to constitute the form factor $\kappa = k\pi^2\beta$. The equation then becomes $L = \kappa dn^2$. The writer has set himself to obtain for $\kappa = F(\beta)$ the most simple formula possible which will include not only the tabulated (Bureau of Standards; Bergtold) or formula-derived (*Radio Amateur's Handbook*; Lang, 3210 of 1942) values for β approximately equal to unity, but also the limiting values when β approaches zero and infinity. This formula he finds to be $\kappa = 2\pi . \log_e(1 + \pi/2 . \beta)$, and the table on p. 376 shows how the values of κ thus obtained, for values of β right through from 0.01 to 100, agree with those obtained piecemeal from Kohlrausch's formulae, the Bureau of Standards, Lang, the *Handbook*, and Bergtold's tables.

3486. THE INDUCTANCE OF ROUND [Air-Cored] COILS.—K. E. Müller. (*Bull. Assoc. Suisse des Élec.*, 16th June 1943, Vol. 34, No. 12, pp. 335–341: in German.)

Author's summary:—"Since the usual text-books give only inadequate information on the inductance of air-cored coils, a new approximate formula (eqn. 18) is announced which is accurate within 1% for all dimensions. Further, new expressions are derived for the special cases of the thin (single-layer) coil and the infinitely long multi-layer coil."

Dealing first with the closely wound single-layer coil, the writer obtains eqn. 5: $L = \{7.6\, D^2N^2/(l + 0.52D)\} . \log_{10}(20 + 2.4D/l)$, accurate within 1% over the whole range $0 < D/l < \infty$. Another approximate formula, also accurate within 1%, was given in a previous paper (3614 of 1935) but this was purely empirical and rather more complicated. Eqn. 5 is not only more accurate but also simpler than that obtained by putting $c = 0$ in the Brooks & Turner formula (ref. "3": eqn. 22).

For the infinitely long multi-layer coil, eqn. 11 (theoretically correct and not an approximation) gives a constant $K = 1 - (2/3)(c/D) + (1/3)(c/D)^2$, apparently unknown hitherto, by which the inductance of a single-layer coil of the same mean diameter and the same number of turns must be multiplied to give the required inductance: eqn. 12 gives K^* for the case where the *external* diameters are equal instead of the mean diameters. Eqn. 14 gives L for a short multi-layer coil of fairly small thickness of winding, c.

After these partial solutions the writer comes to the general problem covering all dimensions, and arrives at eqn. 18: L (in cms) $= 7.6\, D^2N^2k \log_{10}\{20 + 2.4D/(l + c)\} / \{l + 0.52D + c - 0.05c(c/D)^6\}$, where $k = 1 - \{l/(l + 1.5D)\}\{(2/3)(c/D) - (1/3)(c/D)^2\}$. Its errors, compared with Grover's tables, are given in Table 1 for the whole range from the single-layer coil to the thickest, fully-wound coil and from the infinitely thin disc to the infinitely long coil: the supplementary figures, in brackets, are the corresponding errors when the correcting term in the denominator, $0.05c(c/D)^6$, is omitted. The table shows that the full equation is accurate within 1%. Actually, for short multi-layer coils where c/D lies between 0.2 and 0.6 the error can be reduced to a few thousandths by replacing $c - 0.05c(c/D)^6$ by $1.01c - 0.06c(c/D)^6$. The equation as it stands applies to "ideal" coils in which the whole winding cross section is uniformly loaded with current. This is not the case in practice, and eqn. 20 gives an approximate correction $+\Delta L = 14.47\, DN . \log_{10}(1.16d/d_0)$, where d is the external diameter of the insulated wire and d_0 that of the bare wire: this correction has an appreciable effect when the number of turns is small. Section 9 points out that eqn. 20 assumes that the centres of the wires of adjacent turns lie at the corners of a square, and shows how d must be replaced (eqn. 21) when this is not the case. It also discusses the validity of eqn. 18, and of the simple approximation given in eqn. 19, $L = \pi^2 D^2 N^2 / (l + 0.45D + 0.5c)(1 + 0.6c/D)$, for spaced windings.

Section 10 compares with eqn. 18 the rival general formula (eqn. 22) of Brooks & Turner, and Table II shows the errors of this on the same lines as Table I for eqn. 18. The results are very different: even an accuracy within 3% is only attained within a limited range.

3487. Measuring Coil Characteristics without an Impedance Bridge [Inductance, "Q", Impedance, Power Factor, Effective Resistance measured by Cathode-Ray Oscilloscope].—H. D. Brailsford. (*Electronics*, May 1943, Vol. 16, No. 5, pp. 86–88 and 176, 178.) Specially useful when changes are being made in the coils under measurement.

3488. A Resistance, Inductance, and Capacitance Tester [for Rapid Checks *in situ*: One Calibration only for All Measurements, the Different Ranges being obtained by Manipulation of the Ratio-Arm Switch (Possibility of Errors in reading Several Scales avoided)].—I. V. White. (*Electronic Eng:g*, Sept. 1943, Vol. 16, No. 187, p. 162.) From the P.O. Research Station.

3489. Charts for simplifying High-Impedance Measurements with the Radio-Frequency Bridge [Advantages of "Equal-Arm" (One-to-One Ratio) Capacitance Bridge, except for High Impedances: This Limitation removed by "Shunt-Condenser" Method, but Calculations are Tedious: Charts render Method quite Simple: particularly useful for Impedances changing Very Rapidly with Frequency.].—R. L. Nielsen. (*Proc. I.R.E.*, July 1943, Vol. 31, No. 7, pp. 372–378.)

3490. The Centenary of the Wheatstone Bridge: Graphical Methods for Solving the D.C. Bridge Network.—R. Neumann. (*Electronic Eng:g*, July 1943, Vol. 16, No. 185, pp. 73–75.)

The second method (described by the writer in 1914) is also applicable to non-linear resistances such as barretters: "it solves the problem in a closed form without resorting to the geometrical analogy of a divergent or convergent series."

3491. A Simple Test Oscillator [for lining-up Receivers: Tetrode Section of 117L7 connected as Triode in Hartley Circuit, Rectifier Section supplies Plate Voltage].—B. Felsburg. (*QST*, Sept. 1943, Vol. 27, No. 9, p. 65.)

3492. Medium- and Long-Wave Aerial System for a Radio Laboratory [for Study of Radio Receivers: Outdoor Aerial leading through Aperiodic Amplifier to Transmission Line: Connection to This made at Each Bench through Suitable Attenuating Network].—T. B. Rymer. (*Journ. of Scient. Instr.*, Aug. 1943, Vol. 20, No. 8, pp. 132–133.)

3493. Discussion on the Factory Testing of Radio Equipments [Informal Meeting].—I.E.E. Wireless Section. (*Journ. I.E.E.*, Part III, Sept. 1943, Vol. 90, No. 11, pp. 145–146.)

3494. Measurement of Flux ["a Comparatively Simple Method of measuring the Total Flux linking a Solenoid Coil carrying a Steady Magnetising Current": Applicable to Determination of B/H Curve of Any Magnetic Material: Extremely Accurate].—R. N. Buttrey. (*Electrician*, 1st Oct. 1943, Vol. 131, No. 3409, p. 321.)

3495. Current-Transformer Burdens [Low-Impedance Relays, Instrument Coils, etc., in Secondary Circuit of Current Transformers: Determination of Their Impedance Characteristics by Simple Apparatus].—G. W. Stubbings. (*Electrician*, 24th Sept. 1943, Vol. 131, No. 3408, pp. 302–303.)

3496. A Composite Material for preventing a Lowering of the Field Strength of a Permanent Magnet with Rise in Temperature.—Ackermann. (*See* paper dealt with in 3556, below.)

3497. Measuring Instruments for Radio [Magnetic, Thermal, & Electrostatic].—E. H. W. Banner. (*Electronic Eng:g*, July 1943, Vol. 16, No. 185, pp. 76–79.)

3498. A Note on a Compensated Hot-Wire Air Thermometer [for measuring Currents at Frequencies up to Radio-Frequencies: constructed from a Thermally Screened (Cotton-Packed) Differential Micromanometer (Roberts Type) fitted with Hot Wire in Each Limb: Air-Bubble Index (does Not change in Length)].—M. A. El-Sherbini & Y. L. Yousef. (*Proc. Phys. Soc.*, 1st Sept. 1943, Vol. 55, Part 5, No. 311, pp. 427–428.)

3499. A New Water-Resistance [for the Absolutely Continuous Adjustment of a Current from Zero to 10 Amperes, from a 220 Volt Supply] and an Ammeter with Automatic Range-Change.—Fr. W. Ackermann. (*Zeitschr. f. Instr:kunde*, May 1943, Vol. 63, No. 5, pp. 180–182.)

3500. Multi-Purpose Test Meter: Mains-Operated Instrument measuring R.F. and A.F. Voltage, D.C. and A.C. Voltage and Current, and Resistance.—R. F. Blackwell & D. J. Becker. (*Wireless World*, Oct. 1943, Vol. 49, No. 10, pp. 288–292.) From the Murphy laboratories.

3501. Vacuum-Tube Voltmeter for measuring High Negative Potentials [primarily in Geiger-Counter Work: "Inverted Voltmeter" (Terman) using Plate as Input & Grid as Output: Grid-Current/Plate-Voltage Curve approx. Linear from 500 to 5000 Volts].—M. Kupferberg. (*Review Scient. Instr.*, Aug. 1943, Vol. 14, No. 8, p. 254.)

3502. Apparatus for Measuring the Resistance of Lightning-Conductor Earths [Modulated H.F. Potentiometer Method (158 of 1941) and a More Compact & Accurate Apparatus on the "Reiss" (Breaking-Off of Oscillation) Principle].—V. Fritsch. (In paper dealt with in 3282, above.)

3503. Resistance Measurements [in a Circuit which Cannot be Opened: Use of Auxiliary Shunting Resistance & Ammeter].—G. W. Stubbings. (*Electrician*, 13th Aug. 1943, Vol. 131, No. 3402, pp. 154–155.)

3504. The Product-Ratio Meter [851 of March] in Its Various Circuit-Forms.—J. Lorenz. (*E.T.Z.*, 20th May 1943, Vol. 64, No. 19/20, pp. 258–261.)

3505. The A.C. Galvanometer used for the Measurement of Electrical Phase Displacement [in Determination of Dielectric Loss-Angle, Phase-Distribution of Currents in Flat Conductors, etc.].—A. F. Day. (*Journ. Inst. Eng. Australia*, June 1943, Vol. 15, No. 6, p. 139.)

3506. A New Constructional Principle for High-Sensitivity Short-Period Galvanometers.—L. N. Shteyngauz [Steinhaus]. (*Izvestiya Elektroprom. Slab. Toka*, No. 8, 1940, pp. 48–49.)

The moving system of the galvanometer (Fig. 1) is suspended along the axis of a cylindrical permanent magnet and passes between two fixed current-carrying coils. The moving system consists of two longitudinal members of highly permeable ferromagnetic material, which do not meet at the middle of the cylinder but are bent away from each other; they are, however, rigidly fixed to each other by a non-magnetic strip. A mirror is also attached to the moving part at this point, a window for the light beam being provided in the cylindrical magnet. The opposite ends of the longitudinal members are attached to iron pole-pieces covering the ends of the cylindrical magnet. The flux of the cylindrical magnet passes along the axis of rotation of the moving part and does not affect its position. At the same time it magnetises to saturation the longitudinal members and thus creates two sharply defined poles which interact with the field of the fixed coils. A number of advantages are pointed out for the proposed system.

3507. General Purpose Mirror-Pointer Galvanometer. — H. Tinsley & Company. (*Journ. of Scient. Instr.*, Aug. 1943, Vol. 20, No. 8, p. 135.)

3508. Oscillograph Galvanometers [SE301-G Galvanometers, for L.F. & A.F. Phenomena (Communication & Geophysical Engineering, Biological Research, Null Detector, etc.): Type A (0–200 c/s) gives 800 mm/mA at 30 cm Optical Distance].—Heiland Research. (*Review Scient. Instr.*, Aug. 1943, Vol. 14, No. 8, pp. 256–257.)

3509. Push-Pull Gauges [for Measurement of Pull of Relay, Operating Pressure of Push-Button Switches, etc: ½ gm to 100 lb.].—J. Chatillon & Sons. (*Review Scient. Instr.*, July 1943, Vol. 14, No. 7, p. 225.)

3510. "A.S.T.M. Standards and Data on Electrical-Heating and Resistance Alloys" [Book Review]. — A.S.T.M. Committee. (*Electronics*, April 1943, Vol. 16, No. 4, p. 226.)

3511. Codes and Conventions in Electronic Apparatus [Resistors, Capacitors, Transformers, Valves: British & American].—G. Parr. (*Journ. of Scient. Instr.*, Aug. 1943, Vol. 20, No. 8, pp. 121–124.)

3512. Radio Standards go to War [Work of the War Committee on Radio, American Standards Association].—H. P. Westman. (*Proc. I.R.E.*, July 1943, Vol. 31, No. 7, pp. 381–384.)

SUBSIDIARY APPARATUS AND MATERIALS

3513. A Spark-less Relay-Switch for Small Currents and High Voltages.—Möller. (*See* 3339.)

3514. A Wide-Band Oscilloscope [specially designed for Use as a Precision-Measurement Tool: Picture 100 mm × 100 mm with Deflection Linearity of at least 92½% on Symmetrical Wave-Shapes: Sensitivity 140 mm (or more) Peak-to-Peak per Volt, Peak-to-Peak: Amplifier Response within ±10% from 10 c/s to 5 Mc/s, less than 5° Phase Shift at 20 c/s: Horizontal Sweep Linearity, less than 15% Departure from Uniform Spot Velocity: Resolution approx. 25 & 45 Lines/cm on Lowest & Highest Accelerating Voltages: Special Features].—Cook. (*Proc. I.R.E.*, Aug. 1943, Vol. 31, No. 8, pp. 410–419.)

"It has been found feasible to extend the frequency range of the horizontal sweep generator to 1 Mc/s, but this development has not been incorporated in the standard oscilloscope because the majority of users do not seem to have need of such performance at this time." The auxiliary "servo sweep generator," providing one trace for each synchronising pulse, is described: *see* 2771 of October (Travis).

3515. A Monoscope for testing Cathode-Ray Tubes [with Transparent Test Picture inside Tube in Optical Contact with Screen: Other Possible Applications of Technique (*e.g.* Scale in Monitor Tube in Contact with Screen)].—Ehrenberg & Newton. (*See* 3459.)

3516. "Introduction to Valves" [and Cathode-Ray Tubes, etc: Second Edition: Book Review].—Henderson. (*Wireless World*, Oct. 1943, Vol. 49, No. 10, p. 309.)

3517. "The Cathode-Ray Oscillograph in Industry" [Book Reviews].—Wilson. (*Proc. Phys. Soc.*, 1st Sept. 1943, Vol. 55, Part 5, No. 311, pp. 430–431: *Journ. of Scient. Instr.*, Sept. 1943, Vol. 20, No. 9, p. 150.) A *BEAMA Journal* series under a similar title has been dealt with in 3171 of 1942 and 266/7 of January.

3518. A New High-Speed Recurrent-Surge Oscillograph [developed by the E.R.A., with Special Features].—White. (*Journ. of Scient. Instr.*, Aug. 1943, Vol. 20, No. 8, pp. 125–129.)

3519. The Signal Converter: New Discharge Tube [Deflection-Modulated Cathode-Ray Valve] for the Production of Time-Base Potentials.—Nagy & Goddard. (*See* 3393.)

3520. Cathode-Coupled Push-Pull Amplifiers [for Time-Base Circuits].—Puckle. (*Electronic Eng:g*, July 1943, Vol. 16, No. 185, pp. 55–57.) Extract from the book "Time Bases" (3521, below.)

3521. "Time Bases (Scanning Generators): Their Design and Development, with Notes on the Cathode-Ray Tube" [Book Review].—Puckle. (*Nature*, 31st July 1943, Vol. 152, No. 3848, pp. 116–117.)

3522. Electron Microscope: Characteristics and Use [in the Textile Industry: Comparison with Optical Microscope: Sources of Error & Their Elimination].—Barnes & Burton. (*Sci. Abstracts*, Sec. B, Jan. 1943, Vol. 46, No. 541, p. 14.) *Cf.* 3348 of 1942.

3523. A General Experimental Solution of Poisson's Equation for Two Independent Variables [and the Plotting of Electron Paths].—Hogan. (*See* 3398.)

3524. The Spatial Asymmetry of Cerenkov Radiation [and a Possible Means of Determining the Velocity of High-Speed Electrified Particles by Measurement of the Angle of Emission].—Wyckoff & Henderson. (*See* 3592.)

3525. The Fundamental Equations of Electron Motion (Dynamics of High-Speed Particles) [Fundamental Equations & Theorems of Relativistic Particle Dynamics "set forth in Clear & Concise Form, unencumbered with Any Material relating to the Theory of Relativity proper"].—MacColl. (*Bell S. Tech. Journ.*, July 1943, Vol. 22, No. 2, pp. 153–177.)

"According to relativistic dynamics the mass of a five thousand volt electron is about 1% greater than the mass of an electron at rest. From this we can infer that, while Newtonian dynamics may be adequate for many purposes in our studies of electron motion, we do not have any great amount of margin, and that it will be necessary to use relativistic dynamics whenever we wish to obtain really good results concerning the motion of even moderately high-speed electrons."

3526. On the Theory of the Electrostatic Beta-Particle Energy Spectrograph: III [Study of Focusing Action (of Electrostatic Analyser) on Particles having Relativistic Speeds].—Rogers & Horton. (*Review Scient. Instr.*, July 1943, Vol. 14, No. 7, pp. 216–220.)

3527. Oscillograph Galvanometers [SE301-G Galvanometers, for L.F. & A.F. Phenomena].—Heiland Research. (*See* 3508.)

3528. Rochelle-Salt Crystal Devices of Low Impedance ["Monobar" Unit for Mirror Oscilloscope, Loudspeaker, etc.].—Tibbetts. (*See* 3422.)

3529. A Vibrographic [Stretched-Wire] Study of the Output of a Single-Phase Half-Wave Power Rectifier.—Tirunarayanachar. (*See* 3326.)

3530. Operation of Vapour-Tube Rectifier Circuits with Opposing Direct Voltages [as in Accumulator-Charging and the Energising of D.C. Motors: Graphical Analysis & Experimental Confirmation].—Fluke. (*Electronics*, June 1943, Vol. 16, No. 6, pp. 100–103.)

3531. Analysis of Rectifier Operation [taking into Account the Diode Resistance & Protective Resistance: the Emission from Oxide-Coated Cathodes], *and* Analysis of Full-Wave Single-Phase Rectifier with Choke Input.—Schade: Tillotson & Wallis. (*See* 3325 & 3327.)

3532. Current Converters [Oxide-Cathode & Mercury-Cathode Types] as Generators of X-Rays [and the Question of Protection].—Glöde & von Issendorff. (*E.T.Z.*, 20th May 1943, Vol. 64, No. 19/20, pp. 268–270.)

3533. Electronic Regulators for A.C. Generators [Circuit using Single Large Thyratron (FG–57): Simpler Arrangement, for Small Generators, using FG–17 Thyraton & Two Type 866 Rectifiers].—Benson. (*Electronics*, April 1943, Vol. 16, No. 4, pp. 104–107.)

3534. A Note on Volume Rectification of Crystals.—Khastgir. (*See* 3364.)

3535. Silver Plating at Very-High Frequencies: the Effect of Platings and Base Materials on Coil "Q" [Measurements on 100–400 Mc/s.].—White. (*QST*, Sept. 1943, Vol. 27, No. 9, p. 64.)

"Aside from its aesthetic value, silver plating in general is of little help . . . However, if iron or nickel parts must be used in the field of the coil, a very thorough silvering is a definite help."

3536. Cadmium Plating for Variable Condensers [unaffected under Salt-Spray Tests, unlike Silver Plating].—(*Electronic Eng:g*, July 1943, Vol. 16, No. 185, p. 70.)

3537. Self-Inductance of Condensers.—Fomenko. (*Izvestiya Elektroprom. Slab. Toka*, No. 9, 1940, pp. 47–53.)

The author considers (a) plate-type condensers, including spirally wound condensers where the foils are all connected at each end of the tube, and (b) spirally wound condensers with connections by wires to specific points only. Numerous condensers were tested at frequencies from 500 kc/s to 12 Mc/s by the substitution method (Fig. 1), and the results are shown in a number of tables and curves. *Cf.* Leider, 1611 of 1940.

3538. Discussion of the Relatively High Impedance of an Electrolytic Condenser to Radio Frequencies.—Deeley. (*Electronics*, April 1943, Vol. 16, No. 4, pp. 209–211.)

3539. Surge-Limiting Electrolytic Condensers [for Radio Receivers].—Zakgeym & Nikolaeva. (*See* 3365.)

3540. Codes and Conventions in Electronic Apparatus [Resistors, Capacitors, Transformers, Valves: British & American].—Parr. (*Journ. of Scient. Instr.*, Aug. 1943, Vol. 20, No. 8, pp. 121–124.)

3541. Mica Replacement: New Synthetic has Great Possibilities in Electronics [" Polectron "].—General Aniline & Film. (*Scient. American*, July 1943, Vol. 169, No. 1, pp. 11–12: *Journ. Applied Phys.*, Aug. 1943, Vol. 14, No. 8, p. 408.)

3542. India's Mica Industry [Summary of Bulletin issued by Geological Survey of India].—Dunn. (*Sci. & Culture* [Calcutta], May 1943, Vol. 8, No. 11, pp. 445–446.)

3543. Electrical Properties of Indian Mica: I—Power Factor [Measurements of Samples of Different Qualities from Different Parts of India: including Clear, Stained & Spotted Micas].—Datta, Sen Gupta, & Mahanti. (*Indian Journ. of Phys.*, April 1943, Vol. 17, Part 2, pp. 79–95.) *Cf.* 2829 of October.

3544. New Regulation on the Employment of Mica in Electrical Construction.—(*Génie Civil*, 15th Jan. 1943, Vol. 120, No. 2, p. 20.)

3545. Low-Loss Coaxial Cables [with Solid Flexible Dielectric, " Copolene B "].—(*See* 3383.)

3546. Bicolon Covered Wires [replacing Coverings such as Enamel & Cotton, Enamel & Silk, etc: Many Advantages].—British Insulated Cables. (*Electrician*, 6th Aug. 1943, Vol. 131, No. 3401, o. 734.) *See* also *Wireless Engineer*, Sept. 1943, Vol. 20, No. 240, p. 440.

3547. Injection-Moulded Thermo-Setting Parts [Low Cost & Other Advantages: Homogeneity of Section: Conversion Unit for Adaptation of Standard Machine].—Morve. (*Sci. Abstracts*, Sec. B, Aug. 1943, Vol. 46, No. 548, p. 156.)

3548. A Note on the Puncture Strength of Porcelain, etc. [Addendum to Writer's Paper, 1968 of July: Increased Value of Graphs when Indications of the Spread of Individual Observations are given: Curves for Porcelain].—Rosenthal. (*Electronic Eng:g*, Aug. 1943, Vol. 16, No. 186, p. 130.)

3549. Water-Proofing Chemical [" Dri-Film," for Treatment of Ceramic Insulators, etc: " Nine Times More Effective in reducing Leakage than Wax or Varnish "].—General Electric. (*Review Scient. Instr.*, Aug. 1943, Vol. 14, No. 8, p. 257.) *See* also 2229 of August.

3550. Vinyl Product combats Corrosion [Properties of " Tygon," varying in Form from Bone-Hard to Soft Jellies].—(*Sci. Abstracts*, Sec. B, Sept. 1943, Vol. 46, No. 549, p. 172.)

3551. Calculation of the Scattering of Light by " Filament-Chain " Solutions [where the Method of Molecular-Structure Investigation by measuring the Depolarisation of the Scattered Light is Not Effective].—Neugebauer. (*Ann. der Phys.*, 13th May 1943, Vol. 42, 1942/3, No. 7/8, pp. 509–533.) For earlier work *see* 2958 of 1942.

3552. A Contribution to the Determination of the Dielectric Constants of Mixed Bodies.—Vieweg & Gast. (*See* 3467.)

3553. The Resistance of Bimetallic Conductors and Tubes at High Frequencies [in connection with the Replacement of Copper Lines].—Kuleshow. (*Sci. Abstracts*, Sec. B, Jan. 1943, Vol. 46, No. 541, p. 5: from *Elektrosvyaz*, No. 5, 1941.)

3554. The Electrical Heating of Wires and Plates [Theoretical Treatment, with Experimental Confirmation: including Formula for Ratio of Currents raising Wires of Different Diameters to the Same Temperature: Calculation of Thickness of Surrounding Air-Layer by Langmuir's Formula: etc.].—Kussi. (*Bull. Assoc. Suisse des Élec.*, 16th June 1943, Vol. 34, No. 12, pp. 342–347: in German.)

3555. " A.S.T.M. Standards and Data on Electrical-Heating and Resistance Alloys " [Book Review].—A.S.T.M. Committee. (*Electronics*, April 1943, Vol. 16, No. 4, p. 226.)

3556. A New Temperature-Dependent Magnetic Composite Material [for Use in Compensating for the Lowering of Permanent-Magnet Field Strengths with Rising Temperature, or in Transformers with Temperature-Dependent Efficiency, etc.].—Ackermann. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 24, 1943, pp. 45–46.)

It has long been customary to compensate for such lowering of p.m. field strength by means of a magnetic shunt of some alloy (nickel–iron, nickel–copper, platinum–iron, etc.) whose permeability decreases with temperature: a typical form of characteristic for such an alloy is shown in the curve of Fig. 2. The writer has made use of the bimetallic effect to produce a composite material whose permeability *increases* with temperature practically linearly from $-80°$ to $+100°$ C: Fig. 4 gives the curve showing the rise of μ (for a field of 3 oersteds) from below 10 to just over 30. This material is made by riveting together two plates of 10 mm nickel and an intermediate plate of 20 mm invar and rolling out the combination at 1220° to a thickness of 5 mm. This is followed by a heat treatment and further (cold) rolling to 1.2 mm: a final treatment leaves the finished product (now 20% thinner) in a state where at room temperature the nickel is under tension and the invar under compression. Both tension and compression increase as the temperature falls and decrease as it rises, for at the final temperature of 200° C in the finishing process the mutual strains were zero. Since nickel decreases its induction (in a constant field) under tension, and invar does the same under compression, the result is as stated above.

3557. Investigations of Ferromagnetic Impurities [in Copper, Brass, etc.]: II [Effect of Heat Treatment in eliminating the Ferro-magnetism].—Constant, Faires, & Lenander. (*Phys. Review*, 1st/15th June 1943, Vol. 63, No. 11/12, pp. 441–445.) Such magnetic impurities may be objectionable in connection with galvanometer coils, standard inductances, etc. For I *see* 1221 of 1940.

3558. Two-Piece Transformer Cores [Type "C" Wound-Strip Hipersil Cores, cut into Two Segments, with Ends machined to give Coinciding Surfaces].—Westinghouse. (*Review Scient. Intr.*, Aug. 1943, Vol. 14, No. 8, p. 258.)

3559. Dust-Cored Coils: Part I—The Development of Dust-Core Materials: Part II—Analysis of Losses [and Their Experimental Analysis]: Part III—Variation of Q with Frequency.—Welsby. (*Electronic Eng:g*, Aug., Sept., & Oct. 1943, Vol. 16, Nos. 186, 187, & 188, pp. 96–98, 149–153, & 191–194: to be contd.)

3560. Instrument Transformers: American Designs which Conserve Critical Materials.—(*Electrician*, 6th Aug. 1943, Vol. 131, No. 3401, pp. 127–129.) From *Gen. Elec. Review*, June 1943.

3561. Rhenium: Now Available to Researchers from a Domestic Source.—Melaven & Bacon. (*Scient. American*, Sept. 1943, Vol. 169, No. 3, pp. 125–126.)

3562. Mancoloy Alloys: Low-Resistance Materials with Low Temperature-Coefficient [*e.g.* for Drag Elements in Instruments depending on Eddy-Current Braking].—Mallory Metallurgical Products. (*Electronic Eng:g*, Oct. 1943, Vol. 16, No. 188, p. 214.)

3563. Armoured Wood [Plywood between Metal Sheets] in the Service of Electrical Technique [including High Frequency].—Stäger. (*Bull. Assoc. Suisse des Élec.*, 9th Sept. 1942, Vol. 33, No. 18, pp. 500–502.) An Army wireless equipment is photographed as one example.

3564. Solderless Wire Jointing [Rakos Process].—Technotherm, Ltd. (*Wireless Engineer*, July 1943, Vol. 20, No. 238, p. 339.) *See* also 1988 of July, and for a somewhat similar use of carbon electrodes *see* the "soldering pencil," 2516 of September.

3565. Alcho-re Fluxes for Electrical Connections [Resin Type but with High Fluxing Power: Residue sets Hard, Free from Chemical Action, Moisture-Resistant, Insulating].—(*Electrician*, 6th Aug. 1943, Vol. 131, No. 3401, pp. 133–134.)

3566. The Lubrication of Mechanisms and Automatic Devices [especially Lightly Loaded Devices operating only Intermittently: Dangers of Oil & Grease: Dry Lubrication using "Dag" Colloidal Graphite].—Acheson, Ltd. (*Electronic Eng:g*, Sept. 1943, Vol. 16, No. 187, p. 167.)

3567. A Sensitive Polarity-Indicator [Phenol-Phthalein/Sodium-Sulphate Solution: Potentials as Low as 0.001 mV].—(*QST*, Aug. 1943, Vol. 27, No. 8, p. 60.)

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3568. Use of Subcarrier Frequency-Modulation in Communication Systems.—Bliss. (*See* 3344.)

3569. The Resistance of Bimetallic Conductors and Tubes at High Frequencies [in connection with the Replacement of Copper Lines].—Kuleshow. (*Sci. Abstracts*, Sec. B, Jan. 1943, Vol. 46, No. 541, p. 5: from *Elektrosvyaz*, No. 5, 1941.)

3570. *Wireless World* Brains Trust: Wired Broadcasting and Television.—Puckle. (*Wireless World*, Oct. 1943, Vol. 49, No. 10, pp. 301–302.) For letters from Lakin and Batt supporting wired broadcasting *see* pp. 314–315.

3571. Post-War Channels [and the Necessity for a 10 kc/s Separation].—"Diallist." (*Wireless World*, Oct. 1943, Vol. 49, No. 10, p. 317.) *See* also Thomas, 3176 of November.

3572. Radio Data Charts: No. 11—Frequency and Wavelength.—Sowerby. (*Wireless World*, Oct. 1943, Vol. 49, No. 10, pp. 304–305.)

3573. The QRR Portable: a Transmitter-Receiver for 40 and 80 Metres.—Palmer. (*QST*, Sept. 1943, Vol. 27, No. 9, pp. 52–54.)

3574. Invasion Communications: the Jobs of the Signal Corps are Many and Varied.—Sigerson. (*Scient. American*, Aug. 1943, Vol. 169, No. 2, pp. 53–55.)

3575. British Army Radio: Views taken at the Army Exhibition in Oxford Street, W.—(*Electronic Eng:g*, Sept. 1943, Vol. 16, No. 187, pp. 140–141.)

3576. Central Heating of the Sottens Station by Recuperation from the Valve-Cooling Water [with a Saving of 60 000 kWh during the Winter 1942/3].—Pièce. (*Bull. Assoc. Suisse des Élec.*, 11th Aug. 1943, Vol. 34, No. 16, pp. 481–483: in French.)

3577. The Activities of the Radio-Swiss Company in 1942.—(*Bull. Assoc. Suisse des Élec.*, 16th June 1943, Vol. 34, No. 12, p. 350: in German.)

3578. KTKC builds a 5 Kilowatt Transmitter in War-time [Engineers make Whirlwind Shopping Trip (including Many Amateur Radio Parts) and build the Transmitter, etc., Themselves].—Williamson. (*Electronics*, May 1943, Vol. 16, No. 5, pp. 74–79.)

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3579. ROOTS OF SIN $z = z$.—Hillman & Salzer. (*Phil. Mag.*, Aug. 1943, Vol. 34, No. 235, p. 575.) From the Mathematical Tables Project, Nat. Bureau of Stds. (*see* 3187 of November).

3580. ON A TYPE OF POLYNOMIAL MET WITH IN THE STUDY OF ELECTRIC FILTERS.—Parodi. (*See* 3312.)

3581. THE ADVANTAGES IN USING ORTHOGONALISED TERMS IN A POLYNOMIAL FOR CURVE-FITTING.—Satakopan. (*Indian Journ. of Phys.*, April 1943, Vol. 17, Part 2, pp. 115–120.)

Author's summary :—"The paper briefly discusses the relationships between the least-squares solutions of Polynomial Constants obtained by using: (i) ordinary power terms (solutions discussed by S. M. Kerawala, 565 of 1942), and (ii) orthogonalised terms (R. A. Fisher's method) when the polynominal is fitted to a series of observations. It is shown how all the constants of polynomials up to the rth degree obtained by using simple power terms can be determined from the $(r + 1)$ constants obtained from the orthogonal terms. The advantages of using the orthogonalised terms instead of ordinary power terms are also indicated."

3582. INVERSION FORMULAE FOR THE LAPLACE TRANSFORMATION.—Erdélyi. (*Phil. Mag.*, Aug. 1943, Vol. 34, No. 235, pp. 533–537.)

The "complex" inversion formula "often associated with the name Mellin" is so simple and general that it is used almost to the exclusion of the others. Its only drawback for practical application is that it involves complex integration and requires the knowledge of $g(s)$ along a line parallel to the imaginary axis. "The particular feature of the present inversion formula is that the coefficients of the expansion in orthogonal functions of $f(t)$ are finite linear combinations of the values assumed by $g(s)$ at a set of equidistant points. Thus it is not necessary to know the values of $g(s)$ along the whole of the positive real axis . . . only a discrete set of values is relevant. Therefore these formulae might be expected to be useful when $g(s)$ is found by numerical methods."

3583. GRAPHICAL DIFFERENTIATION AND INTEGRATION.—Hansel. (*Phil. Mag.*, Aug. 1943, Vol. 34, No. 235, pp. 565–574.) "Methods supplementary or alternative to those already described" (1324 of April and 2530 of September).

3584. ON RANDOM DISTANCES BETWEEN TWO RECTANGLES.—Ghosh. (*Sci. & Culture* [Calcutta], May 1943, Vol. 8, No. 11, p. 464.)

3585. GENERALISATION OF BATEMAN'S DIFFERENTIAL EQUATIONS [representing Chance that n Events will occur in Time t].—Ruark. (*Phys. Review*, 1st/15th June 1943, Vol. 63, No. 11/12, p. 457: short summary only.)

3586. THE APPLICATION OF STATISTICAL METHODS TO THE QUALITY CONTROL OF MATERIALS AND MANUFACTURED PRODUCTS: SYMPOSIUM.—(*Journ. Inst. Eng. Australia*, April 1943, Vol. 15, No. 4, pp. 86–87.) Continued from 2879 of October.

3587. 36 AND 72 ORDINATE SCHEDULES FOR GENERAL HARMONIC ANALYSIS [Corrections]. —Denman: Grover. (*Electronics*, April 1943, Vol. 16, No. 4, pp. 214 and 215.) *See* 1147 of April.

3588. NUMERICAL FOURIER ANALYSIS TO TWENTY-NINE HARMONICS [Beevers & Lipson's "Printed Strips" Method of Synthesis adapted to Inverse Process].—Ross. (*Nature*, 11th Sept. 1943, Vol. 152, No. 3854, pp. 302–303.) *See* 4246 of 1936. For a letter from Macewan & Beevers *see* p. 303.

3589. NUMERICAL SOLUTION OF THE BOUNDARY VALUE PROBLEM FOR THE POTENTIAL EQUATION BY MEANS OF PUNCHED CARDS [Method applicable to Other Problems involving Successive Approximations].—Kormes. (*Review Scient. Instr.*, Aug. 1943, Vol. 14, No. 8, pp. 248–250.) For another recent paper *see* 2873 of October.

3590. SIMPLE AND ACCURATE FORMULA FOR BAROMETRIC CORRECTIONS [instead of Usual Procedure involving Tables, Abaci, etc., which is Wearisome & Subject to Mistakes]. —do Prado. (*Review Scient. Instr.*, July 1943, Vol. 14, No. 7, pp. 221–222.)

3591. A GENERAL EXPERIMENTAL SOLUTION OF POISSON'S EQUATION FOR TWO INDEPENDENT VARIABLES [and the Plotting of Electron Paths].—Hogan. (*See* 3398.)

3592. THE SPATIAL ASYMMETERY OF CERENKOV RADIATION [375 & 3395 of 1939 and 2107 of 1940] AS A FUNCTION OF ELECTRON ENERGY [Strong Support of Frank & Tamm's Explanation of Mechanism based on Fact that the Electrons are travelling through the Transparent Medium with a Velocity Greater than That of the Light which They Produce].—Wyckoff & Henderson. (*Phys. Review*, 1st/15th July 1943, Vol. 64, No. 1/2, pp. 1–6.)

"If the explanation [p. 6] is valid, an experiment of this type provides a means of determining the velocity of high-speed electrified particles in terms of time and distance, since the angle of emission depends upon the distance the particle moves in the time for the radiation to travel one wavelength of the light observed. The values of β used in computation of the theoretical curves are based upon the relativistic expression for the energy of a particle. In this same sense this expression is substantiated."

3593. JOHN STONE STONE: 1869–1943 [Obituary Notice and Tributes].—(*Proc. I.R.E.*, Sept. 1943, Vol. 31, No. 9, pp. 463 and 521–523.)

3594. FLUORESCENT LAMPS SHOW STANDING WAVES ON LINES [Lecher Wires, Loaded Lines, Aerials, etc.].—Honnell. (*Electronics*, May 1943, Vol. 16, No. 5, pp. 112 and 114.)

3595. Film-Recording Seismograph [Hitherto Unknown Relations between Earthquakes & Large Dams studied with Electro-Magnetic Seismographs : Radio and Electronic Circuits make possible a High Degree of Accuracy].—Benioff & others. (*Electronics*, May 1943, Vol. 16, No. 5, pp. 89–92.)

3596. The Electrical Heating of Wires and Plates [Theoretical Treatment, with Experimental Confirmation].—Kussi. (*See* 3554.)

3597. Cumulative Correction Table for Data Sheets 1 to 50 contained in Vols. 14 & 15, *and* Index to Data Sheets in Vols. 14 & 15.—(*Electronic Eng:g*, July 1943, Vol. 16, No. 185, pp. 65–66 : p. 67.)

3598. Radio Data Charts : No. 11—Frequency and Wavelength.—Sowerby. (*Wireless World*, Oct. 1943, Vol. 49, No. 10, pp. 304–305.)

3599. "The American Leonardo : a Life of Samuel F. B. Morse" [Book Review].—Mabee. (*Science*, 20th Aug. 1943, Vol. 98, No. 2538, pp. 175–176.) "Senator Smith studied Morse's face for signs of insanity."

3600. "Dynamical Analogies" [Book Review].—Olson. (*Proc. I.R.E.*, Sept. 1943, Vol. 31, No. 9, p. 524.)

3601. "Hyper amd Ultra-High Frequency Engineering."—Sarbacher & Edson. (Referred to in 3335, above.)

3602. "Allied Radio Data Handbook" [Book Review].—Cooke. (*Journ. Applied Phys.*, Aug. 1943, Vol. 14, No. 8, p. 409.) From the U.S. Naval Research Laboratory.

3603. "The Cathode-Ray Oscillograph in Industry" [Book Reviews].—Wilson. (*See* 3517.)

3604. Recording Low Relief in Metallic Surfaces by Cellulose Acetate Moulds [Superior to Photograph in being Three-Dimensional, but serving also as Negative for Photographic Copies : Megascopic & Microscopic Details : the Technique].—Dollar. (*Nature*, 28th Aug. 1943, Vol. 152, No. 3852, p. 248.)

3605. Sound Transmission and Reflection in Medical Diagnosis [including Interpretation of Pulse-Wave Propagation along an Artery, Locating of Consolidations, Obstructions, etc : Use of "Monobar" Rochelle-Salt Microphones with Very Large L.F. Response].—Tibbetts. (In paper dealt with in 3422, above.)

3606. Discussion on "The Electrical Amplifying Stethoscope and Phono-Electrocardioscope" [2606 of September].—Donovan. (*Journ. I.E.E.*, Part III, Sept. 1943, Vol. 90, No. 11, pp. 149–150.)

3607. Photoelectric Manometer [primarily for Accurate Recording of Cardiovascular Pressure Changes].—Gilson. (*Electronics*, April 1943, Vol. 16, No. 4, pp. 112 and 140.) Improved from that previously described (1737 of June, where the writer's name is given wrongly).

3608. Surgical Applications for the Electronic Metal Locator [Further Development of the R.F. Probe (1584 of 1942)].—Waugh Laboratories. (*Electronics*, May 1943, Vol. 16, No. 5, p. 114) For an earlier type of detector, for metal in logs, *see* 3697 of 1940.

3609. Amplifying and Recording Technique in Electro-Biology, with Special Reference to the Electrical Activity of the Human Brain.—Parr & Grey Walter. (*Journ. I.E.E.*, Part III, Sept. 1943, Vol. 90, No. 11, pp. 129–142 : Discussion pp. 142–144.) *See* also 2602/3 of September.

3610. A Summary of Researches in Seeing at Low Brightness Levels.—Luckiesh & Taylor. (*Sci. Abstracts*, Sec. A, Sept. 1943, Vol. 46, No. 549, p. 184.)

3611. Light-Beam Modulation by the Photo-elastic Effect in Glass.—LeClair. (*See* 3461.)

3612. Light-Beam Communication over about 2 Miles, with Beam so Concentrated (using Camera as Focusing Lens) that it can be received only at One Window.—Saunders. (*QST*, Aug. 1943, Vol. 27, No. 8, p. 51.)

3613. The German Army "Speech-on-Light" Signalling Apparatus [adjusted to White, Red, or Infra-Red Light by Knob : Beam 6 Yards wide at One Mile : Modulation by Movement of Small Right-Angled Prism, varying Its Pressure against a Large One : made by Carl Zeiss].—Hull. (*Electronic Eng:g*, Oct. 1943, Vol. 16, No. 188, pp. 185–187 and 211.)

3614. The Hercules Rotating-Mirror Camera [Ten Times as Fast as the Rotating-Drum Type : for Explosives Research, etc.]—Cairns. (*Scient. American*, Sept. 1943, Vol. 169, No. 3, p. 124.)

3615. Measuring Photographically : Several Examples wherein Photography provided Convenient Means of recording Measurements under Unfavourable Conditions.—Catlin. (*Gen. Elec. Review*, Sept. 1943, Vol. 46, No. 9, pp. 503–504.)

3616. A Simple, Reliable, abd Inexpensive Phototube Relay [using the 117L7GT Valve, Diode Section providing D.C. Voltage for Amplifier Section].—Seiler. (*QST*, Sept. 1943, Vol. 27, No. 9, pp. 66–67.)

3617. Electronic Time Meter [for Use with Photocell or Other Controls : 0.0001 to 3.0 Seconds].—General Electric. (*Review Scient. Instr.*, Aug. 1943, Vol. 14, No. 8, p. 255.)

3618. Side-Shifts of Paper corrected in Roll-Winding Machine [by Photoelectric Side-Register Control].—Cameron Machine. (*Electronics*, April 1943, Vol. 16, No. 4, pp. 144..148.)

3619. A Recording [Photoelectric-Bridge] Relay for an Infra-Red Spectrograph.—Bell. (*Phys. Review*, 1st/15th June 1943, Vol. 63, No. 11/12, p. 461: summary only.) "A provoked potential of 10^{-8} volt in the thermocouple is recorded as readily distinguishable from the background."

3620. A Spectrophotometric Method for the Analysis of Multicomponent Mixtures, and Its Infra-Red Application [in Control Laboratory of Manufacturing Plant: Thermopile used without Amplifier].—Brattain & others. (*Journ. Applied Phys.*, Aug. 1943, Vol. 14, No. 8, pp. 418–428.)

3621. The Application of Multiplier Phototubes to Quantitative Spectrochemical Analysis.—Boettner & Brewington. (*Phys. Review*, 1st/15th July 1943, Vol. 64, No. 1/2, p. 45: summary only.)

3622. Applications of Physics in Chemical Industry [including *p*H Measurements, Photocell Devices, Detection of Flaws in Iron Rails (Gorelik's Method where Valve, with Semicylindrical Anode opening towards Flattened Top of Bulb, detects Variation in Magnetisation as It moves close to Rail), etc.].—Mee. (*Journ. of Scient. Instr.*, Sept. 1943, Vol. 20, No. 9, pp. 137–141.)

3623. The Physicist in the Chemical Industry.—Bosworth. (*Journ. of Scient. Instr.*, Sept. 1943, Vol. 20, No. 9, pp. 142–145.) "In view of the present very real need for personnel trained in physics in the ranks of chemical and even of biochemical industry, it appears desirable . . . that more publicity be given to the substantial recent contributions made by physics to industrial needs. . . ."

3624. Safety with X-Rays: the Detection and Measurement of Radiation [with Designs of Direction Indicator & Electroscope Detectors].—Long. (*Electronic Eng:g*, July 1943, Vol. 16, No. 185, pp. 52–54 and 84.) For a letter on the use of the name "Cellophane" *see* August issue, No. 186, p. 128.

3625. Radiosulphur Tracer Study of Sulphurised Lubrication Addition Agents [using a Geiger-Müller Counter].—Clark & others. (*Journ Applied Phys.*, Aug. 1943, Vol. 14, No. 8, pp. 428–434.)

3626. Prospecting for Radium Ore [with a Portable Adaptation of the Geiger-Müller Counter: Results at Great Bear Lake].—Locher: Ridland. (*Science*, 20th Aug. 1943, Vol. 98, No. 2538, Supp. p. 8.)

3627. Apparatus for the Detection of Splits in Tungsten Wire [Application of Eddy-Current Principle].—O'Dell. (*See* 3411.)

3628. Measuring Shaft Power Output by means of Acoustics.—Downie. (*BEAMA Journal*, Aug. 1943, Vol. 50, No. 74, p. 255: summary only.)

3629. Controversy [Locomotive Engineers *versus* Electronic Engineers as Designers of Electronic Engine-Indicator, and the General Question].—Cattanes: Robson & Carling. (*Electronic Eng:g*, Oct. 1943, Vol. 16, No. 188, p. 183.) Editorial on correspondence in *Engineering*.

3630. Recording Unit for Strain and Timing Functions [Dynamic Performance of Heavy Machines under Field Conditions].—Meier. (*Electronics*, April 1943, Vol. 16, No. 4, pp. 79–83 and 114.)

3631. Autographic Load–Elongation Apparatus for Fibres [using a Revised Form of the Muller & Garman Automatic Electronic Balance (859 of 1939) with Photoelectric Controls].—Sookne & Rutherford. (*Journ. of Res. of Nat. Bur. of Stds.*, July 1943, Vol. 31, No. 1, pp. 25–31.)

3632. Measuring Small Increments of Length [of Order of 10^{-7} cm] by Hydraulic Michelson Interferometer.—Stergiopoulos & others. (*Phys. Review*, 1st/15th July 1943, Vol. 64, No. 1/2, p. 44: summary only.)

3633. The Pneumatic Measurement of Very Small Displacements: the "Solex" Micrometer.—(*Génie Civil*, 1st April 1943, Vol. 120, No. 7, pp. 79–80.) For a long paper see *Zeitschr. f. tech. Phys.*, No. 3, Vol. 24, 1943, pp. 46–53.

3634. A New Micrometer ["Static Expansion Meter"] on the Inductive Principle.—Lehr & others. (*Arch. f. Tech. Messen*, April 1943, Part 142, V91122-9, Sheet T44.)

An improvement on the device described in a previous paper (1551 of May). Motion of the point affects two electro-magnets connected in opposition, increasing the air-gap of the one and decreasing that of the other. The circuit diagram of the 10 kc/s generator supplying the device is shown in Fig. 3. The equipment is easily and reliably used by operatives with little training.

3635. The Measurement of Small Displacements [and particularly a Mutual-Induction Device working on a 2 Mc/s Frequency: for Movements down to 10μ].—Staiger. (*Zeitschr. V.D.I.*, 29th May 1943, Vol. 87, No. 21/22, pp. 332–333.)

3636. The Haskell Gun-Bore Straightness Indicator [on Electro-Magnetic Induction Principle].—Baldwin Locomotive Works. (*Journ. of Scient. Instr.*, Sept. 1943, Vol. 20, No. 9, p. 148.)

3637. Exterior Ballistics of Small-Arms Ammunition [Results with Method utilising Electrostatic Charge carried by Bullet in Flight].—Bacon. (*Phys. Review*, 1st/15th July 1943, Vol. 64, No. 1/2, p. 44: summary only.) For other recent methods *see* 1268 & 1589/90 of 1942.

3638. The Measurement of Torsional Vibrations [with an Electromagnetic Pick-Up Unit: the Use of an Electrical Filter: Diesel-Engine Torsiograms: etc.].—Stansfield. (*Sci. Abstracts*, Sec. B, June 1943, Vol. 46, No. 546, p. 109.)

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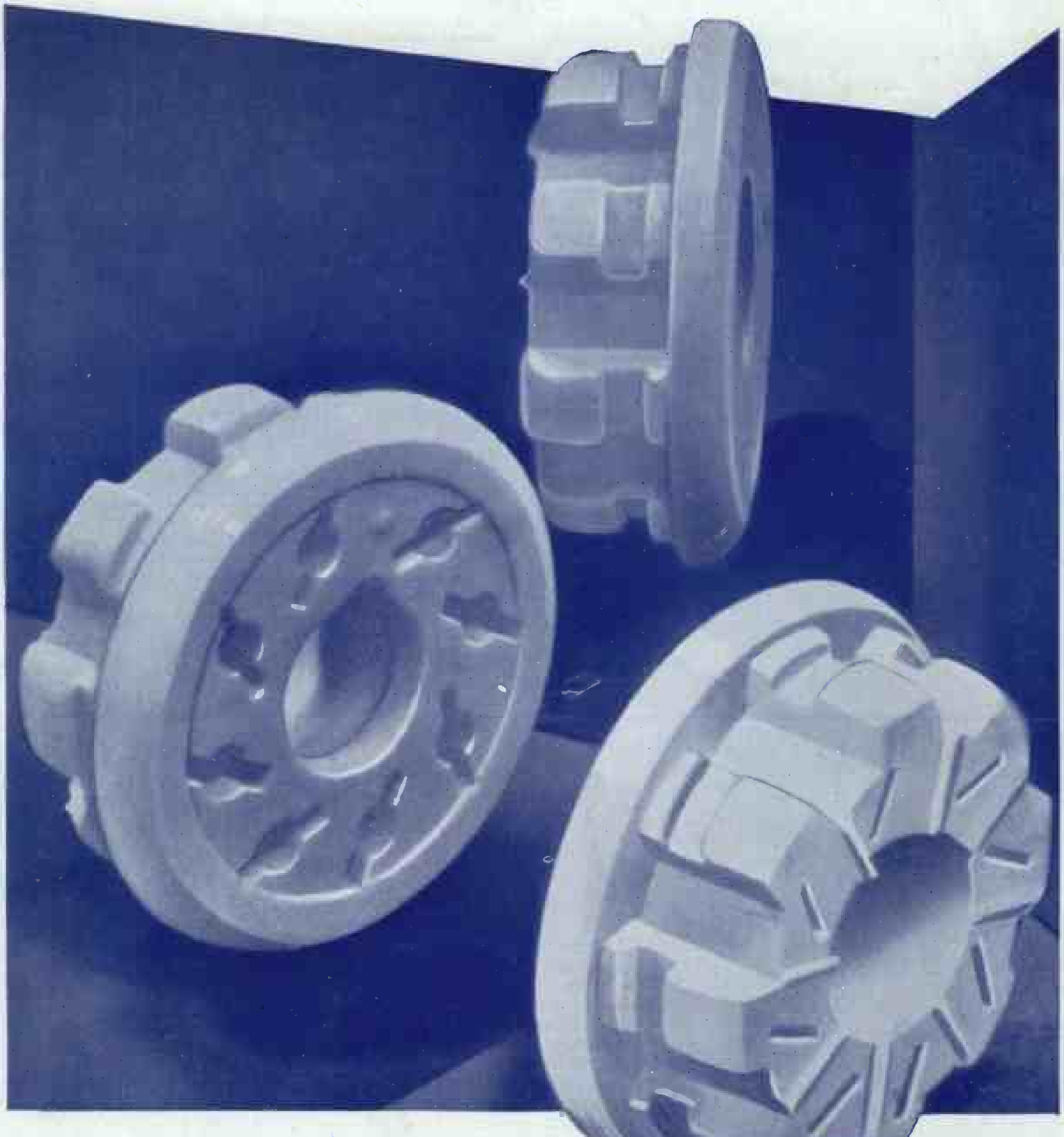

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